7548 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

REJ03B0210-0200
Rev.2.00
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DESCRIPTION

The 7548 Group is the 8-bit microcomputer based on the 740 family core technology.
The 7548 Group has an 8-bit timer, 16-bit timer, serial interface, A/D converter, power-on reset circuit and the low voltage detection circuit. Also, the Function set ROM is equipped.

FEATURES

- Basic machine-language instructions 71
- The minimum instruction execution time ..... 0.25 µs
  (at 8 MHz oscillation frequency, double-speed mode)
- Memory size
  - ROM ..... 2 K, 4K, 6 K bytes
  - RAM ..... 192/256 bytes
- Programmable I/O ports
  - I/O port 15
  - Output port 1
- Key-on wakeup 6
- LED direct drive port 8
- Interrupts ..... 13 sources, 13 vectors
- Timers ..... 8-bit × 2
  ..... 16-bit × 1
- Output compare ..... 3 channel
- Input capture ..... 1 channel
- Serial interface ..... 8-bit × 1
  (UART or clock synchronous)
- A/D converter ..... 10-bit resolution × 6-channel
- Clock generating circuit ..... Built-in type
  (connect to external ceramic resonator or quartz-crystal oscillator, 32 kHz quartz-crystal oscillation available)
- High-speed on-chip oscillator ..... Typ. : 4 MHz
- Low-speed on-chip oscillator ..... Typ. : 250 kHz
- Watchdog timer ..... 16-bit × 1
- Power-on reset circuit ..... Built-in type
- Low voltage detection circuit ..... Built-in type
- Power source voltage
  XIN oscillation frequency
  (at ceramic resonator, in double-speed mode)
  - At 8 MHz ..... 4.5 to 5.5 V
  - At 2 MHz ..... 2.4 to 5.5 V
  - At 1 MHz ..... 2.2 to 5.5 V

  XIN oscillation frequency
  (at ceramic resonator, in high-speed mode)
  - At 8 MHz ..... 4.0 to 5.5 V
  - At 4 MHz ..... 2.4 to 5.5 V
  - At 1 MHz ..... 1.8 to 5.5 V

  High-speed on-chip oscillator oscillation frequency
  - At 4 MHz ..... 4.0 to 5.5 V

  Low-speed on-chip oscillator oscillation frequency
  - At 250 kHz (typ. value at VCC = 5 V) ... 1.8 to 5.5 V
- Power dissipation ..... 30 mW
- Operating temperature range ..... -20 to 85°C

APPLICATION

Office automation equipment, factory automation equipment, home electric appliances, consumer electronics, etc.

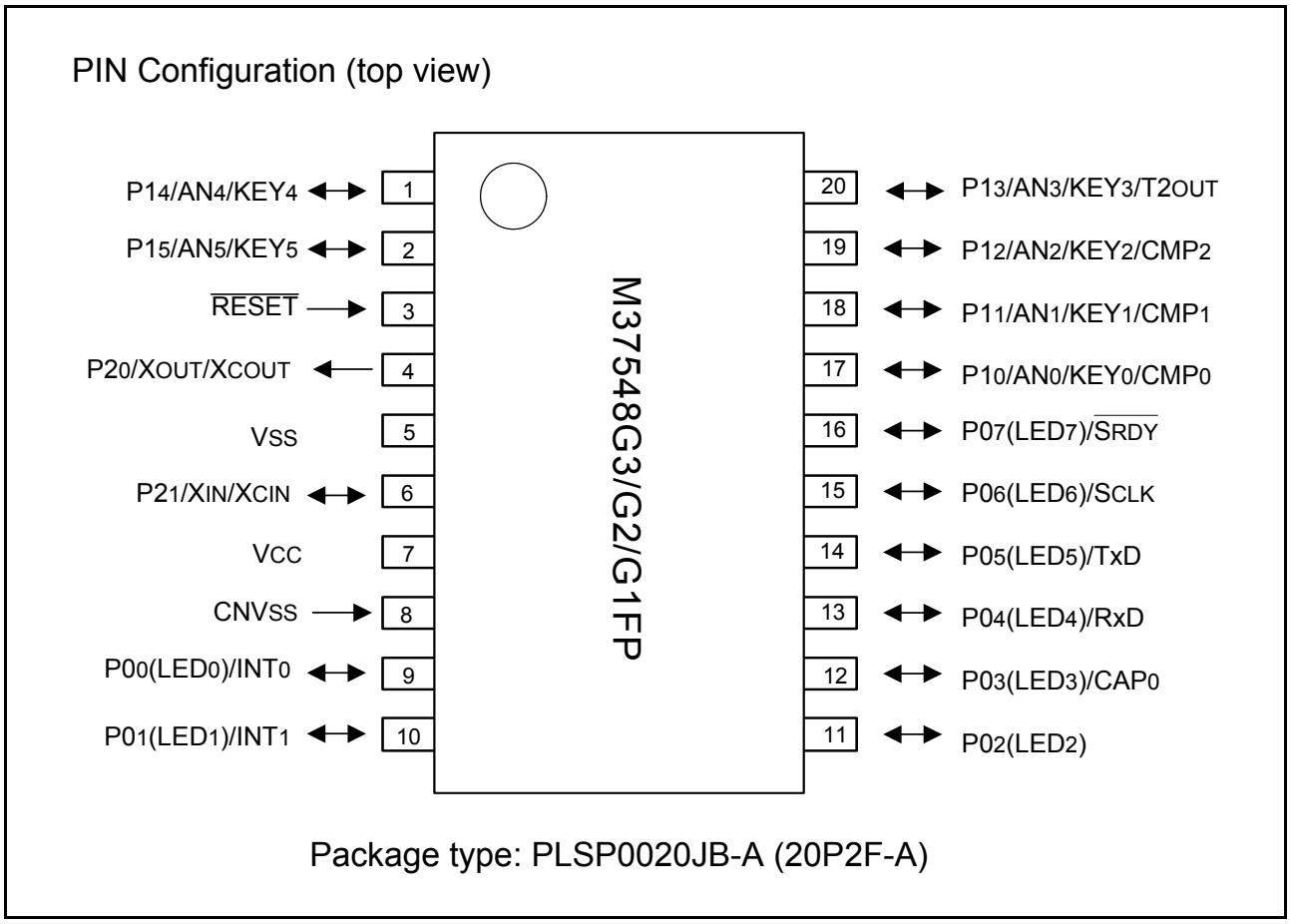


Fig 1. Pin configuration (PLSP0020JB-A type)

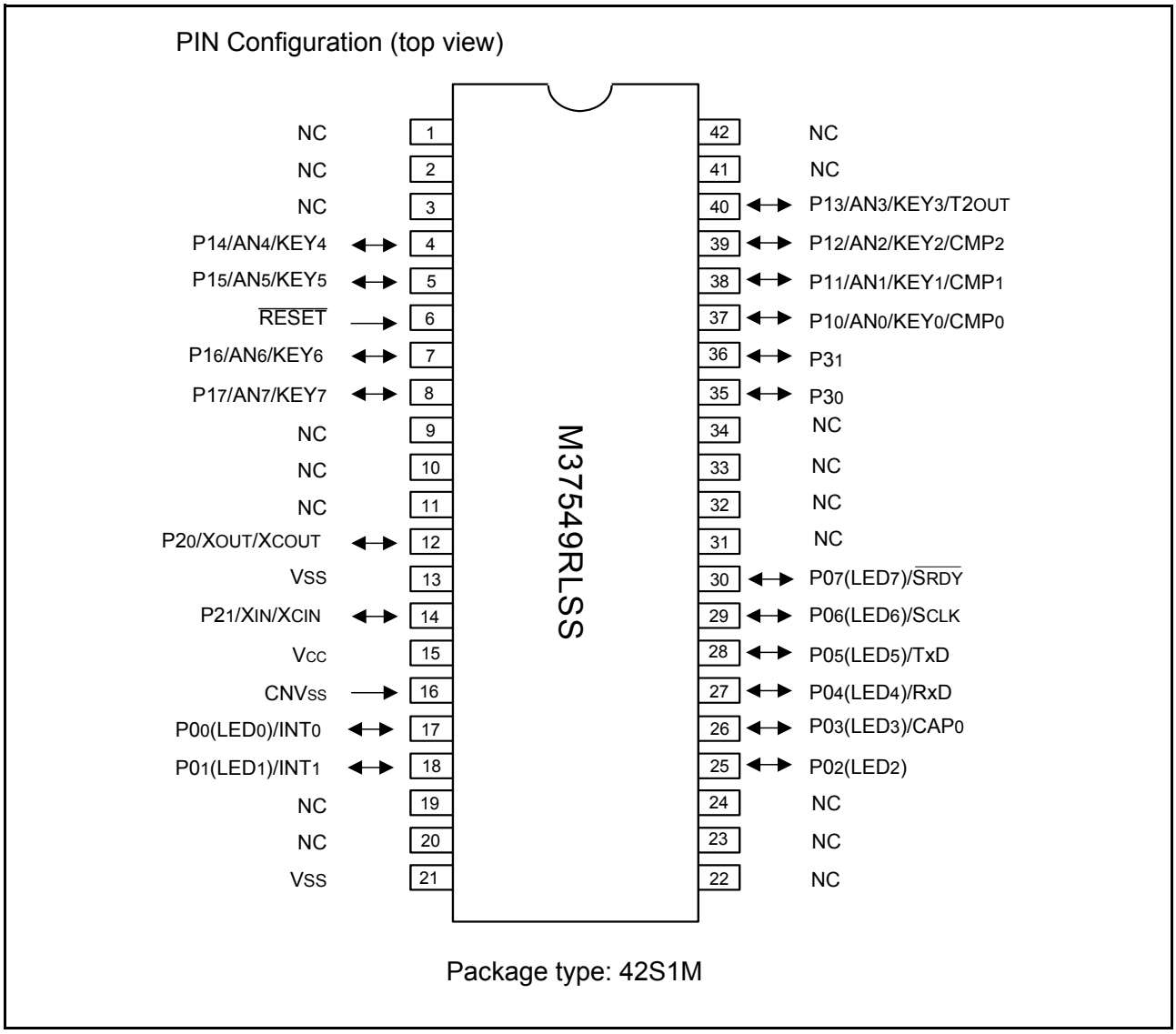


Fig 2. Pin configuration (42S1M type)

PERFORMANCE OVERVIEW

Table 1 Performance overview

Parameter			Function
Number of basic instructions			71
Instruction execution time			0.25 μs (Minimum instruction, oscillation frequency 8 MHz, double-speed mode)
Oscillation frequency			8 MHz (Maximum)
Memory sizes	ROM	M37548G1	2K bytes × 8 bits
		M37548G2	4K bytes × 8 bits
		M37548G3	6K bytes × 8 bits
	RAM	M37548G1	192 bytes × 8 bits
		M37548G2	256 bytes × 8 bits
		M37548G3	256 bytes × 8 bits
I/O port	$P0_0$-$P0_7$	I/O	1-bit × 8, LED direct drive ports
	$P1_0$-$P1_5$	I/O	1-bit × 6
	$P2_0$	Output	1-bit × 1
	$P2_1$	I/O	1-bit × 1
Interrupt	Source		13 sources, 13 vectors
Timer			8-bit × 2, 16-bit × 1
Output compare			3-channel
Input capture			1 channel
Serial interface			8-bit × 1 (UART or clock synchronous)
A/D converter			10-bit resolution × 6 channel
Watchdog timer			16-bit × 1
Power-on reset circuit			Built-in
Low voltage detection circuit			Built-in
Clock generating circuit			Built-in (external ceramic resonator or quartz-crystal oscillator, external 32-kHz quartz-crystal oscillator available) (built-in high/low-speed on-chip oscillator)
Function set ROM area	Function set ROM		Function set ROM is assigned to address $FFD8_{16}$ to $FFDA_{16}$. Valid/invaid of low voltage detection circuit can be selected. Oscillation mode can be selected. Enable/disable of watchdog timer and STP instruction can be selected.
	ROM code protect		ROM code protect is assigned to address $FFDB_{16}$. Read/write the built-in QzROM by serial programmer is disabled by setting “00” to ROM code protect.
Power source voltage (at ceramic resonator)	Double-speed mode	at 8 MHz oscillation	4.5 to 5.5 V
		at 2 MHz oscillation	2.4 to 5.5 V
		at 1 MHz oscillation	2.2 to 5.5 V
	High-speed mode	at 8 MHz oscillation	4.0 to 5.5 V
		at 4 MHz oscillation	2.4 to 5.5 V
		at 1 MHz oscillation	1.8 to 5.5 V
Power source voltage (at high-speed on-chip oscillator)	Double-speed mode	at 4 MHz oscillation	4.0 to 5.5 V
Power source voltage (at low-speed on-chip oscillator)	Double-speed mode	at 250 kHz oscillation	1.8 to 5.5 V
Power dissipation			TBD
Operating temperature range			-20 to 85 °C
Device structure			CMOS sillicon gate
Package			20-pin plastic molded SSOP (PLSP0020JB-A)
			42-pin shrink ceramic PIGGY BACK (42S1M)

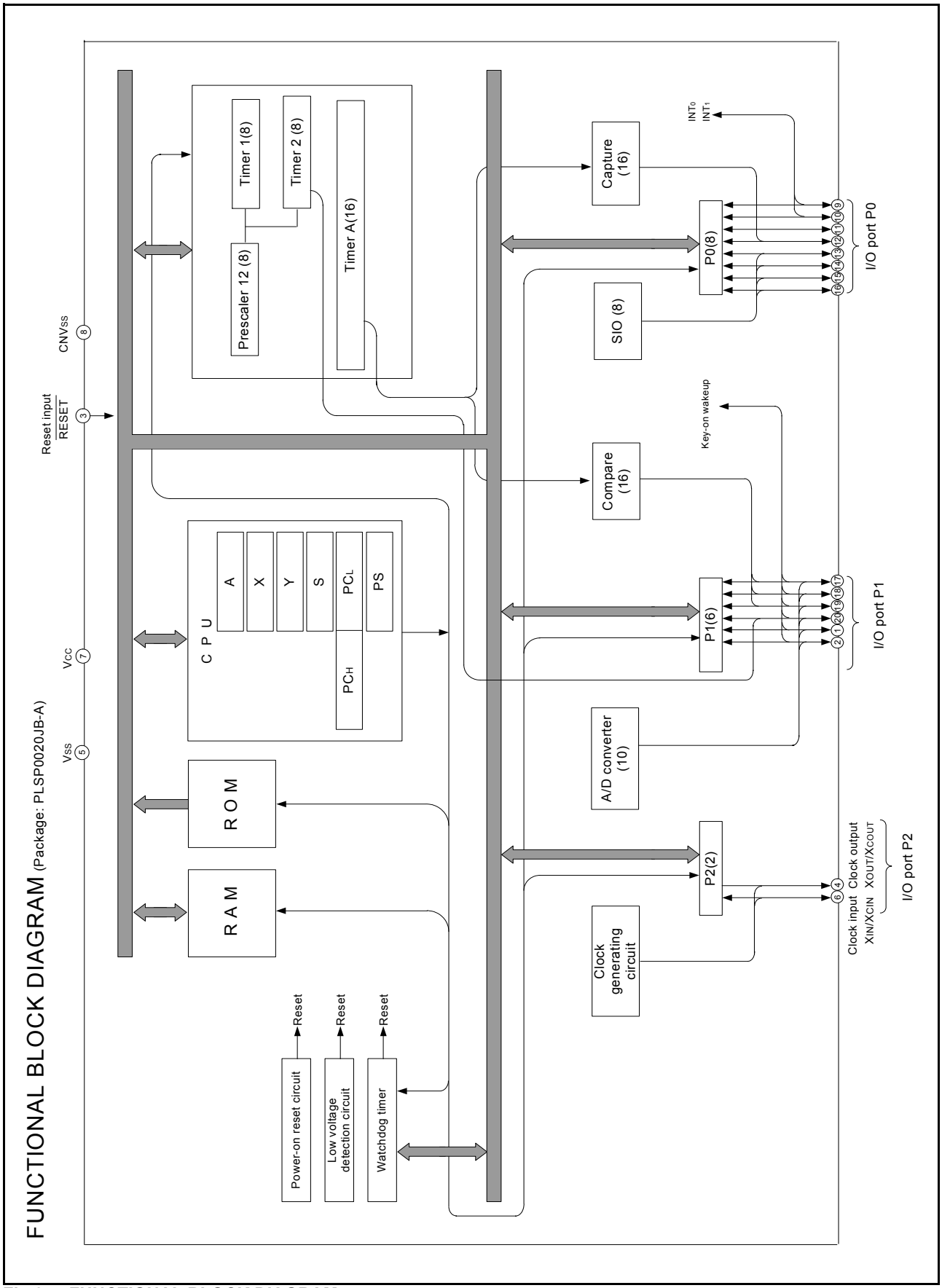


Fig 3. FUNCTIONAL BLOCK DIAGRAM

PIN DESCRIPTION

Table 2 Pin description

Pin	Name	Function	Function expect a port function		
V_{CC},V_{SS}	Power source	Apply voltage of 1.8 to 5.5 V to Vcc, and 0 V to Vss.			
CNV_{SS}	CNV_{SS}	Controls the operation mode of the chip. Connected to V_{SS}.			
$\overline{RESET}$	Reset input	Reset input pin for active “L”			
$P0_0$(LED0)/INT_0 $P0_1$(LED1)/INT_1	I/O port P0	•8-bit I/O port. •I/O direction register allows each pin to be individually programmed as either input or output. •CMOS compatible input level •CMOS 3-state output structure •Whether a built-in pull-up resistor is to be used or not can be determined by program. •High drive capacity for LED drive port can be selected by program.	Interrupt input pin		
$P0_2$(LED2)					
$P0_3$(LED3)/CAP_0			Capture input pin		
$P0_4$(LED4)/R_XD $P0_5$(LED5)/T_XD $P0_6$(LED6)/S_{CLK} $P0_7$(LED7)/$\overline{S_{RDY}}$			Serial interface function pin		
$P1_0$/AN_0/KEY_0/CMP_0 $P1_1$/AN_1/KEY_1/CMP_1 $P1_2$/AN_2/KEY_2/CMP_2	I/O port P1	•6-bit I/O port. •I/O direction register allows each pin to be individually programmed as either input or output. •CMOS compatible input level •CMOS 3-state output structure •Whether a built-in pull-up resistor is to be used or not can be determined by program.	Input pins for A/D converter	Key-input (key-on wake up interrupt input) pin	Compare output pin
$P1_3$/AN_3/KEY_3/$T2_{OUT}$					Timer 2 output pin
$P1_4$/AN_4/KEY_4 $P1_5$/AN_5/KEY_5					
$P2_0$/X_{OUT}/X_{COUT} $P2_1$/X_{IN}/X_{CIN} (Note)	I/O port P2	•2-bit I/O port. ($P2_0$/X_{OUT}/X_{COUT} is only for output) •I/O direction register allows each pin to be individually programmed as either input or output. •CMOS compatible input level •CMOS 3-state output structure •Function set ROM allows pins to be used as clock pins.	Pins X_{IN} and X_{OUT}, or pins X_{CIN} and X_{COUT}, can be used as clock pins by connecting a ceramic resonator, crystal oscillator, or 32 kHz crystal oscillator between them. Alternately, an external clock may be input to the $P2_0$/X_{OUT}/X_{COUT} pin. In this case, the $P2_1$/X_{IN}/X_{CIN} pin can be used as an I/O port.		

NOTE:
1. The oscillation circuit is built in the $P2_0$/X_{OUT}/X_{COUT} pin and the $P2_1$/X_{IN}/X_{CIN} pin. When the Vcc of the microcomputer is lower than the operation lower bound voltage even if these pins are used as I/O ports, the oscillation circuit is connected and undefined values may be output from these pins.

GROUP EXPANSION

Renesas plans to expand the 7548 group as follow:

Memory Type

Support for QzROM version and emulator MCU.

Memory Size

- ROM size ..... 2 K to 6 K bytes
- RAM size ..... 192 to 256 bytes

Packages

- PLSP0020JB-A .... 0.65 mm-pitch 20-pin plastic molded SSOP
- 42S1M ..... 42-pin shrink ceramic PIGGY BACK

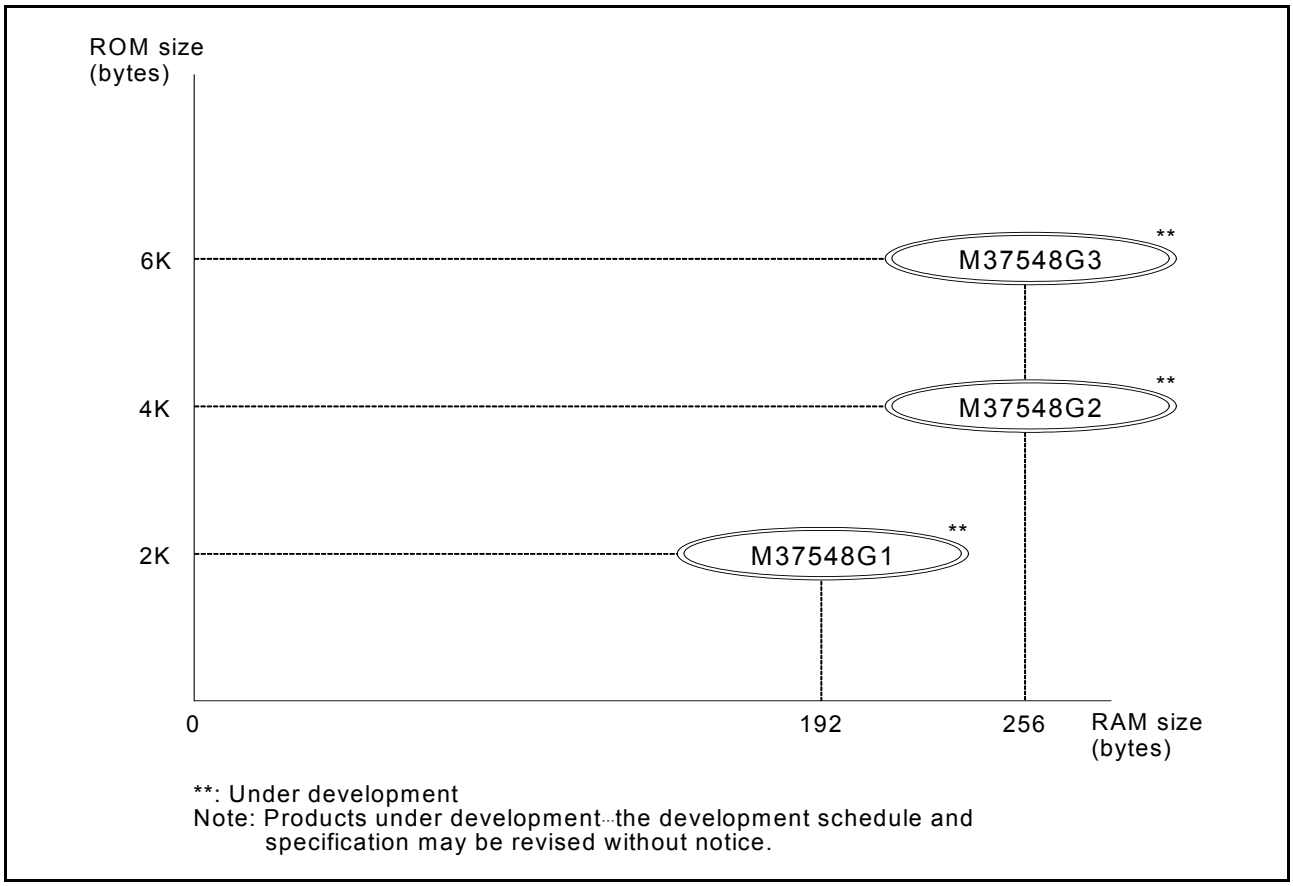


Fig 4. Memory expansion plan

Currently supported products are listed below.

Table 3 List of supported products

Part number	ROM size (bytes) ROM size for User ()	RAM size (bytes)	Package	Remarks
M37548G3-XXXFP	6144 (6014)	256	PLSP0020JB-A	QzROM version
M37548G3FP				QzROM version (blank)
M37548G2-XXXFP	4096 (3966)	256	PLSP0020JB-A	QzROM version
M37548G2FP				QzROM version (blank)
M37548G1-XXXFP	2048 (1918)	192	PLSP0020JB-A	QzROM version
M37548G1FP				QzROM version (blank)
M37549RLSS	–	256	42S1M	Emulator MCU

NOTE:
1. ROM size includes the function set ROM.

FUNCTIONAL DESCRIPTION

Central Processing Unit (CPU)

The MCU uses the standard 740 family instruction set. Refer to the table of 740 family addressing modes and machine-language instructions or the SERIES 740 <SOFTWARE> USER'S MANUAL for details on each instruction set.
Machine-resident 740 family instructions are as follows:

1. The FST and SLW instructions cannot be used.
2. The MUL and DIV instructions can be used.
3. The WIT instruction can be used.
4. The STP instruction can be used.

[Accumulator (A)]

The accumulator is an 8-bit register. Data operations such as data transfer, etc., are executed mainly through the accumulator.

[Index register X (X), Index register Y (Y)]

Both index register X and index register Y are 8-bit registers. In the index addressing modes, the value of the OPERAND is added to the contents of register X or register Y and specifies the real address.
When the T flag in the processor status register is set to "1", the value contained in index register X becomes the address for the second OPERAND.

[Stack Pointer (S)]

The stack pointer is an 8-bit register used during subroutine calls and interrupts. The stack is used to store the current address data and processor status when branching to subroutines or interrupt routines.
The lower eight bits of the stack address are determined by the contents of the stack pointer. The upper eight bits of the stack address are determined by the Stack Page Selection Bit. If the Stack Page Selection Bit is "0", then the RAM in the zero page is used as the stack area. If the Stack Page Selection Bit is "1", then RAM in page 1 is used as the stack area.
The Stack Page Selection Bit is located in the SFR area in the zero page. Note that the initial value of the Stack Page Selection Bit varies with each microcomputer type. Also some microcomputer types have no Stack Page Selection Bit and the upper eight bits of the stack address are fixed. The operations of pushing register contents onto the stack and popping them from the stack are shown in Figure 6.

[Program Counter (PC)]

The program counter is a 16-bit counter consisting of two 8-bit registers PCH and PCL. It is used to indicate the address of the next instruction to be executed.

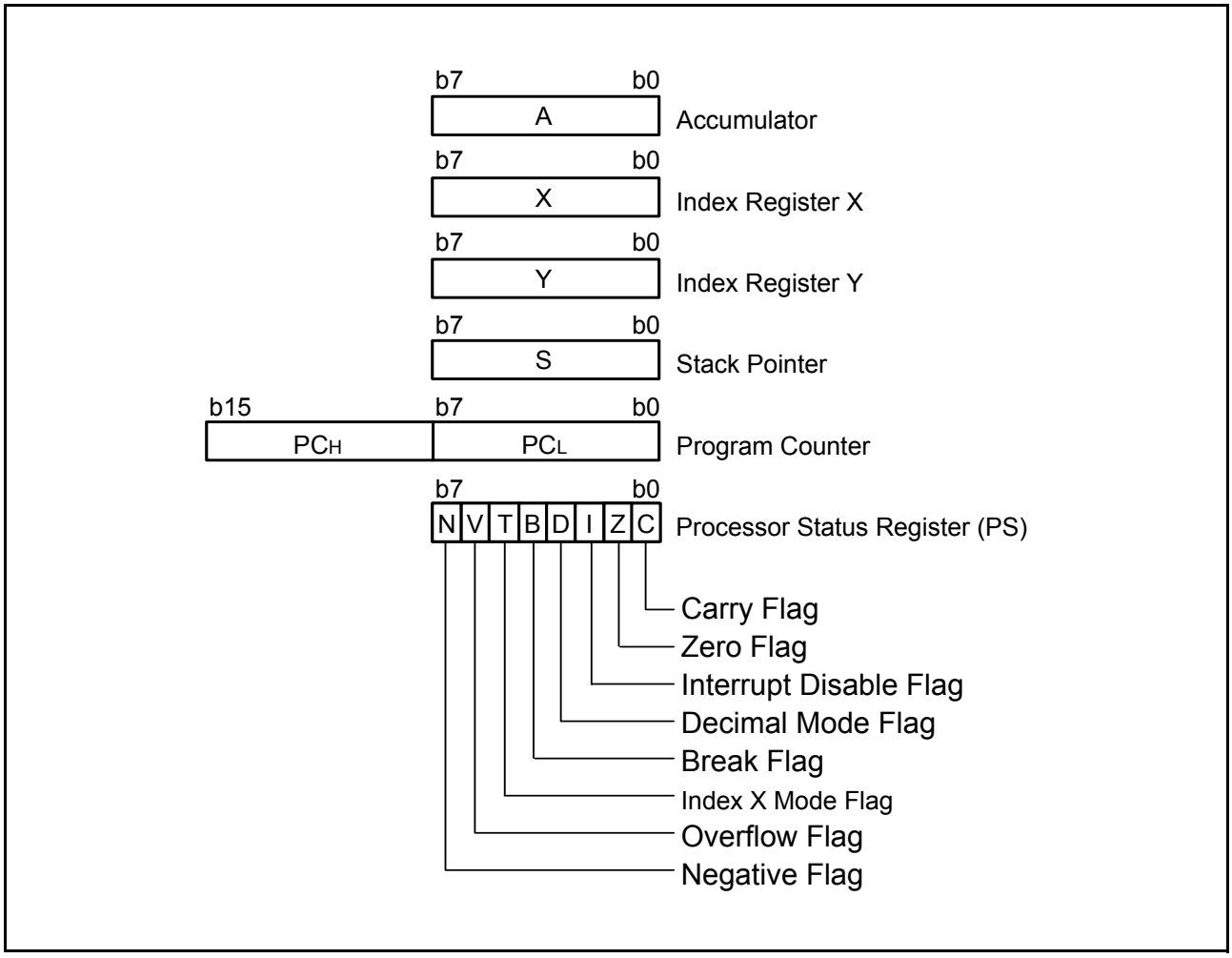


Fig 5. 740 Family CPU register structure

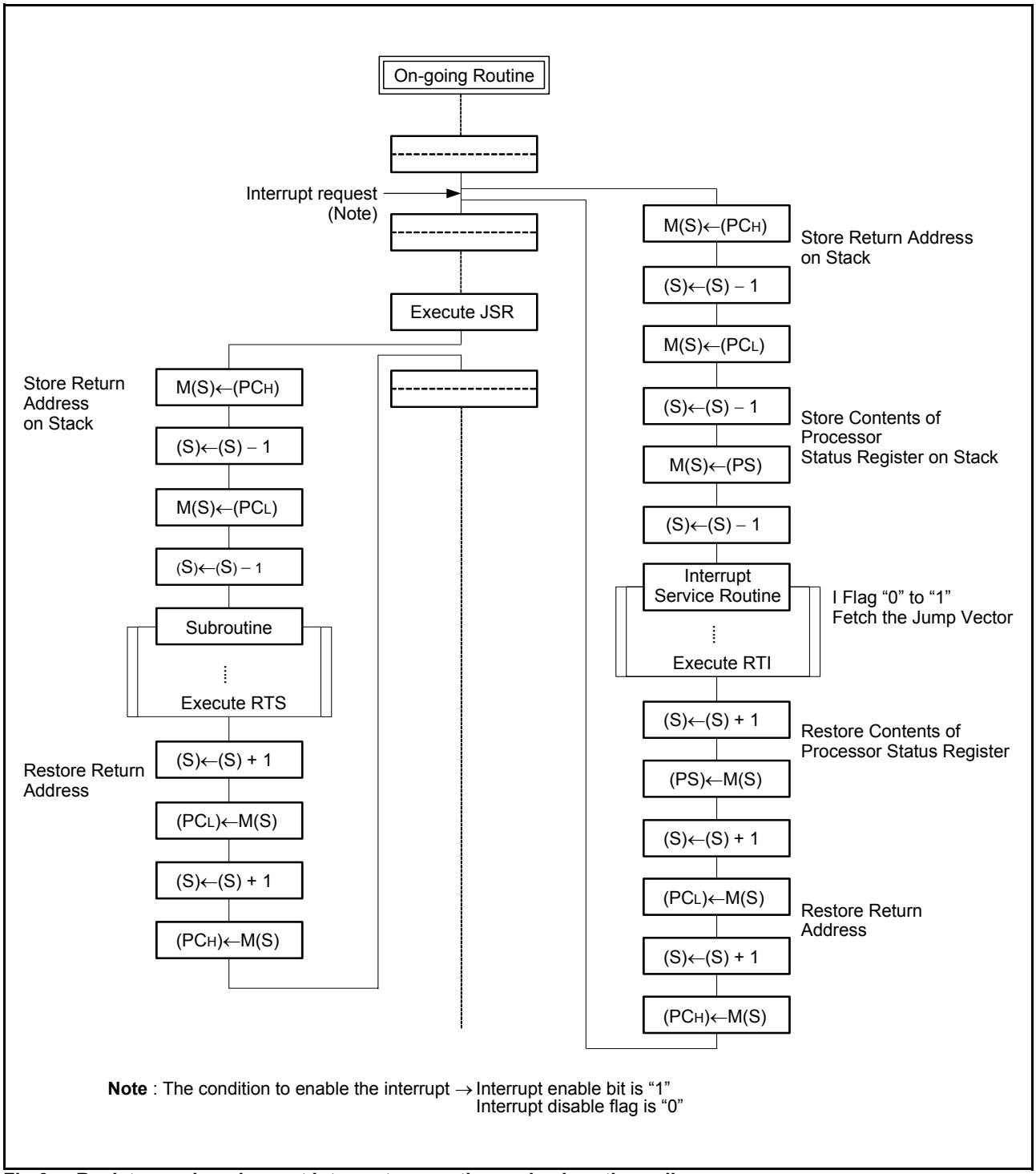


Fig 6. Register push and pop at interrupt generation and subroutine call

Table 4 Push and pop instructions of accumulator or processor status register

	Push instruction to stack	Pop instruction from stack
Accumulator	PHA	PLA
Processor status register	PHP	PLP

[Processor status register (PS)]

The processor status register is an 8-bit register consisting of flags which indicate the status of the processor after an arithmetic operation. Branch operations can be performed by testing the Carry (C) flag, Zero (Z) flag, Overflow (V) flag, or the Negative (N) flag. In decimal mode, the Z, V, N flags are not valid.
After reset, the Interrupt disable (I) flag is set to "1", but all other flags are undefined. Since the Index X mode (T) and Decimal mode (D) flags directly affect arithmetic operations, they should be initialized in the beginning of a program.

