

MITSUBISHI MICROCOMPUTERS 7470/7471 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

DESCRIPTION

The 7470/7471 group is a single-chip microcomputer designed with CMOS silicon gate technology. It is housed in a 32-pin shrink plastic molded DIP. The M37471M2-XXXSP/FP is a single-chip microcomputer designed with CMOS silicon gate technology. It is housed in a 42-pin shrink plastic molded DIP or a 56-pin plastic molded QFP.

These single-chip microcomputer are useful for business equipment and other consumer applications.

In addition to its simple instruction set, the ROM, RAM, and I/O addresses are placed on the same memory map to enable easy programming.

The differences between the M37471M2-XXXSP and the M37471M2-XXXFP are the package outline and the power dissipation ability (absolute maximum ratings).

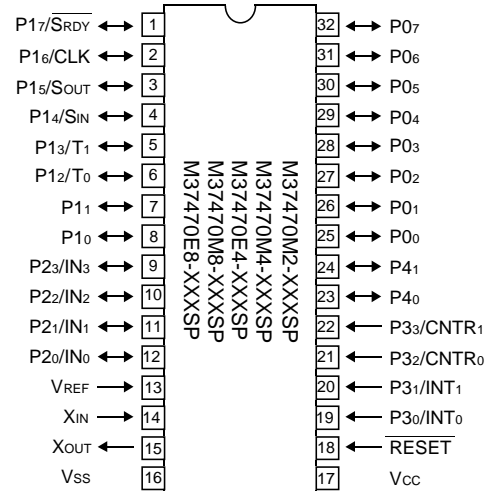
The differences among M37470M2-XXXSP, M37470M4-XXXSP, M37470M8-XXXSP, M37471M2-XXXSP/FP, M37471M4-XXXSP/FP and M37471M8-XXXSP/FP are noted below.

Type name	ROM size	RAM size	I/O ports
M37470M2-XXXSP	4096 bytes	128 bytes	26
M37471M2-XXXSP/FP			36
M37470M4-XXXSP	8192 bytes	192 bytes	26
M37471M4-XXXSP/FP			36
M37470M8-XXXSP	16384 bytes	384 bytes	26
M37471M8-XXXSP/FP			36

FEATURES

- Basic machine-language instructions 71
- Memory size
 - ROM 4096 bytes (M37471M2)
 - RAM 128 bytes (M37471M2)
- The minimum instruction execution time 0.5 μ s (at 8 MHz oscillation frequency)
- Power source voltage 2.7 to 4.5 V (at 2.2V_{CC}–2.0 MHz oscillation frequency)
..... 4.5 to 5.5 V (at 8 MHz oscillation frequency)
- Power dissipation in normal mode 35 mW (at 8.0 MHz oscillation frequency)
- Subroutine nesting 64 levels max. (M37470M2, M37471M2)
- Interrupt 12 sources, 10 vectors
- 8-bit timers 4
- Programmable I/O ports
 - (Ports P0, P1, P2, P4) 22(7470 group)
..... 28(7471 group)
- Input port (Port P3) 4(7470 group)
(Ports P3, P5) 8(7471 group)
- Serial I/O (8-bit) 1
- A-D converter 8-bit, 4channels (7470 group)
..... 8-bit, 8channels (7471 group)

PIN CONFIGURATION (TOP VIEW)

