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Hitachi Single-Chip Microcomputer  
H8/3217 Series  
H8/3217, H8/3216  
H8/3214, H8/3212  
H8/3202  
Hardware Manual



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# Preface

The H8/3217 Series is a family of high-performance single-chip microcomputers ideally suited for embedded control of industrial equipment. The chips are built around an H8/300 CPU core: a high-speed processor. On-chip supporting modules provide ROM, RAM, four types of timers, I/O ports, a serial communication interface, I<sup>2</sup>C bus interface, and host interface for easy implementation of compact, high-speed control systems.

The H8/3217 Series offers a selection of on-chip memory.

H8/3217: 60-kbyte ROM; 2-kbyte RAM

H8/3216: 48-kbyte ROM; 2-kbyte RAM

H8/3214: 32-kbyte ROM; 1-kbyte RAM

H8/3212: 16-kbyte ROM; 512-byte RAM

The H8/3217 and H8/3214 chips are available with electrically programmable ROM. Manufacturers can use the electrically programmable ZTAT™ (Zero Turn-Around Time\*) version to get production off to a fast start and make software changes quickly.

This manual describes the H8/3217 Series hardware. Refer to the *H8/300 Series Programming Manual* for a detailed description of the instruction set.

Note: \* ZTAT is a trademark of Hitachi, Ltd.



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# Section 1 Overview

## 1.1 Overview

The H8/3217 Series is a series of single-chip microcomputers integrating a CPU core together with a variety of peripheral functions needed in control systems.

The H8/300 CPU is a high-speed processor featuring powerful bit-manipulation instructions, ideally suited for realtime control applications. The on-chip supporting modules include ROM, RAM, four types of timers (16-bit free-running timer, 8-bit timer, PWM timer, and watchdog timer), a serial communication interface, I<sup>2</sup>C bus interface (option), host interface, and I/O ports.

Note that the H8/3212 and H8/3202 have a subset specification that does not include certain of the on-chip supporting modules.

The H8/3217 Series can operate in single-chip mode or in two expanded modes, depending on the memory requirements of the application. The operating mode is referred to in this manual as the MCU mode (MCU: MicroComputer Unit).

In addition to the mask ROM versions, ZTAT<sup>TM</sup>\* versions are available with electrically programmable ROM that can be programmed at the user site.

Note: \* ZTAT is a trademark of Hitachi, Ltd.

Table 1-1 lists the features of the H8/3217 Series.

**Table 1-1 Features**

| <b>Feature</b>                                    | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CPU                                               | <p>General register architecture</p> <ul style="list-style-type: none"> <li>• Eight 16-bit general registers, or</li> <li>• Sixteen 8-bit general registers</li> </ul> <p>High speed</p> <ul style="list-style-type: none"> <li>• Maximum clock rate: 16 MHz/5 V, 12 MHz/4 V, 10 MHz/3 V (ø clock)</li> <li>• Add/subtract: 125 ns (16 MHz operation), 167 ns (12 MHz operation), 200 ns (10 MHz operation)</li> <li>• Multiply/divide: 875 ns (16 MHz operation), 1167 ns (12 MHz operation), 1400 ns (10 MHz operation)</li> </ul> <p>Concise, streamlined instruction set</p> <ul style="list-style-type: none"> <li>• All instructions are 2 or 4 bytes long</li> <li>• Register-register arithmetic and logic operations</li> <li>• Register-memory data transfer by MOV instruction</li> </ul> <p>Instruction set features</p> <ul style="list-style-type: none"> <li>• Multiply instruction (8 bits × 8 bits)</li> <li>• Divide instruction (16 bits ÷ 8 bits)</li> <li>• Bit-accumulator instructions</li> <li>• Register-indirect specification of bit positions</li> </ul> |
| Memory                                            | <p>H8/3217</p> <ul style="list-style-type: none"> <li>• ROM: 60 kbytes</li> <li>• RAM: 2 kbytes</li> </ul> <p>H8/3216</p> <ul style="list-style-type: none"> <li>• ROM: 48 kbytes</li> <li>• RAM: 2 kbytes</li> </ul> <p>H8/3214</p> <ul style="list-style-type: none"> <li>• ROM: 32 kbytes</li> <li>• RAM: 1 kbyte</li> </ul> <p>H8/3212 and H8/3202</p> <ul style="list-style-type: none"> <li>• ROM: 16 kbytes</li> <li>• RAM: 512 bytes</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 16-Bit free-running timer module (FRT: 1 channel) | <ul style="list-style-type: none"> <li>• One 16-bit free-running counter (also usable for external event counting)</li> <li>• Two compare outputs</li> <li>• One capture input</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 8-bit timer module*1                              | <p>Each channel has:</p> <ul style="list-style-type: none"> <li>• One 8-bit up-counter (also usable for external event counting)</li> <li>• Two time constant registers</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| PWM timers (except H8/3202)                       | <ul style="list-style-type: none"> <li>• Up to 16 outputs</li> <li>• Duty cycle settable from 0 to 100%</li> <li>• Resolution: 1/256</li> <li>• 1 MHz maximum carrier frequency (at 16 MHz operation)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Watchdog timer (WDT: 1 channel)                   | <ul style="list-style-type: none"> <li>• Reset or NMI generation by overflow</li> <li>• Can be switched to interval timer mode</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Table 1-1 Features (cont)**

| Feature                                   | Description                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Serial communication interface*2          | <ul style="list-style-type: none"> <li>• Selection of asynchronous and synchronous modes</li> <li>• Simultaneous transmit and receive (full duplex operation)</li> <li>• On-chip baud rate generator</li> </ul>                                                                                                                      |
| I <sup>2</sup> C bus interface*3 (option) | <ul style="list-style-type: none"> <li>• Conforms to Philips I<sup>2</sup>C bus interface standard</li> <li>• Single master mode/slave mode</li> </ul>                                                                                                                                                                               |
| Host interface (HIF) (except H8/3212)     | <ul style="list-style-type: none"> <li>• 8-bit host interface port</li> <li>• Three host interrupt requests (HIRQ<sub>1</sub>, HIRQ<sub>11</sub>, HIRQ<sub>12</sub>)</li> <li>• Normal and fast A<sub>20</sub> gate output</li> <li>• Two register sets (each comprising two data registers and a status register)</li> </ul>        |
| Keyboard controller (except H8/3212)      | <ul style="list-style-type: none"> <li>• Controls a matrix keyboard using a keyboard scan with wake-up interrupt and sense port configuration</li> </ul>                                                                                                                                                                             |
| I/O ports                                 | <ul style="list-style-type: none"> <li>• 53 input/output pins (of which 16 can drive large current loads)</li> </ul>                                                                                                                                                                                                                 |
| Interrupts                                | <ul style="list-style-type: none"> <li>• Four external interrupt pins: <math>\overline{\text{NMI}}</math>, <math>\overline{\text{IRQ}}_0</math> to <math>\overline{\text{IRQ}}_2</math></li> <li>• Eight key-sense interrupt pins: KEYIN<sub>0</sub> to KEYIN<sub>7</sub></li> <li>• Twenty-six on-chip interrupt sources</li> </ul> |
| Operating modes                           | <ul style="list-style-type: none"> <li>• Mode 1: expanded mode with on-chip ROM enabled</li> <li>• Mode 2: expanded mode with on-chip ROM enabled</li> <li>• Mode 3: single-chip mode</li> </ul>                                                                                                                                     |
| Power-down state                          | <ul style="list-style-type: none"> <li>• Sleep mode</li> <li>• Software standby mode</li> <li>• Hardware standby mode</li> </ul>                                                                                                                                                                                                     |
| Other features                            | <ul style="list-style-type: none"> <li>• On-chip clock oscillator</li> </ul>                                                                                                                                                                                                                                                         |

| Product Name | Type Code                                         |                        |                                     |      |
|--------------|---------------------------------------------------|------------------------|-------------------------------------|------|
|              | 5 V Series<br>(16 MHz),<br>4 V Series<br>(12 MHz) | 3 V Series<br>(10 MHz) | Package                             | ROM  |
| H8/3217 ZTAT | HD6473217C16                                      | HD6473217C16           | 64-pin windowed shrink DIP (DC-64S) | PROM |
|              | HD6473217P16                                      | HD6473217P16           | 64-pin shrink DIP (DP-64S)          |      |
|              | HD6473217F16                                      | HD6473217F16           | 64-pin QFP (FP-64A)                 |      |
|              | HD6473217TF16                                     | HD6473217TF16          | 80-pin TQFP (TFP-80C)               |      |

**Table 1-1 Features (cont)**

| Feature        | Description                    |                                                   |                               |             |     |
|----------------|--------------------------------|---------------------------------------------------|-------------------------------|-------------|-----|
| Product lineup | Type Code                      |                                                   |                               |             |     |
|                | Product Name                   | 5 V Series<br>(16 MHz),<br>4 V Series<br>(12 MHz) | 3 V Series<br>(10 MHz)        | Package     | ROM |
| H8/3217*       | HD6433217P16<br>HD6433217P12   | HD6433217VP10                                     | 64-pin shrink DIP<br>(DP-64S) | Mask<br>ROM |     |
|                | HD6433217F16<br>HD6433217F12   | HD6433217VF10                                     | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6433217TF16<br>HD6433217TF12 | HD6433217VTF10                                    | 80-pin TQFP<br>(TFP-80C)      |             |     |
| H8/3216*       | HD6433216P16<br>HD6433216P12   | HD6433216VP10                                     | 64-pin shrink DIP<br>(DP-64S) | Mask<br>ROM |     |
|                | HD6433216F16<br>HD6433216F12   | HD6433216VF10                                     | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6433216TF16<br>HD6433216TF12 | HD6433216VTF10                                    | 80-pin TQFP<br>(TFP-80C)      |             |     |
| H8/3214 ZTAT   | HD6473214P16                   | HD6473214P16                                      | 64-pin shrink DIP<br>(DP-64S) | PROM        |     |
|                | HD6473214F16                   | HD6473214F16                                      | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6473214TF16                  | HD6473214TF16                                     | 80-pin TQFP<br>(TFP-80C)      |             |     |
| H8/3214*       | HD6433214P16<br>HD6433214P12   | HD6433214VP10                                     | 64-pin shrink DIP<br>(DP-64S) | Mask<br>ROM |     |
|                | HD6433214F16<br>HD6433214F12   | HD6433214VF10                                     | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6433214TF16<br>HD6433214TF12 | HD6433214VTF10                                    | 80-pin TQFP<br>(TFP-80C)      |             |     |
| H8/3212*       | HD6433212P16<br>HD6433212P12   | HD6433212VP10                                     | 64-pin shrink DIP<br>(DP-64S) | Mask<br>ROM |     |
|                | HD6433212F16<br>HD6433212F12   | HD6433212VF10                                     | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6433212TF16<br>HD6433212TF12 | HD6433212VTF10                                    | 80-pin TQFP<br>(TFP-80C)      |             |     |
| H8/3202*       | HD6433202P16<br>HD6433202P12   | HD6433202VP10                                     | 64-pin shrink DIP<br>(DP-64S) | Mask<br>ROM |     |
|                | HD6433202F16<br>HD6433202F12   | HD6433202VF10                                     | 64-pin QFP<br>(FP-64A)        |             |     |
|                | HD6433202TF16<br>HD6433202TF12 | HD6433202VTF10                                    | 80-pin TQFP<br>(TFP-80C)      |             |     |
|                |                                |                                                   |                               |             |     |

**Table 1-1 Features (cont)**

| Feature                      | Description                |     |              |                              |     |     |     |     |                                |
|------------------------------|----------------------------|-----|--------------|------------------------------|-----|-----|-----|-----|--------------------------------|
|                              | Product Name               | FRT | TMR0<br>TMR1 | TMRX,<br>Timer<br>Connection | PWM | WDT | SCI | IIC | HIF,<br>Key-Sense<br>Interrupt |
| On-chip peripheral functions | Except H8/3212 and H8/3202 | Yes | Yes          | Yes                          | Yes | Yes | × 2 | × 2 | Yes                            |
|                              | H8/3212                    | Yes | Yes          | Yes                          | Yes | Yes | × 1 | × 2 | No                             |
|                              | H8/3202                    | Yes | Yes          | No                           | No  | Yes | × 2 | × 1 | Yes                            |

Notes: The I<sup>2</sup>C bus interface is available as an option. Observe the following notes when using this option.

1. Please inform your Hitachi sales representative if you intend to use this option.
  2. For mask-ROM versions, a W is added to the part number in products in which this optional function is used.  
Examples: HD6433217WF16, HD6433212WP12
  3. The product number is identical for ZTAT version. However, be sure to inform your Hitachi sales representative if you will be using this option.
- \* Under development
- \*1 2 channels incorporated in the H8/3202, and three channels in all other models.
- \*2 1 channel incorporated in the H8/3212, and 2 channels in all other models.
- \*3 1 channel incorporated in the H8/3202, and 2 channels in all other models.

## 1.2 Block Diagram

Figure 1-1 shows a block diagram of the H8/3217 Series.

Note that the H8/3212 and H8/3202 have a subset specification that does not include certain of the on-chip supporting modules. See tables 1-2 to 1-4, Pin Assignments in Each Operating Mode, for differences in the pin functions.

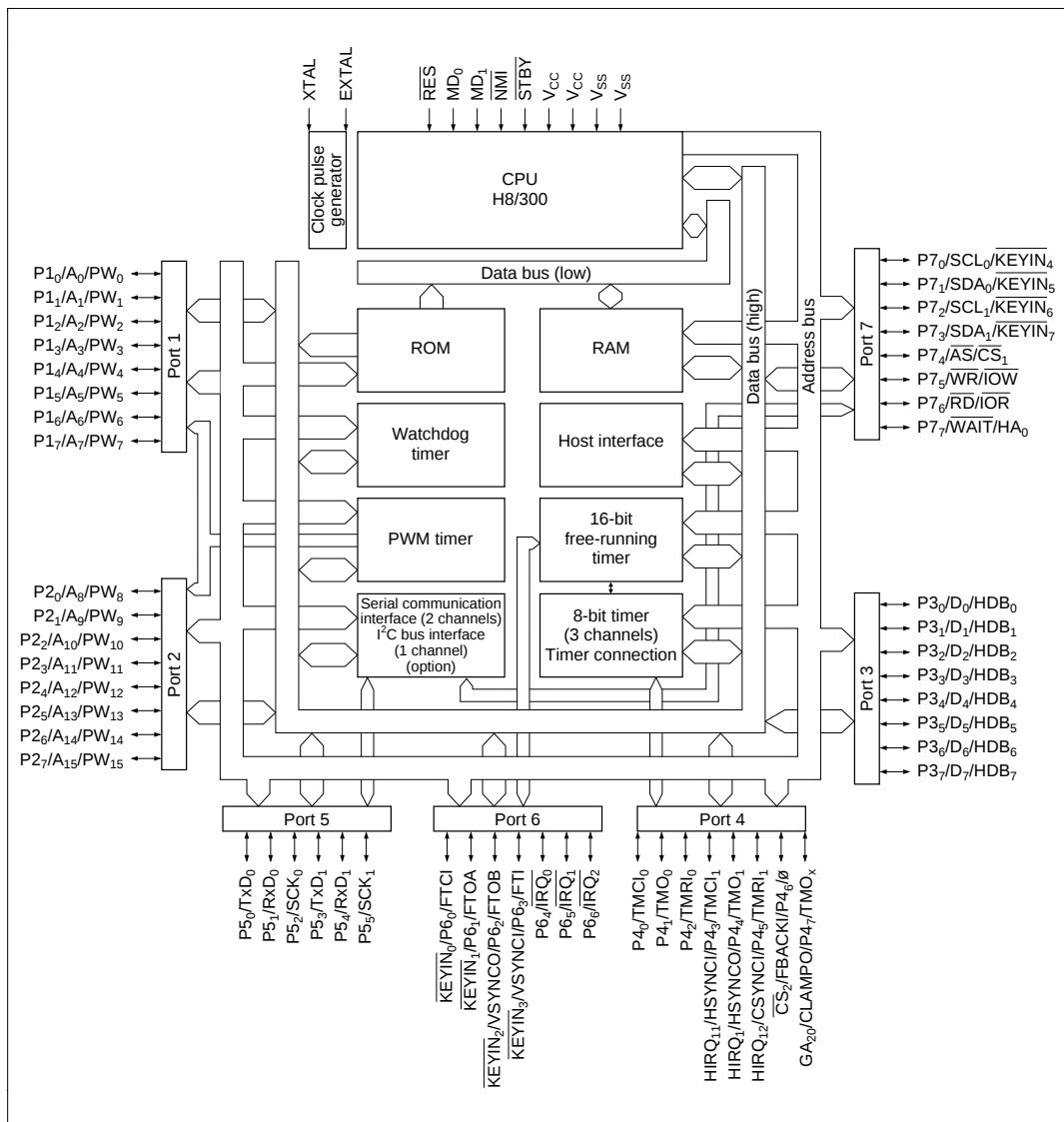


Figure 1-1 Block Diagram

## 1.3 Pin Assignments and Functions

### 1.3.1 Pin Arrangement

Figure 1-2 shows the pin arrangement of the H8/3217 Series in the DC-64S and DP-64S packages. Figure 1-3 shows the pin arrangement in the FP-64A package. Figure 1-4 shows the pin arrangement in the TFP-80C package.

Note that the H8/3212 and H8/3202 have a subset specification that does not include certain of the on-chip supporting modules. See tables 1-2 to 1-4, Pin Assignments in Each Operating Mode, for differences in the pin functions.

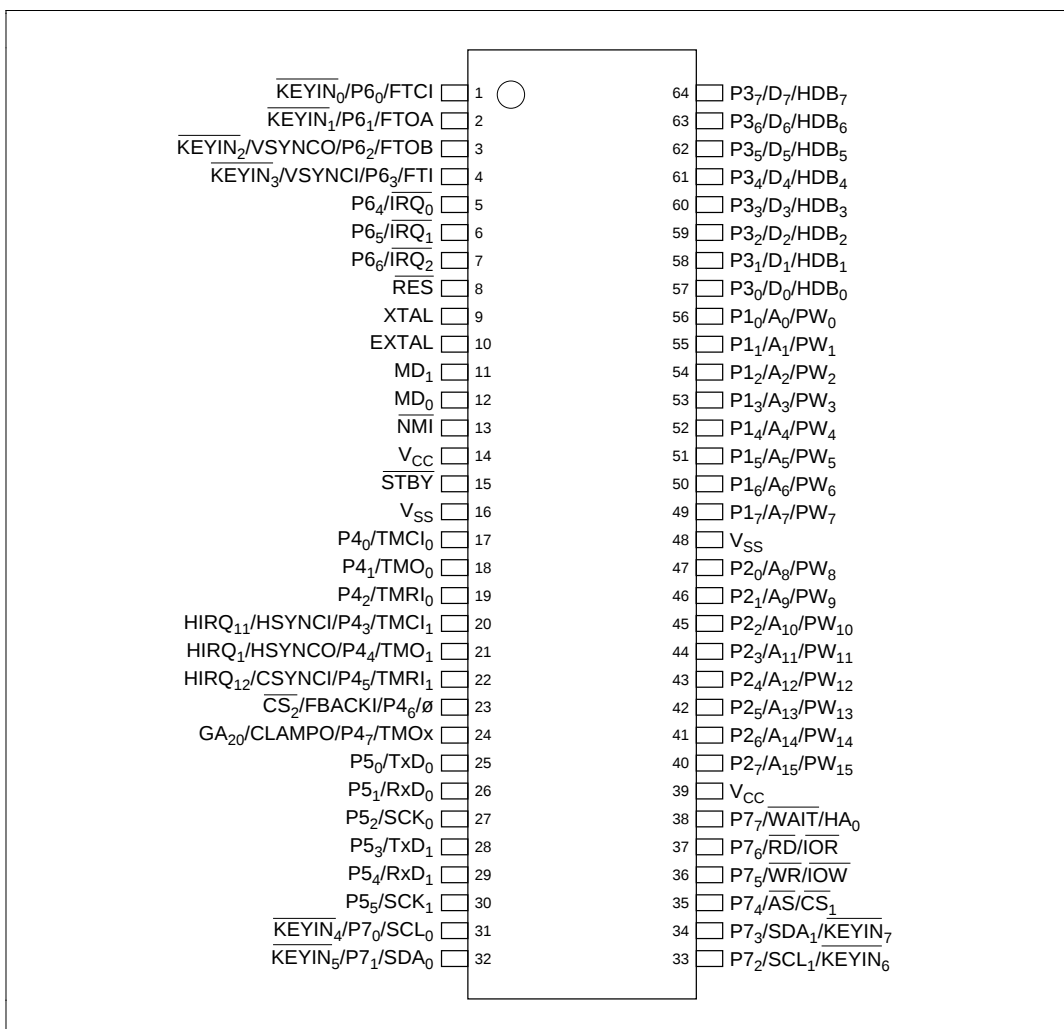


Figure 1-2 Pin Arrangement (DC-64S, DP-64S, Top View)

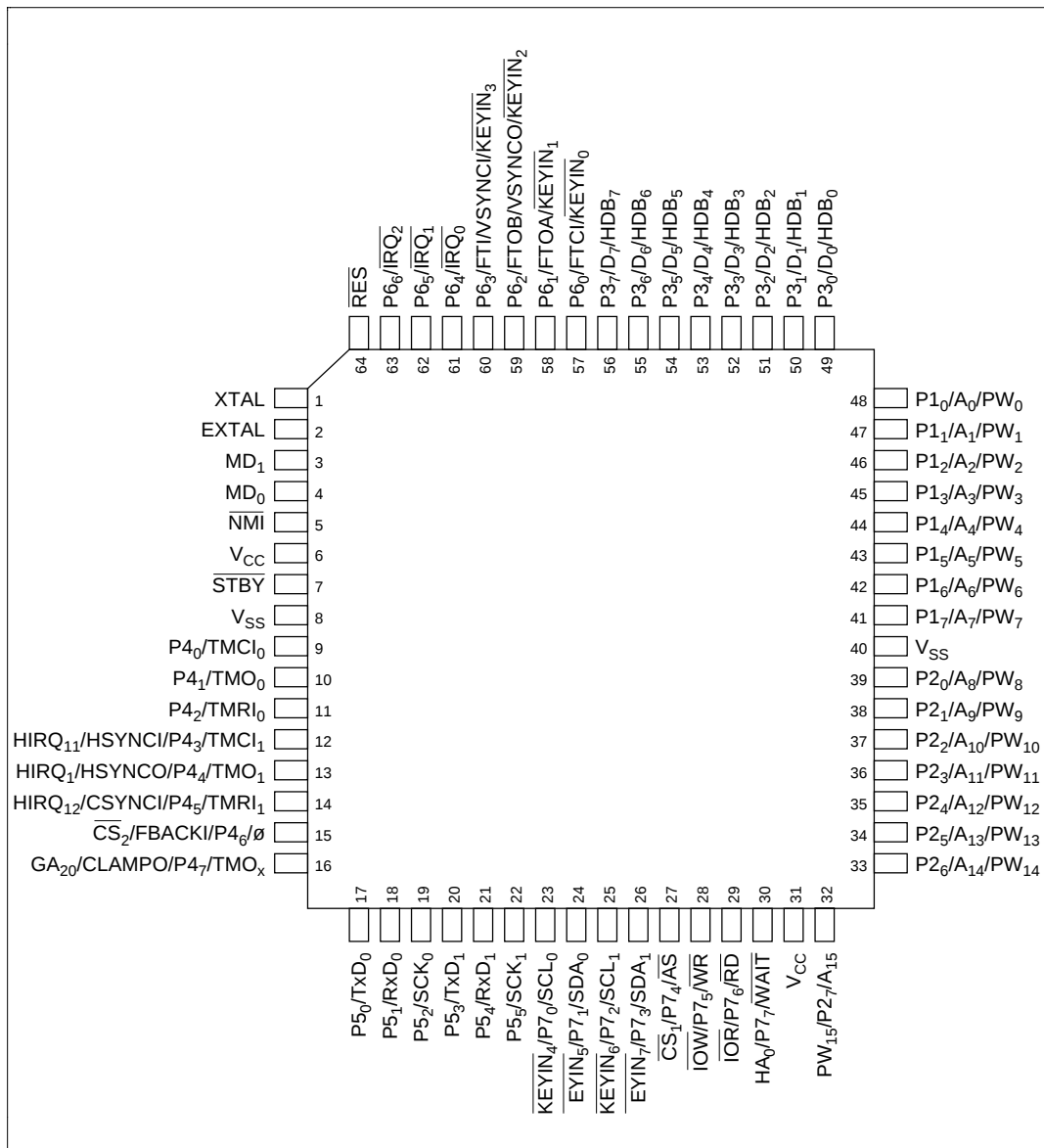


Figure 1-3 Pin Arrangement (FP-64A, Top View)

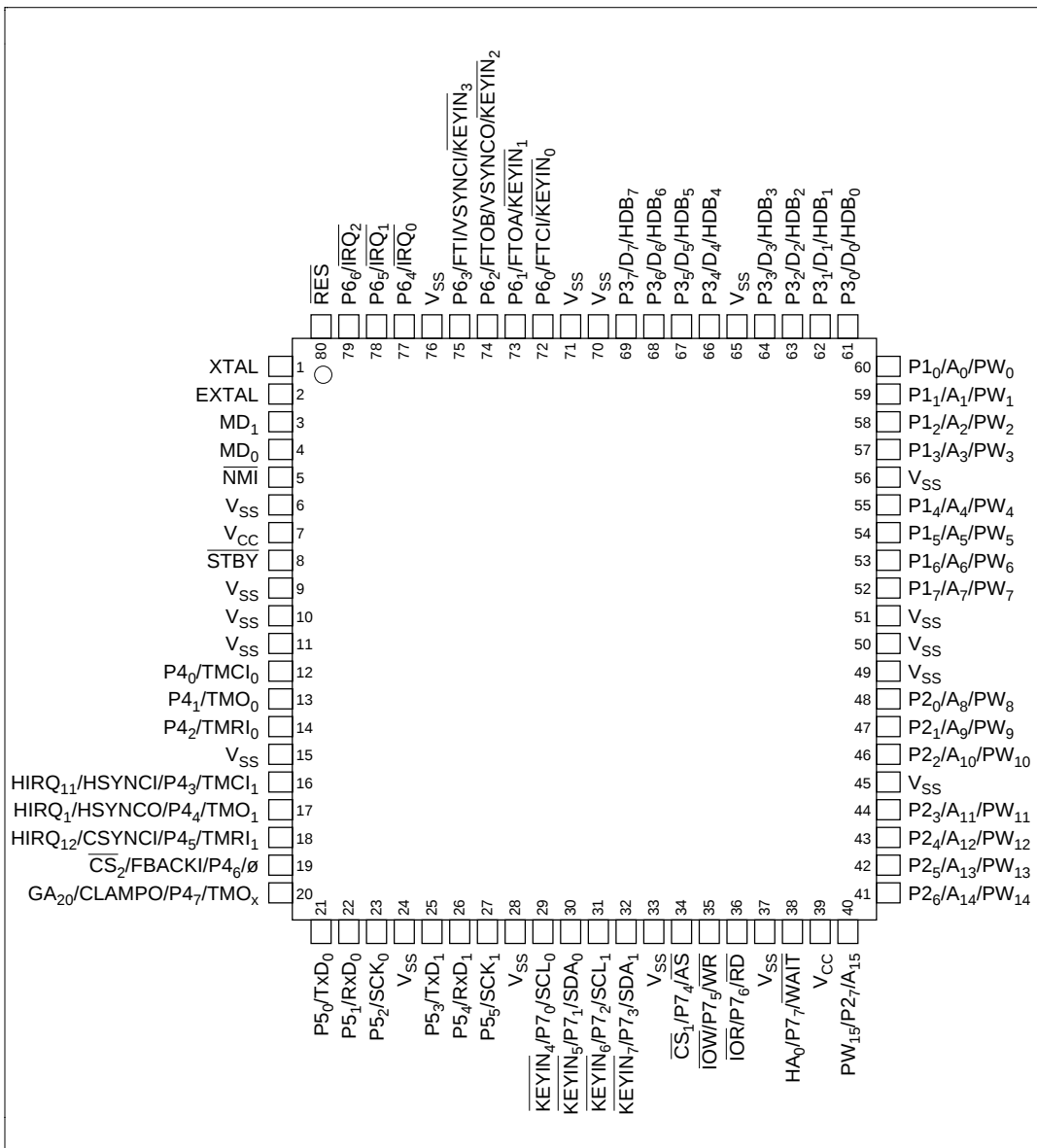


Figure 1-4 Pin Arrangement (TFP-80C, Top View)

### 1.3.2 Pin Functions

**(1) Pin Assignments in Each Operating Mode:** Table 1-2 to table 1-4 list the assignments of the pins of the DC-64S, DP-64S, FP-64A, and TFP-80C packages in each operating mode.

**Table 1-2 Pin Assignments in Each Operating Mode (Except H8/3212 and H8/3202)**

| Pin No. |        |        | Expanded Modes                                                |                                                               | Single-Chip Mode                                              | PROM Mode       |
|---------|--------|--------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|-----------------|
| DC-64S  | DP-64S | FP-64A | TFP-80C                                                       | Mode 1                                                        | Mode 2                                                        |                 |
| —       | —      | 71     | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| 1       | 57     | 72     | P6 <sub>0</sub> /FTCI/ $\overline{\text{KEYIN}}_0$            | P6 <sub>0</sub> /FTCI/ $\overline{\text{KEYIN}}_0$            | P6 <sub>0</sub> /FTCI/ $\overline{\text{KEYIN}}_0$            | NC              |
| 2       | 58     | 73     | P6 <sub>1</sub> /FTOA/ $\overline{\text{KEYIN}}_1$            | P6 <sub>1</sub> /FTOA/ $\overline{\text{KEYIN}}_1$            | P6 <sub>1</sub> /FTOA/ $\overline{\text{KEYIN}}_1$            | NC              |
| 3       | 59     | 74     | P6 <sub>2</sub> /FTOB/<br>VSYNCO/ $\overline{\text{KEYIN}}_2$ | P6 <sub>2</sub> /FTOB/<br>VSYNCO/ $\overline{\text{KEYIN}}_2$ | P6 <sub>2</sub> /FTOB/<br>VSYNCO/ $\overline{\text{KEYIN}}_2$ | NC              |
| 4       | 60     | 75     | P6 <sub>3</sub> /FTI/VSYNCI/<br>$\overline{\text{KEYIN}}_3$   | P6 <sub>3</sub> /FTI/VSYNCI/<br>$\overline{\text{KEYIN}}_3$   | P6 <sub>3</sub> /FTI/VSYNCI/<br>$\overline{\text{KEYIN}}_3$   | NC              |
| —       | —      | 76     | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| 5       | 61     | 77     | P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$                   | P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$                   | P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$                   | NC              |
| 6       | 62     | 78     | P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$                   | P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$                   | P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$                   | NC              |
| 7       | 63     | 79     | P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$                   | P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$                   | P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$                   | NC              |
| 8       | 64     | 80     | $\overline{\text{RES}}$                                       | $\overline{\text{RES}}$                                       | $\overline{\text{RES}}$                                       | V <sub>PP</sub> |
| 9       | 1      | 1      | XTAL                                                          | XTAL                                                          | XTAL                                                          | NC              |
| 10      | 2      | 2      | EXTAL                                                         | EXTAL                                                         | EXTAL                                                         | NC              |
| 11      | 3      | 3      | MD <sub>1</sub>                                               | MD <sub>1</sub>                                               | MD <sub>1</sub>                                               | V <sub>SS</sub> |
| 12      | 4      | 4      | MD <sub>0</sub>                                               | MD <sub>0</sub>                                               | MD <sub>0</sub>                                               | V <sub>SS</sub> |
| 13      | 5      | 5      | $\overline{\text{NMI}}$                                       | $\overline{\text{NMI}}$                                       | $\overline{\text{NMI}}$                                       | EA <sub>9</sub> |
| —       | —      | 6      | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| 14      | 6      | 7      | V <sub>CC</sub>                                               | V <sub>CC</sub>                                               | V <sub>CC</sub>                                               | V <sub>CC</sub> |
| 15      | 7      | 8      | $\overline{\text{STBY}}$                                      | $\overline{\text{STBY}}$                                      | $\overline{\text{STBY}}$                                      | V <sub>SS</sub> |
| 16      | 8      | 9      | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| —       | —      | 10     | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| —       | —      | 11     | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |
| 17      | 9      | 12     | P4 <sub>0</sub> /TMCI <sub>0</sub>                            | P4 <sub>0</sub> /TMCI <sub>0</sub>                            | P4 <sub>0</sub> /TMCI <sub>0</sub>                            | EO <sub>0</sub> |
| 18      | 10     | 13     | P4 <sub>1</sub> /TMO <sub>0</sub>                             | P4 <sub>1</sub> /TMO <sub>0</sub>                             | P4 <sub>1</sub> /TMO <sub>0</sub>                             | EO <sub>1</sub> |
| 19      | 11     | 14     | P4 <sub>2</sub> /TMRI <sub>0</sub>                            | P4 <sub>2</sub> /TMRI <sub>0</sub>                            | P4 <sub>2</sub> /TMRI <sub>0</sub>                            | EO <sub>2</sub> |
| —       | —      | 15     | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub>                                               | V <sub>SS</sub> |

**Table 1-2 Pin Assignments in Each Operating Mode (Except H8/3212 and H8/3202) (cont)**

| Pin No. |        |         | Expanded Modes                                        |                                                       | Single-Chip Mode                                              | PROM Mode        |
|---------|--------|---------|-------------------------------------------------------|-------------------------------------------------------|---------------------------------------------------------------|------------------|
| DC-64S  | FP-64A | TFP-80C | Mode 1                                                | Mode 2                                                | Mode 3                                                        |                  |
| 20      | 12     | 16      | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCl            | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCl            | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCl/HIRQ <sub>11</sub> | EO <sub>3</sub>  |
| 21      | 13     | 17      | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO             | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO             | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO/HIRQ <sub>1</sub>   | EO <sub>4</sub>  |
| 22      | 14     | 18      | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCl            | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCl            | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCl/HIRQ <sub>12</sub> | EO <sub>5</sub>  |
| 23      | 15     | 19      | ∅                                                     | ∅                                                     | P4 <sub>6</sub> /∅/FBACKI/CS <sub>2</sub>                     | EO <sub>6</sub>  |
| 24      | 16     | 20      | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO             | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO             | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO/GA <sub>20</sub>    | EO <sub>7</sub>  |
| 25      | 17     | 21      | P5 <sub>0</sub> /TxDO                                 | P5 <sub>0</sub> /TxDO                                 | P5 <sub>0</sub> /TxDO                                         | EA <sub>15</sub> |
| 26      | 18     | 22      | P5 <sub>1</sub> /RxD <sub>0</sub>                     | P5 <sub>1</sub> /RxD <sub>0</sub>                     | P5 <sub>1</sub> /RxD <sub>0</sub>                             | EA <sub>16</sub> |
| 27      | 19     | 23      | P5 <sub>2</sub> /SCK <sub>0</sub>                     | P5 <sub>2</sub> /SCK <sub>0</sub>                     | P5 <sub>2</sub> /SCK <sub>0</sub>                             | PGM              |
| —       | —      | 24      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                               | V <sub>SS</sub>  |
| 28      | 20     | 25      | P5 <sub>3</sub> /TxDO <sub>1</sub>                    | P5 <sub>3</sub> /TxDO <sub>1</sub>                    | P5 <sub>3</sub> /TxDO <sub>1</sub>                            | NC               |
| 29      | 21     | 26      | P5 <sub>4</sub> /RxD <sub>1</sub>                     | P5 <sub>4</sub> /RxD <sub>1</sub>                     | P5 <sub>4</sub> /RxD <sub>1</sub>                             | NC               |
| 30      | 22     | 27      | P5 <sub>5</sub> /SCK <sub>1</sub>                     | P5 <sub>5</sub> /SCK <sub>1</sub>                     | P5 <sub>5</sub> /SCK <sub>1</sub>                             | NC               |
| —       | —      | 28      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                               | V <sub>SS</sub>  |
| 31      | 23     | 29      | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub> | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub> | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub>         | V <sub>CC</sub>  |
| 32      | 24     | 30      | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub> | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub> | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub>         | V <sub>CC</sub>  |
| 33      | 25     | 31      | P7 <sub>2</sub> /SCL <sub>1</sub> /KEYIN <sub>6</sub> | P7 <sub>2</sub> /SCL <sub>1</sub> /KEYIN <sub>6</sub> | P7 <sub>2</sub> /SCL <sub>1</sub> /KEYIN <sub>6</sub>         | NC               |
| 34      | 26     | 32      | P7 <sub>3</sub> /SDA <sub>1</sub> /KEYIN <sub>7</sub> | P7 <sub>3</sub> /SDA <sub>1</sub> /KEYIN <sub>7</sub> | P7 <sub>3</sub> /SDA <sub>1</sub> /KEYIN <sub>7</sub>         | NC               |
| —       | —      | 33      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                               | V <sub>SS</sub>  |
| 35      | 27     | 34      | AS                                                    | AS                                                    | P7 <sub>4</sub> /CS <sub>1</sub>                              | NC               |
| 36      | 28     | 35      | WR                                                    | WR                                                    | P7 <sub>5</sub> /IOW                                          | NC               |
| 37      | 29     | 36      | RD                                                    | RD                                                    | P7 <sub>6</sub> /IOR                                          | NC               |
| —       | —      | 37      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                               | V <sub>SS</sub>  |
| 38      | 30     | 38      | P7 <sub>7</sub> /WAIT                                 | P7 <sub>7</sub> /WAIT                                 | P7 <sub>7</sub> /HA <sub>0</sub>                              | NC               |
| 39      | 31     | 39      | V <sub>CC</sub>                                       | V <sub>CC</sub>                                       | V <sub>CC</sub>                                               | V <sub>CC</sub>  |
| 40      | 32     | 40      | A <sub>15</sub>                                       | P2 <sub>7</sub> /A <sub>15</sub> /PW <sub>15</sub>    | P2 <sub>7</sub> /PW <sub>15</sub>                             | CE               |
| 41      | 33     | 41      | A <sub>14</sub>                                       | P2 <sub>6</sub> /A <sub>14</sub> /PW <sub>14</sub>    | P2 <sub>6</sub> /PW <sub>14</sub>                             | EA <sub>14</sub> |
| 42      | 34     | 42      | A <sub>13</sub>                                       | P2 <sub>5</sub> /A <sub>13</sub> /PW <sub>13</sub>    | P2 <sub>5</sub> /PW <sub>13</sub>                             | EA <sub>13</sub> |

**Table 1-2 Pin Assignments in Each Operating Mode (Except H8/3212 and H8/3202) (cont)**

| Pin No.          |        |         | Expanded Modes  |                                                    | Single-Chip Mode                  | PROM Mode              |
|------------------|--------|---------|-----------------|----------------------------------------------------|-----------------------------------|------------------------|
| DC-64S<br>DP-64S | FP-64A | TFP-80C | Mode 1          | Mode 2                                             | Mode 3                            |                        |
| 43               | 35     | 43      | A <sub>12</sub> | P <sub>24</sub> /A <sub>12</sub> /PW <sub>12</sub> | P <sub>24</sub> /PW <sub>12</sub> | EA <sub>12</sub>       |
| 44               | 36     | 44      | A <sub>11</sub> | P <sub>23</sub> /A <sub>11</sub> /PW <sub>11</sub> | P <sub>23</sub> /PW <sub>11</sub> | EA <sub>11</sub>       |
| —                | —      | 45      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| 45               | 37     | 46      | A <sub>10</sub> | P <sub>22</sub> /A <sub>10</sub> /PW <sub>10</sub> | P <sub>22</sub> /PW <sub>10</sub> | EA <sub>10</sub>       |
| 46               | 38     | 47      | A <sub>9</sub>  | P <sub>21</sub> /A <sub>9</sub> /PW <sub>9</sub>   | P <sub>21</sub> /PW <sub>9</sub>  | $\overline{\text{OE}}$ |
| 47               | 39     | 48      | A <sub>8</sub>  | P <sub>20</sub> /A <sub>8</sub> /PW <sub>8</sub>   | P <sub>20</sub> /PW <sub>8</sub>  | EA <sub>8</sub>        |
| —                | —      | 49      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| —                | —      | 50      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| 48               | 40     | 51      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| 49               | 41     | 52      | A <sub>7</sub>  | P <sub>17</sub> /A <sub>7</sub> /PW <sub>7</sub>   | P <sub>17</sub> /PW <sub>7</sub>  | EA <sub>7</sub>        |
| 50               | 42     | 53      | A <sub>6</sub>  | P <sub>16</sub> /A <sub>6</sub> /PW <sub>6</sub>   | P <sub>16</sub> /PW <sub>6</sub>  | EA <sub>6</sub>        |
| 51               | 43     | 54      | A <sub>5</sub>  | P <sub>15</sub> /A <sub>5</sub> /PW <sub>5</sub>   | P <sub>15</sub> /PW <sub>5</sub>  | EA <sub>5</sub>        |
| 52               | 44     | 55      | A <sub>4</sub>  | P <sub>14</sub> /A <sub>4</sub> /PW <sub>4</sub>   | P <sub>14</sub> /PW <sub>4</sub>  | EA <sub>4</sub>        |
| —                | —      | 56      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| 53               | 45     | 57      | A <sub>3</sub>  | P <sub>13</sub> /A <sub>3</sub> /PW <sub>3</sub>   | P <sub>13</sub> /PW <sub>3</sub>  | EA <sub>3</sub>        |
| 54               | 46     | 58      | A <sub>2</sub>  | P <sub>12</sub> /A <sub>2</sub> /PW <sub>2</sub>   | P <sub>12</sub> /PW <sub>2</sub>  | EA <sub>2</sub>        |
| 55               | 47     | 59      | A <sub>1</sub>  | P <sub>11</sub> /A <sub>1</sub> /PW <sub>1</sub>   | P <sub>11</sub> /PW <sub>1</sub>  | EA <sub>1</sub>        |
| 56               | 48     | 60      | A <sub>0</sub>  | P <sub>10</sub> /A <sub>0</sub> /PW <sub>0</sub>   | P <sub>10</sub> /PW <sub>0</sub>  | EA <sub>0</sub>        |
| 57               | 49     | 61      | D <sub>0</sub>  | D <sub>0</sub>                                     | P <sub>30</sub> /HDB <sub>0</sub> | NC                     |
| 58               | 50     | 62      | D <sub>1</sub>  | D <sub>1</sub>                                     | P <sub>31</sub> /HDB <sub>1</sub> | NC                     |
| 59               | 51     | 63      | D <sub>2</sub>  | D <sub>2</sub>                                     | P <sub>32</sub> /HDB <sub>2</sub> | NC                     |
| 60               | 52     | 64      | D <sub>3</sub>  | D <sub>3</sub>                                     | P <sub>33</sub> /HDB <sub>3</sub> | NC                     |
| —                | —      | 65      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |
| 61               | 53     | 66      | D <sub>4</sub>  | D <sub>4</sub>                                     | P <sub>34</sub> /HDB <sub>4</sub> | NC                     |
| 62               | 54     | 67      | D <sub>5</sub>  | D <sub>5</sub>                                     | P <sub>35</sub> /HDB <sub>5</sub> | NC                     |
| 63               | 55     | 68      | D <sub>6</sub>  | D <sub>6</sub>                                     | P <sub>36</sub> /HDB <sub>6</sub> | NC                     |
| 64               | 56     | 69      | D <sub>7</sub>  | D <sub>7</sub>                                     | P <sub>37</sub> /HDB <sub>7</sub> | NC                     |
| —                | —      | 70      | V <sub>SS</sub> | V <sub>SS</sub>                                    | V <sub>SS</sub>                   | V <sub>SS</sub>        |

- Notes: 1. Pins marked NC should be left unconnected.  
2. The PROM mode is a non-operating mode used for programming the on-chip ROM. See section 17, ROM, for details.

**Table 1-3 Pin Assignments in Each Operating Mode (H8/3212)**

| Pin No. |        |         | Expanded Modes                             |                                            | Single-Chip Mode                           |
|---------|--------|---------|--------------------------------------------|--------------------------------------------|--------------------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1                                     | Mode 2                                     | Mode 3                                     |
| —       | —      | 71      | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| 1       | 57     | 72      | P6 <sub>0</sub> /FTCI                      | P6 <sub>0</sub> /FTCI                      | P6 <sub>0</sub> /FTCI                      |
| 2       | 58     | 73      | P6 <sub>1</sub> /FTOA                      | P6 <sub>1</sub> /FTOA                      | P6 <sub>1</sub> /FTOA                      |
| 3       | 59     | 74      | P6 <sub>2</sub> /FTOB/VSYNCO               | P6 <sub>2</sub> /FTOB/VSYNCO               | P6 <sub>2</sub> /FTOB/VSYNCO               |
| 4       | 60     | 75      | P6 <sub>3</sub> /FTI/VSYNCI                | P6 <sub>3</sub> /FTI/VSYNCI                | P6 <sub>3</sub> /FTI/VSYNCI                |
| —       | —      | 76      | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| 5       | 61     | 77      | P6 <sub>4</sub> /IRQ <sub>0</sub>          | P6 <sub>4</sub> /IRQ <sub>0</sub>          | P6 <sub>4</sub> /IRQ <sub>0</sub>          |
| 6       | 62     | 78      | P6 <sub>5</sub> /IRQ <sub>1</sub>          | P6 <sub>5</sub> /IRQ <sub>1</sub>          | P6 <sub>5</sub> /IRQ <sub>1</sub>          |
| 7       | 63     | 79      | P6 <sub>6</sub> /IRQ <sub>2</sub>          | P6 <sub>6</sub> /IRQ <sub>2</sub>          | P6 <sub>6</sub> /IRQ <sub>2</sub>          |
| 8       | 64     | 80      | RES                                        | RES                                        | RES                                        |
| 9       | 1      | 1       | XTAL                                       | XTAL                                       | XTAL                                       |
| 10      | 2      | 2       | EXTAL                                      | EXTAL                                      | EXTAL                                      |
| 11      | 3      | 3       | MD <sub>1</sub>                            | MD <sub>1</sub>                            | MD <sub>1</sub>                            |
| 12      | 4      | 4       | MD <sub>0</sub>                            | MD <sub>0</sub>                            | MD <sub>0</sub>                            |
| 13      | 5      | 5       | NMI                                        | NMI                                        | NMI                                        |
| —       | —      | 6       | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| 14      | 6      | 7       | V <sub>CC</sub>                            | V <sub>CC</sub>                            | V <sub>CC</sub>                            |
| 15      | 7      | 8       | STBY                                       | STBY                                       | STBY                                       |
| 16      | 8      | 9       | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| —       | —      | 10      | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| —       | —      | 11      | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| 17      | 9      | 12      | P4 <sub>0</sub> /TMCI <sub>0</sub>         | P4 <sub>0</sub> /TMCI <sub>0</sub>         | P4 <sub>0</sub> /TMCI <sub>0</sub>         |
| 18      | 10     | 13      | P4 <sub>1</sub> /TMO <sub>0</sub>          | P4 <sub>1</sub> /TMO <sub>0</sub>          | P4 <sub>1</sub> /TMO <sub>0</sub>          |
| 19      | 11     | 14      | P4 <sub>2</sub> /TMRI <sub>0</sub>         | P4 <sub>2</sub> /TMRI <sub>0</sub>         | P4 <sub>2</sub> /TMRI <sub>0</sub>         |
| —       | —      | 15      | V <sub>SS</sub>                            | V <sub>SS</sub>                            | V <sub>SS</sub>                            |
| 20      | 12     | 16      | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCI | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCI | P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCI |
| 21      | 13     | 17      | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO  | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO  | P4 <sub>4</sub> /TMO <sub>1</sub> /HSYNCO  |
| 22      | 14     | 18      | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCI | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCI | P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCI |
| 23      | 15     | 19      | Ø                                          | Ø                                          | P4 <sub>6</sub> /Ø/FBACKI                  |
| 24      | 16     | 20      | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO  | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO  | P4 <sub>7</sub> /TMO <sub>x</sub> /CLAMPO  |

**Table 1-3 Pin Assignments in Each Operating Mode (H8/3212) (cont)**

| Pin No. |        |         | Expanded Modes                      |                                                    | Single-Chip Mode                  |
|---------|--------|---------|-------------------------------------|----------------------------------------------------|-----------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1                              | Mode 2                                             | Mode 3                            |
| 25      | 17     | 21      | P5 <sub>0</sub> /TxD <sub>0</sub>   | P5 <sub>0</sub> /TxD <sub>0</sub>                  | P5 <sub>0</sub> /TxD <sub>0</sub> |
| 26      | 18     | 22      | P5 <sub>1</sub> /RxD <sub>0</sub>   | P5 <sub>1</sub> /RxD <sub>0</sub>                  | P5 <sub>1</sub> /RxD <sub>0</sub> |
| 27      | 19     | 23      | P5 <sub>2</sub> /SCK <sub>0</sub>   | P5 <sub>2</sub> /SCK <sub>0</sub>                  | P5 <sub>2</sub> /SCK <sub>0</sub> |
| —       | —      | 24      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| 28      | 20     | 25      | P5 <sub>3</sub>                     | P5 <sub>3</sub>                                    | P5 <sub>3</sub>                   |
| 29      | 21     | 26      | P5 <sub>4</sub>                     | P5 <sub>4</sub>                                    | P5 <sub>4</sub>                   |
| 30      | 22     | 27      | P5 <sub>5</sub>                     | P5 <sub>5</sub>                                    | P5 <sub>5</sub>                   |
| —       | —      | 28      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| 31      | 23     | 29      | P7 <sub>0</sub> /SCL <sub>0</sub>   | P7 <sub>0</sub> /SCL <sub>0</sub>                  | P7 <sub>0</sub> /SCL <sub>0</sub> |
| 32      | 24     | 30      | P7 <sub>1</sub> /SDA <sub>0</sub>   | P7 <sub>1</sub> /SDA <sub>0</sub>                  | P7 <sub>1</sub> /SDA <sub>0</sub> |
| 33      | 25     | 31      | P7 <sub>2</sub> /SCL <sub>1</sub>   | P7 <sub>2</sub> /SCL <sub>1</sub>                  | P7 <sub>2</sub> /SCL <sub>1</sub> |
| 34      | 26     | 32      | P7 <sub>3</sub> /SDA <sub>1</sub>   | P7 <sub>3</sub> /SDA <sub>1</sub>                  | P7 <sub>3</sub> /SDA <sub>1</sub> |
| —       | —      | 33      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| 35      | 27     | 34      | $\overline{AS}$                     | $\overline{AS}$                                    | P7 <sub>4</sub>                   |
| 36      | 28     | 35      | $\overline{WR}$                     | $\overline{WR}$                                    | P7 <sub>5</sub>                   |
| 37      | 29     | 36      | $\overline{RD}$                     | $\overline{RD}$                                    | P7 <sub>6</sub>                   |
| —       | —      | 37      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| 38      | 30     | 38      | P7 <sub>7</sub> / $\overline{WAIT}$ | P7 <sub>7</sub> / $\overline{WAIT}$                | P7 <sub>7</sub>                   |
| 39      | 31     | 39      | V <sub>CC</sub>                     | V <sub>CC</sub>                                    | V <sub>CC</sub>                   |
| 40      | 32     | 40      | A <sub>15</sub>                     | P2 <sub>7</sub> /A <sub>15</sub> /PW <sub>15</sub> | P2 <sub>7</sub> /PW <sub>15</sub> |
| 41      | 33     | 41      | A <sub>14</sub>                     | P2 <sub>6</sub> /A <sub>14</sub> /PW <sub>14</sub> | P2 <sub>6</sub> /PW <sub>14</sub> |
| 42      | 34     | 42      | A <sub>13</sub>                     | P2 <sub>5</sub> /A <sub>13</sub> /PW <sub>13</sub> | P2 <sub>5</sub> /PW <sub>13</sub> |
| 43      | 35     | 43      | A <sub>12</sub>                     | P2 <sub>4</sub> /A <sub>12</sub> /PW <sub>12</sub> | P2 <sub>4</sub> /PW <sub>12</sub> |
| 44      | 36     | 44      | A <sub>11</sub>                     | P2 <sub>3</sub> /A <sub>11</sub> /PW <sub>11</sub> | P2 <sub>3</sub> /PW <sub>11</sub> |
| —       | —      | 45      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| 45      | 37     | 46      | A <sub>10</sub>                     | P2 <sub>2</sub> /A <sub>10</sub> /PW <sub>10</sub> | P2 <sub>2</sub> /PW <sub>10</sub> |
| 46      | 38     | 47      | A <sub>9</sub>                      | P2 <sub>1</sub> /A <sub>9</sub> /PW <sub>9</sub>   | P2 <sub>1</sub> /PW <sub>9</sub>  |
| 47      | 39     | 48      | A <sub>8</sub>                      | P2 <sub>0</sub> /A <sub>8</sub> /PW <sub>8</sub>   | P2 <sub>0</sub> /PW <sub>8</sub>  |
| —       | —      | 49      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |
| —       | —      | 50      | V <sub>SS</sub>                     | V <sub>SS</sub>                                    | V <sub>SS</sub>                   |

**Table 1-3 Pin Assignments in Each Operating Mode (H8/3212) (cont)**

| Pin No. |        |         | Expanded Modes  |                                                  | Single-Chip Mode                 |
|---------|--------|---------|-----------------|--------------------------------------------------|----------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1          | Mode 2                                           | Mode 3                           |
| 48      | 40     | 51      | V <sub>SS</sub> | V <sub>SS</sub>                                  | V <sub>SS</sub>                  |
| 49      | 41     | 52      | A <sub>7</sub>  | P1 <sub>7</sub> /A <sub>7</sub> /PW <sub>7</sub> | P1 <sub>7</sub> /PW <sub>7</sub> |
| 50      | 42     | 53      | A <sub>6</sub>  | P1 <sub>6</sub> /A <sub>6</sub> /PW <sub>6</sub> | P1 <sub>6</sub> /PW <sub>6</sub> |
| 51      | 43     | 54      | A <sub>5</sub>  | P1 <sub>5</sub> /A <sub>5</sub> /PW <sub>5</sub> | P1 <sub>5</sub> /PW <sub>5</sub> |
| 52      | 44     | 55      | A <sub>4</sub>  | P1 <sub>4</sub> /A <sub>4</sub> /PW <sub>4</sub> | P1 <sub>4</sub> /PW <sub>4</sub> |
| —       | —      | 56      | V <sub>SS</sub> | V <sub>SS</sub>                                  | V <sub>SS</sub>                  |
| 53      | 45     | 57      | A <sub>3</sub>  | P1 <sub>3</sub> /A <sub>3</sub> /PW <sub>3</sub> | P1 <sub>3</sub> /PW <sub>3</sub> |
| 54      | 46     | 58      | A <sub>2</sub>  | P1 <sub>2</sub> /A <sub>2</sub> /PW <sub>2</sub> | P1 <sub>2</sub> /PW <sub>2</sub> |
| 55      | 47     | 59      | A <sub>1</sub>  | P1 <sub>1</sub> /A <sub>1</sub> /PW <sub>1</sub> | P1 <sub>1</sub> /PW <sub>1</sub> |
| 56      | 48     | 60      | A <sub>0</sub>  | P1 <sub>0</sub> /A <sub>0</sub> /PW <sub>0</sub> | P1 <sub>0</sub> /PW <sub>0</sub> |
| 57      | 49     | 61      | D <sub>0</sub>  | D <sub>0</sub>                                   | P3 <sub>0</sub>                  |
| 58      | 50     | 62      | D <sub>1</sub>  | D <sub>1</sub>                                   | P3 <sub>1</sub>                  |
| 59      | 51     | 63      | D <sub>2</sub>  | D <sub>2</sub>                                   | P3 <sub>2</sub>                  |
| 60      | 52     | 64      | D <sub>3</sub>  | D <sub>3</sub>                                   | P3 <sub>3</sub>                  |
| —       | —      | 65      | V <sub>SS</sub> | V <sub>SS</sub>                                  | V <sub>SS</sub>                  |
| 61      | 53     | 66      | D <sub>4</sub>  | D <sub>4</sub>                                   | P3 <sub>4</sub>                  |
| 62      | 54     | 67      | D <sub>5</sub>  | D <sub>5</sub>                                   | P3 <sub>5</sub>                  |
| 63      | 55     | 68      | D <sub>6</sub>  | D <sub>6</sub>                                   | P3 <sub>6</sub>                  |
| 64      | 56     | 69      | D <sub>7</sub>  | D <sub>7</sub>                                   | P3 <sub>7</sub>                  |
| —       | —      | 70      | V <sub>SS</sub> | V <sub>SS</sub>                                  | V <sub>SS</sub>                  |

**Table 1-4 Pin Assignments in Each Operating Mode (H8/3202)**

| Pin No. |        |         | Expanded Modes                           |                                          | Single-Chip Mode                                       |
|---------|--------|---------|------------------------------------------|------------------------------------------|--------------------------------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1                                   | Mode 2                                   | Mode 3                                                 |
| —       | —      | 71      | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| 1       | 57     | 72      | P6 <sub>0</sub> /FTCI/KEYIN <sub>0</sub> | P6 <sub>0</sub> /FTCI/KEYIN <sub>0</sub> | P6 <sub>0</sub> /FTCI/KEYIN <sub>0</sub>               |
| 2       | 58     | 73      | P6 <sub>1</sub> /FTOA/KEYIN <sub>1</sub> | P6 <sub>1</sub> /FTOA/KEYIN <sub>1</sub> | P6 <sub>1</sub> /FTOA/KEYIN <sub>1</sub>               |
| 3       | 59     | 74      | P6 <sub>2</sub> /FTOB/KEYIN <sub>2</sub> | P6 <sub>2</sub> /FTOB/KEYIN <sub>2</sub> | P6 <sub>2</sub> /FTOB/KEYIN <sub>2</sub>               |
| 4       | 60     | 75      | P6 <sub>3</sub> /FTI/KEYIN <sub>3</sub>  | P6 <sub>3</sub> /FTI/KEYIN <sub>3</sub>  | P6 <sub>3</sub> /FTI/KEYIN <sub>3</sub>                |
| —       | —      | 76      | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| 5       | 61     | 77      | P6 <sub>4</sub> /IRQ <sub>0</sub>        | P6 <sub>4</sub> /IRQ <sub>0</sub>        | P6 <sub>4</sub> /IRQ <sub>0</sub>                      |
| 6       | 62     | 78      | P6 <sub>5</sub> /IRQ <sub>1</sub>        | P6 <sub>5</sub> /IRQ <sub>1</sub>        | P6 <sub>5</sub> /IRQ <sub>1</sub>                      |
| 7       | 63     | 79      | P6 <sub>6</sub> /IRQ <sub>2</sub>        | P6 <sub>6</sub> /IRQ <sub>2</sub>        | P6 <sub>6</sub> /IRQ <sub>2</sub>                      |
| 8       | 64     | 80      | RES                                      | RES                                      | RES                                                    |
| 9       | 1      | 1       | XTAL                                     | XTAL                                     | XTAL                                                   |
| 10      | 2      | 2       | EXTAL                                    | EXTAL                                    | EXTAL                                                  |
| 11      | 3      | 3       | MD <sub>1</sub>                          | MD <sub>1</sub>                          | MD <sub>1</sub>                                        |
| 12      | 4      | 4       | MD <sub>0</sub>                          | MD <sub>0</sub>                          | MD <sub>0</sub>                                        |
| 13      | 5      | 5       | NMI                                      | NMI                                      | NMI                                                    |
| —       | —      | 6       | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| 14      | 6      | 7       | V <sub>CC</sub>                          | V <sub>CC</sub>                          | V <sub>CC</sub>                                        |
| 15      | 7      | 8       | STBY                                     | STBY                                     | STBY                                                   |
| 16      | 8      | 9       | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| —       | —      | 10      | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| —       | —      | 11      | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| 17      | 9      | 12      | P4 <sub>0</sub> /TMCI <sub>0</sub>       | P4 <sub>0</sub> /TMCI <sub>0</sub>       | P4 <sub>0</sub> /TMCI <sub>0</sub>                     |
| 18      | 10     | 13      | P4 <sub>1</sub> /TMO <sub>0</sub>        | P4 <sub>1</sub> /TMO <sub>0</sub>        | P4 <sub>1</sub> /TMO <sub>0</sub>                      |
| 19      | 11     | 14      | P4 <sub>2</sub> /TMRI <sub>0</sub>       | P4 <sub>2</sub> /TMRI <sub>0</sub>       | P4 <sub>2</sub> /TMRI <sub>0</sub>                     |
| —       | —      | 15      | V <sub>SS</sub>                          | V <sub>SS</sub>                          | V <sub>SS</sub>                                        |
| 20      | 12     | 16      | P4 <sub>3</sub> /TMCI <sub>1</sub>       | P4 <sub>3</sub> /TMCI <sub>1</sub>       | P4 <sub>3</sub> /TMCI <sub>1</sub> /HIRQ <sub>11</sub> |
| 21      | 13     | 17      | P4 <sub>4</sub> /TMO <sub>1</sub>        | P4 <sub>4</sub> /TMO <sub>1</sub>        | P4 <sub>4</sub> /TMO <sub>1</sub> /HIRQ <sub>1</sub>   |
| 22      | 14     | 18      | P4 <sub>5</sub> /TMRI <sub>1</sub>       | P4 <sub>5</sub> /TMRI <sub>1</sub>       | P4 <sub>5</sub> /TMRI <sub>1</sub> /HIRQ <sub>12</sub> |
| 23      | 15     | 19      | ∅                                        | ∅                                        | P4 <sub>6</sub> /∅/CS <sub>2</sub>                     |
| 24      | 16     | 20      | P4 <sub>7</sub>                          | P4 <sub>7</sub>                          | P4 <sub>7</sub> /GA <sub>20</sub>                      |

**Table 1-4 Pin Assignments in Each Operating Mode (H8/3202) (cont)**

| Pin No. |        |         | Expanded Modes                                        |                                                       | Single-Chip Mode                                      |
|---------|--------|---------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1                                                | Mode 2                                                | Mode 3                                                |
| 25      | 17     | 21      | P5 <sub>0</sub> /TxD <sub>0</sub>                     | P5 <sub>0</sub> /TxD <sub>0</sub>                     | P5 <sub>0</sub> /TxD <sub>0</sub>                     |
| 26      | 18     | 22      | P5 <sub>1</sub> /Rx <sub>D0</sub>                     | P5 <sub>1</sub> /Rx <sub>D0</sub>                     | P5 <sub>1</sub> /Rx <sub>D0</sub>                     |
| 27      | 19     | 23      | P5 <sub>2</sub> /SCK <sub>0</sub>                     | P5 <sub>2</sub> /SCK <sub>0</sub>                     | P5 <sub>2</sub> /SCK <sub>0</sub>                     |
| —       | —      | 24      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| 28      | 20     | 25      | P5 <sub>3</sub> /Tx <sub>D1</sub>                     | P5 <sub>3</sub> /Tx <sub>D1</sub>                     | P5 <sub>3</sub> /Tx <sub>D1</sub>                     |
| 29      | 21     | 26      | P5 <sub>4</sub> /Rx <sub>D1</sub>                     | P5 <sub>4</sub> /Rx <sub>D1</sub>                     | P5 <sub>4</sub> /Rx <sub>D1</sub>                     |
| 30      | 22     | 27      | P5 <sub>5</sub> /SCK <sub>1</sub>                     | P5 <sub>5</sub> /SCK <sub>1</sub>                     | P5 <sub>5</sub> /SCK <sub>1</sub>                     |
| —       | —      | 28      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| 31      | 23     | 29      | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub> | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub> | P7 <sub>0</sub> /SCL <sub>0</sub> /KEYIN <sub>4</sub> |
| 32      | 24     | 30      | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub> | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub> | P7 <sub>1</sub> /SDA <sub>0</sub> /KEYIN <sub>5</sub> |
| 33      | 25     | 31      | P7 <sub>2</sub> /KEYIN <sub>6</sub>                   | P7 <sub>2</sub> /KEYIN <sub>6</sub>                   | P7 <sub>2</sub> /KEYIN <sub>6</sub>                   |
| 34      | 26     | 32      | P7 <sub>3</sub> /KEYIN <sub>7</sub>                   | P7 <sub>3</sub> /KEYIN <sub>7</sub>                   | P7 <sub>3</sub> /KEYIN <sub>7</sub>                   |
| —       | —      | 33      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| 35      | 27     | 34      | $\overline{AS}$                                       | $\overline{AS}$                                       | P7 <sub>4</sub> / $\overline{CS_1}$                   |
| 36      | 28     | 35      | $\overline{WR}$                                       | $\overline{WR}$                                       | P7 <sub>5</sub> / $\overline{IOW}$                    |
| 37      | 29     | 36      | $\overline{RD}$                                       | $\overline{RD}$                                       | P7 <sub>6</sub> / $\overline{IOR}$                    |
| —       | —      | 37      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| 38      | 30     | 38      | P7 <sub>7</sub> / $\overline{WAIT}$                   | P7 <sub>7</sub> / $\overline{WAIT}$                   | P7 <sub>7</sub> /HA <sub>0</sub>                      |
| 39      | 31     | 39      | V <sub>CC</sub>                                       | V <sub>CC</sub>                                       | V <sub>CC</sub>                                       |
| 40      | 32     | 40      | A <sub>15</sub>                                       | P2 <sub>7</sub> /A <sub>15</sub>                      | P2 <sub>7</sub>                                       |
| 41      | 33     | 41      | A <sub>14</sub>                                       | P2 <sub>6</sub> /A <sub>14</sub>                      | P2 <sub>6</sub>                                       |
| 42      | 34     | 42      | A <sub>13</sub>                                       | P2 <sub>5</sub> /A <sub>13</sub>                      | P2 <sub>5</sub>                                       |
| 43      | 35     | 43      | A <sub>12</sub>                                       | P2 <sub>4</sub> /A <sub>12</sub>                      | P2 <sub>4</sub>                                       |
| 44      | 36     | 44      | A <sub>11</sub>                                       | P2 <sub>3</sub> /A <sub>11</sub>                      | P2 <sub>3</sub>                                       |
| —       | —      | 45      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| 45      | 37     | 46      | A <sub>10</sub>                                       | P2 <sub>2</sub> /A <sub>10</sub>                      | P2 <sub>2</sub>                                       |
| 46      | 38     | 47      | A <sub>9</sub>                                        | P2 <sub>1</sub> /A <sub>9</sub>                       | P2 <sub>1</sub>                                       |
| 47      | 39     | 48      | A <sub>8</sub>                                        | P2 <sub>0</sub> /A <sub>8</sub>                       | P2 <sub>0</sub>                                       |
| —       | —      | 49      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |
| —       | —      | 50      | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       | V <sub>SS</sub>                                       |

**Table 1-4 Pin Assignments in Each Operating Mode (H8/3202) (cont)**

| Pin No. |        |         | Expanded Modes  |                                 | Single-Chip Mode                  |
|---------|--------|---------|-----------------|---------------------------------|-----------------------------------|
| DP-64S  | FP-64A | TFP-80C | Mode 1          | Mode 2                          | Mode 3                            |
| 48      | 40     | 51      | V <sub>SS</sub> | V <sub>SS</sub>                 | V <sub>SS</sub>                   |
| 49      | 41     | 52      | A <sub>7</sub>  | P1 <sub>7</sub> /A <sub>7</sub> | P1 <sub>7</sub>                   |
| 50      | 42     | 53      | A <sub>6</sub>  | P1 <sub>6</sub> /A <sub>6</sub> | P1 <sub>6</sub>                   |
| 51      | 43     | 54      | A <sub>5</sub>  | P1 <sub>5</sub> /A <sub>5</sub> | P1 <sub>5</sub>                   |
| 52      | 44     | 55      | A <sub>4</sub>  | P1 <sub>4</sub> /A <sub>4</sub> | P1 <sub>4</sub>                   |
| —       | —      | 56      | V <sub>SS</sub> | V <sub>SS</sub>                 | V <sub>SS</sub>                   |
| 53      | 45     | 57      | A <sub>3</sub>  | P1 <sub>3</sub> /A <sub>3</sub> | P1 <sub>3</sub>                   |
| 54      | 46     | 58      | A <sub>2</sub>  | P1 <sub>2</sub> /A <sub>2</sub> | P1 <sub>2</sub>                   |
| 55      | 47     | 59      | A <sub>1</sub>  | P1 <sub>1</sub> /A <sub>1</sub> | P1 <sub>1</sub>                   |
| 56      | 48     | 60      | A <sub>0</sub>  | P1 <sub>0</sub> /A <sub>0</sub> | P1 <sub>0</sub>                   |
| 57      | 49     | 61      | D <sub>0</sub>  | D <sub>0</sub>                  | P3 <sub>0</sub> /HDB <sub>0</sub> |
| 58      | 50     | 62      | D <sub>1</sub>  | D <sub>1</sub>                  | P3 <sub>1</sub> /HDB <sub>1</sub> |
| 59      | 51     | 63      | D <sub>2</sub>  | D <sub>2</sub>                  | P3 <sub>2</sub> /HDB <sub>2</sub> |
| 60      | 52     | 64      | D <sub>3</sub>  | D <sub>3</sub>                  | P3 <sub>3</sub> /HDB <sub>3</sub> |
| —       | —      | 65      | V <sub>SS</sub> | V <sub>SS</sub>                 | V <sub>SS</sub>                   |
| 61      | 53     | 66      | D <sub>4</sub>  | D <sub>4</sub>                  | P3 <sub>4</sub> /HDB <sub>4</sub> |
| 62      | 54     | 67      | D <sub>5</sub>  | D <sub>5</sub>                  | P3 <sub>5</sub> /HDB <sub>5</sub> |
| 63      | 55     | 68      | D <sub>6</sub>  | D <sub>6</sub>                  | P3 <sub>6</sub> /HDB <sub>6</sub> |
| 64      | 56     | 69      | D <sub>7</sub>  | D <sub>7</sub>                  | P3 <sub>7</sub> /HDB <sub>7</sub> |
| —       | —      | 70      | V <sub>SS</sub> | V <sub>SS</sub>                 | V <sub>SS</sub>                   |

(2) **Pin Functions:** Table 1-5 gives a concise description of the function of each pin.

**Table 1-5 Pin Functions**

| Type           | Symbol            | Pin No.                |                       |                                                                                       | I/O | Name and Function                                                                                                                                                                                                                                                            |
|----------------|-------------------|------------------------|-----------------------|---------------------------------------------------------------------------------------|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                |                   | DC-64S<br>DP-64S       | FP-64A                | TFP-80C                                                                               |     |                                                                                                                                                                                                                                                                              |
| Power          | $V_{CC}$          | 14, 39                 | 6, 31                 | 7, 39                                                                                 | I   | <b>Power:</b> Connected to the power supply. Connect both $V_{CC}$ pins to the system power supply.                                                                                                                                                                          |
|                | $V_{SS}$          | 16, 48                 | 8, 40                 | 9, 51<br>6, 10, 11,<br>15, 24, 28,<br>33, 37, 45,<br>49, 50, 56,<br>65, 70, 71,<br>76 | I   | <b>Ground:</b> Connected to ground (0 V). Connect all $V_{SS}$ pins to the system power supply (0 V).                                                                                                                                                                        |
| Clock          | XTAL              | 9                      | 1                     | 1                                                                                     | I   | <b>Crystal:</b> Connected to a crystal oscillator. The crystal frequency must be the same as the desired system clock frequency. If an external clock is input at the EXTAL pin, a reverse-phase clock should be input at the XTAL pin.                                      |
|                | EXTAL             | 10                     | 2                     | 2                                                                                     | I   | <b>External crystal:</b> Connected to a crystal oscillator or external clock. The frequency of the external clock must be the same as the desired system clock frequency. See section 6, Clock Pulse Generator, for examples of connections to a crystal and external clock. |
|                | $\emptyset$       | 23                     | 15                    | 19                                                                                    | O   | <b>System clock:</b> Supplies the system clock to peripheral devices.                                                                                                                                                                                                        |
| System control | $\overline{RES}$  | 8                      | 64                    | 80                                                                                    | I   | <b>Reset:</b> A low input causes the chip to reset.                                                                                                                                                                                                                          |
|                | $\overline{STBY}$ | 15                     | 7                     | 8                                                                                     | I   | <b>Standby:</b> A transition to the hardware standby mode (a power-down state) occurs when a low input is received at the STBY pin.                                                                                                                                          |
| Address bus    | $A_{15}$ to $A_0$ | 40 to 47,<br>49 to 56, | 32 to 39,<br>41 to 48 | 40 to 44,<br>46 to 48,<br>52 to 55,<br>57 to 60                                       | O   | <b>Address bus:</b> Address output pins.                                                                                                                                                                                                                                     |

**Table 1-5 Pin Functions (cont)**

|                        |                                                        | Pin No.          |          |                       |       |                                                                                                                                                                                                                                   |
|------------------------|--------------------------------------------------------|------------------|----------|-----------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Type                   | Symbol                                                 | DC-64S<br>DP-64S | FP-64A   | TFP-80C               | I/O   | Name and Function                                                                                                                                                                                                                 |
| Data bus               | D <sub>7</sub> to D <sub>0</sub>                       | 64 to 57         | 56 to 49 | 69 to 66,<br>64 to 61 | I/O   | <b>Data bus:</b> 8-bit bidirectional data bus.                                                                                                                                                                                    |
| Bus control            | $\overline{\text{WAIT}}$                               | 38               | 30       | 38                    | I     | <b>Wait:</b> Requests the CPU to insert T <sub>W</sub> states into the bus cycle when an off-chip address is accessed.                                                                                                            |
|                        | $\overline{\text{RD}}$                                 | 37               | 29       | 36                    | O     | <b>Read:</b> Goes low to indicate that the CPU is reading an external address.                                                                                                                                                    |
|                        | $\overline{\text{WR}}$                                 | 36               | 28       | 35                    | O     | <b>Write:</b> Goes low to indicate that the CPU is writing to an external address.                                                                                                                                                |
|                        | $\overline{\text{AS}}$                                 | 35               | 27       | 34                    | O     | <b>Address strobe:</b> Goes low to indicate that there is a valid address on the address bus.                                                                                                                                     |
| Interrupt signals      | $\overline{\text{NMI}}$                                | 13               | 5        | 5                     | I     | <b>Non maskable interrupt:</b> Highest-priority interrupt request. The NMIEG bit in the system control register determines whether the interrupt is requested on the rising or falling edge of the $\overline{\text{NMI}}$ input. |
|                        | $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ | 5 to 7           | 61 to 63 | 77 to 79              | I     | <b>Interrupt request 0 to 2:</b> Maskable interrupt request pins.                                                                                                                                                                 |
| Operating mode control | MD <sub>1</sub> ,<br>MD <sub>0</sub>                   | 11<br>12         | 3<br>4   | 3<br>4                | I     | <b>Mode:</b> Input pins for setting the MCU operating mode according to the table below.                                                                                                                                          |
|                        |                                                        |                  |          |                       |       | <b>MD<sub>1</sub></b> <b>MD<sub>0</sub></b> <b>Mode</b> <b>Description</b>                                                                                                                                                        |
|                        |                                                        |                  |          |                       | 0   1 | Mode 1   Expanded mode with on-chip ROM disabled                                                                                                                                                                                  |
|                        |                                                        |                  |          |                       | 1   0 | Mode 2   Expanded mode with on-chip ROM enabled                                                                                                                                                                                   |
|                        |                                                        |                  |          |                       | 1   1 | Mode 3   Single-chip mode                                                                                                                                                                                                         |

**Table 1-5 Pin Functions (cont)**

| Type                                                       | Symbol              | Pin No.          |        |         | I/O | Name and Function                                                                                              |
|------------------------------------------------------------|---------------------|------------------|--------|---------|-----|----------------------------------------------------------------------------------------------------------------|
|                                                            |                     | DC-64S<br>DP-64S | FP-64A | TFP-80C |     |                                                                                                                |
| 16-bit free-running timer                                  | FTCI                | 1                | 57     | 72      | I   | <b>FRT counter clock input:</b> Input pin for an external clock signal for the free-running counter.           |
|                                                            | FTOA                | 2                | 58     | 73      | O   | <b>FRT output compare A:</b> Output pins controlled by comparator A of the free-running timer.                 |
|                                                            | FTOB                | 3                | 59     | 74      | O   | <b>FRT output compare B:</b> Output pins controlled by comparator B of the free-running timer.                 |
|                                                            | FTI                 | 4                | 60     | 75      | I   | <b>FRT input capture:</b> Input capture pin for the free-running timer.                                        |
| 8-bit timer (channel X: except H8/3202)                    | TMO <sub>0</sub> ,  | 18               | 10     | 13      | O   | <b>8-bit timer output (channels 0, 1, and x):</b> Compare- match output pins for the 8-bit timers.             |
|                                                            | TMO <sub>1</sub> ,  | 21               | 13     | 17      |     |                                                                                                                |
|                                                            | TMO <sub>x</sub>    | 24               | 16     | 20      |     |                                                                                                                |
|                                                            | TMCI <sub>0</sub> , | 17               | 9      | 12      | I   | <b>8-bit timer clock input (channels 0, 1, and x):</b> External clock input pins for the 8-bit timer counters. |
|                                                            | TMCI <sub>1</sub> , | 20               | 12     | 16      |     |                                                                                                                |
|                                                            | FBACKI              | 23               | 15     | 19      |     |                                                                                                                |
|                                                            | TMRI <sub>0</sub> , | 19               | 11     | 14      | I   | <b>8-bit timer reset input (channels 0, 1, and x):</b> High input at these pins resets the 8-bit timers.       |
|                                                            | TMRI <sub>1</sub> , | 22               | 14     | 18      |     |                                                                                                                |
|                                                            | FBACKI              | 23               | 15     | 19      |     |                                                                                                                |
| Serial communication interface (channel 1: except H8/3212) | TxD <sub>0</sub>    | 25               | 17     | 21      | O   | <b>Serial transmit data (channels 0 and 1):</b> Data output pins for the serial communication interface.       |
|                                                            | TxD <sub>1</sub>    | 28               | 20     | 25      |     |                                                                                                                |
|                                                            | RxD <sub>0</sub>    | 26               | 18     | 22      | I   | <b>Serial receive data (channels 0 and 1):</b> Data input pins for the serial communication interface.         |
|                                                            | RxD <sub>1</sub>    | 29               | 21     | 26      |     |                                                                                                                |
|                                                            | SCK <sub>0</sub>    | 27               | 19     | 23      | I/O | <b>Serial clock (channels 0 and 1):</b> Input/output pins for the serial clock signals.                        |
|                                                            | SCK <sub>1</sub>    | 30               | 22     | 27      |     |                                                                                                                |

**Table 1-5 Pin Functions (cont)**

| Type                        | Symbol                             | Pin No.            |                    |                                        | I/O | Name and Function                                                                                                                                                                                   |
|-----------------------------|------------------------------------|--------------------|--------------------|----------------------------------------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                             |                                    | DC-64S<br>DP-64S   | FP-64A             | TFP-80C                                |     |                                                                                                                                                                                                     |
| General-purpose I/O         | P1 <sub>7</sub> to P1 <sub>0</sub> | 49 to 56           | 41 to 48           | 52 to 55, 57 to 60                     | I/O | <b>Port 1:</b> An 8-bit input/output port with programmable MOS input pull-ups and LED driving capability. The direction of each bit can be selected in the port 1 data direction register (P1DDR). |
|                             | P2 <sub>7</sub> to P2 <sub>0</sub> | 40 to 47           | 32 to 39           | 40 to 44, 46 to 48                     | I/O | <b>Port 2:</b> An 8-bit input/output port with programmable MOS input pull-ups and LED driving capability. The direction of each bit can be selected in the port 2 data direction register (P2DDR). |
|                             | P3 <sub>7</sub> to P3 <sub>0</sub> | 64 to 57           | 56 to 49           | 69 to 66, 64 to 61                     | I/O | <b>Port 3:</b> An 8-bit input/output port with programmable MOS input pull-ups and LED drive capability. The direction of each bit can be selected in the port 3 data direction register (P3DDR).   |
|                             | P4 <sub>7</sub> to P4 <sub>0</sub> | 24 to 17           | 16 to 9            | 20 to 16, 14 to 12                     | I/O | <b>Port 4:</b> An 8-bit input/output port. The direction of each bit (except P46) can be selected in the port 4 data direction register (P4DDR).                                                    |
|                             | P5 <sub>5</sub> to P5 <sub>0</sub> | 30 to 25           | 22 to 17           | 27 to 25, 23 to 21                     | I/O | <b>Port 5:</b> A 6-bit input/output port. The direction of each bit can be selected in the port 5 data direction register (P5DDR).                                                                  |
|                             | P6 <sub>6</sub> to P6 <sub>0</sub> | 7 to 1             | 63 to 57           | 79 to 77, 75 to 72                     | I/O | <b>Port 6:</b> A 7-bit input/output port. The direction of each bit can be selected in the port 6 data direction register (P6DDR).                                                                  |
|                             | P7 <sub>7</sub> to P7 <sub>0</sub> | 38 to 31           | 30 to 23           | 38, 37 to 34, 32 to 29                 | I/O | <b>Port 7:</b> An 8-bit input/output port. The direction of each bit can be selected in the port 7 data direction register (P7DDR).                                                                 |
| PWM timers (except H8/3202) | PW15 to PW0                        | 40 to 47, 49 to 56 | 32 to 39, 41 to 48 | 40 to 44, 46 to 48, 52 to 55, 57 to 60 | O   | <b>PWM timer outputs:</b> PWM timer pulse output pins.                                                                                                                                              |

**Table 1-5 Pin Functions (cont)**

| Type                                                                | Symbol                                   | Pin No.            |                      |                      | I/O | Name and Function                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------|------------------------------------------|--------------------|----------------------|----------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                     |                                          | DC-64S<br>DP-64S   | FP-64A               | TFP-80C              |     |                                                                                                                                                                                                                                                                                                                            |
| Timer connection (except H8/3202)                                   | VSYNCI                                   | 4                  | 60                   | 75                   | I   | <b>Timer connection inputs:</b> Timer connection (FRT, TMR1, TMRX) input pins.                                                                                                                                                                                                                                             |
|                                                                     | HSYNCI                                   | 20                 | 12                   | 16                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | CSYNCI                                   | 22                 | 14                   | 18                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | FBACKI                                   | 23                 | 15                   | 19                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | VSYNCO                                   | 3                  | 59                   | 74                   | O   | <b>Timer connection outputs:</b> Timer connection (FRT, TMR1, TMRX) output pins.                                                                                                                                                                                                                                           |
|                                                                     | HSYNCO                                   | 21                 | 13                   | 17                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | CLAMPO                                   | 24                 | 16                   | 20                   |     |                                                                                                                                                                                                                                                                                                                            |
| I <sup>2</sup> C bus interface (option) (channel 1: except H8/3202) | SCL <sub>0</sub>                         | 31                 | 23                   | 29                   | I/O | <b>I<sup>2</sup>C clock input/output (channels 0 and 1):</b> I <sup>2</sup> C clock input/output pin. Has a bus driving function.                                                                                                                                                                                          |
|                                                                     | SCL <sub>1</sub>                         | 33                 | 25                   | 31                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | SDA <sub>0</sub>                         | 32                 | 24                   | 30                   | I/O | <b>I<sup>2</sup>C data input/output (channels 0 and 1):</b> I <sup>2</sup> C data input/output pin. Has a bus driving function.                                                                                                                                                                                            |
|                                                                     | SDA <sub>1</sub>                         | 34                 | 26                   | 32                   |     |                                                                                                                                                                                                                                                                                                                            |
| Host interface (HIF) (except H8/3212)                               | HDB <sub>0</sub> to HDB <sub>7</sub>     | 57 to 64           | 49 to 56             | 61 to 64<br>66 to 69 | I/O | <b>Host interface data bus:</b> Bidirectional 8-bit bus for host interface access by the host.                                                                                                                                                                                                                             |
|                                                                     | $\overline{CS}_1$                        | 35                 | 27                   | 34                   | I   | <b>Chip select 1 and 2:</b> Input pins for selecting host interface channel 1 or channel 2.                                                                                                                                                                                                                                |
|                                                                     | $\overline{CS}_2$                        | 23                 | 15                   | 19                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | $\overline{IOR}$                         | 37                 | 29                   | 36                   | I   | <b>I/O read:</b> Input pin that enables reads on the host interface.                                                                                                                                                                                                                                                       |
|                                                                     | $\overline{IOW}$                         | 36                 | 28                   | 35                   | I   | <b>I/O write:</b> Input pin that enables writes to the host interface.                                                                                                                                                                                                                                                     |
|                                                                     | HA <sub>0</sub>                          | 38                 | 30                   | 38                   | I   | <b>Command/data:</b> Input pin that indicates a data access or command access.                                                                                                                                                                                                                                             |
|                                                                     | GA <sub>20</sub>                         | 24                 | 16                   | 20                   | O   | <b>GATE A<sub>20</sub>:</b> GATE A <sub>20</sub> control signal output pin.                                                                                                                                                                                                                                                |
|                                                                     | HIRQ <sub>1</sub>                        | 21                 | 13                   | 17                   | O   | <b>Host interrupt 1, 11, 12:</b> Output pins for interrupt requests to the host.                                                                                                                                                                                                                                           |
|                                                                     | HIRQ <sub>11</sub>                       | 20                 | 12                   | 16                   |     |                                                                                                                                                                                                                                                                                                                            |
|                                                                     | HIRQ <sub>12</sub>                       | 22                 | 14                   | 18                   |     |                                                                                                                                                                                                                                                                                                                            |
| Keyboard control (except H8/3212)                                   | KEYIN <sub>0</sub> to KEYIN <sub>7</sub> | 1 to 4<br>31 to 34 | 57 to 60<br>23 to 26 | 72 to 75<br>29 to 32 | I   | <b>Keyboard input:</b> Input pins for a matrix keyboard. (PI <sub>1</sub> to PI <sub>7</sub> and P2 <sub>0</sub> to P2 <sub>7</sub> are normally used as keyboard scan outputs, enabling a maximum 16-output × 8-input, 128-key matrix to be configured. The number of keys can be increased by using other port outputs.) |



# Section 2 CPU

## 2.1 Overview

The H8/3217 Series has the generic H8/300 CPU: an 8-bit central processing unit with a speed-oriented architecture featuring sixteen general registers. This section describes the CPU features and functions, including a concise description of the addressing modes and instruction set. For further details on the instructions, see the *H8/300 Series Programming Manual*.

### 2.1.1 Features

The main features of the H8/300 CPU are listed below.

- Two-way register configuration
  - Sixteen 8-bit general registers, or
  - Eight 16-bit general registers
- Instruction set with 57 basic instructions, including:
  - Multiply and divide instructions
  - Powerful bit-manipulation instructions
- Eight addressing modes
  - Register direct (Rn)
  - Register indirect (@Rn)
  - Register indirect with displacement (@(d:16, Rn))
  - Register indirect with post-increment or pre-decrement (@Rn+ or @-Rn)
  - Absolute address (@aa:8 or @aa:16)
  - Immediate (#xx:8 or #xx:16)
  - PC-relative (@(d:8, PC))
  - Memory indirect (@@aa:8)
- Maximum 64-kbyte address space
- High-speed operation
  - All frequently-used instructions are executed two to four states
  - The maximum clock rate is 16 MHz/5 V, 12 MHz/4 V, or 10 MHz/3 V (ø clock)
  - 8- or 16-bit register-register add or subtract: 125 ns (16 MHz), 167 ns (12 MHz) or 200 ns (10 MHz)
  - 8 × 8-bit multiply: 875 ns (16 MHz), 1167 ns (12 MHz) or 1400 ns (10 MHz)
  - 16 ÷ 8-bit divide: 875 ns (16 MHz), 1167 ns (12 MHz) or 1400 ns (10 MHz)

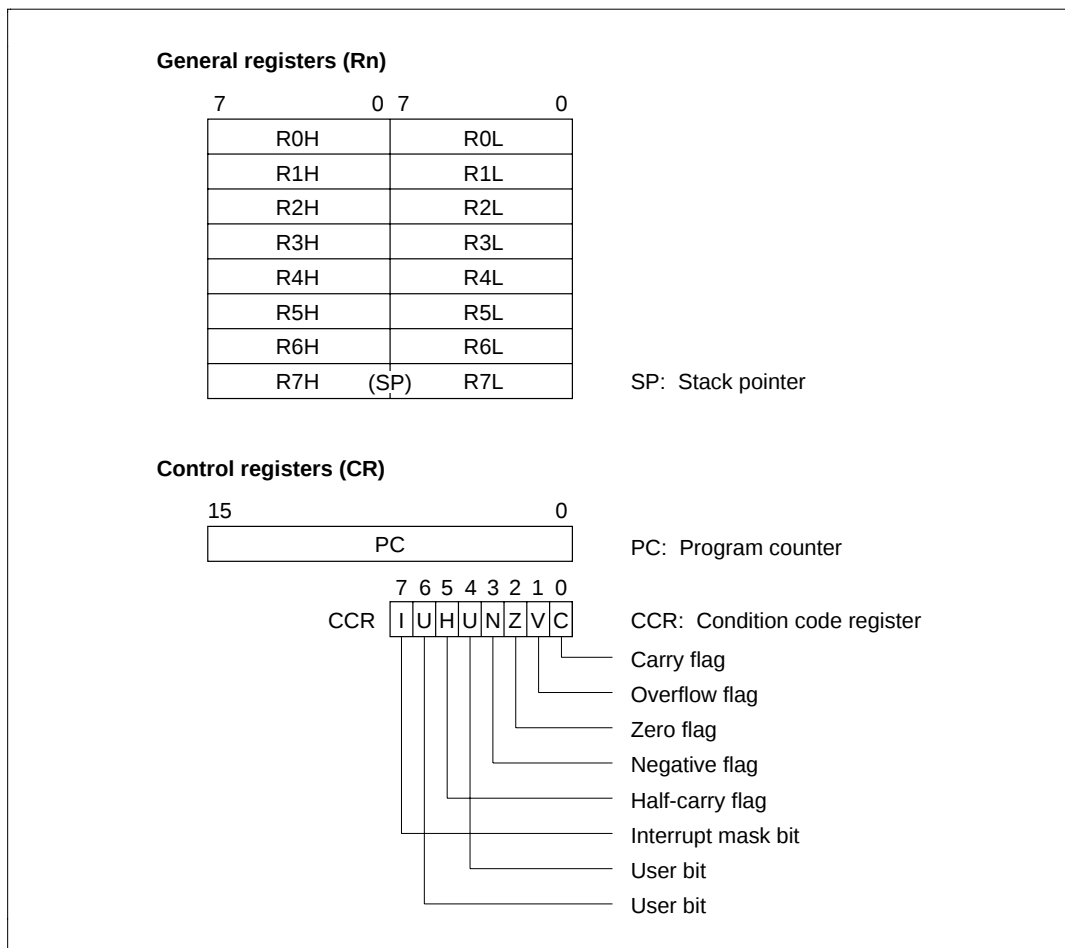
- Power-down mode
  - SLEEP instruction

## 2.1.2 Address Space

The H8/300 CPU supports an address space of up to 64 kbytes for storing program code and data. The memory map is different for each mode (modes 1, 2, and 3). See section 3.5, Address Space Maps for Each Operating Mode, for details.

## 2.1.3 Register Configuration

Figure 2-1 shows the register structure of the CPU. There are two groups of registers: the general registers and control registers.



**Figure 2-1 CPU Registers**

## 2.2 Register Descriptions

### 2.2.1 General Registers

All the general registers can be used as both data registers and address registers. When used as address registers, the general registers are accessed as 16-bit registers (R0 to R7). When used as data registers, they can be accessed as 16-bit registers, or the high and low bytes can be accessed separately as 8-bit registers.

R7 also functions as the stack pointer, used implicitly by hardware in processing interrupts and subroutine calls. In assembly-language coding, R7 can also be denoted by the letters SP. As indicated in figure 2-2, R7 (SP) points to the top of the stack.

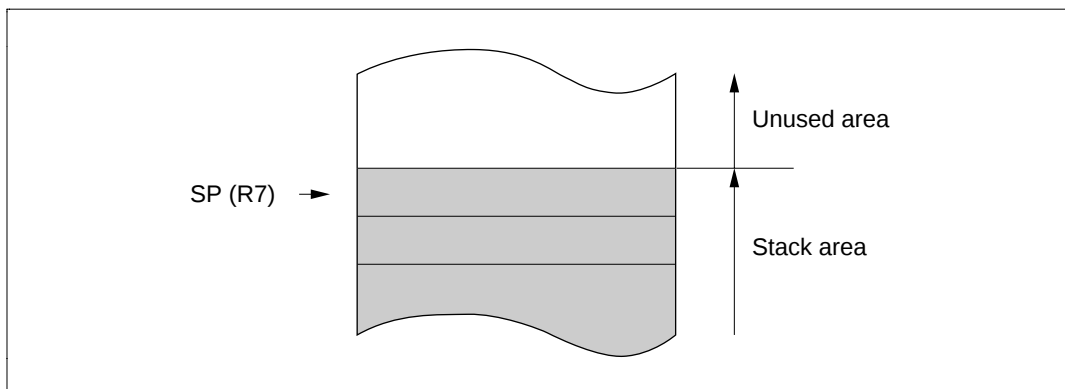


Figure 2-2 Stack Pointer

### 2.2.2 Control Registers

The CPU control registers include a 16-bit program counter (PC) and an 8-bit condition code register (CCR).

**(1) Program Counter (PC):** This 16-bit register indicates the address of the next instruction the CPU will execute. Each instruction is accessed in 16 bits (1 word), so the least significant bit of the PC is ignored (always regarded as 0).

**(2) Condition Code Register (CCR):** This 8-bit register contains internal status information, including carry (C), overflow (V), zero (Z), negative (N), and half-carry (H) flags and the interrupt mask bit (I).

**Bit 7—Interrupt Mask Bit (I):** When this bit is set to 1, all interrupts except NMI are masked. This bit is set to 1 automatically by a reset and at the start of interrupt handling.

**Bit 6—User Bit (U):** This bit can be written and read by software for its own purposes (using the LDC, STC, ANDC, ORC, and XORC instructions).

**Bit 5—Half-Carry (H):** This bit is set to 1 when the ADD.B, ADDX.B, SUB.B, SUBX.B, NEG.B, or CMP.B instruction causes a carry or borrow out of bit 3, and is cleared to 0 otherwise. Similarly, it is set to 1 when the ADD.W, SUB.W, or CMP.W instruction causes a carry or borrow out of bit 11, and cleared to 0 otherwise. It is used implicitly in the DAA and DAS instructions.

**Bit 4—User Bit (U):** This bit can be written and read by software for its own purposes (using the LDC, STC, ANDC, ORC, and XORC instructions).

**Bit 3—Negative (N):** This bit indicates the most significant bit (sign bit) of the result of an instruction.

**Bit 2—Zero (Z):** This bit is set to 1 to indicate a zero result and cleared to 0 to indicate a nonzero result.

**Bit 1—Overflow (V):** This bit is set to 1 when an arithmetic overflow occurs, and cleared to 0 at other times.

**Bit 0—Carry (C):** This bit is used by:

- Add and subtract instructions, to indicate a carry or borrow at the most significant bit of the result
- Shift and rotate instructions, to store the value shifted out of the most significant or least significant bit
- Bit manipulation and bit load instructions, as a bit accumulator

The LDC, STC, ANDC, ORC, and XORC instructions enable the CPU to load and store the CCR, and to set or clear selected bits by logic operations. The N, Z, V, and C flags are used in conditional branching instructions (Bcc).

Some instructions leave some or all of the flag bits unchanged. The action of each instruction on the flag bits is shown in Appendix A.1, Instruction Set List. See the *H8/300 Series Programming Manual* for further details.

### 2.2.3 Initial Register Values

When the CPU is reset, the program counter (PC) is loaded from the vector table and the interrupt mask bit (I) in the CCR is set to 1. The other CCR bits and the general registers are not initialized.

In particular, the stack pointer (R7) is not initialized. To prevent program crashes the stack pointer should be initialized by software, by the first instruction executed after a reset.

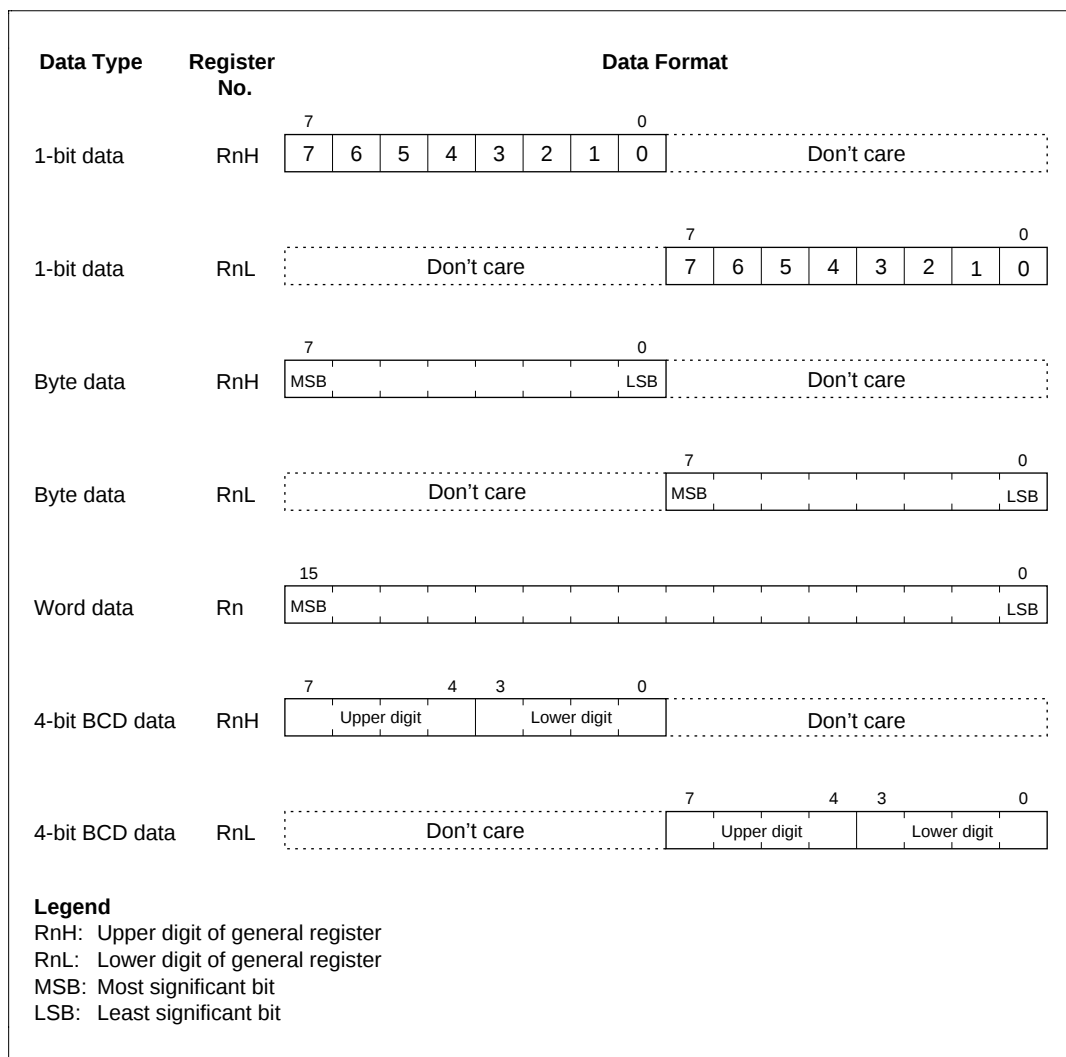
## 2.3 Data Formats

The H8/300 CPU can process 1-bit data, 4-bit (BCD) data, 8-bit (byte) data, and 16-bit (word) data.

- Bit manipulation instructions operate on 1-bit data specified as bit  $n$  ( $n = 0, 1, 2, \dots, 7$ ) in a byte operand.
- All arithmetic and logic instructions except ADDS and SUBS can operate on byte data.
- The DAA and DAS instruction perform decimal arithmetic adjustments on byte data in packed BCD form. Each nibble of the byte is treated as a decimal digit.
- The MOV.W, ADD.W, SUB.W, CMP.W, ADDS, SUBS, MULXU ( $8 \text{ bits} \times 8 \text{ bits}$ ), and DIVXU ( $16 \text{ bits} \div 8 \text{ bits}$ ) instructions operate on word data.

### 2.3.1 Data Formats in General Registers

Data of all the sizes above can be stored in general registers as shown in figure 2-3.



### Figure 2-3 Register Data Formats

### 2.3.2 Memory Data Formats

Figure 2-4 indicates the data formats in memory.

Word data stored in memory must always begin at an even address. In word access the least significant bit of the address is regarded as 0. If an odd address is specified, no address error occurs but the access is performed at the preceding even address. This rule affects MOV.W instructions and branching instructions, and implies that only even addresses should be stored in the vector table.

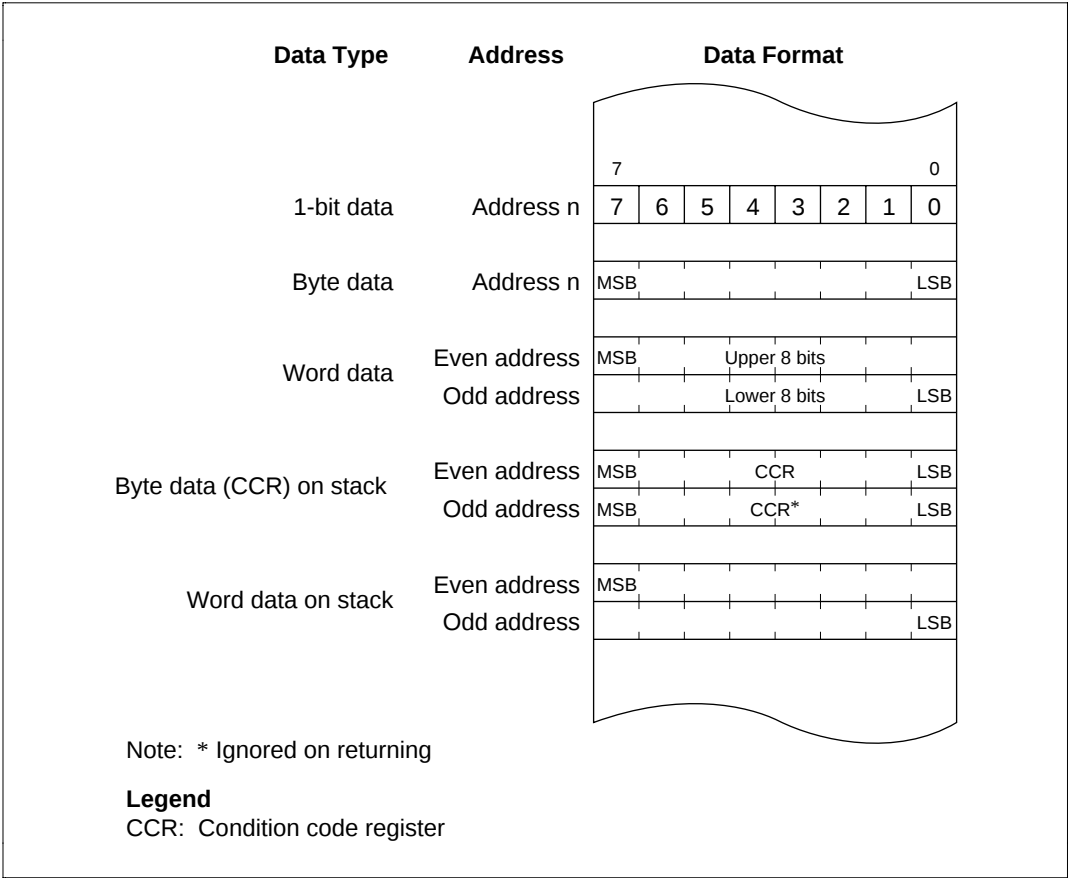


Figure 2-4 Memory Data Formats

The stack must always be accessed a word at a time. When the CCR is pushed on the stack, two identical copies of the CCR are pushed to make a complete word. When they are returned, the lower byte is ignored.

## 2.4 Addressing Modes

### 2.4.1 Addressing Modes

The H8/300 CPU supports eight addressing modes. Each instruction uses a subset of these addressing modes.

**(1) Register Direct—Rn:** The register field of the instruction specifies an 8- or 16-bit general register containing the operand. In most cases the general register is accessed as an 8-bit register. Only the MOV.W, ADD.W, SUB.W, CMP.W, ADDS, SUBS, MULXU (8 bits × 8 bits), and DIVXU (16 bits ÷ 8 bits) instructions have 16-bit operands.

**(2) Register indirect—@Rn:** The register field of the instruction specifies a 16-bit general register containing the address of the operand.

**(3) Register Indirect with Displacement—@(d:16, Rn):** This mode, which is used only in MOV instructions, is similar to register indirect but the instruction has a second word (bytes 3 and 4) which is added to the contents of the specified general register to obtain the operand address. For the MOV.W instruction, the resulting address must be even.

**(4) Register Indirect with Post-Increment or Pre-Decrement—@Rn+ or @-Rn:**

- Register indirect with Post-Increment—@Rn+

The @Rn+ mode is used with MOV instructions that load registers from memory. It is similar to the register indirect mode, but the 16-bit general register specified in the register field of the instruction is incremented after the operand is accessed. The size of the increment is 1 or 2 depending on the size of the operand: 1 for MOV.B; 2 for MOV.W. For MOV.W, the original contents of the 16-bit general register must be even.

- Register Indirect with Pre-Decrement—@-Rn

The @-Rn mode is used with MOV instructions that store register contents to memory. It is similar to the register indirect mode, but the 16-bit general register specified in the register field of the instruction is decremented before the operand is accessed. The size of the decrement is 1 or 2 depending on the size of the operand: 1 for MOV.B; 2 for MOV.W. For MOV.W, the original contents of the 16-bit general register must be even.

**(5) Absolute Address—@aa:8 or @aa:16:** The instruction specifies the absolute address of the operand in memory. The MOV.B instruction uses an 8-bit absolute address of the form H'FFxx. The upper 8 bits are assumed to be 1, so the possible address range is H'FF00 to H'FFFF (65280 to 65535). The MOV.B, MOV.W, JMP, and JSR instructions can use 16-bit absolute addresses.

**(6) Immediate—#xx:8 or #xx:16:** The instruction contains an 8-bit operand in its second byte, or a 16-bit operand in its third and fourth bytes. Only MOV.W instructions can contain 16-bit

immediate values.

The ADDS and SUBS instructions implicitly contain the value 1 or 2 as immediate data. Some bit manipulation instructions contain 3-bit immediate data (#xx:3) in the second or fourth byte of the instruction, specifying a bit number.

**(7) PC-Relative—@ (d:8, PC):** This mode is used to generate branch addresses in the Bcc and BSR instructions. An 8-bit value in byte 2 of the instruction code is added as a sign-extended value to the program counter contents. The result must be an even number. The possible branching range is -126 to +128 bytes (-63 to +64 words) from the current address.

**(8) Memory Indirect—@@aa:8:** This mode can be used by the JMP and JSR instructions. The second byte of the instruction code specifies an 8-bit absolute address from H'0000 to H'00FF (0 to 255). The word located at this address contains the branch address. Note that part of this area is located in the vector table. See section 3.5, Address Space Maps for Each Operating Mode, for details.

If an odd address is specified as a branch destination or as the operand address of a MOV.W instruction, the least significant bit is regarded as 0, causing word access to be performed at the address preceding the specified address. See section 2.3.2, Memory Data Formats, for further information.

## 2.4.2 Effective Address Calculation

Table 2-2 shows how an effective address (EA) is calculated in each addressing mode.

Arithmetic and logic instructions (ADD.B, ADDX, SUBX, CMP.B, AND, OR, XOR instructions) use (1) register direct and (6) immediate addressing modes.

Data transfer instructions can use all addressing modes except (7) program-counter relative and (8) memory indirect.

Bit manipulation instructions can use (1) register direct, (2) register indirect, or (5) absolute (@aa:8) addressing mode to specify an operand, and (1) register direct (BSET, BCLR, BNOT, and BTST instructions) or (6) immediate (3-bit) addressing mode to specify a bit number in the operand.

**Table 2-2 Effective Address Calculation**

| No. | Addressing Mode and Instruction Format                 | Effective Address Calculation | Effective Address (EA) |
|-----|--------------------------------------------------------|-------------------------------|------------------------|
| (1) | Register direct, (Rn)                                  |                               |                        |
| (2) | Register indirect (@Rn)                                |                               |                        |
| (3) | Register indirect with displacement (@d:16, Rn)        |                               |                        |
| (4) | Register indirect with post-increment or pre-decrement |                               |                        |
| (5) | Register indirect with post-increment, @Rn+            |                               |                        |
| (6) | Register indirect with pre-decrement, @-Rn             |                               |                        |

Incremented or decremented by 1 if operand is byte size, and by 2 if word size

Table 2-2 Effective Address Calculation (cont)

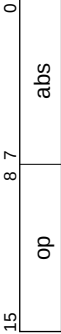
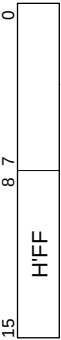
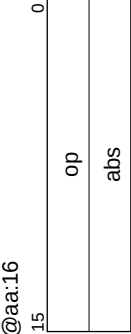
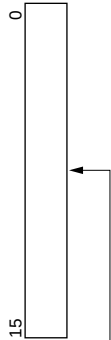
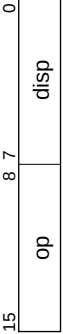
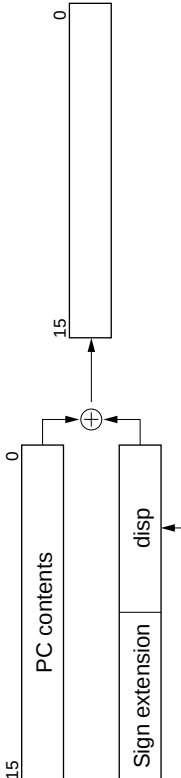
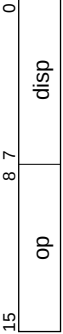
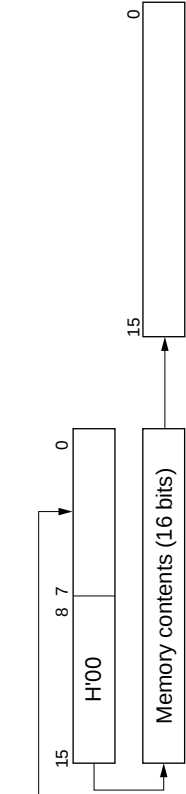
| No.                                    | Addressing Mode and Instruction Format | Effective Address Calculation                                                       | Effective Address (EA)                                                            |
|----------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| (5)                                    | Absolute address<br>@aa:8              |   |   |
|                                        |                                        |   |   |
| (6)                                    | Immediate<br>#xx:8                     |   |                                                                                   |
|                                        |                                        |   |                                                                                   |
| Operand is 1- or 2-byte immediate data |                                        |                                                                                     |                                                                                   |
| (7)                                    | Program-counter relative<br>@(d:8, PC) |  |  |
|                                        |                                        |  |                                                                                   |

Table 2-2 Effective Address Calculation (cont)

| No. | Addressing Mode and Instruction Format |     | Effective Address Calculation                                                    |    | Effective Address (EA) |
|-----|----------------------------------------|-----|----------------------------------------------------------------------------------|----|------------------------|
|     | 15                                     | 8 7 | 0                                                                                | 15 |                        |
| (8) | Memory indirect, @@aa:8                |     |  |    |                        |

**Legend**

- reg, regm, regn: Register field
- op: Operation field
- disp: Displacement
- IMM: Immediate data
- abs: Absolute address

## 2.5 Instruction Set

Table 2-1 lists the H8/300 CPU instruction set.

**Table 2-1 Instruction Classification**

| Function              | Instructions                                                                              | Types    |
|-----------------------|-------------------------------------------------------------------------------------------|----------|
| Data transfer         | MOV, MOVTPE* <sup>1</sup> , MOVFPE* <sup>1</sup> , PUSH* <sup>2</sup> , POP* <sup>2</sup> | 3        |
| Arithmetic operations | ADD, SUB, ADDX, SUBX, INC, DEC, ADDS, SUBS, DAA, DAS, MULXU, DIVXU, CMP, NEG              | 14       |
| Logic operations      | AND, OR, XOR, NOT                                                                         | 4        |
| Shift                 | SHAL, SHAR, SHLL, SHLR, ROTL, ROTR, ROTXL, ROTXR                                          | 8        |
| Bit manipulation      | BSET, BCLR, BNOT, BTST, BAND, BAND, BOR, BIOR, BXOR, BIXOR, BLD, BILD, BST, BIST          | 14       |
| Branch                | Bcc* <sup>3</sup> , JMP, BSR, JSR, RTS                                                    | 5        |
| System control        | RTE, SLEEP, LDC, STC, ANDC, ORC, XORC, NOP                                                | 8        |
| Block data transfer   | EEPMOV                                                                                    | 1        |
|                       |                                                                                           | Total 57 |

- Notes:
1. These instructions cannot be used with the H8/3217 Series.
  2. PUSH Rn is equivalent to MOV.W Rn, @-SP.  
POP Rn is equivalent to MOV.W @SP+, Rn.
  3. Bcc is a conditional branch instruction in which cc represents a condition code.

The following sections give a concise summary of the instructions in each category, and indicate the bit patterns of their object code. The notation used is defined next.

## Operation Notation

|                                 |                                                        |
|---------------------------------|--------------------------------------------------------|
| Rd                              | General register (destination)                         |
| Rs                              | General register (source)                              |
| Rn, Rm                          | General register                                       |
| r <sub>n</sub> , r <sub>m</sub> | General register field                                 |
| <EAs>                           | Effective address: general register or memory location |
| (EAd)                           | Destination operand                                    |
| (EAs)                           | Source operand                                         |
| SP                              | Stack pointer                                          |
| PC                              | Program counter                                        |
| CCR                             | Condition code register                                |
| N                               | N (negative) bit of CCR                                |
| Z                               | Z (zero) bit of CCR                                    |
| V                               | V (overflow) bit of CCR                                |
| C                               | C (carry) bit of CCR                                   |
| #imm                            | Immediate data                                         |
| #xx:3                           | 3-bit immediate data                                   |
| #xx:8                           | 8-bit immediate data                                   |
| #xx:16                          | 16-bit immediate data                                  |

|      |                          |
|------|--------------------------|
| op   | Operation field          |
| disp | Displacement             |
| abs  | Absolute address         |
| B    | Byte                     |
| W    | Word                     |
| +    | Addition                 |
| −    | Subtraction              |
| ×    | Multiplication           |
| ÷    | Division                 |
| ^    | Logical AND              |
| ∨    | Logical OR               |
| ⊕    | Exclusive logical OR     |
| →    | Move                     |
| ↔    | Exchange                 |
| ¬    | NOT (logical complement) |
| cc   | Condition field          |

## 2.5.1 Data Transfer Instructions

Table 2-2 describes the data transfer instructions. Figure 2-5 shows their object code formats.

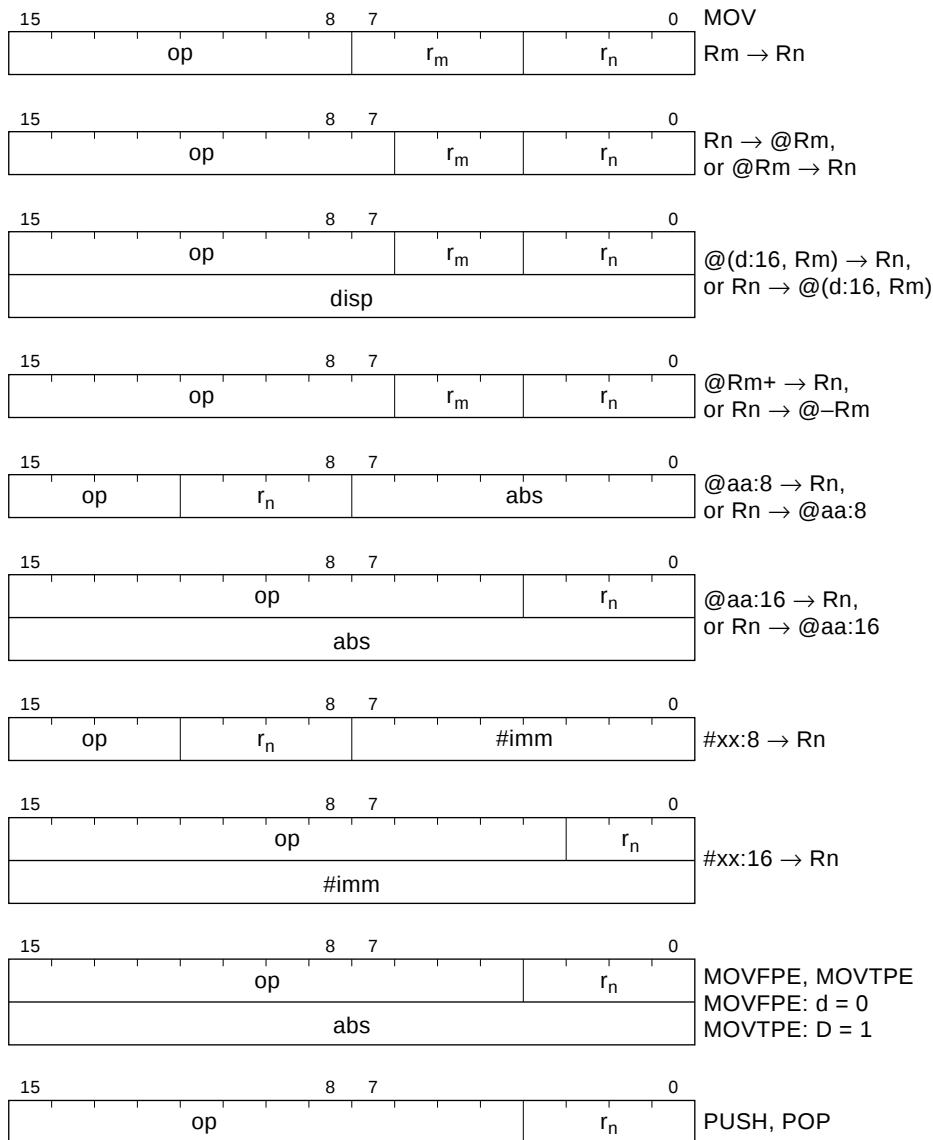
**Table 2-2 Data Transfer Instructions**

| Instruction | Size* | Function                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MOV         | B/W   | (EAs) → Rd, Rs → (EAd)<br>Moves data between two general registers or between a general register and memory, or moves immediate data to a general register. The Rn, @Rn, @(d:16, Rn), @aa:16, #xx:8 or #xx:16, @-Rn, and @Rn+ addressing modes are available for byte or word data. The @aa:8 addressing mode is available for byte data only. The @-R7 and @R7+ modes require word operands. Do not specify byte size for these two modes. |
| MOVTPE      | B     | Cannot be used with the H8/3217 Series.                                                                                                                                                                                                                                                                                                                                                                                                     |
| MOVFPPE     | B     | Cannot be used with the H8/3217 Series.                                                                                                                                                                                                                                                                                                                                                                                                     |
| PUSH        | W     | Rn → @-SP<br>Pushes a 16-bit general register onto the stack. Equivalent to MOV.W Rn, @-SP.                                                                                                                                                                                                                                                                                                                                                 |
| POP         | W     | @SP+ → Rn<br>Pops a 16-bit general register from the stack. Equivalent to MOV.W @SP+, Rn.                                                                                                                                                                                                                                                                                                                                                   |

Note: \* Size: operand size

B: Byte

W: Word



### Legend

op: Operation field  
di: Direction field (0-load from; 1-store to)  
 $r_m, r_n$ : Register field  
disp: Displacement  
abs: Absolute address  
#imm: Immediate data

Figure 2-5 Data Transfer Instruction Codes

## 2.5.2 Arithmetic Operations

Table 2-3 describes the arithmetic instructions. See figure 2-6 in section 2.5.4, Shift Operations for their object codes.

**Table 2-3 Arithmetic Instructions**

| Instruction  | Size* | Function                                                                                                                                                                                                                                                                                                                                              |
|--------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ADD<br>SUB   | B/W   | $Rd \pm Rs \rightarrow Rd$ , $Rd + \#imm \rightarrow Rd$<br>Performs addition or subtraction on data in two general registers, or addition on immediate data and data in a general register. Immediate data cannot be subtracted from data in a general register. Word data can be added or subtracted only when both words are in general registers. |
| ADDX<br>SUBX | B     | $Rd \pm Rs \pm C \rightarrow Rd$ , $Rd \pm \#imm \pm C \rightarrow Rd$<br>Performs addition or subtraction with carry or borrow on byte data in two general registers, or addition or subtraction on immediate data and data in a general register.                                                                                                   |
| INC<br>DEC   | B     | $Rd \pm \#1 \rightarrow Rd$<br>Increments or decrements a general register.                                                                                                                                                                                                                                                                           |
| ADDs<br>SUBs | W     | $Rd \pm \#imm \rightarrow Rd$<br>Adds or subtracts immediate data to or from data in a general register. The immediate data must be 1 or 2.                                                                                                                                                                                                           |
| DAA<br>DAS   | B     | $Rd$ decimal adjust $\rightarrow Rd$<br>Decimal-adjusts (adjusts to packed BCD) an addition or subtraction result in a general register by referring to the CCR.                                                                                                                                                                                      |
| MULXU        | B     | $Rd \times Rs \rightarrow Rd$<br>Performs 8-bit $\times$ 8-bit unsigned multiplication on data in two general registers, providing a 16-bit result.                                                                                                                                                                                                   |
| DIVXU        | B     | $Rd \div Rs \rightarrow Rd$<br>Performs 16-bit $\div$ 8-bit unsigned division on data in two general registers, providing an 8-bit quotient and 8-bit remainder.                                                                                                                                                                                      |
| CMP          | B/W   | $Rd - Rs$ , $Rd - \#imm$<br>Compares data in a general register with data in another general register or with immediate data. Word data can be compared only between two general registers.                                                                                                                                                           |
| NEG          | B     | $0 - Rd \rightarrow Rd$<br>Obtains the two's complement (arithmetic complement) of data in a general register.                                                                                                                                                                                                                                        |

Note: \* Size: operand size

B: Byte

W: Word

### 2.5.3 Logic Operations

Table 2-4 describes the four instructions that perform logic operations. See figure 2-6 in section 2.5.4, Shift Operations for their object codes.

**Table 2-4 Logic Operation Instructions**

| Instruction | Size* | Function                                                                                                                                                                            |
|-------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AND         | B     | $Rd \wedge Rs \rightarrow Rd$ , $Rd \wedge \#imm \rightarrow Rd$<br>Performs a logical AND operation on a general register and another general register or immediate data.          |
| OR          | B     | $Rd \vee Rs \rightarrow Rd$ , $Rd \vee \#imm \rightarrow Rd$<br>Performs a logical OR operation on a general register and another general register or immediate data.               |
| XOR         | B     | $Rd \oplus Rs \rightarrow Rd$ , $Rd \oplus \#imm \rightarrow Rd$<br>Performs a logical exclusive OR operation on a general register and another general register or immediate data. |
| NOT         | B     | $\neg (Rd) \rightarrow (Rd)$<br>Obtains the one's complement (logical complement) of general register contents.                                                                     |

Note: \* Size: operand size  
B: Byte

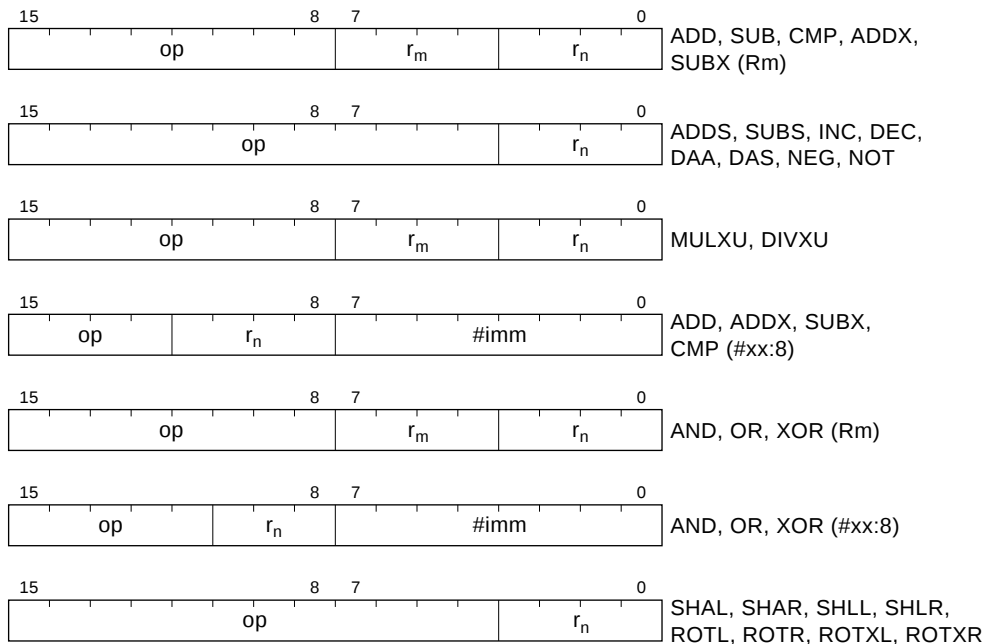
### 2.5.4 Shift Operations

Table 2-5 describes the eight shift instructions. Figure 2-6 shows the object code formats of the arithmetic, logic, and shift instructions.

**Table 2-5 Shift Instructions**

| Instruction    | Size* | Function                                                                                                         |
|----------------|-------|------------------------------------------------------------------------------------------------------------------|
| SHAL<br>SHAR   | B     | $Rd \text{ shift} \rightarrow Rd$<br>Performs an arithmetic shift operation on general register contents.        |
| SHLL<br>SHLR   | B     | $Rd \text{ shift} \rightarrow Rd$<br>Performs a logical shift operation on general register contents.            |
| ROTL<br>ROTR   | B     | $Rd \text{ rotate} \rightarrow Rd$<br>Rotates general register contents.                                         |
| ROTXL<br>ROTXR | B     | $Rd \text{ rotate through carry} \rightarrow Rd$<br>Rotates general register contents through the C (carry) bit. |

Note: \* Size: operand size  
B: Byte



#### Legend

op: Operation field

r<sub>m</sub>, r<sub>n</sub>: Register field

#imm: Immediate data

**Figure 2-6 Arithmetic, Logic, and Shift Instruction Codes**

## 2.5.5 Bit Manipulations

Table 2-6 describes the bit-manipulation instructions. Figure 2-7 shows their object code formats.

**Table 2-6 Bit-Manipulation Instructions**

| Instruction | Size* | Function                                                                                                                                                                                                                                                                                                                                      |
|-------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BSET        | B     | $1 \rightarrow \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle$<br>Sets a specified bit in a general register or memory to 1. The bit is specified by a bit number, given in 3-bit immediate data or the lower three bits of a general register.                                                                        |
| BCLR        | B     | $0 \rightarrow \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle$<br>Clears a specified bit in a general register or memory to 0. The bit is specified by a bit number, given in 3-bit immediate data or the lower three bits of a general register.                                                                      |
| BNOT        | B     | $\neg \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle \rightarrow \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle$<br>Inverts a specified bit in a general register or memory. The bit is specified by a bit number, given in 3-bit immediate data or the lower three bits of a general register. |
| BTST        | B     | $\neg \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle \rightarrow Z$<br>Tests a specified bit in a general register or memory and sets or clears the Z flag accordingly. The bit is specified by a bit number, given in 3-bit immediate data or the lower three bits of a general register.                             |
| BAND        | B     | $C \wedge \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle \rightarrow C$<br>ANDs the C flag with a specified bit in a general register or memory.                                                                                                                                                                       |
| BIAND       |       | $C \wedge [\neg \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle] \rightarrow C$<br>ANDs the C flag with the inverse of a specified bit in a general register or memory.<br>The bit number is specified by 3-bit immediate data.                                                                                         |
| BOR         | B     | $C \vee \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle \rightarrow C$<br>ORs the C flag with a specified bit in a general register or memory.                                                                                                                                                                          |
| BIOR        |       | $C \vee [\neg \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle] \rightarrow C$<br>ORs the C flag with the inverse of a specified bit in a general register or memory.<br>The bit number is specified by 3-bit immediate data.                                                                                            |
| BXOR        | B     | $C \oplus \langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle \rightarrow C$<br>XORs the C flag with a specified bit in a general register or memory.                                                                                                                                                                       |
| BIXOR       | B     | $C \oplus \neg [\langle \text{bit-No.} \rangle \text{ of } \langle \text{EAd} \rangle] \rightarrow C$<br>XORs the C flag with the inverse of a specified bit in a general register or memory.<br>The bit number is specified by 3-bit immediate data.                                                                                         |

**Table 2-6 Bit-Manipulation Instructions (cont)**

| Instruction | Size* | Function                                                                                                                                                                   |
|-------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BLD         | B     | (<bit-No.> of <EAd>) → C<br>Copies a specified bit in a general register or memory to the C flag.                                                                          |
| BILD        |       | ¬ (<bit-No.> of <EAd>) → C<br>Copies the inverse of a specified bit in a general register or memory to the C flag.<br>The bit number is specified by 3-bit immediate data. |
| BST         | B     | C → (<bit-No.> of <EAd>)<br>Copies the C flag to a specified bit in a general register or memory.                                                                          |
| BIST        |       | ¬ C → (<bit-No.> of <EAd>)<br>Copies the inverse of the C flag to a specified bit in a general register or memory.<br>The bit number is specified by 3-bit immediate data. |

Note: \* Size: operand size

B: Byte

**Notes on Bit Manipulation Instructions:** BSET, BCLR, BNOT, BST, and BIST are read-modify-write instructions. They read a byte of data, modify one bit in the byte, then write the byte back. Care is required when these instructions are applied to registers with write-only bits and to the I/O port registers.

| Order  | Operation                                                  |
|--------|------------------------------------------------------------|
| Read   | Read one data byte at the specified address                |
| Modify | Modify one bit in the data byte                            |
| Write  | Write the modified data byte back to the specified address |

**Example:** BCLR is executed to clear bit 0 in the port 4 data direction register (P4DDR) under the following conditions.

P4<sub>7</sub>: Input pin, Low

P4<sub>6</sub>: Input pin, High

P4<sub>5</sub>–P4<sub>0</sub>: Output pins, Low

The intended purpose of this BCLR instruction is to switch P4<sub>0</sub> from output to input.

## Before Execution of BCLR Instruction

|              | P4 <sub>7</sub> | P4 <sub>6</sub> | P4 <sub>5</sub> | P4 <sub>4</sub> | P4 <sub>3</sub> | P4 <sub>2</sub> | P4 <sub>1</sub> | P4 <sub>0</sub> |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Input/output | Input           | Input           | Output          | Output          | Output          | Output          | Output          | Output          |
| Pin state    | Low             | High            | Low             | Low             | Low             | Low             | Low             | Low             |
| DDR          | 0               | 0               | 1               | 1               | 1               | 1               | 1               | 1               |
| DR           | 1               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |

## Execution of BCLR Instruction

BCLR.B #0, @P4DDR ; Clear bit 0 in data direction register

## After Execution of BCLR Instruction

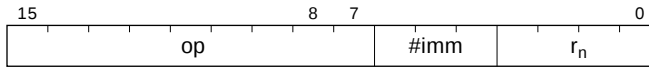
|              | P4 <sub>7</sub> | P4 <sub>6</sub> | P4 <sub>5</sub> | P4 <sub>4</sub> | P4 <sub>3</sub> | P4 <sub>2</sub> | P4 <sub>1</sub> | P4 <sub>0</sub> |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Input/output | Output          | Output          | Output          | Output          | Output          | Output          | Output          | Input           |
| Pin state    | Low             | High            | Low             | Low             | Low             | Low             | Low             | High            |
| DDR          | 1               | 1               | 1               | 1               | 1               | 1               | 1               | 0               |
| DR           | 1               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |

**Explanation:** To execute the BCLR instruction, the CPU begins by reading P4DDR. Since P4DDR is a write-only register, it is read as H'FF, even though its true value is H'3F.

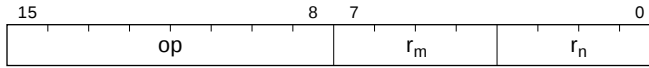
Next the CPU clears bit 0 of the read data, changing the value to H'FE.

Finally, the CPU writes this value (H'FE) back to P4DDR to complete the BCLR instruction.

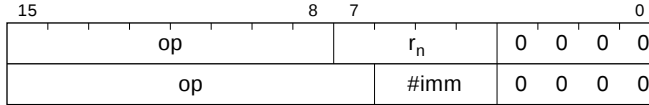
As a result, P4<sub>0</sub>DDR is cleared to 0, making P4<sub>0</sub> an input pin. In addition, P4<sub>7</sub>DDR and P4<sub>6</sub>DDR are set to 1, making P4<sub>7</sub> and P4<sub>6</sub> output pins.

**BSET, BCLR, BNOT, BTST**

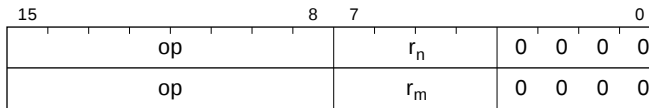
Operand: register direct (Rn)  
Bit No.: immediate (#xx:3)



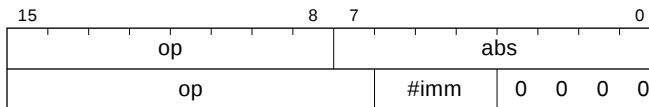
Operand: register direct (Rn)  
Bit No.: register direct (Rm)



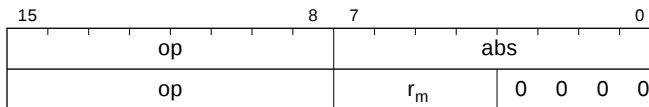
Operand: register indirect (@Rn)  
Bit No.: immediate (#xx:3)



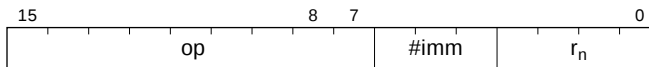
Operand: register indirect (@Rn)  
Bit No.: register direct (Rm)



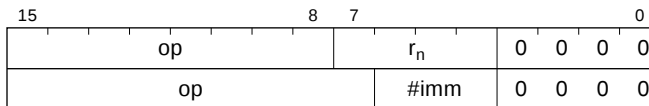
Operand: absolute (@aa:8)  
Bit No.: immediate (#xx:3)



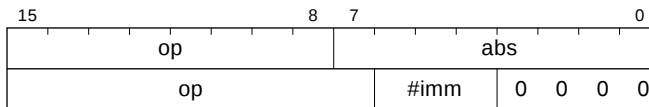
Operand: absolute (@aa:8)  
Bit No.: register direct (Rm)

**BAND, BOR, BXOR, BLD, BST**

Operand: register direct (Rn)  
Bit No.: immediate (#xx:3)



Operand: register indirect (@Rn)  
Bit No.: immediate (#xx:3)

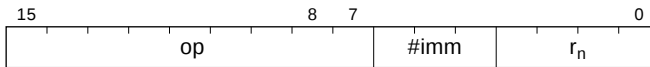


Operand: absolute (@aa:8)  
Bit No.: immediate (#xx:3)

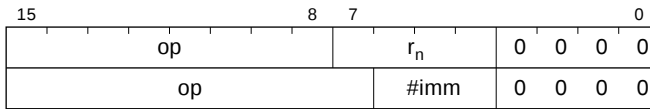
**Legend**

op: Operation field  
r<sub>m</sub>, r<sub>n</sub>: Register field  
abs: Absolute address  
#imm: Immediate data

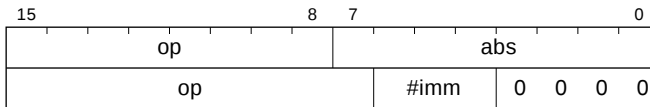
**Figure 2-7 Bit Manipulation Instruction Codes**

**BIAND, BIOR, BIXOR, BILD, BIST**

Operand: register direct (Rn)  
 Bit No.: immediate (#xx:3)



Operand: register indirect (@Rn)  
 Bit No.: immediate (#xx:3)



Operand: absolute (@aa:8)  
 Bit No.: immediate (#xx:3)

**Legend**

op: Operation field

r<sub>m</sub>, r<sub>n</sub>: Register field

abs: Absolute address

#imm: Immediate data

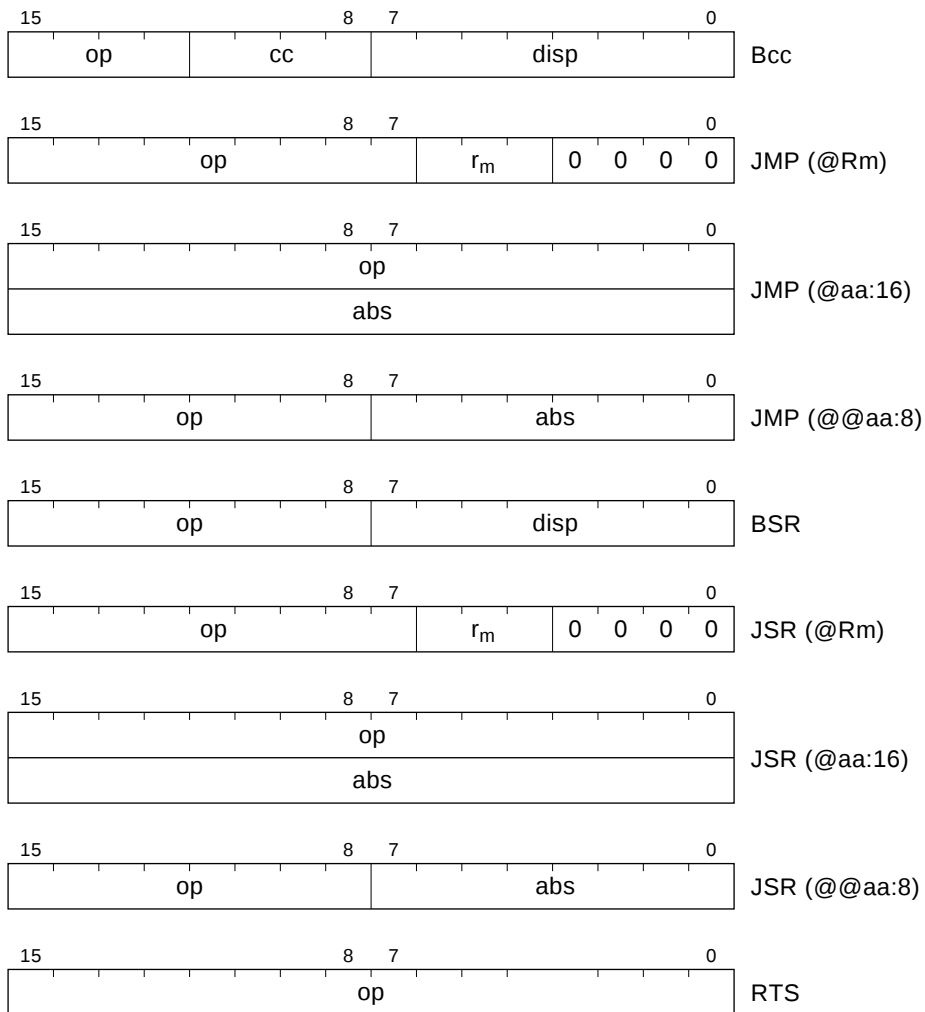
**Figure 2-7 Bit Manipulation Instruction Codes (cont)**

## 2.5.6 Branching Instructions

Table 2-7 describes the branching instructions. Figure 2-8 shows their object code formats.

**Table 2-7 Branching Instructions**

| Instruction | Size    | Function                                                                       |                           |                               |                           |
|-------------|---------|--------------------------------------------------------------------------------|---------------------------|-------------------------------|---------------------------|
| Bcc         | —       | Branches if condition cc is true.                                              |                           |                               |                           |
|             |         | <b>Mnemonic</b>                                                                | <b>cc Field</b>           | <b>Description</b>            | <b>Condition</b>          |
|             |         | BRA (BT)                                                                       | 0 0 0 0                   | Always (true)                 | Always                    |
|             |         | BRN (BF)                                                                       | 0 0 0 1                   | Never (false)                 | Never                     |
|             |         | BHI                                                                            | 0 0 1 0                   | High                          | $C \vee Z = 0$            |
|             |         | BLS                                                                            | 0 0 1 1                   | Low or same                   | $C \vee Z = 1$            |
|             |         | BCC (BHS)                                                                      | 0 1 0 0                   | Carry clear<br>(high or same) | $C = 0$                   |
|             |         | BCS (BLO)                                                                      | 0 1 0 1                   | Carry set (low)               | $C = 1$                   |
|             |         | BNE                                                                            | 0 1 1 0                   | Not equal                     | $Z = 0$                   |
|             |         | BEQ                                                                            | 0 1 1 1                   | Equal                         | $Z = 1$                   |
|             |         | BVC                                                                            | 1 0 0 0                   | Overflow clear                | $V = 0$                   |
|             |         | BVS                                                                            | 1 0 0 1                   | Overflow set                  | $V = 1$                   |
|             |         | BPL                                                                            | 1 0 1 0                   | Plus                          | $N = 0$                   |
|             |         | BMI                                                                            | 1 0 1 1                   | Minus                         | $N = 1$                   |
|             |         | BGE                                                                            | 1 1 0 0                   | Greater or equal              | $N \oplus V = 0$          |
|             |         | BLT                                                                            | 1 1 0 1                   | Less than                     | $N \oplus V = 1$          |
|             |         | BGT                                                                            | 1 1 1 0                   | Greater than                  | $Z \vee (N \oplus V) = 0$ |
| BLE         | 1 1 1 1 | Less or equal                                                                  | $Z \vee (N \oplus V) = 1$ |                               |                           |
| JMP         | —       | Branches unconditionally to a specified address.                               |                           |                               |                           |
| JSR         | —       | Branches to a subroutine at a specified address.                               |                           |                               |                           |
| BSR         | —       | Branches to a subroutine at a specified displacement from the current address. |                           |                               |                           |
| RTS         | —       | Returns from a subroutine                                                      |                           |                               |                           |



### Legend

op: Operation field  
 cc: Condition field  
 r<sub>m</sub>: Register field  
 disp: Displacement  
 abs: Absolute address

**Figure 2-8 Branching Instruction Codes**

### 2.5.7 System Control Instructions

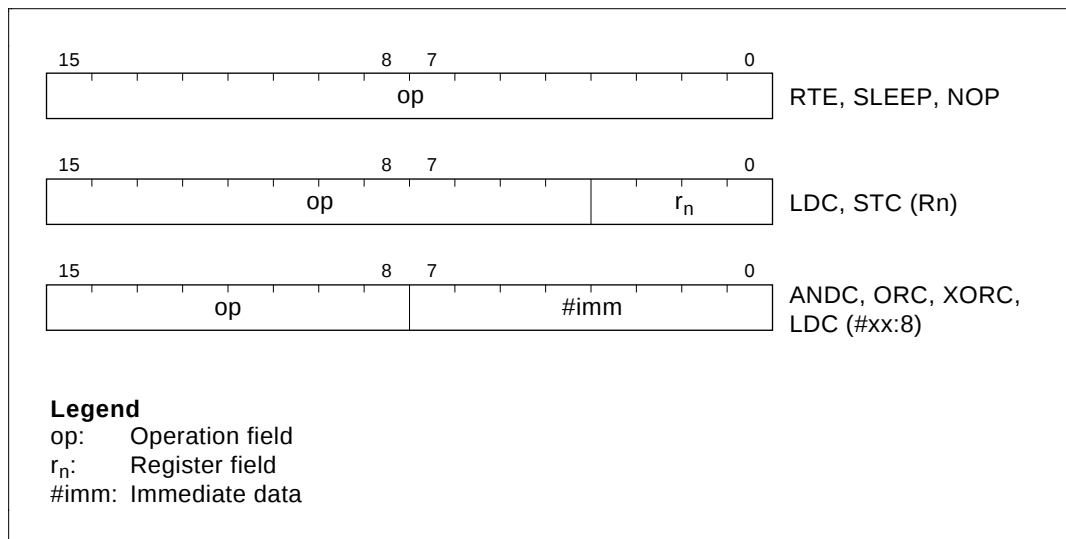
Table 2-8 describes the system control instructions. Figure 2-9 shows their object code formats.

**Table 2-8 System Control Instructions**

| Instruction | Size* | Function                                                                                                                            |
|-------------|-------|-------------------------------------------------------------------------------------------------------------------------------------|
| RTE         | —     | Returns from an exception-handling routine.                                                                                         |
| SLEEP       | —     | Causes a transition to the power-down state.                                                                                        |
| LDC         | B     | $Rs \rightarrow CCR$ , $\#imm \rightarrow CCR$<br>Moves immediate data or general register contents to the condition code register. |
| STC         | B     | $CCR \rightarrow Rd$<br>Copies the condition code register to a specified general register.                                         |
| ANDC        | B     | $CCR \wedge \#imm \rightarrow CCR$<br>Logically ANDs the condition code register with immediate data.                               |
| ORC         | B     | $CCR \vee \#imm \rightarrow CCR$<br>Logically ORs the condition code register with immediate data.                                  |
| XORC        | B     | $CCR \oplus \#imm \rightarrow CCR$<br>Logically exclusive-ORs the condition code register with immediate data.                      |
| NOP         | —     | $PC + 2 \rightarrow PC$<br>Only increments the program counter.                                                                     |

Note: \* Size: operand size

B: Byte



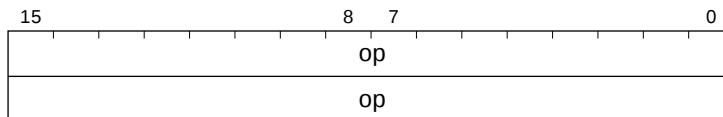
**Figure 2-9 System Control Instruction Codes**

### 2.5.8 Block Data Transfer Instruction

Table 2-9 describes the EEPMOV instruction. Figure 2-10 shows its object code format.

**Table 2-9 Block Data Transfer Instruction**

| Instruction | Size | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EEPMOV      | —    | <p>if R4L <math>\neq</math> 0 then</p> <p>repeat @R5+ <math>\rightarrow</math> @R6+<br/> R4L – 1 <math>\rightarrow</math> R4L</p> <p>until R4L = 0</p> <p>else next;</p> <p>Moves a data block according to parameters set in general registers R4L, R5, and R6.</p> <p>R4L: size of block (bytes)<br/> R5: starting source address<br/> R6: starting destination address</p> <p>Execution of the next instruction starts as soon as the block transfer is completed.</p> |



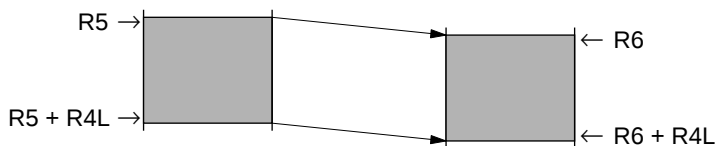
### Legend

op: Operation field

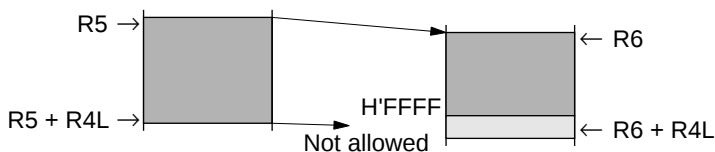
**Figure 2-10 Block Data Transfer Instruction**

### Notes on EEPMOV Instruction

- The EEPMOV instruction is a block data transfer instruction. It moves the number of bytes specified by R4L from the address specified by R5 to the address specified by R6.