Bit 0: Carry flag (C)

The C flag contains a carry or borrow generated by the arithmetic logic unit (ALU) immediately after an arithmetic operation. It can also be changed by a shift or rotate instruction.

Bit 1: Zero flag (Z)

The Z flag is set if the result of an immediate arithmetic operation or a data transfer is "0", and cleared if the result is anything other than "0".

Bit 2: Interrupt disable flag (I)

The I flag disables all interrupts except for the interrupt generated by the BRK instruction. Interrupts are disabled when the I flag is "1".
When an interrupt occurs, this flag is automatically set to "1" to prevent other interrupts from interfering until the current interrupt is serviced.

Bit 3: Decimal mode flag (D)

The D flag determines whether additions and subtractions are executed in binary or decimal. Binary arithmetic is executed when this flag is "0"; decimal arithmetic is executed when it is "1".
Decimal correction is automatic in decimal mode. Only the ADC and SBC instructions can be used for decimal arithmetic.

Bit 4: Break flag (B)

The B flag is used to indicate that the current interrupt was generated by the BRK instruction. The BRK flag in the processor status register is always "0". When the BRK instruction is used to generate an interrupt, the processor status register is pushed onto the stack with the break flag set to "1". The saved processor status is the only place where the break flag is ever set.

Bit 5: Index X mode flag (T)

When the T flag is "0", arithmetic operations are performed between accumulator and memory, e.g. the results of an operation between two memory locations is stored in the accumulator. When the T flag is "1", direct arithmetic operations and direct data transfers are enabled between memory locations, i.e. between memory and memory, memory and I/O, and I/O and I/O. In this case, the result of an arithmetic operation performed on data in memory location 1 and memory location 2 is stored in memory location 1. The address of memory location 1 is specified by index register X, and the address of memory location 2 is specified by normal addressing modes.

Bit 6: Overflow flag (V)

The V flag is used during the addition or subtraction of one byte of signed data. It is set if the result exceeds +127 to -128. When the BIT instruction is executed, bit 6 of the memory location operated on by the BIT instruction is stored in the overflow flag.

Bit 7: Negative flag (N)

The N flag is set if the result of an arithmetic operation or data transfer is negative. When the BIT instruction is executed, bit 7 of the memory location operated on by the BIT instruction is stored in the negative flag.

Table 5 Set and clear instructions of each bit of processor status register

	C flag	Z flag	I flag	D flag	B flag	T flag	V flag	N flag
Set instruction	SEC	–	SEI	SED	–	SET	–	–
Clear instruction	CLC	–	CLI	CLD	–	CLT	CLV	–

[CPU mode register] CPUM

The CPU mode register contains the stack page selection bit.
This register is allocated at address $003B_{16}$.

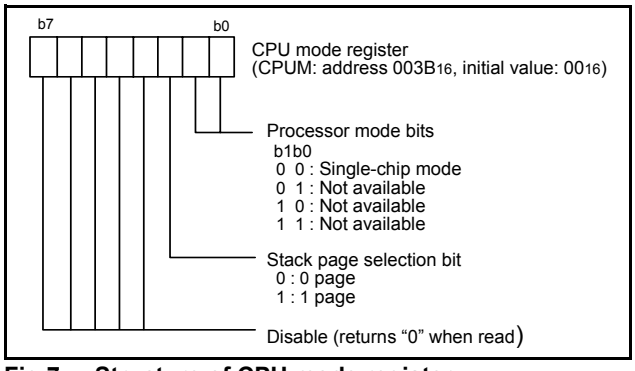


Fig 7. Structure of CPU mode register

The processor mode bits can be written only once after releasing reset. Always set them to "00_2". After written, rewriting any data to these bits is disabled because they are locked. (Emulator MCU is excluded.) Also, the stack page bit (bit 2) is not locked.
In order to prevent error-writing to the processor mode bits (at program runaway), write the CPU mode register at the start of the program that runs after releasing reset.

Memory

• Special Function Register (SFR) Area

The SFR area in the zero page contains control registers such as I/O ports and timers.

• RAM

RAM is used for data storage and for a stack area of subroutine calls and interrupts.

• ROM

The first 128 bytes and the last 2 bytes of ROM are reserved for device testing and the rest is a user area for storing programs.
The user area includes the function set ROM area.

• Interrupt Vector Area

The interrupt vector area contains reset and interrupt vectors.

• Zero Page

The 256 bytes from addresses 0000_{16} to $00FF_{16}$ are called the zero page area. The internal RAM and the special function registers (SFR) are allocated to this area.
The zero page addressing mode can be used to specify memory and register addresses in the zero page area. Access to this area with only 2 bytes is possible in the zero page addressing mode.

• Special Page

The 256 bytes from addresses $FF00_{16}$ to $FFFF_{16}$ are called the special page area. The special page addressing mode can be used to specify memory addresses in the special page area. Access to this area with only 2 bytes is possible in the special page addressing mode.

• Function set ROM Area

[Renesas shipment test area]

Figure 8 shows the Assignment of Function set ROM area.
The random data are set to the Renesas shipment test areas (addresses $FFD4_{16}$ to address $FFD7_{16}$).
Do not rewrite the data of these areas.
When the checksum is included in the user program, avoid assigning it to these areas.

[Function set ROM data] FSROM0, FSROM1, FSROM2

Function set ROM data 0 to 2 (addresses $FFD8_{16}$ to $FFDA_{16}$) are used to set modes of peripheral functions.
By setting values to these areas, the operation mode of each peripheral function are set after releasing reset.
Refer to the descriptions of peripheral functions for the details of operation of peripheral functions.

- Clock circuit
- Watchdog timer
- Low voltage detection circuit

[ROM code protect]

Address $FFDB_{16}$ of QzROM version is ROM code protect address and cannot be used for programming. "00_{16}" is written into this address when selecting the protect bit write by using a serial programmer and selecting protect enabled for writing shipment by Renesas Technology corp.. When "00_{16}" is set to the ROM code protect address, the protect function is enabled, so that reading or writing from/to the corresponding area is disabled by a serial programmer.
As for the QzROM product in blank, the ROM code is protected by selecting the protect bit write at ROM writing with a serial programmer.
As for the QzROM product shipped after writing, "00_{16}" (protect enabled) or "FF_{16}" (protect disabled) is written into the ROM code protect address when Renesas Technology corp. performs writing.
The writing of "00_{16}" or "FF_{16}" can be selected as ROM option setup ("MASK option" written in the mask file converter) when ordering.

<Notes>

(1) Because the contents of RAM are indefinite at reset, set initial values before using.
(2) Do not access to the reserved area.
(3) Random data is written into the Renesas shipment test area and the reserved ROM area. Do not rewrite the data in these areas. Data of these area may be changed without notice. Accordingly, do not include these areas into programs such as checksum of all ROM areas.
(4) The QzROM values in function set ROM data 0 to 2 set the operating modes of the various peripheral functions after an MCU reset is released. Do not fail to set the value for the selected function. Bits designated with a fixed value of 1 or 0 must be set to the designated value.

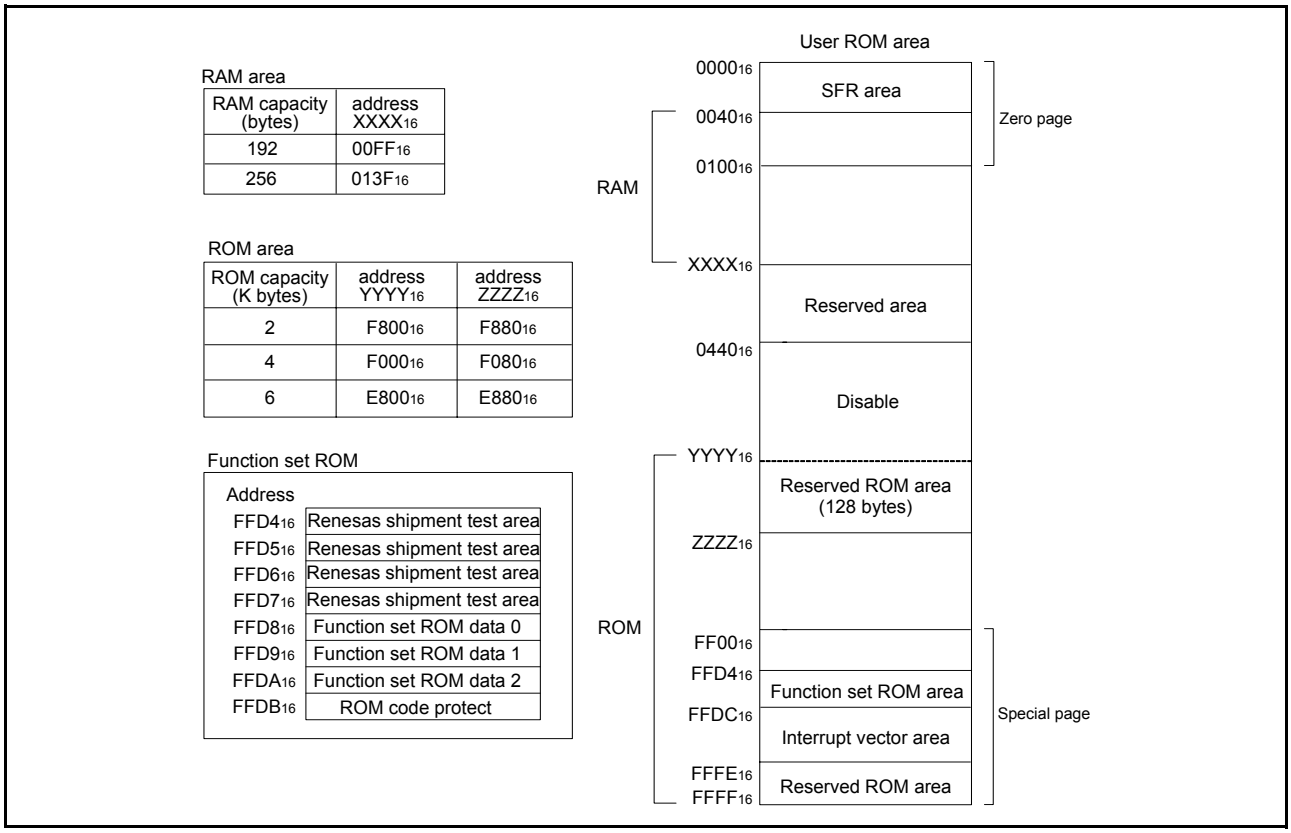


Fig 8. Memory map diagram

0000_{16}	Port P0 (P0)	0020_{16}	Reserved
0001_{16}	Port P0 direction register (P0D)	0021_{16}	Reserved
0002_{16}	Port P1 (P1)	0022_{16}	Reserved
0003_{16}	Port P1 direction register (P1D)	0023_{16}	Reserved
0004_{16}	Port P2 (P2)	0024_{16}	Reserved
0005_{16}	Port P2 direction register (P2D)	0025_{16}	Reserved
0006_{16}	Port P3 (P3) (Note 1)	0026_{16}	Reserved
0007_{16}	Port P3 direction register (P3D) (Note 2)	0027_{16}	Reserved
0008_{16}	Reserved	0028_{16}	Prescaler 12 (PRE12)
0009_{16}	Reserved	0029_{16}	Timer 1 (T1)
$000A_{16}$	Reserved	$002A_{16}$	Timer 2 (T2)
$000B_{16}$	Reserved	$002B_{16}$	Timer mode register (TM)
$000C_{16}$	Port P0 drive capacity control register (DCCR)	$002C_{16}$	Timer count source set register (TCSS)
$000D_{16}$	Port P0 pull-up control register (PULL0)	$002D_{16}$	Compare register re-load register (CMPR)
$000E_{16}$	Port P1 pull-up control register (PULL1)	$002E_{16}$	Capture/Compare port register (CCPR)
$000F_{16}$	Key-on wakeup input selection register (KEYS)	$002F_{16}$	Capture/Compare status register (CCSR)
0010_{16}	Capture/Compare register (low-order) (CRAL)	0030_{16}	Compare interrupt source set register (CISR)
0011_{16}	Capture/Compare register (high-order) (CRAH)	0031_{16}	Capture software trigger register (CSTR)
0012_{16}	Capture/Compare register R/W pointer (CCRP)	0032_{16}	Capture mode register (CAPM)
0013_{16}	Compare output mode register (CMOM)	0033_{16}	Reserved
0014_{16}	Timer A (low-order) (TAL)	0034_{16}	AD control register (ADCON)
0015_{16}	Timer A (high-order) (TAH)	0035_{16}	AD conversion register (low-order) (ADL)
0016_{16}	Reserved	0036_{16}	AD conversion register (high-order) (ADH)
0017_{16}	Reserved	0037_{16}	Clock mode register (CLKM)
0018_{16}	Transmit/Receive buffer register (TB/RB)	0038_{16}	Oscillation stop detection register (CLKSTP)
0019_{16}	Serial I/O status register (SIOSTS)	0039_{16}	Watchdog timer control register (WDTCON)
$001A_{16}$	Serial I/O control register (SIOCON)	$003A_{16}$	Interrupt edge selection register (INTEDGE)
$001B_{16}$	UART control register (UARTCON)	$003B_{16}$	CPU mode register (CPUM)
$001C_{16}$	Baud rate generator (BRG)	$003C_{16}$	Interrupt request register 1 (IREQ1)
$001D_{16}$	Reserved	$003D_{16}$	Interrupt request register 2 (IREQ2)
$001E_{16}$	Reserved	$003E_{16}$	Interrupt control register 1 (ICON1)
$001F_{16}$	Reserved	$003F_{16}$	Interrupt control register 2 (ICON2)

Notes 1: Port P3 pins are nothing.
2: Set "03_{16}" to the port P3 direction register, though the port P3 pins are nothing.
3: Do not access to the reserved addresses.

Fig 9. Memory map of special function register (SFR)

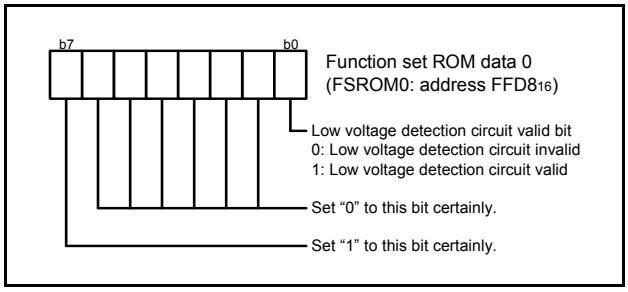
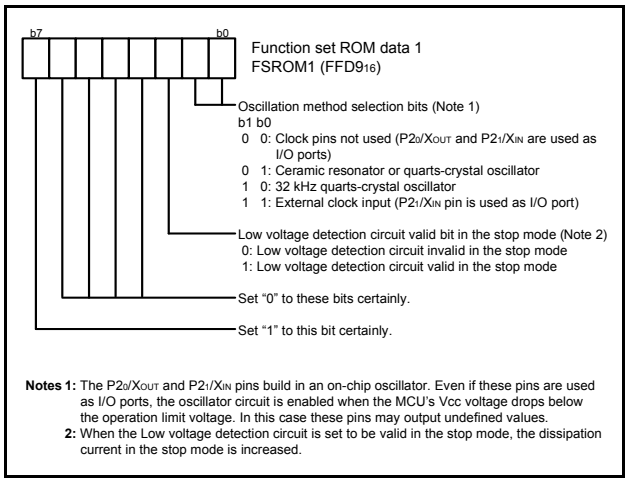
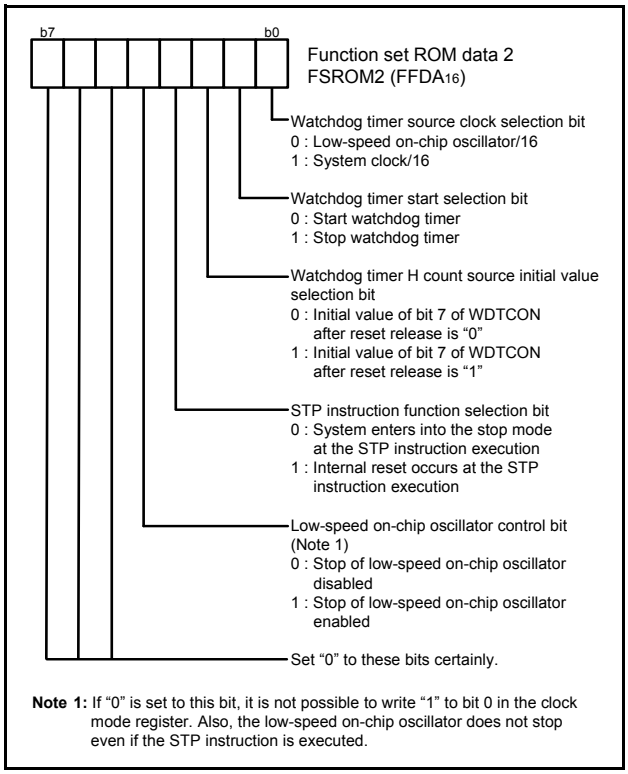


Fig 10. Structure of Function set ROM data 0



Notes 1: The P2₀/XOUT and P2₁/XIN pins build in an on-chip oscillator. Even if these pins are used as I/O ports, the oscillator circuit is enabled when the MCU's Vcc voltage drops below the operation limit voltage. In this case these pins may output undefined values.
2: When the Low voltage detection circuit is set to be valid in the stop mode, the dissipation current in the stop mode is increased.

Fig 11. Structure of Function set ROM data 1



Note 1: If “0” is set to this bit, it is not possible to write “1” to bit 0 in the clock mode register. Also, the low-speed on-chip oscillator does not stop even if the STP instruction is executed.

Fig 12. Structure of Function set ROM data 2

I/O Ports

[Direction registers] PiD

The I/O ports have direction registers which determine the input/output direction of each pin. Each bit in a direction register corresponds to one pin, and each pin can be set to be input or output.

When "1" is set to the bit corresponding to a pin, this pin becomes an output port. When "0" is set to the bit, the pin becomes an input port.

When data is read from a pin set to output, not the value of the pin itself but the value of port latch is read. Pins set to input are floating, and permit reading pin values.

If a pin set to input is written to, only the port latch is written to and the pin remains floating.

- If the port $P2_0$ is used as output port, write "1" to the port $P2_0$ direction register after reset.
- Set "1" to bits 6 and 7 of the port P1 direction register.
- Set "1" to bits 0 and 1 of the port P3 direction register.

[Port P0 drive capacity control register] DCCR

By setting the Port P0 drive capacity control register (address $000C_{16}$), the drive capacity of the N-channel output transistor for the port P0 can be selected.

[Pull-up control registers] PULL0, PULL1

By setting the pull-up control registers (address $000D_{16}$ and $000E_{16}$), ports P0 and P1 can exert pull-up control by program. However, this is valid only when the port direction registers are set to input.

When they are set to output, setting "pull-up on" does not pull up the ports.

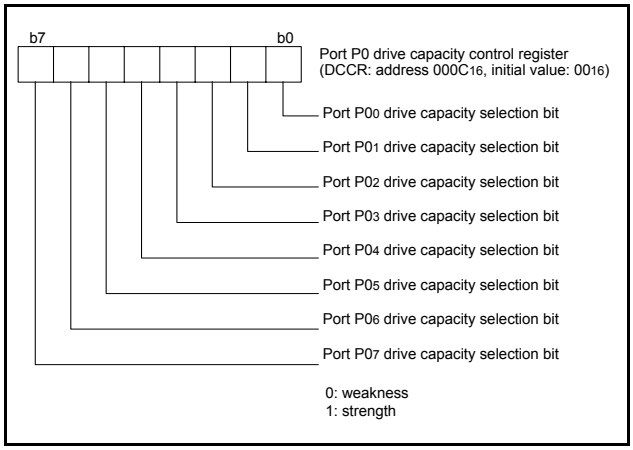


Fig 13. Structure of port P0 drive capacity control register

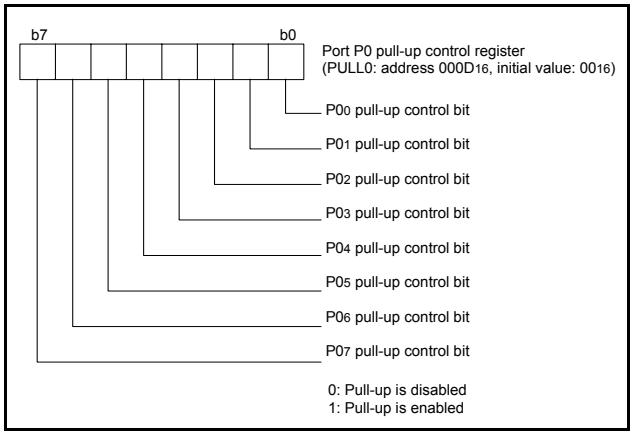


Fig 14. Structure of port P0 pull-up control register

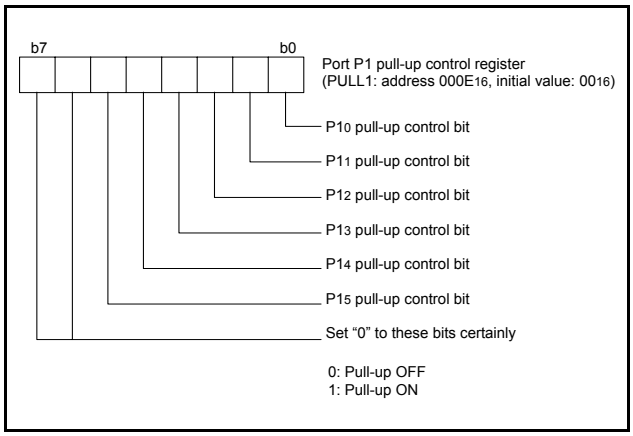


Fig 15. Structure of port P1 control register

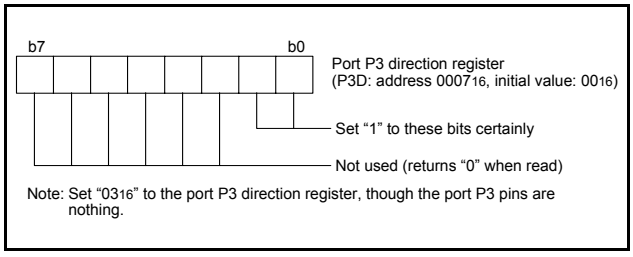


Fig 16. Structure of port P3 direction register

Table 6 I/O port function table

Pin	Name	I/O format	Non-port function	SFRs related each pin
$P0_0(LED_0)/INT_0$ $P0_1(LED_1)/INT_1$	I/O port P0	CMOS compatible input level CMOS 3-state output	External interrupt input	Interrupt edge selection register Port P0 drive capacity control register Port P0 pull-up control register
$P0_2(LED_2)$				Port P0 drive capacity control register Port P0 pull-up control register
$P0_3(LED_3)/CAP_0$			Capture input	Capture/Compare port register Port P0 drive capacity control register Port P0 pull-up control register
$P0_4(LED_4)/RxD$			Serial interface input/ output	Serial I/O control register Port P0 drive capacity control register Port P0 pull-up control register
$P0_5(LED_5)/TxD$				Serial I/O control register UART control register Port P0 drive capacity control register Port P0 pull-up control register
$P0_6(LED_6)/SCLK$				Serial I/O control register Port P0 drive capacity control register Port P0 pull-up control register
$P0_7(LED_7)/\overline{SRDY}$				Serial I/O control register Port P0 drive capacity control register Port P0 pull-up control register
$P1_0/AN_0/KEY_0/CMP_0$ $P1_1/AN_1/KEY_1/$ $CMP_1P1_2/AN_2/KEY_2/$ CMP_2	I/O port P1		Compare output Key input interrupt A/D conversion input	Capture/Compare port register Port P1 pull-up control register Key-on wakeup input selection register AD control register
$P1_3/AN_3/KEY_3/T2_{OUT}$			Timer 2 output Key input interrupt A/D conversion input	Timer mode register Port P1 pull-up control register Key-on wakeup input selection register AD control register
$P1_4/AN_4/KEY_4$ $P1_5/AN_5/KEY_5$			Key input interrupt A/D conversion input	Port P1 pull-up control register Key-on wakeup input selection register AD control register
$P2_0/X_{OUT}/X_{COUT}$	I/O port P2	CMOS 3-state output	Clock pin	Function set ROM data 1 (Note) Clock mode register
$P2_1/X_{IN}/X_{CIN}$		CMOS compatible input level CMOS 3-state output	Clock pin	Function set ROM data 1 (Note) Clock mode register

NOTE:
1. Function set ROM data 1 is included in the function set ROM area.

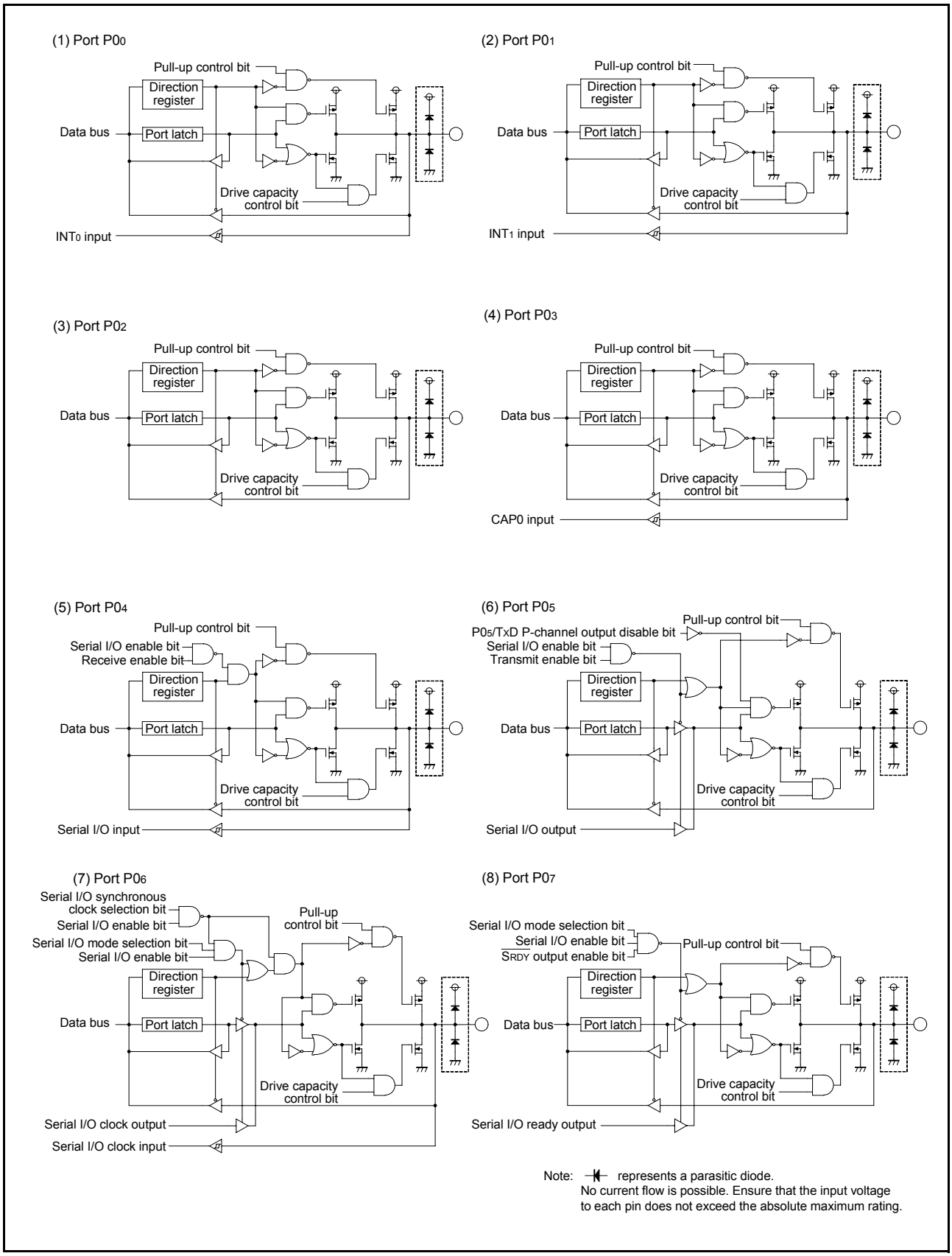


Fig 17. Block diagram of pins (1)

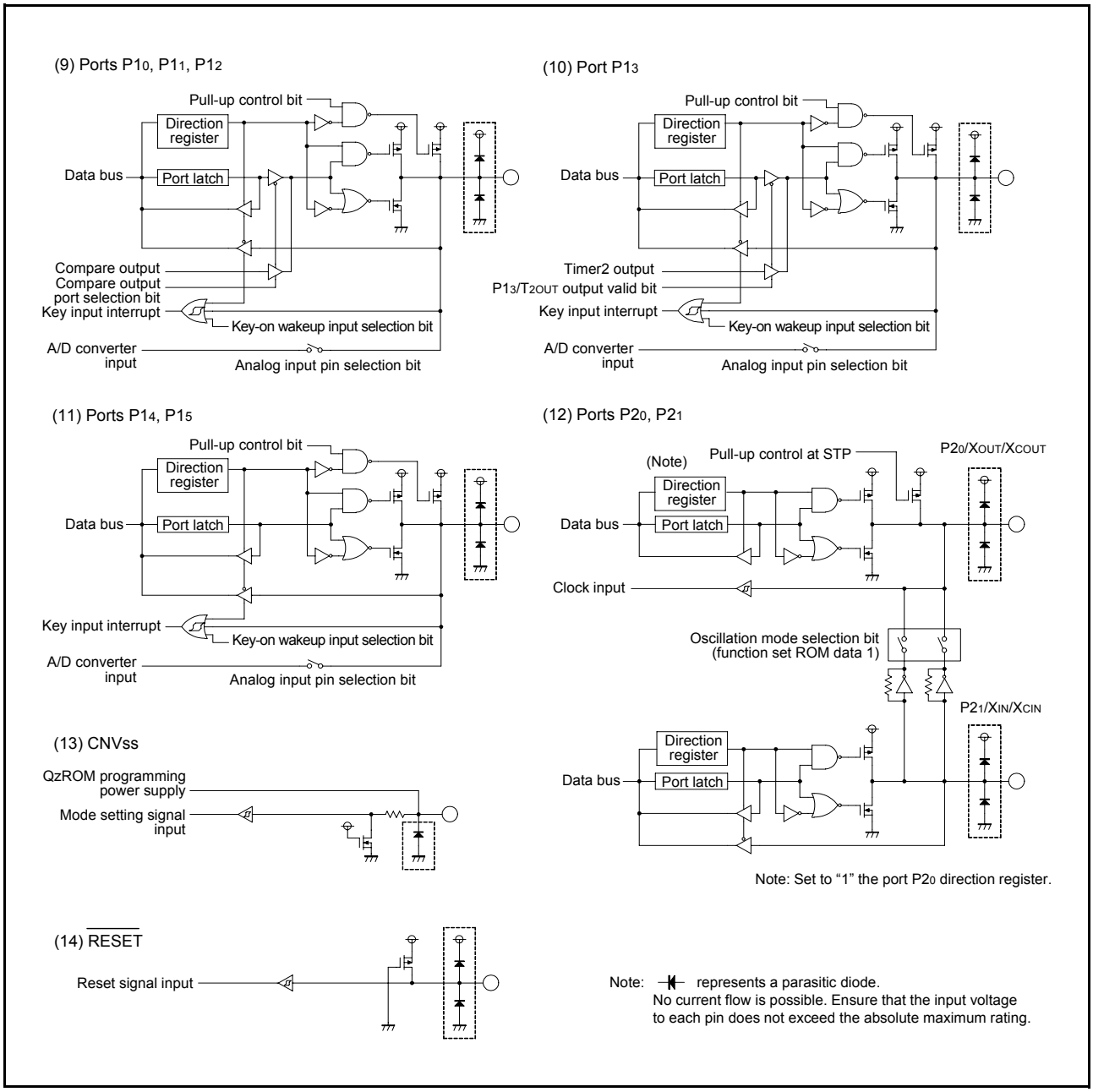


Fig 18. Block diagram of pins (2)

Termination of unused pins

- Termination of common pins

I/O ports: Select an input port or an output port and follow each processing method.

Output ports: Open.

Input ports: If the input level become unstable, through current flow to an input circuit, and the power supply current may increase.
Especially, when expecting low consumption current (at STP or WIT instruction execution etc.), pull-up or pull-down input ports to prevent through current (built-in resistor can be used).
We recommend processing unused pins through a resistor which can secure IOH (avg) or IOL (avg).
Because, when an I/O port or a pin which have an output function is selected as an input port, it may operate as an output port by incorrect operation etc.

Table 7 Termination of unused pins

Pin	Termination
$P0_0/INT_0$	Perform termination of I/O port.
$P0_1/INT_1$	
$P0_2$	
$P0_3$	
$P0_4/R_XD$	
$P0_5/T_XD$	
$P0_6/S_{CLK}$	
$P0_7/\overline{S_{RDY}}$	
$P1_0/AN_0/KEY_0/CMP_0$	
$P1_1/AN_1/KEY_1/CMP_1$	
$P1_2/AN_2/KEY_2/CMP_2$	
$P1_3/AN_3/KEY_3/T2_{OUT}$	
$P1_4/AN_4/KEY_4$	
$P1_5/AN_5/KEY_5$	
$P2_0/X_{OUT}/X_{COUT}$	Set the direction register to “1”, and perform termination of output port.
$P2_1/X_{IN}/X_{CIN}$	Perform termination of I/O port.

Interrupts

Interrupts occur by 13 different sources : 5 external sources, 7 internal sources and 1 software source.

• Interrupt control

All interrupts except the BRK instruction interrupt have an interrupt request bit and an interrupt enable bit, and they are controlled by the interrupt disable flag. When the interrupt enable bit and the interrupt request bit are set to "1" and the interrupt disable flag is set to "0", an interrupt is accepted.
The interrupt request bit can be cleared by program but not be set.
The interrupt enable bit can be set and cleared by program.
The reset and BRK instruction interrupt can never be disabled with any flag or bit. All interrupts except these are disabled when the interrupt disable flag is set.
When several interrupts occur at the same time, the interrupts are received according to priority.

