

3827 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

DESCRIPTION

The 3827 group is the 8-bit microcomputer based on the 740 family core technology.

The 3827 group has the LCD drive control circuit, the A-D/D-A converter, the UART, and the PWM as additional functions.

The various microcomputers in the 3827 group include variations of internal memory size and packaging. For details, refer to the section on part numbering.

For details on availability of microcomputers in the 3827 group, refer to the section on group expansion.

FEATURES

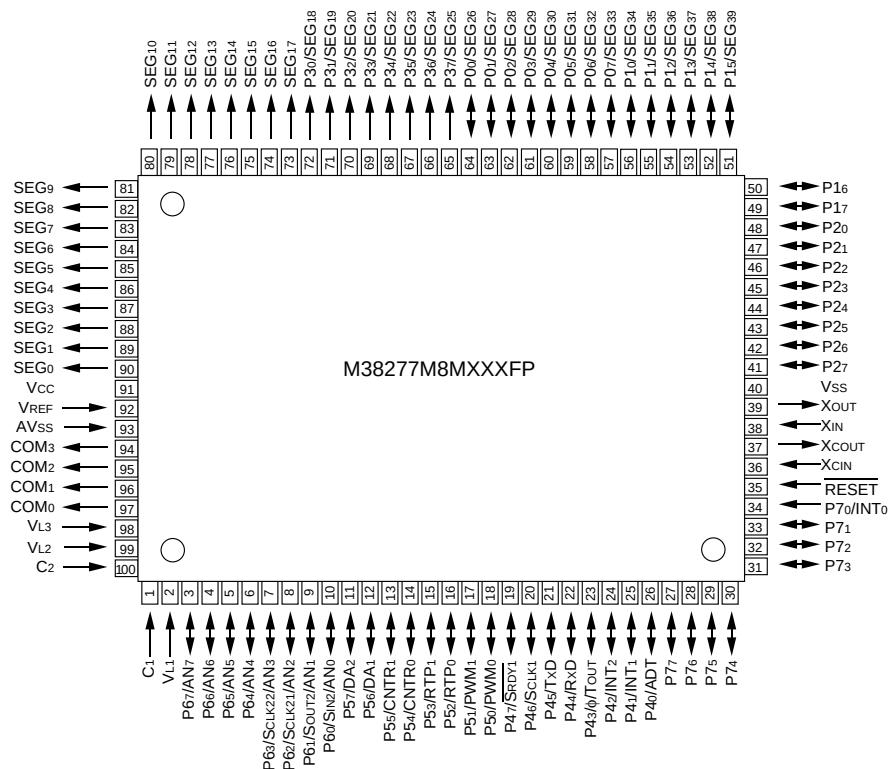
- Basic machine-language instructions 71
- The minimum instruction execution time 0.5 μ s
(at 8MHz oscillation frequency)
- Memory size
 - ROM 4 K to 60 K bytes
 - RAM 192 to 2048 bytes
- Programmable input/output ports 55
- Output port 8
- Input port 1
- Interrupts 17 sources, 16 vectors
(includes key input interrupt)
- Timers 8-bit X 3, 16-bit X 2

- Serial I/O1 8-bit X 1 (UART or Clock-synchronized)
- Serial I/O2 8-bit X 1 (Clock-synchronized)
- PWM output 8-bit X 1
- A-D converter 10-bit X 8 channels
- D-A converter 8-bit X 2 channels
- LCD drive control circuit
 - Bias 1/2, 1/3
 - Duty 1/2, 1/3, 1/4
 - Common output 4
 - Segment output 40
- 2 Clock generating circuits
(connect to external ceramic resonator or quartz-crystal oscillator)
- Watchdog timer 14-bit X 1
- Power source voltage 2.2 to 5.5 V
- Power dissipation
 - In high-speed mode 40 mW
(at 8 MHz oscillation frequency, at 5 V power source voltage)
 - In low-speed mode 60 μ W
(at 32 kHz oscillation frequency, at 3 V power source voltage)
- Operating temperature range - 20 to 85°C

APPLICATIONS

Camera, wireless phone, etc.

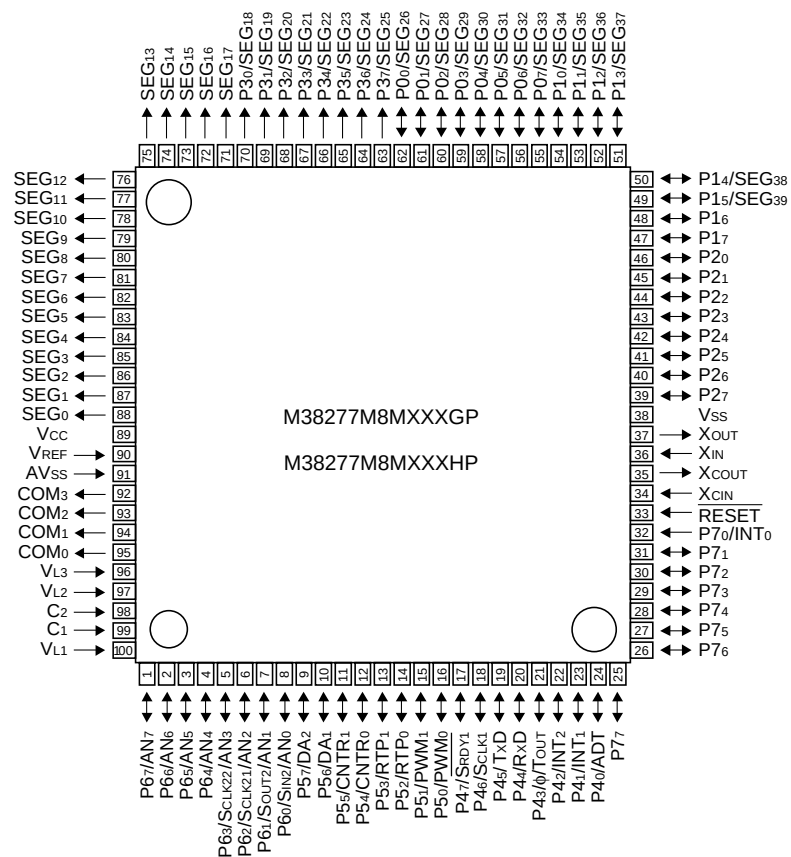
PIN CONFIGURATION (TOP VIEW)



Package type : 100P6S-A (100-pin plastic-molded QFP)

Fig. 1 M38277M8MXXXFP pin configuration

PIN CONFIGURATION (TOP VIEW)



Package type : GP 100P6Q-A (100-pin plastic-molded LQFP)

Package type : HP 100PFB-A (100-pin plastic-molded TQFP)

Fig. 2 M38277M8MXXXGP/M38277M8MXXXHP pin configuration

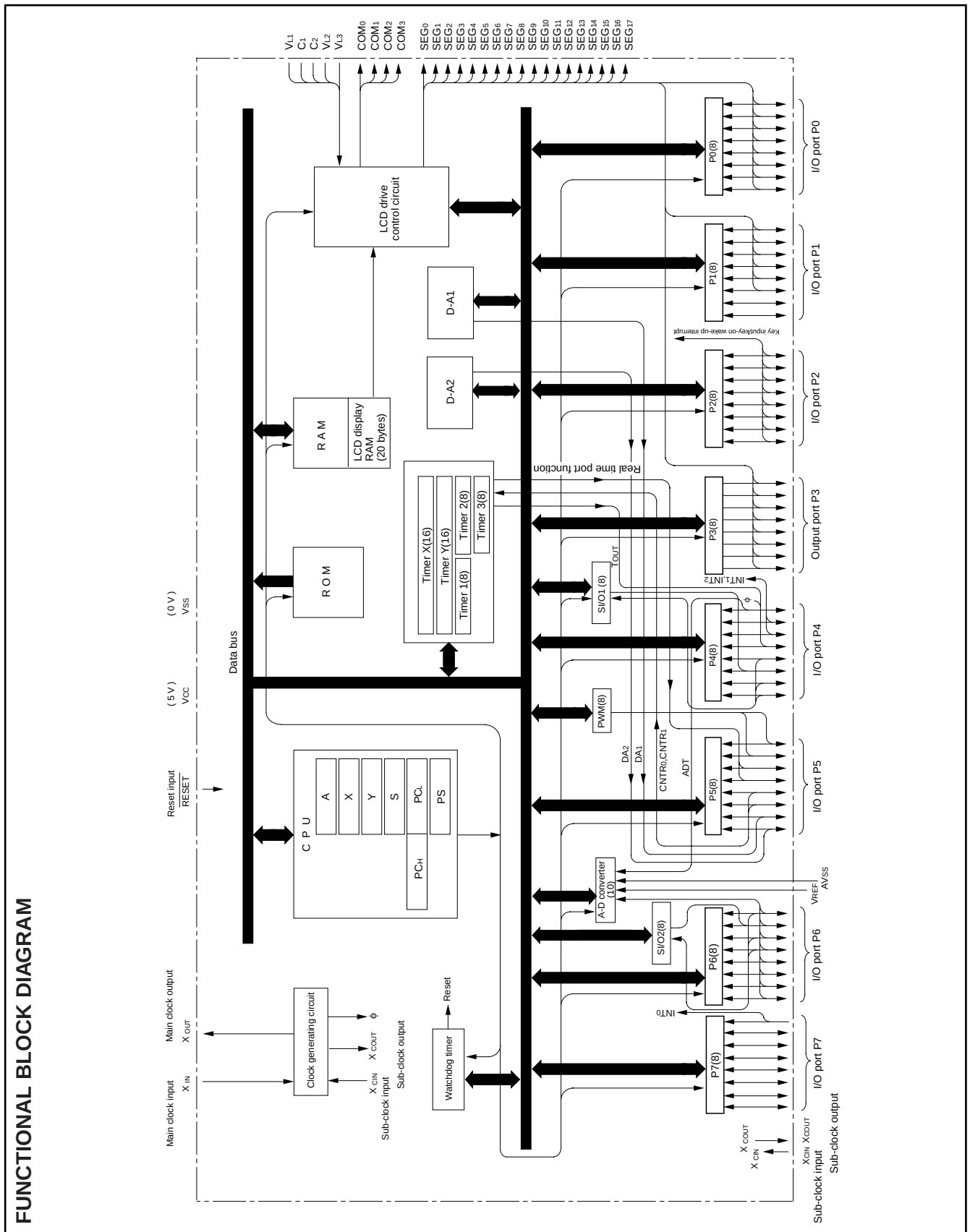


Fig. 3 Functional block diagram

PIN DESCRIPTION

Table 1 Pin description (1)

Pin	Name	Function	
			Function except a port function
VCC, VSS	Power source	•Apply voltage of 2.2 V to 5.5 V to Vcc, and 0 V to Vss.	
VREF	Analog reference voltage	•Reference voltage input pin for A-D converter and D-A converter.	
AVSS	Analog power source	•GND input pin for A-D converter and D-A converter. •Connect to Vss.	
$\overline{\text{RESET}}$	Reset input	•Reset input pin for active "L".	
XIN	Clock input	•Input and output pins for the main clock generating circuit. •Connect a ceramic resonator or a quartz-crystal oscillator between the XIN and XOUT pins to set the oscillation frequency.	
XOUT	Clock output	•If an external clock is used, connect the clock source to the XIN pin and leave the XOUT pin open.	
VL1–VL3	LCD power source	•Input $0 \leq VL1 \leq VL2 \leq VL3 \leq VCC$ voltage. •Input $0 - VL3$ voltage to LCD.	
C1, C2	Charge-pump capacitor pin	•External capacitor pins for a voltage multiplier (3 times) of LCD control.	
COM0–COM3	Common output	•LCD common output pins. •COM2 and COM3 are not used at 1/2 duty ratio. •COM3 is not used at 1/3 duty ratio.	
SEG0–SEG17	Segment output	•LCD segment output pins.	
P00/SEG26– P07/SEG33	I/O port P0	•8-bit output port. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. •I/O direction register allows each port to be individually programmed as either input or output.	•LCD segment output pins
P10/SEG34– P15/SEG39	I/O port P1	•6-bit output port with same function as port P0. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. •I/O direction register allows each 6-bit pin to be programmed as either input or output.	
P16, P17		•2-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	
P20 – P27	I/O port P2	•8-bit I/O port with same function as port P0. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled.	•Key input (key-on wake-up) interrupt input pins
P30/SEG18 – P37/SEG25	Output port P3	•8-bit output port with same function as port P0. •CMOS 3-state output structure. •Port output control is enabled.	•LCD segment output pins

Table 2 Pin description (2)

Pin	Name	Function	Function except a port function
P40/ADT	I/O port P4	•1-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •CMOS 3-state output structure.	•A-D trigger input pin •Interrupt input pin
P41/INT1, P42/INT2			•Interrupt input pins
P43/ ϕ /TOUT			•ϕ clock output pin •Timer 2 output pin
P44/RxD, P45/TxD, P46/SCLK1, P47/SRDY1			•Serial I/O1 I/O pins
P50/PWM0, P51/PWM1	I/O port P5	•8-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled.	•PWM function pins
P52/RTP0, P53/RTP1			•Real time port function pins
P54/CNTR0, P55/CNTR1			•Timer X, Y function pins
P56/DA1, P57/DA2			•D-A conversion output pins
P60/AN0/SIN2, P61/AN1/SOUT2, P62/AN2/SCLK21, P63/AN3/SCLK22	I/O port P6	•8-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled.	•A-D conversion input pins •Serial I/O2 I/O pins
P64/AN4– P67/AN7			•A-D conversion input pins
P70/INT0	Input port P7	•1-bit I/O port. •CMOS compatible input level.	•Interrupt input pin
P71–P77	I/O port P7	•7-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •N-channel open-drain output structure.	
XCOUT	Sub-clock output	•Sub-clock generating circuit I/O pins. (Connect a resonator. External clock cannot be used.)	
XCIN	Sub-clock input		

PART NUMBERING

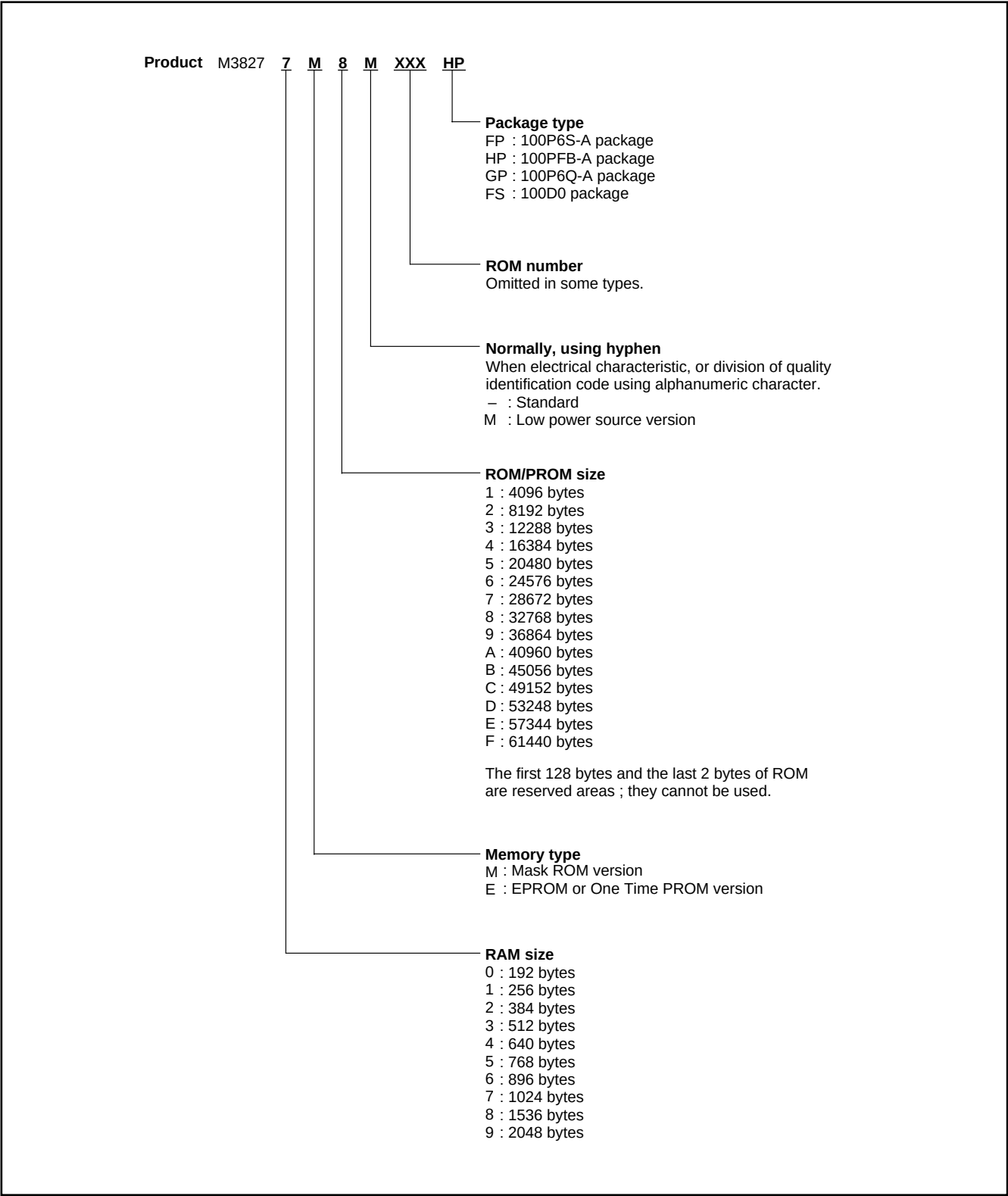


Fig. 4 Part numbering

GROUP EXPANSION

Mitsubishi plans to expand the 3827 group as follows:

Memory Type

Support for Mask ROM, One Time PROM, and EPROM versions

Memory Size

ROM/PROM size 4 K to 60 K bytes

RAM size 192 to 2048 bytes

Package

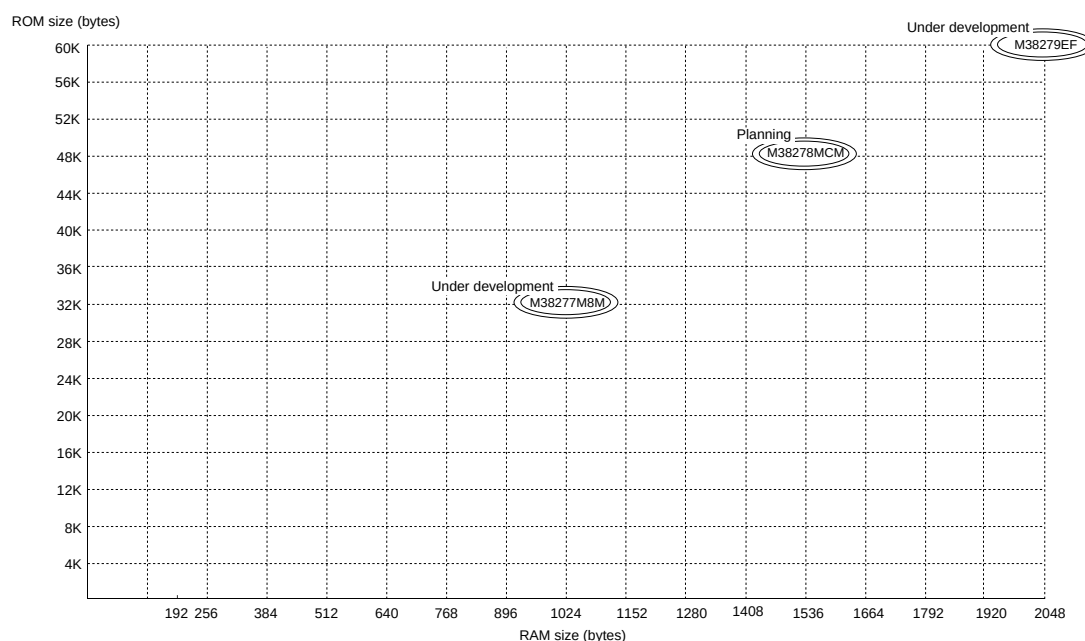
100PFB-A 0.4 mm-pitch plastic molded TQFP

100P6Q-A 0.5 mm-pitch plastic molded LQFP

100P6S-A 0.65 mm-pitch plastic molded QFP

100D0 Window type ceramic LCC (EPROM version)

Memory Expansion Plan



Note: Products under development or planning: the development schedule and specifications may be revised without notice.

Fig. 5 Memory expansion plan

Currently supported products are listed below.

Table 3 List of supported products

As of May 1998

Product	(P) ROM size (bytes) ROM size for User in ()	RAM size (bytes)	Package	Remarks
M38277M8MXXXFP	32768 (32638)	1024	100P6S-A	Mask ROM version
M38277M8MXXXHP			100PFB-A	Mask ROM version
M38277M8MXXXGP			100P6Q-A	Mask ROM version
M38279EF-XXXFP	61440 (61310)	2048	100P6S-A	One Time PROM version
M38279EFFF			100P6S-A	One Time PROM version (blank)
M38279EF-XXXHP			100PFB-A	One Time PROM version
M38279EFHP			100PFB-A	One Time PROM version (blank)
M38279EF-XXXGP			100P6Q-A	One Time PROM version
M38279EFGP			100P6Q-A	One Time PROM version (blank)
M38279EFFF			100D0	EPROM version

FUNCTIONAL DESCRIPTION
Central Processing Unit (CPU)

The 3827 group uses the standard 740 family instruction set. Refer to the table of 740 family addressing modes and machine instructions or the 740 Family Software Manual for details on the instruction set.

Machine-resident 740 family instructions are as follows:

The FST and SLW instruction cannot be used.

The STP, WIT, MUL, and DIV instruction can be used.

[CPU Mode Register (CPUM)] 003B16

The CPU mode register contains the stack page selection bit and the internal system clock selection bit.

The CPU mode register is allocated at address 003B16.

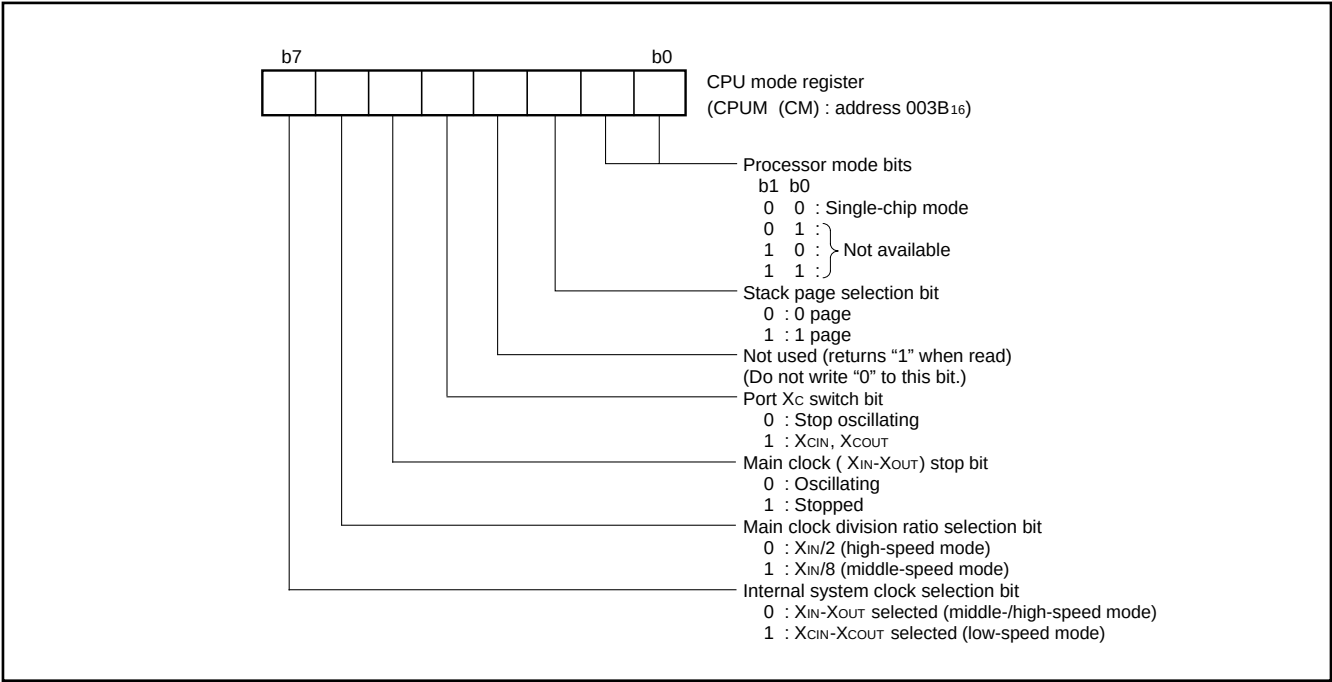


Fig. 6 Structure of CPU mode register

MEMORY

Special Function Register (SFR) Area

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

RAM

RAM is used for data storage and for 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 user area for storing programs.

Interrupt Vector Area

The interrupt vector area contains reset and interrupt vectors.

Zero Page

Access to this area with only 2 bytes is possible in the zero page addressing mode.

Special Page

Access to this area with only 2 bytes is possible in the special page addressing mode.

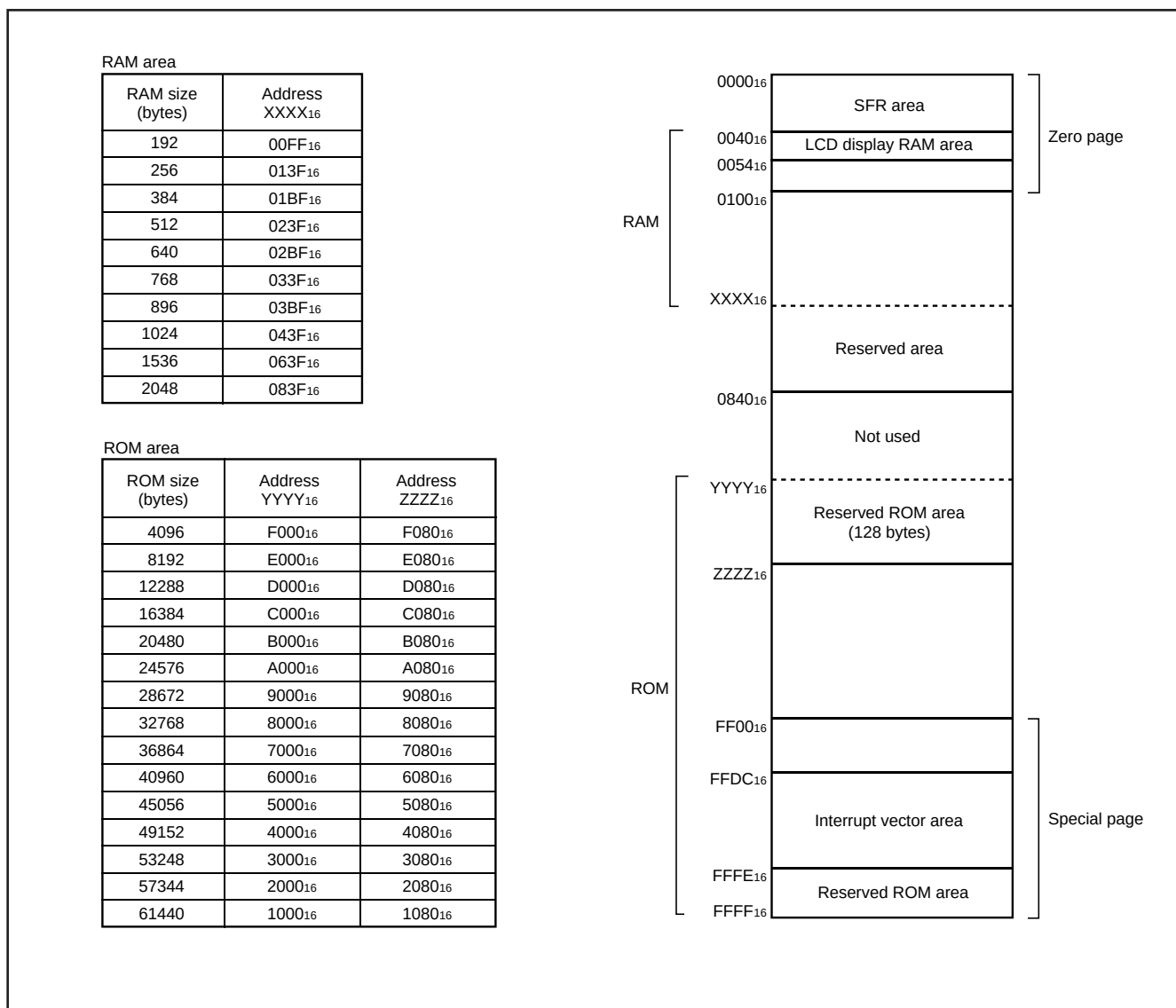


Fig. 7 Memory map diagram

0000 ₁₆	Port P0 (P0)	0020 ₁₆	Timer X (low) (TXL)
0001 ₁₆	Port P0 direction register (P0D)	0021 ₁₆	Timer X (high) (TXH)
0002 ₁₆	Port P1 (P1)	0022 ₁₆	Timer Y (low) (TYL)
0003 ₁₆	Port P1 output control register (P1D)	0023 ₁₆	Timer Y (high) (TYH)
0004 ₁₆	Port P2 (P2)	0024 ₁₆	Timer 1 (T1)
0005 ₁₆	Port P2 direction register (P2D)	0025 ₁₆	Timer 2 (T2)
0006 ₁₆	Port P3 (P3)	0026 ₁₆	Timer 3 (T3)
0007 ₁₆	Port P3 output control register (P3C)	0027 ₁₆	Timer X mode register (TXM)
0008 ₁₆	Port P4 (P4)	0028 ₁₆	Timer Y mode register (TYM)
0009 ₁₆	Port P4 direction register (P4D)	0029 ₁₆	Timer 123 mode register (T123M)
000A ₁₆	Port P5 (P5)	002A ₁₆	Tout/φ output control register (CKCON)
000B ₁₆	Port P5 direction register (P5D)	002B ₁₆	PWM control register (PWMCON)
000C ₁₆	Port P6 (P6)	002C ₁₆	PWM prescaler (PREPWM)
000D ₁₆	Port P6 direction register (P6D)	002D ₁₆	PWM register (PWM)
000E ₁₆	Port P7 (P7)	002E ₁₆	
000F ₁₆	Port P7 direction register (P7D)	002F ₁₆	
0010 ₁₆		0030 ₁₆	
0011 ₁₆		0031 ₁₆	A-D control register (ADCON)
0012 ₁₆		0032 ₁₆	A-D control register (low-order) (ADL)
0013 ₁₆		0033 ₁₆	A-D control register (high-order) (ADH)
0014 ₁₆		0034 ₁₆	D-A1 conversion register (DA1)
0015 ₁₆	Key input control register (KIC)	0035 ₁₆	D-A2 conversion register (DA2)
0016 ₁₆	PULL register A (PULLA)	0036 ₁₆	D-A control register (DACON)
0017 ₁₆	PULL register B (PULLB)	0037 ₁₆	Watchdog timer control register (WDTCN)
0018 ₁₆	Transmit/Receive buffer register (TB/RB)	0038 ₁₆	Segment output enable register (SEG)
0019 ₁₆	Serial I/O1 status register (SIO1STS)	0039 ₁₆	LCD mode register (LM)
001A ₁₆	Serial I/O1 control register (SIO1CON)	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	Serial I/O2 control register (SIO2CON)	003D ₁₆	Interrupt request register 2(IREQ2)
001E ₁₆	Reserved area	003E ₁₆	Interrupt control register 1(ICON1)
001F ₁₆	Serial I/O2 register (SIO2)	003F ₁₆	Interrupt control register 2(ICON2)

Fig. 8 Memory map of special function register (SFR)

I/O PORTS

Direction Registers

The I/O ports have direction registers which determine the input/output direction of each individual pin. (P0₀–P0₇ and P1₀–P1₅ use bit 0 of port P0, P1 direction registers respectively.)