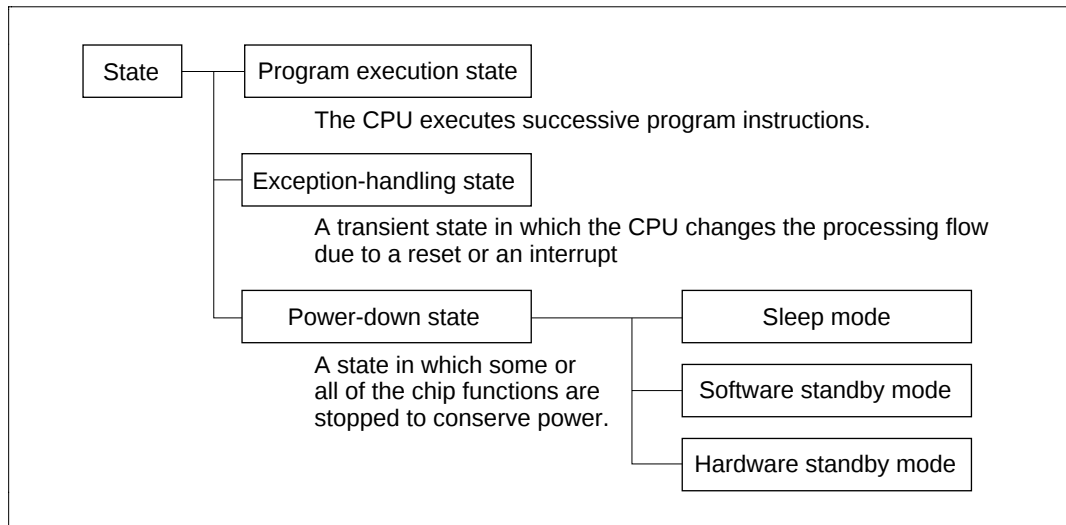


- When setting R4L and R6, make sure that the final destination address (R6 + R4L) does not exceed H'FFFF. The value in R6 must not change from H'FFFF to H'0000 during execution of the instruction.

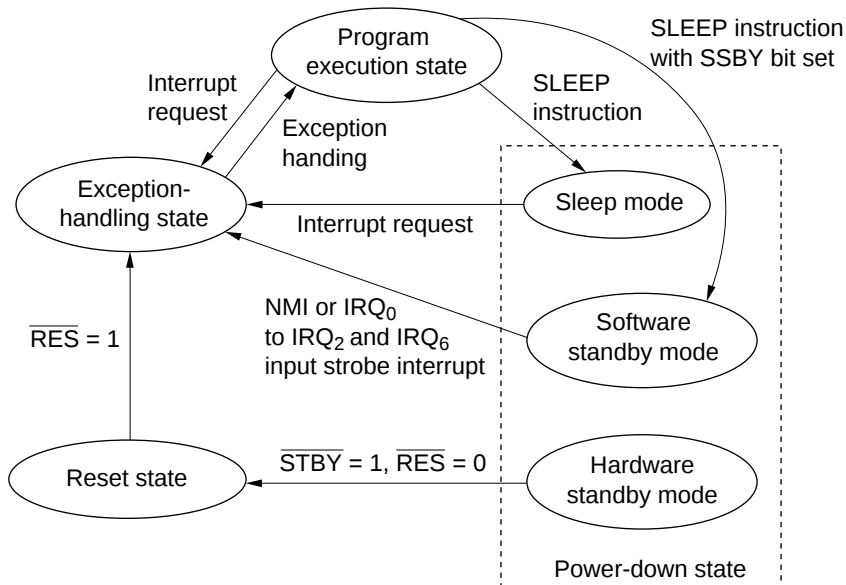


## 2.6 CPU States

The CPU has three states: the program execution state, exception-handling state, and power-down state. The power-down state is further divided into three modes: the sleep mode, software standby mode, and hardware standby mode. Figure 2-11 summarizes these states, and figure 2-12 shows a map of the state transitions.



**Figure 2-11 Operating States**



- Notes: 1. A transition to the reset state occurs when  $\overline{RES}$  goes low, except when the chip is in the hardware standby mode.
2. A transition from any state to the hardware standby mode occurs when  $\overline{STBY}$  goes low.

**Figure 2-12 State Transitions**

### 2.6.1 Program Execution State

In this state the CPU executes program instructions in sequence. The main program, subroutines, and interrupt-handling routines are all executed in this state.

### 2.6.2 Exception-Handling State

The exception-handling state is a transient state that occurs when the CPU is reset or accepts an interrupt. In this state the CPU carries out a hardware-controlled sequence that prepares it to execute a user-coded exception-handling routine.

In the hardware exception-handling sequence the CPU does the following:

1. Saves the program counter and condition code register to the stack (except in the case of a reset).
2. Sets the interrupt mask (I) bit in the condition code register to 1.
3. Fetches the start address of the exception-handling routine from the vector table.

4. Branches to that address, returning to the program execution state.

See section 4, Exception Handling, for further information on the exception-handling state.

### 2.6.3 Power-Down State

The power-down state includes three modes: the sleep mode, the software standby mode, and the hardware standby mode.

**(1) Sleep Mode:** The sleep mode is entered when a SLEEP instruction is executed. The CPU halts, but CPU register contents remain unchanged and the on-chip supporting modules continue to function.

When an interrupt or reset signal is received, the CPU returns through the exception-handling state to the program execution state.

**(2) Software Standby Mode:** The software standby mode is entered if the SLEEP instruction is executed while the SSBY (Software Standby) bit in the system control register (SYSCR) is set. The CPU and all on-chip supporting modules halt. The on-chip supporting modules are initialized, but the contents of the on-chip RAM and CPU registers remain unchanged. I/O port outputs also remain unchanged.

**(3) Hardware Standby Mode:** The hardware standby mode is entered when the input at the  $\overline{\text{STBY}}$  pin goes low. All chip functions halt, including I/O port output. The on-chip supporting modules are initialized, but on-chip RAM contents are held.

See section 18, Power-Down State, for further information.

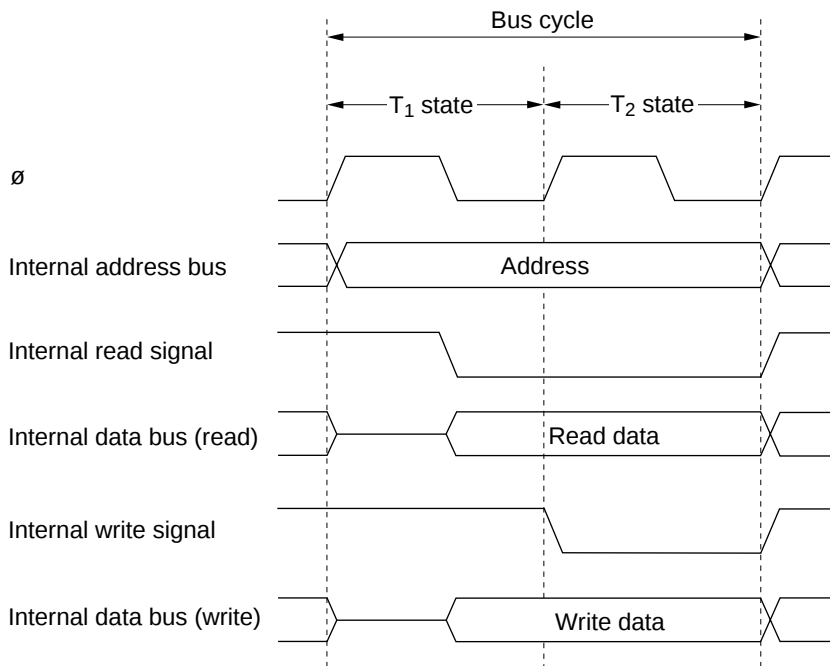
## 2.7 Access Timing and Bus Cycle

The CPU is driven by the system clock ( $\phi$ ). The period from one rising edge of the system clock to the next is referred to as a “state.”

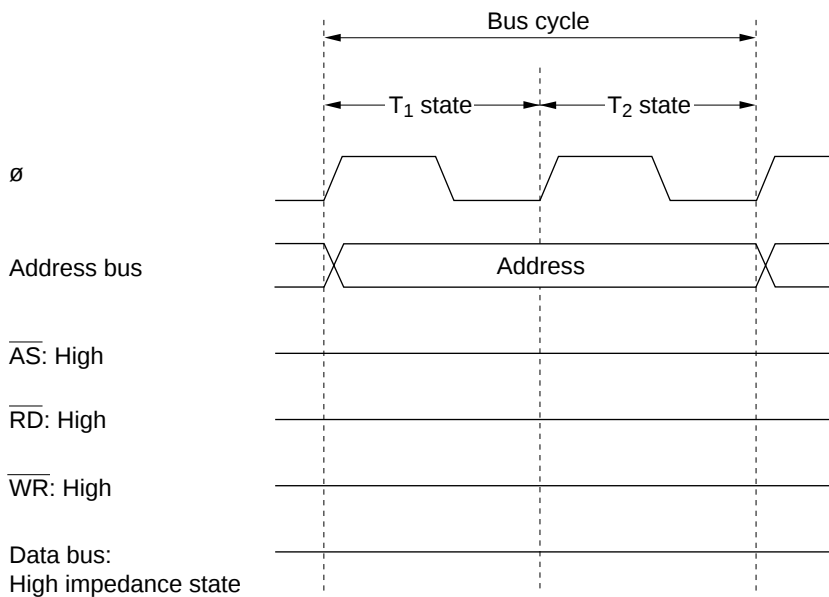
Memory access is performed in a two- or three-state bus cycle as described below. Different accesses are performed to on-chip memory, the on-chip register field, and external devices. For more detailed timing diagrams of the bus cycles, see section 19, Electrical Specifications.

### 2.7.1 Access to On-Chip Memory (RAM and ROM)

On-chip ROM and RAM are accessed in a cycle of two states designated  $T_1$  and  $T_2$ . Either byte or word data can be accessed, via a 16-bit data bus. Figure 2-13 shows the on-chip memory access cycle. Figure 2-14 shows the associated pin states.



**Figure 2-13 On-Chip Memory Access Cycle**

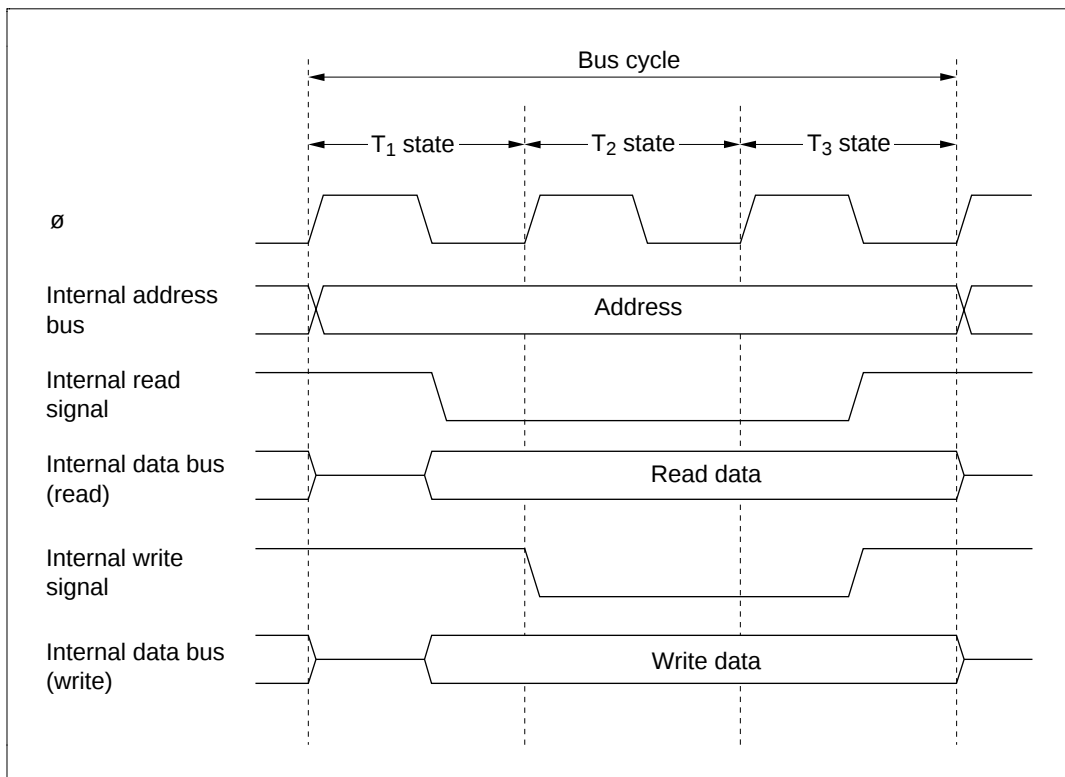


**Figure 2-14 Pin States during On-Chip Memory Access Cycle**

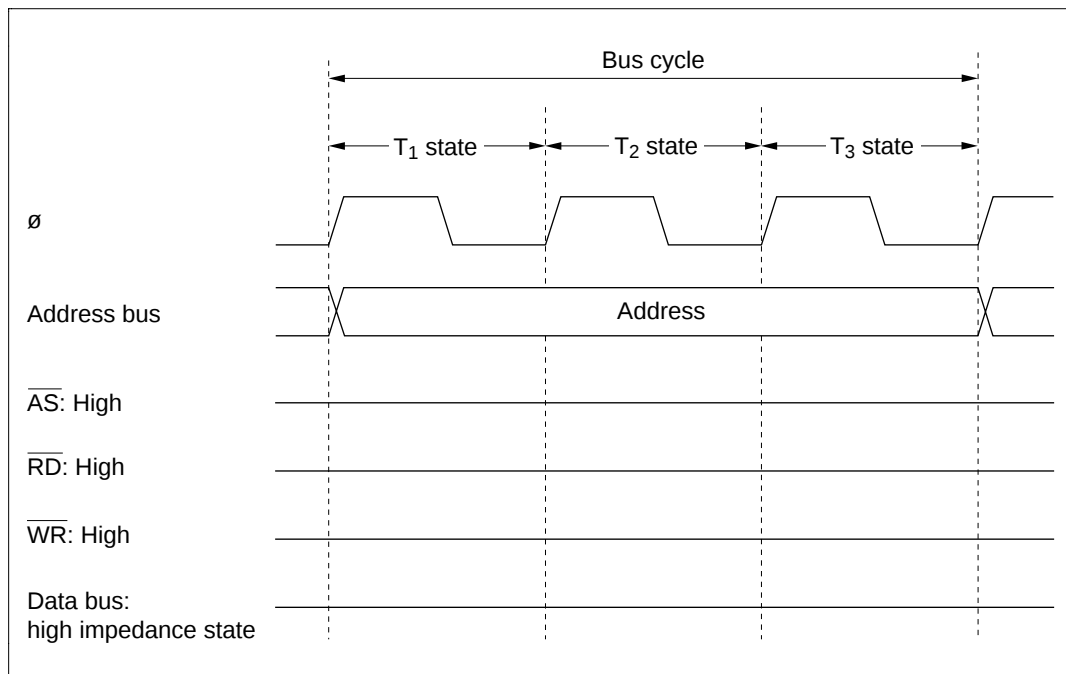
## 2.7.2 Access to On-Chip Register Field and External Devices

The on-chip register field (I/O ports, dual-port RAM, on-chip supporting module registers, etc.) and external devices are accessed in a cycle consisting of three states:  $T_1$ ,  $T_2$ , and  $T_3$ . Only one byte of data can be accessed per cycle, via an 8-bit data bus. Access to word data or instruction codes requires two consecutive cycles (six states).

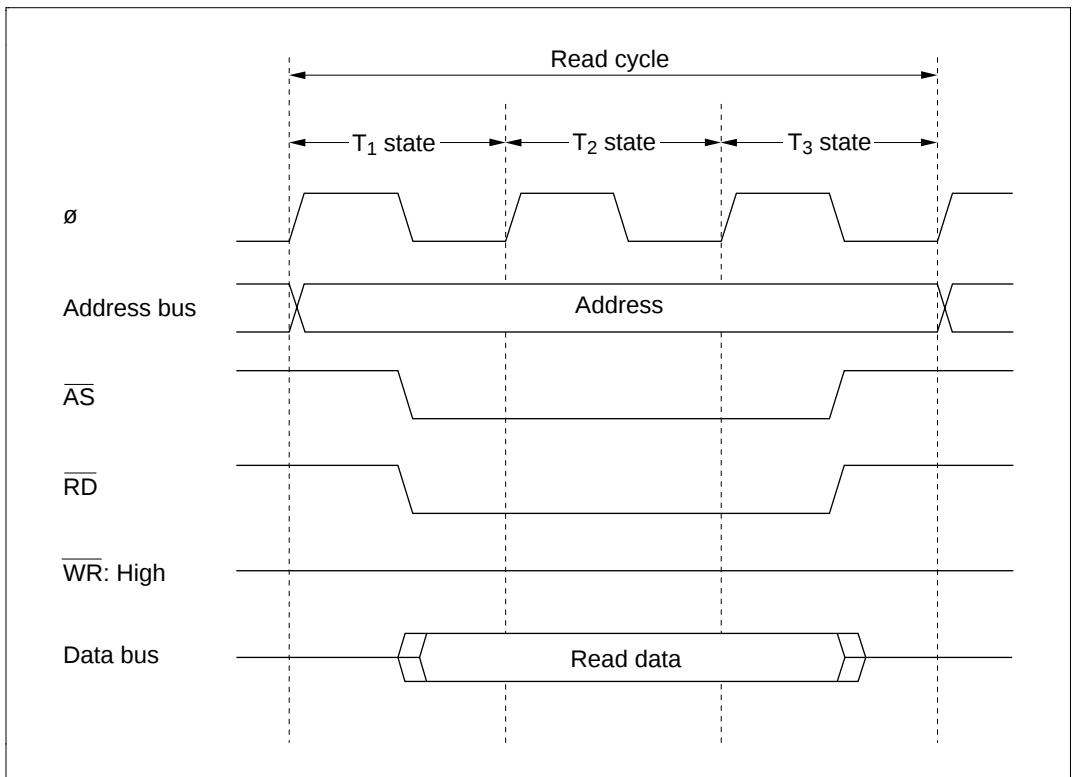
Figure 2-15 shows the access cycle for the on-chip register field. Figure 2-16 shows the associated pin states. Figures 2-17 (a) and (b) show the read and write access timing for external devices.



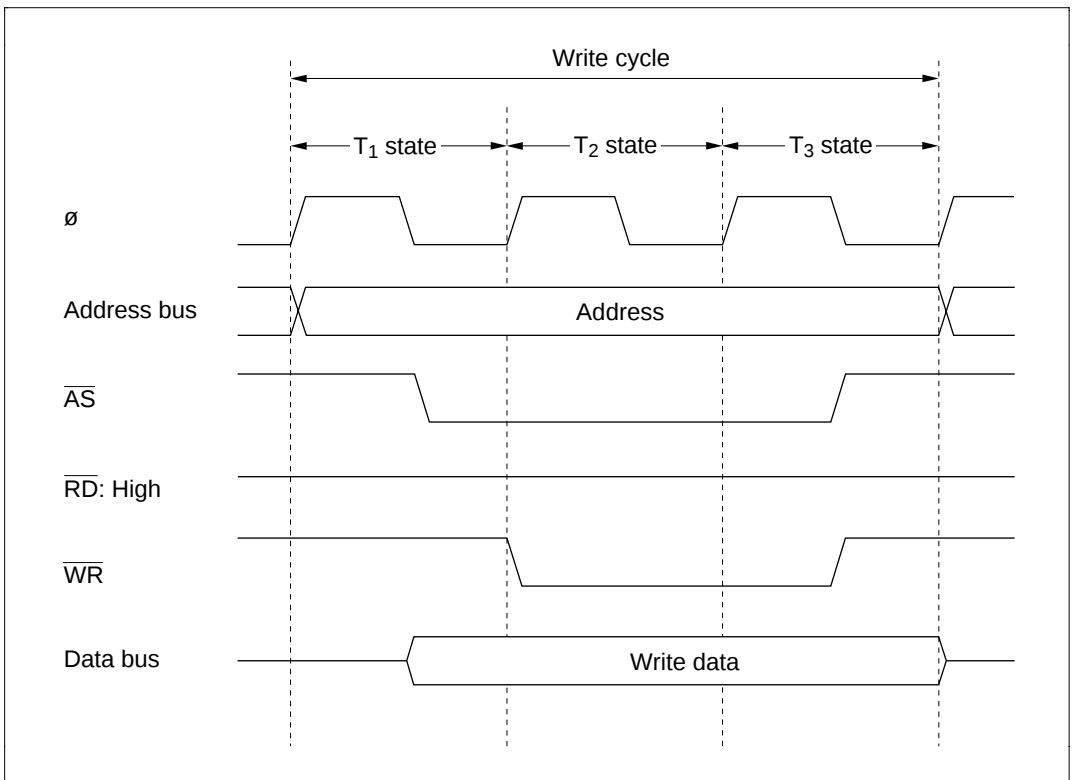
**Figure 2-15 On-Chip Register Field Access Cycle**



**Figure 2-16 Pin States during On-Chip Supporting Module Access**



**Figure 2-17 (a) External Device Access Timing (Read)**



**Figure 2-17 (b) External Device Access Timing (Write)**

## Section 3 MCU Operating Modes and Address Space

### 3.1 Overview

#### 3.1.1 Operating Modes

The H8/3217 Series operates in three modes numbered 1, 2, and 3. An additional non-operating mode (mode 0) is used for PROM version programming. The mode is selected by the inputs at the mode pins (MD<sub>1</sub> and MD<sub>0</sub>) at the instant when the chip comes out of a reset. As indicated in table 3-1, the mode determines the size of the address space and the usage of on-chip ROM and on-chip RAM.

**Table 3-1 Operating Modes**

| MD <sub>1</sub> | MD <sub>0</sub> | Mode   | Address Space | On-Chip ROM | On-Chip RAM |
|-----------------|-----------------|--------|---------------|-------------|-------------|
| Low             | Low             | Mode 0 | —             | —           | —           |
| Low             | High            | Mode 1 | Expanded      | Disabled    | Enabled*    |
| High            | Low             | Mode 2 | Expanded      | Enabled     | Enabled*    |
| High            | High            | Mode 3 | Single-chip   | Enabled     | Enabled     |

Note: \* If the RAME bit in the system control register (SYSCR) is cleared to 0, off-chip memory can be accessed instead.

Modes 1 and 2 are expanded modes that permit access to off-chip memory and peripheral devices. The maximum address space supported by these externally expanded modes is 64 kbytes.

In mode 3 (single-chip mode), only on-chip ROM and RAM and the on-chip register field are used. All ports are available for general-purpose input and output.

Mode 0 is inoperative in the H8/3217 Series. Avoid setting the mode pins to mode 0.

#### 3.1.2 Mode and System Control Registers

Table 3-2 lists the registers related to the chip's operating mode: the system control register (SYSCR) and mode control register (MDCR). The mode control register indicates the inputs to the mode pins MD<sub>1</sub> and MD<sub>0</sub>.

**Table 3-2 Mode and System Control Registers**

| Name                    | Abbreviation | Read/Write | Address |
|-------------------------|--------------|------------|---------|
| System control register | SYSCR        | R/W        | H'FFC4  |
| Mode control register   | MDCR         | R          | H'FFC5  |

## 3.2 System Control Register (SYSCR)

| Bit           | 7    | 6    | 5    | 4    | 3    | 2     | 1   | 0    |
|---------------|------|------|------|------|------|-------|-----|------|
|               | SSBY | STS2 | STS1 | STS0 | XRST | NMIEG | HIE | RAME |
| Initial value | 0    | 0    | 0    | 0    | 1    | 0     | 0   | 1    |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R    | R/W   | R/W | R/W  |

The system control register (SYSCR) is an 8-bit register that controls the operation of the chip.

**Bit 7—Software Standby (SSBY):** Enables transition to the software standby mode. For details, see section 18, Power-Down State.

On recovery from software standby mode by an external interrupt, the SSBY bit remains set to 1. It can be cleared by writing 0.

| Bit 7<br>SSBY | Description                                                              |
|---------------|--------------------------------------------------------------------------|
| 0             | The SLEEP instruction causes a transition to sleep mode. (Initial value) |
| 1             | The SLEEP instruction causes a transition to software standby mode.      |

**Bits 6 to 4—Standby Timer Select 2 to 0 (STS2 to STS0):** These bits select the clock settling time when the chip recovers from the software standby mode by an external interrupt. During the selected time the CPU and on-chip supporting modules continue to stand by. These bits should be set according to the clock frequency so that the settling time is at least 8 ms. For specific settings, see section 18.3.3, Clock Settling Time for Exit from Software Standby Mode.

| Bit 6<br>STS2 | Bit 5<br>STS1 | Bit 4<br>STS0 | Description                                  |
|---------------|---------------|---------------|----------------------------------------------|
| 0             | 0             | 0             | Settling time = 8,192 states (Initial value) |
| 0             | 0             | 1             | Settling time = 16,384 states                |
| 0             | 1             | 0             | Settling time = 32,768 states                |
| 0             | 1             | 1             | Settling time = 65,536 states                |
| 1             | 0             | —             | Settling time = 131,072 states               |
| 1             | 1             | —             | Unused                                       |

**Bit 3—External Reset (XRST):** Indicates the source of a reset. A reset can be generated by input of an external reset signal, or by a watchdog timer overflow when the watchdog timer is used. XRST is a read-only bit. It is set to 1 by an external reset, and cleared to 0 by watchdog timer overflow.

**Bit 3**

| XRST | Description                                         |
|------|-----------------------------------------------------|
| 0    | Reset was caused by watchdog timer overflow.        |
| 1    | Reset was caused by external input. (Initial value) |

**Bit 2—NMI Edge (NMIEG):** Selects the valid edge of the  $\overline{\text{NMI}}$  input.

**Bit 2**

| NMIEG | Description                                                                                         |
|-------|-----------------------------------------------------------------------------------------------------|
| 0     | An interrupt is requested on the falling edge of the $\overline{\text{NMI}}$ input. (Initial value) |
| 1     | An interrupt is requested on the rising edge of the $\overline{\text{NMI}}$ input.                  |

**Bit 1—Host Interface Enable (HIE):** Enables or disables the host interface function. When enabled, the host interface processes host-slave data transfers, operating in slave mode.

**Bit 1**

| HIE | Description                                     |
|-----|-------------------------------------------------|
| 0   | The host interface is disabled. (Initial value) |
| 1   | The host interface is enabled (slave mode).     |

**Bit 0—RAM Enable (RAME):** Enables or disables the on-chip RAM. The RAME bit is initialized by a reset, but is not initialized in the software standby mode.

**Bit 0**

| RAME | Description                                 |
|------|---------------------------------------------|
| 0    | The on-chip RAM is disabled.                |
| 1    | The on-chip RAM is enabled. (Initial value) |

### 3.3 Mode Control Register (MDCR)

| Bit           | 7 | 6 | 5 | 4 | 3 | 2 | 1    | 0    |
|---------------|---|---|---|---|---|---|------|------|
|               | — | — | — | — | — | — | MDS1 | MDS0 |
| Initial value | 1 | 1 | 1 | 0 | 0 | 1 | *    | *    |
| Read/Write    | — | — | — | — | — | — | R    | R    |

Note: \* Initialized according to MD<sub>1</sub> and MD<sub>0</sub> inputs.

The mode control register (MDCR) is an 8-bit register that indicates the operating mode of the chip.

**Bits 7 to 5—Reserved:** These bits cannot be modified and are always read as 1.

**Bits 4 and 3—Reserved:** These bits cannot be modified and are always read as 0.

**Bit 2—Reserved:** This bit cannot be modified and is always read as 1.

**Bits 1 and 0—Mode Select 1 and 0 (MDS1 and MDS0):** These bits indicate the values of the mode pins (MD<sub>1</sub> and MD<sub>0</sub>), thereby indicating the current operating mode of the chip. MDS1 corresponds to MD<sub>1</sub> and MDS0 to MD<sub>0</sub>. These bits can be read but not written. When the mode control register is read, the levels at the mode pins (MD<sub>1</sub> and MD<sub>0</sub>) are latched in these bits.

### 3.4 Mode Descriptions

**Mode 1 (Expanded Mode without On-Chip ROM):** Mode 1 supports a 64-kbyte address space most of which is off-chip. In particular, the interrupt vector table is located in off-chip memory. The on-chip ROM is not used. Software can select whether to use the on-chip RAM. Ports 1, 2, 3 and 7 are used for the address and data bus lines and control signals as follows:

Ports 1 and 2: Address bus  
Port 3: Data bus  
Port 7 (partly): Bus control signals

**Mode 2 (Expanded Mode with On-Chip ROM):** Mode 2 supports a 64-kbyte address space which includes the on-chip ROM. Software can select whether or not to use the on-chip RAM, and can select the usage of pins in ports 1 and 2.

Ports 1 and 2: Address bus (see note)  
Port 3: Data bus  
Port 7 (partly): Bus control signals

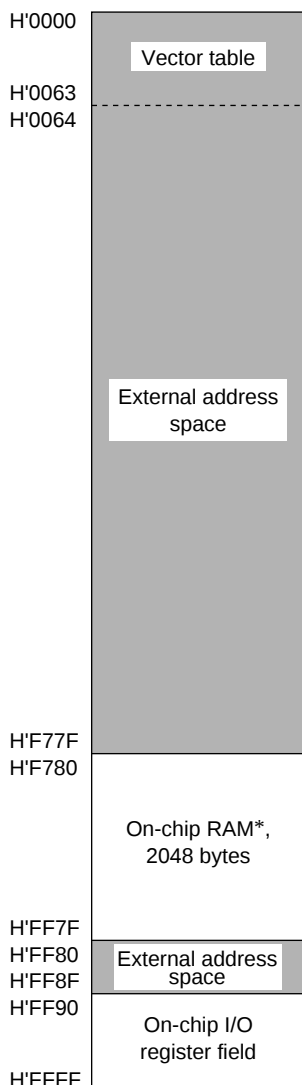
Note: In mode 2, ports 1 and 2 are initially general-purpose input ports. Software must change the desired pins to output before using them for the address bus. See section 7, I/O Ports for details.

**Mode 3 (Single-Chip Mode):** In this mode all memory is on-chip. Since no off-chip memory is accessed, there is no external address bus. All ports are available for general-purpose input and output.

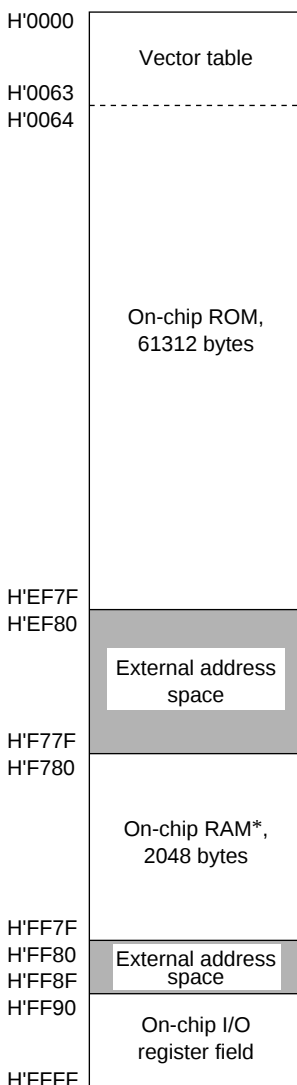
### 3.5 Address Space Maps for Each Operating Mode

Figures 3-1 to 3-4 show memory maps of the H8/3217, H8/3216, H8/3214, H8/3212, and H8/3202 in each of the three operating modes.

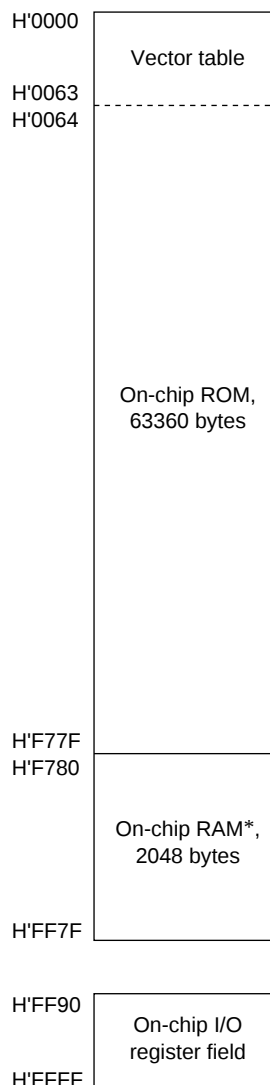
**Mode 1**  
**Expanded mode**  
**without on-chip ROM**



**Mode 2**  
**Expanded mode**  
**with on-chip ROM**

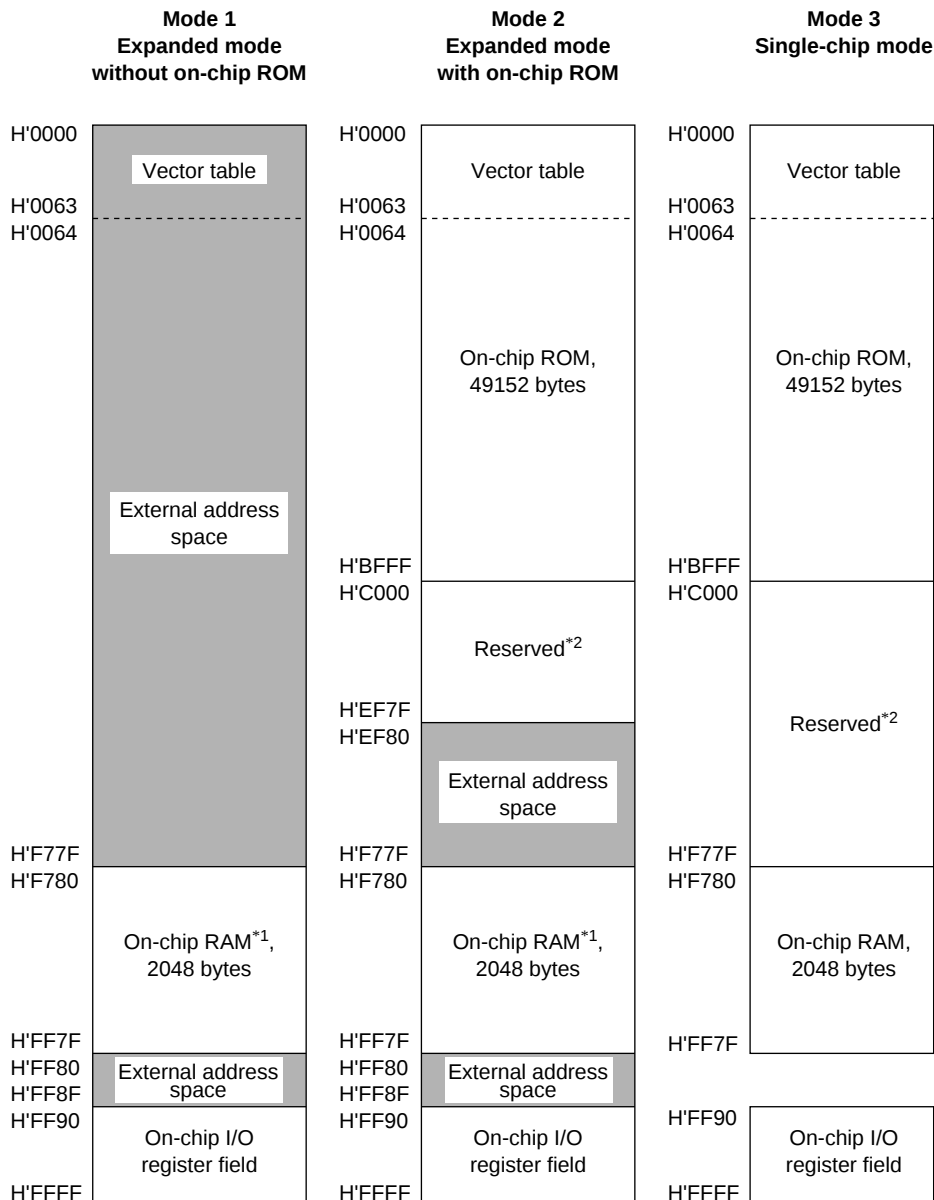


**Mode 3**  
**Single-chip mode**



Note: \* External memory can be accessed at these addresses when the RAME bit in the system control register (SYSCR) is cleared to 0.

**Figure 3-1 H8/3217 Address Space Map**

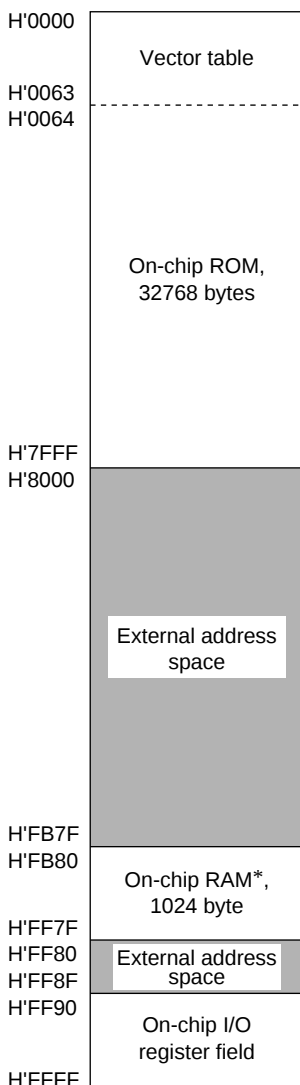


### Figure 3-2 H8/3216 Address Space Map

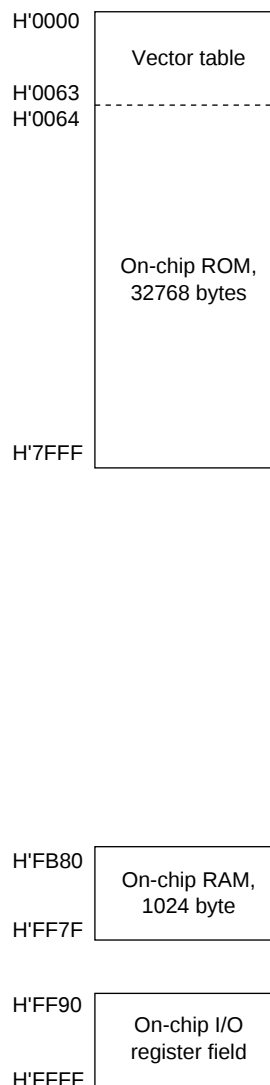
**Mode 1**  
**Expanded mode**  
**without on-chip ROM**



**Mode 2**  
**Expanded mode**  
**with on-chip ROM**



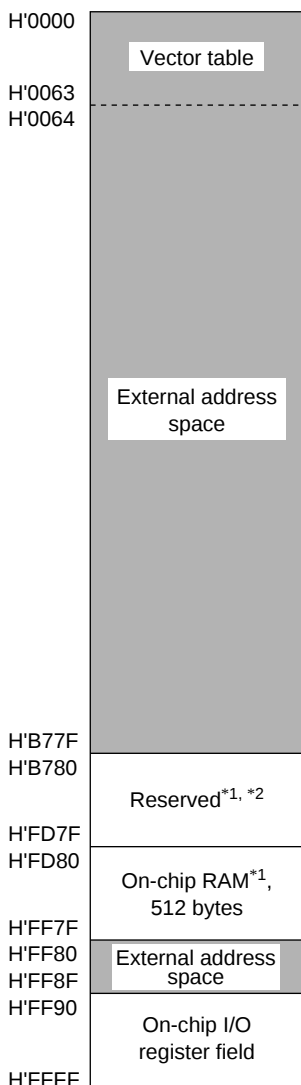
**Mode 3**  
**Single-chip mode**



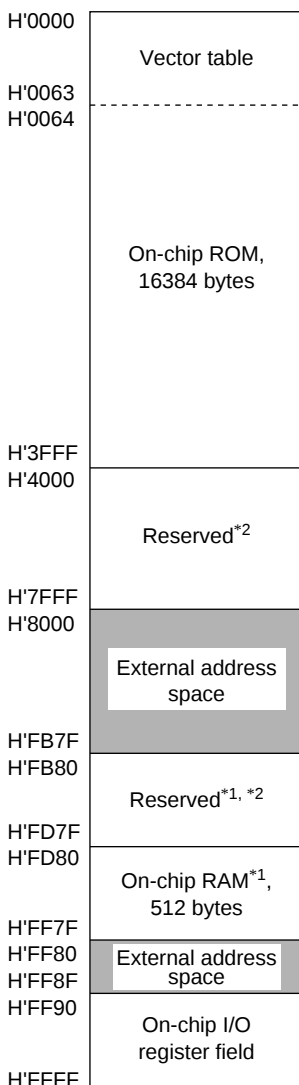
Note: \* External memory can be accessed at these addresses when the RAME bit in the system control register (SYSCR) is cleared to 0.

**Figure 3-3 H8/3214 Address Space Map**

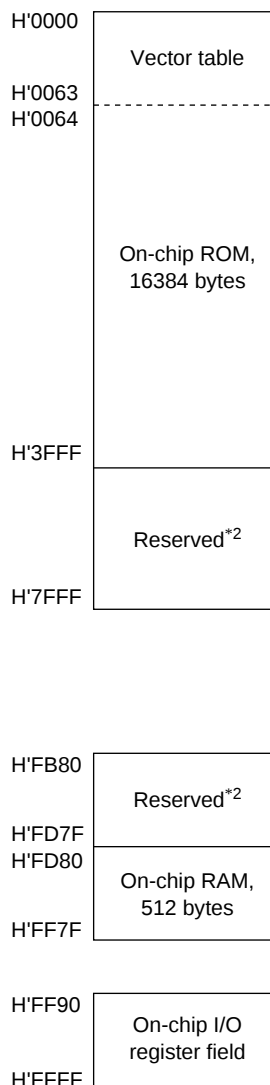
**Mode 1**  
**Expanded mode**  
**without on-chip ROM**



**Mode 2**  
**Expanded mode**  
**with on-chip ROM**



**Mode 3**  
**Single-chip mode**



Notes: \*1. External memory can be accessed at these addresses when the RAME bit in the system control register (SYSCR) is cleared to 0.

\*2. Data read or write is not permitted in these modes.

**Figure 3-4 H8/3212 and H8/3202 Address Space Map**



# Section 4 Exception Handling

[Key-sense interrupt function incorporated in all models except the H8/3212]

Note that the H8/3212 does not have an IRQ<sub>6</sub> interrupt function controlled by the  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$  input signals and the KMIMR register.

## 4.1 Overview

The H8/3217 Series recognizes only two kinds of exceptions: interrupts and the reset. Table 4-1 indicates their priority and the timing of their hardware exception-handling sequence.

**Table 4-1 Reset and Interrupt Exceptions**

| Priority                                                                                         | Type of Exception | Detection Timing                        | Timing of Exception-Handling Sequence                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------|-------------------|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High<br><br>Low | Reset             | Clock synchronous                       | When $\overline{\text{RES}}$ goes low, the chip enters the reset state immediately. The hardware exception-handling sequence (reset sequence) begins as soon as $\overline{\text{RES}}$ goes high again.       |
|                                                                                                  | Interrupt         | On completion of instruction execution* | When an interrupt is requested, the hardware exception-handling sequence (interrupt sequence) begins at the end of the current instruction, or at the end of the current hardware exception-handling sequence. |

Note: \* Not detected in case of ANDC, ORC, XORC, and LDC instructions.

## 4.2 Reset

### 4.2.1 Overview

A reset has the highest exception-handling priority. When the  $\overline{\text{RES}}$  pin goes low or a watchdog reset is started (watchdog timer overflow for which the reset option is selected), all current processing stops and the chip enters the reset state. The internal state of the CPU and the registers of the on-chip supporting modules are initialized. When  $\overline{\text{RES}}$  returns from low to high or the watchdog reset pulse ends, the chip comes out of the reset state via the reset exception-handling sequence.

## 4.2.2 Reset Sequence

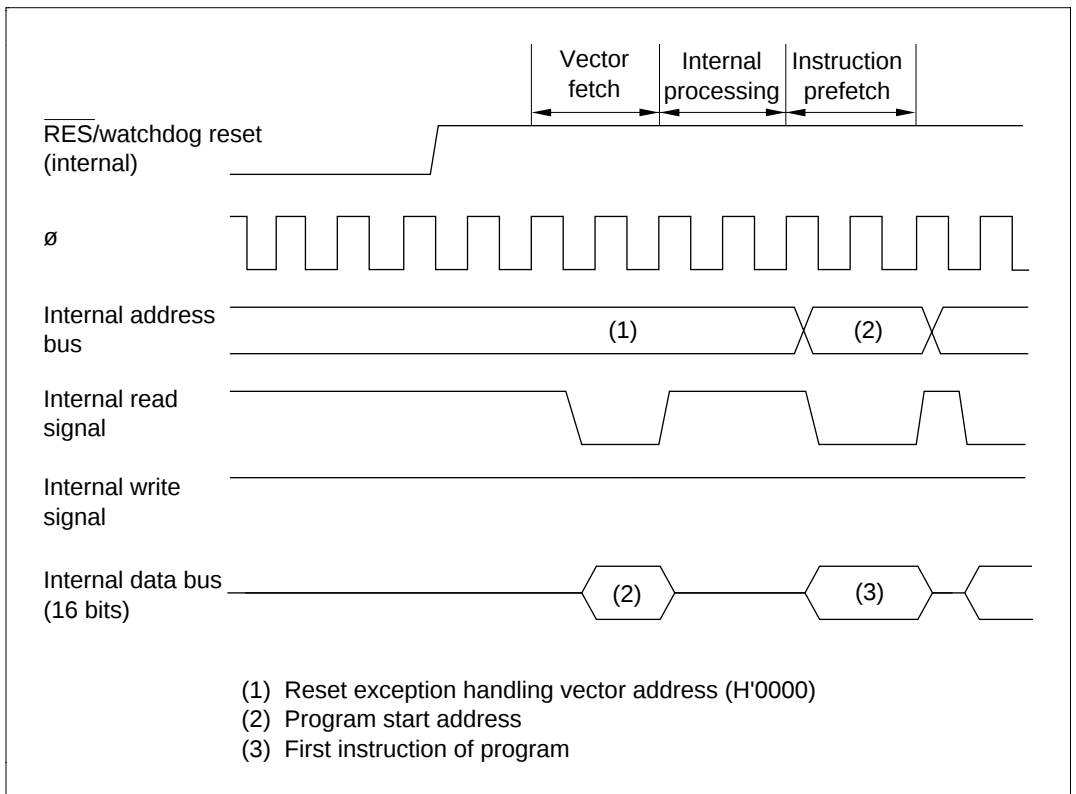
The reset state begins when  $\overline{\text{RES}}$  goes low or a watchdog reset occurs. To ensure correct resetting, at power-on the  $\overline{\text{RES}}$  pin should be held low for at least 20 ms. In a reset during operation, the  $\overline{\text{RES}}$  pin should be held low for at least 10 system clock ( $\phi$ ) cycles. The watchdog reset pulse width is always 518 system clock cycles. For details of pin states in a reset, see appendix D, Pin States.

When reset exception handling is started, hardware carries out the following reset sequence.

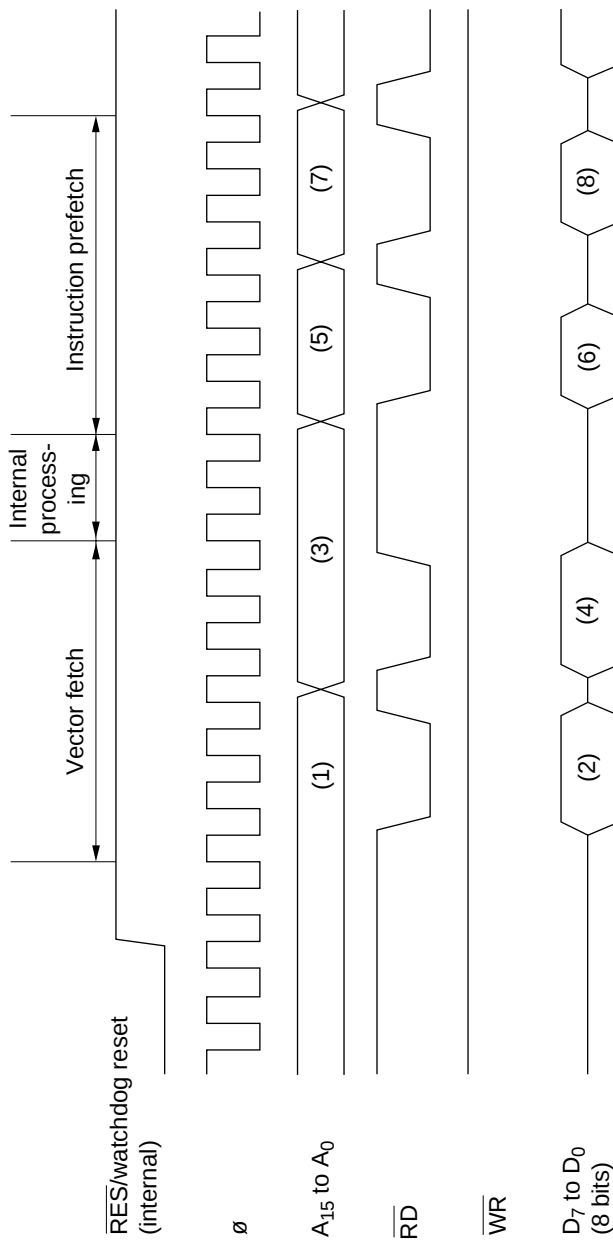
1. In the condition code register (CCR), the I bit is set to 1 to mask interrupts.
2. The registers of the I/O ports and on-chip supporting modules are initialized.
3. The CPU loads the program counter with the first word in the vector table (stored at addresses H'0000 and H'0001) and starts program execution.

The  $\overline{\text{RES}}$  pin should be held low when power is switched off, as well as when power is switched on.

Figure 4-1 indicates the timing of the reset sequence when the vector table and reset routine are located in on-chip ROM (mode 2 or 3). Figure 4-2 indicates the timing when they are in off-chip memory (mode 1).



**Figure 4-1 Reset Sequence (Mode 2 or 3, Program Area in On-Chip ROM)**



- (1), (3) Reset exception handling vector address: (1) = H'0000, (3) = H'0001  
 (2), (4) Start address (contents of reset exception handling vector address): (2) = upper byte, (4) = lower byte  
 (5), (7) Start address: (5) = (2) (4), (7) = (2) (4) + 1  
 (6), (8) First instruction of program: (6) = first byte, (8) = second byte

Figure 4-2 Reset Sequence (Mode 1)

### 4.2.3 Disabling of Interrupts after Reset

All interrupts, including NMI, are disabled immediately after a reset. The first program instruction, located at the address specified at the top of the vector table, is therefore always executed. To prevent program crashes, this instruction should initialize the stack pointer (example: `MOV.W #xx:16, SP`). After execution of this instruction, the NMI interrupt is enabled. Other interrupts remain disabled until their enable bits are set to 1.

After reset exception handling, a CCR manipulation instruction can be executed to fix the CCR contents before the instruction that initializes the stack pointer. After the CCR manipulation instruction is executed, all interrupts, including NMI, are disabled. The next instruction should be the instruction that initializes the stack pointer.

## 4.3 Interrupts

### 4.3.1 Overview

There are twelve input pins for five external interrupt sources (NMI, IRQ<sub>0</sub> to IRQ<sub>2</sub>, and IRQ<sub>6</sub>). There are also 26 internal interrupts originating on-chip. The features of these interrupts are:

- All internal and external interrupts except NMI can be masked by the I bit in the CCR.
- IRQ<sub>0</sub> to IRQ<sub>2</sub> and IRQ<sub>6</sub> can be falling-edge-sensed or level-sensed. The type of sensing can be selected for each interrupt individually. NMI is edge-sensed, and either the rising or falling edge can be selected.
- Interrupts are individually vectored. The software interrupt-handling routine does not have to determine what type of interrupt has occurred.
- IRQ<sub>6</sub> is requested by eight external sources (KEYIN<sub>0</sub> to KEYIN<sub>7</sub>). KEYIN<sub>0</sub> to KEYIN<sub>7</sub> can be masked individually by the user program.
- The watchdog timer can be made to generate an NMI interrupt or OVF interrupt according to its use. For details, see section 12, Watchdog Timer.

Table 4-2 lists all the interrupts in their order of priority and gives their vector numbers and the addresses of their entries in the vector table.

### Table 4-2 Interrupts

| Interrupt Source                                                |                                                              | No.      | Address of Entry in Vector Table | Priority  |
|-----------------------------------------------------------------|--------------------------------------------------------------|----------|----------------------------------|-----------|
| NMI                                                             |                                                              | 3        | H'0006 to H'0007                 | High<br>↑ |
| IRQ <sub>0</sub>                                                |                                                              | 4        | H'0008 to H'0009                 |           |
| IRQ <sub>1</sub>                                                |                                                              | 5        | H'000A to H'000B                 |           |
| IRQ <sub>2</sub>                                                |                                                              | 6        | H'000C to H'000D                 |           |
| Reserved                                                        |                                                              | 7 to 9   | H'000E to H'0013                 |           |
| IRQ <sub>6</sub>                                                | (KEYIN <sub>0</sub> to KEYIN <sub>7</sub> ) (except H8/3212) | 10       | H'0014 to H'0015                 |           |
| Reserved                                                        |                                                              | 11 to 16 | H'0016 to H'0021                 |           |
| Host interface (except H8/3212)                                 | IBF1 (IDR1 reception complete)                               | 17       | H'0022 to H'0023                 |           |
|                                                                 | IBF2 (IDR2 reception complete)                               | 18       | H'0024 to H'0025                 |           |
| 16-bit free-running timer                                       | ICI (Input capture)                                          | 19       | H'0026 to H'0027                 |           |
|                                                                 | OCIA (Output compare A)                                      | 20       | H'0028 to H'0029                 |           |
|                                                                 | OCIB (Output compare B)                                      | 21       | H'002A to H'002B                 |           |
|                                                                 | FOVI (Overflow)                                              | 22       | H'002C to H'002D                 |           |
| 8-bit timer 0                                                   | CMIOA (Compare-match A)                                      | 23       | H'002E to H'002F                 |           |
|                                                                 | CMIOB (Compare-match B)                                      | 24       | H'0030 to H'0031                 |           |
|                                                                 | OVI0 (Overflow)                                              | 25       | H'0032 to H'0033                 |           |
| 8-bit timer 1                                                   | CMI1A (Compare-match A)                                      | 26       | H'0034 to H'0035                 |           |
|                                                                 | CMI1B (Compare-match B)                                      | 27       | H'0036 to H'0037                 |           |
|                                                                 | OVI1 (Overflow)                                              | 28       | H'0038 to H'0039                 |           |
| Serial communication interface 0                                | ERI0 (Receive error)                                         | 29       | H'003A to H'003B                 |           |
|                                                                 | RXI0 (Receive end)                                           | 30       | H'003C to H'003D                 |           |
|                                                                 | TXI0 (TDR empty)                                             | 31       | H'003E to H'003F                 |           |
|                                                                 | TEI0 (TSR empty)                                             | 32       | H'0040 to H'0041                 |           |
| Serial communication interface 1 (except H8/3212)               | ERI1 (Receive error)                                         | 33       | H'0042 to H'0043                 |           |
|                                                                 | RXI1 (Receive end)                                           | 34       | H'0044 to H'0045                 |           |
|                                                                 | TXI1 (TDR empty)                                             | 35       | H'0046 to H'0047                 |           |
|                                                                 | TEI1 (TSR empty)                                             | 36       | H'0048 to H'0049                 |           |
| Reserved                                                        |                                                              | 37 to 43 | H'004A to H'0057                 | ↓<br>Low  |
| Watchdog timer                                                  | WOVF (WDT overflow)                                          | 44       | H'0058 to H'0059                 |           |
| I <sup>2</sup> C bus interface 0* <sup>3</sup>                  | IICIO (Transfer end)                                         | 45       | H'005A to H'005B                 |           |
| I <sup>2</sup> C bus interface 1* <sup>3</sup> (except H8/3202) | IIC11 (Transfer end)                                         | 46       | H'005C to H'005D                 |           |
| 8-bit timer X (except H8/3202)                                  | CMIXA (Compare-match A)                                      | 47       | H'005E to H'005F                 |           |
|                                                                 | CMIXB (Compare-match B)                                      | 48       | H'0060 to H'0061                 |           |
|                                                                 | OVIX (Overflow)                                              | 49       | H'0062 to H'0063                 |           |

- Notes:
1. H'0000 and H'0001 contain the reset vector.
  2. H'0002 to H'0005 are reserved in the H8/3217 Series and are not available to the user.
  3. The I<sup>2</sup>C bus interface is an option.

### 4.3.2 Interrupt-Related Registers

The interrupt-related registers are the system control register (SYSCR), IRQ sense control register (ISCR), IRQ enable register (IER), and keyboard matrix interrupt mask register (KMIMR).

**Table 4-3 Registers Read by Interrupt Controller**

| Name                                    | Abbreviation | Read/Write | Address |
|-----------------------------------------|--------------|------------|---------|
| System control register                 | SYSCR        | R/W        | H'FFC4  |
| IRQ sense control register              | ISCR         | R/W        | H'FFC6  |
| IRQ enable register                     | IER          | R/W        | H'FFC7  |
| Keyboard matrix interrupt mask register | KMIMR        | R/W        | H'FFF1  |

#### (1) System Control Register (SYSCR)—H'FFC4

| Bit           | 7    | 6    | 5    | 4    | 3    | 2     | 1   | 0    |
|---------------|------|------|------|------|------|-------|-----|------|
|               | SSBY | STS2 | STS1 | STS0 | XRST | NMIEG | HIE | RAME |
| Initial value | 0    | 0    | 0    | 0    | 1    | 0     | 0   | 1    |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R    | R/W   | R/W | R/W  |

**Bit 2—Nonmaskable Interrupt Edge (NMIEG):** Determines whether a nonmaskable interrupt is generated on the falling or rising edge of the  $\overline{\text{NMI}}$  input signal.

#### Bit 2

| NMIEG | Description                                                                              |
|-------|------------------------------------------------------------------------------------------|
| 0     | An interrupt is generated on the falling edge of $\overline{\text{NMI}}$ (Initial value) |
| 1     | An interrupt is generated on the rising edge of $\overline{\text{NMI}}$                  |

See section 3.2, System Control Register (SYSCR), for information on the other SYSCR bits.

## (2) IRQ Sense Control Register (ISCR)—H'FFC6

| Bit           | 7 | 6      | 5 | 4 | 3 | 2      | 1      | 0      |
|---------------|---|--------|---|---|---|--------|--------|--------|
|               | — | IRQ6SC | — | — | — | IRQ2SC | IRQ1SC | IRQ0SC |
| Initial value | 1 | 0      | 1 | 1 | 1 | 0      | 0      | 0      |
| Read/Write    | — | R/W    | — | — | — | R/W    | R/W    | R/W    |

**Bits 0 to 2 and 6—IRQ<sub>0</sub> to IRQ<sub>2</sub>, IRQ<sub>6</sub> Sense Control (IRQ0SC to IRQ2SC, IRQ6SC):** These bits select how the input at pins  $\overline{\text{IRQ}}_0$  to  $\overline{\text{IRQ}}_2$  and  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$  is sensed.

**Bit i (i = 0 to 2, 6)**

| IRQiSC | Description                                                                                                                                                                          |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0      | The low level of $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ or $\overline{\text{KEYIN}}_0$ to $\overline{\text{KEYIN}}_7$ generates an interrupt request (Initial value) |
| 1      | The falling edge of $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ or $\overline{\text{KEYIN}}_0$ to $\overline{\text{KEYIN}}_7$ generates an interrupt request              |

## (3) IRQ Enable Register (IER)—H'FFC7

| Bit           | 7 | 6     | 5 | 4 | 3 | 2     | 1     | 0     |
|---------------|---|-------|---|---|---|-------|-------|-------|
|               | — | IRQ6E | — | — | — | IRQ2E | IRQ1E | IRQ0E |
| Initial value | 1 | 0     | 1 | 1 | 1 | 0     | 0     | 0     |
| Read/Write    | — | R/W   | — | — | — | R/W   | R/W   | R/W   |

**Bits 0 to 2, 6—IRQ<sub>0</sub> to IRQ<sub>2</sub> and IRQ<sub>6</sub> Enable (IRQ0E to IRQ2E, IRQ6E):** These bits enable or disable the IRQ<sub>0</sub>, IRQ<sub>1</sub>, IRQ<sub>2</sub>, and IRQ<sub>6</sub> interrupts individually.

**Bit i (i = 0 to 2)**

| IRQiE | Description                                                                            |
|-------|----------------------------------------------------------------------------------------|
| 0     | IRQ <sub>0</sub> to IRQ <sub>2</sub> and IRQ <sub>6</sub> are disabled (Initial value) |
| 1     | IRQ <sub>0</sub> to IRQ <sub>2</sub> and IRQ <sub>6</sub> are enabled                  |

When edge sensing is selected (by setting bits IRQ0SC to IRQ2SC and IRQ6SC to 1), it is possible for an interrupt-handling routine to be executed even though the corresponding enable bit (IRQ0E to IRQ2E and IRQ6E) is cleared to 0 and the interrupt is disabled. If an interrupt is requested while the enable bit (IRQ0E to IRQ2E and IRQ6E) is set to 1, the request will be held pending until served. If the enable bit is cleared to 0 while the request is still pending, the request will remain pending, although new requests will not be recognized. If the interrupt mask bit (I) in the CCR is cleared to 0, the interrupt-handling routine can be executed even though the enable bit is now 0.

If execution of interrupt-handling routines under these conditions is not desired, it can be avoided by using the following procedure to disable and clear interrupt requests.

1. Set the I bit to 1 in the CCR, masking interrupts. Note that the I bit is set to 1 automatically when execution jumps to an interrupt vector.
2. Clear the desired bits from IRQ0E, IRQ1E, IRQ2E, and IRQ6E to 0 to disable new interrupt requests.
3. Clear the corresponding bits from IRQ0SC, IRQ1SC, IRQ2SC, and IRQ6SC to 0, then set them to 1 again. Pending IRQ<sub>n</sub> interrupt requests are cleared when I = 1 in the CCR, IRQ<sub>n</sub>SC = 0, and IRQ<sub>n</sub>E = 0.

#### (4) Keyboard Matrix Interrupt Mask Register (KMIMR)

KMIMR is an 8-bit readable/writable register used in keyboard matrix scanning and sensing. To enable key-sense input interrupts from two or more pins during keyboard scanning and sensing, clear the corresponding mask bits to 0.

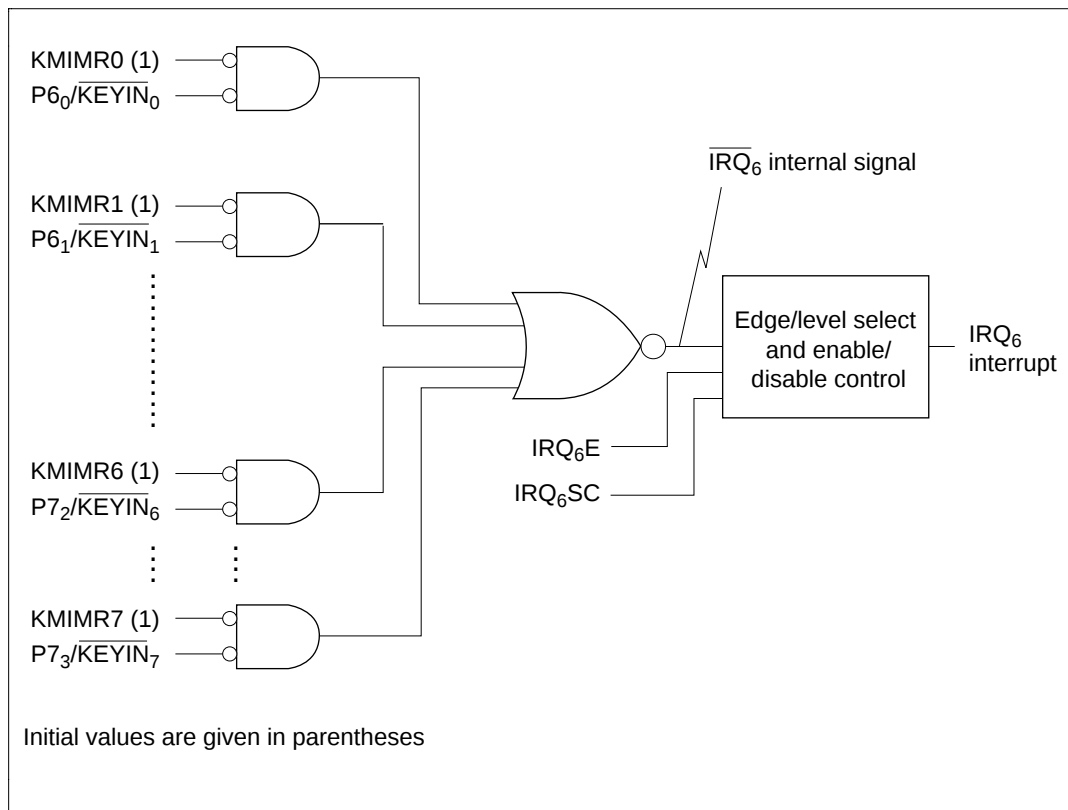
| Bit           | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      |
|---------------|--------|--------|--------|--------|--------|--------|--------|--------|
|               | KMIMR7 | KMIMR6 | KMIMR5 | KMIMR4 | KMIMR3 | KMIMR2 | KMIMR1 | KMIMR0 |
| Initial value | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 1      |
| Read/Write    | R/W    | R/W    | R/W    | R/W    | R/W    | R/W    | R/W    | R/W    |

**Bits 7 to 0—Keyboard Matrix Interrupt Mask (KMIMR7 to KMIMR0):** These bits control key-sense input interrupt requests KEYIN<sub>7</sub> to KEYIN<sub>0</sub>.

##### Bits 7 to 0

| KMIMR7 to KMIMR0 | Description                                                    |
|------------------|----------------------------------------------------------------|
| 0                | Key-sense input interrupt request is enabled.                  |
| 1                | Key-sense input interrupt request is disabled. (Initial value) |

Figure 4-3 shows the relationship between the IRQ<sub>6</sub> interrupt and KMIMR.



**Figure 4-3 KMIMR and IRQ6 Interrupt**

### 4.3.3 External Interrupts

There are five external interrupts: NMI, IRQ<sub>0</sub> to IRQ<sub>2</sub>, and IRQ<sub>6</sub>. These can be used to return from software standby mode.

**(1) NMI:** NMI is the highest-priority interrupt, and is always accepted regardless of the value of the I bit in CCR. Interrupts from the  $\overline{\text{NMI}}$  pin are edge-sensed: rising edge or falling edge can be specified by the NMIEG bit in SYSCR. The NMI exception handling vector number is 3. NMI exception handling sets the I bit in CCR to 1.

**(2) IRQ<sub>0</sub> to IRQ<sub>2</sub> and IRQ<sub>6</sub>:** Interrupts IRQ<sub>0</sub> to IRQ<sub>2</sub> are requested by input signals on pins  $\overline{\text{IRQ}}_0$  to  $\overline{\text{IRQ}}_2$ . The IRQ<sub>6</sub> interrupt is requested by input signals on pins  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$ . Interrupts IRQ<sub>0</sub> to IRQ<sub>2</sub> and IRQ<sub>6</sub> can be specified as falling-edge-sensed or level-sensed by bits IRQ0SC to IRQ2SC and IRQ6SC in ISCR. Interrupt requests are enabled by set bits IRQ0E to IRQ2E and IRQ6E to 1 in IER. Interrupts are masked by setting the I bit to 1 in CCR.

The  $\overline{\text{IRQ}}_6$  input signal is generated as the logical OR of the key-sense inputs. When pins  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$  (P6<sub>0</sub> to P6<sub>3</sub> and P7<sub>0</sub> to P7<sub>3</sub>) are used as key-sense inputs, the corresponding KMIMR bits should be cleared to 0 to enable the corresponding key-sense interrupts. KMIMR bits corresponding to unused key-sense inputs should be set to 1 to disable those interrupts. All eight key-sense input interrupts are combined into a single  $\text{IRQ}_6$  interrupt.

When one of these interrupts is accepted, the I bit is set to 1.  $\text{IRQ}_0$  to  $\text{IRQ}_2$  and  $\text{IRQ}_6$  have interrupt vector numbers 4 to 6 and 10. They are prioritized in order from  $\text{IRQ}_6$  (low) to  $\text{IRQ}_0$  (high). For details, see table 4-2.

Interrupts  $\text{IRQ}_0$  to  $\text{IRQ}_2$  and  $\text{IRQ}_6$  do not depend on whether pins  $\overline{\text{IRQ}}_0$  to  $\overline{\text{IRQ}}_2$  and  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$  are used as input pins or output pins. When interrupts  $\text{IRQ}_0$  to  $\text{IRQ}_2$  and  $\text{IRQ}_6$  are requested by an external signal, clear the corresponding DDR bits to 0 and use the pins as input/output pins.

#### 4.3.4 Internal Interrupts

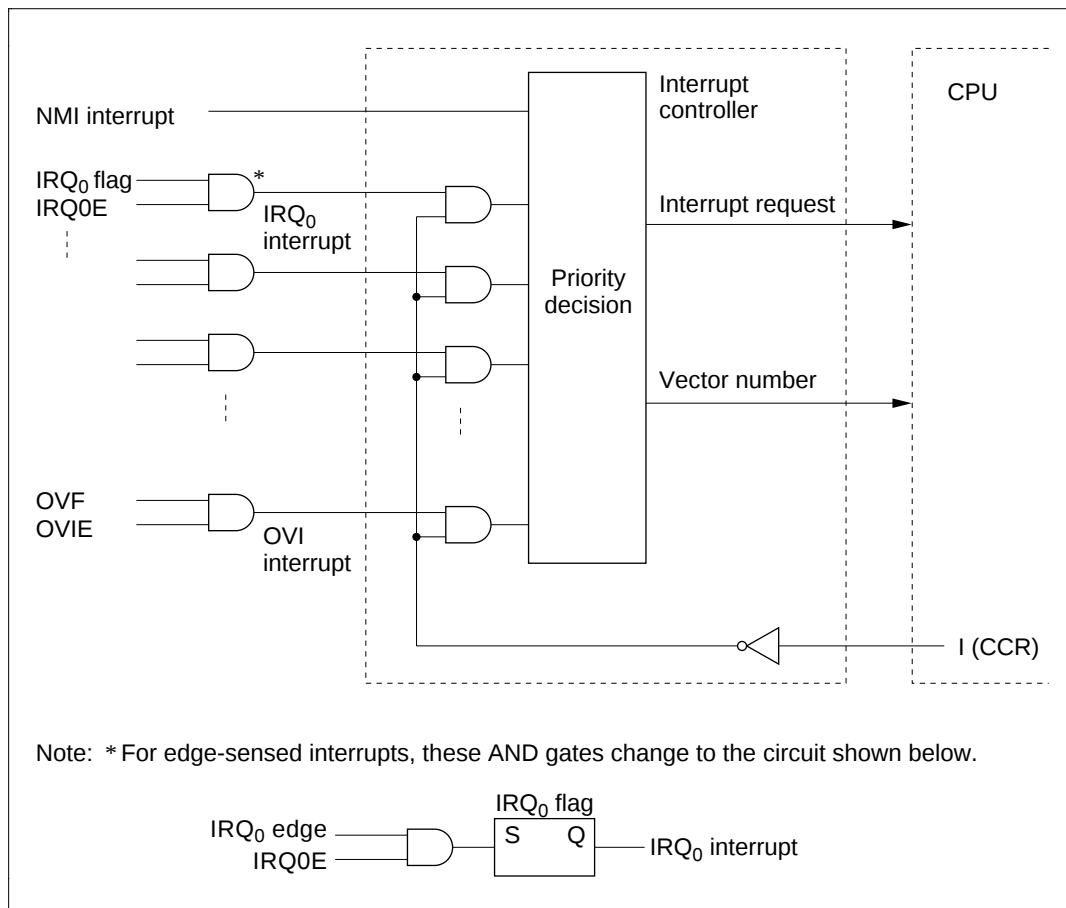
Twenty-six internal interrupts can be requested by the on-chip supporting modules. All of them are masked when the I bit in the CCR is set. In addition, they can all be enabled or disabled by bits in the control registers of the on-chip supporting modules. When one of these interrupts is accepted, the I bit is set to 1 to mask further interrupts (except NMI).

The vector numbers of these interrupts are 17 to 36 and 44 to 49.

For the priority order of these interrupts, see table 4-2.

#### 4.3.5 Interrupt Handling

Interrupts are controlled by an interrupt controller that arbitrates between simultaneous interrupt requests, commands the CPU to start the hardware interrupt exception-handling sequence, and furnishes the necessary vector number. Figure 4-4 shows a block diagram of the interrupt controller.



**Figure 4-4 Block Diagram of Interrupt Controller**

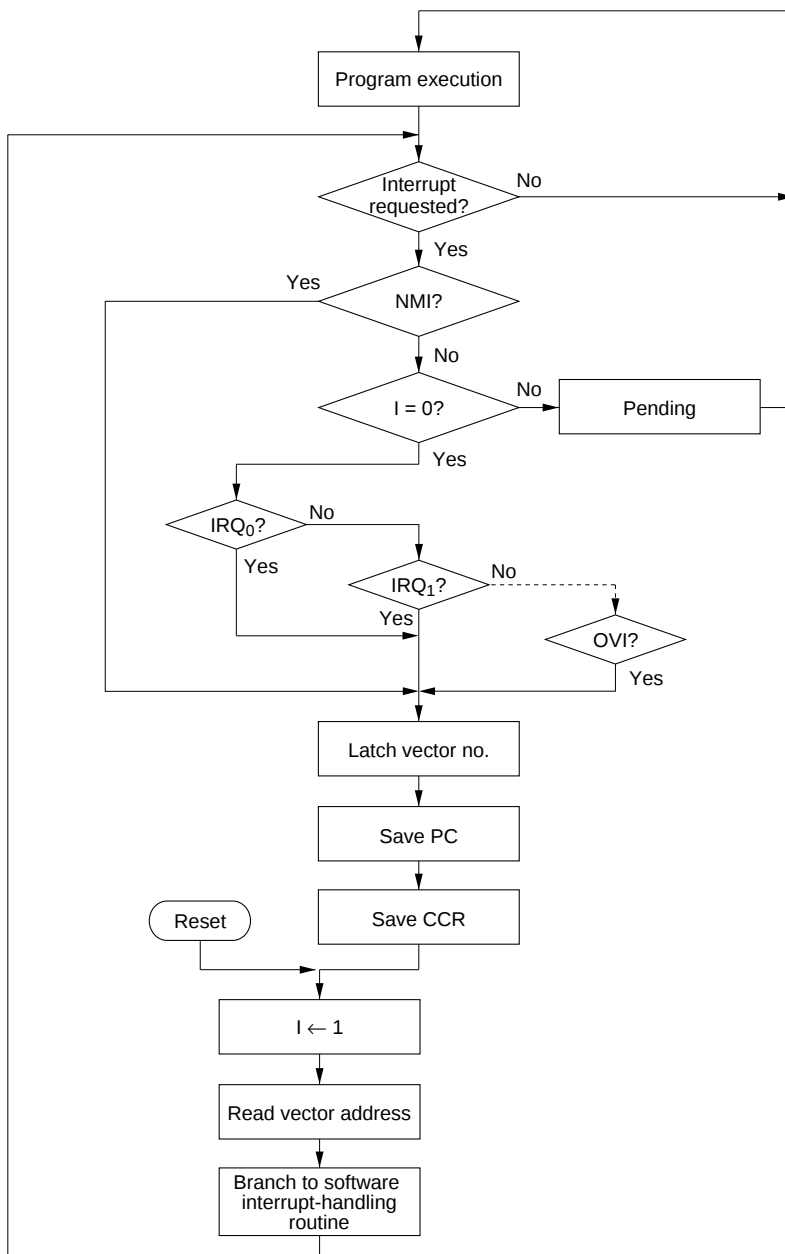
The IRQ interrupts and interrupts from the on-chip supporting modules (except for reset selected for a watchdog timer overflow) all have corresponding enable bits. When the enable bit is cleared to 0, the interrupt signal is not sent to the interrupt controller, so the interrupt is ignored. These interrupts can also all be masked by setting the CPU's interrupt mask bit (I) to 1. Accordingly, these interrupts are accepted only when their enable bit is set to 1 and the I bit is cleared to 0.

The nonmaskable interrupt (NMI) is always accepted, except in the reset state and hardware standby mode.

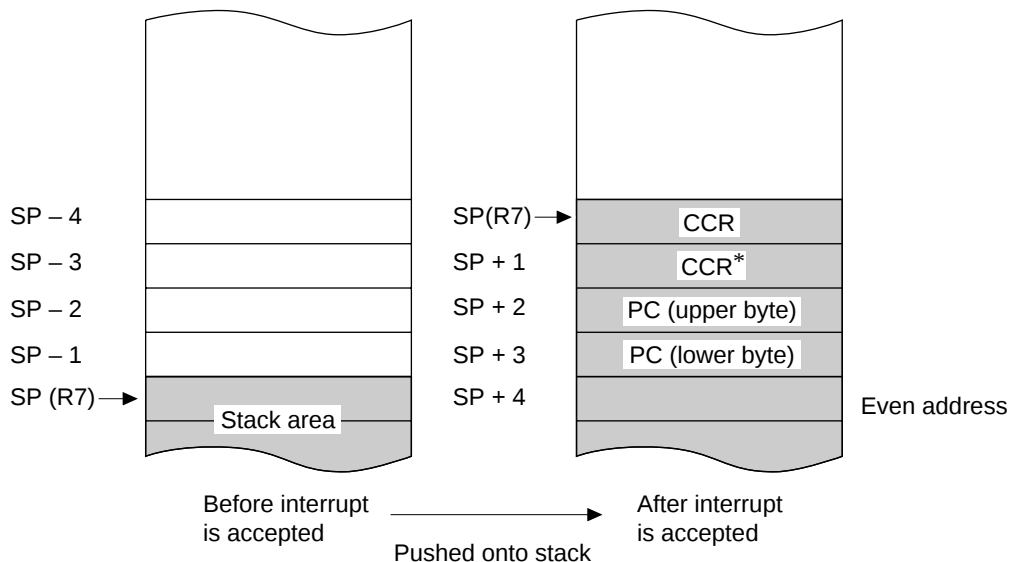
When an NMI or another enabled interrupt is requested, the interrupt controller transfers the interrupt request to the CPU and indicates the corresponding vector number. (When two or more interrupts are requested, the interrupt controller selects the vector number of the interrupt with the highest priority.) When notified of an interrupt request, at the end of the current instruction or current hardware exception-handling sequence, the CPU starts the hardware exception-handling sequence for the interrupt and latches the vector number.

Figure 4-5 is a flowchart of the interrupt (and reset) operations. Figure 4-7 shows the interrupt timing sequence for the case in which the software interrupt-handling routine is in on-chip ROM and the stack is in on-chip RAM.

- (1) An interrupt request is sent to the interrupt controller when an NMI interrupt occurs, and when an interrupt occurs on an IRQ input line or in an on-chip supporting module provided the enable bit of that interrupt is set to 1.
- (2) The interrupt controller checks the I bit in CCR and accepts the interrupt request if the I bit is cleared to 0. If the I bit is set to 1 only NMI requests are accepted; other interrupt requests remain pending.
- (3) Among all accepted interrupt requests, the interrupt controller selects the request with the highest priority and passes it to the CPU. Other interrupt requests remain pending.
- (4) When it receives the interrupt request, the CPU waits until completion of the current instruction or hardware exception-handling sequence, then starts the hardware exception-handling sequence for the interrupt and latches the interrupt vector number.
- (5) In the hardware exception-handling sequence, the CPU first pushes the PC and CCR onto the stack. See figure 4-6. The stacked PC indicates the address of the first instruction that will be executed on return from the software interrupt-handling routine.
- (6) Next the I bit in CCR is set to 1, masking all further interrupts except NMI.
- (7) The vector address corresponding to the vector number is generated, the vector table entry at this vector address is loaded into the program counter, and execution branches to the software interrupt-handling routine at the address indicated by that entry.



**Figure 4-5 Hardware Interrupt-Handling Sequence**

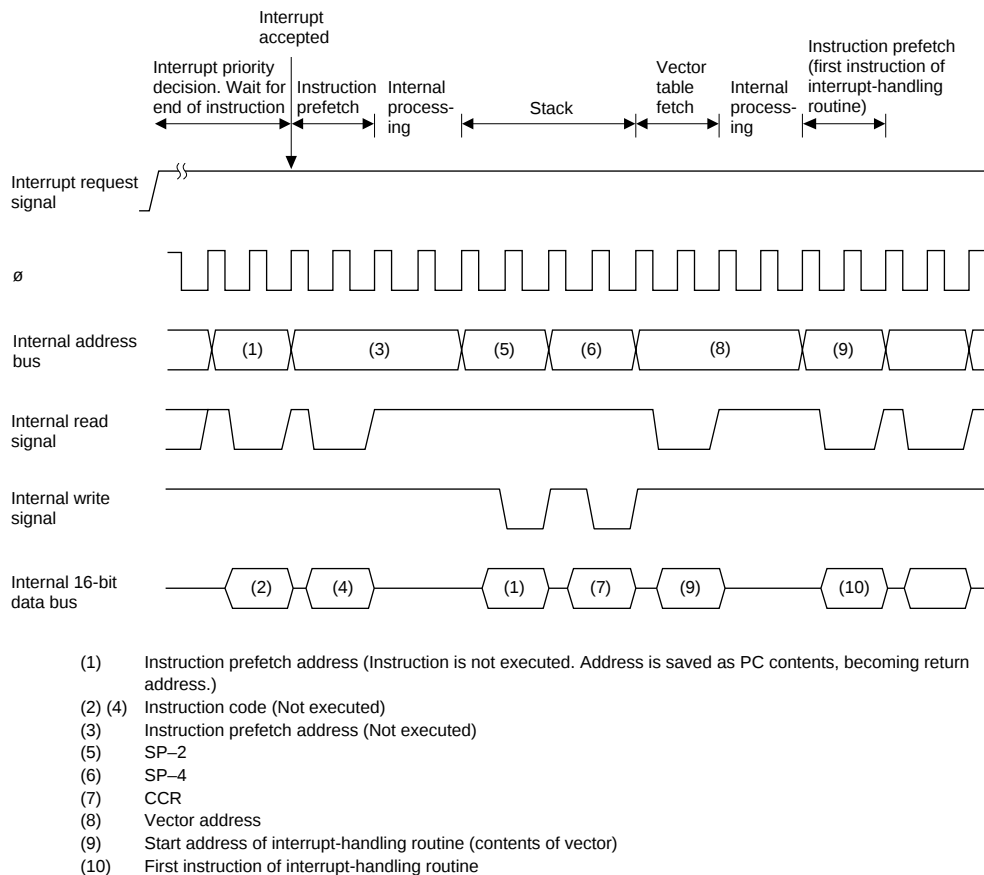


PC: Program counter  
 CCR: Condition code register  
 SP: Stack pointer

- Notes: 1. The PC contains the address of the first instruction executed after return.  
 2. Registers must be saved and restored by word access at an even address.  
 \* Ignored on return.

**Figure 4-6 Usage of Stack in Interrupt Handling**

Although the CCR consists of only one byte, it is treated as word data when pushed on the stack. In the hardware interrupt exception-handling sequence, two identical CCR bytes are pushed onto the stack to make a complete word. When popped from the stack by an RTE instruction, the CCR is loaded from the byte stored at the even address. The byte stored at the odd address is ignored.



**Figure 4-7 Timing of Interrupt Sequence**

### 4.3.6 Interrupt Response Time

Table 4-4 indicates the time that elapses from an interrupt request signal until the first instruction of the software interrupt-handling routine is executed. Since the H8/3217 Series accesses its on-chip memory 16 bits at a time, very fast interrupt service can be obtained by placing interrupt-handling routines in on-chip ROM and the stack in on-chip RAM.

**Table 4-4 Number of States before Interrupt Service**

| No. | Reason for wait                                          | Number of States |                        |
|-----|----------------------------------------------------------|------------------|------------------------|
|     |                                                          | On-Chip Memory   | External Memory        |
| 1   | Interrupt priority decision                              | 2* <sup>3</sup>  | 2* <sup>3</sup>        |
| 2   | Wait for completion of current instruction* <sup>1</sup> | 1 to 13          | 5 to 17* <sup>2</sup>  |
| 3   | Save PC and CCR                                          | 4                | 12* <sup>2</sup>       |
| 4   | Fetch vector                                             | 2                | 6* <sup>2</sup>        |
| 5   | Fetch instruction                                        | 4                | 12* <sup>2</sup>       |
| 6   | Internal processing                                      | 4                | 4                      |
|     | Total                                                    | 17 to 29         | 41 to 53* <sup>2</sup> |

Notes: 1. These values do not apply if the current instruction is an EEPMOV instruction.  
2. If wait states are inserted in external memory access, these values may be longer.  
3. 1 for internal interrupts.

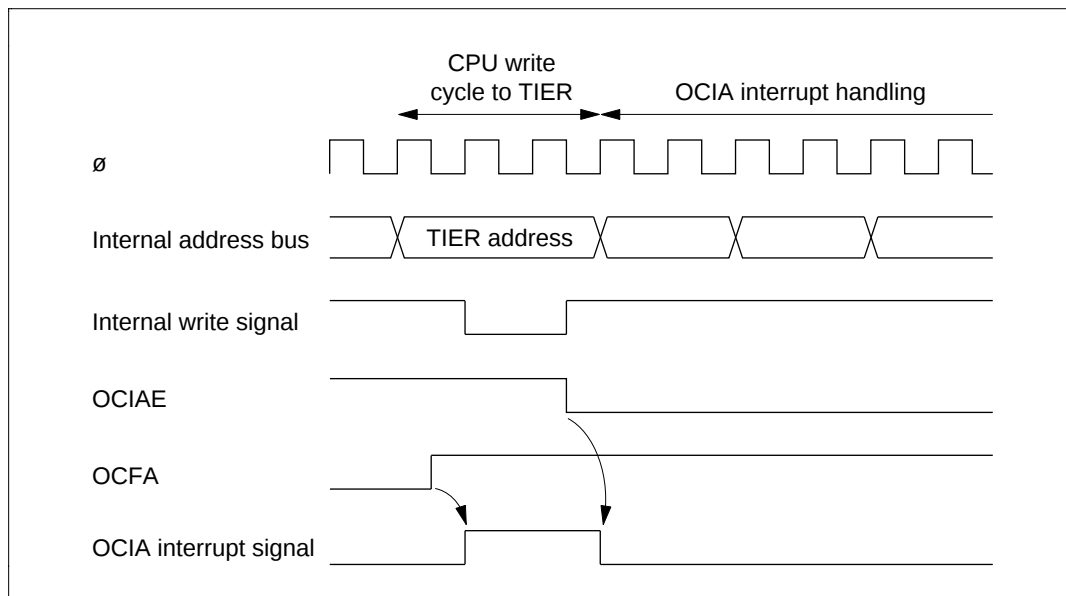
### 4.3.7 Precaution

Note that the following type of contention can occur in interrupt handling.

When software clears the enable bit of an interrupt to 0 to disable the interrupt, the interrupt becomes disabled after execution of the clearing instruction. If an enable bit is cleared by a BCLR or MOV instruction, for example, and the interrupt is requested during execution of that instruction, at the instant when the instruction ends the interrupt is still enabled, so after execution of the instruction, the hardware exception-handling sequence is executed for the interrupt. If a higher-priority interrupt is requested at the same time, however, the hardware exception-handling sequence is executed for the higher-priority interrupt and the interrupt that was disabled is ignored.

Similar considerations apply when an interrupt request flag is cleared to 0.

Figure 4-8 shows an example in which the OCIAE bit is cleared to 0.



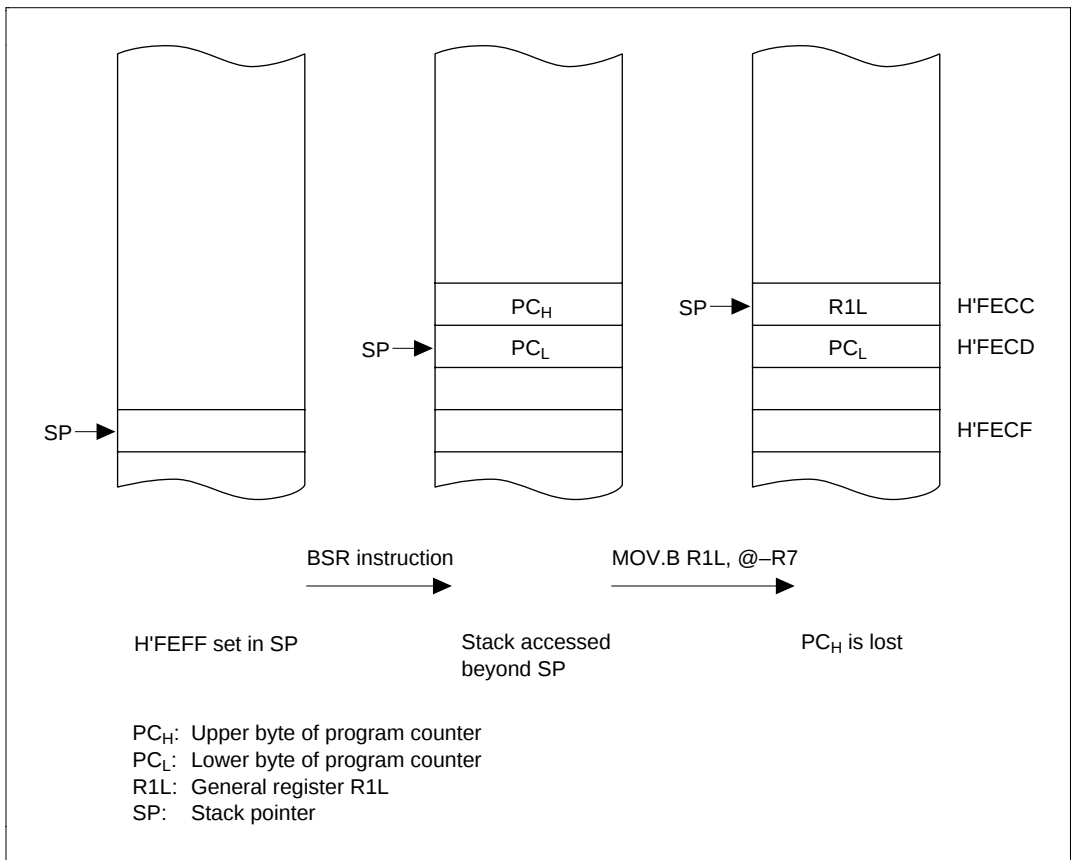
**Figure 4-8 Contention between Interrupt and Disabling Instruction**

The above contention does not occur if the enable bit or flag is cleared to 0 while the interrupt mask bit (I) is set to 1.

## 4.4 Note on Stack Handling

In word access, the least significant bit of the address is always assumed to be 0. The stack is always accessed by word access. Care should be taken to keep an even value in the stack pointer (general register R7). Use the PUSH and POP (or MOV.W Rn, @-SP and MOV.W @SP+, Rn) instructions to push and pop registers on the stack.

Setting the stack pointer to an odd value can cause programs to crash. Figure 4-9 shows an example of damage caused when the stack pointer contains an odd address.



**Figure 4-9 Example of Damage Caused by Setting an Odd Address in R7**

## 4.5 Notes on the Use of Key-Sense Interrupts

The H8/3217 Series incorporates a key-sense interrupt function which can be used in any operating mode. When used in a mode other than slave mode (when the host interface is disabled), the following points must be noted.

In order to use the key-sense interrupt function, it is necessary to write to KMIMR to unmask the relevant KEYIN pins. If MOS pull-up transistors are provided on pins P7<sub>3</sub> to P7<sub>0</sub> and P6<sub>3</sub> to P6<sub>0</sub>, KMPCR must also be written to.

KMIMR and KMPCR can only be accessed when the HIE bit in SYSCR is set to 1. Consequently, the chip is in slave mode during this period. In slave mode, pin states may vary.

- (1) When KMIMR and KMPCR are set in the initialization routine directly after a reset  
External circuitry must be used such that no problem will be caused irrespective of whether the host interface output and I/O pins retain the high-impedance state or are set to the output

state. There are four host interface output pins—GA<sub>20</sub>, HIRQ<sub>12</sub>, HIRQ<sub>1</sub>, and HIRQ<sub>11</sub>—all of which are set to the port function (input state) initially. There are eight host interface I/O pins, HDB<sub>7</sub> to HDB<sub>0</sub>; in single-chip mode, these are outputs when the P7<sub>6</sub>/ $\overline{\text{IOR}}$  pin is low and either one, or both, of the P7<sub>5</sub>/ $\overline{\text{CS}}_1$  and P4<sub>5</sub>/ $\overline{\text{CS}}_2$  pins is low. In expanded mode, these pins function as data bus pins (D<sub>7</sub> to D<sub>0</sub>), and therefore the pin states do not vary.

(2) When KMIMR and KMPCR are set other than in the initialization routine

The states of the host interface input and I/O pins, and the pins with which they are multiplexed, may vary as a result of setting the HIE bit. P7<sub>7</sub>/HA<sub>0</sub>, P7<sub>6</sub>/ $\overline{\text{IOR}}$ , P7<sub>5</sub>/ $\overline{\text{IOW}}$ , P7<sub>5</sub>/ $\overline{\text{CS}}_1$ , P4<sub>6</sub>/ $\overline{\text{CS}}_2$ , and P3<sub>7</sub>/HDB<sub>7</sub> to P3<sub>0</sub>/HDB<sub>0</sub> automatically become input pins and I/O pins. When a particular pin is used, it is designated as a port input pin or expanded bus control pin, and in single-chip mode, it is necessary to prevent the occurrence of a low level of the P7<sub>6</sub>/ $\overline{\text{IOR}}$  pin together with a low level of the P7<sub>5</sub>/ $\overline{\text{CS}}_1$  pin or the P4<sub>6</sub>/ $\overline{\text{CS}}_2$  pin, or both.

In expanded mode, if external space is accessed when the HIE bit is set to 1, both the P7<sub>6</sub>/ $\overline{\text{IOR}}/\overline{\text{RD}}$  pin and the P7<sub>5</sub>/ $\overline{\text{CS}}_1/\overline{\text{AS}}$  pin are driven low automatically. Note that the output values of P4<sub>4</sub>/HIRQ<sub>12</sub>, P4<sub>3</sub>/HIRQ<sub>1</sub>, and P4<sub>2</sub>/HIRQ<sub>11</sub> may vary as a result.

## Section 5 Wait-State Controller

### 5.1 Overview

The H8/3217 Series has an on-chip wait-state controller that enables insertion of wait states into bus cycles for interfacing to low-speed external devices.

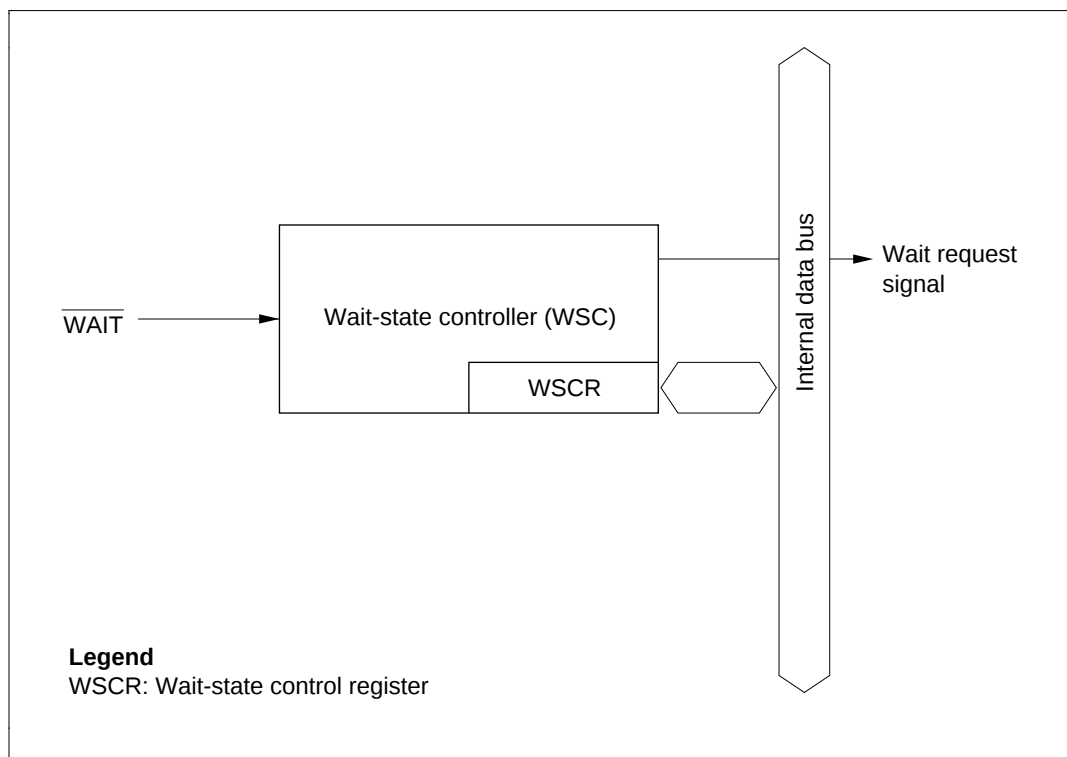
#### 5.1.1 Features

Features of the wait-state controller are listed below.

- Three selectable wait modes: programmable wait mode, pin auto-wait mode, and pin wait mode
- Automatic insertion of zero to three wait states

#### 5.1.2 Block Diagram

Figure 5-1 shows a block diagram of the wait-state controller.



**Figure 5-1 Block Diagram of Wait-State Controller**

### 5.1.3 Input/Output Pins

Table 5-1 summarizes the wait-state controller's input pin.

**Table 5-1 Wait-State Controller Pins**

| Name | Abbreviation             | I/O   | Function                                             |
|------|--------------------------|-------|------------------------------------------------------|
| Wait | $\overline{\text{WAIT}}$ | Input | Wait request signal for access to external addresses |

### 5.1.4 Register Configuration

Table 5-2 summarizes the wait-state controller's register.

**Table 5-2 Register Configuration**

| Name                        | Abbreviation | R/W | Initial Value | Address |
|-----------------------------|--------------|-----|---------------|---------|
| Wait-state control register | WSCR         | R/W | H'C8          | H'FFC2  |

## 5.2 Register Description

### 5.2.1 Wait-State Control Register (WSCR)

WSCR is an 8-bit readable/writable register that selects the wait mode for the wait-state controller (WSC) and specifies the number of wait states. It also controls frequency division of the clock signals supplied to the supporting modules.

| Bit           | 7 | 6 | 5     | 4   | 3    | 2    | 1   | 0   |
|---------------|---|---|-------|-----|------|------|-----|-----|
|               | — | — | CKDBL | —   | WMS1 | WMS0 | WC1 | WC0 |
| Initial value | 1 | 1 | 0     | 0   | 1    | 0    | 0   | 0   |
| Read/Write    | — | — | R/W   | R/W | R/W  | R/W  | R/W | R/W |

WSCR is initialized to H'C8 by a reset and in hardware standby mode. It is not initialized in software standby mode.

**Bits 7 and 6—Reserved:** These bits cannot be modified and are always read as 1.

**Bit 5—Clock Double (CKDBL):** Controls frequency division of clock signals supplied to supporting modules. For details, see section 6, Clock Pulse Generator.

**Bit 4—Reserved:** This bit is reserved, but it can be written and read. Its initial value is 0.

**Bits 3 and 2—Wait Mode Select 1 and 0 (WMS1 and WMS0):** These bits select the wait mode.

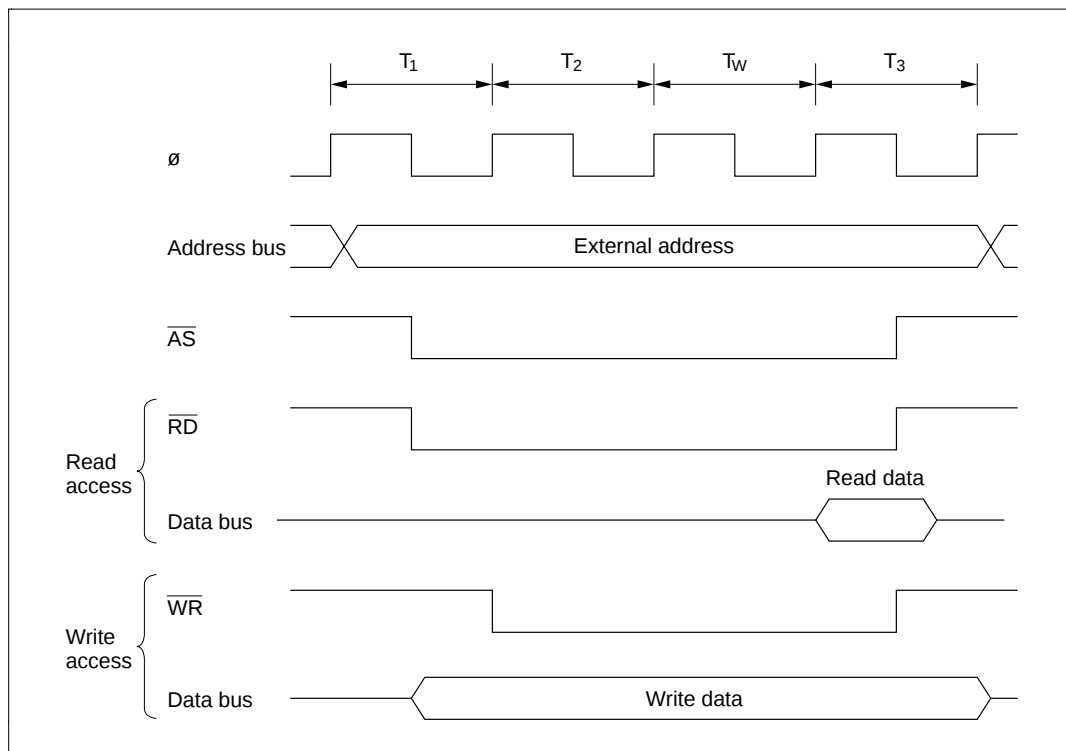
| Bit 3<br>WMS1 | Bit 2<br>WMS0 | Description                                      |
|---------------|---------------|--------------------------------------------------|
| 0             | 0             | Programmable wait mode                           |
|               | 1             | No wait states inserted by wait-state controller |
| 1             | 0             | Pin wait mode (Initial value)                    |
|               | 1             | Pin auto-wait mode                               |

**Bits 1 and 0—Wait Count 1 and 0 (WC1 and WC0):** These bits select the number of wait states inserted in access to external address areas.

| Bit 1<br>WC1 | Bit 0<br>WC0 | Description                                                      |
|--------------|--------------|------------------------------------------------------------------|
| 0            | 0            | No wait states inserted by wait-state controller (Initial value) |
|              | 1            | 1 state inserted                                                 |
| 1            | 0            | 2 states inserted                                                |
|              | 1            | 3 states inserted                                                |

## 5.3 Wait Modes

**Programmable Wait Mode:** The number of wait states ( $T_W$ ) selected by bits WC1 and WC0 are inserted in all accesses to external addresses. Figure 5-2 shows the timing when the wait count is 1 ( $WC1 = 0$ ,  $WC0 = 1$ ).

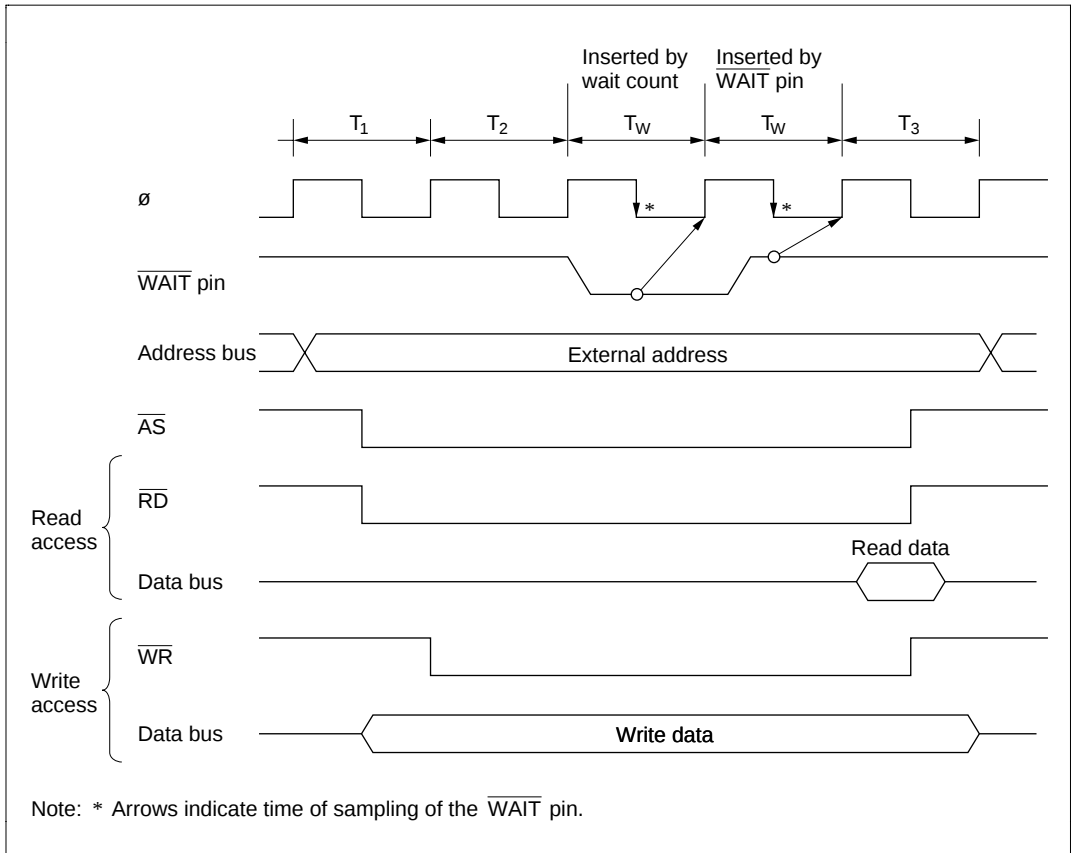


**Figure 5-2 Programmable Wait Mode**

**Pin Wait Mode:** In all accesses to external addresses, the number of wait states ( $T_W$ ) selected by bits WC1 and WC0 are inserted. If the  $\overline{\text{WAIT}}$  pin is low at the fall of the system clock ( $\phi$ ) in the last of these wait states, an additional wait state is inserted. If the  $\overline{\text{WAIT}}$  pin remains low, wait states continue to be inserted until the  $\overline{\text{WAIT}}$  signal goes high.

Pin wait mode is useful for inserting four or more wait states, or for inserting different numbers of wait states for different external devices.

Figure 5-3 shows the timing when the wait count is 1 ( $\text{WC1} = 0$ ,  $\text{WC0} = 1$ ) and one additional wait state is inserted by  $\overline{\text{WAIT}}$  input.

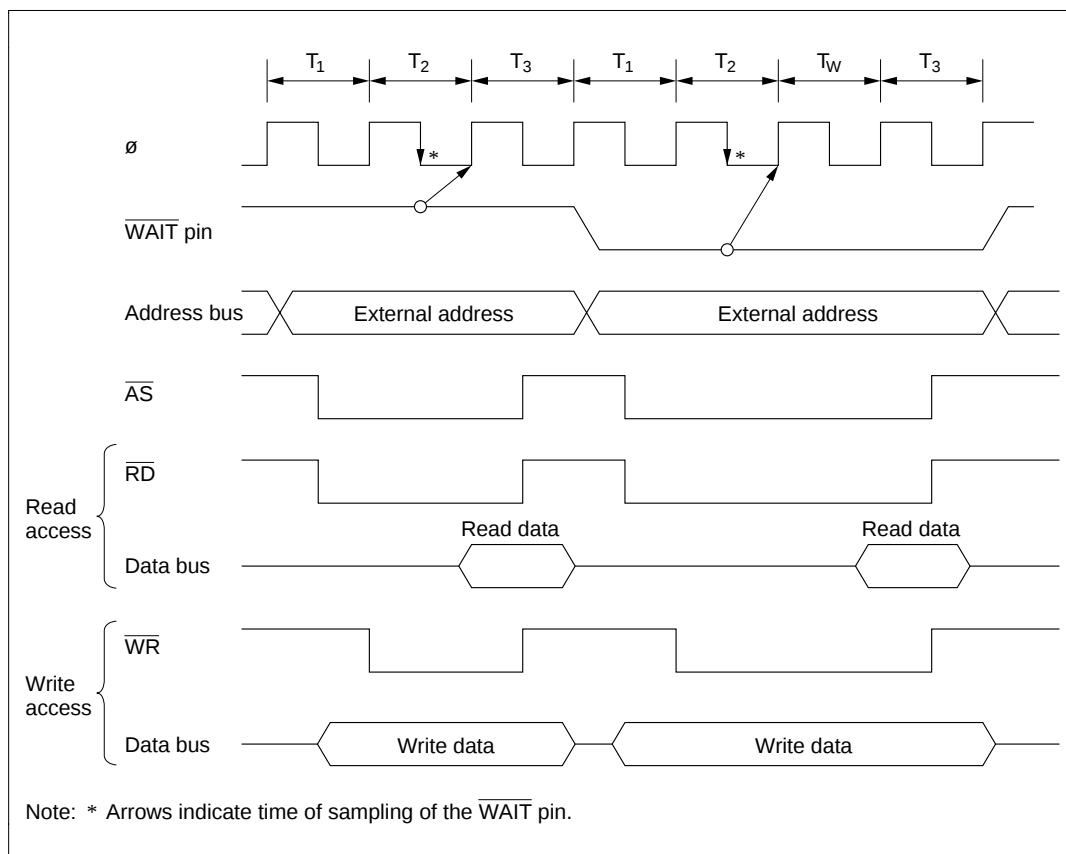


**Figure 5-3 Pin Wait Mode**

**Pin Auto-Wait Mode:** If the  $\overline{\text{WAIT}}$  pin is low, the number of wait states ( $T_W$ ) selected by bits WC1 and WC0 are inserted.

In pin auto-wait mode, if the  $\overline{\text{WAIT}}$  pin is low at the fall of the system clock ( $\phi$ ) in the  $T_2$  state, the number of wait states ( $T_W$ ) selected by bits WC1 and WC0 are inserted. No additional wait states are inserted even if the  $\overline{\text{WAIT}}$  pin remains low. Pin auto-wait mode can be used for an easy interface to low-speed memory, simply by routing the chip select signal to the  $\overline{\text{WAIT}}$  pin.

Figure 5-4 shows the timing when the wait count is 1.



**Figure 5-4 Pin Auto-Wait Mode**

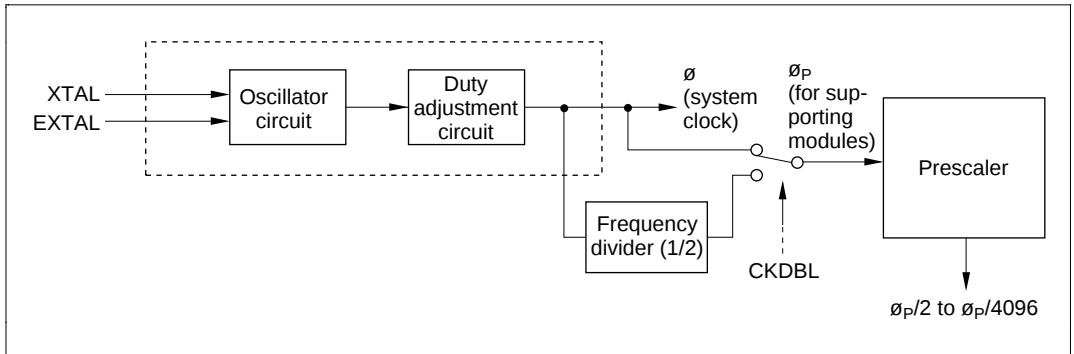
## Section 6 Clock Pulse Generator

### 6.1 Overview

The H8/3217 Series has a built-in clock pulse generator (CPG) consisting of an oscillator circuit, a duty adjustment circuit, and a prescaler that generates clock signals for the on-chip supporting modules.

#### 6.1.1 Block Diagram

Figure 6-1 shows a block diagram of the clock pulse generator.



**Figure 6-1 Block Diagram of Clock Pulse Generator**

Input an external clock signal to the EXTAL pin, or connect a crystal resonator to the XTAL and EXTAL pins. The system clock frequency ( $\phi$ ) will be the same as the input frequency. This same system clock frequency ( $\phi_P$ ) can be supplied to timers and other supporting modules, or it can be divided by two. The selection is made by software, by controlling the CKDBL bit.

### 6.1.2 Wait-State Control Register (WSCR)

WSCR is an 8-bit readable/writable register that controls frequency division of the clock signals supplied to the supporting modules. It also controls wait-state insertion.

WSCR is initialized to H'C8 by a reset and in hardware standby mode. It is not initialized in software standby mode.

| Bit           | 7 | 6 | 5     | 4   | 3    | 2    | 1   | 0   |
|---------------|---|---|-------|-----|------|------|-----|-----|
|               | — | — | CKDBL | —   | WMS1 | WMS0 | WC1 | WC0 |
| Initial value | 1 | 1 | 0     | 0   | 1    | 0    | 0   | 0   |
| Read/Write    | — | — | R/W   | R/W | R/W  | R/W  | R/W | R/W |

**Bits 7 and 6—Reserved:** These bits cannot be modified and are always read as 1.

**Bit 5—Clock Double (CKDBL):** Controls the frequency division of clock signals supplied to supporting modules.

#### CKDBL

| Bit 5 | Description                                                                                                        |
|-------|--------------------------------------------------------------------------------------------------------------------|
| 0     | The undivided system clock ( $\phi$ ) is supplied as the clock ( $\phi_P$ ) for supporting modules (Initial value) |
| 1     | The system clock ( $\phi$ ) is divided by two and supplied as the clock ( $\phi_P$ ) for supporting modules        |

**Bit 4—Reserved:** This bit is reserved, but it can be written and read. Its initial value is 0.

**Bits 3 and 2—Wait Mode Select 1 and 0 (WMS1 and WMS0)**

**Bits 1 and 0—Wait Count 1 and 0 (WC1 and WC0)**

These bits control wait-state insertion. For details, see section 5, Wait-State Controller.

# 6.2 Oscillator Circuit

If an external crystal is connected across the EXTAL and XTAL pins, the on-chip oscillator circuit generates a system clock signal. Alternatively, an external clock signal can be applied to the EXTAL pin.

## (1) Connecting an External Crystal

**Circuit Configuration:** An external crystal can be connected as shown in the example in figure 6-2. Table 6-1 indicates the appropriate damping resistance  $R_d$ . An AT-cut parallel resonance crystal should be used.

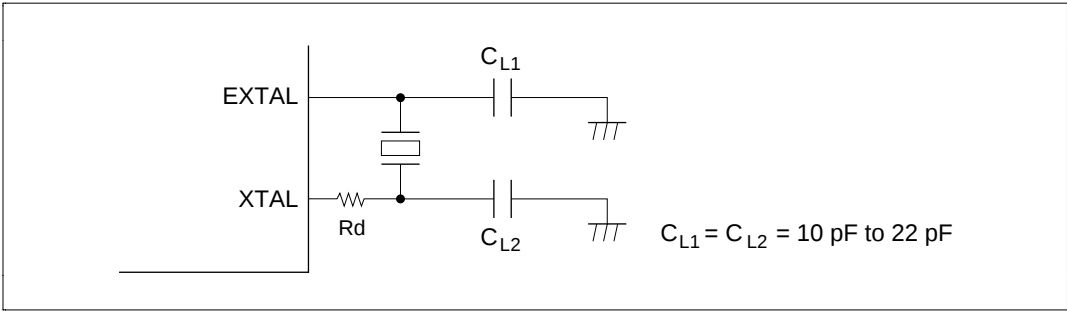
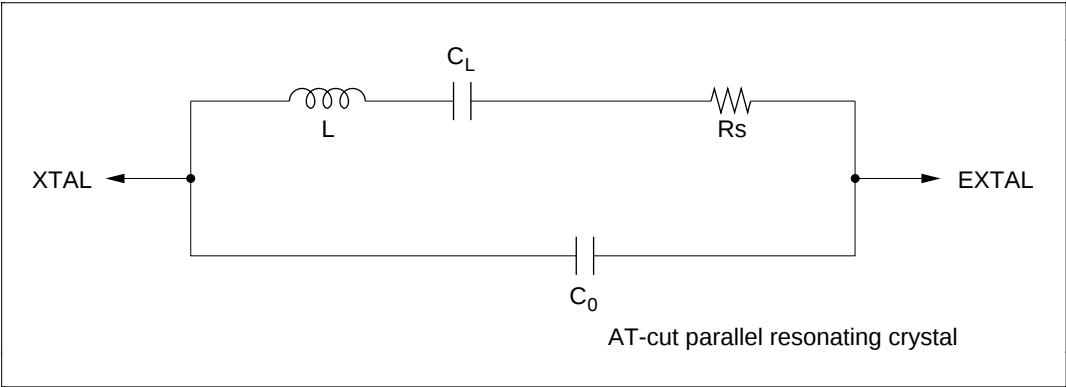


Figure 6-2 Connection of Crystal Oscillator (Example)

Table 6-1 Damping Resistance

| Frequency (MHz)        | 2   | 4   | 8   | 10 | 12 | 16 |
|------------------------|-----|-----|-----|----|----|----|
| $R_d$ max ( $\Omega$ ) | 1 k | 500 | 200 | 0  | 0  | 0  |

**Crystal Oscillator:** Figure 6-3 shows an equivalent circuit of the crystal resonator. The crystal resonator should have the characteristics listed in table 6-2.



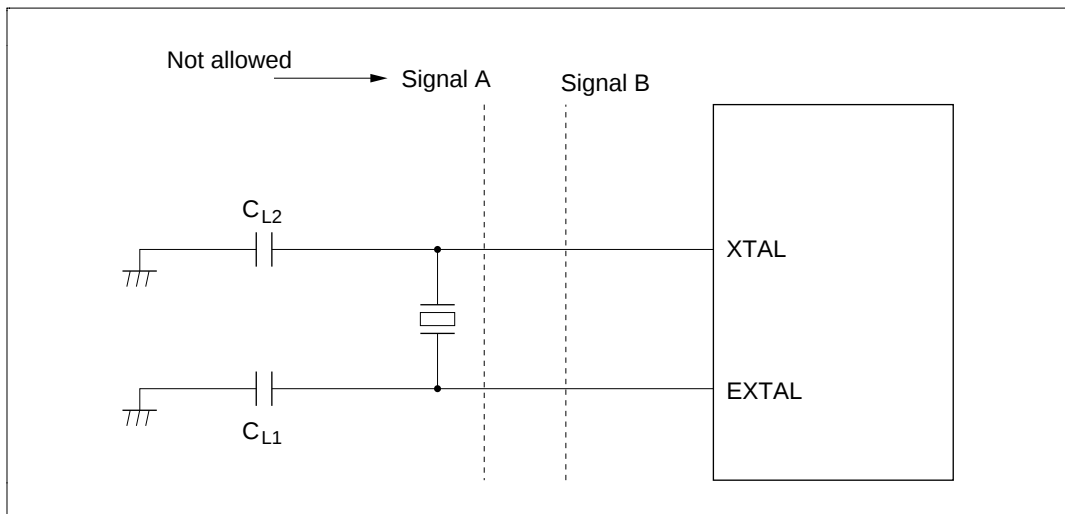
**Figure 6-3    Equivalent Circuit of External Crystal**

**Table 6-2    External Crystal Parameters**

|                     |          |     |    |    |    |    |
|---------------------|----------|-----|----|----|----|----|
| Frequency (MHz)     | 2        | 4   | 8  | 10 | 12 | 16 |
| Rs max (Ω)          | 500      | 120 | 80 | 70 | 60 | 50 |
| C <sub>0</sub> (pF) | 7 pF max |     |    |    |    |    |

Use a crystal with the same frequency as the desired system clock frequency (ø).

**Note on Board Design:** When an external crystal is connected, other signal lines should be kept away from the crystal circuit to prevent induction from interfering with correct oscillation. See figure 6-4. The crystal and its load capacitors should be placed as close as possible to the XTAL and EXTAL pins.

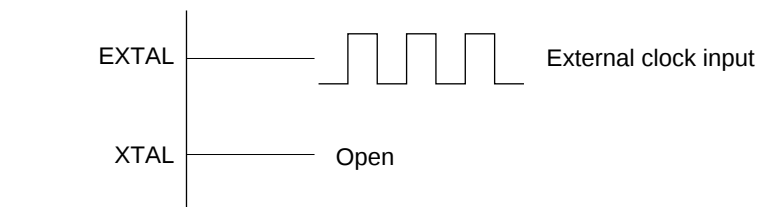


**Figure 6-4 Notes on Board Design around External Crystal**

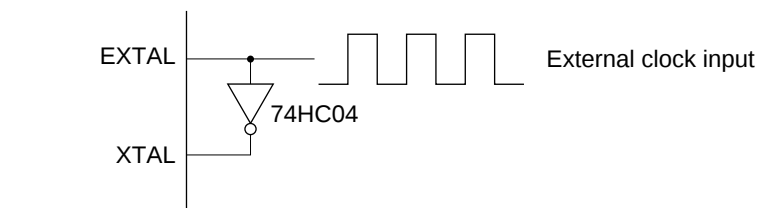
## (2) Input of External Clock Signal

**Circuit Configuration:** An external clock signal can be input as shown in the examples in figure 6-5. In example (b) in figure 6-5, the external clock signal should be kept high during standby.

If the XTAL pin is left open, make sure the stray capacitance does not exceed 10 pF.



(a) Connections with XTAL pin left open



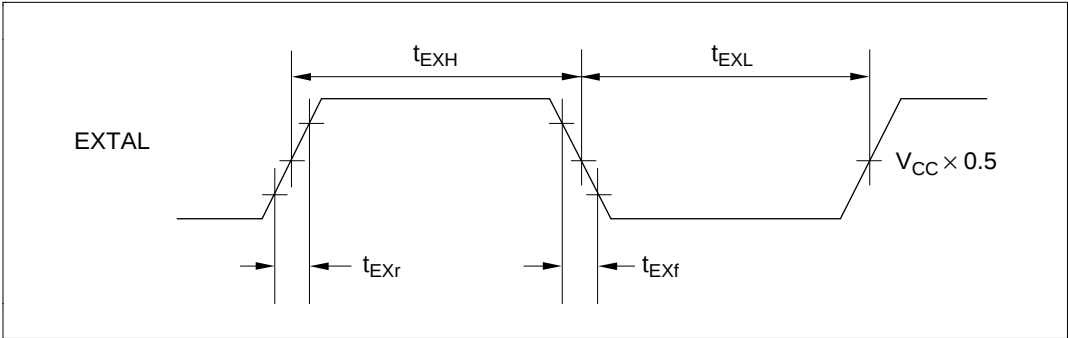
(b) Connections with inverted clock input at XTAL pin

**Figure 6-5 External Clock Input (Example)**

**External Clock Input:** The external clock signal should have the same frequency as the desired system clock ( $\phi$ ). Clock timing parameters are given in table 6-3 and figure 6-6.

**Table 6-3    Clock Timing**

| Item                                     | Symbol    | $V_{CC} = 2.7$<br>to 5.5 V |     | $V_{CC} = 4.0$<br>to 5.5 V |     | $V_{CC} = 5.0$ V<br>$\pm 10\%$ |     | Unit      | Test Conditions   |
|------------------------------------------|-----------|----------------------------|-----|----------------------------|-----|--------------------------------|-----|-----------|-------------------|
|                                          |           | Min                        | Max | Min                        | Max | Min                            | Max |           |                   |
| Low pulse width of external clock input  | $t_{EXL}$ | 40                         | —   | 30                         | —   | 20                             | —   | ns        | Figure 6-6        |
| High pulse width of external clock input | $t_{EXH}$ | 40                         | —   | 30                         | —   | 20                             | —   | ns        |                   |
| External clock rise time                 | $t_{EXr}$ | —                          | 10  | —                          | 10  | —                              | 5   | ns        |                   |
| External clock fall time                 | $t_{EXf}$ | —                          | 10  | —                          | 10  | —                              | 5   | ns        |                   |
| Clock pulse width low                    | $t_{CL}$  | 0.3                        | 0.7 | 0.3                        | 0.7 | 0.3                            | 0.7 | $t_{cyc}$ | $\phi \geq 5$ MHz |
|                                          |           | 0.4                        | 0.6 | 0.4                        | 0.6 | 0.4                            | 0.6 | $t_{cyc}$ | $\phi < 5$ MHz    |
| Clock pulse width high                   | $t_{CH}$  | 0.3                        | 0.7 | 0.3                        | 0.7 | 0.3                            | 0.7 | $t_{cyc}$ | $\phi \geq 5$ MHz |
|                                          |           | 0.4                        | 0.6 | 0.4                        | 0.6 | 0.4                            | 0.6 | $t_{cyc}$ | $\phi < 5$ MHz    |



**Figure 6-6    External Clock Input Timing**

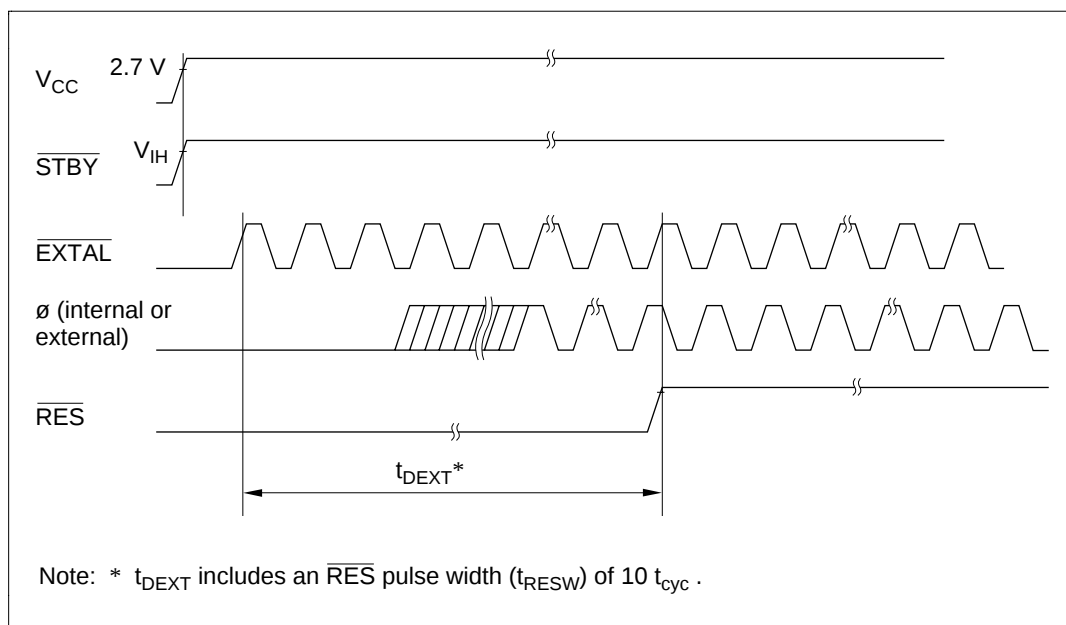
Table 6-4 shows the external clock output settling delay time, and figure 6-7 shows the external clock output settling delay timing. The oscillator circuit and duty adjustment circuit have a function for adjusting the waveform of the external clock input at the EXTAL pin. When the specified clock signal is input at the EXTAL pin, internal clock signal output is fixed after the elapse of the external clock output settling delay time ( $t_{\text{DEXT}}$ ). As the clock signal output is not fixed during the  $t_{\text{DEXT}}$  period, the reset signal should be driven low to maintain the reset state during this time.

**Table 6-4 External Clock Output Settling Delay Time**

(Conditions:  $V_{\text{CC}} = 2.7 \text{ V}$  to  $5.5 \text{ V}$ ,  $AV_{\text{CC}} = 2.7 \text{ V}$  to  $5.5 \text{ V}$ ,  $V_{\text{SS}} = AV_{\text{SS}} = 0 \text{ V}$ )

| Item                                      | Symbol              | Min | Max | Unit          | Notes      |
|-------------------------------------------|---------------------|-----|-----|---------------|------------|
| External clock output settling delay time | $t_{\text{DEXT}}^*$ | 500 | —   | $\mu\text{s}$ | Figure 6-7 |

Note: \*  $t_{\text{DEXT}}$  includes an  $\overline{\text{RES}}$  pulse width ( $t_{\text{RESW}}$ ) of  $10 t_{\text{cyc}}$ .



**Figure 6-7 External Clock Output Settling Delay Time Timing**

## 6.3 Duty Adjustment Circuit

When the clock frequency is 5 MHz or above, the duty adjustment circuit adjusts the duty cycle of the signal from the oscillator circuit to generate the system clock ( $\phi$ ).

## 6.4 Prescaler

The 1/2 frequency divider generates an on-chip supporting module clock ( $\phi_P$ ) from the system clock ( $\phi$ ) according to the setting of the CKDBL bit. The prescaler divides the frequency of  $\phi_P$  to generate internal clock signals with frequencies from  $\phi_P/2$  to  $\phi_P/4096$ .



## Section 7 I/O Ports

### 7.1 Overview

The H8/3217 Series has five 8-bit input/output ports, one 7-bit input/output port, and one 6-bit input/output port.

Table 7-1 lists the functions of each port in each operating mode. As table 7-1 indicates, the port pins are multiplexed, and the pin functions differ depending on the operating mode.

Each port has a data direction register (DDR) that selects input or output, and a data register (DR) that stores output data. If bit manipulation instructions will be executed on the port data direction registers, see “Notes on Bit Manipulation Instructions” in section 2.5.5, Bit Manipulations.

Ports 1, 2, 3, 6, and 7 can drive one TTL load and a 90-pF capacitive load. Port 4 (excluding pin P4<sub>6</sub>) and port 5 can drive one TTL load and a 30-pF capacitive load. Ports 1, 2, and 3 can drive LEDs (with 10-mA current sink). Ports 1 to 7 can drive a Darlington transistor. Ports 1 to 3 and pins P6<sub>0</sub> to P6<sub>3</sub> and P7<sub>0</sub> to P7<sub>3</sub> have built-in MOS pull-ups.

Pins P7<sub>0</sub> to P7<sub>3</sub> (including SCL and SDA) of port 7 can drive a bus buffer. See section 14, I<sup>2</sup>C Bus Interface, for details of bus buffer driving.

Note that the H8/3212 and H8/3202 have a subset specification that does not include certain of the on-chip supporting modules. See tables 1-2 to 1-4, Pin Assignments in Each Operating Mode, and table 7-1, Port Functions, for differences in the pin functions.

For block diagrams of the ports, see appendix C, I/O Port Block Diagrams.

**Table 7-1 (a) H8/3217, H8/3216, and H8/3214 Port Functions**

| Port   | Description                                                                                                               | Pins                                                                                                                                                                                                                                                                                                                                   | Expanded Modes                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                      | Single-Chip Mode                                                                                                       |
|--------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|        |                                                                                                                           |                                                                                                                                                                                                                                                                                                                                        | Mode 1                                                                                                                                                                                                                                                                                                                                                     | Mode 2                                                                                                                               | Mode 3                                                                                                                 |
| Port 1 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P1 <sub>7</sub> to P1 <sub>0</sub> /<br>A <sub>7</sub> to A <sub>0</sub> /<br>PW <sub>7</sub> to PW <sub>0</sub>                                                                                                                                                                                                                       | Lower address output (A <sub>7</sub> to A <sub>0</sub> )                                                                                                                                                                                                                                                                                                   | Lower address output (A <sub>7</sub> to A <sub>0</sub> ), general input, or PWM timer output (PW <sub>7</sub> to PW <sub>0</sub> )   | PWM timer output (PW <sub>7</sub> to PW <sub>0</sub> ) or general input/output                                         |
| Port 2 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P2 <sub>7</sub> to P2 <sub>0</sub> /<br>A <sub>15</sub> to A <sub>8</sub> /<br>PW <sub>15</sub> to PW <sub>8</sub>                                                                                                                                                                                                                     | Upper address output (A <sub>15</sub> to A <sub>8</sub> )                                                                                                                                                                                                                                                                                                  | Upper address output (A <sub>15</sub> to A <sub>8</sub> ), general input, or PWM timer output (PW <sub>15</sub> to PW <sub>8</sub> ) | PWM timer output (PW <sub>15</sub> to PW <sub>8</sub> ) or general input/output                                        |
| Port 3 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P3 <sub>7</sub> to P3 <sub>0</sub> /<br>D <sub>7</sub> to D <sub>0</sub> /<br>HDB <sub>7</sub> to HDB <sub>0</sub>                                                                                                                                                                                                                     | Data bus (D <sub>7</sub> to D <sub>0</sub> )                                                                                                                                                                                                                                                                                                               |                                                                                                                                      | Host interface data bus (HDB <sub>7</sub> to HDB <sub>0</sub> ) or general input/output                                |
| Port 4 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> </ul>                                                          | P4 <sub>7</sub> /TMO <sub>x</sub> /<br>CLAMPO/<br>GA <sub>20</sub>                                                                                                                                                                                                                                                                     | Host interface control output (GA <sub>20</sub> ), 8-bit timer X output (TMO <sub>x</sub> ), general input/output, or timer connection output (CLAMPO)                                                                                                                                                                                                     |                                                                                                                                      |                                                                                                                        |
|        |                                                                                                                           | P4 <sub>6</sub> /ø/<br>FBACKI/ $\overline{\text{CS}}_2$                                                                                                                                                                                                                                                                                | ø output                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                      | Host interface control input ( $\overline{\text{CS}}_2$ ), general input, timer connection input (FBACKI), or ø output |
|        |                                                                                                                           | P4 <sub>5</sub> /TMRI <sub>1</sub> /<br>CSYNCl/<br>HIRQ <sub>12</sub><br>P4 <sub>4</sub> /TMO <sub>1</sub> /<br>HSYNCO/<br>HIRQ <sub>1</sub><br>P4 <sub>3</sub> /TMCI <sub>1</sub> /<br>HSYNCl/<br>HIRQ <sub>11</sub><br>P4 <sub>2</sub> /TMRI <sub>0</sub><br>P4 <sub>1</sub> /TMO <sub>0</sub><br>P4 <sub>0</sub> /TMCI <sub>0</sub> | Host interface host CPU interrupt request output (HIRQ <sub>12</sub> , HIRQ <sub>1</sub> , HIRQ <sub>11</sub> ), 8-bit timer 0 and 1 input/output (TMCI <sub>0</sub> , TMO <sub>0</sub> , TMRI <sub>0</sub> , TMCI <sub>1</sub> , TMO <sub>1</sub> , TMRI <sub>1</sub> ), timer connection input/output (CSYNCl, HSYNCO, HSYNCl), and general input/output |                                                                                                                                      |                                                                                                                        |

**Table 7-1 (a) H8/3217, H8/3216, and H8/3214 Port Functions (cont)**

|        |                                                                                                                                                                                                          |                                                                                                                                                                                                                                                  | Expanded Modes                                                                                                                                                                                                                                          |        | Single-Chip Mode                                                                                           |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------|
| Port   | Description                                                                                                                                                                                              | Pins                                                                                                                                                                                                                                             | Mode 1                                                                                                                                                                                                                                                  | Mode 2 | Mode 3                                                                                                     |
| Port 5 | <ul style="list-style-type: none"><li>6-bit I/O port</li></ul>                                                                                                                                           | P5 <sub>5</sub> /SCK <sub>1</sub><br>P5 <sub>4</sub> /RxD <sub>1</sub><br>P5 <sub>3</sub> /TxD <sub>1</sub><br>P5 <sub>2</sub> /SCK <sub>0</sub><br>P5 <sub>1</sub> /RxD <sub>0</sub><br>P5 <sub>0</sub> /TxD <sub>0</sub>                       | Serial communication interface 0 and 1 input/output (TxD <sub>0</sub> , RxD <sub>0</sub> , SCK <sub>0</sub> , TxD <sub>1</sub> , RxD <sub>1</sub> , SCK <sub>1</sub> ) or 6-bit general input/output                                                    |        |                                                                                                            |
| Port 6 | <ul style="list-style-type: none"><li>7-bit I/O port</li><li>Built-in input pull-ups (P6<sub>3</sub> to P6<sub>0</sub>)</li></ul>                                                                        | P6 <sub>6</sub> /IRQ <sub>2</sub><br>P6 <sub>5</sub> /IRQ <sub>1</sub><br>P6 <sub>4</sub> /IRQ <sub>0</sub>                                                                                                                                      | IRQ <sub>2</sub> to IRQ <sub>0</sub> or general input/output                                                                                                                                                                                            |        |                                                                                                            |
|        |                                                                                                                                                                                                          | P6 <sub>3</sub> /FTI/<br>VSYNCI/<br>KEYIN <sub>3</sub><br>P6 <sub>2</sub> /FTOB/<br>VSYNCO/<br>KEYIN <sub>2</sub><br>P6 <sub>1</sub> /FTOA/<br>KEYIN <sub>1</sub><br>P6 <sub>0</sub> /FTCI/<br>KEYIN <sub>0</sub>                                | 16-bit free-running timer input/output (FTCI, FTOA, FTOB, FTI), timer connection input/output (VSYNCI, VSYNCO), or general input/output (Can also be used as key-scanning key-sense input (KEYIN <sub>3</sub> to KEYIN <sub>0</sub> ))                  |        |                                                                                                            |
| Port 7 | <ul style="list-style-type: none"><li>8-bit I/O port</li><li>Bus buffer drive capability (P7<sub>3</sub> to P7<sub>0</sub>)</li><li>Built-in input pull-ups (P7<sub>3</sub> to P7<sub>0</sub>)</li></ul> | P7 <sub>7</sub> /WAIT/<br>HA <sub>0</sub><br>P7 <sub>6</sub> /RD/IOR<br>P7 <sub>5</sub> /WR/IOW<br>P7 <sub>4</sub> /AS/CS <sub>1</sub>                                                                                                           | Expanded data bus control input/output (WAIT, RD, WR, AS)                                                                                                                                                                                               |        | Host interface control input/output (HA <sub>0</sub> , IOR, IOW, CS <sub>1</sub> ) or general input/output |
|        |                                                                                                                                                                                                          | P7 <sub>3</sub> /SDA <sub>1</sub> /<br>KEYIN <sub>7</sub><br>P7 <sub>2</sub> /SCL <sub>1</sub> /<br>KEYIN <sub>6</sub><br>P7 <sub>1</sub> /SDA <sub>0</sub> /<br>KEYIN <sub>5</sub><br>P7 <sub>0</sub> /SCL <sub>0</sub> /<br>KEYIN <sub>4</sub> | I <sup>2</sup> C bus interface 0 and 1 input/output (SDA <sub>0</sub> , SCL <sub>0</sub> , SDA <sub>1</sub> , SCL <sub>1</sub> ) or general input/output (Can also be used as key-scanning key-sense input (KEYIN <sub>7</sub> to KEYIN <sub>4</sub> )) |        |                                                                                                            |

**Table 7-1 (b) H8/3212 Port Functions**

| Port   | Description                                                                                                               | Pins                                                                                                                                                                                                                                                               | Expanded Modes                                                                                                                                                                                                                            |                                                                                                                                      | Single-Chip Mode                                                                |
|--------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|        |                                                                                                                           |                                                                                                                                                                                                                                                                    | Mode 1                                                                                                                                                                                                                                    | Mode 2                                                                                                                               | Mode 3                                                                          |
| Port 1 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P1 <sub>7</sub> to P1 <sub>0</sub> /<br>A <sub>7</sub> to A <sub>0</sub> /<br>PW <sub>7</sub> to PW <sub>0</sub>                                                                                                                                                   | Lower address output (A <sub>7</sub> to A <sub>0</sub> )                                                                                                                                                                                  | Lower address output (A <sub>7</sub> to A <sub>0</sub> ), general input, or PWM timer output (PW <sub>7</sub> to PW <sub>0</sub> )   | PWM timer output (PW <sub>7</sub> to PW <sub>0</sub> ) or general input/output  |
| Port 2 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P2 <sub>7</sub> to P2 <sub>0</sub> /<br>A <sub>15</sub> to A <sub>8</sub> /<br>PW <sub>15</sub> to PW <sub>8</sub>                                                                                                                                                 | Upper address output (A <sub>15</sub> to A <sub>8</sub> )                                                                                                                                                                                 | Upper address output (A <sub>15</sub> to A <sub>8</sub> ), general input, or PWM timer output (PW <sub>15</sub> to PW <sub>8</sub> ) | PWM timer output (PW <sub>15</sub> to PW <sub>8</sub> ) or general input/output |
| Port 3 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P3 <sub>7</sub> to P3 <sub>0</sub> /<br>D <sub>7</sub> to D <sub>0</sub>                                                                                                                                                                                           | Data bus (D <sub>7</sub> to D <sub>0</sub> )                                                                                                                                                                                              |                                                                                                                                      | General input/output                                                            |
| Port 4 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> </ul>                                                          | P4 <sub>7</sub> /TMO <sub>X</sub> /<br>CLAMPO                                                                                                                                                                                                                      | 8-bit timer X output (TMO <sub>X</sub> ), general input/output, or timer connection output (CLAMPO)                                                                                                                                       |                                                                                                                                      |                                                                                 |
|        |                                                                                                                           | P4 <sub>6</sub> /ø/<br>FBACKI                                                                                                                                                                                                                                      | ø output                                                                                                                                                                                                                                  |                                                                                                                                      | General input, timer connection input (FBACKI), or ø output                     |
|        |                                                                                                                           | P4 <sub>5</sub> /TMRI <sub>1</sub> /<br>CSYNCI<br>P4 <sub>4</sub> /TMO <sub>1</sub> /<br>HSYNCO<br>P4 <sub>3</sub> /TMCI <sub>1</sub> /<br>HSYNCI<br>P4 <sub>2</sub> /TMRI <sub>0</sub><br>P4 <sub>1</sub> /TMO <sub>0</sub><br>P4 <sub>0</sub> /TMCI <sub>0</sub> | 8-bit timer 0 and 1 input/output (TMCI <sub>0</sub> , TMO <sub>0</sub> , TMRI <sub>0</sub> , TMCI <sub>1</sub> , TMO <sub>1</sub> , TMRI <sub>1</sub> ), timer connection input/output (CSYNCI, HSYNCO, HSYNCI), and general input/output |                                                                                                                                      |                                                                                 |

**Table 7-1 (b) H8/3212 Port Functions (cont)**

| Port   | Description                                                                             | Pins                                                                                                                                                                           | Expanded Modes                                                                                                                                           |        | Single-Chip Mode     |
|--------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------|
|        |                                                                                         |                                                                                                                                                                                | Mode 1                                                                                                                                                   | Mode 2 | Mode 3               |
| Port 5 | • 6-bit I/O port                                                                        | P5 <sub>5</sub><br>P5 <sub>4</sub><br>P5 <sub>3</sub><br>P5 <sub>2</sub> /SCK <sub>0</sub><br>P5 <sub>1</sub> /RxD <sub>0</sub><br>P5 <sub>0</sub> /TxD <sub>0</sub>           | Serial communication interface 0 input/output (TxD <sub>0</sub> , RxD <sub>0</sub> , SCK <sub>0</sub> ) or 6-bit general input/output                    |        |                      |
| Port 6 | • 7-bit I/O port                                                                        | P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$<br>P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$<br>P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$                                      | $\overline{\text{IRQ}}_2$ to $\overline{\text{IRQ}}_0$ or general input/output                                                                           |        |                      |
|        |                                                                                         | P6 <sub>3</sub> /FTI/<br>VSYNCl<br>P6 <sub>2</sub> /FTOB/<br>VSYNCO<br>P6 <sub>1</sub> /FTOA<br>P6 <sub>0</sub> /FTCI                                                          | 16-bit free-running timer input/output (FTCI, FTOA, FTOB, FTI), timer connection input/output (VSYNCl, VSYNCO), or general input/output                  |        |                      |
| Port 7 | • 8-bit I/O port<br>• Bus buffer drive capability (P7 <sub>3</sub> to P7 <sub>0</sub> ) | P7 <sub>7</sub> / $\overline{\text{WAIT}}$<br>P7 <sub>6</sub> / $\overline{\text{RD}}$<br>P7 <sub>5</sub> / $\overline{\text{WR}}$<br>P7 <sub>4</sub> / $\overline{\text{AS}}$ | Expanded data bus control input/output ( $\overline{\text{WAIT}}$ , $\overline{\text{RD}}$ , $\overline{\text{WR}}$ , $\overline{\text{AS}}$ )           |        | General input/output |
|        |                                                                                         | P7 <sub>3</sub> /SDA <sub>1</sub><br>P7 <sub>2</sub> /SCL <sub>1</sub><br>P7 <sub>1</sub> /SDA <sub>0</sub><br>P7 <sub>0</sub> /SCL <sub>0</sub>                               | I <sup>2</sup> C bus interface 0 and 1 input/output (SDA <sub>0</sub> , SCL <sub>0</sub> , SDA <sub>1</sub> , SCL <sub>1</sub> ) or general input/output |        |                      |

**Table 7-1 (c) H8/3202 Port Functions**

| Port   | Description                                                                                                               | Pins                                                                                                                                                                                                                                                                                                  | Expanded Modes                                                                                                                                                                                                                                                                                     |                                                                            | Single-Chip Mode                                                                        |
|--------|---------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
|        |                                                                                                                           |                                                                                                                                                                                                                                                                                                       | Mode 1                                                                                                                                                                                                                                                                                             | Mode 2                                                                     | Mode 3                                                                                  |
| Port 1 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P1 <sub>7</sub> to P1 <sub>0</sub> /<br>A <sub>7</sub> to A <sub>0</sub>                                                                                                                                                                                                                              | Lower address output (A <sub>7</sub> to A <sub>0</sub> )                                                                                                                                                                                                                                           | Lower address output (A <sub>7</sub> to A <sub>0</sub> ) or general input  | General input/output                                                                    |
| Port 2 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P2 <sub>7</sub> to P2 <sub>0</sub> /<br>A <sub>15</sub> to A <sub>8</sub>                                                                                                                                                                                                                             | Upper address output (A <sub>15</sub> to A <sub>8</sub> )                                                                                                                                                                                                                                          | Upper address output (A <sub>15</sub> to A <sub>8</sub> ) or general input | General input/output                                                                    |
| Port 3 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> <li>Can drive LEDs</li> <li>Built-in input pull-ups</li> </ul> | P3 <sub>7</sub> to P3 <sub>0</sub> /<br>D <sub>7</sub> to D <sub>0</sub> /<br>HDB <sub>7</sub> to HDB <sub>0</sub>                                                                                                                                                                                    | Data bus (D <sub>7</sub> to D <sub>0</sub> )                                                                                                                                                                                                                                                       |                                                                            | Host interface data bus (HDB <sub>7</sub> to HDB <sub>0</sub> ) or general input/output |
| Port 4 | <ul style="list-style-type: none"> <li>8-bit I/O port</li> </ul>                                                          | P4 <sub>7</sub> /GA <sub>20</sub>                                                                                                                                                                                                                                                                     | Host interface control output (GA <sub>20</sub> ) or general input/output                                                                                                                                                                                                                          |                                                                            |                                                                                         |
|        |                                                                                                                           | P4 <sub>6</sub> /ø/ $\overline{\text{CS}}_2$                                                                                                                                                                                                                                                          | ø output                                                                                                                                                                                                                                                                                           |                                                                            | Host interface control input ( $\overline{\text{CS}}_2$ ), general input, or ø output   |
|        |                                                                                                                           | P4 <sub>5</sub> /TMRI <sub>1</sub> /<br>HIRQ <sub>12</sub><br>P4 <sub>4</sub> /TMO <sub>1</sub> /<br>HIRQ <sub>1</sub><br>P4 <sub>3</sub> /TMCI <sub>1</sub> /<br>HIRQ <sub>11</sub><br>P4 <sub>2</sub> /TMRI <sub>0</sub><br>P4 <sub>1</sub> /TMO <sub>0</sub><br>P4 <sub>0</sub> /TMCI <sub>0</sub> | Host interface host CPU interrupt request output (HIRQ <sub>12</sub> , HIRQ <sub>1</sub> , HIRQ <sub>11</sub> ), 8-bit timer 0 and 1 input/output (TMCI <sub>0</sub> , TMO <sub>0</sub> , TMRI <sub>0</sub> , TMCI <sub>1</sub> , TMO <sub>1</sub> , TMRI <sub>1</sub> ), and general input/output |                                                                            |                                                                                         |

**Table 7-1 (c) H8/3202 Port Functions (cont)**

| Port   | Description                                                                                                                                                | Pins                                                                                                                                                                                                                                                                               | Expanded Modes                                                                                                                                                                                                 |        | Single-Chip Mode                                                                                                                                       |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
|        |                                                                                                                                                            |                                                                                                                                                                                                                                                                                    | Mode 1                                                                                                                                                                                                         | Mode 2 | Mode 3                                                                                                                                                 |
| Port 5 | • 6-bit I/O port                                                                                                                                           | P5 <sub>5</sub> /SCK <sub>1</sub><br>P5 <sub>4</sub> /RxD <sub>1</sub><br>P5 <sub>3</sub> /TxD <sub>1</sub><br>P5 <sub>2</sub> /SCK <sub>0</sub><br>P5 <sub>1</sub> /RxD <sub>0</sub><br>P5 <sub>0</sub> /TxD <sub>0</sub>                                                         | Serial communication interface 0 and 1 input/output (TxD <sub>0</sub> , RxD <sub>0</sub> , SCK <sub>0</sub> , TxD <sub>1</sub> , RxD <sub>1</sub> , SCK <sub>1</sub> ) or 6-bit general input/output           |        |                                                                                                                                                        |
| Port 6 | • 7-bit I/O port<br>• Built-in input pull-ups (P6 <sub>3</sub> to P6 <sub>0</sub> )                                                                        | P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$<br>P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$<br>P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$                                                                                                                                          | $\overline{\text{IRQ}}_2$ to $\overline{\text{IRQ}}_0$ or general input/output                                                                                                                                 |        |                                                                                                                                                        |
|        |                                                                                                                                                            | P6 <sub>3</sub> /FTI/<br>KEYIN <sub>3</sub><br>P6 <sub>2</sub> /FTOB/<br>KEYIN <sub>2</sub><br>P6 <sub>1</sub> /FTOA/<br>KEYIN <sub>1</sub><br>P6 <sub>0</sub> /FTCI/<br>KEYIN <sub>0</sub>                                                                                        | 16-bit free-running timer input/output (FTCI, FTOA, FTOB, FTI) or general input/output<br>(Can also be used as key-scanning key-sense input (KEYIN <sub>3</sub> to KEYIN <sub>0</sub> ))                       |        |                                                                                                                                                        |
| Port 7 | • 8-bit I/O port<br>• Bus buffer drive capability (P7 <sub>3</sub> to P7 <sub>0</sub> )<br>• Built-in input pull-ups (P7 <sub>3</sub> to P7 <sub>0</sub> ) | P7 <sub>7</sub> / $\overline{\text{WAIT}}$ /<br>HA <sub>0</sub><br>P7 <sub>6</sub> / $\overline{\text{RD}}$ / $\overline{\text{IOR}}$<br>P7 <sub>5</sub> / $\overline{\text{WR}}$ / $\overline{\text{IOW}}$<br>P7 <sub>4</sub> / $\overline{\text{AS}}$ / $\overline{\text{CS}}_1$ | Expanded data bus control input/output ( $\overline{\text{WAIT}}$ , $\overline{\text{RD}}$ , $\overline{\text{WR}}$ , $\overline{\text{AS}}$ )                                                                 |        | Host interface control input (HA <sub>0</sub> , $\overline{\text{IOR}}$ , $\overline{\text{IOW}}$ , $\overline{\text{CS}}_1$ ) or general input/output |
|        |                                                                                                                                                            | P7 <sub>3</sub> / $\overline{\text{KEYIN}}_7$<br>P7 <sub>2</sub> / $\overline{\text{KEYIN}}_6$<br>P7 <sub>1</sub> /SDA <sub>0</sub> /<br>KEYIN <sub>5</sub><br>P7 <sub>0</sub> /SCL <sub>0</sub> /<br>KEYIN <sub>4</sub>                                                           | I <sup>2</sup> C bus interface 0 input/output (SDA <sub>0</sub> , SCL <sub>0</sub> ) or general input/output<br>(Can also be used as key-scanning key-sense input (KEYIN <sub>7</sub> to KEYIN <sub>4</sub> )) |        |                                                                                                                                                        |

## 7.2 Port 1

### 7.2.1 Overview

Port 1 is an 8-bit input/output port with the pin configuration shown in figure 7-1. The pin functions differ depending on the operating mode.