• Interrupt operation

Upon acceptance of an interrupt the following operations are automatically performed:

1. The processing being executed is stopped.
2. The contents of the program counter and processor status register are automatically pushed onto the stack.
3. The interrupt disable flag is set and the corresponding interrupt request bit is cleared.
4. Concurrently with the push operation, the interrupt destination address is read from the vector table into the program counter.

[Interrupt edge selection register] INTEDGE

The valid edge of external interrupt INT_0 and INT_1 can be selected by the interrupt edge selection bit, respectively.

[Key-on wakeup input selection register] KEYS

Either of enable or disable of key-on wakeup for pins $P1_0$ to $P1_5$ can be selected by the key-on wakeup input selection bit, respectively.

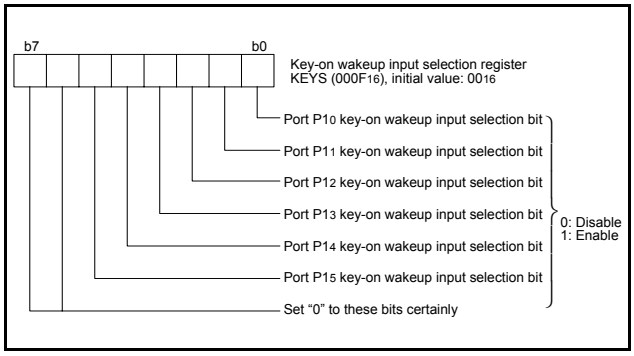


Fig 19. Structure of key-on wakeup input selection register

• Notes on use

(1) When setting the followings, the interrupt request bit may be set to "1".
• When switching external interrupt active edge related register:
Interrupt edge selection register (address $003A_{16}$)
Capture mode register (address 0032_{16})

When not requiring the interrupt occurrence synchronized with these setting, take the following sequence.

1. Set the corresponding interrupt enable bit to "0" (disabled).
2. Set the interrupt edge select bit (active edge switch bit, trigger mode bit).
3. Set the corresponding interrupt request bit to "0" after 1 or more instructions have been executed.
4. Set the corresponding interrupt enable bit to "1" (enabled).

Table 8 Interrupt vector address and priority

Interrupt source	Priority	Vector addresses (Note 1)		Interrupt request generating conditions	Remarks
		High-order	Low-order		
Reset (Note 2)	1	FFFD16	FFFC16	At reset input	Non-maskable
Serial I/O receive	2	FFFB16	FFFA16	At completion of serial I/O data receive	Valid only when serial I/O is selected
Serial I/O transmit	3	FFF916	FFF816	At completion of serial I/O transmit shift or when transmit buffer is empty	Valid only when serial I/O is selected
INT_0	4	FFF716	FFF616	At detection of either rising or falling edge of INT_0 input	External interrupt (active edge selectable)
INT_1	5	FFF516	FFF416	At detection of either rising or falling edge of INT_1 input	External interrupt (active edge selectable)
Key-on wakeup	6	FFF316	FFF216	At falling of conjunction of input logical level for port P1 (at input)	External interrupt (valid at falling edge)
Capture	7	FFF116	FFF016	At detection of either rising or falling edge of Capture 0 input	External interrupt (active edge selectable)
Compare	8	FFEF16	FFEE16	At compare matched	Compare interrupt source is selected.
Timer A	9	FFED16	FFEC16	At timer A underflow	
Timer 2	10	FFEB16	FFEA16	At timer 2 underflow	
A/D conversion	11	FFE916	FFE816	At completion of A/D conversion	
Timer 1	12	FFE716	FFE616	At timer 1 underflow	STP release timer underflow
Not used	13	FFE516	FFE416		
	14	FFE316	FFE216		
	15	FFE116	FFE016		
	16	FFDF16	FFDE16		
BRK instruction	17	FFDD16	FFDC16	At BRK instruction execution	Non-maskable software interrupt

NOTES:
1. Vector addressed contain internal jump destination addresses.
2. Reset function in the same way as an interrupt with the highest priority.

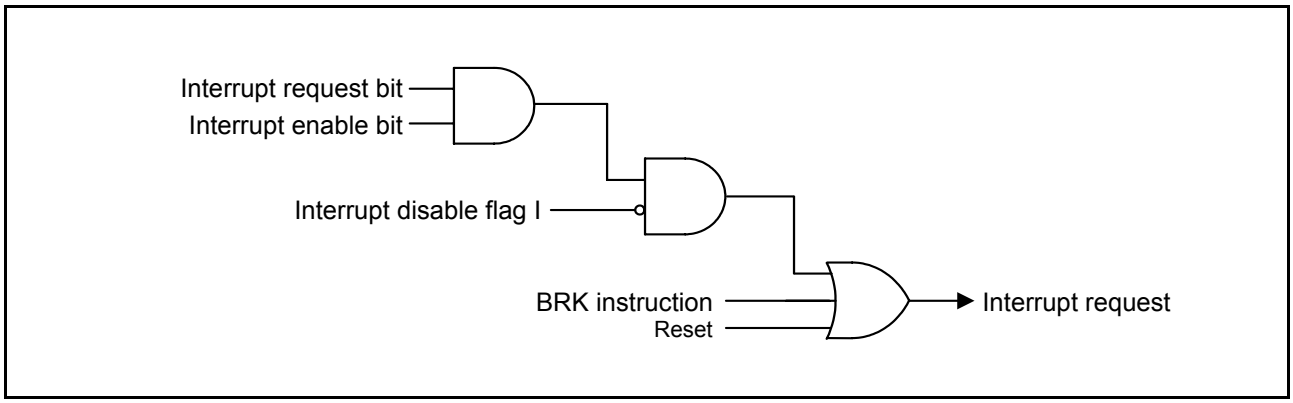


Fig 20. Interrupt control

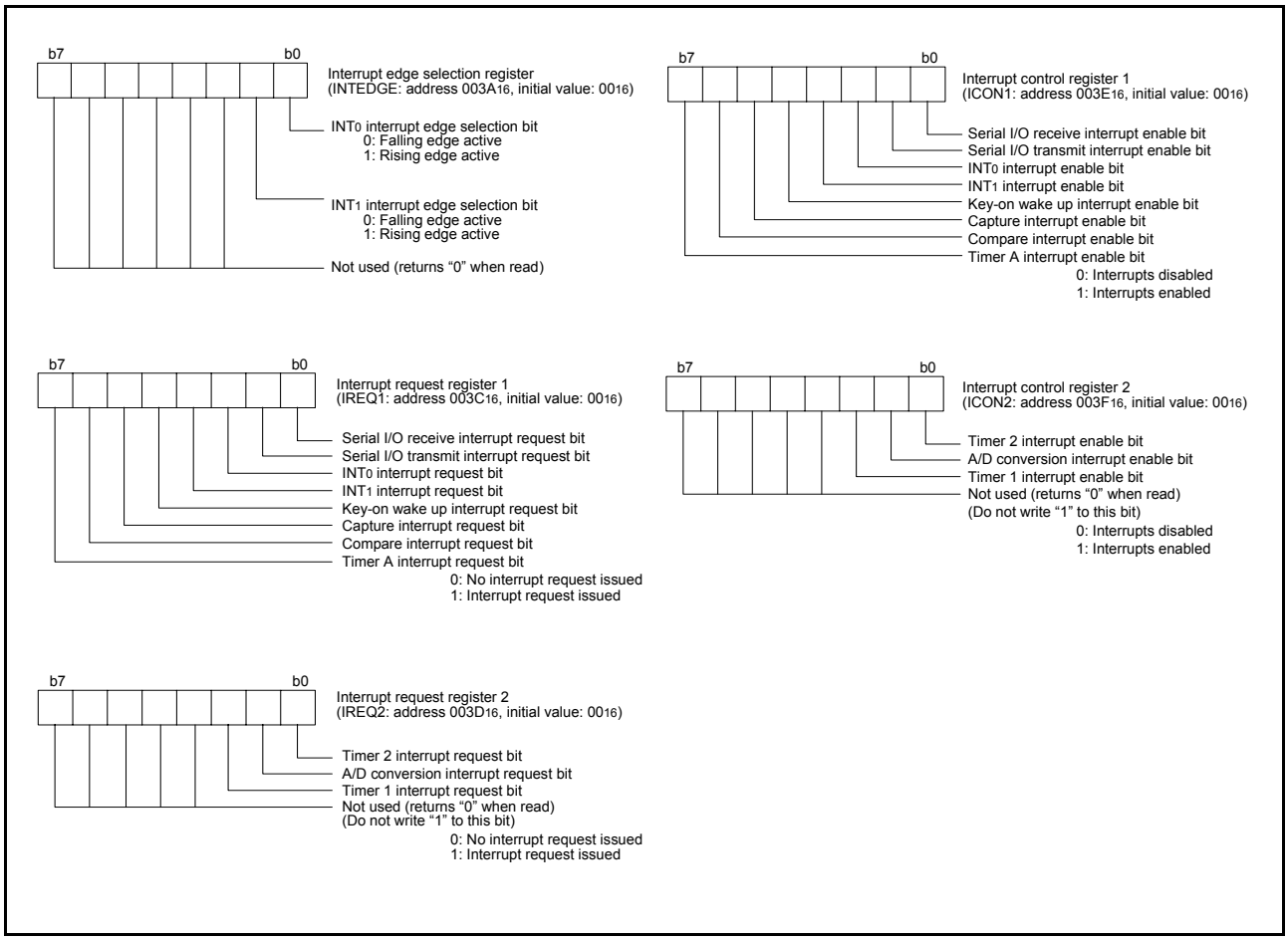


Fig 21. Structure of Interrupt-related registers

Key Input Interrupt (Key-On Wakeup)

A key-on wakeup interrupt request is generated by applying "L" level to any pin of port P1 that has been set to input mode. In other words, it is generated when the AND of input level goes from "1" to "0". An example of using a key input interrupt is shown in Figure 22, where an interrupt request is generated by pressing one of the keys provided as an active-low key matrix which uses ports P10 to P13 as input ports.

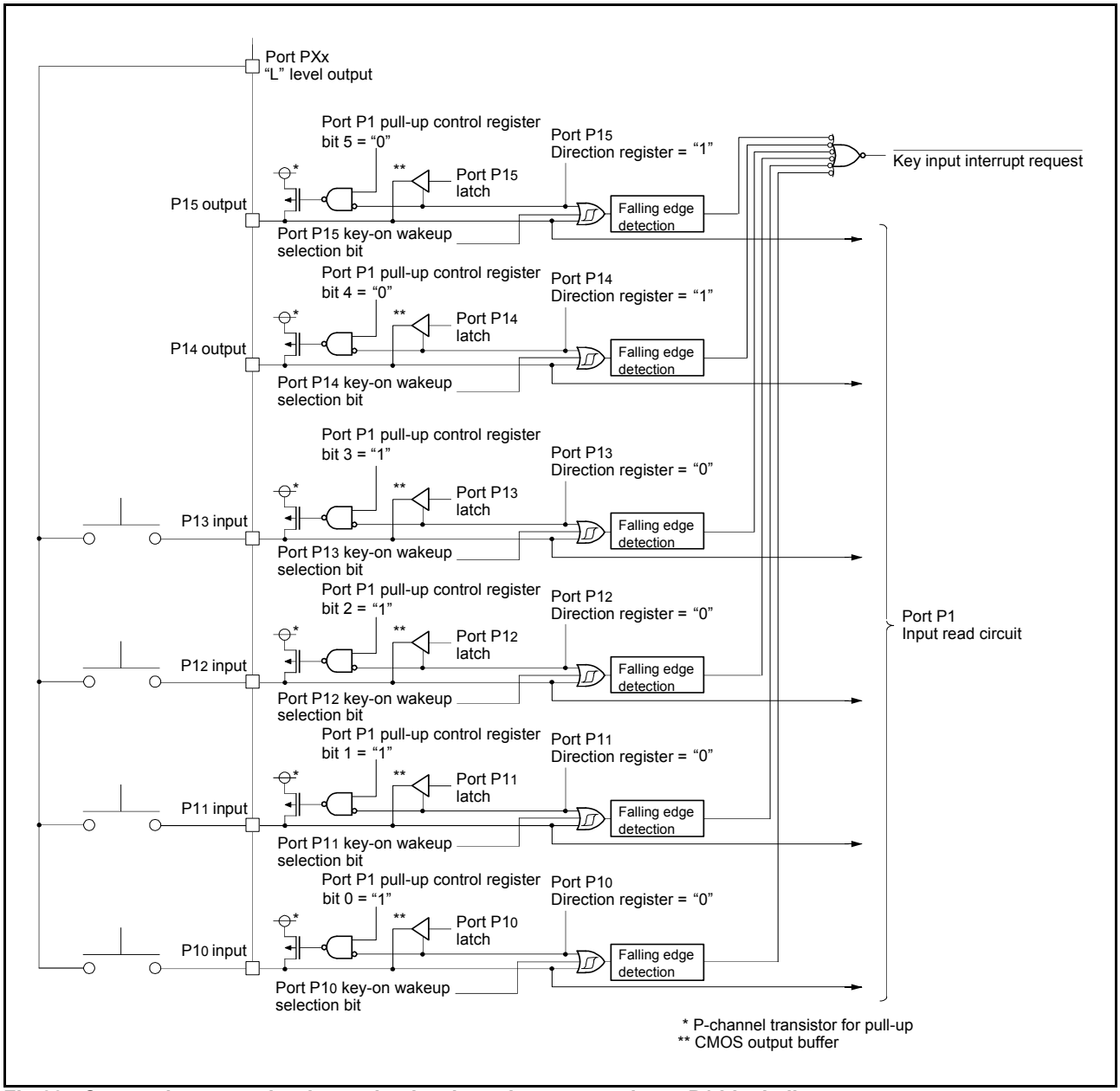


Fig 22. Connection example when using key input interrupt and port P1 block diagram

Timers

The 7548 Group has two 8-bit timers (timer 1 and timer 2) and one 16-bit timer (timer A).
Timer 1 and timer 2 share the same 8-bit prescaler (prescaler 12). Each timer and prescaler has a separate timer latch and prescaler latch.
The division ratio of every timer and prescaler is 1/(n+1), where n is the value of the timer latch or prescaler latch.
The timers decrement at each count clock input. When the count value reaches "0", an underflow occurs at the next count pulse. The value of the corresponding timer latch is reloaded into the timer at underflow and counting is continued. When a timer underflow occurs, the interrupt request bit corresponding to each timer is set to "1".

• Prescaler 12 (PRE12)

Prescaler 12 is an 8-bit prescaler that counts the signal selected by the prescaler 12 count source selection bit. The count source can be selected from ϕSOURCE/16 and XCIN input clock.
Writing to prescaler 12 writes the value to both the prescaler latch and prescaler.
Reading from prescaler 12 reads the prescaler 12 count value.
The initial value is set to "FF_{16}" after reset.
The division ratio of prescaler 12 is 1/(n+1), where n is the setting value.
Prescaler 12 cannot stop counting by software.

• Timer 1 (T1)

Timer 1 is an 8-bit timer that counts the prescaler 12 output.
When Timer 1 underflows, the timer 1 interrupt request bit is set to "1".
Writing to timer 1 writes the value to both the timer 1 latch and timer 1.
Reading from timer 1 reads the timer 1 count value. The initial value is set to "01_{16}" after reset.
The division ratio of timer 1 is 1/(m+1), where m is the setting value. This gives that the division ratio of prescaler 12 and timer 1 is 1/((n+1) × (m+1)), where n is the prescaler 12 setting value and m is the timer 1 setting value.
Timer 1 cannot stop counting by software.

• Timer 2 (T2)

Timer 2 is an 8-bit timer that counts the signal selected by the timer 2 count source selection bit.
The count source can be selected from among ϕSOURCE/16, /256, prescaler 12 output, and timer A output signal.
Timer 2 counts the selected count source and sets the timer 2 interrupt request bit to "1" at underflow.
When writing to timer 2, the value of the timer 2 write control bit can be used to select a write to both the timer 2 latch and timer 2 or a write to only the timer 2 latch.
Reading from timer 2 reads the timer 2 count value.
Timer 2 starts counting from "FF_{16}" after reset.
The division ratio of timer 2 is 1/(n+1), where n is the timer 2 setting value. Timer 2 stops when the timer 2 count stop bit is set to "1".
When the P13/T2OUT output valid bit is set to "1", the polarity of the waveform output from the P13/T2OUT pin can be inverted at each timer 2 underflow. The output start level of the T2OUT pin can be selected using the T2OUT polarity switch bit. When this bit is set to 0, the output starts at "H" level. When this bit is set to "1", the output starts at "L" level.

• Notes on Timers 1 and 2

(1) Reading from and Writing to Timer 1 and 2 and Prescaler 12
If the timer/prescaler count source clock and ϕSOURCE are different clocks, the timers and prescaler cannot be read or written. Select the same clock to enable read and write operations.
Note that timer 2 can be read and written even using a different clock while its counting is stopped.
① Prescaler 12 and timer 1 cannot be read/written in the following conditions:
Prescaler 12 count source: XCIN input clock
ϕSOURCE: Clock other than XCIN input clock
② Timer 2 cannot be read/written during counting in the following conditions:
Timer 2 count source: Prescaler 12
Prescaler 12 count source: XCIN input clock
ϕSOURCE: Clock other than XCIN input clock
or
Timer 2 count source: Timer A underflow
Timer A count source: XCIN input clock
ϕSOURCE: Clock other than XCIN input clock
or
Timer 2 count source: Timer A underflow
Timer A count source: low-speed on-chip oscillator output
ϕSOURCE: Clock other than low-speed on-chip oscillator

(2) Count Source of Prescaler 12
The XCIN input clock can be selected as the prescaler count source only if the 32 kHz quartz crystal oscillator is selected by the oscillation method selection bit in FSROM1.

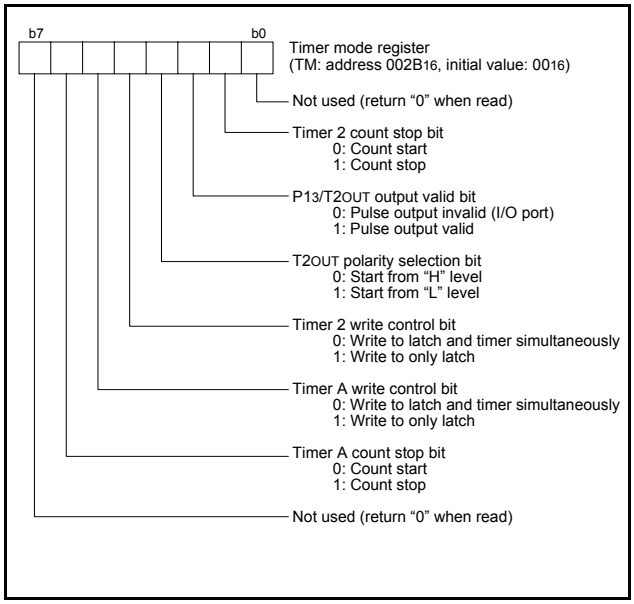


Fig 23. Structure of timer mode register

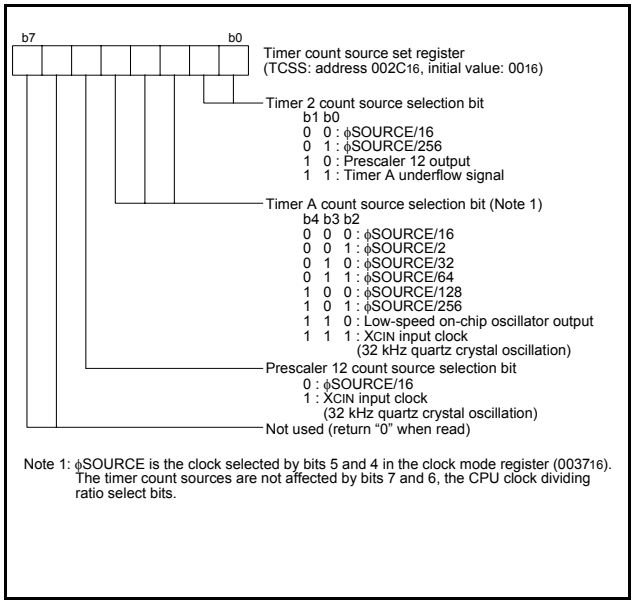


Fig 24. Structure of timer count source set register

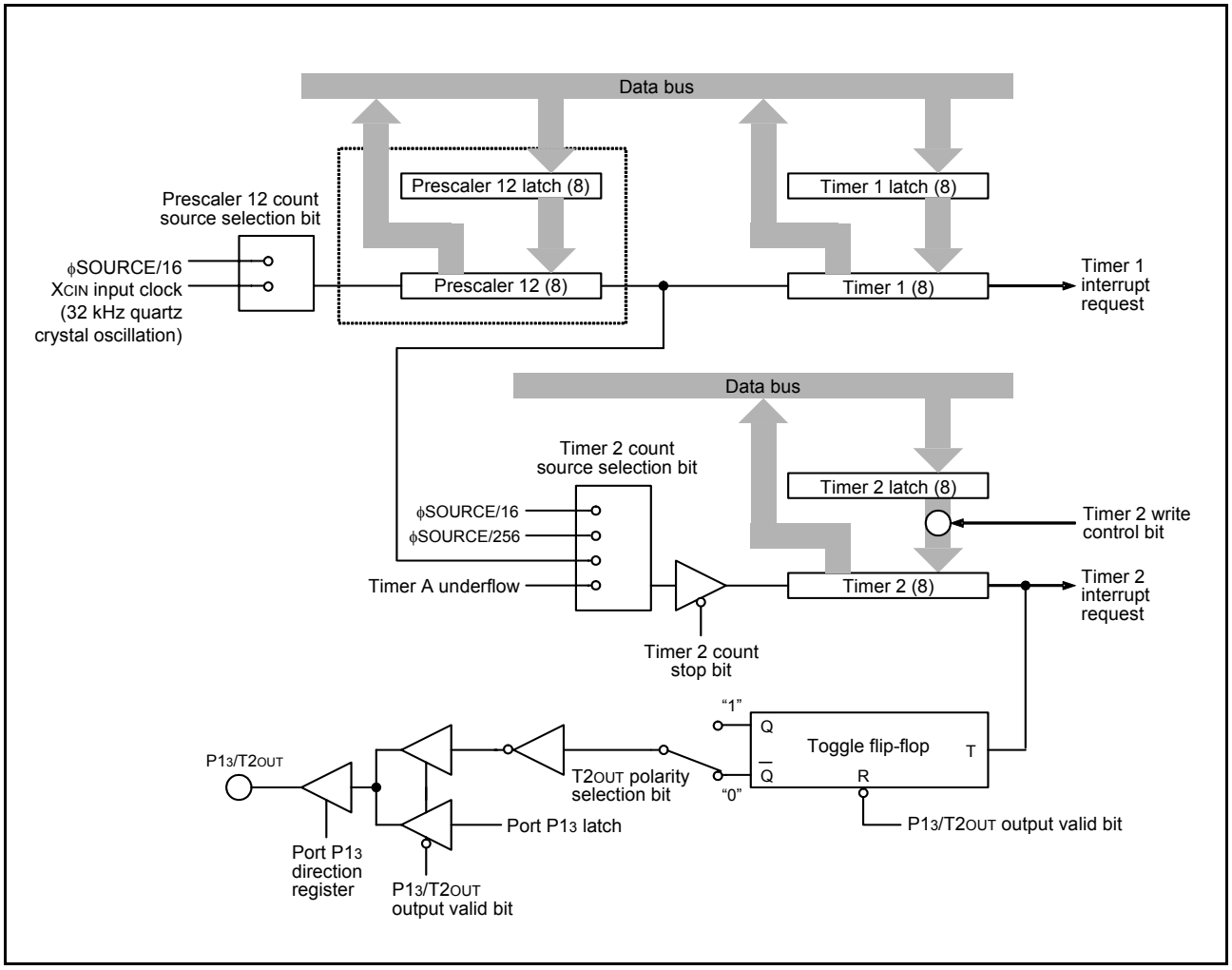


Fig 25. Block diagram of timer 1 and timer 2

Timer A (TA)

Timer A is a 16-bit timer and counts the signal selected by the timer A count source selection bit.
The count source of Timer A can be selected from among ϕSOURCE/2, /16, /32, /64, /128, /256, low-speed on-ship oscillator clock, and XCIN input clock.
Timer A counts the selected count source and sets the timer A interrupt request bit to "1".
When writing to timer A, the setting value of the timer A write control bit can be used to select a write to both the timer A latch and timer or a write to only the timer A latch.
Reading from timer A reads the timer A count value.
Be sure to write to and read from the low-order and the higher order of timer A in the following order:

- Read
  Read the high-order of Timer A (TAH) first, and the low-order of Timer A (TAL) next. Always read both of the registers.
- Write
  Write to the low-order of Timer A (TAL) first and the high-order of Timer A next. Always read both of the registers.

Counting starts from "FFFF16" after reset.
The division ratio of timer A is 1/(n+1), where n is the timer A setting value. Timer A stops when the timer A count stop bit is set to "1".
Timer A can be used as the timing timer for input capture and output compare functions.

• Notes on Timer A

(1) Timer Value Setting
When the timer A write control bit is set to "write to only latch", written data is written to only to the latch even when the timer is stopped. To set the initial setting value when the timer is stopped, select "Write to timer and latch simultaneously" beforehand.

(2) Reading from and Writing to Timer A
If the timer A count source clock and ϕSOURCE are different clocks, timer A cannot be read or written during its counting. Select the same clock or set timer A to stop counting to enable read and write operations.

- Timer A cannot be read/written in the following conditions:
  Timer A count source: XCIN input clock
  ϕSOURCE: Clock other than XCIN input clock
  or
  Timer A count source: Low-speed on-chip oscillator output
  ϕSOURCE: Clock other than low-speed on-chip oscillator

(3) Count Source of Timer A
The XCIN input clock can be selected as the count source of timer A only if the 32 kHz quartz crystal oscillator is selected by the oscillation method selection bit in FSROM1.

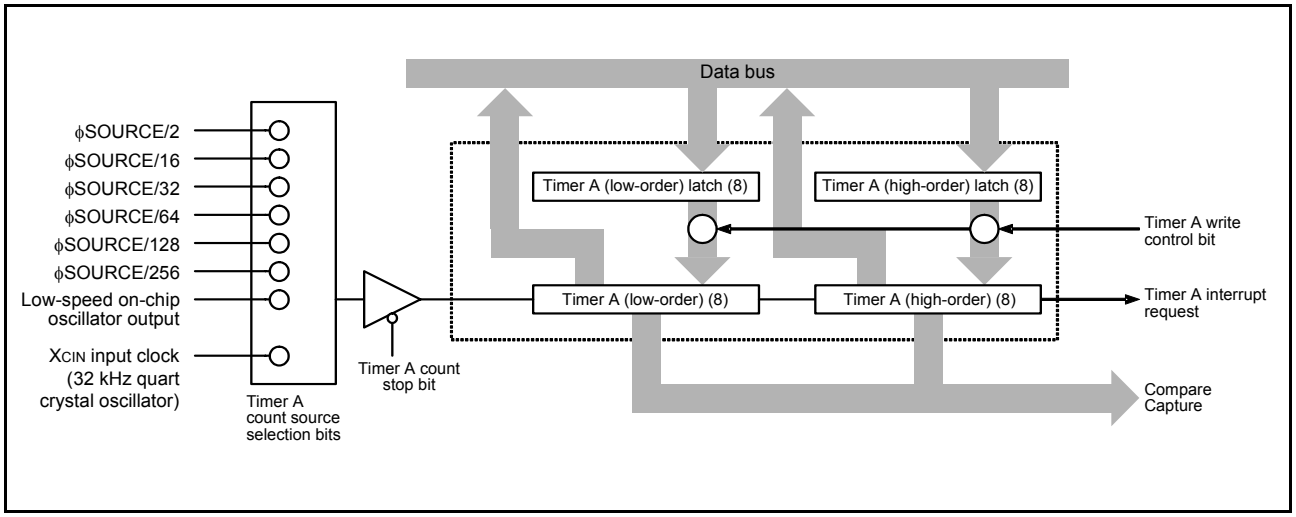


Fig 26. Block diagram of timer A

Output compare

7548 group has 3-output compare channels. Each channel (0 to 2) has the same function and can be used to output waveform by using count value of Timer A.
Three output compare channels share the registers with the input capture (one channel), but their individual circuits operate independently so that all the channels can be used at the same time.

To use each compare channel, set "1" to the compare x (x = 0, 1, 2, 3) output port bit and set the port direction register corresponding to compare channel to output mode.
The compare value for each channel is set to the capture/compare register (low-order) and capture/compare register (high-order).
Writing to the register for each channel is controlled by setting value of capture/compare register RW pointer. Writing to each register is in the following order;

1. Set the corresponding compare latch to the capture/compare register RW pointer.
2. Write a value to the capture/compare register (low-order) and capture/compare register (high-order). (It doesn't care even if either low-order or high-order is written early.)
3. Set "1" to the compare latch y (y = 00, 01, 10, 11, 20, 21) re-load bit.

When "1" is set to the compare latch y re-load bit, the value set to the compare register is loaded to compare latch when the next timer underflow.
After loading, re-load bit is set to "0" automatically.

When the count value of timer A matches the compare latch setting value, a trigger to the compare output circuit is generated. The trigger can be enabled or disabled using the compare x trigger enable bit. When the compare x trigger enable bit is set to 1, the output waveform from the port is as follows.

- When the value of the compare x output level latch is "0"
  High level at compare latch x0 match
  Low level at compare latch x1 match
- When the value of the compare x output level latch is "1"
  Low level at compare latch x0 match
  High level at compare latch x1 match

The output waveform does not change if the compare x trigger enable bit is set to 0, so the port output remains fixed at high or low level.
The compare output level of each channel can be confirmed by reading the compare x output status bit.
Compare interrupt is available when match of each compare channel and timer count value. The interrupt request from each channel can be disabled or enabled by setting value of compare latch y interrupt source selection bit.

• Notes on Output Compare

(1) If timer A is stopped, when a value is written to the capture/compare register it is immediately transferred to the compare latch. In addition, if timer A is stopped and the compare x trigger enable bit is set to "1", the output latch is initialized.
(2) Do not write the same data to both of compare latch x0 and x1.
(3) When setting value of the compare latch is larger than timer setting value, compare match signal is not generated. Accordingly, the output waveform is fixed to "L" or "H" level.
However, when setting value of another compare latch is smaller than timer setting value, this compare match signal is generated. Accordingly, compare interrupt occurs.
(4) When the compare x trigger enable bit is cleared to "0" (disabled), the match trigger to the waveform output circuit is disabled, and the output waveform can be fixed to "L" or "H" level.
However, in this case, the compare match signal is generated.
Accordingly, compare interrupt occurs.