When “1” is written to that bit, that pin becomes an output pin. When “0” is written to the bit corresponding to a pin, that pin becomes an input pin.

If data is read from a pin set to output, the value of the port output latch is read, not the value of the pin itself. Pins set to input are floating and the value of that pin can be read. If a pin set to input is written to, only the port output latch is written to and the pin remains floating.

Port P3 Output Control Register

Bit 0 of the port P3 output control register (address 0007₁₆) enables control of the output of ports P3₀ to P3₇.

When the bit is set to “1”, the port output function is valid.

When resetting, bit 0 of the port P3 output control register is set to “0” (the port output function is invalid.) and ports P3₀ to P3₇ are pulled up.

Pull-up Control

By setting the PULL register A (address 0016₁₆) or the PULL register B (address 0017₁₆), ports P0 to P6 can control pull-up with a program.

However, the contents of PULL register A and PULL register B do not affect ports programmed as the output ports.

The PULL register A setting is invalid for pins set to segment output on the segment output enable register.

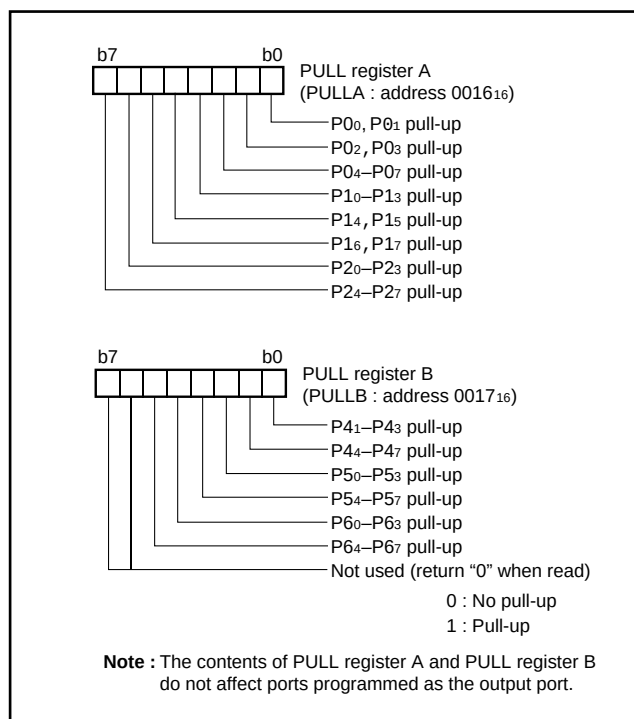


Fig. 9 Structure of PULL register A and PULL register B

Table 4 List of I/O port function (1)

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P00/SEG26– P07/SEG33	Port P0	Input/output, byte unit	CMOS compatible input level CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1) (2)
P10/SEG34– P15/SEG39	Port P1	Input/output, 6-bit unit	CMOS compatible input level CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1) (2)
P16 , P17		Input/output, individual bits	CMOS compatible input level CMOS 3-state output		PULL register A	(4)
P20–P27	Port P2	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Key input (key-on wake-up) interrupt input	PULL register A Interrupt control register2 Key input control register	(4)
P30/SEG18– P37/SEG25	Port P3	Output	CMOS 3-state output	LCD segment output	PULL register A Segment output enable register P3 output enable register	(3)
P40/ADT	Port P4	Input/output, individual bits	CMOS compatible input level N-channel open-drain output	A-D trigger input External interrupt input	A-D control register Interrupt edge selection register	(13)
P41/INT1, P42/INT2			CMOS compatible input level CMOS 3-state output	External interrupt input	PULL register B Interrupt edge selection register	(4)
P43/φ/TOUT				Timer output φ output	PULL register B Timer 123 mode register TOUT/φ output control register	(12)
P44/RxD, P45/TxD, P46/SCLK1, P47/SDY1				Serial I/O1 function I/O	PULL register B Serial I/O1 control register Serial I/O1 status register UART control register	(5) (6) (7) (8)
P50/PWM0, P51/PWM1	Port P5	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	PWM output	PULL register B PWM control register	(10)
P52/RTP0, P53/RTP1				Real time port function output	PULL register B Timer X mode register	(9)
P54/CNTR0				Timer X function I/O	PULL register B Timer X mode register	(11)
P55/CNTR1				Timer Y function input	PULL register B Timer Y mode register	(14)
P56/DA1				DA1 output A-D VREF input	PULL register B D-A control register A-D control register	(15)
P57/DA2				DA2 output	PULL register B D-A control register	(15)

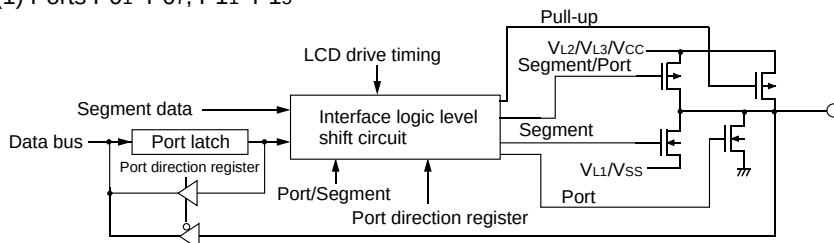
Table 5 List of I/O port function (2)

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P60/SIN2/AN0	Port P6	Input/ output, individual bits	CMOS compatible input level CMOS 3-state output	A-D conversion input Serial I/O2 function I/O	A-D control register Serial I/O2 control register	(17)
P61/SOUT2/ AN1						(18)
P62/SCLK21/ AN2						(19)
P63/SCLK22 / AN3						(20)
P64/AN4– P67/AN7				A-D conversion input	A-D control register	(16)
P70/INT0	Port P7	Input	CMOS compatible input level	External interrupt input	Interrupt edge selection register	(23)
P71–P77		Input/ output, individual bits	CMOS compatible input level N-channel open-drain output			(13)
COM0–COM3	Common	Output	LCD common output		LCD mode register	(21)
SEG0–SEG17	Segment	Output	LCD segment output			(22)

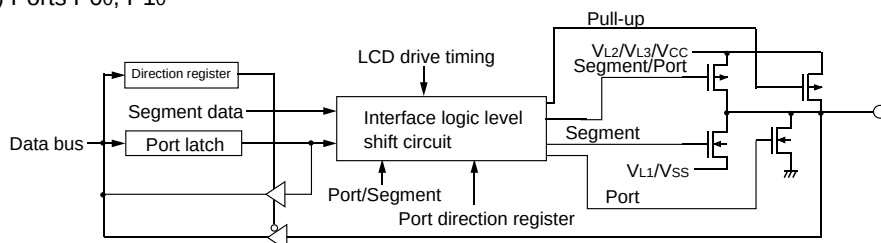
Notes1: How to use double-function ports as function I/O ports, refer to the applicable sections.

2: Make sure that the input level at each pin is either 0 V or V_{CC} during execution of the STP instruction. When an input level is at an intermediate potential, a current will flow V_{CC} to V_{SS} through the input-stage gate.

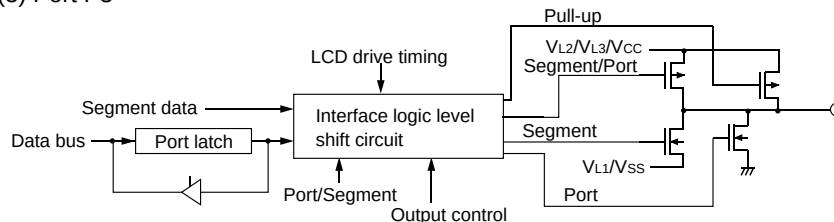
(1) Ports P01–P07, P11–P15



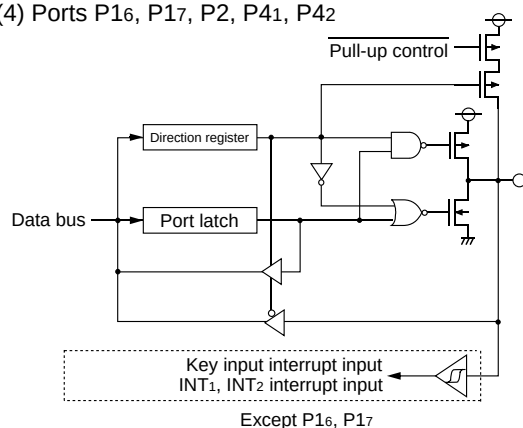
(2) Ports P00, P10



(3) Port P3



(4) Ports P16, P17, P2, P41, P42



(5) Port P44

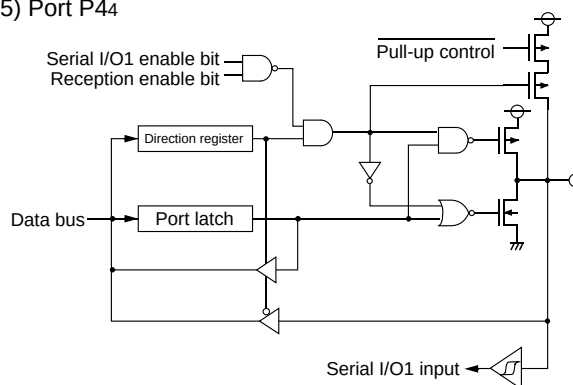


Fig. 10 Port block diagram (1)

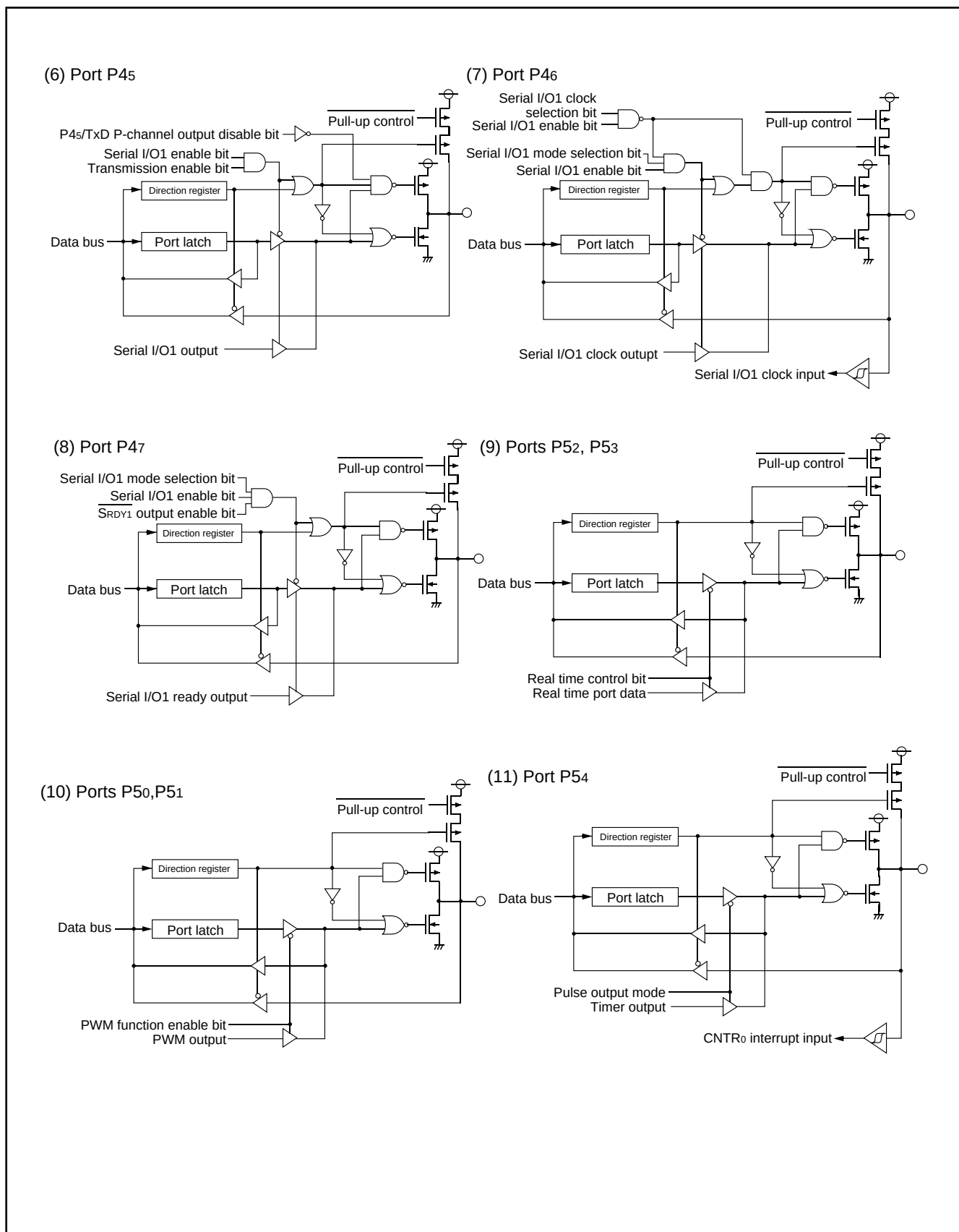
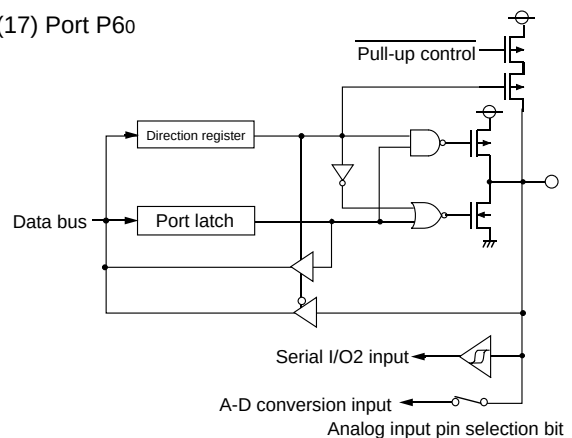
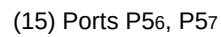
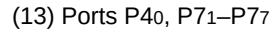
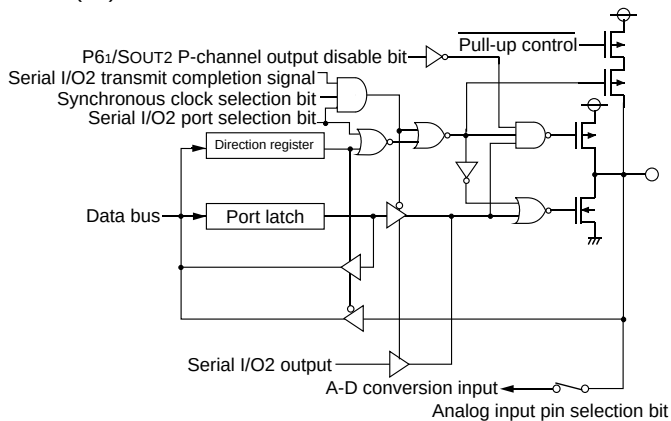


Fig. 11 Port block diagram (2)

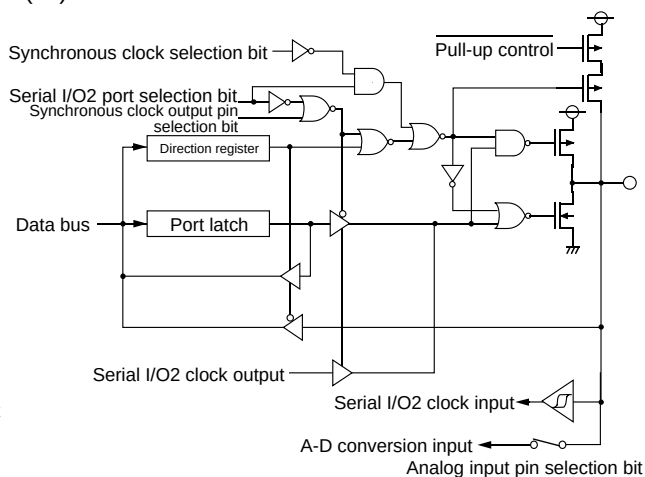


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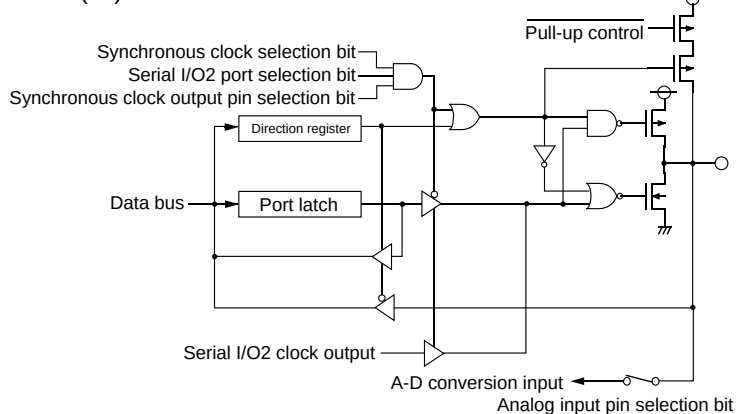
(18) Port P61



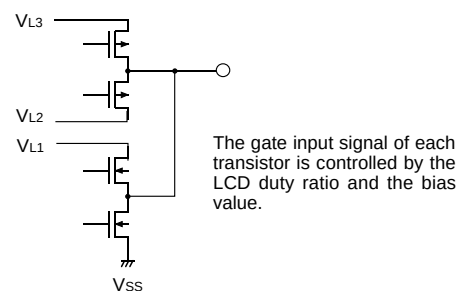
(19) Port P62



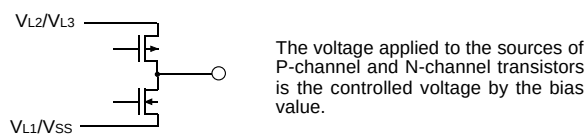
(20) Port P63



(21) COM0-COM3



(22) SEG0-SEG17



(23) Port P70

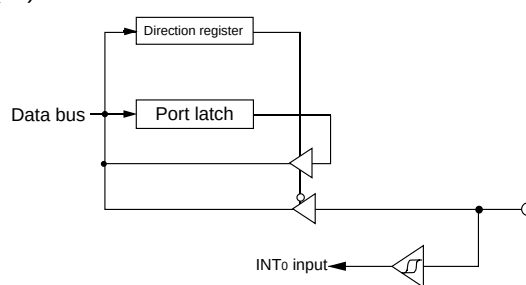


Fig. 13 Port block diagram (4)

INTERRUPTS

Interrupts occur by seventeen sources: seven external, nine internal, and one software.

Interrupt Control

Each interrupt except the BRK instruction interrupt have both an interrupt request bit and an interrupt enable bit, and is controlled by the interrupt disable flag. An interrupt occurs if the corresponding interrupt request and enable bits are "1" and the interrupt disable flag is "0." Interrupt enable bits can be set or cleared by software. Interrupt request bits can be cleared by software, but cannot be set by software. The BRK instruction interrupt and reset cannot be disabled with any flag or bit. The I flag disables all interrupts except the BRK instruction interrupt and reset. If several interrupts requests occurs at the same time the interrupt with highest priority is accepted first.

Interrupt Operation

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

1. The contents of the program counter and processor status register are automatically pushed onto the stack.
2. The interrupt disable flag is set and the corresponding interrupt request bit is cleared.
3. The interrupt jump destination address is read from the vector table into the program counter.

■Notes

When the active edge of an external interrupt (INT0–INT2, CNTR0, CNTR1) is set or when switching interrupt sources of ADT/A-D conversion interrupt, the corresponding interrupt request bit may also be set. Therefore, take following sequence:

- (1) Disable the external interrupt which is selected.
- (2) Change the active edge in interrupt edge selection register (timer XY mode register when using CNTR0, CNTR1)
- (3) Clear the set interrupt request bit to "0."
- (4) Enable the external interrupt which is selected.

Table 6 Interrupt vector addresses and priority

Interrupt Source	Priority	Vector Addresses (Note 1)		Interrupt Request Generating Conditions	Remarks
		High	Low		
Reset (Note 2)	1	FFFD ₁₆	FFFC ₁₆	At reset	Non-maskable
INT0	2	FFFB ₁₆	FFFA ₁₆	At detection of either rising or falling edge of INT0 input	External interrupt (active edge selectable)
INT1	3	FFF9 ₁₆	FFF8 ₁₆	At detection of either rising or falling edge of INT1 input	External interrupt (active edge selectable)
Serial I/O1 reception	4	FFF7 ₁₆	FFF6 ₁₆	At completion of serial I/O1 data reception	Valid when serial I/O1 is selected
Serial I/O1 transmission	5	FFF5 ₁₆	FFF4 ₁₆	At completion of serial I/O1 transmit shift or when transmission buffer is empty	Valid when serial I/O1 is selected
Timer X	6	FFF3 ₁₆	FFF2 ₁₆	At timer X underflow	
Timer Y	7	FFF1 ₁₆	FFF0 ₁₆	At timer Y underflow	
Timer 2	8	FFEF ₁₆	FFEE ₁₆	At timer 2 underflow	
Timer 3	9	FFED ₁₆	FFEC ₁₆	At timer 3 underflow	
CNTR0	10	FFEB ₁₆	FFEA ₁₆	At detection of either rising or falling edge of CNTR0 input	External interrupt (active edge selectable)
CNTR1	11	FFE9 ₁₆	FFE8 ₁₆	At detection of either rising or falling edge of CNTR1 input	External interrupt (active edge selectable)
Timer 1	12	FFE7 ₁₆	FFE6 ₁₆	At timer 1 underflow	
INT2	13	FFE5 ₁₆	FFE4 ₁₆	At detection of either rising or falling edge of INT2 input	External interrupt (active edge selectable)
Serial I/O2	14	FFE3 ₁₆	FFE2 ₁₆	At completion of serial I/O2 data transmission or reception	Valid when serial I/O2 is selected
Key input (Key-on wake-up)	15	FFE1 ₁₆	FFE0 ₁₆	At falling of conjunction of input level for port P2 (at input mode)	External interrupt (valid when an "L" level is applied)
ADT	16	FFDF ₁₆	FFDE ₁₆	At falling of ADT input	Valid when ADT interrupt is selected External interrupt (Valid at falling)
A-D conversion				At completion of A-D conversion	Valid when A-D interrupt is selected
BRK instruction	17	FFDD ₁₆	FFDC ₁₆	At BRK instruction execution	Non-maskable software interrupt

Notes1: Vector addresses contain interrupt jump destination addresses.

2: Reset function in the same way as an interrupt with the highest priority.

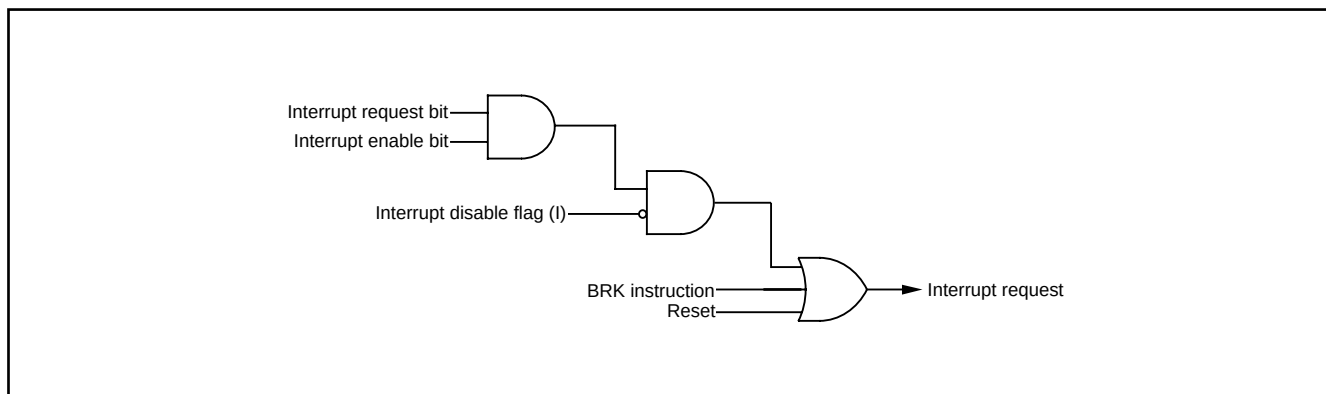


Fig. 14 Interrupt control

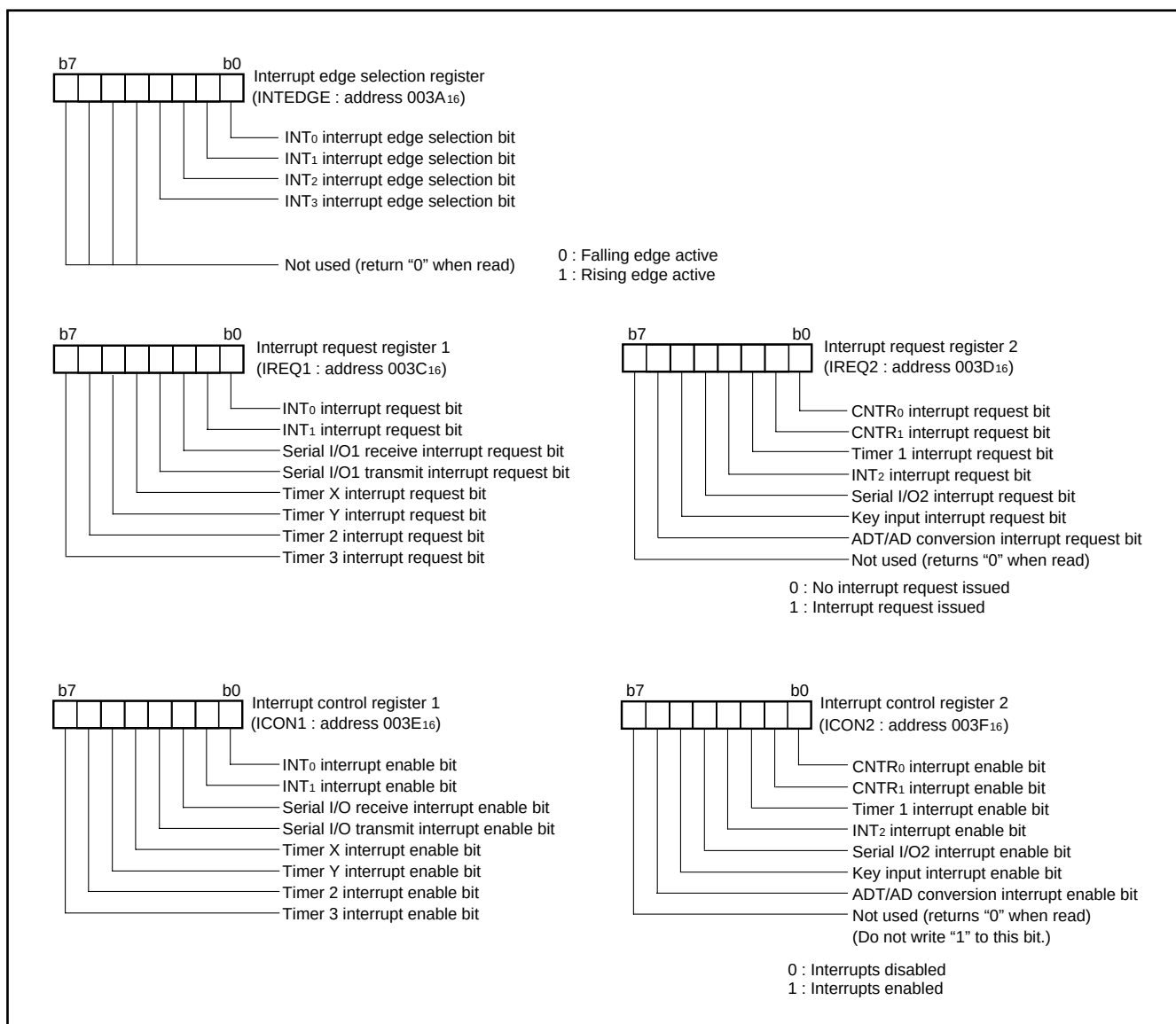


Fig. 15 Structure of interrupt-related registers

Key Input Interrupt (Key-on wake-up)

A Key-on wake up interrupt request is generated by applying "L" level to any pin of port P2 that have been set to input mode. In other words, it is generated when AND of input level goes from "1" to "0". An example of using a key input interrupt is shown in Figure 16, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports P20–P23.

to "0". An example of using a key input interrupt is shown in Figure 16, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports P20–P23.