Port 1 has built-in programmable MOS input pull-ups that can be used in modes 2 and 3.

Pins in port 1 can drive one TTL load and a 90-pF capacitive load. They can also drive LEDs and Darlington transistors.

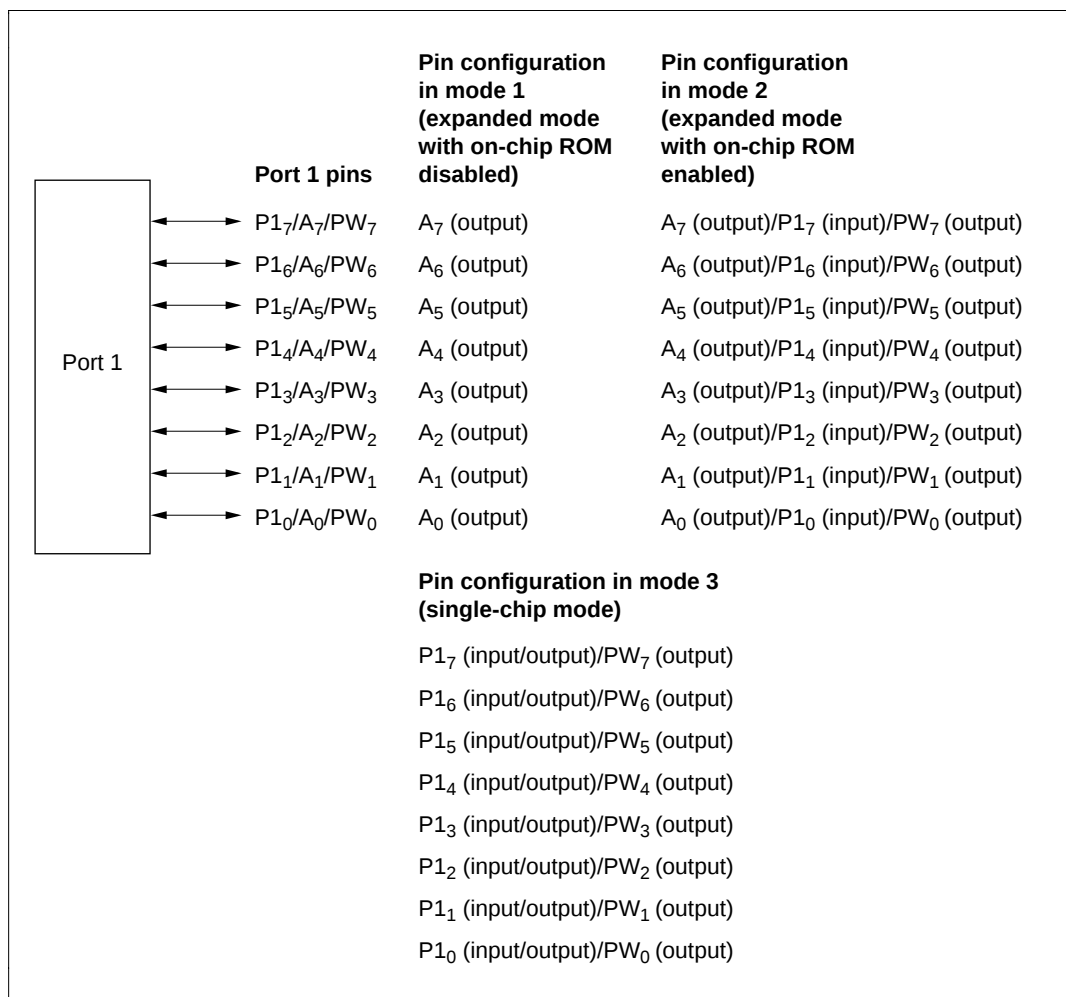


Figure 7-1 Port 1 Pin Configuration

## 7.2.2 Register Configuration and Descriptions

Table 7-2 summarizes the port 1 registers.

**Table 7-2 Port 1 Registers**

| Name                                  | Abbreviation | Read/Write | Initial Value                         | Address |
|---------------------------------------|--------------|------------|---------------------------------------|---------|
| Port 1 data direction register        | P1DDR        | W          | H'FF (mode 1)<br>H'00 (modes 2 and 3) | H'FFB0  |
| Port 1 data register                  | P1DR         | R/W        | H'00                                  | H'FFB2  |
| Port 1 input pull-up control register | P1PCR        | R/W        | H'00                                  | H'FFAC  |

### Port 1 Data Direction Register (P1DDR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR |
| Mode 1        |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   |
| Read/Write    | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |
| Modes 2 and 3 |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P1DDR controls the input/output direction of each pin in port 1.

**Mode 1:** The P1DDR values are fixed at 1. Port 1 consists of lower address output pins. P1DDR values cannot be modified and are always read as 1.

In hardware standby mode, the address bus is in the high-impedance state.

**Mode 2:** A pin in port 1 is used for address output or PWM output if the corresponding P1DDR bit is set to 1, and for general input if this bit is cleared to 0.

**Mode 3:** A pin in port 1 is used for general output or PWM output if the corresponding P1DDR bit is set to 1, and for general input if this bit is cleared to 0.

In modes 2 and 3, P1DDR is a write-only register. Read data is invalid. If read, all bits always read 1. P1DDR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P1DDR bit is set to 1, the corresponding pin remains in the output state.

### Port 1 Data Register (P1DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P1 <sub>7</sub> | P1 <sub>6</sub> | P1 <sub>5</sub> | P1 <sub>4</sub> | P1 <sub>3</sub> | P1 <sub>2</sub> | P1 <sub>1</sub> | P1 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P1DR is an 8-bit register that stores data for pins P1<sub>7</sub> to P1<sub>0</sub>. When a P1DDR bit is set to 1, if port 1 is read, the value in P1DR is obtained directly, regardless of the actual pin state. When a P1DDR bit is cleared to 0, if port 1 is read the pin state is obtained.

P1DR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### Port 1 Input Pull-Up Control Register (P1PCR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P1 <sub>7</sub> PCR | P1 <sub>6</sub> PCR | P1 <sub>5</sub> PCR | P1 <sub>4</sub> PCR | P1 <sub>3</sub> PCR | P1 <sub>2</sub> PCR | P1 <sub>1</sub> PCR | P1 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

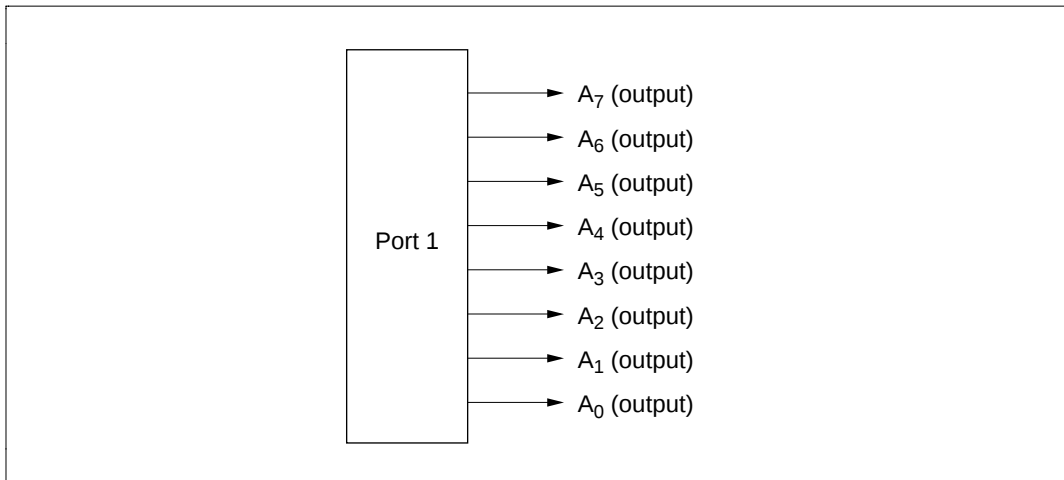
P1PCR is an 8-bit readable/writable register that controls the MOS input pull-ups in port 1. If a P1DDR bit is cleared to 0 (designating input) and the corresponding P1PCR bit is set to 1, the MOS input pull-up is turned on.

P1PCR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### 7.2.3 Pin Functions in Each Mode

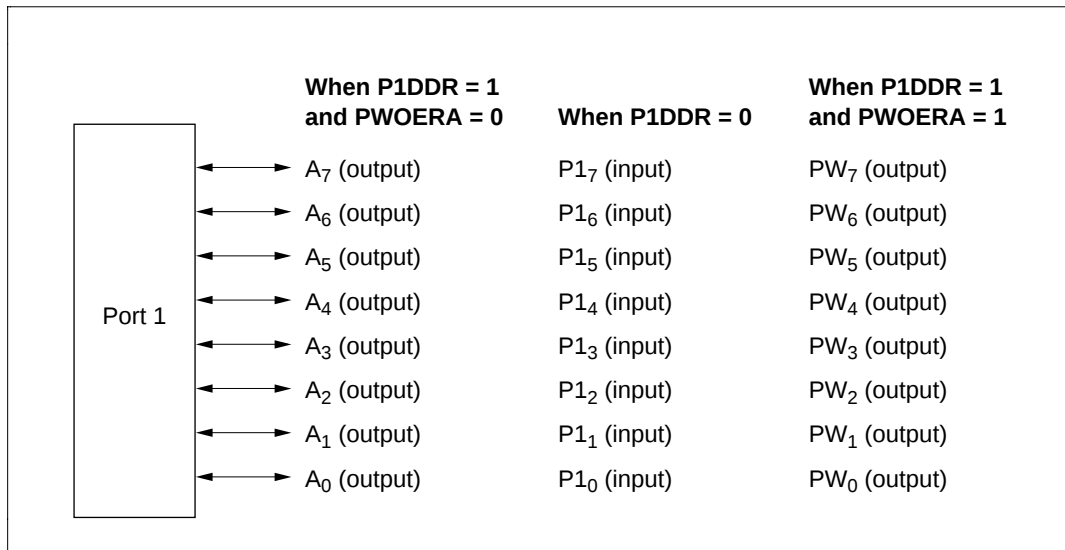
Port 1 has different pin functions in different modes. A separate description for each mode is given below.

**Pin Functions in Mode 1:** In mode 1 (expanded mode with on-chip ROM disabled), port 1 is automatically used for lower address output ( $A_7$  to  $A_0$ ). Figure 7-2 shows the pin functions in mode 1.



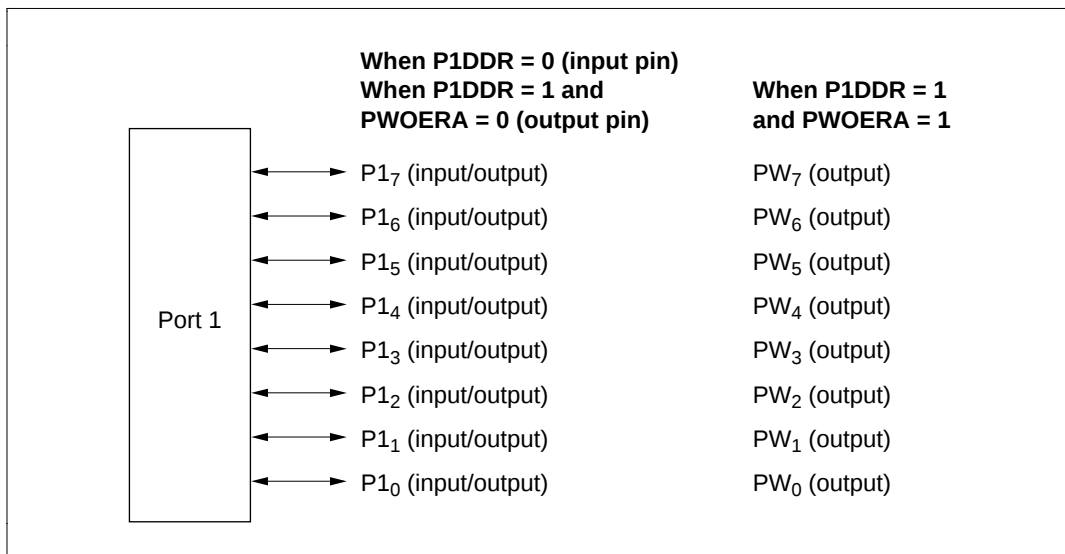
**Figure 7-2 Pin Functions in Mode 1 (Port 1)**

**Mode 2:** In mode 2 (expanded mode with on-chip ROM enabled), port 1 can provide lower address output pins, PWM output pins, and general input pins. Each pin becomes a lower address output pin or PWM output pin if its P1DDR bit is set to 1, and a general input pin if this bit is cleared to 0. Following a reset, all pins are input pins. To be used for address output or PWM output, their P1DDR bits must be set to 1. Figure 7-3 shows the pin functions in mode 2.



**Figure 7-3 Pin Functions in Mode 2 (Port 1)**

**Mode 3:** In mode 3 (single-chip mode), port 1 can provide PWM output pins and general input/output pins. When used for general input/output, the input or output direction of each pin can be selected individually. A pin becomes a general input pin when its P1DDR bit is cleared to 0. When this bit is cleared to 0, the corresponding pin becomes a general output pin if the PWOERA bit is cleared to 0, and a PWM output pin if the PWOERA bit is set to 1. Figure 7-4 shows the pin functions in mode 3.



**Figure 7-4 Pin Functions in Mode 3 (Port 1)**

## 7.2.4 MOS Input Pull-Ups

Port 1 has built-in programmable MOS input pull-ups that are available in modes 2 and 3. The pull-up for each bit can be turned on and off individually. To turn on an input pull-up in mode 2 or 3, set the corresponding P1PCR bit to 1 and clear the corresponding P1DDR bit to 0. P1PCR is cleared to H'00 by a reset and in hardware standby mode, turning all input pull-ups off. In software standby mode, the previous state is maintained.

Table 7-3 indicates the states of the MOS input pull-ups in each operating mode.

**Table 7-3 States of MOS Input Pull-Ups (Port 1)**

| Mode | Reset | Hardware Standby | Software Standby | Other Operating Modes |
|------|-------|------------------|------------------|-----------------------|
| 1    | Off   | Off              | Off              | Off                   |
| 2    | Off   | Off              | On/off           | On/off                |
| 3    | Off   | Off              | On/off           | On/off                |

Notes: Off: The MOS input pull-up is always off.

On/off: The MOS input pull-up is on if P1PCR = 1 and P1DDR = 0, but off otherwise.

## 7.3 Port 2

### 7.3.1 Overview

Port 2 is an 8-bit input/output port with the pin configuration shown in figure 7-5. The pin functions differ depending on the operating mode.

Port 2 has built-in, software-controllable MOS input pull-ups that can be used in modes 2 and 3.

Pins in port 2 can drive one TTL load and a 90-pF capacitive load. They can also drive LEDs and Darlington transistors.

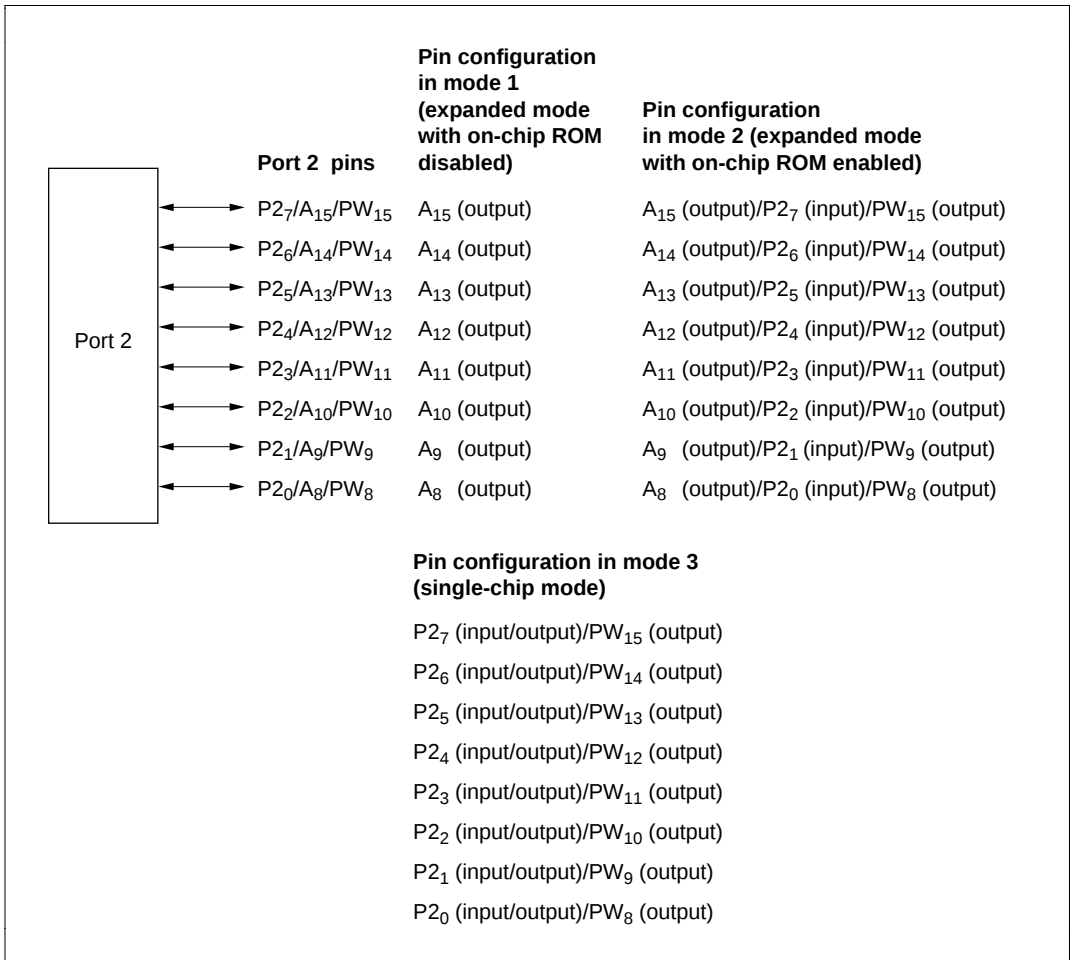


Figure 7-5 Port 2 Pin Configuration

## 7.3.2 Register Configuration and Descriptions

Table 7-4 summarizes the port 2 registers.

**Table 7-4 Port 2 Registers**

| Name                                  | Abbreviation | Read/Write | Initial Value                         | Address |
|---------------------------------------|--------------|------------|---------------------------------------|---------|
| Port 2 data direction register        | P2DDR        | W          | H'FF (mode 1)<br>H'00 (modes 2 and 3) | H'FFB1  |
| Port 2 data register                  | P2DR         | R/W        | H'00                                  | H'FFB3  |
| Port 2 input pull-up control register | P2PCR        | R/W        | H'00                                  | H'FFAD  |

### Port 2 Data Direction Register (P2DDR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR |
| Mode 1        |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   |
| Read/Write    | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |
| Modes 2 and 3 |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P2DDR controls the input/output direction of each pin in port 2.

**Mode 1:** The P2DDR values are fixed at 1. Port 2 consists of upper address output pins. P2DDR values cannot be modified and are always read as 1.

In hardware standby mode, the address bus is in the high-impedance state.

**Mode 2:** A pin in port 2 is used for address output or PWM output if the corresponding P2DDR bit is set to 1, and for general input if this bit is cleared to 0.

**Mode 3:** A pin in port 2 is used for general output or PWM output if the corresponding P2DDR bit is set to 1, and for general input if this bit is cleared to 0.

In modes 2 and 3, P2DDR is a write-only register. Read data is invalid. If read, all bits always read 1. P2DDR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P2DDR bit is set to 1, the corresponding pin remains in the output state.

### Port 2 Data Register (P2DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P2 <sub>7</sub> | P2 <sub>6</sub> | P2 <sub>5</sub> | P2 <sub>4</sub> | P2 <sub>3</sub> | P2 <sub>2</sub> | P2 <sub>1</sub> | P2 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P2DR is an 8-bit register that stores data for pins P2<sub>7</sub> to P2<sub>0</sub>. When a P2DDR bit is set to 1, if port 2 is read, the value in P2DR is obtained directly, regardless of the actual pin state. When a P2DDR bit is cleared to 0, if port 2 is read the pin state is obtained.

P2DR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### Port 2 Input Pull-Up Control Register (P2PCR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P2 <sub>7</sub> PCR | P2 <sub>6</sub> PCR | P2 <sub>5</sub> PCR | P2 <sub>4</sub> PCR | P2 <sub>3</sub> PCR | P2 <sub>2</sub> PCR | P2 <sub>1</sub> PCR | P2 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

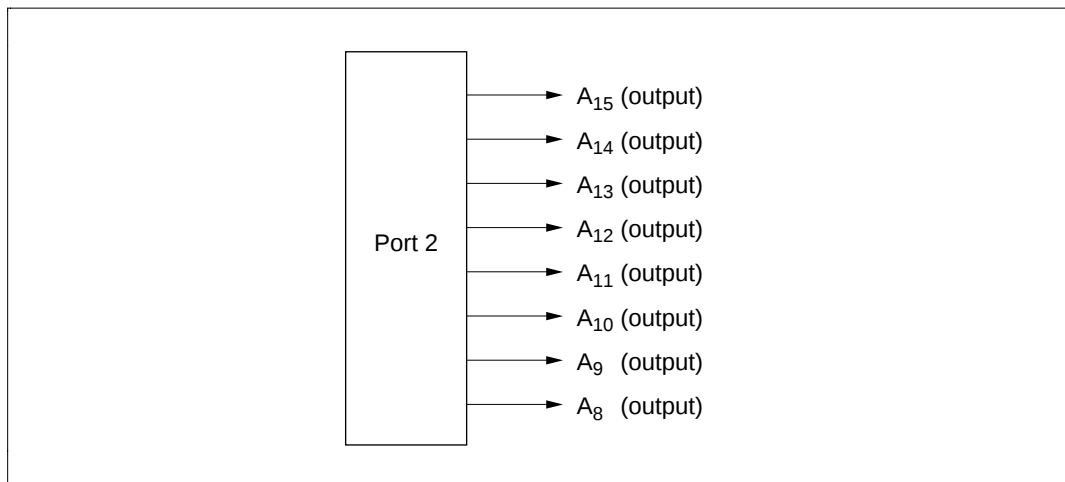
P2PCR is an 8-bit readable/writable register that controls the MOS input pull-ups in port 2. If a P2DDR bit is cleared to 0 (designating input) and the corresponding P2PCR bit is set to 1, the MOS input pull-up is turned on.

P2PCR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### 7.3.3 Pin Functions in Each Mode

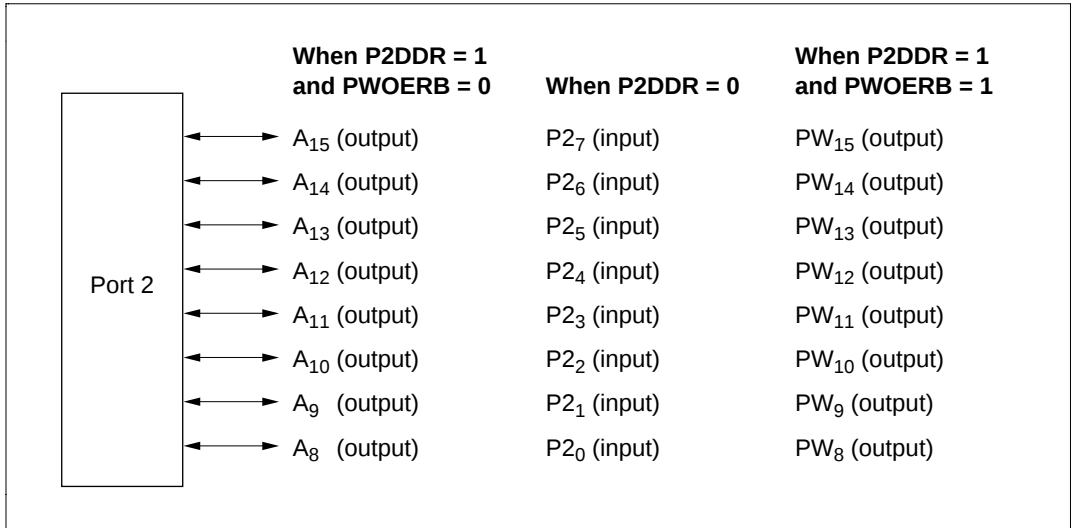
Port 2 has different pin functions in different modes. A separate description for each mode is given below.

**Pin Functions in Mode 1:** In mode 1 (expanded mode with on-chip ROM disabled), port 2 is automatically used for upper address output ( $A_{15}$  to  $A_8$ ). Figure 7-6 shows the pin functions in mode 1.



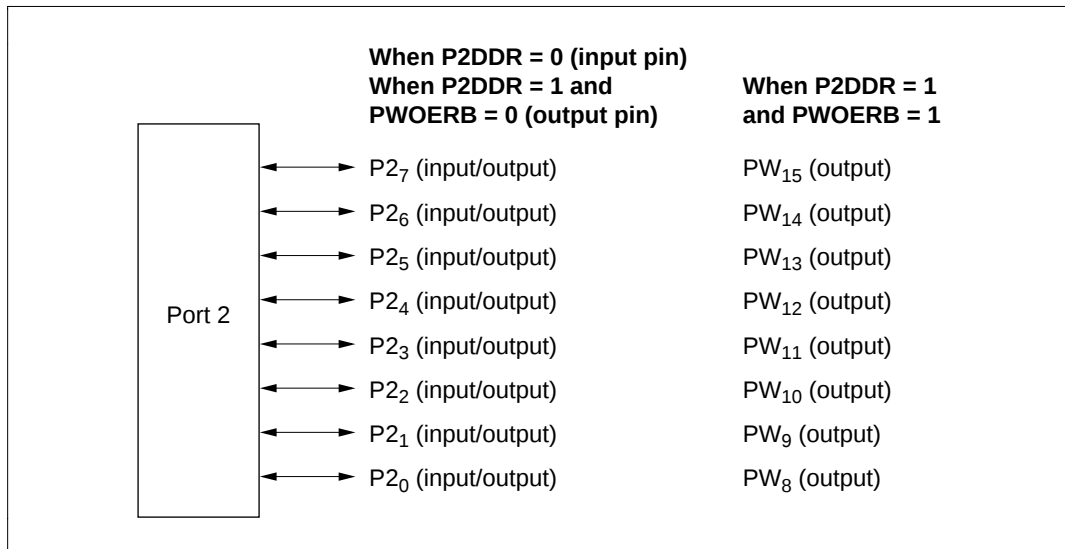
**Figure 7-6 Pin Functions in Mode 1 (Port 2)**

**Mode 2:** In mode 2 (expanded mode with on-chip ROM enabled), port 2 can provide upper address output pins, PWM output pins, and general input pins. Each pin becomes an upper address output pin or PWM output pin if its P2DDR bit is set to 1, and a general input pin if this bit is cleared to 0. Following a reset, all pins are input pins. To be used for address output or PWM output, their P2DDR bits must be set to 1. Figure 7-7 shows the pin functions in mode 2.



**Figure 7-7 Pin Functions in Mode 2 (Port 2)**

**Mode 3:** In mode 3 (single-chip mode) port 2 can provide PWM output pins and general input/output pins. When used for general input/output, the input or output direction of each pin can be selected individually. A pin becomes a general input pin when its P2DDR bit is cleared to 0. When this bit is cleared to 0, the corresponding pin becomes a general output pin if the PWOERB bit is cleared to 0, and a PWM output pin if the PWOERB bit is set to 1. Figure 7-8 shows the pin functions in mode 3.



**Figure 7-8 Pin Functions in Mode 3 (Port 2)**

### 7.3.4 MOS Input Pull-Ups

Port 2 has built-in programmable MOS input pull-ups that are available in modes 2 and 3. The pull-up for each bit can be turned on and off individually. To turn on an input pull-up in mode 2 or 3, set the corresponding P2PCR bit to 1 and clear the corresponding P2DDR bit to 0. P2PCR is cleared to H'00 by a reset and in hardware standby mode, turning all input pull-ups off. In software standby mode, the previous state is maintained.

Table 7-5 indicates the states of the input pull-up transistors in each operating mode.

**Table 7-5 States of MOS Input Pull-Ups (Port 2)**

| Mode | Reset | Hardware Standby | Software Standby | Other Operating Modes |
|------|-------|------------------|------------------|-----------------------|
| 1    | Off   | Off              | Off              | Off                   |
| 2    | Off   | Off              | On/off           | On/off                |
| 3    | Off   | Off              | On/off           | On/off                |

Notes: Off: The MOS input pull-up is always off.

On/off: The MOS input pull-up is on if P2PCR = 1 and P2DDR = 0, but off otherwise.

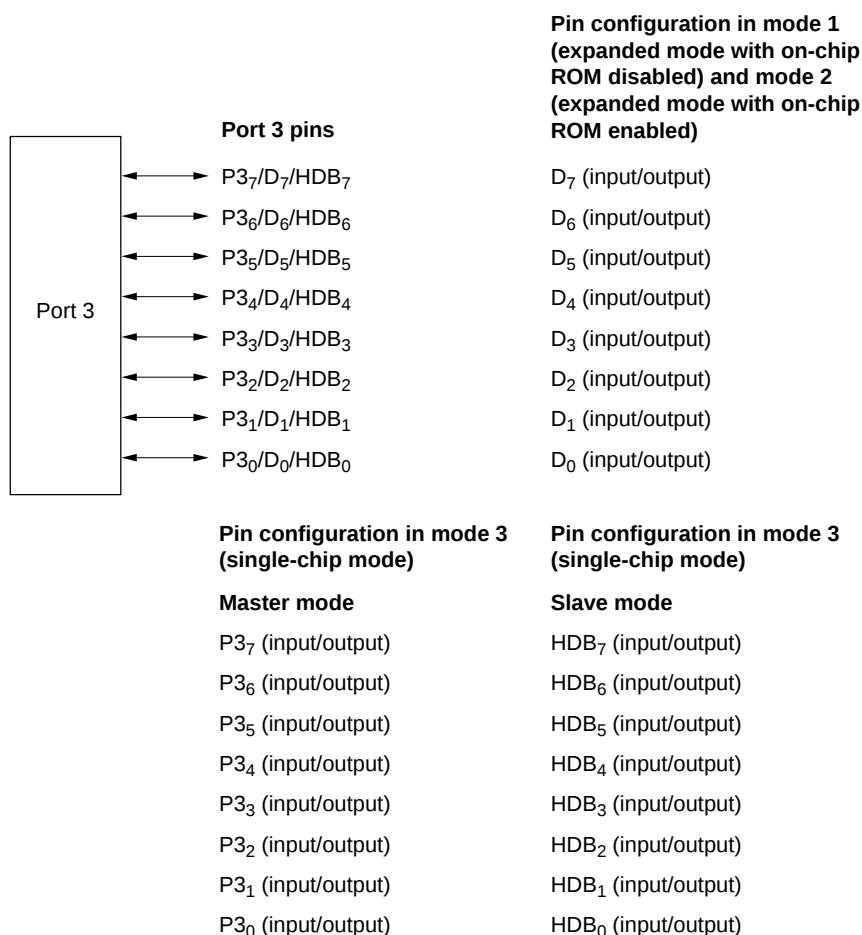
## 7.4 Port 3

### 7.4.1 Overview

Port 3 is an 8-bit input/output port that is multiplexed with the data bus and host interface data bus. Its pin configuration is shown in figure 7-9. The pin functions differ depending on the operating mode.

Port 3 has built-in programmable MOS input pull-ups that can be used in mode 3.

Pins in port 3 can drive one TTL load and a 90-pF capacitive load. They can also drive a LED and a Darlington transistor.



**Figure 7-9 Port 3 Pin Configuration**

## 7.4.2 Register Configuration and Descriptions

Table 7-6 summarizes the port 3 registers.

**Table 7-6 Port 3 Registers**

| Name                                  | Abbreviation | Read/Write | Initial Value | Address |
|---------------------------------------|--------------|------------|---------------|---------|
| Port 3 data direction register        | P3DDR        | W          | H'00          | H'FFB4  |
| Port 3 data register                  | P3DR         | R/W        | H'00          | H'FFB6  |
| Port 3 input pull-up control register | P3PCR        | R/W        | H'00          | H'FFAE  |

### Port 3 Data Direction Register (P3DDR)

| Bit           | 7                  | 6                  | 5                  | 4                  | 3                  | 2                  | 1                  | 0                  |
|---------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|               | P <sub>7</sub> DDR | P <sub>6</sub> DDR | P <sub>5</sub> DDR | P <sub>4</sub> DDR | P <sub>3</sub> DDR | P <sub>2</sub> DDR | P <sub>1</sub> DDR | P <sub>0</sub> DDR |
| Initial value | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  | 0                  |
| Read/Write    | W                  | W                  | W                  | W                  | W                  | W                  | W                  | W                  |

P3DDR is an 8-bit readable/writable register that controls the input/output direction of each pin in port 3. P3DDR is a write-only register. Read data is invalid. If read, all bits always read 1.

**Modes 1 and 2:** In mode 1 (expanded mode with on-chip ROM disabled) and mode 2 (expanded mode with on-chip ROM enabled), the input/output directions designated by P3DDR are ignored. Port 3 automatically consists of the input/output pins of the 8-bit data bus (D<sub>7</sub> to D<sub>0</sub>).

The data bus is in the high-impedance state during reset, and during hardware and software standby.

**Mode 3:** A pin in port 3 is used for general output if the corresponding P3DDR bit is set to 1, and for general input if this bit is cleared to 0. P3DDR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P3DDR bit is set to 1, the corresponding pin remains in the output state.

### Port 3 Data Register (P3DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P3 <sub>7</sub> | P3 <sub>6</sub> | P3 <sub>5</sub> | P3 <sub>4</sub> | P3 <sub>3</sub> | P3 <sub>2</sub> | P3 <sub>1</sub> | P3 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P3DR is an 8-bit register that stores data for pins P3<sub>7</sub> to P3<sub>0</sub>. When a P3DDR bit is set to 1, if port 3 is read, the value in P3DR is obtained directly, regardless of the actual pin state. When a P3DDR bit is cleared to 0, if port 3 is read the pin state is obtained.

P3DR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### Port 3 Input Pull-Up Control Register (P3PCR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P3 <sub>7</sub> PCR | P3 <sub>6</sub> PCR | P3 <sub>5</sub> PCR | P3 <sub>4</sub> PCR | P3 <sub>3</sub> PCR | P3 <sub>2</sub> PCR | P3 <sub>1</sub> PCR | P3 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

P3PCR is an 8-bit readable/writable register that controls the MOS input pull-ups in port 3. If a P3DDR bit is cleared to 0 (designating input) and the corresponding P3PCR bit is set to 1, the MOS input pull-up is turned on.

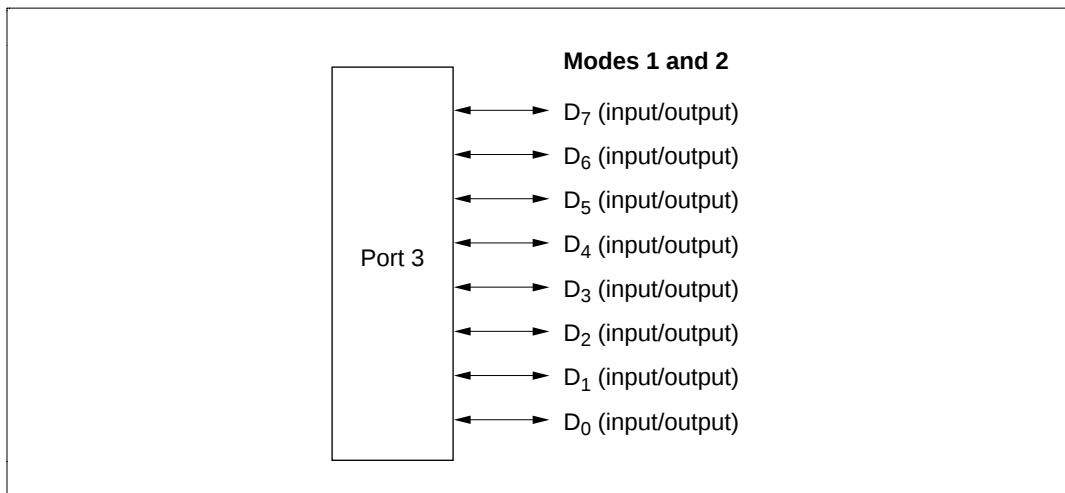
P3PCR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

The MOS input pull-ups cannot be used in slave mode (when the host interface is enabled).

### 7.4.3 Pin Functions in Each Mode

Port 3 has different pin functions in different modes. A separate description for each mode is given below.

**Pin Functions in Modes 1 and 2:** In mode 1 (expanded mode with on-chip ROM disabled) and mode 2 (expanded mode with on-chip ROM enabled), port 3 is automatically used for the input/output pins of the data bus (D<sub>7</sub> to D<sub>0</sub>). Figure 7-10 shows the pin functions in modes 1 and 2.

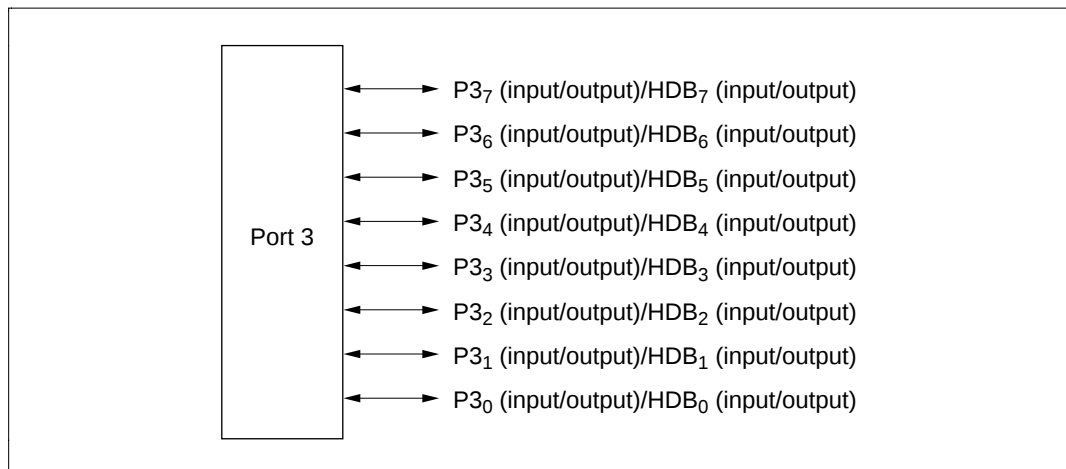


**Figure 7-10 Pin Functions in Modes 1 and 2 (Port 3)**

**Mode 3:** In mode 3 (single-chip mode), port 3 is an input/output port when the host interface enable bit (HIE) in the system control register (SYSCR) is cleared to 0.

If the HIE bit is set to 1 and a transition is made to slave mode, port 3 becomes the host interface data bus (HDB<sub>7</sub> to HDB<sub>0</sub>). In slave mode, P3DR and P3DDR should be cleared to H'00.

Figure 7-11 shows the pin functions in mode 3.



**Figure 7-11 Pin Functions in Mode 3 (Port 3)**

#### 7.4.4 Input Pull-Up Transistors

Port 3 has built-in programmable MOS input pull-ups that are available in mode 3. The pull-up for each bit can be turned on and off individually. To turn on an input pull-up in mode 3, set the corresponding P3PCR bit to 1 and clear the corresponding P3DDR bit to 0. P3PCR is cleared to H'00 by a reset and in hardware standby mode, turning all input pull-ups off. In software standby mode, the previous state is maintained.

Table 7-7 indicates the states of the input MOS pull-ups in each operating mode.

**Table 7-7 States of MOS Input Pull-Ups (Port 3)**

| Mode | Reset | Hardware Standby | Software Standby | Other Operating Modes |
|------|-------|------------------|------------------|-----------------------|
| 1    | Off   | Off              | Off              | Off                   |
| 2    | Off   | Off              | On/off           | On/off                |
| 3    | Off   | Off              | On/off           | On/off                |

Notes: Off: The MOS input pull-up is always off.

On/off: The MOS input pull-up is on if P3PCR = 1 and P3DDR = 0, but off otherwise.

## 7.5 Port 4

### 7.5.1 Overview

Port 4 is an 8-bit input/output port that is multiplexed with the host interface (HIF) input/output pins ( $GA_{20}$ ,  $\overline{CS}_2$ ), host interrupt request output pins ( $HIRQ_{12}$ ,  $HIRQ_1$ ,  $HIRQ_{11}$ ), 8-bit timer 0, 1, and X, and timer connection input/output pins ( $TMRI_0$ ,  $TMRI_1$ ,  $TMCI_0$ ,  $TMCI_1$ ,  $TMO_0$ ,  $TMO_1$ ,  $TMO_X$ ,  $HSYNCl$ ,  $HSYNCO$ ,  $CSYNCl$ ,  $FBACKI$ ,  $CLAMPO$ ), and the  $\emptyset$  clock output pin. Pins  $P4_7$  and  $P4_5$  to  $P4_0$  have the same functions in all operating modes, but the slave mode function which enables the host interface is only valid in single-chip mode. The function of pin  $P4_6$  differs depending on the operating mode.

Figure 7-12 shows the pin configuration of port 4.

Pins in port 4 (except  $P4_6$ ) can drive one TTL load and a 30-pF capacitive load. The  $\emptyset$  clock output pin can drive one TTL load and a 90-pF capacitive load. Port 4 pins can also drive a Darlington transistor.

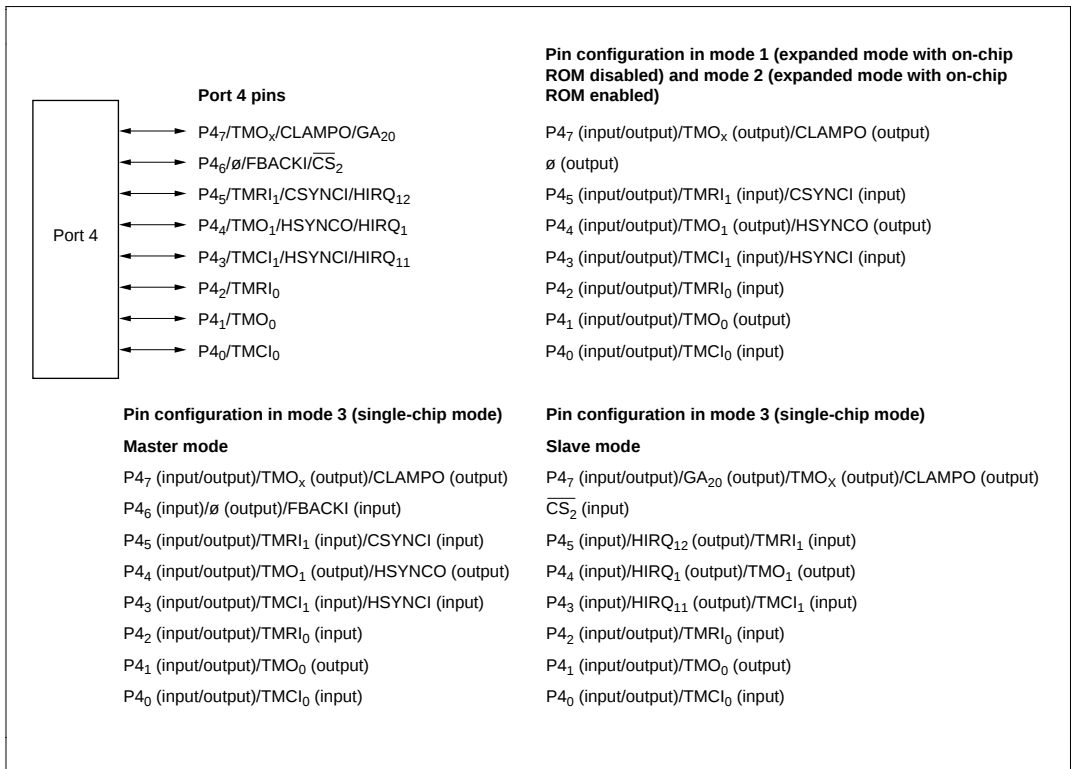


Figure 7-12 Port 4 Pin Configuration

## 7.5.2 Register Configuration and Descriptions

Table 7-8 summarizes the port 4 registers.

**Table 7-8 Port 4 Registers**

| Name                           | Abbreviation | Read/Write        | Initial Value                        | Address |
|--------------------------------|--------------|-------------------|--------------------------------------|---------|
| Port 4 data direction register | P4DDR        | W                 | H'40 (mode 1 and 2)<br>H'00 (mode 3) | H'FFB5  |
| Port 4 data register           | P4DR         | R/W* <sup>1</sup> | Undetermined* <sup>2</sup>           | H'FFB7  |

Notes: 1. Bit 6 is read-only.

2. Bit 6 only is undetermined; the other bits are 0.

### Port 4 Data Direction Register (P4DDR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P4 <sub>7</sub> DDR | P4 <sub>6</sub> DDR | P4 <sub>5</sub> DDR | P4 <sub>4</sub> DDR | P4 <sub>3</sub> DDR | P4 <sub>2</sub> DDR | P4 <sub>1</sub> DDR | P4 <sub>0</sub> DDR |
| Mode 1 and 2  |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 0                   | 1                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | —                   | W                   | W                   | W                   | W                   | W                   | W                   |
| Mode 3        |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P4DDR is an 8-bit register that controls the input/output direction of each pin in port 4. A pin functions as an output pin if the corresponding P4DDR bit is set to 1, and as an input pin if this bit is cleared to 0. However, in modes 1 and 2, P4<sub>6</sub>DDR is fixed at 1 and cannot be modified.

P4DDR is a write-only register. Read data is invalid. If read, all bits always read 1.

P4DDR is initialized—to H'40 in modes 1 and 2, and to H'00 in mode 3—by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P4DDR bit is set to 1, the corresponding pin remains in the output state.

If a transition to software standby mode occurs while port 4 is being used by an on-chip supporting module (for example, for 8-bit timer output), the on-chip supporting module will be initialized, so the pin will revert to general-purpose input/output, controlled by P4DDR and P4DR.

## Port 4 Data Register (P4DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P4 <sub>7</sub> | P4 <sub>6</sub> | P4 <sub>5</sub> | P4 <sub>4</sub> | P4 <sub>3</sub> | P4 <sub>2</sub> | P4 <sub>1</sub> | P4 <sub>0</sub> |
| Initial value | 0               | *               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R               | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

Note: \* Depends on the state of the P4<sub>6</sub> pin.

P4DR is an 8-bit register that stores data for port 4 pins P4<sub>7</sub> to P4<sub>0</sub>. With the exception of P4<sub>6</sub>, when a P4DDR bit is set to 1, if port 4 is read, the value in P4DR is obtained directly, regardless of the actual pin state. When a P4DDR bit is cleared to 0, if port 4 is read the pin state is obtained. When P4<sub>6</sub> is read, the pin state is always obtained. This also applies to the clock output pin and pins used by the on-chip supporting modules.

P4DR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

## 7.5.3 Pin Functions

Port 4 pins are used for 8-bit timer and timer connection input/output and  $\phi$ clock output. Table 7-9 indicates the pin functions of port 4.

**Table 7-9 Port 4 Pin Functions**

| Pin                                                            | Pin Functions and Selection Method                                                                                                                                  |                       |                        |                       |                         |                                          |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------|-----------------------|-------------------------|------------------------------------------|
| P4 <sub>7</sub> /TMO <sub>x</sub> /<br>CLAMPO/GA <sub>20</sub> | Bit FGA20E in HICR, bits OS3 to OS0 in TCSR of 8-bit timer X, bit SYNCE in STCR, bit P4 <sub>7</sub> DDR, and the operating mode select the pin function as follows |                       |                        |                       |                         |                                          |
|                                                                | SYNCE                                                                                                                                                               | 0                     |                        |                       |                         | 1                                        |
|                                                                | OS3 to OS0                                                                                                                                                          | All 0                 |                        |                       | Not all 0               | —                                        |
|                                                                | P4 <sub>7</sub> DDR                                                                                                                                                 | 0                     | 1                      |                       | —                       |                                          |
|                                                                | FGA20E                                                                                                                                                              | —                     | 0                      | 1                     | —                       |                                          |
|                                                                | Operating mode                                                                                                                                                      | —                     | —                      | Other than slave mode | Slave mode              | —                                        |
|                                                                | Pin function                                                                                                                                                        | P4 <sub>7</sub> input | P4 <sub>7</sub> output |                       | GA <sub>20</sub> output | TMO <sub>x</sub> output<br>CLAMPO output |

P4<sub>6</sub>/ $\phi$ /FBACKI/  
CS<sub>2</sub> Bit P4<sub>6</sub>DDR and the operating mode select the pin function as follows

| Operating mode      | Modes 1 and 2       | Mode 3                                 |                     |                                |
|---------------------|---------------------|----------------------------------------|---------------------|--------------------------------|
|                     | —                   | Other than slave mode                  |                     | Slave mode                     |
| P4 <sub>6</sub> DDR | —                   | 0                                      | 1                   | —                              |
| Pin function        | $\phi$ clock output | P4 <sub>6</sub> input,<br>FBACKI input | $\phi$ clock output | $\overline{\text{CS}}_2$ input |

|                                                                   |                     |                                       |                        |                           |
|-------------------------------------------------------------------|---------------------|---------------------------------------|------------------------|---------------------------|
| P4 <sub>5</sub> /TMRI <sub>1</sub> /<br>CSYNCI/HIRQ <sub>12</sub> | P4 <sub>5</sub> DDR | 0                                     | 1                      |                           |
|                                                                   | Operating mode      | —                                     | Other than slave mode  | Slave mode                |
|                                                                   | Pin function        | P4 <sub>5</sub> input                 | P4 <sub>5</sub> output | HIRQ <sub>12</sub> output |
|                                                                   |                     | TMRI <sub>1</sub> input, CSYNCI input |                        |                           |

TMRI<sub>1</sub> input is usable when bits CCLR1 and CCLR0 are both set to 1 in TCR of 8-bit timer 1

**Table 7-9 Port 4 Pin Functions (cont)****Pin Pin Functions and Selection Method**

**P4<sub>4</sub>/TMO<sub>1</sub>/HSYNCO/IRQ<sub>1</sub>** Bits OS3 to OS0 in TCSR of 8-bit timer 1, bit SYNCE in STCR, bit P4<sub>4</sub>DDR, and the operating mode select the pin function as follows

| SYNCE               | 0                     |                        |                         | 1                       |               |
|---------------------|-----------------------|------------------------|-------------------------|-------------------------|---------------|
| OS3 to OS0          | All 0                 |                        |                         | Not all 0               | —             |
| P4 <sub>4</sub> DDR | 0                     | 1                      |                         | —                       |               |
| Operating mode      | —                     | Other than slave mode  | Slave mode              | —                       |               |
| Pin function        | P4 <sub>4</sub> input | P4 <sub>4</sub> output | IRQ <sub>1</sub> output | TMO <sub>1</sub> output | HSYNCO output |

**P4<sub>3</sub>/TMCI<sub>1</sub>/HSYNCI/IRQ<sub>11</sub>**

| P4 <sub>3</sub> DDR | 0                                     | 1                      |                          |
|---------------------|---------------------------------------|------------------------|--------------------------|
| Operating mode      | —                                     | Other than slave mode  | Slave mode               |
| Pin function        | P4 <sub>3</sub> input                 | P4 <sub>3</sub> output | IRQ <sub>11</sub> output |
|                     | TMCI <sub>1</sub> input, HSYNCI input |                        |                          |

TMCI<sub>1</sub> input is usable when bits CKS2 to CKS0 in TCR of 8-bit timer 1 select an external clock source

**P4<sub>2</sub>/TMRI<sub>0</sub>**

| P4 <sub>2</sub> DDR | 0                       | 1                      |
|---------------------|-------------------------|------------------------|
| Pin function        | P4 <sub>2</sub> input   | P4 <sub>2</sub> output |
|                     | TMRI <sub>0</sub> input |                        |

TMRI<sub>0</sub> input is usable when bits CCLR1 and CCLR0 are both set to 1 in TCR of 8-bit timer 0

**Table 7-9 Port 4 Pin Functions (cont)**

| Pin                               | Pin Functions and Selection Method                                                                      |                       |                         |
|-----------------------------------|---------------------------------------------------------------------------------------------------------|-----------------------|-------------------------|
| P4 <sub>1</sub> /TMO <sub>0</sub> | Bits OS3 to OS0 in TCSR of 8-bit timer 0 and bit P4 <sub>1</sub> DDR select the pin function as follows |                       |                         |
|                                   | OS3 to OS0                                                                                              | All 0                 | Not all 0               |
|                                   | P4 <sub>1</sub> DDR                                                                                     | 0                     | 1                       |
|                                   | Pin function                                                                                            | P4 <sub>1</sub> input | P4 <sub>1</sub> output  |
|                                   |                                                                                                         |                       | TMO <sub>0</sub> output |

|                                    |                     |                         |                        |
|------------------------------------|---------------------|-------------------------|------------------------|
| P4 <sub>0</sub> /TMCI <sub>0</sub> | P4 <sub>0</sub> DDR | 0                       | 1                      |
|                                    | Pin function        | P4 <sub>0</sub> input   | P4 <sub>0</sub> output |
|                                    |                     | TMCI <sub>0</sub> input |                        |

TMCI<sub>0</sub> input is usable when bits CKS2 to CKS0 in TCR of 8-bit timer 0 select an external clock source

# 7.6 Port 5

## 7.6.1 Overview

Port 5 is a 6-bit input/output port that is multiplexed with input/output pins (TxD<sub>0</sub>, RxD<sub>0</sub>, SCK<sub>0</sub>, TxD<sub>1</sub>, RxD<sub>1</sub>, SCK<sub>1</sub>) of serial communication interfaces 0 and 1. The port 5 pin functions are the same in all operating modes. Figure 7-13 shows the pin configuration of port 5.

Pins in port 5 can drive one TTL load and a 30-pF capacitive load. They can also drive a Darlington transistor.

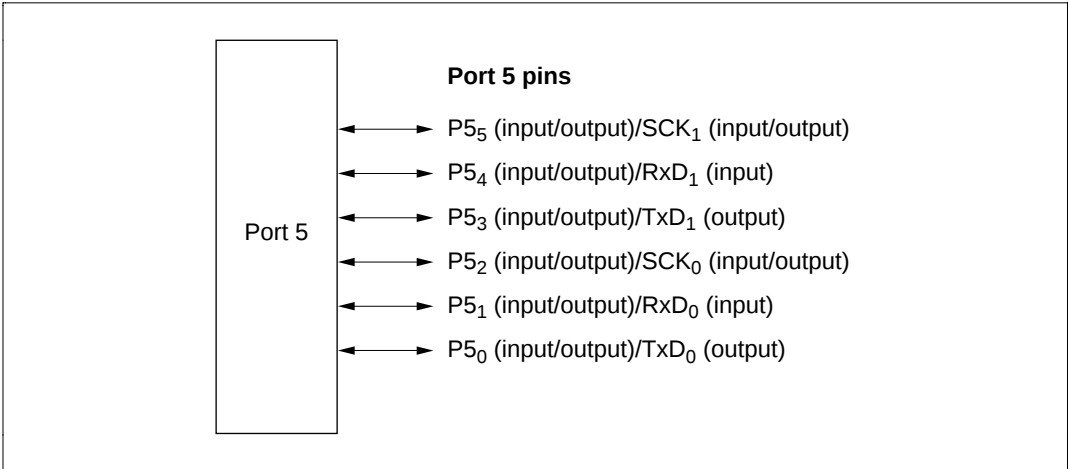


Figure 7-13 Port 5 Pin Configuration

## 7.6.2 Register Configuration and Descriptions

Table 7-10 summarizes the port 5 registers.

Table 7-10 Port 5 Registers

| Name                           | Abbreviation | Read/Write | Initial Value | Address |
|--------------------------------|--------------|------------|---------------|---------|
| Port 5 data direction register | P5DDR        | W          | H'C0          | H'FFB8  |
| Port 5 data register           | P5DR         | R/W        | H'C0          | H'FFBA  |

## Port 5 Data Direction Register (P5DDR)

| Bit           | 7 | 6 | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | — | — | P5 <sub>5</sub> DDR | P5 <sub>4</sub> DDR | P5 <sub>3</sub> DDR | P5 <sub>2</sub> DDR | P5 <sub>1</sub> DDR | P5 <sub>0</sub> DDR |
| Initial value | 1 | 1 | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | — | — | W                   | W                   | W                   | W                   | W                   | W                   |

P5DDR is an 8-bit register that controls the input/output direction of each pin in port 5. A pin functions as an output pin if the corresponding P5DDR bit is set to 1, and as an input pin if this bit is cleared to 0.

P5DDR is a write-only register. Read data is invalid. Bits 7 and 6 are reserved. If read, all bits always read 1.

P5DDR is initialized to H'C0 by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P5DDR bit is set to 1, the corresponding pin remains in the output state.

If a transition to software standby mode occurs while port 5 is being used by the SCI, the SCI will be initialized, so the pin will revert to general-purpose input/output, controlled by P5DDR and P5DR.

## Port 5 Data Register (P5DR)

| Bit           | 7 | 6 | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|---|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | — | — | P5 <sub>5</sub> | P5 <sub>4</sub> | P5 <sub>3</sub> | P5 <sub>2</sub> | P5 <sub>1</sub> | P5 <sub>0</sub> |
| Initial value | 1 | 1 | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | — | — | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P5DR is an 8-bit register that stores data for pins P5<sub>5</sub> to P5<sub>0</sub>. Bits 7 and 6 are reserved. They cannot be modified, and are always read as 1.

When a P5DDR bit is set to 1, if port 5 is read, the value in P5DR is obtained directly, regardless of the actual pin state. When a P5DDR bit is cleared to 0, if port 5 is read the pin state is obtained. This also applies to pins used as SCI pins.

P5DR is initialized to H'C0 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### 7.6.3 Pin Functions

Port 5 has the same pin functions in each operating mode. Individual pins can also be used as SCI0 or SCI1 input/output pins. Table 7-11 indicates the pin functions of port 5.

**Table 7-11 Port 5 Pin Functions**

| Pin                               | Pin Functions and Selection Method                                                                                                 |                       |                        |                         |                        |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------|-------------------------|------------------------|
| P5 <sub>5</sub> /SCK <sub>1</sub> | Bit C/ $\bar{A}$ in SMR of SCI1, bits CKE0 and CKE1 in SCR of SCI1, and bit P5 <sub>5</sub> DDR select the pin function as follows |                       |                        |                         |                        |
|                                   | CKE1                                                                                                                               | 0                     |                        |                         | 1                      |
|                                   | C/ $\bar{A}$                                                                                                                       | 0                     |                        | 1                       | —                      |
|                                   | CKE0                                                                                                                               | 0                     | 1                      | —                       | —                      |
|                                   | P5 <sub>5</sub> DDR                                                                                                                | 0                     | 1                      | —                       | —                      |
|                                   | Pin function                                                                                                                       | P5 <sub>5</sub> input | P5 <sub>5</sub> output | SCK <sub>1</sub> output | SCK <sub>1</sub> input |

---

|                                   |                                                                                      |                       |                        |
|-----------------------------------|--------------------------------------------------------------------------------------|-----------------------|------------------------|
| P5 <sub>4</sub> /RxD <sub>1</sub> | Bit RE in SCR of SCI1 and bit P5 <sub>4</sub> DDR select the pin function as follows |                       |                        |
|                                   | RE                                                                                   | 0                     | 1                      |
|                                   | P5 <sub>4</sub> DDR                                                                  | 0                     | 1                      |
|                                   | Pin function                                                                         | P5 <sub>4</sub> input | RxD <sub>1</sub> input |

---

|                                   |                                                                                      |                       |                         |
|-----------------------------------|--------------------------------------------------------------------------------------|-----------------------|-------------------------|
| P5 <sub>3</sub> /TxD <sub>1</sub> | Bit TE in SCR of SCI1 and bit P5 <sub>3</sub> DDR select the pin function as follows |                       |                         |
|                                   | TE                                                                                   | 0                     | 1                       |
|                                   | P5 <sub>3</sub> DDR                                                                  | 0                     | 1                       |
|                                   | Pin function                                                                         | P5 <sub>3</sub> input | TxD <sub>1</sub> output |

**Table 7-11 Port 5 Pin Functions (cont)****Pin Pin Functions and Selection Method**

**P5<sub>2</sub>/SCK<sub>0</sub>** Bit C/ $\bar{A}$  in SMR of SCI0, bits CKE0 and CKE1 in SCR of SCI0 and bit P5<sub>2</sub>DDR select the pin function as follows

|                     |                       |                        |                         |                         |                        |
|---------------------|-----------------------|------------------------|-------------------------|-------------------------|------------------------|
| CKE1                | 0                     |                        |                         |                         | 1                      |
| C/ $\bar{A}$        | 0                     |                        |                         | 1                       | —                      |
| CKE0                | 0                     |                        | 1                       | —                       | —                      |
| P5 <sub>2</sub> DDR | 0                     | 1                      | —                       | —                       | —                      |
| Pin function        | P5 <sub>2</sub> input | P5 <sub>2</sub> output | SCK <sub>0</sub> output | SCK <sub>0</sub> output | SCK <sub>0</sub> input |

**P5<sub>1</sub>/RxD<sub>0</sub>** Bit RE in SCR of SCI0 and bit P5<sub>1</sub>DDR select the pin function as follows

|                     |                       |                        |                        |
|---------------------|-----------------------|------------------------|------------------------|
| RE                  | 0                     |                        | 1                      |
| P5 <sub>1</sub> DDR | 0                     | 1                      | —                      |
| Pin function        | P5 <sub>1</sub> input | P5 <sub>1</sub> output | RxD <sub>0</sub> input |

**P5<sub>0</sub>/TxD<sub>0</sub>** Bit TE in SCR of SCI0 and bit P5<sub>0</sub>DDR select the pin function as follows

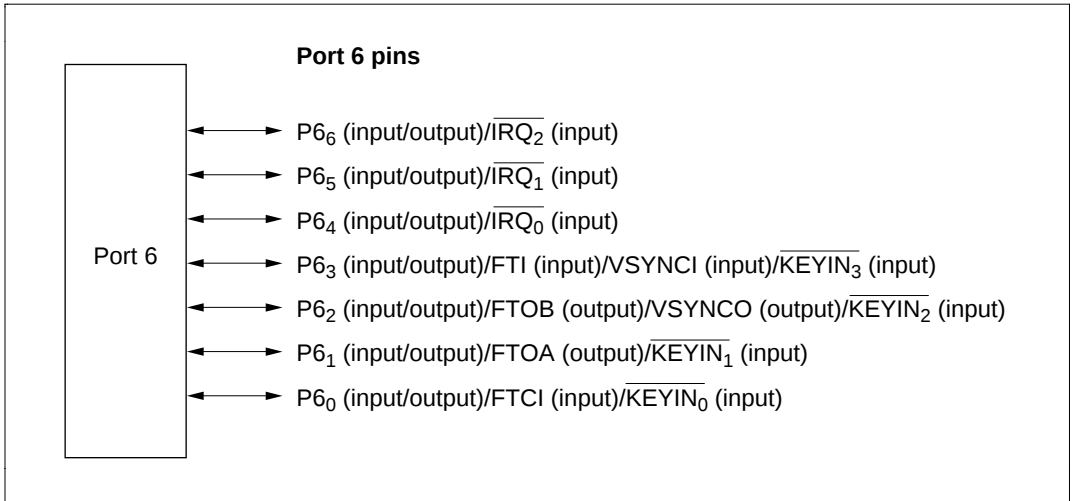
|                     |                       |                        |                         |
|---------------------|-----------------------|------------------------|-------------------------|
| TE                  | 0                     |                        | 1                       |
| P5 <sub>0</sub> DDR | 0                     | 1                      | —                       |
| Pin function        | P5 <sub>0</sub> input | P5 <sub>0</sub> output | TxD <sub>0</sub> output |

## 7.7 Port 6

### 7.7.1 Overview

Port 6 is a 7-bit input/output port that is multiplexed with 16-bit free-running timer (FRT) and timer connection input/output pins (FTCI, FTOA, FTOB, FTI, VSYNCl, VSYNCO), key-sense input pins and with  $\overline{\text{IRQ}}_0$  to  $\overline{\text{IRQ}}_2$  input pins. The port 6 pin functions are the same in all operating modes. Pins P6<sub>0</sub> to P6<sub>3</sub> in port 6 have program-controllable built-in MOS pull-ups. Figure 7-14 shows the pin configuration of port 6.

Pins in port 6 can drive one TTL load and a 90-pF capacitive load. They can also drive a Darlington transistor.



**Figure 7-14 Port 6 Pin Configuration**

## 7.7.2 Register Configuration and Descriptions

Table 7-12 summarizes the port 6 registers.

**Table 7-12 Port 6 Registers**

| Name                                   | Abbreviation | Read/Write | Initial Value | Address |
|----------------------------------------|--------------|------------|---------------|---------|
| Port 6 data direction register         | P6DDR        | W          | H'80          | H'FFB9  |
| Port 6 data register                   | P6DR         | R/W        | H'80          | H'FFBB  |
| Key-sense MOS pull-up control register | KMPCR        | R/W        | H'00          | H'FFF2  |

### Port 6 Data Direction Register (P6DDR)

|               |   |                     |                     |                     |                     |                     |                     |                     |
|---------------|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Bit           | 7 | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|               | — | P6 <sub>6</sub> DDR | P6 <sub>5</sub> DDR | P6 <sub>4</sub> DDR | P6 <sub>3</sub> DDR | P6 <sub>2</sub> DDR | P6 <sub>1</sub> DDR | P6 <sub>0</sub> DDR |
| Initial value | 1 | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | — | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P6DDR is an 8-bit register that controls the input/output direction of each pin in port 6. A pin functions as an output pin if the corresponding P6DDR bit is set to 1, and as an input pin if this bit is cleared to 0.

P6DDR is a write-only register. Read data is invalid. Bit 7 is reserved. If read, all bits always read 1.

P6DDR is initialized to H'80 by a reset and in hardware standby mode. In software standby mode it retains its existing values, so if a transition to software standby mode occurs while a P6DDR bit is set to 1, the corresponding pin remains in the output state.

If a transition to software standby mode occurs while port 6 is being used by an on-chip supporting module (for example, the free-running timer), the on-chip supporting module will be initialized, so the pin will revert to general-purpose input/output, controlled by P6DDR and P6DR.

## Port 6 Data Register (P6DR)

| Bit           | 7 | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | — | P6 <sub>6</sub> | P6 <sub>5</sub> | P6 <sub>4</sub> | P6 <sub>3</sub> | P6 <sub>2</sub> | P6 <sub>1</sub> | P6 <sub>0</sub> |
| Initial value | 1 | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | — | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P6DR is an 8-bit register that stores data for pins P6<sub>6</sub> to P6<sub>0</sub>. Bit 7 is reserved; it cannot be modified and is always read as 1. When a P6DDR bit is set to 1, if port 6 is read, the value in P6DR is obtained directly, regardless of the actual pin state. When a P6DDR bit is cleared to 0, if port 6 is read the pin state is obtained. This also applies to pins used by the on-chip supporting modules.

P6DR is initialized to H'80 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

When a port P6DDR bit is cleared to 0, if port 6 is read, the pin state is obtained; this pin can be selected according to the contents of KMIMR7 to KMIMR4. When KMIMR is set to 1 (initial value), empty bit 7, pins P6<sub>6</sub>, P6<sub>5</sub>, and P6<sub>4</sub> are selected. When KMIMR is cleared to 0, pins P7<sub>3</sub>, P7<sub>2</sub>, P7<sub>1</sub>, and P7<sub>0</sub> are selected, respectively, corresponding to KMIMR7, KMIMR6, KMIMR5, and KMIMR4.

## Key-Sense MOS Pull-Up Control Register (KMPCR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | KM <sub>7</sub> PCR | KM <sub>6</sub> PCR | KM <sub>5</sub> PCR | KM <sub>4</sub> PCR | KM <sub>3</sub> PCR | KM <sub>2</sub> PCR | KM <sub>1</sub> PCR | KM <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

KMPCR is an 8-bit readable/writable register that controls the port 6 and port 7 built-in MOS pull-ups on a bit-by-bit basis.

When a P6DDR or P7DDR bit is cleared to 0 (input port state), if the corresponding KMPCR bit is set to 1 the MOS pull-up is turned on.

KM<sub>7</sub>PCR to KM<sub>4</sub>PCR correspond to P7<sub>3</sub>DDR to P7<sub>0</sub>DDR and pins P7<sub>3</sub> to P7<sub>0</sub>, while KM<sub>3</sub>PCR to KM<sub>0</sub>PCR correspond to P6<sub>3</sub>DDR to P6<sub>0</sub>DDR and pins P6<sub>3</sub> to P6<sub>0</sub>.

KMPCR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### 7.7.3 Pin Functions

Port 6 has the same pin functions in all operating modes. The pins are multiplexed with FRT and timer connection input/output, key-sense input, and  $\overline{\text{IRQ}}_0$  to  $\overline{\text{IRQ}}_2$  input. Table 7-13 indicates the pin functions of port 6.

**Table 7-13 Port 6 Pin Functions**

**Pin Pin Functions and Selection Method**

|                    |              |                                                                 |                                      |
|--------------------|--------------|-----------------------------------------------------------------|--------------------------------------|
| (P6 <sub>7</sub> ) | KMIMR7       | 0                                                               | 1                                    |
|                    | Pin function | P7 <sub>3</sub> pin input function in a P6 <sub>7</sub> DR read | 1 input in a P6 <sub>7</sub> DR read |

|                                             |                     |                                                                 |                       |                        |
|---------------------------------------------|---------------------|-----------------------------------------------------------------|-----------------------|------------------------|
| P6 <sub>6</sub> / $\overline{\text{IRQ}}_2$ | P6 <sub>6</sub> DDR | 0                                                               |                       | 1                      |
|                                             | KMIMR6              | 0                                                               | 1                     | —                      |
|                                             | Pin function        | P7 <sub>2</sub> pin input function in a P6 <sub>6</sub> DR read | P6 <sub>6</sub> input | P6 <sub>6</sub> output |
|                                             |                     | $\overline{\text{IRQ}}_2$ input                                 |                       |                        |

$\overline{\text{IRQ}}_2$  input is usable when bit IRQ2E is set to 1 in IER

|                                             |                     |                                                                 |                       |                        |
|---------------------------------------------|---------------------|-----------------------------------------------------------------|-----------------------|------------------------|
| P6 <sub>5</sub> / $\overline{\text{IRQ}}_1$ | P6 <sub>5</sub> DDR | 0                                                               |                       | 1                      |
|                                             | KMIMR5              | 0                                                               | 1                     | —                      |
|                                             | Pin function        | P7 <sub>1</sub> pin input function in a P6 <sub>5</sub> DR read | P6 <sub>5</sub> input | P6 <sub>5</sub> output |
|                                             |                     | $\overline{\text{IRQ}}_1$ input                                 |                       |                        |

$\overline{\text{IRQ}}_1$  input is usable when bit IRQ1E is set to 1 in IER

|                                             |                     |                                                                 |                       |                        |
|---------------------------------------------|---------------------|-----------------------------------------------------------------|-----------------------|------------------------|
| P6 <sub>4</sub> / $\overline{\text{IRQ}}_0$ | P6 <sub>4</sub> DDR | 0                                                               |                       | 1                      |
|                                             | KMIMR4              | 0                                                               | 1                     | —                      |
|                                             | Pin function        | P7 <sub>0</sub> pin input function in a P6 <sub>4</sub> DR read | P6 <sub>4</sub> input | P6 <sub>4</sub> output |
|                                             |                     | $\overline{\text{IRQ}}_0$ input                                 |                       |                        |

$\overline{\text{IRQ}}_0$  input is usable when bit IRQ0E is set to 1 in IER

**Table 7-13 Port 6 Pin Functions (cont)**

**Pin Pin Functions and Selection Method**

|                                                    |                     |                                                               |                        |
|----------------------------------------------------|---------------------|---------------------------------------------------------------|------------------------|
| P6 <sub>3</sub> /FTI/VSYNCl/<br>KEYIN <sub>3</sub> | P6 <sub>3</sub> DDR | 0                                                             | 1                      |
|                                                    | Pin function        | P6 <sub>3</sub> input                                         | P6 <sub>3</sub> output |
|                                                    |                     | FTI input, VSYNCl input, or $\overline{\text{KEYIN}}_3$ input |                        |

P6<sub>2</sub>/FTOB/  
VSYNCO/  
 $\overline{\text{KEYIN}}_2$

Bit OEB in TCR of the FRT, the SYNCE bit in STCR, and the P6<sub>2</sub>DDR bit select the pin function as follows

|                     |                                   |                        |             |               |
|---------------------|-----------------------------------|------------------------|-------------|---------------|
| SYNCE               | 0                                 |                        |             | 1             |
| OEB                 | 0                                 |                        | 1           | —             |
| P6 <sub>2</sub> DDR | 0                                 | 1                      | —           | —             |
| Pin function        | P6 <sub>2</sub> input             | P6 <sub>2</sub> output | FTOB output | VSYNCO output |
|                     | $\overline{\text{KEYIN}}_2$ input |                        |             |               |

|                                              |                                                                                          |                          |                        |             |
|----------------------------------------------|------------------------------------------------------------------------------------------|--------------------------|------------------------|-------------|
| P6 <sub>1</sub> /FTOA/<br>KEYIN <sub>1</sub> | Bit OEA in TCR of the FRT and bit P6 <sub>1</sub> DDR select the pin function as follows |                          |                        |             |
|                                              | OEA                                                                                      | 0                        |                        | 1           |
|                                              | P6 <sub>1</sub> DDR                                                                      | 0                        | 1                      | —           |
|                                              | Pin function                                                                             | P6 <sub>1</sub> input    | P6 <sub>1</sub> output | FTOA output |
|                                              |                                                                                          | KEYIN <sub>1</sub> input |                        |             |

|                                              |                     |                                                 |                        |
|----------------------------------------------|---------------------|-------------------------------------------------|------------------------|
| P6 <sub>0</sub> /FTCI/<br>KEYIN <sub>0</sub> | P6 <sub>0</sub> DDR | 0                                               | 1                      |
|                                              | Pin function        | P6 <sub>0</sub> input                           | P6 <sub>0</sub> output |
|                                              |                     | FTCI input or $\overline{\text{KEYIN}}_0$ input |                        |

FTCI input is usable when bits CKS1 and CKS0 in TCR of the FRT select an external clock source

## 7.8 Port 7

### 7.8.1 Overview

Port 7 is an 8-bit input/output port that also provides the bus control signal input/output pins ( $\overline{\text{RD}}$ ,  $\overline{\text{WR}}$ ,  $\overline{\text{AS}}$ ,  $\overline{\text{WAIT}}$ ), host interface (HIF) input pins ( $\text{HA}_0$ ,  $\overline{\text{IOR}}$ ,  $\overline{\text{IOW}}$ ,  $\overline{\text{CS}}_1$ ), key-sense input pins, and I<sup>2</sup>C bus interface (IIC0 and IIC1) input/output pins ( $\text{SCL}_0$ ,  $\text{SDA}_0$ ,  $\text{SCL}_1$ ,  $\text{SDA}_1$ ). The functions of pins P7<sub>7</sub> to P7<sub>4</sub> differ depending on the operating mode. Pins P7<sub>0</sub> to P7<sub>3</sub> have program-controllable built-in MOS pull-ups. Figure 7-15 shows the pin configuration of port 7. Pins in port 7 can drive one TTL load and a 90-pF capacitive load. They can also drive a Darlington transistor.

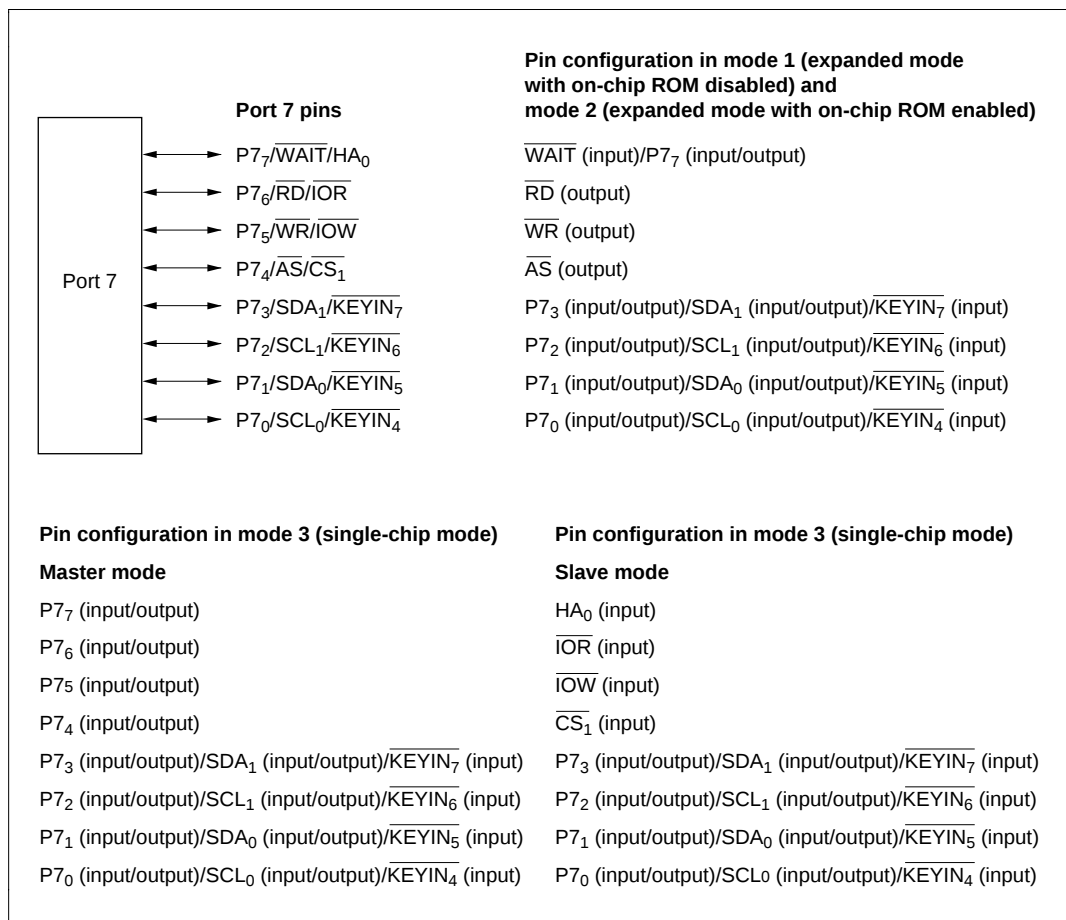


Figure 7-15 Port 7 Pin Configuration

## 7.8.2 Register Configuration and Descriptions

Table 7-15 summarizes the port 7 registers.

**Table 7-15 Port 7 Registers**

| Name                                   | Abbreviation | Read/Write | Initial Value | Address |
|----------------------------------------|--------------|------------|---------------|---------|
| Port 7 data direction register         | P7DDR        | W          | H'00          | H'FFBC  |
| Port 7 data register                   | P7DR         | R/W        | H'00          | H'FFBE  |
| Key-sense MOS pull-up control register | KMPCR        | R/W        | H'00          | H'FFF2  |

### Port 7 Data Direction Register (P7DDR)

|               | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Bit           | P7 <sub>7</sub> DDR | P7 <sub>6</sub> DDR | P7 <sub>5</sub> DDR | P7 <sub>4</sub> DDR | P7 <sub>3</sub> DDR | P7 <sub>2</sub> DDR | P7 <sub>1</sub> DDR | P7 <sub>0</sub> DDR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 1                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P7DDR is an 8-bit register that controls the input/output direction of each pin in port 7. A pin functions as an output pin if the corresponding P7DDR bit is set to 1, and as an input pin if this bit is cleared to 0. P7DDR is a write-only register. Read data is invalid. If read, all bits always read 1.

P7DDR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode P7DDR retains its existing values, so if a transition to software standby mode occurs while a P7DDR bit is set to 1, the corresponding pin remains in the output state.

### Port 7 Data Register (P7DR)

|               | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Bit           | P7 <sub>7</sub> | P7 <sub>6</sub> | P7 <sub>5</sub> | P7 <sub>4</sub> | P7 <sub>3</sub> | P7 <sub>2</sub> | P7 <sub>1</sub> | P7 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P7DR is an 8-bit register that stores data for pins P7<sub>7</sub> to P7<sub>0</sub>.

When a P7DDR bit is set to 1, if port 7 is read, the value in P7DR is obtained directly, regardless of the actual pin state. When a P7DDR bit is cleared to 0, if port 7 is read the pin state is obtained.

P7DR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

When a port P6DDR bit is cleared to 0, if port 6 is read, the pin state is obtained; this pin can be selected according to the contents of KMIMR7 to KMIMR4. When KMIMR is set to 1 (initial value), bit 7 is an empty bit, and pins P6<sub>6</sub>, P6<sub>5</sub>, and P6<sub>4</sub> are selected. When KMIMR is cleared to 0, pins P7<sub>3</sub>, P7<sub>2</sub>, P7<sub>1</sub>, and P7<sub>0</sub> are selected, respectively, corresponding to KMIMR7, KMIMR6, KMIMR5, and KMIMR4.

### Key-Sense MOS Pull-Up Control Register (KMPCR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | KM <sub>7</sub> PCR | KM <sub>6</sub> PCR | KM <sub>5</sub> PCR | KM <sub>4</sub> PCR | KM <sub>3</sub> PCR | KM <sub>2</sub> PCR | KM <sub>1</sub> PCR | KM <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

KMPCR is an 8-bit readable/writable register that controls the port 6 and port 7 built-in MOS pull-ups on a bit-by-bit basis.

When a P6DDR or P7DDR bit is cleared to 0 (input port state), if the corresponding KMPCR bit is set to 1 the MOS pull-up is turned on.

KM<sub>7</sub>PCR to KM<sub>4</sub>PCR correspond to P7<sub>3</sub>DDR to P7<sub>0</sub>DDR and pins P7<sub>3</sub> to P7<sub>0</sub>, while KM<sub>3</sub>PCR to KM<sub>0</sub>PCR correspond to P6<sub>3</sub>DDR to P6<sub>0</sub>DDR and pins P6<sub>3</sub> to P6<sub>0</sub>.

KMPCR is initialized to H'00 by a reset and in hardware standby mode. In software standby mode it retains its existing values.

### 7.8.3 Pin Functions

The pins of port 7 have different functions in modes 1 and 2 and in mode 3. Individual pins are used as bus control signal input/output pins (RD, WR, AS, WAIT), host interface (HIF) input pins (HA<sub>0</sub>, IOR, IOW, CS<sub>1</sub>), key-sense input pins, and I<sup>2</sup>C bus interface (IIC0 and IIC1) input/output pins (SCL<sub>0</sub>, SDA<sub>0</sub>, SCL<sub>1</sub>, SDA<sub>1</sub>). Table 7-19 indicates the pin functions of port 7.

**Table 7-16 Port 7 Pin Functions**

**Pin Pin Functions and Selection Method**

**P7<sub>7</sub>/WAIT/HA<sub>0</sub>** Bit 7<sub>7</sub>DDR, the wait mode determined by WSCR, and the operating mode select the pin function as follows

| Operating mode      | Modes 1 and 2                  |                                   |                        | Mode 3                |                        |                       |
|---------------------|--------------------------------|-----------------------------------|------------------------|-----------------------|------------------------|-----------------------|
|                     | —                              |                                   |                        | Other than slave mode |                        | Slave mode            |
| Wait mode           | $\overline{\text{WAIT}}$ used  | $\overline{\text{WAIT}}$ not used |                        | —                     |                        |                       |
| P7 <sub>7</sub> DDR | —                              | 0                                 | 1                      | 0                     | 1                      | —                     |
| Pin function        | $\overline{\text{WAIT}}$ input | P7 <sub>7</sub> input             | P7 <sub>7</sub> output | P7 <sub>7</sub> input | P7 <sub>7</sub> output | HA <sub>0</sub> input |

**P7<sub>6</sub>/RD/IOR** Bit 7<sub>6</sub>DDR and the operating mode select the pin function as follows

| Operating mode      | Modes 1 and 2 | Mode 3                |                        |            |
|---------------------|---------------|-----------------------|------------------------|------------|
|                     | —             | Other than slave mode |                        | Slave mode |
| P7 <sub>6</sub> DDR | —             | 0                     | 1                      | —          |
| Pin function        | RD output     | P7 <sub>6</sub> input | P7 <sub>6</sub> output | IOR input  |

**P7<sub>5</sub>/WR/IOW** Bit 7<sub>5</sub>DDR and the operating mode select the pin function as follows

| Operating mode      | Modes 1 and 2 | Mode 3                |                        |            |
|---------------------|---------------|-----------------------|------------------------|------------|
|                     | —             | Other than slave mode |                        | Slave mode |
| P7 <sub>5</sub> DDR | —             | 0                     | 1                      | —          |
| Pin function        | WR output     | P7 <sub>5</sub> input | P7 <sub>5</sub> output | IOW input  |

**Table 7-16 Port 7 Pin Functions (cont)****Pin Pin Functions and Selection Method**

**P7<sub>4</sub>/AS/CS<sub>1</sub>** Bit 7<sub>4</sub>DDR and the operating mode select the pin function as follows

| Operating mode      | Modes 1 and 2 | Mode 3                |                        |                       |
|---------------------|---------------|-----------------------|------------------------|-----------------------|
|                     | —             | Other than slave mode |                        | Slave mode            |
| P7 <sub>4</sub> DDR | —             | 0                     | 1                      | —                     |
| Pin function        | AS output     | P7 <sub>4</sub> input | P7 <sub>4</sub> output | CS <sub>1</sub> input |

**P7<sub>3</sub>/SDA<sub>1</sub>/KEYIN<sub>7</sub>** Bit ICE in ICCR of IIC1 and bit P7<sub>3</sub>DDR select the pin function as follows

| ICE                 | 0                        |                        | 1                             |
|---------------------|--------------------------|------------------------|-------------------------------|
| P7 <sub>3</sub> DDR | 0                        | 1                      | —                             |
| Pin function        | P7 <sub>3</sub> input    | P7 <sub>3</sub> output | SDA <sub>1</sub> input/output |
|                     | KEYIN <sub>7</sub> input |                        |                               |

**P7<sub>2</sub>/SCL<sub>1</sub>/KEYIN<sub>6</sub>** Bit ICE in ICCR of IIC1 and bit P7<sub>2</sub>DDR select the pin function as follows

| ICE                 | 0                        |                        | 1                             |
|---------------------|--------------------------|------------------------|-------------------------------|
| P7 <sub>2</sub> DDR | 0                        | 1                      | —                             |
| Pin function        | P7 <sub>2</sub> input    | P7 <sub>2</sub> output | SCL <sub>1</sub> input/output |
|                     | KEYIN <sub>6</sub> input |                        |                               |

**P7<sub>1</sub>/SDA<sub>0</sub>** Bit ICE in ICCR of IIC0 and bit P7<sub>1</sub>DDR select the pin function as follows

| ICE                 | 0                        |                        | 1                             |
|---------------------|--------------------------|------------------------|-------------------------------|
| P7 <sub>1</sub> DDR | 0                        | 1                      | —                             |
| Pin function        | P7 <sub>1</sub> input    | P7 <sub>1</sub> output | SDA <sub>0</sub> input/output |
|                     | KEYIN <sub>5</sub> input |                        |                               |

**Table 7-16 Port 7 Pin Functions (cont)**

| Pin                               | Pin Functions and Selection Method                                                     |                                   |                        |
|-----------------------------------|----------------------------------------------------------------------------------------|-----------------------------------|------------------------|
| P7 <sub>0</sub> /SCL <sub>0</sub> | Bit ICE in ICCR of IIC0 and bit P7 <sub>0</sub> DDR select the pin function as follows |                                   |                        |
|                                   | ICE                                                                                    | 0                                 | 1                      |
|                                   | P7 <sub>0</sub> DDR                                                                    | 0                                 | 1                      |
|                                   | Pin function                                                                           | P7 <sub>0</sub> input             | P7 <sub>0</sub> output |
|                                   |                                                                                        | $\overline{\text{KEYIN}}_4$ input |                        |
|                                   |                                                                                        | SCL <sub>0</sub> input/output     |                        |



# Section 8 PWM Timers

[Incorporated in all models except the H8/3202]

## 8.1 Overview

The H8/3217 Series has an on-chip pulse width modulation (PWM) timer module with sixteen outputs. Sixteen output waveforms are generated from a common time base, enabling PWM output with a high carrier frequency to be produced using pulse division. The PWM timer module has sixteen 8-bit PWM data registers (PWDRs), and an output pulse with a duty cycle of 0 to 100% can be obtained as specified by PWDR and the port data register (P1DR or P2DR).

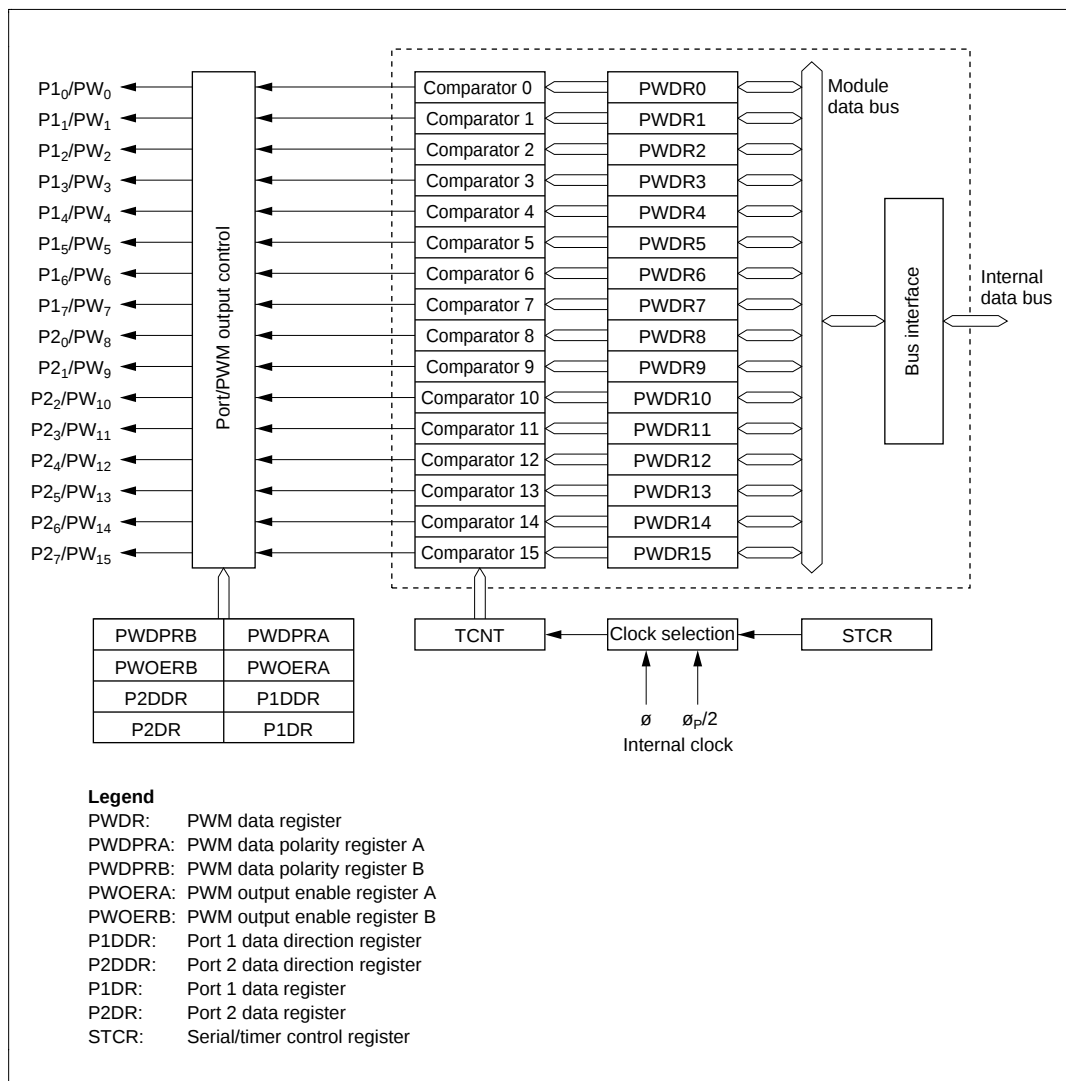
### 8.1.1 Features

The PWM timer module has the following features.

- Operable at a maximum carrier frequency of 1 MHz using pulse division (at 16 MHz operation)
- Duty cycles from 0 to 100% with 1/256 resolution (100% duty realized by port output)
- Direct or inverted PWM output, and software enable/disable control

## 8.1.2 Block Diagram

Figure 8-1 shows a block diagram of the PWM timer module.



**Figure 8-1 Block Diagram of PWM Timer Module**

### 8.1.3 Input and Output Pins

Table 8-1 lists the output pins of the PWM timer. There are no input pins.

**Table 8-1 PWM Timer Module Output Pins**

| Name              | Abbr.            | I/O    | Function                  |
|-------------------|------------------|--------|---------------------------|
| PWM output pin 0  | PW <sub>0</sub>  | Output | PWM timer pulse output 0  |
| PWM output pin 1  | PW <sub>1</sub>  | Output | PWM timer pulse output 1  |
| PWM output pin 2  | PW <sub>2</sub>  | Output | PWM timer pulse output 2  |
| PWM output pin 3  | PW <sub>3</sub>  | Output | PWM timer pulse output 3  |
| PWM output pin 4  | PW <sub>4</sub>  | Output | PWM timer pulse output 4  |
| PWM output pin 5  | PW <sub>5</sub>  | Output | PWM timer pulse output 5  |
| PWM output pin 6  | PW <sub>6</sub>  | Output | PWM timer pulse output 6  |
| PWM output pin 7  | PW <sub>7</sub>  | Output | PWM timer pulse output 7  |
| PWM output pin 8  | PW <sub>8</sub>  | Output | PWM timer pulse output 8  |
| PWM output pin 9  | PW <sub>9</sub>  | Output | PWM timer pulse output 9  |
| PWM output pin 10 | PW <sub>10</sub> | Output | PWM timer pulse output 10 |
| PWM output pin 11 | PW <sub>11</sub> | Output | PWM timer pulse output 11 |
| PWM output pin 12 | PW <sub>12</sub> | Output | PWM timer pulse output 12 |
| PWM output pin 13 | PW <sub>13</sub> | Output | PWM timer pulse output 13 |
| PWM output pin 14 | PW <sub>14</sub> | Output | PWM timer pulse output 14 |
| PWM output pin 15 | PW <sub>15</sub> | Output | PWM timer pulse output 15 |

## 8.1.4 Register Configuration

Table 8-2 lists the registers of the PWM timer module.

**Table 8-2 PWM Timer Module Registers**

| Name                           | Abbreviation | R/W* | Initial Value | Address |
|--------------------------------|--------------|------|---------------|---------|
| PWM data register 0            | PWDR0        | R/W  | H'00          | H'FFF0  |
| PWM data register 1            | PWDR1        | R/W  | H'00          | H'FFF1  |
| PWM data register 2            | PWDR2        | R/W  | H'00          | H'FFF2  |
| PWM data register 3            | PWDR3        | R/W  | H'00          | H'FFF3  |
| PWM data register 4            | PWDR4        | R/W  | H'00          | H'FFF4  |
| PWM data register 5            | PWDR5        | R/W  | H'00          | H'FFF5  |
| PWM data register 6            | PWDR6        | R/W  | H'00          | H'FFF6  |
| PWM data register 7            | PWDR7        | R/W  | H'00          | H'FFF7  |
| PWM data register 8            | PWDR8        | R/W  | H'00          | H'FFF8  |
| PWM data register 9            | PWDR9        | R/W  | H'00          | H'FFF9  |
| PWM data register 10           | PWDR10       | R/W  | H'00          | H'FFFA  |
| PWM data register 11           | PWDR11       | R/W  | H'00          | H'FFFB  |
| PWM data register 12           | PWDR12       | R/W  | H'00          | H'FFFC  |
| PWM data register 13           | PWDR13       | R/W  | H'00          | H'FFFD  |
| PWM data register 14           | PWDR14       | R/W  | H'00          | H'FFFE  |
| PWM data register 15           | PWDR15       | R/W  | H'00          | H'FFFF  |
| PWM data polarity register A   | PWDPRA       | R/W  | H'00          | H'FFCF  |
| PWM data polarity register B   | PWDPRB       | R/W  | H'00          | H'FFCE  |
| PWM output enable register A   | PWOERA       | R/W  | H'00          | H'FFD5  |
| PWM output enable register B   | PWOERB       | R/W  | H'00          | H'FFCD  |
| Port 1 data direction register | P1DDR        | W    | H'00          | H'FFB0  |
| Port 2 data direction register | P2DDR        | W    | H'00          | H'FFB1  |
| Port 1 data register           | P1DR         | R/W  | H'00          | H'FFB2  |
| Port 2 data register           | P2DR         | R/W  | H'00          | H'FFB3  |
| Serial/timer control register  | STCR         | R/W  | H'00          | H'FFC3  |

Note: \* Registers at addresses H'FFF0 to H'FFFF can only be read or written to when the HIE bit in the system control register (SYSCR) is 0.

## 8.2 Register Descriptions

### 8.2.1 PWM Data Registers (PWDR0 to PWDR15)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Each PWDR is an 8-bit readable/writable register that specifies the duty cycle of the basic pulse to be output, and the number of additional pulses. The value set in PWDR corresponds to a 0 or 1 ratio in the conversion period. The upper 4 bits specify the duty cycle of the basic pulse as 0 to 15/16 with a resolution of 1/16. The lower 4 bits specify how many extra pulses are to be added within the conversion period comprising 16 basic pulses. Thus, a specification of 0 to 255/256 is possible for 0/1 ratios within the conversion period. For 256/256 (100%) output, port output should be used.

PWDR is initialized to H'00 by a reset and in the standby modes.

### 8.2.2 PWM Data Polarity Registers A and B (PWPRA and PWPBRB)

#### PWPRA

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               | OS7 | OS6 | OS5 | OS4 | OS3 | OS2 | OS1 | OS0 |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

#### PWPBRB

| Bit           | 7    | 6    | 5    | 4    | 3    | 2    | 1   | 0   |
|---------------|------|------|------|------|------|------|-----|-----|
|               | OS15 | OS14 | OS13 | OS12 | OS11 | OS10 | OS9 | OS8 |
| Initial value | 0    | 0    | 0    | 0    | 0    | 0    | 0   | 0   |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W | R/W |

Each PWPDR is an 8-bit readable/writable register that controls the polarity of the PWM output. Bits OS0 to OS15 correspond to outputs PW0 to PW15.

PWPDR is initialized to H'00 by a reset and in the hardware standby modes.

| OS | Description                                                                        |
|----|------------------------------------------------------------------------------------|
| 0  | PWM direct output (PWDR value corresponds to high width of output) (Initial value) |
| 1  | PWM inverted output (PWDR value corresponds to low width of output)                |

### 8.2.3 PWM Output Enable Registers A and B (PWOERA and PWOERB)

#### PWOERA

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               | OE7 | OE6 | OE5 | OE4 | OE3 | OE2 | OE1 | OE0 |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

#### PWOERB

|               |      |      |      |      |      |      |     |     |
|---------------|------|------|------|------|------|------|-----|-----|
| Bit           | 7    | 6    | 5    | 4    | 3    | 2    | 1   | 0   |
|               | OE15 | OE14 | OE13 | OE12 | OE11 | OE10 | OE9 | OE8 |
| Initial value | 0    | 0    | 0    | 0    | 0    | 0    | 0   | 0   |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W | R/W |

Each PWOER is an 8-bit readable/writable register that switches between PWM output and port output. Bits OE0 to OE15 correspond to outputs PW0 to PW15. To set a pin in the output state, a setting in the port direction register is also necessary. Bits P1DDR0 to P1DDR7 correspond to outputs PW0 to PW7, and bits P2DDR0 to P2DDR7 correspond to outputs PW8 to PW15.

PWOER is initialized to H'00 by a reset and in the hardware standby modes.

| DDR | OE | Description                       |
|-----|----|-----------------------------------|
| 0   | 0  | Port input (Initial value)        |
| 0   | 1  | Port input                        |
| 1   | 0  | Port output or PWM 256/256 output |
| 1   | 1  | PWM output (0 to 255/256 output)  |

### 8.2.4 Port 1 Data Direction Register (P1DDR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P1DDR is an 8-bit write-only register that specifies the input/output direction and PWM output for each pin of port 1 in bit units.

Port 1 pins are multiplexed with pins PW0 to PW7. The bit corresponding to a pin to be used for PWM output should be set to 1.

For details on P1DDR, see section 7.2, Port 1.

### 8.2.5 Port 2 Data Direction Register (P2DDR)

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

P2DDR is an 8-bit write-only register that specifies the input/output direction and PWM output for each pin of port 2 in bit units.

Port 2 pins are multiplexed with pins PW8 to PW15. The bit corresponding to a pin to be used for PWM output should be set to 1.

For details on P2DDR, see section 7.3, Port 2.

### 8.2.6 Port 1 Data Register (P1DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P1 <sub>7</sub> | P1 <sub>6</sub> | P1 <sub>5</sub> | P1 <sub>4</sub> | P1 <sub>3</sub> | P1 <sub>2</sub> | P1 <sub>1</sub> | P1 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P1DR is an 8-bit readable/writable register used to fix PWM output at 1 (when OS = 0) or 0 (when OS = 1).

For details on P1DR, see section 7.2, Port 1.

## 8.2.7 Port 2 Data Register (P2DR)

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P2 <sub>7</sub> | P2 <sub>6</sub> | P2 <sub>5</sub> | P2 <sub>4</sub> | P2 <sub>3</sub> | P2 <sub>2</sub> | P2 <sub>1</sub> | P2 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

P2DR is an 8-bit readable/writable register used to fix PWM output at 1 (when OS = 0) or 0 (when OS = 1).

For details on P2DR, see section 7.3, Port 2.

## 8.2.8 Serial/Timer Control Register (STCR)

| Bit           | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|------|-------|-------|-------|-------|-------|-------|-------|
|               | IICS | IICX1 | IICX0 | SYNCE | PWCKE | PWCKS | ICKS1 | ICKS0 |
| Initial value | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Read/Write    | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

STCR is an 8-bit readable/writable register that controls the I<sup>2</sup>C bus interface operating mode and the TCNT clock source in the PWM timer module and the 8-bit timers.

STCR is initialized to H'00 by a reset.

**Bits 7 to 5—I<sup>2</sup>C Control (IICS, IICX1, IICX0):** These bits control the operation of the I<sup>2</sup>C bus interface. For details, see section 14, I<sup>2</sup>C Bus Interface.

**Bit 4—Timer Connection Output Enable (SYNCE):** This bit controls the outputs (VSYNCO, HSYNCO, CLAMPO) when the timers are interconnected. For details, see section 11, Timer Connection.

**Bits 3 and 2—PWM Clock Enable, PWM Clock Select (PWCKE, PWCKS):** These bits select the internal clock to be input to the timer counter (TCNT) in the PWM timer module.

| Bit 3<br>PWCKE | Bit 2<br>PWCKS | Description                                                            |
|----------------|----------------|------------------------------------------------------------------------|
| 0              | —              | Clock input is disabled (Initial value)                                |
| 1              | 0              | ∅ (system clock) is selected                                           |
| 1              | 1              | ∅ <sub>P</sub> /2 (supporting-module clock divided by two) is selected |

From the frequency of the selected internal clock, the PWM resolution, PWM conversion period, and carrier frequency can be calculated as follows.

Resolution (minimum pulse width)= 1/internal clock frequency

PWM conversion period = resolution × 256

Carrier frequency = 16/PWM conversion period

If the frequency of the system clock ( $\phi$ ) and supporting-module clock ( $\phi_p$ ) is 10 MHz, then the resolution, PWM conversion period, and carrier frequency are as shown in table 8-3.

**Table 8-3 Resolution, PWM Conversion Period, and Carrier Frequency**  
when  $\phi = \phi_p = 10$  MHz

| Internal Clock Frequency | Resolution (Minimum Pulse Width) | PWM Conversion Period | Carrier Frequency |
|--------------------------|----------------------------------|-----------------------|-------------------|
| $\phi$                   | 100 ns                           | 25 $\mu$ s            | 640 kHz           |
| $\phi_p/2$               | 200 ns                           | 50 $\mu$ s            | 320 kHz           |

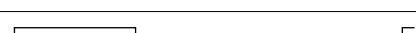
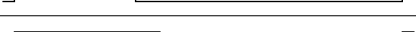
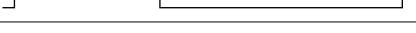
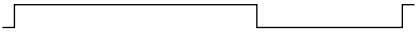
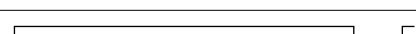
**Bits 1 and 0—Internal Clock Select 1 and 0 (ICKS1 and ICKS0):** These bits, together with bits CKS2 to CKS0 in TCR of the 8-bit timers, select the internal clock to be input to the timer counters (TCNT) in the 8-bit timers. For details, see section 10.2.3, Timer Control Register.

## 8.3 Operation

### 8.3.1 Correspondence between PWM Data Register Contents and Output Waveform

The upper 4 bits of PWDR specify the duty cycle of the basic pulse as 0 to 15/16 with a resolution of 1/16, as shown in table 8-4.

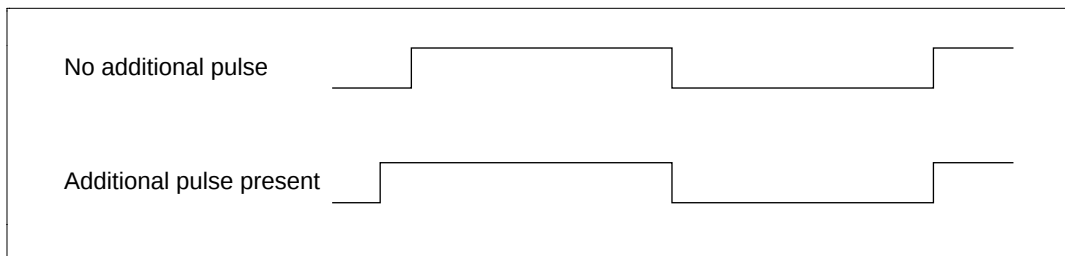
**Table 8-4 Duty Cycle of Basic Pulse**

| Upper 4 Bits | Waveform of Basic Pulse (Internal)                                                  |
|--------------|-------------------------------------------------------------------------------------|
|              | 0 1 2 3 4 5 6 7 8 9 A B C D E F 0                                                   |
| 0000         |    |
| 0001         |    |
| 0010         |    |
| 0011         |    |
| 0100         |    |
| 0101         |    |
| 0110         |    |
| 0111         |    |
| 1000         |    |
| 1001         |    |
| 1010         |    |
| 1011         |    |
| 1100         |   |
| 1101         |  |
| 1110         |  |
| 1111         |  |

The lower 4 bits of PWDR specify the position of pulses added to the 16 basic pulses, as shown in table 8-5. An additional pulse consists of a high period with a width equal to the resolution, added before the rising edge of a basic pulse. When the upper 4 bits of PWDR are 0000, there is no rising edge of the basic pulse, but the timing for adding pulses is the same.

**Table 8-5 Position of Pulses Added to Basic Pulses**

| Lower<br>4 Bits | Basic Pulse No. |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----------------|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                 | 0               | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  |
| 0000            |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 0001            |                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     | Yes |
| 0010            |                 |     |     |     |     |     |     | Yes |     |     |     |     |     |     |     | Yes |
| 0011            |                 |     |     |     |     |     |     | Yes |     |     |     | Yes |     |     |     | Yes |
| 0100            |                 |     |     | Yes |     |     |     | Yes |     |     |     | Yes |     |     |     | Yes |
| 0101            |                 |     |     | Yes |     |     |     | Yes |     |     |     | Yes |     | Yes |     | Yes |
| 0110            |                 |     |     | Yes |     | Yes |     | Yes |     |     |     | Yes |     | Yes |     | Yes |
| 0111            |                 |     |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |
| 1000            |                 | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |
| 1001            |                 | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes |     | Yes | Yes | Yes |
| 1010            |                 | Yes |     | Yes |     | Yes | Yes | Yes |     | Yes |     | Yes |     | Yes | Yes | Yes |
| 1011            |                 | Yes |     | Yes |     | Yes | Yes | Yes |     | Yes | Yes | Yes |     | Yes | Yes | Yes |
| 1100            |                 | Yes | Yes | Yes |     | Yes | Yes | Yes |     | Yes | Yes | Yes |     | Yes | Yes | Yes |
| 1101            |                 | Yes | Yes | Yes |     | Yes | Yes | Yes |     | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 1110            |                 | Yes | Yes | Yes | Yes | Yes | Yes | Yes |     | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 1111            |                 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |



**Figure 8-2 Example of Additional Pulse Timing (When Upper 4 Bits of PWDR = 1000)**



## Section 9 16-Bit Free-Running Timer

### 9.1 Overview

The H8/3217 Series has an on-chip 16-bit free-running timer (FRT) module that uses a 16-bit free-running counter as a time base. Applications of the FRT module include rectangular-wave output (up to two independent waveforms), input pulse width measurement, and measurement of external clock periods.

#### 9.1.1 Features

The features of the free-running timer module are listed below.

- Selection of four clock sources

The free-running counter can be driven by an internal clock source ( $\phi_p/2$ ,  $\phi_p/8$ , or  $\phi_p/32$ ), or an external clock input (enabling use as an external event counter).

- Two independent comparators

Each comparator can generate an independent waveform.

- Input capture

The current count can be captured on the rising or falling edge (selectable) of an input signal.

- Counter can be cleared under program control

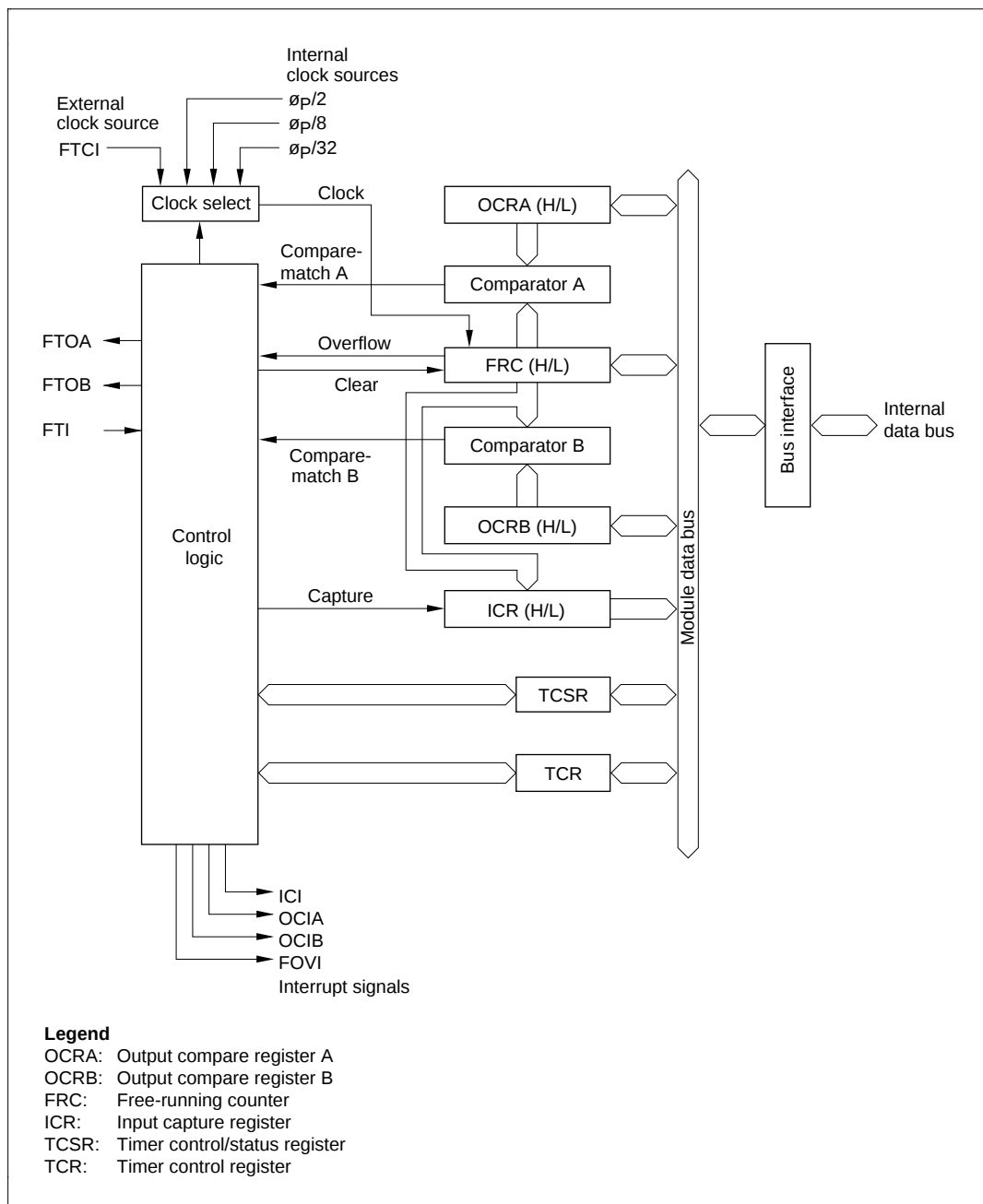
The free-running counter can be cleared on compare-match A.

- Four interrupt sources

Compare-match A and B, input capture, and overflow interrupts are requested independently.

## 9.1.2 Block Diagram

Figure 9-1 shows a block diagram of the free-running timer.



**Figure 9-1 Block Diagram of 16-Bit Free-Running Timer**

### 9.1.3 Input and Output Pins

Table 9-1 lists the input and output pins of the free-running timer module.

**Table 9-1 Input and Output Pins of Free-Running Timer Module**

| Name                | Abbreviation | I/O    | Function                                            |
|---------------------|--------------|--------|-----------------------------------------------------|
| Counter clock input | FTCI         | Input  | Input of external free-running counter clock signal |
| Output compare A    | FTOA         | Output | Output controlled by comparator A                   |
| Output compare B    | FTOB         | Output | Output controlled by comparator B                   |
| Input capture       | FTI          | Input  | Input capture trigger                               |

### 9.1.4 Register Configuration

Table 9-2 lists the registers of the free-running timer module.

**Table 9-2 Register Configuration**

| Name                             | Abbreviation | R/W    | Initial Value | Address |
|----------------------------------|--------------|--------|---------------|---------|
| Timer control register           | TCR          | R/W    | H'00          | H'FF90  |
| Timer control/status register    | TCSR         | R/(W)* | H'00          | H'FF91  |
| Free-running counter (high)      | FRC (H)      | R/W    | H'00          | H'FF92  |
| Free-running counter (low)       | FRC (L)      | R/W    | H'00          | H'FF93  |
| Output compare register A (high) | OCRA (H)     | R/W    | H'FF          | H'FF94  |
| Output compare register A (low)  | OCRA (L)     | R/W    | H'FF          | H'FF95  |
| Output compare register B (high) | OCRB (H)     | R/W    | H'FF          | H'FF96  |
| Output compare register B (low)  | OCRB (L)     | R/W    | H'FF          | H'FF97  |
| Input capture register (high)    | ICR (H)      | R      | H'00          | H'FF98  |
| Input capture register (low)     | ICR (L)      | R      | H'00          | H'FF99  |

Note: \* Software can write a 0 to clear bits 7 to 4, but cannot write a 1 in these bits.

## 9.2 Register Descriptions

### 9.2.1 Free-Running Counter (FRC)—H'FF92

| Bit           | 15  | 14  | 13  | 12  | 11  | 10  | 9   | 8   | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

The FRC is a 16-bit readable/writable up-counter that increments on an internal pulse generated from a clock source. The clock source is selected by the clock select 1 and 0 bits (CKS1 and CKS0) of the timer control register (TCR).

When the FRC overflows from H'FFFF to H'0000, the overflow flag (OVF) in the timer control/status register (TCSR) is set to 1.

Because the FRC is a 16-bit register, a temporary register (TEMP) is used when the FRC is written or read. See section 9.3, CPU Interface, for details.

The FRC is initialized to H'0000 by a reset and in the standby modes.

### 9.2.2 Output Compare Registers A and B (OCRA and OCRB)—H'FF94 and H'FF96

| Bit           | 15  | 14  | 13  | 12  | 11  | 10  | 9   | 8   | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

OCRA and OCRB are 16-bit readable/writable registers, the contents of which are continually compared with the value in the FRC. When a match is detected, the corresponding output compare flag (OCFA or OCFB) is set to 1 in the timer control/status register (TCSR).

In addition, if the output enable bit (OEA or OEB) in the timer output compare control register (TCR) is set to 1, when the output compare register and FRC values match, the logic level selected by the output level bit (OLVLA or OLVLB) in the TCSR is output at the output compare pin (FTOA or FTOB). After a reset, the output of FTOA and FTOB is 0 until the first compare-match event.

Because OCRA and OCRB are 16-bit registers, a temporary register (TEMP) is used for write access, as explained in section 9.3, CPU Interface.

OCRA and OCRB are initialized to H'FFFF by a reset and in the standby modes.

### 9.2.3 Input Capture Register (ICR)—H'FF98

| Bit           | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
|               |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
| Initial value | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write    | R  | R  | R  | R  | R  | R  | R | R | R | R | R | R | R | R | R | R |

The input capture register is a 16-bit read-only register.

When the rising or falling edge of the signal at the input capture pin (FTI) is detected, the current value of the FRC is copied to the input capture register (ICR). At the same time, the input capture flag (ICF) in the timer control/status register (TCSR) is set to 1. The input capture edge is selected by the input edge select bit (IEDG) in the TCSR.

Because the input capture register is a 16-bit register, a temporary register (TEMP) is used when it is read. See Section 9.3, CPU Interface, for details.

To ensure input capture, the width of the input capture pulse (FTI) should be at least 1.5 system clock cycles (1.5  $\phi$ ).

The input capture register is initialized to H'0000 by a reset and in the standby modes.

**Note:** When input capture is detected, the FRC value is transferred to the input capture register even if the input capture flag is already set.

## 9.2.4 Timer Control Register (TCR)—H'FF90

| Bit           | 7    | 6     | 5     | 4    | 3   | 2   | 1    | 0    |
|---------------|------|-------|-------|------|-----|-----|------|------|
|               | ICIE | OCIEB | OCIEA | OVIE | OEB | OEA | CKS1 | CKS0 |
| Initial value | 0    | 0     | 0     | 0    | 0   | 0   | 0    | 0    |
| Read/Write    | R/W  | R/W   | R/W   | R/W  | R/W | R/W | R/W  | R/W  |

TCR is an 8-bit readable/writable register that enables and disables output signals and interrupts, and selects the timer clock source.

TCR is initialized to H'00 by a reset and in the standby modes.

**Bit 7—Input Capture Interrupt Enable (ICIE):** Selects whether to request an input capture interrupt (ICI) when the input capture flag (ICF) in the timer status/control register (TCSR) is set to 1.

### Bit 7

| ICIE | Description                                                       |
|------|-------------------------------------------------------------------|
| 0    | Input capture interrupt request (ICI) is disabled (Initial value) |
| 1    | Input capture interrupt request (ICI) is enabled                  |

**Bit 6—Output Compare Interrupt Enable B (OCIEB):** Selects whether to request output compare interrupt B (OCIB) when output compare flag B (OCFB) in the timer status/control register (TCSR) is set to 1.

### Bit 6

| OCIEB | Description                                                           |
|-------|-----------------------------------------------------------------------|
| 0     | Output compare interrupt request B (OCIB) is disabled (Initial value) |
| 1     | Output compare interrupt request B (OCIB) is enabled                  |

**Bit 5—Output Compare Interrupt Enable A (OCIEA):** Selects whether to request output compare interrupt A (OCIA) when output compare flag A (OCFA) in the timer status/control register (TCSR) is set to 1.

### Bit 5

| OCIEA | Description                                                           |
|-------|-----------------------------------------------------------------------|
| 0     | Output compare interrupt request A (OCIA) is disabled (Initial value) |
| 1     | Output compare interrupt request A (OCIA) is enabled                  |

**Bit 4—Timer Overflow Interrupt Enable (OVIE):** Selects whether to request a free-running timer overflow interrupt (FOVI) when the timer overflow flag (OVF) in the timer status/control register (TCSR) is set to 1.

**Bit 4**

| OVIE | Description                                                         |
|------|---------------------------------------------------------------------|
| 0    | Timer overflow interrupt request (FOVI) is disabled (Initial value) |
| 1    | Timer overflow interrupt request (FOVI) is enabled                  |

**Bit 3—Output Enable B (OEB):** Enables or disables output of the output compare B signal (FTOB). If output compare B is enabled, the FTOB pin is driven to the level selected by OLVLB in the timer status/control register (TCSR) whenever the FRC value matches the value in output compare register B (OCRB).

**Bit 3**

| OEB | Description                                         |
|-----|-----------------------------------------------------|
| 0   | Output compare B output is disabled (Initial value) |
| 1   | Output compare B output is enabled                  |

**Bit 2—Output Enable A (OEA):** Enables or disables output of the output compare A signal (FTOA). If output compare A is enabled, the FTOA pin is driven to the level selected by OLVL A in the timer status/control register (TCSR) whenever the FRC value matches the value in output compare register A (OCRA).

**Bit 2**

| OEA | Description                                         |
|-----|-----------------------------------------------------|
| 0   | Output compare A output is disabled (Initial value) |
| 1   | Output compare A output is enabled                  |

**Bits 1 and 0—Clock Select (CKS1 and CKS0):** These bits select external clock input or one of three internal clock sources for the FRC. External clock pulses are counted on the rising edge at the external clock pin (FTCI).

| Bit 1<br>CKS1 | Bit 0<br>CKS0 | Description                                      |
|---------------|---------------|--------------------------------------------------|
| 0             | 0             | $\phi_P/2$ internal clock source (Initial value) |
| 0             | 1             | $\phi_P/8$ internal clock source                 |
| 1             | 0             | $\phi_P/32$ internal clock source                |
| 1             | 1             | External clock source (rising edge)              |

## 9.2.5 Timer Control/Status Register (TCSR)—H'FF91

| Bit           | 7      | 6      | 5      | 4      | 3     | 2     | 1     | 0     |
|---------------|--------|--------|--------|--------|-------|-------|-------|-------|
|               | ICF    | OCFB   | OCFA   | OVF    | OLVLB | OLVLA | IEDG  | CCLRA |
| Initial value | 0      | 0      | 0      | 0      | 0     | 0     | 0     | 0     |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R/(W) | R/(W) | R/(W) | R/W   |

Note: \* Software can write a 0 in bits 7 to 4 to clear the flags, but cannot write a 1 in these bits.

TCSR is an 8-bit readable and partially writable register that contains four status flags and selects the output compare levels, input capture edge, and whether to clear the counter on compare-match A.

TCSR is initialized to H'00 by a reset and in the standby modes.

**Bit 7—Input Capture Flag (ICF):** This status flag is set to 1 to indicate an input capture event, showing that the FRC value has been copied to the ICR.

ICF must be cleared by software. It is set by hardware, however, and cannot be set by software.

### Bit 7

| ICF | Description                                                                                                   |
|-----|---------------------------------------------------------------------------------------------------------------|
| 0   | To clear ICF, the CPU must read ICF after it has been set to 1, (Initial value)<br>then write a 0 in this bit |
| 1   | This bit is set to 1 when an FTI input signal causes the FRC<br>value to be copied to the ICR                 |

**Bit 6—Output Compare Flag B (OCFB):** This status flag is set to 1 when the FRC value matches the OCRB value.

OCFB must be cleared by software. It is set by hardware, however, and cannot be set by software.

### Bit 6

| OCFB | Description                                                                                                     |
|------|-----------------------------------------------------------------------------------------------------------------|
| 0    | To clear OCFB, the CPU must read OCFB after it has been (Initial value)<br>set to 1, then write a 0 in this bit |
| 1    | This bit is set to 1 when FRC = OCRB                                                                            |

**Bit 5—Output Compare Flag A (OCFA):** This status flag is set to 1 when the FRC value matches the OCRA value.

OCFA must be cleared by software. It is set by hardware, however, and cannot be set by software.

**Bit 5**

| OCFA | Description                                                                                  |                 |
|------|----------------------------------------------------------------------------------------------|-----------------|
| 0    | To clear OCFA, the CPU must read OCFA after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1    | This bit is set to 1 when FRC = OCRA                                                         |                 |

**Bit 4—Timer Overflow Flag (OVF):** This status flag is set to 1 when the FRC overflows (changes from H'FFFF to H'0000).

OVF must be cleared by software. It is set by hardware, however, and cannot be set by software.

**Bit 4**

| OVF | Description                                                                                |                 |
|-----|--------------------------------------------------------------------------------------------|-----------------|
| 0   | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1   | This bit is set to 1 when FRC changes from H'FFFF to H'0000                                |                 |

**Bit 3—Output Level B (OLVLB):** Selects the logic level output at the FTOB pin when the FRC and OCRB values match.

**Bit 3**

| OLVLB | Description                                   |                 |
|-------|-----------------------------------------------|-----------------|
| 0     | A 0 logic level is output for compare-match B | (Initial value) |
| 1     | A 1 logic level is output for compare-match B |                 |

**Bit 2—Output Level A (OLVLA):** Selects the logic level output at the FTOA pin when the FRC and OCRA values match.

**Bit 2**

| OLVLA | Description                                   |                 |
|-------|-----------------------------------------------|-----------------|
| 0     | A 0 logic level is output for compare-match A | (Initial value) |
| 1     | A 1 logic level is output for compare-match A |                 |

**Bit 1—Input Edge Select (IEDG):** Selects the rising or falling edge of the input capture signal (FTI).

**Bit 1**

| IEDG | Description                                                                    |
|------|--------------------------------------------------------------------------------|
| 0    | FRC contents are transferred to ICR on the falling edge of FTI (Initial value) |
| 1    | FRC contents are transferred to ICR on the rising edge of FTI                  |

**Bit 0—Counter Clear A (CCLRA):** Selects whether to clear the FRC at compare-match A (when the FRC and OCRA values match).

**Bit 0**

| CCLRA | Description                            |
|-------|----------------------------------------|
| 0     | The FRC is not cleared (Initial value) |
| 1     | The FRC is cleared at compare-match A  |

## 9.3 CPU Interface

The free-running counter (FRC), output compare registers (OCRA and OCRB), and input capture register (ICR) are 16-bit registers, but they are connected to an 8-bit data bus. When the CPU accesses these registers, to ensure that both bytes are written or read simultaneously, the access is performed using an 8-bit temporary register (TEMP).

These registers are written and read as follows:

- Register write

When the CPU writes to the upper byte, the byte of write data is placed in TEMP. Next, when the CPU writes to the lower byte, this byte of data is combined with the byte in TEMP and all 16 bits are written in the register simultaneously.

- Register read

When the CPU reads the upper byte, the upper byte of data is sent to the CPU and the lower byte is placed in TEMP. When the CPU reads the lower byte, it receives the value in TEMP.

(As an exception, when the CPU reads OCRA or OCRB, it reads both the upper and lower bytes directly, without using TEMP.)

Programs that access these registers should normally use word access. Equivalently, they may access first the upper byte, then the lower byte by two consecutive byte accesses. Data will not be transferred correctly if the bytes are accessed in reverse order, if only one byte is accessed, or if the upper and lower bytes are accessed separately and another register is accessed in between, altering the value in TEMP.

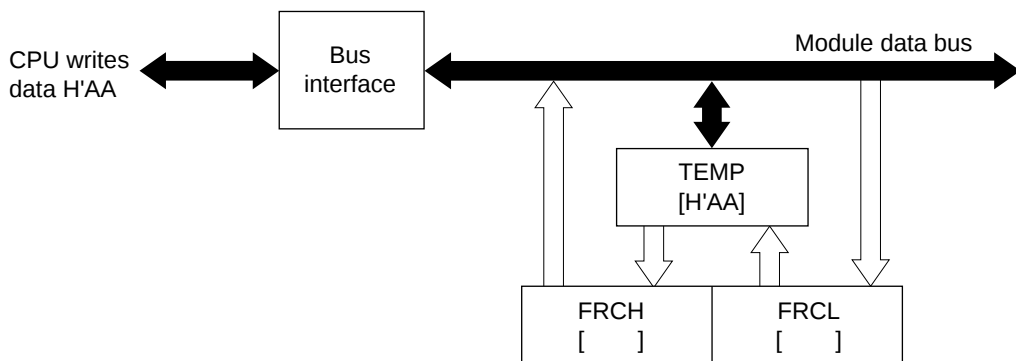
### Coding Examples

To write the contents of general register R0 to OCRA: `MOV.W R0, @OCRA`

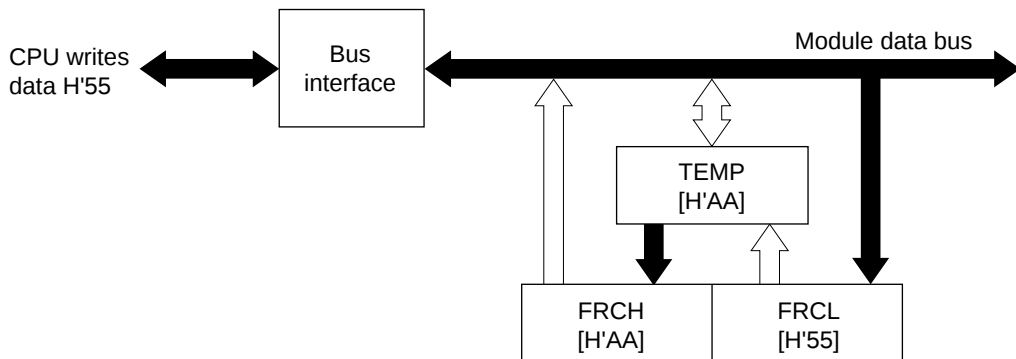
To transfer the ICR contents to general register R0: `MOV.W @ICR, R0`

Figure 9-2 shows the data flow when the FRC is accessed. The other registers are accessed in the same way.

(1) Upper byte write

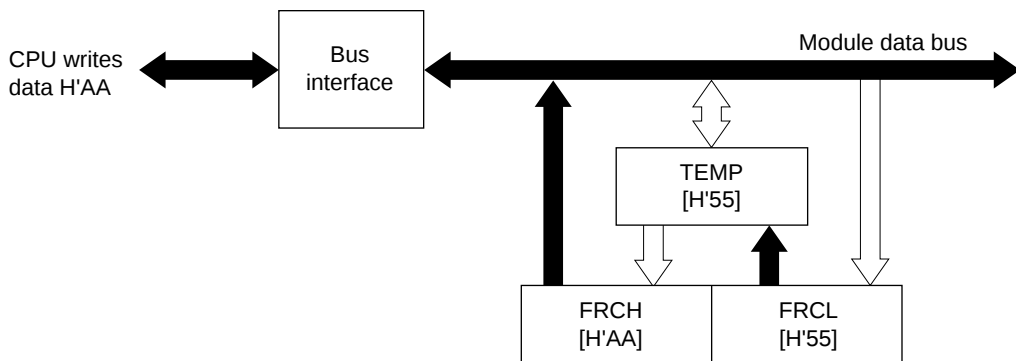


(2) Lower byte write

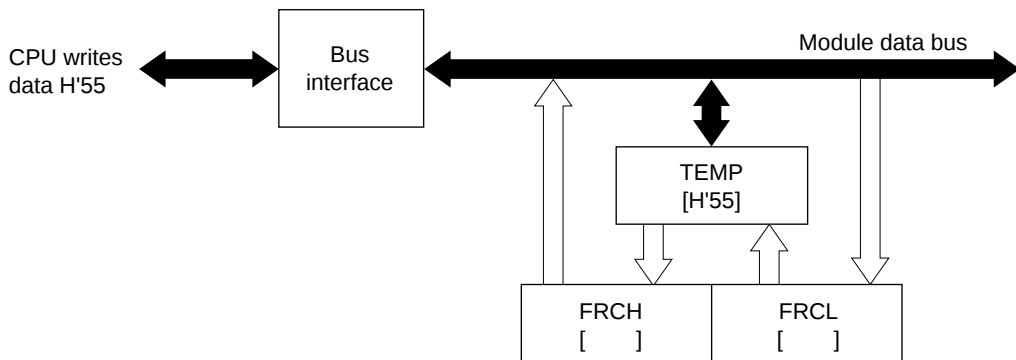


**Figure 9-2 (a) Write Access to FRC (When CPU Writes H'AA55)**

(1) Upper byte read



(2) Lower byte read



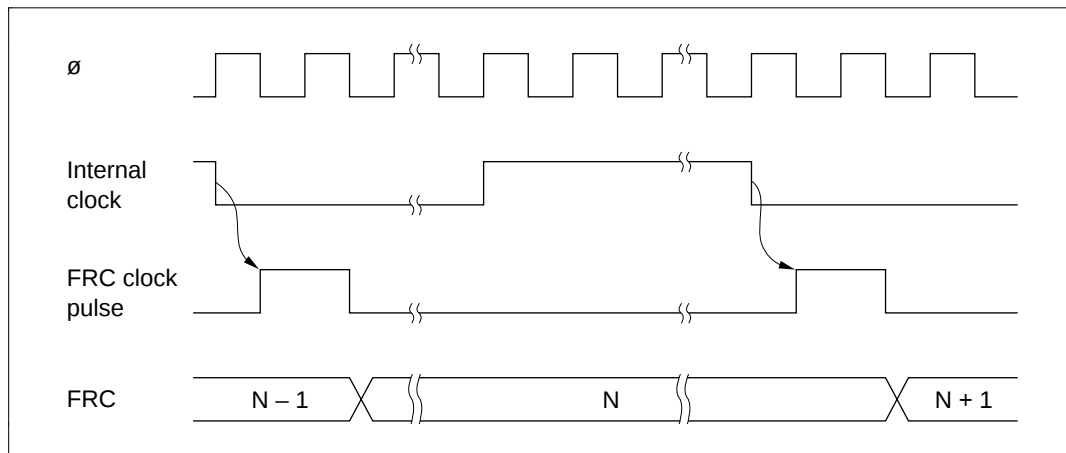
**Figure 9-2 (b) Read Access to FRC (When FRC Contains H'AA55)**

## 9.4 Operation

### 9.4.1 FRC Incrementation Timing

The FRC increments on a pulse generated once for each cycle of the selected (internal or external) clock source.

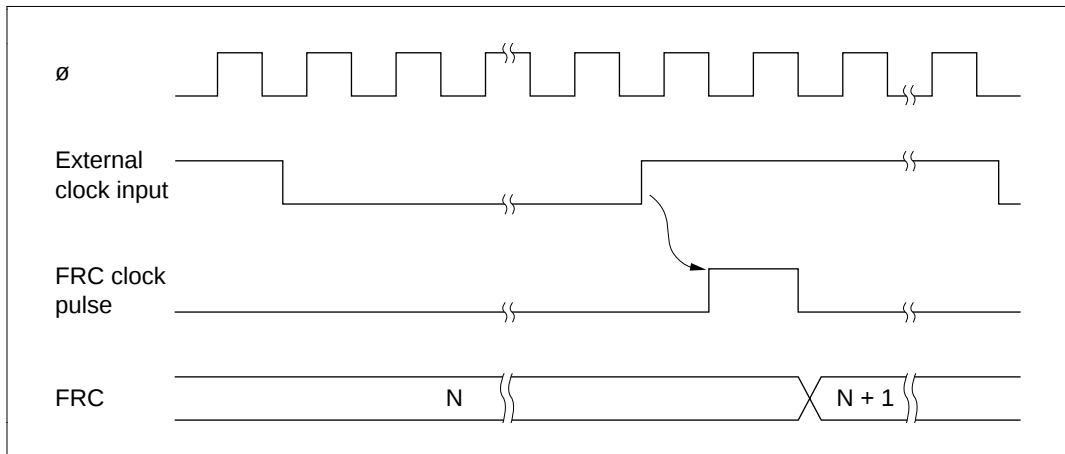
**(1) Internal Clock Sources:** Can be selected by the CKS1 and CKS0 bits in TCR. Internal clock sources are created by dividing the system clock ( $\emptyset$ ). Three internal clock sources are available:  $\emptyset_p/2$ ,  $\emptyset_p/8$ , and  $\emptyset_p/32$ . Figure 9-3 shows the increment timing.



**Figure 9-3 Increment Timing for Internal Clock Source**

**(2) External Clock Input:** Can be selected by the CKS1 and CKS0 bits in the TCR. The FRC increments on the rising edge of the FTCl clock signal. The pulse width of the external clock signal must be at least 1.5 system clock ( $\phi$ ) cycles. The counter will not increment correctly if the pulse width is shorter than this.

Figure 9-4 shows the increment timing.



**Figure 9-4 Increment Timing for External Clock Source**

## 9.4.2 Output Compare Timing

When a compare-match occurs, the logic level selected by the output level bit (OLVLA or OLVLB) in TCSR is output at the output compare pin (FTOA or FTOB). Figure 9-5 shows the timing of this operation for compare-match A.

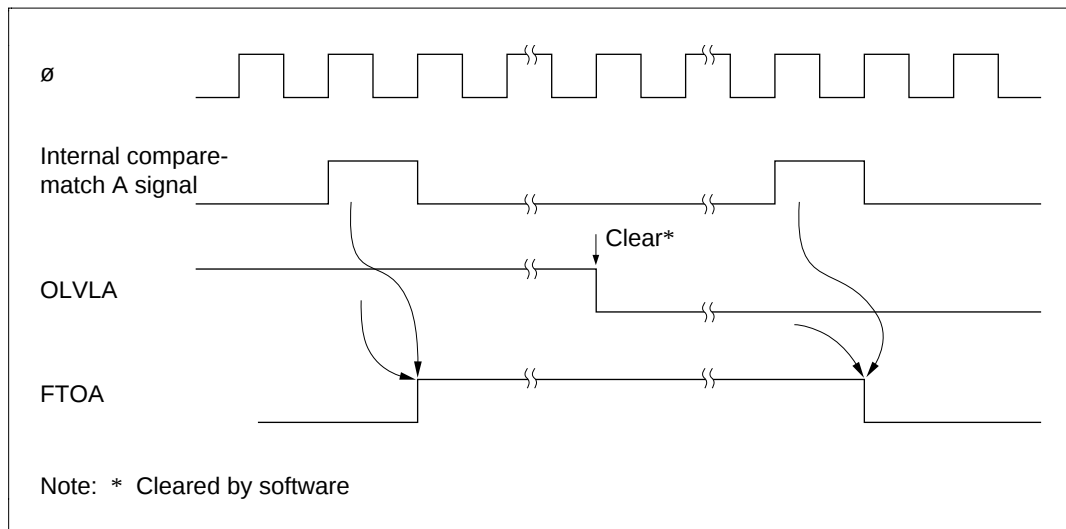


Figure 9-5 Timing of Output Compare A

## 9.4.3 FRC Clear Timing

If the CCLRA bit in TCSR is set to 1, the FRC is cleared when compare-match A occurs. Figure 9-6 shows the timing of this operation.

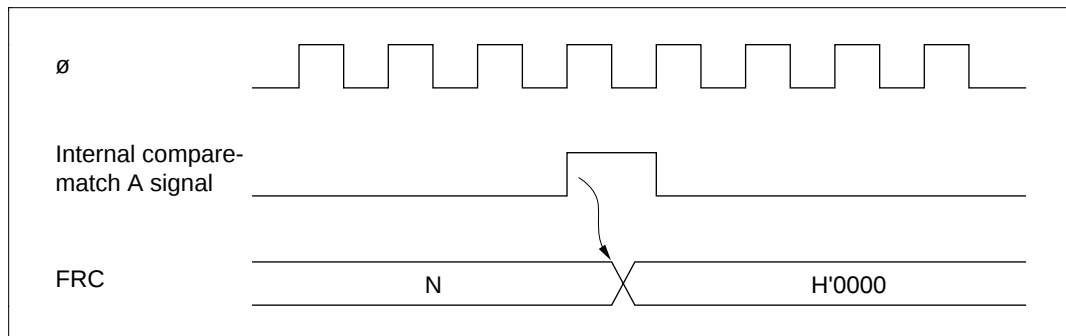
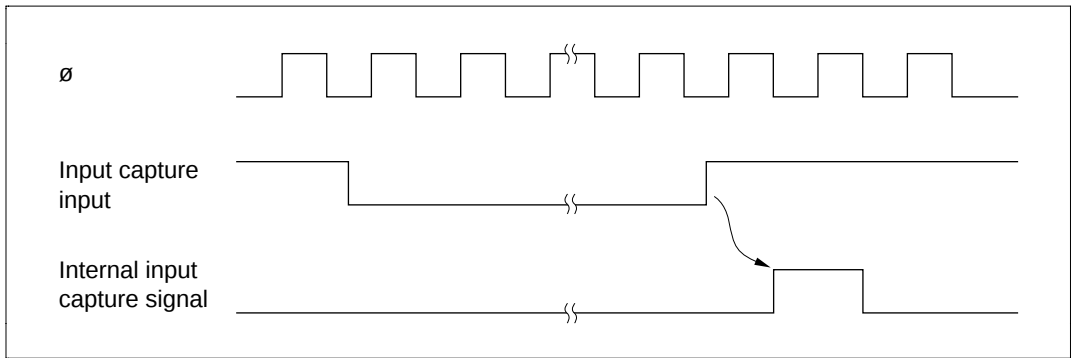


Figure 9-6 Clearing of FRC by Compare-Match A

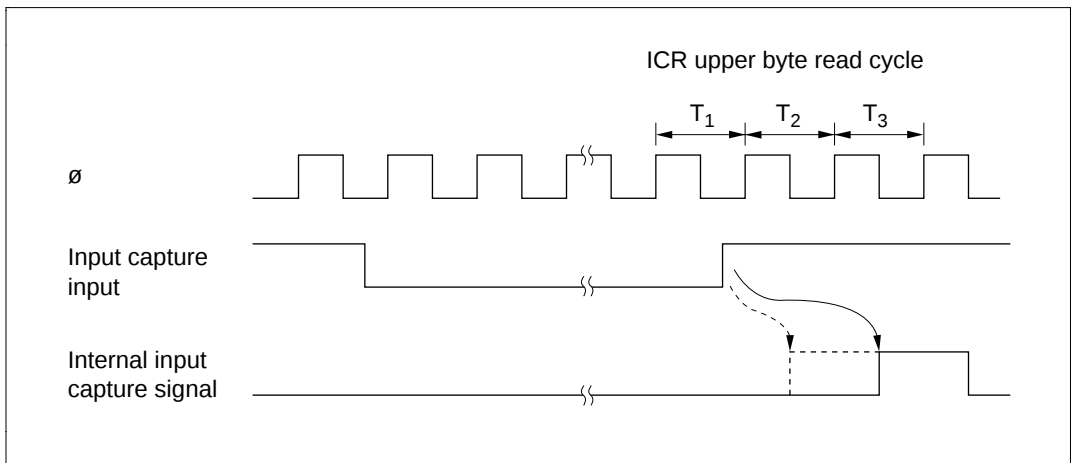
#### 9.4.4 Input Capture Timing

An internal input capture signal is generated from the rising or falling edge of the FTI input, as selected by the IEDG bit in TCSR. Figure 9-7 shows the usual input capture timing when the rising edge is selected (IEDG = 1).



**Figure 9-7 Input Capture Timing (Usual Case)**

If the upper byte of ICR is being read when the internal input capture signal should be generated, the internal input capture signal is delayed by one state. Figure 9-8 shows the timing for this case.