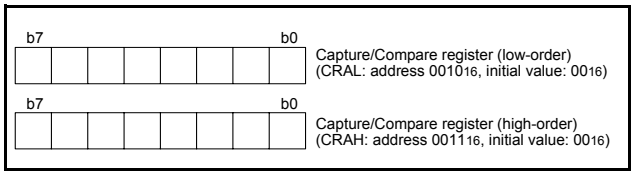


Fig 27. Structure of capture/compare register

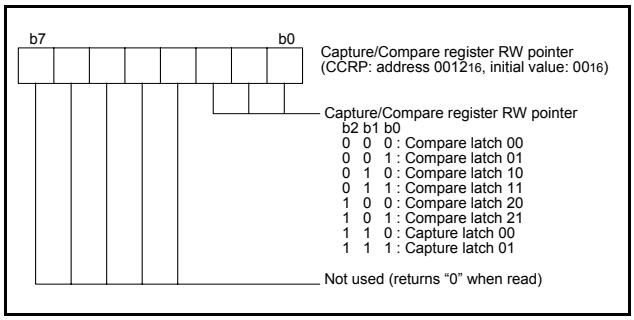


Fig 28. Structure of capture/compare register RW pointer

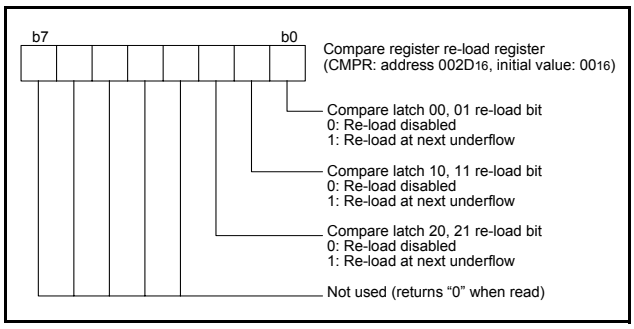


Fig 29. Structure of compare register re-load register

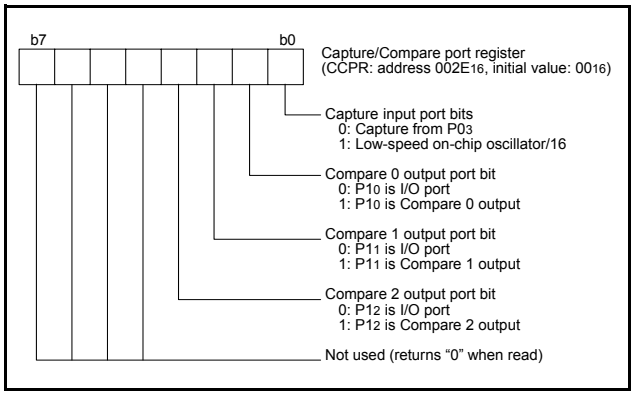


Fig 30. Structure of capture/compare port register

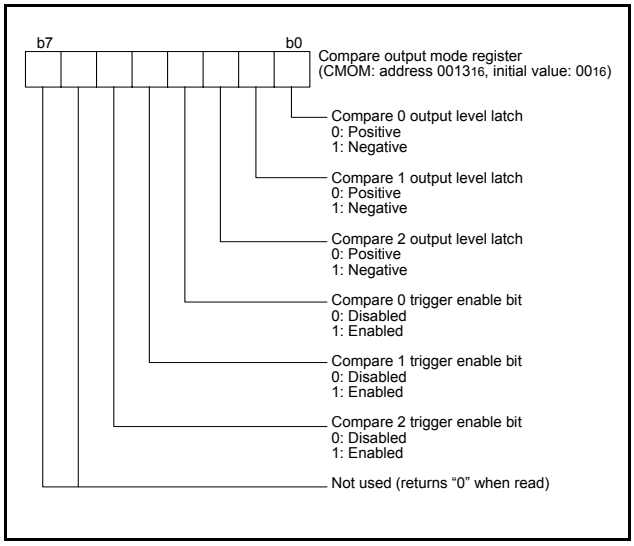


Fig 31. Structure of compare output mode register

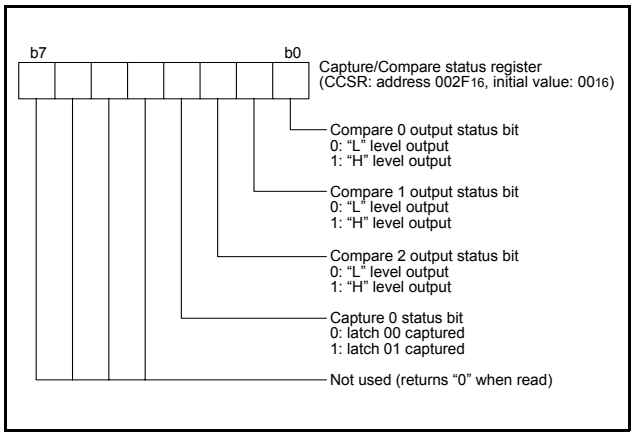


Fig 32. Structure of capture/compare status register

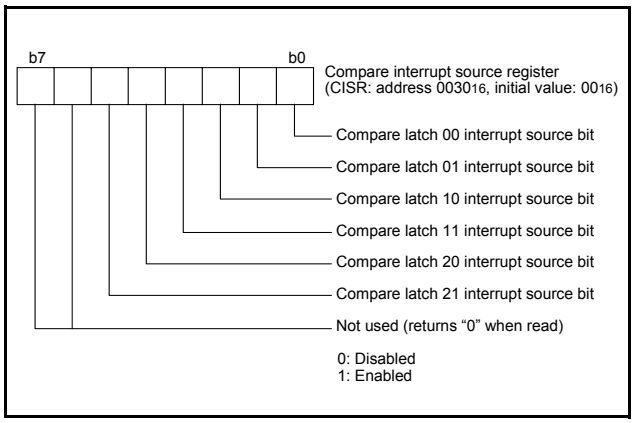


Fig 33. Structure of compare interrupt source register

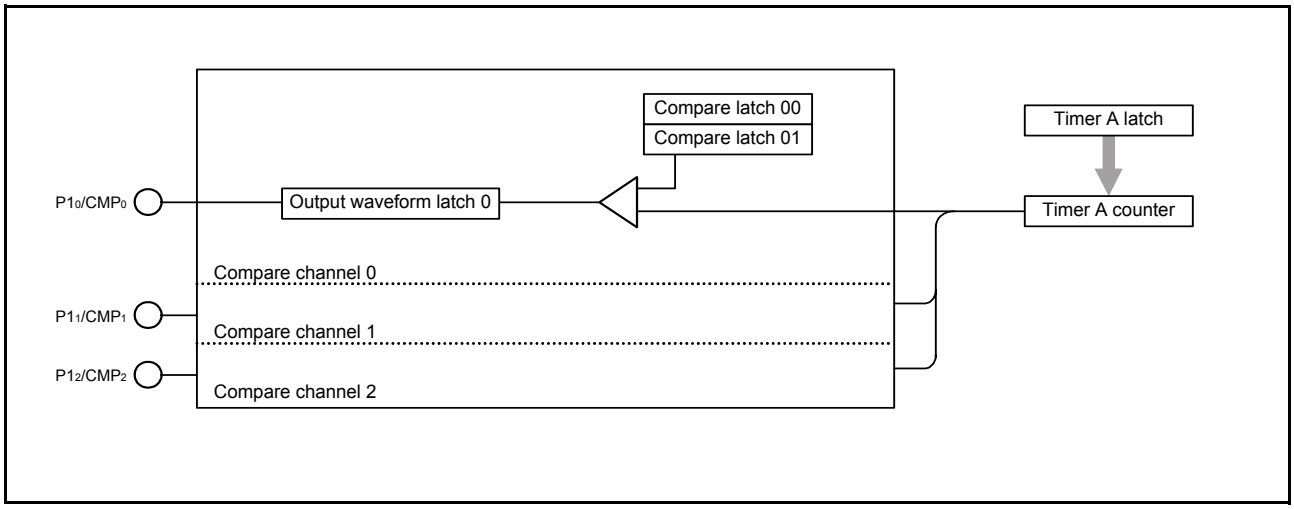


Fig 34. Block diagram of compare output circuit

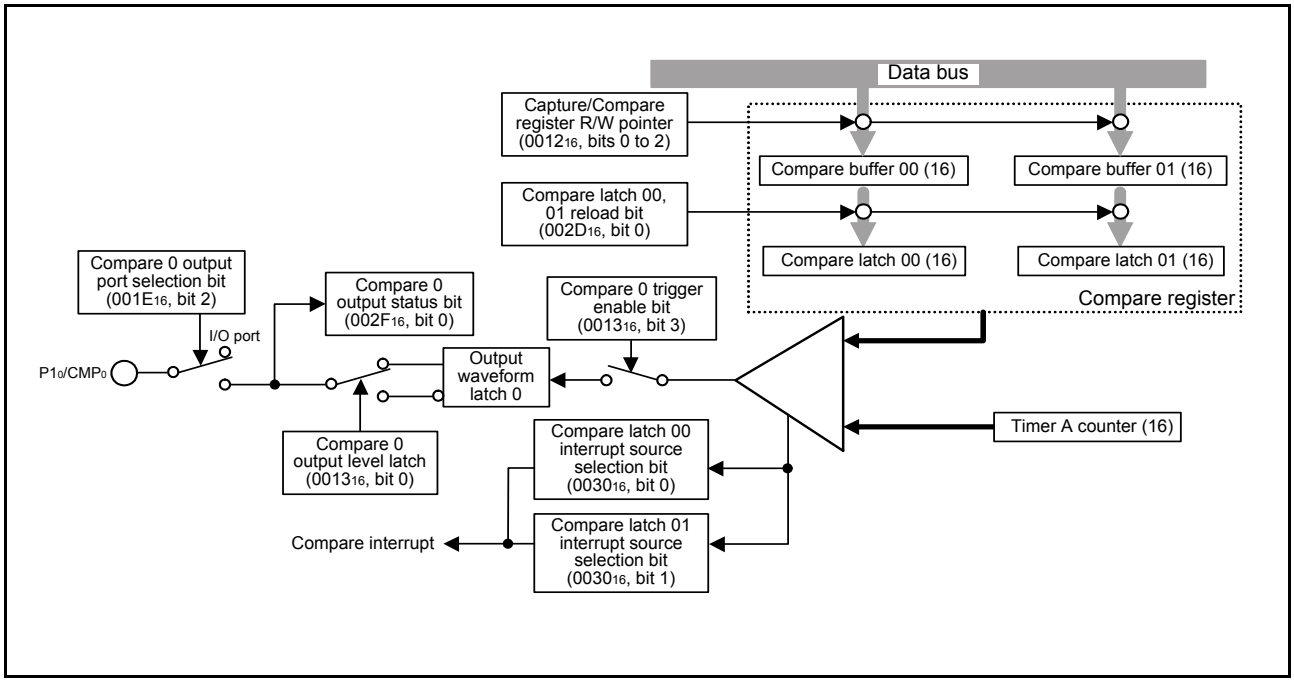
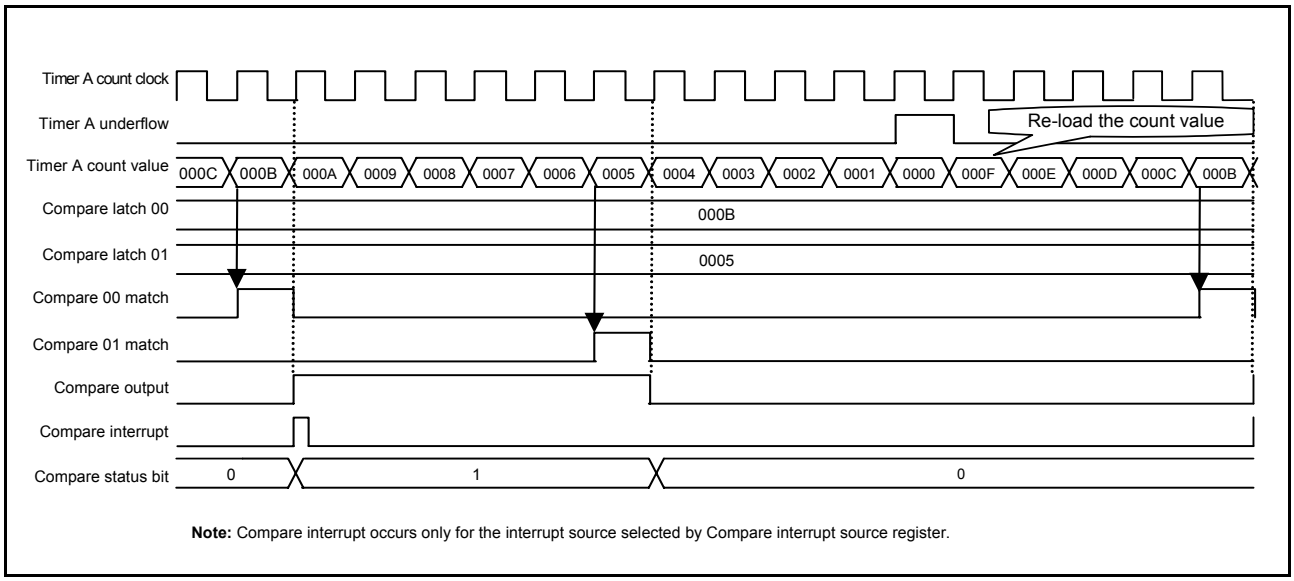


Fig 35. Block diagram of compare channel 0



Note: Compare interrupt occurs only for the interrupt source selected by Compare interrupt source register.

Fig 36. Output compare mode (general waveform)

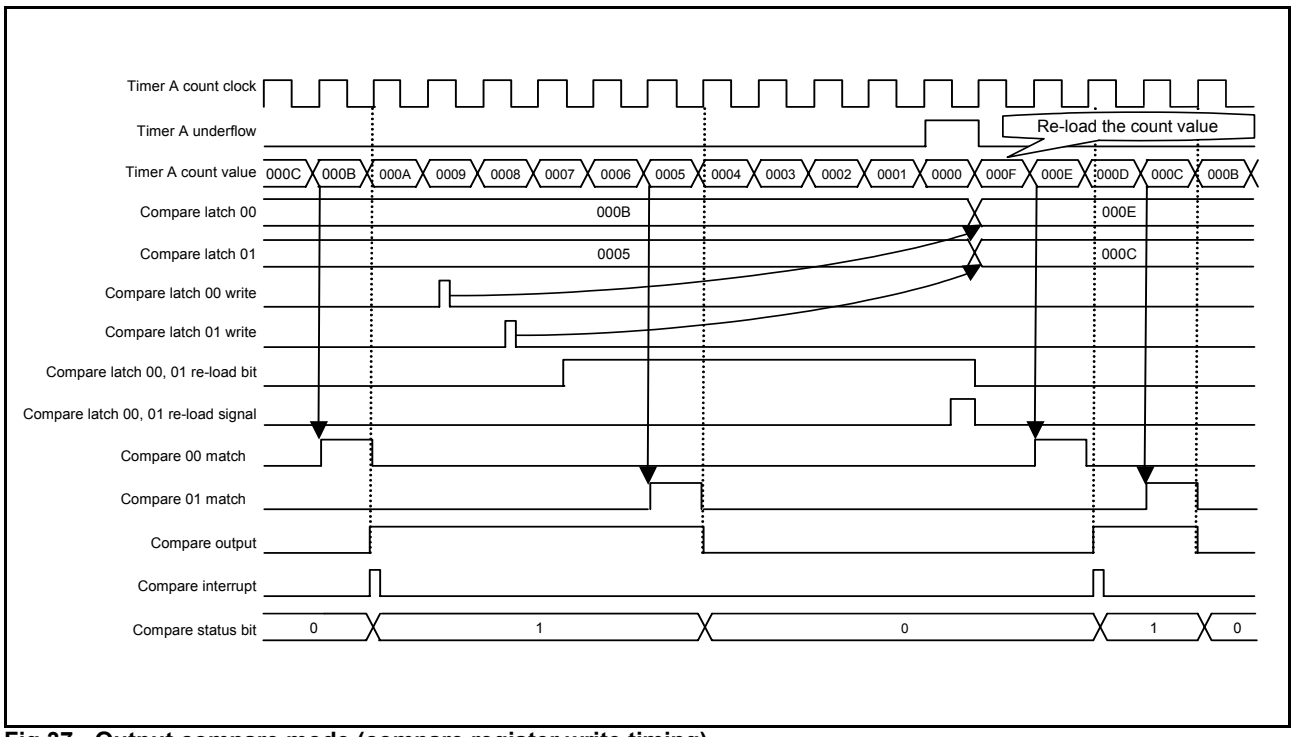


Fig 37. Output compare mode (compare register write timing)

Input capture

7548 group has 1-input capture channel and can be used to capture count value of Timer A.
Input capture shares the registers with three output capture channels, but their individual circuits operate independently so that all the channels can be used at the same time.
To use input capture, set the input capture port selection bits. If P03 is selected, set the P03 direction register to 0. When an input capture trigger is input to the input capture circuit, the count value of timer A is saved to the capture latches. The timer count value at the rising edge of the external input trigger is saved to capture latch 00, and the timer count value at the falling edge of the external input trigger is saved to capture latch 01. Capture latch 00 and capture latch 01 can be read using the following procedure.

1. Set the capture/compare register R/W pointer to the read target address.
2. Read the high-order bits of the capture/compare registers, then read the low-order bits of the capture/compare registers. (Read both the capture/compare registers in the sequence of high-order bits followed by low-order bits.)

The count value of timer can be retained by software by capture y (y = 00, 01, 10, 11) software trigger bit too. When "1" is set to this bit, count value of timer is retained to the corresponded capture latch.
When reading from the capture y software trigger bit is executed, "0" is read out.

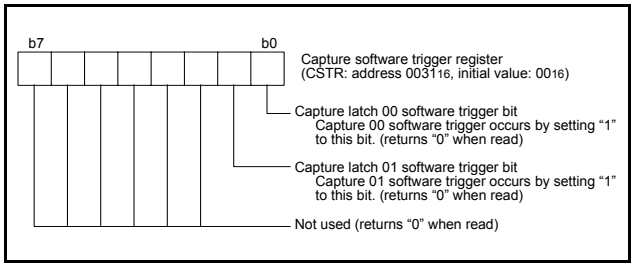


Fig 38. Structure of capture software trigger register

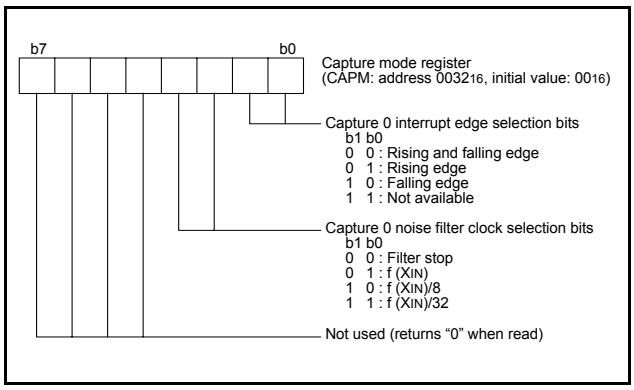


Fig 39. Structure of capture mode register

• Notes on Input Capture

- When the low-speed on-chip oscillator output or XCIN input clock is selected as the count source of timer A, input capture can be used only if the same clock source is selected as ϕSOURCE and as the count source of timer A.
- When writing "1" to capture y software trigger bit of capture latch 00 and 01 at the same time, or external trigger and software trigger occur simultaneously, if capture latches 00 and 01 are input simultaneously, the set value of capture 0 status bit is undefined.
- When setting the interrupt active edge selection bit and noise filter clock selection bit of capture 0 the interrupt request bit may be set to "1".
  When not requiring the interrupt occurrence synchronized with these setting, take the following sequence.

(1) Set the capture interrupt enable bit to "0" (disabled).
(2) Set the interrupt edge selection bit or noise filter clock selection bit.
(3) Set the corresponding interrupt request bit to "0" after 1 or more instructions have been executed.
(4) Set the capture interrupt enable bit to "1" (enabled).

- When the capture interrupt is used as the interrupt for return from stop mode, set the capture 0 noise filter clock selection bits to "00 (Filter stop)".

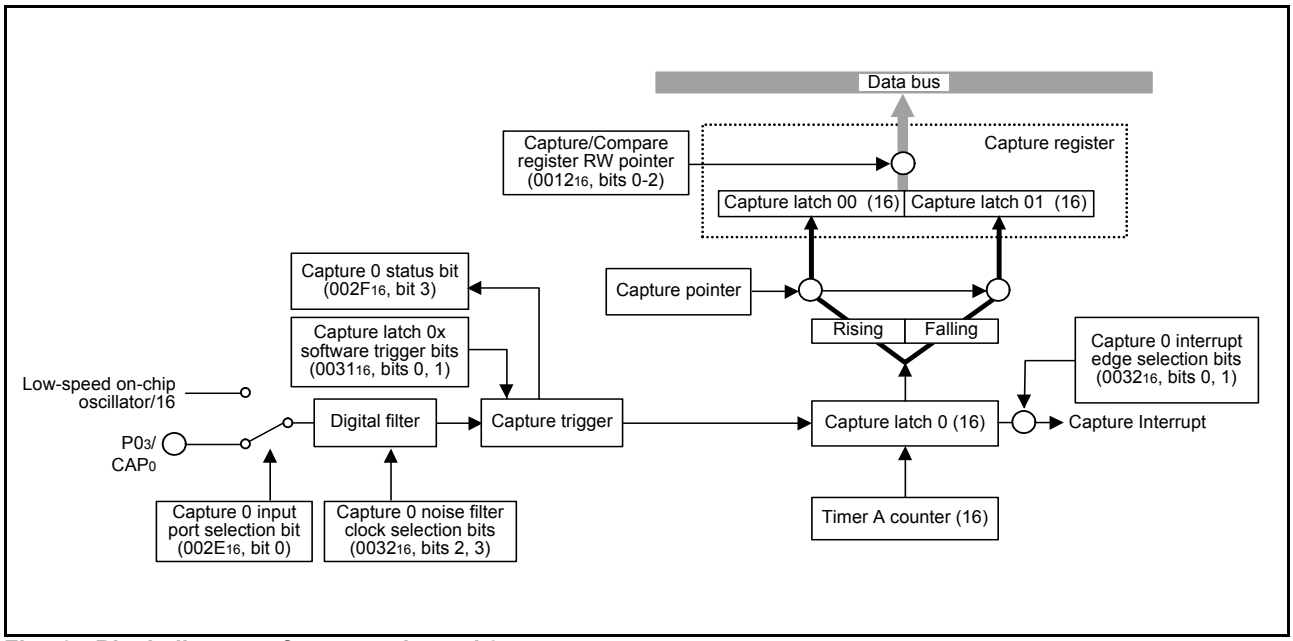


Fig 40. Block diagram of capture channel 0

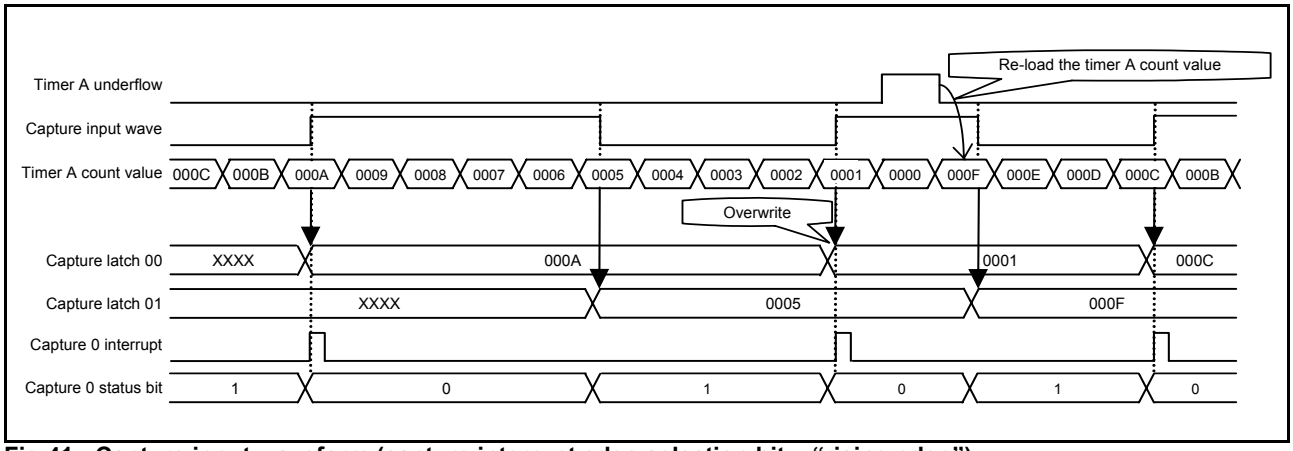


Fig 41. Capture input waveform (capture interrupt edge selection bit = “rising edge”)

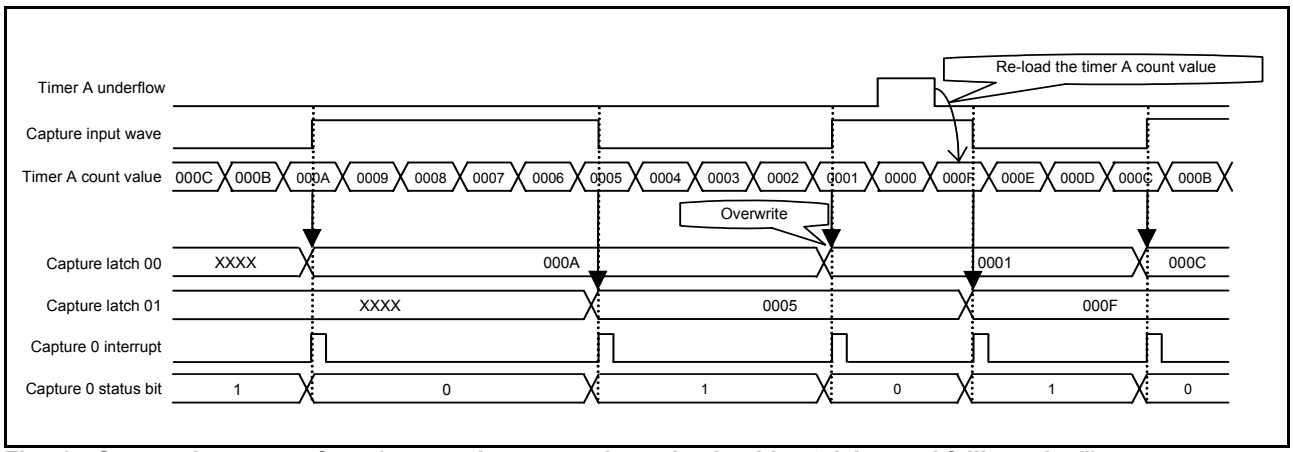


Fig 42. Capture input waveform (capture interrupt edge selection bit = “rising and falling edge”)

Serial Interface

• Serial I/O

Serial I/O can be used as either clock synchronous or asynchronous (UART) serial I/O. A dedicated timer is also provided for baud rate generation.

(1) Clock Synchronous Serial I/O Mode

Clock synchronous serial I/O mode can be selected by setting the serial I/O mode selection bit of the serial I/O control register (bit 6) to "1".

For clock synchronous serial I/O, the transmitter and the receiver must use the same clock. If an internal clock is used, transfer is started by a write signal to the TB/RB.

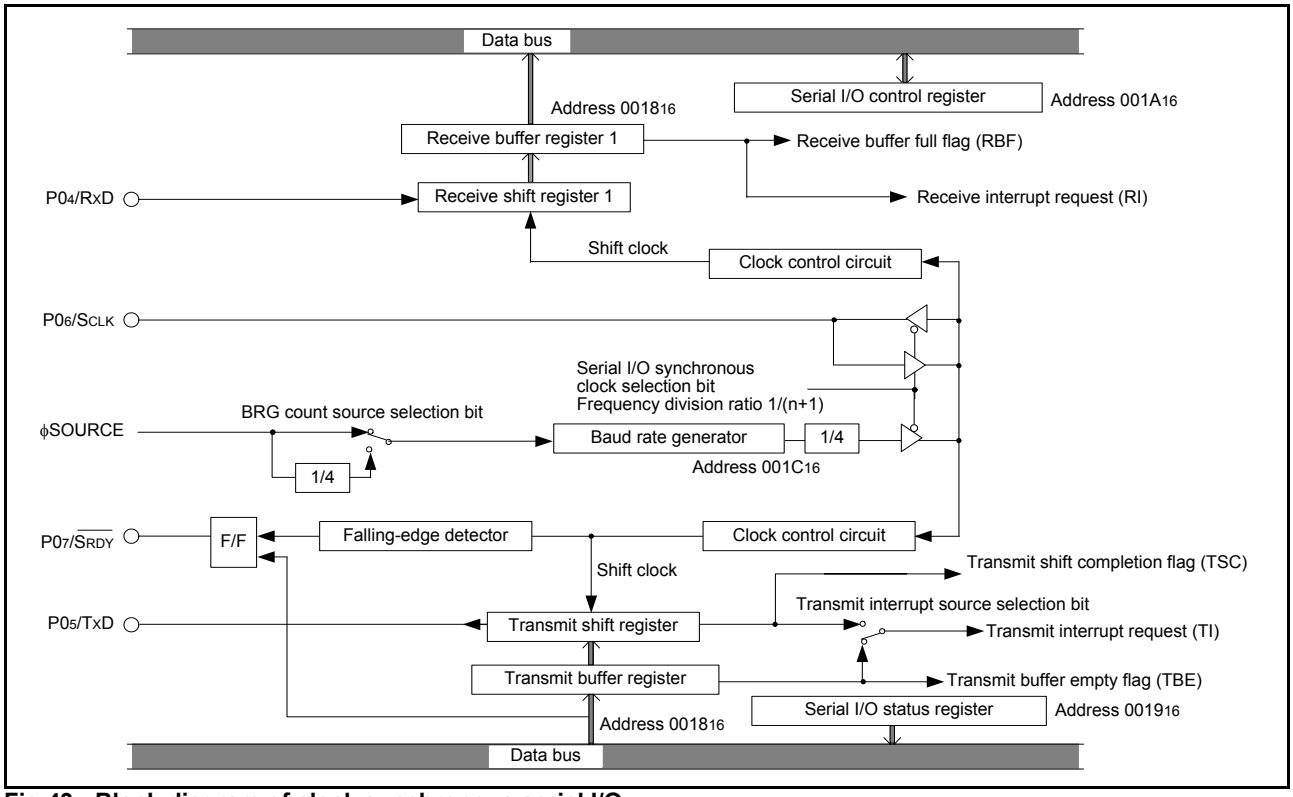
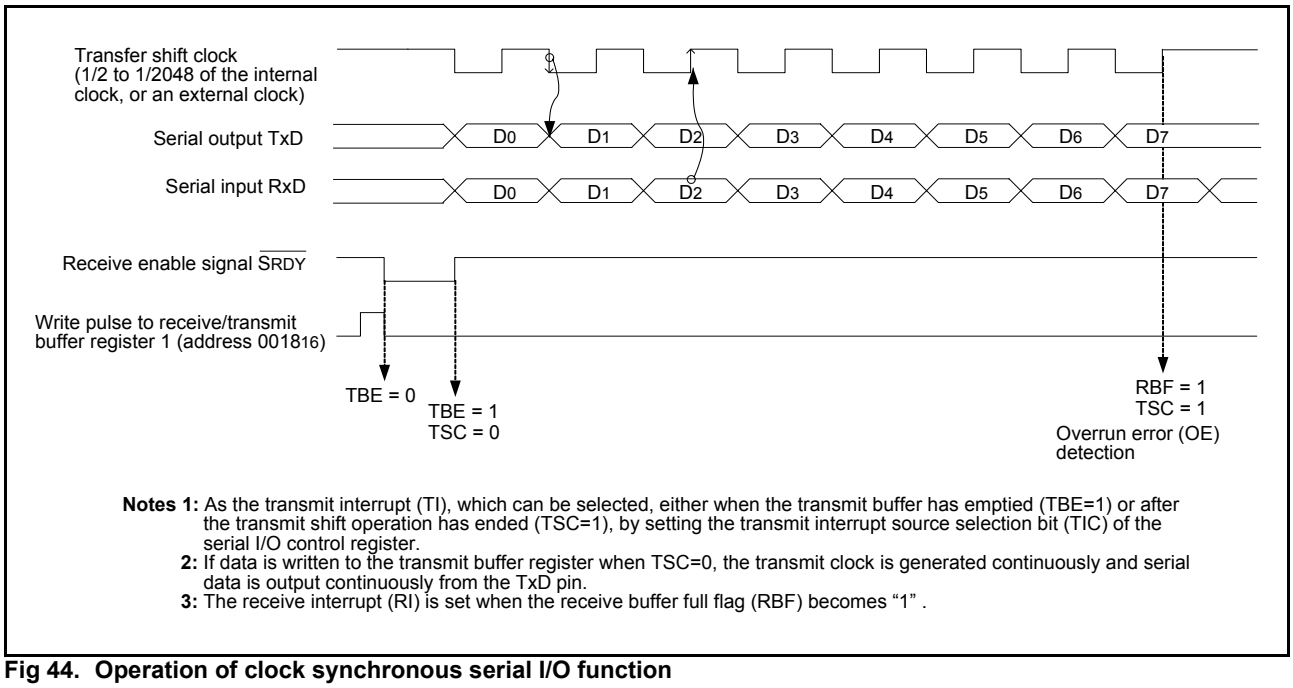


Fig 43. Block diagram of clock synchronous serial I/O



Notes 1: As the transmit interrupt (TI), which can be selected, either when the transmit buffer has emptied (TBE=1) or after the transmit shift operation has ended (TSC=1), by setting the transmit interrupt source selection bit (TIC) of the serial I/O control register.
2: If data is written to the transmit buffer register when TSC=0, the transmit clock is generated continuously and serial data is output continuously from the TxD pin.
3: The receive interrupt (RI) is set when the receive buffer full flag (RBF) becomes "1" .

Fig 44. Operation of clock synchronous serial I/O function

(2) Asynchronous Serial I/O (UART) Mode

Clock asynchronous serial I/O mode (UART) can be selected by clearing the serial I/O mode selection bit of the serial I/O control register to "0".
Eight serial data transfer formats can be selected, and the transfer formats used by a transmitter and receiver must be identical.

The transmit and receive shift registers each have a buffer, but the two buffers have the same address in memory. Since the shift register cannot be written to or read from directly, transmit data is written to the transmit buffer register, and receive data is read from the receive buffer register.
The transmit buffer register can also hold the next data to be transmitted, and the receive buffer register can hold a character while the next character is being received.