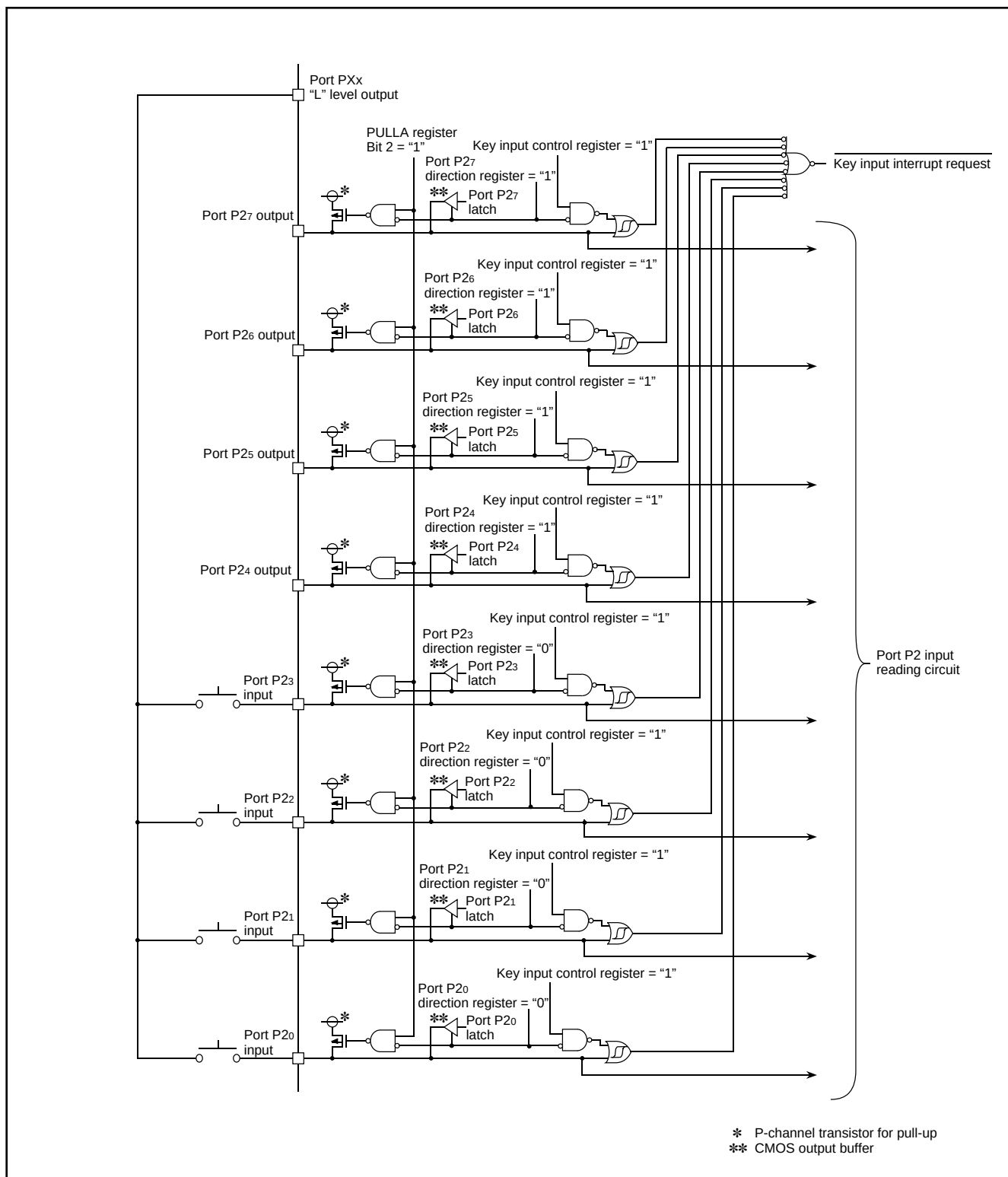


Fig. 16 Connection example when using key input interrupt and port P2 block diagram

TIMERS

The 3827 group has five timers: timer X, timer Y, timer 1, timer 2, and timer 3. Timer X and timer Y are 16-bit timers, and timer 1, timer 2, and timer 3 are 8-bit timers.

All timers are down count timers. When the timer reaches "0016", an underflow occurs at the next count pulse and the corresponding timer latch is reloaded into the timer and the count is continued. When a timer underflows, the interrupt request bit cor-

responding to that timer is set to "1".

Read and write operation on 16-bit timer must be performed for both high and low-order bytes. When reading a 16-bit timer, read the high-order byte first. When writing to a 16-bit timer, write the low-order byte first. The 16-bit timer cannot perform the correct operation when reading during the write operation, or when writing during the read operation.

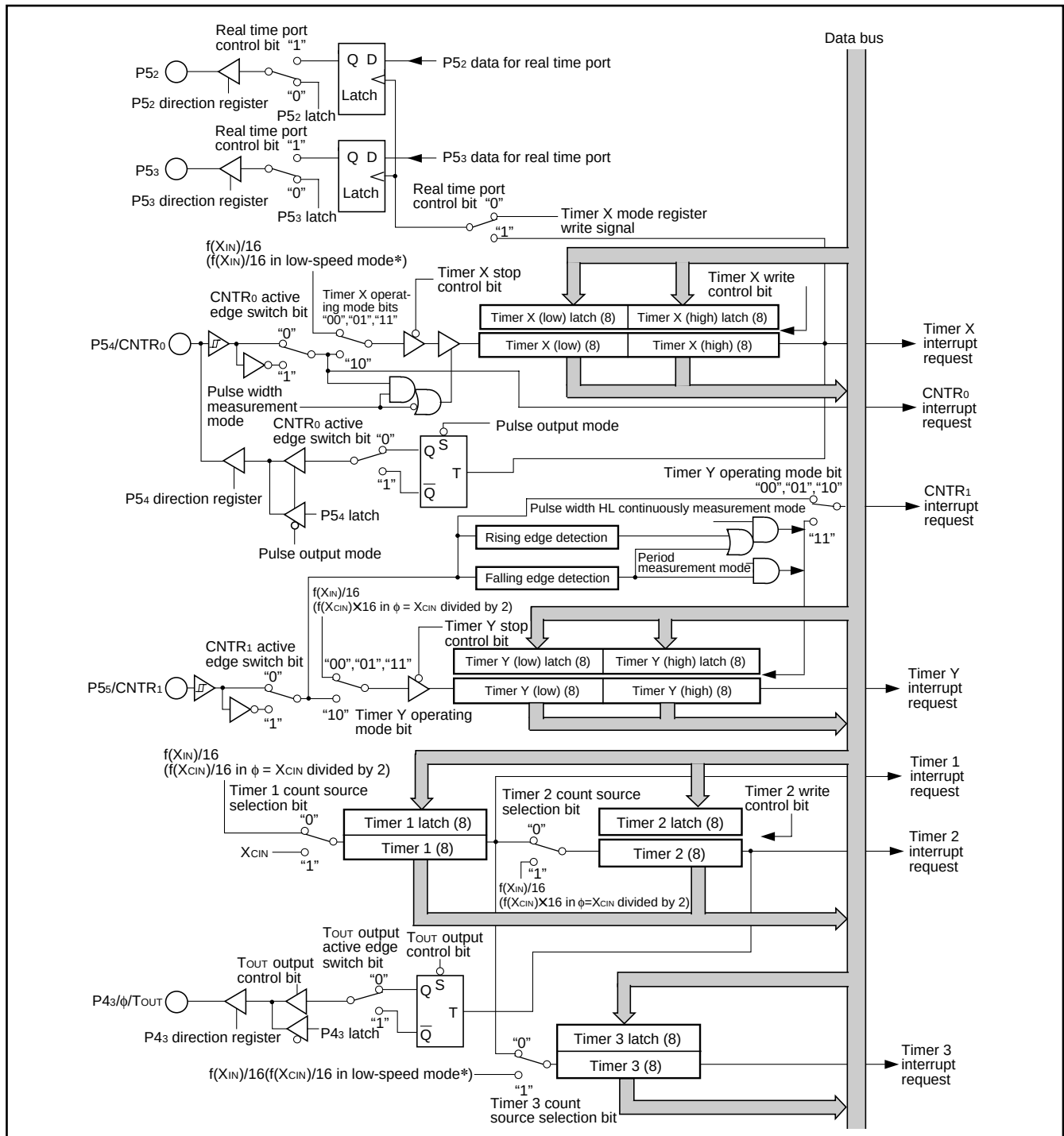


Fig. 17 Timer block diagram

Timer X

Timer X is a 16-bit timer that can be selected in one of four modes and can be controlled the timer X write and the real time port by setting the timer X mode register.

(1) Timer Mode

The timer counts $f(X_{IN})/16$ (or $f(X_{CIN})/16$ in low-speed mode).

(2) Pulse Output Mode

Each time the timer underflows, a signal output from the CNTR₀ pin is inverted. Except for this, the operation in pulse output mode is the same as in timer mode. When using a timer in this mode, set the port shared with the CNTR₀ pin to input.

(3) Event Counter Mode

The timer counts signals input through the CNTR₀ pin. Except for this, the operation in event counter mode is the same as in timer mode. When using a timer in this mode, set the port shared with the CNTR₀ pin to input.

(4) Pulse Width Measurement Mode

The count source is $f(X_{IN})/16$ (or $f(X_{CIN})/16$ in low-speed mode). If CNTR₀ active edge switch bit is "0", the timer counts while the input signal of CNTR₀ pin is at "H". If it is "1", the timer counts while the input signal of CNTR₀ pin is at "L". When using a timer in this mode, set the port shared with the CNTR₀ pin to input.

●Timer X write control

If the timer X write control bit is "0", when the value is written in the address of timer X, the value is loaded in the timer X and the latch at the same time.

If the timer X write control bit is "1", when the value is written in the address of timer X, the value is loaded only in the latch. The value in the latch is loaded in timer X after timer X underflows.

If the value is written in latch only, unexpected value may be set in the high-order counter when the writing in high-order latch and the underflow of timer X are performed at the same timing.

■Note on CNTR₀ interrupt active edge selection

CNTR₀ interrupt active edge depends on the CNTR₀ active edge switch bit.

●Real time port control

While the real time port function is valid, data for the real time port are output from ports P5₂ and P5₃ each time the timer X underflows. (However, if the real time port control bit is changed from "0" to "1", data are output without the timer X.) When the data for the real time port is changed while the real time port function is valid, the changed data are output at the next underflow of timer X. Before using this function, set the corresponding port direction registers to output mode.

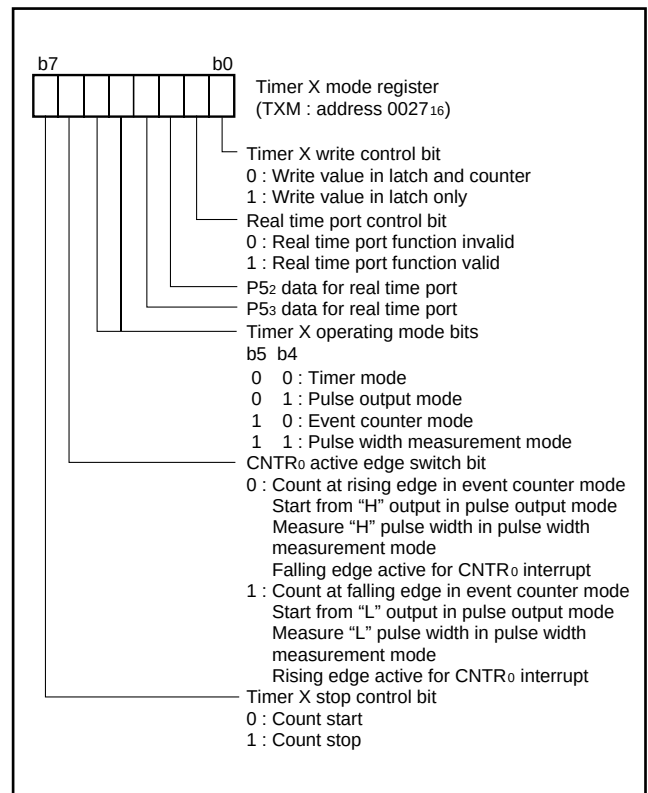


Fig. 18 Structure of timer X mode register

Timer Y

Timer Y is a 16-bit timer that can be selected in one of four modes.

(1) Timer Mode

The timer counts $f(X_{IN})/16$ (or $f(X_{CIN})/16$ in low-speed mode).

(2) Period Measurement Mode

CNTR1 interrupt request is generated at rising/falling edge of CNTR1 pin input signal. Simultaneously, the value in timer Y latch is reloaded in timer Y and timer Y continues counting down. Except for the above-mentioned, the operation in period measurement mode is the same as in timer mode.

The timer value just before the reloading at rising/falling of CNTR1 pin input signal is retained until the timer Y is read once after the reload.

The rising/falling timing of CNTR1 pin input signal is found by CNTR1 interrupt. When using a timer in this mode, set the port shared with the CNTR1 pin to input.

(3) Event Counter Mode

The timer counts signals input through the CNTR1 pin.

Except for this, the operation in event counter mode is the same as in timer mode. When using a timer in this mode, set the port shared with the CNTR1 pin to input.

(4) Pulse Width HL Continuously Measurement Mode

CNTR1 interrupt request is generated at both rising and falling edges of CNTR1 pin input signal. Except for this, the operation in pulse width HL continuously measurement mode is the same as in period measurement mode. When using a timer in this mode, set the port shared with the CNTR1 pin to input.

■Note on CNTR1 interrupt active edge selection

CNTR1 interrupt active edge depends on the CNTR1 active edge switch bit. However, in pulse width HL continuously measurement mode, CNTR1 interrupt request is generated at both rising and falling edges of CNTR1 pin input signal regardless of the setting of CNTR1 active edge switch bit.

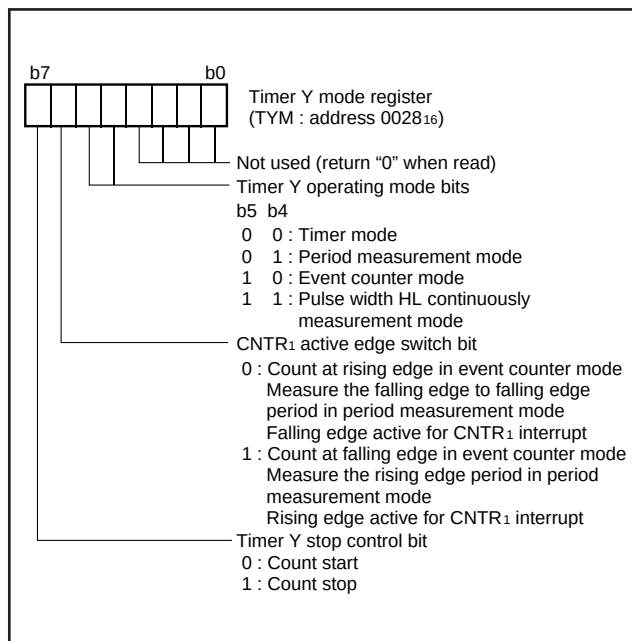


Fig. 19 Structure of timer Y mode register

Timer 1, Timer 2, Timer 3

Timer 1, timer 2, and timer 3 are 8-bit timers. The count source for each timer can be selected by timer 123 mode register. The timer latch value is not affected by a change of the count source. However, because changing the count source may cause an inadvertent count down of the timer. Therefore, rewrite the value of timer whenever the count source is changed.

●Timer 2 write control

If the timer 2 write control bit is "0", when the value is written in the address of timer 2, the value is loaded in the timer 2 and the latch at the same time.

If the timer 2 write control bit is "1", when the value is written in the address of timer 2, the value is loaded only in the latch. The value in the latch is loaded in timer 2 after timer 2 underflows.

●Timer 2 output control

When the timer 2 (TOUT) is output enabled, an inversion signal from the TOUT pin is output each time timer 2 underflows.

In this case, set the port shared with the TOUT pin to the output.

■Notes on timer 1 to timer 3

When the count source of timer 1 to 3 is changed, the timer counting value may be changed large because a thin pulse is generated in count input of timer. If timer 1 output is selected as the count source of timer 2 or timer 3, when timer 1 is written, the counting value of timer 2 or timer 3 may be changed large because a thin pulse is generated in timer 1 output.

Therefore, set the value of timer in the order of timer 1, timer 2 and timer 3 after the count source selection of timer 1 to 3.

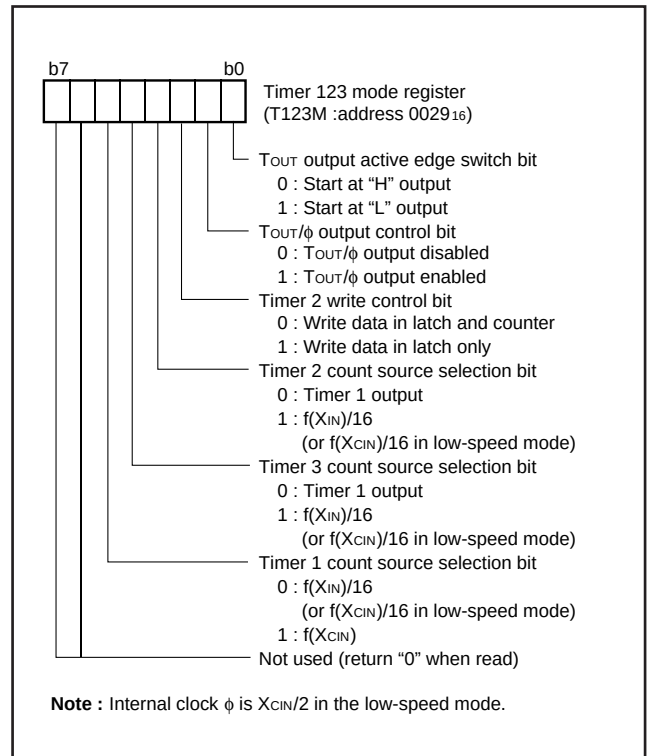


Fig. 20 Structure of timer 123 mode register

SERIAL I/O Serial I/O1

Serial I/O1 can be used as either clock synchronous or asynchronous (UART) serial I/O. A dedicated timer (baud rate generator) is also provided for baud rate generation.

(1) Clock Synchronous Serial I/O Mode

Clock synchronous serial I/O1 can be selected by setting the mode selection bit of the serial I/O1 control register to "1".

For clock synchronous serial I/O1, 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 transmit/receive buffer registers.

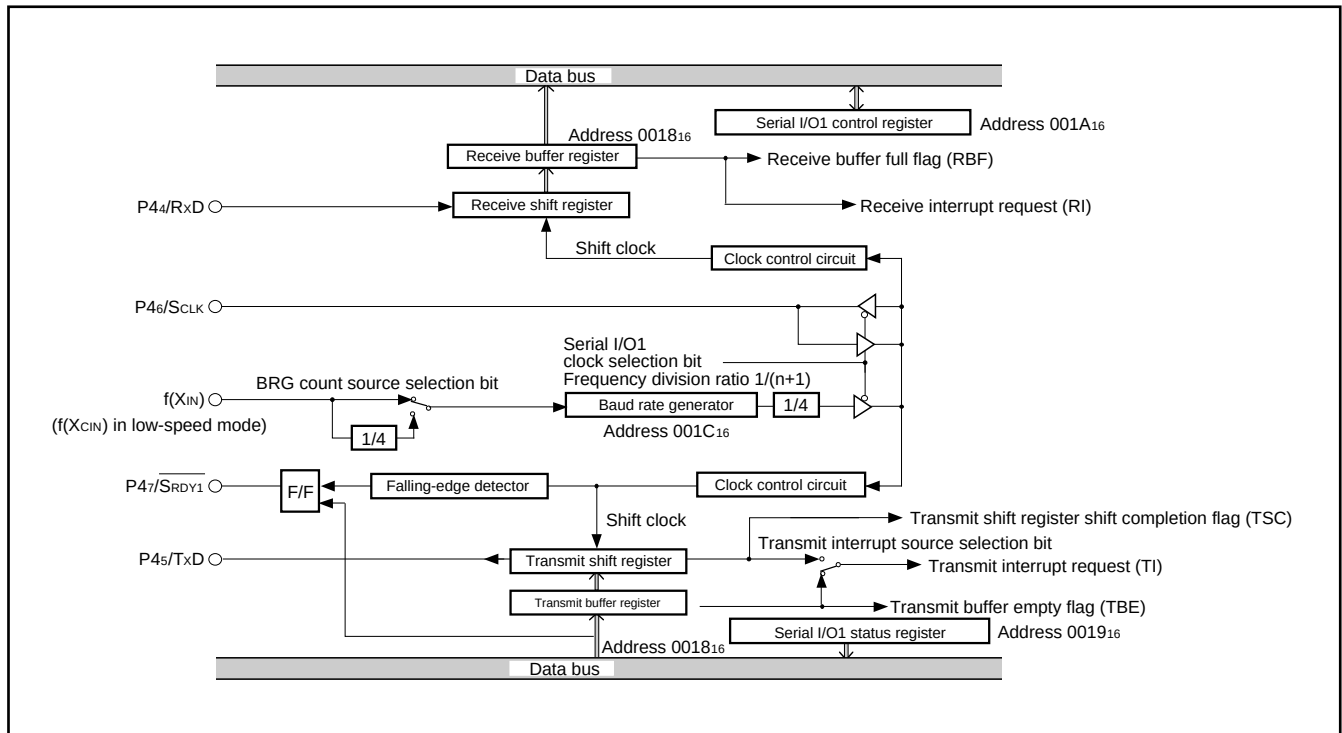


Fig. 21 Block diagram of clock synchronous serial I/O1

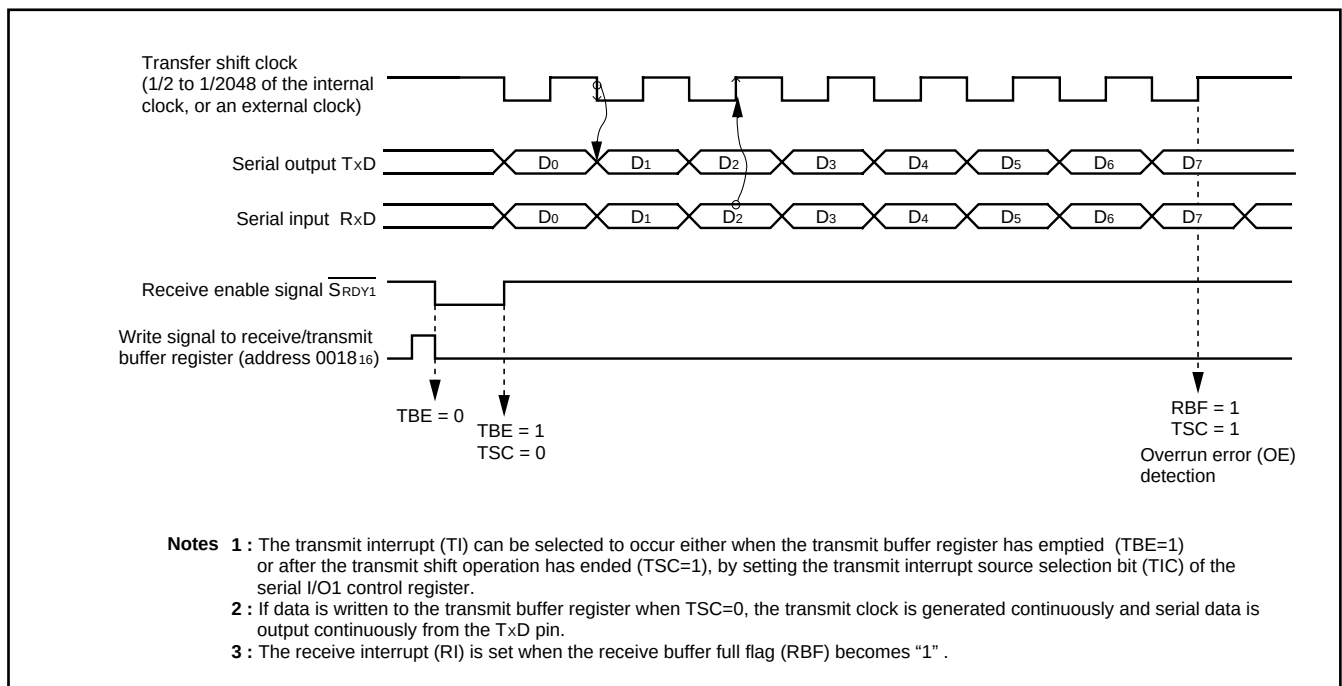


Fig. 22 Operation of clock synchronous serial I/O1 function

(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/O1 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 regis-

ter, 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, and receive data is read from the receive buffer.

The transmit buffer 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.

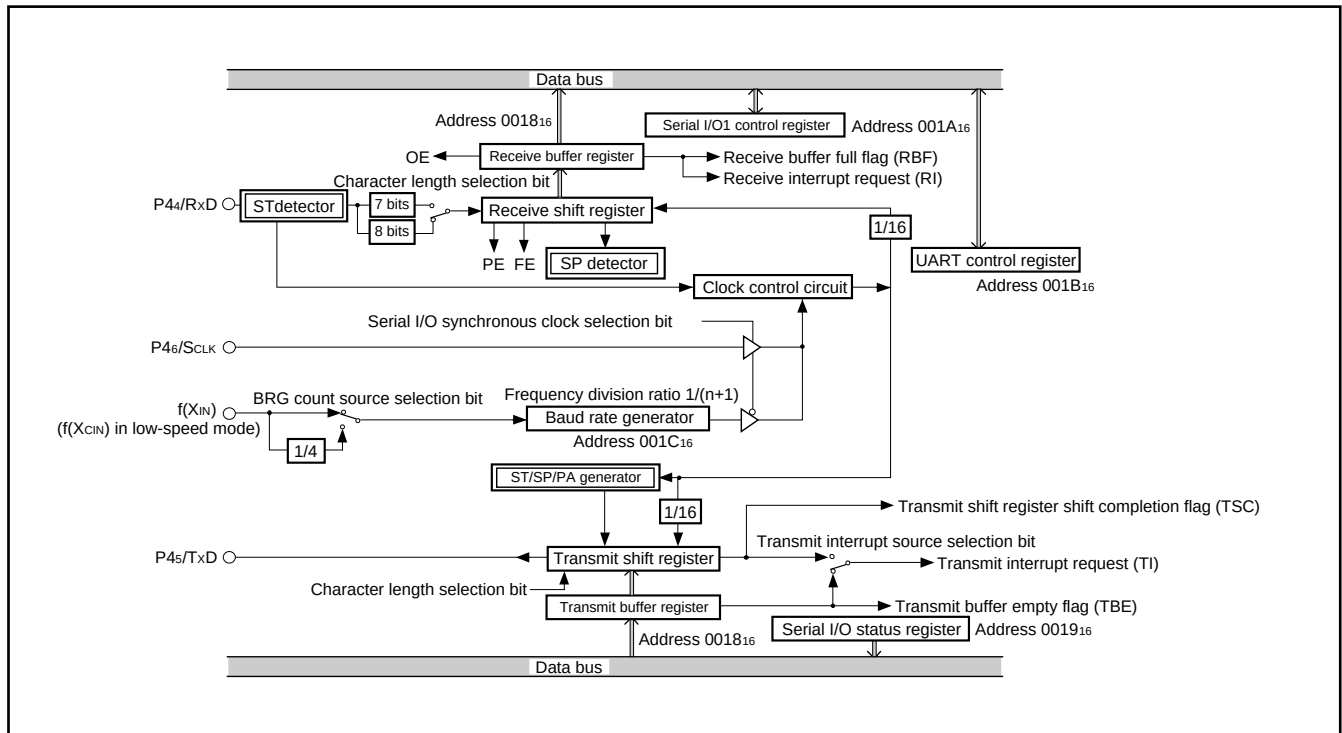


Fig. 23 Block diagram of UART serial I/O1

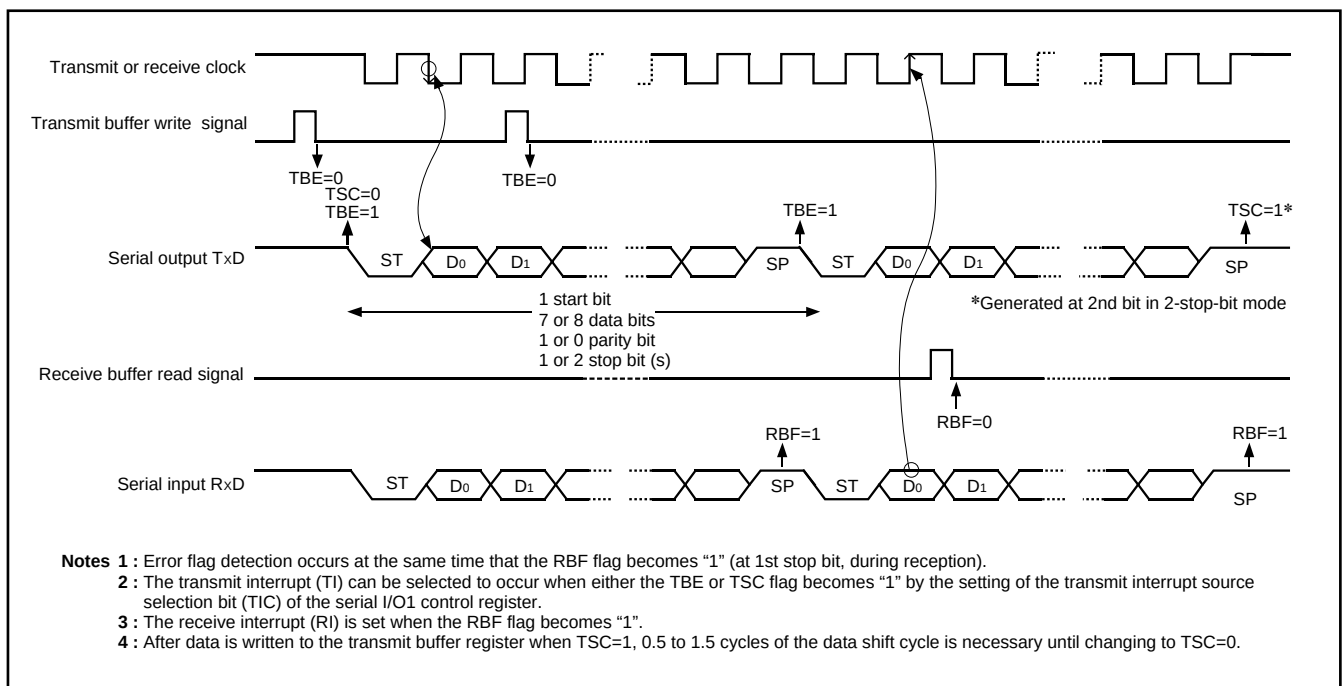


Fig. 24 Operation of UART serial I/O1 function

[Transmit Buffer/Receive Buffer Register (TB/RB)] 0018₁₆

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

[Serial I/O1 Status Register (SIO1STS)] 0019₁₆

The read-only serial I/O1 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 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/O1 status register clears all the error flags OE, PE, FE, and SE. Writing "0" to the serial I/O1 enable bit (SIOE) also clears all the status flags, including the error flags.