**Figure 9-8 Input Capture Timing (1-State Delay Due to ICR Read)**

### 9.4.5 Timing of Input Capture Flag (ICF) Setting

The input capture flag ICF is set to 1 by the internal input capture signal. The FRC contents are transferred to ICR at the same time. Figure 9-9 shows the timing of this operation.

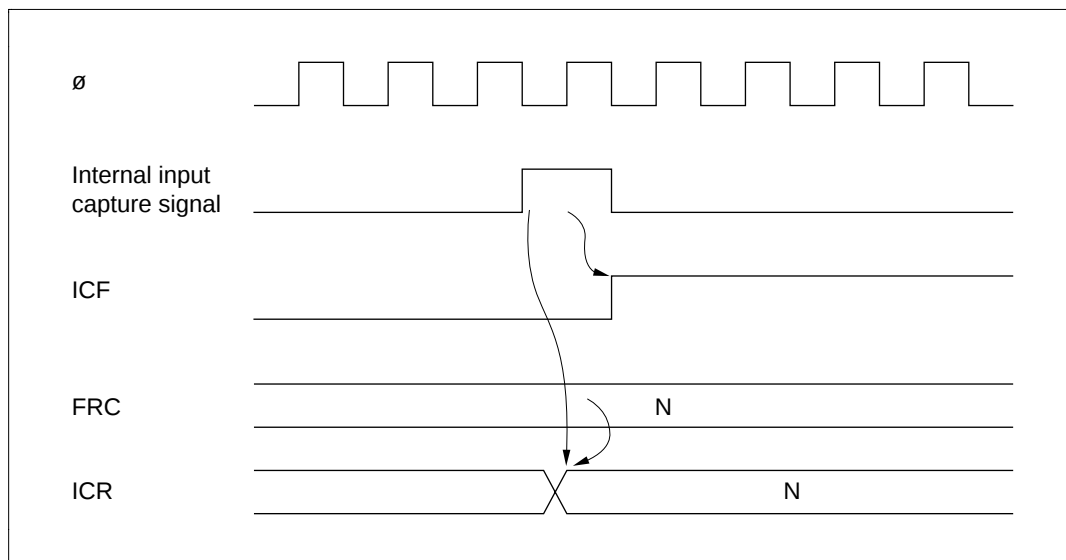


Figure 9-9 Setting of Input Capture Flag

### 9.4.6 Setting of FRC Overflow Flag (OVF)

The FRC overflow flag (OVF) is set to 1 when the FRC changes from H'FFFF to H'0000. Figure 9-10 shows the timing of this operation.

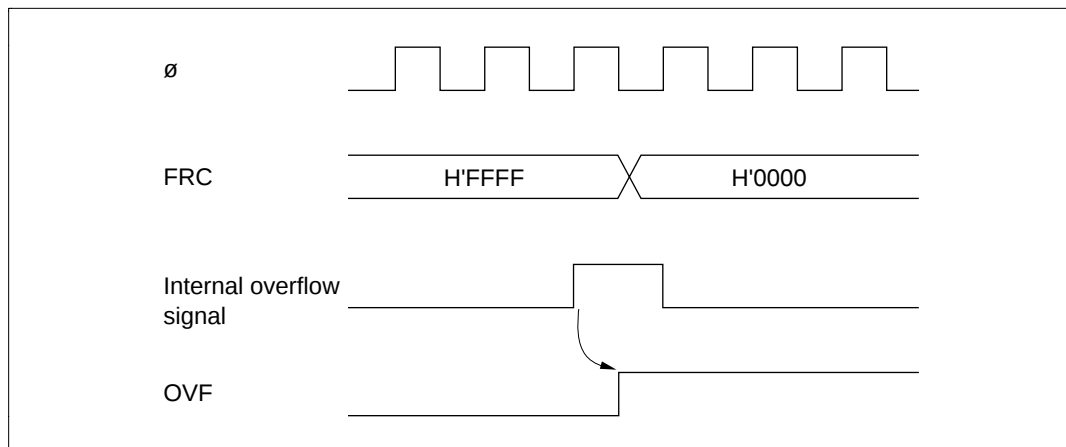


Figure 9-10 Setting of Overflow Flag

## 9.5 Interrupts

The free-running timer module can request four types of interrupts: input capture (ICI), output compare A and B (OCIA and OCIB), and overflow (FOVI). Each interrupt is requested when the corresponding flag bit is set, provided the corresponding enable bit is also set. Independent signals are sent to the interrupt controller for each type of interrupt. Table 9-3 lists information about these interrupts.

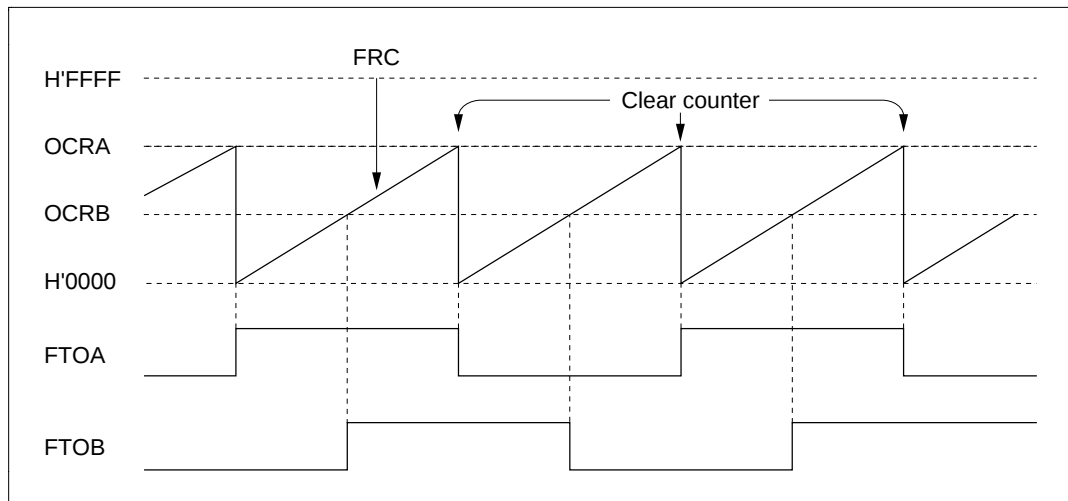
**Table 9-3 Free-Running Timer Interrupts**

| Interrupt | Description                | Priority                                                                           |
|-----------|----------------------------|------------------------------------------------------------------------------------|
| ICI       | Requested when ICF is set  | High                                                                               |
| OCIA      | Requested when OCFA is set |  |
| OCIB      | Requested when OCFB is set |                                                                                    |
| FOVI      | Requested when OVF is set  | Low                                                                                |

## 9.6 Sample Application

In the example below, the free-running timer module is used to generate two square-wave outputs with a 50% duty factor and arbitrary phase relationship. The programming is as follows:

1. The CCLRA bit in TCSR is set to 1.
2. Each time a compare-match interrupt occurs, software inverts the corresponding output level bit in TCSR (OLVLA or OLVLB).



**Figure 9-11 Square-Wave Output (Example)**

## 9.7 Application Notes

Application programmers should note that the following types of contention can occur in the free-running timer.

**(1) Contention between FRC Write and Clear:** If an internal counter clear signal is generated during the  $T_3$  state of a write cycle to the lower byte of the free-running counter, the clear signal takes priority and the write is not performed.

Figure 9-12 shows this type of contention.

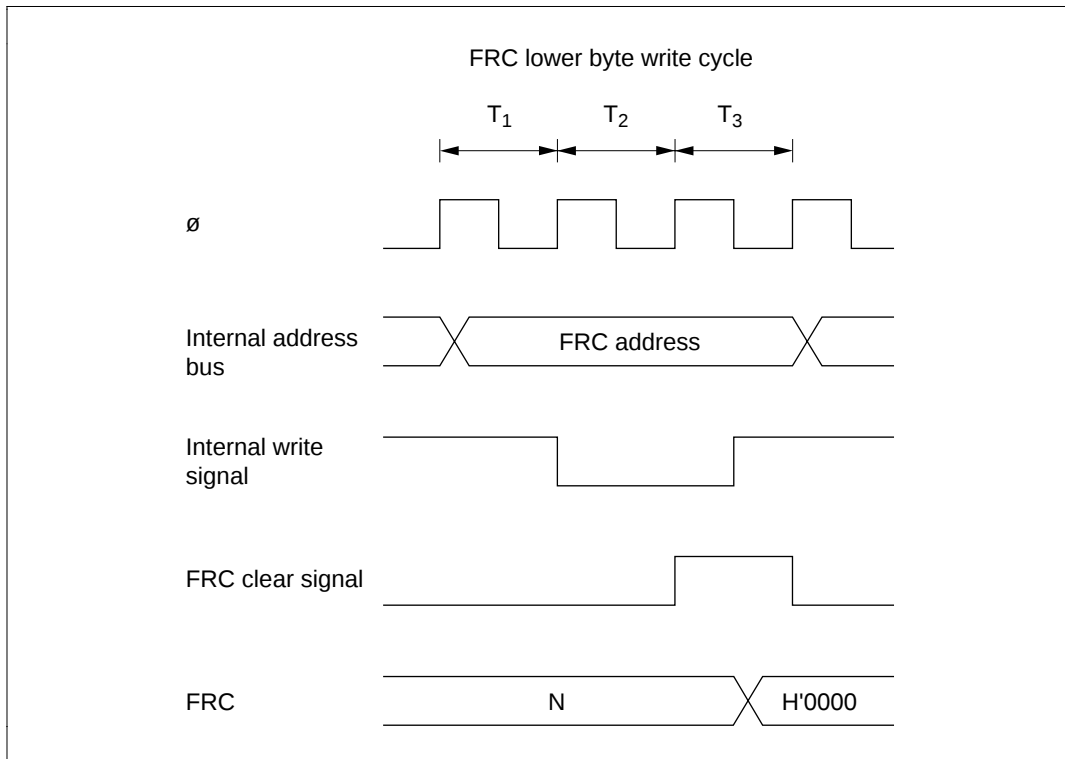
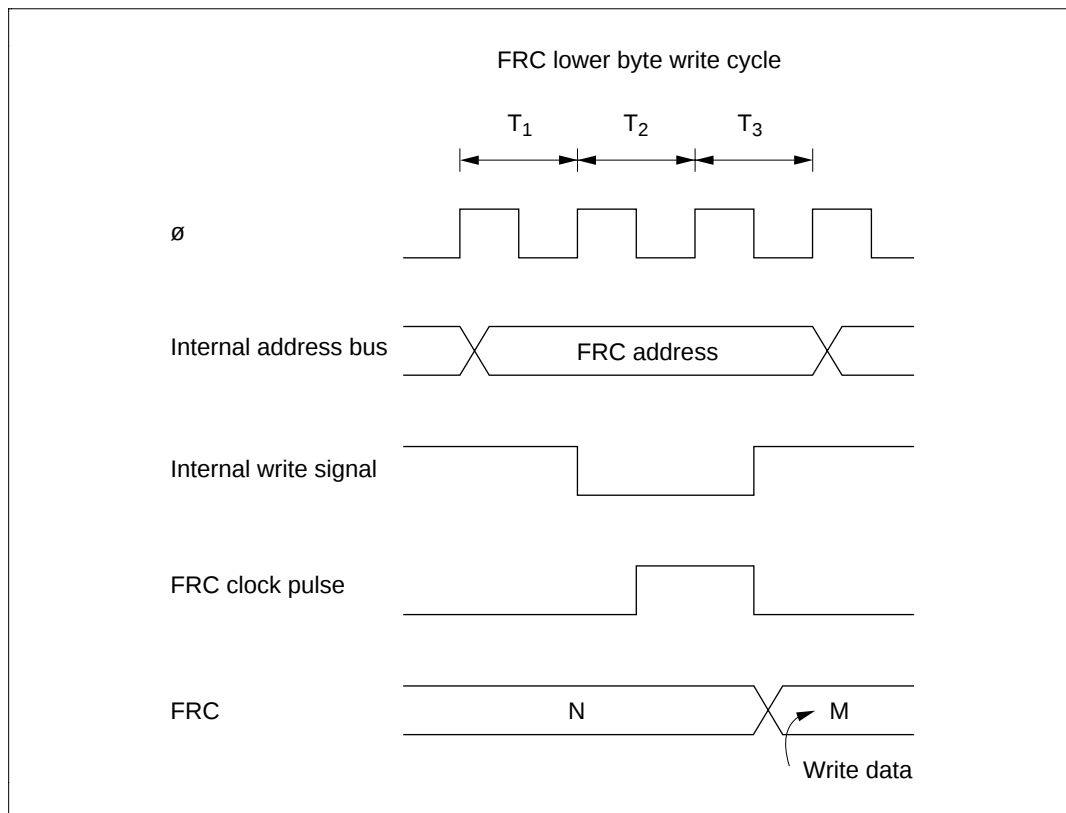


Figure 9-12 FRC Write-Clear Contention

**(2) Contention between FRC Write and Increment:** If an FRC increment pulse is generated during the  $T_3$  state of a write cycle to the lower byte of the free-running counter, the write takes priority and the FRC is not incremented.

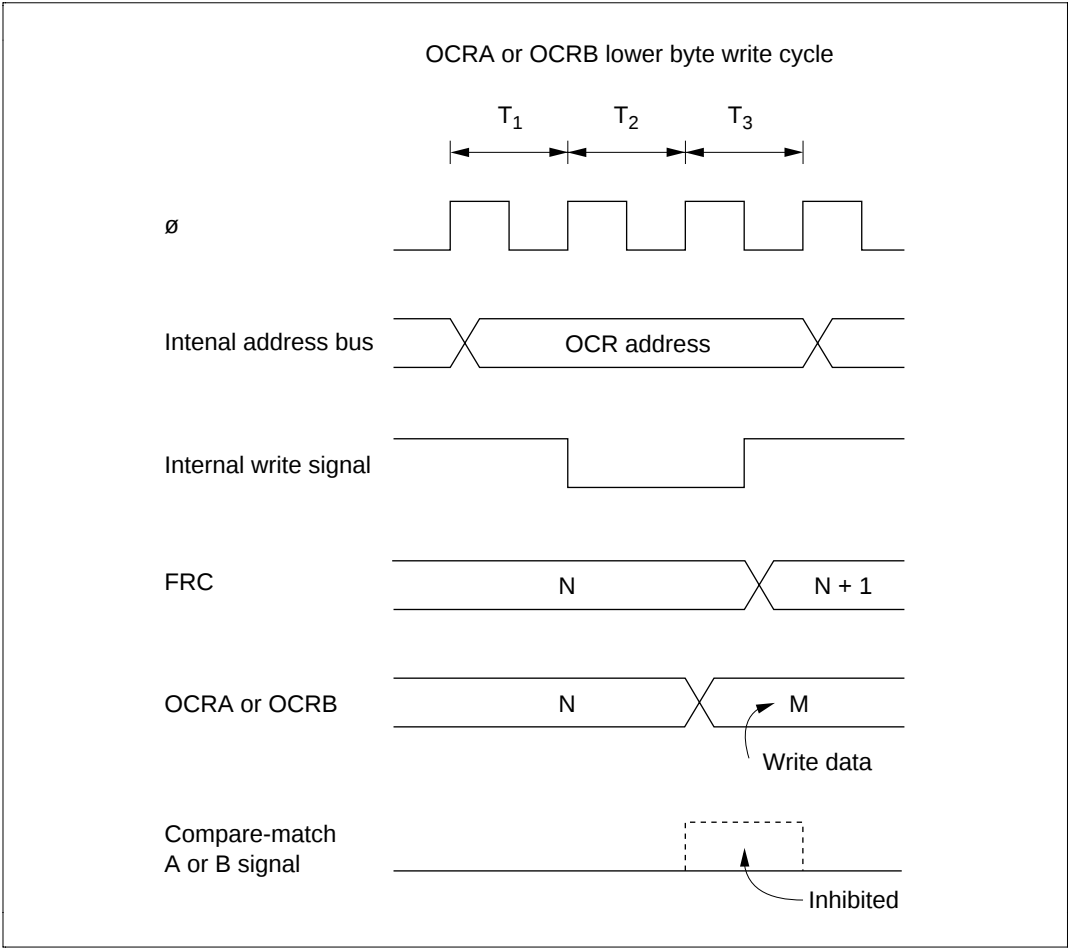
Figure 9-13 shows this type of contention.



**Figure 9-13 FRC Write-Increment Contention**

**(3) Contention between OCR Write and Compare-Match:** If a compare-match occurs during the  $T_3$  state of a write cycle to the lower byte of OCRA or OCRB, the write takes priority and the compare-match signal is inhibited.

Figure 9-14 shows this type of contention.



**Figure 9-14 Contention between OCR Write and Compare-Match**

**(4) Increment Caused by Changing of Internal Clock Source:** When an internal clock source is changed, the changeover may cause the FRC to increment. This depends on the time at which the clock select bits (CKS1 and CKS0) are rewritten, as shown in table 9-4.

The pulse that increments the FRC is generated at the falling edge of the internal clock source. If clock sources are changed when the old source is high and the new source is low, as in case No. 3 in table 9-4, the changeover generates a falling edge that triggers the FRC increment clock pulse.

Switching between an internal and external clock source can also cause the FRC to increment.

**Table 9-4    Effect of Changing Internal Clock Sources**

| No. | Description                                                                                            | Timing Chart                                                                                                                    |
|-----|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 1   | Low → low:<br>CKS1 and CKS0 are rewritten while both clock sources are low.                            | <p>Old clock source</p> <p>New clock source</p> <p>FRC clock pulse</p> <p>FRC</p> <p>N    N + 1</p> <p>CKS rewrite</p>          |
| 2   | Low → high:<br>CKS1 and CKS0 are rewritten while old clock source is low and new clock source is high. | <p>Old clock source</p> <p>New clock source</p> <p>FRC clock pulse</p> <p>FRC</p> <p>N    N + 1    N + 2</p> <p>CKS rewrite</p> |

**Table 9-4 Effect of Changing Internal Clock Sources (cont)**

| No. | Description                                                                                            | Timing Chart                                                                                                                    |
|-----|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 3   | High → low:<br>CKS1 and CKS0 are rewritten while old clock source is high and new clock source is low. | <p>Old clock source</p> <p>New clock source</p> <p>FRC clock pulse</p> <p>FRC</p> <p>N    N + 1    N + 2</p> <p>CKS rewrite</p> |
| 4   | High → high:<br>CKS1 and CKS0 are rewritten while both clock sources are high.                         | <p>Old clock source</p> <p>New clock source</p> <p>FRC clock pulse</p> <p>FRC</p> <p>N    N + 1    N + 2</p> <p>CKS rewrite</p> |

Note: \* The switching of clock sources is regarded as a falling edge that increments the FRC.

## Section 10 8-Bit Timers

[Two channels incorporated in the H8/3202, and three channels in all other models]

Note that the H8/3202 does not have a channel X (TMRX).

### 10.1 Overview

The H8/3217 Series has an 8-bit timer module with three channels: timers 0, 1, and X. Each channel has an 8-bit counter (TCNT) and two time constant registers (TCORA and TCORB) that are constantly compared with the TCNT value to detect compare-match events. One application of the 8-bit timer module is to generate a rectangular-wave output with an arbitrary duty factor.

#### 10.1.1 Features

The features of the 8-bit timer module are listed below.

- Selection of seven clock sources for TMR0 and TMR1, and four clock sources for TMRX

The counters can be driven by an internal clock signal (selection of six signals for TMR0 and TMR1, and three signals for TMRX) or an external clock input (enabling use as an external event counter).

- Selection of three ways to clear the counters

The counters can be cleared on compare-match A or B, or by an external reset signal.

- Timer output controlled by two compare-match signals

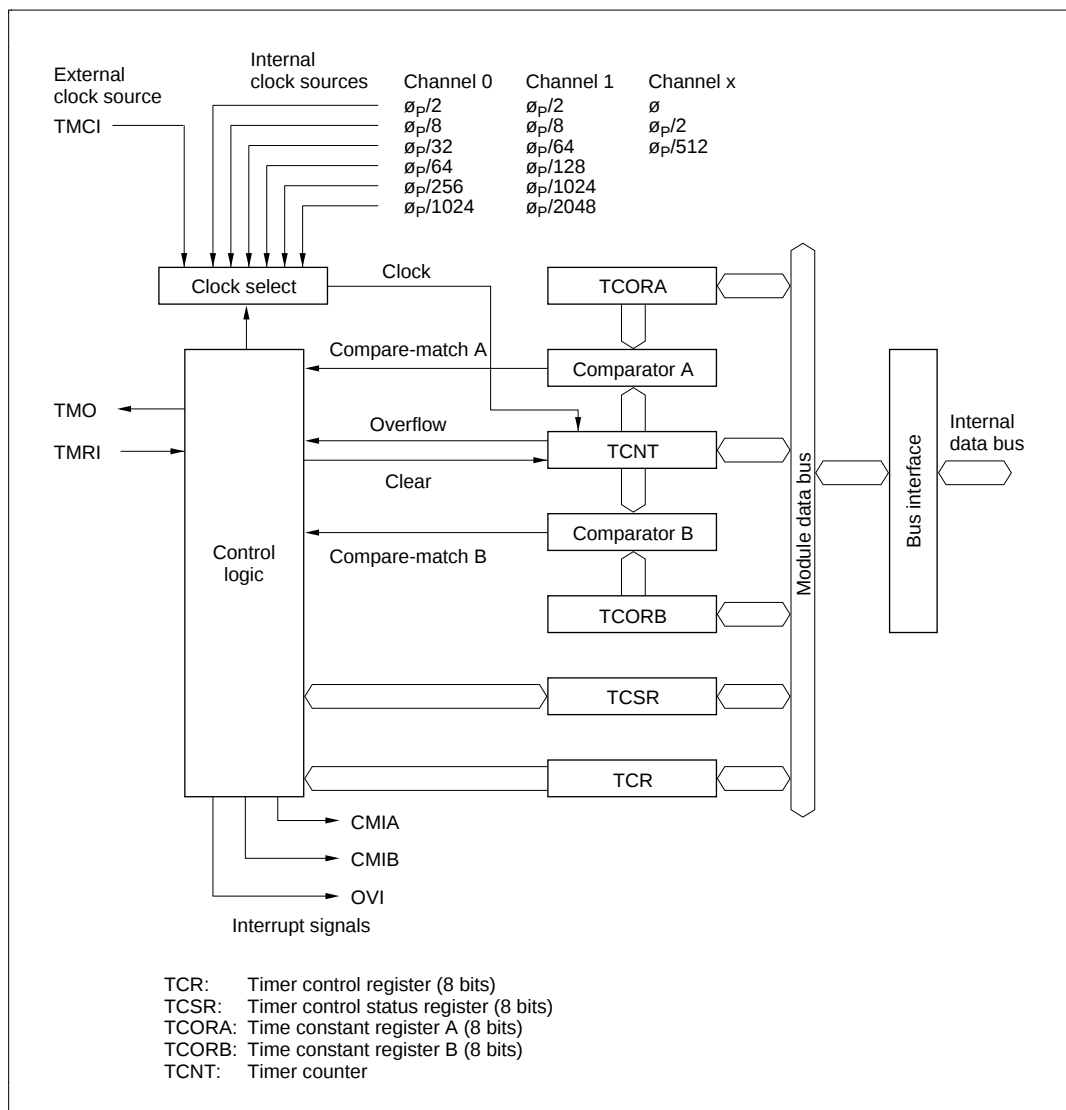
The timer output signal in each channel is controlled by two independent compare-match signals, enabling the timer to generate output waveforms with an arbitrary duty factor. PWM mode can be selected, enabling PWM output of 0% to 100%.

- Three independent interrupts

Compare-match A and B and overflow interrupts can be requested independently.

## 10.1.2 Block Diagram

Figure 10-1 shows a block diagram of one channel in the 8-bit timer module. The other channels are identical.



**Figure 10-1 Block Diagram of 8-Bit Timer (One Channel)**

### 10.1.3 Input and Output Pins

Table 10-1 lists the input and output pins of the 8-bit timer.

**Table 10-1 Input and Output Pins of 8-Bit Timer**

| Channel | Name                    | Abbreviation*                                  | I/O    | Function                                           |
|---------|-------------------------|------------------------------------------------|--------|----------------------------------------------------|
| 0       | Timer output            | TMO <sub>0</sub>                               | Output | Output controlled by compare-match                 |
|         | Timer clock input       | TMCI <sub>0</sub>                              | Input  | External clock source for the counter              |
|         | Timer reset input       | TMRI <sub>0</sub>                              | Input  | External reset signal for the counter              |
| 1       | Timer output            | TMO <sub>1</sub>                               | Output | Output controlled by compare-match                 |
|         | Timer clock input       | TMCI <sub>1</sub>                              | Input  | External clock source for the counter              |
|         | Timer reset input       | TMRI <sub>1</sub>                              | Input  | External reset signal for the counter              |
| X       | Timer output            | CLAMPO (TMO <sub>x</sub> )                     | Output | Output controlled by compare-match                 |
|         | Timer clock/reset input | FBACKI (TMCI <sub>x</sub> /TMRI <sub>x</sub> ) | Input  | External clock source/reset signal for the counter |

Note: \* The abbreviations TMO, TMCI, and TMRI are used in the text, omitting the channel number.

Channel X I/O pins have the same internal configuration as channels 0 and 1, and therefore the same abbreviations are used.

### 10.1.4 Register Configuration

Table 10-2 lists the registers of the 8-bit timer module. Each channel has an independent set of registers.

**Table 10-2 8-Bit Timer Registers**

| Name                          | Abbreviation | R/W    | Initial Value | Address |        |        |
|-------------------------------|--------------|--------|---------------|---------|--------|--------|
|                               |              |        |               | TMR0    | TMR1   | TMRX   |
| Timer control register        | TCR          | R/W    | H'00          | H'FFC8  | H'FFD0 | H'FF9A |
| Timer control/status register | TCSR         | R/(W)* | H'00          | H'FFC9  | H'FFD1 | H'FF9B |
| Timer constant register A     | TCORA        | R/W    | H'FF          | H'FFCA  | H'FFD2 | H'FF9C |
| Timer constant register B     | TCORB        | R/W    | H'FF          | H'FFCB  | H'FFD3 | H'FF9D |
| Timer counter                 | TCNT         | R/W    | H'00          | H'FFCC  | H'FFD4 | H'FF9E |
| Serial timer control register | STCR         | R/W    | H'00          | H'FFC3  | H'FFC3 | —      |

Note: \* Software can write a 0 to clear bits 7 to 5, but cannot write a 1 in these bits.

## 10.2 Register Descriptions

### 10.2.1 Timer Counter (TCNT)—H'FFCC (TMR0), H'FFD4 (TMR1), H'FF9E (TMRX)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Each timer counter (TCNT) is an 8-bit up-counter that increments on a pulse generated from the selected clock source. The clock source is selected by clock select bits 2 to 0 (CKS2 to CKS0) of the timer control register (TCR). The CPU can always read or write the timer counter.

The timer counter can be cleared by an external reset input or by an internal compare-match signal generated at a compare-match event. Counter clear bits 1 and 0 (CCLR1 and CCLR0) of the timer control register select the method of clearing.

When a timer counter overflows from H'FF to H'00, the overflow flag (OVF) in the timer control/status register (TCSR) is set to 1.

The timer counters are initialized to H'00 by a reset and in the standby modes.

### 10.2.2 Time Constant Registers A and B (TCORA and TCORB)—H'FFCA and H'FFCB (TMR0), H'FFD2 and H'FFD3 (TMR1), H'FF9C and H'FF9D (TMRX)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

TCORA and TCORB are 8-bit readable/writable registers. The timer count is continually compared with the constants written in these registers. When a match is detected, the corresponding compare-match flag (CMFA or CMFB) is set in the timer control/status register (TCSR).

The timer output signal is controlled by these compare-match signals as specified by output select bits 3 to 0 (OS3 to OS0) in the timer control/status register (TCSR).

TCORA and TCORB are initialized to H'FF at a reset and in the standby modes.

### 10.2.3 Timer Control Register (TCR)—H'FFC8 (TMR0), H'FFD0 (TMR1), H'FF9A (TMRX)

| Bit           | 7     | 6     | 5    | 4     | 3     | 2    | 1    | 0    |
|---------------|-------|-------|------|-------|-------|------|------|------|
|               | CMIEB | CMIEA | OVIE | CCLR1 | CCLR0 | CKS2 | CKS1 | CKS0 |
| Initial value | 0     | 0     | 0    | 0     | 0     | 0    | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  | R/W  |

TCR is an 8-bit readable/writable register that selects the clock source and the time at which the timer counter is cleared, and enables interrupts.

TCR is initialized to H'00 at a reset and in the standby modes.

For the timing, see section 10.3, Operation.

**Bit 7—Compare-Match Interrupt Enable B (CMIEB):** This bit selects whether to request compare-match interrupt B (CMIB) when compare-match flag B (CMFB) in the timer control/status register (TCSR) is set to 1.

#### Bit 7

| CMIEB | Description                                                          |
|-------|----------------------------------------------------------------------|
| 0     | Compare-match interrupt request B (CMIB) is disabled (Initial value) |
| 1     | Compare-match interrupt request B (CMIB) is enabled                  |

**Bit 6—Compare-Match Interrupt Enable A (CMIEA):** This bit selects whether to request compare-match interrupt A (CMIA) when compare-match flag A (CMFA) in the timer control/status register (TCSR) is set to 1.

#### Bit 6

| CMIEA | Description                                                          |
|-------|----------------------------------------------------------------------|
| 0     | Compare-match interrupt request A (CMIA) is disabled (Initial value) |
| 1     | Compare-match interrupt request A (CMIA) is enabled                  |

**Bit 5—Timer Overflow Interrupt Enable (OVIE):** This bit selects whether to request a timer overflow interrupt (OVI) when the overflow flag (OVF) in the timer control/status register (TCSR) is set to 1.

**Bit 5**

| OVIE | Description                                                            |
|------|------------------------------------------------------------------------|
| 0    | The timer overflow interrupt request (OVI) is disabled (Initial value) |
| 1    | The timer overflow interrupt request (OVI) is enabled                  |

**Bits 4 and 3—Counter Clear 1 and 0 (CCLR1 and CCLR0):** These bits select how the timer counter is cleared: by compare-match A or B or by an external reset input at the TMRI pin.

| Bit 4<br>CCLR1 | Bit 3<br>CCLR0 | Description                                           |
|----------------|----------------|-------------------------------------------------------|
| 0              | 0              | Not cleared (Initial value)                           |
| 0              | 1              | Cleared on compare-match A                            |
| 1              | 0              | Cleared on compare-match B                            |
| 1              | 1              | Cleared on rising edge of external reset input signal |

**Bits 2, 1, and 0—Clock Select (CKS2, CKS1, and CKS0):** Together with the ICKS0 and ICKS1 bits in STCR, these bits select the internal or external clock source for the timer counter. For the external clock source they select whether to increment the count on the rising or falling edge of the external clock input (TMCI), or on both edges. For the internal clock sources the count is incremented on the falling edge of the clock input.

| Channel | TCR           |               |               | STCR           |                | Description                                                         |
|---------|---------------|---------------|---------------|----------------|----------------|---------------------------------------------------------------------|
|         | Bit 2<br>CKS2 | Bit 1<br>CKS1 | Bit 0<br>CKS0 | Bit 1<br>ICKS1 | Bit 0<br>ICKS0 |                                                                     |
| 0       | 0             | 0             | 0             | —              | —              | No clock source (timer stopped)                                     |
|         | 0             | 0             | 1             | —              | 0              | $\phi_p/8$ internal clock source, counted on the falling edge       |
|         | 0             | 0             | 1             | —              | 1              | $\phi_p/2$ internal clock source, counted on the falling edge       |
|         | 0             | 1             | 0             | —              | 0              | $\phi_p/64$ internal clock source, counted on the falling edge      |
|         | 0             | 1             | 0             | —              | 1              | $\phi_p/32$ internal clock source, counted on the falling edge      |
|         | 0             | 1             | 1             | —              | 0              | $\phi_p/1024$ internal clock source, counted on the falling edge    |
|         | 0             | 1             | 1             | —              | 1              | $\phi_p/256$ internal clock source, counted on the falling edge     |
|         | 1             | 0             | 0             | —              | —              | No clock source (timer stopped)                                     |
|         | 1             | 0             | 1             | —              | —              | External clock source, counted on the rising edge                   |
|         | 1             | 1             | 0             | —              | —              | External clock source, counted on the falling edge                  |
|         | 1             | 1             | 1             | —              | —              | External clock source, counted on both the rising and falling edges |

| Channel | TCR           |               |               | STCR           |                | Description                                                             |
|---------|---------------|---------------|---------------|----------------|----------------|-------------------------------------------------------------------------|
|         | Bit 2<br>CKS2 | Bit 1<br>CKS1 | Bit 0<br>CKS0 | Bit 1<br>ICKS1 | Bit 0<br>ICKS0 |                                                                         |
| 1       | 0             | 0             | 0             | —              | —              | No clock source (timer stopped)                                         |
|         | 0             | 0             | 1             | 0              | —              | $\varnothing_P/8$ internal clock source, counted on the falling edge    |
|         | 0             | 0             | 1             | 1              | —              | $\varnothing_P/2$ internal clock source, counted on the falling edge    |
|         | 0             | 1             | 0             | 0              | —              | $\varnothing_P/64$ internal clock source, counted on the falling edge   |
|         | 0             | 1             | 0             | 1              | —              | $\varnothing_P/128$ internal clock source, counted on the falling edge  |
|         | 0             | 1             | 1             | 0              | —              | $\varnothing_P/1024$ internal clock source, counted on the falling edge |
|         | 0             | 1             | 1             | 1              | —              | $\varnothing_P/2048$ internal clock source, counted on the falling edge |
|         | 1             | 0             | 0             | —              | —              | No clock source (timer stopped)                                         |
|         | 1             | 0             | 1             | —              | —              | External clock source, counted on the rising edge                       |
|         | 1             | 1             | 0             | —              | —              | External clock source, counted on the falling edge                      |
|         | 1             | 1             | 1             | —              | —              | External clock source, counted on both the rising and falling edges     |
|         | 1             | 1             | 1             | —              | —              | External clock source, counted on both the rising and falling edges     |
| X       | 0             | 0             | 0             | —              | —              | No clock source (timer stopped)                                         |
|         | 0             | 0             | 1             | —              | —              | $\varnothing$ internal clock source                                     |
|         | 0             | 1             | 0             | —              | —              | $\varnothing_P/2$ internal clock source, counted on the falling edge    |
|         | 0             | 1             | 1             | —              | —              | $\varnothing_P/512$ internal clock source, counted on the falling edge  |
|         | 1             | 0             | 0             | —              | —              | No clock source (timer stopped)                                         |
|         | 1             | 0             | 1             | —              | —              | External clock source, counted on the rising edge                       |
|         | 1             | 1             | 0             | —              | —              | External clock source, counted on the falling edge                      |
|         | 1             | 1             | 1             | —              | —              | External clock source, counted on both the rising and falling edges     |

## 10.2.4 Timer Control/Status Register (TCSR)—H'FFC9 (TMR0), H'FFD1 (TMR1), H'FF9B (TMRX)

| Bit           | 7      | 6      | 5      | 4    | 3   | 2   | 1   | 0   |
|---------------|--------|--------|--------|------|-----|-----|-----|-----|
|               | CMFB   | CMFA   | OVF    | PWME | OS3 | OS2 | OS1 | OS0 |
| Initial value | 0      | 0      | 0      | 0    | 0   | 0   | 0   | 0   |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/W  | R/W | R/W | R/W | R/W |

Note: \* Software can write a 0 in bits 7 to 5 to clear the flags, but cannot write a 1 in these bits.

TCSR is an 8-bit readable and partially writable register that indicates compare-match and overflow status and selects the effect of compare-match events on the timer output signal.

TCSR is initialized to H'00 at a reset and in the standby modes.

**Bit 7—Compare-Match Flag B (CMFB):** This status flag is set to 1 when the timer count matches the time constant set in TCORB. CMFB must be cleared by software. It is set by hardware, however, and cannot be set by software.

### Bit 7

| CMFB | Description                                                                                                  |
|------|--------------------------------------------------------------------------------------------------------------|
| 0    | To clear CMFB, the CPU must read CMFB after it has been set to 1, then write a 0 in this bit (Initial value) |
| 1    | This bit is set to 1 when TCNT = TCORB                                                                       |

**Bit 6—Compare-Match Flag A (CMFA):** This status flag is set to 1 when the timer count matches the time constant set in TCORA. CMFA must be cleared by software. It is set by hardware, however, and cannot be set by software.

### Bit 6

| CMFA | Description                                                                                                  |
|------|--------------------------------------------------------------------------------------------------------------|
| 0    | To clear CMFA, the CPU must read CMFA after it has been set to 1, then write a 0 in this bit (Initial value) |
| 1    | This bit is set to 1 when TCNT = TCORA                                                                       |

**Bit 5—Timer Overflow Flag (OVF):** This status flag is set to 1 when the timer count overflows (changes from H'FF to H'00). OVF must be cleared by software. It is set by hardware, however, and cannot be set by software.

**Bit 5**

| OVF | Description                                                                                                |
|-----|------------------------------------------------------------------------------------------------------------|
| 0   | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit (Initial value) |
| 1   | This bit is set to 1 when TCNT changes from H'FF to H'00                                                   |

**Bit 4—PWM Mode Enable (PWME):** This bit sets the timer output to PWM mode.

**Bit 4**

| PWME | Description                       |
|------|-----------------------------------|
| 0    | Normal timer mode (Initial value) |
| 1    | PWM mode                          |

In PWM mode, bits CCLR1 and CCLR0 and bits OS3 to OS0 must be set so that the contents of TCORA determine the timer output period and the contents of TCORB determine the timer output duty cycle. The timer output pulse period, pulse width, and duty cycle are given by the following equations. If  $TCORA < TCORB$ , the output is saturated at a100% duty cycle.

(When  $TCORB \leq TCORA$ )

Timer output pulse period = Selected internal clock period  $\times$  (TCORA + 1)

Timer output pulse width = Selected internal clock period  $\times$  TCORB

Timer output duty cycle =  $TCORB / (TCORA + 1)$

| PWM Output Mode                                           | TCR   |       | TCSR |     |     |     |
|-----------------------------------------------------------|-------|-------|------|-----|-----|-----|
|                                                           | CCLR1 | CCLR0 | OS3  | OS2 | OS1 | OS0 |
| Direct output (when the above timer pulse width is high)  | 0     | 1     | 0    | 1   | 1   | 0   |
| Inverted output (when the above timer pulse width is low) | 0     | 1     | 1    | 0   | 0   | 1   |

In PWM mode, a buffer register is inserted between TCORB and the module data bus, and the data written to TCORB is held in the buffer register until a TCORA compare-match occurs. This makes it easy to achieve PWM output with an undisturbed waveform. With the timer output specification made by bits OS3 to OS0, the priority of a change due to compare-match B is higher. Caution is required since the operation differs from that in normal timer mode.

**Bits 3 to 0—Output Select 3 to 0 (OS3 to OS0):** These bits specify the effect of compare-match events on the timer output signal (TMO). Bits OS3 and OS2 control the effect of compare-match B on the output level. Bits OS1 and OS0 control the effect of compare-match A on the output level.

In normal timer mode, if compare-match A and B occur simultaneously, any conflict is resolved by giving highest priority to toggle, second-highest priority to 1 output, and third-highest priority to 0 output, as explained in item 10.6.4 in section 10.6, Application Notes.

After a reset, the timer output is 0 until the first compare-match event.

When all four output select bits (bits OS3 to OS0) are cleared to 0 the timer output signal is disabled.

| Bit 3<br>OS3 | Bit 2<br>OS2 | Description                                           |
|--------------|--------------|-------------------------------------------------------|
| 0            | 0            | No change when compare-match B occurs (Initial value) |
| 0            | 1            | Output changes to 0 when compare-match B occurs       |
| 1            | 0            | Output changes to 1 when compare-match B occurs       |
| 1            | 1            | Output inverts (toggles) when compare-match B occurs  |

| Bit 1<br>OS1 | Bit 0<br>OS0 | Description                                           |
|--------------|--------------|-------------------------------------------------------|
| 0            | 0            | No change when compare-match A occurs (Initial value) |
| 0            | 1            | Output changes to 0 when compare-match A occurs       |
| 1            | 0            | Output changes to 1 when compare-match A occurs       |
| 1            | 1            | Output inverts (toggles) when compare-match A occurs  |

### 10.2.5 Serial/Timer Control Register (STCR)

| Bit           | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|------|-------|-------|-------|-------|-------|-------|-------|
|               | IICS | IICX1 | IICX0 | SYNCE | PWCKE | PWCKS | ICKS1 | ICKS0 |
| Initial value | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Read/Write    | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

STCR is an 8-bit readable/writable register that controls the I<sup>2</sup>C bus interface operating mode and the TCNT clock source in the PWM timer module and the 8-bit timers.

STCR is initialized to H'00 by a reset.

**Bits 7 to 5—I<sup>2</sup>C Control (IICS, IICX1, IICX0):** These bits control the operation of the I<sup>2</sup>C bus interface. For details, see section 14, I<sup>2</sup>C Bus Interface.

**Bit 4—Timer Connection Output Enable (SYNCE):** This bit controls the outputs (VSYNCO, HSYNCO, CLAMPO) when the timers are interconnected. For details, see section 11, Timer Connection.

**Bits 3 and 2—PWM Timer Control (PWCKE, PWCKS):** These bits control the internal clock to be input to the timer counter (TCNT) in the PWM timer module. For details, see section 8, PWM Timers.

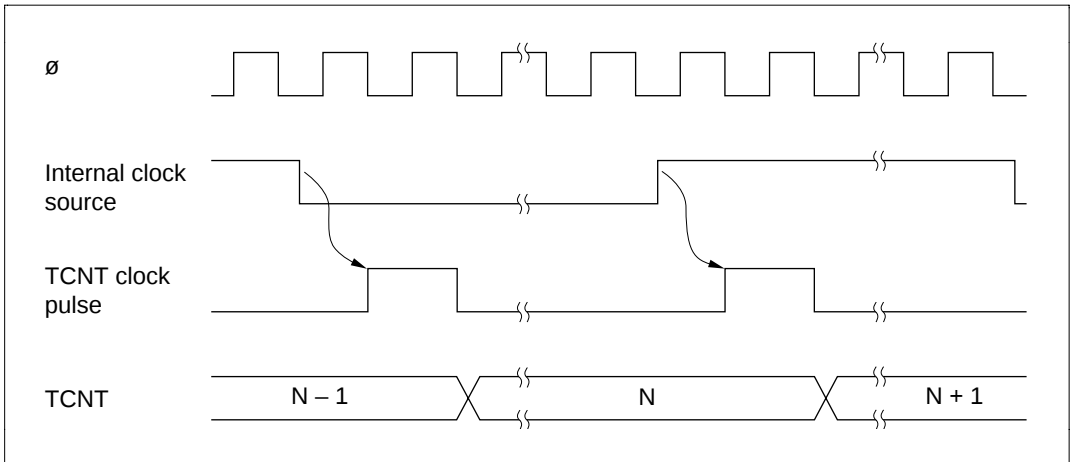
**Bits 1 and 0—Internal Clock Select 1 and 0 (ICKS1 and ICKS0):** These bits, together with bits CKS2 to CKS0 in TCR of the 8-bit timers, select the internal clock to be input to the timer counters (TCNT) in the 8-bit timers. For details, see section 10.2.3, Timer Control Register.

## 10.3 Operation

### 10.3.1 TCNT Incrementation Timing

The timer counter increments on a pulse generated once for each period of the clock source selected by bits CKS2 to CKS0 of the TCR.

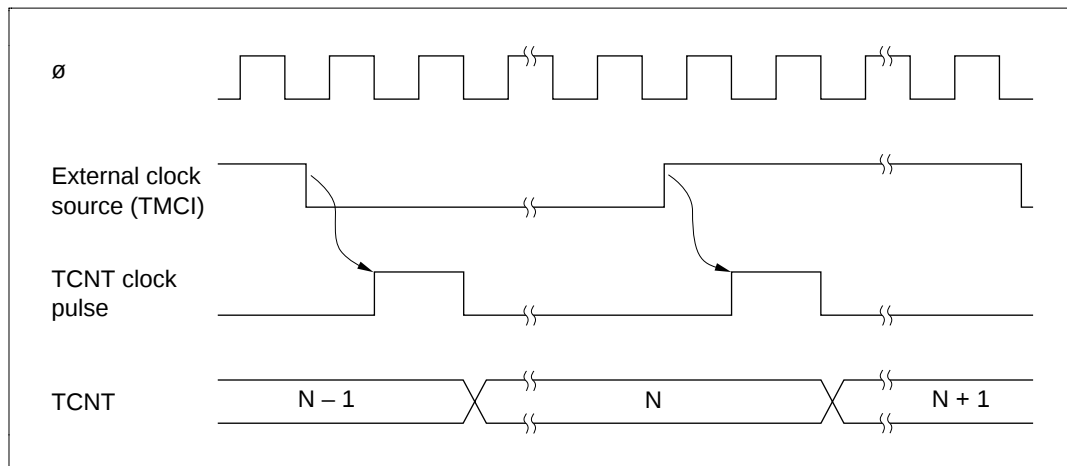
**Internal Clock:** Internal clock sources are created from the system clock by a prescaler. The counter increments on an internal TCNT clock pulse generated from the falling edge of the prescaler output, as shown in figure 10-2. Bits CKS2 to CKS0 of the TCR can select one of six, or one of three, internal clocks.



**Figure 10-2 Count Timing for Internal Clock Input**

**External Clock:** If external clock input (TMCI) is selected, the timer counter can increment on the rising edge, the falling edge, or both edges of the external clock signal. Figure 10-3 shows incrementation on both edges of the external clock signal.

The external clock pulse width must be at least 1.5 system clock periods for incrementation on a single edge, and at least 2.5 system clock periods for incrementation on both edges.

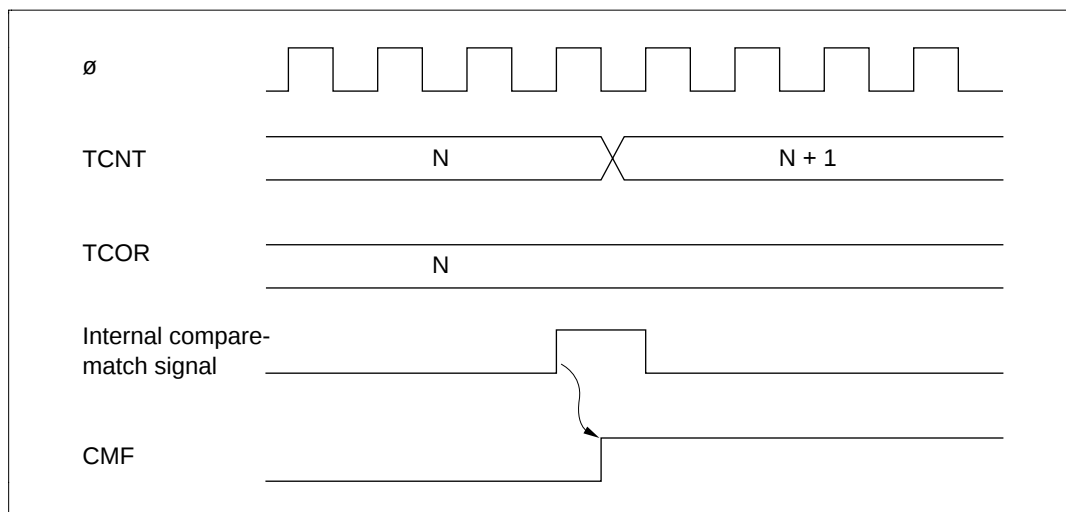


**Figure 10-3 Count Timing for External Clock Input**

### 10.3.2 Compare Match Timing

**(1) Setting of Compare-Match Flags A and B (CMFA and CMFB):** The compare-match flags are set to 1 by an internal compare-match signal generated when the timer count matches the time constant in TCNT or TCOR. The compare-match signal is generated at the last state in which the match is true, just before the timer counter increments to a new value.

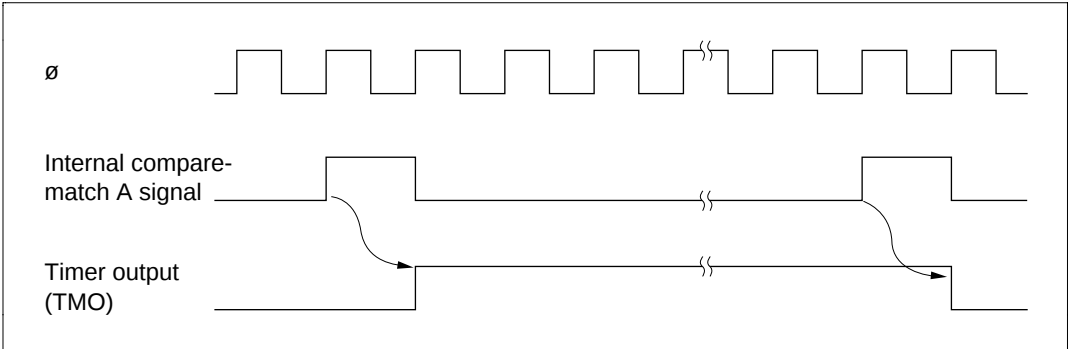
Accordingly, when the timer count matches one of the time constants, the compare-match signal is not generated until the next period of the clock source. Figure 10-4 shows the timing of the setting of the compare-match flags.



**Figure 10-4 Setting of Compare-Match Flags**

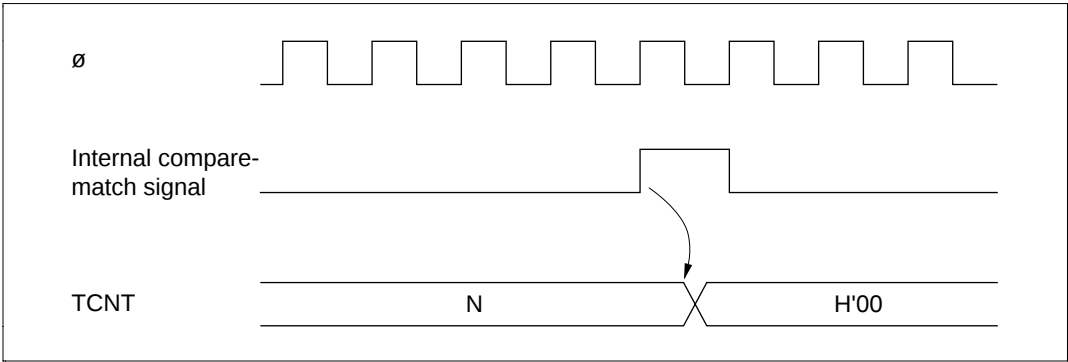
**(2) Output Timing (Normal Timer Mode):** When a compare-match event occurs, the timer output (TMO0 or TMO1) changes as specified by the output select bits (OS3 to OS0) in the TCSR. Depending on these bits, the output can remain the same, change to 0, change to 1, or toggle. If compare-match A and B occur simultaneously, the higher priority compare-match determines the output level. See item 10.6.4 in section 10.6, Application Notes, for details.

Figure 10-5 shows the timing when the output is set to toggle on compare-match A.



**Figure 10-5 Timing of Timer Output**

**(3) Timing of Compare-Match Clear:** Depending on the CCLR1 and CCLR0 bits in the TCR, the timer counter can be cleared when compare-match A or B occurs. Figure 10-6 shows the timing of this operation.



**Figure 10-6 Timing of Compare-Match Clear**

### 10.3.3 External Reset of TCNT

When the CCLR1 and CCLR0 bits in the TCR are both set to 1, the timer counter is cleared on the rising edge of an external reset input. Figure 10-7 shows the timing of this operation. The timer reset pulse width must be at least 1.5 system clock periods.

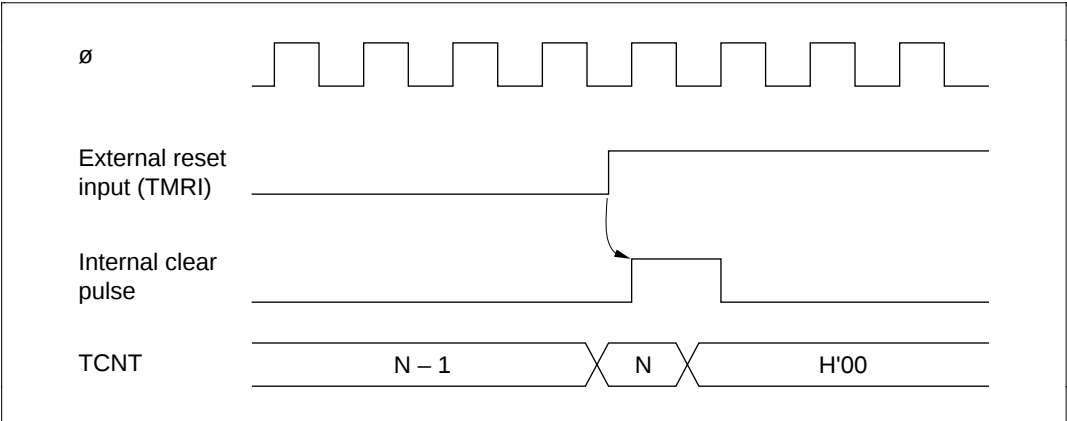


Figure 10-7 Timing of External Reset

### 10.3.4 Setting of TCSR Overflow Flag

**(1) Setting of TCSR Overflow Flag (OVF):** The overflow flag (OVF) is set to 1 when the timer count overflows (changes from H'FF to H'00). Figure 10-8 shows the timing of this operation.

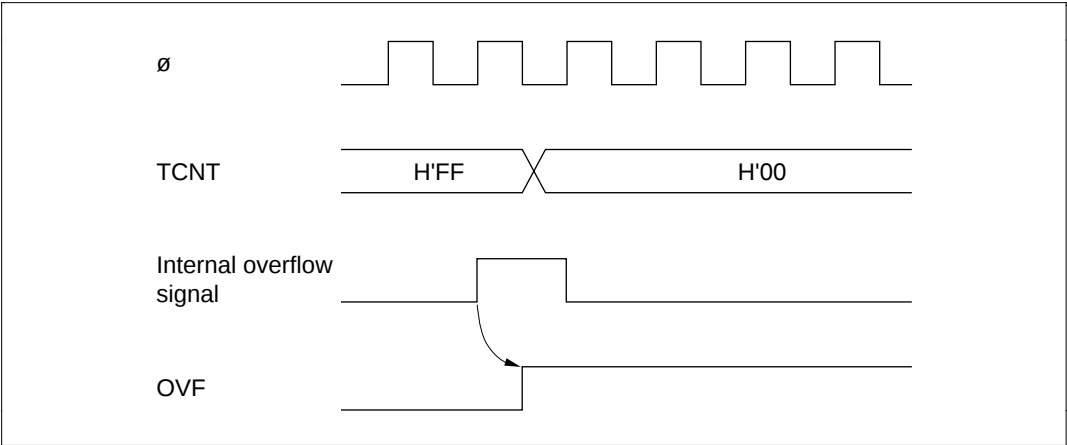


Figure 10-8 Setting of Overflow Flag

## 10.4 Interrupts

Each channel in the 8-bit timer can generate three types of interrupts: compare-match A and B (CMIA and CMIB), and overflow (OVI). Each interrupt is requested when the corresponding enable bits are set in the TCR and TCSR. Independent signals are sent to the interrupt controller for each interrupt. Table 10-3 lists information about these interrupts.

**Table 10-3 8-Bit Timer Interrupts**

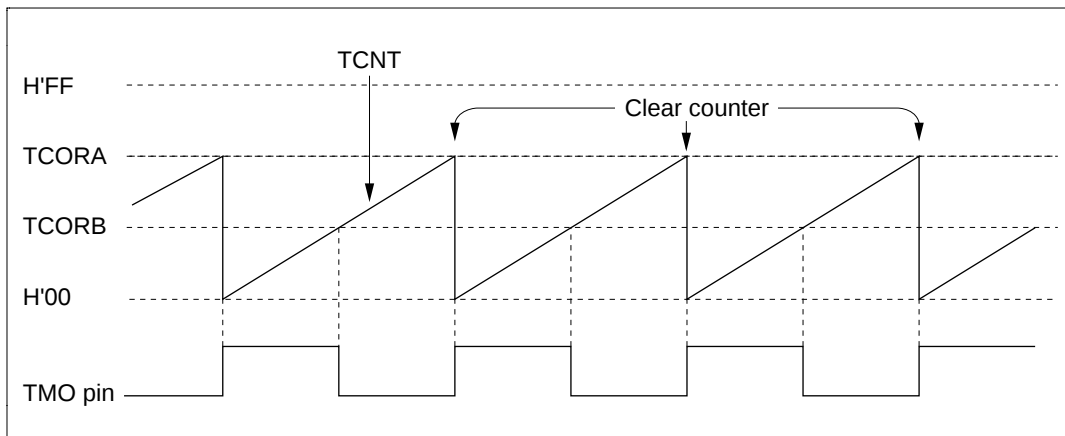
| Interrupt | Description                           | Priority |
|-----------|---------------------------------------|----------|
| CMIA      | Requested when CMFA and CMIEA are set | High     |
| CMIB      | Requested when CMFB and CMIEB are set | ↕        |
| OVI       | Requested when OVF and OVIE are set   | Low      |

## 10.5 Sample Application

In the example below, the 8-bit timer is used to generate a pulse output with a selected duty factor. The control bits are set as follows:

1. In the TCR, CCLR1 is cleared to 0 and CCLR0 is set to 1 so that the timer counter is cleared when its value matches the constant in TCORA.
2. In the TCSR, bits OS3 to OS0 are set to 0110, causing the output to change to 1 on compare-match A and to 0 on compare-match B.

With these settings, the 8-bit timer provides output of pulses at a rate determined by TCORA with a pulse width determined by TCORB. No software intervention is required.



**Figure 10-9 Example of Pulse Output**

# 10.6 Application Notes

Application programmers should note that the following types of contention can occur in the 8-bit timer.

## 10.6.1 Contention between TCNT Write and Clear

If an internal counter clear signal is generated during the T<sub>3</sub> state of a write cycle to the timer counter, the clear signal takes priority and the write is not performed.

Figure 10-10 shows this type of contention.

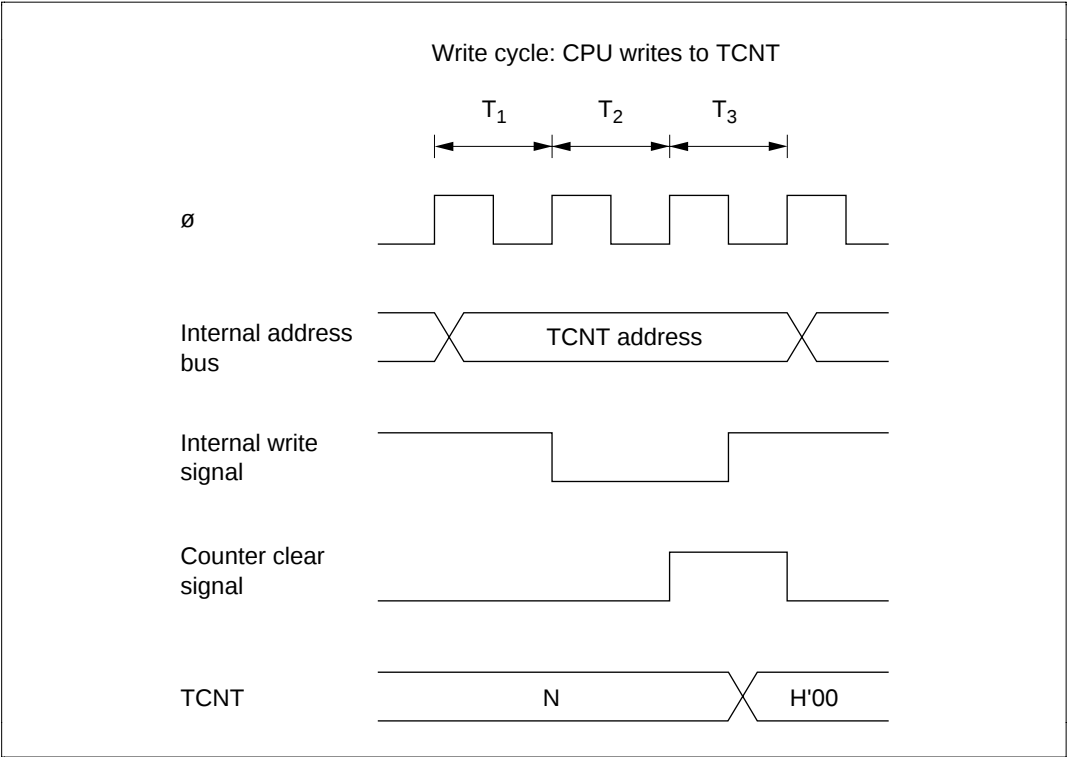
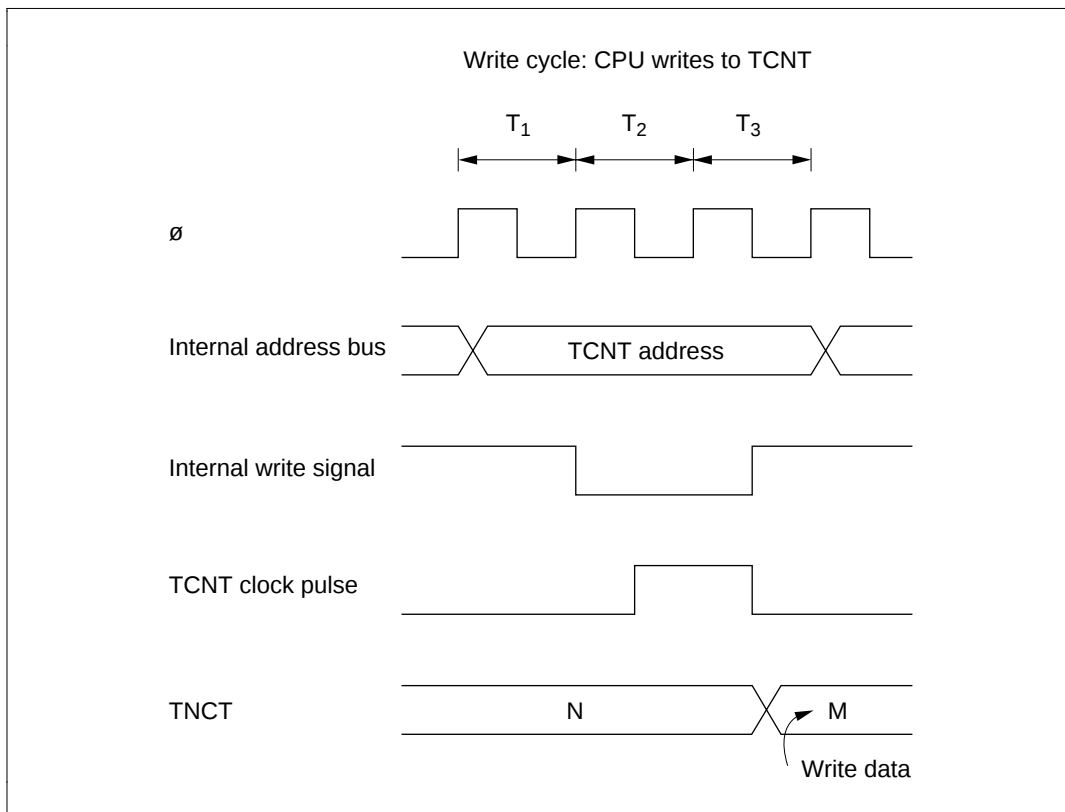


Figure 10-10 TCNT Write-Clear Contention

## 10.6.2 Contention between TCNT Write and Increment

If a timer counter increment pulse is generated during the  $T_3$  state of a write cycle to the timer counter, the write takes priority and the timer counter is not incremented.

Figure 10-11 shows this type of contention.



**Figure 10-11 TCNT Write-Increment Contention**

### 10.6.3 Contention between TCOR Write and Compare-Match

If a compare-match occurs during the  $T_3$  state of a write cycle to TCOR, the write takes precedence and the compare-match signal is inhibited.

Figure 10-12 shows this type of contention (in normal timer mode).

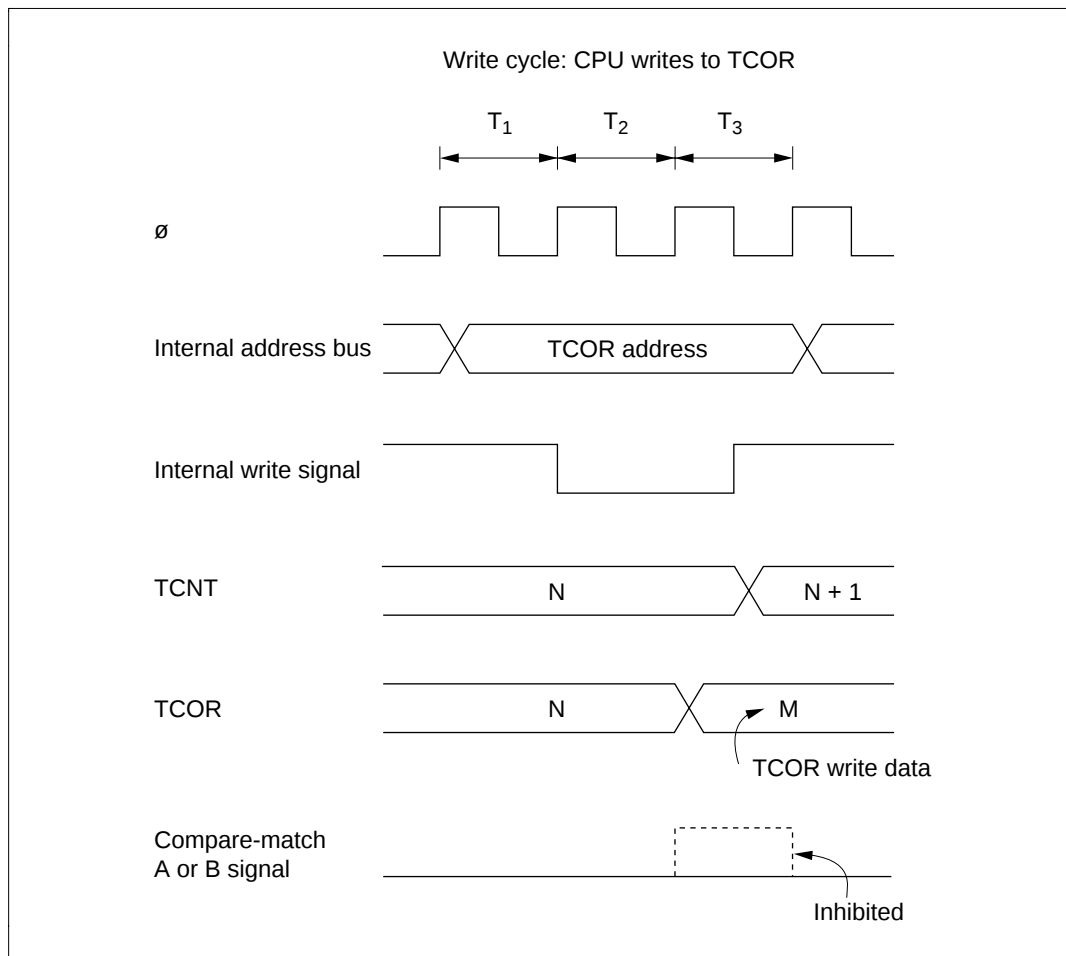


Figure 10-12 Contention between TCOR Write and Compare-Match

#### 10.6.4 Contention between Compare-Match A and Compare-Match B

If identical time constants are written in TCORA and TCORB, causing compare-match A and B to occur simultaneously, any conflict between the output selections for compare-match A and B is resolved by following the priority order in table 10-4 (this applies to normal timer mode).

**Table 10-4 Priority of Timer Output**

| Output Selection | Priority                                                                          |
|------------------|-----------------------------------------------------------------------------------|
| Toggle           | High                                                                              |
| 1 output         |  |
| 0 output         |                                                                                   |
| No change        |                                                                                   |
|                  | Low                                                                               |

#### 10.6.5 Incrementation Caused by Changing of Internal Clock Source

When an internal clock source is changed, the changeover may cause the timer counter to increment. This depends on the time at which the clock select bits (CKS1, CKS0) are rewritten, as shown in table 10-5.

The pulse that increments the timer counter is generated at the falling edge of the internal clock source signal. If clock sources are changed when the old source is high and the new source is low, as in case no. 3 in table 10-5, the changeover generates a falling edge that triggers the TCNT clock pulse and increments the timer counter.

Switching between an internal and external clock source can also cause the timer counter to increment.

Table 10-5 Effect of Changing Internal Clock Sources

| No. | Description  | Timing                                                                                                                                    |
|-----|--------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Low → low*1  | <p>Old clock source</p> <p>New clock source</p> <p>TCNT clock pulse</p> <p>TCNT</p> <p>N</p> <p>N + 1</p> <p>CKS rewrite</p>              |
| 2   | Low → high*2 | <p>Old clock source</p> <p>New clock source</p> <p>TCNT clock pulse</p> <p>TCNT</p> <p>N</p> <p>N + 1</p> <p>N + 2</p> <p>CKS rewrite</p> |

**Table 10-5 Effect of Changing Internal Clock Sources (cont)**

| No. | Description  | Timing chart                                                                                                                      |
|-----|--------------|-----------------------------------------------------------------------------------------------------------------------------------|
| 3   | High → low*3 | <p>Old clock source</p> <p>New clock source</p> <p>TCNT clock pulse</p> <p>TCNT</p> <p>N    N + 1    N + 2</p> <p>CKS rewrite</p> |
| 4   | High → high  | <p>Old clock source</p> <p>New clock source</p> <p>TCNT clock pulse</p> <p>TCNT</p> <p>N    N + 1    N + 2</p> <p>CKS rewrite</p> |

- Notes:
1. Including a transition from low to the stopped state (CKS1 = 0, CKS0 = 0), or a transition from the stopped state to low.
  2. Including a transition from the stopped state to high.
  3. Including a transition from high to the stopped state.
  4. The switching of clock sources is regarded as a falling edge that increments TCNT.



# Section 11 Timer Connection

[Incorporated in all models except the H8/3202]

## 11.1 Overview

The H8/3217 Series allows interconnection between the input/output of the single free-running timer (FRT) channel and two 8-bit timer channels (TMR1 and TMRX). This capability can be used to implement complex functions such as PWM decoding and clamp waveform output. All the timers are initially set for independent operation.

### 11.1.1 Features

The features of the timer connection facility are as follows.

- Four input pins and three output pins, of which three input pins and two output pins can be designated for phase inversion
- An edge-detection circuit is connected to the input pins, simplifying signal input detection.
- TMRX can be used for PWM input signal decoding and clamp waveform generation.
- An input signal can be converted to phase-inverted waveform, PWM decode waveform, or clamp waveform output.
- An external clock signal divided by TMR1 can be used as the FRT capture input signal.

## 11.1.2 Block Diagram

Figure 11-1 shows a block diagram of the timer connection facility.

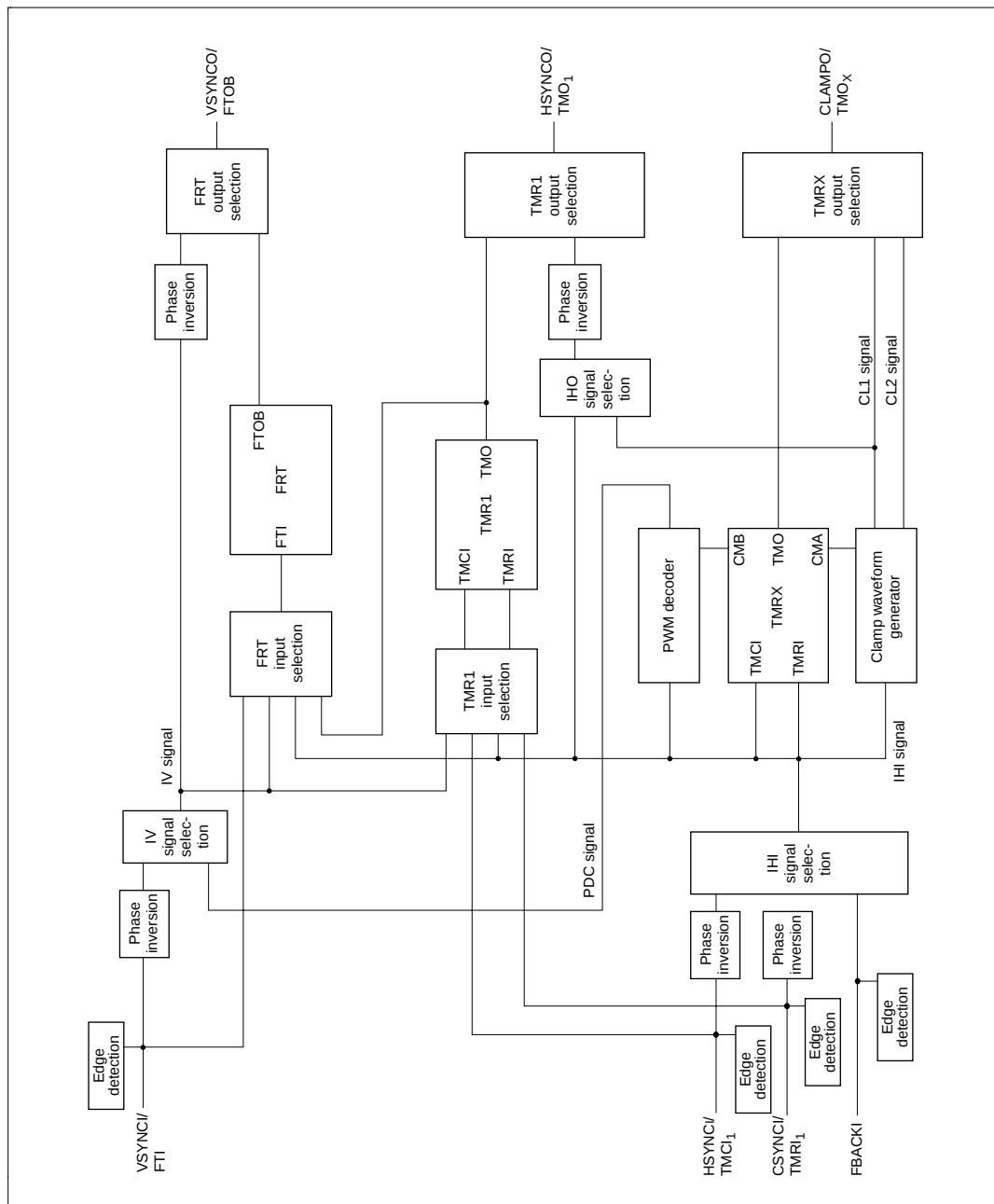


Figure 11-1 Block Diagram of Timer Connection

### 11.1.3 Input and Output Pins

Table 11-1 lists the timer connection input and output pins.

**Table 11-1 Timer Connection Input and Output Pins**

| <b>Name</b>                                  | <b>Abbreviation</b> | <b>Input/<br/>Output</b> | <b>Function</b>                                                                               |
|----------------------------------------------|---------------------|--------------------------|-----------------------------------------------------------------------------------------------|
| Vertical synchronization signal input pin    | VSYNCI              | Input                    | Vertical synchronization signal input pin<br>or FTI input pin<br>or TMRI1 pin                 |
| Horizontal synchronization signal input pin  | HSYNCI              | Input                    | Horizontal synchronization signal input pin<br>or TMC11 input pin<br>or TMC1x/TMR1x input pin |
| Composite synchronization signal input pin   | CSYNCI              | Input                    | Composite synchronization signal input pin<br>or TMC11 input pin<br>or TMC1x/TMR1x input pin  |
| Spare synchronization signal input pin       | FBACKI              | Input                    | Spare synchronization signal input pin<br>or TMC1x/TMR1x input pin                            |
| Vertical synchronization signal output pin   | VSYNCO              | Output                   | Vertical synchronization signal output pin<br>or FTOB output pin                              |
| Horizontal synchronization signal output pin | HSYNCO              | Output                   | Horizontal synchronization signal output pin<br>or TMO1 output pin                            |
| Clamp waveform output pin                    | CLAMPO              | Output                   | Clamp waveform output pin<br>or TMOx output pin                                               |

### 11.1.4 Register Configuration

Table 11-2 lists the timer connection registers.

**Table 11-2 Register Configuration**

| Name                          | Abbreviation | R/W    | Initial Value | Address |
|-------------------------------|--------------|--------|---------------|---------|
| Timer connection register     | TCONR        | R/W    | H'00          | H'FF9F  |
| Serial/timer control register | STCR         | R/W    | H'00          | H'FFC3  |
| Edge sense register           | SEDGR        | R/(W)* | H'0F          | H'FFA8  |

Note: \* Software can write a 0 to clear the flag bits, but cannot write 1.

## 11.2 Register Descriptions

### 11.2.1 Timer Connection Register (TCONR)

| Bit           | 7     | 6     | 5     | 4    | 3     | 2     | 1    | 0    |
|---------------|-------|-------|-------|------|-------|-------|------|------|
|               | SMOD1 | SMOD0 | CLMOD | INVV | SCON1 | SCON0 | INVI | INVO |
| Initial value | 0     | 0     | 0     | 0    | 0     | 0     | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  |

TCONR is an 8-bit readable/writable register that controls connection between timers and phase inversion of I/O signals.

TCONR is initialized to H'00 by a reset and in the standby modes.

**Bits 7 and 6—Synchronization Mode Select 1 and 0 (SMOD1 and SMOD0):** These bits select the signal source of the IHI, IHO, and IV signals.

| Bit 7<br>SMOD1 | Bit 6<br>SMOD0 | Description                                         |              |            |              |
|----------------|----------------|-----------------------------------------------------|--------------|------------|--------------|
|                |                | Mode                                                | IHI Signal   | IHO Signal | IV Signal    |
| 0              | 0              | No signal<br>(normal connection)<br>(Initial value) | FBACKI input | IHI signal | VSYNCl input |
| 0              | 1              | S-on-G mode                                         | CSYNCl input | CL1 signal | PDC signal   |
| 1              | 0              | Composite mode                                      | HSYNCl input | CL1 signal | PDC signal   |
| 1              | 1              | Separate mode                                       | HSYNCl input | IHI signal | VSYNCl input |

Together with the SYNCE bit in STCR and bits OS3 to OS0 in TMR1, these bits also select the function of the P4<sub>4</sub>/TMO<sub>1</sub>/HSYNCO pin. For details, see section 11.2.2, Serial/Timer Control Register.

**Bit 5—Clamp Waveform Mode Select (CLMOD):** Together with the SYNCE bit in STCR and bits OS3 to OS0 in TMR1, this bit selects the function of the P4<sub>7</sub>/TMO<sub>x</sub>/CLAMPO pin. For details, see section 11.2.2, Serial/Timer Control Register.

**Bits 3 and 2—Synchronization Signal Connection 1 and 0 (SCON1 and SCON0):** These bits select the signal source of the FTI input for FRT and the TMCI<sub>1</sub>/TMRI<sub>1</sub> input for TMR1.

| Bit 3<br>SCON1 | Bit 2<br>SCON0 | Description                                              |                         |                         |                         |
|----------------|----------------|----------------------------------------------------------|-------------------------|-------------------------|-------------------------|
|                |                | Mode                                                     | FTI                     | TMCI1                   | TMRI1                   |
| 0              | 0              | Normal connection<br>(Initial value)                     | FTI input               | TMCI <sub>1</sub> input | TMRI <sub>1</sub> input |
| 0              | 1              | Vertical<br>synchronization period<br>measurement mode   | IV signal               | IHI signal              | IV signal               |
| 1              | 0              | Horizontal<br>synchronization period<br>measurement mode | IHI signal              | IHI signal              | IV signal               |
| 1              | 1              | TMR1 frequency<br>division measurement<br>mode           | TMO <sub>1</sub> signal | IHI signal              | IV signal               |

**Bits 4, 1 and 0—Input Synchronization Signal Inversion, Output Synchronization Signal Inversion (INVV, INVI, INVO):** These bits select input/output phase inversion for the input synchronization signals (VSYNCl, HSYNCl, CSYNCl) and the output synchronization signals (VSYNCO, HSYNCO).

| Bit 4<br>INVV | Description                                                            |
|---------------|------------------------------------------------------------------------|
| 0             | The VSYNCl pin state is used directly as VSYNCl input. (Initial value) |
| 1             | The VSYNCl pin state is inverted to create VSYNCl input.               |

| Bit 1<br>INVI | Description                                                                                 |
|---------------|---------------------------------------------------------------------------------------------|
| 0             | HSYNCl and CSYNCl pin states are used directly as HSYNCl and CSYNCl inputs. (Initial value) |
| 1             | HSYNCl and CSYNCl pin states are inverted to create HSYNCl and CSYNCl inputs.               |

| Bit 0<br>INVO | Description                                                                        |
|---------------|------------------------------------------------------------------------------------|
| 0             | IV and IHO signals are used directly as VSYNCO and HSYNCO outputs. (Initial value) |
| 1             | IV and IHO signals are inverted to create VSYNCO and HSYNCO outputs.               |

### 11.2.2 Serial/Timer Control Register (STCR)

| Bit           | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|------|-------|-------|-------|-------|-------|-------|-------|
|               | IICS | IICX1 | IICX0 | SYNCE | PWCKE | PWCKS | ICKS1 | ICKS0 |
| Initial value | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Read/Write    | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

STCR is an 8-bit readable/writable register that controls the I<sup>2</sup>C bus interface operating mode and the TCNT clock source in the PWM timers and the 8-bit timers.

STCR is initialized to H'00 by a reset.

**Bits 7 to 5—I<sup>2</sup>C Control (IICS, IICX1, IICX0):** These bits control the operation of the I<sup>2</sup>C bus interface. For details, see section 14, I<sup>2</sup>C Bus Interface.

**Bit 4—Timer Connection Output Enable (SYNCE):** This bit controls timer connection output.

| Bit 4<br>SYNCE | Description                                                                                                                       |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------|
| 0              | Timer connection output is not performed.<br>The relevant pins have port input/output and timer output functions. (Initial value) |
| 1              | Timer connection output is performed.<br>The relevant pins function as VSYNCO, HSYNCO, and CLAMPO output pins.                    |

Control of the function of each pin is related to bits SMOD1 and SMOD0 and bit CLMOD in TCONR, the OEB bit in TCR for the free-running timer (FRT), and bits OS3 to OS0 in TCR for TMR1 and TMRX.

| STCR           | TCR          |                                                   |
|----------------|--------------|---------------------------------------------------|
| Bit 4<br>SYNCE | Bit 3<br>OEB | Function of VSYNCO Pin                            |
| 0              | 0            | P6 <sub>2</sub> port input/output (Initial value) |
| 0              | 1            | FTOB output                                       |
| 1              | —            | IV signal output                                  |

| STCR           | TCONR          |                | TCR                       |                                   |                 |
|----------------|----------------|----------------|---------------------------|-----------------------------------|-----------------|
| Bit 4<br>SYNCE | Bit 7<br>SMOD1 | Bit 6<br>SMOD0 | Bits 3 to 0<br>OS3 to OS0 | Function of HSYNCO Pin            |                 |
| 0              | —              | —              | All 0                     | P4 <sub>4</sub> port input/output | (Initial value) |
| 0              | —              | —              | Not all 0                 | TMO <sub>1</sub> output           |                 |
| 1              | 0              | 0              | —                         | IHI signal output                 |                 |
|                | 1              | 1              |                           |                                   |                 |
| 1              | 0              | 1              | —                         | CL1 signal output                 |                 |
|                | 1              | 0              |                           |                                   |                 |

| STCR           | TCONR          | TCR                       |                                   |                 |
|----------------|----------------|---------------------------|-----------------------------------|-----------------|
| Bit 4<br>SYNCE | Bit 5<br>CLMOD | Bits 3 to 0<br>OS3 to OS0 | Function of CLAMPO Pin            |                 |
| 0              | —              | All 0                     | P4 <sub>7</sub> port input/output | (Initial value) |
| 0              | —              | Not all 0                 | TMO <sub>x</sub> output           |                 |
| 1              | 0              | —                         | CL1 signal output                 |                 |
| 1              | 1              | —                         | CL2 signal output                 |                 |

**Bits 3 and 2—PWM Clock Enable, PWM Clock Select (PWCKE, PWCKS):** These bits select the internal clock to be input to the timer counter (TCNT) in the PWM timer module. For details, see section 8, PWM Timers.

**Bits 1 and 0—Internal Clock Select 1 and 0 (ICKS1 and ICKS0):** These bits, together with bits CKS2 to CKS0 in TCR of the 8-bit timers, select the internal clock to be input to the timer counters (TCNT) in the 8-bit timers. For details, see section 10.2.3, Timer Control Register.

### 11.2.3 Edge Sense Register (SEDGR)

| Bit           | 7      | 6      | 5      | 4      | 3 | 2 | 1 | 0 |
|---------------|--------|--------|--------|--------|---|---|---|---|
|               | VEDG   | HEDG   | CEDG   | FEDG   | — | — | — | — |
| Initial value | 0      | 0      | 0      | 0      | 1 | 1 | 1 | 1 |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | — | — | — | — |

Note: \* Software can write a 0 to bits 7 to 4 to clear the flags, but cannot write 1.

SEDGR is an 8-bit register used to detect a rising edge on the timer connection input pins.

SEDGR is initialized to H'0F by a reset and in the standby modes.

**Bit 7—VSYNCI Edge (VEDG):** This bit detects a rising edge on the P6<sub>3</sub>/FTI/VSYNCI pin.

**Bit 7**

| VEDG | Description                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------|
| 0    | To clear VEDG, the CPU must read VEDG after it has been set to 1, then write a 0 in this bit. (Initial value) |
| 1    | Set to 1 when a rising edge is detected on the P6 <sub>3</sub> /FTI/VSYNCI pin.                               |

**Bit 6—HSYNCI Edge (HEDG):** This bit detects a rising edge on the P4<sub>3</sub>/TMCI<sub>1</sub>/HSYNCI pin.

**Bit 6**

| HEDG | Description                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------|
| 0    | To clear HEDG, the CPU must read HEDG after it has been set to 1, then write a 0 in this bit. (Initial value) |
| 1    | Set to 1 when a rising edge is detected on the P4 <sub>3</sub> /TMCI <sub>1</sub> /HSYNCI pin.                |

**Bit 5—CSYNCI Edge (CEDG):** This bit detects a rising edge on the P4<sub>5</sub>/TMRI<sub>1</sub>/CSYNCI pin.

**Bit 5**

| CEDG | Description                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------|
| 0    | To clear CEDG, the CPU must read CEDG after it has been set to 1, then write a 0 in this bit. (Initial value) |
| 1    | Set to 1 when a rising edge is detected on the P4 <sub>5</sub> /TMRI <sub>1</sub> /CSYNCI pin.                |

**Bit 4—FBACKI Edge (FEDG):** This bit detects a rising edge on the P4<sub>6</sub>/FBACKI pin.

**Bit 4**

| FEDG | Description                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------|
| 0    | To clear FEDG, the CPU must read FEDG after it has been set to 1, then write a 0 in this bit. (Initial value) |
| 1    | Set to 1 when a rising edge is detected on the P4 <sub>6</sub> /FBACKI pin.                                   |

## 11.3 Operation

### 11.3.1 PWM Decoding

Timer connection TMRX can be used to decode a PWM signal in which 0 and 1 are represented by the pulse width. To do this, a signal in which a rising edge is generated at regular intervals must be selected as the IHI signal.

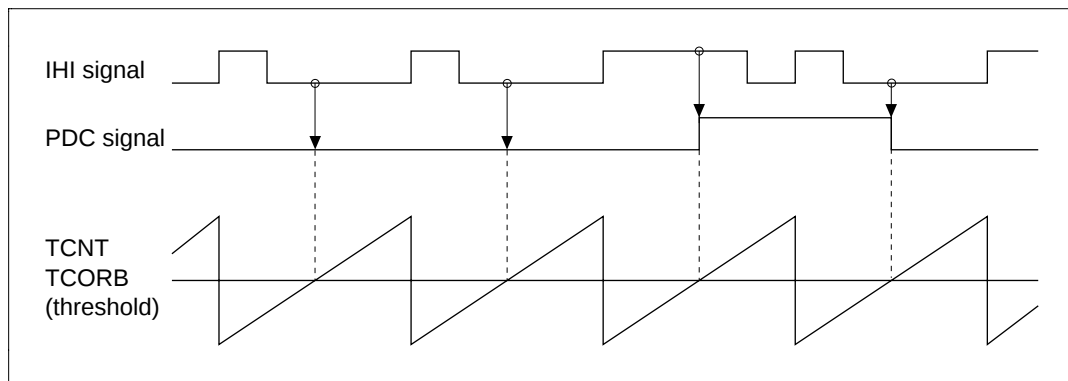
The timer counter (TCNT) in TMRX is set to count the internal clock pulses and to be cleared on the rising edge of the external reset signal (IHI signal). The value to be used as the threshold for deciding the pulse width is written in TCORB. The PWM decoder contains a delay latch which uses the IHI signal as data and compare-match signal B (CMB) as a clock, and the result of the pulse width decision at the compare-match signal B timing after the rise of the IHI signal is output as the PDC signal. Examples of TCR and TCORB settings are shown in tables 11-3 and 11-4, and the timing chart is shown in figure 11-2.

**Table 11-3 Examples of TCR Settings**

| Bit(s) | Abbreviation   | Contents | Description                                                                  |
|--------|----------------|----------|------------------------------------------------------------------------------|
| 7      | CMIEB          | 0        | Interrupts due to compare-match and overflow are disabled                    |
| 6      | CMIEA          | 0        |                                                                              |
| 5      | OVIE           | 0        |                                                                              |
| 4 to 3 | CCLR1 to CCLR0 | 11       | TCNT is cleared by the rising edge of the external reset signal (IHI signal) |
| 2 to 0 | CKS2 to CKS0   | 001      | Incremented on internal clock: $\emptyset$                                   |

**Table 11-4 Examples of TCORB (Pulse Width Threshold) Settings**

|      | $\emptyset$ :10 MHz | $\emptyset$ : 12 MHz | $\emptyset$ : 16 MHz |
|------|---------------------|----------------------|----------------------|
| H'07 | 0.8 $\mu$ s         | 0.67 $\mu$ s         | 0.5 $\mu$ s          |
| H'0F | 1.6 $\mu$ s         | 1.33 $\mu$ s         | 1 $\mu$ s            |
| H'1F | 3.2 $\mu$ s         | 2.67 $\mu$ s         | 2 $\mu$ s            |
| H'3F | 6.4 $\mu$ s         | 5.33 $\mu$ s         | 4 $\mu$ s            |
| H'7F | 12.8 $\mu$ s        | 10.67 $\mu$ s        | 8 $\mu$ s            |

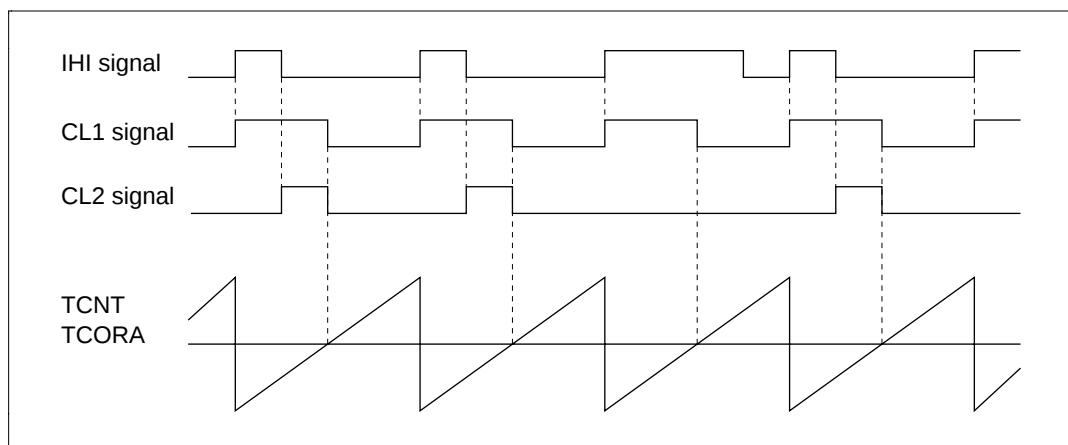


**Figure 11-2 Timing Chart for PWM Decoding**

### 11.3.2 Clamp Waveform Generation

Timer connection TMRX can be used to generate signals with different duty cycles and rising/falling edges (clamp waveforms) in synchronization with the input signal (IHI signal) waveform. Two clamp waveforms can be generated, the CL1 signal and the CL2 signal. The rise of the CL1 signal can be specified as simultaneous with the rise of the IHI signal, and the rise of the CL2 signal as simultaneous with the fall of the IHI signal, while the fall of both can be specified by TCORA.

TCNT in TMRX is set to count the internal clock pulses and to be cleared on the rising edge of the external reset signal (IHI signal). The value to be used for the timing of the fall of the clamp waveform is written in TCORA. Examples of TCR and TCORA settings are the same as those in tables 11-3 and 11-4. The clamp waveform timing chart is shown in figure 11-3.



**Figure 11-3 Timing Chart for Clamp Waveform Generation**

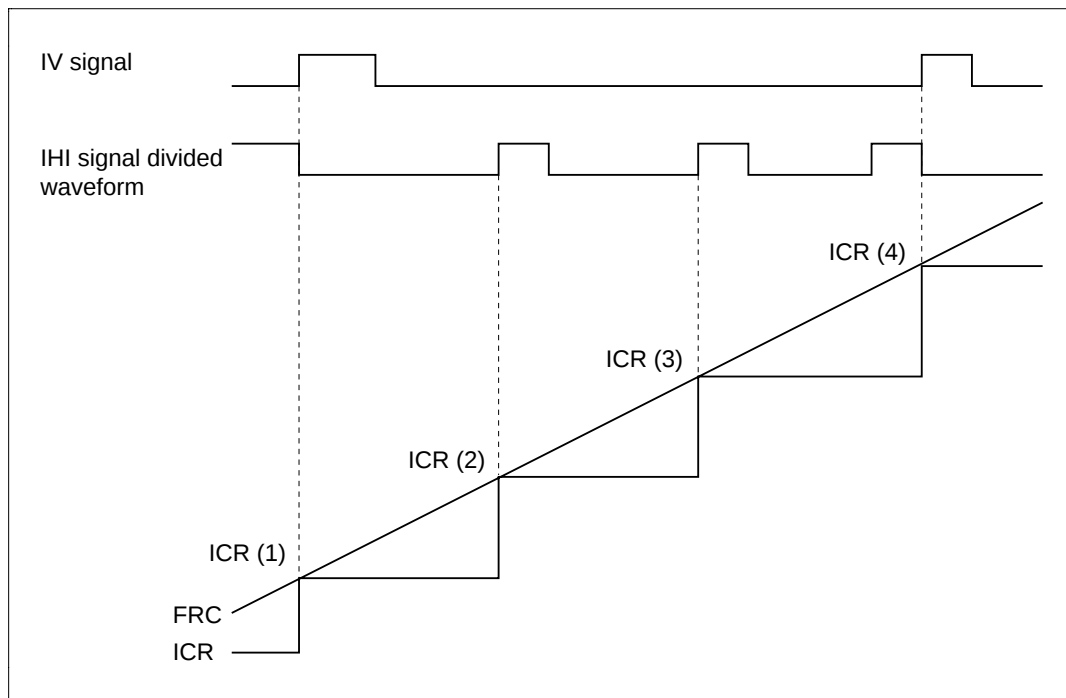
### 11.3.3 Measurement of 8-Bit Timer Divided Waveform Period

Timer connection TMR1 and the free-running timer (FRT) can be used to switch and measure the period of input signals (the IV signal and IHI signal) and an IHI signal divided waveform. Since TMR1 can be cleared by a rising edge of the IV signal, the rise and fall of the IHI signal divided waveform can be virtually synchronized with the IV signal. This enables period measurement to be carried out efficiently.

To measure the period of an IHI signal divided waveform, TCNT in TMR1 is set to count the external clock (IHI signal) pulses and to be cleared on the rising edge of the external reset signal (IV signal). The value to be used as the division factor is written in TCOR, and the TMO output method is specified by the OS bits in TCSR. Examples of TCR and TCORA settings are shown in table 11-5, and the timing chart for measurement of the IV signal and IHI signal divided waveform periods is shown in figure 11-4. The period of the IV signal is given by  $(ICR(4) - ICR(1)) \times \text{the resolution}$ , and the period of the IHI signal divided waveform by  $(ICR(3) - ICR(2)) \times \text{the resolution}$ .

**Table 11-5 Examples of TCR and TCSR Settings**

| Register     | Bit(s) | Abbreviation   | Contents | Description                                                                                              |
|--------------|--------|----------------|----------|----------------------------------------------------------------------------------------------------------|
| TCR in TMR1  | 7      | CMIEB          | 0        | Interrupts due to compare-match and overflow are disabled                                                |
|              | 6      | CMIEA          | 0        |                                                                                                          |
|              | 5      | OVIE           | 0        |                                                                                                          |
|              | 4 to 3 | CCLR1 to CCLR0 | 11       | TCNT is cleared by the rising edge of the external reset signal (IV signal)                              |
|              | 2 to 0 | CKS2 to CKS0   | 101      | TCNT is incremented on the rising edge of the external clock (IHI signal)                                |
| TCSR in TMR1 | 4      | PWME           | 0        | Normal timer mode                                                                                        |
|              | 3 to 0 | OS3 to OS0     | 0011     | Not changed by compare-match B; output inverted by compare-match A (toggle output)                       |
| TCR in FRT   | 1 to 0 | CKS1 to CKS0   | 00       | Incremented on internal clock: $\phi p/2$                                                                |
| TCSR in FRT  | 1      | IEDG           | 1        | FRC value is transferred to ICR on rising edge of capture input (IHI divided signal waveform, IV signal) |
|              | 0      | CCLR           | 0        | FRC clearing is disabled                                                                                 |



**Figure 11-4 Timing Chart for measurement of IV Signal and IHI Signal Divided Waveform Periods**

# Section 12 Watchdog Timer

## 12.1 Overview

The H8/3217 Series has an on-chip watchdog timer (WDT) that can monitor system operation by resetting the CPU or generating a nonmaskable interrupt if a system crash allows the timer count to overflow.

When this watchdog function is not needed, the watchdog timer module can be used as an interval timer. In interval timer mode, it requests an OVF interrupt at each counter overflow.

### 12.1.1 Features

- Selection of eight clock sources
- Selection of two modes:
  - Watchdog timer mode
  - Interval timer mode
- Counter overflow generates an interrupt request or reset:
  - Reset or NMI request in watchdog timer mode
  - OVF interrupt request in interval timer mode

12.1.2 Block Diagram

Figure 12-1 is a block diagram of the watchdog timer.

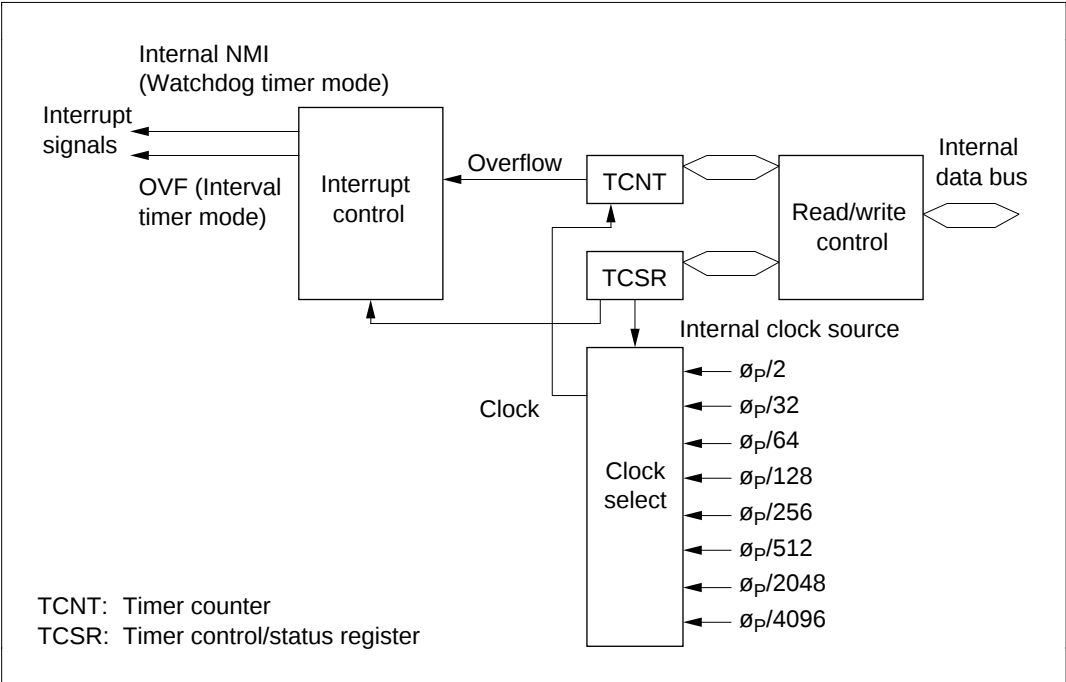


Figure 12-1 Block Diagram of Watchdog Timer

12.1.3 Register Configuration

Table 12-1 lists information on the watchdog timer registers.

Table 12-1 Register Configuration

| Name                          | Abbreviation | R/W    | Initial Value | Addresses |        |
|-------------------------------|--------------|--------|---------------|-----------|--------|
|                               |              |        |               | Write     | Read   |
| Timer control/status register | TCSR         | R/(W)* | H'10          | H'FFAA    | H'FFAA |
| Timer counter                 | TCNT         | R/W    | H'00          | H'FFAA    | H'FFAB |

Note: \* Software can write a 0 in bit 7 to clear the flag, but cannot write 1.

## 12.2 Register Descriptions

### 12.2.1 Timer Counter (TCNT)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

TCNT is an 8-bit readable/writable up-counter. When the timer enable bit (TME) in the timer control/status register (TCSR) is set to 1, the timer counter starts counting pulses of an internal clock source selected by clock select bits 2 to 0 (CKS2 to CKS0) in TCSR. When the count overflows (changes from H'FF to H'00), the overflow flag (OVF) in TCSR is set to 1.

TCNT is initialized to H'00 at a reset and when the TME bit is cleared to 0.

Note: TCNT is more difficult to write to than other registers. See section 12.2.3, Register Access, for details.

### 12.2.2 Timer Control/Status Register (TCSR)

| Bit           | 7      | 6                   | 5   | 4 | 3                     | 2    | 1    | 0    |
|---------------|--------|---------------------|-----|---|-----------------------|------|------|------|
|               | OVF    | WT/ $\overline{IT}$ | TME | — | RST/ $\overline{NMI}$ | CKS2 | CKS1 | CKS0 |
| Initial value | 0      | 0                   | 0   | 1 | 0                     | 0    | 0    | 0    |
| Read/Write    | R/(W)* | R/W                 | R/W | — | R/W                   | R/W  | R/W  | R/W  |

Note: \* Software can write a 0 in bit 7 to clear the flag, but cannot write a 1 in this bit. TCSR is more difficult to write to than other registers. See section 12.2.3, Register Access, for details.

TCSR is an 8-bit readable/writable register that selects the timer mode and clock source and performs other functions. (TCSR is write-protected by a password. See section 12.2.3, Register Access, for details.)

Bits 7 to 5 and bit 3 are initialized to 0 by a reset and in the standby modes. Bits 2 to 0 are initialized to 0 by a reset, but retain their values in the standby modes.

**Bit 7—Overflow Flag (OVF):** Indicates that the watchdog timer count has overflowed.

| Bit 7<br>OVF | Description                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------------------|
| 0            | To clear OVF, the CPU must read OVF after it has been set to 1, (Initial value)<br>then write a 0 in this bit |
| 1            | Set to 1 when TCNT changes from H'FF to H'00                                                                  |

**Bit 6—Timer Mode Select (WT/ $\overline{\text{IT}}$ ):** Selects whether to operate in watchdog timer mode or interval timer mode. In interval timer mode, an OVF interrupt request is sent to the CPU when TCNT overflows. In watchdog timer mode, a reset or NMI interrupt is requested.

| Bit 6<br>WT/ $\overline{\text{IT}}$ | Description                                       |
|-------------------------------------|---------------------------------------------------|
| 0                                   | Interval timer mode (OVF request) (Initial value) |
| 1                                   | Watchdog timer mode (reset or NMI request)        |

**Bit 5—Timer Enable (TME):** Enables or disables the timer.

| Bit 5<br>TME | Description                                                      |
|--------------|------------------------------------------------------------------|
| 0            | TCNT is initialized to H'00 and stopped (Initial value)          |
| 1            | TCNT runs and requests a reset or an interrupt when it overflows |

**Bit 4—Reserved:** This bit cannot be modified and is always read as 1.

**Bit 3: Reset or NMI Select (RST/ $\overline{\text{NMI}}$ ):** Selects either an internal reset or the NMI function at watchdog timer overflow.

| Bit 3<br>RST/ $\overline{\text{NMI}}$ | Description                          |
|---------------------------------------|--------------------------------------|
| 0                                     | NMI function enabled (Initial value) |
| 1                                     | Reset function enabled               |

**Bits 2—0: Clock Select (CKS2–CKS0):** These bits select one of eight clock sources obtained by dividing the system clock ( $\phi$ ).

The overflow interval is the time from when the watchdog timer counter begins counting from H'00 until an overflow occurs. In interval timer mode, OVF interrupts are requested at this interval.

| Bit 2<br>CKS2 | Bit 1<br>CKS1 | Bit 0<br>CKS0 | Clock Source  | Overflow Interval ( $\phi_P = 10\text{ MHz}$ ) |
|---------------|---------------|---------------|---------------|------------------------------------------------|
| 0             | 0             | 0             | $\phi_P/2$    | 51.2 $\mu\text{s}$ (Initial value)             |
| 0             | 0             | 1             | $\phi_P/32$   | 819.2 $\mu\text{s}$                            |
| 0             | 1             | 0             | $\phi_P/64$   | 1.6 ms                                         |
| 0             | 1             | 1             | $\phi_P/128$  | 3.3 ms                                         |
| 1             | 0             | 0             | $\phi_P/256$  | 6.6 ms                                         |
| 1             | 0             | 1             | $\phi_P/512$  | 13.1 ms                                        |
| 1             | 1             | 0             | $\phi_P/2048$ | 52.4 ms                                        |
| 1             | 1             | 1             | $\phi_P/4096$ | 104.9 ms                                       |

### 12.2.3 Register Access

The watchdog timer’s TCNT and TCSR registers are more difficult to write than other registers. The procedures for writing and reading these registers are given below.

**Writing to TCNT and TCSR:** Word access is required. Byte data transfer instructions cannot be used for write access.

The TCNT and TCSR registers have the same write address. The write data must be contained in the lower byte of a word written at this address. The upper byte must contain H'5A (password for TCNT) or H'A5 (password for TCSR). See figure 12-2. The result of the access depicted in figure 12-2 is to transfer the write data from the lower byte to TCNT or TCSR.

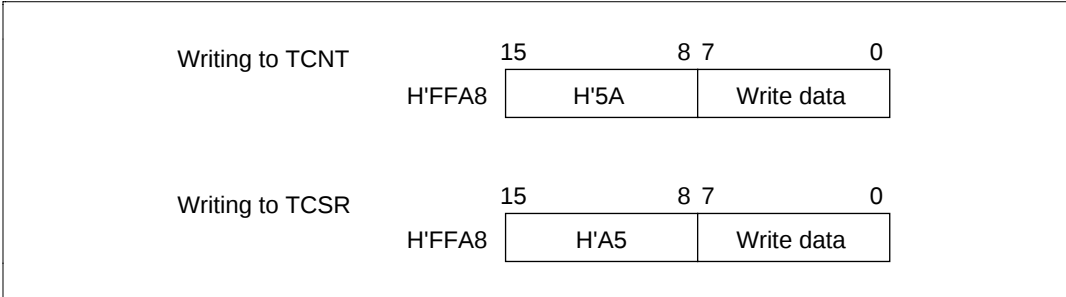


Figure 12-2 Writing to TCNT and TCSR

**Reading TCNT and TCSR:** The read addresses are H'FFA8 for TCSR and H'FFA9 for TCNT, as indicated in table 12-2.

These two registers are read like other registers. Byte access instructions can be used.

**Table 12-2 Read Addresses of TCNT and TCSR**

| Read Address | Register |
|--------------|----------|
| H'FFA8       | TCSR     |
| H'FFA9       | TCNT     |

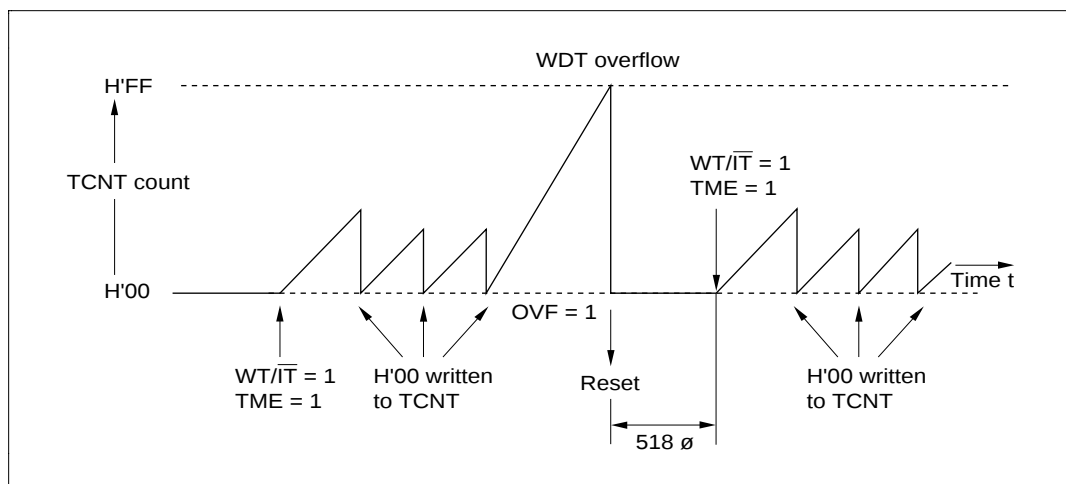
## 12.3 Operation

### 12.3.1 Watchdog Timer Mode

The watchdog timer function begins operating when software sets the  $WT/\overline{IT}$  and TME bits to 1 in TCSR. Thereafter, software should periodically rewrite the contents of the timer counter (normally by writing H'00) to prevent the count from overflowing. If a program crash allows the timer count to overflow, the entire chip is reset for 518 system clocks (518  $\phi$ ), or an NMI interrupt is requested. Figure 12-3 shows the operation.

NMI requests from the watchdog timer have the same vector as NMI requests from the  $\overline{NMI}$  pin. Avoid simultaneous handling of watchdog timer NMI requests and NMI requests from pin  $\overline{NMI}$ .

A reset from the watchdog timer has the same vector as an external reset from the  $\overline{RES}$  pin. The reset source can be determined by the XRST bit in SYSCR.



**Figure 12-3 Operation in Watchdog Timer Mode**

### 12.3.2 Interval Timer Mode

Interval timer operation begins when the  $WT/\overline{IT}$  bit is cleared to 0 and the TME bit is set to 1.

In interval timer mode, an OVF request is generated each time the timer count overflows. This function can be used to generate OVF requests at regular intervals. See figure 12-4.

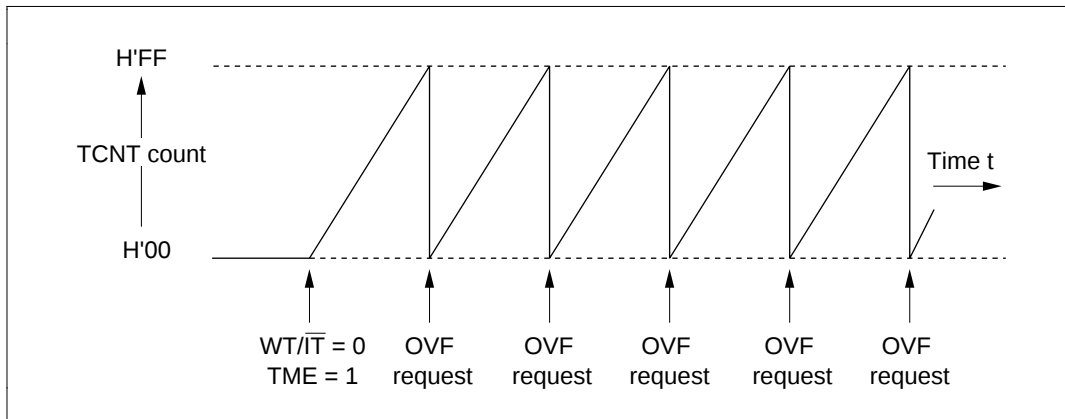


Figure 12-4 Operation in Interval Timer Mode

### 12.3.3 Setting the Overflow Flag

The OVF bit is set to 1 when the timer count overflows. Simultaneously, the WDT module requests an internal reset, NMI, or OVF interrupt. The timing is shown in figure 12-5.

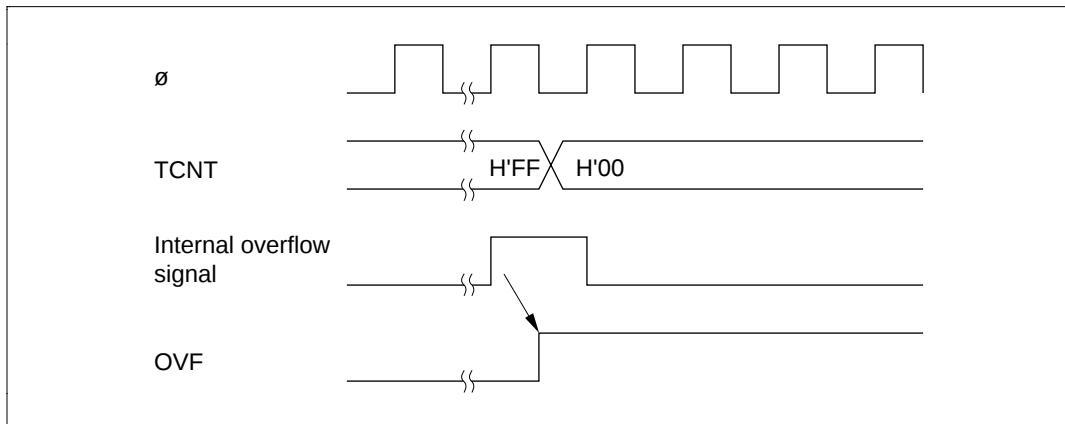
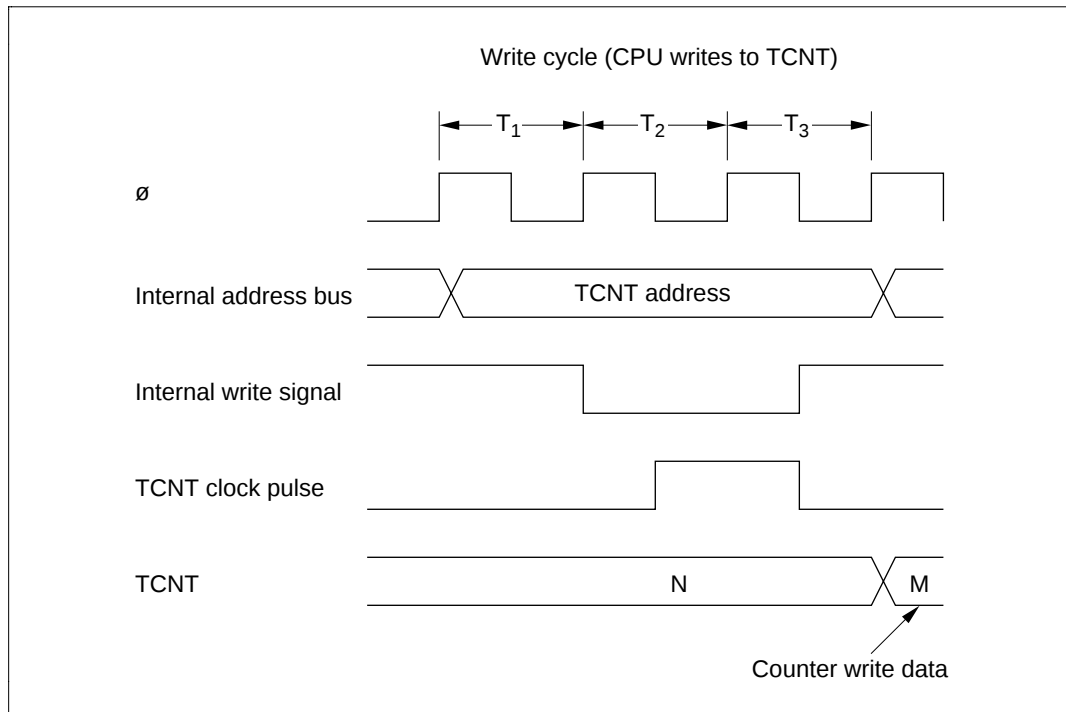


Figure 12-5 Setting the OVF Bit

## 12.4 Application Notes

### 12.4.1 Contention between TCNT Write and Increment

If a timer counter clock pulse is generated during the  $T_3$  state of a write cycle to the timer counter, the write takes priority and the timer counter is not incremented. See figure 12-6.



**Figure 12-6 TCNT Write-Increment Contention**

### 12.4.2 Changing the Clock Select Bits (CKS2 to CKS0)

Software should stop the watchdog timer (by clearing the TME bit to 0) before changing the value of the clock select bits. If the clock select bits are modified while the watchdog timer is running, the timer count may be incremented incorrectly.

### 12.4.3 Recovery from Software Standby Mode

TCSR bits, except bits 0–2, and the TCNT counter are reset when the chip recovers from software standby mode. Re-initialize the watchdog timer as necessary to resume normal operation.

# Section 13 Serial Communication Interface

[One channel incorporated in the H8/3212, and two channels in all other models]

Note that the H8/3212 does not have a channel 1 (SCI1).

## 13.1 Overview

The H8/3217 Series includes two serial communication interface channels (SCI0 and SCI1) for transferring serial data to and from other chips. Either synchronous or asynchronous communication can be selected.

### 13.1.1 Features

The features of the on-chip serial communication interface are:

- Asynchronous mode

The H8/3217 Series can communicate with a UART (Universal Asynchronous Receiver/Transmitter), ACIA (Asynchronous Communication Interface Adapter), or other chip that employs standard asynchronous serial communication. It also has a multiprocessor communication function for communication with other processors. Twelve data formats are available.

- Data length: 7 or 8 bits
- Stop bit length: 1 or 2 bits
- Parity: Even, odd, or none
- Multiprocessor bit: 1 or 0
- Error detection: Parity, overrun, and framing errors
- Break detection: When a framing error occurs, the break condition can be detected by reading the level of the RxD line directly.

- Synchronous mode

The SCI can communicate with chips able to perform clocked synchronous data transfer.

- Data length: 8 bits
- Error detection: Overrun errors

- Full duplex communication

The transmitting and receiving sections are independent, so each channel can transmit and receive simultaneously. Both the transmit and receive sections use double buffering, so continuous data transfer is possible in either direction.

- Built-in bit rate generator

Any specified bit rate can be generated.

- Internal or external clock source

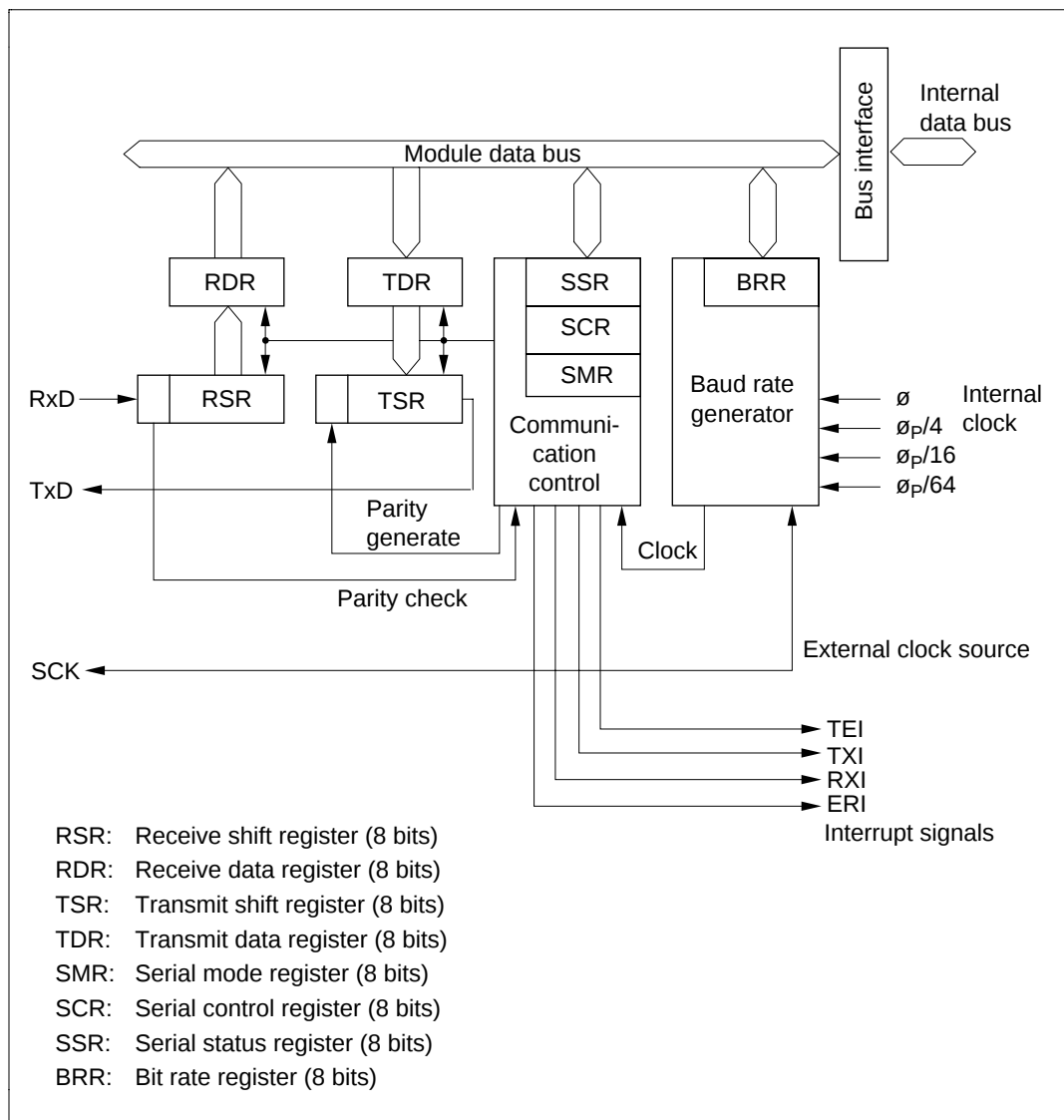
The SCI can operate on an internal clock signal from the baud rate generator, or an external clock signal input at the SCK0 or SCK1 pin.

- Four interrupts

TDR-empty, TSR-empty, receive-end, and receive-error interrupts are requested independently.

### 13.1.2 Block Diagram

Figure 13-1 shows a block diagram of one serial communication interface channel.



**Figure 13-1 Block Diagram of Serial Communication Interface**

### 13.1.3 Input and Output Pins

Table 13-1 lists the input and output pins used by the SCI module.

**Table 13-1 SCI Input/Output Pins**

| Channel | Name                      | Abbr.            | I/O          | Function                      |
|---------|---------------------------|------------------|--------------|-------------------------------|
| 0       | Serial clock input/output | SCK <sub>0</sub> | Input/output | Serial clock input and output |
|         | Receive data input        | RxD <sub>0</sub> | Input        | Receive data input            |
|         | Transmit data output      | TxD <sub>0</sub> | Output       | Transmit data output          |
| 1       | Serial clock input/output | SCK <sub>1</sub> | Input/output | Serial clock input and output |
|         | Receive data input        | RxD <sub>1</sub> | Input        | Receive data input            |
|         | Transmit data output      | TxD <sub>1</sub> | Output       | Transmit data output          |

Note: In this manual, the channel subscript has been deleted, and only SCK, RxD, and TxD are used.

### 13.1.4 Register Configuration

Table 13-2 lists the SCI registers. These registers specify the operating mode (synchronous or asynchronous), data format and bit rate, and control the transmit and receive sections.

**Table 13-2 SCI Registers**

| Channel | Name                               | Abbr. | R/W    | Value | Address |
|---------|------------------------------------|-------|--------|-------|---------|
| 0       | Receive shift register             | RSR   | —      | —     | —       |
|         | Receive data register              | RDR   | R      | H'00  | H'FFDD  |
|         | Transmit shift register            | TSR   | —      | —     | —       |
|         | Transmit data register             | TDR   | R/W    | H'FF  | H'FFDB  |
|         | Serial mode register               | SMR   | R/W    | H'00  | H'FFD8  |
|         | Serial control register            | SCR   | R/W    | H'00  | H'FFDA  |
|         | Serial status register             | SSR   | R/(W)* | H'84  | H'FFDC  |
|         | Bit rate register                  | BRR   | R/W    | H'FF  | H'FFD9  |
|         | Serial communication mode register | SCMR  | R/W    | H'F2  | H'FFDE  |
| 1       | Receive shift register             | RSR   | —      | —     | —       |
|         | Receive data register              | RDR   | R      | H'00  | H'FFE5  |
|         | Transmit shift register            | TSR   | —      | —     | —       |
|         | Transmit data register             | TDR   | R/W    | H'FF  | H'FFE3  |
|         | Serial mode register               | SMR   | R/W    | H'00  | H'FFE0  |
|         | Serial control register            | SCR   | R/W    | H'00  | H'FFE2  |
|         | Serial status register             | SSR   | R/(W)* | H'84  | H'FFE4  |
|         | Bit rate register                  | BRR   | R/W    | H'FF  | H'FFE1  |

Note: \* Software can write a 0 to clear the flags in bits 7 to 3, but cannot write 1 in these bits.

## 13.2 Register Descriptions

### 13.2.1 Receive Shift Register (RSR)

| Bit        | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------|---|---|---|---|---|---|---|---|
|            |   |   |   |   |   |   |   |   |
| Read/Write | — | — | — | — | — | — | — | — |

RSR is a shift register that converts incoming serial data to parallel data. When one data character has been received, it is transferred to the receive data register (RDR).

The CPU cannot read or write RSR directly.

### 13.2.2 Receive Data Register (RDR)

| Bit           | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------|---|---|---|---|---|---|---|---|
|               |   |   |   |   |   |   |   |   |
| Initial value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write    | R | R | R | R | R | R | R | R |

RDR stores received data. As each character is received, it is transferred from RSR to RDR, enabling RSR to receive the next character. This double-buffering allows the SCI to receive data continuously.

RDR is a read-only register. RDR is initialized to H'00 by a reset and in the standby modes.

### 13.2.3 Transmit Shift Register (TSR)

| Bit        | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------|---|---|---|---|---|---|---|---|
|            |   |   |   |   |   |   |   |   |
| Read/Write | — | — | — | — | — | — | — | — |

TSR is a shift register that converts parallel data to serial transmit data. When transmission of one character is completed, the next character is moved from the transmit data register (TDR) to TSR and transmission of that character begins. If the TDRE bit is still set to 1, however, nothing is transferred to TSR.

The CPU cannot read or write TSR directly.

### 13.2.4 Transmit Data Register (TDR)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

TDR is an 8-bit readable/writable register that holds the next data to be transmitted. When TSR becomes empty, the data written in TDR is transferred to TSR. Continuous data transmission is possible by writing the next data in TDR while the current data is being transmitted from TSR.

TDR is initialized to H'FF by a reset and in the standby modes.

### 13.2.5 Serial Mode Register (SMR)

| Bit           | 7                 | 6   | 5   | 4                 | 3    | 2   | 1    | 0    |
|---------------|-------------------|-----|-----|-------------------|------|-----|------|------|
|               | C/ $\overline{A}$ | CHR | PE  | O/ $\overline{E}$ | STOP | MP  | CKS1 | CKS0 |
| Initial value | 0                 | 0   | 0   | 0                 | 0    | 0   | 0    | 0    |
| Read/Write    | R/W               | R/W | R/W | R/W               | R/W  | R/W | R/W  | R/W  |

SMR is an 8-bit readable/writable register that controls the communication format and selects the clock source of the on-chip baud rate generator. It is initialized to H'00 by a reset and in the standby modes. For further information on the SMR settings and communication formats, see tables 13-5 and 13-7 in section 13.3, Operation.

**Bit 7—Communication Mode (C/ $\overline{A}$ ):** This bit selects asynchronous or synchronous communication mode.

#### Bit 7

| C/ $\overline{A}$ | Description                                |
|-------------------|--------------------------------------------|
| 0                 | Asynchronous communication (Initial value) |
| 1                 | Synchronous communication                  |

**Bit 6—Character Length (CHR):** This bit selects the character length in asynchronous mode. It is ignored in synchronous mode.

**Bit 6**

| CHR | Description                                                                                             |                 |
|-----|---------------------------------------------------------------------------------------------------------|-----------------|
| 0   | 8 bits per character                                                                                    | (Initial value) |
| 1   | 7 bits per character (Bits 6 to 0 of TDR and RDR are used for transmitting and receiving, respectively) |                 |

**Bit 5—Parity Enable (PE):** This bit selects whether to add and check for a parity bit in asynchronous mode. It is ignored in synchronous mode, and when a multiprocessor format is used.

**Bit 5**

| PE | Description                      |                 |
|----|----------------------------------|-----------------|
| 0  | Transmit: No parity bit is added | (Initial value) |
|    | Receive: Parity is not checked   |                 |
| 1  | Transmit: A parity bit is added  |                 |
|    | Receive: Parity is checked       |                 |

**Bit 4—Parity Mode ( $O/\bar{E}$ ):** In asynchronous mode, when parity is enabled ( $PE = 1$ ), this bit selects even or odd parity.

Even parity means that a parity bit is added to the data bits for each character to make the total number of 1's even. Odd parity means that the total number of 1's is made odd.

This bit is ignored when  $PE = 0$ , or when a multiprocessor format is used. It is also ignored in synchronous mode.

**Bit 4**

| $O/\bar{E}$ | Description |                 |
|-------------|-------------|-----------------|
| 0           | Even parity | (Initial value) |
| 1           | Odd parity  |                 |

**Bit 3—Stop Bit Length (STOP):** This bit selects the number of stop bits. It is ignored in synchronous mode, and when a multiprocessor format is used.

| Bit 3<br>STOP | Description                                                                                                                                                                                           |                 |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 0             | One stop bit<br>Transmit: One stop bit is added<br>Receive: One stop bit is checked to detect framing errors                                                                                          | (Initial value) |
| 1             | Two stop bits<br>Transmit: Two stop bits are added<br>Receive: The first stop bit is checked to detect framing errors<br>If the second stop bit is a space (0), it is regarded as the next start bit. |                 |

**Bit 2—Multiprocessor Mode (MP):** This bit selects the multiprocessor format. When multiprocessor format is selected, the parity settings of the parity enable bit (PE) and parity mode bit (O/ $\overline{E}$ ) are ignored. The MP bit is valid only in asynchronous mode, and is ignored in synchronous mode.

| Bit 2<br>MP | Description                                       |                 |
|-------------|---------------------------------------------------|-----------------|
| 0           | Multiprocessor communication function is disabled | (Initial value) |
| 1           | Multiprocessor communication function is enabled  |                 |

**Bits 1 and 0—Clock Select 1 and 0 (CKS1 and CKS0):** These bits select the clock source of the on-chip baud rate generator.

| Bit 1<br>CKS1 | Bit 0<br>CKS0 | Description            |                 |
|---------------|---------------|------------------------|-----------------|
| 0             | 0             | $\emptyset$ clock      | (Initial value) |
| 0             | 1             | $\emptyset_P/4$ clock  |                 |
| 1             | 0             | $\emptyset_P/16$ clock |                 |
| 1             | 1             | $\emptyset_P/64$ clock |                 |

### 13.2.6 Serial Control Register (SCR)

| Bit           | 7   | 6   | 5   | 4   | 3    | 2    | 1    | 0    |
|---------------|-----|-----|-----|-----|------|------|------|------|
|               | TIE | RIE | TE  | RE  | MPIE | TEIE | CKE1 | CKE0 |
| Initial value | 0   | 0   | 0   | 0   | 0    | 0    | 0    | 0    |
| Read/Write    | R/W | R/W | R/W | R/W | R/W  | R/W  | R/W  | R/W  |

SCR is an 8-bit readable/writable register that enables or disables various SCI functions. It is initialized to H'00 by a reset and in the standby modes.

**Bit 7—Transmit Interrupt Enable (TIE):** This bit enables or disables the TDR-empty interrupt (TXI) requested when the transmit data register empty (TDRE) bit in the serial status register (SSR) is set to 1.

#### Bit 7

| TIE | Description                                                       |
|-----|-------------------------------------------------------------------|
| 0   | The TDR-empty interrupt request (TXI) is disabled (Initial value) |
| 1   | The TDR-empty interrupt request (TXI) is enabled                  |

**Bit 6—Receive Interrupt Enable (RIE):** This bit enables or disables the receive-end interrupt (RXI) requested when the receive data register full (RDRF) bit in the serial status register (SSR) is set to 1, and the receive error interrupt (ERI) requested when the overrun error (ORER), framing error (FER), or parity error (PER) bit in the serial status register (SSR) is set to 1.

#### Bit 6

| RIE | Description                                                                                             |
|-----|---------------------------------------------------------------------------------------------------------|
| 0   | The receive-end interrupt (RXI) and receive-error interrupt (ERI) requests are disabled (Initial value) |
| 1   | The receive-end interrupt (RXI) and receive-error interrupt (ERI) requests are enabled                  |

**Bit 5—Transmit Enable (TE):** This bit enables or disables the transmit function. When the transmit function is enabled, the TxD pin is automatically used for output. When the transmit function is disabled, the TxD pin can be used as a general-purpose I/O port.

#### Bit 5

| TE | Description                                                                                          |
|----|------------------------------------------------------------------------------------------------------|
| 0  | The transmit function is disabled (Initial value)<br>The TxD pin can be used for general-purpose I/O |
| 1  | The transmit function is enabled<br>The TxD pin is used for output                                   |

**Bit 4—Receive Enable (RE):** This bit enables or disables the receive function. When the receive function is enabled, the RxD pin is automatically used for input. When the receive function is disabled, the RxD pin is available as a general-purpose I/O port.

**Bit 4**

| RE | Description                                                                                         |
|----|-----------------------------------------------------------------------------------------------------|
| 0  | The receive function is disabled<br>The RxD pin can be used for general-purpose I/O (Initial value) |
| 1  | The receive function is enabled<br>The RxD pin is used for input                                    |

**Bit 3—Multiprocessor Interrupt Enable (MPIE):** When serial data is received in a multiprocessor format, this bit enables or disables the receive-end interrupt (RXI) and receive-error interrupt (ERI) until data with the multiprocessor bit set to 1 is received. It also enables or disables the transfer of receive data from RSR to RDR, and enables or disables setting of the RDRF, FER, PER, and ORER bits in the serial status register (SSR).

The MPIE bit is ignored when the MP bit is cleared to 0, and in synchronous mode.

Clearing the MPIE bit to 0 disables the multiprocessor receive interrupt function. In this condition data is received regardless of the value of the multiprocessor bit in the receive data.

Setting the MPIE bit to 1 enables the multiprocessor receive interrupt function. In this condition, if the multiprocessor bit in the receive data is 0, the receive-end interrupt (RXI) and receive-error interrupt (ERI) are disabled, the receive data is not transferred from RSR to RDR, and the RDRF, FER, PER, and ORER bits in the serial status register (SSR) are not set. If the multiprocessor bit is 1, however, the MPB bit in SSR is set to 1, the MPIE bit is cleared to 0, the receive data is transferred from RSR to RDR, the FER, PER, and ORER bits can be set, and the receive-end and receive-error interrupts are enabled.

**Bit 3**

| MPIE | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | The multiprocessor receive interrupt function is disabled (Initial value)<br>(Normal receive operation)                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1    | The multiprocessor receive interrupt function is enabled. During the interval before data with the multiprocessor bit set to 1 is received, the receive interrupt request (RXI) and receive-error interrupt request (ERI) are disabled, the RDRF, FER, PER, and ORER bits are not set in the serial status register (SSR), and no data is transferred from the RSR to the RDR. The MPIE bit is cleared at the following times:<br>(1) When 0 is written in MPIE<br>(2) When data with the multiprocessor bit set to 1 is received |

**Bit 2—Transmit-End Interrupt Enable (TEIE):** This bit enables or disables the TSR-empty interrupt (TEI) requested when the transmit-end bit (TEND) in the serial status register (SSR) is set to 1.

**Bit 2**

| TEIE | Description                                                       |
|------|-------------------------------------------------------------------|
| 0    | The TSR-empty interrupt request (TEI) is disabled (Initial value) |
| 1    | The TSR-empty interrupt request (TEI) is enabled                  |

**Bit 1—Clock Enable 1 (CKE1):** This bit selects the internal or external clock source for the baud rate generator. When the external clock source is selected, the SCK pin is automatically used for input of the external clock signal.

**Bit 1**

| CKE1 | Description                                                                                                                                                               |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | Internal clock source (Initial value)<br>When $C/\bar{A} = 1$ , the serial clock signal is output at the SCK pin<br>When $C/\bar{A} = 0$ , output depends on the CKE0 bit |
| 1    | External clock source<br>The SCK pin is used for input                                                                                                                    |

**Bit 0—Clock Enable 0 (CKE0):** When an internal clock source is used in asynchronous mode, this bit enables or disables serial clock output at the SCK pin.

This bit is ignored when the external clock is selected, or when synchronous mode is selected.

For further information on the communication format and clock source selection, see table 13-6 in section 13.3, Operation.

**Bit 0**

| CKE0 | Description                                                                                         |
|------|-----------------------------------------------------------------------------------------------------|
| 0    | The SCK pin is not used by the SCI (and is available as a general-purpose I/O port) (Initial value) |
| 1    | The SCK pin is used for serial clock output                                                         |

### 13.2.7 Serial Status Register (SSR)

| Bit           | 7      | 6      | 5      | 4      | 3      | 2    | 1   | 0    |
|---------------|--------|--------|--------|--------|--------|------|-----|------|
|               | TDRE   | RDRF   | ORER   | FER    | PER    | TEND | MPB | MPBT |
| Initial value | 1      | 0      | 0      | 0      | 0      | 1    | 0   | 0    |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R    | R   | R/W  |

Note: \* Software can write a 0 in bits 7 to 3 to clear the flags, but cannot write a 1 in these bits.

SSR is an 8-bit register that indicates transmit and receive status. It is initialized to H'84 by a reset and in the standby modes.

**Bit 7—Transmit Data Register Empty (TDRE):** This bit indicates when transmit data can safely be written in TDR.

#### Bit 7

| TDRE | Description                                                                                                                                                |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | To clear TDRE, the CPU must read TDRE after it has been set to 1, then write a 0 in this bit                                                               |
| 1    | This bit is set to 1 at the following times: (Initial value)<br>(1) When TDR contents are transferred to TSR<br>(2) When the TE bit in SCR is cleared to 0 |

**Bit 6—Receive Data Register Full (RDRF):** This bit indicates when one character has been received and transferred to the RDR.

#### Bit 6

| RDRF | Description                                                                                                  |
|------|--------------------------------------------------------------------------------------------------------------|
| 0    | To clear RDRF, the CPU must read RDRF after it has been set to 1, then write a 0 in this bit (Initial value) |
| 1    | This bit is set to 1 when one character is received without error and transferred from RSR to RDR            |

**Bit 5—Overrun Error (ORER):** This bit indicates an overrun error during reception.

**Bit 5**

| ORER | Description                                                                                                           |                 |
|------|-----------------------------------------------------------------------------------------------------------------------|-----------------|
| 0    | To clear ORER, the CPU must read ORER after it has been set to 1, then write a 0 in this bit                          | (Initial value) |
| 1    | This bit is set to 1 if reception of the next character ends while the receive data register is still full (RDRF = 1) |                 |

**Bit 4—Framing Error (FER):** This bit indicates a framing error during data reception in asynchronous mode. It has no meaning in synchronous mode.

**Bit 4**

| FER | Description                                                                                |                 |
|-----|--------------------------------------------------------------------------------------------|-----------------|
| 0   | To clear FER, the CPU must read FER after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1   | This bit is set to 1 if a framing error occurs (stop bit = 0)                              |                 |

**Bit 3—Parity Error (PER):** This bit indicates a parity error during data reception in asynchronous mode, when a communication format with parity bits is used.

This bit has no meaning in synchronous mode, or when a communication format without parity bits is used.

**Bit 3**

| PER | Description                                                                                                                                         |                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 0   | To clear PER, the CPU must read PER after it has been set to 1, then write a 0 in this bit                                                          | (Initial value) |
| 1   | This bit is set to 1 when a parity error occurs (the parity of the received data does not match the parity selected by the O/ $\bar{E}$ bit in SMR) |                 |

**Bit 2—Transmit End (TEND):** This bit indicates that the serial communication interface has stopped transmitting because there was no valid data in TDR when the last bit of the current character was transmitted. The TEND bit is also set to 1 when the TE bit in the serial control register (SCR) is cleared to 0.

The TEND bit is a read-only bit and cannot be modified directly. To use the TEI interrupt, first start transmitting data, which clears TEND to 0, then set TEIE to 1.

**Bit 2**

| <b>TEND</b> | <b>Description</b>                                                                                         |
|-------------|------------------------------------------------------------------------------------------------------------|
| 0           | To clear TEND, the CPU must read TDRE after TDRE has been set to 1, then write a 0 in TDRE (Initial value) |
| 1           | This bit is set to 1 when:<br>(1) TE = 0<br>(2) TDRE = 1 at the end of transmission of a character         |

**Bit 1—Multiprocessor Bit (MPB):** Stores the value of the multiprocessor bit in data received in a multiprocessor format in asynchronous communication mode. This bit retains its previous value in synchronous mode, when a multiprocessor format is not used, or when the RE bit is cleared to 0 even if a multiprocessor format is used.

MPB can be read but not written.

**Bit 1**

| <b>MPB</b> | <b>Description</b>                                     |
|------------|--------------------------------------------------------|
| 0          | Multiprocessor bit = 0 in receive data (Initial value) |
| 1          | Multiprocessor bit = 1 in receive data                 |

**Bit 0—Multiprocessor Bit Transfer (MPBT):** Stores the value of the multiprocessor bit inserted in transmit data when a multiprocessor format is used in asynchronous communication mode. The MPBT bit is double-buffered in the same way as TSR and TDR. The MPBT bit has no effect in synchronous mode, or when a multiprocessor format is not used.

**Bit 0**

| <b>MPBT</b> | <b>Description</b>                                      |
|-------------|---------------------------------------------------------|
| 0           | Multiprocessor bit = 0 in transmit data (Initial value) |
| 1           | Multiprocessor bit = 1 in transmit data                 |

### 13.2.8 Bit Rate Register (BRR)

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

BRR is an 8-bit register that, together with the CKS1 and CKS0 bits in SMR, determines the bit rate output by the baud rate generator.

BRR is initialized to H'FF by a reset and in the standby modes.

Tables 13-3 and 13-4 show examples of BRR settings.