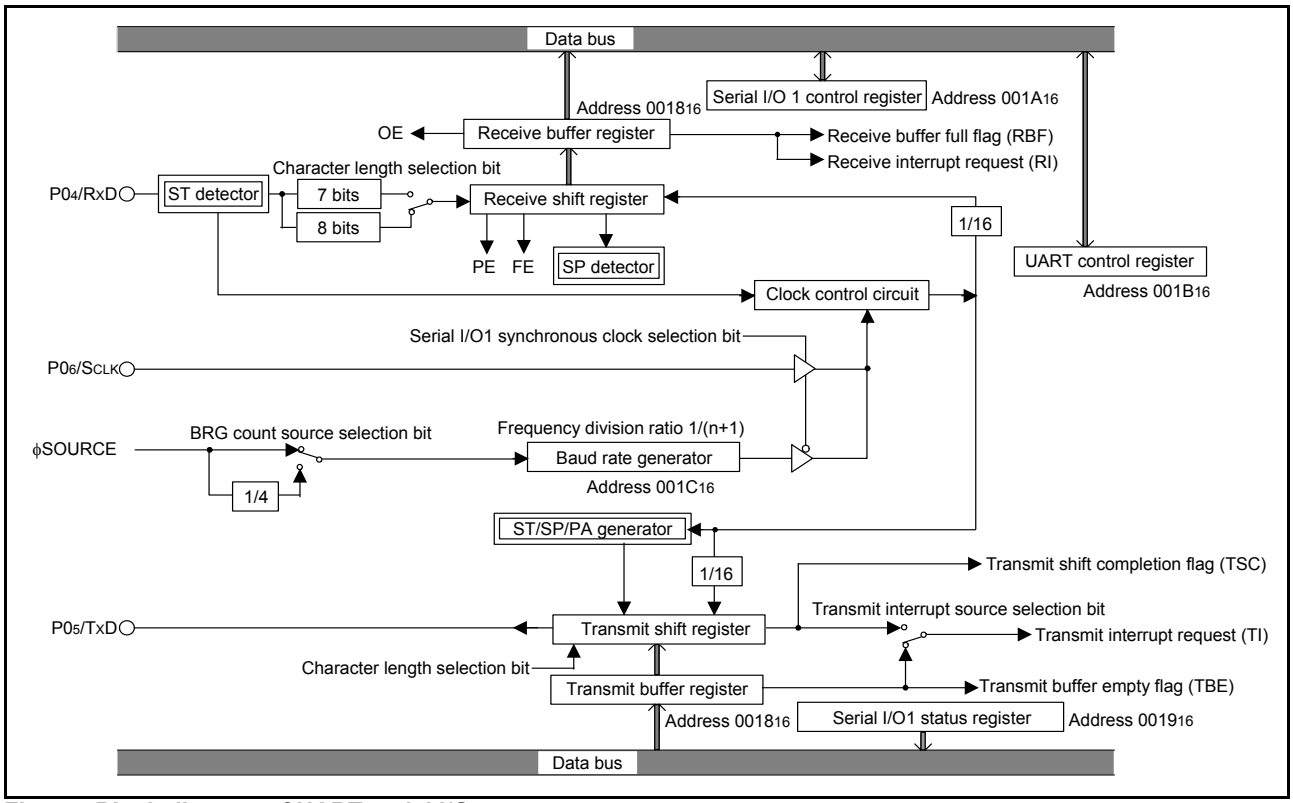
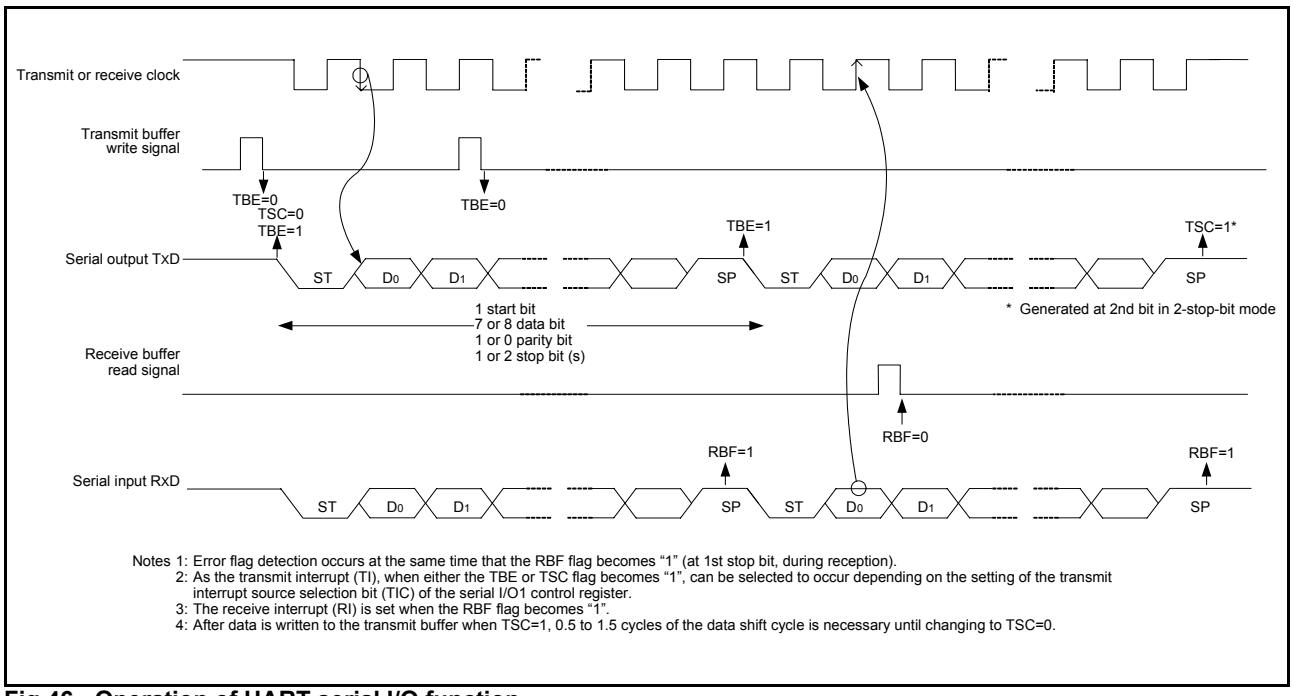


Fig 45. Block diagram of UART serial I/O



Notes 1: Error flag detection occurs at the same time that the RBF flag becomes "1" (at 1st stop bit, during reception).
2: As the transmit interrupt (TI), when either the TBE or TSC flag becomes "1", can be selected to occur depending on the setting of the transmit interrupt source selection bit (TIC) of the serial I/O1 control register.
3: The receive interrupt (RI) is set when the RBF flag becomes "1".
4: After data is written to the transmit buffer when TSC=1, 0.5 to 1.5 cycles of the data shift cycle is necessary until changing to TSC=0.

Fig 46. Operation of UART serial I/O function

[Transmit buffer register/receive buffer register (TB/RB)] 0018$_{16}$

The transmit buffer register and the receive buffer register are located at the same address. The transmit buffer is write-only and the receive buffer is read-only. If a character bit length is 7 bits, the MSB of data stored in the receive buffer is "0".

[Serial I/O status register (SIOSTS)] 0019$_{16}$

The read-only serial I/O status register consists of seven flags (bits 0 to 6) which indicate the operating status of the serial I/O function and various errors.
Three of the flags (bits 4 to 6) are valid only in UART mode.
The receive buffer full flag (bit 1) is cleared to "0" when the receive buffer register is read.
If there is an error, it is detected at the same time that data is transferred from the receive shift register to the receive buffer register, and the receive buffer full flag is set. A write to the serial I/O status register clears all the error flags OE, PE, FE, and SE (bit 3 to bit 6, respectively). Writing "0" to the serial I/O enable bit SIOE (bit 7 of the serial I/O control register) also clears all the status flags, including the error flags.
Bits 0 to 6 of the serial I/O status register are initialized to "0" at reset, but if the transmit enable bit of the serial I/O control register has been set to "1", the transmit shift completion flag (bit 2) and the transmit buffer empty flag (bit 0) become "1".

[Serial I/O control register (SIOCON)] 001A$_{16}$

The serial I/O control register consists of eight control bits for the serial I/O function.

[UART control register (UARTCON)] 001B$_{16}$

The UART control register consists of four control bits (bits 0 to 3) which are valid when asynchronous serial I/O is selected and set the data format of an data transfer and one bit (bit 4) which is always valid and sets the output structure of the P05/TxD pin.

[Baud rate generator (BRG)] 001C$_{16}$

The baud rate generator determines the baud rate for serial transfer.
The baud rate generator divides the frequency of the count source by 1/(n + 1), where n is the value written to the baud rate generator.

•Notes on Serial I/O

• Serial I/O interrupt

When setting the transmit enable bit to "1", the serial I/O transmit interrupt request bit is automatically set to "1". When not requiring the interrupt occurrence synchronized with the transmission enabled, take the following sequence.

1. Set the serial I/O transmit interrupt enable bit to "0" (disabled).
2. Set the transmit enable bit to "1".
3. Set the serial I/O transmit interrupt request bit to "0" after 1 or more instructions have been executed.
4. Set the serial I/O transmit interrupt enable bit to "1" (enabled).

• I/O pin function when serial I/O is enabled.

The functions of P06 and P07 are switched with the setting values of a serial I/O mode selection bit and a serial I/O synchronous clock selection bit as follows.

(1) Serial I/O mode selection bit → "1" :
Clock synchronous type serial I/O is selected.
Setup of a serial I/O synchronous clock selection bit
"0" : P06 pin turns into an output pin of a synchronous clock.
"1" : P06 pin turns into an input pin of a synchronous clock.
Setup of a $\overline{\text{SRDY}}$ output enable bit (SRDY)
"0" : P07 pin can be used as a normal I/O pin.
"1" : P07 pin turns into a $\overline{\text{SRDY}}$ output pin.

(2) Serial I/O mode selection bit → "0" :
Clock asynchronous (UART) type serial I/O is selected.
Setup of a serial I/O synchronous clock selection bit
"0" : P06 pin can be used as a normal I/O pin.
"1" : P06 pin turns into an input pin of an external clock.
When clock asynchronous (UART) type serial I/O is selected, it is P07 pin. It can be used as a normal I/O pin.

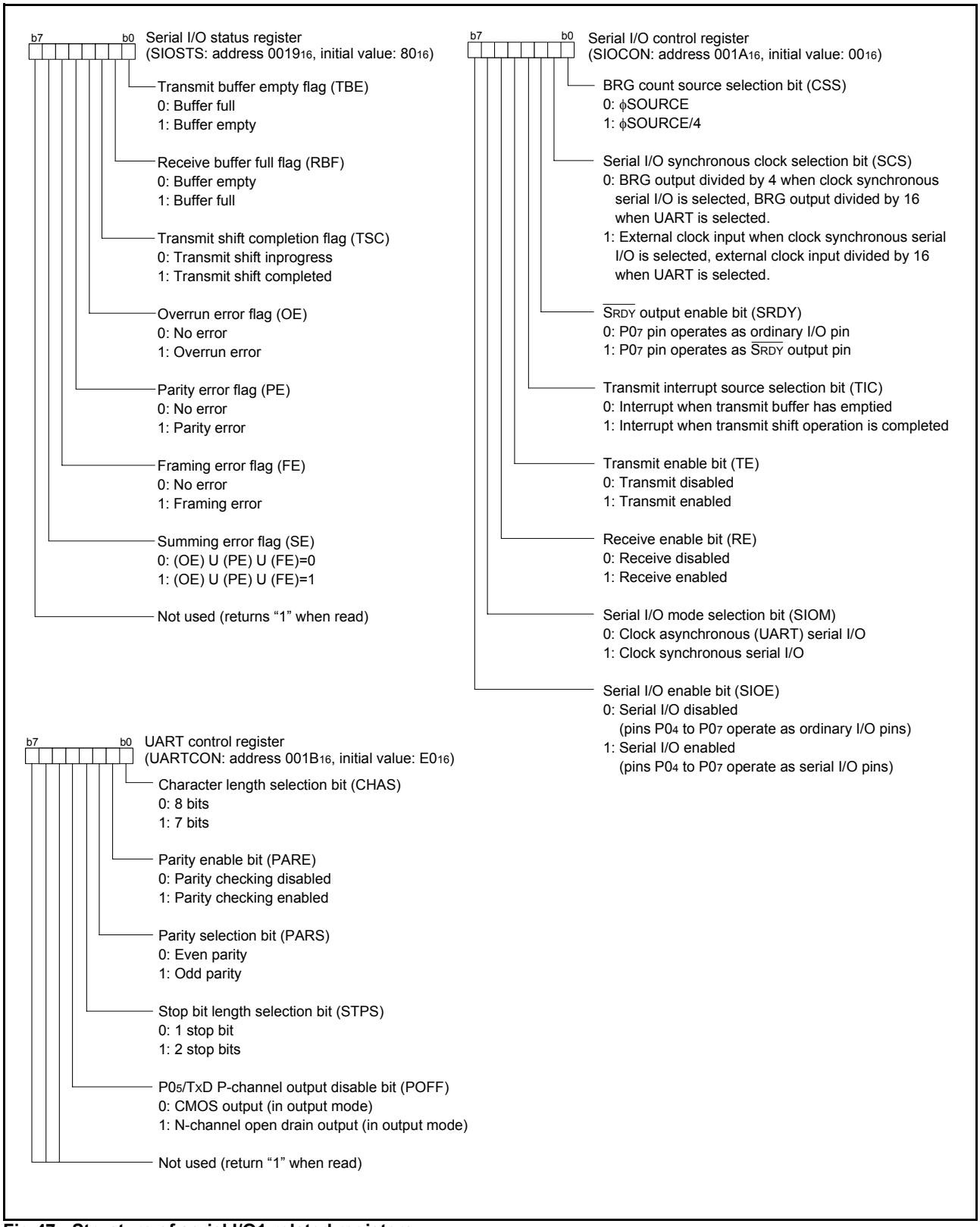


Fig 47. Structure of serial I/O1-related registers

A/D Converter

The functional blocks of the A/D converter are described below.

[AD conversion register] AD

The A/D conversion register is a read-only register that stores the result of A/D conversion. Do not read out this register during an A/D conversion.

[AD control register] ADCON

The AD control register controls the A/D converter.
Bit 2 to 0 are analog input pin selection bits.
Bit 3 is the AD conversion clock selection bit. When "0" is set to this bit, the A/D conversion clock is ϕSOURCE/2 and the A/D conversion time is 122 cycles of ϕSOURCE. When "1" is set to this bit, the A/D conversion clock is ϕSOURCE and the A/D conversion time is 61 cycles of ϕSOURCE.
Bit 4 is the AD conversion completion bit. The value of this bit remains at "0" during A/D conversion, and changes to "1" at completion of A/D conversion.
A/D conversion is started by setting this bit to "0".

[Comparison voltage generator]

The comparison voltage generator divides the voltage between V_{SS} and V_{CC} by 1024, and outputs the divided voltages.

[Channel selector]

The channel selector selects one of ports $P1_5/AN_5$ to $P1_0/AN_0$, and inputs the voltage to the comparator.

[Comparator and control circuit]

The comparator and control circuit compares an analog input voltage with the comparison voltage and stores its result into the AD conversion register. When A/D conversion is completed, the control circuit sets the AD conversion completion bit and the A/D interrupt request bit to "1". Because the comparator is constructed linked to a capacitor, set ϕSOURCE in order that the A/D conversion clock is 250 kHz or over during A/D conversion.

• Notes on A/D converter

As for AD translation accuracy, on the following operating conditions,
accuracy may become low.

(1) When V_{CC} voltage is lower than [3.0 V], the accuracy at the low temperature may become extremely low compared with that at room temperature. When the system would be used at low temperature, the use at V_{CC} = 3.0 V or more is recommended.

(2) When X_{CIN} or the low-speed on-chip oscillator is selected as ϕSOURCE, the A/D converter cannot be used.

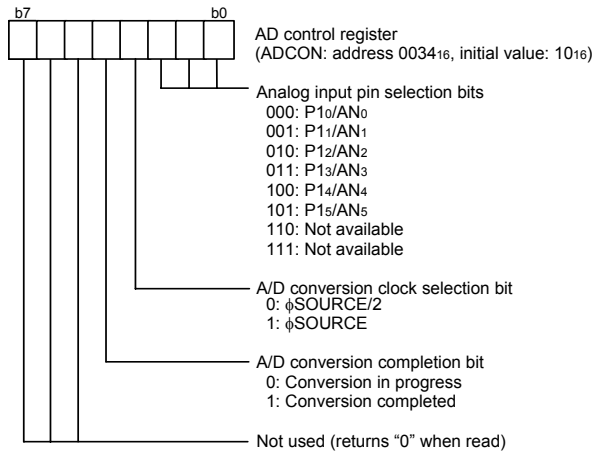


Fig 48. Structure of AD control register

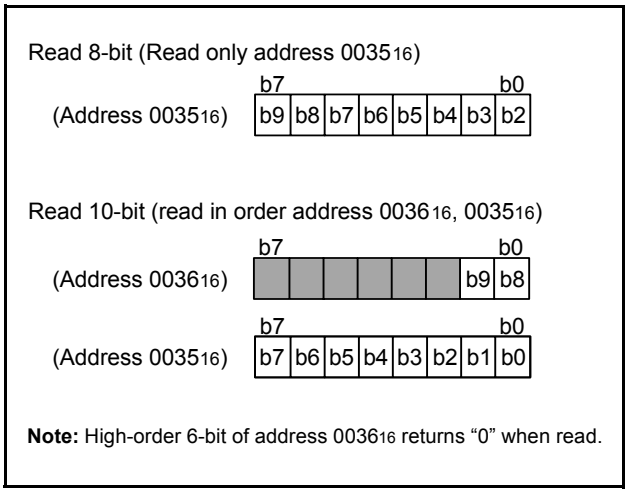


Fig 49. Structure of AD conversion register

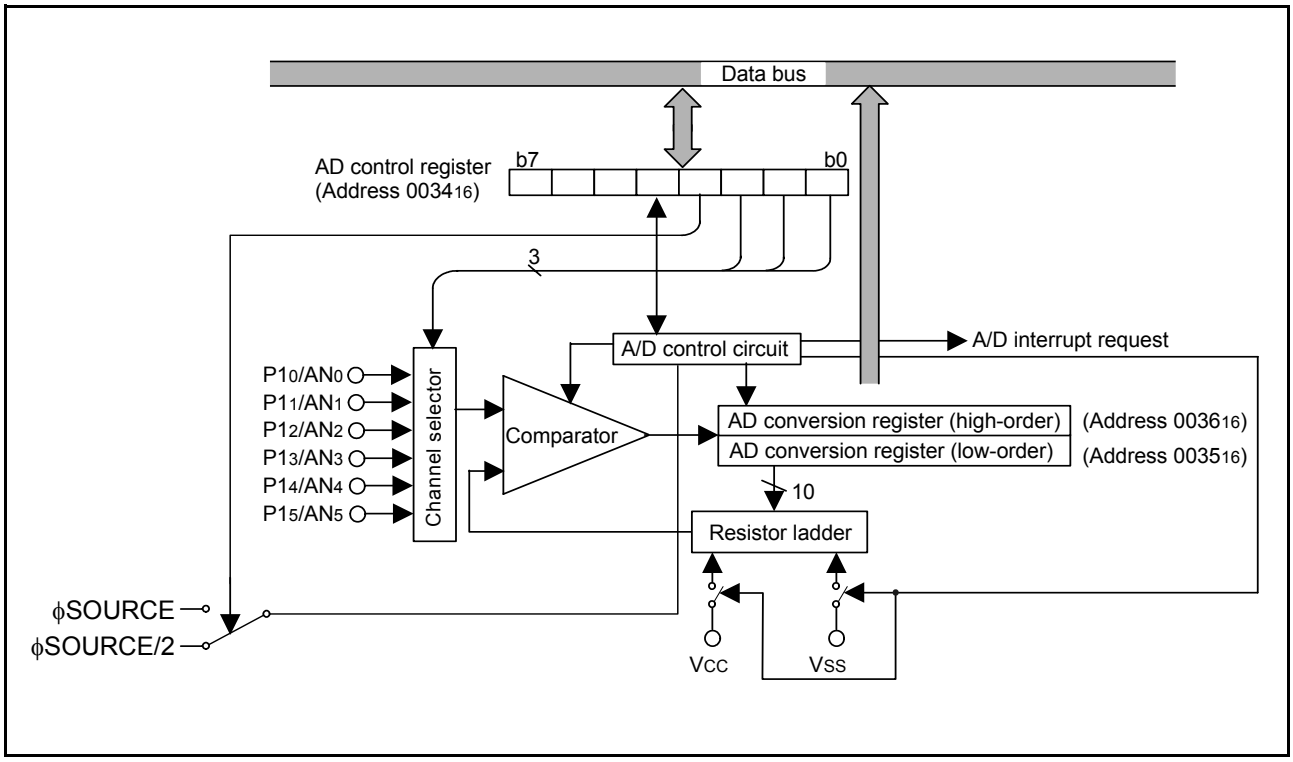


Fig 50. Block diagram of A/D converter

Watchdog Timer

The watchdog timer gives a means for returning to a reset status when the program fails to run on its normal loop due to a runaway. The watchdog timer consists of an 8-bit watchdog timer H and an 8-bit watchdog timer L, being a 16-bit counter. The operation of the watchdog timer is controlled by bits 2 to "0" in function set ROM data 2 and the watchdog timer control register.

• Watchdog timer disable bit

When the watchdog timer disable bit (bit 1 in function set ROM data 2(FSROM2)) is set to "0", the watchdog timer is enabled and starts counting after reset.
Setting this bit to "1" does not operate the watchdog timer.
This bit cannot be rewritten by executing the instruction.
To use the watchdog timer, always set this bit to "0".
After reset, the watchdog timer cannot start counting by a program.

• Watchdog timer source clock selection bit

The count source of the watchdog timer is selected by the watchdog timer source clock selection bit (bit 0 in FSROM2). This bit cannot be rewritten by executing the instruction.
When this bit is set to "0", the count source is always set to the low-speed on-chip oscillator output/16.
When this bit is set to "1", the count source is set to ϕSOURCE/16. ϕSOURCE is changed by setting the clock selection bits (bits 5 and 4 in the clock mode register (CLKM: address 0037_{16})).

• Watchdog timer H count source selection bit

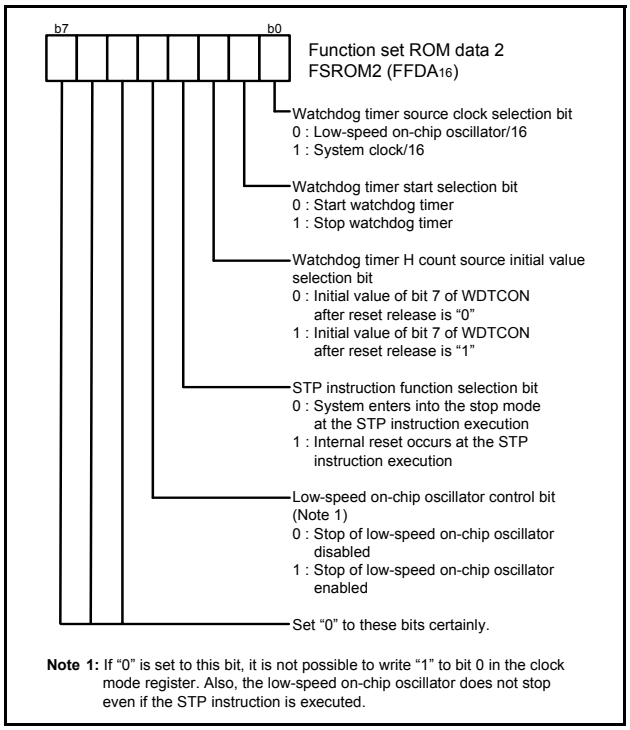
The count source of watchdog timer H is selected by the watchdog timer control register (WDTCON: address 0039_{16}).
When the watchdog timer H count source selection bit (bit 7 in WDTCON) is set to "0", the count source is set to an underflow signal from watch dog timer L. When this bit is set to "1", the clock selected as the count source of watchdog timer L is input to watchdog timer H.
The initial value of this bit after releasing reset can be set by the bit 2 in FSROM2.

• Watchdog Timer Operation

Resetting or writing any data to WDTCON sets watchdog timer H to "FF_{16}" and watchdog timer L to "FF_{16}". When the watchdog timer starts, the selected clock is counted and internal reset occurs by the watchdog timer H underflow. Writing to WDTCON is usually programmed to be performed before underflow.
Reading WDTCON reads the values of the high-order 6 bits in the watchdog timer H counter and the watch dog timer count source selection bit.

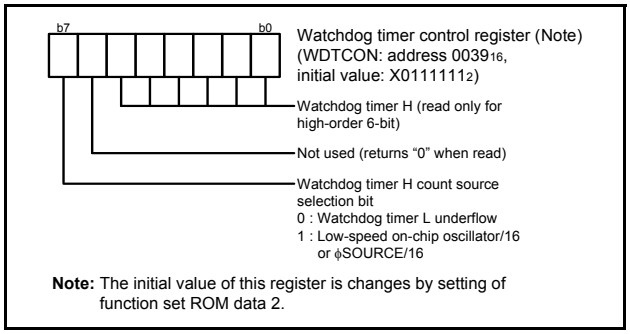
The following shows the time to watchdog timer underflow after writing to the watchdog timer control register.
The example applies when the XIN input clock is selected as ϕSOURCE and f(XIN) = 8 MHz.

- Watchdog timer H count source selection bit = 0: 131.072 ms
- Watchdog timer H count source selection bit = 1: 512 µs



Note 1: If "0" is set to this bit, it is not possible to write "1" to bit 0 in the clock mode register. Also, the low-speed on-chip oscillator does not stop even if the STP instruction is executed.

Fig 51. Structure of Function set ROM data 2



Note: The initial value of this register is changes by setting of function set ROM data 2.

Fig 52. Structure of watchdog timer control register

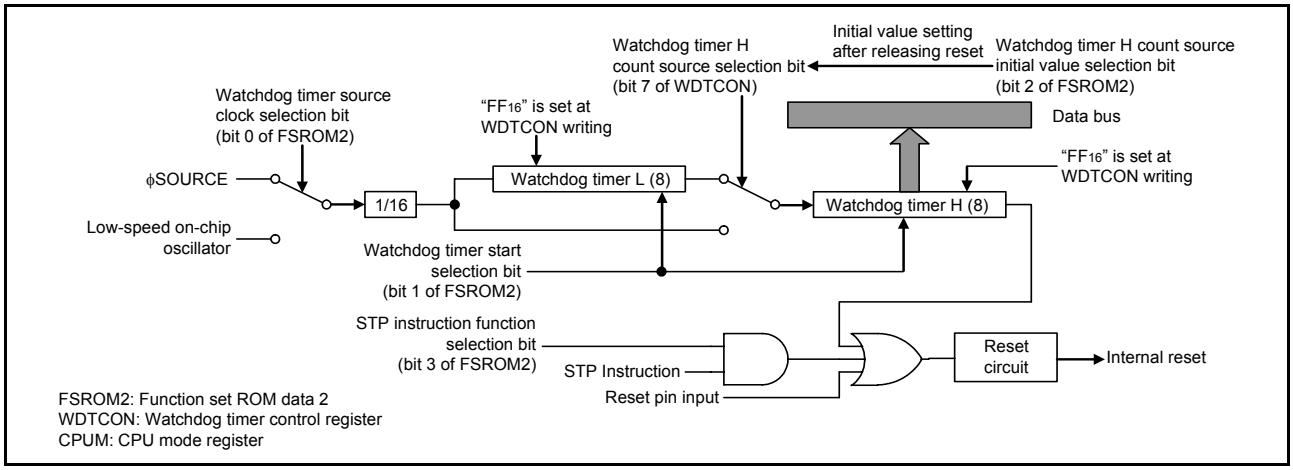


Fig 53. Block diagram of watchdog timer

• Notes on Watchdog Timer

(1) The watchdog timer operates in wait mode. To prevent underflow, write to the watchdog timer control register.
The watchdog timer stops in stop mode, but starts counting at the same time as exiting stop mode. After exiting stop mode, it continues counting during oscillation stabilization time. To prevent underflow during the period, the watchdog timer H count source selection bit (bit 7) in the watchdog timer control register (address 0039_{16}) should be set to "0" before executing the STP instruction.
Note that the watchdog timer continues counting even if the STP instruction is executed in the following two conditions:
① Stopping the low-speed on-chip oscillator: Disabled (bit 4 in FSROM2)
Source clock of the watchdog timer: Low-speed on-chip oscillator/16 (bit 0 in FSROM2)
② Stopping the low-speed on-chip oscillator: Disabled (bit 4 in FSROM2)
Source clock of the watchdog timer: ϕSOURCE (bit 0 in FSROM2)
ϕSOURCE: Low-speed on-chip oscillator (bits 5 and 4 in CLKM)

(2) STP instruction function selection bit
The function of the STP instruction can be selected by the bit 2 in FSROM2. This bit cannot be used for rewriting by executing the STP instruction.
- When this bit is set to "0", stop mode is entered by executing the STP instruction.
- When this bit is set to "1", internal reset occurs by executing the STP instruction.

Power-on Reset Circuit

Reset can be automatically performed at power on (power-on reset) by the built-in power-on reset circuit.
To use the built-in power-on reset circuit, leave the $\overline{\text{RESET}}$ pin open (the pull-up resistor is built-in).

Low Voltage Detection Circuit

The built-in low voltage detection circuit is designed to detect a drop in voltage and to reset the microcomputer if the power source voltage drops below a set value (Typ.1.95 V).
The low voltage detection circuit is valid by setting "1" to bit 0 of the function set ROM data 0.
Also, when "1" is set to bit 2 of the function set ROM data 1, the low voltage detection circuit can be valid even in the stop mode.
The low voltage detection circuit is stopped in the stop mode by setting "0" to this bit, so that the power dissipation is reduced.

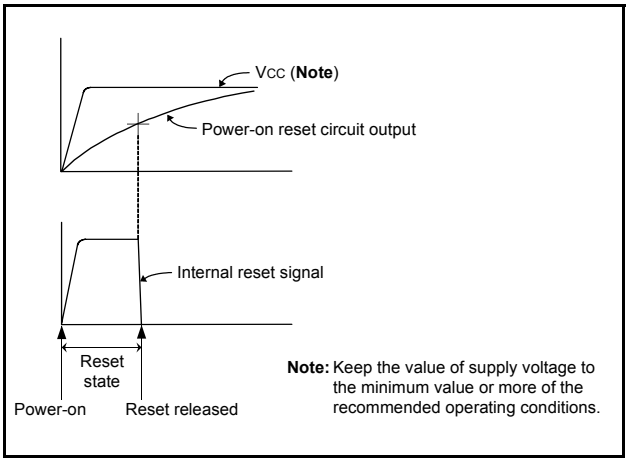


Fig 54. Operation waveform diagram of power-on reset circuit

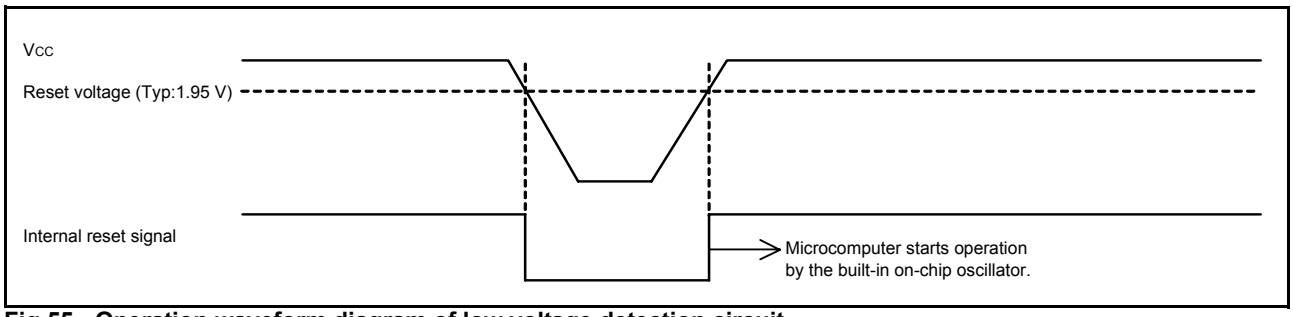


Fig 55. Operation waveform diagram of low voltage detection circuit

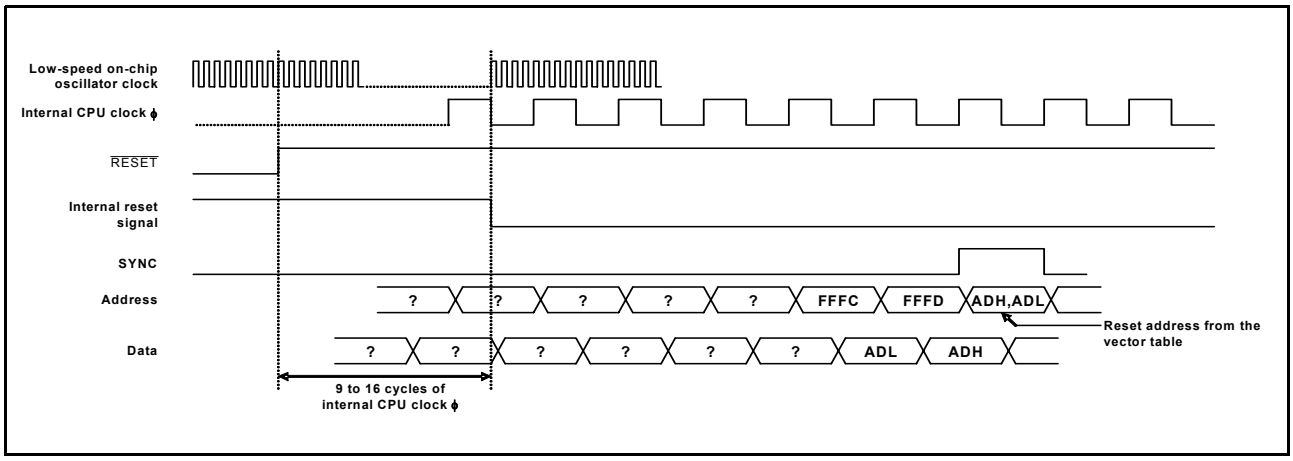


Fig 56. Timing diagram at reset

(1)	Port P0 direction register (P0D)	0001_{16}	00_{16}						
(2)	Port P1 direction register (P1D)	0003_{16}	00_{16}						
(3)	Port P2 direction register (P2D)	0005_{16}	00_{16}						
(4)	Port P3 direction register (P3D)	0007_{16}	00_{16}						
(5)	Port P0 drive capacity control register (DCCR)	$000C_{16}$	00_{16}						
(6)	Port P0 pull-up control register (PULL0)	$000D_{16}$	00_{16}						
(7)	Port P1 pull-up control register (PULL1)	$000E_{16}$	00_{16}						
(8)	Key-on wakeup input selection register (KEYS)	$000F_{16}$	00_{16}						
(9)	Capture/Compare register (low-order) (CRAL)	0010_{16}	00_{16}						
(10)	Capture/Compare register (high-order) (CRAH)	0011_{16}	00_{16}						
(11)	Capture/Compare register R/W pointer (CCRP)	0012_{16}	00_{16}						
(12)	Compare output mode register (CMOM)	0013_{16}	00_{16}						
(13)	Timer A (low-order) (TAL)	0014_{16}	FF_{16}						
(14)	Timer A (high-order) (TAH)	0015_{16}	FF_{16}						
(15)	Serial I/O status register (SIOSTS)	0019_{16}	1	0	0	0	0	0	0	0
(16)	Serial I/O control register (SIOCON)	$001A_{16}$	00_{16}						
(17)	UART control register (UARTCON)	$001B_{16}$	1	1	1	0	0	0	0	0
(18)	Prescaler 12 (PRE12)	0028_{16}	FF_{16}						
(19)	Timer 1 (T1)	0029_{16}	0	0	0	0	0	0	0	1
(20)	Timer 2 (T2)	$002A_{16}$	FF_{16}						
(21)	Timer mode register (TM)	$002B_{16}$	00_{16}						
(22)	Timer count source set register (TCSS)	$002C_{16}$	00_{16}						
(23)	Compare register re-load register (CMPR)	$002D_{16}$	00_{16}						
(24)	Capture/Compare port register (CCPR)	$002E_{16}$	00_{16}						
(25)	Capture/Compare status register (CCSR)	$002F_{16}$	00_{16}						
(26)	Compare interrupt source set register (CISR)	0030_{16}	00_{16}						
(27)	Capture software trigger register (CSTR)	0031_{16}	00_{16}						
(28)	Capture mode register (CAPM)	0032_{16}	00_{16}						
(29)	AD control register (ADCON)	0034_{16}	0	0	0	1	0	0	0	0
(30)	Clock mode register (CLKM)	0037_{16}	0	0	0	0	0	0	1	0
(31)	Oscillation stop detection register (CLKSTP)	0038_{16}	00_{16}						
(32)	Watchdog timer control register (WDTCON)	0039_{16}	Note 4	0	1	1	1	1	1	1
(33)	Interrupt edge selection register (INTEDGE)	$003A_{16}$	00_{16}						
(34)	CPU mode register (CPUM)	$003B_{16}$	00_{16}						
(35)	Interrupt request register 1 (IREQ1)	$003C_{16}$	00_{16}						
(36)	Interrupt request register 2 (IREQ2)	$003D_{16}$	00_{16}						
(37)	Interrupt control register 1 (ICON1)	$003E_{16}$	00_{16}						
(38)	Interrupt control register 2 (ICON2)	$003F_{16}$	00_{16}						

Notes 1: X : Undefined
2: The content of other registers is undefined when the microcomputer is reset.
The initial values must be surely set before you use it.
3: Do not access to the SFR area including nothing.
4: When the setting by the function set ROM data 2 (FSROM2) is performed,
the initial values of this bit at reset are changed.