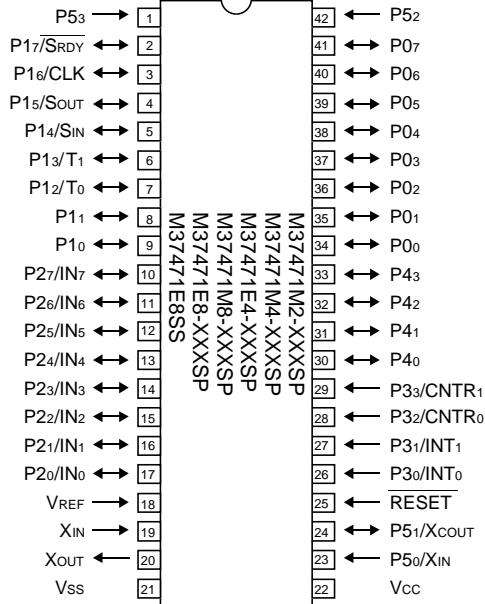


Outline 32P4B

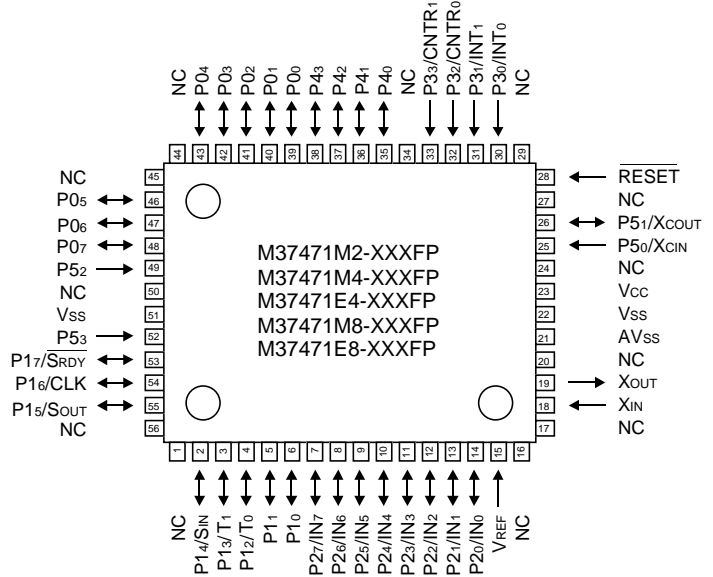
APPLICATION

Audio-visual equipment, VCR, Tuner,
Office automation equipment

PIN CONFIGURATION (TOP VIEW)