**Table 13-3 Examples of BRR Settings in Asynchronous Mode (When  $\theta_P = \theta$ )**

| Bit Rate | $\theta$ Frequency (MHz) |     |           |        |     |           |   |     |           |          |     |           |
|----------|--------------------------|-----|-----------|--------|-----|-----------|---|-----|-----------|----------|-----|-----------|
|          | 1                        |     |           | 1.2296 |     |           | 2 |     |           | 2.097152 |     |           |
|          | n                        | N   | Error (%) | n      | N   | Error (%) | n | N   | Error (%) | n        | N   | Error (%) |
| 110      | 1                        | 70  | +0.03     | 1      | 86  | +0.31     | 1 | 141 | +0.03     | 1        | 148 | -0.04     |
| 150      | 0                        | 207 | +0.16     | 0      | 255 | 0         | 1 | 103 | +0.16     | 1        | 108 | +0.21     |
| 300      | 0                        | 103 | +0.16     | 0      | 127 | 0         | 0 | 207 | +0.16     | 0        | 217 | +0.21     |
| 600      | 0                        | 51  | +0.16     | 0      | 63  | 0         | 0 | 103 | +0.16     | 0        | 108 | +0.21     |
| 1200     | 0                        | 25  | +0.16     | 0      | 31  | 0         | 0 | 51  | +0.16     | 0        | 54  | -0.70     |
| 2400     | 0                        | 12  | +0.16     | 0      | 15  | 0         | 0 | 25  | +0.16     | 0        | 26  | +1.14     |
| 4800     | —                        | —   | —         | 0      | 7   | 0         | 0 | 12  | +0.16     | 0        | 13  | -2.48     |
| 9600     | —                        | —   | —         | 0      | 3   | 0         | — | —   | —         | 0        | 6   | -2.48     |
| 19200    | —                        | —   | —         | 0      | 1   | 0         | — | —   | —         | —        | —   | —         |
| 31250    | 0                        | 0   | 0         | —      | —   | —         | 0 | 1   | 0         | —        | —   | —         |
| 38400    | —                        | —   | —         | 0      | 0   | 0         | — | —   | —         | —        | —   | —         |

**Table 13-3 Examples of BRR Settings in Asynchronous Mode (When  $\theta_P = \theta$ ) (cont)**

| Bit Rate | $\theta$ Frequency (MHz) |     |           |   |     |           |        |     |           |   |     |           |
|----------|--------------------------|-----|-----------|---|-----|-----------|--------|-----|-----------|---|-----|-----------|
|          | 2.4576                   |     |           | 3 |     |           | 3.6864 |     |           | 4 |     |           |
|          | n                        | N   | Error (%) | n | N   | Error (%) | n      | N   | Error (%) | n | N   | Error (%) |
| 110      | 1                        | 174 | -0.26     | 2 | 52  | +0.50     | 2      | 64  | +0.70     | 2 | 70  | +0.03     |
| 150      | 1                        | 127 | 0         | 1 | 155 | +0.16     | 1      | 191 | 0         | 1 | 207 | +0.16     |
| 300      | 0                        | 255 | 0         | 1 | 77  | +0.16     | 1      | 95  | 0         | 1 | 103 | +0.16     |
| 600      | 0                        | 127 | 0         | 0 | 155 | +0.16     | 0      | 191 | 0         | 0 | 207 | +0.16     |
| 1200     | 0                        | 63  | 0         | 0 | 77  | +0.16     | 0      | 95  | 0         | 0 | 103 | +0.16     |
| 2400     | 0                        | 31  | 0         | 0 | 38  | +0.16     | 0      | 47  | 0         | 0 | 51  | +0.16     |
| 4800     | 0                        | 15  | 0         | 0 | 19  | -2.34     | 0      | 23  | 0         | 0 | 25  | +0.16     |
| 9600     | 0                        | 7   | 0         | 0 | 9   | -2.34     | 0      | 11  | 0         | 0 | 12  | +0.16     |
| 19200    | 0                        | 3   | 0         | 0 | 4   | -2.34     | 0      | 5   | 0         | — | —   | —         |
| 31250    | —                        | —   | —         | 0 | 2   | 0         | —      | —   | —         | 0 | 3   | 0         |
| 38400    | 0                        | 1   | 0         | — | —   | —         | 0      | 2   | 0         | — | —   | —         |

**Table 13-3 Examples of BRR Settings in Asynchronous Mode (When  $\theta_P = \theta$ ) (cont)**

| Bit Rate | $\theta$ Frequency (MHz) |     |           |   |     |           |   |     |           |       |     |           |
|----------|--------------------------|-----|-----------|---|-----|-----------|---|-----|-----------|-------|-----|-----------|
|          | 4.9152                   |     |           | 5 |     |           | 6 |     |           | 6.144 |     |           |
|          | n                        | N   | Error (%) | n | N   | Error (%) | n | N   | Error (%) | n     | N   | Error (%) |
| 110      | 2                        | 86  | +0.31     | 2 | 88  | -0.25     | 2 | 106 | -0.44     | 2     | 108 | +0.08     |
| 150      | 1                        | 255 | 0         | 2 | 64  | +0.16     | 2 | 77  | 0         | 2     | 79  | 0         |
| 300      | 1                        | 127 | 0         | 1 | 129 | +0.16     | 1 | 155 | 0         | 1     | 159 | 0         |
| 600      | 0                        | 255 | 0         | 1 | 64  | +0.16     | 1 | 77  | 0         | 1     | 79  | 0         |
| 1200     | 0                        | 127 | 0         | 0 | 129 | +0.16     | 0 | 155 | +0.16     | 0     | 159 | 0         |
| 2400     | 0                        | 63  | 0         | 0 | 64  | +0.16     | 0 | 77  | +0.16     | 0     | 79  | 0         |
| 4800     | 0                        | 31  | 0         | 0 | 32  | -1.36     | 0 | 38  | +0.16     | 0     | 39  | 0         |
| 9600     | 0                        | 15  | 0         | 0 | 15  | +1.73     | 0 | 19  | -2.34     | 0     | 19  | 0         |
| 19200    | 0                        | 7   | 0         | 0 | 7   | +1.73     | — | —   | —         | 0     | 4   | 0         |
| 31250    | 0                        | 4   | -1.70     | 0 | 4   | 0         | 0 | 5   | 0         | 0     | 5   | +2.40     |
| 38400    | 0                        | 3   | 0         | 0 | 3   | +1.73     | — | —   | —         | —     | —   | —         |

**Table 13-3 Examples of BRR Settings in Asynchronous Mode (When  $\theta_P = \theta$ ) (cont)**

| Bit Rate | $\phi$ Frequency (MHz) |     |           |   |     |           |        |     |           |    |     |           |
|----------|------------------------|-----|-----------|---|-----|-----------|--------|-----|-----------|----|-----|-----------|
|          | 7.3728                 |     |           | 8 |     |           | 9.8304 |     |           | 10 |     |           |
|          | n                      | N   | Error (%) | n | N   | Error (%) | n      | N   | Error (%) | n  | N   | Error (%) |
| 110      | 2                      | 130 | -0.07     | 2 | 141 | +0.03     | 2      | 174 | -0.26     | 3  | 43  | +0.88     |
| 150      | 2                      | 95  | 0         | 2 | 103 | +0.16     | 2      | 127 | 0         | 2  | 129 | +0.16     |
| 300      | 1                      | 191 | 0         | 1 | 207 | +0.16     | 1      | 255 | 0         | 2  | 64  | +0.16     |
| 600      | 1                      | 95  | 0         | 1 | 103 | +0.16     | 1      | 127 | 0         | 1  | 129 | +0.16     |
| 1200     | 0                      | 191 | 0         | 0 | 207 | +0.16     | 0      | 255 | 0         | 1  | 64  | +0.16     |
| 2400     | 0                      | 95  | 0         | 0 | 103 | +0.16     | 0      | 127 | 0         | 0  | 129 | +0.16     |
| 4800     | 0                      | 47  | 0         | 0 | 51  | +0.16     | 0      | 63  | 0         | 0  | 64  | +0.16     |
| 9600     | 0                      | 23  | 0         | 0 | 25  | +0.16     | 0      | 31  | 0         | 0  | 32  | -1.36     |
| 19200    | 0                      | 11  | 0         | 0 | 12  | +0.16     | 0      | 15  | 0         | 0  | 15  | +1.73     |
| 31250    | —                      | —   | —         | 0 | 7   | 0         | 0      | 9   | -1.70     | 0  | 9   | 0         |
| 38400    | 0                      | 5   | 0         | — | —   | —         | 0      | 7   | 0         | 0  | 7   | +1.73     |

**Table 13-3 Examples of BRR Settings in Asynchronous Mode (When  $\theta_P = \theta$ ) (cont)**

| Bit Rate | $\phi$ Frequency (MHz) |     |           |        |     |           |         |     |           |    |     |           |
|----------|------------------------|-----|-----------|--------|-----|-----------|---------|-----|-----------|----|-----|-----------|
|          | 12                     |     |           | 12.288 |     |           | 14.7456 |     |           | 16 |     |           |
|          | n                      | N   | Error (%) | n      | N   | Error (%) | n       | N   | Error (%) | n  | N   | Error (%) |
| 110      | 2                      | 212 | +0.03     | 2      | 217 | +0.08     | 3       | 64  | +0.70     | 3  | 70  | +0.03     |
| 150      | 2                      | 155 | +0.16     | 2      | 159 | 0         | 2       | 191 | 0         | 2  | 207 | +0.16     |
| 300      | 2                      | 77  | +0.16     | 2      | 79  | 0         | 2       | 95  | 0         | 2  | 103 | +0.16     |
| 600      | 1                      | 155 | +0.16     | 1      | 159 | 0         | 1       | 191 | 0         | 1  | 207 | +0.16     |
| 1200     | 1                      | 77  | +0.16     | 1      | 79  | 0         | 1       | 95  | 0         | 1  | 103 | +0.16     |
| 2400     | 0                      | 155 | +0.16     | 0      | 159 | 0         | 0       | 191 | 0         | 0  | 207 | +0.16     |
| 4800     | 0                      | 77  | +0.16     | 0      | 79  | 0         | 0       | 95  | 0         | 0  | 103 | +0.16     |
| 9600     | 0                      | 38  | +0.16     | 0      | 39  | 0         | 0       | 47  | 0         | 0  | 51  | +0.16     |
| 19200    | 0                      | 19  | -2.34     | 0      | 19  | 0         | 0       | 23  | 0         | 0  | 25  | +0.16     |
| 31250    | 0                      | 11  | 0         | 0      | 11  | +2.4      | 0       | 14  | -1.7      | 0  | 15  | 0         |
| 38400    | 0                      | 9   | -2.34     | 0      | 9   | 0         | 0       | 11  | 0         | 0  | 12  | +0.16     |

Note: If possible, the error should be within 1%.

In the shaded section, if  $\varnothing_P = \varnothing/2$ , the bit rate is cut in half. In this case, BRR settings for the desired bit rate should be referenced from the column of one-half the actual system clock frequency ( $\varnothing$ ).

$$B = F \times 10^6 / [64 \times 2^{2n-1} \times (N + 1)] \rightarrow N = F \times 10^6 / [64 \times 2^{2n-1} \times B] - 1$$

B: Bit rate (bits/second)

N: BRR value ( $0 \leq N \leq 255$ )

F:  $\varnothing_P$  (MHz) when  $n \neq 0$ , or  $\varnothing$  (MHz) when  $n = 0$

n: Internal clock source (0, 1, 2, or 3)

The meaning of n is given by the table below:

| n | CKS1 | CKS0 | Clock              |
|---|------|------|--------------------|
| 0 | 0    | 0    | $\varnothing$      |
| 1 | 0    | 1    | $\varnothing_P/4$  |
| 2 | 1    | 0    | $\varnothing_P/16$ |
| 3 | 1    | 1    | $\varnothing_P/64$ |

Bit rate error can be calculated with the formula below.

$$\text{Error (\%)} = \left\{ \frac{F \times 10^6}{(N + 1) \times B \times 64 \times 2^{2n-1}} - 1 \right\} \times 100$$

**Table 13-4 Examples of BRR Settings in Synchronous Mode (When  $\phi_P = \phi$ )**

| Bit Rate | $\phi$ Frequency (MHz) |     |   |     |   |     |   |     |   |     |    |     |    |     |
|----------|------------------------|-----|---|-----|---|-----|---|-----|---|-----|----|-----|----|-----|
|          | 1                      |     | 2 |     | 4 |     | 5 |     | 8 |     | 10 |     | 16 |     |
|          | n                      | N   | n | N   | n | N   | n | N   | n | N   | n  | N   | n  | N   |
| 100      | —                      | —   | — | —   | — | —   | — | —   | — | —   | —  | —   | —  | —   |
| 250      | 1                      | 249 | 2 | 124 | 2 | 249 | — | —   | 3 | 124 | —  | —   | 3  | 249 |
| 500      | 1                      | 124 | 1 | 249 | 2 | 124 | — | —   | 2 | 249 | —  | —   | 3  | 124 |
| 1 k      | 0                      | 249 | 1 | 124 | 1 | 249 | — | —   | 2 | 124 | —  | —   | 2  | 249 |
| 2.5 k    | 0                      | 99  | 0 | 199 | 1 | 99  | 1 | 124 | 1 | 199 | 1  | 249 | 2  | 99  |
| 5 k      | 0                      | 49  | 0 | 99  | 0 | 199 | 0 | 249 | 1 | 99  | 1  | 124 | 1  | 199 |
| 10 k     | 0                      | 24  | 0 | 49  | 0 | 99  | 0 | 124 | 0 | 199 | 0  | 249 | 1  | 99  |
| 25 k     | 0                      | 9   | 0 | 19  | 0 | 39  | 0 | 49  | 0 | 79  | 0  | 99  | 0  | 159 |
| 50 k     | 0                      | 4   | 0 | 9   | 0 | 19  | 0 | 24  | 0 | 39  | 0  | 49  | 0  | 79  |
| 100 k    | —                      | —   | 0 | 4   | 0 | 9   | — | —   | 0 | 19  | 0  | 24  | 0  | 39  |
| 250 k    | 0                      | 0*  | 0 | 1   | 0 | 3   | 0 | 4   | 0 | 7   | 0  | 9   | 0  | 15  |
| 500 k    |                        |     | 0 | 0*  | 0 | 1   | — | —   | 0 | 3   | 0  | 4   | 0  | 7   |
| 1 M      |                        |     |   |     | 0 | 0*  | — | —   | 0 | 1   | —  | —   | 0  | 3   |
| 2.5 M    |                        |     |   |     |   |     |   |     |   |     | 0  | 0*  | —  | —   |
| 4 M      |                        |     |   |     |   |     |   |     |   |     |    |     | 0  | 0*  |

Notes: In the shaded section, if  $\phi_P = \phi/2$ , the bit rate is cut in half. In this case, BRR settings for the desired bit rate should be referenced from the column of one-half the actual system clock frequency ( $\phi$ ).

Blank: No setting is available.

—: A setting is available, but the bit rate is inaccurate.

\*: Continuous transfer is not possible.

$$B = F \times 10^6 / [8 \times 2^{2n} \times (N + 1)] \rightarrow N = F \times 10^6 / [8 \times 2^{2n-1} \times B] - 1$$

B: Bit rate (bits per second)

N: BRR value ( $0 \leq N \leq 255$ )

F:  $\phi_P$  (MHz) when  $n \neq 0$ , or  $\phi$  (MHz) when  $n = 0$

n: Internal clock source (0, 1, 2, or 3)

The meaning of n is given by the table below:

| n | CKS1 | CKS0 | Clock       |
|---|------|------|-------------|
| 0 | 0    | 0    | $\phi$      |
| 1 | 0    | 1    | $\phi_P/4$  |
| 2 | 1    | 0    | $\phi_P/16$ |
| 3 | 1    | 1    | $\phi_P/64$ |

### 13.2.9 Serial Communication Mode Register (SCMR)

| Bit           | 7 | 6 | 5 | 4 | 3    | 2    | 1 | 0    |
|---------------|---|---|---|---|------|------|---|------|
|               | — | — | — | — | SDIR | SINV | — | SMIF |
| Initial value | 1 | 1 | 1 | 1 | 0    | 0    | 1 | 0    |
| Read/Write    | — | — | — | — | R/W  | R/W  | — | R/W  |

SCMR is an 8-bit readable/writable register that selects the function of SCI0. SCMR is initialized to H'F2 by a reset and in the standby modes.

**Bits 7 to 4—Reserved:** These bits cannot be modified and are always read as 1.

**Bit 3—Data Transfer Direction (SDIR):** This bit selects the serial/parallel conversion format.

#### Bit 3

| SDIR | Description                                                                                       |
|------|---------------------------------------------------------------------------------------------------|
| 0    | TDR contents are transmitted LSB-first<br>Receive data is stored in RDR LSB-first (Initial value) |
| 1    | TDR contents are transmitted MSB-first<br>Receive data is stored in RDR MSB-first                 |

**Bit 2—Data Invert (SINV):** This bit specifies inversion of the data logic level. Inversion specified by the SINV bit applies only to data bits D<sub>7</sub> to D<sub>0</sub>. In order to invert the parity bit, the O/ $\overline{E}$  bit in SMR must be inverted.

#### Bit 2

| SINV | Description                                                                                            |
|------|--------------------------------------------------------------------------------------------------------|
| 0    | TDR contents are transmitted as they are<br>TDR contents are stored in RDR as they are (Initial value) |
| 1    | TDR contents are inverted before being transmitted<br>Receive data is stored in RDR in inverted form   |

**Bit 1—Reserved:** This bit cannot be modified and is always read as 1.

**Bit 0—Serial Communication Mode Select (SMIF):** This bit is reserved. A 1 must not be written to this bit.

#### Bit 0

| SMIF | Description                     |
|------|---------------------------------|
| 0    | Normal SCI mode (Initial value) |
| 1    | Reserved mode                   |

## 13.3 Operation

### 13.3.1 Overview

The SCI supports serial data transfer in two modes. In asynchronous mode each character is synchronized individually. In synchronous mode communication is synchronized with a clock signal.

The selection of asynchronous or synchronous mode and the communication format depend on SMR settings as indicated in table 13-5. The clock source depends on the settings of the C/ $\overline{A}$  bit in SMR and the CKE1 and CKE0 bits in SCR as indicated in table 13-6.

#### Asynchronous Mode

- Data length: 7 or 8 bits can be selected.
- A parity bit or multiprocessor bit can be added, and stop bit lengths of 1 or 2 bits can be selected. (These selections determine the communication format and character length.)
- Framing errors (FER), parity errors (PER), and overrun errors (ORER) can be detected in receive data, and the line-break condition can be detected.
- SCI clock source: an internal or external clock source can be selected.
  - Internal clock: The SCI is clocked by the on-chip baud rate generator and can output a clock signal at the bit-rate frequency.
  - External clock: The external clock frequency must be 16 times the bit rate. (The on-chip baud rate generator is not used.)

#### Synchronous Mode

- Communication format: The data length is 8 bits.
- Overrun errors (ORER) can be detected in receive data.
- SCI clock source: an internal or external clock source can be selected.
  - Internal clock: The SCI is clocked by the on-chip baud rate generator and outputs a serial clock signal to external devices.
  - External clock: The on-chip baud rate generator is not used. The SCI operates on the input serial clock.

**Table 13-5 Communication Formats Used by SCI**

| SMR Settings               |              |             |             |                     |                                                  | Communication Format |                        |               |                        |        |        |   |        |       |
|----------------------------|--------------|-------------|-------------|---------------------|--------------------------------------------------|----------------------|------------------------|---------------|------------------------|--------|--------|---|--------|-------|
| Bit 7<br>C/ $\overline{A}$ | Bit 6<br>CHR | Bit 2<br>MP | Bit 5<br>PE | Bit 3<br>STOP       | Mode                                             | Data<br>Length       | Multi-processor<br>Bit | Parity<br>Bit | Stop-<br>Bit<br>Length |        |        |   |        |       |
| 0                          | 0            | 0           | 0           | 0                   | Asynchronous<br>mode                             | 8 bits               | None                   | None          | 1 bit                  |        |        |   |        |       |
|                            |              |             |             | 1                   |                                                  |                      |                        |               | 2 bits                 |        |        |   |        |       |
|                            |              |             |             | 1                   |                                                  |                      |                        | 0             | Present                | 1 bit  |        |   |        |       |
|                            |              |             |             | 1                   |                                                  |                      |                        | 2 bits        |                        |        |        |   |        |       |
|                            |              | 1           | 0           | 0                   |                                                  | 7 bits               |                        | None          | 1 bit                  |        |        |   |        |       |
|                            |              |             |             | 1                   |                                                  |                      |                        |               | 2 bits                 |        |        |   |        |       |
|                            |              |             |             | 1                   |                                                  |                      |                        | 0             | Present                | 1 bit  |        |   |        |       |
|                            |              |             |             |                     |                                                  |                      |                        | 1             |                        | 2 bits |        |   |        |       |
|                            | 0            | 1           | —           | 0                   | Asynchronous<br>mode (multi-processor<br>format) | 8 bits               | Present                | None          | 1 bit                  |        |        |   |        |       |
|                            |              |             |             |                     |                                                  |                      |                        |               | 1                      | 2 bits |        |   |        |       |
|                            |              |             |             |                     |                                                  | 1                    |                        |               | 0                      | 7 bits | 1 bit  |   |        |       |
|                            |              |             |             |                     |                                                  |                      |                        |               | 1                      |        | 2 bits |   |        |       |
|                            |              |             |             |                     |                                                  |                      |                        |               | 1                      |        | —      | — | 0      | 1 bit |
|                            |              |             |             |                     |                                                  |                      |                        |               | 1                      |        |        |   | 2 bits |       |
| 1                          | —            | —           | —           | Synchronous<br>mode | 8 bits                                           | None                 | None                   |               |                        |        |        |   |        |       |

**Table 13-6 SCI Clock Source Selection**

| SMR          | SCR           |               | Serial Transmit/Receive Clock |              |                                     |
|--------------|---------------|---------------|-------------------------------|--------------|-------------------------------------|
| Bit 7<br>C/A | Bit 1<br>CKE1 | Bit 0<br>CKE0 | Mode                          | Clock Source | SCK Pin Function                    |
| 0            | 0             | 0             | Async                         | Internal     | Input/output port (not used by SCI) |
|              |               | 1             |                               |              | Serial clock output at bit rate     |
|              | 1             | 0             |                               | External     | Serial clock input at 16 × bit rate |
|              |               | 1             |                               |              |                                     |
| 1            | 0             | 0             | Sync                          | Internal     | Serial clock output                 |
|              |               | 1             |                               |              |                                     |
|              | 1             | 0             |                               | External     | Serial clock input                  |
|              |               | 1             |                               |              |                                     |

### 13.3.2 Asynchronous Mode

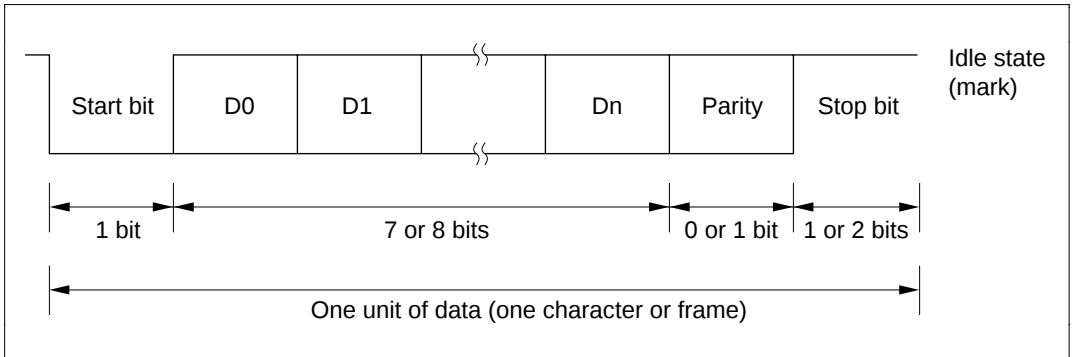
In asynchronous mode, each transmitted or received character is individually synchronized by framing it with a start bit and stop bit.

Full duplex data transfer is possible because the SCI has independent transmit and receive sections. Double buffering in both sections enables the SCI to be programmed for continuous data transfer.

Figure 13-2 shows the general format of one character sent or received in asynchronous mode. The communication channel is normally held in the mark state (high). Character transmission or reception starts with a transition to the space state (low).

The first bit transmitted or received is the start bit (low). It is followed by the data bits, in which the least significant bit (LSB) comes first. The data bits are followed by the parity or multiprocessor bit, if present, then the stop bit or bits (high) confirming the end of the frame.

In receiving, the SCI synchronizes on the falling edge of the start bit, and samples each bit at the center of the bit (at the 8th cycle of the internal serial clock, which runs at 16 times the bit rate).



**Figure 13-2 Data Format in Asynchronous Mode**  
**(Example of 8-Bit Data with Parity Bit and Two Stop Bits)**

**(1) Data Format:** Table 13-7 lists the data formats that can be sent and received in asynchronous mode. Twelve formats can be selected by bits in the serial mode register (SMR).

**Table 13-7 Data Formats in Asynchronous Mode**

| SMR Bits |    |    |      | 1 | 2          | 3 | 4 | 5 | 6 | 7 | 8 | 9    | 10   | 11   | 12   |
|----------|----|----|------|---|------------|---|---|---|---|---|---|------|------|------|------|
| CHR      | PE | MP | STOP |   |            |   |   |   |   |   |   |      |      |      |      |
| 0        | 0  | 0  | 0    | S | 8-bit data |   |   |   |   |   |   |      | STOP |      |      |
| 0        | 0  | 0  | 1    | S | 8-bit data |   |   |   |   |   |   |      | STOP | STOP |      |
| 0        | 1  | 0  | 0    | S | 8-bit data |   |   |   |   |   |   |      | P    | STOP |      |
| 0        | 1  | 0  | 1    | S | 8-bit data |   |   |   |   |   |   |      | P    | STOP | STOP |
| 1        | 0  | 0  | 0    | S | 7-bit data |   |   |   |   |   |   | STOP |      |      |      |
| 1        | 0  | 0  | 1    | S | 7-bit data |   |   |   |   |   |   | STOP | STOP |      |      |
| 1        | 1  | 0  | 0    | S | 7-bit data |   |   |   |   |   |   | P    | STOP |      |      |
| 1        | 1  | 0  | 1    | S | 7-bit data |   |   |   |   |   |   | P    | STOP | STOP |      |
| 0        | —  | 1  | 0    | S | 8-bit data |   |   |   |   |   |   |      | MPB  | STOP |      |
| 0        | —  | 1  | 1    | S | 8-bit data |   |   |   |   |   |   |      | MPB  | STOP | STOP |
| 1        | —  | 1  | 0    | S | 7-bit data |   |   |   |   |   |   | MPB  | STOP |      |      |
| 1        | —  | 1  | 1    | S | 7-bit data |   |   |   |   |   |   | MPB  | STOP | STOP |      |

Notes: SMR: Serial mode register

S: Start bit

STOP: Stop bit

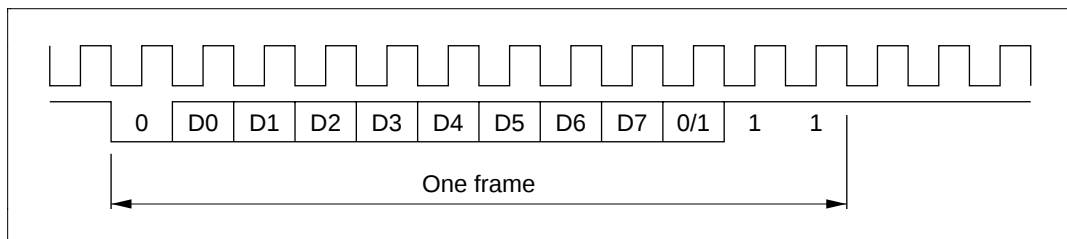
P: Parity bit

MPB: Multiprocessor bit

**(2) Clock:** In asynchronous mode it is possible to select either an internal clock created by the on-chip baud rate generator, or an external clock input at the SCK pin. The selection is made by the C/A bit in the serial mode register (SMR) and the CKE1 and CKE0 bits in the serial control register (SCR). Refer to table 13-6.

If an external clock is input at the SCK pin, its frequency should be 16 times the desired bit rate.

If the internal clock provided by the on-chip baud rate generator is selected and the SCK pin is used for clock output, the output clock frequency is equal to the bit rate, and the clock pulse rises at the center of the transmit data bits. Figure 13-3 shows the phase relationship between the output clock and transmit data.



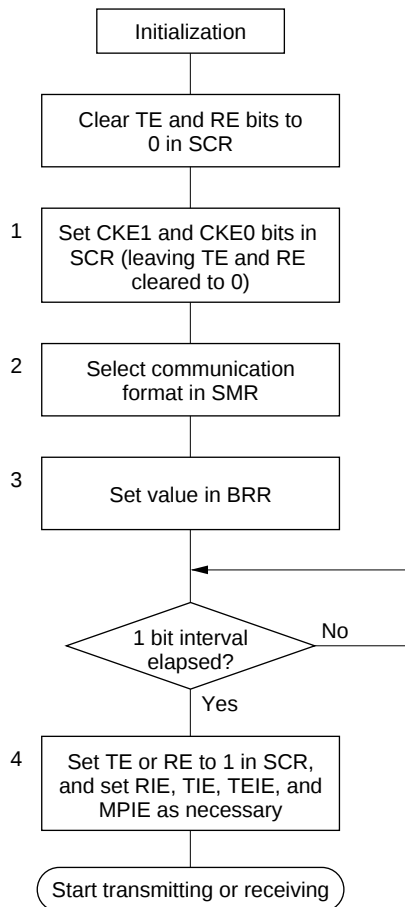
**Figure 13-3 Phase Relationship between Clock Output and Transmit Data (Asynchronous Mode)**

### (3) Transmitting and Receiving Data

**SCI Initialization:** Before transmitting or receiving, software must clear the TE and RE bits to 0 in the serial control register (SCR), then initialize the SCI following the procedure in figure 13-4.

**Note:** When changing the communication mode or format, always clear the TE and RE bits to 0 before following the procedure given below. Clearing TE to 0 sets TDRE to 1 and initializes the transmit shift register (TSR). Clearing RE to 0, however, does not initialize the RDRF, PER, FER, and ORER flags and receive data register (RDR), which retain their previous contents.

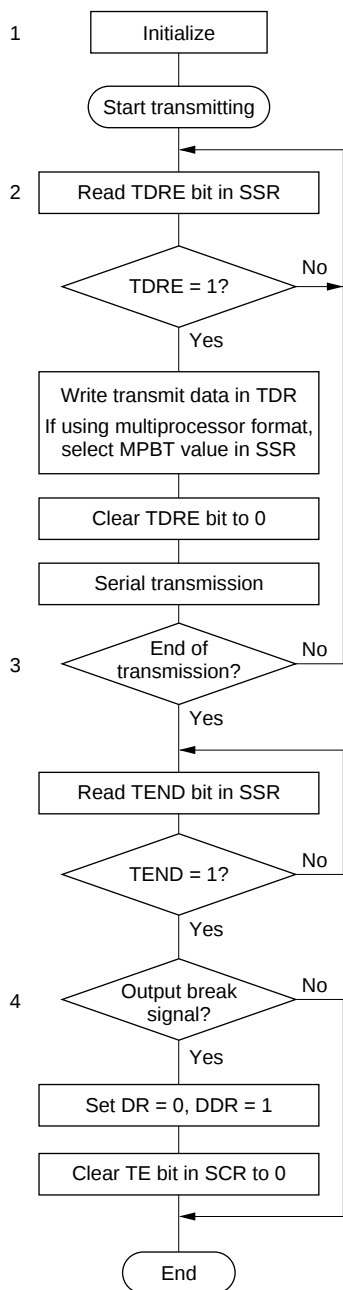
When an external clock is used, the clock should not be stopped during initialization or subsequent operation. SCI operation becomes unreliable if the clock is stopped.



1. Select the clock source in the serial control register (SCR). Leave TE and RE cleared to 0. If clock output is selected, in asynchronous mode, clock output starts immediately after the setting is made in SCR.
2. Select the communication format in the serial mode register (SMR).
3. Write the value corresponding to the bit rate in the bit rate register (BRR). This step is not necessary when an external clock is used.
4. Wait for at least the interval required to transmit or receive one bit, then set TE or RE in the serial control register (SCR). Setting TE or RE enables the SCI to use the TxD or RxD pin. Also set the RIE, TIE, TEIE, and MPIE bits as necessary to enable interrupts. The initial states are the mark transmit state, and the idle receive state (waiting for a start bit).

**Figure 13-4 Sample Flowchart for SCI Initialization**

**Transmitting Serial Data:** Follow the procedure in figure 13-5 for transmitting serial data.



1. SCI initialization: the transmit data output function of the TxD pin is selected automatically.
2. SCI status check and transmit data write: read the serial status register (SSR), check that the TDRE bit is 1, then write transmit data in the transmit data register (TDR) and clear TDRE to 0. If a multiprocessor format is selected, after writing the transmit data write 0 or 1 in the multiprocessor bit transfer (MPBT) in SSR. Transition of the TDRE bit from 0 to 1 can be reported by an interrupt.
3. (a) To continue transmitting serial data: read the TDRE bit to check whether it is safe to write; if TDRE = 1, write data in TDR, then clear TDRE to 0.  
(b) To end serial transmission: end of transmission can be confirmed by checking transition of the TEND bit from 0 to 1. This can be reported by a TEI interrupt.
4. To output a break signal at the end of serial transmission: set the DDR bit to 1 and clear the DR bit to 0 (DDR and DR are I/O port registers), then clear TE to 0 in SCR.

**Figure 13-5 Sample Flowchart for Transmitting Serial Data**

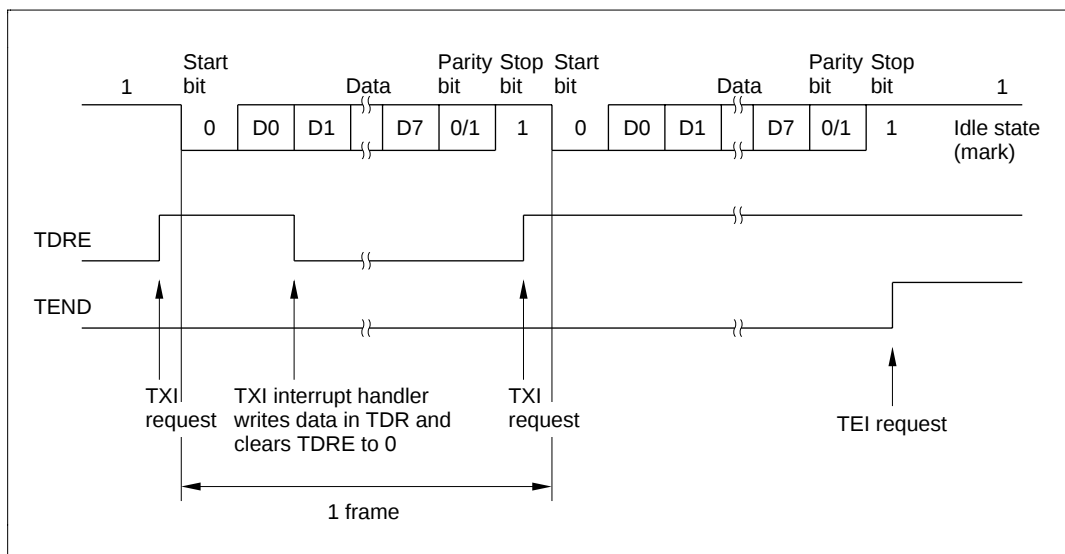
In transmitting serial data, the SCI operates as follows.

1. The SCI monitors the TDRE bit in SSR. When TDRE is cleared to 0 the SCI recognizes that the transmit data register (TDR) contains new data, and loads this data from TDR into the transmit shift register (TSR).
2. After loading the data from TDR into TSR, the SCI sets the TDRE bit to 1 and starts transmitting. If the TIE bit (TDR-empty interrupt enable) is set to 1 in SCR, the SCI requests a TXI interrupt (TDR-empty interrupt) at this time.

Serial transmit data is transmitted in the following order from the TxD pin:

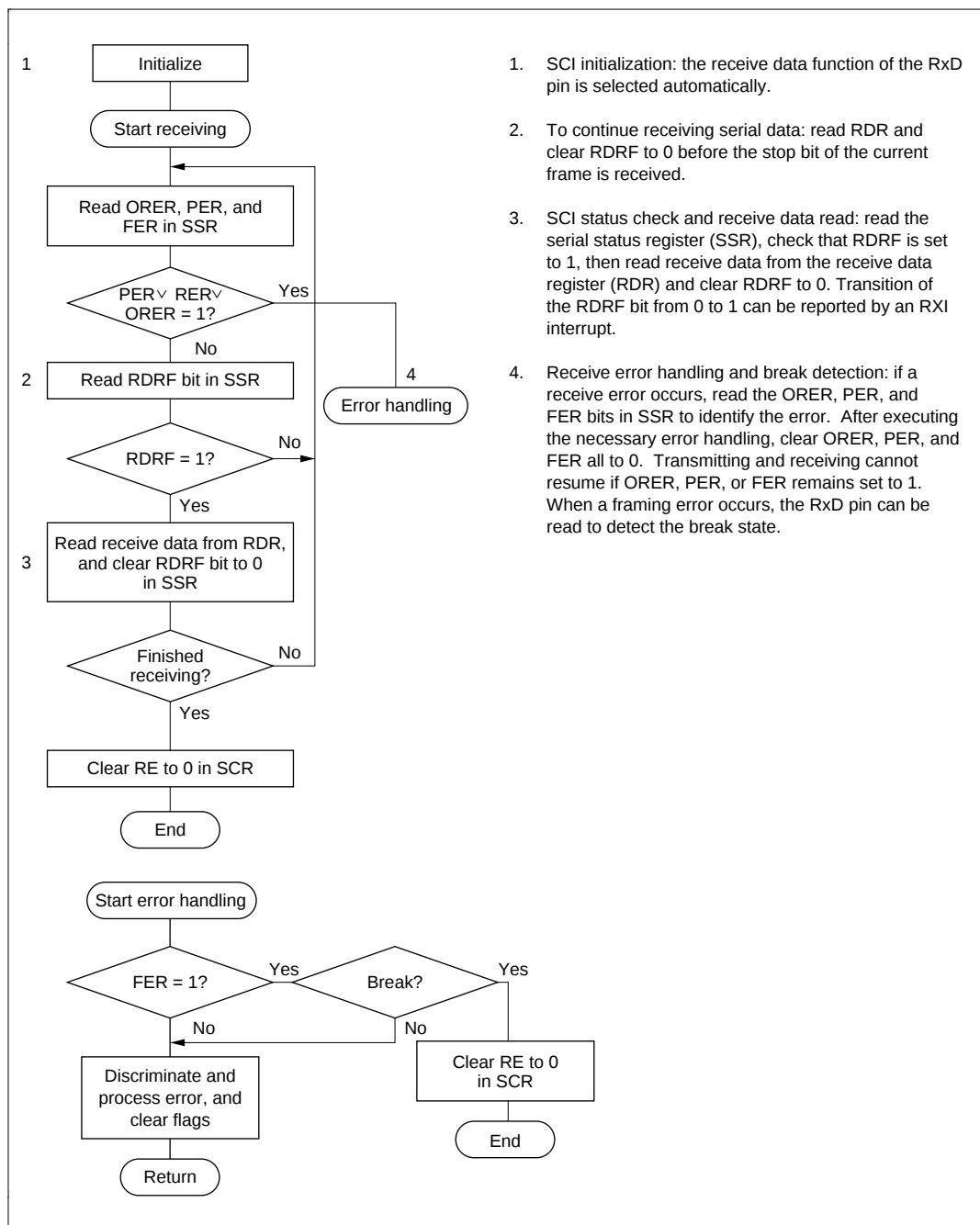
- a. Start bit: One 0 bit is output.
  - b. Transmit data: Seven or eight bits are output, LSB-first.
  - c. Parity bit or multiprocessor bit: One parity bit (even or odd parity) or one multiprocessor bit is output. Formats in which neither a parity bit nor a multiprocessor bit is output can also be selected.
  - d. Stop bit: One or two 1 bits (stop bits) are output.
  - e. Mark state: Output of 1 bits continues until the start bit of the next transmit data.
3. The SCI checks the TDRE bit when it outputs the stop bit. If TDRE is 0, after loading new data from TDR into TSR and transmitting the stop bit, the SCI begins serial transmission of the next frame. If TDRE is 1, after setting the TEND bit to 1 in SSR and transmitting the stop bit, the SCI continues 1-level output in the mark state, and if the TEIE bit (TSR-empty interrupt enable) in SCR is set to 1, the SCI generates a TEI interrupt request (TSR-empty interrupt).

Figure 13-6 shows an example of SCI transmit operation in asynchronous mode.



**Figure 13-6 Example of SCI Transmit Operation (8-Bit Data with Parity and One Stop Bit)**

**Receiving Serial Data:** Follow the procedure in figure 13-7 for receiving serial data.



**Figure 13-7 Sample Flowchart for Receiving Serial Data**

In receiving, the SCI operates as follows.

1. The SCI monitors the receive data line and synchronizes internally when it detects a start bit.
2. Receive data is shifted into RSR in order from LSB to MSB.
3. The parity bit and stop bit are received.

After receiving these bits, the SCI makes the following checks:

- a. Parity check: The number of 1s in the receive data must match the even or odd parity setting of the  $O/\bar{E}$  bit in SMR.
- b. Stop bit check: The stop bit value must be 1. If there are two stop bits, only the first stop bit is checked.
- c. Status check: RDRF must be 0 so that receive data can be loaded from RSR into RDR.

If these checks all pass, the SCI sets RDRF to 1 and stores the received data in RDR. If one of the checks fails (receive error), the SCI operates as indicated in table 13-8.

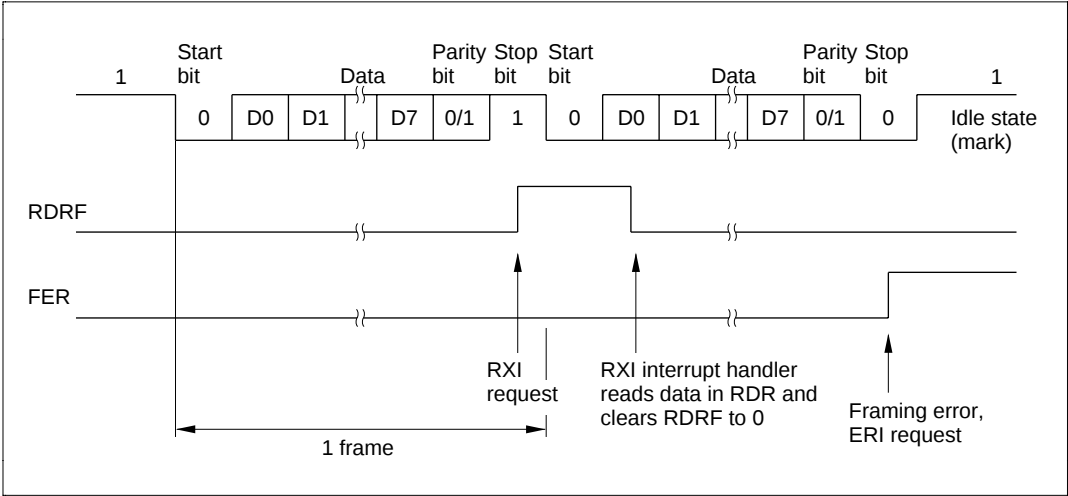
Note: When a receive error flag is set, further receiving is disabled. The RDRF bit is not set to 1. Be sure to clear the error flags.

4. After setting RDRF to 1, if the RIE bit (receive-end interrupt enable) is set to 1 in SCR, the SCI requests an RXI (receive-end) interrupt. If one of the error flags (ORER, PER, or FER) is set to 1 and the RIE bit in SCR is also set to 1, the SCI requests an ERI (receive-error) interrupt.

Figure 13-8 shows an example of SCI receive operation in asynchronous mode.

**Table 13-8    Receive Error Conditions and SCI Operation**

| Receive error | Abbreviation | Condition                                                          | Data Transfer                             |
|---------------|--------------|--------------------------------------------------------------------|-------------------------------------------|
| Overrun error | ORER         | Receiving of next data ends while RDRF is still set to 1 in SSR    | Receive data not loaded from RSR into RDR |
| Framing error | FER          | Stop bit is 0                                                      | Receive data loaded from RSR into RDR     |
| Parity error  | PER          | Parity of receive data differs from even/odd parity setting in SMR | Receive data loaded from RSR into RDR     |



**Figure 13-8    Example of SCI Receive Operation (8-Bit Data with Parity and One Stop Bit)**

#### **(4) Multiprocessor Communication**

The multiprocessor communication function enables several processors to share a single serial communication line. The processors communicate in asynchronous mode using a format with an additional multiprocessor bit (multiprocessor format).

In multiprocessor communication, each receiving processor is addressed by an ID.

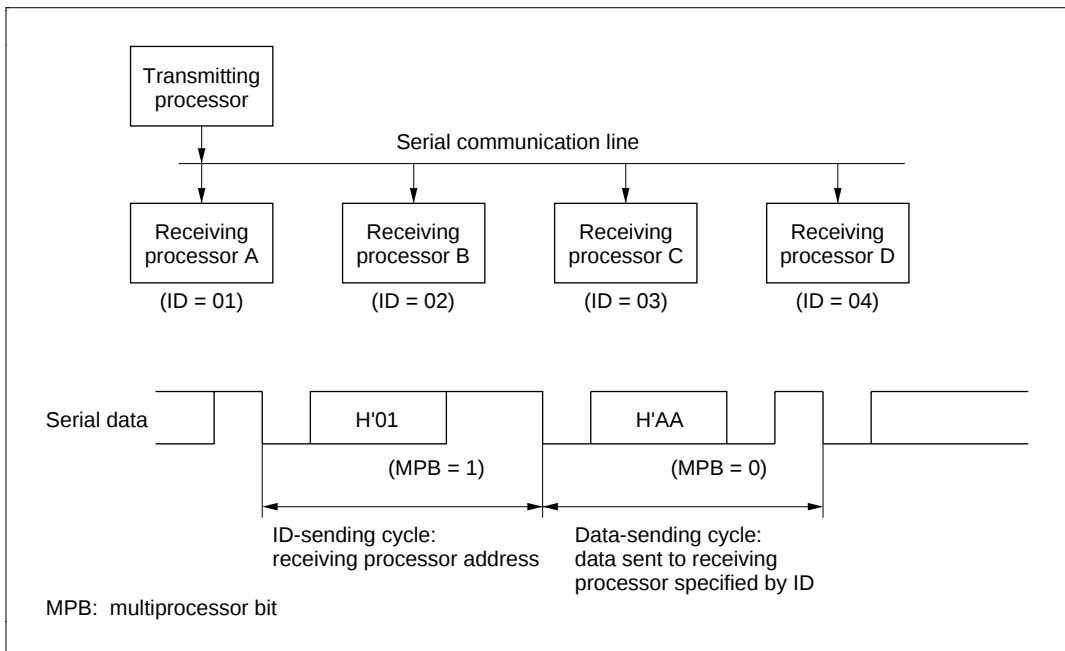
A serial communication cycle consists of two cycles: an ID-sending cycle that identifies the receiving processor, and a data-sending cycle. The multiprocessor bit distinguishes ID-sending cycles from data-sending cycles.

The transmitting processor starts by sending the ID of the receiving processor with which it wants to communicate as data with the multiprocessor bit set to 1. Next the transmitting processor sends transmit data with the multiprocessor bit cleared to 0.

Receiving processors skip incoming data until they receive data with the multiprocessor bit set to 1.

After receiving data with the multiprocessor bit set to 1, the receiving processor with an ID matching the received data continues to receive further incoming data. Multiple processors can send and receive data in this way.

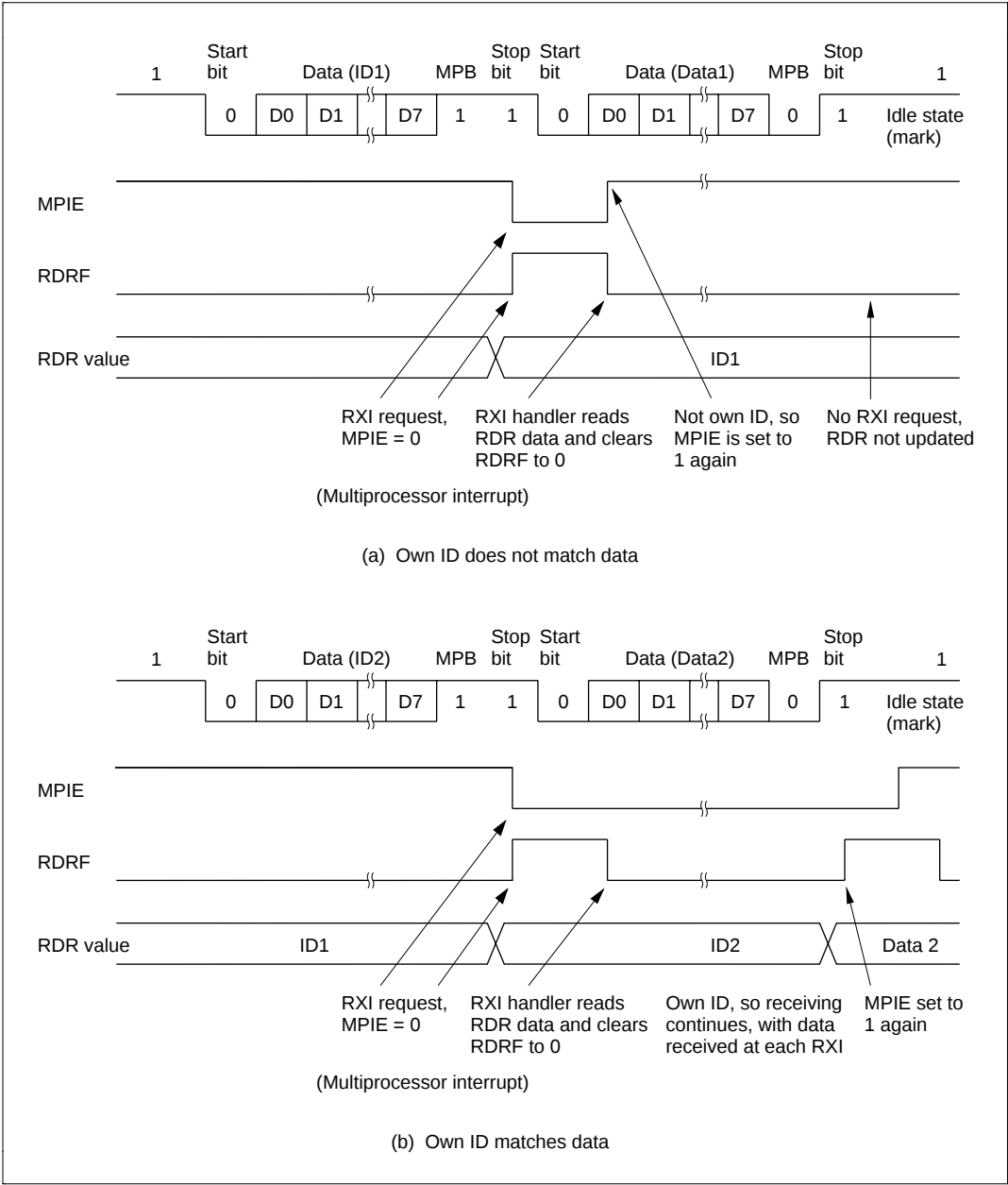
Four formats are available. Parity-bit settings are ignored when a multiprocessor format is selected. For details see table 13-7.



**Figure 13-9 Example of Communication among Processors using Multiprocessor Format (Sending Data H'AA to Receiving Processor A)**



Figure 13-11 shows an example of an SCI receive operation using a multiprocessor format (8-bit data with multiprocessor bit and one stop bit).



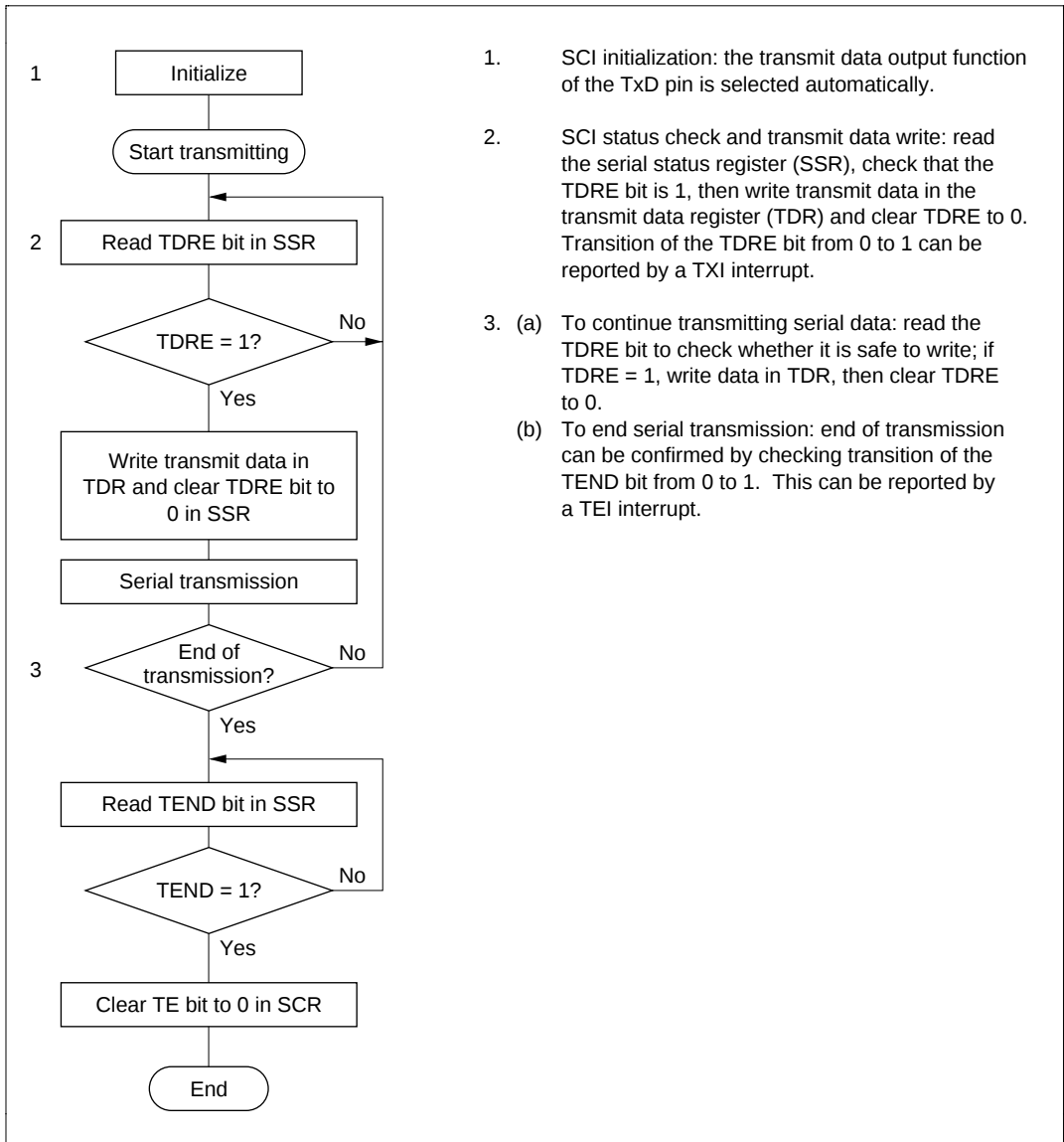
**Figure 13-11 Example of SCI Receive Operation  
(8-Bit Data with Multiprocessor Bit and One Stop Bit)**



## (2) Transmitting and Receiving Data

**SCI Initialization:** The SCI must be initialized in the same way as in asynchronous mode. See figure 13-4. When switching from asynchronous mode to synchronous mode, check that the ORER, FER, and PER bits are cleared to 0. Transmitting and receiving cannot begin if ORER, FER, or PER is set to 1.

**Transmitting Serial Data:** Follow the procedure in figure 13-13 for transmitting serial data.



**Figure 13-13 Sample Flowchart for Serial Transmitting**

In transmitting serial data, the SCI operates as follows.

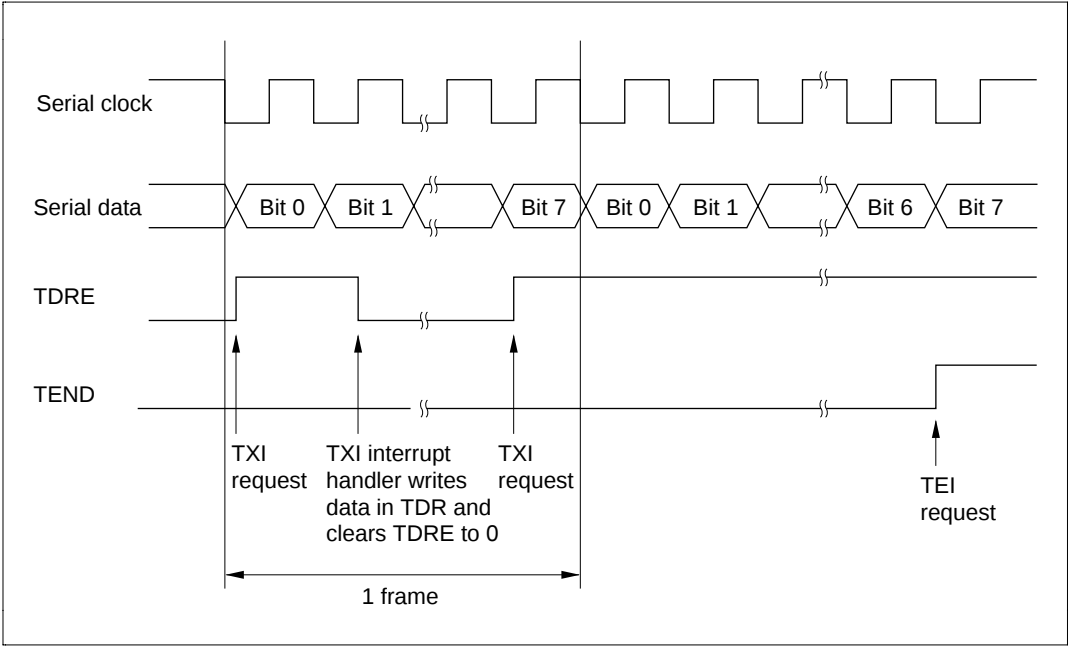
1. The SCI monitors the TDRE bit in SSR. When TDRE is cleared to 0 the SCI recognizes that the transmit data register (TDR) contains new data, and loads this data from TDR into the transmit shift register (TSR).
2. After loading the data from TDR into TSR, the SCI sets the TDRE bit to 1 and starts transmitting. If the TIE bit (TDR-empty interrupt enable) in SCR is set to 1, the SCI requests a TXI interrupt (TDR-empty interrupt) at this time.

If clock output is selected the SCI outputs eight serial clock pulses, triggered by the clearing of the TDRE bit to 0. If an external clock source is selected, the SCI outputs data in synchronization with the input clock.

Data is output from the TxD pin in order from LSB (bit 0) to MSB (bit 7).

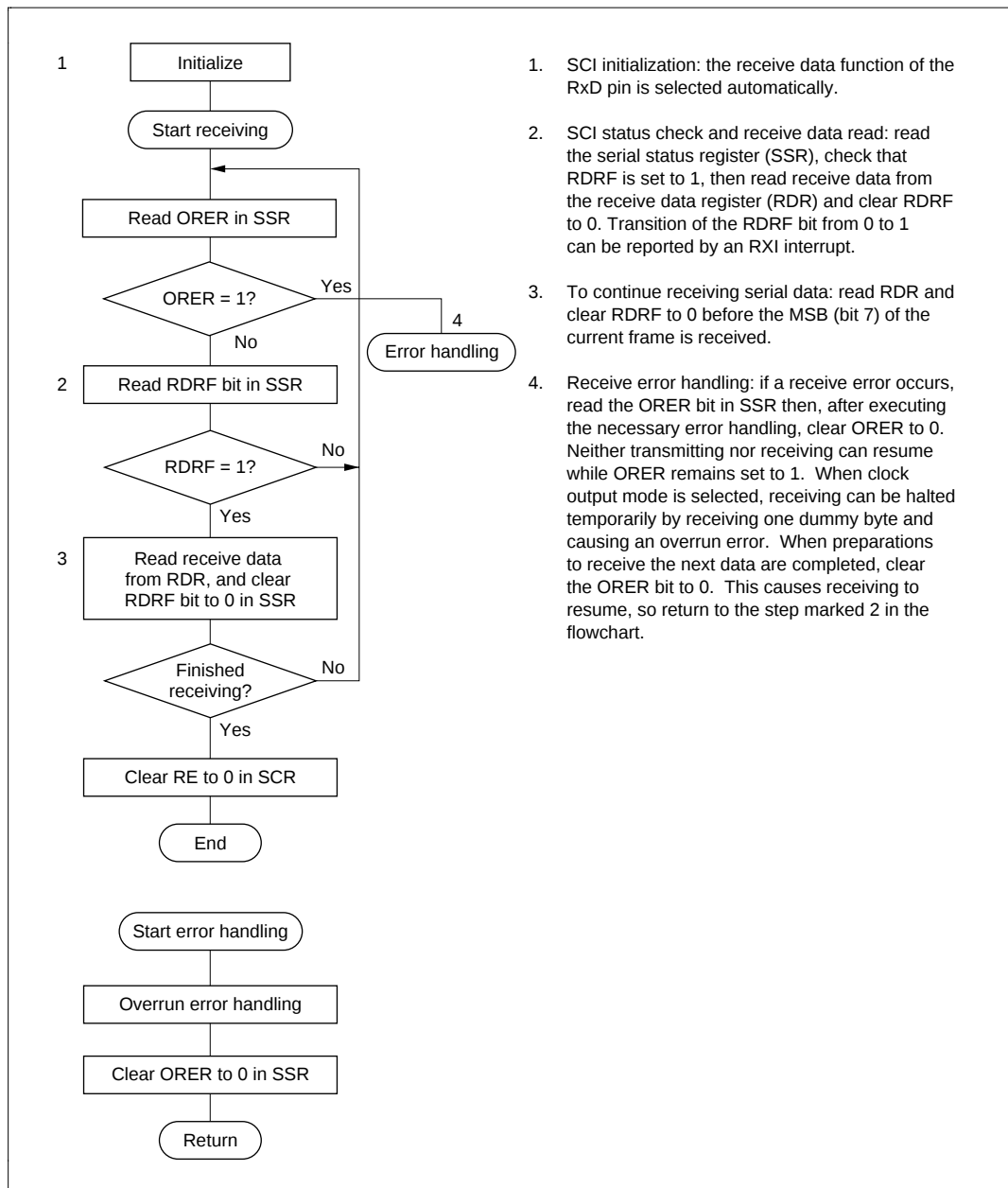
3. The SCI checks the TDRE bit when it outputs the MSB (bit 7). If TDRE is 0, the SCI loads data from TDR into TSR, then begins serial transmission of the next frame. If TDRE is 1, the SCI sets the TEND bit in SSR to 1, transmits the MSB, then holds the output in the MSB state. If the TEIE bit (transmit-end interrupt enable) in SCR is set to 1, a TEI interrupt (TSR-empty interrupt) is requested at this time.
4. After the end of serial transmission, the SCK pin is held at the high level.

Figure 13-14 shows an example of SCI transmit operation.



**Figure 13-14 Example of SCI Transmit Operation**

**Receiving Serial Data:** Follow the procedure in figure 13-15 for receiving serial data. When switching from asynchronous mode to synchronous mode, be sure to check that PER and FER are cleared to 0. If PER or FER is set to 1 the RDRF bit will not be set and both transmitting and receiving will be disabled.



**Figure 13-15 Sample Flowchart for Serial Receiving**

In receiving, the SCI operates as follows.

1. If an external clock is selected, data is input in synchronization with the input clock. If clock output is selected, as soon as the RE bit is set to 1 the SCI begins outputting the serial clock and inputting data. If clock output is stopped because the ORER bit is set to 1, output of the serial clock and input of data resume as soon as the ORER bit is cleared to 0.
2. Receive data is shifted into RSR in order from LSB to MSB.

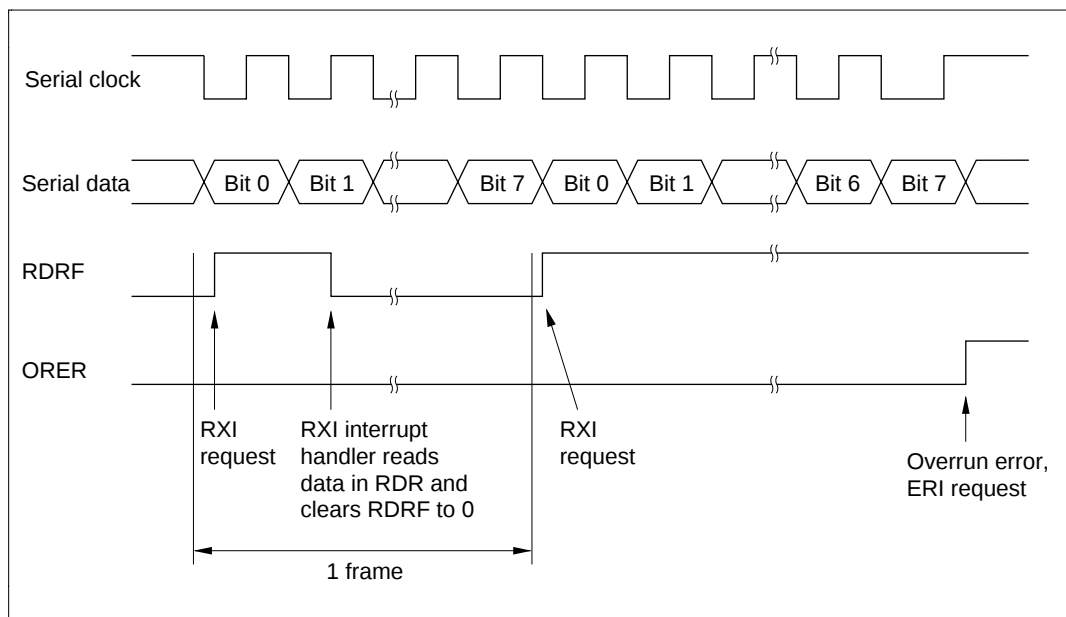
After receiving the data, the SCI checks that RDRF is 0 so that receive data can be loaded from RSR into RDR. If this check passes, the SCI sets RDRF to 1 and stores the received data in RDR. If the check does not pass (receive error), the SCI operates as indicated in table 13-8.

Note: Both transmitting and receiving are disabled while a receive error flag is set. The RDRF bit is not set to 1. Be sure to clear the error flag.

3. After setting RDRF to 1, if the RIE bit (receive-end interrupt enable) is set to 1 in SCR, the SCI requests an RXI (receive-end) interrupt. If the ORER bit is set to 1 and the RIE bit in SCR is set to 1, the SCI requests an ERI (receive-error) interrupt.

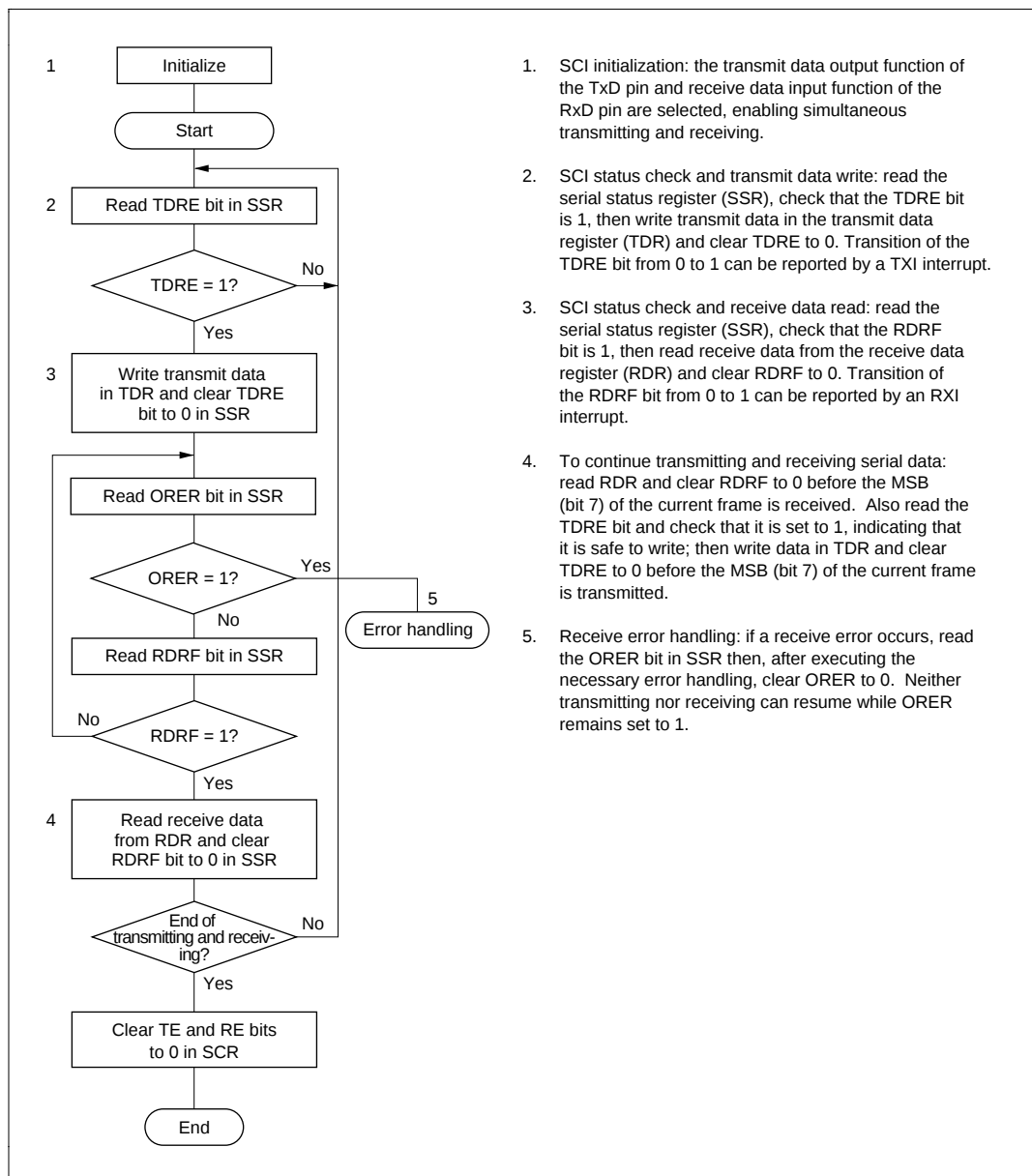
When clock output mode is selected, clock output stops when the RE bit is cleared to 0 or the ORER bit is set to 1. To prevent clock count errors, it is safest to receive one dummy byte and generate an overrun error.

Figure 13-16 shows an example of SCI receive operation.



**Figure 13-16 Example of SCI Receive Operation**

**Transmitting and Receiving Serial Data Simultaneously:** Follow the procedure in figure 13-17 for transmitting and receiving serial data simultaneously. If clock output mode is selected, output of the serial clock begins simultaneously with serial transmission.



**Figure 13-17 Sample Flowchart for Serial Transmitting and Receiving**

**Note:** In switching from transmitting or receiving to simultaneous transmitting and receiving, clear both TE and RE to 0, then set both TE and RE to 1.

## 13.4 Interrupts

The SCI can request four types of interrupts: ERI, RXI, TXI, and TEI. Table 13-9 indicates the source and priority of these interrupts. The interrupt sources can be enabled or disabled by the TIE, RIE, and TEIE bits in the SCR. Independent signals are sent to the interrupt controller for each interrupt source, except that the receive-error interrupt (ERI) is the logical OR of three sources: overrun error, framing error, and parity error.

The TXI interrupt indicates that the next transmit data can be written. The TEI interrupt indicates that the SCI has stopped transmitting data.

**Table 13-9** SCI Interrupt Sources

| Interrupt | Description                                 | Priority                                                                          |
|-----------|---------------------------------------------|-----------------------------------------------------------------------------------|
| ERI       | Receive-error interrupt (ORER, FER, or PER) | High                                                                              |
| RXI       | Receive-end interrupt (RDRF)                |  |
| TXI       | TDR-empty interrupt (TDRE)                  |                                                                                   |
| TEI       | TSR-empty interrupt (TEND)                  |                                                                                   |
|           |                                             | Low                                                                               |

## 13.5 Application Notes

Application programmers should note the following features of the SCI.

**(1) TDR Write:** The TDRE bit in SSR is simply a flag that indicates that the TDR contents have been transferred to TSR. The TDR contents can be rewritten regardless of the TDRE value. If a new byte is written in TDR while the TDRE bit is 0, before the old TDR contents have been moved into TSR, the old byte will be lost. Software should check that the TDRE bit is set to 1 before writing to TDR.

**(2) Multiple Receive Errors:** Table 13-10 lists the values of flag bits in SSR when multiple receive errors occur, and indicates whether the RSR contents are transferred to RDR.

**Table 13-10 SSR Bit States and Data Transfer when Multiple Receive Errors Occur**

| Receive error                          | SSR Bits |      |     |     | RSR →<br>RDR*2 |
|----------------------------------------|----------|------|-----|-----|----------------|
|                                        | RDRF     | ORER | FER | PER |                |
| Overrun error                          | 1*1      | 1    | 0   | 0   | No             |
| Framing error                          | 0        | 0    | 1   | 0   | Yes            |
| Parity error                           | 0        | 0    | 0   | 1   | Yes            |
| Overrun and framing errors             | 1*1      | 1    | 1   | 0   | No             |
| Overrun and parity errors              | 1*1      | 1    | 0   | 1   | No             |
| Framing and parity errors              | 0        | 0    | 1   | 1   | Yes            |
| Overrun, framing, and parity errors1*1 |          | 1    | 1   | 1   | No             |

Notes: 1. Set to 1 before the overrun error occurs.

2. Yes: The RSR contents are transferred to RDR.

No: The RSR contents are not transferred to RDR.

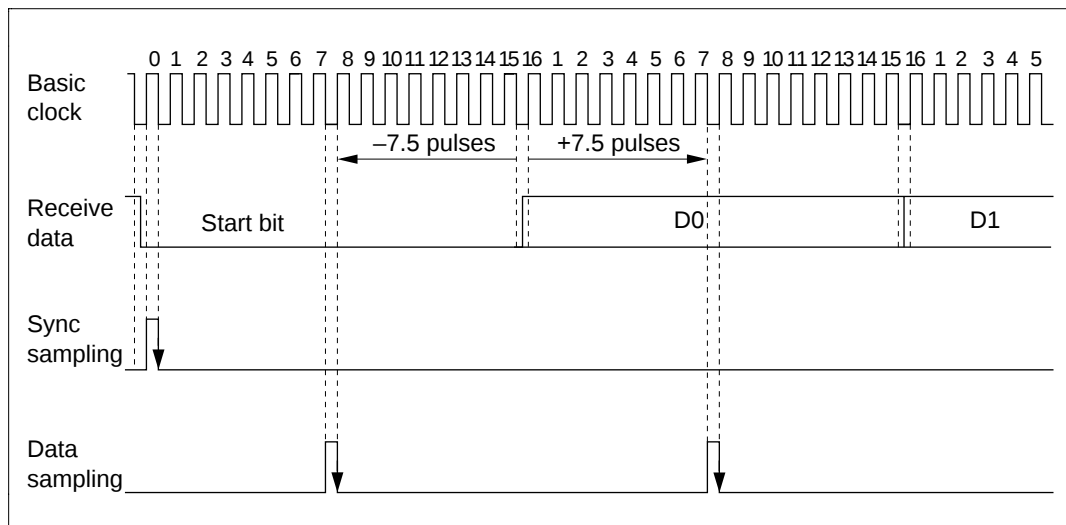
**(3) Line Break Detection:** When the RxD pin receives a continuous stream of 0's in asynchronous mode (line-break state), a framing error occurs because the SCI detects a 0 stop bit. The value H'00 is transferred from RSR to RDR. Software can detect the line-break state as a framing error accompanied by H'00 data in RDR.

The SCI continues to receive data, so if the FER bit is cleared to 0 another framing error will occur.

**(4) Sampling Timing and Receive Margin in Asynchronous Mode:** The serial clock used by the SCI in asynchronous mode runs at 16 times the bit rate. The falling edge of the start bit is detected by sampling the RxD input on the falling edge of this clock. After the start bit is detected, each bit of receive data in the frame (including the start bit, parity bit, and stop bit or bits) is sampled on the rising edge of the serial clock pulse at the center of the bit. See figure 13-18.

It follows that the receive margin can be calculated as in equation (1).

When the absolute frequency deviation of the clock signal is 0 and the clock duty cycle is 0.5, data can theoretically be received with distortion up to the margin given by equation (2). This is a theoretical limit, however. In practice, system designers should allow a margin of 20% to 30%.



**Figure 13-18 Sampling Timing (Asynchronous Mode)**

$$M = \{(0.5 - 1/2N) - (D - 0.5)/N - (L - 0.5)F\} \times 100 [\%] \quad (1)$$

M: Receive margin

N: Ratio of basic clock to bit rate (N=16)

D: Duty factor of clock—ratio of high pulse width to low width (0.5 to 1.0)

L: Frame length (9 to 12)

F: Absolute clock frequency deviation

When D = 0.5 and F = 0

$$M = (0.5 - 1/2 \times 16) \times 100 [\%] = 46.875\% \quad (2)$$

## Section 14 I<sup>2</sup>C Bus Interface [Option]

[One channel incorporated in the H8/3202, and two channels in all other models]

Note that the H8/3202 does not have a channel 1 (IIC1).

An I<sup>2</sup>C bus interface is available as an option. Observe the following notes when using this option.

1. Please inform your Hitachi sales representative if you intend to use this option.
2. For mask-ROM versions, a W is added to the part number in products in which this optional function is used.

Examples: HD6433217WF16, HD6433212WP12

3. The product number is identical for ZTAT version. However, be sure to inform your Hitachi sales representative if you will be using this option.

### 14.1 Overview

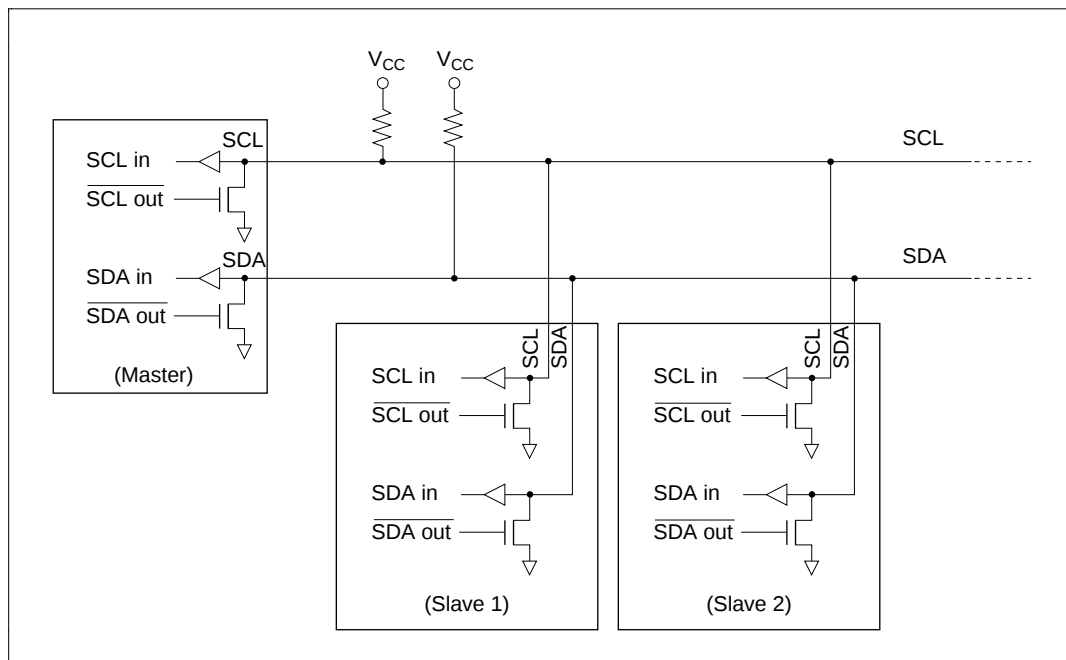
The I<sup>2</sup>C bus interface conforms to and provides a subset of the Philips I<sup>2</sup>C bus (inter-IC bus) interface functions. The register configuration that controls the I<sup>2</sup>C bus differs partly from the Philips configuration, however.

Each I<sup>2</sup>C bus interface channel uses only one data line (SDA) and one clock line (SCL) to transfer data, saving board and connector space. Figure 14-1 shows typical I<sup>2</sup>C bus interface connections.

#### 14.1.1 Features

- Conforms to Philips I<sup>2</sup>C bus interface
- Start and stop conditions generated automatically
- Selectable acknowledge output level when receiving
- Auto-loading of acknowledge bit when transmitting
- Selection of eight internal clocks (in master mode)
- Selection of acknowledgement mode, or serial mode without acknowledge bit
- Wait function: A wait can be inserted in acknowledgement mode by holding the SCL pin low after a data transfer, before acknowledgement of the transfer.

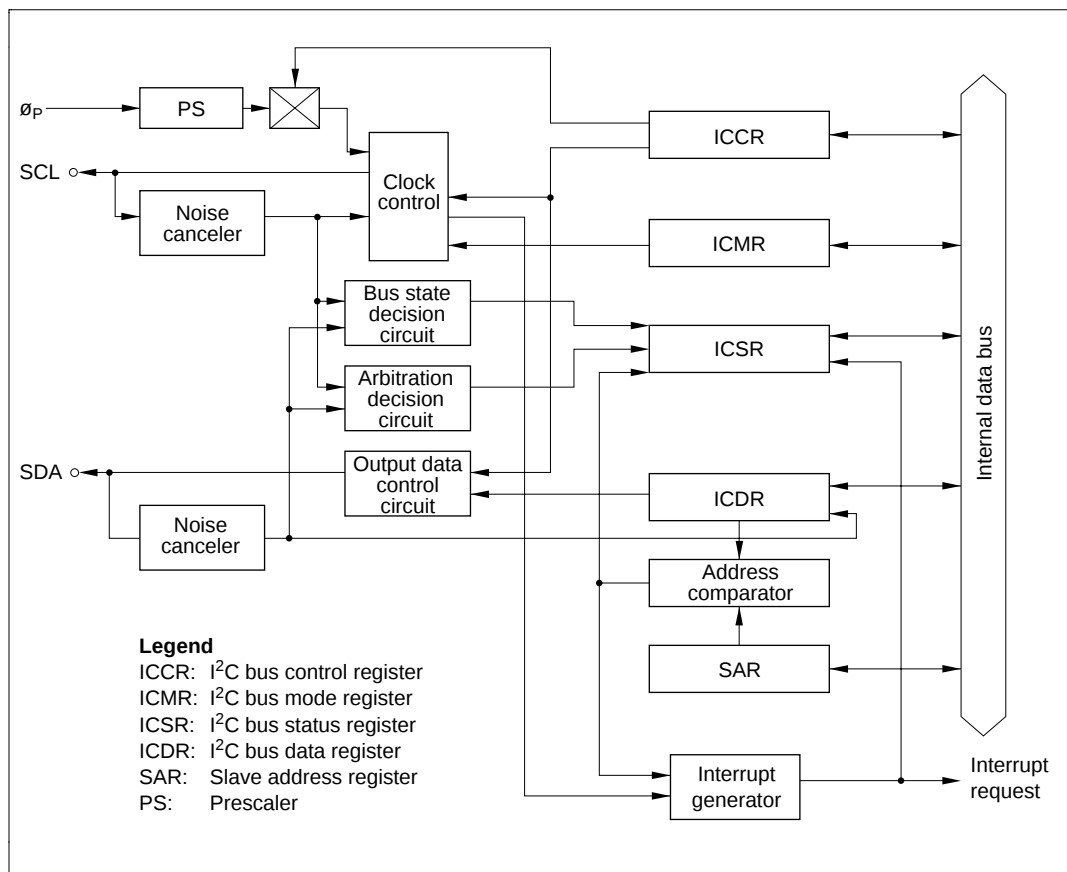
- Three interrupt sources
  - Data transfer end
  - In slave receive mode: slave address matched, or general call address received
  - In master transmit mode: bus arbitration lost
- Direct bus drive (with pins SCL and SDA)
- Four pins—P7<sub>0</sub>/SCL<sub>0</sub>, P7<sub>1</sub>/SDA<sub>0</sub>, P7<sub>2</sub>/SCL<sub>1</sub>, and P7<sub>3</sub>/SDA<sub>1</sub>—function as NMOS-only outputs when the bus drive function is selected.



**Figure 14-1 I<sup>2</sup>C Bus Interface Connections (Example: H8/3217 Series Chip as Master)**

### 14.1.2 Block Diagram

Figure 14-2 shows a block diagram of the I<sup>2</sup>C bus interface.



**Figure 14-2 Block Diagram of I<sup>2</sup>C Bus Interface**

### 14.1.3 Input/Output Pins

Table 14-1 summarizes the input/output pins used by the I<sup>2</sup>C bus interface.

**Table 14-1 I<sup>2</sup>C Bus Interface Pins**

| Channel | Name         | Abbreviation     | I/O          | Function                       |
|---------|--------------|------------------|--------------|--------------------------------|
| 0       | Serial clock | SCL <sub>0</sub> | Input/output | IIC0 Serial clock input/output |
|         | Serial data  | SDA <sub>0</sub> | Input/output | IIC0 Serial data input/output  |
| 1       | Serial clock | SCL <sub>1</sub> | Input/output | IIC1 Serial clock input/output |
|         | Serial data  | SDA <sub>1</sub> | Input/output | IIC1 Serial data input/output  |

Note: In this manual, the channel subscript has been deleted, and only SCL and SDA are used.

### 14.1.4 Register Configuration

Table 14-2 summarizes the registers of the I<sup>2</sup>C bus interface.

**Table 14-2 Register Configuration**

| Channel | Name                                  | Abbreviation | R/W | Initial Value | Address |
|---------|---------------------------------------|--------------|-----|---------------|---------|
| 0       | I <sup>2</sup> C bus control register | ICCR         | R/W | H'00          | H'FFA0  |
|         | I <sup>2</sup> C bus status register  | ICSR         | R/W | H'30          | H'FFA1  |
|         | I <sup>2</sup> C bus data register    | ICDR         | R/W | —             | H'FFA2  |
|         | I <sup>2</sup> C bus mode register    | ICMR         | R/W | H'38          | H'FFA3* |
|         | Slave address register                | SAR          | R/W | H'00          | H'FFA3* |
| 1       | I <sup>2</sup> C bus control register | ICCR         | R/W | H'00          | H'FFA4  |
|         | I <sup>2</sup> C bus status register  | ICSR         | R/W | H'30          | H'FFA5  |
|         | I <sup>2</sup> C bus data register    | ICDR         | R/W | —             | H'FFA6  |
|         | I <sup>2</sup> C bus mode register    | ICMR         | R/W | H'38          | H'FFA7* |
|         | Slave address register                | SAR          | R/W | H'00          | H'FFA7* |
| —       | Serial/timer control register         | STCR         | R/W | H'00          | H'FFC3  |

Note: \* The register that can be written or read depends on the ICE bit in the I<sup>2</sup>C bus control register. The slave address register can be accessed when ICE = 0. The I<sup>2</sup>C bus mode register can be accessed when ICE = 1.

## 14.2 Register Descriptions

### 14.2.1 I<sup>2</sup>C Bus Data Register (ICDR)

| Bit           | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|               | ICDR7 | ICDR6 | ICDR5 | ICDR4 | ICDR3 | ICDR2 | ICDR1 | ICDR0 |
| Initial value | —     | —     | —     | —     | —     | —     | —     | —     |
| Read/Write    | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

ICDR is an 8-bit readable/writable register that is used as a transmit data register when transmitting and a receive data register when receiving. Transmitting is started by writing data in ICDR. Receiving is started by reading data from ICDR.

ICDR is also used as a shift register, so it must not be written or read until data has been completely transmitted or received. Read or write access while data is being transmitted or received may result in incorrect data.

The value in ICDR following a reset is undetermined.

### 14.2.2 Slave Address Register (SAR)

| Bit           | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0   |
|---------------|------|------|------|------|------|------|------|-----|
|               | SVA6 | SVA5 | SVA4 | SVA3 | SVA2 | SVA1 | SVA0 | FS  |
| Initial value | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0   |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W |

SAR is an 8-bit readable/writable register that stores the slave address and selects the communication format. When the chip is in slave mode (and the addressing format is selected), if the upper 7 bits of SAR match the upper 7 bits of the first byte received after a start condition, the chip operates as the slave device specified by the master device. SAR is assigned to the same address as ICMR. SAR can be written and read only when the ICE bit is cleared to 0 in ICCR.

SAR is initialized to H'00 by a reset.

**Bits 7 to 1—Slave Address (SVA6 to SVA0):** Set a unique address in bits SVA6 to SVA0, differing from the addresses of other slave devices connected to the I<sup>2</sup>C bus.

**Bit 0—Format Select (FS):** Selects whether to use the addressing format or non-addressing format in slave mode. The addressing format is used to recognize slave addresses.

**Bit 0**

| FS | Description                                                   |
|----|---------------------------------------------------------------|
| 0  | Addressing format, slave addresses recognized (Initial value) |
| 1  | Non-addressing format                                         |

### 14.2.3 I<sup>2</sup>C Bus Mode Register (ICMR)

| Bit           | 7   | 6    | 5 | 4 | 3 | 2   | 1   | 0   |
|---------------|-----|------|---|---|---|-----|-----|-----|
|               | MLS | WAIT | — | — | — | BC2 | BC1 | BC0 |
| Initial value | 0   | 0    | 1 | 1 | 1 | 0   | 0   | 0   |
| Read/Write    | R/W | R/W  | — | — | — | R/W | R/W | R/W |

ICMR is an 8-bit readable/writable register that selects whether the MSB or LSB is transferred first, performs wait control, and selects the transfer bit count. ICMR is assigned to the same address as SAR. ICMR can be written and read only when the ICE bit is set to 1 in ICCR.

ICMR is initialized to H'38 by a reset.

**Bit 7—MSB-First/LSB-First Select (MLS):** Selects whether data is transferred MSB-first or LSB-first.

**Bit 7**

| MLS | Description               |
|-----|---------------------------|
| 0   | MSB-first (Initial value) |
| 1   | LSB-first                 |

**Bit 6—Wait Insertion Bit (WAIT):** Selects whether to insert a wait between the transfer of data and the acknowledge bit, in acknowledgement mode. When WAIT is set to 1, after the fall of the clock for the final data bit, a wait state begins (with SCL staying at the low level). When bit IRIC is cleared in ICSR, the wait ends and the acknowledge bit is transferred. If WAIT is cleared to 0, data and acknowledge bits are transferred consecutively with no wait inserted.

**Bit 6**

| WAIT | Description                                                    |
|------|----------------------------------------------------------------|
| 0    | Data and acknowledge transferred consecutively (Initial value) |
| 1    | Wait inserted between data and acknowledge                     |

**Bits 5 to 3—Reserved:** These bits cannot be modified and are always read as 1.

**Bits 2 to 0—Bit Counter (BC2 to BC0):** BC2 to BC0 specify the number of bits to be transferred next. When the ACK bit is cleared to 0 in ICCR (acknowledgement mode), the data is transferred with one additional acknowledge bit. BC2 to BC0 settings should be made during an interval between transfer frames. If BC2 to BC0 are set to a value other than 000, the setting should be made while the SCL line is low.

The bit counter is initialized to 000 by a reset and when a start condition is detected. The value returns to 000 at the end of a data transfer, including the acknowledge.

| Bit 2<br>BC2 | Bit 1<br>BC1 | Bit 0<br>BC0 | Bits/Frame  |                      |
|--------------|--------------|--------------|-------------|----------------------|
|              |              |              | Serial Mode | Acknowledgement Mode |
| 0            | 0            | 0            | 8           | 9 (Initial value)    |
|              |              | 1            | 1           | 2                    |
|              | 1            | 0            | 2           | 3                    |
|              |              | 1            | 3           | 4                    |
| 1            | 0            | 0            | 4           | 5                    |
|              |              | 1            | 5           | 6                    |
|              | 1            | 0            | 6           | 7                    |
|              |              | 1            | 7           | 8                    |

### 14.2.4 I<sup>2</sup>C Bus Control Register (ICCR)

| Bit           | 7   | 6    | 5   | 4   | 3   | 2    | 1    | 0    |
|---------------|-----|------|-----|-----|-----|------|------|------|
|               | ICE | IEIC | MST | TRS | ACK | CKS2 | CKS1 | CKS0 |
| Initial value | 0   | 0    | 0   | 0   | 0   | 0    | 0    | 0    |
| Read/Write    | R/W | R/W  | R/W | R/W | R/W | R/W  | R/W  | R/W  |

ICCR is an 8-bit readable/writable register that enables or disables the I<sup>2</sup>C bus interface, enables or disables interrupts, and selects master or slave mode, transmit or receive, acknowledgement or serial mode, and the clock frequency.

ICCR is initialized to H'00 by a reset.

**Bit 7—I<sup>2</sup>C Bus Interface Enable (ICE):** Selects whether or not to use the I<sup>2</sup>C bus interface. When ICE is set to 1, the SCL and SDA signals are assigned to input/output pins and transfer operations are enabled. When ICE is cleared to 0, SCL and SDA are placed in the high-impedance state and the interface module is disabled.

The SAR register can be accessed when ICE is 0. The ICMR register can be accessed when ICE is 1.

#### Bit 7

| ICE | Description                                                                                  |
|-----|----------------------------------------------------------------------------------------------|
| 0   | Interface module disabled, with SCL and SDA signal pins set to port function (Initial value) |
| 1   | Interface module enabled for transfer operations (pins SCL and SCA are driving the bus)      |

**Bit 6—I<sup>2</sup>C Bus Interface Interrupt Enable (IEIC):** Enables or disables interrupts from the I<sup>2</sup>C bus interface to the CPU.

#### Bit 6

| IEIC | Description                         |
|------|-------------------------------------|
| 0    | Interrupts disabled (Initial value) |
| 1    | Interrupts enabled                  |

### Bit 5—Master/Slave Select (MST)

### Bit 4—Transmit/Receive Select (TRS)

MST selects whether the I<sup>2</sup>C bus interface operates in master mode or slave mode.

TRS selects whether the I<sup>2</sup>C bus interface operates in transmit mode or receive mode.

In master mode, when arbitration is lost, MST and TRS are both reset by hardware, causing a transition to slave receive mode. In slave receive mode with the addressing format (FS = 0), hardware automatically selects transmit or receive mode according to the R/W bit in the first byte after a start condition.

MST and TRS select the operating mode as follows.

| Bit 5<br>MST | Bit 4<br>TRS | Operating Mode                     |
|--------------|--------------|------------------------------------|
| 0            | 0            | Slave receive mode (Initial value) |
|              | 1            | Slave transmit mode                |
| 1            | 0            | Master receive mode                |
|              | 1            | Master transmit mode               |

**Bit 3—Acknowledgement Mode Select (ACK):** Selects acknowledgement mode or serial mode.

In acknowledgement mode (ACK = 0), data is transferred in frames consisting of the number of data bits selected by BC2 to BC0 in ICMR, plus an extra acknowledge bit. In serial mode (ACK = 1), the number of data bits selected by BC2 to BC0 in ICMR is transferred as one frame.

| Bit 3<br>ACK | Description                          |
|--------------|--------------------------------------|
| 0            | Acknowledgement mode (Initial value) |
| 1            | Serial mode                          |

**Bits 2 to 0—Serial Clock Select (CKS2 to CKS0):** These bits, together with the IICX0 or IICX1 bit in the STCR register, select the serial clock frequency in master mode. They should be set according to the required transfer rate.

| (STCR)<br>IICX | Bit 2<br>CKS2 | Bit 1<br>CKS1 | Bit 0<br>CKS0 | Clock               | Transfer Rate*             |                            |                            |                             |                             |
|----------------|---------------|---------------|---------------|---------------------|----------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|
|                |               |               |               |                     | $\varnothing_P =$<br>4 MHz | $\varnothing_P =$<br>5 MHz | $\varnothing_P =$<br>8 MHz | $\varnothing_P =$<br>10 MHz | $\varnothing_P =$<br>16 MHz |
| 0              | 0             | 0             | 0             | $\varnothing_P/28$  | 143 kHz                    | 179 kHz                    | 286 kHz                    | 357 kHz                     | 571 kHz                     |
|                | 0             | 0             | 1             | $\varnothing_P/40$  | 100 kHz                    | 125 kHz                    | 200 kHz                    | 250 kHz                     | 400 kHz                     |
|                | 0             | 1             | 0             | $\varnothing_P/48$  | 83.3 kHz                   | 104 kHz                    | 167 kHz                    | 208 kHz                     | 333 kHz                     |
|                | 0             | 1             | 1             | $\varnothing_P/64$  | 62.5 kHz                   | 78.1 kHz                   | 125 kHz                    | 156 kHz                     | 250 kHz                     |
|                | 1             | 0             | 0             | $\varnothing_P/80$  | 50.0 kHz                   | 62.5 kHz                   | 100 kHz                    | 125 kHz                     | 200 kHz                     |
|                | 1             | 0             | 1             | $\varnothing_P/100$ | 40.0 kHz                   | 50.0 kHz                   | 80.0 kHz                   | 100 kHz                     | 160 kHz                     |
|                | 1             | 1             | 0             | $\varnothing_P/112$ | 35.7 kHz                   | 44.6 kHz                   | 71.4 kHz                   | 89.3 kHz                    | 143 kHz                     |
|                | 1             | 1             | 1             | $\varnothing_P/128$ | 31.3 kHz                   | 39.1 kHz                   | 62.5 kHz                   | 78.1 kHz                    | 125 kHz                     |
| 1              | 0             | 0             | 0             | $\varnothing_P/56$  | 71.4 kHz                   | 89.3 kHz                   | 143 kHz                    | 179 kHz                     | 286 kHz                     |
|                | 0             | 0             | 1             | $\varnothing_P/80$  | 50.0 kHz                   | 62.5 kHz                   | 100 kHz                    | 125 kHz                     | 200 kHz                     |
|                | 0             | 1             | 0             | $\varnothing_P/96$  | 41.7 kHz                   | 52.1 kHz                   | 83.3 kHz                   | 104 kHz                     | 167 kHz                     |
|                | 0             | 1             | 1             | $\varnothing_P/128$ | 31.3 kHz                   | 39.1 kHz                   | 62.5 kHz                   | 78.1 kHz                    | 125 kHz                     |
|                | 1             | 0             | 0             | $\varnothing_P/160$ | 25.0 kHz                   | 31.3 kHz                   | 50.0 kHz                   | 62.5 kHz                    | 100 kHz                     |
|                | 1             | 0             | 1             | $\varnothing_P/200$ | 20.0 kHz                   | 25.0 kHz                   | 40.0 kHz                   | 50.0 kHz                    | 80.0 kHz                    |
|                | 1             | 1             | 0             | $\varnothing_P/224$ | 17.9 kHz                   | 22.3 kHz                   | 35.7 kHz                   | 44.6 kHz                    | 71.4 kHz                    |
|                | 1             | 1             | 1             | $\varnothing_P/256$ | 15.6 kHz                   | 19.5 kHz                   | 31.3 kHz                   | 39.1 kHz                    | 62.5 kHz                    |

Note: \*  $\varnothing_P = \varnothing$ .

### 14.2.5 I<sup>2</sup>C Bus Status Register (ICSR)

| Bit           | 7    | 6      | 5   | 4 | 3      | 2      | 1      | 0    |
|---------------|------|--------|-----|---|--------|--------|--------|------|
|               | BBSY | IRIC   | SCP | — | AL     | AAS    | ADZ    | ACKB |
| Initial value | 0    | 0      | 1   | 1 | 0      | 0      | 0      | 0    |
| Read/Write    | R/W  | R/(W)* | W   | — | R/(W)* | R/(W)* | R/(W)* | R/W  |

Note: \* Software can write a 0 in these bits to clear the flags, but cannot write a 1.

ICSR is an 8-bit readable/writable register with flags that indicate the status of the I<sup>2</sup>C bus interface. It is also used for issuing start and stop conditions, and recognizing and controlling acknowledge data.

ICSR is initialized to H'30 by a reset.

**Bit 7—Bus Busy (BBSY):** This bit can be read to check whether the I<sup>2</sup>C bus (SCL and SDA) is busy or free. In master mode this bit is also used in issuing start and stop conditions.

A high-to-low transition of SDA while SCL is high is recognized as a start condition, setting BBSY to 1. A low-to-high transition of SDA while SCL is high is recognized as a stop condition, clearing BBSY to 0.

To issue a start condition, use a MOV instruction to write 1 in BBSY and 0 in SCP. A retransmit start condition is issued in the same way. To issue a stop condition, use a MOV instruction to write 0 in BBSY and 0 in SCP. It is not possible to write to BBSY in slave mode.

#### Bit 7

| BBSY | Description                                                                                |
|------|--------------------------------------------------------------------------------------------|
| 0    | Bus is free<br>This bit is cleared to 0 when a stop condition is detected. (Initial value) |
| 1    | Bus is busy<br>This bit is set to 1 when a start condition is detected.                    |

**Bit 6—I<sup>2</sup>C Bus Interface Interrupt Request Flag (IRIC):** Indicates that the I<sup>2</sup>C bus interface has issued an interrupt request to the CPU. IRIC is set to 1 at the end of a data transfer, when a slave address or general call address is detected in slave receive mode, and when bus arbitration is lost in master transmit mode. IRIC is set at different timings depending on the ACK bit in ICCR and the WAIT bit in ICMR. See the item on IRIC Set Timing and SCL Control in section 14.3.6.

IRIC is cleared by reading IRIC after it has been set to 1, then writing 0 in IRIC.

| Bit 6<br>IRIC | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0             | Waiting for transfer, or transfer in progress (Initial value)<br>To clear this bit, the CPU must read IRIC when IRIC = 1, then write 0 in IRIC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 1             | Interrupt requested<br>This bit is set to 1 at the following times:<br>Master mode <ul style="list-style-type: none"> <li>• End of data transfer</li> <li>• When bus arbitration is lost</li> </ul> Slave mode (when FS = 0) <ul style="list-style-type: none"> <li>• When the slave address is matched, and whenever a data transfer ends after that, until a retransmit start condition or a stop condition is detected</li> <li>• When a general call address is detected, and whenever a data transfer ends after that, until a retransmit start condition or a stop condition is detected</li> </ul> Slave mode (when FS = 1) <ul style="list-style-type: none"> <li>• End of data transfer</li> </ul> |

**Bit 5—Start Condition/Stop Condition Prohibit (SCP):** Controls the issuing of start and stop conditions in master mode. To issue a start condition, write 1 in BBSY and 0 in SCP. A start condition for retransmit is issued in the same way. To issue a stop condition, write 0 in BBSY and 0 in SCP. This bit always reads 1. Written data is not stored.

| Bit 5<br>SCP | Description                                                          |
|--------------|----------------------------------------------------------------------|
| 0            | Writing 0 issues a start or stop condition, in combination with BBSY |
| 1            | Reading always results in 1 (Initial value)<br>Writing is ignored    |

**Bit 4—Reserved:** This bit cannot be modified and is always read as 1.

**Bit 3—Arbitration Lost (AL):** This flag indicates that arbitration was lost in master mode. The I<sup>2</sup>C bus interface monitors the bus. When two or more master devices attempt to seize the bus at nearly the same time, if the I<sup>2</sup>C bus interface detects data differing from the data it sent, it sets AL to 1 to indicate that the bus has been taken by another master. At the same time, it sets the IRIC bit in ICSR to generate an interrupt request.

AL is cleared by reading AL after it has been set to 1, then writing 0 in AL. In addition, AL is reset automatically by write access to ICDR in transmit mode, or read access to ICDR in receive mode.

#### Bit 3

| AL | Description                                                                                                                                                                                                                                                                                        |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0  | Bus arbitration won (Initial value)<br>This bit is cleared to 0 at the following times: <ul style="list-style-type: none"> <li>• When ICDR data is written (transmit mode) or read (receive mode)</li> <li>• When AL is read while AL = 1, then 0 is written in AL</li> </ul>                      |
| 1  | Arbitration lost<br>This bit is set to 1 at the following times: <ul style="list-style-type: none"> <li>• If the internal SDA signal and bus line disagree at the rise of SCL in master transmit mode</li> <li>• If the internal SCL is high at the fall of SCL in master transmit mode</li> </ul> |

**Bit 2—Slave Address Recognition Flag (AAS):** When the addressing format is selected (FS = 0) in slave receive mode, this flag is set to 1 if the first byte following a start condition matches bits SVA6 to SVA0 in SAR, or if the general call address (H'00) is detected.

AAS is cleared by reading AAS after it has been set to 1, then writing 0 in AAS. In addition, AAS is reset automatically by write access to ICDR in transmit mode, or read access to ICDR in receive mode.

#### Bit 2

| AAS | Description                                                                                                                                                                                                                                                                                                       |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | Slave address or general call address not recognized (Initial value)<br>This bit is cleared to 0 at the following times: <ul style="list-style-type: none"> <li>• When ICDR data is written (transmit mode) or read (receive mode)</li> <li>• When AAS is read while AAS = 1, then 0 is written in AAS</li> </ul> |
| 1   | Slave address or general call address recognized<br>This bit is set to 1 at the following times: <ul style="list-style-type: none"> <li>• When the slave address or general call address is detected in slave receive mode</li> </ul>                                                                             |

**Bit 1—General Call Address Recognition Flag (ADZ):** When the addressing format is selected (FS = 0) in slave receive mode, this flag is set to 1 if the first byte following a start condition is the general call address (H'00).

ADZ is cleared by reading ADZ after it has been set to 1, then writing 0 in ADZ. In addition, ADZ is reset automatically by write access to ICDR in transmit mode, or read access to ICDR in receive mode.

**Bit 1**

| ADZ | Description                                                                                                                                                                                                                                                                                      |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | General call address not recognized (Initial value)<br>This bit is cleared to 0 at the following times: <ul style="list-style-type: none"> <li>• When ICDR data is written (transmit mode) or read (receive mode)</li> <li>• When ADZ is read while ADZ = 1, then 0 is written in ADZ</li> </ul> |
| 1   | General call address recognized<br>This bit is set to 1 when the general call address is detected in slave receive mode                                                                                                                                                                          |

**Bit 0—Acknowledge Bit (ACKB):** Stores acknowledge data in acknowledgement mode. In transmit mode, after the receiving device receives data, it returns acknowledge data, and this data is loaded into ACKB. In receive mode, after data has been received, the acknowledge data set in this bit is sent to the transmitting device.

When this bit is read, if TRS = 1, the value loaded from the bus line is read. If TRS = 0, the value set by internal software is read.

**Bit 0**

| ACKB | Description                                                                                                                                            |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0    | Receive mode: 0 is output at acknowledge output timing (Initial value)<br>Transmit mode: Indicates that the receiving device has acknowledged the data |
| 1    | Receive mode: 1 is output at acknowledge output timing<br>Transmit mode: Indicates that the receiving device has not acknowledged the data             |

## 14.2.6 Serial/Timer Control Register (STCR)

| Bit           | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|------|-------|-------|-------|-------|-------|-------|-------|
|               | IICS | IICX1 | IICX0 | SYNCE | PWCKE | PWCKS | ICKS1 | ICKS0 |
| Initial value | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Read/Write    | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

STCR is an 8-bit readable/writable register that controls the I<sup>2</sup>C interface operating mode and selects the TCNT clock source in the PWM timer module and the 8-bit timers. STCR is initialized to H'00 by a reset.

**Bit 7—I<sup>2</sup>C Extra Buffer Select (IICS):** This bit designates bits 3 and 2 of port 7 as the same kind of output buffer as bits SCL and SDA. This bit is used when implementing the I<sup>2</sup>C interface by software.

### Bit 7

| IICS | Description                                                                  |
|------|------------------------------------------------------------------------------|
| 0    | P7 <sub>3</sub> and P7 <sub>2</sub> are normal I/O pins (Initial value)      |
| 1    | P7 <sub>3</sub> and P7 <sub>2</sub> are I/O pins with bus driving capability |

**Bit 6—I<sup>2</sup>C Transfer Select 1 (IICX1):** This bit, together with bits CKS2 to CKS0 in IICR of IIC1, selects the transfer rate in master mode. For details, see section 14.2.4, I<sup>2</sup>C Bus Control Register.

**Bit 5—I<sup>2</sup>C Transfer Select 0 (IICX0):** This bit, together with bits CKS2 to CKS0 in IICR of IIC0, selects the transfer rate in master mode. For details, see section 14.2.4, I<sup>2</sup>C Bus Control Register.

**Bit 4—Timer Connection Output Enable (SYNCE):** This bit controls the outputs (VSYNCO, HSYNCO, CLAMPO) when the timers are interconnected. For details, see section 11, Timer Connection.

**Bits 3 and 2—PWM Timer Control (PWCKE, PWCKS):** These bits control the internal clock to be input to the timer counter (TCNT) in the PWM timer module. For details, see section 8, PWM Timers.

**Bits 1 and 0—Internal Clock Source Select 1 and 0 (ICKS1, ICKS0):** These bits select the clock input to the timer counters (TCNT) in the 8-bit timers. For details, see section 10, 8-Bit Timers.

# 14.3 Operation

## 14.3.1 I<sup>2</sup>C Bus Data Format

The I<sup>2</sup>C bus interface has three data formats: two addressing formats, shown as (a) and (b) in figure 14-3, and a non-addressing format, shown as (c) in figure 14-4. The first byte following a start condition always consists of 8 bits. Figure 14-5 shows the I<sup>2</sup>C bus timing.

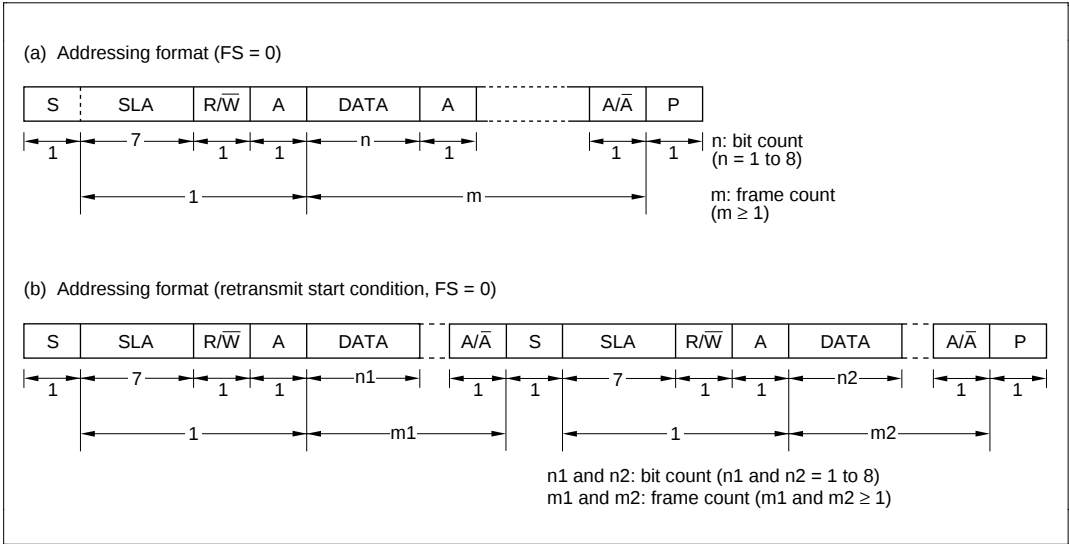
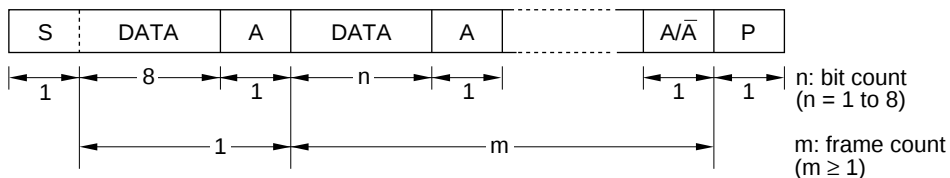


Figure 14-3 I<sup>2</sup>C Bus Data Formats (Addressing Formats)

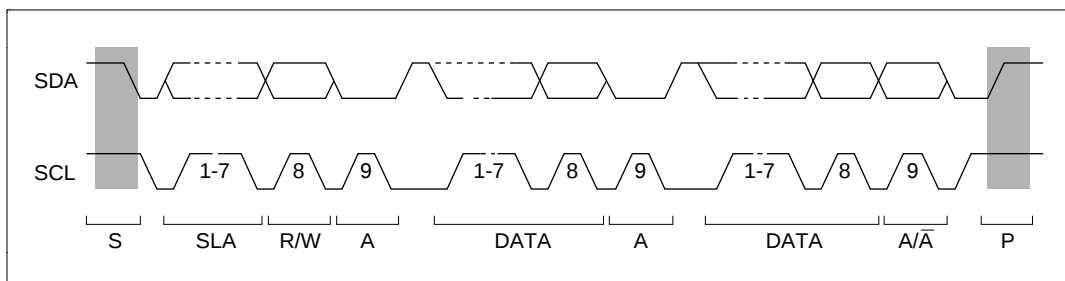
(c) Non-addressing format (FS = 1)



**Legend**

- S: Start condition. The master device drives SDA from high to low while SCL is high.
- SLA: Slave address, by which the master device selects a slave device.
- R/W: Indicates the direction of data transfer: from the slave device to the master device when R/W is 1, or from the master device to the slave device when R/W is 0.
- A: Acknowledge. The receiving device (the slave in master transmit mode, or the master in master receive mode) drives SDA low to acknowledge a transfer. If transfers need not be acknowledged, set the ACK bit to 1 in ICCR to keep the interface from generating the acknowledge signal and its clock pulse.
- DATA: Transferred data. The bit length is set by bits BC2 to BC0 in ICMR. The MSB-first or LSB-first format is selected by bit MLS in ICMR.
- P: Stop condition. The master device drives SDA from low to high while SCL is high.

**Figure 14-4 I<sup>2</sup>C Bus Data Format (Non-Addressing Format)**



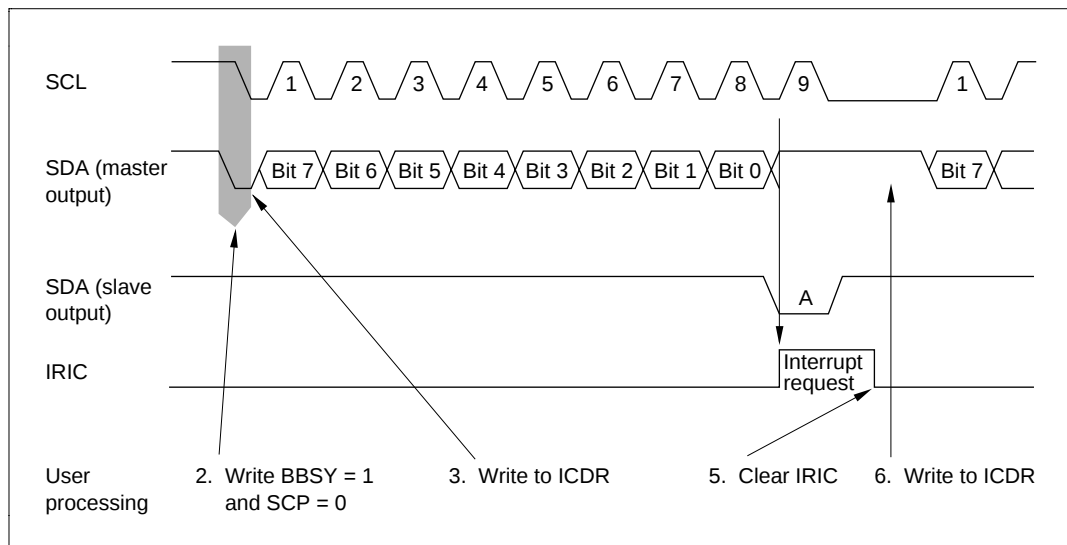
**Figure 14-5 I<sup>2</sup>C Bus Timing**

### 14.3.2 Master Transmit Operation

In master transmit mode, the master device outputs the transmit clock and transmit data, and the slave device returns an acknowledge signal. The transmit procedure and operations in master transmit mode are described below.

1. Set bits MLS and WAIT in ICMR and bits ACK and CKS2 to CKS0 in ICCR according to the operating mode. Set bit ICE in ICCR to 1.
2. Read BBSY in ICSR, check that the bus is free, then set MST and TRS to 1 in ICCR to select master transmit mode. After that, write 1 in BBSY and 0 in SCP. This generates a start condition by causing a high-to-low transition of SDA while SCL is high.
3. Write data in ICDR. The master device outputs the written data together with a sequence of transmit clock pulses at the timing shown in figure 14-6. If FS is 0 in SAR, the first byte following the start condition contains a 7-bit slave address and indicates the transmit/receive direction. The selected slave device (the device with the matching slave address) drives SDA low at the ninth transmit clock pulse to acknowledge the data.
4. When one byte of data has been transmitted, IRIC is set to 1 in ICSR at the rise of the ninth transmit clock pulse. If IEIC is set to 1 in ICCR, a CPU interrupt is requested. After one frame has been transferred, SCL is automatically brought to the low level in synchronization with the internal clock and held low.
5. Software clears IRIC to 0 in ICSR.
6. To continue transmitting, write the next transmit data in ICDR. Transmission of the next byte will begin in synchronization with the internal clock.

Steps 4 to 6 can be repeated to transmit data continuously. To end the transmission, write 0 in BBSY and 0 in SCP in ICSR. This generates a stop condition by causing a low-to-high transition of SDA while SCL is high.



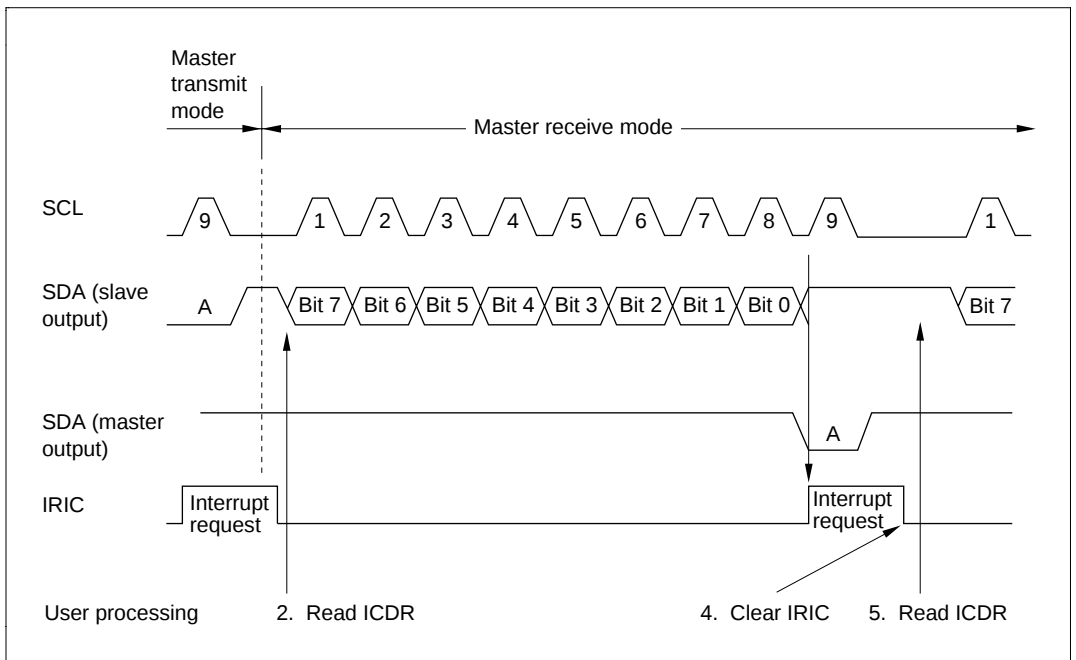
**Figure 14-6 Timing in Master Transmit Mode**  
(MLS = WAIT = ACK = 0)

### 14.3.3 Master Receive Operation

In master receive mode, the master device outputs the receive clock, receives data, and returns an acknowledge signal. The slave device transmits the data. The receive procedure and operations in master receive mode are described below. See also figure 14-7.

1. Clear TRS to 0 in ICCR to switch from transmit mode to receive mode.
2. Read ICDR to start receiving. When ICDR is read, a receive clock is output in synchronization with the internal clock, and data is received. At the ninth clock pulse the master device drives SDA low to acknowledge the data.
3. When one byte of data has been received, IRIC is set to 1 in ICSR at the rise of the ninth receive clock pulse. If IEIC is set to 1 in ICCR, a CPU interrupt is requested. After one frame has been transferred, SCL is automatically brought to the low level in synchronization with the internal clock and held low.
4. Software clears IRIC to 0 in ICSR.
6. When ICDR is read, receiving of the next data starts in synchronization with the internal clock.

Steps 3 to 5 can be repeated to receive data continuously. To stop receiving, set TRS to 1, read ICDR, then write 0 in BBSY and 0 in SCP in ICSR. This generates a stop condition by causing a low-to-high transition of SDA while SCL is high. If it is not necessary to acknowledge each byte of data, set ACKB to 1 in ICSR before receiving starts.



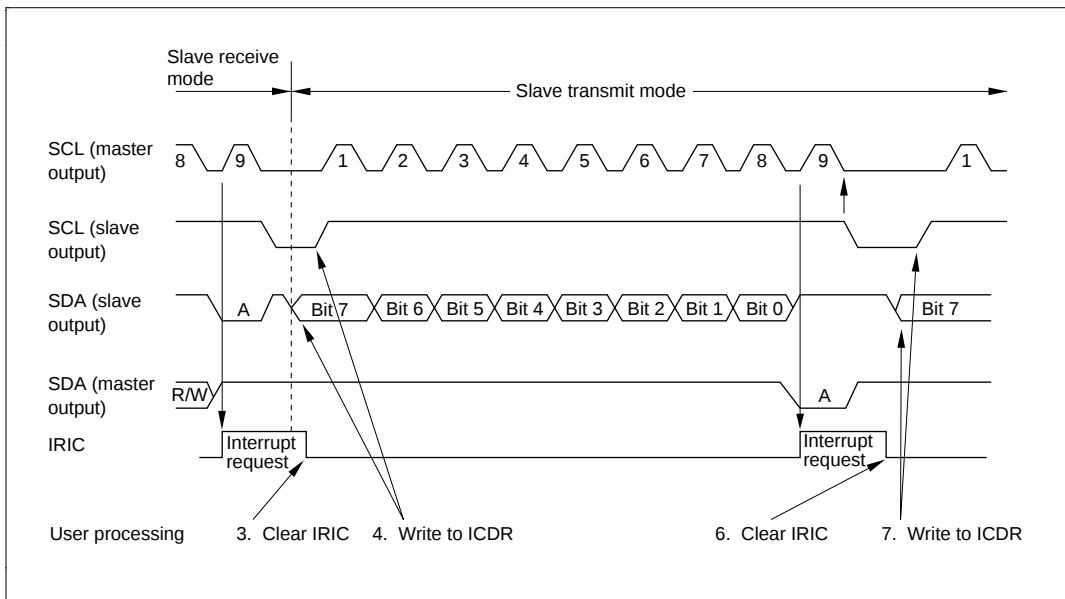
**Figure 14-7 Timing in Master Receive Mode**  
**(MLS = WAIT = ACK = ACKB = 0)**

### 14.3.4 Slave Transmit Operation

In slave transmit mode, the slave device outputs the transmit data, and the master device outputs the transmit clock and returns an acknowledge signal. The transmit procedure and operations in slave transmit mode are described below.

1. Set bits MLS and WAIT in ICMR and bits MST, TRS, ACK, and CKS2 to CKS0 in ICCR according to the operating mode. Set bit ICE in ICCR to 1.
2. After the slave device detects a start condition, if the first byte matches its slave address, at the ninth clock pulse the slave device drives SDA low to acknowledge the transfer. At the same time, IRIC is set to 1 in ICSR, generating an interrupt. If the eighth data bit ( $R/\overline{W}$ ) is 1, the TRS bit is set to 1 in ICCR, automatically causing a transition to slave transmit mode. The slave device holds SCL low from the fall of the transmit clock until data is written in ICDR.
3. Software clears IRIC to 0 in ICSR.
4. Write data in ICDR. The slave device outputs the written data serially in step with the clock output by the master device, with the timing shown in figure 14-8.
5. When one byte of data has been transmitted, at the rise of the ninth transmit clock pulse IRIC is set to 1 in ICSR. If IEIC is set to 1 in ICCR, a CPU interrupt is requested. The slave device holds SCL low from the fall of the transmit clock until data is written in ICDR. The master device drives SDA low at the ninth clock pulse to acknowledge the data. The acknowledge signal is stored in ACKB in ICSR, and can be used to check whether the transfer was carried out normally.
6. Software clears IRIC to 0 in ICSR.
7. To continue transmitting, write the next transmit data in ICDR.

Steps 5 to 7 can be repeated to transmit continuously. To end the transmission, write H'FF in ICDR. When a stop condition is detected (a low-to-high transition of SDA while SCL is high), BBSY will be cleared to 0 in ICSR.



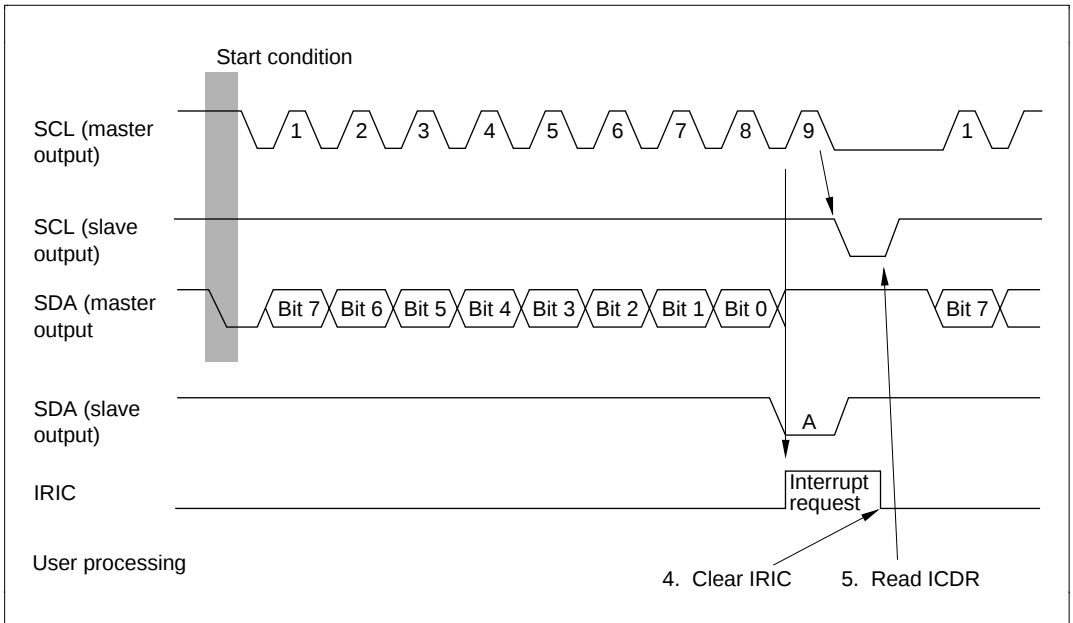
**Figure 14-8 Timing in Slave Transmit Mode**  
**(MLS = WAIT = ACK = ACKB = 0)**

### 14.3.5 Slave Receive Operation

In slave receive mode, the master device outputs the transmit clock and transmit data, and the slave device returns an acknowledge signal. The receive procedure and operations in slave receive mode are described below. See also figure 14-9.

1. Set bits MLS and WAIT in ICMR and bits MST, TRS, and ACK in ICCR according to the operating mode. Set bit ICE in ICCR to 1, establishing slave receive mode.
2. A start condition output by the master device sets BBSY to 1 in ICSR.
3. After the slave device detects the start condition, if the first byte matches its slave address, at the ninth clock pulse the slave device drives SDA low to acknowledge the transfer. At the same time, IRIC is set to 1 in ICSR. If IEIC is 1 in ICCR, a CPU interrupt is requested. The slave device holds SCL low from the fall of the receive clock until it has read the data in ICDR.
4. Software clears IRIC to 0 in ICSR.
5. When ICDR is read, receiving of the next data starts.

Steps 4 and 5 can be repeated to receive data continuously. When a stop condition is detected (a low-to-high transition of SDA while SCL is high), BBSY is cleared to 0 in ICSR.

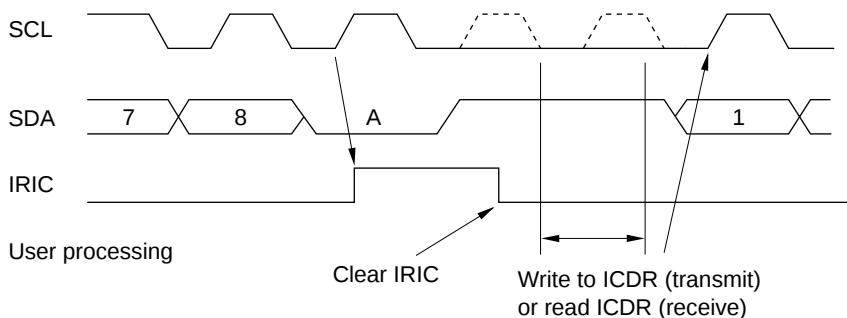


**Figure 14-9 Timing in Slave Receive Mode**  
(MLS = WAIT = ACK = 0)

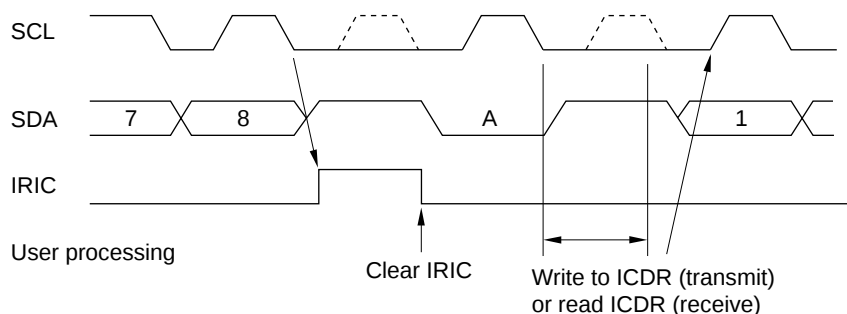
### 14.3.6 IRIC Set Timing and SCL Control

The interrupt request flag (IRIC) is set at different times depending on the WAIT bit in ICMR and ACK bit in ICCR. SCL is automatically held low after one frame has been transferred; this timing is synchronized with the internal clock. Figure 14-10 shows the IRIC set timing and SCL control.

(a) When WAIT = 0 and ACK = 0



(b) When WAIT = 1 and ACK = 0



Note: The ICDR write (transmit) or read (receive) following the clearing of IRIC should be executed after the rise of SCL (ninth clock pulse).

(c) When ACK = 1

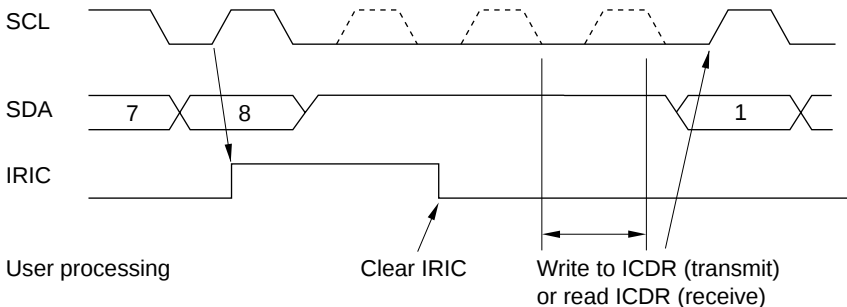
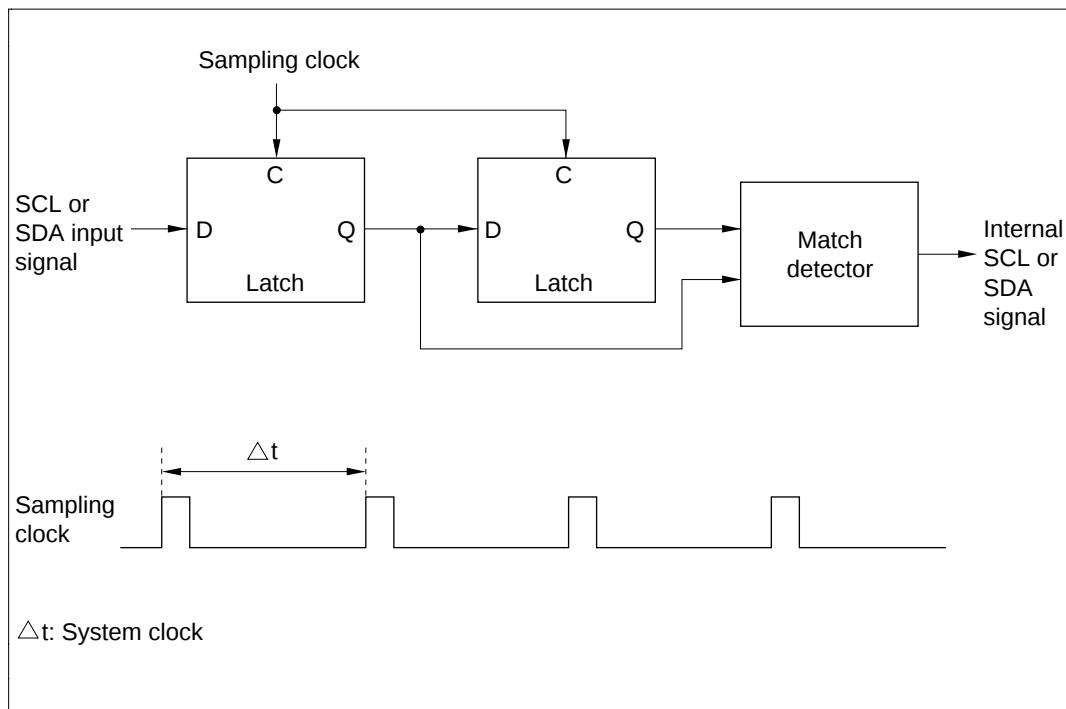


Figure 14-10 IRIC Set Timing and SCL Control

### 14.3.7 Noise Canceler

The logic levels at the SCL and SDA pins are routed through noise cancelers before being latched internally. Figure 14-11 shows a block diagram of the noise canceler circuit.

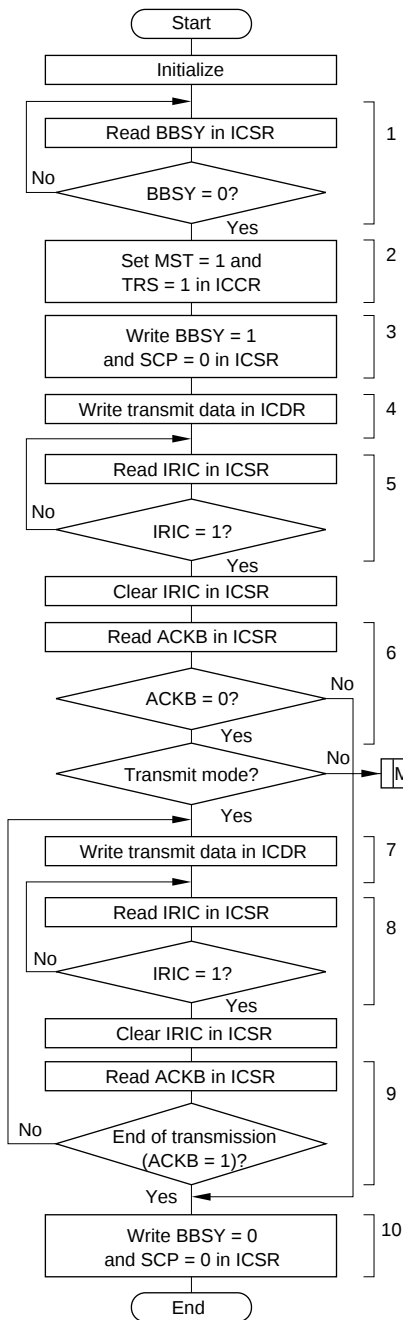
The noise canceler consists of two cascaded latches and a match detector. The SCL (or SDA) input signal is sampled on the system clock, but is not passed forward to the next circuit unless the outputs of both latches agree. If they do not agree, the previous value is held.



**Figure 14-11 Block Diagram of Noise Canceler**

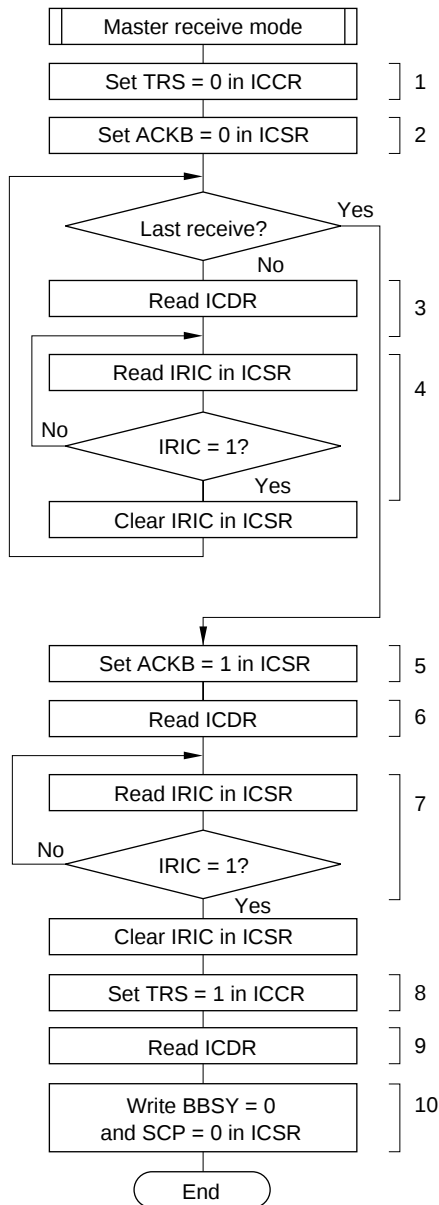
### 14.3.8 Sample Flowcharts

Figures 14-12 to 14-15 show typical flowcharts for using the I<sup>2</sup>C bus interface in each mode.



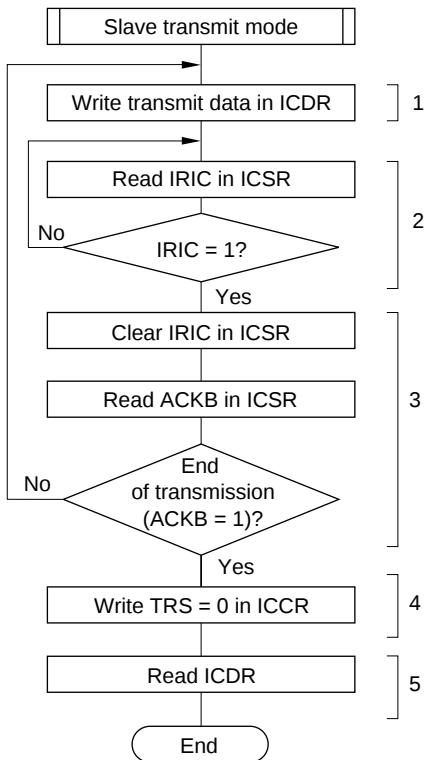
1. Test the status of the SCL and SDA lines.
2. Select master transmit mode.
3. Generate a start condition.
4. Set transmit data for the first byte (slave address + R/W).
5. Wait for 1 byte to be transmitted.
6. Test for acknowledgement by the designated slave device.
7. Set transmit data for the second and subsequent bytes.
8. Wait for 1 byte to be transmitted.
9. Test for end of transfer.
10. Generate a stop condition.

**Figure 14-12 Flowchart for Master Transmit Mode (Example)**



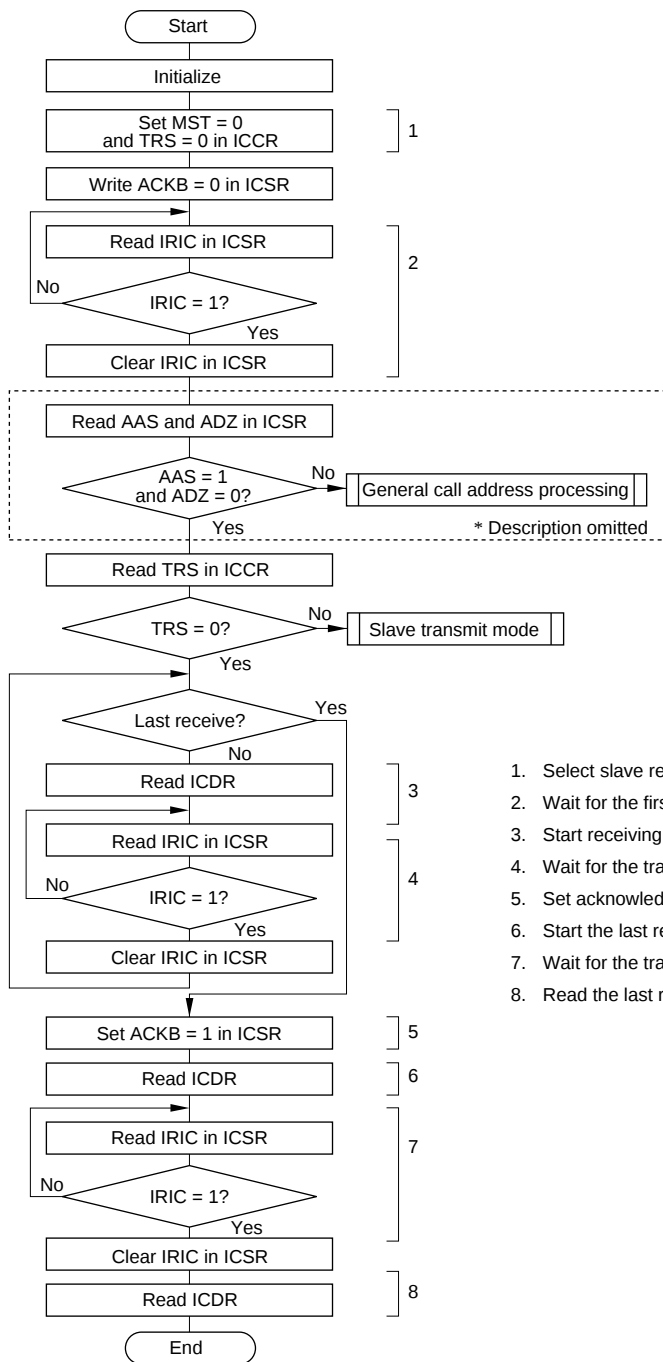
1. Select receive mode.
2. Set acknowledgement data.
3. Start receiving. The first read is a dummy read.
4. Wait for 1 byte to be received.
5. Set acknowledgement data for the last receive.
6. Start the last receive.
7. Wait for 1 byte to be received.
8. Select transmit mode.
9. Read the last receive data (if ICDR is read without selecting transmit mode, receive operations will resume).
10. Generate a stop condition.

**Figure 14-13 Flowchart for Master Receive Mode (Example)**



1. Set transmit data for the second and subsequent bytes.
2. Wait for 1 byte to be transmitted.
3. Test for end of transfer.
4. Select slave receive mode.
5. Dummy read (to release the SCL line).

**Figure 14-14 Flowchart for Slave Transmit Mode (Example)**



1. Select slave receive mode.
2. Wait for the first byte to be received.
3. Start receiving. The first read is a dummy read.
4. Wait for the transfer to end.
5. Set acknowledgement data for the last receive.
6. Start the last receive.
7. Wait for the transfer to end.
8. Read the last receive data.

**Figure 14-15 Flowchart for Slave Receive Mode (Example)**

## 14.4 Application Notes

- In master mode, if an instruction to generate a start condition is immediately followed by an instruction to generate a stop condition, neither condition will be output correctly. To output consecutive start and stop conditions, after issuing the instruction that generates the start condition, read the relevant ports, check that SCL and SDA are both low, then issue the instruction that generates the stop condition.
- Either of the following two conditions will start the next transfer. Pay attention to these conditions when reading or writing to ICDR.
  - Write access to ICDR when ICE = 1 and TRS = 1
  - Read access to ICDR when ICE = 1 and TRS = 0
- The I<sup>2</sup>C bus interface specification for the SCL rise time  $t_{sr}$  is under 1000 ns (300 ns for high-speed mode). In master mode, the I<sup>2</sup>C bus interface monitors the SCL line and synchronizes one bit at a time during communication. If  $t_{sr}$  (the time for SCL to go from low to  $V_{IH}$ ) exceeds the time determined by the input clock of the I<sup>2</sup>C bus interface, the high period of SCL is extended. SCL rise time is determined by the pull-up resistance and load capacitance of the SCL line. To insure proper operation at the set transfer rate, adjust the pull-up resistance and load capacitance so that the SCL rise time falls below the values given in the table below.

| CLKDBL | IICX | t <sub>cyc</sub><br>Display | Time Display    |              |              |              |               |               |
|--------|------|-----------------------------|-----------------|--------------|--------------|--------------|---------------|---------------|
|        |      |                             |                 | Ø =<br>4 MHz | Ø =<br>5 MHz | Ø =<br>8 MHz | Ø =<br>10 MHz | Ø =<br>16 MHz |
| 0      | 0    | 2.5t <sub>cyc</sub>         | Normal mode     | 625 ns       | 500 ns       | 312 ns       | 250 ns        | 156 ns        |
|        |      |                             | High-speed mode | 300 ns       | 300 ns       | 300 ns       |               |               |
| 0      | 1    | 7.5t <sub>cyc</sub>         | Normal mode     | 1000 ns      | 1000 ns      | 937 ns       | 750 ns        | 468 ns        |
| 1      | 0    |                             | High-speed mode | 300 ns       | 300 ns       | 300 ns       | 300 ns        | 300 ns        |
| 1      | 1    | 17.5t <sub>cyc</sub>        | Normal mode     | 1000 ns      | 1000 ns      | 1000 ns      | 1000 ns       | 1000 ns       |
|        |      |                             | High-speed mode | 300 ns       | 300 ns       | 300 ns       | 300 ns        | 300 ns        |



# Section 15 Host Interface

[Incorporated in all models except the H8/3212]

## 15.1 Overview

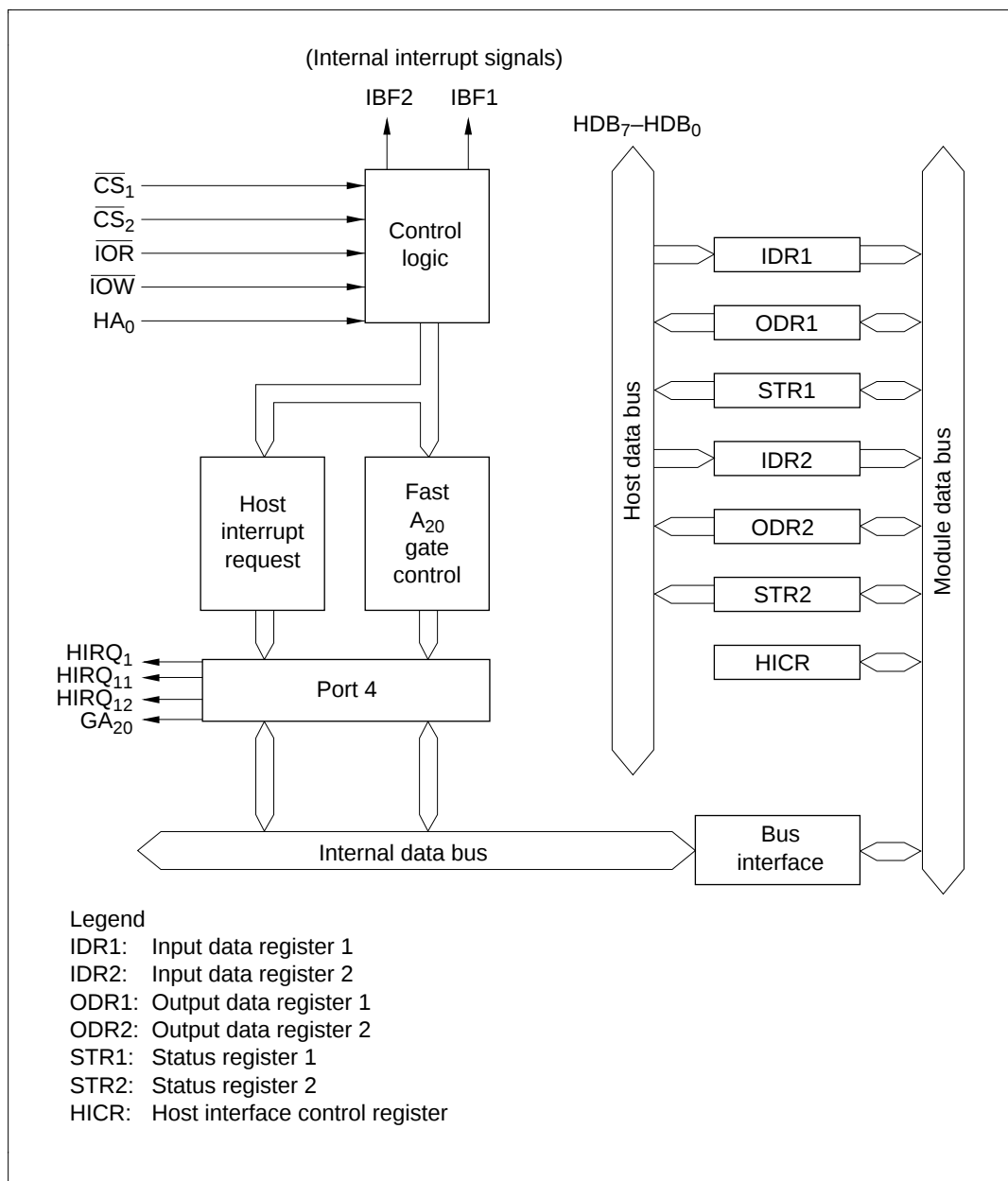
The H8/3217 Series has an on-chip host interface (HIF) that provides a dual-channel parallel interface between the on-chip CPU and a host processor. The host interface is available only when the HIE bit is set to 1 in SYSCR. This mode is called slave mode, because it is designed for a master-slave communication system in which the H8/3217-Series chip is slaved to a host processor.

The host interface consists of four 1-byte data registers, two 1-byte status registers, a 1-byte control register, fast  $A_{20}$  gate logic, and a host interrupt request circuit. Communication is carried out via five control signals from the host processor ( $\overline{CS}_1$ ,  $\overline{CS}_2$ ,  $HA_0$ ,  $\overline{IOR}$ , and  $\overline{IOW}$ ), four output signals to the host processor ( $GA_{20}$ ,  $HIRQ_1$ ,  $HIRQ_{11}$ , and  $HIRQ_{12}$ ), and an 8-bit bidirectional command/data bus ( $HDB_7$  to  $HDB_0$ ). The  $\overline{CS}_1$  and  $\overline{CS}_2$  signals select one of the two interface channels.

**Note:** If one of the two interface channels will not be used, tie the unused  $\overline{CS}$  pin to  $V_{CC}$ . For example, if interface channel 1 (IDR1, ODR1, STR1) is not used, tie  $\overline{CS}_1$  to  $V_{CC}$ .

## 15.1.1 Block Diagram

Figure 15-1 is a block diagram of the host interface.



**Figure 15-1 Host Interface Block Diagram**

## 15.1.2 Input and Output Pins

Table 15-1 lists the input and output pins of the host interface module.