Fig 57. Timing diagram at reset

Clock Circuit

The clock circuit includes the XIN clock (ceramic oscillator or crystal oscillator can be used), XCIN clock (32 kHz oscillator can be used), external clock input, high-speed on-chip oscillator, and low-speed on-chip oscillator.
Pins P20/XOUT/XCOUT and P21/XIN/XCIN can be shared for the ports, XIN oscillation, and XCIN oscillation.
Use the oscillation method selection bits (bits 1 and bit 0 in function set ROM data 1 (FSROM1)) to set the function of these pins.

• Ceramic Resonator or Crystal Oscillator

Set the oscillation method selection bits (bits 1 and bit 0 in FSROM1) to "01$_2$", and connect the resonator (or the oscillator) and external circuit with the shortest wiring length possible.
The constants of the oscillator circuit differ depending on the resonator. Use the values recommended by the resonator manufacturer. (An external feedback resistor may be necessary under some conditions.)
Setting the XIN/XCIN oscillation control bit to "0" starts oscillation. This bit is sets to "0" after reset.

• 32 kHz Crystal Oscillator

Set the oscillation method selection bits to "10$_2$", and connect the 32 kHz crystal oscillator and external circuit with the shortest wiring length possible.
The constants of the oscillator circuit differ depending on the resonator. Use the values recommended by the resonator manufacturer. (An external feedback resistor may be necessary under some conditions.)
Setting the XIN/XCIN oscillation control bit to "0" starts oscillation. This bit is sets to "0" after reset.

• External Clock Input

Set the oscillation method selection bits to "11$_2$", and connect the clock source to the P20/XOUT pin. In this case, the P21/XIN pin can be used as an I/O port.

• High-Speed On-Chip Oscillator

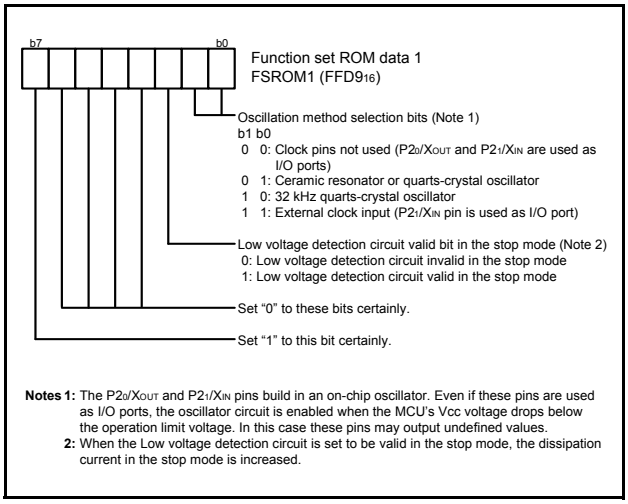
The high-speed on-chip oscillator is stopped after reset.
Setting the high-speed on-chip oscillator oscillation control bit (bit 1 in CLKM) to "0" starts oscillation. This bit is sets to "1" after reset.

• Low-Speed On-Chip Oscillator

The low-speed on-chip oscillator automatically starts oscillating after reset.
Setting the low-speed on-chip oscillator oscillation control bit (bit 0 in CLKM) to "1" stops oscillation. This bit is sets to "0" after reset. If the low-speed on-chip oscillator control bit (bit 4 in FSROM2) is set to "0" and stopping the low-speed on-chip oscillator is disabled, the low-speed on-chip oscillator oscillation control bit cannot be set to "1" and oscillation cannot be stopped. Also, the oscillator does not stop even when the STP instruction is executed.

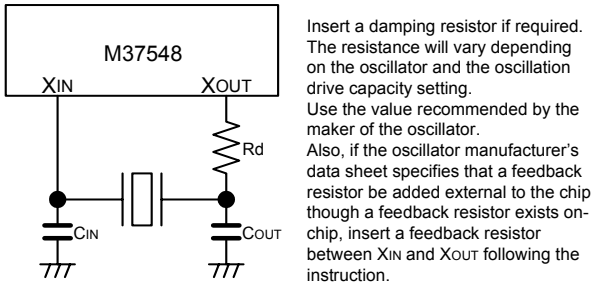
• Using No Oscillator Pins (P20 as output port and P21 as I/O port)

To use only an internal on-chip oscillator, set the oscillation method selection bits to "00$_2$". The P20/XOUT pin can be used as an output port and the P21/XIN pin can be used as an I/O port.



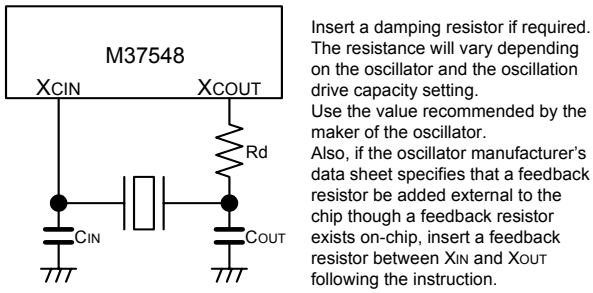
Notes 1: The P20/XOUT and P21/XIN pins build in an on-chip oscillator. Even if these pins are used as I/O ports, the oscillator circuit is enabled when the MCU's Vcc voltage drops below the operation limit voltage. In this case these pins may output undefined values.
2: When the Low voltage detection circuit is set to be valid in the stop mode, the dissipation current in the stop mode is increased.

Fig 58. Structure of function set ROM data 1



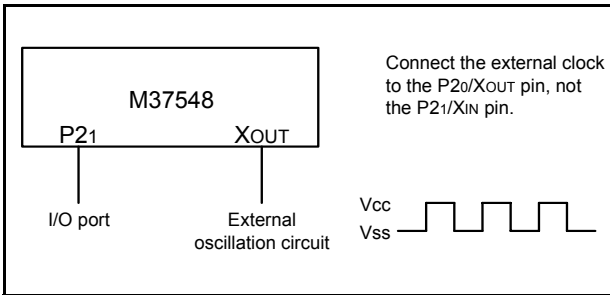
Insert a damping resistor if required. The resistance will vary depending on the oscillator and the oscillation drive capacity setting.
Use the value recommended by the maker of the oscillator.
Also, if the oscillator manufacturer's data sheet specifies that a feedback resistor be added external to the chip though a feedback resistor exists on-chip, insert a feedback resistor between XIN and XOUT following the instruction.

Fig 59. External circuit of ceramic resonator



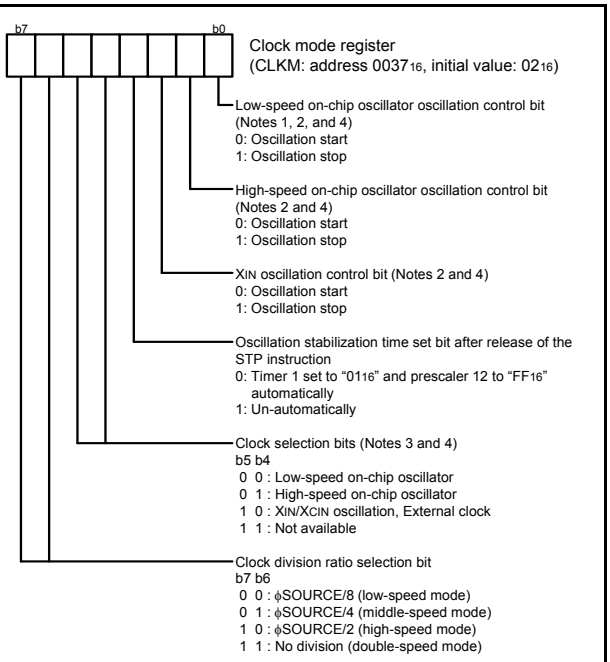
Insert a damping resistor if required. The resistance will vary depending on the oscillator and the oscillation drive capacity setting.
Use the value recommended by the maker of the oscillator.
Also, if the oscillator manufacturer's data sheet specifies that a feedback resistor be added external to the chip though a feedback resistor exists on-chip, insert a feedback resistor between XIN and XOUT following the instruction.

Fig 60. External circuit of 32 kHz quarts-crystal oscillator



Connect the external clock to the P20/XOUT pin, not the P21/XIN pin.

Fig 61. External clock input circuit



Notes 1: When stopping the low-speed on-chip oscillator is disabled by setting the low-speed on-chip oscillator control bit (bit 4 in FSROM2), "1" cannot be written to this bit. The low-speed on-chip oscillator does not stop even in stop mode.
2: "1" cannot be written to the oscillation control bits (bits 2 to 0) of the clock selected as ϕSOURCE by the clock selection bits.
3: When "oscillation pins not used" is set by the oscillation method selection bits (bits 1 and 0 in FSROM1), "10₂" cannot be written to these bits.
4: Do not change the values of the clock selection bits and the clock oscillation control bits at the same time using a single instruction. Always use different instructions to rewrite these values.

Fig 62. Structure of clock mode register

• Note on Clock Circuit

• Switching to XIN/XCIN Oscillator

After a reset is cleared, operation starts using the low-speed on-chip oscillator. When switching to XIN/XCIN oscillator, make sure to set a sufficient wait duration with the on-chip oscillator to allow the XIN/XCIN oscillator to stabilize.

Oscillation Control

• Clock mode register

Clock mode register contains the oscillation control bits of each oscillation circuits, clock selection bits and etc

• Clock selection bits

ϕSOURCE can be selected by the clock selection bits (bits 5 and 4 in clock mode register). ϕSOURCE can be selected from low-speed on-chip oscillator, high-speed on-chip oscillator, XIN/XCIN oscillation or external clock input by the clock selection bits. ϕSOURCE is also used to the clock for peripheral functions.
When the oscillation method selection bits (bits 1 and 0 in FSROM1) is set to "00$_2$" (oscillation pins not used), setting the clock selection bits to "10$_2$" (XIN/XCIN oscillation, external clock input) is disabled.

• Clock division ratio selection bit

The internal clock ϕ is generated by dividing ϕSOURCE.
Select the division ratio using the clock division ration selection bits (bits 7 and 6 in CLKM).
The division ratio can be selected from among ϕSOURCE/8 (low-speed mode), /4 (middle-speed mode), /2 (high-speed mode), and no division (double-speed mode).
Table 9 shows the division ratio (mode) settings.

When releasing reset, the low-speed on-chip oscillator is selected as ϕSOURCE, and ϕSOURCE/8 is selected as the internal clock. The high-speed on-chip oscillator is stopped at this time. If an oscillation circuit is connected to the clock pin, oscillation starts. To switch ϕSOURCE to XIN/XCIN oscillation, generate wait time using the on-chip oscillator until the oscillation is stabilized.

Table 9 Setting the clock division (mode)

ϕSOURCE	bit / Mode	CLKM					FSROM1	FSROM2
		Clock division ratio selection bits	Clock selection bits	XIN/XCIN oscillation control bit	High-speed on-chip oscillator oscillation control bit	Low-speed on-chip oscillator oscillation control bit	Oscillation method selection bits	Low-speed on-chip oscillator control bit
		Bit 7, 6	Bit 5, 4	Bit 2	Bit 1	Bit 0	Bit 1, 0	Bit 4
XIN	Double-speed	11	10	0	–	–	01	–
	High-speed	10	10	0	–	–	01	–
	Middle-speed	01	10	0	–	–	01	–
	Low-speed	00	10	0	–	–	01	–
XCIN	Double-speed	11	10	0	–	–	10	–
	High-speed	10	10	0	–	–	10	–
	Middle-speed	01	10	0	–	–	10	–
	Low-speed	00	10	0	–	–	10	–
External clock	Double-speed	11	10	–	–	–	11	–
	High-speed	10	10	–	–	–	11	–
	Middle-speed	01	10	–	–	–	11	–
	Low-speed	00	10	–	–	–	11	–
High-speed on-chip oscillator	Double-speed	11	01	–	0	–	–	–
	High-speed	10	01	–	0	–	–	–
	Middle-speed	01	01	–	0	–	–	–
	Low-speed	00	01	–	0	–	–	–
Low-speed on-chip oscillator	Double-speed	11	00	–	–	0	–	1/0
	High-speed	10	00	–	–	0	–	1/0
	Middle-speed	01	00	–	–	0	–	1/0
	Low-speed	00	00	–	–	0	–	1/0

–: can be "0" or "1", no change in outcome

• Stop mode

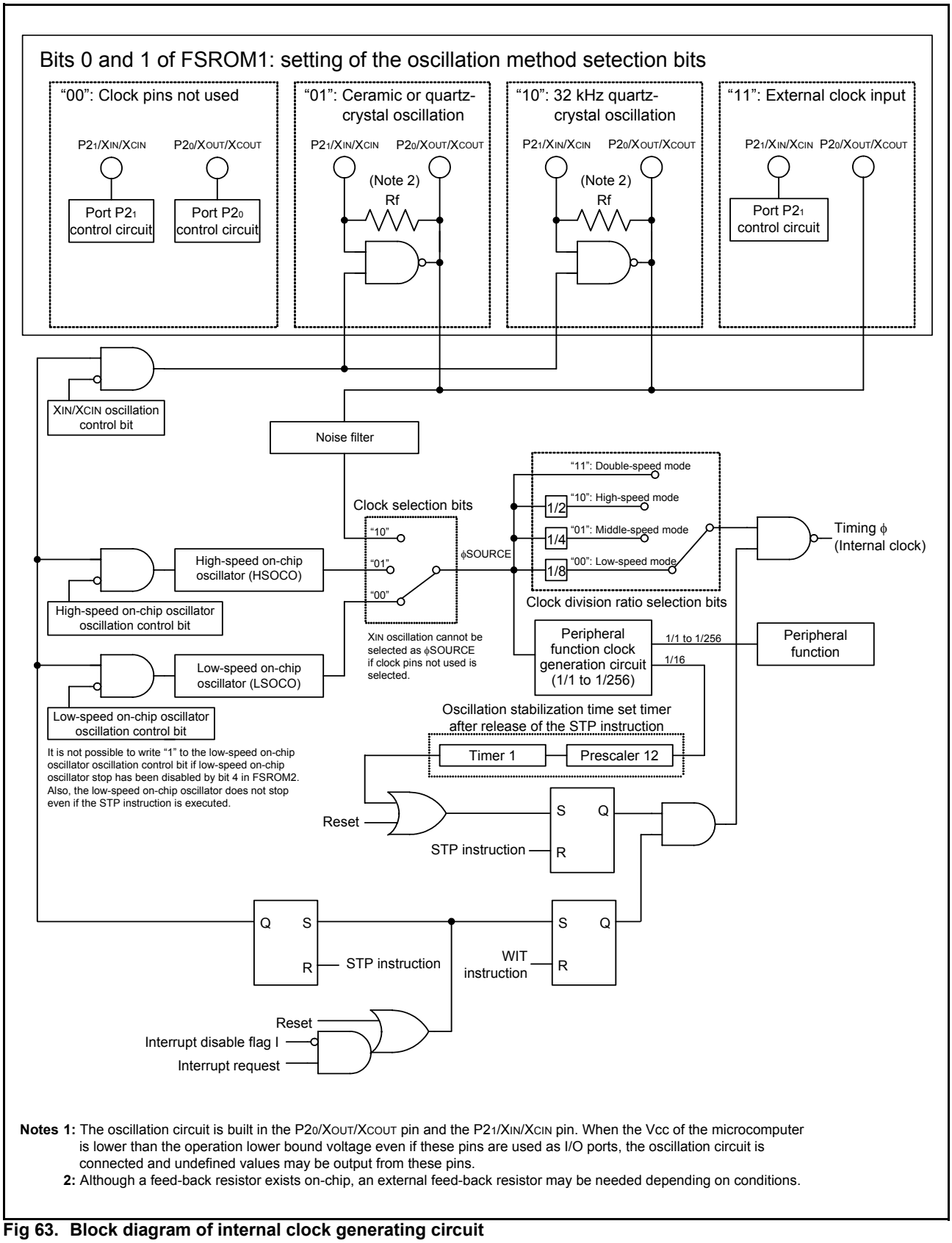
When the STP instruction is executed, the internal clock ϕ stops at an "H" level and the XIN/XCIN and on-chip oscillator stops. At this time, timer 1 is set to "01$_{16}$" and prescaler 12 is set to "FF$_{16}$" when the oscillation stabilization time set bit after release of the STP instruction is "0". On the other hand, timer 1 and prescaler 12 are not set when the above bit is "1". Accordingly, set the wait time fit for the oscillation stabilization time of the oscillator to be used. When an external interrupt is accepted, oscillation is restarted but the internal clock ϕ remains at "H" until timer 1 underflows. As soon as timer 1 underflows, the internal clock ϕ is supplied. This is because when a ceramic resonator is used, some time is required until a start of oscillation. In case oscillation is restarted by reset, no wait time is generated. So apply an "L" level to the $\overline{\text{RESET}}$ pin while oscillation becomes stable, or set the wait time by on-chip oscillator operation after system is released from reset until the oscillation is stabled.

• Wait mode

If the WIT instruction is executed, the internal clock ϕ stops at an "H" level, but the oscillator does not stop. The internal clock restarts if a reset occurs or when an interrupt is received. Since the oscillator does not stop, normal operation can be started immediately after the clock is restarted. To ensure that interrupts will be received to release the STP or WIT state, interrupt enable bits must be set to "1" before the STP or WIT instruction is executed.

• Note on Oscillation Control

For use with the oscillation stabilization set bit after release of the STP instruction set to "1", set values in timer 1 and prescaler 12 after fully appreciating the oscillation stabilization time of the oscillator to be used.

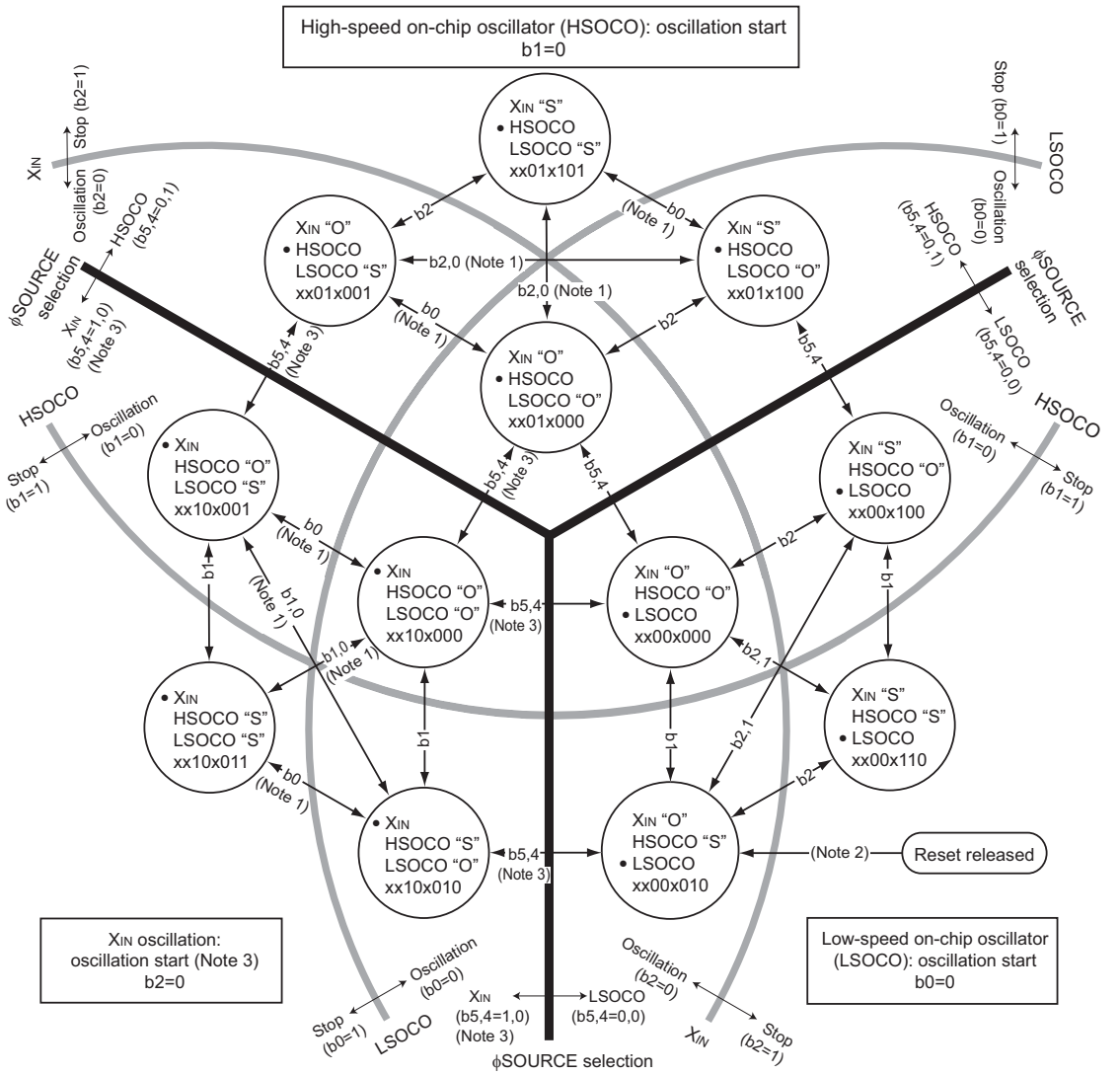


Notes 1: The oscillation circuit is built in the P20/XOUT/XCOUT pin and the P21/XIN/XCIN pin. When the Vcc of the microcomputer is lower than the operation lower bound voltage even if these pins are used as I/O ports, the oscillation circuit is connected and undefined values may be output from these pins.

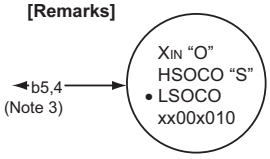
2: Although a feed-back resistor exists on-chip, an external feed-back resistor may be needed depending on conditions.

Fig 63. Block diagram of internal clock generating circuit

State transition of clock mode register CLKM (address: 0037$_{16}$) setting value and clock
(When X_{IN} oscillation is used. The same applies when X_{CIN} oscillation and external clock input are used.)



[Remarks]



XIN, HSOCO, LSOCO, and respective oscillation and stop status in each mode are shown.
The symbol (•) indicates ϕSOURCE (oscillation) selected by the clock selection bits.
"O" indicates oscillation and "S" indicates stopping.
The values such as "xx00x010" indicate the values (binary) of the clock mode register in the mode.
The arrow (bx) indicates a bit in the clock mode register, showing a transition by changing the bit values.

Entering the mode should be performed according to the arrows. Wait mode and stop mode can be entered from all modes, and the original mode is returned after exiting.

Wait mode
- Low-speed on-chip oscillator: Status before executing WIT instruction is kept
- High-speed on-chip oscillator: Status before executing WIT instruction is kept
- X_{IN} oscillation: Status before executing the WIT instruction is kept

Stop mode
- Low-speed on-chip oscillator: Stopped (Note 1)
- High-speed on-chip oscillator: Stopped
- X_{IN} oscillation: Stopped

Notes 1: When stopping the low-speed on-chip oscillator is disabled by the low-speed on-chip oscillator control bit (bit 4 in FSROM2), "1" cannot be written to the bit 0 in CLKM. The low-speed on-chip oscillator does not stop even in stop mode.
2: After releasing reset, the low-speed on-chip oscillator is selected as ϕSOURCE and divided by 8 is selected as the CPU clock.
3: When the oscillation pins not used is set by the oscillation method selection bits (bits 1 and 0 in FSROM1), "10" cannot be written to bits 5 and 5 in CLKM. To use X_{IN} oscillation as ϕSOURCE, switch after X_{IN} oscillation is stabilized. Supply a stable clock when an external clock is used.
4: Do not change the values of the clock selection bits (bits 5 and 4) in CLKM and the individual clock oscillation control bits (bits 2 to 0) at the same time using a singe instruction. Always use different instructions to rewrite these values.
5: Wait until the oscillation used in the destination mode is stabilized before entering.

Fig 64. ϕSOURCE state transition

• Oscillation stop detection circuit

The oscillation stop detection circuit is used for reset occurrence when a ceramic resonator or RC oscillation circuit stops by disconnection. To use this circuit, set an on-chip oscillator to be in active.

The oscillation stop detection circuit is in active to set "1" to the XIN oscillation stop detection function active bit.

When the oscillation stop detection circuit is enabled, the operation status of the XIN oscillator circuit is monitored using the low-speed on-chip oscillator, and if oscillation stop is detected the oscillation stop detection status bit is set to 1. If additionally the oscillation stop detection reset enable bit is set to "1", an internal reset is triggered when the oscillator stops operating.

The oscillation stop detection status bit is not initialized by an oscillation stop detection reset and retains its value of 1. Since the oscillation stop detection status bit is initialized to "0" by an external reset, it is possible to determine if a reset was due to oscillation stop detection by checking the oscillation stop detection status bit.

The XIN oscillation and external clock input are set as the clocks to detect the oscillation stop.

Refer to the electrical characteristics for the frequencies to detect the oscillation stop.

• Notes on Oscillation Stop Detection Circuit

(1) Do not execute the transition to "state 2'a" shown in Figure 66 because in this "state 2'a", MCU is stopped without reset even when XIN oscillation is stopped.

(2) XIN oscillation stop detection function active bit is not cleared by the oscillation stop detection reset. Accordingly, the oscillation stop detection circuit is in active when system is released from internal reset cause of oscillation stop detection.

(3) Oscillation stop detection status bit is initialized by the following operation.
- External reset, power-on reset, low voltage detection reset, watchdog timer reset, and reset by STP instruction function
- Write "0" data to the XIN oscillation stop detection function active bit.

(4) The oscillation stop detection circuit is not included in the emulator MCU "M37549RLSS".

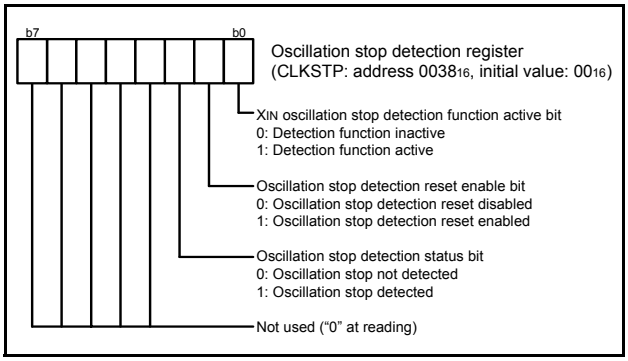
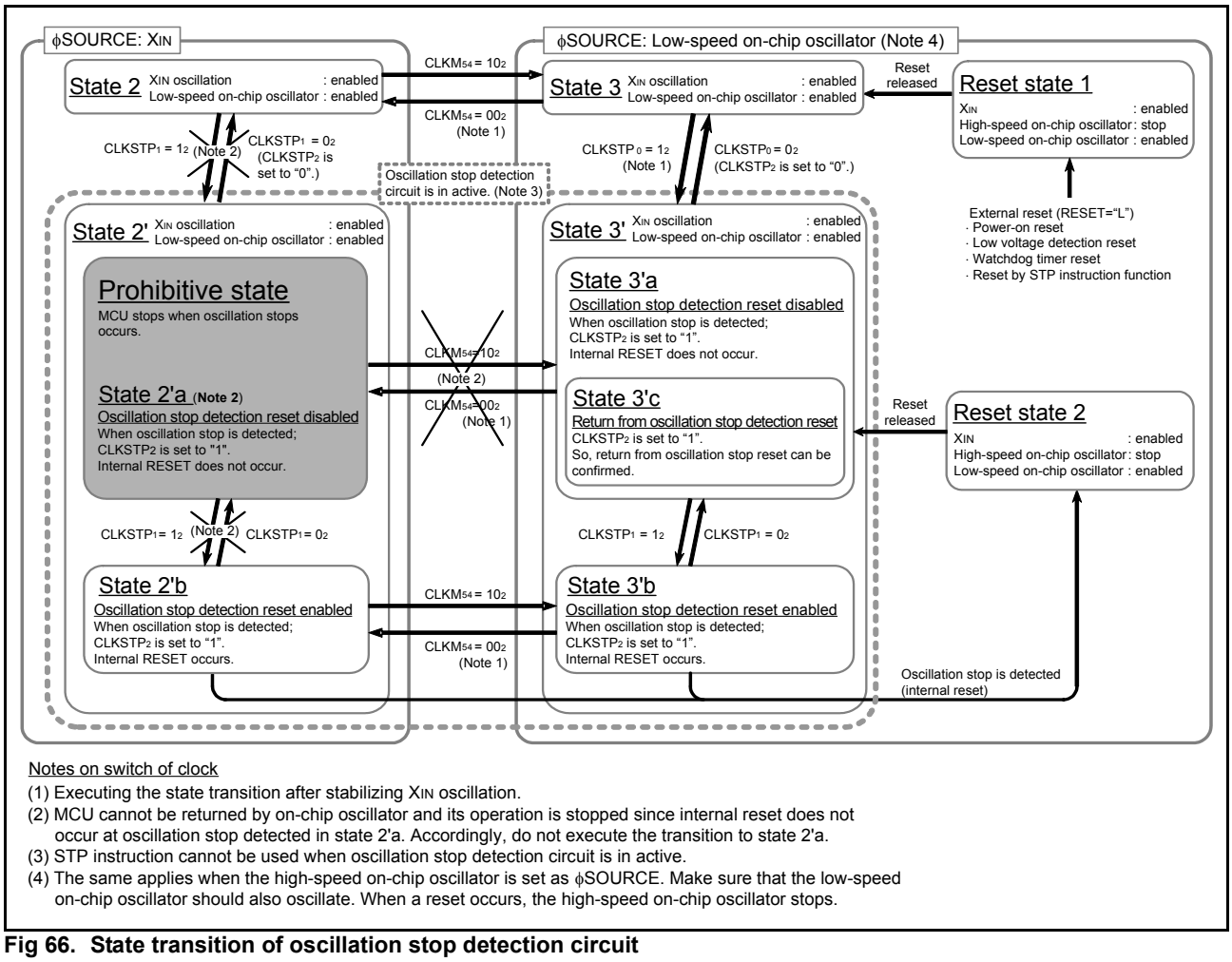


Fig 65. Structure of oscillation stop detection register



Notes on switch of clock

(1) Executing the state transition after stabilizing XIN oscillation.

(2) MCU cannot be returned by on-chip oscillator and its operation is stopped since internal reset does not occur at oscillation stop detected in state 2'a. Accordingly, do not execute the transition to state 2'a.

(3) STP instruction cannot be used when oscillation stop detection circuit is in active.

(4) The same applies when the high-speed on-chip oscillator is set as φSOURCE. Make sure that the low-speed on-chip oscillator should also oscillate. When a reset occurs, the high-speed on-chip oscillator stops.

Fig 66. State transition of oscillation stop detection circuit

QzROM Writing Mode

In the QzROM writing mode, the user ROM area can be rewritten while the microcomputer is mounted on-board by using a serial programmer which is applicable for this microcomputer. Table 10 lists the pin description (QzROM writing mode) and Figure 67 shows the pin connections.

Refer to Figure 68 and Figure 69 for examples of a connection with a serial programmer.
Contact the manufacturer of your serial programmer for serial programmer.
Refer to the user's manual of your serial programmer for details on how to use it.

Table 10 Pin description (QzROM writing mode)

Pin	Name	I/O	Function
V_{CC}, V_{SS}	Power source	Input	Apply 1.8 to 5.5 V to V_{CC}, and 0 V to V_{SS}.
RESET	Reset input	Input	Reset input pin.
$P2_1$ /X_{IN}	Clock input	Input	Set the same termination as the single-chip mode.
$P2_0$ /X_{OUT}	Clock output	Output	
$P0_0$ – $P0_5$ $P1_1$ – $P1_5$	I/O port	I/O	Input “H” or “L” level signal or leave the pin open.
CNV$_{SS}$	V_{PP} input	Input	QzROM programmable power source pin.
$P1_0$	ESDA I/O	I/O	Serial data I/O pin.
$P0_6$	ESCLK input	Input	Serial clock input pin.
$P0_7$	ESPGMB input	Input	Read/program pulse input pin.