**Outline 42P4B
42S1B-A (Window)**

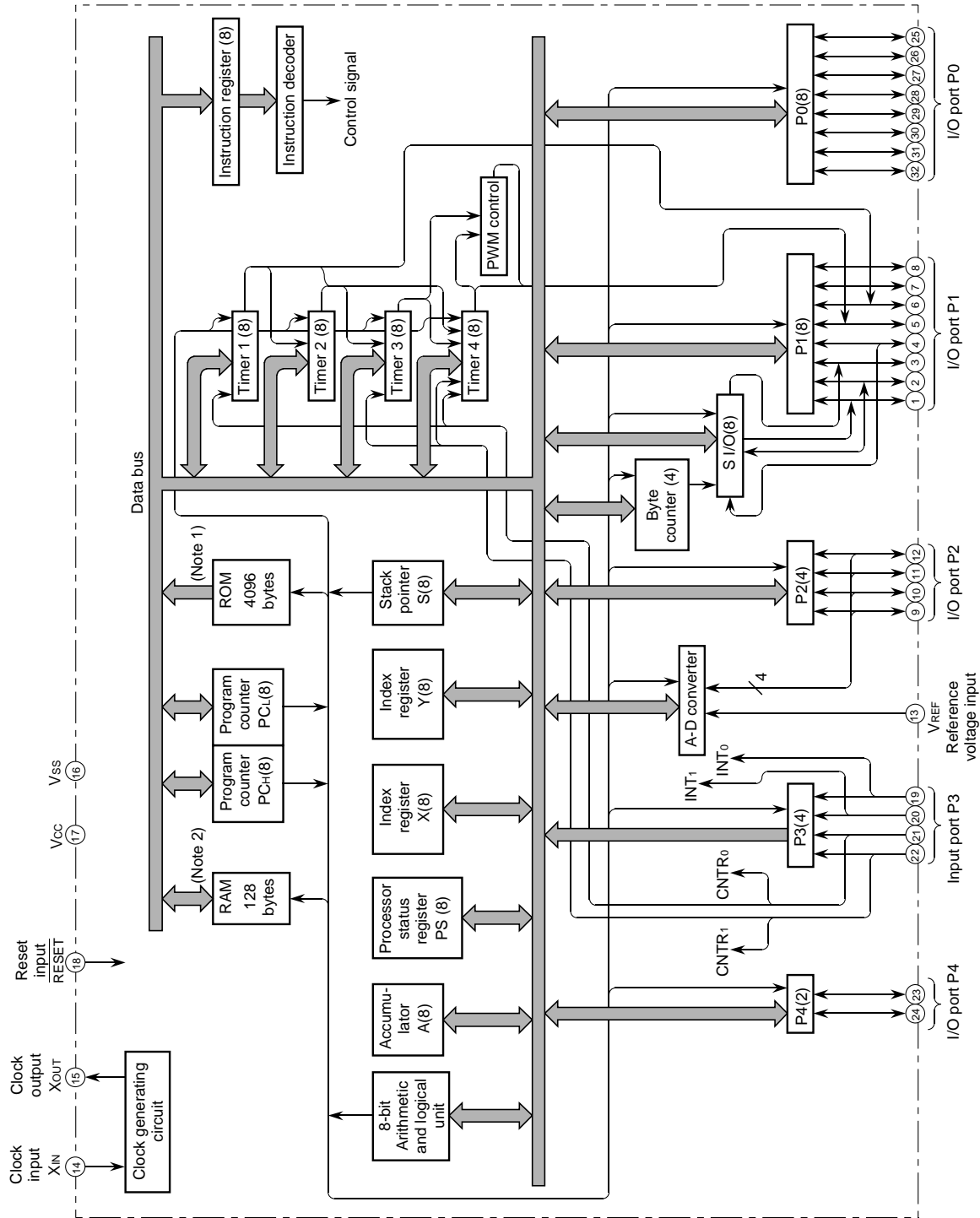


Outline 56P6N-A

Note : The differences between 42P4B package type of 7471 group and 56P6N-A package type of 7471 group are package outline, power dissipation ability (absolute maximum ratings), and the provision of an AV ss pin by the 56P6N-A package type.