All bits of the serial I/O1 status register are initialized to "0" at reset, but if the transmit enable bit (bit 4) of the serial I/O1 control register has been set to "1", the transmit shift register shift completion flag (bit 2) and the transmit buffer empty flag (bit 0) become "1".

[Serial I/O1 Control Register (SIO1CON)] 001A₁₆

The serial I/O1 control register contains eight control bits for the serial I/O1 function.

[UART Control Register (UARTCON)] 001B₁₆

This is a 5 bit register containing four control bits, which are valid when UART is selected and set the data format of an data receiver/transfer, and one control bit, which is always valid and sets the output structure of the P45/TxD pin.

[Baud Rate Generator(BRG)] 0016₁₆

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.

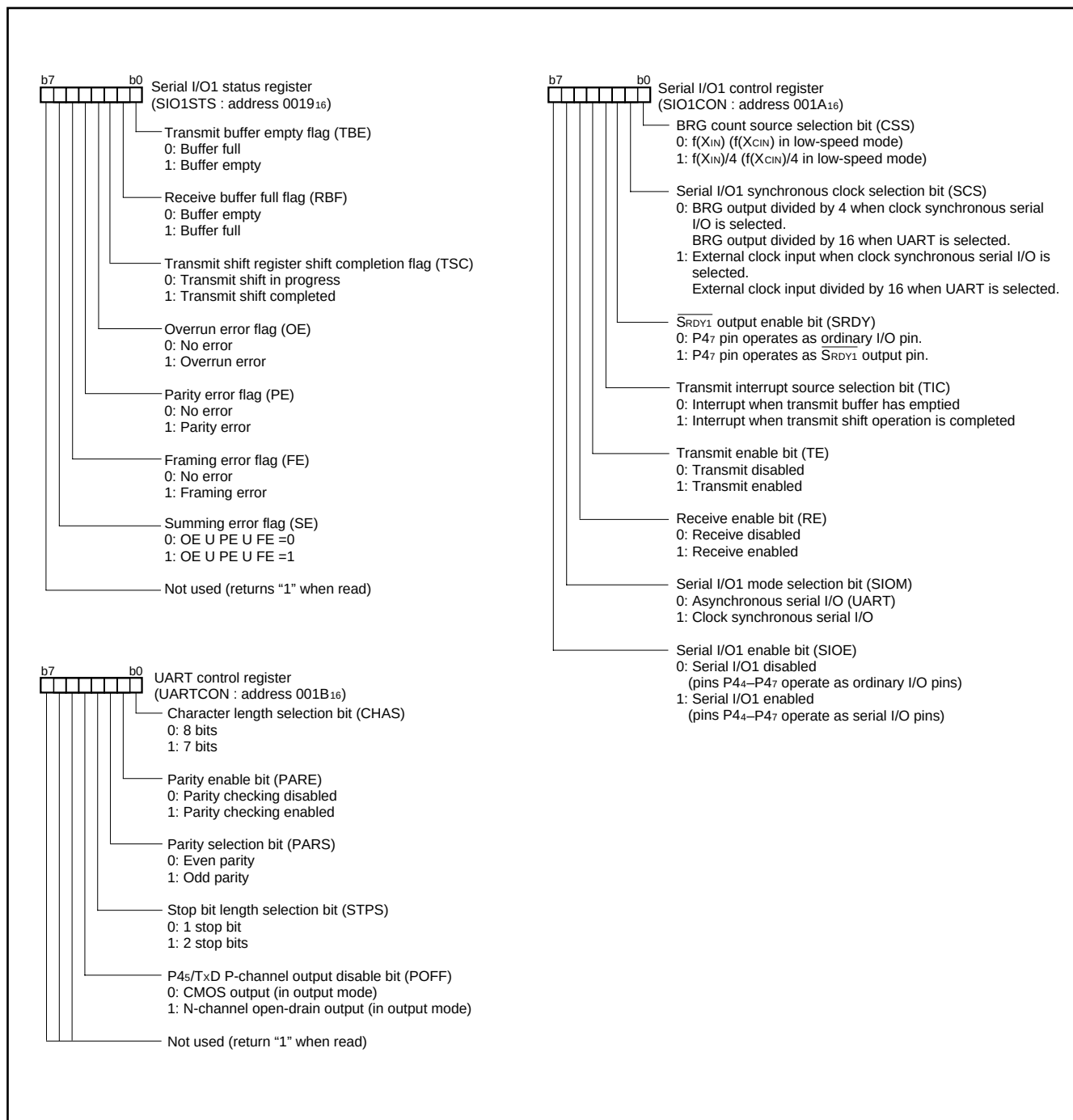


Fig. 25 Structure of serial I/O1 control registers

Serial I/O2

The serial I/O2 function can be used only for clock synchronous serial I/O.

For clock synchronous serial I/O2 the transmitter and the receiver must use the same clock. When the internal clock is used, transfer is started by a write signal to the serial I/O2 register.

When an internal clock is selected as the synchronous clock of the serial I/O2, either P62 or P63 can be selected as an output pin of the synchronous clock. In this case, the pin that is not selected as an output pin of the synchronous clock functions as a port.

[Serial I/O2 Control Register (SIO2CON)] 001D16

The serial I/O2 control register contains 8 bits which control various serial I/O2 functions.

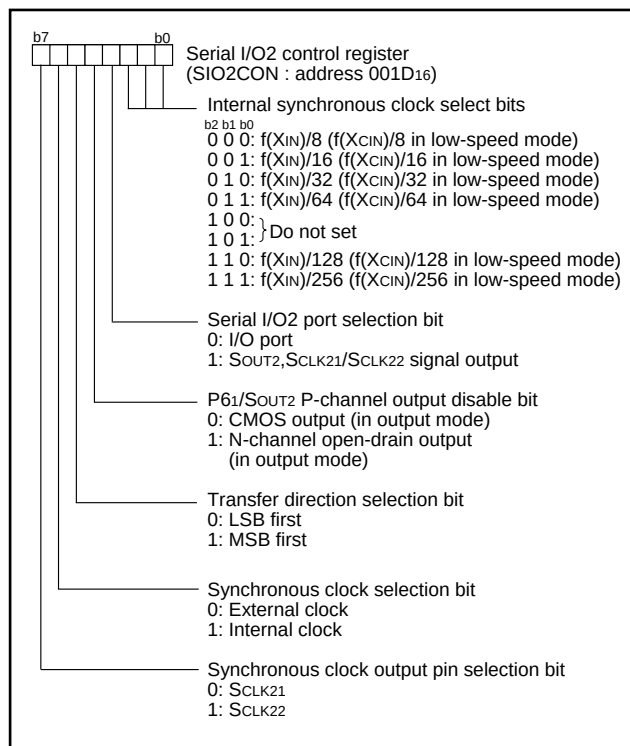


Fig. 26 Structure of serial I/O2 control register

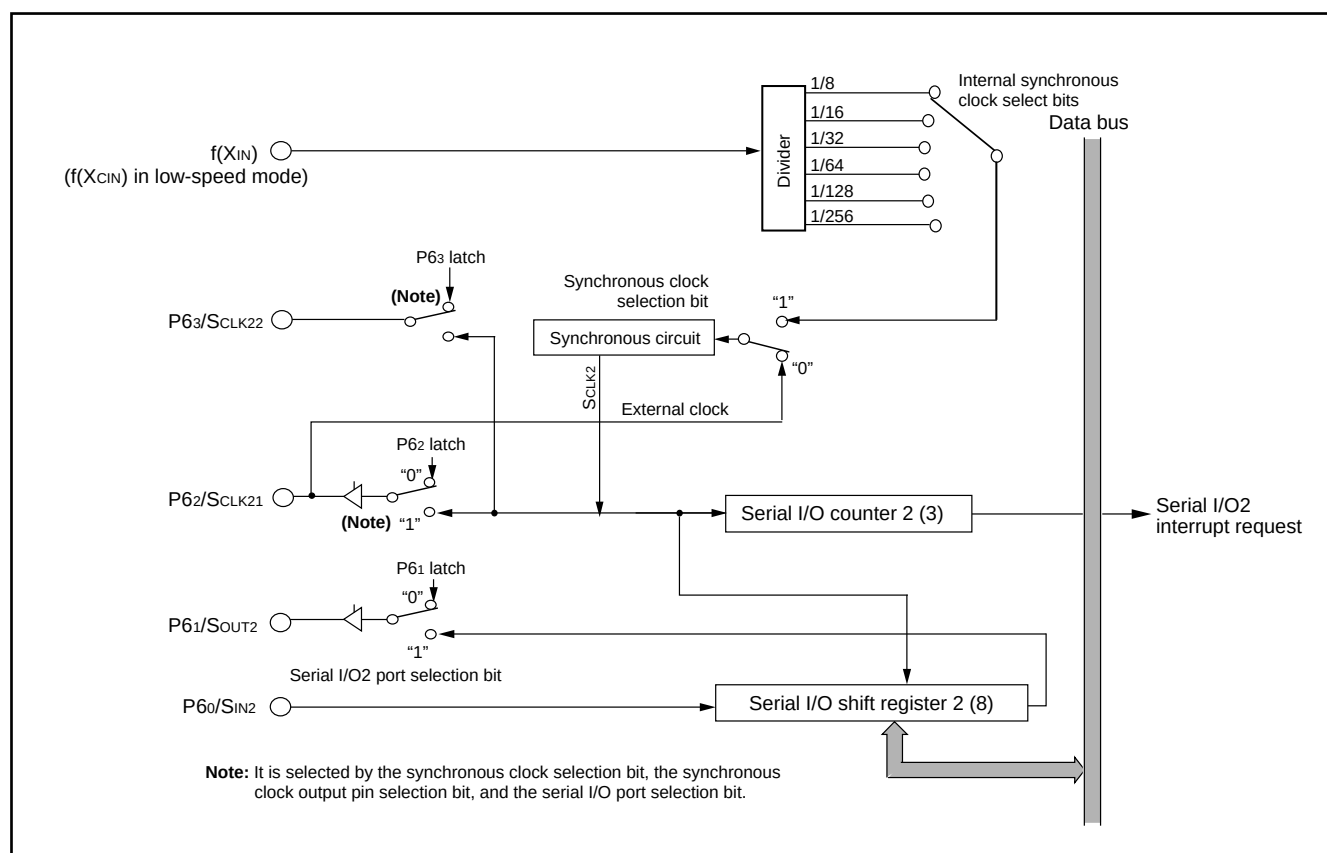


Fig. 27 Block diagram of serial I/O2 function

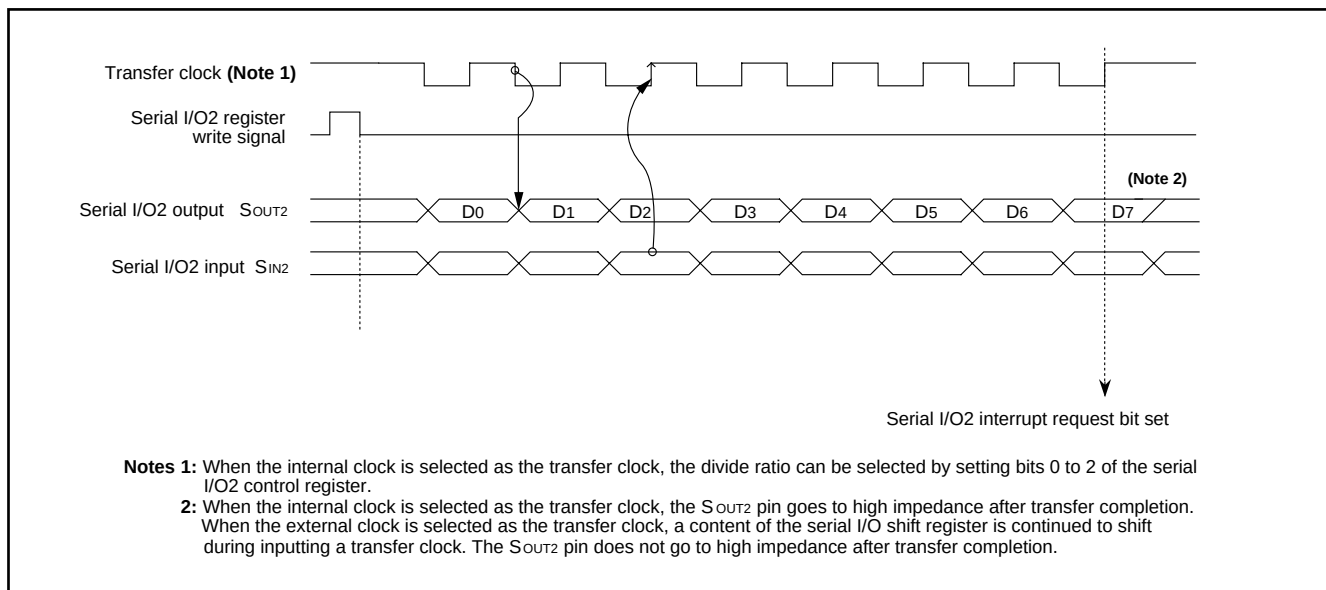


Fig. 28 Timing of serial I/O2 function

PULSE WIDTH MODULATION (PWM)

The 3827 group has a PWM function with an 8-bit resolution, based on a signal that is the clock input X_{IN} or that clock input divided by 2.

Data Setting

The PWM output pin also functions as ports P50 and P51. Set the PWM period by the PWM prescaler, and set the period during which the output pulse is an "H" by the PWM register.

If PWM count source is $f(X_{IN})$ and the value in the PWM prescaler is n and the value in the PWM register is m (where $n = 0$ to 255 and $m = 0$ to 255) :

$$\begin{aligned} \text{PWM period} &= 255 \times (n+1)/f(X_{IN}) \\ &= 51 \times (n+1) \mu\text{s} \text{ (when } X_{IN} = 5 \text{ MHz)} \end{aligned}$$

$$\begin{aligned} \text{Output pulse "H" period} &= \text{PWM period} \times m/255 \\ &= 0.2 \times (n+1) \times m \mu\text{s} \\ &\text{(when } X_{IN} = 5 \text{ MHz)} \end{aligned}$$

PWM Operation

When at least either bit 1 (PWM0 output enable bit) or bit 2 (PWM1 output enable bit) of the PWM control register is set to "1", operation starts by initializing the PWM output circuit, and pulses are output starting at an "H". When one PWM output is enabled and that the other PWM output is enabled, PWM output which is enabled to output later starts pulse output from halfway.

When the PWM register or PWM prescaler is updated during PWM output, the pulses will change in the cycle after the one in which the change was made.

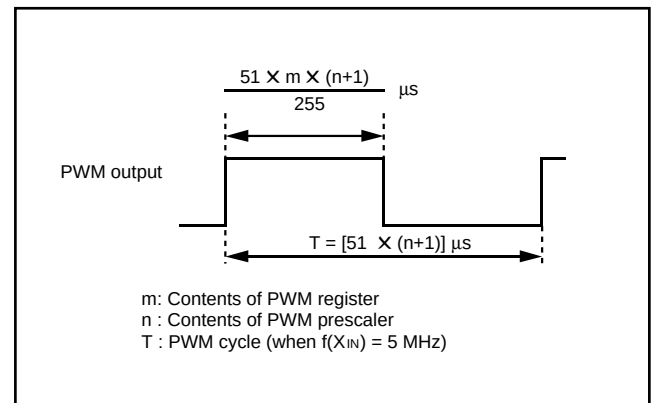


Fig. 29 Timing of PWM cycle

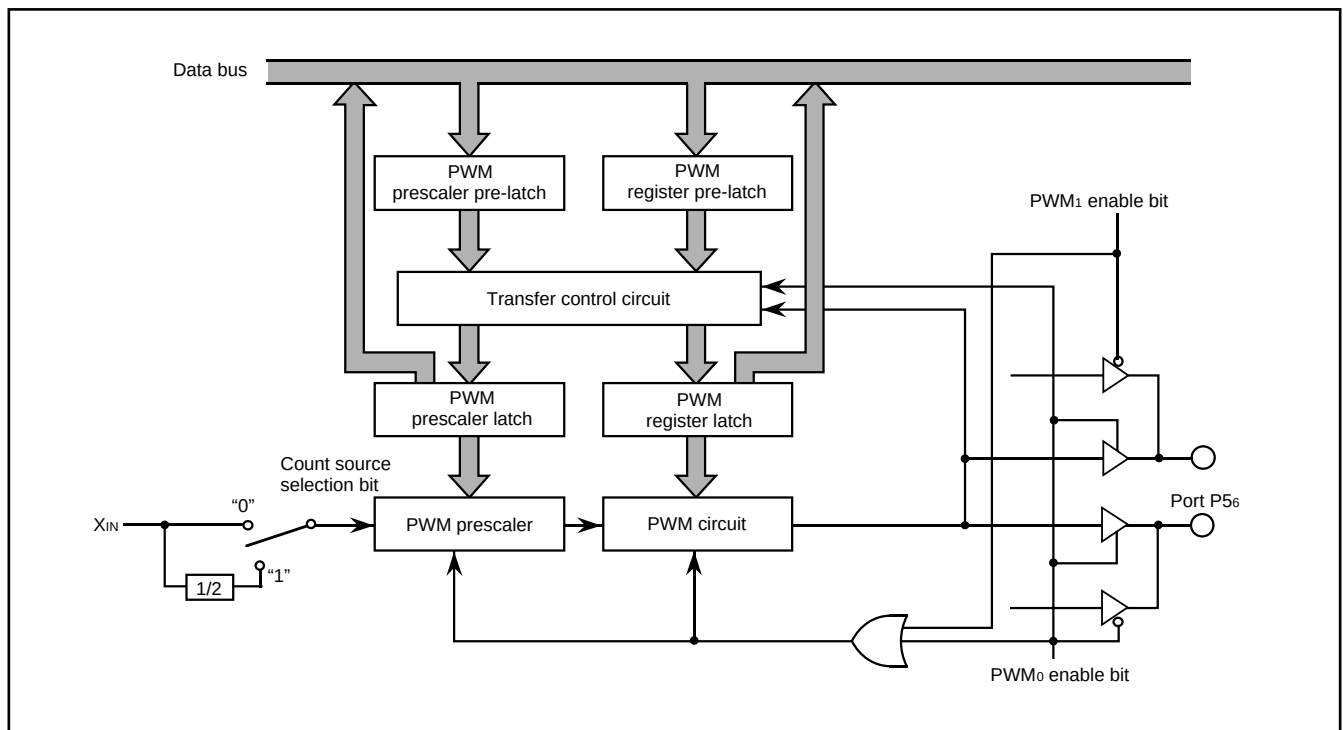


Fig. 30 Block diagram of PWM function

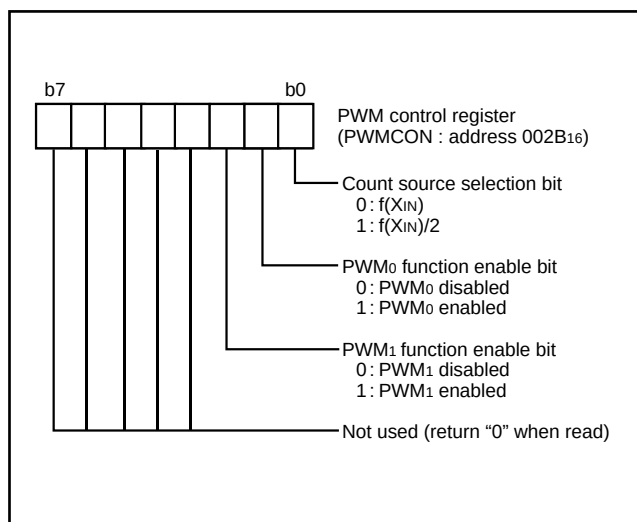


Fig. 31 Structure of PWM control register

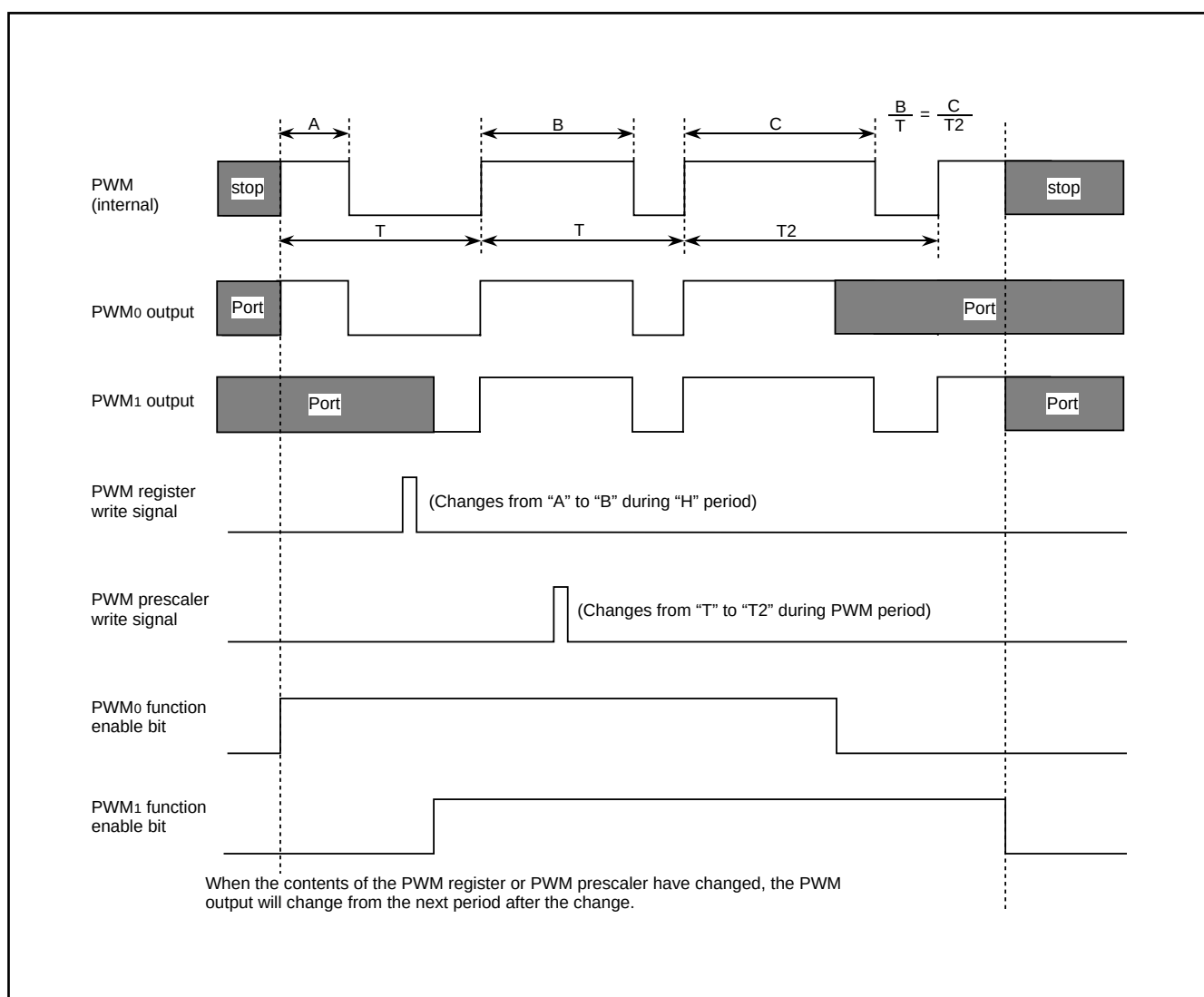


Fig. 32 PWM output timing when PWM register or PWM prescaler is changed

A-D CONVERTER

[A-D Conversion Register (AD)] 0035₁₆

The A-D conversion register is a read-only register that contains the result of an A-D conversion. During A-D conversion, do not read this register.

[A-D Control Register (ADCON)] 0034₁₆

The A-D control register controls the A-D conversion process. Bits 0 to 2 are analog input pin selection bits. Bit 3 is an A-D conversion completion bit and "0" during A-D conversion, then changes to "1" when the A-D conversion is completed. Writing "0" to this bit starts the A-D conversion. Bit 4 controls the transistor which breaks the through current of the resistor ladder. When bit 5, which is the AD external trigger valid bit, is set to "1", A-D conversion is started even by a rising edge or falling edge of an ADT input. Set ports which share with ADT pins to input when using an A-D external trigger.

[Comparison Voltage Generator]

The comparison voltage generator divides the voltage between AVSS and VREF, and outputs the divided voltages.

[Channel Selector]

The channel selector selects one of the input ports P67/AN7–P60/AN0, and inputs it to the comparator.

[Comparator and Control Circuit]

The comparator and control circuit compares an analog input voltage with the comparison voltage and stores the result in the A-D conversion register. When an A-D conversion is completed, the control circuit sets the AD conversion completion bit and the AD interrupt request bit to "1".

Note that the comparator is constructed linked to a capacitor, so set $f(X_{IN})$ to at least 500 kHz during A-D conversion. Use a clock divided the main clock X_{IN} as the internal clock ϕ .