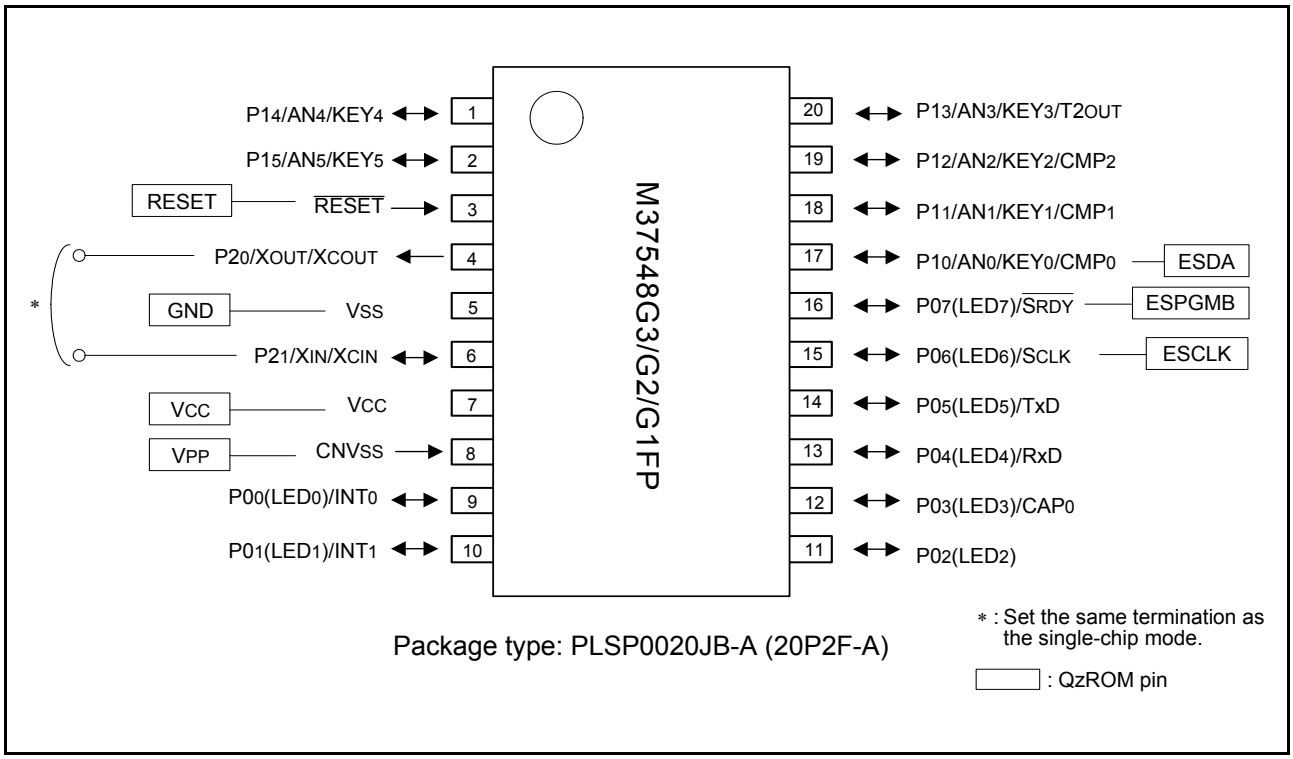
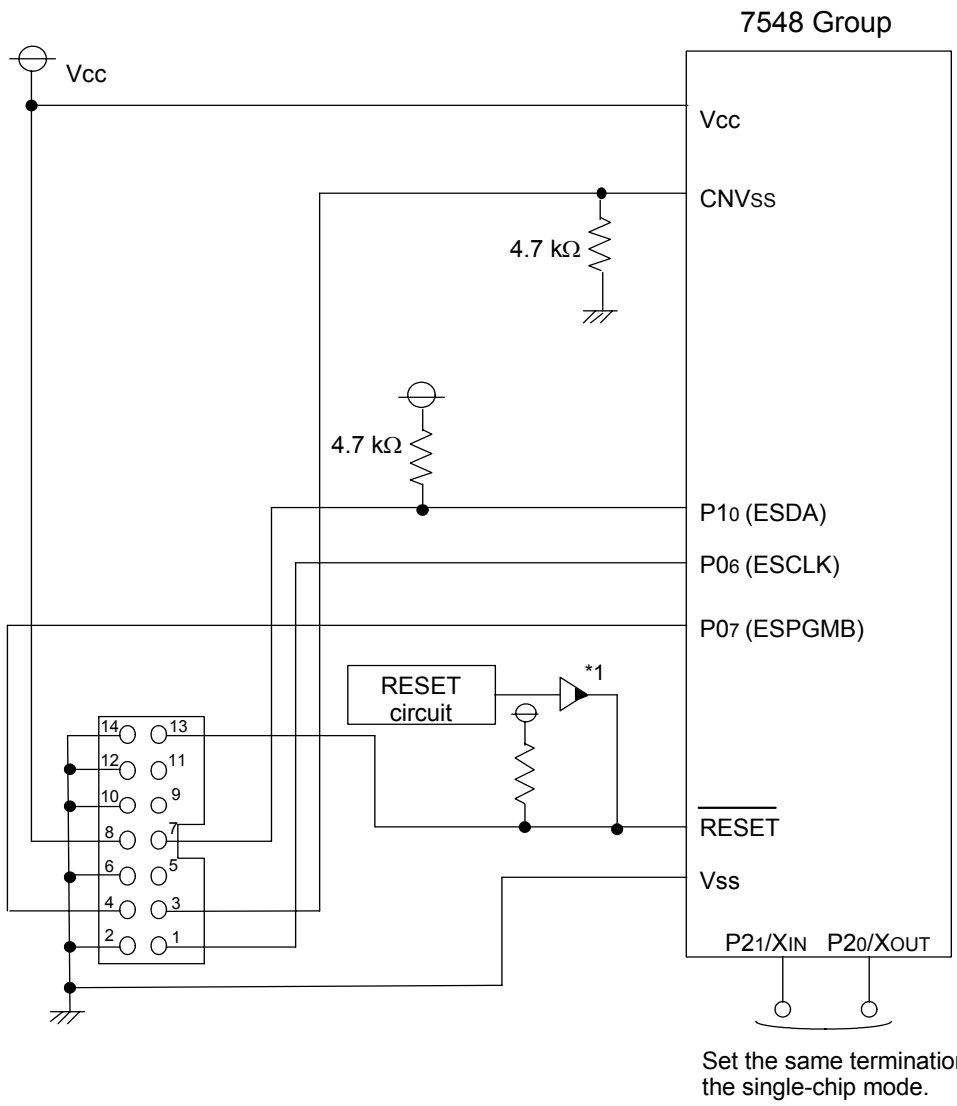


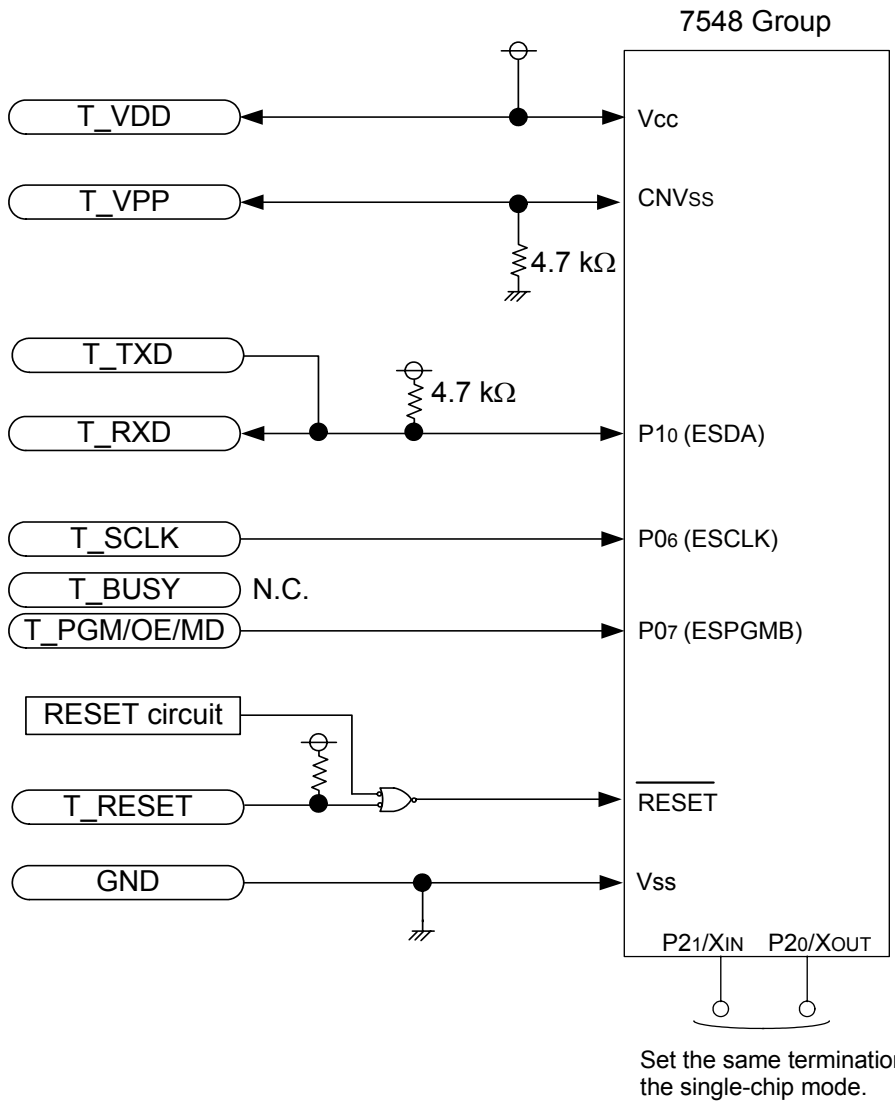
Fig 67. Pin connection diagram (M37548G3/G2/G1FP)



* 1: Open-collector buffer

Note : For the programming circuit, the wiring capacity of each signal pin must not exceed 47 pF

Fig 68. When using E8 programmer, connection example



Note: For the programming circuit, the wiring capacity of each signal pin must not exceed 47 pF.

Fig 69. When using programmer of Suisei Electronics System Co., LTD, connection example

NOTES ON PROGRAMMING

(1) Processor Status Register

The contents of the processor status register (PS) after reset are undefined except for the interrupt disable flag I which is "1". After reset, initialize flags which affect program execution. In particular, it is essential to initialize the T flag and the D flag because of their effect on calculations.

(2) Interrupts

The contents of the interrupt request bit do not change even if the BBC or BBS instruction is executed immediately after they are changed by program because this instruction is executed for the previous contents. For executing the instruction for the changed contents, execute one instruction before executing the BBC or BBS instruction.

(3) Decimal Calculations

- For calculations in decimal notation, set the decimal mode flag D to "1", then execute the ADC instruction or SBC instruction. In this case, execute SEC instruction, CLC instruction or CLD instruction after executing one instruction before the ADC instruction or SBC instruction.
- In the decimal mode, the values of the N (negative), V (overflow) and Z (zero) flags are invalid.

(4) Ports

The values of the port direction registers cannot be read. That is, it is impossible to use the LDA instruction, memory operation instruction when the T flag is "1", addressing mode using direction register values as qualifiers, and bit test instructions such as BBC and BBS.
It is also impossible to use bit operation instructions such as CLB and SEB and read/modify/write instructions of direction registers for calculations such as ROR.
For setting direction registers, use the LDM instruction, STA instruction, etc.

(5) A/D Conversion

Do not execute the STP instruction during A/D conversion.

(6) Instruction Execution Timing

The instruction execution time can be obtained by multiplying the frequency of the internal clock ϕ by the number of cycles mentioned in the machine-language instruction table.
The frequency of the internal clock ϕ is the same as that of the ϕSOURCE in double-speed mode, twice the ϕSOURCE cycle in high-speed mode, 4 times the ϕSOURCE cycle in middle-speed mode and 8 times the ϕSOURCE cycle in low-speed mode.

(7) CPU Mode Register

The processor mode bits can be written only once after releasing reset. Always set them to "00_2". After written, rewriting any data to these bits is disabled because they are locked. (Emulator MCU is excluded.)
Also, the stack page bit (bit 2) is not locked.
In order to prevent error-writing to the processor mode bits (at program runaway), write the CPU mode register at the start of the program that runs after releasing reset.

(8) State transition

Do not stop the clock selected as the operation clock because of setting of bits 0 to 2.

NOTES ON HARDWARE

(1) Handling of Power Source Pin

In order to avoid a latch-up occurrence, connect a capacitor suitable for high frequencies as bypass capacitor between power source pin (V_{CC} pin) and GND pin (V_{SS} pin). A ceramic capacitor of 0.01 μF to 0.1 μF is recommended.
Connect a capacitor across the power source pin and GND pin with the shortest possible wiring.

NOTES ON USE

Countermeasures against noise

It is necessary not only design the system taking measures against the noise as follows but to evaluate before actual use.

1. Shortest wiring length

(1) Package

Select the smallest possible package to make the total wiring length short.

<Reason>

The wiring length depends on a microcomputer package. Use of a small package, for example QFP and not DIP, makes the total wiring length short to reduce influence of noise.

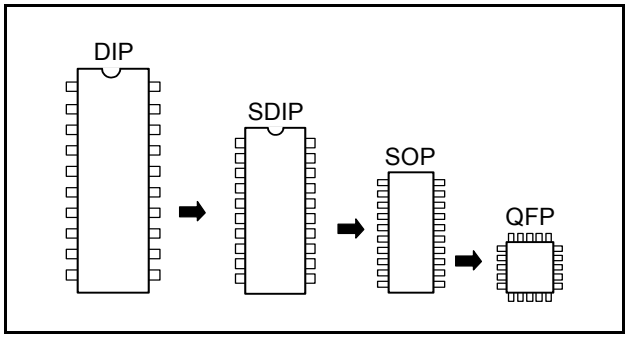


Fig 70. Selection of packages

(2) Wiring for $\overline{\text{RESET}}$ pin

Make the length of wiring which is connected to the $\overline{\text{RESET}}$ pin as short as possible. Especially, connect a capacitor across the $\overline{\text{RESET}}$ pin and the Vss pin with the shortest possible wiring (within 20 mm).

<Reason>

The width of a pulse input into the $\overline{\text{RESET}}$ pin is determined by the timing necessary conditions. If noise having a shorter pulse width than the standard is input to the $\overline{\text{RESET}}$ pin, the reset is released before the internal state of the microcomputer is completely initialized. This may cause a program runaway.

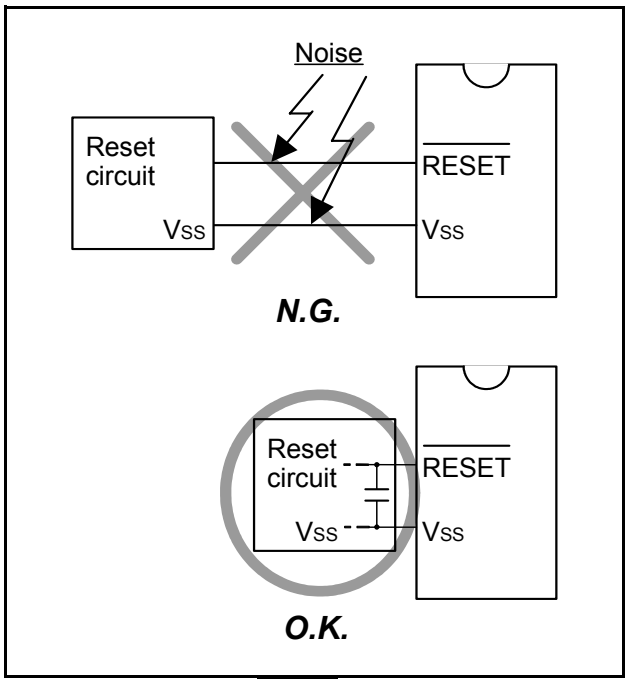


Fig 71. Wiring for the $\overline{\text{RESET}}$ pin

(3) Wiring for clock input/output pins

- Make the length of wiring which is connected to clock I/O pins as short as possible.
- Make the length of wiring (within 20 mm) across the grounding lead of a capacitor which is connected to an oscillator and the Vss pin of a microcomputer as short as possible.
- Separate the Vss pattern only for oscillation from other Vss patterns.

<Reason>

If noise enters clock I/O pins, clock waveforms may be deformed. This may cause a program failure or program runaway. Also, if a potential difference is caused by the noise between the Vss level of a microcomputer and the Vss level of an oscillator, the correct clock will not be input in the microcomputer.

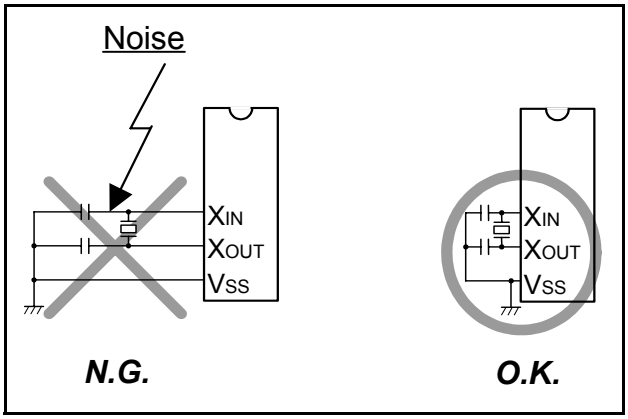


Fig 72. Wiring for clock I/O pins

(4) Wiring to CNVss pin

Connect CNVss pin to a GND pattern at the shortest distance. The GND pattern is required to be as close as possible to the GND supplied to Vss.

In order to improve the noise reduction, to connect a 5 kΩ resistor serially to the CNVss pin - GND line may be valid.

As well as the above-mentioned, in this case, connect to a GND pattern at the shortest distance. The GND pattern is required to be as close as possible to the GND supplied to Vss.

<Reason>

The CNVss pin of the QzROM is the power source input pin for the built-in QzROM. When programming in the built-in QzROM, the impedance of the CNVss pin is low to allow the electric current for writing flow into the QzROM. Because of this, noise can enter easily. If noise enters the CNVss pin, abnormal instruction codes or data are read from the built-in QzROM, which may cause a program runaway.

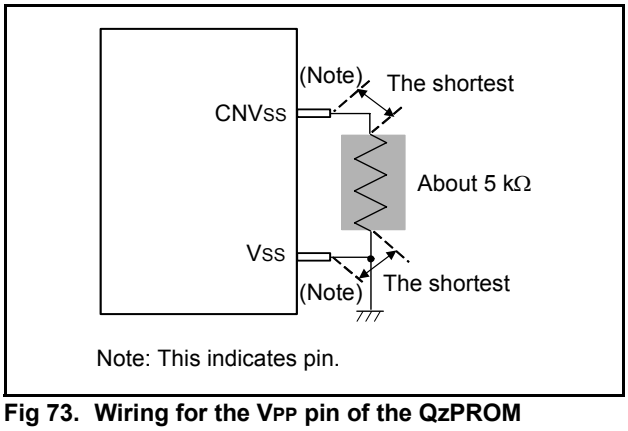


Fig 73. Wiring for the VPP pin of the QzPROM

2. Connection of bypass capacitor across Vss line and Vcc line

Connect an approximately 0.1 µF bypass capacitor across the Vss line and the Vcc line as follows:

- Connect a bypass capacitor across the Vss pin and the Vcc pin at equal length.
- Connect a bypass capacitor across the Vss pin and the Vcc pin with the shortest possible wiring.
- Use lines with a larger diameter than other signal lines for Vss line and Vcc line.
- Connect the power source wiring via a bypass capacitor to the Vss pin and the Vcc pin.

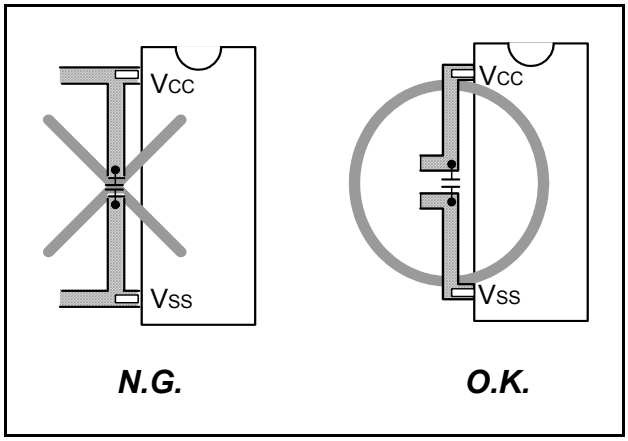


Fig 74. Bypass capacitor across the Vss line and the Vcc line

3. Wiring to analog input pins

- Connect an approximately 100 Ω to 1 kΩ resistor to an analog signal line which is connected to an analog input pin in series.
  Besides, connect the resistor to the microcomputer as close as possible.
- Connect an approximately 1000 pF capacitor across the Vss pin and the analog input pin. Besides, connect the capacitor to the Vss pin as close as possible. Also, connect the capacitor across the analog input pin and the Vss pin at equal length.

<Reason>
Signals which is input in an analog input pin (such as an A/D converter/comparator input pin) are usually output signals from sensor. The sensor which detects a change of event is installed far from the printed circuit board with a microcomputer, the wiring to an analog input pin is longer necessarily. This long wiring functions as an antenna which feeds noise into the microcomputer, which causes noise to an analog input pin.

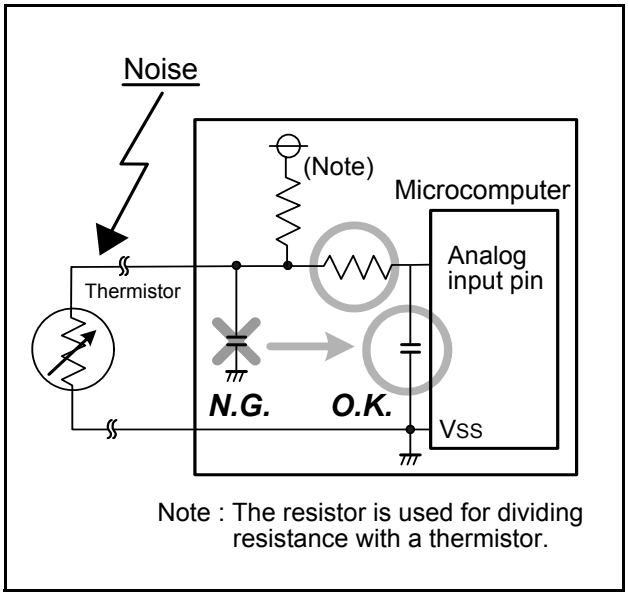


Fig 75. Analog signal line and a resistor and a capacitor

- The analog input pin is connected to the capacitor of a voltage comparator. Accordingly, sufficient accuracy may not be obtained by the charge/discharge current at the time of A/D conversion when the analog signal source of high-impedance is connected to an analog input pin. In order to obtain the A/D conversion result stabilized more, please lower the impedance of an analog signal source, or add the smoothing capacitor to an analog input pin.

4. Oscillator concerns

Take care to prevent an oscillator that generates clocks for a microcomputer operation from being affected by other signals.

(1) Keeping oscillator away from large current signal lines

Install a microcomputer (and especially an oscillator) as far as possible from signal lines where a current larger than the tolerance of current value flows.

<Reason>

In the system using a microcomputer, there are signal lines for controlling motors, LEDs, and thermal heads or others. When a large current flows through those signal lines, strong noise occurs because of mutual inductance.

(2) Installing oscillator away from signal lines where potential levels change frequently

Install an oscillator and a connecting pattern of an oscillator away from signal lines where potential levels change frequently. Also, do not cross such signal lines over the clock lines or the signal lines which are sensitive to noise.

<Reason>

Signal lines where potential levels change frequently (such as the CNTR pin signal line) may affect other lines at signal rising edge or falling edge. If such lines cross over a clock line, clock waveforms may be deformed, which causes a microcomputer failure or a program runaway.

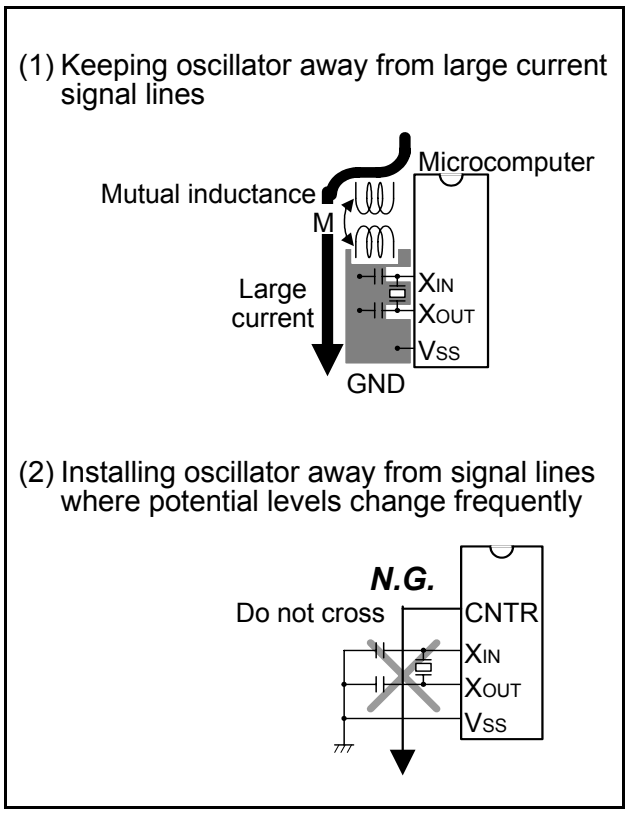


Fig 76. Wiring for a large current signal line/Writing of signal lines where potential levels change frequently

(3) Oscillator protection using VSS pattern

As for a two-sided printed circuit board, print a VSS pattern on the underside (soldering side) of the position (on the component side) where an oscillator is mounted.

Connect the VSS pattern to the microcomputer VSS pin with the shortest possible wiring. Besides, separate this VSS pattern from other VSS patterns.

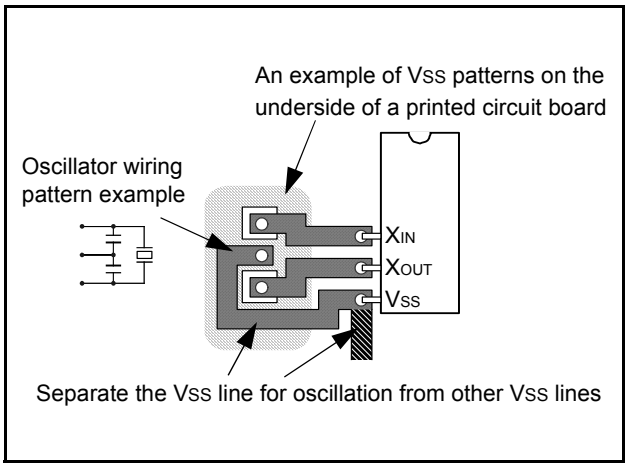


Fig 77. Vss pattern on the underside of an oscillator

5. Setup for I/O ports

Setup I/O ports using hardware and software as follows:

<Hardware>
- Connect a resistor of 100 Ω or more to an I/O port in series.

<Software>
- As for an input port, read data several times by a program for checking whether input levels are equal or not.
- As for an output port, since the output data may reverse because of noise, rewrite data to its port latch at fixed periods.
- Rewrite data to direction registers and pull-up control registers at fixed periods.

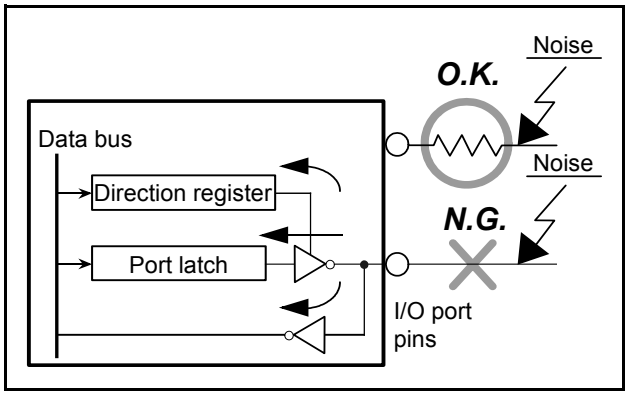


Fig 78. Setup for I/O ports

6. Providing of watchdog timer function by software

If a microcomputer runs away because of noise or others, it can be detected by a software watchdog timer and the microcomputer can be reset to normal operation. This is equal to or more effective than program runaway detection by a hardware watchdog timer. The following shows an example of a watchdog timer provided by software.
In the following example, to reset a microcomputer to normal operation, the main routine detects errors of the interrupt processing routine and the interrupt processing routine detects errors of the main routine.
This example assumes that interrupt processing is repeated multiple times in a single main routine processing.

<The main routine>
- Assigns a single byte of RAM to a software watchdog timer (SWDT) and writes the initial value N in the SWDT once at each execution of the main routine. The initial value N should satisfy the following condition:
  N + 1 ≥ (Counts of interrupt processing executed in each main routine)
  As the main routine execution cycle may change because of an interrupt processing or others, the initial value N should have a margin.
- Watches the operation of the interrupt processing routine by comparing the SWDT contents with counts of interrupt processing after the initial value N has been set.
- Detects that the interrupt processing routine has failed and determines to branch to the program initialization routine for recovery processing in the following case:
  If the SWDT contents do not change after interrupt processing.

<The interrupt processing routine>
- Decrements the SWDT contents by 1 at each interrupt processing.
- Determines that the main routine operates normally when the SWDT contents are reset to the initial value N at almost fixed cycles (at the fixed interrupt processing count).
- Detects that the main routine has failed and determines to branch to the program initialization routine for recovery processing in the following case:
  If the SWDT contents are not initialized to the initial value N but continued to decrement and if they reach 0 or less.

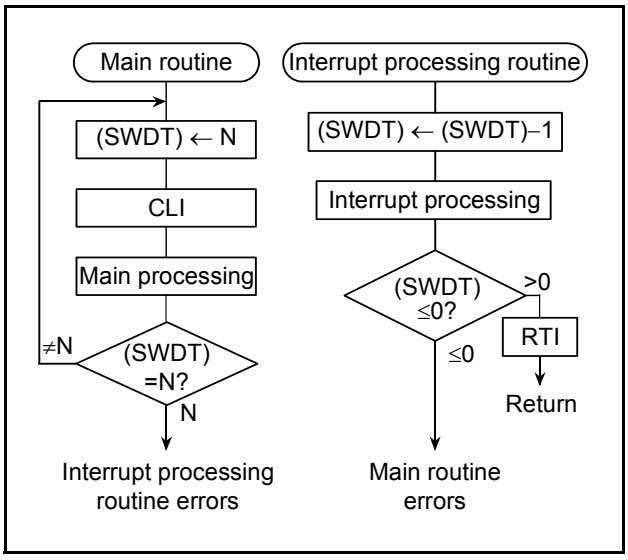


Fig 79. Watchdog timer by software

NOTES ON USE

Note on Power Source Voltage

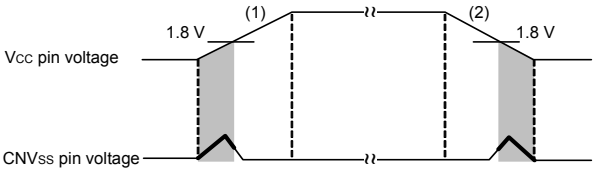
When the power source voltage value of a microcomputer is less than the value which is indicated as the recommended operating conditions, the microcomputer does not operate normally and may perform unstable operation.
In a system where the power source voltage drops slowly when the power source voltage drops or the power supply is turned off, reset a microcomputer when the supply voltage is less than the recommended operating conditions and design a system not to cause errors to the system by this unstable operation.

Product shipped in blank

As for the product shipped in blank, Renesas does not perform the writing test to user ROM area after the assembly process though the QzROM writing test is performed enough before the assembly process. Therefore, a writing error of approx.0.1 % may occur.
Moreover, please note the contact of cables and foreign bodies on a socket, etc. because a writing environment may cause some writing errors.

Overvoltage

Take care not to apply the voltage above the Vcc pin voltage to other pins. Make sure that the voltage of the CNVSS pin (VPP power input pin for QzROM) does not change as shown in the bold-lined periods (Figure 80) when powering on and off. If the voltage changes as shown, the QzROM contents may be rewritten.



(1) The input voltage to other MCU pins rises before the Vcc pin voltage rises.
(2) The input voltage to other MCU pins falls before the Vcc pin voltage falls.
Note: If Vcc falls below the minimum value 1.8 V (shaded areas), the internal circuit becomes unstable. Take additional care to prevent overvoltage.

Fig 80. Timing Diagram (bold-lined periods are applicable)

NOTES ON QzROM

Notes On QzROM Writing Orders

When ordering the QzROM product shipped after writing, submit the mask file (extension: .mask) which is made by the mask file converter MM.
Be sure to set the ROM option ("MASK option" written in the mask file converter) setup when making the mask file by using the mask file converter MM.

Notes On ROM Code Protect

(QzROM product shipped after writing)

As for the QzROM product shipped after writing, the ROM code protect is specified according to the ROM option setup data in the mask file which is submitted at ordering.
Renesas Technology corp. write the value of the ROM option setup data in the ROM code protect address (address FFDB16) when writing to the QzROM. As a result, in the contents of the ROM code protect address the ordered value may differ from the actual written value.
The ROM option setup data in the mask file is "0016" for protect enabled or "FF16" for protect disabled. Therefore, the contents of the ROM code protect address (other than the user ROM area) of the QzROM product shipped after writing is "0016" or "FF16".
Note that the mask file which has nothing at the ROM option data or has the data other than "0016" and "FF16" can not be accepted.

DATA REQUIRED FOR QzROM WRITING ORDERS

The following are necessary when ordering a QzROM product shipped after writing:
1. QzROM Writing Confirmation Form*
2. Mark Specification Form*
3. ROM data ..... Mask file

* For the QzROM writing confirmation form and the mark specification form, refer to the "Renesas Technology Corp." Homepage (http://www.renesas.com/homepage.jsp).
Note that we cannot deal with special font marking (customer's trademark etc.) in QzROM microcomputer.