**Table 15-1 HIF Input/Output Pins**

| Name                 | Abbreviation                       | Port                             | I/O    | Function                                                                                                                                                                                                                                                                         |
|----------------------|------------------------------------|----------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I/O read             | $\overline{\text{IOR}}$            | P7 <sub>6</sub>                  | Input  | Host interface read signal                                                                                                                                                                                                                                                       |
| I/O write            | $\overline{\text{IOW}}$            | P7 <sub>5</sub>                  | Input  | Host interface write signal                                                                                                                                                                                                                                                      |
| Chip select 1        | $\overline{\text{CS}}_1$           | P7 <sub>4</sub>                  | Input  | Host interface chip select signal for IDR1, ODR1, STR1                                                                                                                                                                                                                           |
| Chip select 2        | $\overline{\text{CS}}_2$           | P4 <sub>6</sub>                  | Input  | Host interface chip select signal for IDR2, ODR2, STR2                                                                                                                                                                                                                           |
| Command/data         | HA <sub>0</sub>                    | P7 <sub>7</sub>                  | Input  | Host interface address select signal<br>In host read access, this signal selects the status registers (STR1, STR2) or data registers (ODR1, ODR2). In host write access to the data registers (IDR1, IDR2), this signal indicates whether the host is writing a command or data. |
| Data bus             | HDB <sub>7</sub> –HDB <sub>0</sub> | P3 <sub>7</sub> –P3 <sub>0</sub> | I/O    | Host interface data bus (single-chip mode)                                                                                                                                                                                                                                       |
| Host interrupt 1     | HIRQ <sub>1</sub>                  | P4 <sub>4</sub>                  | Output | Interrupt output 1 to host                                                                                                                                                                                                                                                       |
| Host interrupt 11    | HIRQ <sub>11</sub>                 | P4 <sub>3</sub>                  | Output | Interrupt output 11 to host                                                                                                                                                                                                                                                      |
| Host interrupt 12    | HIRQ <sub>12</sub>                 | P4 <sub>5</sub>                  | Output | Interrupt output 12 to host                                                                                                                                                                                                                                                      |
| Gate A <sub>20</sub> | GA <sub>20</sub>                   | P4 <sub>7</sub>                  | Output | A <sub>20</sub> gate control signal output                                                                                                                                                                                                                                       |

### 15.1.3 Register Configuration

Table 15-2 lists the host interface registers.

**Table 15-2 HIF Registers**

| Name                            | Abbreviation | R/W                 |      | Initial Value | Slave Address* <sup>3</sup> | Master Address* <sup>4</sup> |                   |                   |
|---------------------------------|--------------|---------------------|------|---------------|-----------------------------|------------------------------|-------------------|-------------------|
|                                 |              | Slave               | Host |               |                             | $\overline{CS}_1$            | $\overline{CS}_2$ | HA <sub>0</sub>   |
| System control register         | SYSCR        | R/W* <sup>1</sup>   | —    | H'09          | H'FFC4                      | —                            | —                 | —                 |
| Host interface control register | HICR         | R/W                 | —    | H'F8          | H'FFF0                      | —                            | —                 | —                 |
| Input data register 1           | IDR1         | R                   | W    | —             | H'FFF4                      | 0                            | 1                 | 0/1* <sup>5</sup> |
| Output data register 1          | ODR1         | R/W                 | R    | —             | H'FFF5                      | 0                            | 1                 | 0                 |
| Status register 1               | STR1         | R/(W)* <sup>2</sup> | R    | H'00          | H'FFF6                      | 0                            | 1                 | 1                 |
| Input data register 2           | IDR2         | R                   | W    | —             | H'FFFC                      | 1                            | 0                 | 0                 |
| Output data register 2          | ODR2         | R/W                 | R    | —             | H'FFFD                      | 1                            | 0                 | 0/1* <sup>5</sup> |
| Status register 2               | STR2         | R/(W)* <sup>2</sup> | R    | H'00          | H'FFFE                      | 1                            | 0                 | 1                 |
| Serial/timer control register   | STCR         | R/W                 | —    | H'00          | H'FFC3                      | —                            | —                 | —                 |

- Notes:
1. Bit 3 is a read-only bit.
  2. The user-defined bits (bits 7 to 4, 2) are read/write accessible from the slave processor.
  3. Address when accessed from the slave processor.
  4. Pin inputs used in access from the host processor.
  5. The HA<sub>0</sub> input discriminates between writing of commands and data.
  6. Registers in slave addresses H'FFF0 to H'FFFF can only be read or written to when the HIE bit in the system control register (SYSCR) is set to 1.

## 15.2 Register Descriptions

### 15.2.1 System Control Register (SYSCR)

| Bit           | 7    | 6    | 5    | 4    | 3    | 2     | 1   | 0    |
|---------------|------|------|------|------|------|-------|-----|------|
|               | SSBY | STS2 | STS1 | STS0 | XRST | NMIEG | HIE | RAME |
| Initial value | 0    | 0    | 0    | 0    | 1    | 0     | 0   | 1    |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R    | R/W   | R/W | R/W  |

SYSCR is an 8-bit readable/writable register which controls chip operations. Host interface functions are enabled or disabled by the HIE bit of SYSCR. See section 3.2, System Control Register, for information on other SYSCR bits. SYSCR is initialized to H'09 by an external reset and in the hardware standby modes.

**Bit 1—Host Interface Enable (HIE):** Enables or disables the host interface. When enabled, the host interface handles host-slave data transfers, operating in slave mode.

| Bit 1<br>HIE | Description |
|--------------|-------------|
|--------------|-------------|

|   |                                                |
|---|------------------------------------------------|
| 0 | The host interface is disabled (Initial value) |
| 1 | The host interface is enabled (slave mode)     |

### 15.2.2 Host Interface Control Register (HICR)

| Bit              | 7 | 6 | 5 | 4 | 3 | 2      | 1      | 0      |
|------------------|---|---|---|---|---|--------|--------|--------|
|                  | — | — | — | — | — | IBFIE2 | IBFIE1 | FGA20E |
| Initial value    | 1 | 1 | 1 | 1 | 1 | 0      | 0      | 0      |
| Slave Read/Write | — | — | — | — | — | R/W    | R/W    | R/W    |
| Host Read/Write  | — | — | — | — | — | —      | —      | —      |

HICR is an 8-bit readable/writable register which controls host interface interrupts and the fast A<sub>20</sub> gate function. HICR is initialized to H'F8 by a reset and in the standby modes.

**Bits 7 to 3—Reserved:** These bits cannot be modified and are always read as 1.

**Bit 2—Input Buffer Full Interrupt Enable 2 (IBFIE2):** Enables or disables the IBF2 interrupt to the slave CPU.

**Bit 2**

**IBFIE2 Description**

|   |                                              |                 |
|---|----------------------------------------------|-----------------|
| 0 | IDR2 input buffer full interrupt is disabled | (Initial value) |
| 1 | IDR2 input buffer full interrupt is enabled  |                 |

**Bit 1—Input Buffer Full Interrupt Enable 1 (IBFIE1):** Enables or disables the IBF1 interrupt to the slave CPU.

**Bit 1**

**IBFIE1 Description**

|   |                                              |                 |
|---|----------------------------------------------|-----------------|
| 0 | IDR1 input buffer full interrupt is disabled | (Initial value) |
| 1 | IDR1 input buffer full interrupt is enabled  |                 |

**Bit 0—Fast Gate A<sub>20</sub> Enable (FGA20E):** Enables or disables the fast A<sub>20</sub> gate function. When the fast A<sub>20</sub> gate is disabled, a regular-speed A<sub>20</sub> gate signal can be implemented by using software to manipulate the P8<sub>1</sub> output.

**Bit 0**

**FGA20E Description**

|   |                                             |                 |
|---|---------------------------------------------|-----------------|
| 0 | Disables fast A <sub>20</sub> gate function | (Initial value) |
| 1 | Enables fast A <sub>20</sub> gate function  |                 |

### 15.2.3 Input Data Register 1 (IDR1)

|                  |      |      |      |      |      |      |      |      |
|------------------|------|------|------|------|------|------|------|------|
| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|                  | IDR7 | IDR6 | IDR5 | IDR4 | IDR3 | IDR2 | IDR1 | IDR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R    | R    | R    | R    | R    | R    | R    | R    |
| Host Read/Write  | W    | W    | W    | W    | W    | W    | W    | W    |

IDR1 is an 8-bit read-only register to the slave processor, and an 8-bit write-only register to the host processor. When CS<sub>1</sub> is low, information on the host data bus is written into IDR1 at the rising edge of IOW. The HA<sub>0</sub> state is also latched into the C/D bit in STR1 to indicate whether the written information is a command or data.

The initial values of IDR1 after a reset and in the standby modes are undetermined.

### 15.2.4 Output Data Register 1 (ODR1)

| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | ODR7 | ODR6 | ODR5 | ODR4 | ODR3 | ODR2 | ODR1 | ODR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  |
| Host Read/Write  | R    | R    | R    | R    | R    | R    | R    | R    |

ODR1 is an 8-bit readable/writable register to the slave processor, and an 8-bit read-only register to the host processor. The ODR1 contents are output on the host data bus when  $\overline{HA_0}$  is low,  $\overline{CS_1}$  is low, and  $\overline{IOR}$  is low.

The initial values of ODR1 after a reset and in standby mode are undetermined.

### 15.2.5 Status Register 1 (STR1)

| Bit              | 7   | 6   | 5   | 4   | 3                | 2   | 1   | 0   |
|------------------|-----|-----|-----|-----|------------------|-----|-----|-----|
|                  | DBU | DBU | DBU | DBU | $C/\overline{D}$ | DBU | IBF | OBF |
| Initial value    | 0   | 0   | 0   | 0   | 0                | 0   | 0   | 0   |
| Slave Read/Write | R/W | R/W | R/W | R/W | R                | R/W | R   | R   |
| Host Read/Write  | R   | R   | R   | R   | R                | R   | R   | R   |

STR1 is an 8-bit register that indicates status information during host interface processing. Bits 3, 1, and 0 are read-only bits to both the host and slave processors.

STR1 is initialized to H'00 by a reset and in the standby modes.

**Bits 7 to 4 and Bit 2—Defined by User (DBU):** The user can use these bits as necessary.

**Bit 3—Command/Data ( $C/\overline{D}$ ):** Receives the  $\overline{HA_0}$  input when the host processor writes to IDR1, and indicates whether IDR1 contains data or a command.

| Bit 3<br>$C/\overline{D}$ | Description                               |
|---------------------------|-------------------------------------------|
| 0                         | Contents of IDR1 are data (Initial value) |
| 1                         | Contents of IDR1 are a command            |

**Bit 1—Input Buffer Full (IBF):** Set to 1 when the host processor writes to IDR1. This bit is an internal interrupt source to the slave processor. IBF is cleared to 0 when the slave processor reads IDR1.

**Bit 1**

| IBF | Description                                                             |
|-----|-------------------------------------------------------------------------|
| 0   | This bit is cleared when the slave processor reads IDR1 (Initial value) |
| 1   | This bit is set when the host processor writes to IDR1                  |

**Bit 0—Output Buffer Full (OBF):** Set to 1 when the slave processor writes to ODR1. Cleared to 0 when the host processor reads ODR1.

**Bit 0**

| OBF | Description                                                            |
|-----|------------------------------------------------------------------------|
| 0   | This bit is cleared when the host processor reads ODR1 (Initial value) |
| 1   | This bit is set when the slave processor writes to ODR1                |

Table 15-3 shows the conditions for setting and clearing the STR1 flags.

**Table 15-3 Set/Clear Timing for STR1 Flags**

| Flag              | Setting Condition                                                                      | Clearing Condition                                                                 |
|-------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| C/ $\overline{D}$ | Rising edge of host's write signal ( $\overline{IOW}$ ) when $HA_0$ is high            | Rising edge of host's write signal ( $\overline{IOW}$ ) when $HA_0$ is low         |
| IBF               | Rising edge of host's write signal ( $\overline{IOW}$ ) when writing to IDR1           | Falling edge of slave's internal read signal ( $\overline{RD}$ ) when reading IDR1 |
| OBF               | Falling edge of slave's internal write signal ( $\overline{WR}$ ) when writing to ODR1 | Rising edge of host's read signal ( $\overline{IOR}$ ) when reading ODR1           |

### 15.2.6 Input Data Register 2 (IDR2)

| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | IDR7 | IDR6 | IDR5 | IDR4 | IDR3 | IDR2 | IDR1 | IDR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R    | R    | R    | R    | R    | R    | R    | R    |
| Host Read/Write  | W    | W    | W    | W    | W    | W    | W    | W    |

IDR2 is an 8-bit read-only register to the slave processor, and an 8-bit write-only register to the host processor. When  $\overline{CS}_2$  is low, information on the host data bus is written into IDR2 at the

rising edge of  $\overline{\text{IOW}}$ . The  $\text{HA}_0$  state is also latched into the  $\text{C}/\overline{\text{D}}$  bit in STR2 to indicate whether the written information is a command or data.

The initial values of IDR2 after a reset and in the standby modes are undetermined.

### 15.2.7 Output Data Register 2 (ODR2)

| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | ODR7 | ODR6 | ODR5 | ODR4 | ODR3 | ODR2 | ODR1 | ODR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  |
| Host Read/Write  | R    | R    | R    | R    | R    | R    | R    | R    |

ODR2 is an 8-bit read/write register to the slave processor, and an 8-bit read-only register to the host processor. The ODR2 contents are output on the host data bus when  $\text{HA}_0$  is low,  $\overline{\text{CS}}_2$  is low, and  $\overline{\text{IOR}}$  is low.

### 15.2.8 Status Register 2 (STR2)

| Bit              | 7   | 6   | 5   | 4   | 3                              | 2   | 1   | 0   |
|------------------|-----|-----|-----|-----|--------------------------------|-----|-----|-----|
|                  | DBU | DBU | DBU | DBU | $\text{C}/\overline{\text{D}}$ | DBU | IBF | OBF |
| Initial value    | 0   | 0   | 0   | 0   | 0                              | 0   | 0   | 0   |
| Slave Read/Write | R/W | R/W | R/W | R/W | R                              | R/W | R   | R   |
| Host Read/Write  | R   | R   | R   | R   | R                              | R   | R   | R   |

STR2 is an 8-bit register that indicates status information during host interface processing. Bits 3, 1, and 0 are read-only bits to both the host and slave processors.

STR2 is initialized to H'00 by a reset and in the standby modes.

**Bits 7 to 4 and Bit 2—Defined by User (DBU):** The user can use these bits as necessary.

**Bit 3—Command/Data ( $\text{C}/\overline{\text{D}}$ ):** Receives the  $\text{HA}_0$  input when the host processor writes to IDR2, and indicates whether IDR2 contains data or a command.

#### Bit 3

| $\text{C}/\overline{\text{D}}$ | Description                               |
|--------------------------------|-------------------------------------------|
| 0                              | Contents of IDR2 are data (Initial value) |
| 1                              | Contents of IDR2 are a command            |

**Bit 1—Input Buffer Full (IBF):** Set to 1 when the host processor writes to IDR2. This bit is an internal interrupt source to the slave processor. IBF is cleared to 0 when the slave processor reads IDR2.

**Bit 1**

| IBF | Description                                                             |
|-----|-------------------------------------------------------------------------|
| 0   | This bit is cleared when the slave processor reads IDR2 (Initial value) |
| 1   | This bit is set when the host processor writes to IDR2                  |

**Bit 0—Output Buffer Full (OBF):** Set to 1 when the slave processor writes to ODR2. Cleared to 0 when the host processor reads ODR2.

**Bit 0**

| OBF | Description                                                            |
|-----|------------------------------------------------------------------------|
| 0   | This bit is cleared when the host processor reads ODR2 (Initial value) |
| 1   | This bit is set when the slave processor writes to ODR2                |

Table 15-4 shows the conditions for setting and clearing the STR2 flags.

**Table 15-4 Set/Clear Timing for STR2 Flags**

| Flag              | Setting Condition                                                                      | Clearing Condition                                                                 |
|-------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| C/ $\overline{D}$ | Rising edge of host's write signal ( $\overline{IOW}$ ) when $HA_0$ is high            | Rising edge of host's write signal ( $\overline{IOW}$ ) when $HA_0$ is low         |
| IBF               | Rising edge of host's write signal ( $\overline{IOW}$ ) when writing to IDR2           | Falling edge of slave's internal read signal ( $\overline{RD}$ ) when reading IDR2 |
| OBF               | Falling edge of slave's internal write signal ( $\overline{WR}$ ) when writing to ODR2 | Rising edge of host's read signal ( $\overline{IOR}$ ) when reading ODR2           |

## 15.3 Operation

### 15.3.1 Host Interface Operation

The host interface is activated by setting the HIE bit (bit 1) to 1 in SYSCR, establishing slave mode. Activation of the host interface (entry to slave mode) appropriates the related I/O lines in port 3 (data), port 4 or 7 (control) and port 4 (host interrupt requests) for interface use.

For host interface read/write timing diagrams, see section 19.3.8, Host Interface Timing.

### 15.3.2 Control States

Table 15-5 indicates the slave operations carried out in response to host interface signals from the host processor.

**Table 15-5 Host Interface Operation**

| $\overline{CS}_2$ | $\overline{CS}_1$ | $\overline{IOR}$ | $\overline{IOW}$ | $HA_0$ | Operation                                     |
|-------------------|-------------------|------------------|------------------|--------|-----------------------------------------------|
| 1                 | 0                 | 0                | 0                | 0      | Prohibited                                    |
| 1                 | 0                 | 0                | 0                | 1      | Prohibited                                    |
| 1                 | 0                 | 0                | 1                | 0      | Data read from output data register 1 (ODR1)  |
| 1                 | 0                 | 0                | 1                | 1      | Status read from status register 1 (STR1)     |
| 1                 | 0                 | 1                | 0                | 0      | Data write to input data register 1 (IDR1)    |
| 1                 | 0                 | 1                | 0                | 1      | Command write to input data register 1 (IDR1) |
| 1                 | 0                 | 1                | 1                | 0      | Idle state                                    |
| 1                 | 0                 | 1                | 1                | 1      | Idle state                                    |
| 0                 | 1                 | 0                | 0                | 0      | Prohibited                                    |
| 0                 | 1                 | 0                | 0                | 1      | Prohibited                                    |
| 0                 | 1                 | 0                | 1                | 0      | Data read from output data register 2 (ODR2)  |
| 0                 | 1                 | 0                | 1                | 1      | Status read from status register 2 (STR2)     |
| 0                 | 1                 | 1                | 0                | 0      | Data write to input data register 2 (IDR2)    |
| 0                 | 1                 | 1                | 0                | 1      | Command write to input data register 2 (IDR2) |
| 0                 | 1                 | 1                | 1                | 0      | Idle state                                    |
| 0                 | 1                 | 1                | 1                | 1      | Idle state                                    |

### 15.3.3 A<sub>20</sub> Gate

The A<sub>20</sub> gate signal can mask address A<sub>20</sub> to emulate an addressing mode used by personal computers with an 8086\*-family CPU. In slave mode, a regular-speed A<sub>20</sub> gate signal can be output under software control, or a fast A<sub>20</sub> gate signal can be output under hardware control. Fast A<sub>20</sub> gate output is enabled by setting the FGA20E bit (bit 0) to 1 in HICR (H'FFF0).

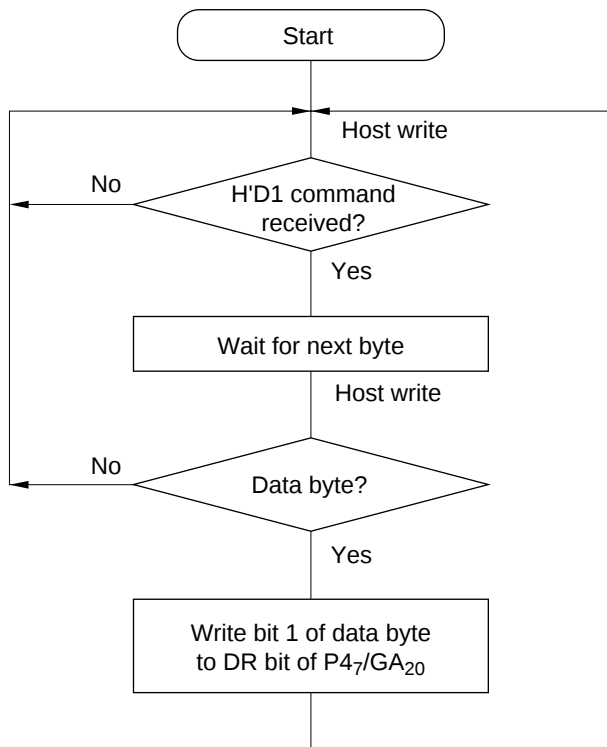
Note: \* Intel microprocessor.

**Regular A<sub>20</sub> Gate Operation:** Output of the A<sub>20</sub> gate signal can be controlled by an H'D1 command followed by data. When the slave processor receives data, it normally uses an interrupt routine activated by the IBF1 interrupt to read IDR1. If the data follows an H'D1 command, software copies bit 1 of the data and outputs it at the gate A<sub>20</sub> pin (P4<sub>7</sub>/GA<sub>20</sub>).

**Fast A<sub>20</sub> Gate Operation:** When the FGA20E bit is set to 1, P4<sub>7</sub>/GA<sub>20</sub> is used for output of a fast A<sub>20</sub> gate signal. Bit P4<sub>7</sub>DDR must be set to 1 to assign this pin for output. The initial output from this pin will be a logic 1, which is the initial DR value. Afterward, the host processor can manipulate the output from this pin by sending commands and data. This function is available only when register IDR1 is accessed using  $\overline{CS}_1$ . Slave logic decodes the commands input from the host processor. When an H'D1 host command is detected, bit 1 of the data following the host command is output from the GA<sub>20</sub> output pin. This operation does not depend on software or interrupts, and is faster than the regular processing using interrupts. Table 15-6 lists the conditions that set and clear GA<sub>20</sub> (P4<sub>7</sub>). Figure 15-2 describes the GA<sub>20</sub> output in flowchart form. Table 15-7 indicates the GA<sub>20</sub> output signal values.

**Table 15-6 GA<sub>20</sub> (P4<sub>7</sub>) Set/Clear Timing**

| Pin Name                            | Setting Condition                                                                                                                         | Clearing Condition                                                                                                                        |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| GA <sub>20</sub> (P4 <sub>7</sub> ) | Rising edge of the host's write signal ( $\overline{IOW}$ ) when bit 1 of the written data is 1 and the data follows an H'D1 host command | Rising edge of the host's write signal ( $\overline{IOW}$ ) when bit 1 of the written data is 0 and the data follows an H'D1 host command |



**Figure 15-2 GA<sub>20</sub> Output**

**Table 15-7 Fast A<sub>20</sub> Gate Output Signal**

| HA <sub>0</sub> | Data/Command                     | Internal CPU Interrupt Flag | GA <sub>20</sub> (P4 <sub>7</sub> ) | Remarks                          |
|-----------------|----------------------------------|-----------------------------|-------------------------------------|----------------------------------|
| 1               | H'D1 command                     | 0                           | Q                                   | Turn-on sequence                 |
| 0               | "1" data* <sup>1</sup>           | 0                           | 1                                   |                                  |
| 1               | H'FF command                     | 0                           | Q (1)                               |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Turn-off sequence                |
| 0               | "0" data* <sup>2</sup>           | 0                           | 0                                   |                                  |
| 1               | H'FF command                     | 0                           | Q (0)                               |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Short turn-on sequence           |
| 0               | "1" data* <sup>1</sup>           | 0                           | 1                                   |                                  |
| 1/0             | Command other than H'FF and H'D1 | 1                           | Q (1)                               |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Short turn-off sequence          |
| 0               | "0" data* <sup>2</sup>           | 0                           | 0                                   |                                  |
| 1/0             | Command other than H'FF and H'D1 | 1                           | Q (0)                               |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Cancelled sequence               |
| 1               | Command other than H'D1          | 1                           | Q                                   |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Retriggered sequence             |
| 1               | H'D1 command                     | 0                           | Q                                   |                                  |
| 1               | H'D1 command                     | 0                           | Q                                   | Consecutively executed sequences |
| 0               | Any data                         | 0                           | 1/0                                 |                                  |
| 1               | H'D1 command                     | 0                           | Q (1/0)                             |                                  |

Notes: 1. Arbitrary data with bit 1 set to 1.  
2. Arbitrary data with bit 1 cleared to 0.

## 15.4 Interrupts

### 15.4.1 IBF1, IBF2

The host interface can request two interrupts to the slave CPU: IBF1 and IBF2. They are input buffer full interrupts for input data registers IDR1 and IDR2 respectively. Each interrupt is enabled when the corresponding enable bit is set (table 15-8).

**Table 15-8 Input Buffer Full Interrupts**

| Interrupt | Description                                        |
|-----------|----------------------------------------------------|
| IBF1      | Requested when IBFIE1 is set to 1 and IDR1 is full |
| IBF2      | Requested when IBFIE2 is set to 1 and IDR2 is full |

### 15.4.2 HIRQ<sub>11</sub>, HIRQ<sub>1</sub>, and HIRQ<sub>12</sub>

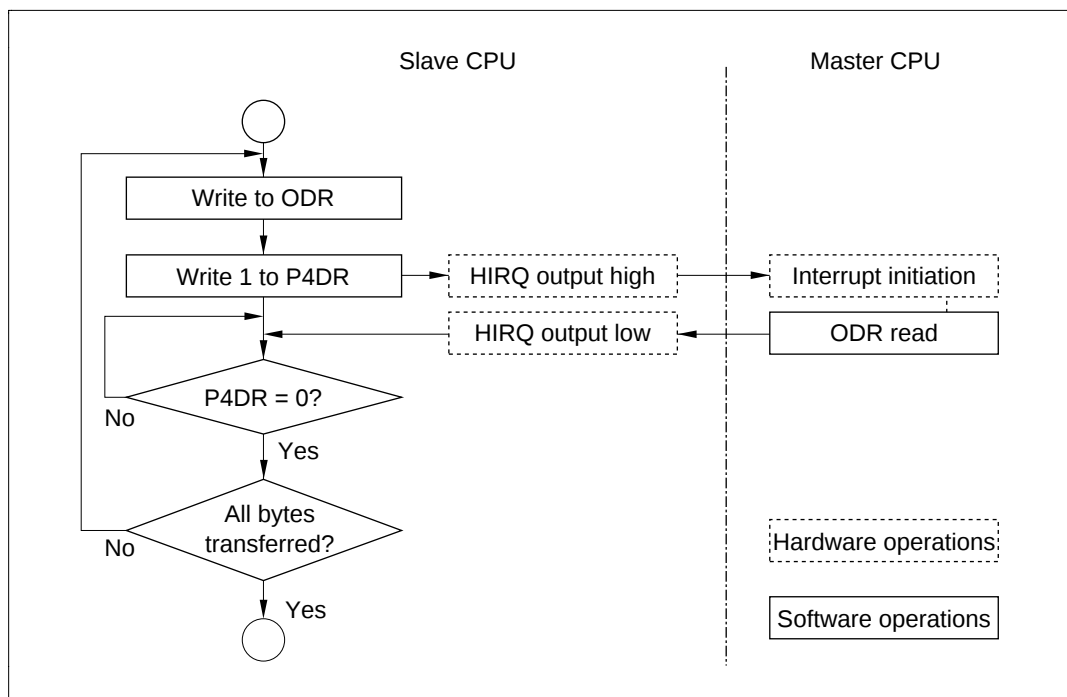
In slave mode (when HIE = 1 in SYSCR), three bits in the port 4 data register (P4DR) can be used as host interrupt request latches.

These three P4DR bits are cleared to 0 by the host processor's read signal ( $\overline{\text{IOR}}$ ). If  $\overline{\text{CS}}_1$  and  $\text{HA}_0$  are low, when  $\overline{\text{IOR}}$  goes low and the host reads ODR1, HIRQ<sub>1</sub> and HIRQ<sub>12</sub> are cleared to 0. If  $\overline{\text{CS}}_2$  and  $\text{HA}_0$  are low, when  $\overline{\text{IOR}}$  goes low and the host reads ODR2, HIRQ<sub>11</sub> is cleared to 0. To generate a host interrupt request, normally on-chip software writes 1 to the corresponding bit. In processing the interrupt, the host's interrupt-handling routine reads the output data register (ODR1 or ODR2), and this clears the host interrupt latch to 0.

Table 15-9 indicates how these bits are set and cleared. Figure 15-3 shows the processing in flowchart form.

**Table 15-9 Host Interrupt Set/Clear Conditions**

| Host Interrupt Signal                 | Setting Condition                                | Clearing Condition                                                     |
|---------------------------------------|--------------------------------------------------|------------------------------------------------------------------------|
| HIRQ <sub>11</sub> (P4 <sub>3</sub> ) | Slave CPU reads 0 from P4DR bit 3, then writes 1 | Slave CPU writes 0 in P4DR bit 3, or host reads output data register 2 |
| HIRQ <sub>1</sub> (P4 <sub>4</sub> )  | Slave CPU reads 0 from P4DR bit 4, then writes 1 | Slave CPU writes 0 in P4DR bit 4, or host reads output data register 1 |
| HIRQ <sub>12</sub> (P4 <sub>5</sub> ) | Slave CPU reads 0 from P4DR bit 5, then writes 1 | Slave CPU writes 0 in P4DR bit 5, or host reads output data register 1 |



**Figure 15-3 HIRQ Output Flowchart**

## 15.5 Application Note

The host interface provides buffering of asynchronous data from the host and slave processors, but an interface protocol must be followed to implement necessary functions and avoid data contention. For example, if the host and slave processors try to access the same input or output data register simultaneously, the data will be corrupted. Interrupts can be used to design a simple and effective protocol.

# Section 16 RAM

## 16.1 Overview

The H8/3217 and H8/3216 have 2 kbytes of on-chip static RAM, the H8/3214 has 1 kbyte, and the H8/3212 and H8/3202 have 512 bytes. The on-chip RAM is connected to the CPU by a 16-bit data bus. Both byte and word access to the on-chip RAM are performed in two states, enabling rapid data transfer and instruction execution.

The on-chip RAM occupies the following addresses in the chip's address space.

H8/3217, H8/3216: H'F780 to H'FF7F

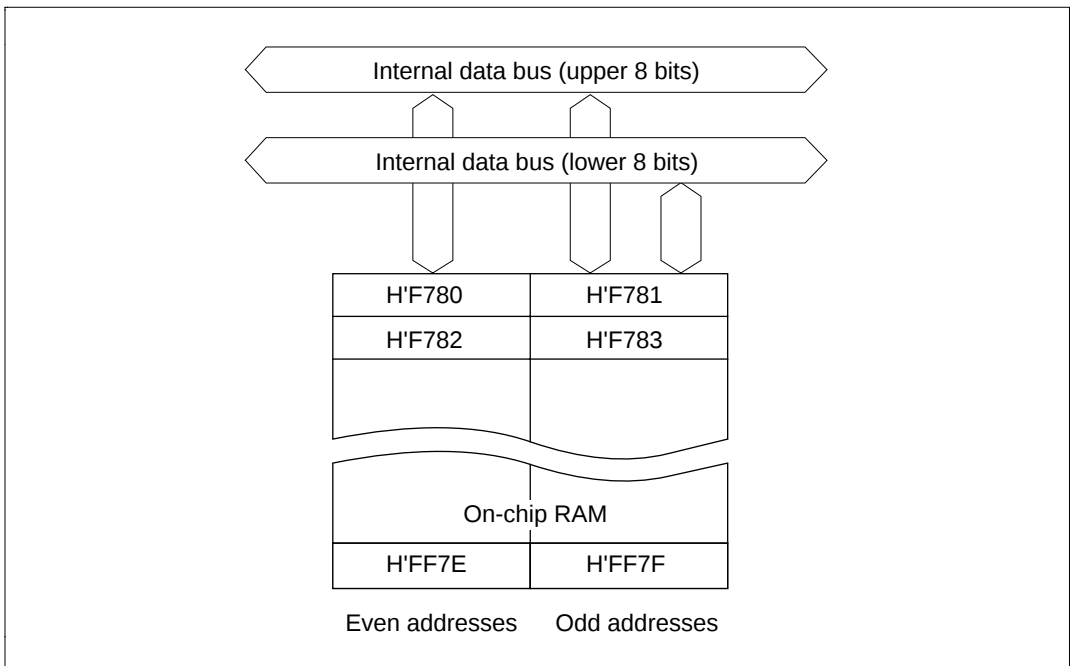
H8/3214: H'FB80 to H'FF7F

H8/3212, H8/3202: H'FD80 to H'FF7F

The RAME bit in the system control register (SYSCR) can enable or disable the on-chip RAM, permitting these addresses to be allocated to external memory instead, if so desired.

## 16.2 Block Diagram

Figure 16-1 is a block diagram of the on-chip RAM.



**Figure 16-1 Block Diagram of On-Chip RAM (H8/3217)**

### 16.3 RAM Enable Bit (RAME)

The on-chip RAM is enabled or disabled by the RAME (RAM Enable) bit in the system control register (SYSCR). Table 16-1 lists information about the system control register.

Table 16-1 System Control Register

| Name                    | Abbreviation |      | R/W  | Initial value |      | Address |     |      |
|-------------------------|--------------|------|------|---------------|------|---------|-----|------|
| System control register | SYSCR        |      | R/W  | H'09          |      | H'FFC4  |     |      |
| Bit                     | 7            | 6    | 5    | 4             | 3    | 2       | 1   | 0    |
|                         | SSBY         | STS2 | STS1 | STS0          | XRST | NMIEG   | HIE | RAME |
| Initial value           | 0            | 0    | 0    | 0             | 1    | 0       | 0   | 1    |
| Read/Write              | R/W          | R/W  | R/W  | R/W           | R    | R/W     | R/W | R/W  |

The only bit in the system control register that concerns the on-chip RAM is the RAME bit. See section 3.2, System Control Register for the other bits.

**Bit 0—RAM Enable (RAME):** This bit enables or disables the on-chip RAM.

The RAME bit is initialized to 1 on the rising edge of the  $\overline{\text{RES}}$  signal, so a reset enables the on-chip RAM. The RAME bit is not initialized in the software standby mode.

| Bit 7 |                                        |
|-------|----------------------------------------|
| RAME  | Description                            |
| 0     | On-chip RAM is disabled                |
| 1     | On-chip RAM is enabled (Initial value) |

## 16.4 Operation

### 16.4.1 Expanded Modes (Modes 1 and 2)

If the RAME bit is set to 1, accesses to the following addresses are directed to the on-chip RAM.

H8/3217, H8/3216: H'F780 to H'FF7F

H8/3214: H'FB80 to H'FF7F

H8/3212, H8/3202: H'FD80 to H'FF7F

If the RAME bit is cleared to 0, accesses to these addresses are directed to the external data bus.

### 16.4.2 Single-Chip Mode (Mode 3)

If the RAME bit is set to 1, accesses to the following addresses are directed to the on-chip RAM.

H8/3217, H8/3216: H'F780 to H'FF7F

H8/3214: H'FB80 to H'FF7F

H8/3212, H8/3202: H'FD80 to H'FF7F

If the RAME bit is cleared to 0, the on-chip RAM data cannot be accessed. Attempted write access has no effect. Attempted read access always results in H'FF data being read.



# Section 17 ROM

## 17.1 Overview

The H8/3217 has 60 kbytes of high-speed, on-chip ROM, the H8/3216 has 48 kbytes, the H8/3214 has 32 kbytes, and the H8/3212 and H8/3202 have 16 kbytes. The on-chip ROM is connected to the CPU via a 16-bit data bus. Both byte data and word data are accessed in two states, enabling rapid data transfer and instruction fetching.

The H8/3217 and H8/3214 are available in two versions: one with electrically programmable ROM (PROM); the other with masked ROM. The PROM version has a PROM mode in which the chip can be programmed with a standard PROM writer.

The on-chip ROM is enabled or disabled depending on the MCU operating mode, which is determined by the inputs at the mode pins ( $MD_1$  and  $MD_0$ ) when the chip comes out of the reset state. See table 17-1.

The H8/3217 has 61,312 bytes of ROM (addresses H'0000 to H'EF7F) enabled in mode 2, and 63,360 bytes (addresses H'0000 to H'F77F) in mode 3. See section 3, MCU Operating Modes and Address Space, for details.

**Table 17-1 On-Chip ROM Usage in Each MCU Mode**

| Mode                      | Mode Pins |        | On-Chip ROM                   |
|---------------------------|-----------|--------|-------------------------------|
|                           | $MD_1$    | $MD_0$ |                               |
| Mode 1 (expanded mode)    | 0         | 1      | Disabled (external addresses) |
| Mode 2 (expanded mode)    | 1         | 0      | Enabled                       |
| Mode 3 (single-chip mode) | 1         | 1      | Enabled                       |

17.1.1 Block Diagram

Figure 17-1 is a block diagram of the on-chip ROM.

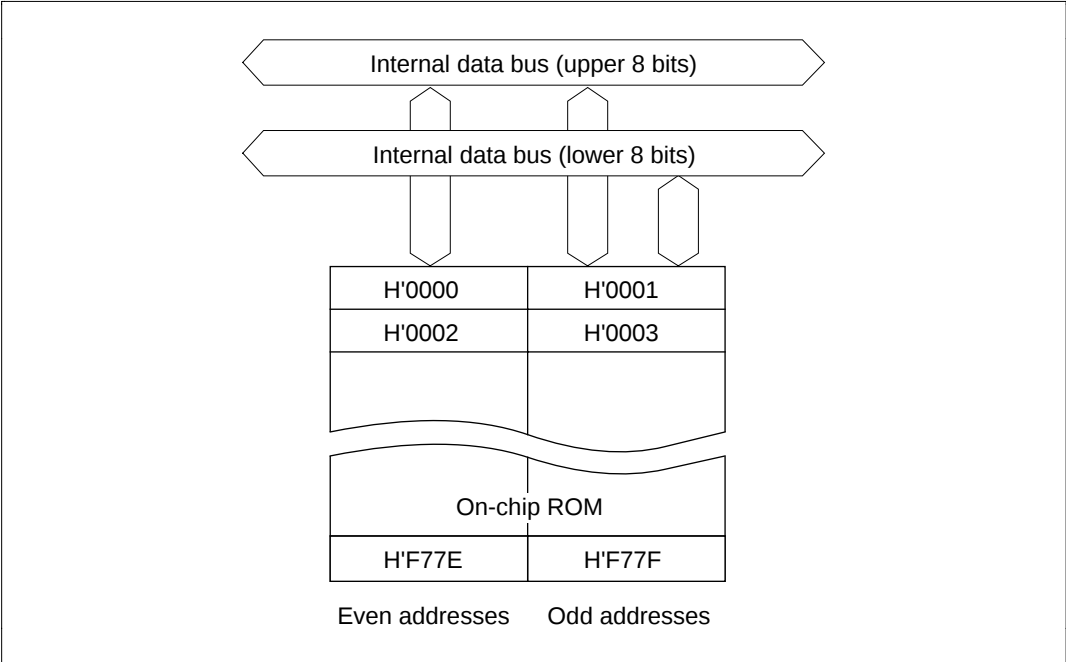


Figure 17-1 Block Diagram of On-Chip ROM (H8/3217, Single-Chip Mode)

17.2 PROM Mode (H8/3217 and H8/3214)

17.2.1 PROM Mode Setup

In the PROM mode of the PROM version of the H8/3217 and H8/3214, the usual microcomputer functions are halted to allow the on-chip PROM to be programmed. The programming method is the same as for the HN27C101. However, page programming is not supported.

To select the PROM mode, apply the signal inputs listed in table 17-2.

**Table 17-2 Selection of PROM Mode**

| Pin                                      | Input |
|------------------------------------------|-------|
| Mode pin MD <sub>1</sub>                 | Low   |
| Mode pin MD <sub>0</sub>                 | Low   |
| $\overline{\text{STBY}}$ pin             | Low   |
| Pins P7 <sub>0</sub> and P7 <sub>1</sub> | High  |

### 17.2.2 Socket Adapter Pin Assignments and Memory Map

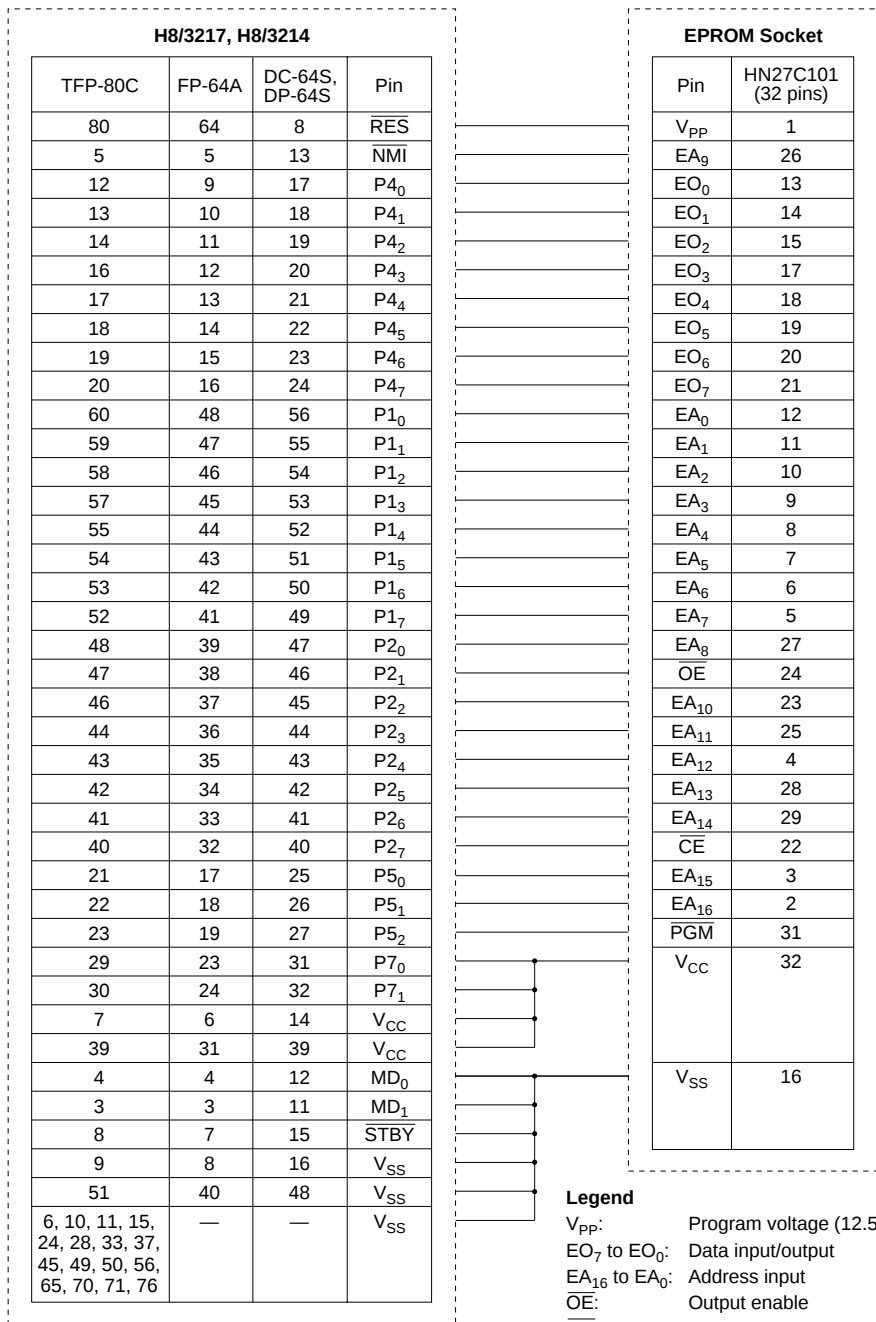
The H8/3217 and H8/3214 can be programmed with a general-purpose PROM writer. Since the microcontroller package has 64 or 80 pins, a socket adapter is necessary. Table 17-3 lists recommended socket adapters. Figure 17-2 shows the socket adapter pin assignments by giving the correspondence between microcontroller pins and HN27C101 pin functions.

The H8/3217 has 60 kbytes of PROM, and the H8/3214 has 32 kbytes. Figures 17-3 and 17-4 show memory maps of the H8/3217 and H8/3214 in PROM mode. H'FF data should be specified for unused address areas.

When programming with a PROM writer, specify an address range of H'0000 to H'F77F for the H8/3217, or H'0000 to H'7FFF for the H8/3214. Specify H'FF data for addresses equal to or greater than H'F780 for the H8/3217, or H'8000 for the H8/3214. If these areas are programmed by mistake, it may become impossible to write or verify PROM data. The same applies if page programming is attempted. Be particularly careful with microcontrollers in plastic packages, in which the PROM cannot be reprogrammed.

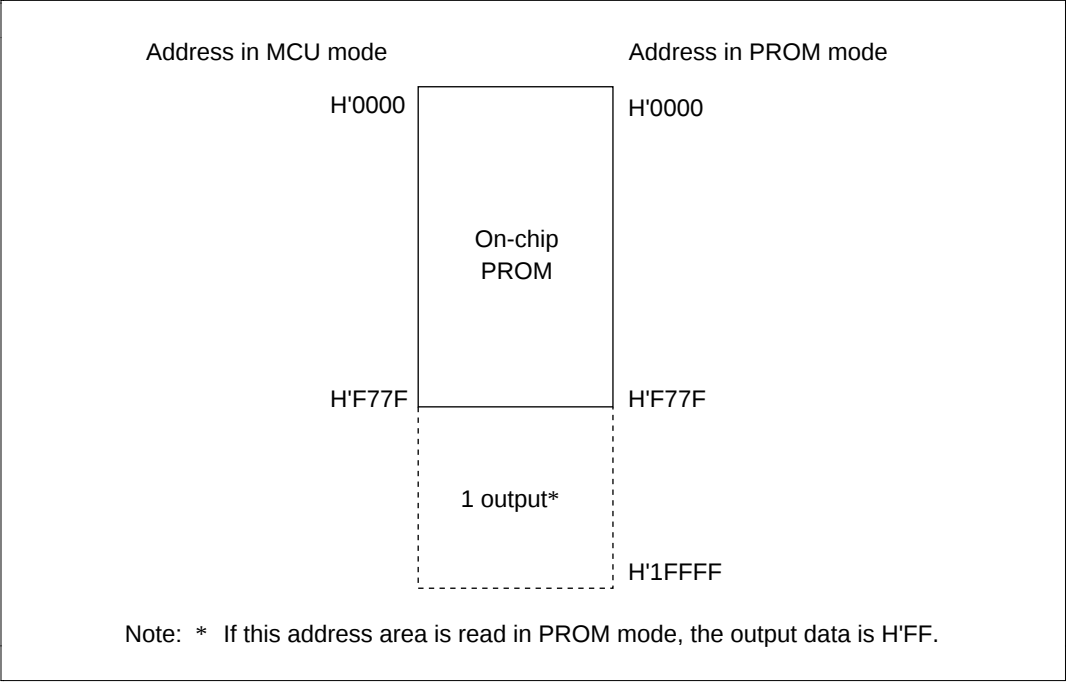
**Table 17-3 Recommended Socket Adapters**

| Type    | Package                             | Recommended Socket Adapter |
|---------|-------------------------------------|----------------------------|
| H8/3217 | 64-pin windowed shrink DIP (DC-64S) | HS3217ESSS1H               |
| H8/3214 | 64-pin shrink DIP (DP-64S)          |                            |
|         | 64-pin QFP (FP-64A)                 | HS3217ESHS1H               |
|         | 80-pin TQFP (TFP-80C)               | HS3217ESNS1H               |

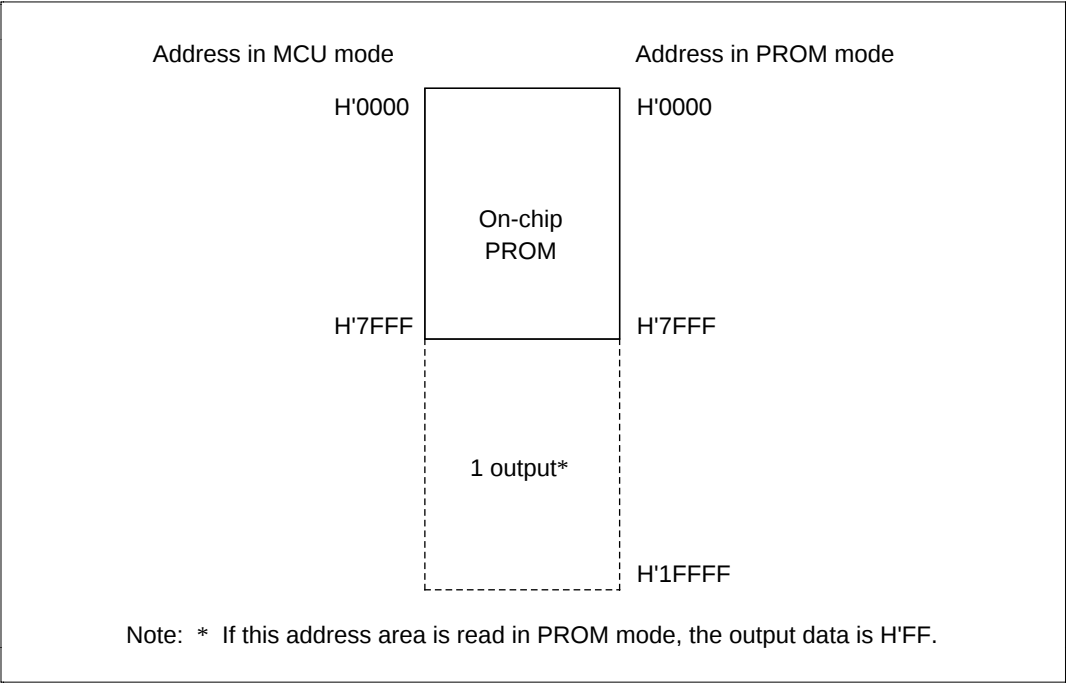


Note: All pins not listed in this figure should be left open.

**Figure 17-2 Socket Adapter Pin Assignments**



**Figure 17-3 H8/3217 Memory Map in PROM Mode**



**Figure 17-4 H8/3214 Memory Map in PROM Mode**

## 17.3 Programming

### 17.3.1 Selection of Sub-Modes in PROM Mode

The write, verify, and other sub-modes of the PROM mode are selected as shown in table 17-4.

**Table 17-4 Selection of Sub-Modes in PROM Mode**

| Sub-Mode              | Pins                   |                        |                         |                        |                        |                                |                                   |
|-----------------------|------------------------|------------------------|-------------------------|------------------------|------------------------|--------------------------------|-----------------------------------|
|                       | $\overline{\text{CE}}$ | $\overline{\text{OE}}$ | $\overline{\text{PGM}}$ | $\text{V}_{\text{PP}}$ | $\text{V}_{\text{CC}}$ | $\text{E0}_7$ to $\text{E0}_0$ | $\text{EA}_{16}$ to $\text{EA}_0$ |
| Write                 | Low                    | High                   | Low                     | $\text{V}_{\text{PP}}$ | $\text{V}_{\text{CC}}$ | Data input                     | Address input                     |
| Verify                | Low                    | Low                    | High                    | $\text{V}_{\text{PP}}$ | $\text{V}_{\text{CC}}$ | Data output                    | Address input                     |
| Programming inhibited | Low                    | Low                    | Low                     | $\text{V}_{\text{PP}}$ | $\text{V}_{\text{CC}}$ | High-impedance                 | Address input                     |
|                       | Low                    | High                   | High                    |                        |                        |                                |                                   |
|                       | High                   | Low                    | Low                     |                        |                        |                                |                                   |
|                       | High                   | High                   | High                    |                        |                        |                                |                                   |

The H8/3217 or H8/3214 PROM has the same standard read/write specifications as the HN27C101 EPROM. Page programming is not supported, however, so do not select page programming mode. PROM writers that provide only page programming cannot be used. When selecting a PROM writer, check that it supports the byte-at-a-time high-speed programming mode. Be sure to set the address range to H'0000 to H'777F for the H8/3217, and to H'0000 to H'7FFF for the H8/3214.

### 17.3.2 Programming and Verification

An efficient, high-speed programming procedure can be used to write and verify PROM data. This procedure writes data quickly without subjecting the chip to voltage stress and without sacrificing data reliability. It leaves the data H'FF written in unused addresses.

Figures 17-5 show the basic high-speed programming flowchart.

Tables 17-5 and 17-6 list the electrical characteristics of the chip in the PROM mode. Figure 17-6 shows a write/verify timing chart.

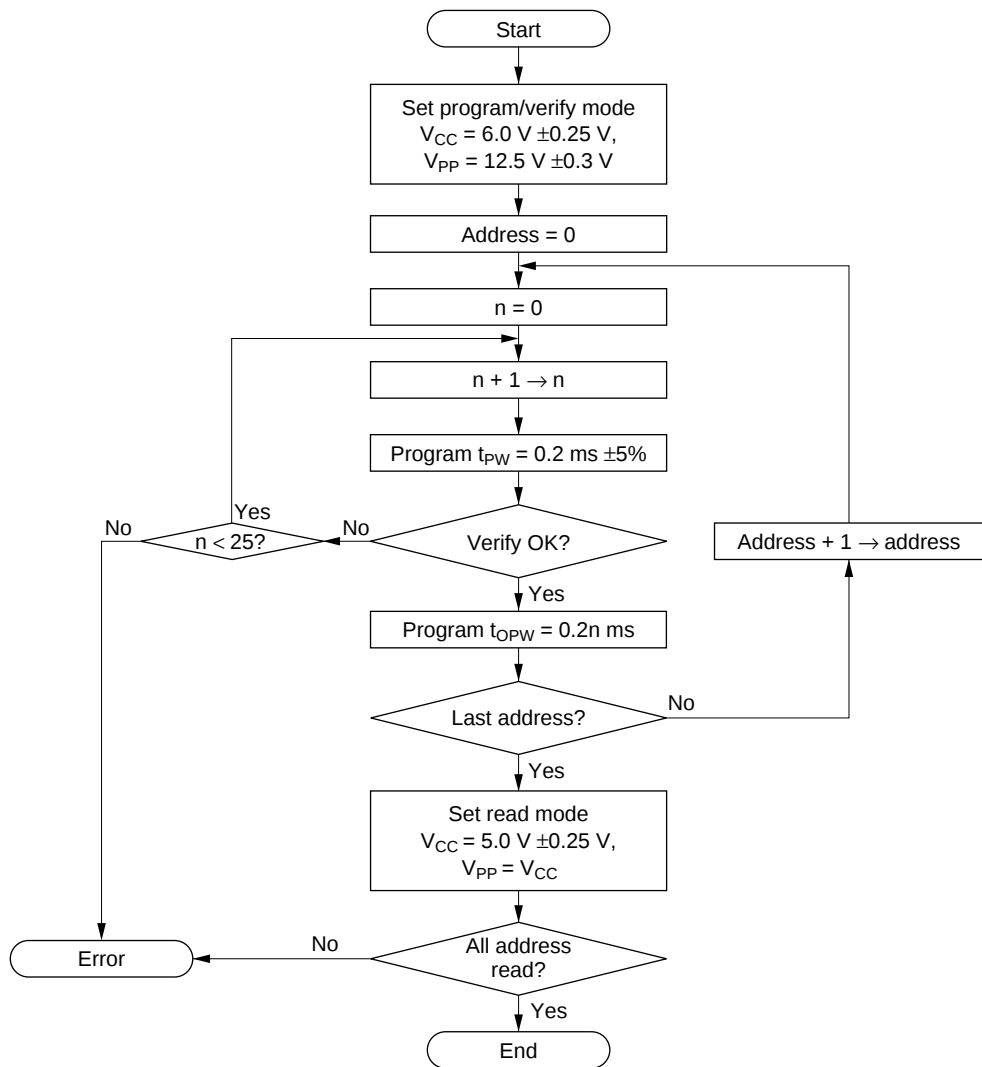


Figure 17-5 High-Speed Programming Flowchart

**Table 17-5 DC Characteristics (When  $V_{CC} = 6.0 \text{ V} \pm 0.25 \text{ V}$ ,  $V_{PP} = 12.5 \text{ V} \pm 0.3 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  
 $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$ )**

| Item                    |                                                                                             | Symbol          | Min   | Typ | Max                   | Unit | Measurement Conditions       |
|-------------------------|---------------------------------------------------------------------------------------------|-----------------|-------|-----|-----------------------|------|------------------------------|
| Input high voltage      | EO <sub>7</sub> –EO <sub>0</sub> ,<br>EA <sub>16</sub> –EA <sub>0</sub> ,<br>OE, CE,<br>PGM | V <sub>IH</sub> | 2.4   | —   | V <sub>CC</sub> + 0.3 | V    |                              |
| Input low voltage       | EO <sub>7</sub> –EO <sub>0</sub> ,<br>EA <sub>16</sub> –EA <sub>0</sub> ,<br>OE, CE,<br>PGM | V <sub>IL</sub> | – 0.3 | —   | 0.8                   | V    |                              |
| Output high voltage     | EO <sub>7</sub> –EO <sub>0</sub>                                                            | V <sub>OH</sub> | 2.4   | —   | —                     | V    | I <sub>OH</sub> = –200 μA    |
| Output low voltage      | EO <sub>7</sub> –EO <sub>0</sub>                                                            | V <sub>OL</sub> | —     | —   | 0.45                  | V    | I <sub>OL</sub> = 1.6 mA     |
| Input leakage current   | EO <sub>7</sub> –EO <sub>0</sub> ,<br>EA <sub>16</sub> –EA <sub>0</sub> ,<br>OE, CE,<br>PGM | I <sub>LI</sub> | —     | —   | 2                     | μA   | V <sub>in</sub> = 5.25V/0.5V |
| V <sub>CC</sub> current |                                                                                             | I <sub>CC</sub> | —     | —   | 40                    | mA   |                              |
| V <sub>PP</sub> current |                                                                                             | I <sub>PP</sub> | —     | —   | 40                    | mA   |                              |

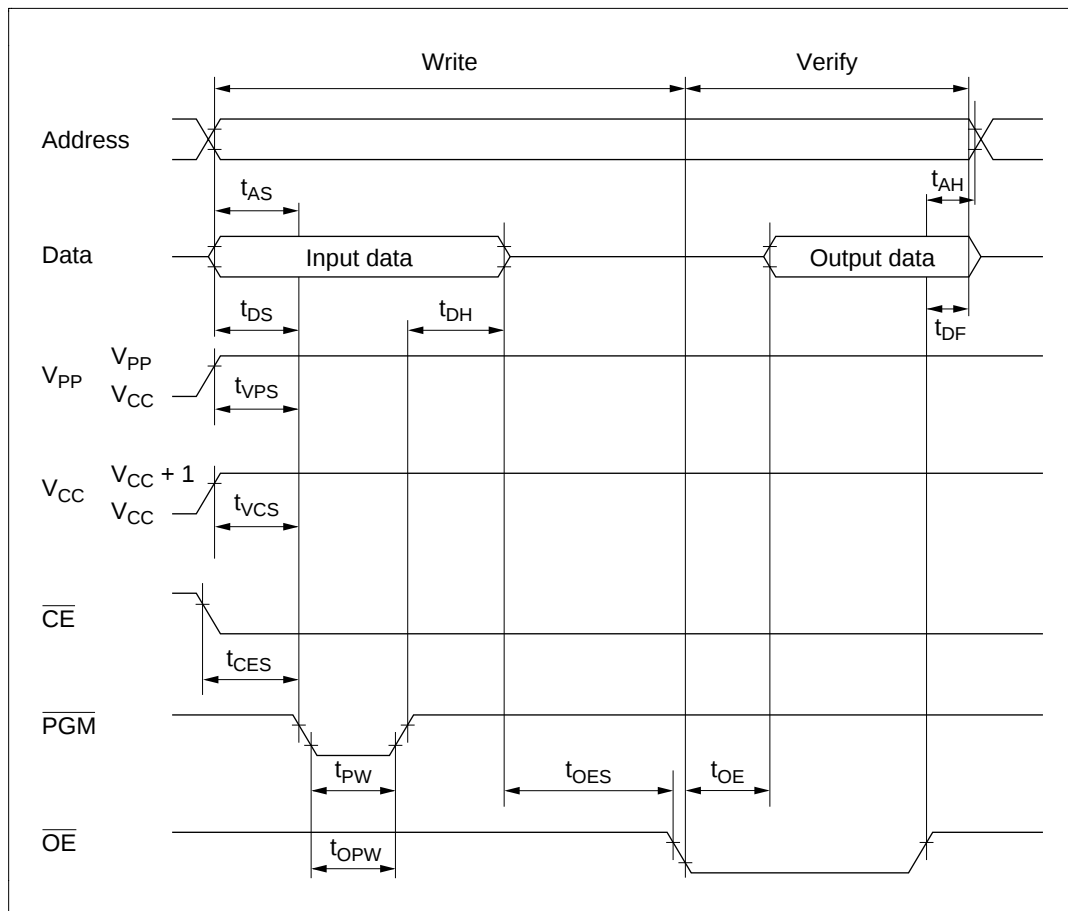
**Table 17-6 AC Characteristics (When  $V_{CC} = 6.0V \pm 0.25V$ ,  $V_{PP} = 12.5V \pm 0.3V$ ,  
 $T_a = 25^{\circ}C \pm 5^{\circ}C$ )**

| Item                                                  | Symbol    | Min  | Typ  | Max  | Unit    | Measurement Conditions |
|-------------------------------------------------------|-----------|------|------|------|---------|------------------------|
| Address setup time                                    | $t_{AS}$  | 2    | —    | —    | $\mu s$ | See figure 17-6*       |
| $\overline{OE}$ setup time                            | $t_{OES}$ | 2    | —    | —    | $\mu s$ |                        |
| Data setup time                                       | $t_{DS}$  | 2    | —    | —    | $\mu s$ |                        |
| Address hold time                                     | $t_{AH}$  | 0    | —    | —    | $\mu s$ |                        |
| Data hold time                                        | $t_{DH}$  | 2    | —    | —    | $\mu s$ |                        |
| Data output disable time                              | $t_{DF}$  | —    | —    | 130  | ns      |                        |
| $V_{PP}$ setup time                                   | $t_{VPS}$ | 2    | —    | —    | $\mu s$ |                        |
| Program pulse width                                   | $t_{PW}$  | 0.19 | 0.20 | 0.21 | ms      |                        |
| $\overline{OE}$ pulse width for overwrite-programming | $t_{OPW}$ | 0.19 | —    | 5.25 | ms      |                        |
| $V_{CC}$ setup time                                   | $t_{VCS}$ | 2    | —    | —    | $\mu s$ |                        |
| $\overline{CE}$ setup time                            | $t_{CES}$ | 2    | —    | —    | $\mu s$ |                        |
| Data output delay time                                | $t_{OE}$  | 0    | —    | 150  | ns      |                        |

Note: \* Input pulse level: 0.8 V to 2.2 V

Input rise/fall time  $\leq 20$  ns

Timing reference levels: input—1.0 V, 2.0 V; output—0.8 V, 2.0 V



**Figure 17-6 PROM Write/Verify Timing**

### 17.3.3 Notes on Writing

**(1) Write with the specified voltages and timing. The programming voltage ( $V_{pp}$ ) is 12.5 V.**

**Caution:** Applied voltages in excess of the specified values can permanently destroy the chip. Be particularly careful about the PROM writer's overshoot characteristics.

If the PROM writer is set to Hitachi HN27C101 specifications,  $V_{pp}$  will be 12.5 V.

**(2) Before writing data, check that the socket adapter and chip are correctly mounted in the PROM writer.** Overcurrent damage to the chip can result if the index marks on the PROM writer, socket adapter, and chip are not correctly aligned.

**(3) Don't touch the socket adapter or chip while writing.** Touching either of these can cause contact faults and write errors.

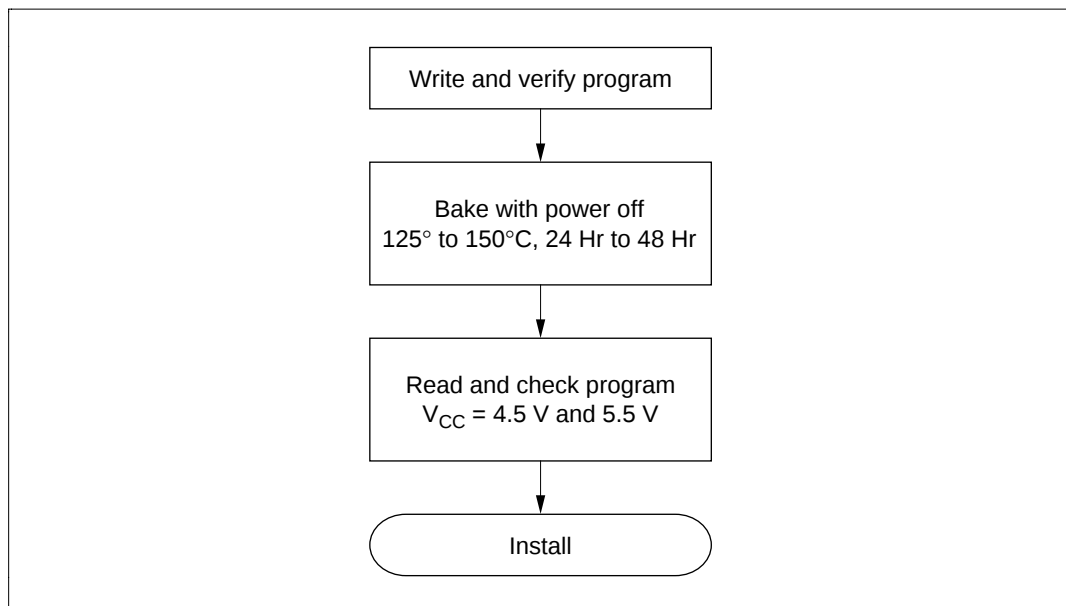
**(4) Page programming is not supported.** Do not select a fast programming mode.

**(5) The PROM size is 60 kbytes in the H8/3217 and 32 kbytes in the H8/3214.** Be sure to set an address space of H'0000 to H'F77F for the H8/3217, or H'0000 to H'7FFF for the H8/3214. H'FF data should be specified for unused address areas (H'F780 to H'1FFFF in the H8/3217, H'8000 to H'1FFFF in the H8/3214).

### 17.3.4 Reliability of Written Data

An effective way to assure the data holding characteristics of the programmed chips is to bake them at 150°C, then screen them for data errors. This procedure quickly eliminates chips with PROM memory cells prone to early failure.

Figure 17-7 shows the recommended screening procedure.



**Figure 17-7 Recommended Screening Procedure**

If a series of write errors occurs while the same PROM writer is in use, stop programming and check the PROM writer and socket adapter for defects, using a microcomputer chip with a windowed package and on-chip EPROM.

Please inform Hitachi of any abnormal conditions noted during programming or in screening of program data after high-temperature baking.

### 17.3.5 Erasing of Data

The windowed package enables data to be erased by illuminating the window with ultraviolet light. Table 17-7 lists the erasing conditions.

**Table 17-7 Erasing Conditions**

| Item                   | Value                 |
|------------------------|-----------------------|
| Ultraviolet wavelength | 253.7 nm              |
| Minimum illumination   | 15W·s/cm <sup>2</sup> |

The conditions in table 17-7 can be satisfied by placing a 12000-μW/cm<sup>2</sup> ultraviolet lamp 2 or 3 centimeters directly above the chip and leaving it on for about 20 minutes.

## 17.4 Handling of Windowed Packages

**(1) Glass Erasing Window:** Rubbing the glass erasing window of a windowed package with a plastic material or touching it with an electrically charged object can create a static charge on the window surface which may cause the chip to malfunction.

If the erasing window becomes charged, the charge can be neutralized by a short exposure to ultraviolet light. This returns the chip to its normal condition, but it also reduces the charge stored in the floating gates of the PROM, so it is recommended that the chip be reprogrammed afterward.

Accumulation of static charge on the window surface can be prevented by the following precautions:

- When handling the package, ground yourself. Don't wear gloves. Avoid other possible sources of static charge.
- Avoid friction between the glass window and plastic or other materials that tend to accumulate static charge.
- Be careful when using cooling sprays, since they may have a slight ion content.
- Cover the window with an ultraviolet-shield label, preferably a label including a conductive material. Besides protecting the PROM contents from ultraviolet light, the label protects the chip by distributing static charge uniformly.

**(2) Handling after Programming:** Fluorescent light and sunlight contain small amounts of ultraviolet, so prolonged exposure to these types of light can cause programmed data to invert. In addition, exposure to any type of intense light can induce photoelectric effects that may lead to chip malfunction. It is recommended that after programming the chip, you cover the erasing window with a light-proof label (such as an ultraviolet-shield label).

## Section 18 Power-Down State

[Key-sense interrupt function incorporated in all models except the H8/3212]

Note that the H8/3212 does not have an IRQ6 interrupt function controlled by the  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$  input signals and the KMIMR register.

### 18.1 Overview

The H8/3217 Series has a power-down state that greatly reduces power consumption by stopping some or all of the chip functions. The power-down state includes three modes:

1. Sleep mode
2. Software standby mode
3. Hardware standby mode

Table 18-1 lists the conditions for entering and leaving the power-down modes. It also indicates the status of the CPU, on-chip supporting modules, etc., in each power-down mode.

**Table 18-1 Power-Down State**

| Mode                  | Entering Procedure                                         | Clock | CPU  | CPU Reg's. | Sup. Mod.*           | RAM  | I/O Ports            | Exiting Methods                                                                                                                                                                                                                                                                                                                                             |
|-----------------------|------------------------------------------------------------|-------|------|------------|----------------------|------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sleep mode            | Execute SLEEP instruction                                  | Run   | Halt | Held       | Run                  | Held | Held                 | <ul style="list-style-type: none"><li>• Interrupt</li><li>• <math>\overline{\text{RES}}</math></li><li>• <math>\overline{\text{STBY}}</math></li></ul>                                                                                                                                                                                                      |
| Software standby mode | Set SSBY bit in SYSCR to 1, then execute SLEEP instruction | Halt  | Halt | Held       | Halt and initialized | Held | Held                 | <ul style="list-style-type: none"><li>• <math>\overline{\text{NMI}}</math></li><li>• <math>\overline{\text{IRQ}}_0</math>–<math>\overline{\text{IRQ}}_2</math></li><li>• <math>\overline{\text{KEYIN}}_0</math>–<math>\overline{\text{KEYIN}}_7</math></li><li>• <math>\overline{\text{STBY}}</math></li><li>• <math>\overline{\text{RES}}</math></li></ul> |
| Hardware standby mode | Set $\overline{\text{STBY}}$ pin to low level              | Halt  | Halt | Not held   | Halt and initialized | Held | High impedance state | <ul style="list-style-type: none"><li>• <math>\overline{\text{STBY}}</math> high, then <math>\overline{\text{RES}}</math> low → high</li></ul>                                                                                                                                                                                                              |

Notes: 1. SYSCR: System control register

2. SSBY: Software standby bit

\* On-chip supporting modules.

18.1.1 System Control Register (SYSCR)

Bits 7 to 4 of the system control register (SYSCR) concern the power-down state. Specifically, they concern the software standby mode.

Table 18-2 lists the attributes of the system control register.

Table 18-2 System Control Register

| Name                    | Abbreviation | R/W | Initial Value | Address |
|-------------------------|--------------|-----|---------------|---------|
| System control register | SYSCR        | R/W | H'09          | H'FFC4  |

|               |      |      |      |      |      |       |     |      |
|---------------|------|------|------|------|------|-------|-----|------|
| Bit           | 7    | 6    | 5    | 4    | 3    | 2     | 1   | 0    |
|               | SSBY | STS2 | STS1 | STS0 | XRST | NMIEG | HIE | RAME |
| Initial value | 0    | 0    | 0    | 0    | 1    | 0     | 0   | 1    |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R    | R/W   | R/W | R/W  |

**Bit 7—Software Standby (SSBY):** This bit enables or disables the transition to the software standby mode.

On recovery from the software standby mode by an external interrupt SSBY remains set to 1. To clear this bit, software must write a 0.

| Bit 7 |                                                                             |
|-------|-----------------------------------------------------------------------------|
| SSBY  | Description                                                                 |
| 0     | The SLEEP instruction causes a transition to the sleep mode (Initial value) |
| 1     | The SLEEP instruction causes a transition to the software standby mode      |

**Bits 6 to 4—Standby Timer Select 2 to 0 (STS2 to STS0):** These bits select the clock settling time when the chip recovers from the software standby mode by means of an external interrupt. During the selected time, the clock oscillator runs but clock pulses are not supplied to the CPU or the on-chip supporting modules. Refer to table 18-3 to select an appropriate settling time for the operating frequency.

| Bit 6<br>STS2 | Bit 5<br>STS1 | Bit 4<br>STS0 | Description                                 |
|---------------|---------------|---------------|---------------------------------------------|
| 0             | 0             | 0             | Settling time = 8192 states (Initial value) |
| 0             | 0             | 1             | Settling time = 16384 states                |
| 0             | 1             | 0             | Settling time = 32768 states                |
| 0             | 1             | 1             | Settling time = 65536 states                |
| 1             | 0             | —             | Settling time = 131072 states               |
| 1             | 1             | —             | Use prohibited                              |

## 18.2 Sleep Mode

### 18.2.1 Transition to Sleep Mode

When the SSBY bit in the system control register is cleared to 0, execution of the SLEEP instruction causes a transition from the program execution state to the sleep mode. After executing the SLEEP instruction, the CPU halts, but the contents of its internal registers remain unchanged. The on-chip supporting modules continue to operate normally.

### 18.2.2 Exit from Sleep Mode

The chip wakes up from the sleep mode when it receives an internal or external interrupt request, or a low input at the  $\overline{\text{RES}}$  or  $\overline{\text{STBY}}$  pin.

**(1) Wake-Up by Interrupt:** An interrupt releases the sleep mode and starts the CPU's interrupt-handling sequence.

If an interrupt from an on-chip supporting module is disabled by the corresponding enable/disable bit in the module's control register, the interrupt cannot be requested, so it cannot wake the chip up. Similarly, the CPU cannot be awoken by an interrupt other than NMI if the I (interrupt mask) bit in CCR (the condition code register) is set when the SLEEP instruction is executed.

**(2) Wake-Up by  $\overline{\text{RES}}$  pin:** When the  $\overline{\text{RES}}$  pin goes low, the chip exits from the sleep mode to the reset state.

**(3) Wake-Up by  $\overline{\text{STBY}}$  pin:** When the  $\overline{\text{STBY}}$  pin goes low, the chip exits from the sleep mode to the hardware standby mode.

## 18.3 Software Standby Mode

### 18.3.1 Transition to Software Standby Mode

To enter software standby mode, set the standby bit (SSBY) in the system control register (SYSCR) to 1, then execute the SLEEP instruction.

In software standby mode, the system clock stops and chip functions halt, including both CPU functions and the functions of the on-chip supporting modules. Power consumption is reduced to an extremely low level. The on-chip supporting modules and their registers are reset to their initial states, but as long as a minimum necessary voltage supply is maintained, the contents of the CPU registers and on-chip RAM remain unchanged.

### 18.3.2 Exit from Software Standby Mode

The chip can be brought out of the software standby mode by an input at one of the following pins:  $\overline{\text{NMI}}$ ,  $\text{IRQ}_0$ , to  $\text{IRQ}_2$ ,  $\overline{\text{KEYIN}}_0$  to  $\overline{\text{KEYIN}}_7$ ,  $\overline{\text{RES}}$ , or  $\overline{\text{STBY}}$ .

**(1) Recovery by External Interrupt:** When an  $\overline{\text{NMI}}$ ,  $\text{IRQ}_0$ ,  $\text{IRQ}_1$ ,  $\text{IRQ}_2$  or key-sense interrupt ( $\text{IRQ}_6$ ) request signal is received, the clock oscillator begins operating. After the waiting time set in the system control register (bits STS2 to STS0), clock pulses are supplied to the CPU and on-chip supporting modules. The CPU executes the interrupt-handling sequence for the requested interrupt, then returns to the instruction after the SLEEP instruction.

See Section 18.1.1, System Control Register, for information about the STS bits.

**(2) Recovery by  $\overline{\text{RES}}$  Pin:** When the  $\overline{\text{RES}}$  pin goes low, the clock oscillator starts. Next, when the  $\overline{\text{RES}}$  pin goes high, the CPU begins executing the reset sequence.

The  $\overline{\text{RES}}$  pin must be held low long enough for the clock to stabilize.

**(3) Recovery by  $\overline{\text{STBY}}$  Pin:** When the  $\overline{\text{STBY}}$  pin goes low, the chip exits from the software standby mode to the hardware standby mode.

### 18.3.3 Clock Settling Time for Exit from Software Standby Mode

Set bits STS2 to STS0 in SYSCR as follows:

- Crystal oscillator

Set STS2 to STS0 for a settling time of at least 8 ms. Table 18-3 lists the settling times selected by these bits at several clock frequencies.

- External clock

The STS bits can be set to any value. Normally, the minimum time (STS2 = STS1 = STS0 = 0) is recommended.

**Table 18-3 Times Set by Standby Timer Select Bits (Unit: ms)**

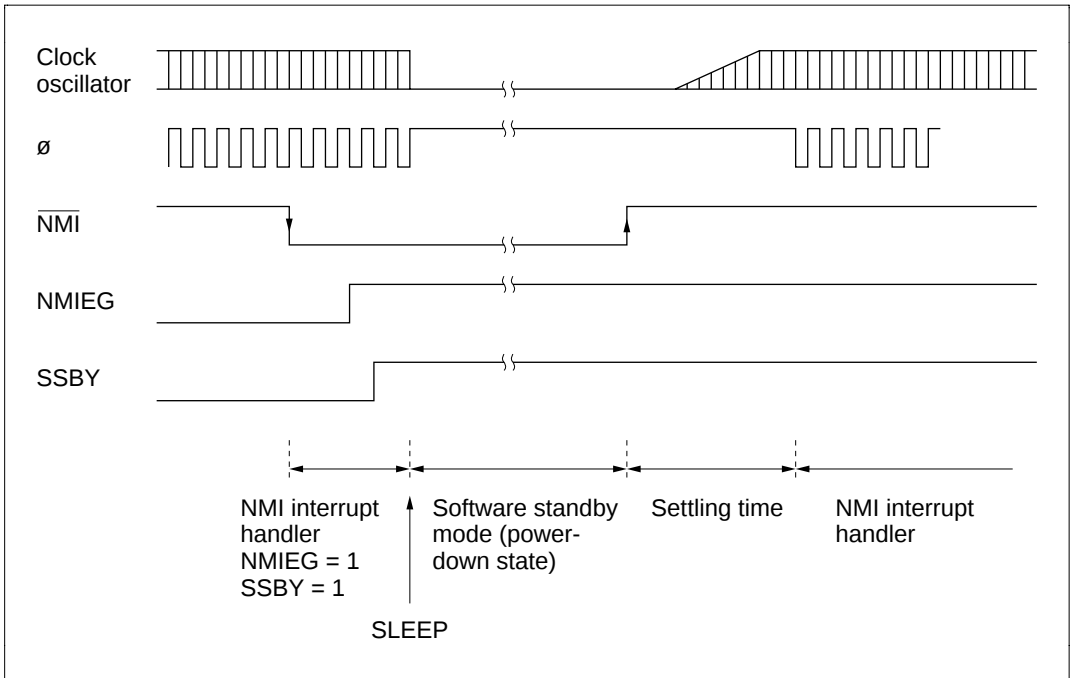
| STS2 | STS1 | STS0 | Settling<br>Time<br>(States) | System Clock Frequency (MHz) |             |             |            |             |            |            |            |             |
|------|------|------|------------------------------|------------------------------|-------------|-------------|------------|-------------|------------|------------|------------|-------------|
|      |      |      |                              | 16                           | 12          | 10          | 8          | 6           | 4          | 2          | 1          | 0.5         |
| 0    | 0    | 0    | 8.192                        | 0.51                         | 0.65        | 0.8         | 1.0        | 1.3         | 2.0        | 4.1        | <b>8.2</b> | <b>16.4</b> |
| 0    | 0    | 1    | 16,384                       | 1.0                          | 1.3         | 1.6         | 2.0        | 2.7         | 4.1        | <b>8.2</b> | 16.4       | 32.8        |
| 0    | 1    | 0    | 32,768                       | 2.0                          | 2.7         | 3.3         | 4.1        | 5.5         | <b>8.2</b> | 16.4       | 32.8       | 65.5        |
| 0    | 1    | 1    | 65,536                       | 4.1                          | 5.5         | 6.6         | <b>8.2</b> | <b>10.9</b> | 16.4       | 32.8       | 65.5       | 131.1       |
| 1    | 0    | 0    | 131,072                      | <b>8.2</b>                   | <b>10.9</b> | <b>13.1</b> | 16.4       | 21.8        | 32.8       | 65.5       | 131.1      | 262.1       |

- Notes: 1. All times are in milliseconds.  
 2. Recommended values are printed in boldface.

### 18.3.4 Sample Application of Software Standby Mode

In this example the chip enters the software standby mode when  $\overline{\text{NMI}}$  goes low and exits when  $\overline{\text{NMI}}$  goes high, as shown in figure 18-1.

The NMI edge bit (NMIEG) in the system control register is originally cleared to 0, selecting the falling edge. When  $\overline{\text{NMI}}$  goes low, the  $\overline{\text{NMI}}$  interrupt handling routine sets NMIEG to 1 (selecting the rising edge), sets SSBY to 1, then executes the SLEEP instruction. The chip enters the software standby mode. It recovers from the software standby mode on the next rising edge of  $\overline{\text{NMI}}$ .



**Figure 18-1 Software Standby Mode NMI Timing (Example)**

### 18.3.5 Note on Current Dissipation

The I/O ports remain in their current states in software standby mode. If a port is in the high output state, it continues to dissipate power in proportion to the output current.

## 18.4 Hardware Standby Mode

### 18.4.1 Transition to Hardware Standby Mode

Regardless of its current state, the chip enters the hardware standby mode whenever the  $\overline{\text{STBY}}$  pin goes low.

The hardware standby mode reduces power consumption drastically by halting the CPU, stopping all the functions of the on-chip supporting modules, and placing I/O ports in the high-impedance state. The registers of the on-chip supporting modules are reset to their initial values. Only the on-chip RAM is held unchanged, provided the minimum necessary voltage supply is maintained.

- Notes:
1. The RAME bit in the system control register should be cleared to 0 before the  $\overline{\text{STBY}}$  pin goes low, to disable the on-chip RAM during the hardware standby mode.
  2. Do not change the inputs at the mode pins ( $\text{MD}_1$ ,  $\text{MD}_0$ ) during hardware standby mode. Be particularly careful not to let both mode pins go low in hardware standby mode, since that places the chip in PROM mode and increases current drain.

### 18.4.2 Recovery from Hardware Standby Mode

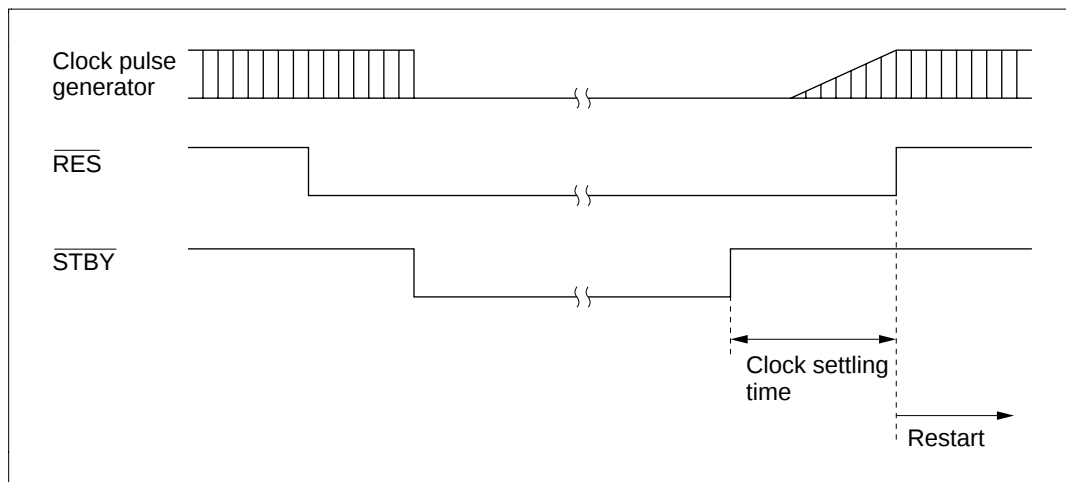
Recovery from the hardware standby mode requires inputs at both the  $\overline{\text{STBY}}$  and  $\overline{\text{RES}}$  pins.

When the  $\overline{\text{STBY}}$  pin goes high the clock oscillator begins running. The  $\overline{\text{RES}}$  pin should be low at this time and should be held low long enough for the clock to stabilize. When the  $\overline{\text{RES}}$  pin changes from low to high, the reset sequence is executed and the chip returns to the program execution state.

### 18.4.3 Timing Relationships

Figure 18-2 shows the timing relationships in the hardware standby mode.

In the sequence shown, first  $\overline{\text{RES}}$  goes low, then  $\overline{\text{STBY}}$  goes low, at which point the chip enters the hardware standby mode. To recover, first  $\overline{\text{STBY}}$  goes high, then after the clock settling time,  $\overline{\text{RES}}$  goes high.



**Figure 18-2 Hardware Standby Mode Timing**

## Section 19 Electrical Specifications

### 19.1 Absolute Maximum Ratings

Table 19-1 lists the absolute maximum ratings.

**Table 19-1 Absolute Maximum Ratings**

| Item                  | Symbol    | Rating                                | Unit |
|-----------------------|-----------|---------------------------------------|------|
| Supply voltage        | $V_{CC}$  | −0.3 to +7.0                          | V    |
| Programming voltage   | $V_{PP}$  | −0.3 to +13.5                         | V    |
| Input voltage         | $V_{in}$  | −0.3 to $V_{CC} + 0.3$                | V    |
| Operating temperature | $T_{opr}$ | Regular specifications: −20 to +75    | °C   |
|                       |           | Wide-range specifications: −40 to +85 | °C   |
| Storage temperature   | $T_{stg}$ | −55 to +125                           | °C   |

Note: Exceeding the absolute maximum ratings shown in table 19-1 can permanently damage the chip.

### 19.2 Electrical Characteristics

#### 19.2.1 DC Characteristics

Tables 19-2, 19-3, and 19-4 list the DC characteristics of the 5 V, 4 V, and 3 V versions, respectively. Table 19-5 gives the allowable current output values of the 5 V and 4 V versions, and table 19-6 gives the allowable current output values of the 3 V version. Bus drive characteristics common to the 5 V, 4 V, and 3 V versions are listed in table 19-7.

Table 19-2 DC Characteristics (5 V Version)

— Preliminary —

Conditions:  $V_{CC} = 5.0 \text{ V} \pm 10\%$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C}$  to  $+75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  (wide-range specifications)

| Item                          |                                                                                                                                                                                                                                                                                                                                   | Symbol          | Min                 | Typ | Max                 | Unit | Test Conditions             |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------|-----|---------------------|------|-----------------------------|
| Schmitt trigger input voltage | P7 <sub>7</sub> ,<br>P7 <sub>5</sub> to P7 <sub>0</sub> * <sup>3</sup> ,<br>FTCI, FTI,<br>TMR <sub>I0</sub> ,<br>TMR <sub>I1</sub> ,<br>TMC <sub>I0</sub> ,<br>TMC <sub>I1</sub> ,<br>VSYN <sub>CI</sub> ,<br>HSYN <sub>CI</sub> ,<br>CSYN <sub>CI</sub> ,<br>FBACK <sub>I</sub> ,<br>KEYIN <sub>7</sub> to<br>KEYIN <sub>0</sub> | (1) $V_T^-$     | 1.0                 | —   | —                   | V    |                             |
|                               |                                                                                                                                                                                                                                                                                                                                   | $V_T^+$         | —                   | —   | $V_{CC} \times 0.7$ |      |                             |
|                               |                                                                                                                                                                                                                                                                                                                                   | $V_T^+ - V_T^-$ | 0.4                 | —   | —                   |      |                             |
| Input high voltage            | RES, STBY,<br>MD <sub>1</sub> , MD <sub>0</sub> ,<br>EXTAL, NMI                                                                                                                                                                                                                                                                   | (2) $V_{IH}$    | $V_{CC} - 0.7$      | —   | $V_{CC} + 0.3$      | V    |                             |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> ,<br>SDA <sub>0</sub> , SDA <sub>1</sub> ,<br>P7 <sub>3</sub> , P7 <sub>2</sub><br>(when bus<br>drive function<br>is selected)                                                                                                                                                                |                 | $V_{CC} \times 0.7$ | —   | $V_{CC} + 0.3$      |      |                             |
|                               | All input pins other<br>than (1) and (2)<br>above                                                                                                                                                                                                                                                                                 |                 | 2.0                 | —   | $V_{CC} + 0.3$      |      |                             |
| Input low voltage             | RES, STBY,<br>MD <sub>1</sub> , MD <sub>0</sub>                                                                                                                                                                                                                                                                                   | (3) $V_{IL}$    | -0.3                | —   | 0.5                 | V    |                             |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> ,<br>SDA <sub>0</sub> , SDA <sub>1</sub> ,<br>P7 <sub>3</sub> , P7 <sub>2</sub><br>(when bus<br>drive function<br>is selected)                                                                                                                                                                |                 | -0.3                | —   | 1.0                 |      |                             |
|                               | All input pins other<br>than (1) and (3)<br>above                                                                                                                                                                                                                                                                                 |                 | -0.3                | —   | 0.8                 |      |                             |
| Output high voltage           | All output pins* <sup>4</sup>                                                                                                                                                                                                                                                                                                     | $V_{OH}$        | $V_{CC} - 0.5$      | —   | —                   | V    | $I_{OH} = -200 \mu\text{A}$ |
|                               |                                                                                                                                                                                                                                                                                                                                   |                 | 3.5                 | —   | —                   |      | $I_{OH} = -1.0 \text{ mA}$  |

**Table 19-2 DC Characteristics (5 V Version) (cont)**
**— Preliminary —**

Conditions:  $V_{CC} = 5.0 \text{ V} \pm 10\%$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C}$  to  $+75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  (wide-range specifications)

| Item                                       |                                                                                                                    | Symbol      | Min | Typ  | Max  | Unit          | Test Conditions                                                               |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------|-----|------|------|---------------|-------------------------------------------------------------------------------|
| Output low voltage                         | All output pins <sup>*4</sup>                                                                                      | $V_{OL}$    | —   | —    | 0.4  | V             | $I_{OL} = 1.6 \text{ mA}$                                                     |
|                                            | P1 <sub>7</sub> to P1 <sub>0</sub> ,<br>P2 <sub>7</sub> to P2 <sub>0</sub> ,<br>P3 <sub>7</sub> to P3 <sub>0</sub> |             | —   | —    | 1.0  |               | $I_{OL} = 10.0 \text{ mA}$                                                    |
| Input leakage current                      | $\overline{RES}$                                                                                                   | $ I_{in} $  | —   | —    | 10.0 | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V}$ to $V_{CC} - 0.5 \text{ V}$                          |
|                                            | $\overline{STBY}$ , $\overline{NMI}$ ,<br>MD <sub>1</sub> , MD <sub>0</sub>                                        |             | —   | —    | 1.0  |               |                                                                               |
| Leakage current in three-state (off state) | Ports 1 to 7                                                                                                       | $ I_{TSI} $ | —   | —    | 1.0  | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V}$ to $V_{CC} - 0.5 \text{ V}$                          |
| Input pull-up MOS current                  | Ports 1 to 3                                                                                                       | $-I_p$      | 30  | —    | 250  | $\mu\text{A}$ | $V_{in} = 0 \text{ V}$                                                        |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub> ,<br>P6 <sub>3</sub> to P6 <sub>0</sub>                                         |             | 60  | —    | 500  |               |                                                                               |
| Input capacitance                          | $\overline{RES}$ (4)                                                                                               | $C_{in}$    | —   | —    | 60   | pF            | $V_{in} = 0 \text{ V}$ ,<br>$f = 1 \text{ MHz}$ ,<br>$T_a = 25^\circ\text{C}$ |
|                                            | $\overline{NMI}$                                                                                                   |             | —   | —    | 50   |               |                                                                               |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub>                                                                                 |             | —   | —    | 20   |               |                                                                               |
|                                            | All input pins other than (4)                                                                                      |             | —   | —    | 15   |               |                                                                               |
| Current dissipation <sup>*1</sup>          | Normal operation                                                                                                   | $I_{CC}$    | —   | 27   | 45   | mA            | $f = 12 \text{ MHz}$                                                          |
|                                            |                                                                                                                    |             | —   | 36   | 60   |               | $f = 16 \text{ MHz}$                                                          |
|                                            | Sleep mode                                                                                                         |             | —   | 18   | 30   |               | $f = 12 \text{ MHz}$                                                          |
|                                            |                                                                                                                    |             | —   | 24   | 40   |               | $f = 16 \text{ MHz}$                                                          |
|                                            | Standby modes <sup>*2</sup>                                                                                        |             | —   | 0.01 | 5.0  | $\mu\text{A}$ | $T_a \leq 50^\circ\text{C}$                                                   |
|                                            |                                                                                                                    |             | —   | —    | 20.0 |               | $50^\circ\text{C} < T_a$                                                      |
| RAM standby voltage                        |                                                                                                                    | $V_{RAM}$   | 2.0 | —    | —    | V             |                                                                               |

- Notes: 1. Value when  $V_{IH \min} = V_{CC} - 0.5 \text{ V}$ ,  $V_{IL \max} = 0.5 \text{ V}$ , all output pins are unloaded, and input MOS pull-ups are off.
2. Value when  $V_{RAM} \leq V_{CC} < 4.5 \text{ V}$ ,  $V_{IH \min} = V_{CC} \times 0.9$  and  $V_{IL \max} = 0.3 \text{ V}$ .
3. P7<sub>7</sub> and P7<sub>5</sub> to P7<sub>0</sub> do not include SCL<sub>0</sub>, SDA<sub>0</sub>, SCL<sub>1</sub>, SDA<sub>1</sub>, HA<sub>0</sub>,  $\overline{IOW}$ ,  $\overline{CS_1}$ , and  $\overline{WAIT}$ .
4. When IICS = ICE = 0. The output low level when the bus drive function is selected with P7<sub>3</sub>, P7<sub>2</sub>, SDA<sub>1</sub>, SCL<sub>1</sub>, SDA<sub>0</sub>, and SCL<sub>0</sub> is determined separately.

**Table 19-3 DC Characteristics (4 V Version)**
**— Preliminary —**

Conditions:  $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C to } +85^\circ\text{C}$  (wide-range specifications)

| Item                          |                                                                                                                                                        | Symbol          | Min                 | Typ | Max                 | Unit | Test Conditions                            |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------|-----|---------------------|------|--------------------------------------------|
| Schmitt trigger input voltage | P7 <sub>7</sub> , (1)                                                                                                                                  | $V_T^-$         | 1.0                 | —   | —                   | V    | $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ |
|                               | P7 <sub>5</sub> to P7 <sub>0</sub> * <sup>3</sup> , FTCL, FTI,                                                                                         | $V_T^+$         | —                   | —   | $V_{CC} \times 0.7$ |      |                                            |
|                               | TMRI <sub>0</sub> , TMRI <sub>1</sub> , TMC <sub>0</sub> , TMC <sub>1</sub> , VSYNCL, HSYNCL, CSYNCL, FBACKI, KEYIN <sub>7</sub> to KEYIN <sub>0</sub> | $V_T^+ - V_T^-$ | 0.4                 | —   | —                   |      |                                            |
|                               |                                                                                                                                                        | $V_T^-$         | 0.8                 | —   | —                   |      | $V_{CC} = 4.0 \text{ V to } 4.5 \text{ V}$ |
|                               |                                                                                                                                                        | $V_T^+$         | —                   | —   | $V_{CC} \times 0.7$ |      |                                            |
|                               |                                                                                                                                                        | $V_T^+ - V_T^-$ | 0.3                 | —   | —                   |      |                                            |
| Input high voltage            | RES, STBY, MD <sub>1</sub> , MD <sub>0</sub> , EXTAL, NMI                                                                                              | $V_{IH}$        | $V_{CC} - 0.7$      | —   | $V_{CC} + 0.3$      | V    |                                            |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> , SDA <sub>0</sub> , SDA <sub>1</sub> , P7 <sub>3</sub> , P7 <sub>2</sub> (when bus drive function is selected)    |                 | $V_{CC} \times 0.7$ | —   | $V_{CC} + 0.3$      |      |                                            |
|                               | All input pins other than (1) and (2) above                                                                                                            |                 | 2.0                 | —   | $V_{CC} + 0.3$      |      |                                            |
| Input low voltage             | RES, STBY, MD <sub>1</sub> , MD <sub>0</sub>                                                                                                           | $V_{IL}$        | -0.3                | —   | 0.5                 | V    |                                            |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> , SDA <sub>0</sub> , SDA <sub>1</sub> , P7 <sub>3</sub> , P7 <sub>2</sub> (when bus drive function is selected)    |                 | -0.3                | —   | 1.0                 |      | $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ |
|                               |                                                                                                                                                        |                 | -0.3                | —   | 0.8                 |      | $V_{CC} = 4.0 \text{ V to } 4.5 \text{ V}$ |
|                               | All input pins other than (1) and (3) above                                                                                                            |                 | -0.3                | —   | 0.8                 |      | $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ |
|                               |                                                                                                                                                        |                 | -0.3                | —   | 0.6                 |      | $V_{CC} = 4.0 \text{ V to } 4.5 \text{ V}$ |

**Table 19-3 DC Characteristics (4 V Version) (cont)**
**— Preliminary —**

Conditions:  $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C to } +85^\circ\text{C}$  (wide-range specifications)

| Item                                       |                                                                                                                    | Symbol       | Min            | Typ | Max  | Unit          | Test Conditions                                                               |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|--------------|----------------|-----|------|---------------|-------------------------------------------------------------------------------|
| Output high voltage                        | All output pins*4                                                                                                  | $V_{OH}$     | $V_{CC} - 0.5$ | —   | —    | V             | $I_{OH} = -200 \mu\text{A}$                                                   |
|                                            |                                                                                                                    |              | 3.5            | —   | —    |               | $I_{OH} = -1.0 \text{ mA}$ ,<br>$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$    |
|                                            |                                                                                                                    |              | 2.8            | —   | —    |               | $I_{OH} = -1.0 \text{ mA}$ ,<br>$V_{CC} = 4.0 \text{ V to } 4.5 \text{ V}$    |
| Output low voltage                         | All output pins*4                                                                                                  | $V_{OL}$     | —              | —   | 0.4  | V             | $I_{OL} = 1.6 \text{ mA}$                                                     |
|                                            | P1 <sub>7</sub> to P1 <sub>0</sub> ,<br>P2 <sub>7</sub> to P2 <sub>0</sub> ,<br>P3 <sub>7</sub> to P3 <sub>0</sub> |              | —              | —   | 1.0  |               | $I_{OL} = 10.0 \text{ mA}$                                                    |
| Input leakage current                      | RES                                                                                                                | $ I_{in} $   | —              | —   | 10.0 | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V to } V_{CC} - 0.5 \text{ V}$                           |
|                                            | STBY, NMI,<br>MD <sub>1</sub> , MD <sub>0</sub>                                                                    |              | —              | —   | 1.0  |               |                                                                               |
| Leakage current in three-state (off state) | Ports 1 to 7                                                                                                       | $ I_{TSI} $  | —              | —   | 1.0  | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V to } V_{CC} - 0.5 \text{ V}$                           |
| Input pull-up MOS current                  | Ports 1 to 3                                                                                                       | $-I_p$       | 30             | —   | 250  | $\mu\text{A}$ | $V_{in} = 0 \text{ V}$ ,<br>$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$        |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub> ,<br>P6 <sub>3</sub> to P6 <sub>0</sub>                                         |              | 60             | —   | 500  |               |                                                                               |
|                                            | Ports 1 to 3                                                                                                       |              | 20             | —   | 200  |               | $V_{in} = 0 \text{ V}$ ,<br>$V_{CC} = 4.0 \text{ V to } 4.5 \text{ V}$        |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub> ,<br>P6 <sub>3</sub> to P6 <sub>0</sub>                                         |              | 40             | —   | 400  |               |                                                                               |
| Input capacitance                          | RES                                                                                                                | (4) $C_{in}$ | —              | —   | 60   | pF            | $V_{in} = 0 \text{ V}$ ,<br>$f = 1 \text{ MHz}$ ,<br>$T_a = 25^\circ\text{C}$ |
|                                            | NMI                                                                                                                |              | —              | —   | 50   |               |                                                                               |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub>                                                                                 |              | —              | —   | 20   |               |                                                                               |
|                                            | All input pins other than (4)                                                                                      |              | —              | —   | 15   |               |                                                                               |

**Table 19-3 DC Characteristics (4 V Version) (cont)**
**— Preliminary —**

Conditions:  $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C to } +85^\circ\text{C}$  (wide-range specifications)

| Item                  |                  | Symbol    | Min | Typ  | Max  | Unit          | Test Conditions                                                      |
|-----------------------|------------------|-----------|-----|------|------|---------------|----------------------------------------------------------------------|
| Current dissipation*1 | Normal operation | $I_{CC}$  | —   | 27   | 45   | mA            | $f = 12 \text{ MHz}$                                                 |
|                       |                  |           | —   | 36   | 60   |               | $f = 16 \text{ MHz}$ ,<br>$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ |
|                       | Sleep mode       |           | —   | 18   | 30   |               | $f = 12 \text{ MHz}$                                                 |
|                       |                  |           | —   | 24   | 40   |               | $f = 16 \text{ MHz}$ ,<br>$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ |
|                       | Standby modes*2  |           | —   | 0.01 | 5.0  | $\mu\text{A}$ | $T_a \leq 50^\circ\text{C}$                                          |
|                       |                  |           | —   | —    | 20.0 |               | $50^\circ\text{C} < T_a$                                             |
| RAM standby voltage   |                  | $V_{RAM}$ | 2.0 | —    | —    | V             |                                                                      |

- Notes: 1. Value when  $V_{IH \min} = V_{CC} - 0.5 \text{ V}$ ,  $V_{IL \max} = 0.5 \text{ V}$ , all output pins are unloaded, and input MOS pull-ups are off.
2. Value when  $V_{RAM} \leq V_{CC} < 4.0 \text{ V}$ ,  $V_{IH \min} = V_{CC} \times 0.9$  and  $V_{IL \max} = 0.3 \text{ V}$ .
3.  $P7_7$  and  $P7_5$  to  $P7_0$  do not include  $SCL_0$ ,  $SDA_0$ ,  $SCL_1$ ,  $SDA_1$ ,  $HA_0$ ,  $\overline{IOW}$ ,  $\overline{CS}_1$ , and  $\overline{WAIT}$ .
4. When  $IICS = ICE = 0$ . The output low level when the bus drive function is selected with  $P7_3$ ,  $P7_2$ ,  $SDA_1$ ,  $SCL_1$ ,  $SDA_0$ , and  $SCL_0$  is determined separately.

**Table 19-4 DC Characteristics (3 V Version)**
**— Preliminary —**

 Conditions:  $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$ 

| Item                          |                                                                                                                                                                                                                                                                 | Symbol          | Min                  | Typ | Max                  | Unit | Test Conditions             |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------------|-----|----------------------|------|-----------------------------|
| Schmitt trigger input voltage | P7 <sub>7</sub> ,<br>P7 <sub>5</sub> to P7 <sub>0</sub> *3,<br>FTCI, FTI,<br>TMRI <sub>0</sub> ,<br>TMRI <sub>1</sub> ,<br>TMCI <sub>0</sub> ,<br>TMCI <sub>1</sub> ,<br>VSYNCl,<br>HSYNCl,<br>CSYNCl,<br>FBACKI<br>KEYIN <sub>7</sub> to<br>KEYIN <sub>0</sub> | (1) $V_T^-$     | $V_{CC} \times 0.15$ | —   | —                    | V    |                             |
|                               |                                                                                                                                                                                                                                                                 | $V_T^+$         | —                    | —   | $V_{CC} \times 0.7$  |      |                             |
|                               |                                                                                                                                                                                                                                                                 | $V_T^+ - V_T^-$ | 0.2                  | —   | —                    |      |                             |
|                               |                                                                                                                                                                                                                                                                 |                 |                      |     |                      |      |                             |
| Input high voltage            | RES, $\overline{\text{STBY}}$ ,<br>MD <sub>1</sub> , MD <sub>0</sub> ,<br>EXTAL, $\overline{\text{NMI}}$                                                                                                                                                        | (2) $V_{IH}$    | $V_{CC} \times 0.9$  | —   | $V_{CC} + 0.3$       | V    |                             |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> ,<br>SDA <sub>0</sub> , SDA <sub>1</sub> ,<br>P7 <sub>3</sub> , P7 <sub>2</sub><br>(when bus<br>drive function<br>is selected)                                                                                              |                 | $V_{CC} \times 0.7$  | —   | $V_{CC} + 0.3$       |      |                             |
|                               | All input pins other<br>than (1) and (2)<br>above                                                                                                                                                                                                               |                 | $V_{CC} \times 0.7$  | —   | $V_{CC} + 0.3$       |      |                             |
| Input low voltage             | RES, $\overline{\text{STBY}}$ ,<br>MD <sub>1</sub> , MD <sub>0</sub>                                                                                                                                                                                            | (3) $V_{IL}$    | −0.3                 | —   | $V_{CC} \times 0.1$  | V    |                             |
|                               | SCL <sub>0</sub> , SCL <sub>1</sub> ,<br>SDA <sub>0</sub> , SDA <sub>1</sub> ,<br>P7 <sub>3</sub> , P7 <sub>2</sub><br>(when bus<br>drive function<br>is selected)                                                                                              |                 | −0.3                 | —   | $V_{CC} \times 0.15$ |      |                             |
|                               | All input pins other<br>than (1) and (3)<br>above                                                                                                                                                                                                               |                 | −0.3                 | —   | $V_{CC} \times 0.15$ |      |                             |
| Output high voltage           | All output pins *4                                                                                                                                                                                                                                              | $V_{OH}$        | $V_{CC} - 0.5$       | —   | —                    | V    | $I_{OH} = -200 \mu\text{A}$ |
|                               |                                                                                                                                                                                                                                                                 |                 | $V_{CC} - 1.0$       | —   | —                    |      | $I_{OH} = -1.0 \text{ mA}$  |

**Table 19-4 DC Characteristics (3 V Version) (cont)**
**— Preliminary —**

 Conditions:  $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$ 

| Item                                       |                                                                                                                    | Symbol      | Min | Typ | Max  | Unit          | Test Conditions                                                               |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------|-----|-----|------|---------------|-------------------------------------------------------------------------------|
| Output low voltage                         | All output pins* <sup>4</sup>                                                                                      | $V_{OL}$    | —   | —   | 0.4  | V             | $I_{OL} = 0.8 \text{ mA}$                                                     |
|                                            | P1 <sub>7</sub> to P1 <sub>0</sub> ,<br>P2 <sub>7</sub> to P2 <sub>0</sub> ,<br>P3 <sub>7</sub> to P3 <sub>0</sub> |             | —   | —   | 0.4  |               | $I_{OL} = 1.6 \text{ mA}$                                                     |
| Input leakage current                      | $\overline{RES}$                                                                                                   | $ I_{in} $  | —   | —   | 10.0 | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V to } V_{CC} - 0.5 \text{ V}$                           |
|                                            | $\overline{STBY}$ , $\overline{NMI}$ ,<br>MD <sub>1</sub> , MD <sub>0</sub>                                        |             | —   | —   | 1.0  |               |                                                                               |
| Leakage current in three-state (off state) | Ports 1 to 7                                                                                                       | $ I_{TSL} $ | —   | —   | 1.0  | $\mu\text{A}$ | $V_{in} = 0.5 \text{ V to } V_{CC} - 0.5 \text{ V}$                           |
| Input pull-up MOS current                  | Ports 1 to 3                                                                                                       | $-I_p$      | 3   | —   | 120  | $\mu\text{A}$ | $V_{in} = 0 \text{ V}$ ,<br>$V_{CC} = 2.7 \text{ V to } 4.0 \text{ V}$        |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub> ,<br>P6 <sub>3</sub> to P6 <sub>0</sub>                                         |             | 30  | —   | 250  |               |                                                                               |
| Input capacitance                          | $\overline{RES}$ (4)                                                                                               | $C_{in}$    | —   | —   | 60   | pF            | $V_{in} = 0 \text{ V}$ ,<br>$f = 1 \text{ MHz}$ ,<br>$T_a = 25^\circ\text{C}$ |
|                                            | $\overline{NMI}$                                                                                                   |             | —   | —   | 50   |               |                                                                               |
|                                            | P7 <sub>3</sub> to P7 <sub>0</sub>                                                                                 |             | —   | —   | 20   |               |                                                                               |
|                                            | All input pins other than (4)                                                                                      |             | —   | —   | 15   |               |                                                                               |

**Table 19-4 DC Characteristics (3 V Version) (cont)**

— Preliminary —

Conditions:  $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$

| Item                  |                  | Symbol           | Min | Typ  | Max  | Unit | Test Conditions                                 |
|-----------------------|------------------|------------------|-----|------|------|------|-------------------------------------------------|
| Current dissipation*1 | Normal operation | I <sub>CC</sub>  | —   | 7    | —    | mA   | f = 6 MHz,<br>V <sub>CC</sub> = 2.7 V to 3.6 V  |
|                       |                  |                  | —   | 12   | 22   |      | f = 10 MHz,<br>V <sub>CC</sub> = 2.7 V to 3.6 V |
|                       |                  |                  | —   | 25   | —    |      | f = 10 MHz,<br>V <sub>CC</sub> = 4.0 V to 5.5 V |
|                       | Sleep mode       |                  | —   | 5    | —    |      | f = 6 MHz,<br>V <sub>CC</sub> = 2.7 V to 3.6 V  |
|                       |                  |                  | —   | 9    | 16   |      | f = 10 MHz,<br>V <sub>CC</sub> = 2.7 V to 3.6 V |
|                       |                  |                  | —   | 18   | —    |      | f = 10 MHz,<br>V <sub>CC</sub> = 4.0 V to 5.5 V |
|                       | Standby modes*2  |                  | —   | 0.01 | 5.0  | μA   | Ta ≤ 50°C                                       |
|                       |                  |                  | —   | —    | 20.0 |      | 50°C < Ta                                       |
| RAM standby voltage   |                  | V <sub>RAM</sub> | 2.0 | —    | —    | V    |                                                 |

- Notes: 1. Value when  $V_{IH \text{ min}} = V_{CC} - 0.5 \text{ V}$ ,  $V_{IL \text{ max}} = 0.5 \text{ V}$ , all output pins are unloaded, and input MOS pull-ups are off.
2. Value when  $V_{RAM} \leq V_{CC} < 2.7 \text{ V}$ ,  $V_{IH \text{ min}} = V_{CC} \times 0.9$  and  $V_{IL \text{ max}} = 0.3 \text{ V}$ .
3.  $P7_7$  and  $P7_5$  to  $P7_0$  do not include  $SCL_0$ ,  $SDA_0$ ,  $SCL_1$ ,  $SDA_1$ ,  $HA_0$ ,  $\overline{IOW}$ ,  $\overline{CS}_1$ , and  $\overline{WAIT}$ .
4. When  $IICS = ICE = 0$ . The output low level when the bus drive function is selected with  $P7_3$ ,  $P7_2$ ,  $SDA_1$ ,  $SCL_1$ ,  $SDA_0$ , and  $SCL_0$  is determined separately.

**Table 19-5 Allowable Output Current Values  
(5 V and 4 V Versions)**

— Preliminary —

Conditions:  $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$  (regular specifications),  
 $T_a = -40^\circ\text{C to } +85^\circ\text{C}$  (wide-range specifications)

| Item                                    |                                                                                                                                                        | Symbol           | Min | Typ | Max | Unit |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|------|
| Allowable output low current (per pin)  | SCL <sub>0</sub> , SCL <sub>1</sub> , SDA <sub>0</sub> , SDA <sub>1</sub> , P7 <sub>2</sub> , P7 <sub>3</sub><br>(when bus drive function is selected) | I <sub>OL</sub>  | —   | —   | 20  | mA   |
|                                         | Ports 1, 2 and 3                                                                                                                                       |                  | —   | —   | 10  |      |
|                                         | Other output pins                                                                                                                                      |                  | —   | —   | 2   |      |
| Allowable output low current (total)    | Ports 1, 2 and 3 total                                                                                                                                 | $\Sigma I_{OL}$  | —   | —   | 80  | mA   |
|                                         | Total of all output                                                                                                                                    |                  | —   | —   | 120 |      |
| Allowable output high current (per pin) | All output pins                                                                                                                                        | -I <sub>OH</sub> | —   | —   | 2   | mA   |
| Allowable output high current (total)   | Total of all output                                                                                                                                    | $\Sigma -I_{OH}$ | —   | —   | 40  | mA   |

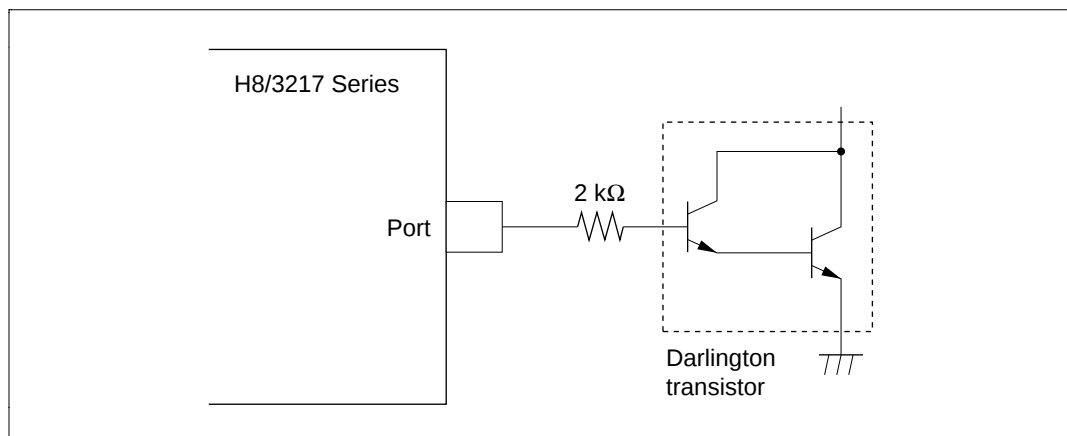
**Table 19-6 Allowable Output Current Values (3 V Version)**

— Preliminary —

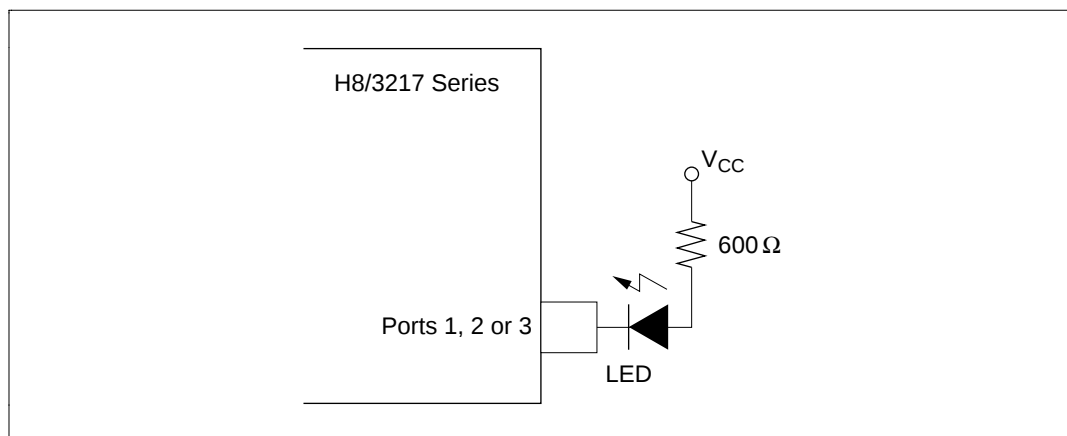
Conditions:  $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_a = -20^\circ\text{C to } +75^\circ\text{C}$

| Item                                    |                                                                                                                                                        | Symbol           | Min | Typ | Max | Unit |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|------|
| Allowable output low current (per pin)  | SCL <sub>0</sub> , SCL <sub>1</sub> , SDA <sub>0</sub> , SDA <sub>1</sub> , P7 <sub>2</sub> , P7 <sub>3</sub><br>(when bus drive function is selected) | I <sub>OL</sub>  | —   | —   | 10  | mA   |
|                                         | Ports 1, 2 and 3                                                                                                                                       |                  | —   | —   | 2   |      |
|                                         | Other output pins                                                                                                                                      |                  | —   | —   | 1   |      |
| Allowable output low current (total)    | Ports 1, 2 and 3 total                                                                                                                                 | $\Sigma I_{OL}$  | —   | —   | 40  | mA   |
|                                         | Total of all output                                                                                                                                    |                  | —   | —   | 60  |      |
| Allowable output high current (per pin) | All output pins                                                                                                                                        | -I <sub>OH</sub> | —   | —   | 2   | mA   |
| Allowable output high current (total)   | Total of all output                                                                                                                                    | $\Sigma -I_{OH}$ | —   | —   | 30  | mA   |

Note: To avoid degrading the reliability of the chip, be careful not to exceed the output current values in tables 19-5 and 19-6. In particular, when driving a Darlington transistor or LED directly, be sure to insert a current-limiting resistor in the output path. See figures 19-1 and 19-2.



**Figure 19-1 Example of Circuit for Driving a Darlington Transistor (5 V Version)**



**Figure 19-2 Example of Circuit for Driving an LED (5 V Version)**

**Table 19-7 Bus Drive Characteristics****— Preliminary —**Conditions:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = -20^{\circ}\text{C to }+75^{\circ}\text{C}$ 

| Item               |                                                                                                                                                                    | Symbol          | Min | Typ | Max | Unit | Test Conditions                                                      |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----|-----|-----|------|----------------------------------------------------------------------|
| Output low voltage | SCL <sub>0</sub> , SCL <sub>1</sub> ,<br>SDA <sub>0</sub> , SDA <sub>1</sub> ,<br>P7 <sub>2</sub> , P7 <sub>3</sub><br>(when bus<br>drive function<br>is selected) | V <sub>OL</sub> | —   | —   | 0.5 | V    | $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,<br>$I_{OL} = 16\text{ mA}$ |
|                    |                                                                                                                                                                    |                 | —   | —   | 0.5 |      | $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,<br>$I_{OL} = 8\text{ mA}$  |

### 19.2.2 AC Characteristics

The AC characteristics are listed in five tables. Bus timing parameters are given in table 19-8, control signal timing parameters in table 19-9, timing parameters of the on-chip supporting modules in table 19-10, I<sup>2</sup>C bus interface timing parameters in table 19-11, and External Clock Output Settling Delay Time in table 19-12.

**Table 19-8 Bus Timing****— Preliminary —**

Condition A:  $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition B:  $V_{CC} = 4.0\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition C:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$

| Item                      | Symbol           | Condition C |     | Condition B |     | Condition A |     | Unit | Test Conditions |
|---------------------------|------------------|-------------|-----|-------------|-----|-------------|-----|------|-----------------|
|                           |                  | 10 MHz      |     | 12 MHz      |     | 16 MHz      |     |      |                 |
|                           |                  | Min         | Max | Min         | Max | Min         | Max |      |                 |
| Clock cycle time          | t <sub>cyc</sub> | 100         | 500 | 83.3        | 500 | 62.5        | 500 | ns   | Fig. 19-4       |
| Clock pulse width low     | t <sub>CL</sub>  | 30          | —   | 30          | —   | 20          | —   |      |                 |
| Clock pulse width high    | t <sub>CH</sub>  | 30          | —   | 30          | —   | 20          | —   |      |                 |
| Clock rise time           | t <sub>Cr</sub>  | —           | 20  | —           | 10  | —           | 10  |      |                 |
| Clock fall time           | t <sub>Cf</sub>  | —           | 20  | —           | 10  | —           | 10  |      |                 |
| Address delay time        | t <sub>AD</sub>  | —           | 50  | —           | 35  | —           | 30  |      |                 |
| Address hold time         | t <sub>AH</sub>  | 20          | —   | 15          | —   | 10          | —   |      |                 |
| Address strobe delay time | t <sub>ASD</sub> | —           | 50  | —           | 35  | —           | 30  |      |                 |
| Write strobe delay time   | t <sub>WSD</sub> | —           | 50  | —           | 35  | —           | 30  |      |                 |
| Strobe delay time         | t <sub>SD</sub>  | —           | 50  | —           | 35  | —           | 30  |      |                 |
| Write strobe pulse width* | t <sub>WSW</sub> | 110         | —   | 90          | —   | 60          | —   |      |                 |
| Address setup time 1*     | t <sub>AS1</sub> | 15          | —   | 10          | —   | 10          | —   |      |                 |
| Address setup time 2*     | t <sub>AS2</sub> | 65          | —   | 50          | —   | 40          | —   |      |                 |
| Read data setup time      | t <sub>RDS</sub> | 35          | —   | 20          | —   | 20          | —   |      |                 |
| Read data hold time*      | t <sub>RDH</sub> | 0           | —   | 0           | —   | 0           | —   |      |                 |
| Read data access time*    | t <sub>ACC</sub> | —           | 170 | —           | 160 | —           | 110 |      |                 |
| Write data delay time     | t <sub>WDD</sub> | —           | 75  | —           | 60  | —           | 60  |      |                 |
| Write data setup time     | t <sub>WDS</sub> | 5           | —   | 5           | —   | 5           | —   |      |                 |
| Write data hold time      | t <sub>WDH</sub> | 20          | —   | 20          | —   | 20          | —   |      |                 |
| Wait setup time           | t <sub>WTS</sub> | 40          | —   | 35          | —   | 30          | —   |      | Fig. 19-5       |
| Wait hold time            | t <sub>WTH</sub> | 10          | —   | 10          | —   | 10          | —   |      |                 |

Note: \* Values at maximum operating frequency

Condition A:  $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition B:  $V_{CC} = 4.0\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition C:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$

| Item                                                                                                                                                                              | Symbol            | Condition C |     | Condition B |     | Condition A |     | Unit             | Test Conditions |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------|-----|-------------|-----|-------------|-----|------------------|-----------------|
|                                                                                                                                                                                   |                   | 10 MHz      |     | 12 MHz      |     | 16 MHz      |     |                  |                 |
|                                                                                                                                                                                   |                   | Min         | Max | Min         | Max | Min         | Max |                  |                 |
| $\overline{\text{RES}}$ setup time                                                                                                                                                | $t_{\text{RESS}}$ | 300         | —   | 200         | —   | 200         | —   | ns               | Fig. 19-6       |
| $\overline{\text{RES}}$ pulse width                                                                                                                                               | $t_{\text{RESW}}$ | 10          | —   | 10          | —   | 10          | —   | $t_{\text{cyc}}$ |                 |
| $\overline{\text{NMI}}$ setup time<br>( $\overline{\text{NMI}}$ , $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ , $\overline{\text{IRQ}}_6$ )                            | $t_{\text{NMIS}}$ | 300         | —   | 150         | —   | 150         | —   | ns               | Fig. 19-7       |
| $\overline{\text{NMI}}$ hold time<br>( $\overline{\text{NMI}}$ , $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ , $\overline{\text{IRQ}}_6$ )                             | $t_{\text{NMIH}}$ | 10          | —   | 10          | —   | 10          | —   |                  |                 |
| Interrupt pulse width for recovery from software standby mode<br>( $\overline{\text{NMI}}$ , $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_2$ , $\overline{\text{IRQ}}_6$ ) | $t_{\text{NMIW}}$ | 300         | —   | 200         | —   | 200         | —   |                  |                 |
| Crystal oscillator settling time (reset)                                                                                                                                          | $t_{\text{OSC1}}$ | 20          | —   | 20          | —   | 20          | —   | ms               | Fig. 19-8       |
| Crystal oscillator settling time (software standby)                                                                                                                               | $t_{\text{OSC2}}$ | 8           | —   | 8           | —   | 8           | —   |                  | Fig. 19-9       |

## Measurement Conditions for AC Characteristics

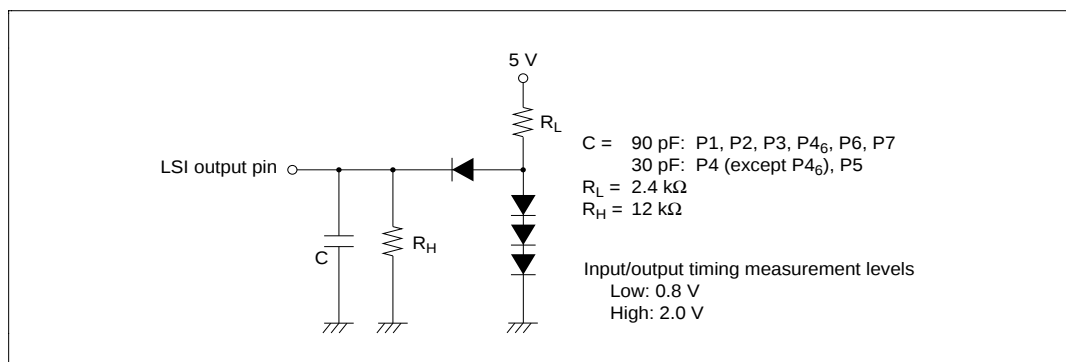


Figure 19-3 Test Conditions for AC Characteristics

**Table 19-10 Timing Conditions of On-Chip Supporting Modules****— Preliminary —**

Condition A:  $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition B:  $V_{CC} = 4.0\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition C:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$

| Item |                                       | Symbol                                   | Condition C |        | Condition B |        | Condition A |        | Unit              | Test Conditions |
|------|---------------------------------------|------------------------------------------|-------------|--------|-------------|--------|-------------|--------|-------------------|-----------------|
|      |                                       |                                          | 10 MHz      |        | 12 MHz      |        | 16 MHz      |        |                   |                 |
|      |                                       |                                          | Min         | Max    | Min         | Max    | Min         | Max    |                   |                 |
| FRT  | Timer output delay time               | t <sub>FTOD</sub>                        | —           | 150    | —           | 100    | —           | 100    | ns                | Fig. 19-10      |
|      | Timer input setup time                | t <sub>FTIS</sub>                        | 80          | —      | 50          | —      | 50          | —      |                   |                 |
|      | Timer clock input setup time          | t <sub>FTCS</sub>                        | 80          | —      | 50          | —      | 50          | —      |                   | Fig. 19-11      |
|      | Timer clock pulse width               | t <sub>FTCWH</sub><br>t <sub>FTCWL</sub> | 1.5         | —      | 1.5         | —      | 1.5         | —      | t <sub>cyc</sub>  |                 |
| TMR  | Timer output delay time               | t <sub>TMOD</sub>                        | —           | 150    | —           | 100    | —           | 100    | ns                | Fig. 19-12      |
|      | Timer reset input setup time          | t <sub>TMRS</sub>                        | 80          | —      | 50          | —      | 50          | —      |                   | Fig. 19-14      |
|      | Timer clock input setup time          | t <sub>TMCS</sub>                        | 80          | —      | 50          | —      | 50          | —      |                   | Fig. 19-13      |
|      | Timer clock pulse width (single edge) | t <sub>TMCWH</sub><br>t <sub>TMCWL</sub> | 1.5         | —      | 1.5         | —      | 1.5         | —      | t <sub>cyc</sub>  |                 |
|      | Timer clock pulse width (both edges)  |                                          | 2.5         | —      | 2.5         | —      | 2.5         | —      |                   |                 |
| PWM  | Timer output delay time               | t <sub>PWOD</sub>                        | —           | 150    | —           | 100    | —           | 100    | ns                | Fig. 19-15      |
| SCI  | Input clock cycle                     | (Async) t <sub>Scyc</sub><br>(Sync)      | 4<br>6      | —<br>— | 4<br>6      | —<br>— | 4<br>6      | —<br>— | t <sub>cyc</sub>  | Fig. 19-16      |
|      | Transmit data delay time (Sync)       | t <sub>TXD</sub>                         | —           | 200    | —           | 100    | —           | 100    | ns                |                 |
|      | Receive data setup time (Sync)        | t <sub>RXS</sub>                         | 150         | —      | 100         | —      | 100         | —      |                   |                 |
|      | Receive data hold time (Sync)         | t <sub>RXH</sub>                         | 150         | —      | 100         | —      | 100         | —      |                   |                 |
|      | Input clock pulse width               | t <sub>SCKW</sub>                        | 0.4         | 0.6    | 0.4         | 0.6    | 0.4         | 0.6    | t <sub>Scyc</sub> | Fig. 19-17      |

**Table 19-10 Timing Conditions of On-Chip Supporting Modules (cont) — Preliminary —**

Condition A:  $V_{CC} = 4.5\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition B:  $V_{CC} = 4.0\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$  (regular specifications),  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$  (wide-range specifications)

Condition C:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $\phi = 2.0\text{ MHz}$  to maximum operating frequency,  $T_a = -20^\circ\text{C to }+75^\circ\text{C}$

| Item            |                                 |                   | Condition C |     | Condition B |     | Condition A |     | Unit | Test Conditions |
|-----------------|---------------------------------|-------------------|-------------|-----|-------------|-----|-------------|-----|------|-----------------|
|                 |                                 |                   | 10 MHz      |     | 12 MHz      |     | 16 MHz      |     |      |                 |
|                 |                                 |                   | Min         | Max | Min         | Max | Min         | Max |      |                 |
| PORT            | Output data delay time          | t <sub>PWD</sub>  | —           | 150 | —           | 100 | —           | 100 | ns   | Fig. 19-18      |
|                 | Input data setup time           | t <sub>PRS</sub>  | 80          | —   | 50          | —   | 50          | —   |      |                 |
|                 | Input data hold time            | t <sub>PRH</sub>  | 80          | —   | 50          | —   | 50          | —   |      |                 |
| HIF read cycle  | $\overline{CS}/HA_0$ setup time | t <sub>HAR</sub>  | 10          | —   | 10          | —   | 10          | —   | ns   | Fig. 19-19      |
|                 | $\overline{CS}/HA_0$ hold time  | t <sub>HRA</sub>  | 10          | —   | 10          | —   | 10          | —   |      |                 |
|                 | $\overline{IOR}$ pulse width    | t <sub>HRPW</sub> | 220         | —   | 120         | —   | 120         | —   |      |                 |
|                 | HDB delay time                  | t <sub>HRD</sub>  | —           | 200 | —           | 100 | —           | 100 |      |                 |
|                 | HDB hold time                   | t <sub>HRF</sub>  | 0           | 40  | 0           | 25  | 0           | 25  |      |                 |
|                 | HIRQ delay time                 | t <sub>HIRQ</sub> | —           | 200 | —           | 120 | —           | 120 |      |                 |
| HIF write cycle | $\overline{CS}/HA_0$ setup time | t <sub>HAW</sub>  | 10          | —   | 10          | —   | 10          | —   | ns   | Fig. 19-20      |
|                 | $\overline{CS}/HA_0$ hold time  | t <sub>HWA</sub>  | 10          | —   | 10          | —   | 10          | —   |      |                 |
|                 | $\overline{IOW}$ pulse width    | t <sub>HWPW</sub> | 100         | —   | 60          | —   | 60          | —   |      |                 |
|                 | HDB setup time                  | t <sub>HDW</sub>  | 50          | —   | 30          | —   | 30          | —   |      |                 |
|                 | HDB hold time                   | t <sub>HWD</sub>  | 25          | —   | 15          | —   | 15          | —   |      |                 |
|                 | GA <sub>20</sub> delay time     | t <sub>HGA</sub>  | —           | 180 | —           | 90  | —           | 90  |      |                 |

**Table 19-11 I<sup>2</sup>C Bus Timing****— Preliminary —**Conditions:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = -20^{\circ}\text{C to }+75^{\circ}\text{C}$ 

| Item                                  | Symbol     | Min              | Typ | Max  | Unit | Test Conditions                      | Note       |
|---------------------------------------|------------|------------------|-----|------|------|--------------------------------------|------------|
| SCL clock cycle time                  | $t_{SCL}$  | $12t_{cyc}$      | —   | —    | ns   |                                      | Fig. 19-21 |
| SCL clock high pulse width            | $t_{SCLH}$ | $3t_{cyc}$       | —   | —    | ns   |                                      |            |
| SCL clock low pulse width             | $t_{SCLL}$ | $5t_{cyc}$       | —   | —    | ns   |                                      |            |
| SCL, SDA rise time                    | $t_{Sr}$   | —                | —   | 1000 | ns   | Normal mode<br>100 kbits/s (max)     |            |
|                                       |            | $20 + 0.1C_b$    | —   | 300  |      | High-speed mode<br>400 kbits/s (max) |            |
| SCL, SDA fall time                    | $t_{Sf}$   | —                | —   | 300  | ns   | Normal mode<br>100 kbits/s (max)     |            |
|                                       |            | $20 + 0.1C_b$    | —   | 300  |      | High-speed mode<br>400 kbits/s (max) |            |
| SDA bus free time                     | $t_{BUF}$  | $7t_{cyc} - 300$ | —   | —    | ns   |                                      |            |
| SCL start condition hold time         | $t_{STAH}$ | $3t_{cyc}$       | —   | —    | ns   |                                      |            |
| SCL resend start condition setup time | $t_{STAS}$ | $3t_{cyc}$       | —   | —    | ns   |                                      |            |
| SDA stop condition setup time         | $t_{STOS}$ | $3t_{cyc}$       | —   | —    | ns   |                                      |            |
| SDA data setup time                   | $t_{SDAS}$ | $1t_{cyc} + 10$  | —   | —    | ns   |                                      |            |
| SDA data hold time                    | $t_{SDAH}$ | 0                | —   | —    | ns   |                                      |            |
| SDA load capacitance                  | $C_b$      | —                | —   | 400  | pF   |                                      |            |

**Table 19-12 External Clock Output Settling Delay Time****— Preliminary —**Conditions:  $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = -40^{\circ}\text{C to }+85^{\circ}\text{C}$ 

| Item                                      | Symbol       | Min | Max | Unit          | Notes        |
|-------------------------------------------|--------------|-----|-----|---------------|--------------|
| External clock output settling delay time | $t_{DEXT}^*$ | 500 | —   | $\mu\text{s}$ | Figure 19-22 |

Note: \*  $t_{DEXT}$  includes a 10  $t_{cyc}$   $\overline{\text{RES}}$  pulse width ( $t_{RESW}$ ).