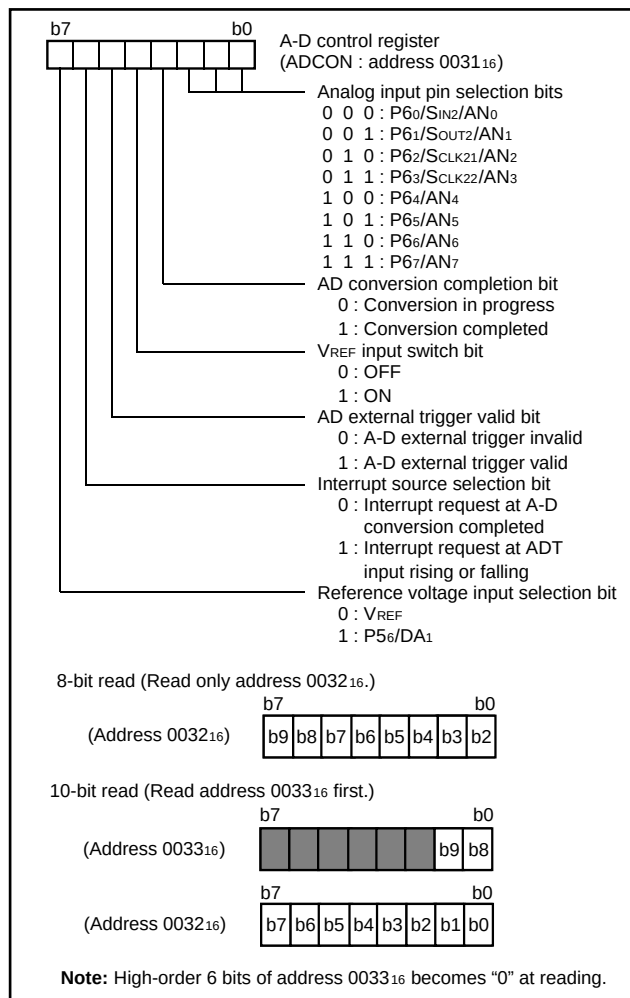


Fig. 33 Structure of A-D control register

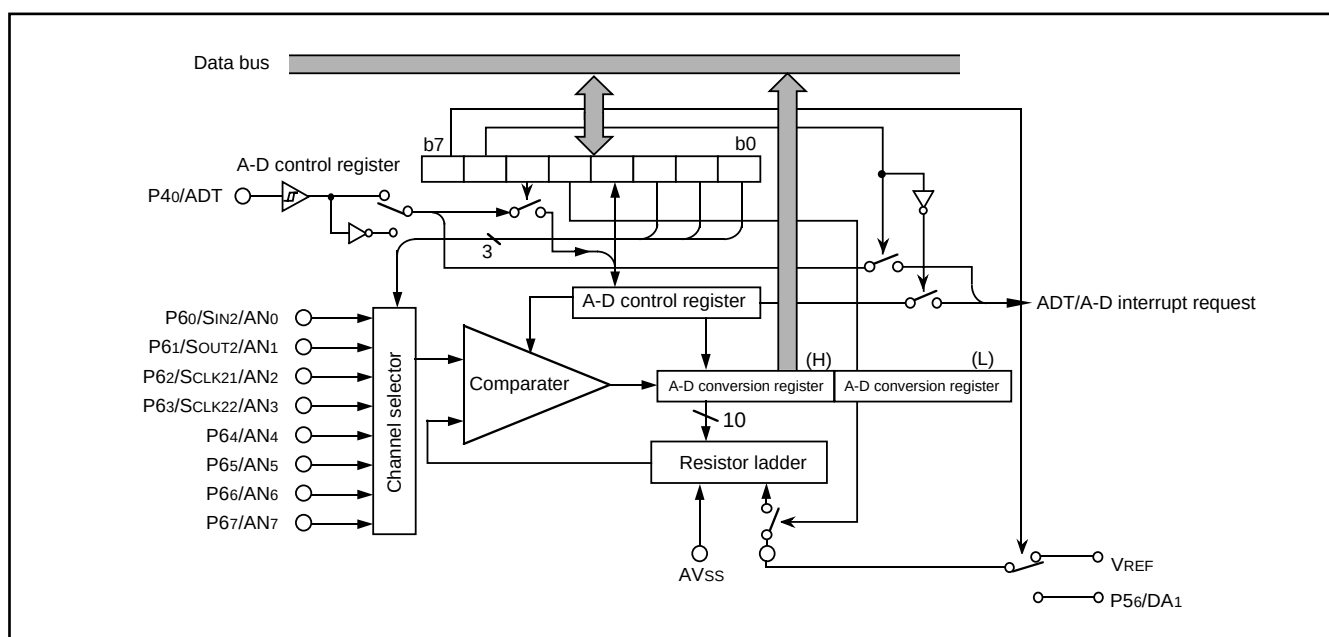


Fig. 34 A-D converter block diagram

D-A CONVERTER

The 3827 group has an on-chip D-A converter with 8-bit resolution and 2 channels (DA_i (i=1, 2)). The D-A converter is performed by setting the value in the D-A conversion register. The result of D-A converter is output from DA_i pin. When using the D-A converter, the corresponding port direction register bit (P56/DA₁, P57/DA₂) should be set to "0" (input status).

The output analog voltage V is determined by the value n (base 10) in the D-A conversion register as follows:

$$V = V_{REF} \times n / 256 \quad (n=0 \text{ to } 255)$$

Where V_{REF} is the reference voltage.

At reset, the D-A conversion registers are cleared to "0016", the DA_i output enable bits are cleared to "0", and DA_i pin goes to high impedance state. The DA output is not buffered, so connect an external buffer when driving a low-impedance load.

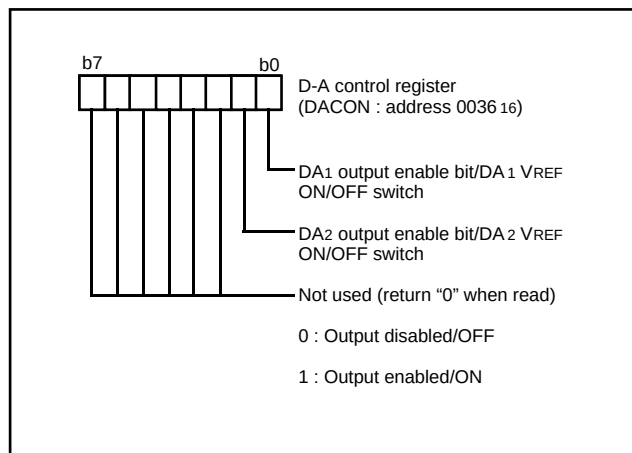


Fig. 35 Structure of D-A control register

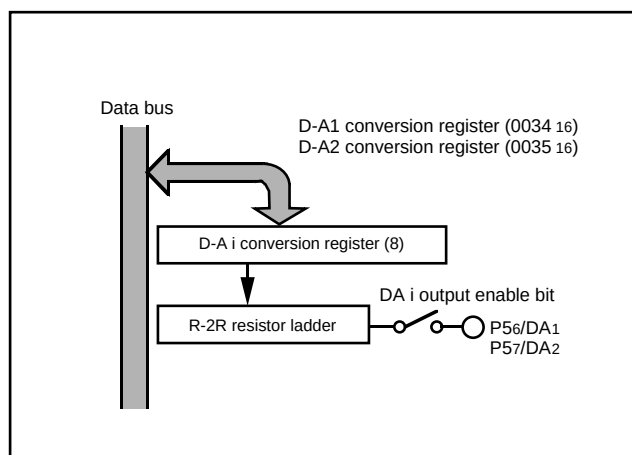


Fig. 36 Block diagram of D-A converter

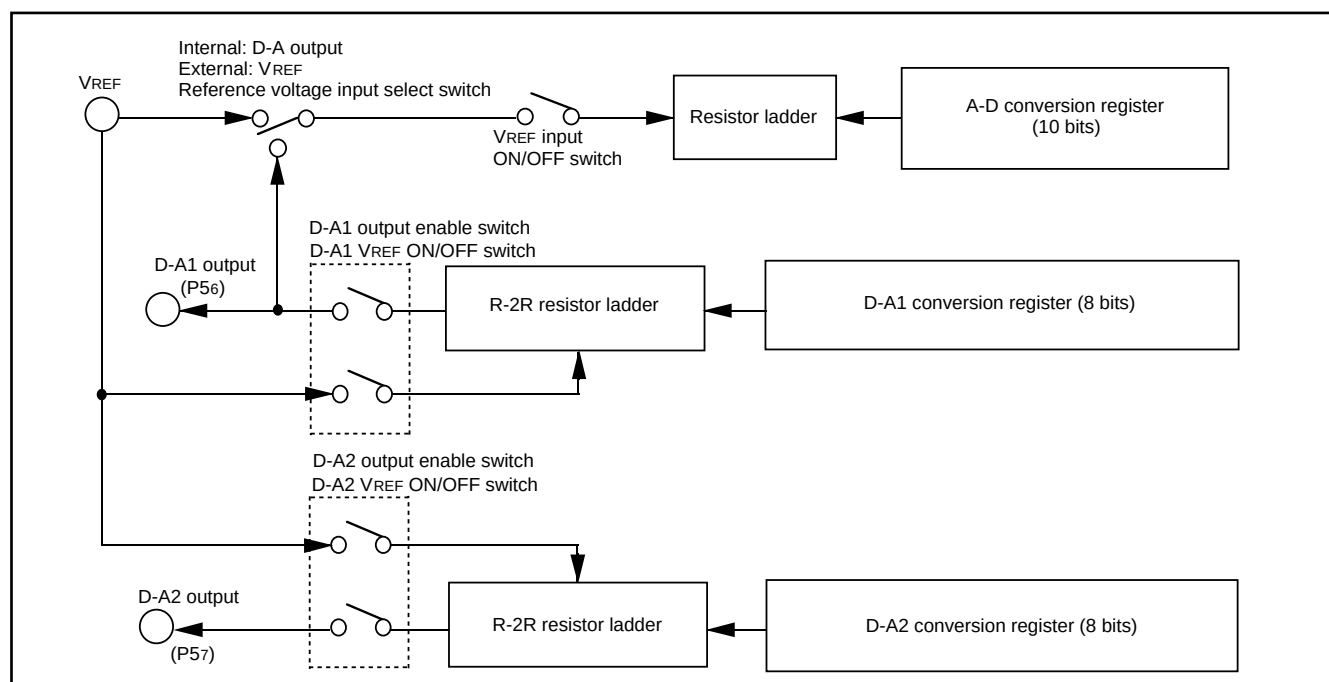


Fig. 37 A-D converter, D-A converter block diagram

LCD DRIVE CONTROL CIRCUIT

The 3827 group has the built-in Liquid Crystal Display (LCD) drive control circuit consisting of the following.

- LCD display RAM
- Segment output enable register
- LCD mode register
- Voltage multiplier
- Selector
- Timing controller
- Common driver
- Segment driver
- Bias control circuit

A maximum of 40 segment output pins and 4 common output pins can be used.

Up to 160 pixels can be controlled for LCD display. When the LCD enable bit is set to "1" after data is set in the LCD mode register, the segment output enable register and the LCD display RAM, the LCD drive control circuit starts reading the display data automatically, performs the bias control and the duty ratio control, and displays the data on the LCD panel.

Table 7 Maximum number of display pixels at each duty ratio

Duty ratio	Maximum number of display pixel
2	80 dots or 8 segment LCD 10 digits
3	120 dots or 8 segment LCD 15 digits
4	160 dots or 8 segment LCD 20 digits

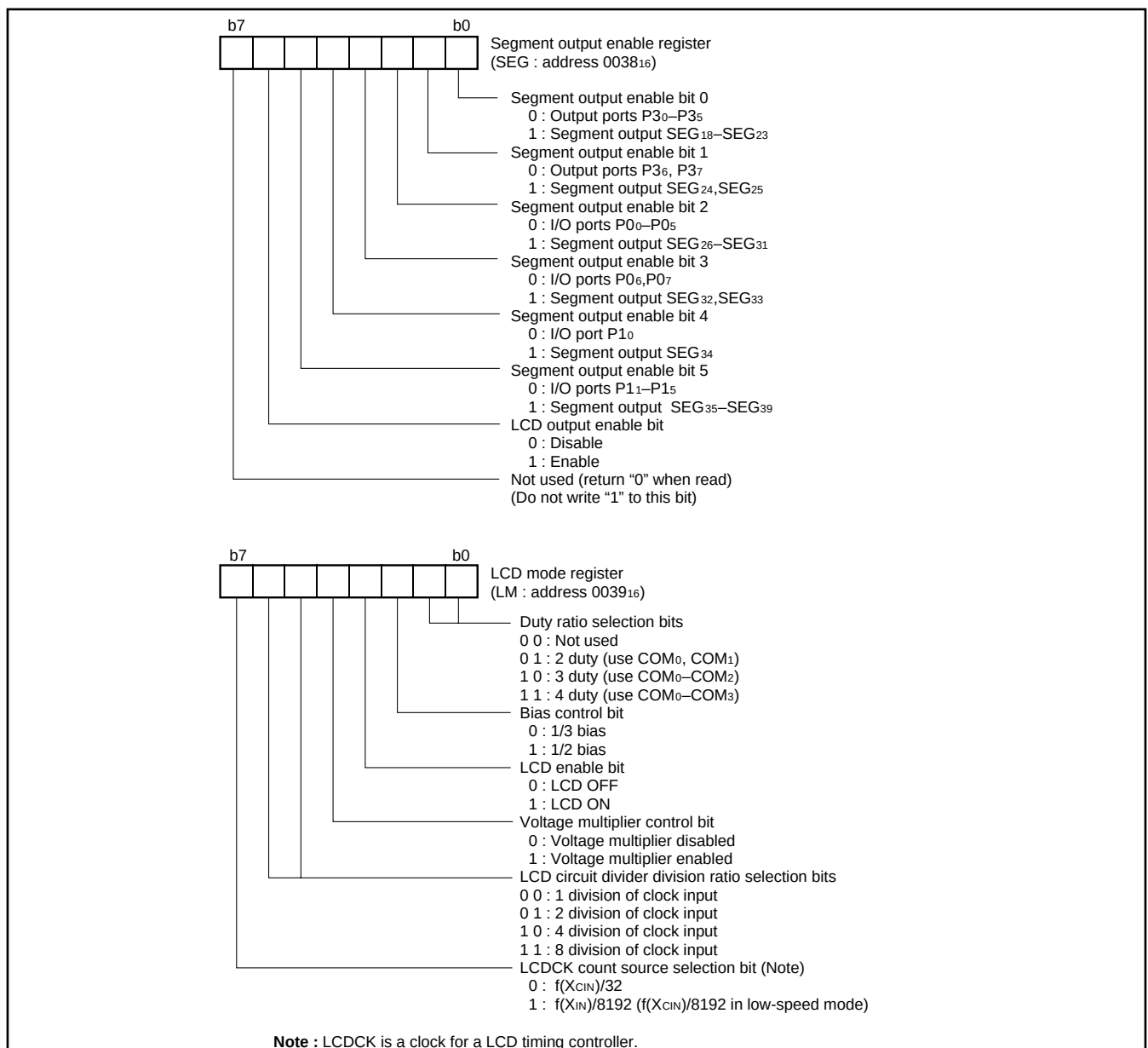


Fig. 38 Structure of LCD mode register

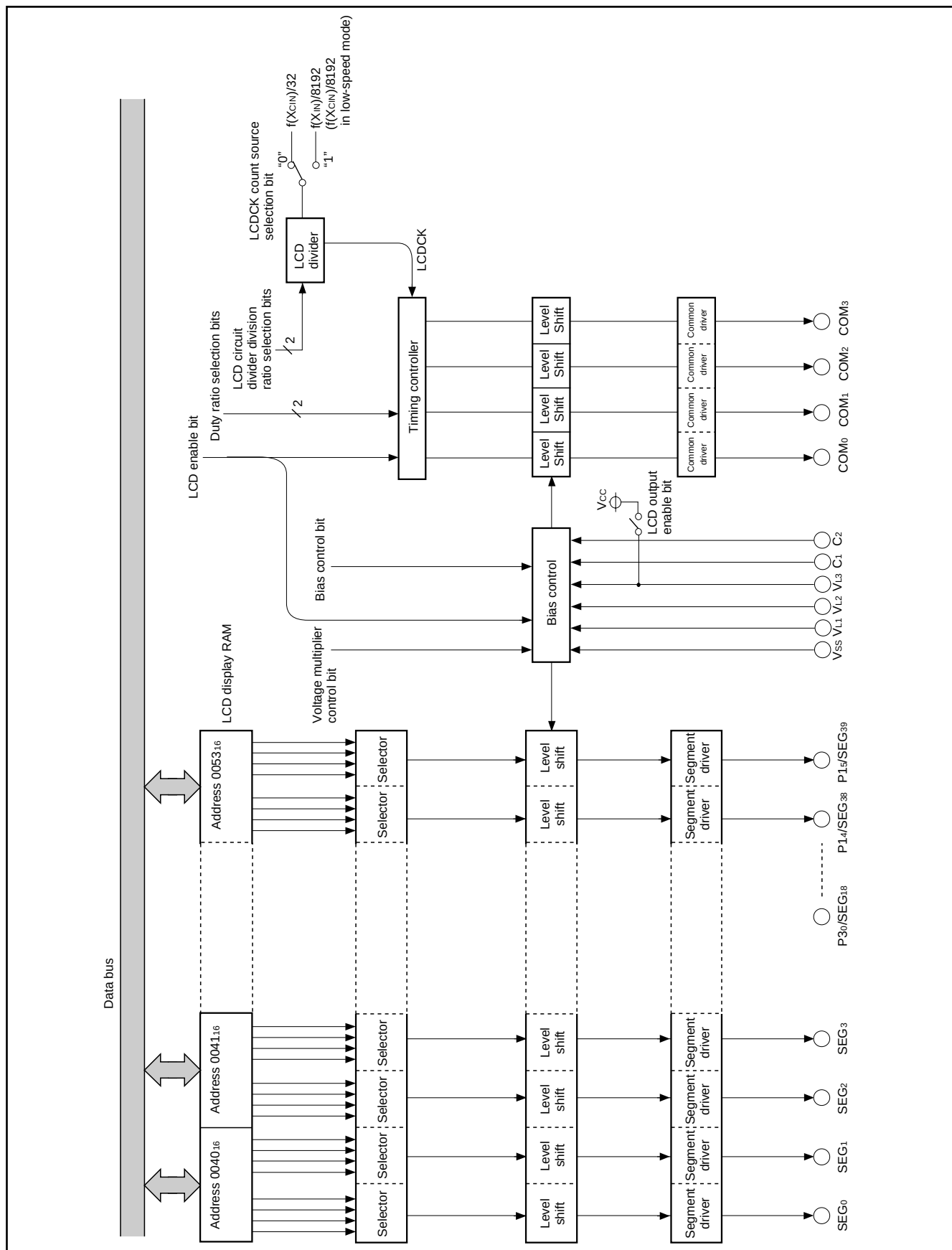


Fig. 39 Block diagram of LCD controller/driver

VOLTAGE MULTIPLIER (3 TIMES)

The voltage multiplier performs threefold boosting. This circuit inputs a reference voltage for boosting from LCD power input pin VL1. (However, when using a 1/2 bias, connect VL1 and VL2 and apply voltage by external resistor division.)

Set each bit of the segment output enable register and the LCD mode register in the following order for operating the voltage multiplier.

1. Set the segment output enable bits (bits 0 to 5) of the segment output enable register to "0" or "1."
2. Set the duty ratio selection bits (bits 0 and 1), the bias control bit (bit 2), the LCD circuit divider division ratio selection bits (bits 5 and 6), and the LCDCK count source selection bit (bit 7) of the LCD mode register to "0" or "1."
3. Set the LCD output enable bit (bit 6) of the segment output enable register to "1."
4. Set the voltage multiplier control bit (bit 4) of the LCD mode register to "1."

When voltage is input to the VL1 pin during operating the voltage multiplier, voltage that is twice as large as VL1 occurs at the VL2 pin, and voltage that is three times as large as VL1 occurs at the VL3 pin.

When using the voltage multiplier, apply $1.3\text{ V} \leq \text{Voltage} \leq 2.3\text{ V}$ to the VL1 pin.

When not using the voltage multiplier, apply proper voltage to the LCD power input pins (VL1–VL3). Then set the LCD output enable bit to "1."

When the LCD output enable bit is set to "0," the VCC voltage is applied to the VL3 pin inside of this microcomputer.

The voltage multiplier control bit (bit 4 of the LCD mode register) controls the voltage multiplier.

Bias Control and Applied Voltage to LCD Power Input Pins

To the LCD power input pins (VL1–VL3), apply the voltage shown in Table 8 according to the bias value.

Select a bias value by the bias control bit (bit 2 of the LCD mode register).

Table 8 Bias control and applied voltage to VL1–VL3

Bias value	Voltage value
1/3 bias	VL3=VLCD VL2=2/3 VLCD VL1=1/3 VLCD
1/2 bias	VL3=VLCD VL2=VL1=1/2 VLCD

Note 1: VLCD is the maximum value of supplied voltage for the LCD panel.

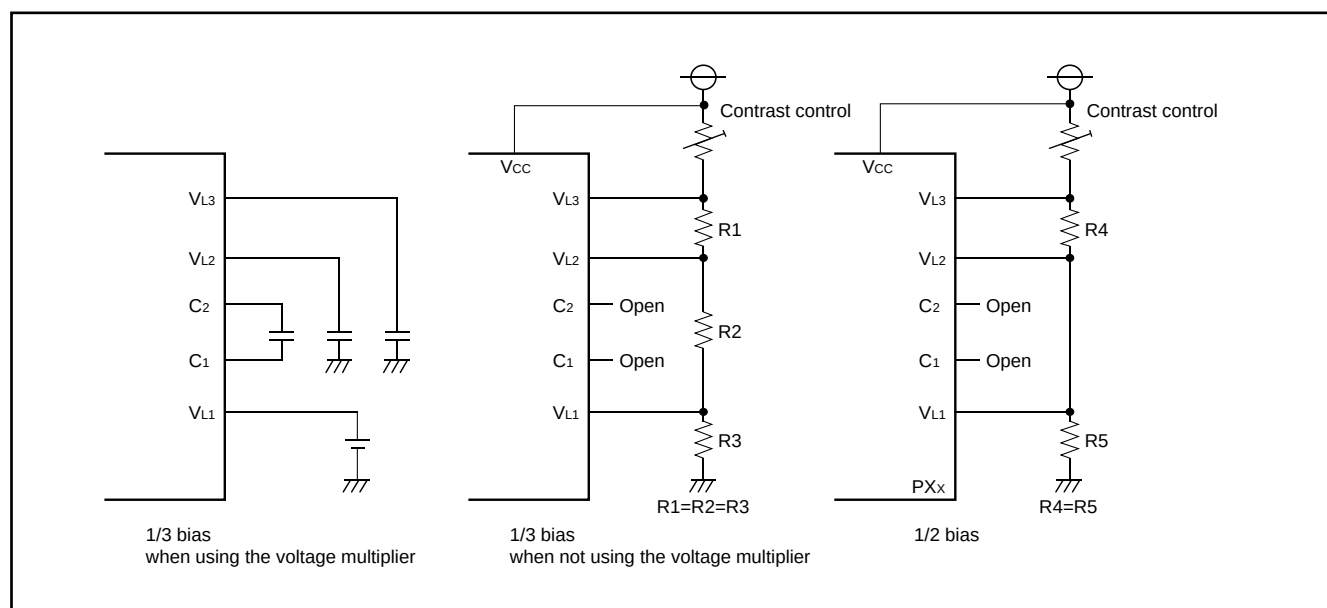


Fig. 40 Example of circuit at each bias

Common Pin and Duty Ratio Control

The common pins (COM0–COM3) to be used are determined by duty ratio.

Select duty ratio by the duty ratio selection bits (bits 0 and 1 of the LCD mode register).

When releasing from reset, the V_{CC} (V_{L3}) voltage is output from the common pins.

Table 9 Duty ratio control and common pins used

Duty ratio	Duty ratio selection bit		Common pins used
	Bit 1	Bit 0	
2	0	1	COM0, COM1 (Note 1)
3	1	0	COM0–COM2 (Note 2)
4	1	1	COM0–COM3

Notes1: COM2 and COM3 are open.

2: COM3 is open.

Segment Signal Output Pin

Segment signal output pins are classified into the segment-only pins (SEG0–SEG17), the segment/output port pins (SEG18–SEG25), and the segment/I/O port pins (SEG26–SEG39).

Segment signals are output according to the bit data of the LCD RAM corresponding to the duty ratio. After reset release, a V_{CC} (=V_{L3}) voltage is output to the segment-only pins and the seg-

ment/output port pins are pulled up to the V_{CC} (=V_{L3}) voltage in the high impedance condition. The segment/I/O port pins are set to input ports, and V_{CC} (=V_{L3}) is applied to them by pull-up resistor.

LCD Display RAM

Address 0040₁₆ to 0053₁₆ is the designated RAM for the LCD display. When “1” are written to these addresses, the corresponding segments of the LCD display panel are turned on.

LCD Drive Timing

The LCDCK timing frequency (LCD drive timing) is generated internally and the frame frequency can be determined with the following equation;

$$f(\text{LCDCK}) = \frac{(\text{frequency of count source for LCDCK})}{(\text{divider division ratio for LCD})}$$

$$\text{Frame frequency} = \frac{f(\text{LCDCK})}{(\text{duty ratio})}$$

Bit address	7	6	5	4	3	2	1	0
0040 ₁₆	SEG1				SEG0			
0041 ₁₆	SEG3				SEG2			
0042 ₁₆	SEG5				SEG4			
0043 ₁₆	SEG7				SEG6			
0044 ₁₆	SEG9				SEG8			
0045 ₁₆	SEG11				SEG10			
0046 ₁₆	SEG13				SEG12			
0047 ₁₆	SEG15				SEG14			
0048 ₁₆	SEG17				SEG16			
0049 ₁₆	SEG19				SEG18			
004A ₁₆	SEG21				SEG20			
004B ₁₆	SEG23				SEG22			
004C ₁₆	SEG25				SEG24			
004D ₁₆	SEG27				SEG26			
004E ₁₆	SEG29				SEG28			
004F ₁₆	SEG31				SEG30			
0050 ₁₆	SEG33				SEG32			
0051 ₁₆	SEG35				SEG34			
0052 ₁₆	SEG37				SEG36			
0053 ₁₆	SEG39				SEG38			
	COM3	COM2	COM1	COM0	COM3	COM2	COM1	COM0

Fig. 41 LCD display RAM map

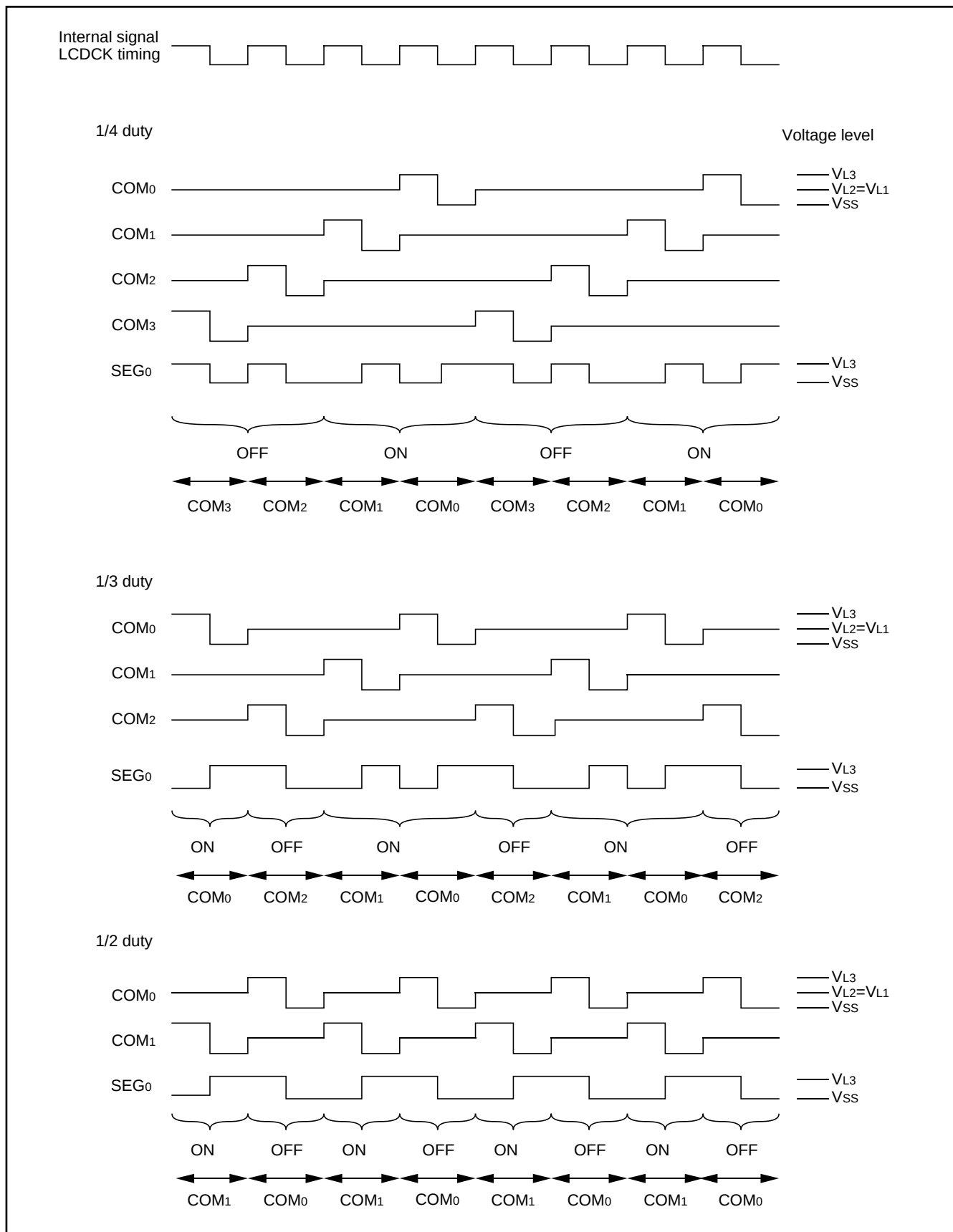


Fig. 42 LCD drive waveform (1/2 bias)

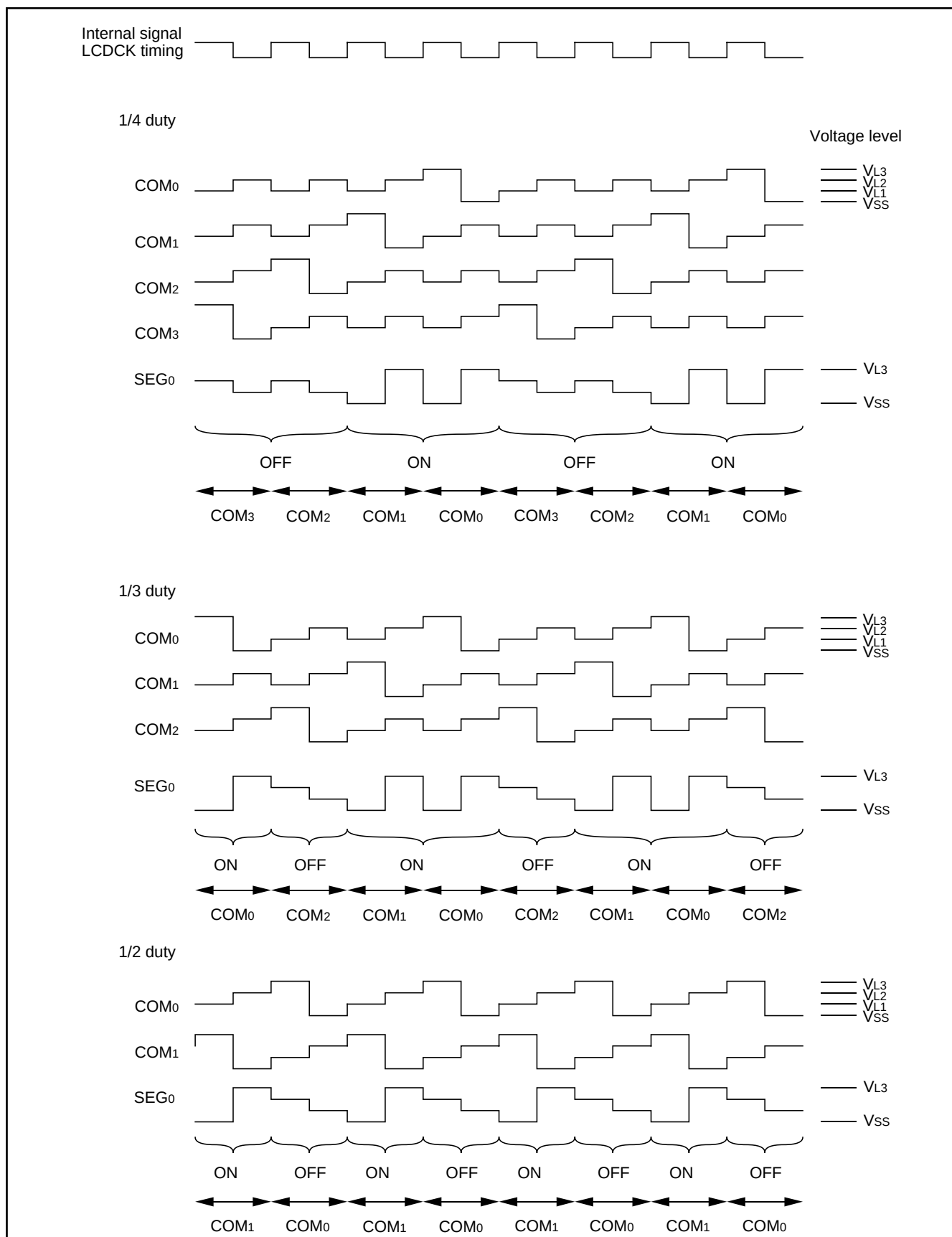


Fig. 43 LCD drive waveform (1/3 bias)

WATCHDOG TIMER

The watchdog timer gives a mean of returning to the reset status when a program cannot run on a normal loop (for example, because of a software runaway).