ELECTRICAL CHARACTERISTICS of 7548 Group

Absolute Maximum Ratings

Absolute maximum ratings

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage	All voltages are based on V_{SS}. When an input voltage is measured, output transistors are cut off.	–0.3 to 6.5	V
V_I	Input voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$		–0.3 to V_{CC} + 0.3	V
V_I	Input voltage $\overline{RESET}$		–0.3 to V_{CC} + 0.3	V
V_I	Input voltage CNV_{SS}		–0.3 to V_{CC} + 0.3	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$		–0.3 to V_{CC} + 0.3	V
P_d	Power dissipation	T_a = 25 °C	300	mW
T_{opr}	Operating temperature		–20 to 85	°C
T_{stg}	Storage temperature		–40 to 125	°C

Recommended Operating Conditions

Recommended operating conditions (1)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = −20 to 85 °C, unless otherwise noted)

Symbol	Parameter				Limits			Unit
					Min.	Typ.	Max.	
V_{CC}	Power source voltage	High-speed on-chip oscillator	Double-, high-, middle-, low-speed mode		4.0	5.0	5.5	V
		Low-speed on-chip oscillator	Double-, high-, middle-, low-speed mode		1.8	5.0	5.5	V
		X_{IN} oscillation, X_{CIN} oscillation, external clock input	Double-speed mode	$f(X_{IN}) \leq 8$ MHz	4.5	5.0	5.5	V
				$f(X_{IN}) \leq 2$ MHz	2.4	5.0	5.5	V
				$f(X_{IN}) \leq 1$ MHz	2.2	5.0	5.5	V
			High-, middle-, low-speed mode	$f(X_{IN}) \leq 8$ MHz	4.0	5.0	5.5	V
				$f(X_{IN}) \leq 4$ MHz	2.4	5.0	5.5	V
				$f(X_{IN}) \leq 1$ MHz	1.8	5.0	5.5	V
		X_{CIN} oscillation	Double-, high-, middle-, low-speed mode	$f(X_{CIN}) \leq 50$ kHz	1.8	5.0	5.5	V
V_{SS}	Power source voltage					0		V
V_{IH}	"H" input voltage (Note 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_1$				0.8V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage (Note 5) $\overline{RESET}$, X_{IN}, X_{CIN}				0.8V_{CC}		V_{CC}	V
V_{IL}	"L" input voltage (Note 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_1$				0		0.2V_{CC}	V
V_{IL}	"L" input voltage $\overline{RESET}$, CNV_{SS}				0		0.2V_{CC}	V
V_{IL}	"L" input voltage (Note 5) X_{IN}, X_{CIN}				0		0.16V_{CC}	V
$\Sigma I_{OH(peak)}$	"H" total peak output current (Notes 1, 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$						−60	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current (Note 1) $P0_0$–$P0_7$						60	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current (Notes 1, 4) $P1_0$–$P1_5$, $P2_0$, $P2_1$						60	mA
$\Sigma I_{OH(avg)}$	"H" total average output current (Notes 1, 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$						−30	mA
$\Sigma I_{OL(avg)}$	"L" total average output current (Note 1) $P0_0$–$P0_7$						30	mA
$\Sigma I_{OL(avg)}$	"L" total average output current (Notes 1, 4) $P1_0$–$P1_5$, $P2_0$, $P2_1$						30	mA
$I_{OH(peak)}$	"H" peak output current (Notes 2, 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$						−10	mA
$I_{OL(peak)}$	"L" peak output current (Notes 2, 4) $P0_0$–$P0_7$ (drive capacity: weakness), $P1_0$–$P1_5$, $P2_0$, $P2_1$						10	mA
$I_{OL(peak)}$	"L" peak output current (Note 2) $P0_0$–$P0_7$ (drive capacity: strength)						30	mA
$I_{OH(avg)}$	"H" average output current (Notes 3, 4) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_0$, $P2_1$						−5	mA
$I_{OL(avg)}$	"L" average output current (Notes 3, 4) $P0_0$–$P0_7$ (drive capacity: weakness), $P1_0$–$P1_5$, $P2_0$, $P2_1$						5	mA
$I_{OL(avg)}$	"L" average output current (Notes 3) $P0_0$–$P0_7$ (drive capacity: strength)						15	mA

NOTES:
1. The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.
2. The peak output current is the peak current flowing in each port.
3. The average output current I_{OL} (avg), I_{OH} (avg) in an average value measured over 100 ms.
4. $P2_0$ and $P2_1$ indicates these pins are used as I/O ports.
5. X_{IN} and X_{CIN} indicates these pins are used as clock pins.

Recommended operating conditions (2)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter				Limits			Unit
					Min.	Typ.	Max.	
f(XIN)	XIN oscillation frequency (Note 1)	XIN oscillation External clock input	Double-speed mode	Vcc = 4.5–5.5 V			8	MHz
				Vcc = 2.4–4.5 V			$\frac{(Vcc - 2.4) \times 2}{0.7} + 2$	MHz
				Vcc = 2.2–2.4 V			$\frac{(Vcc - 2.2)}{0.2} + 1$	MHz
			High-, middle-, low-speed mode	Vcc = 4.0–5.5 V			8	MHz
				Vcc = 2.4–4.0 V			$\frac{(Vcc - 2.4)}{0.4} + 4$	MHz
				Vcc = 1.8–2.4 V			$\frac{(Vcc - 1.8)}{0.2} + 1$	MHz
	XCIN oscillation frequency (Note 1)	XCIN oscillation	Double-, high-, middle-, low-speed mode	Vcc = 1.8–5.5 V		32.768	50	kHz

NOTE:
1. When the oscillation frequency has a duty cycle of 50 %.

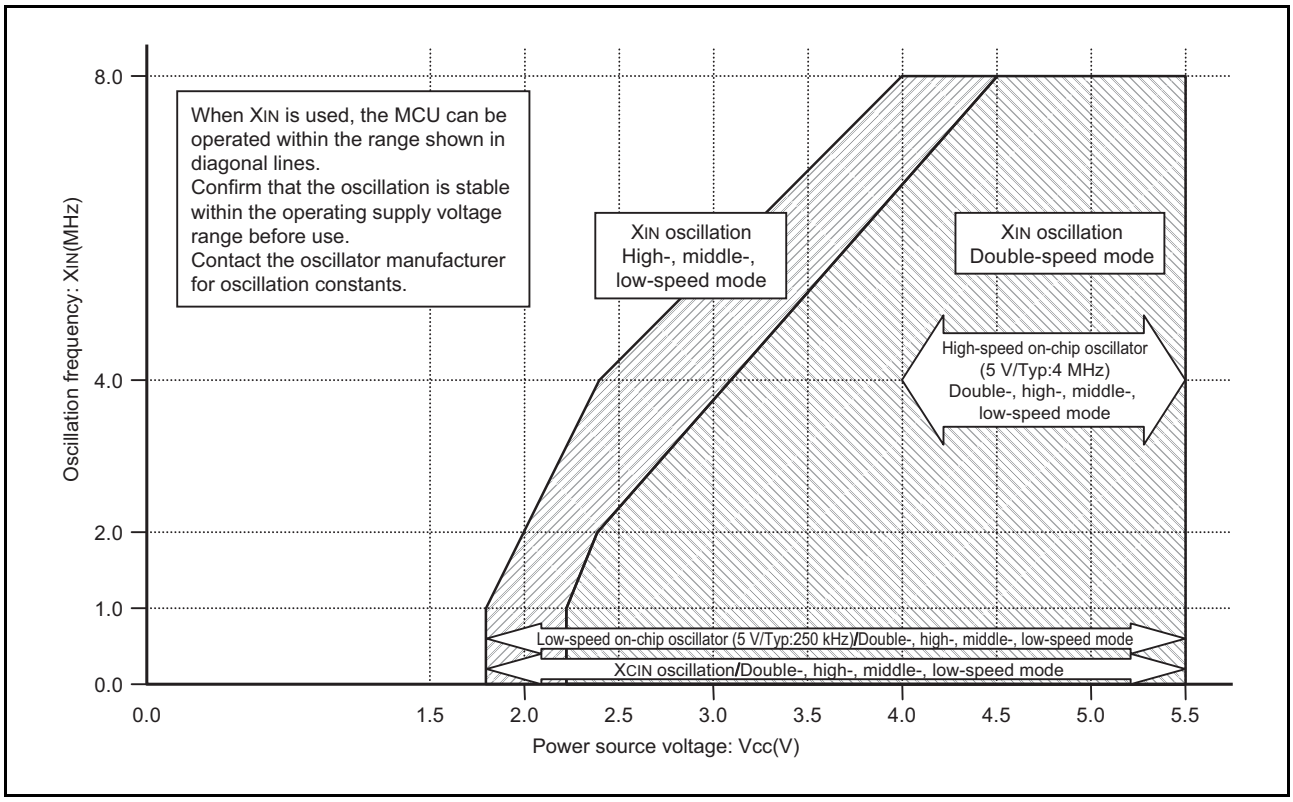


Fig 81. Power source voltage and oscillation frequency

Electrical Characteristics

Electrical characteristics (1)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{OH}	"H" output voltage (Notes 1, 3) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_1$	I_{OH} = –5 mA, Vcc = 4.0–5.5 V	Vcc–1.5			V
		I_{OH} = –1.0 mA, Vcc = 1.8–5.5 V	Vcc–1.0			V
V_{OL}	"L" output voltage (Note 1) $P0_0$–$P0_7$ (drive capacity: weakness) $P1_0$–$P1_5$, $P2_1$	I_{OL} = 5 mA, Vcc = 4.0–5.5 V			1.5	V
		I_{OL} = 1.5 mA, Vcc = 4.0–5.5 V			0.3	V
		I_{OL} = 1.0 mA, Vcc = 1.8–5.5 V			1.0	V
V_{OL}	"L" output voltage $P0_0$–$P0_7$ (drive capacity: strength)	I_{OL} = 15 mA, Vcc = 4.0–5.5 V			2.0	V
		I_{OL} = 1.5 mA, Vcc = 4.0–5.5 V			0.3	V
		I_{OL} = 1.0 mA, Vcc = 1.8–5.5 V			1.0	V
$V_{T+} - V_{T-}$	Hysteresis INT_0, INT_1, CAP_0, $P1_0$–$P1_5$ (Note 4) RxD, SCLK, $\overline{RESET}$			0.5		V
I_{IH}	"H" input current (Note 1) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_1$	V_I = Vcc (Pin floating. Pull up transistors is disable)			5.0	µA
I_{IH}	"H" input current $\overline{RESET}$	V_I = Vcc			5	µA
I_{IH}	"H" input current (Note 2) X_{IN}	V_I = Vcc		4.0		µA
I_{IH}	"H" input current (Note 2) X_{CIN}	V_I = Vcc		0.5		µA
I_{IL}	"L" input current (Note 1) $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P2_1$	V_I = Vss (Pin floating. Pull up transistors is disable)			–5.0	µA
I_{IL}	"L" input current $\overline{RESET}$	V_I = Vss			–0.7	mA
I_{IL}	"L" input current (Note 2) X_{IN}	V_I = Vss		–4.0		µA
I_{IL}	"L" input current (Note 2) X_{CIN}	V_I = Vss		–0.3		µA
I_{IL}	"L" input current $P0_0$–$P0_7$, $P1_0$–$P1_5$	V_I = Vss (Pull up transistors is enable)		–0.2	–0.5	mA
R_{PH}	Pull-up resistor value $\overline{RESET}$	V_I = Vss		25		kΩ
V_{RAM}	RAM hold voltage	When clock stopped	1.6		5.5	V
R_{HSOSC}	High-speed on-chip oscillator oscillation frequency	Vcc = 4.0–5.5 V, Ta = 0–50 °C	TBD	4	TBD	MHz
		Vcc = 4.0–5.5 V, Ta = –20–85 °C	TBD	4	TBD	
R_{LSOSC}	Low-speed on-chip oscillator oscillation frequency	Vcc = 5.0 V, Ta = 25 °C	125	250	500	kHz
D_{OSC}	Oscillation stop detection circuit detection frequency	Vcc = 5.0 V, Ta = 25 °C	62.5	150	250	kHz

NOTES:
1. $P2_0$ and $P2_1$ indicates these pins are used as I/O ports.
2. X_{IN} and X_{CIN} indicates these pins are used as clock pins.
3. $P0_5$ is measured when the $P0_5$/TxD P-channel output disable bit of the UART1 control register (bit 4 of address $001B_{16}$) is "0".
4. It is available only when operating key-on wake up.

Electrical characteristics (2)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
Icc	Power source current	High-speed on-chip oscillator: oscillation · Vcc = 5.0 V · Low-speed on-chip oscillator: stop · XIN: stop · Output transistors "off" · Low voltage detection circuit: enable	Double-speed mode		2.5	5.2	mA
			Low-speed mode		0.6	1.7	mA
			Wait mode, functions except timer 1 disabled		0.35	1.0	mA
		Low-speed on-chip oscillator: oscillation · Vcc = 5.0 V · High-speed on-chip oscillator: stop · XIN: stop · Output transistors "off" · Low voltage detection circuit: enable	Double-speed mode		230	600	µA
			Low-speed mode		120	400	µA
			Wait mode, functions except timer 1 disabled		105	350	µA
		f(XIN)=8 MHz (ceramic resonator) · Vcc = 5.0 V · High-speed on-chip oscillator: stop · Low-speed on-chip oscillator: stop · Output transistors "off" · Low voltage detection circuit: enable	Double-speed mode		6.0	10	mA
			Low-speed mode		2.6	6.0	mA
			Wait mode, functions except timer 1 disabled		1.9	5.0	mA
		f(XCIN)=32.768 kHz · Vcc = 5.0 V · High-speed on-chip oscillator: stop · Low-speed on-chip oscillator: stop · Output transistors "off" · Low voltage detection circuit: enable	Double-speed mode		100	200	µA
			Low-speed mode		85	180	µA
			Wait mode, functions except timer 1 disabled		80	170	µA
		Low-speed on-chip oscillator: oscillation · Vcc = 2.0 V · High-speed on-chip oscillator: stop · XIN: stop · Output transistors "off" · Low voltage detection circuit: enable	Low-speed mode		25	70	µA
			Wait mode, functions except timer 1 disabled		23	60	µA
		f(XIN) = 2 MHz (ceramic resonator) · Vcc = 2.0 V · High-speed on-chip oscillator: stop · Low-speed on-chip oscillator: stop · Output transistors "off" · Low voltage detection circuit: enable	Low-speed mode		190	450	µA
			Wait mode, functions except timer 1 disabled		150	430	µA
		f(XCIN) = 32.768 kHz · Vcc = 2.0 V · High-speed on-chip oscillator: stop · Low-speed on-chip oscillator: stop · Output transistors "off" · Low voltage detection circuit: enable	Low-speed mode		24	65	µA
			Wait mode, functions except timer 1 disabled		23	55	µA
		Low voltage detection circuit self consumption current	Ta = 25 °C Vcc = 5.0 V		70		µA
			Ta = 25 °C Vcc = 2.0 V		20		µA
		Increment when A/D conversion is executed f(XIN) = 8 MHz, Vcc = 5.0 V			0.5		mA
		Stop mode · Output transistors "off" · Low-speed on-chip oscillator: stop · Low voltage detection circuit: stop	Ta = 25 °C		0.1	1.0	µA
			Ta = 85 °C			10	µA

A/D Converter Characteristics

A/D Converter characteristics
(V_{CC} = 2.7 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
———	Resolution				10	bits
———	Absolute accuracy (excluding quantization error)	Ta = –20–85 °C, 2.7 ≤ Vcc ≤ 5.5 V			TBD	LSB
t_{CONV}	Conversion time	A/D conversion clock = f(φSOURCE)/2			122	tc(φSOURCE)
		A/D conversion clock = f(φSOURCE)			61	tc(φSOURCE)
R_{LADDER}	Ladder resistor			55		kΩ
$I_{I(AD)}$	A/D port input current				5.0	μA

A/D Converter Recommended Operating Conditions
(V_{CC} = 2.7 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{CC}	Power source voltage	Ta = –20–85 °C	2.7		5.5	V
φ(AD)	A/D conversion clock frequency (Note)	4.0 ≤ Vcc ≤ 5.5 V	TBD		8	MHz
		2.7 ≤ Vcc < 4.0 V	TBD		4	MHz

NOTE:
1. When X_{CIN} or the low-speed on-chip oscillator is selected as φSOURCE, the A/D converter cannot be used.

Power-on reset circuit characteristics

Power-on reset circuit characteristics
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{POR}	Valid start voltage of power-on reset circuit (Note)				0	V
TW(V_{POR})	V_{POR} hold time				10	s
TW(V_{POR}-V_{DET})	Rising time of valid power source of power-on reset circuit	TW(V_{POR}) > 10 s			20	ms

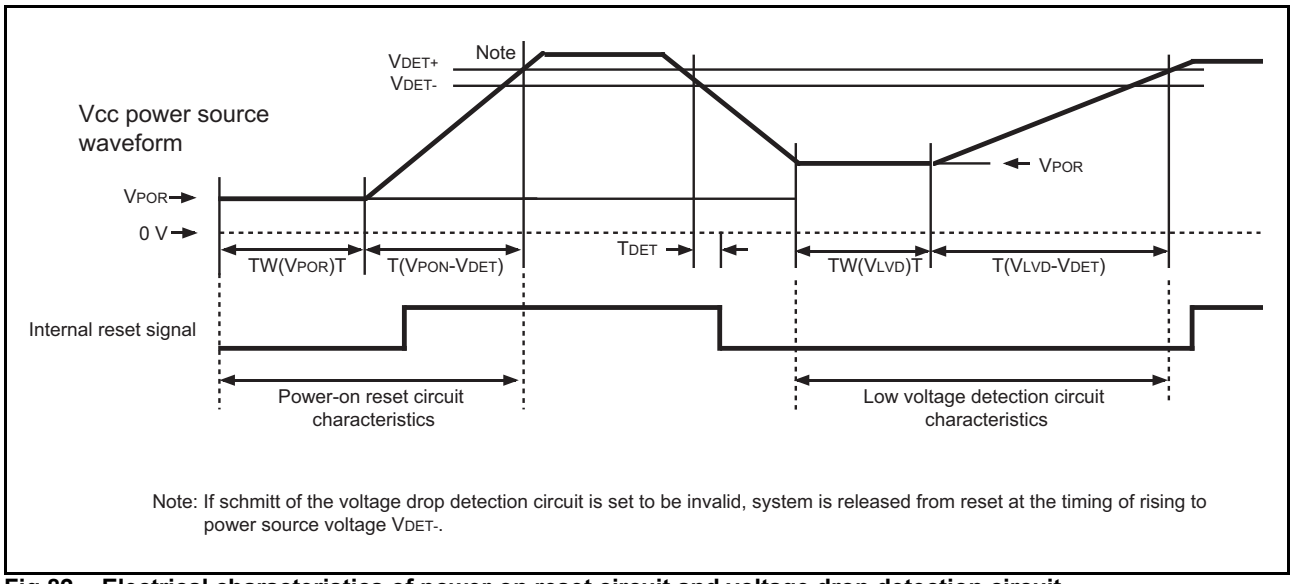
NOTE:
1. V_{POR} is the start voltage level of Vcc for the built-in power-on reset circuit to operate normally.
Keep V_{POR} to be lower than the Vcc voltage before rising of the Vcc power source to use the built-in power-on reset circuit.
Set the built-in low voltage detection circuit to be valid when the built-in power-on reset is used.

Low voltage detection circuit characteristics

Low voltage detection circuit characteristics
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{LVD}	Valid start voltage of low voltage detection circuit (Note)		1.0			V
TW(V_{LVD})	V_{LVD} hold time				10	s
TW(V_{LVD}-V_{DET})	Rising time of valid power source of low voltage detection circuit	TW(V_{LVD}) > 10 s			10	s
V_{DET-}	Detection voltage of low voltage detection circuit	Ta = 0–50 °C	1.85	1.95	2.05	V
		Ta = –20–85 °C	1.80	1.95	2.10	V
V(V_{DET+}- V_{DET-})	Detection voltage Hysteresis (when hysteresis is valid)	Ta = –20–85 °C		0.10		V
T_{DET}	Detection time of low 5voltage detection circuit			20		µs

NOTE:
1. V_{LVD} is the start voltage level of Vcc for the built-in low voltage detection circuit to operate normally.
If the Vcc power source becomes lower than V_{LVD}, first set the Vcc voltage to be lower than V_{POR}. Next, according to the electrical characteristics of the power-on reset circuit, perform the rising of Vcc.



Note: If schmitt of the voltage drop detection circuit is set to be invalid, system is released from reset at the timing of rising to power source voltage V_{DET-}.

Fig 82. Electrical characteristics of power-on reset circuit and voltage drop detection circuit

Timing Requirements

Timing requirements (1)
(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = −20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{W(\overline{RESET})}$	Reset input “L” pulse width	2			μs
$t_{C(XIN)}$	External clock input cycle time	125			ns
$t_{WH(XIN)}$	External clock input “H” pulse width	50			ns
$t_{WL(XIN)}$	External clock input “L” pulse width	50			ns
$t_{WH(INT0)}$	INT_0, INT_1, CAP_0 input “H” pulse width (Note 1)	80			ns
$t_{WL(INT0)}$	INT_0, INT_1, CAP_0 input “L” pulse width (Note 1)	80			ns
$t_{C(SCLK)}$	Serial I/O clock input cycle time (Note 2)	800			ns
$t_{WH(SCLK)}$	Serial I/O clock input “H” pulse width (Note 2)	370			ns
$t_{WL(SCLK)}$	Serial I/O clock input “L” pulse width (Note 2)	370			ns
$t_{su(RXD-SCLK)}$	Serial I/O input set up time	220			ns
$t_{h(SCLK-RXD)}$	Serial I/O input hold time	100			ns

NOTES:
1. As for CAP_0, it is the value when noise filter is not used.
2. In this time, bit 6 of the serial I/O control register (address $001A_{16}$) is set to “1” (clock synchronous serial I/O is selected). When bit 6 of the serial I/O control register is “0” (clock asynchronous serial I/O is selected), the rating values are divided by 4.

Timing requirements (2)
(V_{CC} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = −20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{W(\overline{RESET})}$	Reset input “L” pulse width	2			μs
$t_{C(XIN)}$	External clock input cycle time	250			ns
$t_{WH(XIN)}$	External clock input “H” pulse width	100			ns
$t_{WL(XIN)}$	External clock input “L” pulse width	100			ns
$t_{WH(INT0)}$	INT_0, INT_1, CAP_0 input “H” pulse width (Note 1)	230			ns
$t_{WL(INT0)}$	INT_0, INT_1, CAP_0 input “L” pulse width (Note 1)	230			ns
$t_{C(SCLK)}$	Serial I/O clock input cycle time (Note 2)	2000			ns
$t_{WH(SCLK)}$	Serial I/O clock input “H” pulse width (Note 2)	950			ns
$t_{WL(SCLK)}$	Serial I/O clock input “L” pulse width (Note 2)	950			ns
$t_{su(RXD-SCLK)}$	Serial I/O input set up time	400			ns
$t_{h(SCLK-RXD)}$	Serial I/O input hold time	200			ns

NOTES:
1. As for CAP_0, it is the value when noise filter is not used.
2. In this time, bit 6 of the serial I/O control register (address $001A_{16}$) is set to “1” (clock synchronous serial I/O is selected). When bit 6 of the serial I/O control register is “0” (clock asynchronous serial I/O is selected), the rating values are divided by 4.

Timing requirements (3)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{W(\overline{RESET})}$	Reset input “L” pulse width	2			μs
$t_{C(XIN)}$	External clock input cycle time	500			ns
$t_{WH(XIN)}$	External clock input “H” pulse width	200			ns
$t_{WL(XIN)}$	External clock input “L” pulse width	200			ns
$t_{WH(INT0)}$	INT_0, INT_1, CAP_0 input “H” pulse width (Note 1)	460			ns
$t_{WL(INT0)}$	INT_0, INT_1, CAP_0 input “L” pulse width (Note 1)	460			ns
$t_{C(SCLK)}$	Serial I/O clock input cycle time (Note 2)	4000			ns
$t_{WH(SCLK)}$	Serial I/O clock input “H” pulse width (Note 2)	1900			ns
$t_{WL(SCLK)}$	Serial I/O clock input “L” pulse width (Note 2)	1900			ns
$t_{su(RXD-SCLK)}$	Serial I/O input set up time	800			ns
$t_{h(SCLK-RXD)}$	Serial I/O input hold time	400			ns

NOTES:
1. As for CAP_0, it is the value when noise filter is not used.
2. In this time, bit 6 of the serial I/O control register (address $001A_{16}$) is set to “1” (clock synchronous serial I/O is selected).
When bit 6 of the serial I/O control register is “0” (clock asynchronous serial I/O is selected), the rating values are divided by 4.

Switching Characteristics

Switching characteristics (1)
(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
t_{WH}(SCLK)	Serial I/O clock output “H” pulse width	tc(SCLK)/2–30			ns
t_{WL}(SCLK)	Serial I/O clock output “L” pulse width	tc(SCLK)/2–30			ns
td(SCLK-TxD)	Serial I/O output delay time			140	ns
tv(SCLK-TxD)	Serial I/O output valid time	–30			ns
tr(SCLK)	Serial I/O clock output rising time			30	ns
tf(SCLK)	Serial I/O clock output falling time			30	ns
tr(CMOS)	CMOS output rising time (Note 1)		10	30	ns
tf(CMOS)	CMOS output falling time (Note 1)		10	30	ns

NOTE:
1. Pin X_{OUT} is excluded.

Switching characteristics (2)
(V_{CC} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
t_{WH}(SCLK)	Serial I/O clock output “H” pulse width	tc(SCLK)/2–50			ns
t_{WL}(SCLK)	Serial I/O clock output “L” pulse width	tc(SCLK)/2–50			ns
td(SCLK-TxD)	Serial I/O output delay time			350	ns
tv(SCLK-TxD)	Serial I/O output valid time	–30			ns
tr(SCLK)	Serial I/O clock output rising time			50	ns
tf(SCLK)	Serial I/O clock output falling time			50	ns
tr(CMOS)	CMOS output rising time (Note 1)		20	50	ns
tf(CMOS)	CMOS output falling time (Note 1)		20	50	ns

NOTE:
1. Pin X_{OUT} is excluded.

Switching characteristics (3)
(V_{CC} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
t_{WH}(SCLK)	Serial I/O clock output “H” pulse width	tc(SCLK)/2–70			ns
t_{WL}(SCLK)	Serial I/O clock output “L” pulse width	tc(SCLK)/2–70			ns
td(SCLK-TxD)	Serial I/O output delay time			450	ns
tv(SCLK-TxD)	Serial I/O output valid time	–30			ns
tr(SCLK)	Serial I/O clock output rising time			70	ns
tf(SCLK)	Serial I/O clock output falling time			70	ns
tr(CMOS)	CMOS output rising time (Note 1)		25	70	ns
tf(CMOS)	CMOS output falling time (Note 1)		25	70	ns

NOTE:
1. Pin X_{OUT} is excluded.

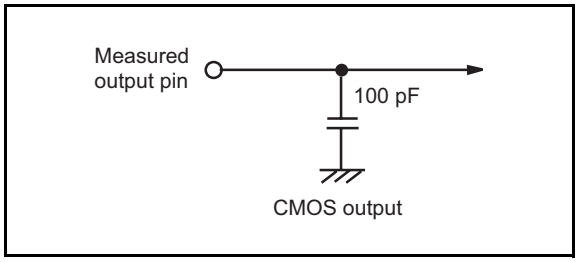


Fig 83. Switching characteristics measurement circuit diagram

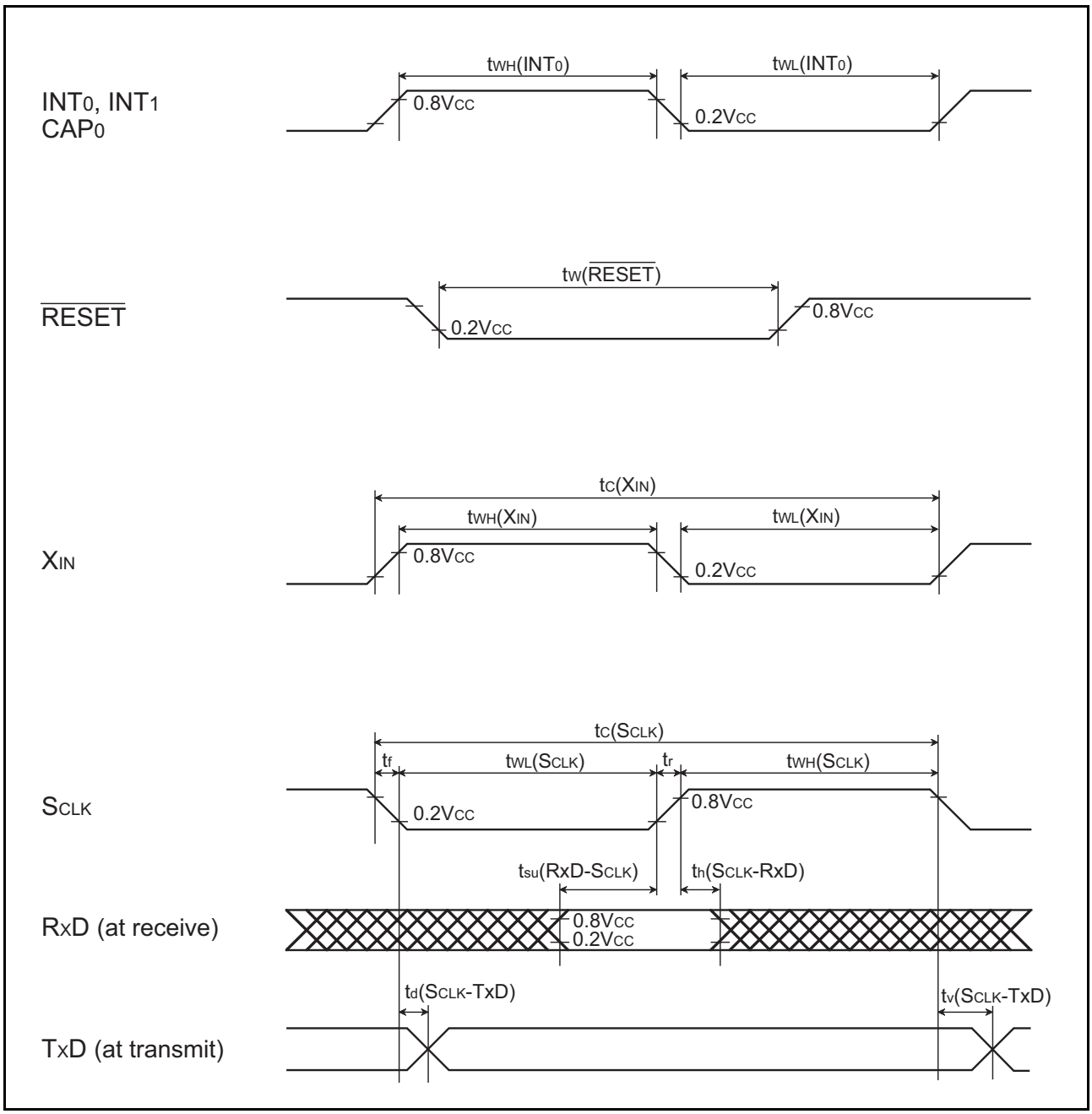
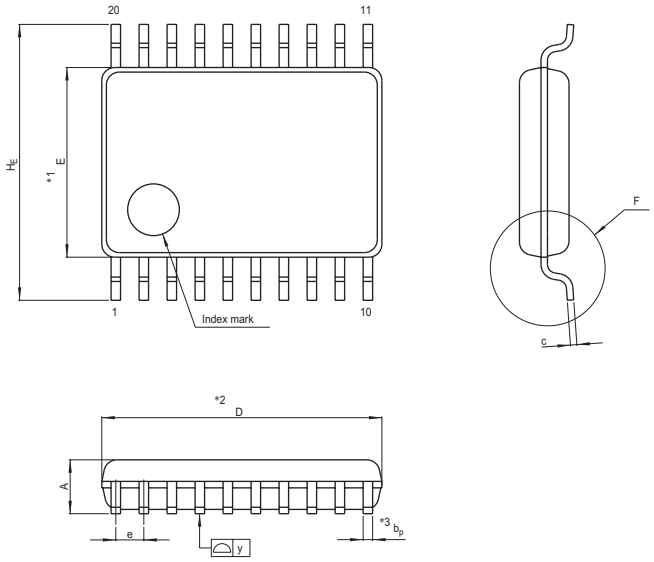


Fig 84. Timing chart

PACKAGE OUTLINE

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-LSSOP20-4.4x6.5-0.65	PLSP0020JB-A	20P2F-A	0.1g



NOTE)
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	6.4	6.5	6.6
E	4.3	4.4	4.5
A_2	—	1.15	—
A	—	—	1.45
A_1	0	0.1	0.2
b_p	0.17	0.22	0.32
c	0.13	0.15	0.2
θ	0°	—	10°
H_E	6.2	6.4	6.6
e	0.53	0.65	0.77
y	—	—	0.10
L	0.3	0.5	0.7

REVISION HISTORY	7548 Group Datasheet

Rev.	Date	Description	
		Page	Summary
1.00	Dec 28, 2006	-	First edition issued
1.01	Dec 28, 2006	1	Key-on wakeup is changed.
		14	Fig.12 is revised.
		19	Fig.16 is revised.
2.00	Mar 15, 2007	1	FEATURES: "• LED output port" → "• LED direct drive port" "• Built-in high-speed on-chip oscillator" → "High-speed on-chip oscillator" "• Built-in low-speed on-chip oscillator" → "Low-speed on-chip oscillator" •Power dissipation; "TBD" → "30 mW"
		4	Table 1: I/O port $P0_0$-$P0_7$; "LED direct drive ports" is added A/D converter; "8 channel" → "× 8 channel"
		6	Table 2: $P0_3$ "Capture function pin" → "Capture input pin" $P1_0$-$P1_2$ "Compare function pin" → "Compare output pin" $P1_3$ "Timer 2 function pin" → "Timer 2 output pin" $P2_0$, $P2_1$ "external oscillator pin" → "clock pins"
		10	[CPU mode register]: Description is revised and moved from the page 12.
		11	Function set ROM Area: Description is revised and moved from the page 47. <Notes>: (2) is added, (3) is revised
		12	Fig 8 Note is deleted
		14	Fig 10, Fig 11, Fig 12 is moved from the page 47. Fig 12 is revised
		15	[Pull-up control registers]: Description revised Fig 13, Fig 14, Fig 15 is revised
		16	Table 6 is revised
		17, 18	Fig 17, Fig 18; Title is revised
		19	Contents of Table 7 is added
		21	Table 8: Key-on wakeup "P0" → "P1"
		24	Timers, • Notes on Timers 1 and 2: Description is revised
		26	Timer A (TA), • Notes on Timer A: Description is revised
		27	Output compare: Contents of description added Fig 30 "oscillator/512" → "oscillator/16"
		31	Input capture: Contents of description added
		32	Fig 40 "oscillator/512" → "oscillator/16"
		37, 38	register name: "A/D" → "AD"
		38	• Notes on A/D converter: (2) is added
		39	Watchdog Timer is revised Fig 51, Fig 54 is revised
		40	• Notes on Watchdog Timer is revised
		42	Fig 57 is revised
		43	Clock Circuit is revised
		44	Oscillation Control is added Table 9 is added Fig 62 is revised
		47	Fig 63 is revised
		48	Fig 64 is revised

REVISION HISTORY	7548 Group Datasheet

Rev.	Date	Description	
		Page	Summary
2.00	Mar 15, 2007	49	“oscillation stop” → “oscillation stop detection” Fig 65 is revised Fig 66 is revised, Note 4 is added • Notes on Function Set ROM Data 2 is deleted
		50	Table 10: $P1_0$ “ESDA input” → “ESDA I/O”, “Output” → “I/O”
		53	(7) CPU Mode Register is revised
		58	Overvoltage: Description revised, Fig 80 is added
		59	ELECTRICAL CHARACTERISTICS is added

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