## 19.3 MCU Operational Timing

This section provides the following timing charts:

|         |                                                |                         |
|---------|------------------------------------------------|-------------------------|
| 19.3.1  | Bus Timing                                     | Figures 19-4 and 19-5   |
| 19.3.2  | Control Signal Timing                          | Figures 19-6 to 19-9    |
| 19.3.3  | 16-Bit Free-Running Timer Timing               | Figures 19-10 and 19-11 |
| 19.3.4  | 8-Bit Timer Timing                             | Figures 19-12 to 19-14  |
| 19.3.5  | Pulse Width Modulation Timer Timing            | Figure 19-15            |
| 19.3.6  | Serial Communication Interface Timing          | Figures 19-16 and 19-17 |
| 19.3.7  | I/O Port Timing                                | Figure 19-18            |
| 19.3.8  | Host Interface Timing                          | Figure 19-19 and 19-20  |
| 19.3.9  | I <sup>2</sup> C Bus Interface Timing (Option) | Figure 19-21            |
| 19.3.10 | External Clock Output Timing                   | Figure 19-22            |

### 19.3.1 Bus Timing

#### (1) Basic Bus Cycle (without Wait States) in Expanded Modes

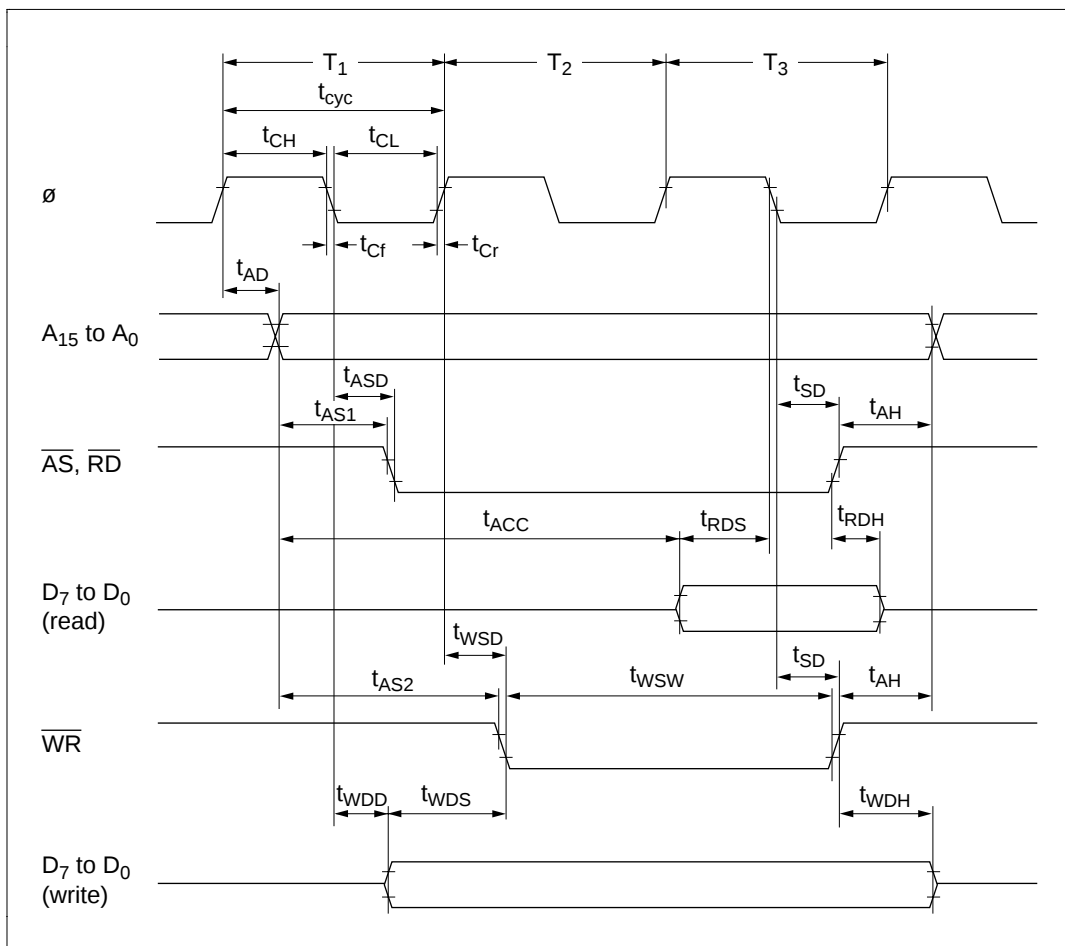
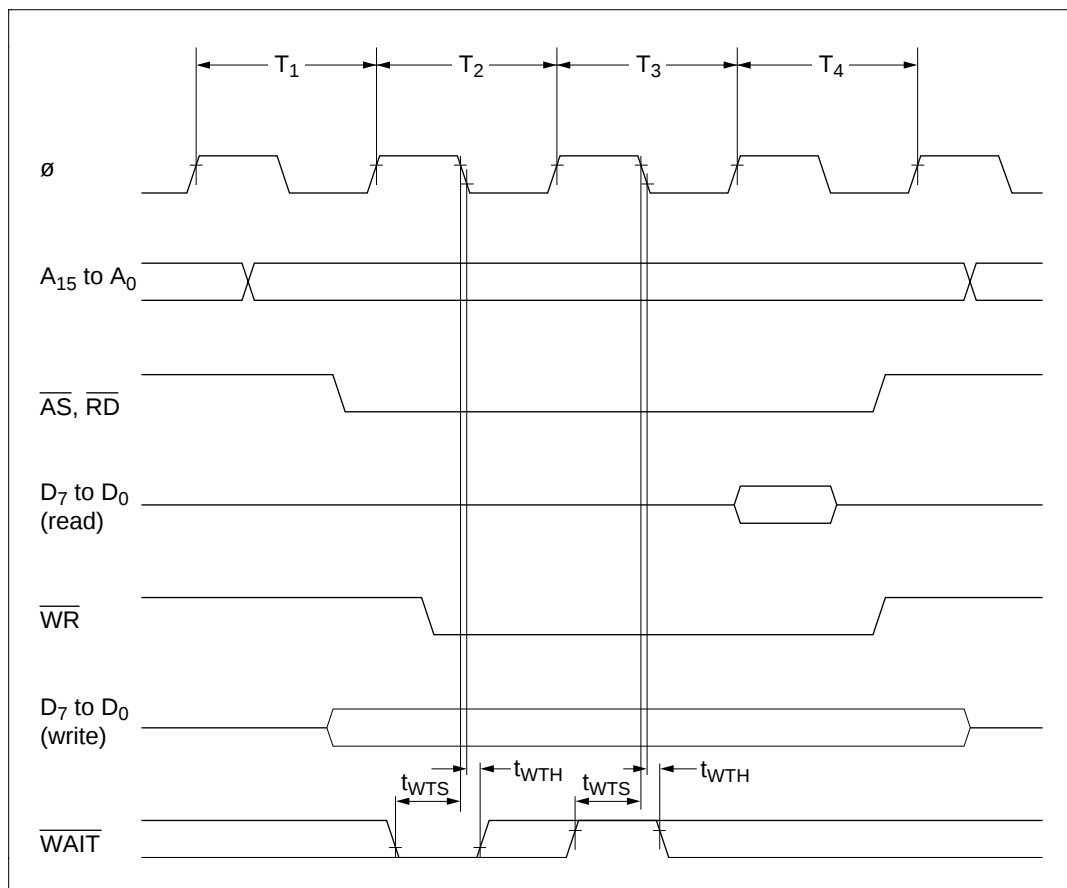


Figure 19-4 Basic Bus Cycle (without Wait States) in Expanded Modes

## (2) Basic Bus Cycle (with 1 Wait State) in Expanded Modes



**Figure 19-5 Basic Bus Cycle (with 1 Wait State) in Expanded Modes**

## 19.3.2 Control Signal Timing

### (1) Reset Input Timing

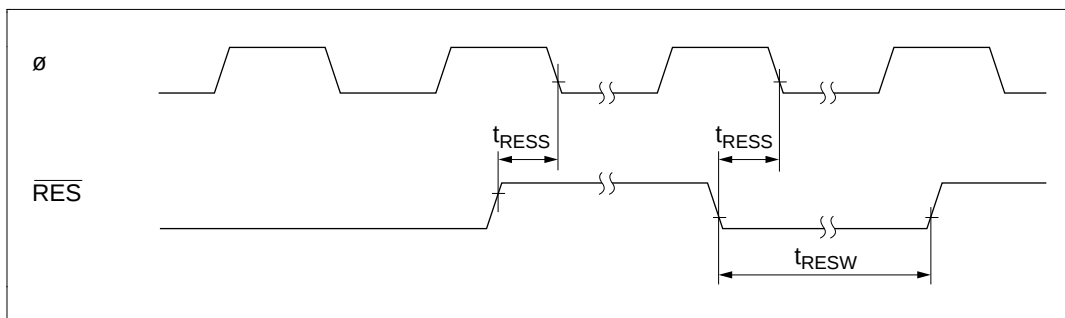


Figure 19-6 Reset Input Timing

### (2) Interrupt Input Timing

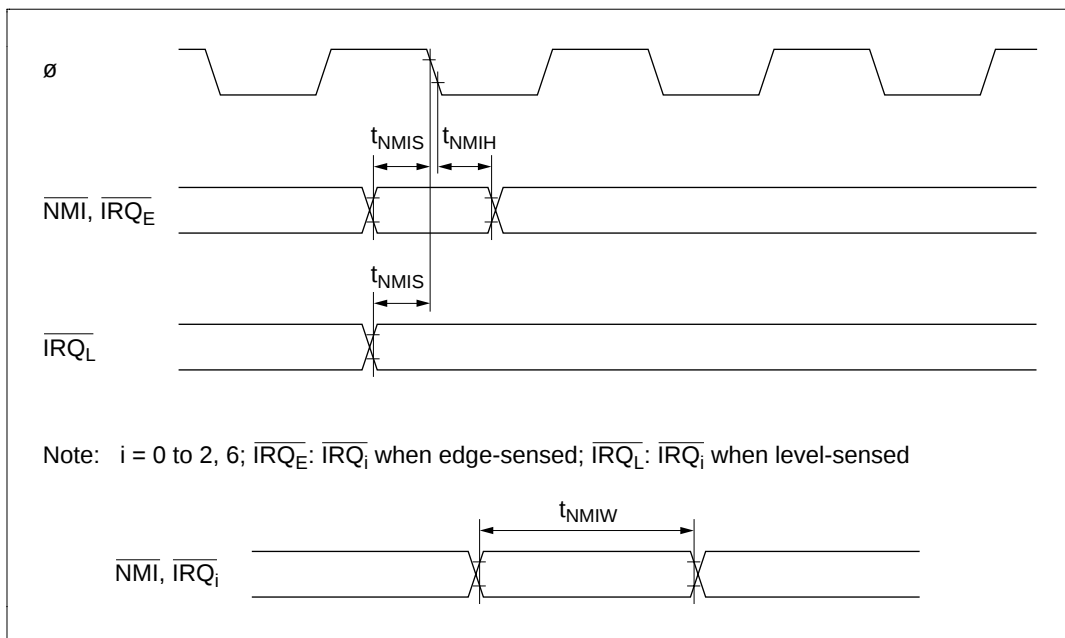


Figure 19-7 Interrupt Input Timing

### (3) Clock Settling Timing

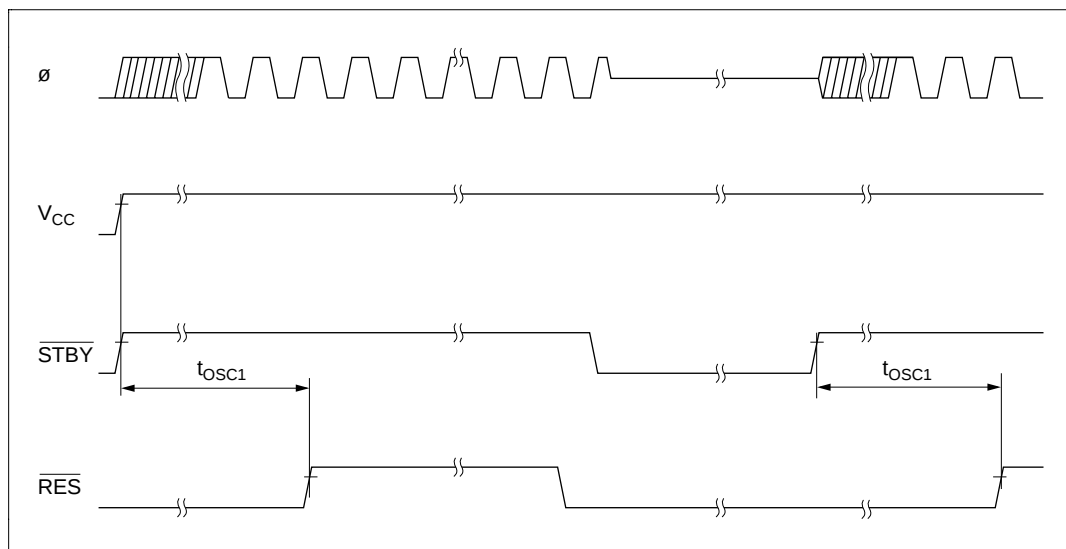


Figure 19-8 Clock Settling Timing

### (4) Clock Settling Timing for Recovery from Software Standby Mode

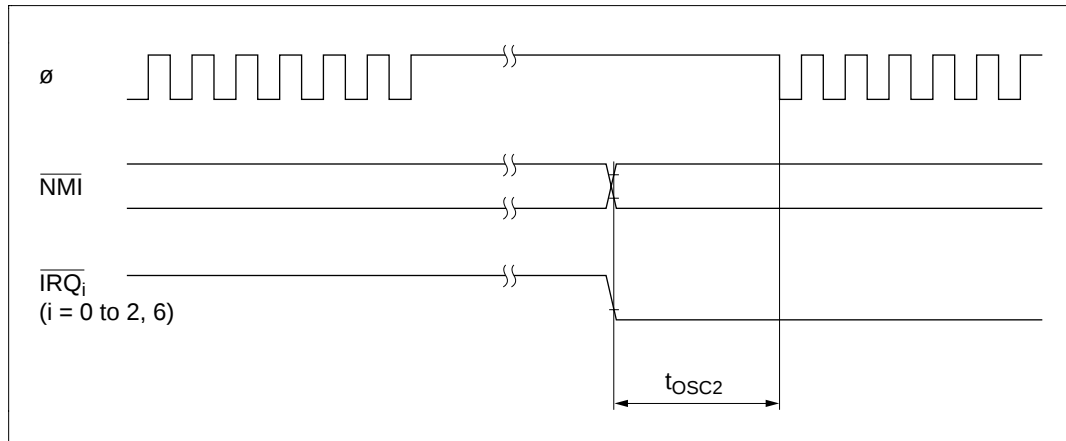


Figure 19-9 Clock Settling Timing for Recovery from Software Standby Mode

19.3.3 16-Bit Free-Running Timer Timing

(1) Free-Running Timer Input/Output Timing

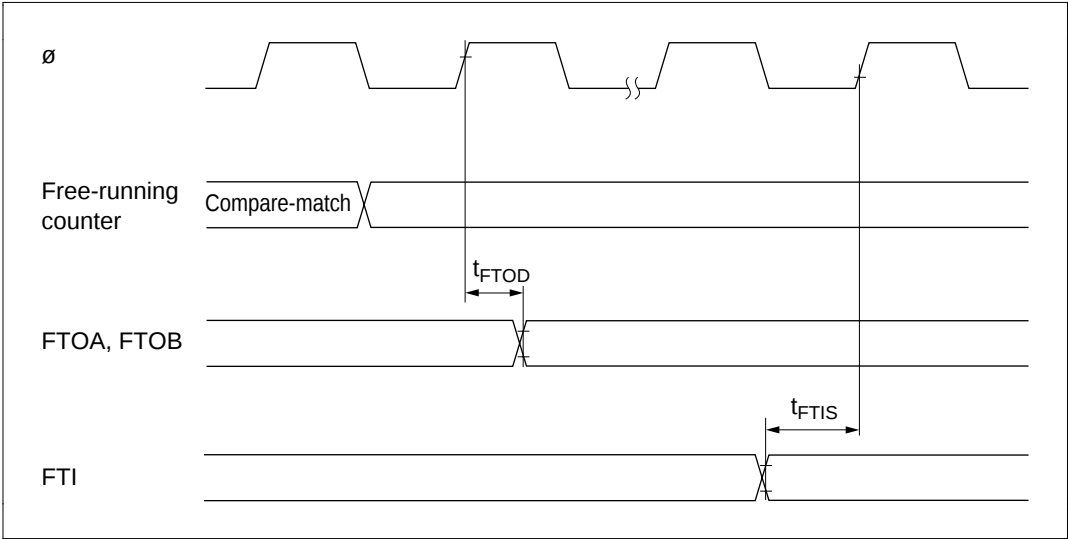


Figure 19-10 Free-Running Timer Input/Output Timing

(2) External Clock Input Timing for Free-Running Timer

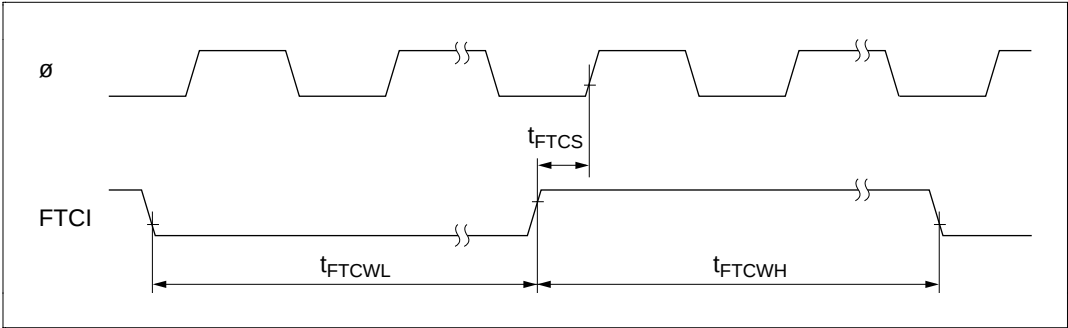


Figure 19-11 External Clock Input Timing for Free-Running Timer

19.3.4 8-Bit Timer Timing

(1) 8-Bit Timer Output Timing

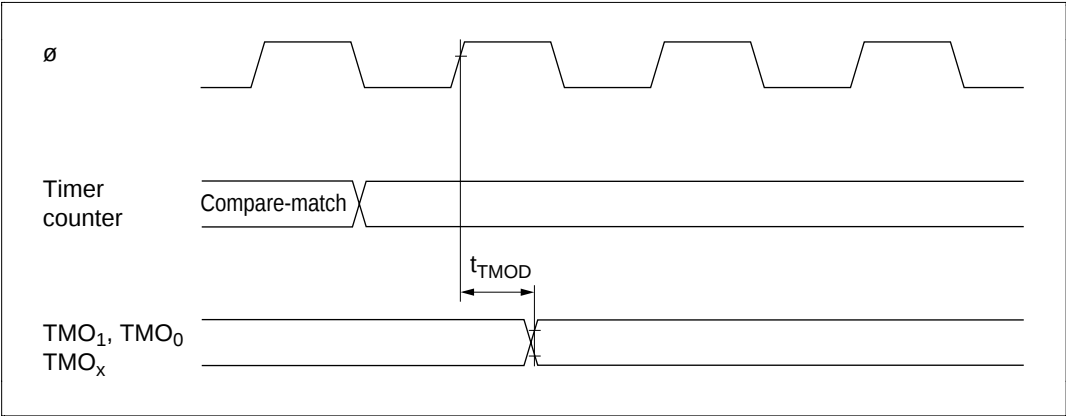


Figure 19-12 8-Bit Timer Output Timing

(2) 8-Bit Timer Clock Input Timing

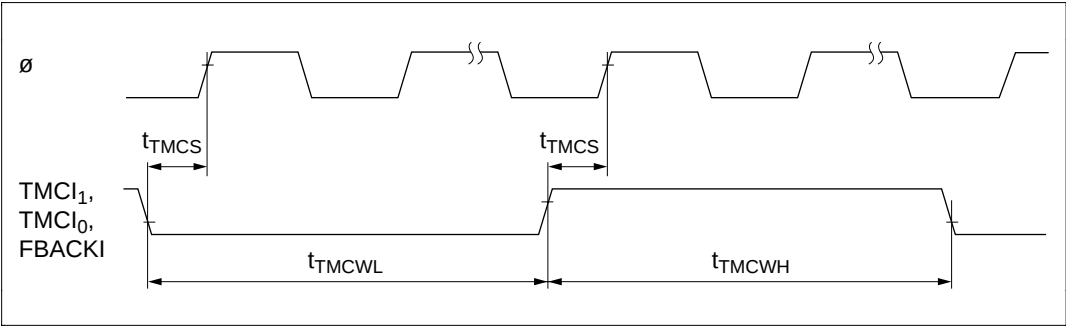


Figure 19-13 8-Bit Timer Clock Input Timing

### (3) 8-Bit Timer Reset Input Timing

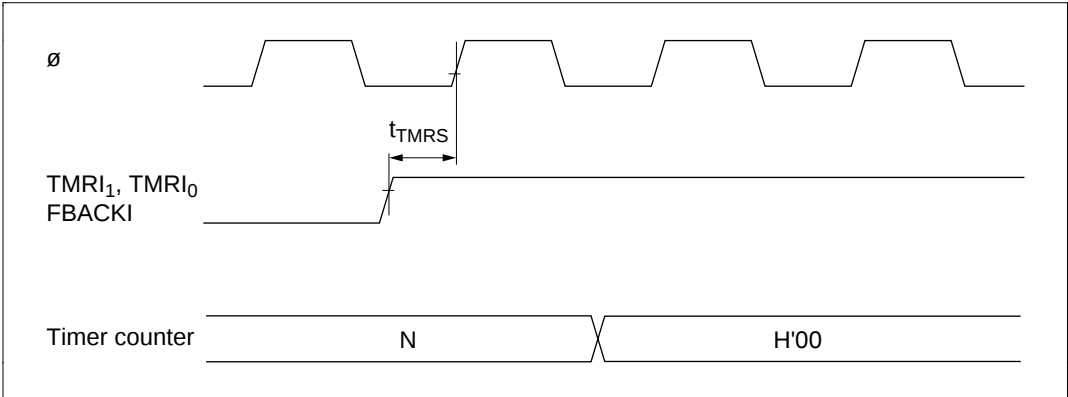


Figure 19-14 8-Bit Timer Reset Input Timing

### 19.3.5 Pulse Width Modulation Timer Output Timing

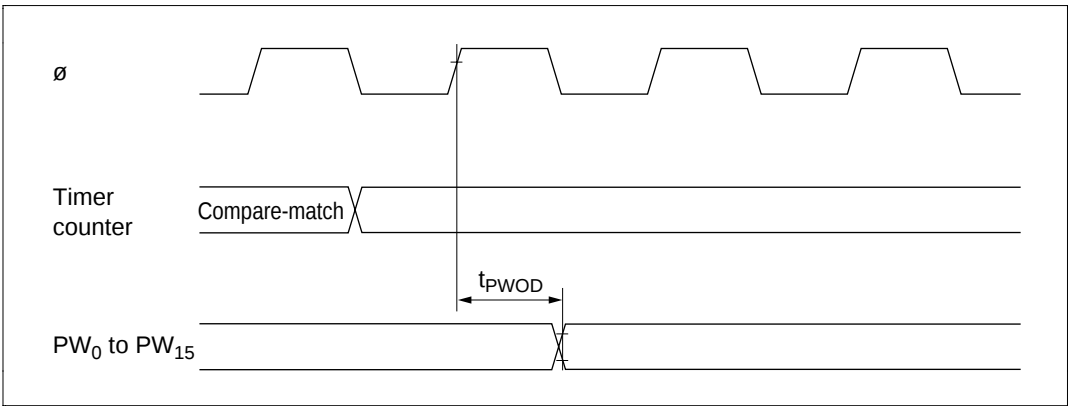


Figure 19-15 Pulse Width Modulation Timer Output Timing

## 19.3.6 Serial Communication Interface Timing

### (1) SCI Input/Output Timing

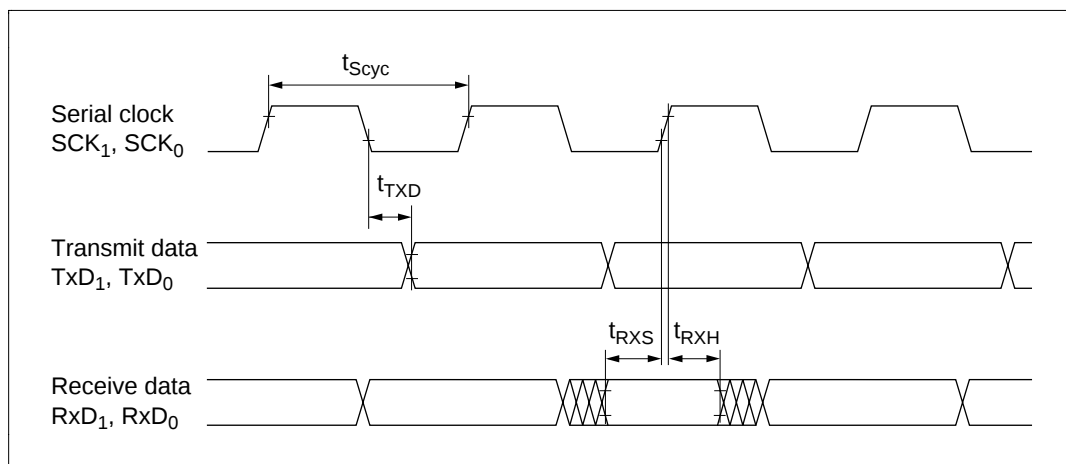


Figure 19-16 SCI Input/Output Timing (Synchronous Mode)

### (2) SCI Input Clock Timing

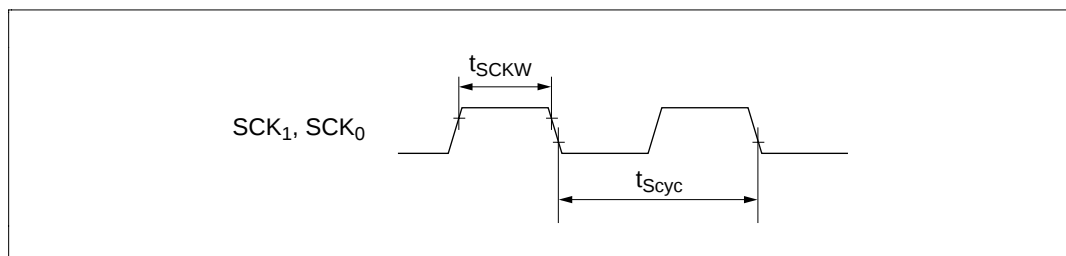


Figure 19-17 SCI Input Clock Timing

19.3.7 I/O Port Timing

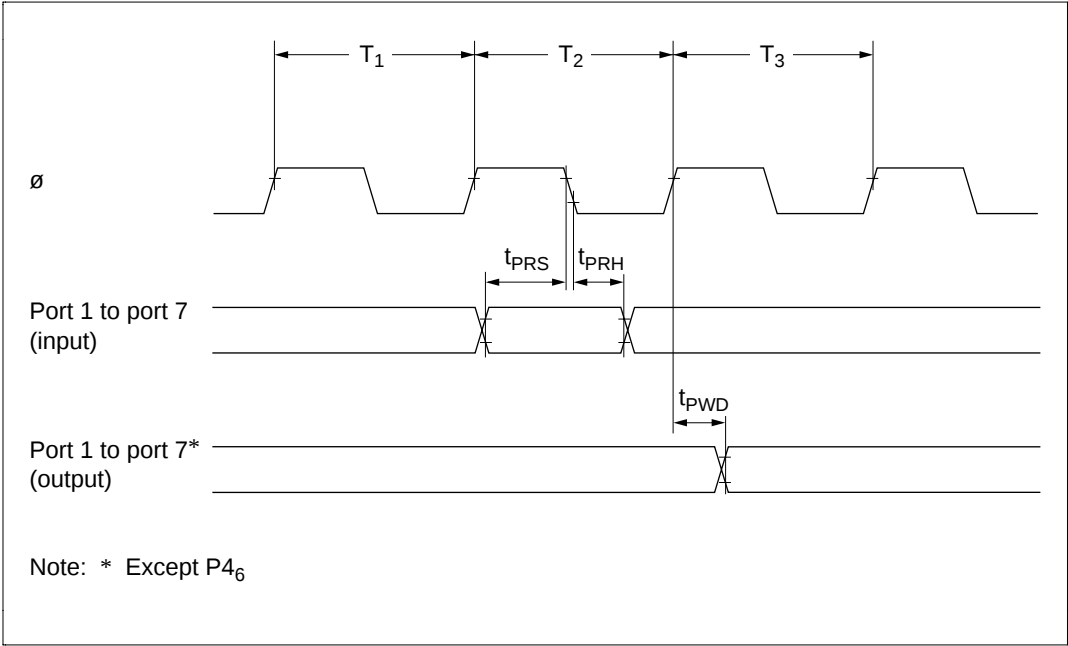


Figure 19-18 I/O Port Input/Output Timing

### 19.3.8 Host Interface Timing

#### (1) Host Interface Read Timing

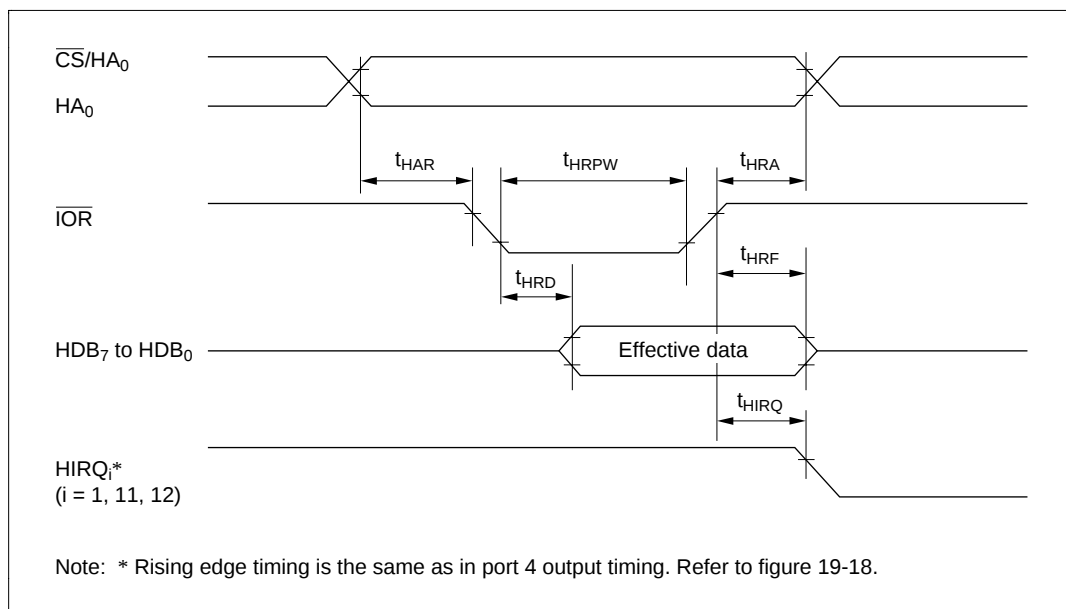


Figure 19-19 Host Interface Read Timing

#### (2) Host Interface Write Timing

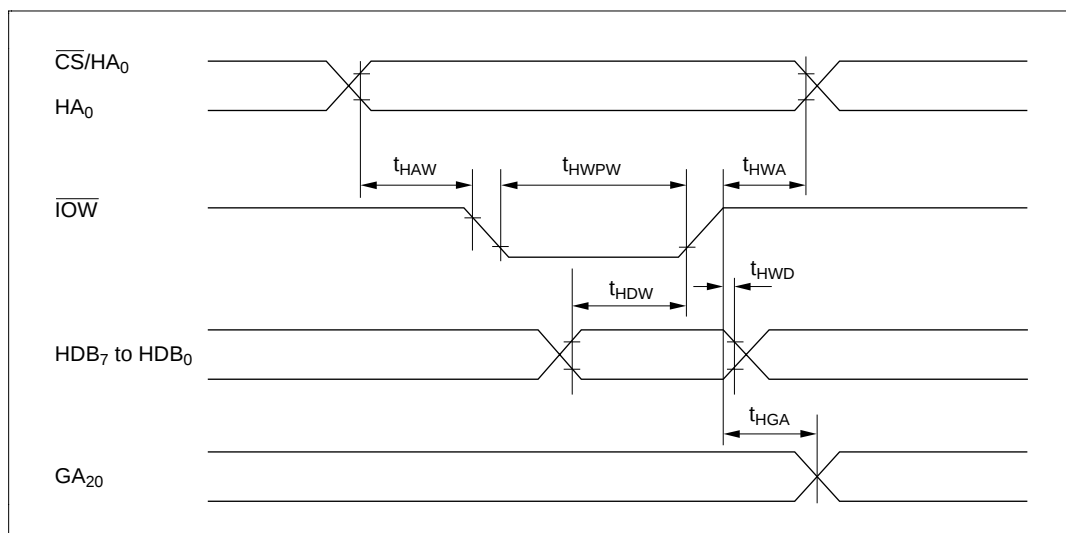
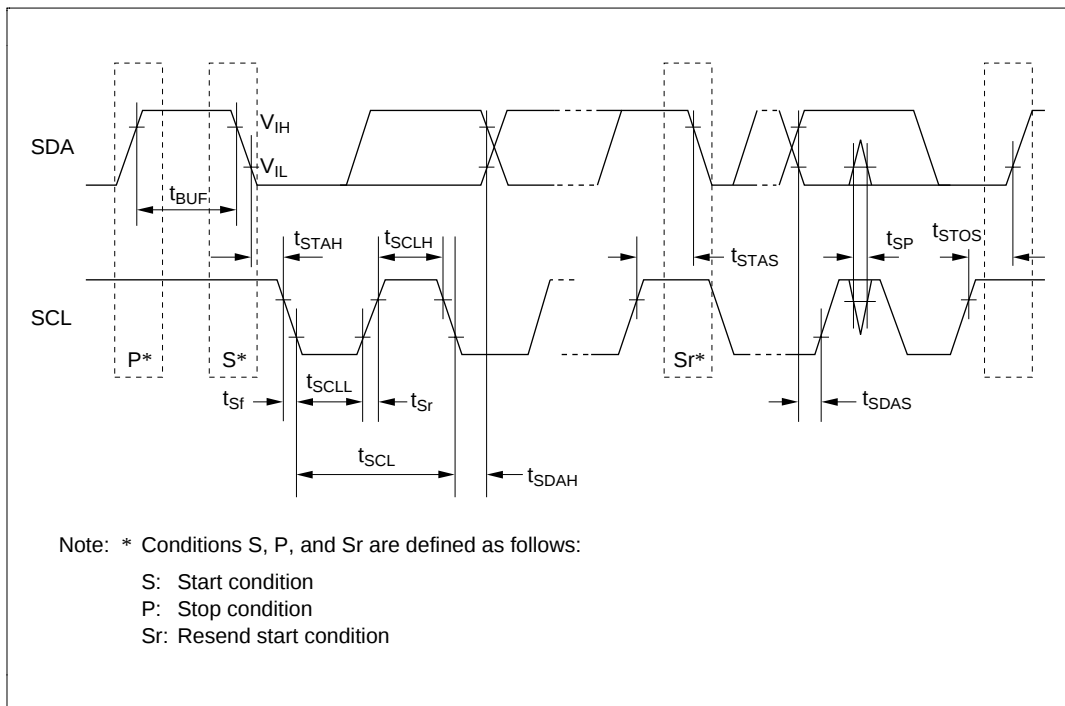


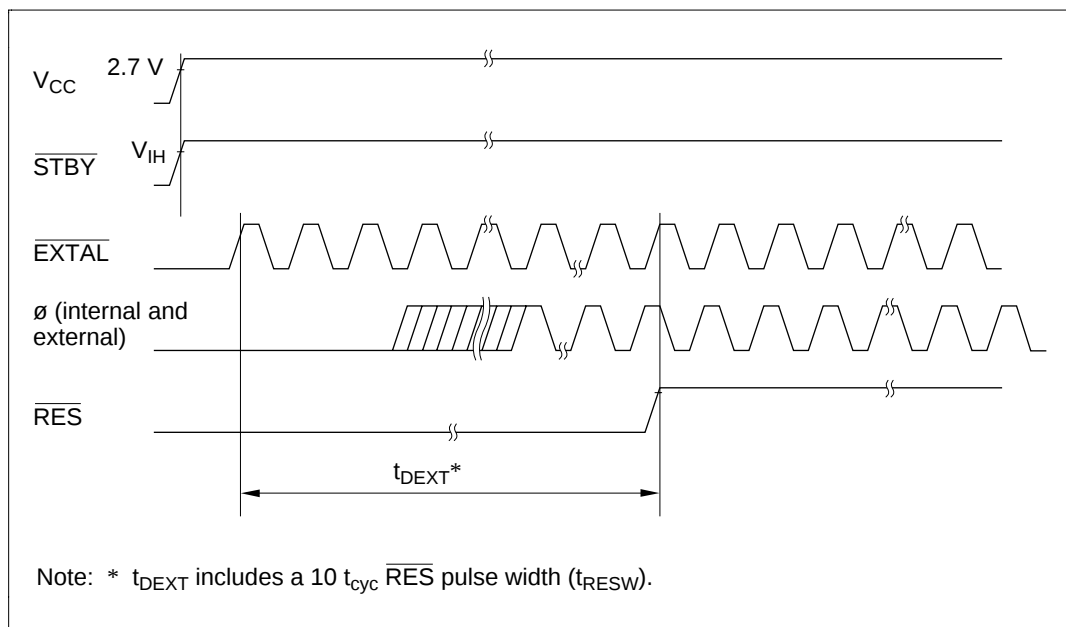
Figure 19-20 Host Interface Write Timing

### 19.3.9 I<sup>2</sup>C Bus Interface (Option) Timing



**Figure 19-21 I<sup>2</sup>C Bus Interface Input/Output Timing**

### 19.3.10 External Clock Output Timing



**Figure 19-22 External Clock Output Settling Delay Timing**

# Appendix A CPU Instruction Set

## A.1 Instruction Set List

### Operation Notation

|            |                                               |
|------------|-----------------------------------------------|
| Rd8/16     | General register (destination) (8 or 16 bits) |
| Rs8/16     | General register (source) (8 or 16 bits)      |
| Rn8/16     | General register (8 or 16 bits)               |
| CCR        | Condition code register                       |
| N          | N (negative) flag in CCR                      |
| Z          | Z (zero) flag in CCR                          |
| V          | V (overflow) flag in CCR                      |
| C          | C (carry) flag in CCR                         |
| PC         | Program counter                               |
| SP         | Stack pointer                                 |
| #xx:3/8/16 | Immediate data (3, 8, or 16 bits)             |
| d:8/16     | Displacement (8 or 16 bits)                   |
| @aa:8/16   | Absolute address (8 or 16 bits)               |
| +          | Addition                                      |
| −          | Subtraction                                   |
| ×          | Multiplication                                |
| ÷          | Division                                      |
| ^          | AND logical                                   |
| ∨          | OR logical                                    |
| ⊕          | Exclusive OR logical                          |
| →          | Move                                          |
| —          | Not                                           |

### Condition Code Notation

|   |                                              |
|---|----------------------------------------------|
| ↑ | Modified according to the instruction result |
| * | Undetermined (unpredictable)                 |
| 0 | Always cleared to 0                          |
| — | Not affected by the instruction result       |

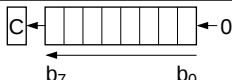
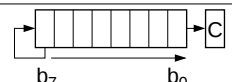
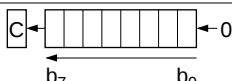
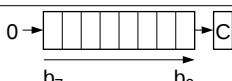
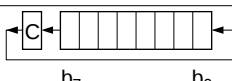
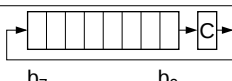
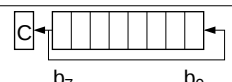
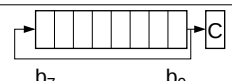
**Table A-1 Instruction Set**

| Mnemonic              | Operand Size | Operation                     | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |   |   |   |   | No. of States* |
|-----------------------|--------------|-------------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|---|---|---|---|----------------|
|                       |              |                               | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | I              | H | N | Z | V | C |                |
| MOV.B #xx:8, Rd       | B            | #xx:8 → Rd8                   | 2                                              |    |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 2              |
| MOV.B Rs, Rd          | B            | Rs8 → Rd8                     | 2                                              |    |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 2              |
| MOV.B @Rs, Rd         | B            | @Rs16 → Rd8                   |                                                | 2  |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.B @(d:16, Rs), Rd | B            | @(d:16, Rs16) → Rd8           |                                                |    | 4   |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.B @Rs+, Rd        | B            | @Rs16 → Rd8<br>Rs16+1 → Rs16  |                                                |    |     |             | 2         |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.B @aa:8, Rd       | B            | @aa:8 → Rd8                   |                                                |    |     |             |           | 2        |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.B @aa:16, Rd      | B            | @aa:16 → Rd8                  |                                                |    |     |             |           | 4        |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.B Rs, @Rd         | B            | Rs8 → @Rd16                   |                                                | 2  |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.B Rs, @(d:16, Rd) | B            | Rs8 → @(d:16, Rd16)           |                                                |    | 4   |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.B Rs, @-Rd        | B            | Rd16-1 → Rd16<br>Rs8 → @Rd16  |                                                |    |     |             | 2         |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.B Rs, @aa:8       | B            | Rs8 → @aa:8                   |                                                |    |     |             |           | 2        |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.B Rs, @aa:16      | B            | Rs8 → @aa:16                  |                                                |    |     |             |           | 4        |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W #xx:16, Rd      | W            | #xx:16 → Rd                   | 4                                              |    |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.W Rs, Rd          | W            | Rs16 → Rd16                   | 2                                              |    |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 2              |
| MOV.W @Rs, Rd         | W            | @Rs16 → Rd16                  |                                                | 2  |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.W @(d:16, Rs), Rd | W            | @(d:16, Rs16) → Rd16          |                                                |    | 4   |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W @Rs+, Rd        | W            | @Rs16 → Rd16<br>Rs16+2 → Rs16 |                                                |    |     |             | 2         |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W @aa:16, Rd      | W            | @aa:16 → Rd16                 |                                                |    |     |             |           | 4        |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W Rs, @Rd         | W            | Rs16 → @Rd16                  |                                                | 2  |     |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 4              |
| MOV.W Rs, @(d:16, Rd) | W            | Rs16 → @(d:16, Rd16)          |                                                |    | 4   |             |           |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W Rs, @-Rd        | W            | Rd16-2 → Rd16<br>Rs16 → @Rd16 |                                                |    |     |             | 2         |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| MOV.W Rs, @aa:16      | W            | Rs16 → @aa:16                 |                                                |    |     |             |           | 4        |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |
| POP Rd                | W            | @SP → Rd16<br>SP+2 → SP       |                                                |    |     |             | 2         |          |            |      | —              | — | ↑ | ↑ | 0 | — | 6              |

**Table A-1 Instruction Set (cont)**

| Mnemonic           | Operand Size | Operation               | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |     |   |     |   | No. of States* |    |
|--------------------|--------------|-------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|-----|---|-----|---|----------------|----|
|                    |              |                         | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | —              | I | H   | N | Z   | V |                | C  |
| PUSH Rs            | W            | SP-2 → SP<br>Rs16 → @SP |                                                |    |     |             | 2         |          |            |      |                | — | —   | ↑ | ↑   | 0 | —              | 6  |
| MOVFP E @aa:16, Rd | B            | Not supported           |                                                |    |     |             |           |          |            |      |                |   |     |   |     |   |                |    |
| MOVTPE Rs, @aa:16  | B            | Not supported           |                                                |    |     |             |           |          |            |      |                |   |     |   |     |   |                |    |
| ADD.B #xx:8, Rd    | B            | Rd8+#x:8 → Rd8          | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| ADD.B Rs, Rd       | B            | Rd8+Rs8 → Rd8           | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| ADD.W Rs, Rd       | W            | Rd16+Rs16 → Rd16        | 2                                              |    |     |             |           |          |            |      |                | — | (1) | ↑ | ↑   | ↑ | ↑              | 2  |
| ADDX.B #xx:8, Rd   | B            | Rd8+#x:8+C → Rd8        | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | (2) | ↑ | ↑              | 2  |
| ADDX.B Rs, Rd      | B            | Rd8+Rs8+C → Rd8         | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | (2) | ↑ | ↑              | 2  |
| ADDS.W #1, Rd      | W            | Rd16+1 → Rd16           | 2                                              |    |     |             |           |          |            |      |                | — | —   | — | —   | — | —              | 2  |
| ADDS.W #2, Rd      | W            | Rd16+2 → Rd16           | 2                                              |    |     |             |           |          |            |      |                | — | —   | — | —   | — | —              | 2  |
| INC.B Rd           | B            | Rd8+1 → Rd8             | 2                                              |    |     |             |           |          |            |      |                | — | —   | ↑ | ↑   | ↑ | —              | 2  |
| DAA.B Rd           | B            | Rd8 decimal adjust →Rd8 | 2                                              |    |     |             |           |          |            |      |                | — | *   | ↑ | ↑   | * | (3)            | 2  |
| SUB.B Rs, Rd       | B            | Rd8-Rs8 → Rd8           | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| SUB.W Rs, Rd       | W            | Rd16-Rs16 → Rd16        | 2                                              |    |     |             |           |          |            |      |                | — | (1) | ↑ | ↑   | ↑ | ↑              | 2  |
| SUBX.B #xx:8, Rd   | B            | Rd8-#x:8-C → Rd8        | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | (2) | ↑ | ↑              | 2  |
| SUBX.B Rs, Rd      | B            | Rd8-Rs8-C → Rd8         | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | (2) | ↑ | ↑              | 2  |
| SUBS.W #1, Rd      | W            | Rd16-1 → Rd16           | 2                                              |    |     |             |           |          |            |      |                | — | —   | — | —   | — | —              | 2  |
| SUBS.W #2, Rd      | W            | Rd16-2 → Rd16           | 2                                              |    |     |             |           |          |            |      |                | — | —   | — | —   | — | —              | 2  |
| DEC.B Rd           | B            | Rd8-1 → Rd8             | 2                                              |    |     |             |           |          |            |      |                | — | —   | ↑ | ↑   | ↑ | —              | 2  |
| DAS.B Rd           | B            | Rd8 decimal adjust →Rd8 | 2                                              |    |     |             |           |          |            |      |                | — | *   | ↑ | ↑   | * | —              | 2  |
| NEG.B Rd           | B            | 0-Rd → Rd               | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| CMP.B #xx:8, Rd    | B            | Rd8-#x:8                | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| CMP.B Rs, Rd       | B            | Rd8-Rs8                 | 2                                              |    |     |             |           |          |            |      |                | — | ↑   | ↑ | ↑   | ↑ | ↑              | 2  |
| CMP.W Rs, Rd       | W            | Rd16-Rs16               | 2                                              |    |     |             |           |          |            |      |                | — | (1) | ↑ | ↑   | ↑ | ↑              | 2  |
| MULXU.B Rs, Rd     | B            | Rd8 × Rs8 → Rd16        | 2                                              |    |     |             |           |          |            |      |                | — | —   | — | —   | — | —              | 14 |

**Table A-1 Instruction Set (cont)**

| Mnemonic        | Operand Size | Operation                                                                           | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |     |     |   |   | No. of States* |
|-----------------|--------------|-------------------------------------------------------------------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|-----|-----|---|---|----------------|
|                 |              |                                                                                     | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | I              | H | N   | Z   | V | C |                |
| DIVXU.B Rs, Rd  | B            | Rd16+Rs8 → Rd16<br>(RdH: remainder,<br>RdL: quotient)                               | 2                                              |    |     |             |           |          |            |      | —              | — | (6) | (7) | — | — | 14             |
| AND.B #xx:8, Rd | B            | Rd8∧#xx:8 → Rd8                                                                     | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| AND.B Rs, Rd    | B            | Rd8∧Rs8 → Rd8                                                                       | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| OR.B #xx:8, Rd  | B            | Rd8∨#xx:8 → Rd8                                                                     | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| OR.B Rs, Rd     | B            | Rd8∨Rs8 → Rd8                                                                       | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| XOR.B #xx:8, Rd | B            | Rd8⊕#xx:8 → Rd8                                                                     | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| XOR.B Rs, Rd    | B            | Rd8⊕Rs8 → Rd8                                                                       | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| NOT.B Rd        | B            | $\overline{\text{Rd}} \rightarrow \text{Rd}$                                        | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | — | 2              |
| SHAL.B Rd       | B            |    | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | ↑ | ↑ | 2              |
| SHAR.B Rd       | B            |    | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |
| SHLL.B Rd       | B            |   | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |
| SHLR.B Rd       | B            |  | 2                                              |    |     |             |           |          |            |      | —              | — | 0   | ↑   | 0 | ↑ | 2              |
| ROTXL.B Rd      | B            |  | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |
| ROTXR.B Rd      | B            |  | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |
| ROTL.B Rd       | B            |  | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |
| ROTR.B Rd       | B            |  | 2                                              |    |     |             |           |          |            |      | —              | — | ↑   | ↑   | 0 | ↑ | 2              |

**Table A-1 Instruction Set (cont)**

| Mnemonic          | Operand Size | Operation                              | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |   |   |   |   | No. of States* |
|-------------------|--------------|----------------------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|---|---|---|---|----------------|
|                   |              |                                        | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | —              | I | H | N | Z | V |                |
| BSET #xx:3, Rd    | B            | (#xx:3 of Rd8) ← 1                     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BSET #xx:3, @Rd   | B            | (#xx:3 of @Rd16) ← 1                   |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BSET #xx:3, @aa:8 | B            | (#xx:3 of @aa:8) ← 1                   |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BSET Rn, Rd       | B            | (Rn8 of Rd8) ← 1                       | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BSET Rn, @Rd      | B            | (Rn8 of @Rd16) ← 1                     |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BSET Rn, @aa:8    | B            | (Rn8 of @aa:8) ← 1                     |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BCLR #xx:3, Rd    | B            | (#xx:3 of Rd8) ← 0                     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BCLR #xx:3, @Rd   | B            | (#xx:3 of @Rd16) ← 0                   |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BCLR #xx:3, @aa:8 | B            | (#xx:3 of @aa:8) ← 0                   |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BCLR Rn, Rd       | B            | (Rn8 of Rd8) ← 0                       | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BCLR Rn, @Rd      | B            | (Rn8 of @Rd16) ← 0                     |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BCLR Rn, @aa:8    | B            | (Rn8 of @aa:8) ← 0                     |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BNOT #xx:3, Rd    | B            | (#xx:3 of Rd8) ←<br>(#xx:3 of Rd8)     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BNOT #xx:3, @Rd   | B            | (#xx:3 of @Rd16) ←<br>(#xx:3 of @Rd16) |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BNOT #xx:3, @aa:8 | B            | (#xx:3 of @aa:8) ←<br>(#xx:3 of @aa:8) |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BNOT Rn, Rd       | B            | (Rn8 of Rd8) ←<br>(Rn8 of Rd8)         | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BNOT Rn, @Rd      | B            | (Rn8 of @Rd16) ←<br>(Rn8 of @Rd16)     |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BNOT Rn, @aa:8    | B            | (Rn8 of @aa:8) ←<br>(Rn8 of @aa:8)     |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BTST #xx:3, Rd    | B            | (#xx:3 of Rd8) → Z                     | 2                                              |    |     |             |           |          |            |      | —              | — | — | ↑ | — | — | 2              |
| BTST #xx:3, @Rd   | B            | (#xx:3 of @Rd16) → Z                   |                                                | 4  |     |             |           |          |            |      | —              | — | — | ↑ | — | — | 6              |
| BTST #xx:3, @aa:8 | B            | (#xx:3 of @aa:8) → Z                   |                                                |    |     |             | 4         |          |            |      | —              | — | — | ↑ | — | — | 6              |
| BTST Rn, Rd       | B            | (Rn8 of Rd8) → Z                       | 2                                              |    |     |             |           |          |            |      | —              | — | — | ↑ | — | — | 2              |

**Table A-1 Instruction Set (cont)**

| Mnemonic           | Operand Size | Operation              | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |   |   |   |   | No. of States* |
|--------------------|--------------|------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|---|---|---|---|----------------|
|                    |              |                        | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | —              | I | H | N | Z | V |                |
| BTST Rn, @Rd       | B            | (Rn8 of @Rd16) → Z     |                                                | 4  |     |             |           |          |            |      | —              | — | — | ↑ | — | — | 6              |
| BTST Rn, @aa:8     | B            | (Rn8 of @aa:8) → Z     |                                                |    |     |             | 4         |          |            |      | —              | — | — | ↑ | — | — | 6              |
| BLD #xx:3, Rd      | B            | (#xx:3 of Rd8) → C     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BLD #xx:3, @Rd     | B            | (#xx:3 of @Rd16) → C   |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BLD #xx:3, @aa:8   | B            | (#xx:3 of @aa:8) → C   |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BILD #xx:3, Rd     | B            | (#xx:3 of Rd8) → C     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BILD #xx:3, @Rd    | B            | (#xx:3 of @Rd16) → C   |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BILD #xx:3, @aa:8  | B            | (#xx:3 of @aa:8) → C   |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BST #xx:3, Rd      | B            | C → (#xx:3 of Rd8)     | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BST #xx:3, @Rd     | B            | C → (#xx:3 of @Rd16)   |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BST #xx:3, @aa:8   | B            | C → (#xx:3 of @aa:8)   |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BIST #xx:3, Rd     | B            | C̄ → (#xx:3 of Rd8)    | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| BIST #xx:3, @Rd    | B            | C̄ → (#xx:3 of @Rd16)  |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | — | 8              |
| BIST #xx:3, @aa:8  | B            | C̄ → (#xx:3 of @aa:8)  |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| BAND #xx:3, Rd     | B            | C∧(#xx:3 of Rd8) → C   | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BAND #xx:3, @Rd    | B            | C∧(#xx:3 of @Rd16) → C |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BAND #xx:3, @aa:8  | B            | C∧(#xx:3 of @aa:8) → C |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BIAND #xx:3, Rd    | B            | C∧(#xx:3 of Rd8) → C   | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BIAND #xx:3, @Rd   | B            | C∧(#xx:3 of @Rd16) → C |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BIAND #xx:3, @aa:8 | B            | C∧(#xx:3 of @aa:8) → C |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BOR #xx:3, Rd      | B            | C∨(#xx:3 of Rd8) → C   | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BOR #xx:3, @Rd     | B            | C∨(#xx:3 of @Rd16) → C |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BOR #xx:3, @aa:8   | B            | C∨(#xx:3 of @aa:8) → C |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BIOR #xx:3, Rd     | B            | C∨(#xx:3 of Rd8) → C   | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 2              |
| BIOR #xx:3, @Rd    | B            | C∨(#xx:3 of @Rd16) → C |                                                | 4  |     |             |           |          |            |      | —              | — | — | — | — | ↑ | 6              |
| BIOR #xx:3, @aa:8  | B            | C∨(#xx:3 of @aa:8) → C |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | ↑ | 6              |

**Table A-1 Instruction Set (cont)**

| Mnemonic           | Operand Size | Operation                                                                    |          | Addressing Mode/<br>Instruction Length (Bytes) |     |             |           |          |            |      |   | Condition Code |   |   |   |   |   | No. of States* |
|--------------------|--------------|------------------------------------------------------------------------------|----------|------------------------------------------------|-----|-------------|-----------|----------|------------|------|---|----------------|---|---|---|---|---|----------------|
|                    |              | Branching<br>Condition                                                       | #xx:8/16 | Rn                                             | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | — | I              | H | N | Z | V | C |                |
| BXOR #xx:3, Rd     | B            | $C \oplus (\#xx:3 \text{ of } Rd8) \rightarrow C$                            | 2        |                                                |     |             |           |          |            |      |   | —              | — | — | — | — | ↑ | 2              |
| BXOR #xx:3, @Rd    | B            | $C \oplus (\#xx:3 \text{ of } @Rd16) \rightarrow C$                          |          | 4                                              |     |             |           |          |            |      |   | —              | — | — | — | — | ↑ | 6              |
| BXOR #xx:3, @aa:8  | B            | $C \oplus (\#xx:3 \text{ of } @aa:8) \rightarrow C$                          |          |                                                |     |             |           | 4        |            |      |   | —              | — | — | — | — | ↑ | 6              |
| BIXOR #xx:3, Rd    | B            | $C \oplus (\#xx:3 \text{ of } Rd8) \rightarrow C$                            | 2        |                                                |     |             |           |          |            |      |   | —              | — | — | — | — | ↑ | 2              |
| BIXOR #xx:3, @Rd   | B            | $C \oplus (\#xx:3 \text{ of } @Rd16) \rightarrow C$                          |          | 4                                              |     |             |           |          |            |      |   | —              | — | — | — | — | ↑ | 6              |
| BIXOR #xx:3, @aa:8 | B            | $C \oplus (\#xx:3 \text{ of } @aa:8) \rightarrow C$                          |          |                                                |     |             |           | 4        |            |      |   | —              | — | — | — | — | ↑ | 6              |
| BRA d:8 (BT d:8)   | —            | $PC \leftarrow PC + d:8$                                                     |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BRN d:8 (BF d:8)   | —            | $PC \leftarrow PC + 2$                                                       |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BHI d:8            | —            | If<br>condition<br>is true<br>then<br>$PC \leftarrow PC + d:8$<br>else next; |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BLS d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BCC d:8 (BHS d:8)  | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BCS d:8 (BLO d:8)  | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BNE d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BEQ d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BVC d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BVS d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BPL d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BMI d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BGE d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BLT d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BGT d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| BLE d:8            | —            |                                                                              |          |                                                |     |             |           |          | 2          |      |   | —              | — | — | — | — | — | 4              |
| JMP @Rn            | —            | $PC \leftarrow Rn16$                                                         |          | 2                                              |     |             |           |          |            |      |   | —              | — | — | — | — | — | 4              |
| JMP @aa:16         | —            | $PC \leftarrow aa:16$                                                        |          |                                                |     |             |           | 4        |            |      |   | —              | — | — | — | — | — | 6              |
| JMP @@aa:8         | —            | $PC \leftarrow @@aa:8$                                                       |          |                                                |     |             |           |          |            | 2    |   | —              | — | — | — | — | — | 8              |

**Table A-1 Instruction Set (cont)**

| Mnemonic        | Operand Size | Operation                                       | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |   |   |   |   | No. of States* |
|-----------------|--------------|-------------------------------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|---|---|---|---|----------------|
|                 |              |                                                 | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | I              | H | N | Z | V | C |                |
| BSR d:8         | —            | SP-2 → SP<br>PC → @SP<br>PC ← PC+d:8            |                                                |    |     |             |           | 2        |            |      | —              | — | — | — | — | — | 6              |
| JSR @Rn         | —            | SP-2 → SP<br>PC → @SP<br>PC ← Rn16              |                                                | 2  |     |             |           |          |            |      | —              | — | — | — | — | — | 6              |
| JSR @aa:16      | —            | SP-2 → SP<br>PC → @SP<br>PC ← aa:16             |                                                |    |     |             | 4         |          |            |      | —              | — | — | — | — | — | 8              |
| JSR @@aa:8      | —            | SP-2 → SP<br>PC → @SP<br>PC ← @aa:8             |                                                |    |     |             |           | 2        |            |      | —              | — | — | — | — | — | 8              |
| RTS             | —            | PC ← @SP<br>SP+2 → SP                           |                                                |    |     |             |           |          | 2          |      | —              | — | — | — | — | — | 8              |
| RTE             | —            | CCR ← @SP<br>SP+2 → SP<br>PC ← @SP<br>SP+2 → SP |                                                |    |     |             |           |          | 2          | ↑    | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 10             |
| SLEEP           | —            | Transition to power-down state                  |                                                |    |     |             |           |          | 2          | —    | —              | — | — | — | — | — | 2              |
| LDC #xx:8, CCR  | B            | #xx:8 → CCR                                     | 2                                              |    |     |             |           |          |            |      | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 2              |
| LDC Rs, CCR     | B            | Rs8 → CCR                                       | 2                                              |    |     |             |           |          |            |      | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 2              |
| STC CCR, Rd     | B            | CCR → Rd8                                       | 2                                              |    |     |             |           |          |            |      | —              | — | — | — | — | — | 2              |
| ANDC #xx:8, CCR | B            | CCR ∧ #xx:8 → CCR                               | 2                                              |    |     |             |           |          |            |      | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 2              |
| ORC #xx:8, CCR  | B            | CCR ∨ #xx:8 → CCR                               | 2                                              |    |     |             |           |          |            |      | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 2              |
| XORC #xx:8, CCR | B            | CCR ⊕ #xx:8 → CCR                               | 2                                              |    |     |             |           |          |            |      | ↑              | ↑ | ↑ | ↑ | ↑ | ↑ | 2              |
| NOP             | —            | PC ← PC+2                                       |                                                |    |     |             |           |          | 2          |      | —              | — | — | — | — | — | 2              |

**Table A-1 Instruction Set (cont)**

| Mnemonic | Operand Size | Operation                                                                                                         | Addressing Mode/<br>Instruction Length (Bytes) |    |     |             |           |          |            |      | Condition Code |   |   |   |   |   | No. of States* |
|----------|--------------|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------|----|-----|-------------|-----------|----------|------------|------|----------------|---|---|---|---|---|----------------|
|          |              |                                                                                                                   | #xx:8/16                                       | Rn | @Rn | @(d:16, Rn) | @-Rn/@Rn+ | @aa:8/16 | @(d:8, PC) | @@aa | —              | I | H | N | Z | V |                |
| EEPMOV   | —            | if R4L≠0<br>Repeat @R5 → @R6<br>R5+1 → R5<br>R6+1 → R6<br>R4L-1 → R4L<br>Until R4L=0<br>Until R4L=0<br>else next; |                                                |    |     |             |           |          |            |      | 4              | — | — | — | — | — | (4)            |

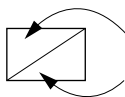
Notes: The number of states is the number of states required for execution when the instruction and its operands are located in on-chip memory.

- (1) Set to 1 when there is a carry or borrow from bit 11; otherwise cleared to 0.
- (2) If the result is zero, the previous value of the flag is retained: otherwise the flag is cleared to 0.
- (3) Set to 1 if decimal adjustment produces a carry; otherwise cleared to 0.
- (4) The number of states required for execution is  $4n + 8$  ( $n$  = value of R4L).
- (5) These instructions are not supported by the H8/3217 Series.
- (6) Set to 1 if the divisor is negative: otherwise cleared to 0.
- (7) Cleared to 0 if the divisor is not zero; set to 1 if the divisor is zero.

## A.2 Operation Code Map

Table A-2 is a map of the operation codes contained in the first byte of the instruction code (bits 15 to 8 of the first instruction word).

Some pairs of instructions have identical first bytes. These instructions are differentiated by the first bit of the second byte (bit 7 of the first instruction word).



Instruction when first bit of byte 2 (bit 7 of first instruction word) is 0.

Instruction when first bit of byte 2 (bit 7 of first instruction word) is 1.

**Table A-2 Operation Code Map**

| Low<br>High | 0            | 1            | 2             | 3             | 4     | 5     | 6    | 7           | 8   | 9   | A    | B      | C                             | D   | E   | F   |
|-------------|--------------|--------------|---------------|---------------|-------|-------|------|-------------|-----|-----|------|--------|-------------------------------|-----|-----|-----|
| 0           | NOP          | SLEEP        | STC           | LDC           | ORC   | XORC  | ANDC | LDC         | ADD | INC | ADDS | MOV    | ADDX                          | DAA |     |     |
| 1           | SHLL<br>SHAL | SHLR<br>SHAR | ROTXL<br>ROTL | ROTXR<br>ROTR | OR    | XOR   | AND  | NOT<br>NEG  | SUB | DEC | SUBS | CMP    | SUBX                          | DAS |     |     |
| 2           | MOV          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| 3           |              |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| 4           | BRA*2        | BRN*2        | BHI           | BLS           | BCC*2 | BCS*2 | BNE  | BEQ         | BVC | BVS | BPL  | BMI    | BGE                           | BLT | BGT | BLE |
| 5           | MULXU        | DIVXU        |               |               | RTS   | BSR   | RTE  |             |     |     | JMP  |        |                               |     | JSR |     |
| 6           |              |              |               |               |       |       |      | BST         |     |     |      | MOV*1  |                               |     |     |     |
| 7           | BSET         | BNOT         | BCLR          | BTS           | BOR   | BXOR  | BAND | BIST<br>BLD |     | MOV |      | EEPMOV | Bit manipulation instructions |     |     |     |
| 8           | ADD          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| 9           | ADDX         |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| A           | CMP          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| B           | SUBX         |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| C           | OR           |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| D           | XOR          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| E           | AND          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |
| F           | MOV          |              |               |               |       |       |      |             |     |     |      |        |                               |     |     |     |

Notes: 1. The PUSH and POP instructions are identical in machine language to MOV instructions.  
2. The BT, BF, BHS, and BLO instructions are identical in machine language to BRA, BRN, BCC, and BCS, respectively.

### A.3 Number of States Required for Execution

The tables below can be used to calculate the number of states required for instruction execution. Table A-3 indicates the number of states required for each cycle (instruction fetch, branch address read, stack operation, byte data access, word data access, internal operation). Table A-4 indicates the number of cycles of each type occurring in each instruction. The total number of states required for execution of an instruction can be calculated from these two tables as follows:

$$\text{Execution states} = I \times S_I + J \times S_J + K \times S_K + L \times S_L + M \times S_M + N \times S_N$$

**Examples:** Mode 1 (on-chip ROM disabled), stack located in external memory, 1 wait state inserted in external memory access.

1. BSET #0, @FFC7

From table A-4:  $I = L = 2$ ,  $J = K = M = N = 0$

From table A-3:  $S_I = 8$ ,  $S_L = 3$

Number of states required for execution:  $2 \times 8 + 2 \times 3 = 22$

2. JSR @@30

From table A-4:  $I = 2$ ,  $J = K = 1$ ,  $L = M = N = 0$

From table A-3:  $S_I = S_J = S_K = 8$

Number of states required for execution:  $2 \times 8 + 1 \times 8 + 1 \times 8 = 32$

**Table A-3 Number of States Taken by Each Cycle in Instruction Execution**

| Execution Status<br>(Instruction Cycle) |       | Access location |                    |                 |
|-----------------------------------------|-------|-----------------|--------------------|-----------------|
|                                         |       | On-Chip Memory  | On-Chip Reg. Field | External Memory |
| Instruction fetch                       | $S_I$ | 2               | 6                  | $6 + 2m$        |
| Branch address read                     | $S_J$ |                 |                    |                 |
| Stack operation                         | $S_K$ |                 |                    |                 |
| Byte data access                        | $S_L$ |                 | 3                  | $3 + m$         |
| Word data access                        | $S_M$ |                 | 6                  | $6 + 2m$        |
| Internal operation                      | $S_N$ | 1               | 1                  | 1               |

Note: m: Number of wait states inserted in access to external device.

**Table A-4 Number of Cycles in Each Instruction**

| Instruction | Mnemonic          | Instruction | Branch  | Stack | Byte | Word | Internal |
|-------------|-------------------|-------------|---------|-------|------|------|----------|
|             |                   | Fetch       | Address |       | Data | Data |          |
|             |                   | I           | J       | K     | L    | M    | N        |
| ADD         | ADD.B #xx:8, Rd   | 1           |         |       |      |      |          |
|             | ADD.B Rs, Rd      | 1           |         |       |      |      |          |
|             | ADD.W Rs, Rd      | 1           |         |       |      |      |          |
| ADDS        | ADDS.W #1/2, Rd   | 1           |         |       |      |      |          |
| ADDX        | ADDX.B #xx:8, Rd  | 1           |         |       |      |      |          |
|             | ADDX.B Rs, Rd     | 1           |         |       |      |      |          |
| AND         | AND.B #xx:8, Rd   | 1           |         |       |      |      |          |
|             | AND.B Rs, Rd      | 1           |         |       |      |      |          |
| ANDC        | ANDC #xx:8, CCR   | 1           |         |       |      |      |          |
| BAND        | BAND #xx:3, Rd    | 1           |         |       |      |      |          |
|             | BAND #xx:3, @Rd   | 2           |         |       | 1    |      |          |
|             | BAND #xx:3, @aa:8 | 2           |         |       | 1    |      |          |
| Bcc         | BRA d:8 (BT d:8)  | 2           |         |       |      |      |          |
|             | BRN d:8 (BF d:8)  | 2           |         |       |      |      |          |
|             | BHI d:8           | 2           |         |       |      |      |          |
|             | BLS d:8           | 2           |         |       |      |      |          |
|             | BCC d:8 (BHS d:8) | 2           |         |       |      |      |          |
|             | BCS d:8 (BLO d:8) | 2           |         |       |      |      |          |
|             | BNE d:8           | 2           |         |       |      |      |          |
|             | BEQ d:8           | 2           |         |       |      |      |          |
|             | BVC d:8           | 2           |         |       |      |      |          |
|             | BVS d:8           | 2           |         |       |      |      |          |
|             | BPL d:8           | 2           |         |       |      |      |          |
|             | BMI d:8           | 2           |         |       |      |      |          |
|             | BGE d:8           | 2           |         |       |      |      |          |
|             | BLT d:8           | 2           |         |       |      |      |          |
|             | BGT d:8           | 2           |         |       |      |      |          |
|             | BLE d:8           | 2           |         |       |      |      |          |

**Table A-4 Number of Cycles in Each Instruction (cont)**

| Instruction | Mnemonic           | Instruction<br>Fetch<br>I | Branch<br>Address<br>Read<br>J | Stack<br>Operation<br>K | Byte<br>Data<br>Access<br>L | Word<br>Data<br>Access<br>M | Internal<br>Operation<br>N |
|-------------|--------------------|---------------------------|--------------------------------|-------------------------|-----------------------------|-----------------------------|----------------------------|
| BCLR        | BCLR #xx:3, Rd     | 1                         |                                |                         |                             |                             |                            |
|             | BCLR #xx:3, @Rd    | 2                         |                                |                         | 2                           |                             |                            |
|             | BCLR #xx:3, @aa:8  | 2                         |                                |                         | 2                           |                             |                            |
|             | BCLR Rn, Rd        | 1                         |                                |                         |                             |                             |                            |
|             | BCLR Rn, @Rd       | 2                         |                                |                         | 2                           |                             |                            |
|             | BCLR Rn, @aa:8     | 2                         |                                |                         | 2                           |                             |                            |
| BIAND       | BIAND #xx:3, Rd    | 1                         |                                |                         |                             |                             |                            |
|             | BIAND #xx:3, @Rd   | 2                         |                                |                         | 1                           |                             |                            |
|             | BIAND #xx:3, @aa:8 | 2                         |                                |                         | 1                           |                             |                            |
| BILD        | BILD #xx:3, Rd     | 1                         |                                |                         |                             |                             |                            |
|             | BILD #xx:3, @Rd    | 2                         |                                |                         | 1                           |                             |                            |
|             | BILD #xx:3, @aa:8  | 2                         |                                |                         | 1                           |                             |                            |
| BIOR        | BIOR #xx:3, Rd     | 1                         |                                |                         |                             |                             |                            |
|             | BIOR #xx:3, @Rd    | 2                         |                                |                         | 1                           |                             |                            |
|             | BIOR #xx:3, @aa:8  | 2                         |                                |                         | 1                           |                             |                            |
| BIST        | BIST #xx:3, Rd     | 1                         |                                |                         |                             |                             |                            |
|             | BIST #xx:3, @Rd    | 2                         |                                |                         | 2                           |                             |                            |
|             | BIST #xx:3, @aa:8  | 2                         |                                |                         | 2                           |                             |                            |
| BIXOR       | BIXOR #xx:3, Rd    | 1                         |                                |                         |                             |                             |                            |
|             | BIXOR #xx:3, @Rd   | 2                         |                                |                         | 1                           |                             |                            |
|             | BIXOR #xx:3, @aa:8 | 2                         |                                |                         | 1                           |                             |                            |
| BLD         | BLD #xx:3, Rd      | 1                         |                                |                         |                             |                             |                            |
|             | BLD #xx:3, @Rd     | 2                         |                                |                         | 1                           |                             |                            |
|             | BLD #xx:3, @aa:8   | 2                         |                                |                         | 1                           |                             |                            |
| BNOT        | BNOT #xx:3, Rd     | 1                         |                                |                         |                             |                             |                            |
|             | BNOT #xx:3, @Rd    | 2                         |                                |                         | 2                           |                             |                            |
|             | BNOT #xx:3, @aa:8  | 2                         |                                |                         | 2                           |                             |                            |
|             | BNOT Rn, Rd        | 1                         |                                |                         |                             |                             |                            |
|             | BNOT Rn, @Rd       | 2                         |                                |                         | 2                           |                             |                            |
|             | BNOT Rn, @aa:8     | 2                         |                                |                         | 2                           |                             |                            |

**Table A-4 Number of Cycles in Each Instruction (cont)**

| Instruction | Mnemonic          | Instruction | Branch  | Stack     | Byte    | Word   | Internal  |
|-------------|-------------------|-------------|---------|-----------|---------|--------|-----------|
|             |                   | Fetch       | Address |           | Data    | Data   |           |
|             |                   | I           | Read    | Operation | Access  | Access | Operation |
|             |                   |             | J       | K         | L       | M      | N         |
| BOR         | BOR #xx:3, Rd     | 1           |         |           |         |        |           |
|             | BOR #xx:3, @Rd    | 2           |         |           | 1       |        |           |
|             | BOR #xx:3, @aa:8  | 2           |         |           | 1       |        |           |
| BSET        | BSET #xx:3, Rd    | 1           |         |           |         |        |           |
|             | BSET #xx:3, @Rd   | 2           |         |           | 2       |        |           |
|             | BSET #xx:3, @aa:8 | 2           |         |           | 2       |        |           |
|             | BSET Rn, Rd       | 1           |         |           |         |        |           |
|             | BSET Rn, @Rd      | 2           |         |           | 2       |        |           |
|             | BSET Rn, @aa:8    | 2           |         |           | 2       |        |           |
| BSR         | BSR d:8           | 2           |         | 1         |         |        |           |
| BST         | BST #xx:3, Rd     | 1           |         |           |         |        |           |
|             | BST #xx:3, @Rd    | 2           |         |           | 2       |        |           |
|             | BST #xx:3, @aa:8  | 2           |         |           | 2       |        |           |
| BTST        | BTST #xx:3, Rd    | 1           |         |           |         |        |           |
|             | BTST #xx:3, @Rd   | 2           |         |           | 1       |        |           |
|             | BTST #xx:3, @aa:8 | 2           |         |           | 1       |        |           |
|             | BTST Rn, Rd       | 1           |         |           |         |        |           |
|             | BTST Rn, @Rd      | 2           |         |           | 1       |        |           |
|             | BTST Rn, @aa:8    | 2           |         |           | 1       |        |           |
| BXOR        | BXOR #xx:3, Rd    | 1           |         |           |         |        |           |
|             | BXOR #xx:3, @Rd   | 2           |         |           | 1       |        |           |
|             | BXOR #xx:3, @aa:8 | 2           |         |           | 1       |        |           |
| CMP         | CMP.B #xx:8, Rd   | 1           |         |           |         |        |           |
|             | CMP.B Rs, Rd      | 1           |         |           |         |        |           |
|             | CMP.W Rs, Rd      | 1           |         |           |         |        |           |
| DAA         | DAA.B Rd          | 1           |         |           |         |        |           |
| DAS         | DAS.B Rd          | 1           |         |           |         |        |           |
| DEC         | DEC.B Rd          | 1           |         |           |         |        |           |
| DIVXU       | DIVXU.B Rs, Rd    | 1           |         |           |         |        | 12        |
| EEPMOV      | EEPMOV            | 2           |         |           | 2n + 2* |        | 1         |
| INC         | INC.B Rd          | 1           |         |           |         |        |           |

**Table A-4 Number of Cycles in Each Instruction (cont)**

| Instruction | Mnemonic              | Instruction<br>Fetch<br>I | Branch<br>Address<br>Read<br>J | Stack<br>Operation<br>K | Byte<br>Data<br>Access<br>L | Word<br>Data<br>Access<br>M | Internal<br>Operation<br>N |
|-------------|-----------------------|---------------------------|--------------------------------|-------------------------|-----------------------------|-----------------------------|----------------------------|
| JMP         | JMP @Rn               | 2                         |                                |                         |                             |                             |                            |
|             | JMP @aa:16            | 2                         |                                |                         |                             |                             | 2                          |
|             | JMP @@aa:8            | 2                         | 1                              |                         |                             |                             | 2                          |
| JSR         | JSR @Rn               | 2                         |                                | 1                       |                             |                             |                            |
|             | JSR @aa:16            | 2                         |                                | 1                       |                             |                             | 2                          |
|             | JSR @@aa:8            | 2                         | 1                              | 1                       |                             |                             |                            |
| LDC         | LDC #xx:8, CCR        | 1                         |                                |                         |                             |                             |                            |
|             | LDC Rs, CCR           | 1                         |                                |                         |                             |                             |                            |
| MOV         | MOV.B #xx:8, Rd       | 1                         |                                |                         |                             |                             |                            |
|             | MOV.B Rs, Rd          | 1                         |                                |                         |                             |                             |                            |
|             | MOV.B @Rs, Rd         | 1                         |                                |                         | 1                           |                             |                            |
|             | MOV.B @(d:16,Rs), Rd  | 2                         |                                |                         | 1                           |                             |                            |
|             | MOV.B @Rs+, Rd        | 1                         |                                |                         | 1                           |                             | 2                          |
|             | MOV.B @aa:8, Rd       | 1                         |                                |                         | 1                           |                             |                            |
|             | MOV.B @aa:16, Rd      | 2                         |                                |                         | 1                           |                             |                            |
|             | MOV.B Rs, @Rd         | 1                         |                                |                         | 1                           |                             |                            |
|             | MOV.B Rs, @(d:16, Rd) | 2                         |                                |                         | 1                           |                             |                            |
|             | MOV.B Rs, @-Rd        | 1                         |                                |                         | 1                           |                             | 2                          |
|             | MOV.B Rs, @aa:8       | 1                         |                                |                         | 1                           |                             |                            |
|             | MOV.B Rs, @aa:16      | 2                         |                                |                         | 1                           |                             |                            |
|             | MOV.W #xx:16, Rd      | 2                         |                                |                         |                             |                             |                            |
|             | MOV.W Rs, Rd          | 1                         |                                |                         |                             |                             |                            |
|             | MOV.W @Rs, Rd         | 1                         |                                |                         |                             | 1                           |                            |
|             | MOV.W @(d:16, Rs), Rd | 2                         |                                |                         |                             | 1                           |                            |
|             | MOV.W @Rs+, Rd        | 1                         |                                |                         |                             | 1                           | 2                          |
|             | MOV.W @aa:16, Rd      | 2                         |                                |                         |                             | 1                           |                            |
|             | MOV.W Rs, @Rd         | 1                         |                                |                         |                             | 1                           |                            |
|             | MOV.W Rs, @(d:16, Rd) | 2                         |                                |                         |                             | 1                           |                            |
|             | MOV.W Rs, @-Rd        | 1                         |                                |                         |                             | 1                           | 2                          |
|             | MOV.W Rs, @aa:16      | 2                         |                                |                         |                             | 1                           |                            |
|             |                       |                           |                                |                         |                             |                             |                            |
|             |                       |                           |                                |                         |                             |                             |                            |
| MOVFPPE     | MOVFPPE @aa:16, Rd    | Not supported             |                                |                         |                             |                             |                            |

**Table A-4 Number of Cycles in Each Instruction (cont)**

| Instruction | Mnemonic          | Instruction<br>Fetch<br>I | Branch<br>Address<br>Read<br>J | Stack<br>Operation<br>K | Byte<br>Data<br>Access<br>L | Word<br>Data<br>Access<br>M | Internal<br>Operation<br>N |
|-------------|-------------------|---------------------------|--------------------------------|-------------------------|-----------------------------|-----------------------------|----------------------------|
| MOVTPE      | MOVTPE Rs, @aa:16 | Not supported             |                                |                         |                             |                             |                            |
| MULXU       | MULXU.B Rs, Rd    | 1                         |                                |                         |                             |                             | 12                         |
| NEG         | NEG.B Rd          | 1                         |                                |                         |                             |                             |                            |
| NOP         | NOP               | 1                         |                                |                         |                             |                             |                            |
| NOT         | NOT.B Rd          | 1                         |                                |                         |                             |                             |                            |
| OR          | OR.B #xx:8, Rd    | 1                         |                                |                         |                             |                             |                            |
|             | OR.B Rs, Rd       | 1                         |                                |                         |                             |                             |                            |
| ORC         | ORC #xx:8, CCR    | 1                         |                                |                         |                             |                             |                            |
| ROTL        | ROTL.B Rd         | 1                         |                                |                         |                             |                             |                            |
| ROTR        | ROTR.B Rd         | 1                         |                                |                         |                             |                             |                            |
| ROTXL       | ROTXL.B Rd        | 1                         |                                |                         |                             |                             |                            |
| ROTXR       | ROTXR.B Rd        | 1                         |                                |                         |                             |                             |                            |
| RTE         | RTE               | 2                         |                                | 2                       |                             |                             | 2                          |
| RTS         | RTS               | 2                         |                                | 1                       |                             |                             | 2                          |
| SHAL        | SHAL.B Rd         | 1                         |                                |                         |                             |                             |                            |
| SHAR        | SHAR.B Rd         | 1                         |                                |                         |                             |                             |                            |
| SHLL        | SHLL.B Rd         | 1                         |                                |                         |                             |                             |                            |
| SHLR        | SHLR.B Rd         | 1                         |                                |                         |                             |                             |                            |
| SLEEP       | SLEEP             | 1                         |                                |                         |                             |                             |                            |
| STC         | STC CCR, Rd       | 1                         |                                |                         |                             |                             |                            |
| SUB         | SUB.B Rs, Rd      | 1                         |                                |                         |                             |                             |                            |
|             | SUB.W Rs, Rd      | 1                         |                                |                         |                             |                             |                            |
| SUBS        | SUBS.W #1/2, Rd   | 1                         |                                |                         |                             |                             |                            |
| SUBX        | SUBX.B #xx:8, Rd  | 1                         |                                |                         |                             |                             |                            |
|             | SUBX.B Rs, Rd     | 1                         |                                |                         |                             |                             |                            |
| XOR         | XOR.B #xx:8, Rd   | 1                         |                                |                         |                             |                             |                            |
|             | XOR.B Rs, Rd      | 1                         |                                |                         |                             |                             |                            |
| XORC        | XORC #xx:8, CCR   | 1                         |                                |                         |                             |                             |                            |

Note: All values left blank are zero.

\* n: Initial value in R4L. Source and destination are accessed n + 1 times each.

# Appendix B Register Field

## B.1 Register Addresses and Bit Names

### B.1.1 I/O Registers in Maximum Specification (Except H8/3212 and H8/3202)

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names |       |       |       |       |       |       |       | Module<br>Name                                    |
|---------------------------|------------------|-----------|-------|-------|-------|-------|-------|-------|-------|---------------------------------------------------|
|                           |                  | Bit 7     | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                                                   |
| H'80                      |                  |           |       |       |       |       |       |       |       | External<br>memory<br>(in ex-<br>panded<br>modes) |
| H'81                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'82                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'83                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'84                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'85                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'86                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'87                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'88                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'89                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8A                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8B                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8C                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8D                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8E                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8F                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'90                      | TCR              | ICIE      | OCIEB | OCIEA | OVIE  | OEB   | OEA   | CKS1  | CKS0  | FRT                                               |
| H'91                      | TCSR             | ICF       | OCFB  | OCFA  | OVF   | OLVLB | OLVLA | IEDG  | CCLRA |                                                   |
| H'92                      | FRCH             |           |       |       |       |       |       |       |       |                                                   |
| H'93                      | FRCL             |           |       |       |       |       |       |       |       |                                                   |
| H'94                      | OCRAH            |           |       |       |       |       |       |       |       |                                                   |
| H'95                      | OCRAL            |           |       |       |       |       |       |       |       |                                                   |
| H'96                      | OCRBH            |           |       |       |       |       |       |       |       |                                                   |
| H'97                      | OCRBL            |           |       |       |       |       |       |       |       |                                                   |
| H'98                      | ICRH             |           |       |       |       |       |       |       |       |                                                   |
| H'99                      | ICRL             |           |       |       |       |       |       |       |       |                                                   |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                     |                     |                     |                     |                     |                     |                     | Module<br>Name           |
|---------------------------|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------------|
|                           |                  | Bit 7               | Bit 6               | Bit 5               | Bit 4               | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                          |
| H'9A                      | TCR              | CMIEB               | CMIEA               | OVIE                | CCLR1               | CCLR0               | CKS2                | CKS1                | CKS0                | TMRX                     |
| H'9B                      | TCSR             | CMFB                | CMFA                | OVF                 | PWME                | OS3                 | OS2                 | OS1                 | OS0                 |                          |
| H'9C                      | TCORA            |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9D                      | TCORB            |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9E                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9F                      | TCONR            | SMOD1               | SMOD0               | CLMOD               | INVV                | SCON1               | SCON0               | INVI                | INVO                | Timer<br>connec-<br>tion |
| H'A0                      | ICCR             | ICE                 | IEIC                | MST                 | TRS                 | ACK                 | CKS2                | CKS1                | CKS0                | IIC0                     |
| H'A1                      | ICSR             | BBSY                | IRIC                | SCP                 | —                   | AL                  | AAS                 | ADZ                 | ACKB                |                          |
| H'A2                      | ICDR             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'A3                      | ICMR/<br>SAR     | MLS/<br>SVA6        | WAIT/<br>SVA5       | —/<br>SVA4          | —/<br>SVA3          | —/<br>SVA2          | BC2/<br>SVA1        | BC1/<br>SVA0        | BC0/<br>FS          |                          |
| H'A4                      | ICCR             | ICE                 | IEIC                | MST                 | TRS                 | ACK                 | CKS2                | CKS1                | CKS0                | IIC1                     |
| H'A5                      | ICSR             | BBSY                | IRIC                | SCP                 | —                   | AL                  | AAS                 | ADZ                 | ACKB                |                          |
| H'A6                      | ICDR             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'A7                      | ICMR/<br>SAR     | MLS/<br>SVA6        | WAIT/<br>SVA5       | —/<br>SVA4          | —/<br>SVA3          | —/<br>SVA2          | BC2/<br>SVA1        | BC1/<br>SVA0        | BC0/<br>FS          |                          |
| H'A8                      | SEDGR            | VEDG                | HEDG                | CEDG                | FEDG                | —                   | —                   | —                   | —                   | Timer<br>connec-<br>tion |
| H'A9                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'AA                      | TCSR/<br>TCNT    | OVF                 | WT/IT               | TME                 | —                   | RST/<br>NMI         | CKS2                | CKS1                | CKS0                | WDT                      |
| H'AB                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'AC                      | P1PCR            | P1 <sub>7</sub> PCR | P1 <sub>6</sub> PCR | P1 <sub>5</sub> PCR | P1 <sub>4</sub> PCR | P1 <sub>3</sub> PCR | P1 <sub>2</sub> PCR | P1 <sub>1</sub> PCR | P1 <sub>0</sub> PCR | Port 1                   |
| H'AD                      | P2PCR            | P2 <sub>7</sub> PCR | P2 <sub>6</sub> PCR | P2 <sub>5</sub> PCR | P2 <sub>4</sub> PCR | P2 <sub>3</sub> PCR | P2 <sub>2</sub> PCR | P2 <sub>1</sub> PCR | P2 <sub>0</sub> PCR | Port 2                   |
| H'AE                      | P3PCR            | P3 <sub>7</sub> PCR | P3 <sub>6</sub> PCR | P3 <sub>5</sub> PCR | P3 <sub>4</sub> PCR | P3 <sub>3</sub> PCR | P3 <sub>2</sub> PCR | P3 <sub>1</sub> PCR | P3 <sub>0</sub> PCR | Port 3                   |
| H'AF                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'B0                      | P1DDR            | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR | Port 1                   |
| H'B1                      | P2DDR            | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR | Port 2                   |
| H'B2                      | P1DR             | P1 <sub>7</sub>     | P1 <sub>6</sub>     | P1 <sub>5</sub>     | P1 <sub>4</sub>     | P1 <sub>3</sub>     | P1 <sub>2</sub>     | P1 <sub>1</sub>     | P1 <sub>0</sub>     | Port 1                   |
| H'B3                      | P2DR             | P2 <sub>7</sub>     | P2 <sub>6</sub>     | P2 <sub>5</sub>     | P2 <sub>4</sub>     | P2 <sub>3</sub>     | P2 <sub>2</sub>     | P2 <sub>1</sub>     | P2 <sub>0</sub>     | Port 2                   |
| H'B4                      | P3DDR            | P3 <sub>7</sub> DDR | P3 <sub>6</sub> DDR | P3 <sub>5</sub> DDR | P3 <sub>4</sub> DDR | P3 <sub>3</sub> DDR | P3 <sub>2</sub> DDR | P3 <sub>1</sub> DDR | P3 <sub>0</sub> DDR | Port 3                   |
| H'B5                      | P4DDR            | P4 <sub>7</sub> DDR | P4 <sub>6</sub> DDR | P4 <sub>5</sub> DDR | P4 <sub>4</sub> DDR | P4 <sub>3</sub> DDR | P4 <sub>2</sub> DDR | P4 <sub>1</sub> DDR | P4 <sub>0</sub> DDR | Port 4                   |
| H'B6                      | P3DR             | P3 <sub>7</sub>     | P3 <sub>6</sub>     | P3 <sub>5</sub>     | P3 <sub>4</sub>     | P3 <sub>3</sub>     | P3 <sub>2</sub>     | P3 <sub>1</sub>     | P3 <sub>0</sub>     | Port 3                   |
| H'B7                      | P4DR             | P4 <sub>7</sub>     | P4 <sub>6</sub>     | P4 <sub>5</sub>     | P4 <sub>4</sub>     | P4 <sub>3</sub>     | P4 <sub>2</sub>     | P4 <sub>1</sub>     | P4 <sub>0</sub>     | Port 4                   |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                                  |                                  |                                  |                     |                     |                     |                     | Module<br>Name |
|---------------------------|------------------|---------------------|----------------------------------|----------------------------------|----------------------------------|---------------------|---------------------|---------------------|---------------------|----------------|
|                           |                  | Bit 7               | Bit 6                            | Bit 5                            | Bit 4                            | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                |
| H'B8                      | P5DDR            | —                   | —                                | P5 <sub>5</sub> DDR              | P5 <sub>4</sub> DDR              | P5 <sub>3</sub> DDR | P5 <sub>2</sub> DDR | P5 <sub>1</sub> DDR | P5 <sub>0</sub> DDR | Port 5         |
| H'B9                      | P6DDR            | —                   | P6 <sub>6</sub> DDR              | P6 <sub>5</sub> DDR              | P6 <sub>4</sub> DDR              | P6 <sub>3</sub> DDR | P6 <sub>2</sub> DDR | P6 <sub>1</sub> DDR | P6 <sub>0</sub> DDR | Port 6         |
| H'BA                      | P5DR             | —                   | —                                | P5 <sub>5</sub>                  | P5 <sub>4</sub>                  | P5 <sub>3</sub>     | P5 <sub>2</sub>     | P5 <sub>1</sub>     | P5 <sub>0</sub>     | Port 5         |
| H'BB                      | P6DR             | —/P7 <sub>3</sub>   | P6 <sub>6</sub> /P7 <sub>2</sub> | P6 <sub>5</sub> /P7 <sub>1</sub> | P6 <sub>4</sub> /P7 <sub>0</sub> | P6 <sub>3</sub>     | P6 <sub>2</sub>     | P6 <sub>1</sub>     | P6 <sub>0</sub>     | Port 6         |
| H'BC                      | P7DDR            | P7 <sub>7</sub> DDR | P7 <sub>6</sub> DDR              | P7 <sub>5</sub> DDR              | P7 <sub>4</sub> DDR              | P7 <sub>3</sub> DDR | P7 <sub>2</sub> DDR | P7 <sub>1</sub> DDR | P7 <sub>0</sub> DDR | Port 7         |
| H'BD                      | —                | —                   | —                                | —                                | —                                | —                   | —                   | —                   | —                   | —              |
| H'BE                      | P7DR             | P7 <sub>7</sub>     | P7 <sub>6</sub>                  | P7 <sub>5</sub>                  | P7 <sub>4</sub>                  | P7 <sub>3</sub>     | P7 <sub>2</sub>     | P7 <sub>1</sub>     | P7 <sub>0</sub>     | Port 7         |
| H'BF                      | —                | —                   | —                                | —                                | —                                | —                   | —                   | —                   | —                   | —              |
| H'C0                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'C1                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'C2                      | WSCR             | —                   | —                                | CLKDBL                           | —                                | WMS1                | WMS0                | WC1                 | WC0                 |                |
| H'C3                      | STCR             | IICS                | IICX1                            | IICX0                            | SYNCE                            | PWCKE               | PWCKS               | ICKS1               | ICKS0               |                |
| H'C4                      | SYSCR            | SSBY                | STS2                             | STS1                             | STS0                             | XRST                | NMIEG               | HIE                 | RAME                |                |
| H'C5                      | MDCR             | —                   | —                                | —                                | —                                | —                   | —                   | MDS1                | MDS0                |                |
| H'C6                      | ISCR             | —                   | IRQ6SC                           | —                                | —                                | —                   | IRQ2SC              | IRQ1SC              | IRQ0SC              |                |
| H'C7                      | IER              | —                   | IRQ6E                            | —                                | —                                | —                   | IRQ2E               | IRQ1E               | IRQ0E               |                |
| H'C8                      | TCR              | CMIEB               | CMIEA                            | OVIE                             | CCLR1                            | CCLR0               | CKS2                | CKS1                | CKS0                | TMR0           |
| H'C9                      | TCSR             | CMFB                | CMFA                             | OVF                              | PWME                             | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'CA                      | TCORA            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CB                      | TCORB            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CC                      | TCNT             |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CD                      | PWOERB           | OE15                | OE14                             | OE13                             | OE12                             | OE11                | OE10                | OE9                 | OE8                 | PWM            |
| H'CE                      | PWDPRB           | OS15                | OS14                             | OS13                             | OS12                             | OS11                | OS10                | OS9                 | OS8                 |                |
| H'CF                      | PWDPRB           | OS7                 | OS6                              | OS5                              | OS4                              | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'D0                      | TCR              | CMIEB               | CMIEA                            | OVIE                             | CCLR1                            | CCLR0               | CKS2                | CKS1                | CKS0                | TMR1           |
| H'D1                      | TCSR             | CMFB                | CMFA                             | OVF                              | PWME                             | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'D2                      | TCORA            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D3                      | TCORB            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D4                      | TCNT             |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D5                      | PWOERA           | OE7                 | OE6                              | OE5                              | OE4                              | OE3                 | OE2                 | OE1                 | OE0                 | PWM            |
| H'D6                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D7                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names    |       |       |              |       |       |       |       | Module<br>Name |
|---------------------------|------------------|--------------|-------|-------|--------------|-------|-------|-------|-------|----------------|
|                           |                  | Bit 7        | Bit 6 | Bit 5 | Bit 4        | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                |
| H'D8                      | SMR              | C/ $\bar{A}$ | CHR   | PE    | O/ $\bar{E}$ | STOP  | MP    | CKS1  | CKS0  | SCI0           |
| H'D9                      | BRR              |              |       |       |              |       |       |       |       |                |
| H'DA                      | SCR              | TIE          | RIE   | TE    | RE           | MPIE  | TEIE  | CKE1  | CKE0  |                |
| H'DB                      | TDR              |              |       |       |              |       |       |       |       |                |
| H'DC                      | SSR              | TDRE         | RDRF  | ORER  | FER          | PER   | TEND  | MPB   | MPBT  |                |
| H'DD                      | RDR              |              |       |       |              |       |       |       |       |                |
| H'DE                      | SCMR             | —            | —     | —     | —            | SDIR  | SINV  | —     | SMIF  | SCI1           |
| H'DF                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E0                      | SMR              | C/ $\bar{A}$ | CHR   | PE    | O/ $\bar{E}$ | STOP  | MP    | CKS1  | CKS0  |                |
| H'E1                      | BRR              |              |       |       |              |       |       |       |       |                |
| H'E2                      | SCR              | TIE          | RIE   | TE    | RE           | MPIE  | TEIE  | CKE1  | CKE0  |                |
| H'E3                      | TDR              |              |       |       |              |       |       |       |       |                |
| H'E4                      | SSR              | TDRE         | RDRF  | ORER  | FER          | PER   | TEND  | MPB   | MPBT  |                |
| H'E5                      | RDR              |              |       |       |              |       |       |       |       |                |
| H'E6                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E7                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E8                      |                  |              |       |       |              |       |       |       |       |                |
| H'E9                      |                  |              |       |       |              |       |       |       |       |                |
| H'EA                      |                  |              |       |       |              |       |       |       |       |                |
| H'EB                      |                  |              |       |       |              |       |       |       |       |                |
| H'EC                      |                  |              |       |       |              |       |       |       |       |                |
| H'ED                      |                  |              |       |       |              |       |       |       |       |                |
| H'EE                      |                  |              |       |       |              |       |       |       |       |                |
| H'EF                      |                  |              |       |       |              |       |       |       |       |                |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names            |                      |                      |                      |                      |                      |                      |                      | Module<br>Name |
|---------------------------|------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------|
|                           |                  | Bit 7                | Bit 6                | Bit 5                | Bit 4                | Bit 3                | Bit 2                | Bit 1                | Bit 0                |                |
| H'F0                      | PWDR0<br>/HICR   | /—                   | /—                   | /—                   | /—                   | /—                   | /IBFIE2              | /IBFIE1              | /FGA <sub>20</sub> E | PWM<br>and HIF |
| H'F1                      | PWDR1<br>/KMIMR  | /KMIMR7              | /KMIMR6              | /KMIMR5              | /KMIMR4              | /KMIMR3              | /KMIMR2              | /KMIMR1              | /KMIMR0              |                |
| H'F2                      | PWDR2<br>/KMPCR  | /KM <sub>7</sub> PCR | /KM <sub>6</sub> PCR | /KM <sub>5</sub> PCR | /KM <sub>4</sub> PCR | /KM <sub>3</sub> PCR | /KM <sub>2</sub> PCR | /KM <sub>1</sub> PCR | /KM <sub>0</sub> PCR |                |
| H'F3                      | PWDR3            | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'F4                      | PWDR4<br>/IDR1   |                      |                      |                      |                      |                      |                      |                      |                      |                |
| H'F5                      | PWDR5<br>/ODR1   |                      |                      |                      |                      |                      |                      |                      |                      |                |
| H'F6                      | PWDR6<br>/STR1   | /DBU                 | /DBU                 | /DBU                 | /DBU                 | /C/ $\overline{D}$   | /DBU                 | /IBF                 | /OBF                 |                |
| H'F7                      | PWDR7            | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'F8                      | PWDR8            | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'F9                      | PWDR9            | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'FA                      | PWDR10           | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'FB                      | PWDR11           | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |
| H'FC                      | PWDR12<br>/IDR2  |                      |                      |                      |                      |                      |                      |                      |                      |                |
| H'FD                      | PWDR13<br>/ODR2  |                      |                      |                      |                      |                      |                      |                      |                      |                |
| H'FE                      | PWDR14<br>/STR2  | /DBU                 | /DBU                 | /DBU                 | /DBU                 | /C/ $\overline{D}$   | /DBU                 | /IBF                 | /OBF                 |                |
| H'FF                      | PWDR15           | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   | /—                   |                |

Notes: FRT: Free-running timer  
TMR0: 8-bit timer channel 0  
TMR1: 8-bit timer channel 1  
SCIO: Serial communication interface 0  
SCI1: Serial communication interface 1  
PWM: Pulse width modulation timer  
HIF: Host interface

## B.1.2 H8/3212 I/O Registers

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names |       |       |       |       |       |       |       | Module<br>Name                                    |
|---------------------------|------------------|-----------|-------|-------|-------|-------|-------|-------|-------|---------------------------------------------------|
|                           |                  | Bit 7     | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                                                   |
| H'80                      |                  |           |       |       |       |       |       |       |       | External<br>memory<br>(in ex-<br>panded<br>modes) |
| H'81                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'82                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'83                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'84                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'85                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'86                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'87                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'88                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'89                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8A                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8B                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8C                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8D                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8E                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8F                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'90                      | TCR              | ICIE      | OCIEB | OCIEA | OVIE  | OEB   | OEA   | CKS1  | CKS0  | FRT                                               |
| H'91                      | TCSR             | ICF       | OCFB  | OCFA  | OVF   | OLVLB | OLVLA | IEDG  | CCLRA |                                                   |
| H'92                      | FRCH             |           |       |       |       |       |       |       |       |                                                   |
| H'93                      | FRCL             |           |       |       |       |       |       |       |       |                                                   |
| H'94                      | OCRAH            |           |       |       |       |       |       |       |       |                                                   |
| H'95                      | OCRAL            |           |       |       |       |       |       |       |       |                                                   |
| H'96                      | OCRBH            |           |       |       |       |       |       |       |       |                                                   |
| H'97                      | OCRBL            |           |       |       |       |       |       |       |       |                                                   |
| H'98                      | ICRH             |           |       |       |       |       |       |       |       |                                                   |
| H'99                      | ICRL             |           |       |       |       |       |       |       |       |                                                   |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                     |                     |                     |                     |                     |                     |                     | Module<br>Name           |
|---------------------------|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------------|
|                           |                  | Bit 7               | Bit 6               | Bit 5               | Bit 4               | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                          |
| H'9A                      | TCR              | CMIEB               | CMIEA               | OVIE                | CCLR1               | CCLR0               | CKS2                | CKS1                | CKS0                | TMRX                     |
| H'9B                      | TCSR             | CMFB                | CMFA                | OVF                 | PWME                | OS3                 | OS2                 | OS1                 | OS0                 |                          |
| H'9C                      | TCORA            |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9D                      | TCORB            |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9E                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'9F                      | TCONR            | SMOD1               | SMOD0               | CLMOD               | INVV                | SCON1               | SCON0               | INVI                | INVO                | Timer<br>connec-<br>tion |
| H'A0                      | ICCR             | ICE                 | IEIC                | MST                 | TRS                 | ACK                 | CKS2                | CKS1                | CKS0                | IIC0                     |
| H'A1                      | ICSR             | BBSY                | IRIC                | SCP                 | —                   | AL                  | AAS                 | ADZ                 | ACKB                |                          |
| H'A2                      | ICDR             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'A3                      | ICMR/<br>SAR     | MLS/<br>SVA6        | WAIT/<br>SVA5       | —/<br>SVA4          | —/<br>SVA3          | —/<br>SVA2          | BC2/<br>SVA1        | BC1/<br>SVA0        | BC0/<br>FS          |                          |
| H'A4                      | ICCR             | ICE                 | IEIC                | MST                 | TRS                 | ACK                 | CKS2                | CKS1                | CKS0                | IIC1                     |
| H'A5                      | ICSR             | BBSY                | IRIC                | SCP                 | —                   | AL                  | AAS                 | ADZ                 | ACKB                |                          |
| H'A6                      | ICDR             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'A7                      | ICMR/<br>SAR     | MLS/<br>SVA6        | WAIT/<br>SVA5       | —/<br>SVA4          | —/<br>SVA3          | —/<br>SVA2          | BC2/<br>SVA1        | BC1/<br>SVA0        | BC0/<br>FS          |                          |
| H'A8                      | SEDGR            | VEDG                | HEDG                | CEDG                | FEDG                | —                   | —                   | —                   | —                   | Timer<br>connec-<br>tion |
| H'A9                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'AA                      | TCSR/<br>TCNT    | OVF                 | WT/IT               | TME                 | —                   | RST/<br>NMI         | CKS2                | CKS1                | CKS0                | WDT                      |
| H'AB                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'AC                      | P1PCR            | P1 <sub>7</sub> PCR | P1 <sub>6</sub> PCR | P1 <sub>5</sub> PCR | P1 <sub>4</sub> PCR | P1 <sub>3</sub> PCR | P1 <sub>2</sub> PCR | P1 <sub>1</sub> PCR | P1 <sub>0</sub> PCR | Port 1                   |
| H'AD                      | P2PCR            | P2 <sub>7</sub> PCR | P2 <sub>6</sub> PCR | P2 <sub>5</sub> PCR | P2 <sub>4</sub> PCR | P2 <sub>3</sub> PCR | P2 <sub>2</sub> PCR | P2 <sub>1</sub> PCR | P2 <sub>0</sub> PCR | Port 2                   |
| H'AE                      | P3PCR            | P3 <sub>7</sub> PCR | P3 <sub>6</sub> PCR | P3 <sub>5</sub> PCR | P3 <sub>4</sub> PCR | P3 <sub>3</sub> PCR | P3 <sub>2</sub> PCR | P3 <sub>1</sub> PCR | P3 <sub>0</sub> PCR | Port 3                   |
| H'AF                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                          |
| H'B0                      | P1DDR            | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR | Port 1                   |
| H'B1                      | P2DDR            | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR | Port 2                   |
| H'B2                      | P1DR             | P1 <sub>7</sub>     | P1 <sub>6</sub>     | P1 <sub>5</sub>     | P1 <sub>4</sub>     | P1 <sub>3</sub>     | P1 <sub>2</sub>     | P1 <sub>1</sub>     | P1 <sub>0</sub>     | Port 1                   |
| H'B3                      | P2DR             | P2 <sub>7</sub>     | P2 <sub>6</sub>     | P2 <sub>5</sub>     | P2 <sub>4</sub>     | P2 <sub>3</sub>     | P2 <sub>2</sub>     | P2 <sub>1</sub>     | P2 <sub>0</sub>     | Port 2                   |
| H'B4                      | P3DDR            | P3 <sub>7</sub> DDR | P3 <sub>6</sub> DDR | P3 <sub>5</sub> DDR | P3 <sub>4</sub> DDR | P3 <sub>3</sub> DDR | P3 <sub>2</sub> DDR | P3 <sub>1</sub> DDR | P3 <sub>0</sub> DDR | Port 3                   |
| H'B5                      | P4DDR            | P4 <sub>7</sub> DDR | P4 <sub>6</sub> DDR | P4 <sub>5</sub> DDR | P4 <sub>4</sub> DDR | P4 <sub>3</sub> DDR | P4 <sub>2</sub> DDR | P4 <sub>1</sub> DDR | P4 <sub>0</sub> DDR | Port 4                   |
| H'B6                      | P3DR             | P3 <sub>7</sub>     | P3 <sub>6</sub>     | P3 <sub>5</sub>     | P3 <sub>4</sub>     | P3 <sub>3</sub>     | P3 <sub>2</sub>     | P3 <sub>1</sub>     | P3 <sub>0</sub>     | Port 3                   |
| H'B7                      | P4DR             | P4 <sub>7</sub>     | P4 <sub>6</sub>     | P4 <sub>5</sub>     | P4 <sub>4</sub>     | P4 <sub>3</sub>     | P4 <sub>2</sub>     | P4 <sub>1</sub>     | P4 <sub>0</sub>     | Port 4                   |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                     |                     |                     |                     |                     |                     |                     | Module<br>Name |
|---------------------------|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------|
|                           |                  | Bit 7               | Bit 6               | Bit 5               | Bit 4               | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                |
| H'B8                      | P5DDR            | —                   | —                   | P5 <sub>5</sub> DDR | P5 <sub>4</sub> DDR | P5 <sub>3</sub> DDR | P5 <sub>2</sub> DDR | P5 <sub>1</sub> DDR | P5 <sub>0</sub> DDR | Port 5         |
| H'B9                      | P6DDR            | —                   | P6 <sub>6</sub> DDR | P6 <sub>5</sub> DDR | P6 <sub>4</sub> DDR | P6 <sub>3</sub> DDR | P6 <sub>2</sub> DDR | P6 <sub>1</sub> DDR | P6 <sub>0</sub> DDR | Port 6         |
| H'BA                      | P5DR             | —                   | —                   | P5 <sub>5</sub>     | P5 <sub>4</sub>     | P5 <sub>3</sub>     | P5 <sub>2</sub>     | P5 <sub>1</sub>     | P5 <sub>0</sub>     | Port 5         |
| H'BB                      | P6DR             | —                   | P6 <sub>6</sub>     | P6 <sub>5</sub>     | P6 <sub>4</sub>     | P6 <sub>3</sub>     | P6 <sub>2</sub>     | P6 <sub>1</sub>     | P6 <sub>0</sub>     | Port 6         |
| H'BC                      | P7DDR            | P7 <sub>7</sub> DDR | P7 <sub>6</sub> DDR | P7 <sub>5</sub> DDR | P7 <sub>4</sub> DDR | P7 <sub>3</sub> DDR | P7 <sub>2</sub> DDR | P7 <sub>1</sub> DDR | P7 <sub>0</sub> DDR | Port 7         |
| H'BD                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —              |
| H'BE                      | P7DR             | P7 <sub>7</sub>     | P7 <sub>6</sub>     | P7 <sub>5</sub>     | P7 <sub>4</sub>     | P7 <sub>3</sub>     | P7 <sub>2</sub>     | P7 <sub>1</sub>     | P7 <sub>0</sub>     | Port 7         |
| H'BF                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —              |
| H'C0                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'C1                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'C2                      | WSCR             | —                   | —                   | CLKDBL              | —                   | WMS1                | WMS0                | WC1                 | WC0                 |                |
| H'C3                      | STCR             | IICS                | IICX1               | IICX0               | SYNCE               | PWCKE               | PWCKS               | ICKS1               | ICKS0               |                |
| H'C4                      | SYSCR            | SSBY                | STS2                | STS1                | STS0                | XRST                | NMIEG               | HIE                 | RAME                |                |
| H'C5                      | MDCR             | —                   | —                   | —                   | —                   | —                   | —                   | MDS1                | MDS0                |                |
| H'C6                      | ISCR             | —                   | IRQ6SC              | —                   | —                   | —                   | IRQ2SC              | IRQ1SC              | IRQ0SC              |                |
| H'C7                      | IER              | —                   | IRQ6E               | —                   | —                   | —                   | IRQ2E               | IRQ1E               | IRQ0E               |                |
| H'C8                      | TCR              | CMIEB               | CMIEA               | OVIE                | CCLR1               | CCLR0               | CKS2                | CKS1                | CKS0                | TMR0           |
| H'C9                      | TCSR             | CMFB                | CMFA                | OVF                 | PWME                | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'CA                      | TCORA            |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'CB                      | TCORB            |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'CC                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'CD                      | PWOERB           | OE15                | OE14                | OE13                | OE12                | OE11                | OE10                | OE9                 | OE8                 | PWM            |
| H'CE                      | PWDPRB           | OS15                | OS14                | OS13                | OS12                | OS11                | OS10                | OS9                 | OS8                 |                |
| H'CF                      | PWDPRB           | OS7                 | OS6                 | OS5                 | OS4                 | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'D0                      | TCR              | CMIEB               | CMIEA               | OVIE                | CCLR1               | CCLR0               | CKS2                | CKS1                | CKS0                | TMR1           |
| H'D1                      | TCSR             | CMFB                | CMFA                | OVF                 | PWME                | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'D2                      | TCORA            |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'D3                      | TCORB            |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'D4                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'D5                      | PWOERA           | OE7                 | OE6                 | OE5                 | OE4                 | OE3                 | OE2                 | OE1                 | OE0                 | PWM            |
| H'D6                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'D7                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names    |       |       |              |       |       |       |       | Module<br>Name |
|---------------------------|------------------|--------------|-------|-------|--------------|-------|-------|-------|-------|----------------|
|                           |                  | Bit 7        | Bit 6 | Bit 5 | Bit 4        | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                |
| H'D8                      | SMR              | C/ $\bar{A}$ | CHR   | PE    | O/ $\bar{E}$ | STOP  | MP    | CKS1  | CKS0  | SCI0           |
| H'D9                      | BRR              |              |       |       |              |       |       |       |       |                |
| H'DA                      | SCR              | TIE          | RIE   | TE    | RE           | MPIE  | TEIE  | CKE1  | CKE0  |                |
| H'DB                      | TDR              |              |       |       |              |       |       |       |       |                |
| H'DC                      | SSR              | TDRE         | RDRF  | ORER  | FER          | PER   | TEND  | MPB   | MPBT  |                |
| H'DD                      | RDR              |              |       |       |              |       |       |       |       |                |
| H'DE                      | SCMR             | —            | —     | —     | —            | SDIR  | SINV  | —     | SMIF  |                |
| H'DF                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E0                      |                  |              |       |       |              |       |       |       |       |                |
| H'E1                      |                  |              |       |       |              |       |       |       |       |                |
| H'E2                      |                  |              |       |       |              |       |       |       |       |                |
| H'E3                      |                  |              |       |       |              |       |       |       |       |                |
| H'E4                      |                  |              |       |       |              |       |       |       |       |                |
| H'E5                      |                  |              |       |       |              |       |       |       |       |                |
| H'E6                      |                  |              |       |       |              |       |       |       |       |                |
| H'E7                      |                  |              |       |       |              |       |       |       |       |                |
| H'E8                      |                  |              |       |       |              |       |       |       |       |                |
| H'E9                      |                  |              |       |       |              |       |       |       |       |                |
| H'EA                      |                  |              |       |       |              |       |       |       |       |                |
| H'EB                      |                  |              |       |       |              |       |       |       |       |                |
| H'EC                      |                  |              |       |       |              |       |       |       |       |                |
| H'ED                      |                  |              |       |       |              |       |       |       |       |                |
| H'EE                      |                  |              |       |       |              |       |       |       |       |                |
| H'EF                      |                  |              |       |       |              |       |       |       |       |                |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names |       |       |       |       |       |       |       | Module<br>Name |
|---------------------------|------------------|-----------|-------|-------|-------|-------|-------|-------|-------|----------------|
|                           |                  | Bit 7     | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                |
| H'F0                      | PWDR0            |           |       |       |       |       |       |       |       | PWM            |
| H'F1                      | PWDR1            |           |       |       |       |       |       |       |       |                |
| H'F2                      | PWDR2            |           |       |       |       |       |       |       |       |                |
| H'F3                      | PWDR3            |           |       |       |       |       |       |       |       |                |
| H'F4                      | PWDR4            |           |       |       |       |       |       |       |       |                |
| H'F5                      | PWDR5            |           |       |       |       |       |       |       |       |                |
| H'F6                      | PWDR6            |           |       |       |       |       |       |       |       |                |
| H'F7                      | PWDR7            |           |       |       |       |       |       |       |       |                |
| H'F8                      | PWDR8            |           |       |       |       |       |       |       |       |                |
| H'F9                      | PWDR9            |           |       |       |       |       |       |       |       |                |
| H'FA                      | PWDR10           |           |       |       |       |       |       |       |       |                |
| H'FB                      | PWDR11           |           |       |       |       |       |       |       |       |                |
| H'FC                      | PWDR12           |           |       |       |       |       |       |       |       |                |
| H'FD                      | PWDR13           |           |       |       |       |       |       |       |       |                |
| H'FE                      | PWDR14           |           |       |       |       |       |       |       |       |                |
| H'FF                      | PWDR15           |           |       |       |       |       |       |       |       |                |

Notes: FRT: Free-running timer  
TMR0: 8-bit timer channel 0  
TMR1: 8-bit timer channel 1  
SCI0: Serial communication interface 0  
SCI1: Serial communication interface 1  
PWM: Pulse width modulation timer

### B.1.3 H8/3202 I/O Registers

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names |       |       |       |       |       |       |       | Module<br>Name                                    |
|---------------------------|------------------|-----------|-------|-------|-------|-------|-------|-------|-------|---------------------------------------------------|
|                           |                  | Bit 7     | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                                                   |
| H'80                      |                  |           |       |       |       |       |       |       |       | External<br>memory<br>(in ex-<br>panded<br>modes) |
| H'81                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'82                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'83                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'84                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'85                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'86                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'87                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'88                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'89                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8A                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8B                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8C                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8D                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8E                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'8F                      |                  |           |       |       |       |       |       |       |       |                                                   |
| H'90                      | TCR              | ICIE      | OCIEB | OCIEA | OVIE  | OEB   | OEA   | CKS1  | CKS0  | FRT                                               |
| H'91                      | TCSR             | ICF       | OCFB  | OCFA  | OVF   | OLVLB | OLVLA | IEDG  | CCLRA |                                                   |
| H'92                      | FRCH             |           |       |       |       |       |       |       |       |                                                   |
| H'93                      | FRCL             |           |       |       |       |       |       |       |       |                                                   |
| H'94                      | OCRAH            |           |       |       |       |       |       |       |       |                                                   |
| H'95                      | OCRAL            |           |       |       |       |       |       |       |       |                                                   |
| H'96                      | OCRBH            |           |       |       |       |       |       |       |       |                                                   |
| H'97                      | OCRBL            |           |       |       |       |       |       |       |       |                                                   |
| H'98                      | ICRH             |           |       |       |       |       |       |       |       |                                                   |
| H'99                      | ICRL             |           |       |       |       |       |       |       |       |                                                   |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                     |                     |                     |                     |                     |                     |                     | Module<br>Name   |
|---------------------------|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|------------------|
|                           |                  | Bit 7               | Bit 6               | Bit 5               | Bit 4               | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                  |
| H'9A                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'9B                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'9C                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'9D                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'9E                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'9F                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A0                      | ICCR             | ICE                 | IEIC                | MST                 | TRS                 | ACK                 | CKS2                | CKS1                | CKS0                | I <sup>2</sup> C |
| H'A1                      | ICSR             | BBSY                | IRIC                | SCP                 | —                   | AL                  | AAS                 | ADZ                 | ACKB                |                  |
| H'A2                      | ICDR             |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A3                      | ICMR/<br>SAR     | MLS/<br>SVA6        | WAIT/<br>SVA5       | —/<br>SVA4          | —/<br>SVA3          | —/<br>SVA2          | BC2/<br>SVA1        | BC1/<br>SVA0        | BC0/<br>FS          |                  |
| H'A4                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A5                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A6                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A7                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A8                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'A9                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'AA                      | TCSR             | OVF                 | WT/IT               | TME                 | —                   | RST/<br>NMI         | CKS2                | CKS1                | CKS0                | WDT              |
| H'AB                      | TCNT             |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'AC                      | P1PCR            | P1 <sub>7</sub> PCR | P1 <sub>6</sub> PCR | P1 <sub>5</sub> PCR | P1 <sub>4</sub> PCR | P1 <sub>3</sub> PCR | P1 <sub>2</sub> PCR | P1 <sub>1</sub> PCR | P1 <sub>0</sub> PCR | Port 1           |
| H'AD                      | P2PCR            | P2 <sub>7</sub> PCR | P2 <sub>6</sub> PCR | P2 <sub>5</sub> PCR | P2 <sub>4</sub> PCR | P2 <sub>3</sub> PCR | P2 <sub>2</sub> PCR | P2 <sub>1</sub> PCR | P2 <sub>0</sub> PCR | Port 2           |
| H'AE                      | P3PCR            | P3 <sub>7</sub> PCR | P3 <sub>6</sub> PCR | P3 <sub>5</sub> PCR | P3 <sub>4</sub> PCR | P3 <sub>3</sub> PCR | P3 <sub>2</sub> PCR | P3 <sub>1</sub> PCR | P3 <sub>0</sub> PCR | Port 3           |
| H'AF                      |                  |                     |                     |                     |                     |                     |                     |                     |                     |                  |
| H'B0                      | P1DDR            | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR | Port 1           |
| H'B1                      | P2DDR            | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR | Port 2           |
| H'B2                      | P1DR             | P1 <sub>7</sub>     | P1 <sub>6</sub>     | P1 <sub>5</sub>     | P1 <sub>4</sub>     | P1 <sub>3</sub>     | P1 <sub>2</sub>     | P1 <sub>1</sub>     | P1 <sub>0</sub>     | Port 1           |
| H'B3                      | P2DR             | P2 <sub>7</sub>     | P2 <sub>6</sub>     | P2 <sub>5</sub>     | P2 <sub>4</sub>     | P2 <sub>3</sub>     | P2 <sub>2</sub>     | P2 <sub>1</sub>     | P2 <sub>0</sub>     | Port 2           |
| H'B4                      | P3DDR            | P3 <sub>7</sub> DDR | P3 <sub>6</sub> DDR | P3 <sub>5</sub> DDR | P3 <sub>4</sub> DDR | P3 <sub>3</sub> DDR | P3 <sub>2</sub> DDR | P3 <sub>1</sub> DDR | P3 <sub>0</sub> DDR | Port 3           |
| H'B5                      | P4DDR            | P4 <sub>7</sub> DDR | P4 <sub>6</sub> DDR | P4 <sub>5</sub> DDR | P4 <sub>4</sub> DDR | P4 <sub>3</sub> DDR | P4 <sub>2</sub> DDR | P4 <sub>1</sub> DDR | P4 <sub>0</sub> DDR | Port 4           |
| H'B6                      | P3DR             | P3 <sub>7</sub>     | P3 <sub>6</sub>     | P3 <sub>5</sub>     | P3 <sub>4</sub>     | P3 <sub>3</sub>     | P3 <sub>2</sub>     | P3 <sub>1</sub>     | P3 <sub>0</sub>     | Port 3           |
| H'B7                      | P4DR             | P4 <sub>7</sub>     | P4 <sub>6</sub>     | P4 <sub>5</sub>     | P4 <sub>4</sub>     | P4 <sub>3</sub>     | P4 <sub>2</sub>     | P4 <sub>1</sub>     | P4 <sub>0</sub>     | Port 4           |

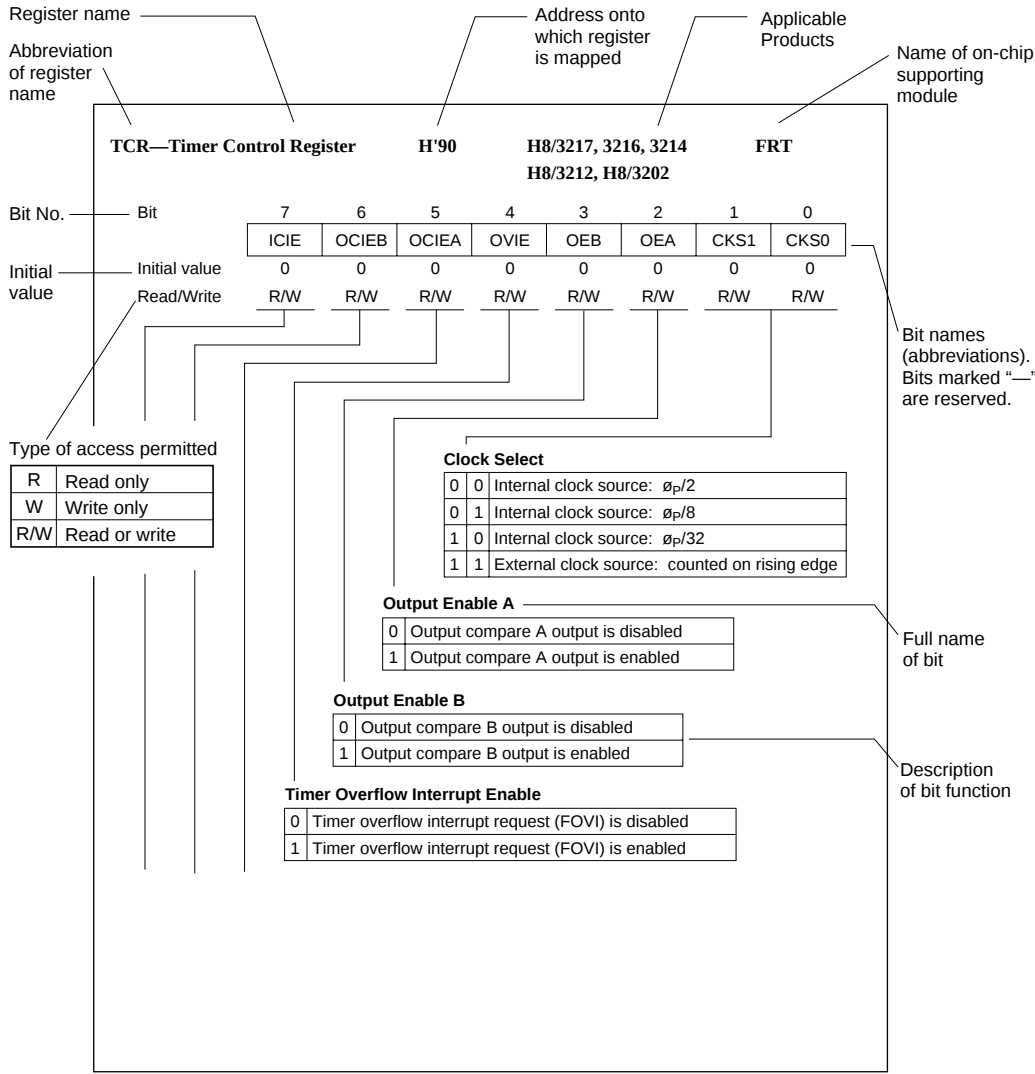
| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                                  |                                  |                                  |                     |                     |                     |                     | Module<br>Name |
|---------------------------|------------------|---------------------|----------------------------------|----------------------------------|----------------------------------|---------------------|---------------------|---------------------|---------------------|----------------|
|                           |                  | Bit 7               | Bit 6                            | Bit 5                            | Bit 4                            | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                |
| H'B8                      | P5DDR            | —                   | —                                | P5 <sub>5</sub> DDR              | P5 <sub>4</sub> DDR              | P5 <sub>3</sub> DDR | P5 <sub>2</sub> DDR | P5 <sub>1</sub> DDR | P5 <sub>0</sub> DDR | Port 5         |
| H'B9                      | P6DDR            | —                   | P6 <sub>6</sub> DDR              | P6 <sub>5</sub> DDR              | P6 <sub>4</sub> DDR              | P6 <sub>3</sub> DDR | P6 <sub>2</sub> DDR | P6 <sub>1</sub> DDR | P6 <sub>0</sub> DDR | Port 6         |
| H'BA                      | P5DR             | —                   | —                                | P5 <sub>5</sub>                  | P5 <sub>4</sub>                  | P5 <sub>3</sub>     | P5 <sub>2</sub>     | P5 <sub>1</sub>     | P5 <sub>0</sub>     | Port 5         |
| H'BB                      | P6DR             | —/P7 <sub>3</sub>   | P6 <sub>6</sub> /P7 <sub>2</sub> | P6 <sub>5</sub> /P7 <sub>1</sub> | P6 <sub>4</sub> /P7 <sub>0</sub> | P6 <sub>3</sub>     | P6 <sub>2</sub>     | P6 <sub>1</sub>     | P6 <sub>0</sub>     | Port 6         |
| H'BC                      | P7DDR            | P7 <sub>7</sub> DDR | P7 <sub>6</sub> DDR              | P7 <sub>5</sub> DDR              | P7 <sub>4</sub> DDR              | P7 <sub>3</sub> DDR | P7 <sub>2</sub> DDR | P7 <sub>1</sub> DDR | P7 <sub>0</sub> DDR | Port 7         |
| H'BD                      | —                | —                   | —                                | —                                | —                                | —                   | —                   | —                   | —                   | —              |
| H'BE                      | P7DR             | P7 <sub>7</sub>     | P7 <sub>6</sub>                  | P7 <sub>5</sub>                  | P7 <sub>4</sub>                  | P7 <sub>3</sub>     | P7 <sub>2</sub>     | P7 <sub>1</sub>     | P7 <sub>0</sub>     | Port 7         |
| H'BF                      | —                | —                   | —                                | —                                | —                                | —                   | —                   | —                   | —                   | —              |
| H'C0                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'C1                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'C2                      | WSCR             | —                   | —                                | CLKDBL                           | —                                | WMS1                | WMS0                | WC1                 | WC0                 |                |
| H'C3                      | STCR             | IICS                | IICX1                            | IICX0                            | SYNCE                            | PWCKE               | PWCKS               | ICKS1               | ICKS0               |                |
| H'C4                      | SYSCR            | SSBY                | STS2                             | STS1                             | STS0                             | XRST                | NMIEG               | HIE                 | RAME                |                |
| H'C5                      | MDCR             | —                   | —                                | —                                | —                                | —                   | —                   | MDS1                | MDS0                |                |
| H'C6                      | ISCR             | —                   | IRQ6SC                           | —                                | —                                | —                   | IRQ2SC              | IRQ1SC              | IRQ0SC              |                |
| H'C7                      | IER              | —                   | IRQ6E                            | —                                | —                                | —                   | IRQ2E               | IRQ1E               | IRQ0E               |                |
| H'C8                      | TCR              | CMIEB               | CMIEA                            | OVIE                             | CCLR1                            | CCLR0               | CKS2                | CKS1                | CKS0                | TMR0           |
| H'C9                      | TCSR             | CMFB                | CMFA                             | OVF                              | PWME                             | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'CA                      | TCORA            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CB                      | TCORB            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CC                      | TCNT             |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CD                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CE                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'CF                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D0                      | TCR              | CMIEB               | CMIEA                            | OVIE                             | CCLR1                            | CCLR0               | CKS2                | CKS1                | CKS0                | TMR1           |
| H'D1                      | TCSR             | CMFB                | CMFA                             | OVF                              | PWME                             | OS3                 | OS2                 | OS1                 | OS0                 |                |
| H'D2                      | TCORA            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D3                      | TCORB            |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D4                      | TCNT             |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D5                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D6                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |
| H'D7                      |                  |                     |                                  |                                  |                                  |                     |                     |                     |                     |                |

| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names    |       |       |              |       |       |       |       | Module<br>Name |
|---------------------------|------------------|--------------|-------|-------|--------------|-------|-------|-------|-------|----------------|
|                           |                  | Bit 7        | Bit 6 | Bit 5 | Bit 4        | Bit 3 | Bit 2 | Bit 1 | Bit 0 |                |
| H'D8                      | SMR              | C/ $\bar{A}$ | CHR   | PE    | O/ $\bar{E}$ | STOP  | MP    | CKS1  | CKS0  | SCI0           |
| H'D9                      | BRR              |              |       |       |              |       |       |       |       |                |
| H'DA                      | SCR              | TIE          | RIE   | TE    | RE           | MPIE  | TEIE  | CKE1  | CKE0  |                |
| H'DB                      | TDR              |              |       |       |              |       |       |       |       |                |
| H'DC                      | SSR              | TDRE         | RDRF  | ORER  | FER          | PER   | TEND  | MPB   | MPBT  |                |
| H'DD                      | RDR              |              |       |       |              |       |       |       |       |                |
| H'DE                      | SCMR             | —            | —     | —     | —            | SDIR  | SINV  | —     | SMIF  | SCI1           |
| H'DF                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E0                      | SMR              | C/ $\bar{A}$ | CHR   | PE    | O/ $\bar{E}$ | STOP  | MP    | CKS1  | CKS0  |                |
| H'E1                      | BRR              |              |       |       |              |       |       |       |       |                |
| H'E2                      | SCR              | TIE          | RIE   | TE    | RE           | MPIE  | TEIE  | CKE1  | CKE0  |                |
| H'E3                      | TDR              |              |       |       |              |       |       |       |       |                |
| H'E4                      | SSR              | TDRE         | RDRF  | ORER  | FER          | PER   | TEND  | MPB   | MPBT  |                |
| H'E5                      | RDR              |              |       |       |              |       |       |       |       |                |
| H'E6                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E7                      | —                | —            | —     | —     | —            | —     | —     | —     | —     |                |
| H'E8                      |                  |              |       |       |              |       |       |       |       |                |
| H'E9                      |                  |              |       |       |              |       |       |       |       |                |
| H'EA                      |                  |              |       |       |              |       |       |       |       |                |
| H'EB                      |                  |              |       |       |              |       |       |       |       |                |
| H'EC                      |                  |              |       |       |              |       |       |       |       |                |
| H'ED                      |                  |              |       |       |              |       |       |       |       |                |
| H'EE                      |                  |              |       |       |              |       |       |       |       |                |
| H'EF                      |                  |              |       |       |              |       |       |       |       |                |

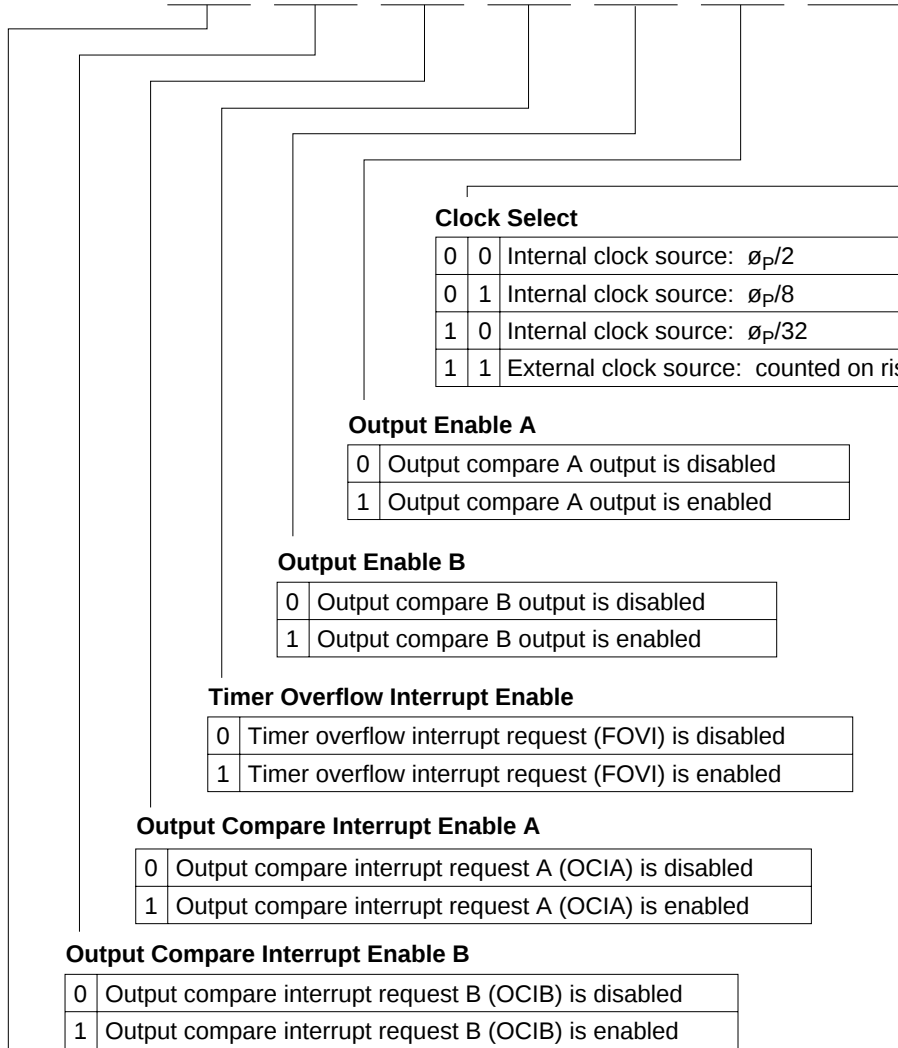
| Address<br>(Last<br>Byte) | Register<br>Name | Bit Names           |                     |                     |                     |                     |                     |                     |                     | Module<br>Name |
|---------------------------|------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------|
|                           |                  | Bit 7               | Bit 6               | Bit 5               | Bit 4               | Bit 3               | Bit 2               | Bit 1               | Bit 0               |                |
| H'F0                      | HICR             | —                   | —                   | —                   | —                   | —                   | IBFIE2              | IBFIE1              | FGA <sub>20</sub> E | HIF            |
| H'F1                      | KMIMR            | KMIMR7              | KMIMR6              | KMIMR5              | KMIMR4              | KMIMR3              | KMIMR2              | KMIMR1              | KMIMR0              |                |
| H'F2                      | KMPCR            | KM <sub>7</sub> PCR | KM <sub>6</sub> PCR | KM <sub>5</sub> PCR | KM <sub>4</sub> PCR | KM <sub>3</sub> PCR | KM <sub>2</sub> PCR | KM <sub>1</sub> PCR | KM <sub>0</sub> PCR |                |
| H'F3                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'F4                      | IDR1             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'F5                      | ODR1             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'F6                      | STR1             | DBU                 | DBU                 | DBU                 | DBU                 | C/ $\overline{D}$   | DBU                 | IBF                 | OBF                 |                |
| H'F7                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'F8                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'F9                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'FA                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'FB                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |
| H'FC                      | IDR2             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'FD                      | ODR2             |                     |                     |                     |                     |                     |                     |                     |                     |                |
| H'FE                      | STR2             | DBU                 | DBU                 | DBU                 | DBU                 | C/ $\overline{D}$   | DBU                 | IBF                 | OBF                 |                |
| H'FF                      | —                | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |                |

Notes: FRT: Free-running timer  
TMR0: 8-bit timer channel 0  
TMR1: 8-bit timer channel 1  
SCI0: Serial communication interface 0  
SCI1: Serial communication interface 1  
HIF: Host interface

# B.2 Register Descriptions



|               |      |       |       |      |     |     |      |      |
|---------------|------|-------|-------|------|-----|-----|------|------|
| Bit           | 7    | 6     | 5     | 4    | 3   | 2   | 1    | 0    |
|               | ICIE | OCIEB | OCIEA | OVIE | OEB | OEA | CKS1 | CKS0 |
| Initial value | 0    | 0     | 0     | 0    | 0   | 0   | 0    | 0    |
| Read/Write    | R/W  | R/W   | R/W   | R/W  | R/W | R/W | R/W  | R/W  |



### Input Capture Interrupt Enable

|   |                                                   |
|---|---------------------------------------------------|
| 0 | Input capture interrupt request (ICI) is disabled |
| 1 | Input capture interrupt request (ICI) is enabled  |

| Bit           | 7      | 6      | 5      | 4      | 3     | 2     | 1    | 0     |
|---------------|--------|--------|--------|--------|-------|-------|------|-------|
|               | ICF    | OCFB   | OCFA   | OVF    | OLVLB | OLVLA | IEDG | CCLRA |
| Initial value | 0      | 0      | 0      | 0      | 0     | 0     | 0    | 0     |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R/W   | R/W   | R/W  | R/W   |

**Counter Clear A**

|   |                                       |
|---|---------------------------------------|
| 0 | The FRC is not cleared                |
| 1 | The FRC is cleared at compare-match A |

**Input Edge Select**

|   |                                                                |
|---|----------------------------------------------------------------|
| 0 | FRC contents are transferred to ICR on the falling edge of FTI |
| 1 | FRC contents are transferred to ICR on the rising edge of FTI  |

**Output Level A**

|   |                                               |
|---|-----------------------------------------------|
| 0 | A 0 logic level is output for compare-match A |
| 1 | A 1 logic level is output for compare-match A |

**Output Level B**

|   |                                               |
|---|-----------------------------------------------|
| 0 | A 0 logic level is output for compare-match B |
| 1 | A 1 logic level is output for compare-match B |

**Timer Overflow**

|   |                                                                                            |
|---|--------------------------------------------------------------------------------------------|
| 0 | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when FRC changes from H'FFFF to H'0000                                |

**Output Compare Flag A**

|   |                                                                                              |
|---|----------------------------------------------------------------------------------------------|
| 0 | To clear OCFA, the CPU must read OCFA after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when FRC = OCRA                                                         |

**Output Compare Flag B**

|   |                                                                                              |
|---|----------------------------------------------------------------------------------------------|
| 0 | To clear OCFB, the CPU must read OCFB after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when FRC = OCRB                                                         |

**Input Capture Flag**

|   |                                                                                            |
|---|--------------------------------------------------------------------------------------------|
| 0 | To clear ICF, the CPU must read ICF after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when an FTI input signal causes the FRC value to be copied to the ICR |

Note: \* Software can write a 0 in bits 7 to 4 to clear the flags, but cannot write a 1 in these bits.

# **FRC (H and L)—Free-Running Counter**

**H'92, H'93**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**FRT**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Count value

# **OCRA (H and L)—Output Compare Register A**

**H'94, H'95**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**FRT**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

OCRA is constantly compared with the FRC value, and the OCFA bit is set to 1 when OCRA = FRC

# **OCRB (H and L)—Output Compare Register B**

**H'96, H'97**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**FRT**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

OCRB is constantly compared with the FRC value, and the OCFB bit is set to 1 when OCRB = FRC

| Bit                                                                          | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|
|                                                                              |   |   |   |   |   |   |   |   |
| Initial value                                                                | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write                                                                   | R | R | R | R | R | R | R | R |
| <div> <div></div> <div>Contains FRC count captured on FTI input</div> </div> |   |   |   |   |   |   |   |   |

| Bit           | 7     | 6     | 5    | 4     | 3     | 2    | 1    | 0    |
|---------------|-------|-------|------|-------|-------|------|------|------|
|               | CMIEB | CMIEA | OVIE | CCLR1 | CCLR0 | CKS2 | CKS1 | CKS0 |
| Initial value | 0     | 0     | 0    | 0     | 0     | 0    | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  | R/W  |

**Clock Select 2 to 0**

Together with the ICKS0 and ICKS1 bits in STCR, these bits select the clock input to TCNT

| Channel | TCR   |       |       | Description                                                          |
|---------|-------|-------|-------|----------------------------------------------------------------------|
|         | Bit 2 | Bit 1 | Bit 0 |                                                                      |
|         | CKS2  | CKS1  | CKS0  |                                                                      |
| X       | 0     | 0     | 0     | No clock source (timer stopped)                                      |
|         | 0     | 0     | 1     | $\emptyset$ internal clock source                                    |
|         | 0     | 1     | 0     | $\emptyset_P/2$ internal clock source, counted on the falling edge   |
|         | 0     | 1     | 1     | $\emptyset_P/512$ internal clock source, counted on the falling edge |
|         | 1     | 0     | 0     | No clock source (timer stopped)                                      |
|         | 1     | 0     | 1     | External clock source, counted on the rising edge                    |
|         | 1     | 1     | 0     | External clock source, counted on the falling edge                   |
|         | 1     | 1     | 1     | External clock source, counted on both the rising and falling edges  |

**Counter Clear 1 and 0**

|   |   |                                                       |                 |
|---|---|-------------------------------------------------------|-----------------|
| 0 | 0 | Not cleared                                           | (Initial value) |
| 0 | 1 | Cleared on compare-match A                            |                 |
| 1 | 0 | Cleared on compare-match B                            |                 |
| 1 | 1 | Cleared on rising edge of external reset input signal |                 |

**Timer Overflow Interrupt Enable**

|   |                                                        |                 |
|---|--------------------------------------------------------|-----------------|
| 0 | The timer overflow interrupt request (OVI) is disabled | (Initial value) |
| 1 | The timer overflow interrupt request (OVI) is enabled  |                 |

**Compare-Match Interrupt Enable A**

|   |                                                      |                 |
|---|------------------------------------------------------|-----------------|
| 0 | Compare-match interrupt request A (CMIA) is disabled | (Initial value) |
| 1 | Compare-match interrupt request A (CMIA) is enabled  |                 |

**Compare-Match Interrupt Enable B**

|   |                                                      |                 |
|---|------------------------------------------------------|-----------------|
| 0 | Compare-match interrupt request B (CMIB) is disabled | (Initial value) |
| 1 | Compare-match interrupt request B (CMIB) is enabled  |                 |

| Bit           | 7       | 6       | 5       | 4    | 3     | 2     | 1     | 0     |
|---------------|---------|---------|---------|------|-------|-------|-------|-------|
|               | CMFB    | CMFA    | OVF     | PWME | OS3*1 | OS2*1 | OS1*1 | OS0*1 |
| Initial value | 0       | 0       | 0       | 0    | 0     | 0     | 0     | 0     |
| Read/Write    | R/(W)*2 | R/(W)*2 | R/(W)*2 | R/W  | R/W   | R/W   | R/W   | R/W   |

**Output Select 1 and 0**

|   |   |                                                      |                 |
|---|---|------------------------------------------------------|-----------------|
| 0 | 0 | No change when compare-match A occurs                | (Initial value) |
| 0 | 1 | Output changes to 0 when compare-match A occurs      |                 |
| 1 | 0 | Output changes to 1 when compare-match A occurs      |                 |
| 1 | 1 | Output inverts (toggles) when compare-match A occurs |                 |

**Output Select 3 and 2**

|   |   |                                                      |                 |
|---|---|------------------------------------------------------|-----------------|
| 0 | 0 | No change when compare-match B occurs                | (Initial value) |
| 0 | 1 | Output changes to 0 when compare-match B occurs      |                 |
| 1 | 0 | Output changes to 1 when compare-match B occurs      |                 |
| 1 | 1 | Output inverts (toggles) when compare-match B occurs |                 |

**PWM Mode Enable**

|   |                   |                 |
|---|-------------------|-----------------|
| 0 | Normal timer mode | (Initial value) |
| 1 | PWM mode          |                 |

**Timer Overflow Flag**

|   |                                                                                            |                 |
|---|--------------------------------------------------------------------------------------------|-----------------|
| 0 | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1 | This bit is set to 1 when TCNT changes from H'FF to H'00                                   |                 |

**Compare-Match Flag A**

|   |                                                                                              |                 |
|---|----------------------------------------------------------------------------------------------|-----------------|
| 0 | To clear CMFA, the CPU must read CMFA after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1 | This bit is set to 1 when TCNT = TCORA                                                       |                 |

**Compare-Match Flag B**

|   |                                                                                              |                 |
|---|----------------------------------------------------------------------------------------------|-----------------|
| 0 | To clear CMFB, the CPU must read CMFB after it has been set to 1, then write a 0 in this bit | (Initial value) |
| 1 | This bit is set to 1 when TCNT = TCORB                                                       |                 |

Notes: \*1. When all four output select bits (bits OS3 to OS0) are cleared to 0, the timer output signal is disabled.

\*2. Software can write a 0 in bits 7 to 5 to clear the flags, but cannot write a 1 in these bits.