The watchdog timer consists of an 8-bit watchdog timer L and a 6-bit watchdog timer H. At reset or writing to the watchdog timer control register (address 0037₁₆), the watchdog timer is set to "3FFF₁₆." When any data is not written to the watchdog timer control register (address 0037₁₆) after reset, the watchdog timer is in stop state. The watchdog timer starts to count down from "3FFF₁₆" by writing an optional value into the watchdog timer control register (address 0037₁₆) and an internal reset occurs at an underflow. Accordingly, programming is usually performed so that writing to the watchdog timer control register (address 0037₁₆) may be started before an underflow. The watchdog timer does not function when an optional value have not written to the watchdog timer control register (address 0037₁₆). When address 0037₁₆ is read, the following values are read:

- value of high-order 6-bit counter
- value of STP instruction disable bit
- value of count source selection bit.

When bit 6 of the watchdog timer control register (address 0037₁₆) is set to "0," the STP instruction is valid. The STP instruction is disabled by rewriting this bit to "1." At this time, if the STP instruction is executed, it is processed as an undefined instruction, so that a reset occurs inside.

This bit cannot be rewritten to "0" by programming. This bit is "0" immediately after reset.

The count source of the watchdog timer becomes the system clock ϕ divided by 8. The detection time in this case is set to 8.19 s at $X_{CIN} = 32$ kHz and 65.536 ms at $X_{IN} = 4$ MHz.

However, count source of high-order 6-bit timer can be connected to a signal divided system clock by 8 directly by writing the bit 7 of the watchdog timer control register (address 0037₁₆) to "1." The detection time in this case is set to 32 ms at $X_{CIN} = 32$ kHz and 256 μ s at $X_{IN} = 4$ MHz. There is no difference in the detection time between the middle-speed mode and the high-speed mode.

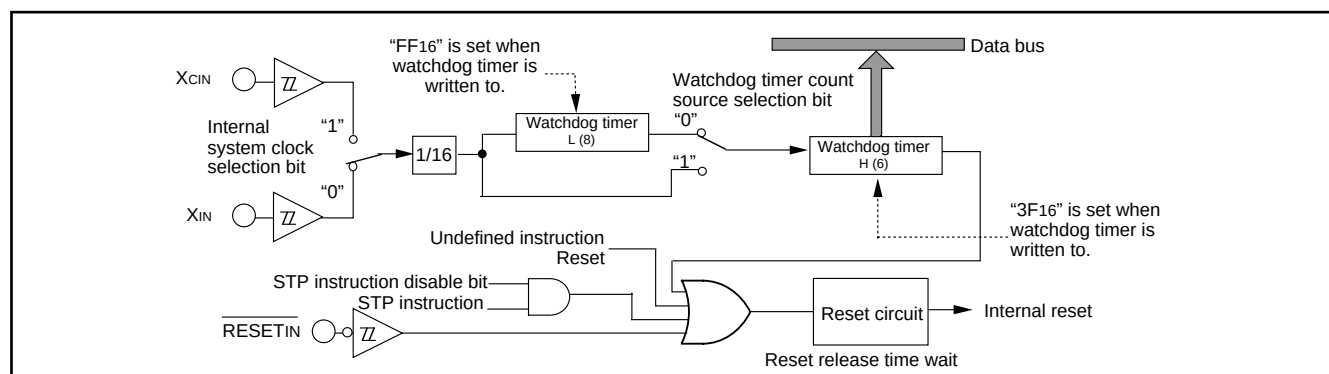


Fig. 44 Block diagram of watchdog timer

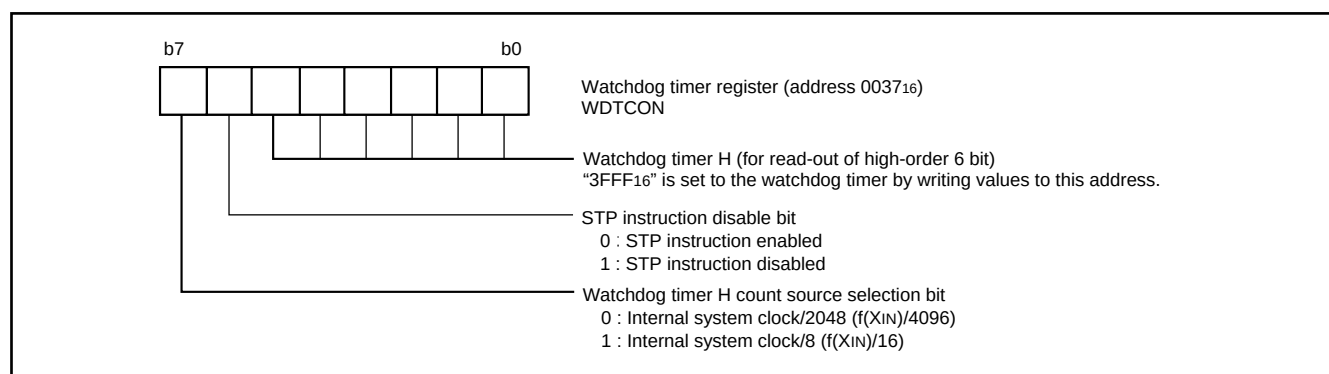


Fig. 45 Structure of watchdog timer control register

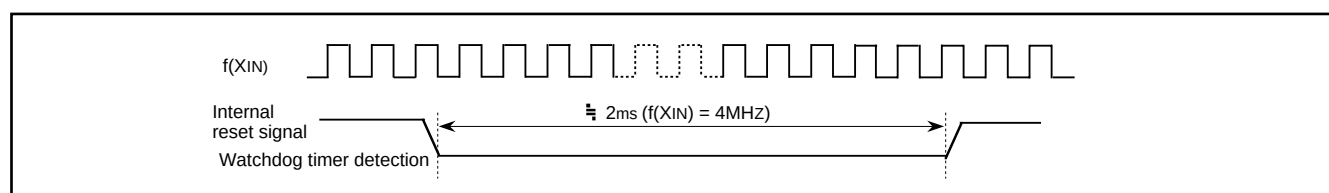


Fig. 46 Timing of reset output

TOUT/φ CLOCK OUTPUT FUNCTION

The internal system clock φ or timer 2 divided by 2 (TOUT output) can be output from port P43 by setting the TOUT/φ output control bit (bit 1) of the timer 123 mode register and the TOUT/φ output control register. Set bit 3 of the port P4 direction register to "1" when outputting the clock.

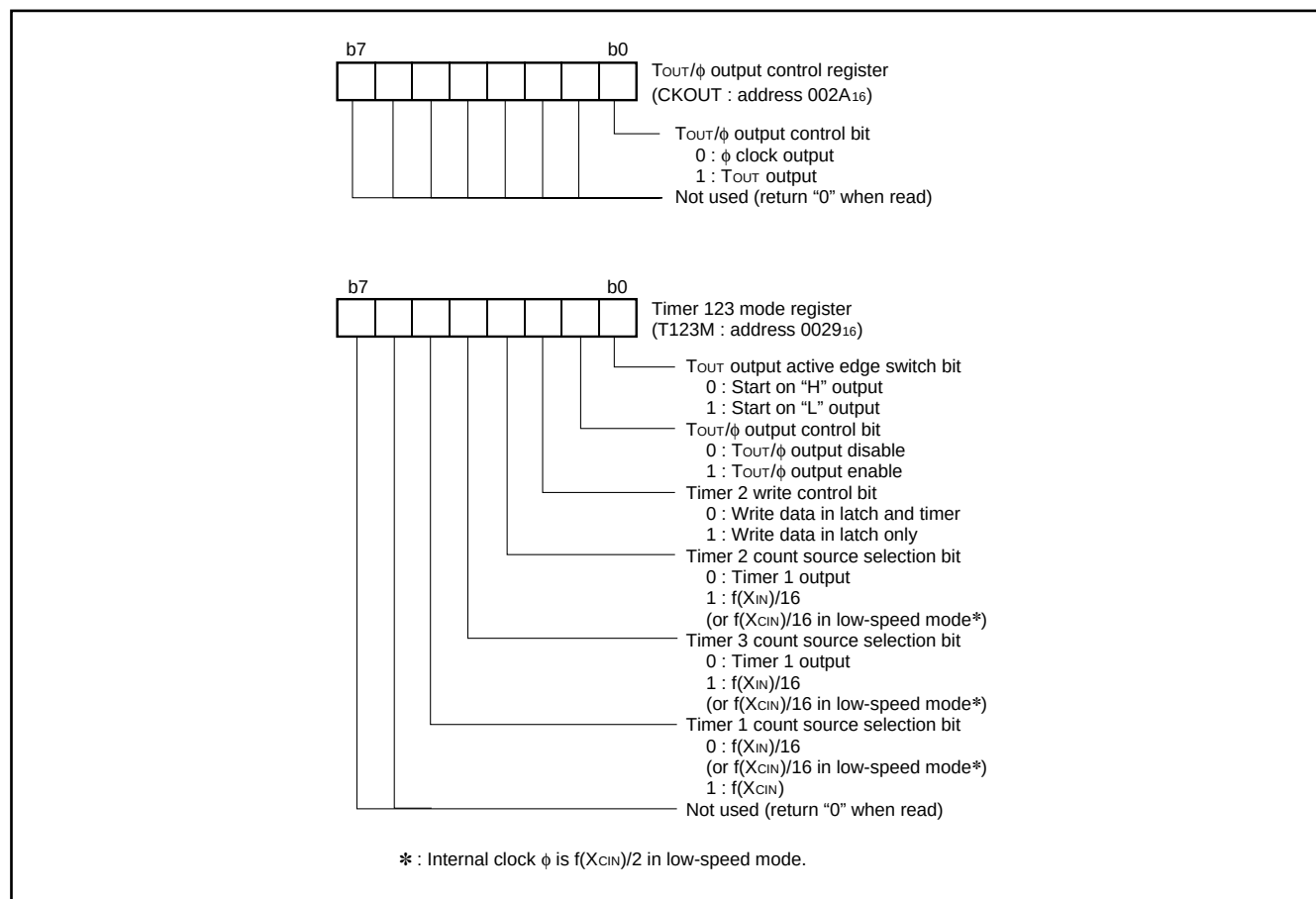


Fig. 47 Structure of TOUT/φ output-related register

RESET CIRCUIT

To reset the microcomputer, $\overline{\text{RESET}}$ pin should be held at an "L" level for 2 μs or more. Then the $\overline{\text{RESET}}$ pin is returned to an "H" level (the power source voltage should be between $V_{\text{CC}}(\text{min.})$ and 5.5 V, and the oscillation should be stable), reset is released. After the reset is completed, the program starts from the address FFFD_{16} (high-order byte) and address FFFC_{16} (low-order byte). Make sure that the reset input voltage is less than 0.2 V_{CC} for V_{CC} of $V_{\text{CC}}(\text{min.})$.

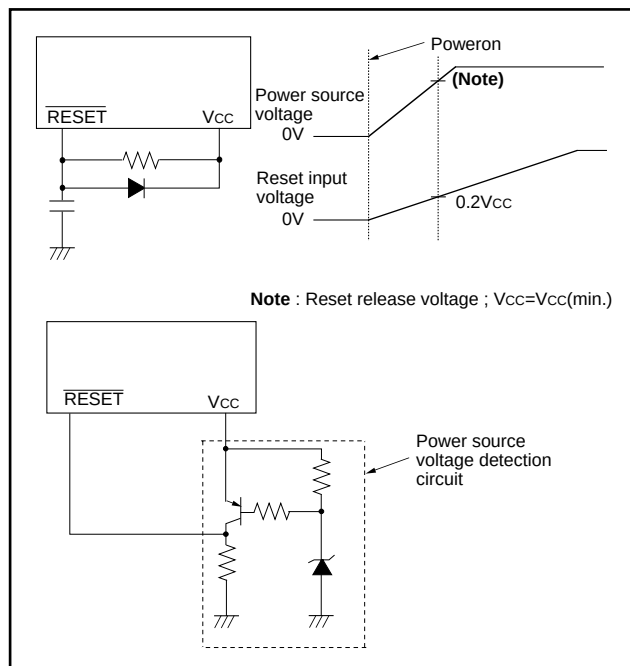


Fig. 48 Reset Circuit Example

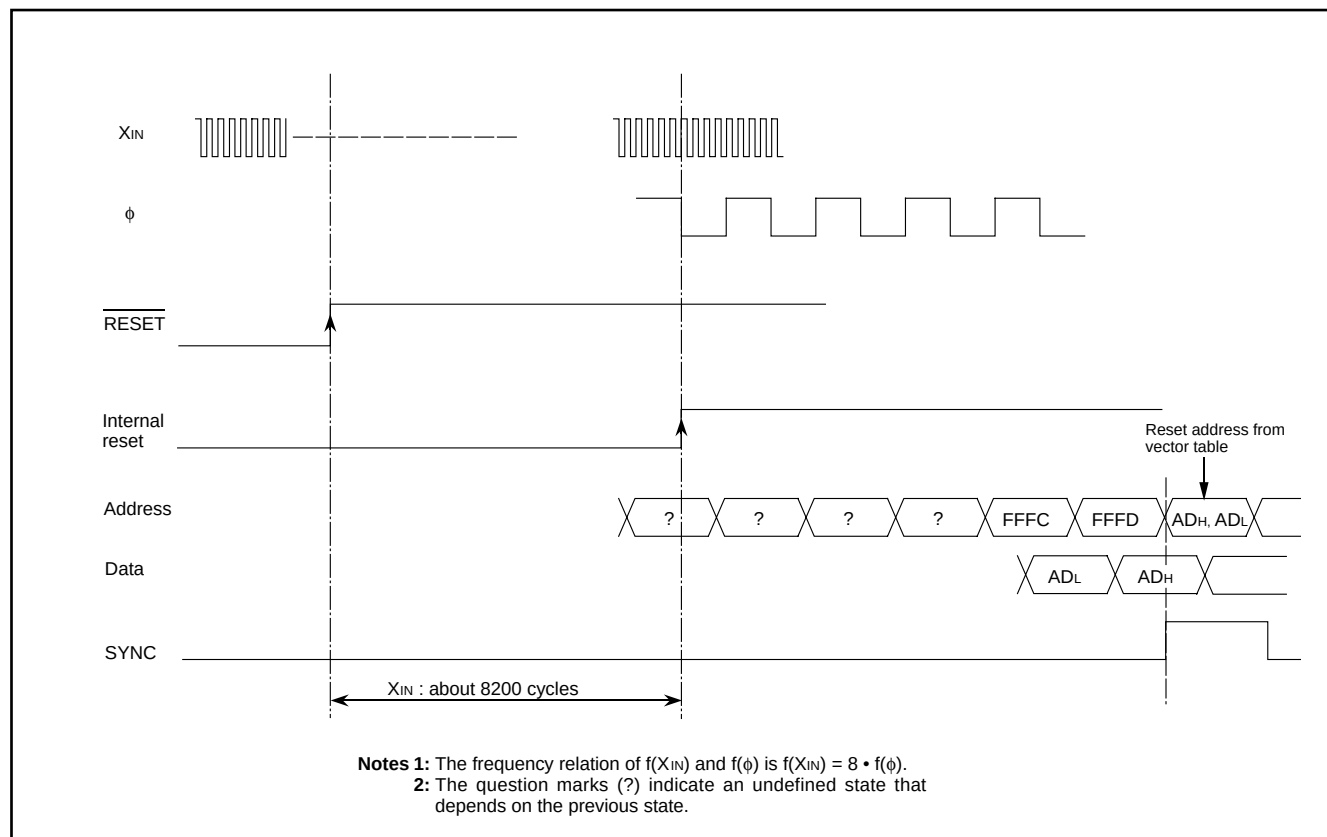


Fig. 49 Reset Sequence

	Address	Register contents		Address	Register contents
(1) Port P0 direction register	0001 ₁₆	00 ₁₆	(28) A-D control register	0031 ₁₆	08 ₁₆
(2) Port P1 direction register	0003 ₁₆	00 ₁₆	(29) A-D conversion register (low-order)	0032 ₁₆	XX ₁₆
(3) Port P2 direction register	0005 ₁₆	00 ₁₆	(30) A-D conversion register (high-order)	0033 ₁₆	XX ₁₆
(4) Port P3 output control register	0007 ₁₆	00 ₁₆	(31) D-A1 conversion register	0034 ₁₆	00 ₁₆
(5) Port P4 direction register	0009 ₁₆	00 ₁₆	(32) D-A2 conversion register	0035 ₁₆	00 ₁₆
(6) Port P5 direction register	000B ₁₆	00 ₁₆	(33) D-A control register	0036 ₁₆	00 ₁₆
(7) Port P6 direction register	000D ₁₆	00 ₁₆	(34) Watchdog timer control register	0037 ₁₆	0 0 1 1 1 1 1 1
(8) Port P7 direction register	000F ₁₆	00 ₁₆	(35) Segment output enable register	0038 ₁₆	00 ₁₆
(9) Key input control register	0015 ₁₆	00 ₁₆	(36) LCD mode register	0039 ₁₆	00 ₁₆
(10) PULL register A	0016 ₁₆	3F ₁₆	(37) Interrupt edge selection register	003A ₁₆	00 ₁₆
(11) PULL register B	0017 ₁₆	00 ₁₆	(38) CPU mode register	003B ₁₆	0 1 0 0 1 0 0 0
(12) Serial I/O1 status register	0019 ₁₆	1 0 0 0 0 0 0 0	(39) Interrupt request register 1	003C ₁₆	00 ₁₆
(13) Serial I/O1 control register	001A ₁₆	00 ₁₆	(40) Interrupt request register 2	003D ₁₆	00 ₁₆
(14) UART control register	001B ₁₆	1 1 1 0 0 0 0 0	(41) Interrupt control register 1	003E ₁₆	00 ₁₆
(15) Serial I/O2 control register	001D ₁₆	00 ₁₆	(42) Interrupt control register 2	003F ₁₆	00 ₁₆
(16) Timer X (low-order)	0020 ₁₆	FF ₁₆	(43) Processor status register (PS)		X X X X X 1 X X
(17) Timer X (high-order)	0021 ₁₆	FF ₁₆	(44) Program counter (PC _H)		Contents of address FFFD ₁₆
(18) Timer Y (low-order)	0022 ₁₆	FF ₁₆	(PC _L)		Contents of address FFFC ₁₆
(19) Timer Y (high-order)	0023 ₁₆	FF ₁₆	(45) Watchdog timer (high-order)		3F ₁₆
(20) Timer 1	0024 ₁₆	FF ₁₆	(46) Watchdog timer (low-order)		FF ₁₆
(21) Timer 2	0025 ₁₆	01 ₁₆			
(22) Timer 3	0026 ₁₆	FF ₁₆			
(23) Timer X mode register	0027 ₁₆	00 ₁₆			
(24) Timer Y mode register	0028 ₁₆	00 ₁₆			
(25) Timer 123 mode register	0029 ₁₆	00 ₁₆			
(26) T _{OUT} /φ output control register	002A ₁₆	00 ₁₆			
(27) PWM control register	002B ₁₆	00 ₁₆			

Note: The contents of all other register and RAM are undefined after reset, so they must be initialized by software.
X : Undefined

Fig. 50 Initial status at reset

CLOCK GENERATING CIRCUIT

The 3827 group has two built-in oscillation circuits. An oscillation circuit can be formed by connecting a resonator between X_{IN} and X_{OUT} (X_{CIN} and X_{COUT}). Use the circuit constants in accordance with the resonator manufacturer's recommended values. No external resistor is needed between X_{IN} and X_{OUT} since a feed-back resistor exists on-chip. However, an external feed-back resistor is needed between X_{CIN} and X_{COUT} .

To supply a clock signal externally, input it to the X_{IN} pin and make the X_{OUT} pin open. The sub-clock X_{CIN} - X_{COUT} oscillation circuit cannot directly input clocks that are externally generated. Accordingly, be sure to cause an external resonator to oscillate.

Immediately after poweron, only the X_{IN} oscillation circuit starts oscillating, and X_{CIN} and X_{COUT} pins go to high impedance state.

Frequency Control

(1) Middle-speed Mode

The internal clock ϕ is the frequency of X_{IN} divided by 8.

After reset, this mode is selected.

(2) High-speed Mode

The internal clock ϕ is half the frequency of X_{IN} .

(3) Low-speed Mode

- The internal clock ϕ is half the frequency of X_{CIN} .
 - A low-power consumption operation can be realized by stopping the main clock X_{IN} in this mode. To stop the main clock, set bit 5 of the CPU mode register to "1".
- When the main clock X_{IN} is restarted, set enough time for oscillation to stabilize by programming.

Note: If you switch the mode between middle/high-speed and low-speed, stabilize both X_{IN} and X_{CIN} oscillations. The sufficient time is required for the sub-clock to stabilize, especially immediately after poweron and at returning from stop mode. When switching the mode between middle/high-speed and low-speed, set the frequency on condition that $f(X_{IN}) > 3f(X_{CIN})$.

Oscillation Control

(1) Stop Mode

If the STP instruction is executed, the internal clock ϕ stops at an "H" level, and X_{IN} and X_{CIN} oscillators stop. The value set to the timer latch 1 and the timer latch 2 is loaded automatically to the timer 1 and the timer 2. Thus, a value generated time for stabilizing oscillation should be set to the timer 1 latch and the timer 2 latch (low-order 8 bits for the timer 1, high-order 8 bits for the timer 2) before executing the STP instruction.

Either X_{IN} or X_{CIN} divided by 16 is input to timer 1 as count source, and the output of timer 1 is connected to timer 2. The bits of the timer 123 mode register except bit 4 are cleared to "0." Set the timer 1 and timer 2 interrupt enable bits to disabled ("0") before executing the STP instruction. Oscillator restarts at reset or when an external interrupt is received, but the internal clock ϕ is not supplied to the CPU until timer 2 underflows. This allows timer for the clock circuit oscillation to stabilize.

(2) Wait Mode

If the WIT instruction is executed, the internal clock ϕ stops at an "H" level. The states of X_{IN} and X_{CIN} are the same as the state before the executing the WIT instruction. The internal clock restarts at reset or when an interrupt is received. Since the oscillator does not stop, normal operation can be started immediately after the clock is restarted.

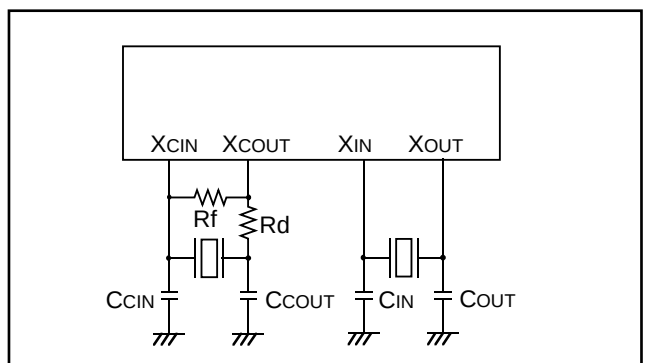


Fig. 51 Ceramic resonator circuit

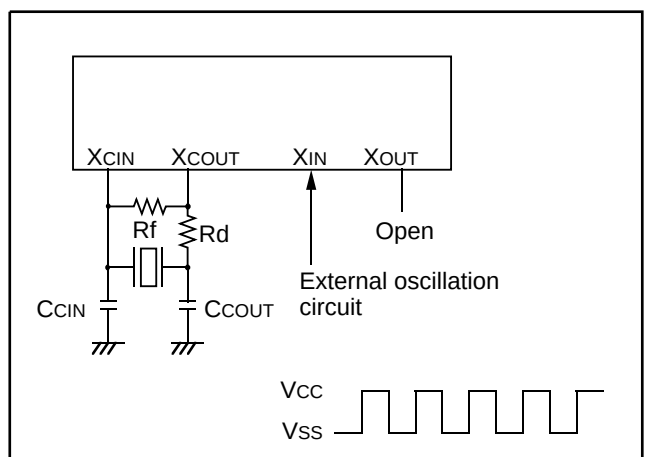


Fig. 52 External clock input circuit

46

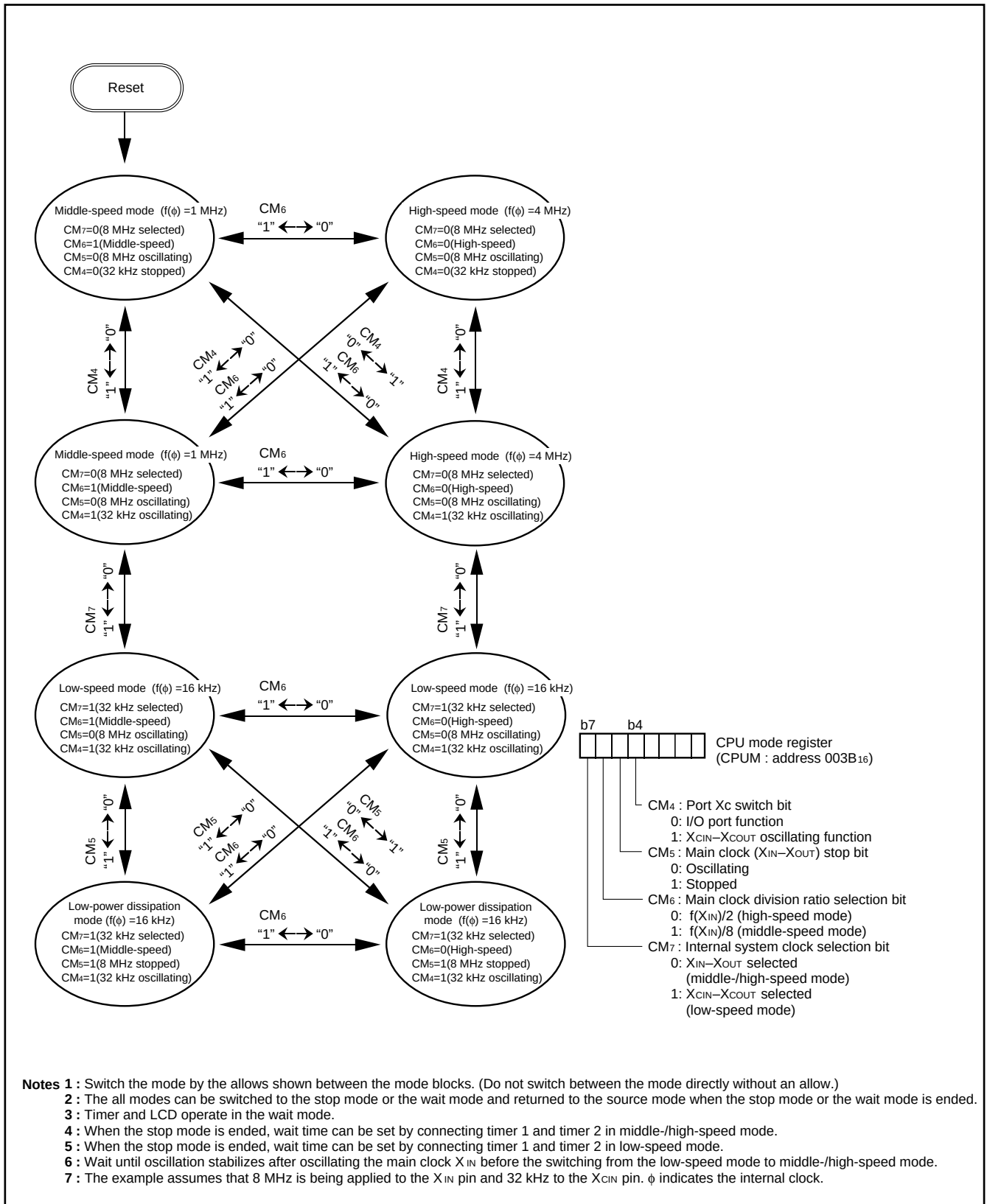


Fig. 54 State transitions of system clock

NOTES ON PROGRAMMING

Processor Status Register

The contents of the processor status register (PS) after a reset are undefined, except for the interrupt disable flag (I) which is "1". After a reset, initialize flags which affect program execution.