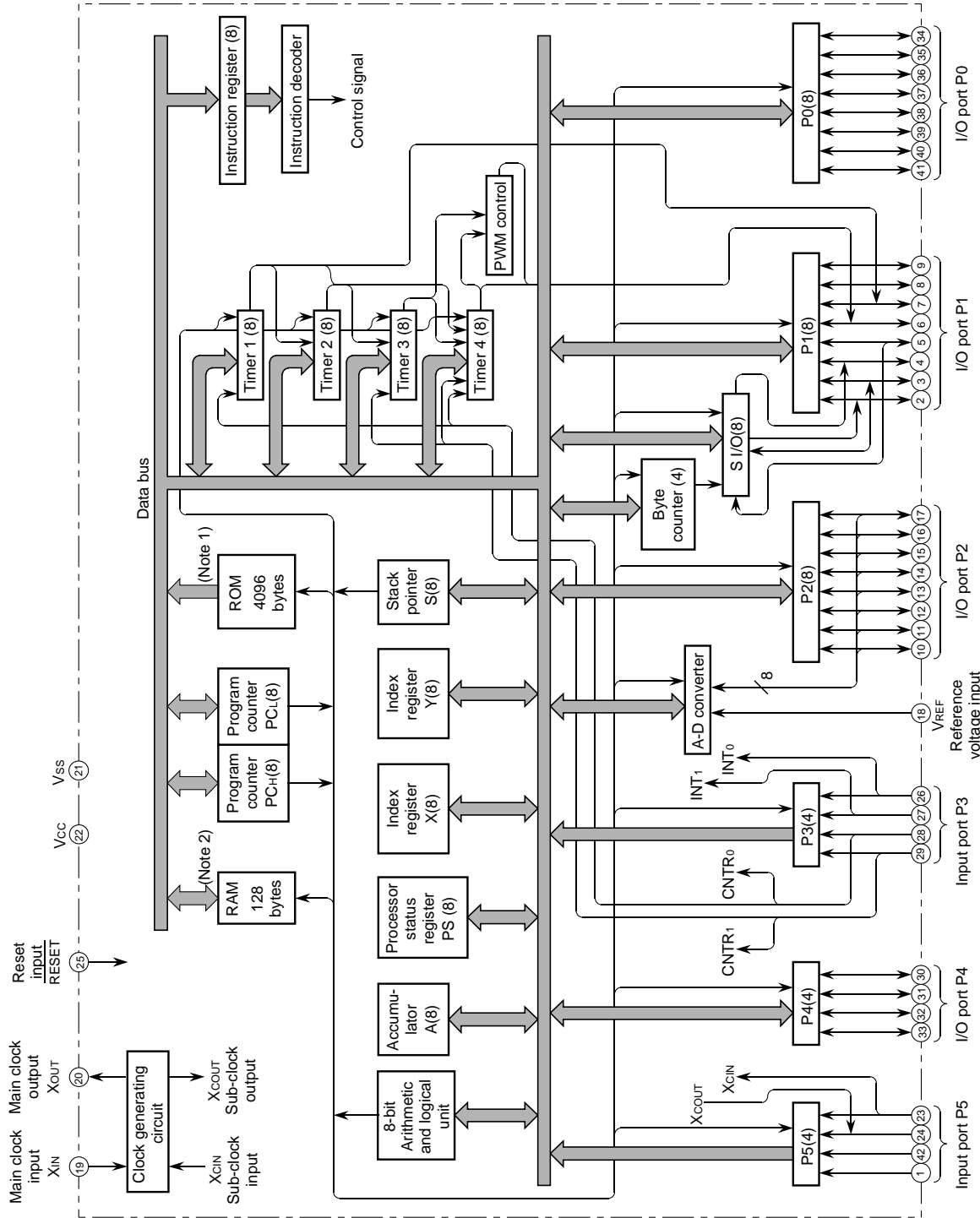
NC : No connection

M37470M2-XXXSP BLOCK DIAGRAM



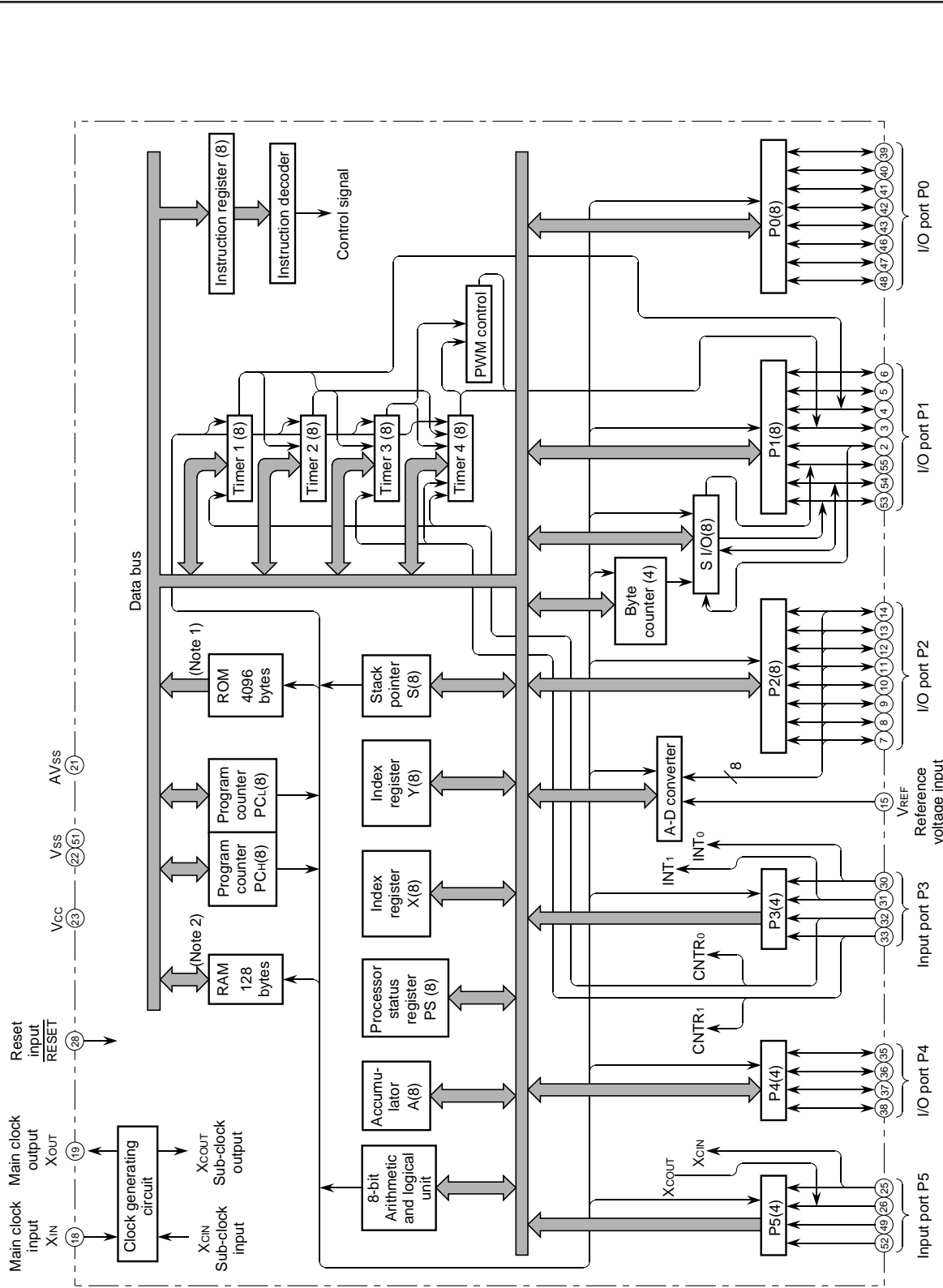
Notes
 1 : 8192 bytes for M37470M4/E4-XXXSP, and 16384 bytes for M37470M8/E8-XXXSP
 2 : 192 bytes for M37470M4/E4-XXXSP, and 384 bytes for M37470M8/E8-XXXSP