**TCORA—Time Constant  
Registers A**

**H'9C**

**H8/3217, 3216, 3214,  
H8/3212**

**TMRX**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

The CMFA bit is set to 1 when TCORA = TCNT

**TCORB—Time Constant  
Registers B**

**H'9D**

**H8/3217, 3216, 3214,  
H8/3212**

**TMRX**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

The CMFB bit is set to 1 when TCORB = TCNT

**TCNT—Timer Counter**

**H'9E**

**H8/3217, 3216, 3214,  
H8/3212**

**TMRX**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Count value

| Bit           | 7     | 6     | 5     | 4    | 3     | 2     | 1    | 0    |
|---------------|-------|-------|-------|------|-------|-------|------|------|
|               | SMOD1 | SMOD2 | CLMOD | INVV | SCON1 | SCON0 | INVI | INVO |
| Initial value | 0     | 0     | 0     | 0    | 0     | 0     | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  |

**Output Synchronization Signal Inversion**

|   |                                                                                      |
|---|--------------------------------------------------------------------------------------|
| 0 | IV and IHO signals are used directly as VSYNCO and HSYNCO outputs<br>(Initial value) |
| 1 | IV and IHO signals are inverted to create VSYNCO and HSYNCO outputs                  |

**Input Synchronization Signal Inversion**

|   |                                                                                               |
|---|-----------------------------------------------------------------------------------------------|
| 0 | HSYNCI and CSYNCI pin states are used directly as HSYNCI and CSYNCI inputs<br>(Initial value) |
| 1 | HSYNCI and CSYNCI pin states are inverted to create HSYNCI and CSYNCI inputs                  |

**Synchronization Signal Connection 1 and 0**

|   |   |                                                    |             |             |             |
|---|---|----------------------------------------------------|-------------|-------------|-------------|
| 0 | 0 | Normal connection<br>(Initial value)               | FTI input   | TMC1I input | TMR1I input |
| 0 | 1 | Vertical synchronization period measurement mode   | IV signal   | IHI signal  | IV signal   |
| 1 | 0 | Horizontal synchronization period measurement mode | IHI signal  | IHI signal  | IV signal   |
| 1 | 1 | TMR1 frequency division measurement mode           | TMO1 signal | IHI signal  | IV signal   |

**Input Synchronization Signal Inversion**

|   |                                                                          |
|---|--------------------------------------------------------------------------|
| 0 | The VSYNCI pin state is used directly as VSYNCI input<br>(Initial value) |
| 1 | The VSYNCI pin state is inverted to create VSYNCI input                  |

**Clamp Waveform Mode Select**

**Synchronization Mode Select 1 and 0**

|   |   |                                                  |              |            |              |
|---|---|--------------------------------------------------|--------------|------------|--------------|
|   |   | Mode                                             | IHI Signal   | IHO Signal | IV Signal    |
| 0 | 0 | No signal (normal connection)<br>(Initial value) | FBACKI input | IHI signal | VSYNCI input |
| 0 | 1 | S-on-G mode                                      | CSYNCI input | CL1 signal | PDC signal   |
| 1 | 0 | Composite mode                                   | HSYNCI input | CL1 signal | PDC signal   |
| 1 | 1 | Separate mode                                    | HSYNCI input | IHI signal | VSYNCI input |

| Bit           | 7   | 6    | 5   | 4   | 3   | 2    | 1    | 0    |
|---------------|-----|------|-----|-----|-----|------|------|------|
|               | ICE | IEIC | MST | TRS | ACK | CKS2 | CKS1 | CKS0 |
| Initial value | 0   | 0    | 0   | 0   | 0   | 0    | 0    | 0    |
| Read/Write    | R/W | R/W  | R/W | R/W | R/W | R/W  | R/W  | R/W  |

#### Transfer Clock Select

These bits are used in combination with the ICCX bit in STCR to select the serial clock frequency

| (STCR) | Bit 2 | Bit 1 | Bit 0 | Clock               | Transfer Rate*                  |                                 |                                 |                                  |                                  |
|--------|-------|-------|-------|---------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|
|        |       |       |       |                     | $\varnothing_P = 4 \text{ MHz}$ | $\varnothing_P = 5 \text{ MHz}$ | $\varnothing_P = 8 \text{ MHz}$ | $\varnothing_P = 10 \text{ MHz}$ | $\varnothing_P = 16 \text{ MHz}$ |
| 0      | 0     | 0     | 0     | $\varnothing_P/28$  | 143 kHz                         | 179 kHz                         | 286 kHz                         | 357 kHz                          | 571 kHz                          |
|        | 0     | 0     | 1     | $\varnothing_P/40$  | 100 kHz                         | 125 kHz                         | 200 kHz                         | 250 kHz                          | 400 kHz                          |
|        | 0     | 1     | 0     | $\varnothing_P/48$  | 83.3 kHz                        | 104 kHz                         | 167 kHz                         | 208 kHz                          | 333 kHz                          |
|        | 0     | 1     | 1     | $\varnothing_P/64$  | 62.5 kHz                        | 78.1 kHz                        | 125 kHz                         | 156 kHz                          | 250 kHz                          |
|        | 1     | 0     | 0     | $\varnothing_P/80$  | 50.0 kHz                        | 62.5 kHz                        | 100 kHz                         | 125 kHz                          | 200 kHz                          |
|        | 1     | 0     | 1     | $\varnothing_P/100$ | 40.0 kHz                        | 50.0 kHz                        | 80.0 kHz                        | 100 kHz                          | 160 kHz                          |
|        | 1     | 1     | 0     | $\varnothing_P/112$ | 35.7 kHz                        | 44.6 kHz                        | 71.4 kHz                        | 89.3 kHz                         | 143 kHz                          |
|        | 1     | 1     | 1     | $\varnothing_P/128$ | 31.3 kHz                        | 39.1 kHz                        | 62.5 kHz                        | 78.1 kHz                         | 125 kHz                          |
| 1      | 0     | 0     | 0     | $\varnothing_P/56$  | 71.4 kHz                        | 89.3 kHz                        | 143 kHz                         | 179 kHz                          | 286 kHz                          |
|        | 0     | 0     | 1     | $\varnothing_P/80$  | 50.0 kHz                        | 62.5 kHz                        | 100 kHz                         | 125 kHz                          | 200 kHz                          |
|        | 0     | 1     | 0     | $\varnothing_P/96$  | 41.7 kHz                        | 52.1 kHz                        | 83.3 kHz                        | 104 kHz                          | 167 kHz                          |
|        | 0     | 1     | 1     | $\varnothing_P/128$ | 31.3 kHz                        | 39.1 kHz                        | 62.5 kHz                        | 78.1 kHz                         | 125 kHz                          |
|        | 1     | 0     | 0     | $\varnothing_P/160$ | 25.0 kHz                        | 31.3 kHz                        | 50.0 kHz                        | 62.5 kHz                         | 100 kHz                          |
|        | 1     | 0     | 1     | $\varnothing_P/200$ | 20.0 kHz                        | 25.0 kHz                        | 40.0 kHz                        | 50.0 kHz                         | 80.0 kHz                         |
|        | 1     | 1     | 0     | $\varnothing_P/224$ | 17.9 kHz                        | 22.3 kHz                        | 35.7 kHz                        | 44.6 kHz                         | 71.4 kHz                         |
|        | 1     | 1     | 1     | $\varnothing_P/256$ | 15.6 kHz                        | 19.5 kHz                        | 31.3 kHz                        | 39.1 kHz                         | 62.5 kHz                         |

Note: \*  $\varnothing_P = \varnothing$

#### Acknowledgement Mode Select

|   |                      |                 |
|---|----------------------|-----------------|
| 0 | Acknowledgement mode | (Initial value) |
| 1 | Serial mode          |                 |

#### Master/Slave Select (MST), Transmit/Receive Select (TRS)

|   |   |                      |                 |
|---|---|----------------------|-----------------|
| 0 | 0 | Slave receive mode   | (Initial value) |
|   | 1 | Slave transmit mode  |                 |
| 1 | 0 | Master receive mode  |                 |
|   | 1 | Master transmit mode |                 |

#### I<sup>2</sup>C Bus Interface Interrupt Enable

|   |                     |                 |
|---|---------------------|-----------------|
| 0 | Interrupts disabled | (Initial value) |
| 1 | Interrupts enabled  |                 |

#### I<sup>2</sup>C Bus Interface Enable

|   |                                                                                         |                 |
|---|-----------------------------------------------------------------------------------------|-----------------|
| 0 | Interface module disabled, with SCL and SDA signals in high-impedance state             | (Initial value) |
| 1 | Interface module enabled for transfer operations (pins SCL and SDA are driving the bus) |                 |

| Bit           | 7    | 6      | 5   | 4 | 3      | 2      | 1      | 0    |
|---------------|------|--------|-----|---|--------|--------|--------|------|
|               | BBSY | IRIC   | SCP | — | AL     | AAS    | ADZ    | ACKB |
| Initial value | 0    | 0      | 1   | 1 | 0      | 0      | 0      | 0    |
| Read/Write    | R/W  | R/(W)* | W   | — | R/(W)* | R/(W)* | R/(W)* | R/W  |

|                        |                                                                                                                                                        |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Acknowledge Bit</b> |                                                                                                                                                        |
| 0                      | Receive mode: 0 is output at acknowledge output timing<br>Transmit mode: indicates that the receiving device has acknowledged the data (Initial value) |
| 1                      | Receive mode: 1 is output at acknowledge output timing<br>Transmit mode: indicates that the receiving device has not acknowledged the data             |

|                                              |                                                                                                                                                                                                                                             |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>General Call Address Recognition Flag</b> |                                                                                                                                                                                                                                             |
| 0                                            | General call address not recognized<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When ADZ is read while ADZ = 1, then 0 is written in ADZ (Initial value) |
| 1                                            | General call address recognized<br>This bit is set to 1 when the general call address is detected in slave receive mode                                                                                                                     |

|                                       |                                                                                                                                                                                                                                                              |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Slave Address Recognition Flag</b> |                                                                                                                                                                                                                                                              |
| 0                                     | Slave address or general call address not recognized<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When AAS is read while AAS = 1, then 0 is written in AAS (Initial value) |
| 1                                     | Slave address or general call address recognized<br>This bit is set to 1 when the slave address or general call address is detected in slave receive mode                                                                                                    |

|                              |                                                                                                                                                                                                                                                   |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Arbitration Lost Flag</b> |                                                                                                                                                                                                                                                   |
| 0                            | Bus arbitration won<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When AL is read while AL = 1, then 0 is written in AL (Initial value)                          |
| 1                            | Bus arbitration lost<br>This bit is set to 1 at the following times:<br>• If the internal SDA signal and bus line disagree at the rise of SCL in master transmit mode<br>• If the internal SCL is high at the fall of SCL in master transmit mode |

|                                                |                                                                      |
|------------------------------------------------|----------------------------------------------------------------------|
| <b>Start Condition/Stop Condition Prohibit</b> |                                                                      |
| 0                                              | Writing 0 issues a start or stop condition, in combination with BBSY |
| 1                                              | Reading always results in 1 (Initial value)<br>Writing is ignored    |

|                                                            |                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>I<sup>2</sup>C Bus Interface Interrupt Request Flag</b> |                                                                                                                                                                                                                                                                                                                                                                                             |
| 0                                                          | Waiting for transfer, or transfer in progress<br>To clear this bit, the CPU must read IRIC when IRIC = 1, then write 0 in IRIC (Initial value)                                                                                                                                                                                                                                              |
| 1                                                          | Interrupt requested<br>This bit is set to 1 at the following times:<br>Master mode<br>• End of data transfer<br>• When burst arbitration is lost<br>Slave mode (when FS = 0)<br>• When the slave address is matched, and whenever a data transfer ends after that, until a retransmit start condition or a stop condition is detected<br>Slave mode (when FS = 1)<br>• End of data transfer |

|                 |                                                                                           |
|-----------------|-------------------------------------------------------------------------------------------|
| <b>Bus Busy</b> |                                                                                           |
| 0               | Bus is free<br>This bit is cleared to 0 when a stop condition is detected (Initial value) |
| 1               | Bus is busy<br>This bit is set to 1 when a start condition is detected                    |

Note: \* Software can write a 0 in bits 6, 3, 2, and 1 to clear the flags, but cannot write a 1 in these bits.

|               |       |       |       |       |       |       |       |       |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit           | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|               | ICDR7 | ICDR6 | ICDR5 | ICDR4 | ICDR3 | ICDR2 | ICDR1 | ICDR0 |
| Initial value | —     | —     | —     | —     | —     | —     | —     | —     |
| Read/Write    | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

|               |       |       |       |       |       |       |       |       |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit           | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|               | SVA6  | SVA5  | SVA4  | SVA3  | SVA2  | SVA1  | SVA0  | FS    |
| Initial value | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Read/Write    | R/(W) | R/(W) | R/(W) | R/(W) | R/(W) | R/(W) | R/(W) | R/(W) |

Format Select

|   |                                               |                 |
|---|-----------------------------------------------|-----------------|
| 0 | Addressing format, slave addresses recognized | (Initial value) |
| 1 | Non-addressing format                         |                 |

**Slave Address 6 to 0**

Set a unique address in bits SVA6 to SVA0, differing from the address of other slave devices connected to the I<sup>2</sup>C bus.

| Bit           | 7   | 6    | 5 | 4 | 3 | 2   | 1   | 0   |
|---------------|-----|------|---|---|---|-----|-----|-----|
|               | MLS | WAIT | — | — | — | BC2 | BC1 | BC0 |
| Initial value | 0   | 0    | 1 | 1 | 1 | 0   | 0   | 0   |
| Read/Write    | R/W | R/W  | — | — | — | R/W | R/W | R/W |

**Bit Counter 2 to 0**

| Bit 2 | Bit 1 | Bit 0 | Bits/Frame  |                      |
|-------|-------|-------|-------------|----------------------|
| BC2   | BC1   | BC0   | Serial Mode | Acknowledgement Mode |
| 0     | 0     | 0     | 8           | 9 (Initial value)    |
|       |       | 1     | 1           | 2                    |
|       | 1     | 0     | 2           | 3                    |
|       |       | 1     | 3           | 4                    |
| 1     | 0     | 0     | 4           | 5                    |
|       |       | 1     | 5           | 6                    |
|       | 1     | 0     | 6           | 7                    |
|       |       | 1     | 7           | 8                    |

**Wait Insertion Bit**

|   |                                                |                 |
|---|------------------------------------------------|-----------------|
| 0 | Data and acknowledge transferred consecutively | (Initial value) |
| 1 | Wait inserted between data and acknowledge     |                 |

**MSB-First/LSB-First Select**

|   |           |                 |
|---|-----------|-----------------|
| 0 | MSB-first | (Initial value) |
| 1 | LSB-first |                 |

| Bit           | 7   | 6    | 5   | 4   | 3   | 2    | 1    | 0    |
|---------------|-----|------|-----|-----|-----|------|------|------|
|               | ICE | IEIC | MST | TRS | ACK | CKS2 | CKS1 | CKS0 |
| Initial value | 0   | 0    | 0   | 0   | 0   | 0    | 0    | 0    |
| Read/Write    | R/W | R/W  | R/W | R/W | R/W | R/W  | R/W  | R/W  |

### Transfer Clock Select

These bits are used in combination with the ICCX bit in STCR to select the serial clock frequency

| (STCR) | Bit 2 | Bit 1 | Bit 0 | Clock               | Transfer Rate*          |                         |                         |                          |                          |
|--------|-------|-------|-------|---------------------|-------------------------|-------------------------|-------------------------|--------------------------|--------------------------|
| IICX0  | CKS2  | CKS1  | CKS0  |                     | $\varnothing_P = 4$ MHz | $\varnothing_P = 5$ MHz | $\varnothing_P = 8$ MHz | $\varnothing_P = 10$ MHz | $\varnothing_P = 16$ MHz |
| 0      | 0     | 0     | 0     | $\varnothing_P/28$  | 143 kHz                 | 179 kHz                 | 286 kHz                 | 357 kHz                  | 571 kHz                  |
|        | 0     | 0     | 1     | $\varnothing_P/40$  | 100 kHz                 | 125 kHz                 | 200 kHz                 | 250 kHz                  | 400 kHz                  |
|        | 0     | 1     | 0     | $\varnothing_P/48$  | 83.3 kHz                | 104 kHz                 | 167 kHz                 | 208 kHz                  | 333 kHz                  |
|        | 0     | 1     | 1     | $\varnothing_P/64$  | 62.5 kHz                | 78.1 kHz                | 125 kHz                 | 156 kHz                  | 250 kHz                  |
|        | 1     | 0     | 0     | $\varnothing_P/80$  | 50.0 kHz                | 62.5 kHz                | 100 kHz                 | 125 kHz                  | 200 kHz                  |
|        | 1     | 0     | 1     | $\varnothing_P/100$ | 40.0 kHz                | 50.0 kHz                | 80.0 kHz                | 100 kHz                  | 160 kHz                  |
|        | 1     | 1     | 0     | $\varnothing_P/112$ | 35.7 kHz                | 44.6 kHz                | 71.4 kHz                | 89.3 kHz                 | 143 kHz                  |
| 1      | 1     | 1     | 1     | $\varnothing_P/128$ | 31.3 kHz                | 39.1 kHz                | 62.5 kHz                | 78.1 kHz                 | 125 kHz                  |
|        | 0     | 0     | 0     | $\varnothing_P/56$  | 71.4 kHz                | 89.3 kHz                | 143 kHz                 | 179 kHz                  | 286 kHz                  |
|        | 0     | 0     | 1     | $\varnothing_P/80$  | 50.0 kHz                | 62.5 kHz                | 100 kHz                 | 125 kHz                  | 200 kHz                  |
|        | 0     | 1     | 0     | $\varnothing_P/96$  | 41.7 kHz                | 52.1 kHz                | 83.3 kHz                | 104 kHz                  | 167 kHz                  |
|        | 0     | 1     | 1     | $\varnothing_P/128$ | 31.3 kHz                | 39.1 kHz                | 62.5 kHz                | 78.1 kHz                 | 125 kHz                  |
|        | 1     | 0     | 0     | $\varnothing_P/160$ | 25.0 kHz                | 31.3 kHz                | 50.0 kHz                | 62.5 kHz                 | 100 kHz                  |
|        | 1     | 0     | 1     | $\varnothing_P/200$ | 20.0 kHz                | 25.0 kHz                | 40.0 kHz                | 50.0 kHz                 | 80.0 kHz                 |
|        | 1     | 1     | 0     | $\varnothing_P/224$ | 17.9 kHz                | 22.3 kHz                | 35.7 kHz                | 44.6 kHz                 | 71.4 kHz                 |
|        | 1     | 1     | 1     | $\varnothing_P/256$ | 15.6 kHz                | 19.5 kHz                | 31.3 kHz                | 39.1 kHz                 | 62.5 kHz                 |

Note: \*  $\varnothing_P = \varnothing$

### Acknowledgement Mode Select

|   |                      |                 |
|---|----------------------|-----------------|
| 0 | Acknowledgement mode | (Initial value) |
| 1 | Serial mode          |                 |

### Master/Slave Select (MST), Transmit/Receive Select (TRS)

|   |   |                      |                 |
|---|---|----------------------|-----------------|
| 0 | 0 | Slave receive mode   | (Initial value) |
|   | 1 | Slave transmit mode  |                 |
| 1 | 0 | Master receive mode  |                 |
|   | 1 | Master transmit mode |                 |

### I<sup>2</sup>C Bus Interface Interrupt Enable

|   |                     |                 |
|---|---------------------|-----------------|
| 0 | Interrupts disabled | (Initial value) |
| 1 | Interrupts enabled  |                 |

### I<sup>2</sup>C Bus Interface Enable

|   |                                                                                         |                 |
|---|-----------------------------------------------------------------------------------------|-----------------|
| 0 | Interface module disabled, with SCL and SDA signals in high-impedance state             | (Initial value) |
| 1 | Interface module enabled for transfer operations (pins SCL and SDA are driving the bus) |                 |

| Bit           | 7    | 6      | 5   | 4 | 3      | 2      | 1      | 0    |
|---------------|------|--------|-----|---|--------|--------|--------|------|
|               | BBSY | IRIC   | SCP | — | AL     | AAS    | ADZ    | ACKB |
| Initial value | 0    | 0      | 1   | 1 | 0      | 0      | 0      | 0    |
| Read/Write    | R/W  | R/(W)* | W   | — | R/(W)* | R/(W)* | R/(W)* | R/W  |

|                        |                                                                                                                                                        |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Acknowledge Bit</b> |                                                                                                                                                        |
| 0                      | Receive mode: 0 is output at acknowledge output timing<br>Transmit mode: indicates that the receiving device has acknowledged the data (Initial value) |
| 1                      | Receive mode: 1 is output at acknowledge output timing<br>Transmit mode: indicates that the receiving device has not acknowledged the data             |

|                                              |                                                                                                                                                                                                                                             |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>General Call Address Recognition Flag</b> |                                                                                                                                                                                                                                             |
| 0                                            | General call address not recognized (Initial value)<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When ADZ is read while ADZ = 1, then 0 is written in ADZ |
| 1                                            | General call address recognized<br>This bit is set to 1 when the general call address is detected in slave receive mode                                                                                                                     |

|                                       |                                                                                                                                                                                                                                                              |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Slave Address Recognition Flag</b> |                                                                                                                                                                                                                                                              |
| 0                                     | Slave address or general call address not recognized (Initial value)<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When AAS is read while AAS = 1, then 0 is written in AAS |
| 1                                     | Slave address or general call address recognized<br>This bit is set to 1 when the slave address or general call address is detected in slave receive mode                                                                                                    |

|                         |                                                                                                                                                                                                                                                   |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Arbitration Lost</b> |                                                                                                                                                                                                                                                   |
| 0                       | Bus arbitration won (Initial value)<br>This bit is cleared to 0 at the following times:<br>• When ICDR data is written (transmit mode) or read (receive mode)<br>• When AL is read while AL = 1, then 0 is written in AL                          |
| 1                       | Bus arbitration lost<br>This bit is set to 1 at the following times:<br>• If the internal SDA signal and bus line disagree at the rise of SCL in master transmit mode<br>• If the internal SCL is high at the fall of SCL in master transmit mode |

|                                                |                                                                      |
|------------------------------------------------|----------------------------------------------------------------------|
| <b>Start Condition/Stop Condition Prohibit</b> |                                                                      |
| 0                                              | Writing 0 issues a start or stop condition, in combination with BBSY |
| 1                                              | Reading always results in 1 (Initial value)<br>Writing is ignored    |

|                                                            |                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>I<sup>2</sup>C Bus Interface Interrupt Request Flag</b> |                                                                                                                                                                                                                                                                                                                                                                                             |
| 0                                                          | Waiting for transfer, or transfer in progress (Initial value)<br>To clear this bit, the CPU must read IRIC when IRIC = 1, then write 0 in IRIC                                                                                                                                                                                                                                              |
| 1                                                          | Interrupt requested<br>This bit is set to 1 at the following times:<br>Master mode<br>• End of data transfer<br>• When burst arbitration is lost<br>Slave mode (when FS = 0)<br>• When the slave address is matched, and whenever a data transfer ends after that, until a retransmit start condition or a stop condition is detected<br>Slave mode (when FS = 1)<br>• End of data transfer |

|                 |                                                                                           |
|-----------------|-------------------------------------------------------------------------------------------|
| <b>Bus Busy</b> |                                                                                           |
| 0               | Bus is free (Initial value)<br>This bit is cleared to 0 when a stop condition is detected |
| 1               | Bus is busy<br>This bit is set to 1 when a start condition is detected                    |

Note: \* Software can write a 0 in bits 6, 3, 2, and 1 to clear the flags, but cannot write a 1 in these bits.

| Bit           | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|               | ICDR7 | ICDR6 | ICDR5 | ICDR4 | ICDR3 | ICDR2 | ICDR1 | ICDR0 |
| Initial value | —     | —     | —     | —     | —     | —     | —     | —     |
| Read/Write    | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

| Bit           | 7   | 6    | 5 | 4 | 3 | 2   | 1   | 0   |
|---------------|-----|------|---|---|---|-----|-----|-----|
|               | MLS | WAIT | — | — | — | BC2 | BC1 | BC0 |
| Initial value | 0   | 0    | 1 | 1 | 1 | 0   | 0   | 0   |
| Read/Write    | R/W | R/W  | — | — | — | R/W | R/W | R/W |

## Bit Counter 2 to 0

| Bit 2 | Bit 1 | Bit 0 | Bits/Frame  |                      |
|-------|-------|-------|-------------|----------------------|
| BC2   | BC1   | BC0   | Serial Mode | Acknowledgement Mode |
| 0     | 0     | 0     | 8           | 9 (Initial value)    |
|       |       | 1     | 1           | 2                    |
|       | 1     | 0     | 2           | 3                    |
|       |       | 1     | 3           | 4                    |
| 1     | 0     | 0     | 4           | 5                    |
|       |       | 1     | 5           | 6                    |
|       | 1     | 0     | 6           | 7                    |
|       |       | 1     | 7           | 8                    |

## Wait Insertion Bit

|   |                                                                |
|---|----------------------------------------------------------------|
| 0 | Data and acknowledge transferred consecutively (Initial value) |
| 1 | Wait inserted between data and acknowledge                     |

## MSB-First/LSB-First Select

|   |                           |
|---|---------------------------|
| 0 | MSB-first (Initial value) |
| 1 | LSB-first                 |

|                                                                                                                                                                                                     |      |      |      |      |      |      |      |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|-----|
| Bit                                                                                                                                                                                                 | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0   |
|                                                                                                                                                                                                     | SVA6 | SVA5 | SVA4 | SVA3 | SVA2 | SVA1 | SVA0 | FS  |
| Initial value                                                                                                                                                                                       | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0   |
| Read/Write                                                                                                                                                                                          | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W |
| <div> <div>Format Select</div> <div> <div>0</div> <div>Addressing format, slave addresses recognized (Initial value)</div> </div> <div> <div>1</div> <div>Non-addressing format</div> </div> </div> |      |      |      |      |      |      |      |     |

**Slave Address 6 to 0**

Set a unique address in bits SVA6 to SVA0, differing from the address of other slave devices connected to the I<sup>2</sup>C bus.

| Bit           | 7      | 6      | 5      | 4      | 3 | 2 | 1 | 0 |
|---------------|--------|--------|--------|--------|---|---|---|---|
|               | VEDG   | HEDG   | CEDG   | FEDG   | — | — | — | — |
| Initial value | 0      | 0      | 0      | 0      | 1 | 1 | 1 | 1 |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | — | — | — | — |

**FBACKI Edge**

|   |                                                                                                                 |
|---|-----------------------------------------------------------------------------------------------------------------|
| 0 | To clear FEDG, the CPU must read FEDG after it has been set to 1, then write a 0 in this bit<br>(Initial value) |
| 1 | Set to 1 when a rising edge is detected on the P4 <sub>6</sub> /ø/FBACKI pin                                    |

**CSYNCI Edge**

|   |                                                                                                                 |
|---|-----------------------------------------------------------------------------------------------------------------|
| 0 | To clear CEDG, the CPU must read CEDG after it has been set to 1, then write a 0 in this bit<br>(Initial value) |
| 1 | Set to 1 when a rising edge is detected on the P4 <sub>5</sub> /TMRI1/CSYNCI pin                                |

**HSYNCI Edge**

|   |                                                                                                                 |
|---|-----------------------------------------------------------------------------------------------------------------|
| 0 | To clear HEDG, the CPU must read HEDG after it has been set to 1, then write a 0 in this bit<br>(Initial value) |
| 1 | Set to 1 when a rising edge is detected on the P4 <sub>3</sub> /TMC11/HSYNCI pin                                |

**VSYNCI Edge**

|   |                                                                                                                 |
|---|-----------------------------------------------------------------------------------------------------------------|
| 0 | To clear VEDG, the CPU must read VEDG after it has been set to 1, then write a 0 in this bit<br>(Initial value) |
| 1 | Set to 1 when a rising edge is detected on the P6 <sub>3</sub> /FTI/VSYNCI pin                                  |

Note: \* Software can write a 0 in bits 7 to 4 to clear the flags, but cannot write a 1 in these bits.

| Bit           | 7      | 6              | 5   | 4 | 3       | 2    | 1    | 0    |
|---------------|--------|----------------|-----|---|---------|------|------|------|
|               | OVF    | WT/I $\bar{T}$ | TMB | — | RST/NMI | CKS2 | CKS1 | CKS0 |
| Initial value | 0      | 0              | 0   | 1 | 0       | 0    | 0    | 0    |
| Read/Write    | R/(W)* | R/W            | R/W | — | R/W     | R/W  | R/W  | R/W  |

**Clock Select 2 to 0**

| CKS2 | CKS1 | CKS0 | Clock Source  | Overflow Interval ( $\phi_P = 10$ MHz) |
|------|------|------|---------------|----------------------------------------|
| 0    | 0    | 0    | $\phi_P/2$    | 51.2 $\mu$ s (Initial value)           |
| 0    | 0    | 1    | $\phi_P/32$   | 819.2 $\mu$ s                          |
| 0    | 1    | 0    | $\phi_P/64$   | 1.6 ms                                 |
| 0    | 1    | 1    | $\phi_P/128$  | 3.3 ms                                 |
| 1    | 0    | 0    | $\phi_P/256$  | 6.6 ms                                 |
| 1    | 0    | 1    | $\phi_P/512$  | 13.1 ms                                |
| 1    | 1    | 0    | $\phi_P/2048$ | 52.4 ms                                |
| 1    | 1    | 1    | $\phi_P/4096$ | 104.9 ms                               |

**Reset or NMI Select**

|   |                                      |
|---|--------------------------------------|
| 0 | NMI function enabled (Initial value) |
| 1 | Reset function enabled               |

**Timer Enable**

|   |                                                               |
|---|---------------------------------------------------------------|
| 0 | TCNT is initialized to H'00 and stopped (Initial value)       |
| 1 | TCNT runs and requests a reset or interrupt when it overflows |

**Timer Mode Select**

|   |                                                   |
|---|---------------------------------------------------|
| 0 | Interval timer mode (OVF request) (Initial value) |
| 1 | Watchdog timer mode (reset or NMI request)        |

**Overflow Flag**

|   |                                                                                                            |
|---|------------------------------------------------------------------------------------------------------------|
| 0 | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit (Initial value) |
| 1 | Set to 1 when TCNT changes from H'FF to H'00                                                               |

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Count value   |     |     |     |     |     |     |     |     |

**P1PCR—Port 1 Pull-Up MOS  
Control Register**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P1 <sub>7</sub> PCR | P1 <sub>6</sub> PCR | P1 <sub>5</sub> PCR | P1 <sub>4</sub> PCR | P1 <sub>3</sub> PCR | P1 <sub>2</sub> PCR | P1 <sub>1</sub> PCR | P1 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

**Port 1 Input Pull-Up Control**

|   |                                 |
|---|---------------------------------|
| 0 | Input pull-up transistor is off |
| 1 | Input pull-up transistor is on  |

**P2PCR—Port 2 Pull-Up MOS  
Control Register**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P2 <sub>7</sub> PCR | P2 <sub>6</sub> PCR | P2 <sub>5</sub> PCR | P2 <sub>4</sub> PCR | P2 <sub>3</sub> PCR | P2 <sub>2</sub> PCR | P2 <sub>1</sub> PCR | P2 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

**Port 2 Input Pull-Up Control**

|   |                                 |
|---|---------------------------------|
| 0 | Input pull-up transistor is off |
| 1 | Input pull-up transistor is on  |

**P3PCR—Port 3 Pull-Up MOS  
Control Register**

**H'AE**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P3**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P3 <sub>7</sub> PCR | P3 <sub>6</sub> PCR | P3 <sub>5</sub> PCR | P3 <sub>4</sub> PCR | P3 <sub>3</sub> PCR | P3 <sub>2</sub> PCR | P3 <sub>1</sub> PCR | P3 <sub>0</sub> PCR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 | R/W                 |

**Port 3 Input Pull-Up Control**

|   |                                 |
|---|---------------------------------|
| 0 | Input pull-up transistor is off |
| 1 | Input pull-up transistor is on  |

**P1DDR—Port 1 Data Direction  
Register**

**H'B0**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P1**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P1 <sub>7</sub> DDR | P1 <sub>6</sub> DDR | P1 <sub>5</sub> DDR | P1 <sub>4</sub> DDR | P1 <sub>3</sub> DDR | P1 <sub>2</sub> DDR | P1 <sub>1</sub> DDR | P1 <sub>0</sub> DDR |
| Mode 1        |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   | 1                   |
| Read/Write    | —                   | —                   | —                   | —                   | —                   | —                   | —                   | —                   |
| Modes 2 and 3 |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 1 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P1DR—Port 1 Data Register**

**H'B2**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P1**

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P1 <sub>7</sub> | P1 <sub>6</sub> | P1 <sub>5</sub> | P1 <sub>4</sub> | P1 <sub>3</sub> | P1 <sub>2</sub> | P1 <sub>1</sub> | P1 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

**P2DDR—Port 2 Data Direction Register**

**H'B1**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P2**

| Bit | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|-----|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|     | P2 <sub>7</sub> DDR | P2 <sub>6</sub> DDR | P2 <sub>5</sub> DDR | P2 <sub>4</sub> DDR | P2 <sub>3</sub> DDR | P2 <sub>2</sub> DDR | P2 <sub>1</sub> DDR | P2 <sub>0</sub> DDR |

Mode 1

|               |   |   |   |   |   |   |   |   |
|---------------|---|---|---|---|---|---|---|---|
| Initial value | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Read/Write    | — | — | — | — | — | — | — | — |

Modes 2 and 3

|               |   |   |   |   |   |   |   |   |
|---------------|---|---|---|---|---|---|---|---|
| Initial value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write    | W | W | W | W | W | W | W | W |

**Port 2 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P2DR—Port 2 Data Register**

**H'B3**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P2**

| Bit | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|-----|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|     | P2 <sub>7</sub> | P2 <sub>6</sub> | P2 <sub>5</sub> | P2 <sub>4</sub> | P2 <sub>3</sub> | P2 <sub>2</sub> | P2 <sub>1</sub> | P2 <sub>0</sub> |

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

**P3DDR—Port 3 Data Direction Register**

**H'B4**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P3**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P3 <sub>7</sub> DDR | P3 <sub>6</sub> DDR | P3 <sub>5</sub> DDR | P3 <sub>4</sub> DDR | P3 <sub>3</sub> DDR | P3 <sub>2</sub> DDR | P3 <sub>1</sub> DDR | P3 <sub>0</sub> DDR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 3 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P3DR—Port 3 Data Register**

**H'B6**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**P3**

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P3 <sub>7</sub> | P3 <sub>6</sub> | P3 <sub>5</sub> | P3 <sub>4</sub> | P3 <sub>3</sub> | P3 <sub>2</sub> | P3 <sub>1</sub> | P3 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P4 <sub>7</sub> DDR | P4 <sub>6</sub> DDR | P4 <sub>5</sub> DDR | P4 <sub>4</sub> DDR | P4 <sub>3</sub> DDR | P4 <sub>2</sub> DDR | P4 <sub>1</sub> DDR | P4 <sub>0</sub> DDR |
| Modes 1 and 2 |                     |                     |                     |                     |                     |                     |                     |                     |
| Initial value | 1                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 4 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P4 <sub>7</sub> | P4 <sub>6</sub> | P4 <sub>5</sub> | P4 <sub>4</sub> | P4 <sub>3</sub> | P4 <sub>2</sub> | P4 <sub>1</sub> | P4 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

**P5DDR—Port 5 Data Direction Register**      **H'B8**

**H8/3217, 3216, 3214**  
**H8/3212, H8/3202**

**P5**

| Bit           | 7 | 6 | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | — | — | P5 <sub>5</sub> DDR | P5 <sub>4</sub> DDR | P5 <sub>3</sub> DDR | P5 <sub>2</sub> DDR | P5 <sub>1</sub> DDR | P5 <sub>0</sub> DDR |
| Initial value | 1 | 1 | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | — | — | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 5 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P5DR—Port 5 Data Register**      **H'BA**

**H8/3217, 3216, 3214**  
**H8/3212, H8/3202**

**P5**

| Bit           | 7 | 6 | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|---|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | — | — | P5 <sub>5</sub> | P5 <sub>4</sub> | P5 <sub>3</sub> | P5 <sub>2</sub> | P5 <sub>1</sub> | P5 <sub>0</sub> |
| Initial value | 1 | 1 | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | — | — | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

**P6DDR—Port 6 Data Direction Register**      **H'B9**

**H8/3217, 3216, 3214**  
**H8/3212, H8/3202**

**P6**

| Bit           | 7 | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | — | P6 <sub>6</sub> DDR | P6 <sub>5</sub> DDR | P6 <sub>4</sub> DDR | P6 <sub>3</sub> DDR | P6 <sub>2</sub> DDR | P6 <sub>1</sub> DDR | P6 <sub>0</sub> DDR |
| Initial value | 1 | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | — | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 6 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P6DR—Port 6 Data Register****H'BB****H8/3217, 3216, 3214  
H8/3202****P6**

| Bit           | 7                 | 6                                | 5                                | 4                                | 3               | 2               | 1               | 0               |
|---------------|-------------------|----------------------------------|----------------------------------|----------------------------------|-----------------|-----------------|-----------------|-----------------|
|               | —/P7 <sub>3</sub> | P6 <sub>6</sub> /P7 <sub>2</sub> | P6 <sub>5</sub> /P7 <sub>1</sub> | P6 <sub>4</sub> /P7 <sub>0</sub> | P6 <sub>3</sub> | P6 <sub>2</sub> | P6 <sub>1</sub> | P6 <sub>0</sub> |
| Initial value | 1                 | 0                                | 0                                | 0                                | 0               | 0               | 0               | 0               |
| Read/Write    | —                 | R/W                              | R/W                              | R/W                              | R/W             | R/W             | R/W             | R/W             |

**P6DR—Port 6 Data Register****H'BB****H8/3212****P6**

| Bit           | 7 | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | — | P6 <sub>6</sub> | P6 <sub>5</sub> | P6 <sub>4</sub> | P6 <sub>3</sub> | P6 <sub>2</sub> | P6 <sub>1</sub> | P6 <sub>0</sub> |
| Initial value | 1 | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | — | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

**P7DDR—Port 7 Data Direction  
Register****H'BC****H8/3217, 3216, 3214  
H8/3212, H8/3202****P7**

| Bit           | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |
|---------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | P7 <sub>7</sub> DDR | P7 <sub>6</sub> DDR | P7 <sub>5</sub> DDR | P7 <sub>4</sub> DDR | P7 <sub>3</sub> DDR | P7 <sub>2</sub> DDR | P7 <sub>1</sub> DDR | P7 <sub>0</sub> DDR |
| Initial value | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Read/Write    | W                   | W                   | W                   | W                   | W                   | W                   | W                   | W                   |

**Port 7 Input/Output Control**

|   |             |
|---|-------------|
| 0 | Input port  |
| 1 | Output port |

**P7DR—Port 7 Data Register****H'BE****H8/3217, 3216, 3214  
H8/3212, H8/3202****P7**

| Bit           | 7               | 6               | 5               | 4               | 3               | 2               | 1               | 0               |
|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|               | P7 <sub>7</sub> | P7 <sub>6</sub> | P7 <sub>5</sub> | P7 <sub>4</sub> | P7 <sub>3</sub> | P7 <sub>2</sub> | P7 <sub>1</sub> | P7 <sub>0</sub> |
| Initial value | 0               | 0               | 0               | 0               | 0               | 0               | 0               | 0               |
| Read/Write    | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             | R/W             |

| Bit           | 7 | 6 | 5     | 4   | 3    | 2    | 1   | 0   |
|---------------|---|---|-------|-----|------|------|-----|-----|
|               | — | — | CKDBL | —   | WMS1 | WMS0 | WC1 | WC0 |
| Initial value | 1 | 1 | 0     | 0   | 1    | 0    | 0   | 0   |
| Read/Write    | — | — | R/W   | R/W | R/W  | R/W  | R/W | R/W |

**Wait Count 1 and 0**

|   |   |                                                                  |
|---|---|------------------------------------------------------------------|
| 0 | 0 | No wait states inserted by wait state controller (Initial value) |
|   | 1 | 1 state inserted                                                 |
| 1 | 0 | 2 states inserted                                                |
|   | 1 | 3 states inserted                                                |

**Wait Mode Select 1 and 0**

|   |   |                                                  |
|---|---|--------------------------------------------------|
| 0 | 0 | Programmable wait mode                           |
|   | 1 | No wait states inserted by wait state controller |
| 1 | 0 | Pin wait mode (Initial value)                    |
|   | 1 | Pin auto-wait mode                               |

**Clock Double**

|   |                                                                                                                    |
|---|--------------------------------------------------------------------------------------------------------------------|
| 0 | The undivided system clock ( $\phi$ ) is supplied as the clock ( $\phi_p$ ) for supporting modules (Initial value) |
| 1 | The system clock ( $\phi$ ) is divided by two and supplied as the clock ( $\phi_p$ ) for supporting modules        |

| Bit           | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------------|------|-------|-------|-------|-------|-------|-------|-------|
|               | IICS | IICX1 | IICX0 | SYNCE | PWCKE | PWCKS | ICKS1 | ICKS0 |
| Initial value | 1    | 1     | 0     | 0     | 1     | 0     | 0     | 0     |
| Read/Write    | R/W  | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   | R/W   |

Internal Clock Select 1 and 0  
See TCSR for details.

**PWM Timer Control**

|   |   |                                                                      |                 |
|---|---|----------------------------------------------------------------------|-----------------|
| 0 | — | Clock input is disabled                                              | (Initial value) |
| 1 | 0 | $\emptyset$ (system clock) is selected                               |                 |
| 1 | 1 | $\emptyset_P/2$ (supporting module clock divided by two) is selected |                 |

**Timer Connection Output Enable**

|   |                                                                                                                 |                 |
|---|-----------------------------------------------------------------------------------------------------------------|-----------------|
| 0 | Timer connection output is not performed<br>The relevant pins have port input/output and timer output functions | (Initial value) |
| 1 | Timer connection output is performed<br>The relevant pins function as VSYNCO, HSYNCO, and CLAMPO output pins    |                 |

Control of the function of each pin is related to bits SMOD1 and SMOD0 and bit CLMOD in TCONR, the OEB bit in TCR for the free-running timer (FRT), and bits OS3 to OS0 in TCR for TMR1 and TMRx.

| STCR  | TCR   | Function of VSYNCO Pin                            |
|-------|-------|---------------------------------------------------|
| Bit 4 | Bit 3 |                                                   |
| SYNCE | OEB   |                                                   |
| 0     | 0     | P6 <sub>2</sub> port input/output (Initial value) |
| 0     | 1     | FTOB output                                       |
| 1     | —     | IV signal output                                  |

| STCR  | TCONR |       | TCR         | Function of HSYNCO Pin                            |
|-------|-------|-------|-------------|---------------------------------------------------|
| Bit 4 | Bit 7 | Bit 6 | Bits 3 to 0 |                                                   |
| SYNCE | SMOD1 | SMOD0 | OS3 to 0    |                                                   |
| 0     | —     | —     | All 0       | P4 <sub>4</sub> port input/output (Initial value) |
| 0     | —     | —     | Not all 0   | TMO1 output                                       |
| 1     | 0     | 0     | —           | IHI signal output                                 |
| 1     | 1     | 1     | —           | CL1 signal output                                 |
| 1     | 0     | 1     | —           | CL1 signal output                                 |
| 1     | 1     | 0     | —           | CL1 signal output                                 |

| STCR  | TCONR | TCR         | Function of CLAMPO Pin                            |
|-------|-------|-------------|---------------------------------------------------|
| Bit 4 | Bit 5 | Bits 3 to 0 |                                                   |
| SYNCE | CLMOD | OS3 to 0    |                                                   |
| 0     | —     | All 0       | P4 <sub>7</sub> port input/output (Initial value) |
| 0     | —     | Not all 0   | TMOx output                                       |
| 1     | 0     | —           | CL1 signal output                                 |
| 1     | 1     | —           | CL2 signal output                                 |

**I<sup>2</sup>C Transfer Select**

See ICCR for details.

**I<sup>2</sup>C Extra Buffer Select**

|   |                                                                                          |                 |
|---|------------------------------------------------------------------------------------------|-----------------|
| 0 | Pins P7 <sub>3</sub> and P7 <sub>2</sub> are normal input/output pins                    | (Initial value) |
| 1 | Pins P7 <sub>3</sub> and P7 <sub>2</sub> are input/output pins with bus drive capability |                 |

| Bit           | 7    | 6    | 5    | 4    | 3    | 2     | 1   | 0    |
|---------------|------|------|------|------|------|-------|-----|------|
|               | SSBY | STS2 | STS1 | STS0 | XRST | NMIEG | HIE | RAME |
| Initial value | 0    | 0    | 0    | 0    | 1    | 0     | 0   | 1    |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R    | R/W   | R/W | R/W  |

**RAM Enable**

|   |                         |
|---|-------------------------|
| 0 | On-chip RAM is disabled |
| 1 | On-chip RAM is enabled  |

**Host Interface Enable**

|   |                                            |
|---|--------------------------------------------|
| 0 | Host interface is disabled (initial value) |
| 1 | Host interface is enabled (slave mode)     |

**NMI Edge**

|   |                                                     |
|---|-----------------------------------------------------|
| 0 | Falling edge of $\overline{\text{NMI}}$ is detected |
| 1 | Rising edge of $\overline{\text{NMI}}$ is detected  |

**Standby Timer Select 2 to 0**

|   |   |   |                                      |
|---|---|---|--------------------------------------|
| 0 | 0 | 0 | Clock settling time = 8,192 states   |
| 0 | 0 | 1 | Clock settling time = 16,384 states  |
| 0 | 1 | 0 | Clock settling time = 32,768 states  |
| 0 | 1 | 1 | Clock settling time = 65,536 states  |
| 1 | 0 | — | Clock settling time = 131,072 states |
| 1 | 1 | — | Unused                               |

**Software Standby**

|   |                                                              |
|---|--------------------------------------------------------------|
| 0 | SLEEP instruction causes transition to sleep mode            |
| 1 | SLEEP instruction causes transition to software standby mode |

| Bit           | 7 | 6 | 5 | 4 | 3 | 2 | 1    | 0    |
|---------------|---|---|---|---|---|---|------|------|
|               | — | — | — | — | — | — | MDS1 | MDS0 |
| Initial value | 1 | 1 | 1 | 0 | 0 | 1 | —*   | —*   |
| Read/Write    | — | — | — | — | — | — | R    | R    |

**Mode Select**  
 Mode pin values

Note: \* Initialized according to MD<sub>1</sub> and MD<sub>0</sub> inputs.

### ISCR—IRQ Sense Control Register

H'C6

H8/3217, 3216, 3214

System Control

H8/3212, H8/3202

| Bit           | 7 | 6      | 5 | 4 | 3 | 2      | 1      | 0      |
|---------------|---|--------|---|---|---|--------|--------|--------|
|               | — | IRQ6SC | — | — | — | IRQ2SC | IRQ1SC | IRQ0SC |
| Initial value | 1 | 0      | 1 | 1 | 1 | 0      | 0      | 0      |
| Read/Write    | — | R/W    | — | — | — | R/W    | R/W    | R/W    |

#### IRQ<sub>0</sub> Sense Control

| IRQ0SC | Description                                                                  |
|--------|------------------------------------------------------------------------------|
| 0      | The low level of $\overline{\text{IRQ}}_0$ generates an interrupt request    |
| 1      | The falling edge of $\overline{\text{IRQ}}_0$ generates an interrupt request |

#### IRQ<sub>1</sub> Sense Control

| IRQ1SC | Description                                                                  |
|--------|------------------------------------------------------------------------------|
| 0      | The low level of $\overline{\text{IRQ}}_1$ generates an interrupt request    |
| 1      | The falling edge of $\overline{\text{IRQ}}_1$ generates an interrupt request |

#### IRQ<sub>2</sub> Sense Control

| IRQ2SC | Description                                                                  |
|--------|------------------------------------------------------------------------------|
| 0      | The low level of $\overline{\text{IRQ}}_2$ generates an interrupt request    |
| 1      | The falling edge of $\overline{\text{IRQ}}_2$ generates an interrupt request |

#### IRQ<sub>6</sub> Sense Control

| IRQ6SC | Description                                                                                 |
|--------|---------------------------------------------------------------------------------------------|
| 0      | The low level of KEYIN <sub>0</sub> to KEYIN <sub>7</sub> generates an interrupt request    |
| 1      | The falling edge of KEYIN <sub>0</sub> to KEYIN <sub>7</sub> generates an interrupt request |

|               |   |                                |   |   |   |                                                                    |       |       |
|---------------|---|--------------------------------|---|---|---|--------------------------------------------------------------------|-------|-------|
| Bit           | 7 | 6                              | 5 | 4 | 3 | 2                                                                  | 1     | 0     |
|               | — | IRQ6E                          | — | — | — | IRQ2E                                                              | IRQ1E | IRQ0E |
| Initial value | 1 | 0                              | 1 | 1 | 1 | 0                                                                  | 0     | 0     |
| Read/Write    | — | R/W                            | — | — | — | R/W                                                                | R/W   | R/W   |
|               |   | IRQ Enable                     |   |   |   | IRQ Enable                                                         |       |       |
|               |   | 0 IRQ <sub>6</sub> is disabled |   |   |   | 0 IRQ <sub>0</sub> /IRQ <sub>1</sub> /IRQ <sub>2</sub> is disabled |       |       |
|               |   | 1 IRQ <sub>6</sub> is enabled  |   |   |   | 1 IRQ <sub>0</sub> /IRQ <sub>1</sub> /IRQ <sub>2</sub> is enabled  |       |       |

| Bit           | 7     | 6     | 5    | 4     | 3     | 2    | 1    | 0    |
|---------------|-------|-------|------|-------|-------|------|------|------|
|               | CMIEB | CMIEA | OVIE | CCLR1 | CCLR0 | CKS2 | CKS1 | CKS0 |
| Initial value | 0     | 0     | 0    | 0     | 0     | 0    | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  | R/W  |

## Clock Select 2 to 0

| Channel | TCR   |       |       | STCR  |       | Description                                                         |
|---------|-------|-------|-------|-------|-------|---------------------------------------------------------------------|
|         | Bit 2 | Bit 1 | Bit 0 | Bit 1 | Bit 0 |                                                                     |
| 0       | CKS2  | CKS1  | CKS0  | ICKS1 | ICKS0 |                                                                     |
|         | 0     | 0     | 0     | —     | —     | No clock source (timer stopped)                                     |
|         | 0     | 0     | 1     | —     | 0     | $\phi_P/8$ internal clock source, counted on the falling edge       |
|         | 0     | 0     | 1     | —     | 1     | $\phi_P/2$ internal clock source, counted on the falling edge       |
|         | 0     | 1     | 0     | —     | 0     | $\phi_P/64$ internal clock source, counted on the falling edge      |
|         | 0     | 1     | 0     | —     | 1     | $\phi_P/32$ internal clock source, counted on the falling edge      |
|         | 0     | 1     | 1     | —     | 0     | $\phi_P/1024$ internal clock source, counted on the falling edge    |
|         | 0     | 1     | 1     | —     | 1     | $\phi_P/256$ internal clock source, counted on the falling edge     |
|         | 1     | 0     | 0     | —     | —     | No clock source (timer stopped)                                     |
|         | 1     | 0     | 1     | —     | —     | External clock source, counted on the rising edge                   |
|         | 1     | 1     | 0     | —     | —     | External clock source, counted on the falling edge                  |
|         | 1     | 1     | 1     | —     | —     | External clock source, counted on both the rising and falling edges |
| 1       | 0     | 0     | 0     | —     | —     | No clock source (timer stopped)                                     |
|         | 0     | 0     | 1     | 0     | —     | $\phi_P/8$ internal clock source, counted on the falling edge       |
|         | 0     | 0     | 1     | 1     | —     | $\phi_P/2$ internal clock source, counted on the falling edge       |
|         | 0     | 1     | 0     | 0     | —     | $\phi_P/64$ internal clock source, counted on the falling edge      |
|         | 0     | 1     | 0     | 1     | —     | $\phi_P/128$ internal clock source, counted on the falling edge     |
|         | 0     | 1     | 1     | 0     | —     | $\phi_P/1024$ internal clock source, counted on the falling edge    |
|         | 0     | 1     | 1     | 1     | —     | $\phi_P/2048$ internal clock source, counted on the falling edge    |
|         | 1     | 0     | 0     | —     | —     | No clock source (timer stopped)                                     |
|         | 1     | 0     | 1     | —     | —     | External clock source, counted on the rising edge                   |
|         | 1     | 1     | 0     | —     | —     | External clock source, counted on the falling edge                  |
|         | 1     | 1     | 1     | —     | —     | External clock source, counted on both the rising and falling edges |

## Counter Clear 1 and 0

|   |   |                                                       |
|---|---|-------------------------------------------------------|
| 0 | 0 | Not cleared                                           |
| 0 | 1 | Cleared on compare-match A                            |
| 1 | 0 | Cleared on compare-match B                            |
| 1 | 1 | Cleared on rising edge of external reset input signal |

## Timer Overflow Interrupt Enable

|   |                                                        |
|---|--------------------------------------------------------|
| 0 | The timer overflow interrupt request (OVI) is disabled |
| 1 | The timer overflow interrupt request (OVI) is enabled  |

## Compare-Match Interrupt Enable A

|   |                                                      |
|---|------------------------------------------------------|
| 0 | Compare-match interrupt request A (CMIA) is disabled |
| 1 | Compare-match interrupt request A (CMIA) is enabled  |

## Compare-Match Interrupt Enable B

|   |                                                      |
|---|------------------------------------------------------|
| 0 | Compare-match interrupt request B (CMIB) is disabled |
| 1 | Compare-match interrupt request B (CMIB) is enabled  |

| Bit           | 7       | 6       | 5       | 4    | 3     | 2     | 1     | 0     |
|---------------|---------|---------|---------|------|-------|-------|-------|-------|
|               | CMFB    | CMFA    | OVF     | PWME | OS3*1 | OS2*1 | OS1*1 | OS0*1 |
| Initial value | 0       | 0       | 0       | 0    | 0     | 0     | 0     | 0     |
| Read/Write    | R/(W)*2 | R/(W)*2 | R/(W)*2 | R/W  | R/W   | R/W   | R/W   | R/W   |

**Output Select 1 and 0**

|   |   |                                                      |
|---|---|------------------------------------------------------|
| 0 | 0 | No change when compare-match A occurs                |
| 0 | 1 | Output changes to 0 when compare-match A occurs      |
| 1 | 0 | Output changes to 1 when compare-match A occurs      |
| 1 | 1 | Output inverts (toggles) when compare-match A occurs |

**Output Select 3 and 2**

|   |   |                                                      |
|---|---|------------------------------------------------------|
| 0 | 0 | No change when compare-match B occurs                |
| 0 | 1 | Output changes to 0 when compare-match B occurs      |
| 1 | 0 | Output changes to 1 when compare-match B occurs      |
| 1 | 1 | Output inverts (toggles) when compare-match B occurs |

**PWM Mode Enable**

|   |                   |               |
|---|-------------------|---------------|
| 0 | Normal timer mode | Initial value |
| 1 | PWM mode          |               |

**Timer Overflow Flag**

|   |                                                                                            |
|---|--------------------------------------------------------------------------------------------|
| 0 | To clear OVF, the CPU must read OVF after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when TCNT changes from H'FF to H'00                                   |

**Compare-Match Flag A**

|   |                                                                                              |
|---|----------------------------------------------------------------------------------------------|
| 0 | To clear CMFA, the CPU must read CMFA after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when TCNT = TCORA                                                       |

**Compare-Match Flag B**

|   |                                                                                              |
|---|----------------------------------------------------------------------------------------------|
| 0 | To clear CMFB, the CPU must read CMFB after it has been set to 1, then write a 0 in this bit |
| 1 | This bit is set to 1 when TCNT = TCORB                                                       |

Notes: \*1. When all four output select bits (bits OS3 to OS0) are cleared to 0, the timer output signal is disabled.

\*2. Software can write a 0 in bits 7 to 5 to clear the flags, but cannot write a 1 in these bits.

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

The CMFA bit is set to 1 when TCORA = TCNT

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

The CMFB bit is set to 1 when TCORB = TCNT

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Count value

**PWOERB—PWM Output  
Enable Register B**

**H'CD**

**H8/3217, 3216, 3214  
H8/3212**

**PWM**

| Bit           | 7    | 6    | 5    | 4    | 3    | 2    | 1   | 0   |
|---------------|------|------|------|------|------|------|-----|-----|
|               | OE15 | OE14 | OE13 | OE12 | OE11 | OE10 | OE9 | OE8 |
| Initial value | 0    | 0    | 0    | 0    | 0    | 0    | 0   | 0   |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W | R/W |

**PWM Output Enable 15 to 8**

|   |                                                                                        |
|---|----------------------------------------------------------------------------------------|
| 0 | When input is set: port input<br>When output is set: port output or PWM 256/256 output |
| 1 | When input is set: port input<br>When output is set: PWM output (0 to 255/256 output)  |

**PWDPRB—PWM Data Polarity  
Register B**

**H'CE**

**H8/3217, 3216, 3214  
H8/3212**

**PWM**

| Bit           | 7    | 6    | 5    | 4    | 3    | 2    | 1   | 0   |
|---------------|------|------|------|------|------|------|-----|-----|
|               | OS15 | OS14 | OS13 | OS12 | OS11 | OS10 | OS9 | OS8 |
| Initial value | 0    | 0    | 0    | 0    | 0    | 0    | 0   | 0   |
| Read/Write    | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W | R/W |

**PWM Data Polarity 15 to 8**

|   |                                                                                       |
|---|---------------------------------------------------------------------------------------|
| 0 | PWM direct output (PWDR value corresponds to high width of output)<br>(Initial value) |
| 1 | PWM inverted output (PWDR value corresponds to low width of output)                   |

**PWDPRA—PWM Data Polarity Register A**      **H'CF**

**H8/3217, 3216, 3214**  
**H8/3212**

**PWM**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               | OS7 | OS6 | OS5 | OS4 | OS3 | OS2 | OS1 | OS0 |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

**PWM Data Polarity 7 to 0**

|   |                                                                                       |
|---|---------------------------------------------------------------------------------------|
| 0 | PWM direct output (PWDR value corresponds to high width of output)<br>(Initial value) |
| 1 | PWM inverted output (PWDR value corresponds to low width of output)                   |

**TCR—Timer Control Register**      **H'D0**

**H8/3217, 3216, 3214**  
**H8/3212, H8/3202**

**TMR1**

| Bit           | 7     | 6     | 5    | 4     | 3     | 2    | 1    | 0    |
|---------------|-------|-------|------|-------|-------|------|------|------|
|               | CMIEB | CMIEA | OVIE | CCLR1 | CCLR0 | CKS2 | CKS1 | CKS0 |
| Initial value | 0     | 0     | 0    | 0     | 0     | 0    | 0    | 0    |
| Read/Write    | R/W   | R/W   | R/W  | R/W   | R/W   | R/W  | R/W  | R/W  |

Note: Bit functions are the same as for TMR0.

**TCSR—Timer Status Control Register**      **H'D1**

**H8/3217, 3216, 3214**  
**H8/3212, H8/3202**

**TMR1**

| Bit           | 7       | 6       | 5       | 4    | 3     | 2     | 1     | 0     |
|---------------|---------|---------|---------|------|-------|-------|-------|-------|
|               | CMFB    | CMFA    | OVF     | PWME | OS3*1 | OS2*1 | OS1*1 | OS0*1 |
| Initial value | 0       | 0       | 0       | 0    | 0     | 0     | 0     | 0     |
| Read/Write    | R/(W)*2 | R/(W)*2 | R/(W)*2 | R/W  | R/W   | R/W   | R/W   | R/W   |

Notes: Bit functions are the same as for TMR0.

- \*1. When all four output select bits (bits OS3 to OS0) are cleared to 0, the timer output signal is disabled.
- \*2. Software can write a 0 in bits 7 to 5 to clear the flags, but cannot write a 1 in these bits.

**TCORA—Time Constant  
Register A**

**H'D2**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**TMR1**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Note: Bit functions are the same as for TMR0.

**TCORB—Time Constant  
Register B**

**H'D3**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**TMR1**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Note: Bit functions are the same as for TMR0.

**TCNT—Timer Counter**

**H'D4**

**H8/3217, 3216, 3214  
H8/3212, H8/3202**

**TMR1**

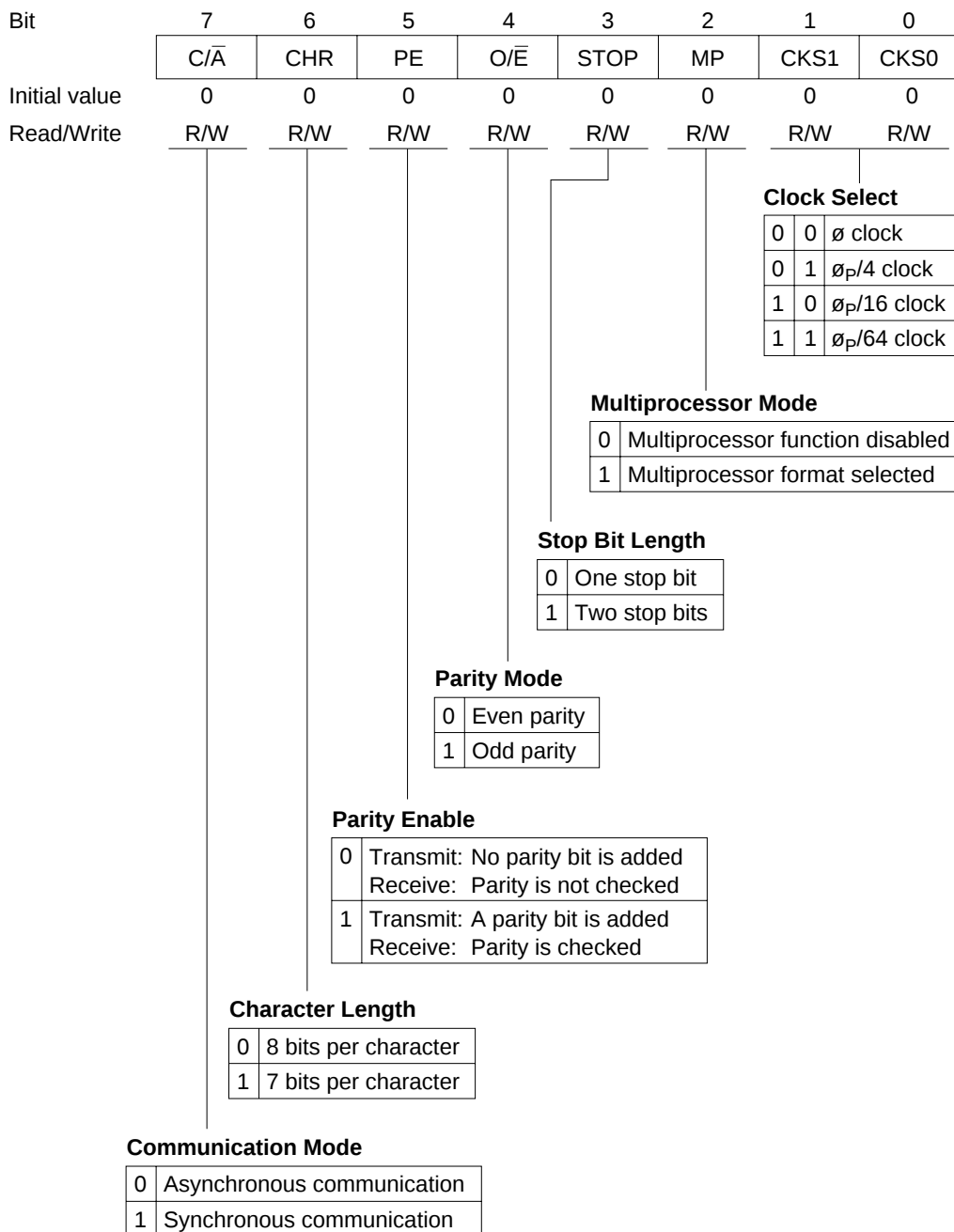
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Note: Bit functions are the same as for TMR0.

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               | OE7 | OE6 | OE5 | OE4 | OE3 | OE2 | OE1 | OE0 |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

PWM Output Enable 7 to 0

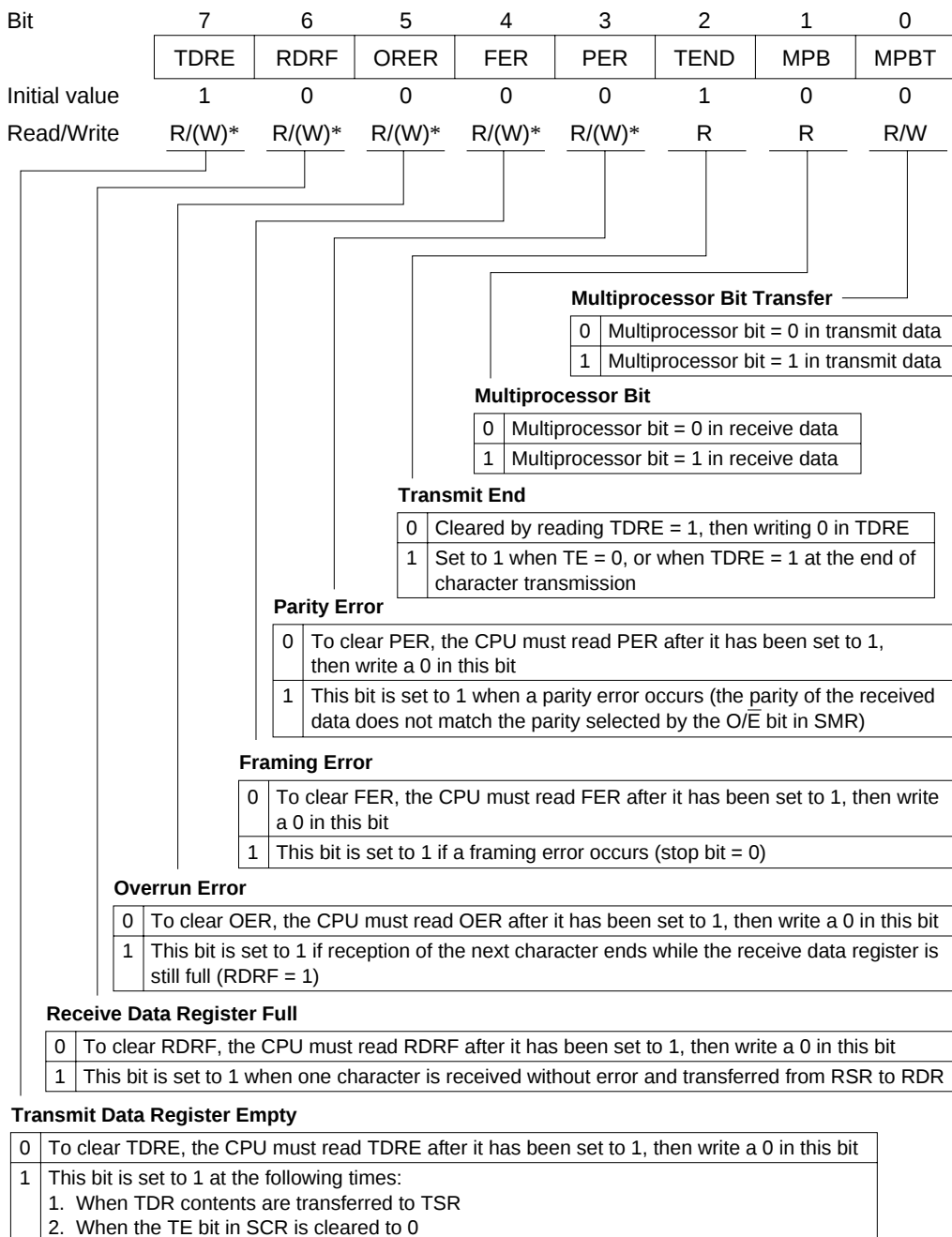
|   |                                                                                        |
|---|----------------------------------------------------------------------------------------|
| 0 | When input is set: port input<br>When output is set: port output or PWM 256/256 output |
| 1 | When input is set: port input<br>When output is set: PWM output (0 to 255/256 output)  |



|                   |     |     |     |     |     |     |     |     |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit               | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|                   |     |     |     |     |     |     |     |     |
| Initial value     | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write        | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Sets the bit rate |     |     |     |     |     |     |     |     |

|                      |     |     |     |     |     |     |     |     |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit                  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|                      |     |     |     |     |     |     |     |     |
| Initial value        | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write           | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Stores transmit data |     |     |     |     |     |     |     |     |





Note: \* Software can write a 0 in bits 7 to 3 to clear the flags, but cannot write a 1 in these bits.

| Bit           | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------|---|---|---|---|---|---|---|---|
|               |   |   |   |   |   |   |   |   |
| Initial value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write    | R | R | R | R | R | R | R | R |

Stores receive data

SCMR—Serial Communication  
Mode Register

| Bit           | 7 | 6 | 5 | 4 | 3    | 2    | 1 | 0    |
|---------------|---|---|---|---|------|------|---|------|
|               | — | — | — | — | SDIR | SINV | — | SMIF |
| Initial value | 1 | 1 | 1 | 1 | 0    | 0    | 1 | 0    |
| Read/Write    | — | — | — | — | R/W  | R/W  | — | R/W  |

## Serial Communication Mode Select

|   |                                 |
|---|---------------------------------|
| 0 | Normal SCI mode (Initial value) |
| 1 | Reserved mode                   |

## Data Invert

|   |                                                                                                        |
|---|--------------------------------------------------------------------------------------------------------|
| 0 | TDR contents are transmitted as they are (Initial value)<br>TDR contents are stored in RDR as they are |
| 1 | TDR contents are inverted before being transmitted<br>Receive data is stored in RDR in inverted form   |

## Data Transfer Direction

|   |                                                                                                   |
|---|---------------------------------------------------------------------------------------------------|
| 0 | TDR contents are transmitted LSB-first (Initial value)<br>Receive data is stored in RDR LSB-first |
| 1 | TDR contents are transmitted MSB-first<br>Receive data is stored in RDR MSB-first                 |

**SMR—Serial Mode Register 1****H'E0****H8/3217, 3216, 3214****SCI1****H8/3202**

| Bit           | 7            | 6   | 5   | 4            | 3    | 2   | 1    | 0    |
|---------------|--------------|-----|-----|--------------|------|-----|------|------|
|               | C/ $\bar{A}$ | CHR | PE  | O/ $\bar{E}$ | STOP | MP  | CKS1 | CKS0 |
| Initial value | 0            | 0   | 0   | 0            | 0    | 0   | 0    | 0    |
| Read/Write    | R/W          | R/W | R/W | R/W          | R/W  | R/W | R/W  | R/W  |

Note: Bit functions are the same as for SCI0.

**BRR—Bit Rate Register****H'E1****H8/3217, 3216, 3214****SCI1****H8/3202**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Note: Bit functions are the same as for SCI0.

**SCR—Serial Control Register****H'E2****H8/3217, 3216, 3214****SCI1****H8/3202**

| Bit           | 7   | 6   | 5   | 4   | 3    | 2    | 1    | 0    |
|---------------|-----|-----|-----|-----|------|------|------|------|
|               | TIE | RIE | TE  | RE  | MPIE | TEIE | CKE1 | CKE0 |
| Initial value | 0   | 0   | 0   | 0   | 0    | 0    | 0    | 0    |
| Read/Write    | R/W | R/W | R/W | R/W | R/W  | R/W  | R/W  | R/W  |

Note: Bit functions are the same as for SCI0.

**TDR—Transmit Data Register****H'E3****H8/3217, 3216, 3214  
H8/3202****SCI1**

| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
|               |     |     |     |     |     |     |     |     |
| Initial value | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

Note: Bit functions are the same as for SCI0.

**SSR—Serial Status Register 1****H'E4****H8/3217, 3216, 3214  
H8/3202****SCI1**

| Bit           | 7      | 6      | 5      | 4      | 3      | 2    | 1   | 0    |
|---------------|--------|--------|--------|--------|--------|------|-----|------|
|               | TDRE   | RDRF   | ORER   | FER    | PER    | TEND | MPB | MPBT |
| Initial value | 0      | 0      | 0      | 0      | 0      | 1    | 0   | 0    |
| Read/Write    | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R/(W)* | R    | R   | R/W  |

Note: Bit functions are the same as for SCI0.

**RDR—Receive Data register 1****H'E5****H8/3217, 3216, 3214  
H8/3202****SCI1**

| Bit           | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------|---|---|---|---|---|---|---|---|
|               |   |   |   |   |   |   |   |   |
| Initial value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read/Write    | R | R | R | R | R | R | R | R |

Note: Bit functions are the same as for SCI0.

|               |     |     |     |     |     |     |     |     |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit           | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|               |     |     |     |     |     |     |     |     |
| Initial value | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Read/Write    | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |

|                  |   |   |   |   |   |        |        |        |
|------------------|---|---|---|---|---|--------|--------|--------|
| Bit              | 7 | 6 | 5 | 4 | 3 | 2      | 1      | 0      |
|                  | — | — | — | — | — | IBFIE2 | IBFIE1 | FGA20E |
| Initial value    | 0 | 0 | 0 | 0 | 0 | 0      | 0      | 0      |
| Slave Read/Write | — | — | — | — | — | R/W    | R/W    | R/W    |
| Host Read/Write  | — | — | — | — | — | —      | —      | —      |

Fast Gate A<sub>20</sub> Enable

|   |                                                             |
|---|-------------------------------------------------------------|
| 0 | Disables fast A <sub>20</sub> gate function (Initial value) |
| 1 | Enables fast A <sub>20</sub> gate function                  |

Input Buffer Full Interrupt Enable 1

|   |                                                              |
|---|--------------------------------------------------------------|
| 0 | IDR1 input buffer full interrupt is disabled (Initial value) |
| 1 | IDR1 input buffer full interrupt is enabled                  |

Input Buffer Full Interrupt Enable 2

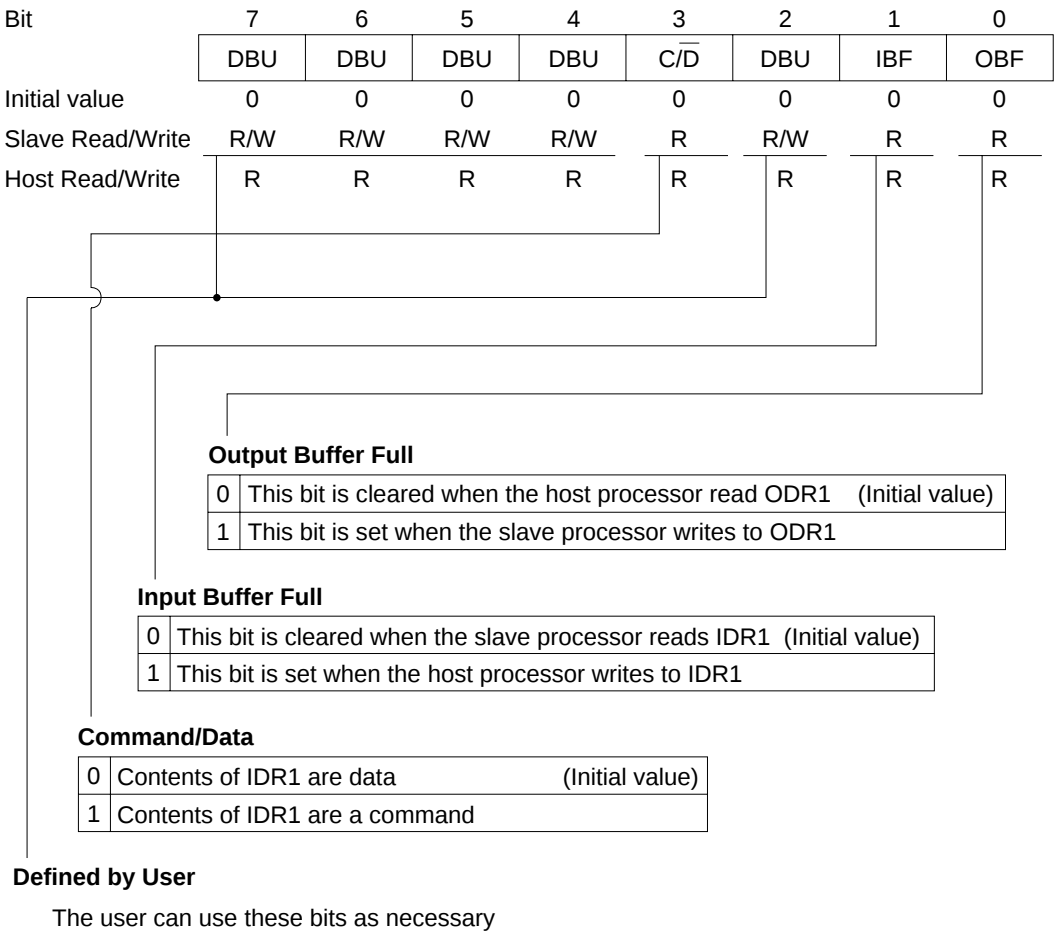
|   |                                                              |
|---|--------------------------------------------------------------|
| 0 | IDR2 input buffer full interrupt is disabled (Initial value) |
| 1 | IDR2 input buffer full interrupt is enabled                  |

**IDR1—Input Data Register****H'F4****H8/3217, 3216, 3214  
H8/3202****HIF**

| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | IDR7 | IDR6 | IDR5 | IDR4 | IDR3 | IDR2 | IDR1 | IDR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R    | R    | R    | R    | R    | R    | R    | R    |
| Host Read/Write  | W    | W    | W    | W    | W    | W    | W    | W    |

**ODR1—Output Data Register****H'F5****H8/3217, 3216, 3214  
H8/3202****HIF**

| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | ODR7 | ODR6 | ODR5 | ODR4 | ODR3 | ODR2 | ODR1 | ODR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  |
| Host Read/Write  | R    | R    | R    | R    | R    | R    | R    | R    |



| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|------------------|------|------|------|------|------|------|------|------|
|                  | IDR7 | IDR6 | IDR5 | IDR4 | IDR3 | IDR2 | IDR1 | IDR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R    | R    | R    | R    | R    | R    | R    | R    |
| Host Read/Write  | W    | W    | W    | W    | W    | W    | W    | W    |

**ODR2—Output Data Register**

**H'FD**

**H8/3217, 3216, 3214**  
**H8/3202**

**HIF**

|                  |      |      |      |      |      |      |      |      |
|------------------|------|------|------|------|------|------|------|------|
| Bit              | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|                  | ODR7 | ODR6 | ODR5 | ODR4 | ODR3 | ODR2 | ODR1 | ODR0 |
| Initial value    | —    | —    | —    | —    | —    | —    | —    | —    |
| Slave Read/Write | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  |
| Host Read/Write  | R    | R    | R    | R    | R    | R    | R    | R    |

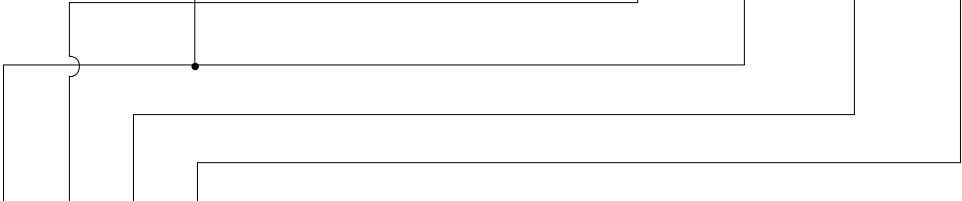
**STR2—Status Register**

**H'FE**

**H8/3217, 3216, 3214**  
**H8/3202**

**HIF**

|                  |     |     |     |     |     |     |     |     |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Bit              | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|                  | DBU | DBU | DBU | DBU | C/D | DBU | IBF | OBF |
| Initial value    | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Slave Read/Write | R/W | R/W | R/W | R/W | R   | R/W | R   | R   |
| Host Read/Write  | R   | R   | R   | R   | R   | R   | R   | R   |



**Output Buffer Full**

|   |                                                                       |
|---|-----------------------------------------------------------------------|
| 0 | This bit is cleared when the host processor read ODR1 (Initial value) |
| 1 | This bit is set when the slave processor writes to ODR1               |

**Input Buffer Full**

|   |                                                                         |
|---|-------------------------------------------------------------------------|
| 0 | This bit is cleared when the slave processor reads IDR1 (Initial value) |
| 1 | This bit is set when the host processor writes to IDR1                  |

**Command/Data**

|   |                                           |
|---|-------------------------------------------|
| 0 | Contents of IDR1 are data (Initial value) |
| 1 | Contents of IDR1 are a command            |

**Defined by User**

The user can use these bits as necessary

# Appendix C I/O Port Block Diagrams

## C.1 Port 1 Block Diagram

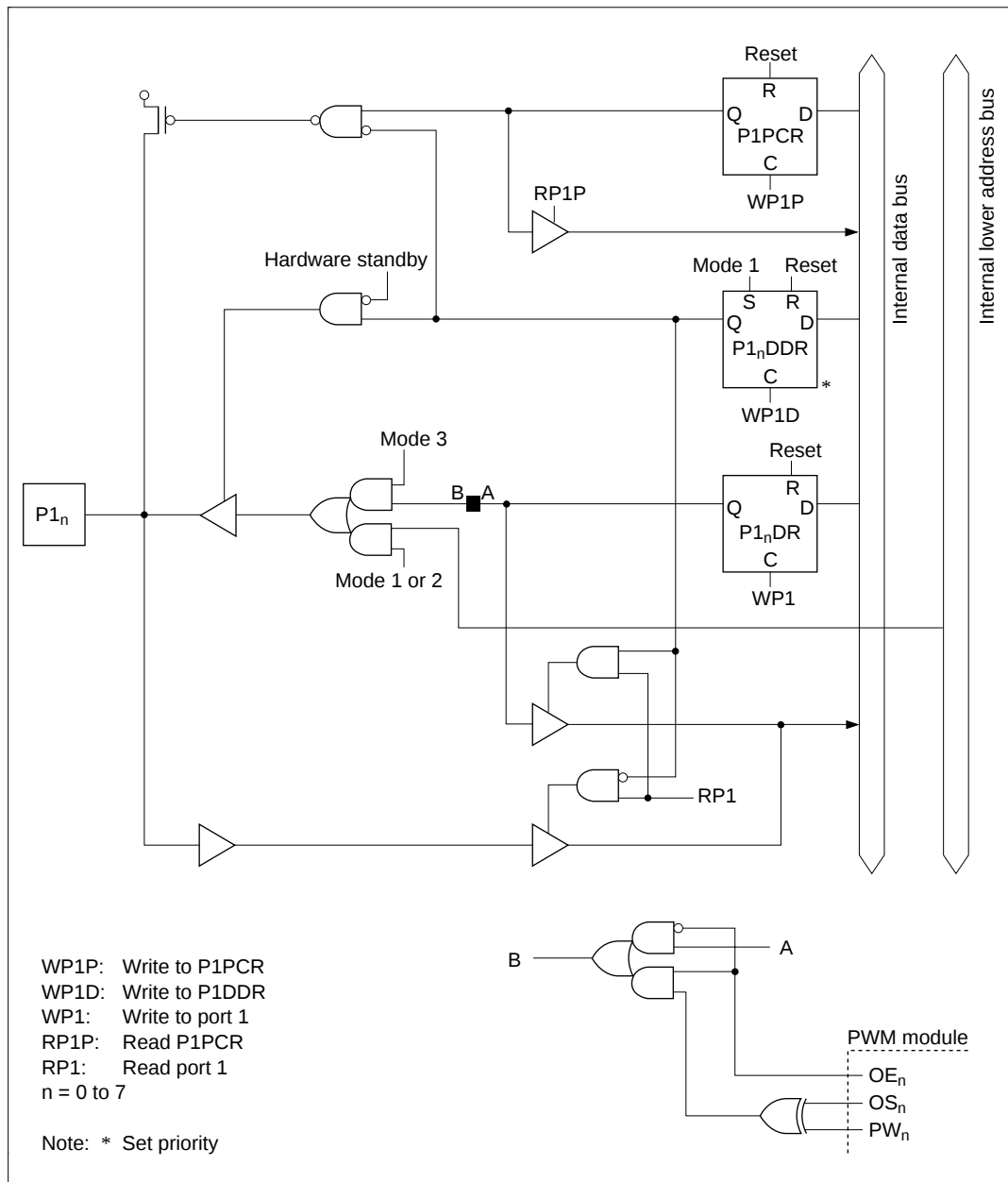


Figure C-1 Port 1 Block Diagram

## C.2 Port 2 Block Diagram

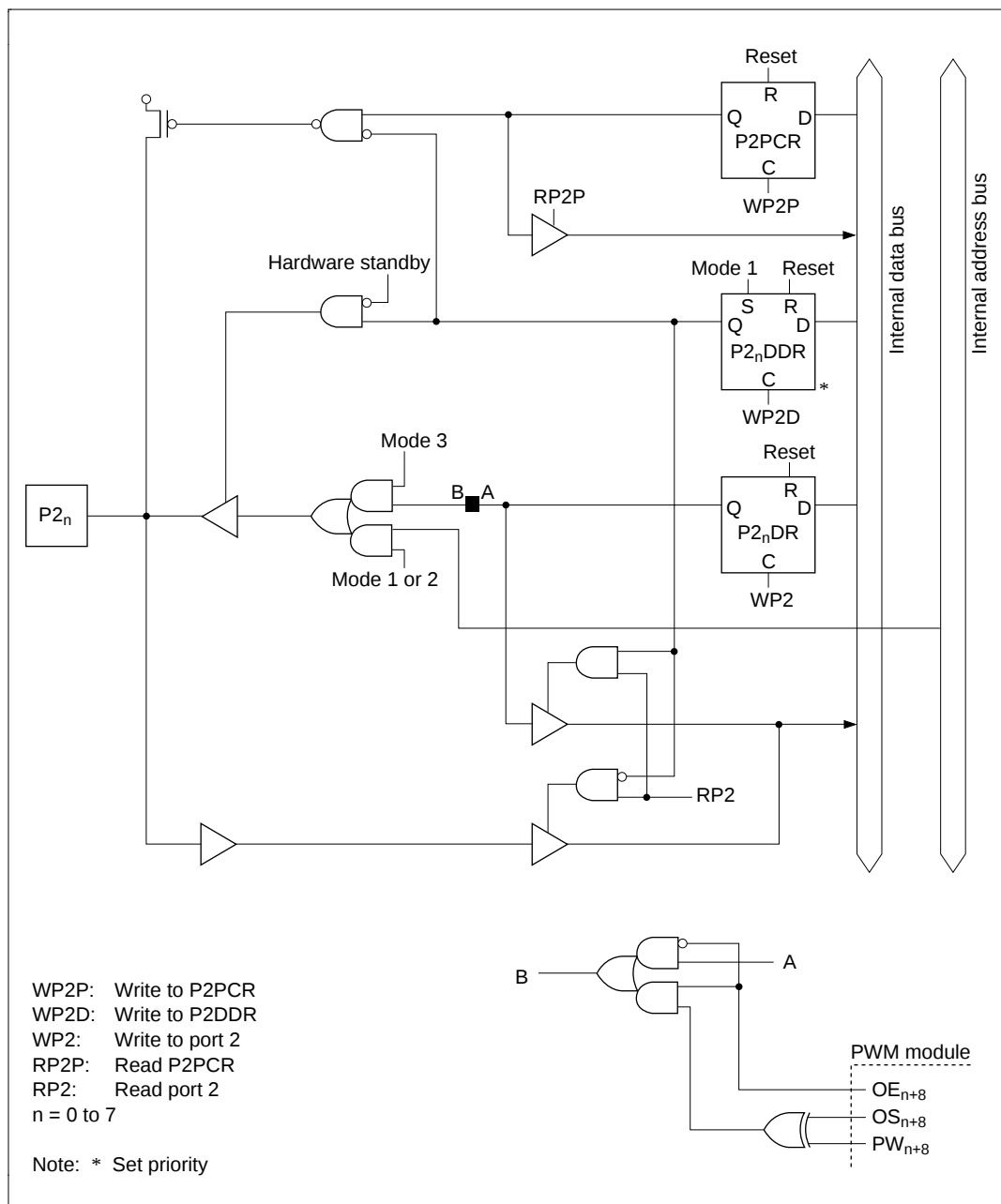


Figure C-2 Port 2 Block Diagram

## C.3 Port 3 Block Diagram

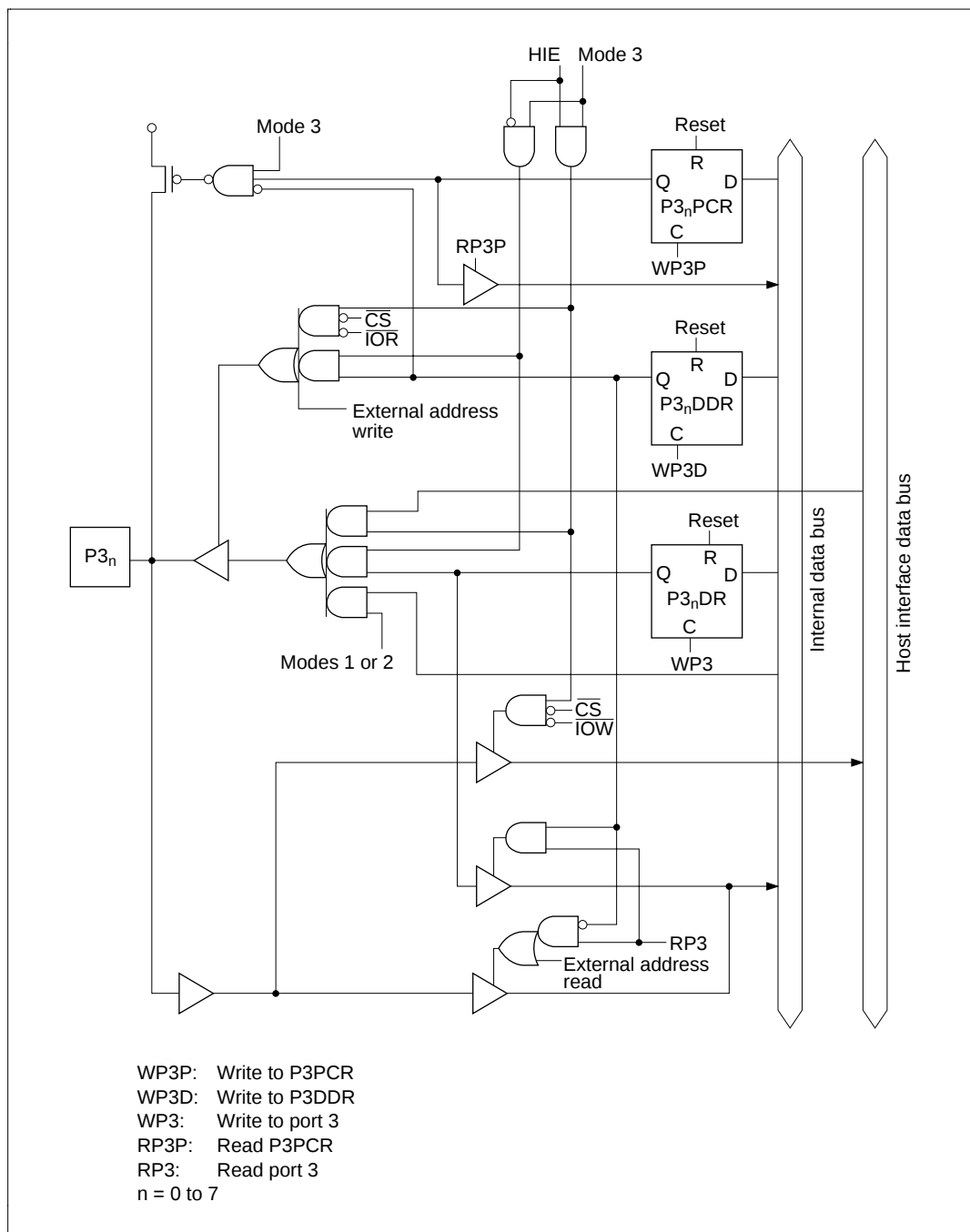


Figure C-3 Port 3 Block Diagram

# C.4 Port 4 Block Diagrams

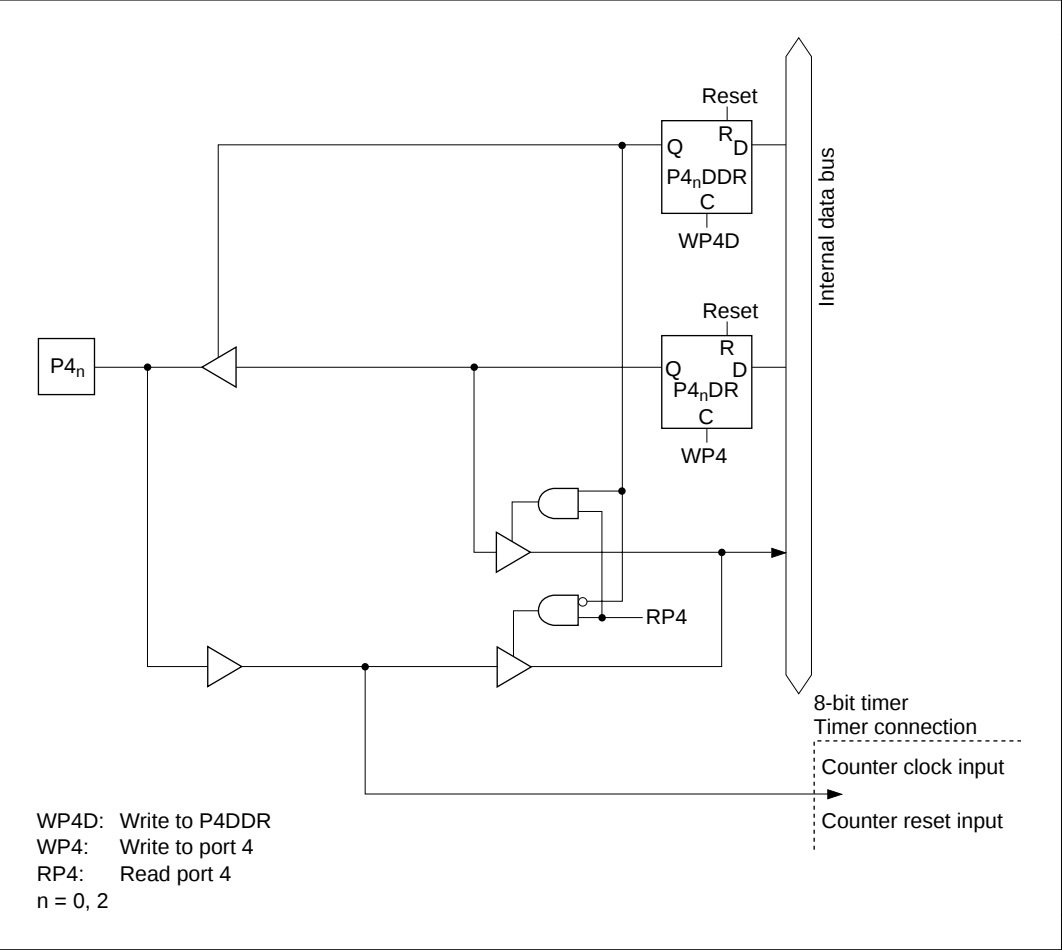
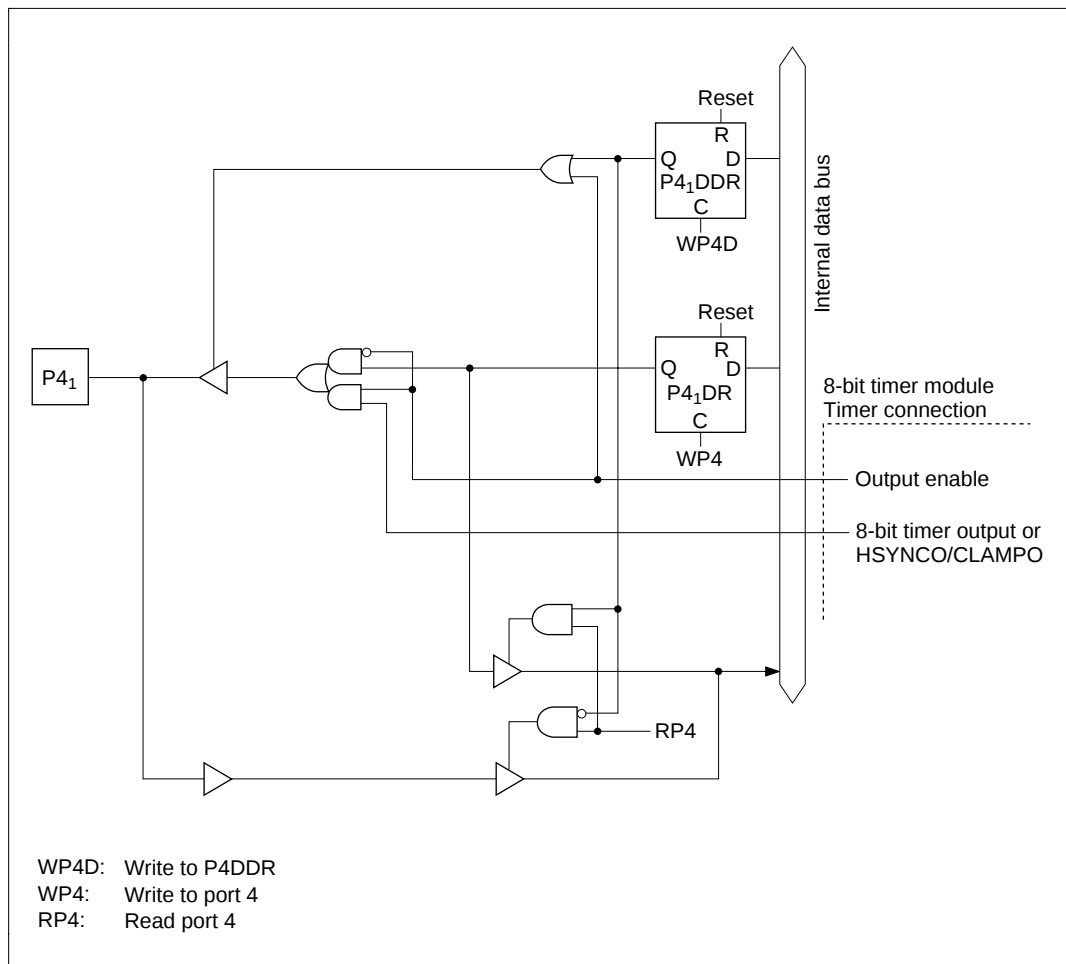
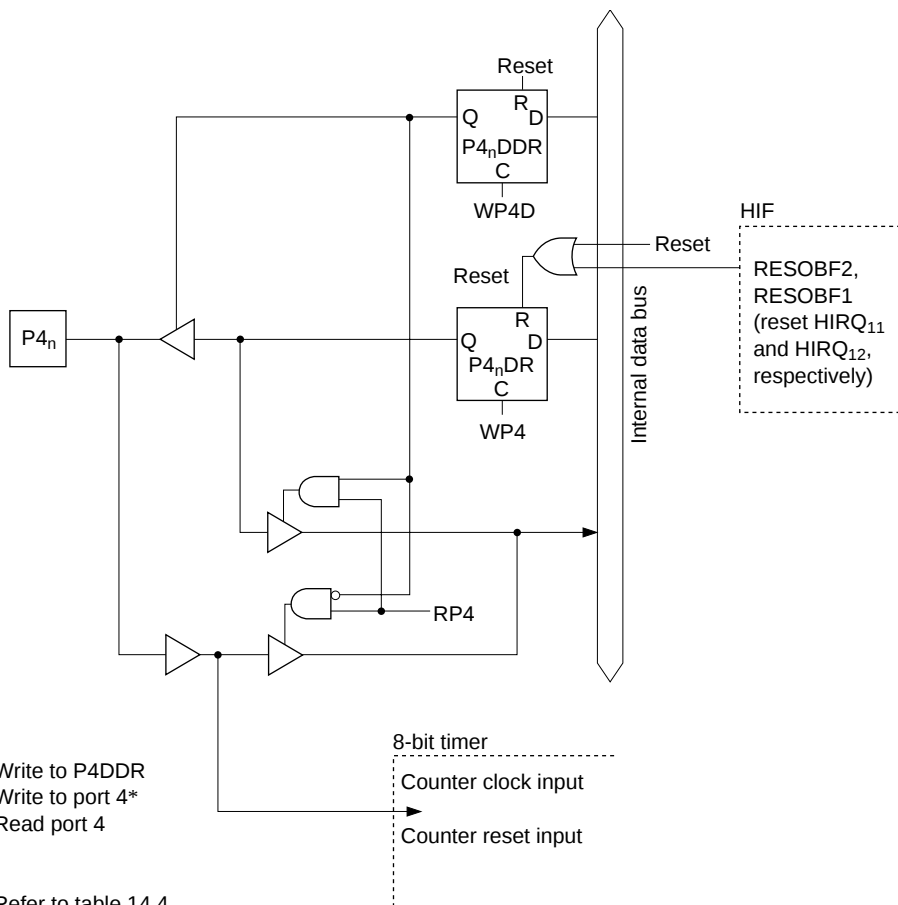


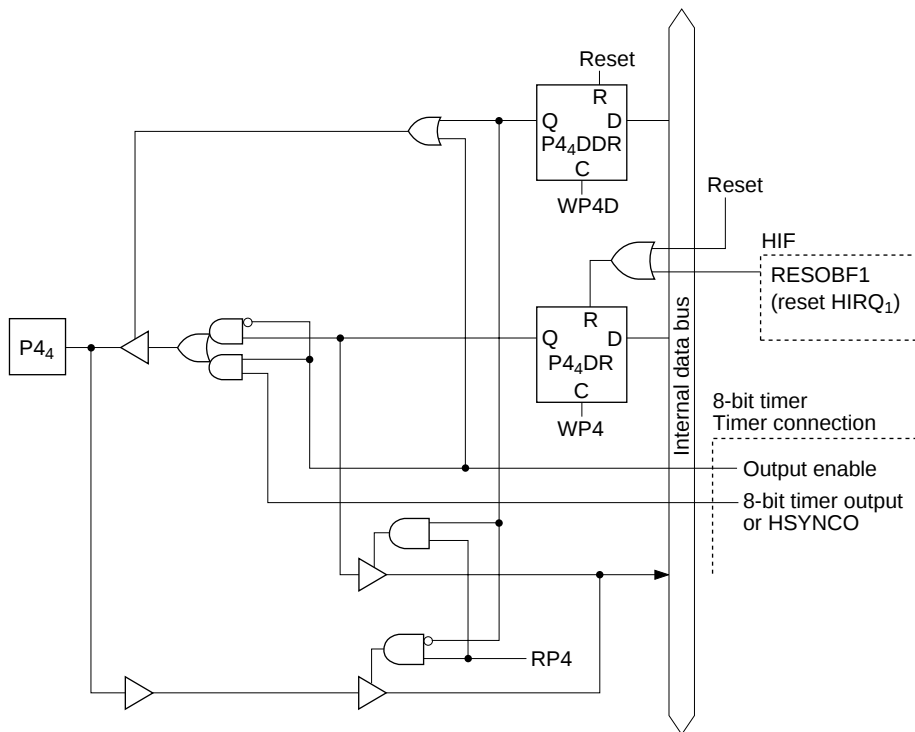
Figure C-4 (a) Port 4 Block Diagram (Pins P4<sub>0</sub>, P4<sub>2</sub>)



**Figure C-4 (b) Port 4 Block Diagram (Pin P4<sub>1</sub>)**

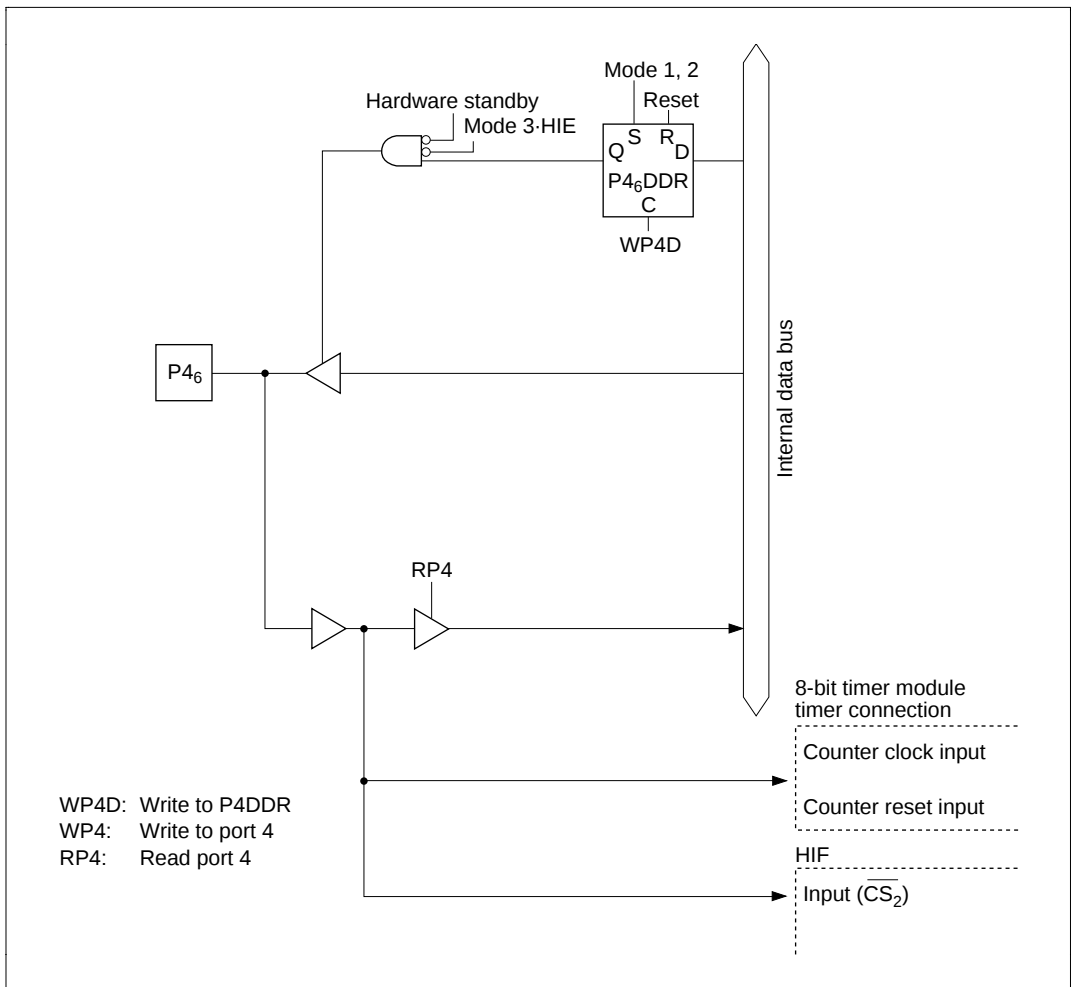


**Figure C-4 (c) Port 4 Block Diagram (Pins P4<sub>3</sub>, P4<sub>5</sub>)**



WP4D: Write to P4DDR  
 WP4: Write to port 4  
 RP4: Read port 4

**Figure C-4 (d) Port 4 Block Diagram (Pin P4<sub>4</sub>)**



**Figure C-4 (e) Port 4 Block Diagram (Pin P4<sub>6</sub>)**

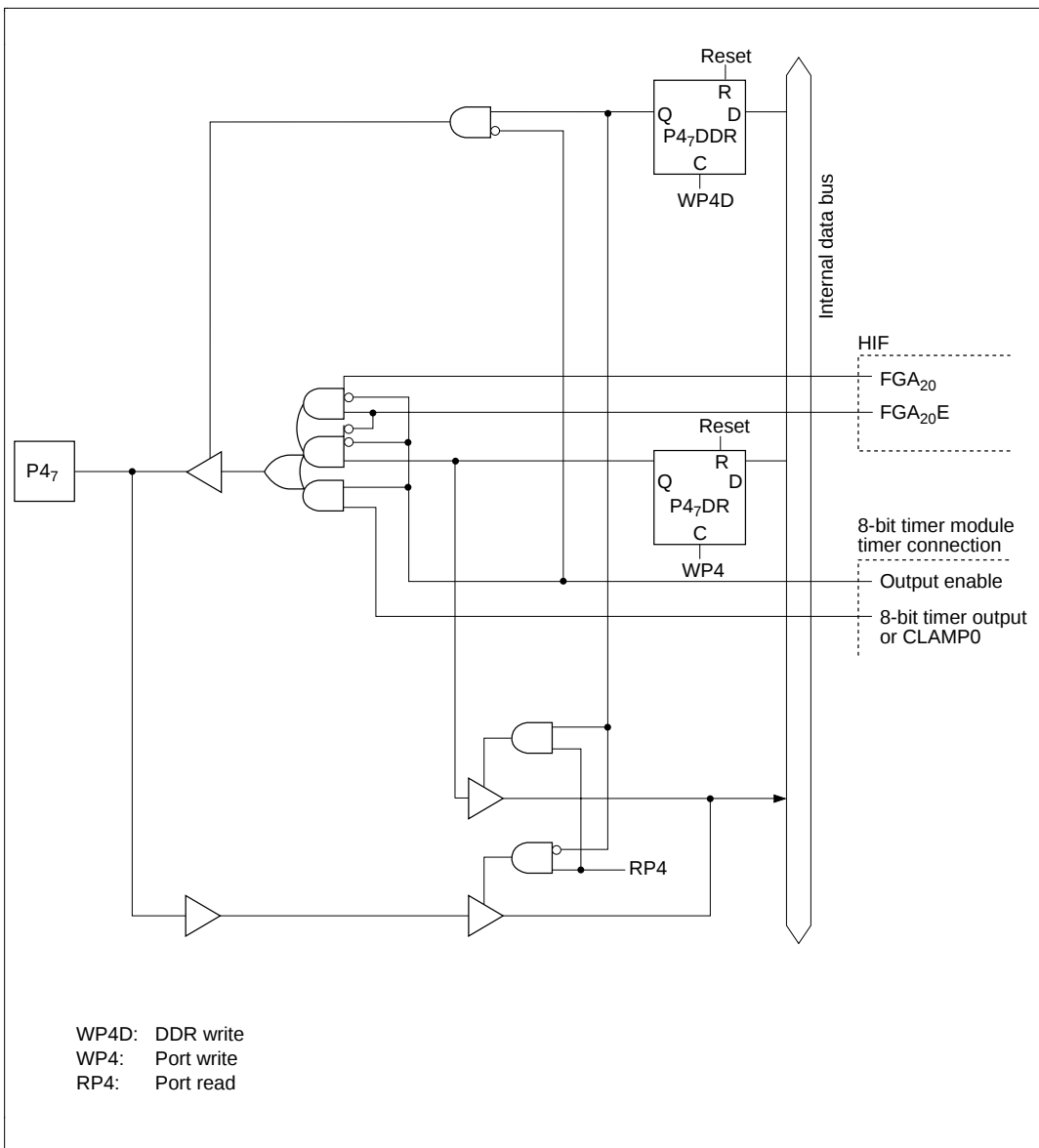
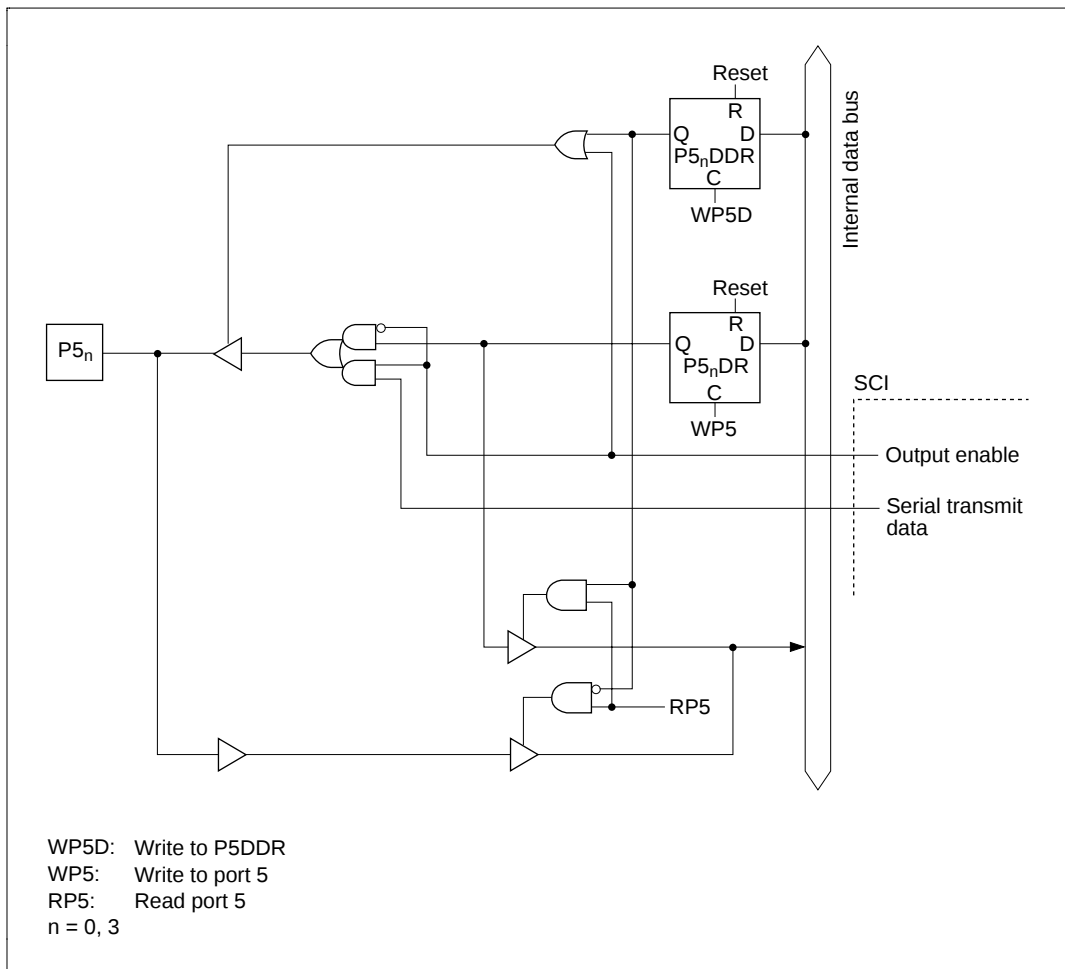
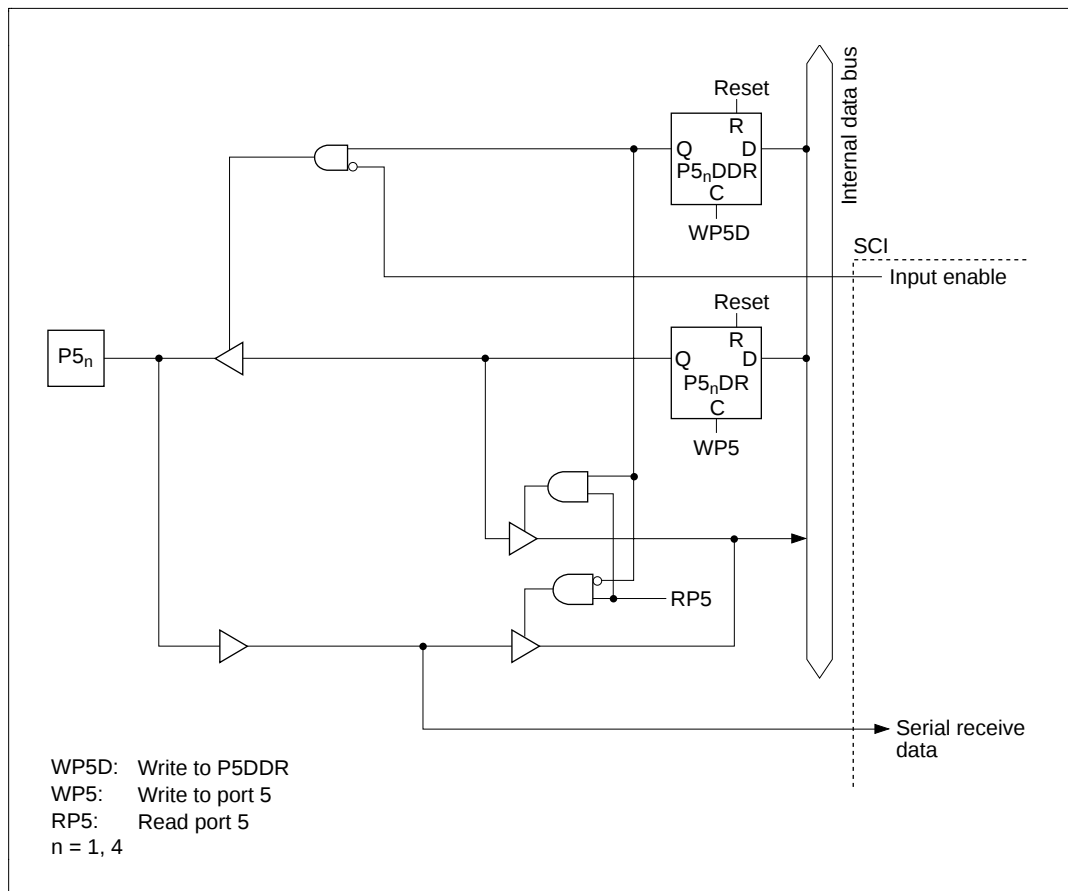


Figure C-4 (f) Port 4 Block Diagram (Pin P4<sub>7</sub>)

## C.5 Port 5 Block Diagrams



**Figure C-5 (a) Port 5 Block Diagram (Pins P5<sub>0</sub>, P5<sub>3</sub>)**



**Figure C-5 (b) Port 5 Block Diagram (Pins P5<sub>1</sub>, P5<sub>4</sub>)**



## C.6 Port 6 Block Diagrams

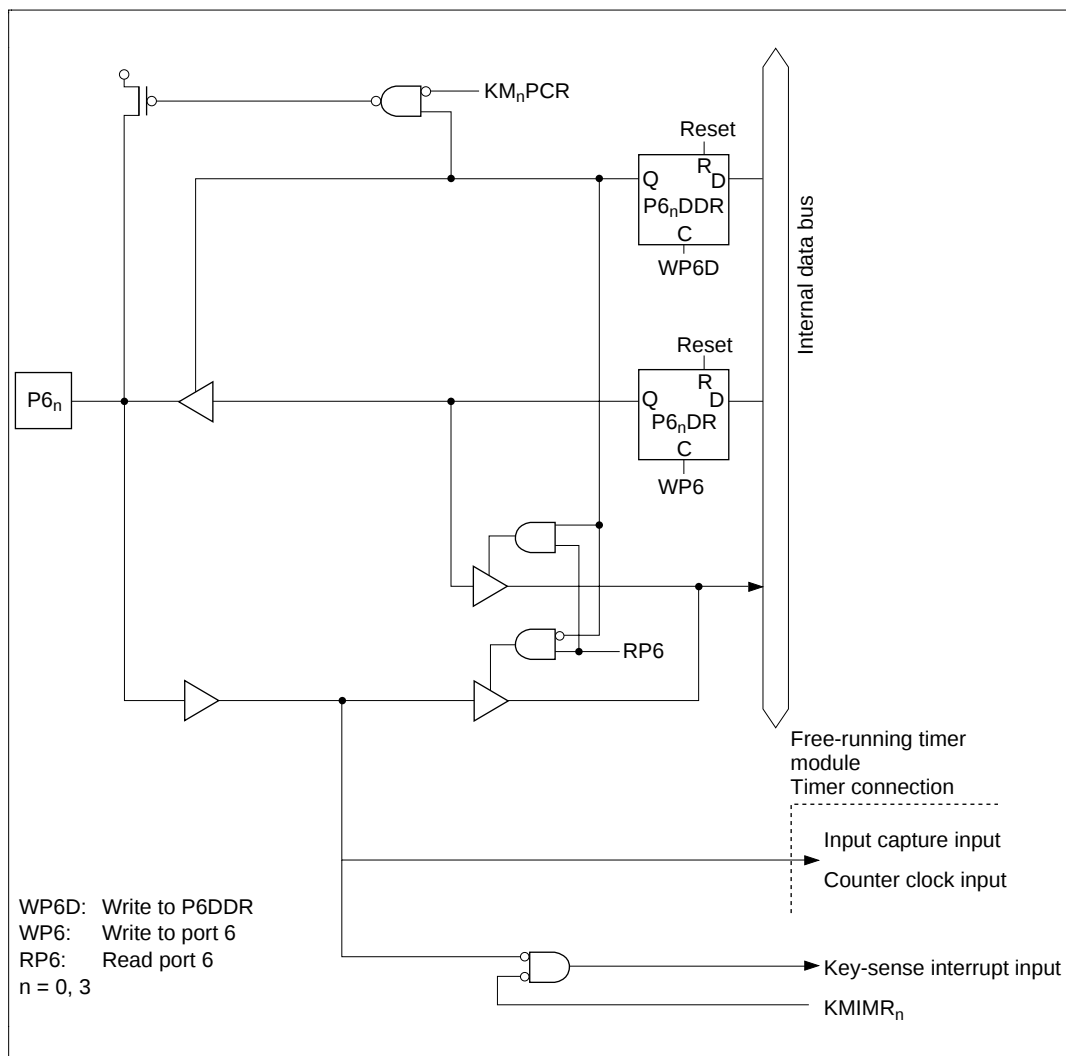
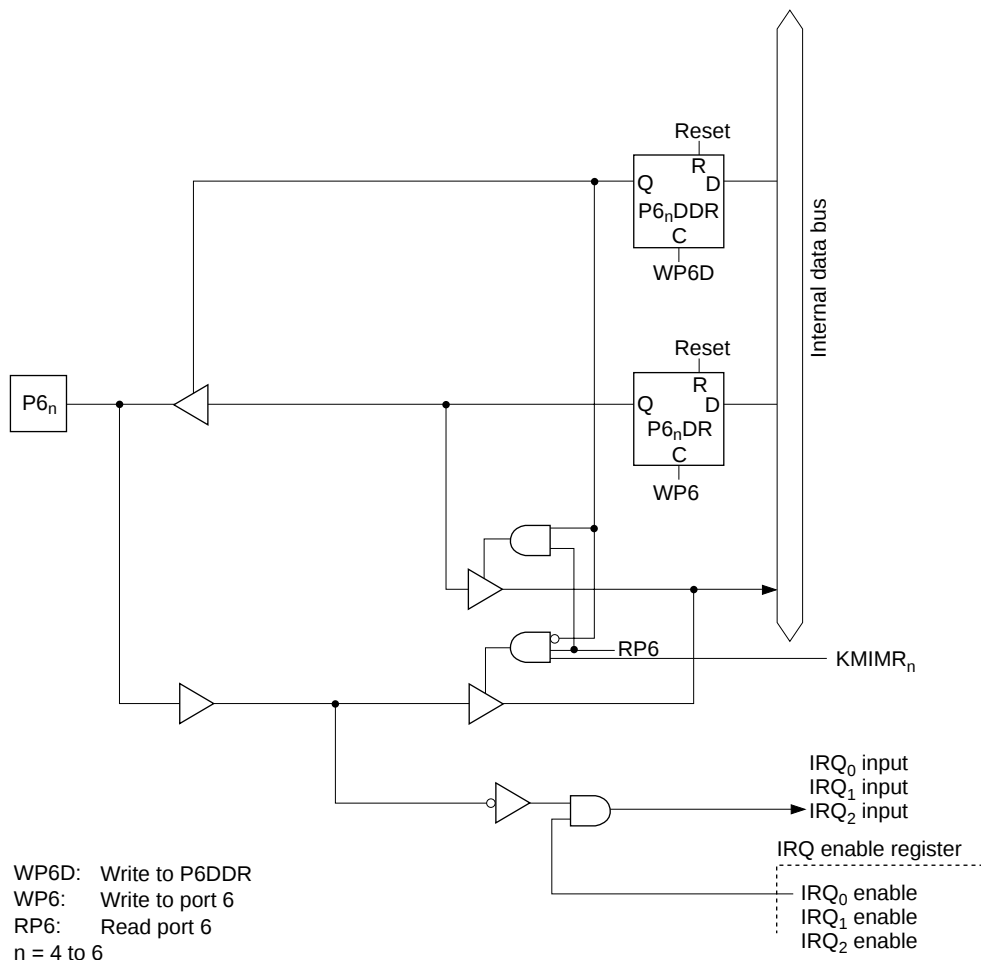


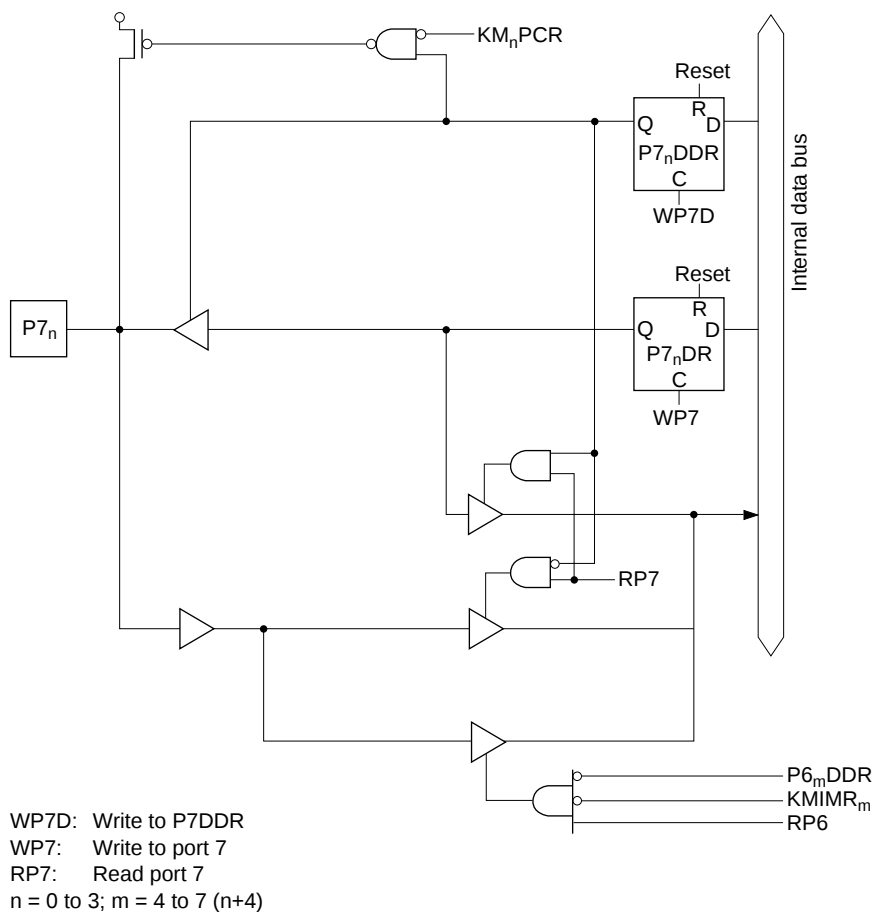
Figure C-6 (a) Port 6 Block Diagram (Pins P6<sub>0</sub>, P6<sub>3</sub>)





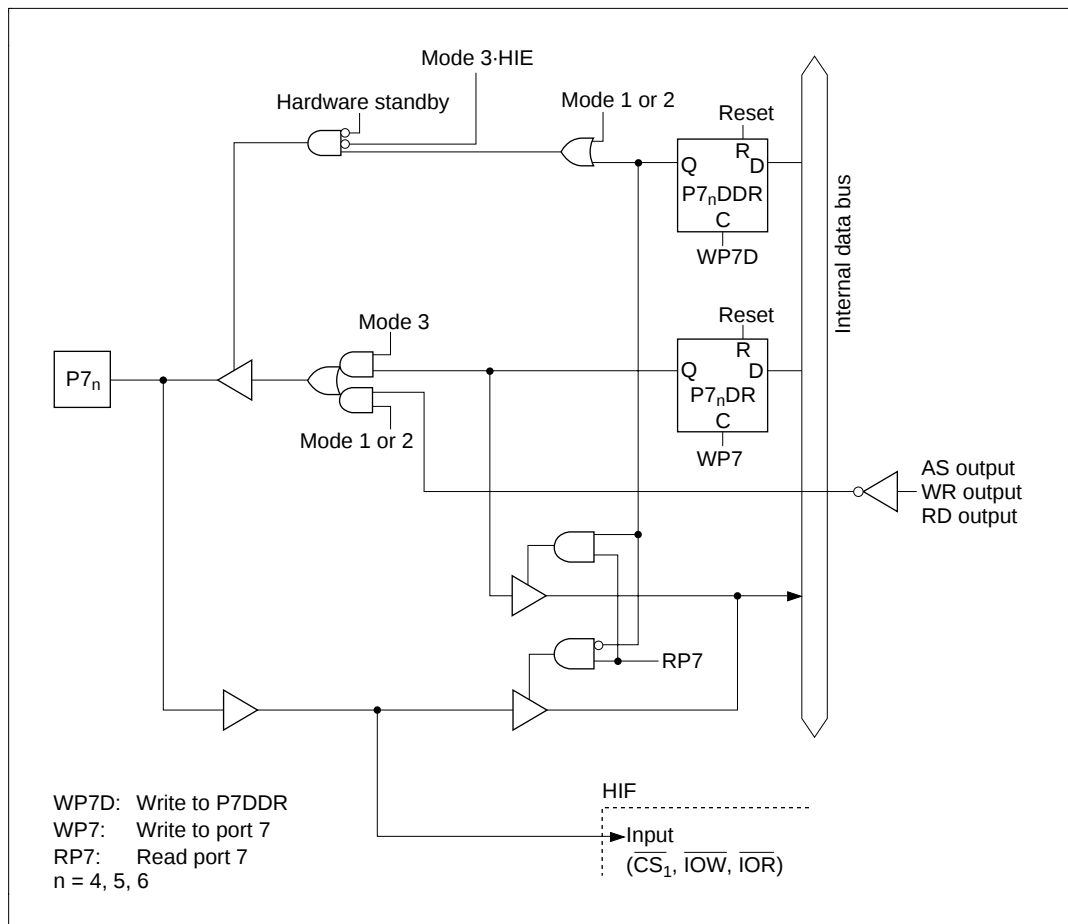
**Figure C-6 (c) Port 6 Block Diagram (Pins P6<sub>4</sub>, P6<sub>5</sub>, P6<sub>6</sub>)**

## C.7 Port 7 Block Diagrams

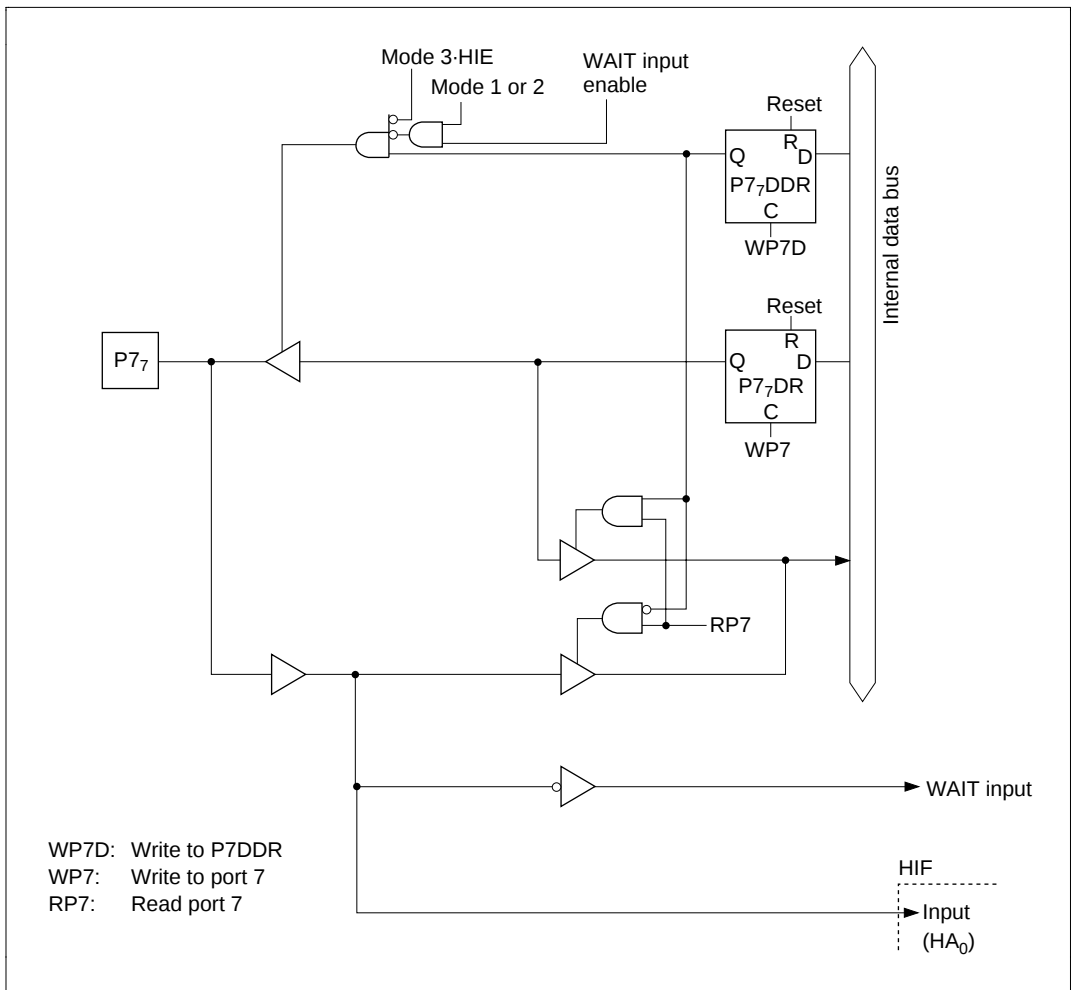


Note: See section 12, I<sup>2</sup>C Bus Interface, for the block diagram when SCL and SDA pin designations are made and the bus drive function is selected.

**Figure C-7 (a) Port 7 Block Diagram (Pins P7<sub>0</sub>, P7<sub>1</sub>, P7<sub>2</sub>, P7<sub>3</sub>)**



**Figure C-7 (b) Port 7 Block Diagram (Pins P7<sub>4</sub>, P7<sub>5</sub>, P7<sub>6</sub>)**



**Figure C-7 (c) Port 7 Block Diagram (Pin P7)**

# Appendix D Pin States

**Table D-1 Port States in Each Mode**

| Pin Name                           | MCU Mode | Reset        | Hardware Standby | Software Standby                                | Sleep Mode                                     | Normal Operation                                  |
|------------------------------------|----------|--------------|------------------|-------------------------------------------------|------------------------------------------------|---------------------------------------------------|
| P1 <sub>7</sub> to P1 <sub>0</sub> | 1        | Low          | 3-state          | Low                                             | Prev. state                                    | A <sub>7</sub> to A <sub>0</sub>                  |
| A <sub>7</sub> to A <sub>0</sub>   | 2        | 3-state      |                  | Low if<br>DDR = 1,<br>prev. state<br>if DDR = 0 | Addr. output pins:<br>last address accessed)   | Addr. output or input port                        |
|                                    | 3        |              |                  | Prev. state                                     |                                                | I/O port                                          |
| P2 <sub>7</sub> to P2 <sub>0</sub> | 1        | Low          | 3-state          | Low                                             | Prev. state                                    | A <sub>15</sub> to A <sub>8</sub>                 |
| A <sub>15</sub> to A <sub>8</sub>  | 2        | 3-state      |                  | Low if<br>DDR = 1,<br>prev. state<br>if DDR = 0 | Addr. output pins:<br>last address accessed)   | Addr. output or input port                        |
|                                    | 3        |              |                  | Prev. state                                     |                                                | I/O port                                          |
| P3 <sub>7</sub> to P3 <sub>0</sub> | 1        | 3-state      | 3-state          | 3-state                                         | 3-state                                        | D <sub>7</sub> to D <sub>0</sub>                  |
| D <sub>7</sub> to D <sub>0</sub>   | 2        |              |                  |                                                 |                                                |                                                   |
|                                    | 3        |              |                  | Prev. state                                     | Prev. state                                    | I/O port                                          |
| P4 <sub>5</sub> to P4 <sub>0</sub> | 1        | 3-state      | 3-state          | Prev. state (note 3)                            | Prev. state                                    | I/O port                                          |
|                                    | 2        |              |                  |                                                 |                                                |                                                   |
|                                    | 3        |              |                  |                                                 |                                                |                                                   |
| P4 <sub>6</sub> /ø                 | 1        | Clock output | 3-state          | High                                            | Clock output                                   | Clock output                                      |
|                                    | 2        |              |                  |                                                 |                                                |                                                   |
|                                    | 3        | 3-state      |                  | High if<br>DDR = 1,<br>3-state if<br>DDR = 0    | Clock output if DDR = 1,<br>3-state if DDR = 0 | Clock output if DDR = 1,<br>input port if DDR = 0 |
| P4 <sub>7</sub>                    | 1        | 3-state      | 3-state          | Prev. state (note 3)                            | Prev. state                                    | I/O port                                          |
|                                    | 2        |              |                  |                                                 |                                                |                                                   |
|                                    | 3        |              |                  |                                                 |                                                |                                                   |
| P5 <sub>5</sub> to P5 <sub>0</sub> | 1        | 3-state      | 3-state          | Prev. state (note 3)                            | Prev. state                                    | I/O port                                          |
|                                    | 2        |              |                  |                                                 |                                                |                                                   |
|                                    | 3        |              |                  |                                                 |                                                |                                                   |

**Table D-1 Port States in Each Mode**

| Pin Name                                         | MCU Mode | Reset   | Hardware Standby | Software Standby        | Sleep Mode          | Normal Operation  |
|--------------------------------------------------|----------|---------|------------------|-------------------------|---------------------|-------------------|
| P6 <sub>6</sub> to P6 <sub>0</sub>               | 1        | 3-state | 3-state          | Prev. state<br>(note 3) | Prev. state         | I/O port          |
|                                                  | 2        |         |                  |                         |                     |                   |
|                                                  | 3        |         |                  |                         |                     |                   |
| P7 <sub>7</sub> /WAIT                            | 1        | 3-state | 3-state          | 3-state/prev. state     | 3-state/prev. state | WAIT/<br>I/O port |
|                                                  | 2        |         |                  |                         |                     |                   |
|                                                  | 3        |         |                  | Prev. state             | Prev. state         | I/O port          |
| P7 <sub>6</sub> to P7 <sub>4</sub><br>AS, WR, RD | 1        | High    | 3-state          | High                    | High                | AS, WR, RD        |
|                                                  | 2        |         |                  |                         |                     |                   |
|                                                  | 3        |         |                  | Prev. state             | Prev. state         | I/O port          |
| P7 <sub>3</sub> to P7 <sub>0</sub>               | 1        | 3-state | 3-state          | Prev. state<br>(note 3) | Prev. state         | I/O port          |
|                                                  | 2        |         |                  |                         |                     |                   |
|                                                  | 3        |         |                  |                         |                     |                   |

Notes: 1. 3-state: High-impedance state

2. Prev. State: Previous state. Input ports are in the high-impedance state (with the MOS pull-up on if DDR = 0 and DR = 1). Output ports hold their previous output level.

3. On-chip supporting modules are initialized, so these pins revert to I/O ports according to the DDR and DR bits.

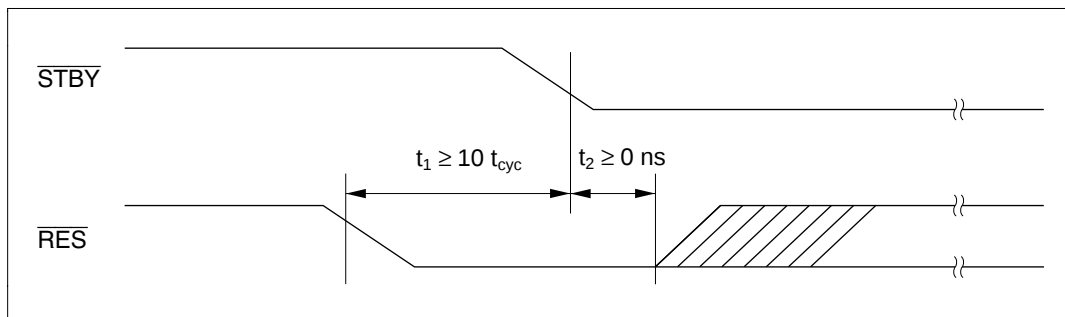
4. I/O port: Direction depends on the data direction (DDR) bit. Note that these pins may also be used by the on-chip supporting modules.

See section 7, I/O Ports, for further information.

# Appendix E Timing of Transition to and Recovery from Hardware Standby Mode

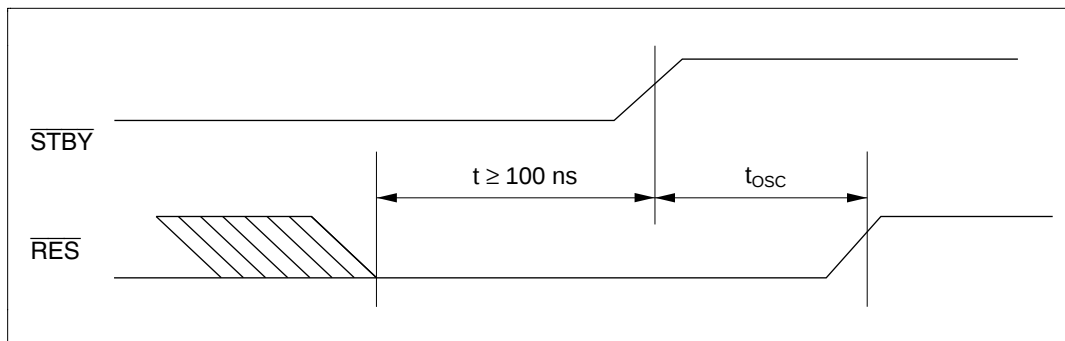
## Timing of Transition to Hardware Standby Mode

- (1) To retain RAM contents when the RAME bit in SYSCR is set to 1, drive the  $\overline{\text{RES}}$  signal low 10 system clock cycles before the  $\overline{\text{STBY}}$  signal goes low, as shown below.  $\overline{\text{RES}}$  must remain low until  $\overline{\text{STBY}}$  goes low (minimum delay from  $\overline{\text{STBY}}$  low to  $\overline{\text{RES}}$  high: 0 ns).



- (2) When the RAME bit in SYSCR is cleared to 0 or when it is not necessary to retain RAM contents,  $\overline{\text{RES}}$  does not have to be driven low as in (1).

**Timing of Recovery From Hardware Standby Mode:** Drive the  $\overline{\text{RES}}$  signal low approximately 100 ns before  $\overline{\text{STBY}}$  goes high.



# Appendix F Option List

## F.1 HD6433217, HD6433216, HD6433214, HD6433212 Option List

Please check off the appropriate applications and enter the necessary information.

### 1 ROM Size

|                                              |
|----------------------------------------------|
| <input type="checkbox"/> HD6433212: 16-kbyte |
| <input type="checkbox"/> HD6433214: 32-kbyte |
| <input type="checkbox"/> HD6433216: 48-kbyte |
| <input type="checkbox"/> HD6433217: 60-kbyte |

|                               |  |
|-------------------------------|--|
| Date of order                 |  |
| Customer                      |  |
| Department                    |  |
| Name                          |  |
| ROM code name                 |  |
| LSI number<br>(Hitachi entry) |  |

### 2 System Oscillator

|                                             |     |     |
|---------------------------------------------|-----|-----|
| <input type="checkbox"/> Ceramic oscillator | f = | MHz |
| <input type="checkbox"/> External clock     | f = | MHz |

### 3 Power Supply Voltage/Maximum Operating Frequency

|                                                                                   |
|-----------------------------------------------------------------------------------|
| <input type="checkbox"/> $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ (16 MHz max.) |
| <input type="checkbox"/> $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ (12 MHz max.) |
| <input type="checkbox"/> $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ (10 MHz max.) |

- Notes: 1. Please select the power supply voltage/operating frequency version according to the power supply voltage used.  
Example: For use at  $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$  /  $f = 10 \text{ MHz}$ ,  
select  $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$  (16 MHz max.).
2. The power supply voltage and maximum operating frequency of the selected version should also be entered on the Single-Chip Microcomputer Ordering Specifications Sheet.

Continued on the following page.

|                               |  |
|-------------------------------|--|
| ROM code name                 |  |
| LSI number<br>(Hitachi entry) |  |

#### 4 I<sup>2</sup>C Bus Option

|                                                        |
|--------------------------------------------------------|
| <input type="checkbox"/> I <sup>2</sup> C bus used     |
| <input type="checkbox"/> I <sup>2</sup> C bus not used |

- Notes:
1. The "I<sup>2</sup>C bus used" option includes all cases where data transfer is performed via the SCL and SDA pins using the on-chip I<sup>2</sup>C bus interface function (hardware module). If the I<sup>2</sup>C bus interface function (hardware module) is used, various bus interfaces with different bus specifications and names are also included in "I<sup>2</sup>C bus used". The case in which only one of two channels is used is also included in "I<sup>2</sup>C bus used".
  2. When "I<sup>2</sup>C bus not used" is selected, values cannot be set in registers relating to the I<sup>2</sup>C bus interface (ICCR, ICSR, ICDR, ICMR). These register always read H'FF. With emulators, and ZTAT and F-ZTAT versions, the "I<sup>2</sup>C bus used" option is selected. If the "I<sup>2</sup>C bus not used" option is selected, it is essential to ensure that I<sup>2</sup>C bus interface related registers are not accessed.

For the Microcomputer Family item in 1. Basic Specifications in the Single-Chip Microcomputer Ordering Specifications Sheet, please specify the appropriate item from the table below according to the combination of items 1 and 4 above. If the "I<sup>2</sup>C bus used" option is selected, please also specify this in Special Specifications (Product Specifications, Mark Specifications, etc.) in 1. Basic Specifications.

| ROM Size \ I <sup>2</sup> C | I <sup>2</sup> C bus used | I <sup>2</sup> C bus not used |
|-----------------------------|---------------------------|-------------------------------|
| 16-kbyte                    | HD6433212W                | HD6433212                     |
| 32-kbyte                    | HD6433214W                | HD6433214                     |
| 48-kbyte                    | HD6433216W                | HD6433216                     |
| 60-kbyte                    | HD6433217W                | HD6433217                     |

## F.2 HD6433202 Option List

Please check off the appropriate applications and enter the necessary information.

### 1 System Oscillator

|                                             |                    |
|---------------------------------------------|--------------------|
| <input type="checkbox"/> Ceramic oscillator | f =            MHz |
| <input type="checkbox"/> External clock     | f =            MHz |

|                               |  |
|-------------------------------|--|
| Date of order                 |  |
| Customer                      |  |
| Department                    |  |
| Name                          |  |
| ROM code name                 |  |
| LSI number<br>(Hitachi entry) |  |

### 2 Power Supply Voltage/Maximum Operating Frequency

|                                                                                   |
|-----------------------------------------------------------------------------------|
| <input type="checkbox"/> $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ (16 MHz max.) |
| <input type="checkbox"/> $V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ (12 MHz max.) |
| <input type="checkbox"/> $V_{CC} = 2.7 \text{ V to } 5.5 \text{ V}$ (10 MHz max.) |

Notes: 1. Please select the power supply voltage/operating frequency version according to the power supply voltage used.

Example: For use at  $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$  /  $f = 10 \text{ MHz}$ ,  
select  $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$  (16 MHz max.).

2. The power supply voltage and maximum operating frequency of the selected version should also be entered on the Single-Chip Microcomputer Ordering Specifications Sheet.

Continued on the following page.

|                               |  |
|-------------------------------|--|
| ROM code name                 |  |
| LSI number<br>(Hitachi entry) |  |

### 3 I<sup>2</sup>C Bus Option

|                                                        |
|--------------------------------------------------------|
| <input type="checkbox"/> I <sup>2</sup> C bus used     |
| <input type="checkbox"/> I <sup>2</sup> C bus not used |

- Notes:
1. The "I<sup>2</sup>C bus used" option includes all cases where data transfer is performed via the SCL and SDA pins using the on-chip I<sup>2</sup>C bus interface function (hardware module). If the I<sup>2</sup>C bus interface function (hardware module) is used, various bus interfaces with different bus specifications and names are also included in "I<sup>2</sup>C bus used".
  2. When "I<sup>2</sup>C bus not used" is selected, values cannot be set in registers relating to the I<sup>2</sup>C bus interface (ICCR, ICSR, ICDR, ICMR). These register always read H'FF. With emulators, and ZTAT and F-ZTAT versions, the "I<sup>2</sup>C bus used" option is selected. If the "I<sup>2</sup>C bus not used" option is selected, it is essential to ensure that I<sup>2</sup>C bus interface related registers are not accessed.

For the Microcomputer Family item in 1. Basic Specifications in the Single-Chip Microcomputer Ordering Specifications Sheet, please specify the appropriate item from the table below according to the combination of items 1 and 4 above. If the "I<sup>2</sup>C bus used" option is selected, please also specify this in Special Specifications (Product Specifications, Mark Specifications, etc.) in 1. Basic Specifications.

| ROM Size \ I <sup>2</sup> C | I <sup>2</sup> C bus used | I <sup>2</sup> C bus not used |
|-----------------------------|---------------------------|-------------------------------|
| 16-kbyte                    | HD6433202W                | HD6433202                     |

# Appendix G Product Code Lineup

**Table G-1 H8/3217 Series Product Code Lineup**

| Product Type |                         |                                              | Product Code | Mark Code         | Order Code Name  | Package<br>(Hitachi<br>Package<br>Code)      |
|--------------|-------------------------|----------------------------------------------|--------------|-------------------|------------------|----------------------------------------------|
| H8/3217      | PROM<br>version         | ZTAT<br>version                              | HD6473217C16 | HD6473217C16      | HD6473217C16     | 64-pin<br>windowed<br>shrink DIP<br>(DP-64S) |
|              |                         |                                              | HD6473217P16 | HD6473217P16      | HD6473217P16     | 64-pin<br>shrink DIP<br>(DP-64S)             |
|              |                         |                                              | HD6473217F16 | HD6473217F16      | HD6473217F16     | 64-pin QFP<br>(FP-64A)                       |
|              |                         |                                              | HD643217TF16 | HD643217TF16      | HD643217TF16     | 80-pin TQFP<br>(TFP-80C)                     |
|              | Mask<br>ROM<br>version* | With<br>I <sup>2</sup> C bus<br>interface    | HD6433217WP  | HD6433217W(***)P  | HD6433217W(***)P | 64-pin<br>shrink DIP<br>(DP-64S)             |
|              |                         |                                              | HD6433813WF  | HD6433217W(***)F  | HD6433217W(***)F | 64-pin QFP<br>(FP-64A)                       |
|              |                         |                                              | HD6433813WTF | HD6433217W(***)TF | HD6433217W(***)X | 80-pin TQFP<br>(TFP-80C)                     |
|              | Mask<br>ROM<br>version* | Without<br>I <sup>2</sup> C bus<br>interface | HD3433217P   | HD6433217(***)P   | HD6433217(***)P  | 64-pin<br>shrink DIP<br>(DP-64S)             |
|              |                         |                                              | HD3433217F   | HD6433217(***)F   | HD6433217(***)F  | 64-pin QFP<br>(FP-64A)                       |
|              |                         |                                              | HD3433217TF  | HD6433217(***)TF  | HD6433217(***)X  | 80-pin TQFP<br>(TFP-80C)                     |
| H8/3216      | Mask<br>ROM<br>version* | With<br>I <sup>2</sup> C bus<br>interface    | HD6433216WP  | HD6433216W(***)P  | HD6433216W(***)P | 64-pin<br>shrink DIP<br>(DP-64S)             |
|              |                         |                                              | HD6433216WF  | HD6433216W(***)F  | HD6433216W(***)F | 64-pin QFP<br>(FP-64A)                       |
|              |                         |                                              | HD6433216WTF | HD6433216W(***)TF | HD6433216W(***)X | 80-pin TQFP<br>(TFP-80C)                     |
|              | Mask<br>ROM<br>version* | Without<br>I <sup>2</sup> C bus<br>interface | HD3433216P   | HD6433216(***)P   | HD6433216(***)P  | 64-pin<br>shrink DIP<br>(DP-64S)             |
|              |                         |                                              | HD3433216F   | HD6433216(***)F   | HD6433216(***)F  | 64-pin QFP<br>(FP-64A)                       |
|              |                         |                                              | HD3433216TF  | HD6433216(***)TF  | HD6433216(***)X  | 80-pin TQFP<br>(TFP-80C)                     |

**Table G-1 H8/3217 Series Product Code Lineup (cont)**

| Product Type |                         |                                              | Product Code | Mark Code         | Order Code Name  | Package<br>(Hitachi<br>Package<br>Code) |
|--------------|-------------------------|----------------------------------------------|--------------|-------------------|------------------|-----------------------------------------|
| H8/3214      | PROM<br>version         | ZTAT<br>version                              | HD6473214P16 | HD6473214P16      | HD6473214P16     | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD6473214F16 | HD6473214F16      | HD6473214F16     | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD6473214F16 | HD6473214F16      | HD6473214F16     | 80-pin TQFP<br>(TFP-80C)                |
|              | Mask<br>ROM<br>version* | With<br>I <sup>2</sup> C bus<br>interface    | HD6433214WP  | HD6433214W(***)P  | HD6433214W(***)P | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD6433214WF  | HD6433214W(***)F  | HD6433214W(***)F | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD6433214WTF | HD6433214W(***)TF | HD6433214W(***)X | 80-pin TQFP<br>(TFP-80C)                |
|              | Mask<br>ROM<br>version* | Without<br>I <sup>2</sup> C bus<br>interface | HD3433214P   | HD6433214(***)P   | HD6433214(***)P  | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD3433214F   | HD6433214(***)F   | HD6433214(***)F  | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD3433214TF  | HD6433214(***)TF  | HD6433214(***)X  | 80-pin TQFP<br>(TFP-80C)                |
| H8/3212      | Mask<br>ROM<br>version* | With<br>I <sup>2</sup> C bus<br>interface    | HD6433212WP  | HD6433212W(***)P  | HD6433212W(***)P | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD6433212WF  | HD6433212W(***)F  | HD6433212W(***)F | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD6433212WTF | HD6433212W(***)TF | HD6433212W(***)X | 80-pin TQFP<br>(TFP-80C)                |
|              | Mask<br>ROM<br>version* | Without<br>I <sup>2</sup> C bus<br>interface | HD3433212P   | HD6433212(***)P   | HD6433212(***)P  | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD3433212F   | HD6433212(***)F   | HD6433212(***)F  | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD3433212TF  | HD6433212(***)TF  | HD6433212(***)X  | 80-pin TQFP<br>(TFP-80C)                |

**Table G-1 H8/3217 Series Product Code Lineup (cont)**

| Product Type |                         |                                              | Product Code | Mark Code         | Order Code Name  | Package<br>(Hitachi<br>Package<br>Code) |
|--------------|-------------------------|----------------------------------------------|--------------|-------------------|------------------|-----------------------------------------|
| H8/3202      | Mask<br>ROM<br>version* | With<br>I <sup>2</sup> C bus<br>interface    | HD6433202WP  | HD6433202W(***)P  | HD6433202W(***)P | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD6433202WF  | HD6433202W(***)F  | HD6433202W(***)F | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD6433202WTF | HD6433202W(***)TF | HD6433202W(***)X | 80-pin TQFP<br>(TFP-80C)                |
|              | Mask<br>ROM<br>version* | Without<br>I <sup>2</sup> C bus<br>interface | HD3433202P   | HD6433202(***)P   | HD6433202(***)P  | 64-pin<br>shrink DIP<br>(DP-64S)        |
|              |                         |                                              | HD3433202F   | HD6433202(***)F   | HD6433202(***)F  | 64-pin QFP<br>(FP-64A)                  |
|              |                         |                                              | HD3433202TF  | HD6433202(***)TF  | HD6433202(***)X  | 80-pin TQFP<br>(TFP-80C)                |

Notes: 1. \* Under development  
 2. (\*\*\*) in mask versions is the ROM code.

The I<sup>2</sup>C bus interface is available as an option. Observe the following notes when using this option.

1. Please inform your Hitachi sales representative if you intend to use this option.
2. For mask ROM versions, a W is added to the part number for products in which this optional function is used.

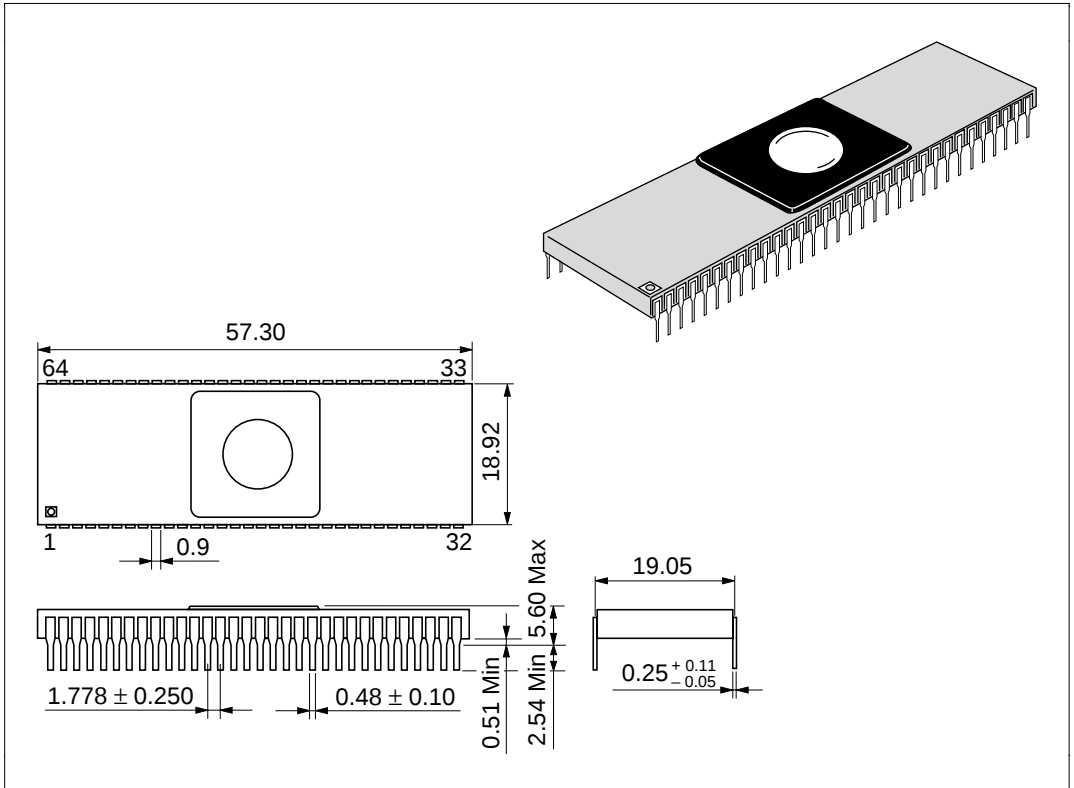
Examples: HD6433217WF16, HD6433212WP

3. The product code is identical for ZTAT versions. However, be sure to inform your Hitachi sales representative if you will be using this option.

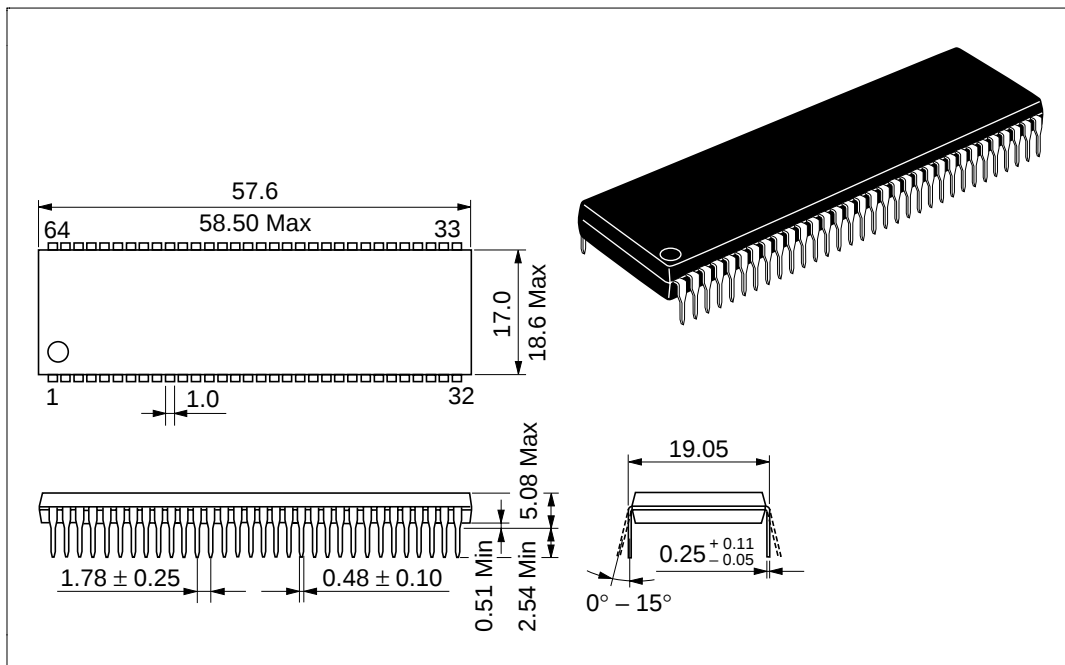
## Appendix H Package Dimensions

Figure H-1 shows the dimensions of the DC-64S package. Figure H-2 shows the dimensions of the DP-64S package. Figure H-3 shows the dimensions of the FP-64A package. Figure H-4 shows the dimensions of the TFP-80C package.

Unit: mm



**Figure H-1 Package Dimensions (DC-64S)**

**Figure H-2 Package Dimensions (DP-64S)**



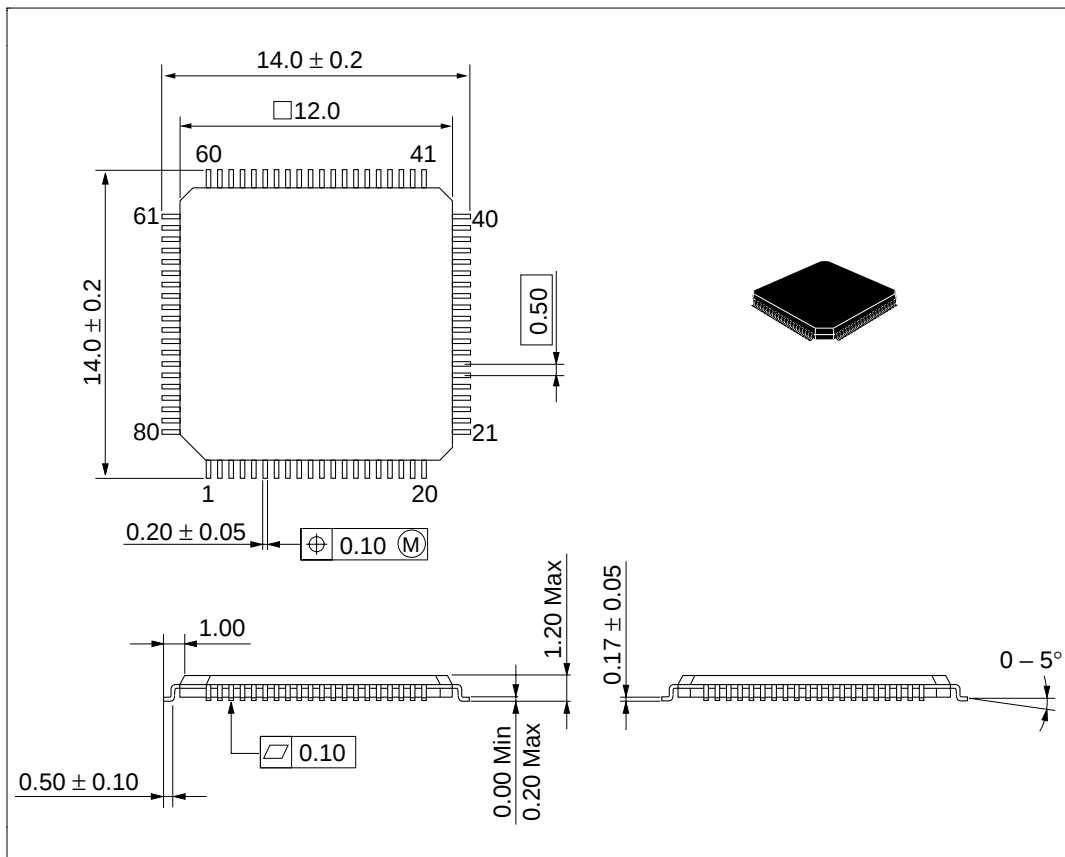


Figure H-4 Package Dimensions (TFP-80C)