In particular, it is essential to initialize the index X mode (T) and the decimal mode (D) flags because of their effect on calculations.

Interrupt

The contents of the interrupt request bits do not change immediately after they have been written. After writing to an interrupt request register, execute at least one instruction before performing a BBC or BBS instruction.

Decimal Calculations

- To calculate in decimal notation, set the decimal mode flag (D) to "1", then execute an ADC or SBC instruction. After executing an ADC or SBC instruction, execute at least one instruction before executing a SEC, CLC, or CLD instruction.
- In decimal mode, the values of the negative (N), overflow (V), and zero (Z) flags are invalid.

Timers

If a value n (between 0 and 255) is written to a timer latch, the frequency division ratio is $1/(n + 1)$.

Multiplication and Division Instructions

The index mode (T) and the decimal mode (D) flags do not affect the MUL and DIV instruction.

The execution of these instructions does not change the contents of the processor status register.

Ports

The contents of the port direction registers cannot be read.

The following cannot be used:

- The data transfer instruction (LDA, etc.)
- The operation instruction when the index X mode flag (T) is "1"
- The addressing mode which uses the value of a direction register as an index
- The bit-test instruction (BBC or BBS, etc.) to a direction register
- The read-modify-write instruction (ROR, CLB, or SEB, etc.) to a direction register

Use instructions such as LDM and STA, etc., to set the port direction registers.

Serial I/O

In clock synchronous serial I/O, if the receive side is using an external clock and it is to output the $\overline{\text{SRDY}}$ signal, set the transmit enable bit, the receive enable bit, and the $\overline{\text{SRDY}}$ output enable bit to "1".

Serial I/O1 continues to output the final bit from the TxD pin after transmission is completed.

In serial I/O2, the Sout2 pin goes to high impedance state after transmission is completed.

A-D Converter

The comparator uses internal capacitors whose charge will be lost if the clock frequency is too low.

Make sure that $f(\text{XIN})$ is at least 500 kHz during an A-D conversion.

Do not execute the STP or WIT instruction during an A-D conversion.

Instruction Execution Time

The instruction execution time is obtained by multiplying the frequency of the internal clock ϕ by the number of cycles needed to execute an instruction.

The number of cycles required to execute an instruction is shown in the list of machine instructions.

The frequency of the internal clock ϕ is half of the XIN frequency.

DATA REQUIRED FOR MASK ORDERS

The following are necessary when ordering a mask ROM production:

- (1) Mask ROM Order Confirmation Form
- (2) Mask Specification Form
- (3) Data to be written to ROM, in EPROM form (three identical copies)

DATA REQUIRED FOR ROM WRITING ORDERS

The following are necessary when ordering a ROM writing:

- (1) ROM Writing Confirmation Form
- (2) Mask Specification Form
- (3) Data to be written to ROM, in EPROM form (three identical copies)

ROM PROGRAMMING METHOD

The built-in PROM of the blank One Time PROM version and built-in EPROM version can be read or programmed with a general-purpose PROM programmer using a special programming adapter. Set the address of PROM programmer in the user ROM area.

Table 10 Special programming adapter

Package	Name of Programming Adapter
100PFB-A	Under development (PCA4738H-100A)
100P6Q-A	PCA4738G-100A
100P6S-A	PCA4738F-100A
100D0	PCA4738L-100A

The PROM of the blank One Time PROM version is not tested or screened in the assembly process and following processes. To ensure proper operation after programming, the procedure shown in Figure 55 is recommended to verify programming.

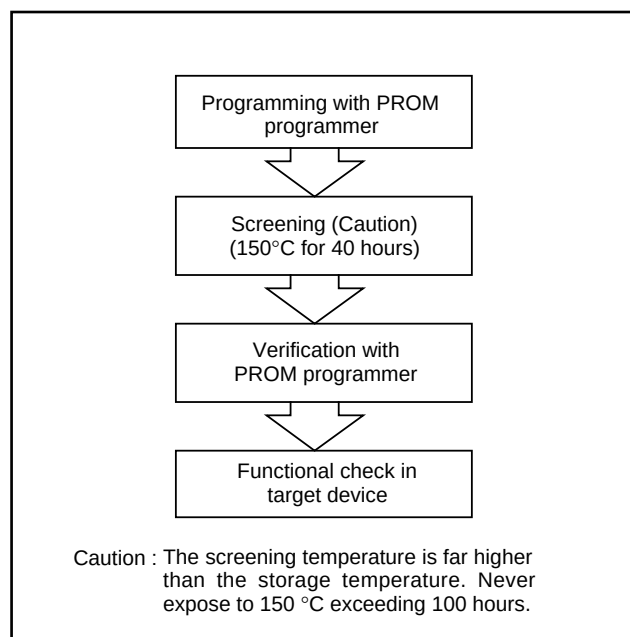


Fig. 55 Programming and testing of One Time PROM version

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

Table 11 Absolute maximum ratings

Symbol	Parameter	Conditions	Ratings	Unit
V _{CC}	Power source voltage	All voltages are based on V _{SS} . Output transistors are cut off.	−0.3 to 7.0	V
V _I	Input voltage P00–P07, P10–P17, P20–P27, P41–P47, P50–P57, P60–P67		−0.3 to V _{CC} +0.3	V
V _I	Input voltage P40, P71–P77		−0.3 to 7.0	V
V _I	Input voltage P70		−0.3 to V _{CC} +0.3	V
V _I	Input voltage V _{L1}		−0.3 to V _{L2}	V
V _I	Input voltage V _{L2}		V _{L1} to V _{L3}	V
V _I	Input voltage V _{L3}		V _{L2} to 7.0	V
V _I	Input voltage C1, C2		−0.3 to 7.0	V
V _I	Input voltage $\overline{\text{RESET}}$, X _{IN}		−0.3 to V _{CC} +0.3	V
V _O	Output voltage C1, C2		−0.3 to 7.0	V
V _O	Output voltage P00–P07, P10–P15, P30–P37	At output port	−0.3 to V _{CC}	V
		At segment output	−0.3 to V _{L3}	V
V _O	Output voltage P16, P17, P20–P27, P41–P47, P50–P57, P60–P67, P80, P81		−0.3 to V _{CC} +0.3	V
V _O	Output voltage P40, P71–P77		−0.3 to 7.0	V
V _O	Output voltage V _{L3}		−0.3 to 7.0	V
V _O	Output voltage V _{L2} , SEG0–SEG17		−0.3 to V _{L3}	V
V _O	Output voltage X _{OUT}		−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

Table 12 Recommended operating conditions (V_{CC} = 2.5 to 5.5 V, T_a = −20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V _{CC}	Power source voltage	High-speed mode f(X _{IN}) = 8 MHz	4.0	5.0	5.5	V
		Middle-speed mode f(X _{IN}) = 8 MHz	2.2	5.0	5.5	
		Low-speed mode	2.2	5.0	5.5	
V _{SS}	Power source voltage			0		V
V _{REF}	A-D, D-A conversion reference voltage		2.7		V _{CC} +0.3	V
AV _{SS}	Analog power source voltage			0		V
V _{IA}	Analog input voltage AN0–AN7		AV _{SS}		V _{CC}	V
V _{IH}	"H" input voltage	P00–P07, P10–P17, P40, P43, P45, P47, P50–P53, P56, P61, P64–P67, P71–P77	0.7 V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage	P20–P27, P41, P42, P44, P46, P54, P55, P57, P60, P62, P63, P70	0.8 V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage	$\overline{\text{RESET}}$	0.8 V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage	X _{IN}	0.8 V _{CC}		V _{CC}	V
V _{IL}	"L" input voltage	P00–P07, P10–P17, P40, P43, P45, P47, P50–P53, P56, P61, P64–P67, P71–P77	0		0.3 V _{CC}	V
V _{IL}	"L" input voltage	P20–P27, P41, P42, P44, P46, P54, P55, P57, P60, P62, P63, P70	0		0.2 V _{CC}	V
V _{IL}	"L" input voltage	$\overline{\text{RESET}}$	0		0.2 V _{CC}	V
V _{IL}	"L" input voltage	X _{IN}	0		0.2 V _{CC}	V

Table 13 Recommended operating conditions (V_{CC} = 2.2 to 5.5 V, T_a = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
ΣIOH(peak)	"H" total peak output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			–20	mA
ΣIOH(peak)	"H" total peak output current P41–P47, P50–P57, P60–P67 (Note 1)			–20	mA
ΣIOL(peak)	"L" total peak output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			20	mA
ΣIOL(peak)	"L" total peak output current P41–P47, P50–P57, P60–P67 (Note 1)			20	mA
ΣIOL(peak)	"L" total peak output current P40, P71–P77 (Note 1)			80	mA
ΣIOH(avg)	"H" total average output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			–10	mA
ΣIOH(avg)	"H" total average output current P41–P47, P50–P57, P60–P67 (Note 1)			–10	mA
ΣIOL(avg)	"L" total average output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			10	mA
ΣIOL(avg)	"L" total average output current P41–P47, P50–P57, P60–P67 (Note 1)			10	mA
ΣIOL(avg)	"L" total average output current P40, P71–P77 (Note 1)			40	mA
IOH(peak)	"H" peak output current P00–P07, P10–P15, P30–P37 (Note 2)			–1.0	mA
IOH(peak)	"H" peak output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 2)			–5.0	mA
IOL(peak)	"L" peak output current P00–P07, P10–P15, P30–P37 (Note 2)			5.0	mA
IOL(peak)	"L" peak output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 2)			10	mA
IOL(peak)	"L" peak output current P40, P71–P77 (Note 2)			20	mA
IOH(avg)	"H" average output current P00–P07, P10–P15, P30–P37 (Note 3)			–0.5	mA
IOH(avg)	"H" average output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67			–2.5	mA
IOL(avg)	"L" average output current P00–P07, P10–P15, P30–P37 (Note 3)			2.5	mA
IOL(avg)	"L" average output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 3)			5.0	mA
IOL(avg)	"L" average output current P40, P71–P77 (Note 3)			10	mA

Notes1: 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 is an average value measured over 100 ms.

Table 14 Recommended operating conditions (Mask ROM version) ($V_{CC} = 2.2$ to 5.5 V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$f(\text{CNTR0})$ $f(\text{CNTR1})$	Input frequency for timers X and Y (duty cycle 50%)	$(4.0 \text{ V} \leq V_{CC} \leq 5.5 \text{ V})$			4.0	MHz
		$(2.2 \text{ V} \leq V_{CC} \leq 4.0 \text{ V})$			$(10 \times V_{CC} - 4)/9$	MHz
$f(X_{IN})$	Main clock input oscillation frequency (Note 1)	High-speed mode $(4.0 \text{ V} \leq V_{CC} \leq 5.5 \text{ V})$			8.0	MHz
		High-speed mode $(2.2 \text{ V} \leq V_{CC} \leq 4.0 \text{ V})$			$(20 \times V_{CC} - 8)/9$	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency (Notes 1, 2)			32.768	50	kHz

Notes1: When the oscillation frequency has a duty cycle of 50%.

2: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

Table 15 Recommended operating conditions (PROM version) ($V_{CC} = 2.5$ to 5.5 V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$f(\text{CNTR0})$ $f(\text{CNTR1})$	Input frequency for timers X and Y (duty cycle 50%)	$(4.0 \text{ V} \leq V_{CC} \leq 5.5 \text{ V})$			4.0	MHz
		$(2.5 \text{ V} \leq V_{CC} \leq 4.0 \text{ V})$			$(2 \times V_{CC}) - 4$	MHz
$f(X_{IN})$	Main clock input oscillation frequency (Note 1)	High-speed mode $(4.0 \text{ V} \leq V_{CC} \leq 5.5 \text{ V})$			8.0	MHz
		High-speed mode $(2.5 \text{ V} \leq V_{CC} \leq 4.0 \text{ V})$			$(4 \times V_{CC}) - 8$	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency (Notes 1, 2)			32.768	50	kHz

Notes1: When the oscillation frequency has a duty cycle of 50%.

2: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

Table 16 Electrical characteristics ($V_{CC} = 4.0$ to 5.5 V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{OH}	“H” output voltage P00–P07, P10–P15, P30–P37	$I_{OH} = -1$ mA	$V_{CC} - 2.0$			V
		$I_{OH} = -0.25$ mA $V_{CC} = 2.2$ V	$V_{CC} - 0.8$			V
V_{OH}	“H” output voltage P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 1)	$I_{OH} = -5$ mA	$V_{CC} - 2.0$			V
		$I_{OH} = -1.5$ mA	$V_{CC} - 0.5$			V
		$I_{OH} = -1.25$ mA $V_{CC} = 2.2$ V	$V_{CC} - 0.8$			V
V_{OL}	“L” output voltage P00–P07, P10–P15, P30–P37	$I_{OL} = 5$ mA			2.0	V
		$I_{OL} = 1.5$ mA			0.5	V
		$I_{OL} = 1.25$ mA $V_{CC} = 2.2$ V			0.8	V
V_{OL}	“L” output voltage P16, P17, P20–P27, P41–P47, P50–P57, P60–P67	$I_{OL} = 10$ mA			2.0	V
		$I_{OL} = 3.0$ mA			0.5	V
		$I_{OL} = 2.5$ mA $V_{CC} = 2.2$ V			0.8	V
V_{OL}	“L” output voltage P40, P71–P77	$I_{OL} = 10$ mA			0.5	V
		$I_{OL} = 5$ mA $V_{CC} = 2.2$ V			0.3	V
$V_{T+} - V_{T-}$	Hysteresis INT0–INT2, ADT, CNTR0, CNTR1, P20–P27			0.5		V
$V_{T+} - V_{T-}$	Hysteresis SCLK, RxD			0.5		V
$V_{T+} - V_{T-}$	Hysteresis RESET			0.5		V
I_{IH}	“H” input current P00–P07, P10–P17, P20–P27, P40–P47, P50–P57, P60–P67, P70–P77	$V_I = V_{CC}$			5.0	μA
I_{IH}	“H” input current RESET	$V_I = V_{CC}$			5.0	μA
I_{IH}	“H” input current XIN	$V_I = V_{CC}$		4.0		μA
I_{IL}	“L” input current P00–P07, P10–P17, P20–P27, P40–P47, P50–P57, P60–P67, P70–P77	$V_I = V_{SS}$ Pull-ups “off”			–5.0	μA
		$V_{CC} = 5$ V, $V_I = V_{SS}$ Pull-ups “on”	–60.0	–120.0	–240.0	μA
		$V_{CC} = 2.2$ V, $V_I = V_{SS}$ Pull-ups “on”	–5.0	–20.0	–40.0	μA
I_{IL}	“L” input current P70				–5.0	μA
I_{IL}	“L” input current RESET	$V_I = V_{SS}$			–5.0	μA
I_{IL}	“L” input current XIN	$V_I = V_{SS}$		–4.0		μA
I_{LOAD}	Output load current P30–P37	$V_{CC} = 5.0$ V, $V_O = V_{CC}$, Pull-ups “on” Output transistors “off”	–60.0	–120.0	–240.0	μA
		$V_{CC} = 2.2$ V, $V_O = V_{CC}$, Pull-ups “on” Output transistors “off”	–5.0	–20.0	–40.0	μA
I_{LEAK}	Output leak current P30–P37	$V_O = V_{CC}$, Pull-ups “off” Output transistors “off”			5.0	μA
		$V_O = V_{SS}$, Pull-ups “off” Output transistors “off”			–5.0	μA

Table 17 Electrical characteristics ($V_{CC} = 2.2$ to 5.5 V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
VRAM	RAM retention voltage	At clock stop mode	2.0		5.5	V
I _{CC}	Power source current	High-speed mode, $V_{CC} = 5$ V $f(X_{IN}) = 8$ MHz $f(X_{CIN}) = 32.768$ kHz Output transistors "off" A-D converter in operating		6.4	13	mA
		High-speed mode, $V_{CC} = 5$ V $f(X_{IN}) = 8$ MHz (in WIT state) $f(X_{CIN}) = 32.768$ kHz Output transistors "off" A-D converter in operating		1.6	3.2	mA
		Low-speed mode, $V_{CC} = 5$ V, $T_a \leq 55^\circ\text{C}$ $f(X_{IN}) =$ stopped $f(X_{CIN}) = 32.768$ kHz Output transistors "off"		35	70	μA
		Low-speed mode, $V_{CC} = 5$ V, $T_a = 25^\circ\text{C}$ $f(X_{IN}) =$ stopped $f(X_{CIN}) = 32.768$ kHz (in WIT state) Output transistors "off"		20	40	μA
		Low-speed mode, $V_{CC} = 3$ V, $T_a \leq 55^\circ\text{C}$ $f(X_{IN}) =$ stopped $f(X_{CIN}) = 32.768$ kHz Output transistors "off"		15.0	22.0	μA
		Low-speed mode, $V_{CC} = 3$ V, $T_a \leq 25^\circ\text{C}$ $f(X_{IN}) =$ stopped $f(X_{CIN}) = 32.768$ kHz (in WIT state) Output transistors "off"		4.5	9.0	μA
		All oscillation stopped (in STP state) Output transistors "off"	$T_a = 25^\circ\text{C}$ $T_a = 85^\circ\text{C}$	0.1	1.0 10.0	μA
V _{L1}	Power source voltage	When using voltage multiplier	1.3	1.8	2.3	V
I _{L1}	Power source current (V _{L1}) (Note)	V _{L1} = 1.8 V		3.0	6.0	μA
		V _{L1} < 1.3 V		10.0	50.0	

Note: When the voltage multiplier control bit of the LCD mode register (bit 4 at address 0039₁₆) is "1".

Table 18 A-D converter characteristics

($V_{CC} = 2.2$ to 5.5 V, $V_{SS} = 0$ V, $T_a = -20$ to 85°C , $4\text{ MHz} \leq f(X_{IN}) \leq 8\text{ MHz}$, in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
—	Resolution				10	Bits
—	Absolute accuracy (excluding quantization error)	$V_{CC} \geq V_{REF} = 4\text{ V}$			± 2.5	LSB
		$V_{CC} \geq V_{REF} = 2.7\text{ V}$			± 4.0	LSB
tCONV	Conversion time	$f(X_{IN}) = 4\text{ MHz}$	30.5		31 (Note)	μs
RLADDER	Ladder resistor			35		$\text{k}\Omega$
IVREF	Reference power source input current	$V_{REF} = 5\text{ V}$	50	150	200	μA
I _{IA}	Analog port input current			0.5	5.0	μA

Note: When an internal trigger is used in middle-speed mode, it is 34 μs .

Table 19 D-A converter characteristics

($V_{CC} = 2.2$ to 5.5 V, $V_{CC} = V_{REF}$, $V_{SS} = AV_{SS} = 0$ V, $T_a = -20$ to 85°C , in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
—	Resolution				8	Bits
—	Absolute accuracy	$V_{CC} = V_{REF} = 5\text{ V}$			1.0	%
		$V_{CC} = V_{REF} = 2.7\text{ V}$			2.0	%
t _{su}	Setting time			3		μs
R _O	Output resistor		1	2.5	4	$\text{k}\Omega$
IVREF	Reference power source input current	(Note)			6.0	mA

Note: Using one D-A converter, with the value in the D-A conversion register of the other D-A converter being "0016", and excluding currents flowing through the A-D resistance ladder.

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_w(\overline{\text{RESET}})$	Reset input "L" pulse width	2			μs
$t_c(X_{IN})$	Main clock input cycle time (X_{IN} input)	125			ns
$t_wH(X_{IN})$	Main clock input "H" pulse width	45			ns
$t_wL(X_{IN})$	Main clock input "L" pulse width	40			ns
$t_c(\text{CNTR})$	CNTR0, CNTR1 input cycle time	250			ns
$t_wH(\text{CNTR})$	CNTR0, CNTR1 input "H" pulse width	105			ns
$t_wL(\text{CNTR})$	CNTR0, CNTR1 input "L" pulse width	105			ns
$t_wH(\text{INT})$	INT0 to INT2 input "H" pulse width	80			ns
$t_wL(\text{INT})$	INT0 to INT2 input "L" pulse width	80			ns
$t_c(\text{SCLK1})$	Serial I/O1 clock input cycle time (Note)	800			ns
$t_wH(\text{SCLK1})$	Serial I/O1 clock input "H" pulse width (Note)	370			ns
$t_wL(\text{SCLK1})$	Serial I/O1 clock input "L" pulse width (Note)	370			ns
$t_{su}(\text{Rx}D-\text{SCLK1})$	Serial I/O1 input set up time	220			ns
$t_h(\text{SCLK1}-\text{Rx}D)$	Serial I/O1 input hold time	100			ns
$t_c(\text{SCLK2})$	Serial I/O2 clock input cycle time (Note)	1000			ns
$t_wH(\text{SCLK2})$	Serial I/O2 clock input "H" pulse width (Note)	400			ns
$t_wL(\text{SCLK2})$	Serial I/O2 clock input "L" pulse width (Note)	400			ns
$t_{su}(\text{SIN2}-\text{SCLK2})$	Serial I/O2 input set up time	200			ns
$t_h(\text{SCLK2}-\text{SIN2})$	Serial I/O2 input hold time	200			ns

Note: When bit 6 of address 001A16 is "1".

Divide this value by four when bit 6 of address 001A16 is "0".

Table 21 Timing requirements 2 ($V_{CC} = 2.2$ to 4.0 V, $V_{SS} = 0$ V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_w(\overline{\text{RESET}})$	Reset input "L" pulse width	2			μs
$t_c(X_{IN})$	Main clock input cycle time (X_{IN} input)	125			ns
$t_wH(X_{IN})$	Main clock input "H" pulse width	45			ns
$t_wL(X_{IN})$	Main clock input "L" pulse width	40			ns
$t_c(\text{CNTR})$	CNTR0, CNTR1 input cycle time	$900/(V_{CC}-0.4)$			ns
$t_wH(\text{CNTR})$	CNTR0, CNTR1 input "H" pulse width	$t_c(\text{CNTR})/2-20$			ns
$t_wL(\text{CNTR})$	CNTR0, CNTR1 input "L" pulse width	$t_c(\text{CNTR})/2-20$			ns
$t_wH(\text{INT})$	INT0 to INT2 input "H" pulse width	230			ns
$t_wL(\text{INT})$	INT0 to INT2 input "L" pulse width	230			ns
$t_c(\text{SCLK1})$	Serial I/O1 clock input cycle time (Note)	2000			ns
$t_wH(\text{SCLK1})$	Serial I/O1 clock input "H" pulse width (Note)	950			ns
$t_wL(\text{SCLK1})$	Serial I/O1 clock input "L" pulse width (Note)	950			ns
$t_{su}(\text{Rx}D-\text{SCLK1})$	Serial I/O1 input set up time	400			ns
$t_h(\text{SCLK1}-\text{Rx}D)$	Serial I/O1 input hold time	200			ns
$t_c(\text{SCLK2})$	Serial I/O2 clock input cycle time (Note)	2000			ns
$t_wH(\text{SCLK2})$	Serial I/O2 clock input "H" pulse width (Note)	950			ns
$t_wL(\text{SCLK2})$	Serial I/O2 clock input "L" pulse width (Note)	950			ns
$t_{su}(\text{SIN2}-\text{SCLK2})$	Serial I/O2 input set up time	400			ns
$t_h(\text{SCLK2}-\text{SIN2})$	Serial I/O2 input hold time	300			ns

Note: When bit 6 of address 001A16 is "1".

Divide this value by four when bit 6 of address 001A16 is "0".

Table 22 Switching characteristics 1 (V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
t _{WH} (SCLK1)	Serial I/O1 clock output "H" pulse width	t _c (SCLK1)/2–30			ns
t _{WL} (SCLK1)	Serial I/O1 clock output "L" pulse width	t _c (SCLK1)/2–30			ns
t _d (SCLK1–TxD)	Serial I/O1 output delay time (Note 1)			140	ns
t _v (SCLK1–TxD)	Serial I/O1 output valid time (Note 1)	–30			ns
t _r (SCLK1)	Serial I/O1 clock output rising time			30	ns
t _f (SCLK1)	Serial I/O1 clock output falling time			30	ns
t _{WH} (SCLK2)	Serial I/O2 clock output "H" pulse width	t _c (SCLK2)/2–160			ns
t _{WL} (SCLK2)	Serial I/O2 clock output "L" pulse width	t _c (SCLK2)/2–160			ns
t _d (SCLK2–SOUT2)	Serial I/O2 output delay time			0.2 X t _c (SCLK2)	ns
t _v (SCLK2–SOUT2)	Serial I/O2 output valid time	0			ns
t _f (SCLK2)	Serial I/O2 clock output falling time			40	ns
t _r (CMOS)	CMOS output rising time (Note 2)		10	30	ns
t _f (CMOS)	CMOS output falling time (Note 2)		10	30	ns

Notes1: When the P45/TxD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is "0".

2: XOUT and XCOUNT pins are excluded.

Table 23 Switching characteristics 2 (V_{CC} = 2.2 to 4.0 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
t _{WH} (SCLK1)	Serial I/O1 clock output "H" pulse width	t _c (SCLK1)/2–50			ns
t _{WL} (SCLK1)	Serial I/O1 clock output "L" pulse width	t _c (SCLK1)/2–50			ns
t _d (SCLK1–TxD)	Serial I/O1 output delay time (Note 1)			350	ns
t _v (SCLK1–TxD)	Serial I/O1 output valid time (Note 1)	–30			ns
t _r (SCLK1)	Serial I/O1 clock output rising time			50	ns
t _f (SCLK1)	Serial I/O1 clock output falling time			50	ns
t _{WH} (SCLK2)	Serial I/O2 clock output "H" pulse width	t _c (SCLK2)/2–240			ns
t _{WL} (SCLK2)	Serial I/O2 clock output "L" pulse width	t _c (SCLK2)/2–240			ns
t _d (SCLK2–SOUT2)	Serial I/O2 output delay time			0.2 X t _c (SCLK2)	ns
t _v (SCLK2–SOUT2)	Serial I/O2 output valid time	0			ns
t _f (SCLK2)	Serial I/O2 clock output falling time			50	ns
t _r (CMOS)	CMOS output rising time (Note 2)		20	50	ns
t _f (CMOS)	CMOS output falling time (Note 2)		20	50	ns

Notes1: When the P45/TxD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is "0".

2: XOUT and XCOUNT pins are excluded.

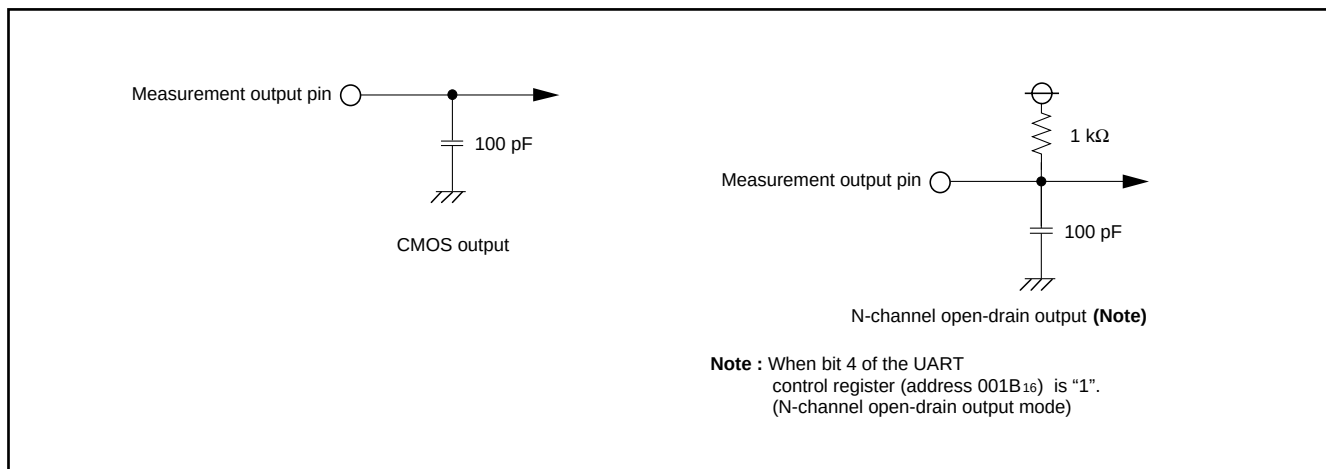


Fig. 56 Circuit for measuring output switching characteristics

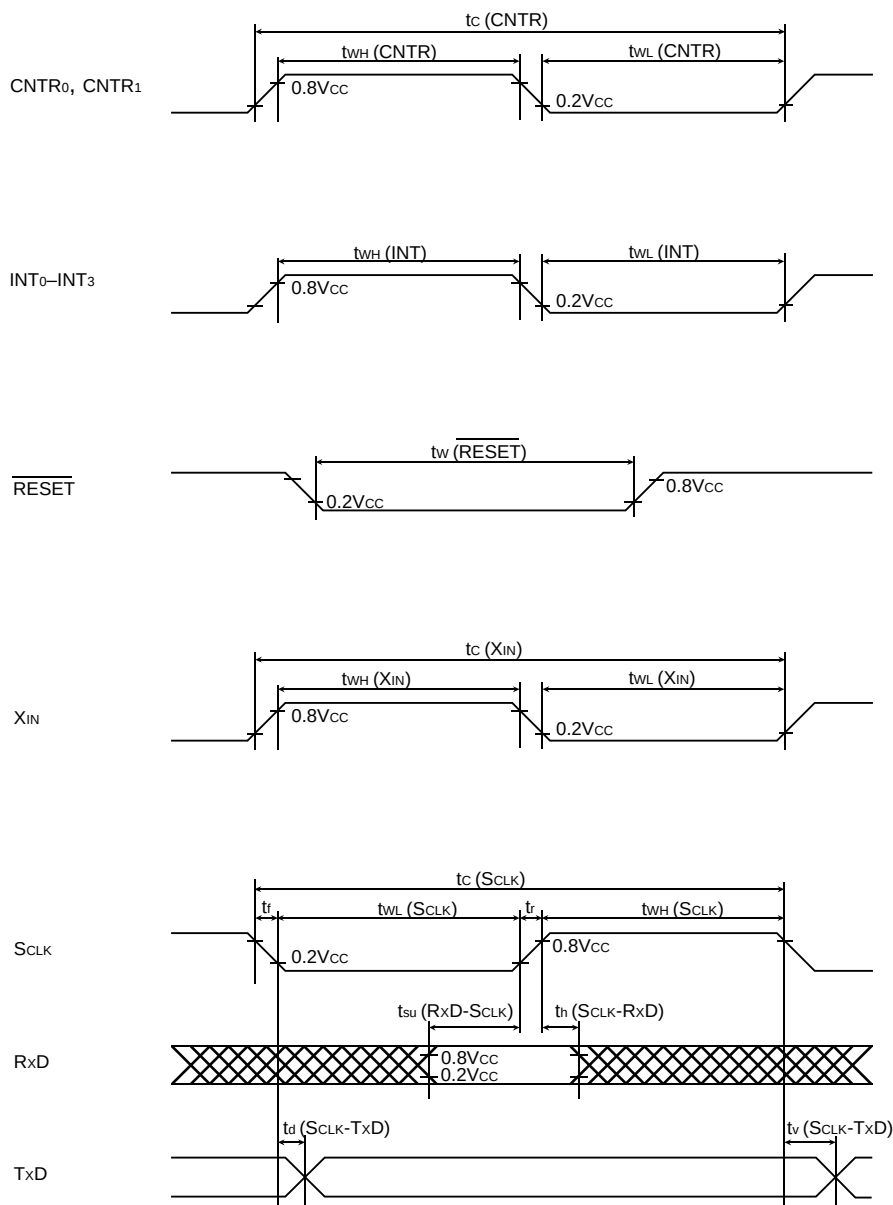


Fig. 57 Timing diagram

MASK ROM ORDER CONFIRMATION FORM

GZZ-SH52-92B<85A0>

Mask ROM number

740 FAMILY MASK ROM CONFIRMATION FORM
SINGLE-CHIP MICROCOMPUTER M38277M8MXXXFP/GP/HP
MITSUBISHI ELECTRIC

Receipt	Date:	
	Section head signature	Supervisor signature

Note : Please fill in all items marked *.

*	Customer	Company name	TEL ()	Issuance signature	Submitted by	Supervisor
		Date issued	Date:			

* 1. Confirmation

Specify the name of the product being ordered and the type of EPROMs submitted.

Three EPROMs are required for each pattern.

If at least two of the three sets of EPROMs submitted contain identical data, we will produce masks based on this data. We shall assume the responsibility for errors only if the mask ROM data on the products we produce differs from this data. Thus, extreme care must be taken to verify the data in the submitted EPROMs.

Product name: ☐ M38277M8MXXXFP ☐ M38277M8MXXXGP ☐ M38277M8MXXXHP

Checksum code for entire EPROM

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(hexadecimal notation)

EPROM type (indicate the type used)

☐ 27512													
<table border="1"> <tr> <td>EPROM address</td> <td></td> </tr> <tr> <td>0000₁₆</td> <td rowspan="3">Product name ASCII code : 'M38277M8M'</td> </tr> <tr> <td>000F₁₆</td> </tr> <tr> <td>0010₁₆</td> </tr> <tr> <td>807F₁₆</td> <td rowspan="2">Data ROM 32K-130 bytes</td> </tr> <tr> <td>8080₁₆</td> </tr> <tr> <td>FFFD₁₆</td> <td rowspan="3"> </td> </tr> <tr> <td>FFFE₁₆</td> </tr> <tr> <td>FFFF₁₆</td> </tr> </table>	EPROM address		0000 ₁₆	Product name ASCII code : 'M38277M8M'	000F ₁₆	0010 ₁₆	807F ₁₆	Data ROM 32K-130 bytes	8080 ₁₆	FFFD ₁₆		FFFE ₁₆	FFFF ₁₆
EPROM address													
0000 ₁₆	Product name ASCII code : 'M38277M8M'												
000F ₁₆													
0010 ₁₆													
807F ₁₆	Data ROM 32K-130 bytes												
8080 ₁₆													
FFFD ₁₆													
FFFE ₁₆													
FFFF ₁₆													

In the address space of the microcomputer, the internal ROM area is from address 8080₁₆ to FFFD₁₆. The reset vector is stored in addresses FFFC₁₆ and FFFD₁₆.

- (1) Set the data in the unused area (the shaded area of the diagram) to "FF₁₆".
- (2) The ASCII codes of the product name "M38277M8M" must be entered in addresses 0000₁₆ to 0008₁₆. And set data "FF₁₆" in addresses 0009₁₆ to 000F₁₆. The ASCII codes and addresses are listed to the right in hexadecimal notation.

Address

0000 ₁₆	'M' = 4D ₁₆
0001 ₁₆	'3' = 33 ₁₆
0002 ₁₆	'8' = 38 ₁₆
0003 ₁₆	'2' = 32 ₁₆
0004 ₁₆	'7' = 37 ₁₆
0005 ₁₆	'7' = 37 ₁₆
0006 ₁₆	'M' = 4D ₁₆
0007 ₁₆	'8' = 38 ₁₆

Address

0008 ₁₆	' M ' = 4D ₁₆
0009 ₁₆	FF ₁₆
000A ₁₆	FF ₁₆
000B ₁₆	FF ₁₆
000C ₁₆	FF ₁₆
000D ₁₆	FF ₁₆
000E ₁₆	FF ₁₆
000F ₁₆	FF ₁₆

(1/2)

GZZ-SH52-92B<85A0>

Mask ROM number

740 FAMILY MASK ROM CONFIRMATION FORM
SINGLE-CHIP MICROCOMPUTER M38277M8MXXXFP/GP/HP
MITSUBISHI ELECTRIC

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000₁₆ to 0008₁₆ of EPROM.

EPROM type	27512
The pseudo-command	*=Δ\$0000 .BYTEΔ 'M38277M8M'

Note: If the name of the product written to the EPROMs does not match the name of the mask ROM confirmation form, the ROM will not be processed.

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate mark specification form (100P6S for M38277M8MXXXFP, 100P6Q for M38277M8MXXXGP, 100PFB for M38277M8MXXXHP) and attach it to the mask ROM confirmation form.

※ 3. Usage conditions

Please answer the following questions about usage for use in our product inspection :

(1) How will you use the X_{IN}-X_{OUT} oscillator?

- ☐ Ceramic resonator
 ☐ Quartz crystal
☐ External clock input
 ☐ Other ()

At what frequency?

f(X_{IN}) = MHz

(2) How will you use the X_{CIN}-X_{COU}T oscillator?

- ☐ Ceramic resonator
 ☐ Quartz crystal
☐ Other ()

At what frequency?

f(X_{CIN}) = MHz

※ 4. Comments

ROM PROGRAMMING CONFIRMATION FORM
GZZ-SH51-93B<85A0>

ROM number	
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740 FAMILY ROM PROGRAMMING CONFIRMATION FORM
SINGLE-CHIP MICROCOMPUTER M38279EF-XXXFP/GP/HP
MITSUBISHI ELECTRIC

Receipt	Date:	
	Section head signature	Supervisor signature

Note : Please fill in all items marked *.

*	Customer	Company name	TEL ()	Issuance signature	Submitted by	Supervisor
		Date issued	Date:			

* 1. Confirmation

Specify the name of the product being ordered and the type of EPROMs submitted.
Three EPROMs are required for each pattern.
If at least two of the three sets of EPROMs submitted contain identical data, we will produce ROM programming based on this data. We shall assume the responsibility for errors only if the programming data on the products we produce differs from this data. Thus, extreme care must be taken to verify the data in the submitted EPROMs.

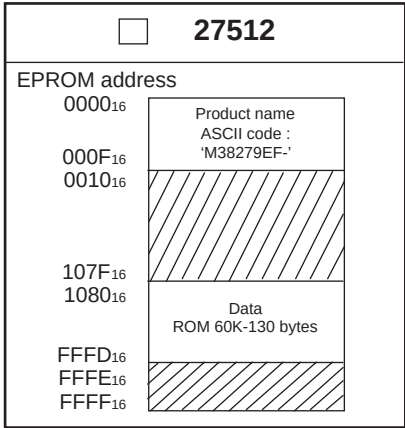
Product name: ☐ M38279EF-XXXFP ☐ M38279EF-XXXGP ☐ M38279EF-XXXHP

Checksum code for entire EPROM

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 (hexadecimal notation)

EPROM type (indicate the type used)



In the address space of the microcomputer, the internal ROM area is from address 1080₁₆ to FFFD₁₆. The reset vector is stored in addresses FFFC₁₆ and FFFD₁₆.

- (1) Set the data in the unused area (the shaded area of the diagram) to "FF₁₆".
- (2) The ASCII codes of the product name "M38279EF-" must be entered in addresses 0000₁₆ to 0008₁₆. And set data "FF₁₆" in addresses 0009₁₆ to 000F₁₆. The ASCII codes and addresses are listed to the right in hexadecimal notation.

Address		Address	
0000 ₁₆	'M' = 4D ₁₆	0008 ₁₆	'-' = 2D ₁₆
0001 ₁₆	'3' = 33 ₁₆	0009 ₁₆	FF ₁₆
0002 ₁₆	'8' = 38 ₁₆	000A ₁₆	FF ₁₆
0003 ₁₆	'2' = 32 ₁₆	000B ₁₆	FF ₁₆
0004 ₁₆	'7' = 37 ₁₆	000C ₁₆	FF ₁₆
0005 ₁₆	'9' = 39 ₁₆	000D ₁₆	FF ₁₆
0006 ₁₆	'E' = 45 ₁₆	000E ₁₆	FF ₁₆
0007 ₁₆	'F' = 46 ₁₆	000F ₁₆	FF ₁₆

GZZ-SH51-93B<85A0>

ROM number

740 FAMILY ROM PROGRAMMING CONFIRMATION FORM

SINGLE-CHIP MICROCOMPUTER M38279EF-XXXFP/GP/HP

MITSUBISHI ELECTRIC

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000₁₆ to 0008₁₆ of EPROM.

EPROM type	27512
The pseudo-command	*=Δ\$0000 .BYTEΔ 'M38279EF-'

Note: If the name of the product written to the EPROMs does not match the name of the ROM programming confirmation form, the ROM will not be processed.

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate mark specification form (100P6S for M38279EF-XXXFP, 100P6Q for M38279EF-XXXGP, 100PFB for M38279EF-XXXHP) and attach it to the ROM programming confirmation form.

※ 3. Usage conditions

Please answer the following questions about usage for use in our product inspection :

(1) How will you use the X_{IN}-X_{OUT} oscillator?

- ☐ Ceramic resonator
 ☐ Quartz crystal
☐ External clock input
 ☐ Other ()

At what frequency?

f(X_{IN}) = MHz

(2) How will you use the X_{CIN}-X_{COU}T oscillator?

- ☐ Ceramic resonator
 ☐ Quartz crystal
☐ Other ()

At what frequency?

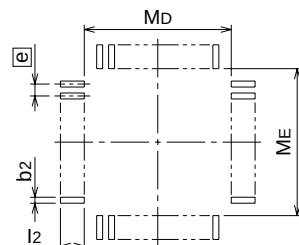
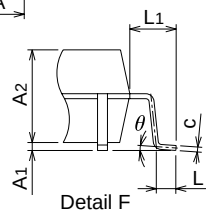
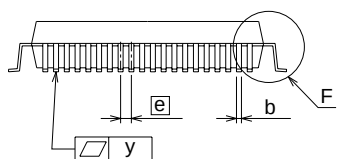
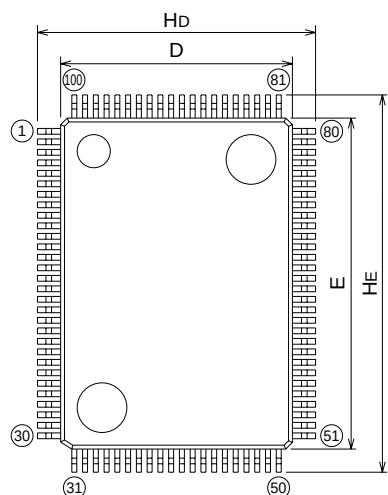
f(X_{CIN}) = MHz

※ 4. Comments

100P6S-A

Plastic 100pin 14X20mm body QFP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
QFP100-P-1420-0.65	—	1.58	Alloy 42



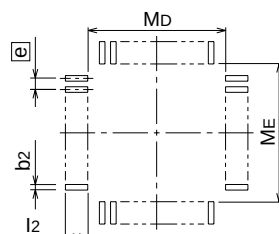
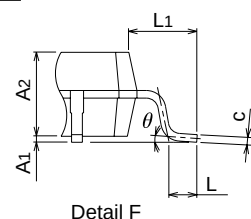
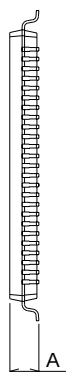
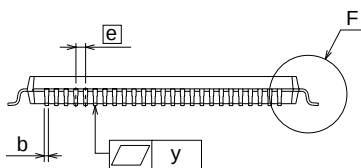
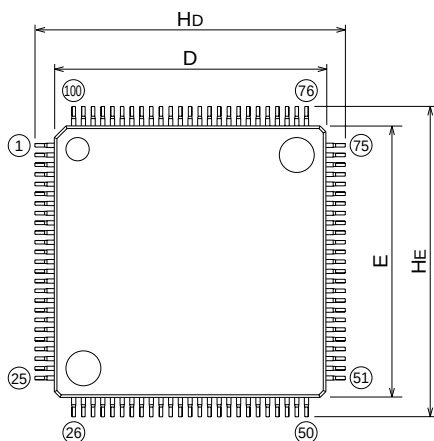
Recommended Mount Pad

Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	—	—	3.05
A1	0	0.1	0.2
A2	—	2.8	—
b	0.25	0.3	0.4
c	0.13	0.15	0.2
D	13.8	14.0	14.2
E	19.8	20.0	20.2
e	—	0.65	—
Hd	16.5	16.8	17.1
HE	22.5	22.8	23.1
L	0.4	0.6	0.8
L1	—	1.4	—
y	—	—	0.1
theta	0°	—	10°
b2	—	0.35	—
l2	1.3	—	—
Md	—	14.6	—
ME	—	20.6	—

100P6Q-A

Plastic 100pin 14X14mm body LQFP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
LQFP100-P-1414-0.50	—	—	Cu Alloy

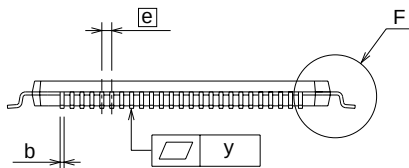
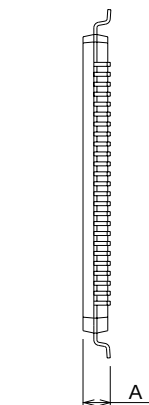


Recommended Mount Pad

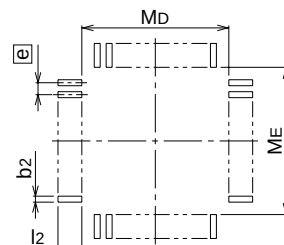
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	—	—	1.7
A1	0	0.1	0.2
A2	—	1.4	—
b	0.13	0.18	0.28
c	0.105	0.125	0.175
D	13.9	14.0	14.1
E	13.9	14.0	14.1
e	—	0.5	—
Hd	15.8	16.0	16.2
HE	15.8	16.0	16.2
L	0.3	0.5	0.7
L1	—	1.0	—
y	—	—	0.1
theta	0°	—	10°
b2	—	0.225	—
l2	1.0	—	—
Md	—	14.4	—
ME	—	14.4	—

Plastic 100pin 12X12mm body TQFP

Under Development



Detail F



Recommended Mount Pad

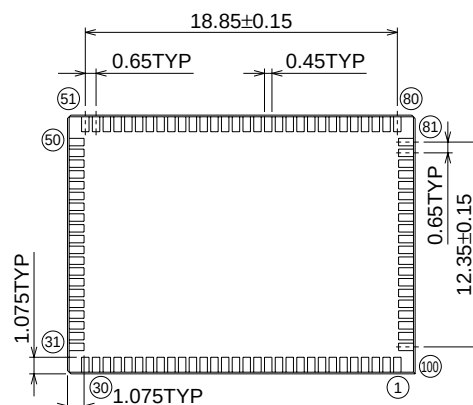
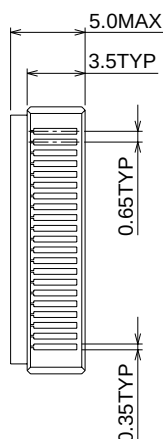
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	—	—	1.2
A1	0.05	0.1	0.15
A2	—	1.0	—
b	0.13	0.18	0.23
c	0.105	0.125	0.175
D	11.9	12.0	12.1
E	11.9	12.0	12.1
Ⓔ	—	0.4	—
H _D	13.8	14.0	14.2
H _E	13.8	14.0	14.2
L	0.4	0.5	0.6
L1	—	1.0	—
y	—	—	0.08
θ	0°	—	8°
b2	—	0.225	—
l2	1.0	—	—
M _D	—	12.4	—
M _F	—	12.4	—

100D0

Glass seal 100pin QFN

Technical drawing of a rectangular plate with a central circular hole. The dimensions are specified as follows:

- Width: 21.0 ± 0.13
- Height: 15.6 ± 0.13
- A leader line points to the bottom-left corner with the label "INDEX".

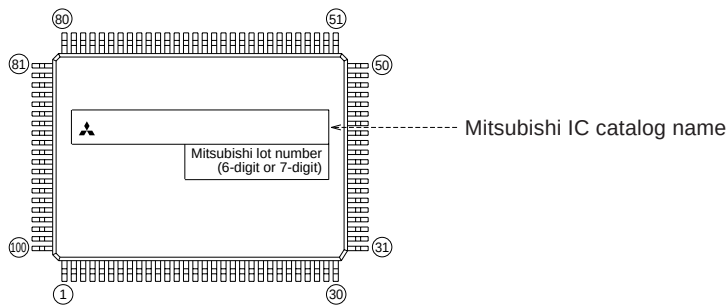


100P6S (100-PIN QFP) MARK SPECIFICATION FORM

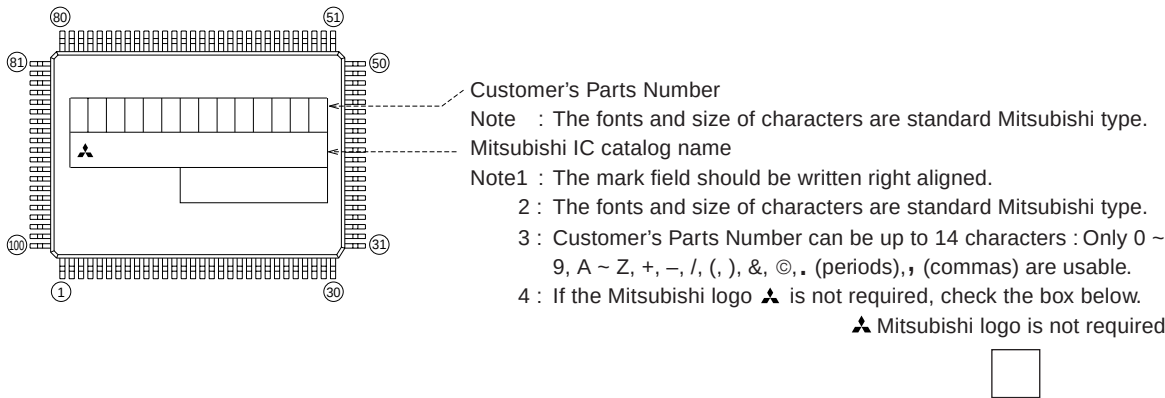
Mitsubishi IC catalog name

Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

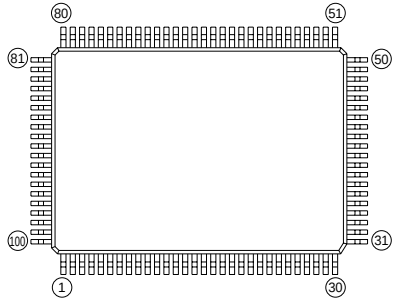
A. Standard Mitsubishi Mark



B. Customer's Parts Number + Mitsubishi catalog name



C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.
Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.
2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.
Please submit a clean original of the logo.
For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

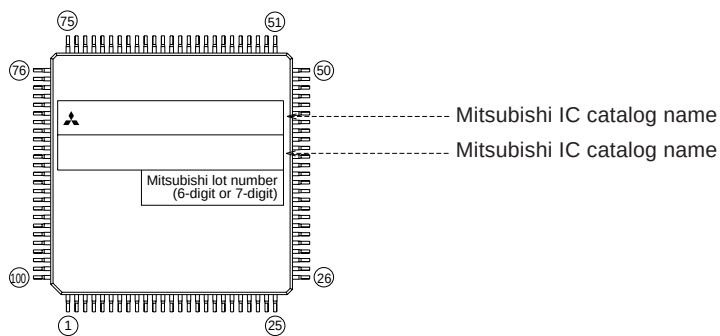
Special logo required ☐

100P6Q (100-PIN LQFP) MARK SPECIFICATION FORM

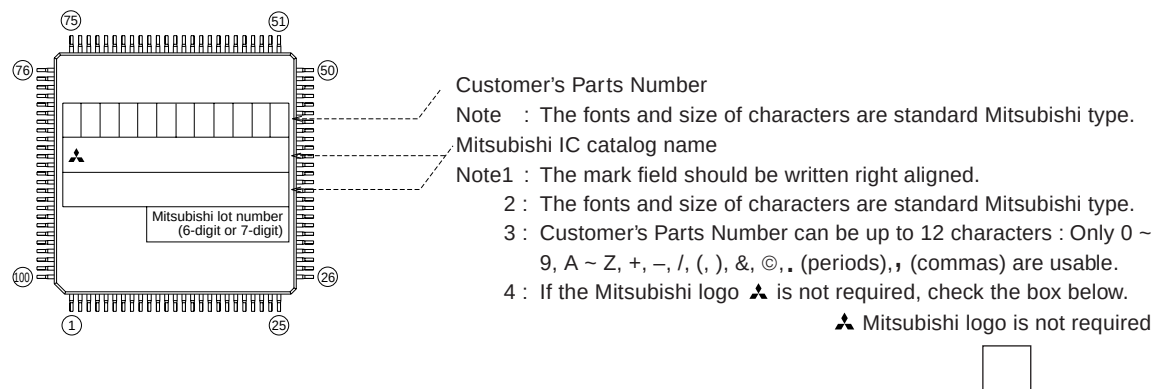
Mitsubishi IC catalog name

Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

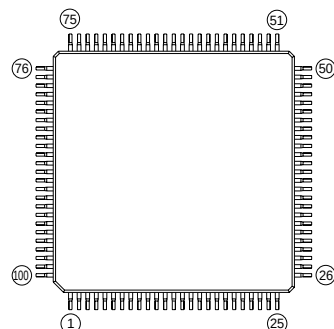
A. Standard Mitsubishi Mark



B. Customer's Parts Number + Mitsubishi catalog name



C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.

Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.

2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.

Please submit a clean original of the logo.

For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

Special logo required

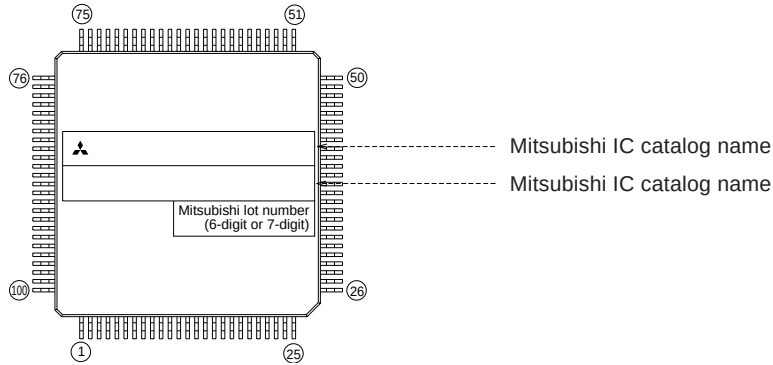
☐

100PFB (100-PIN TQFP) MARK SPECIFICATION FORM

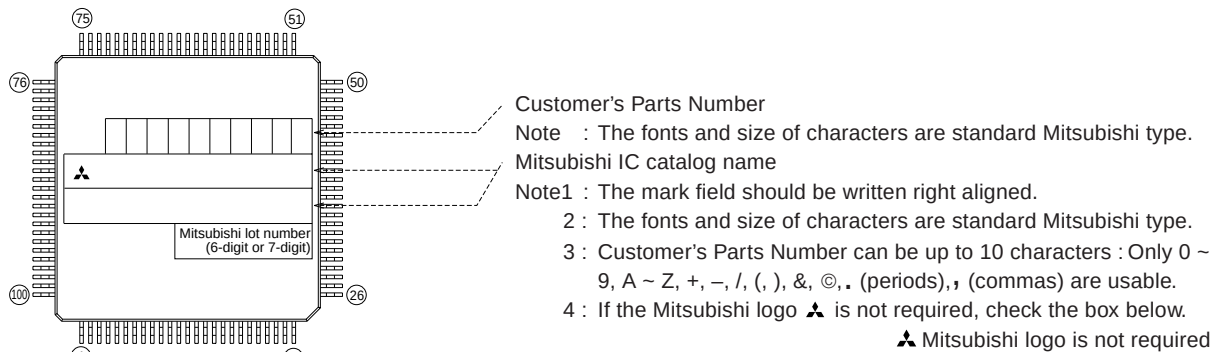
Mitsubishi IC catalog name

Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

A. Standard Mitsubishi Mark



B. Customer's Parts Number + Mitsubishi catalog name

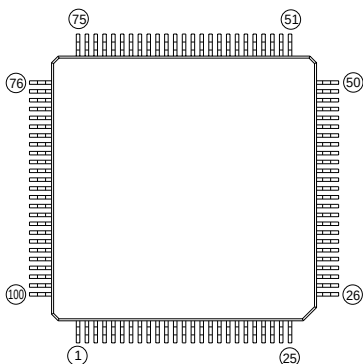


☐ Mitsubishi logo is not required

☐

5 : The allocation of Mitsubishi IC catalog name and Mitsubishi Product number depend on the Mitsubishi IC catalog name's characters, and requiring Mitsubishi logo or not.

C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.

Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.

2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.

Please submit a clean original of the logo.

For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

Special logo required

☐

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