M37471M2-XXXSP BLOCK DIAGRAM



Notes
 1 : 8192 bytes for M37471M4/E4-XXXSP, and 16384 bytes for M37471M8/E8-XXXSP, M37471E8SS
 2 : 192 bytes for M37471M4/E4-XXXSP, and 384 bytes for M37471M8/E8-XXXSP, M37471E8SS

M37471M2-XXXFP BLOCK DIAGRAM



Notes
 Note 1 : 8192 bytes for M37471M4/E4-XXXFP, and 16384 bytes for M37471M8/E8-XXXFP
 Note 2 : 192 bytes for M37471M4/E4-XXXFP, and 384 bytes for M37471M8/E8-XXXFP

FUNCTIONS OF 7470/7471 GROUP

Parameter		Functions	
Basic machine-language instructions		71	
Instruction execution time		0.5 μ s (the minimum instructions, at 8 MHz oscillation frequency)	
Clock input oscillation frequency		8 MHz (max.)	
Memory size	M37470M2	ROM	4096 bytes
	M37471M2	RAM	128 bytes
	M37470M4/E4	ROM	8192 bytes
	M37471M4/E4	RAM	192 bytes
	M37470M8/E8	ROM	16384 bytes
	M37471M8/E8	RAM	384 bytes
Input/Output port	P0, P1	I/O	8-bit \times 2
	P2	I/O	8-bit \times 1 (4-bit \times 1 for 7470 group)
	P3, P5	Input	4-bit \times 2 (Port P5 is not included in 7470 group)
	P4	I/O	4-bit \times 1 (2-bit \times 1 for 7470 group)
Serial I/O		8-bit \times 1	
Timers		8-bit timer \times 4	
A-D converter		8-bit \times 1 (8 channels) (8-bit \times 1 (4 channels) for M37470M2/M4/M8)	
Subroutine nesting		64 level max. (M37470M2, M37471M2)	
		96 level max. (M37470M4/E4, M37471M4/E4)	
		192 level max. (M37470M8/E8, M37471M8/E8)	
Interrupt		5 external interrupts, 6 internal interrupts, 1 software interrupt	
Clock generating circuit		Built-in circuit with internal feedback resistor (a ceramic or a quartz-crystal oscillator)	
Power source voltage		2.7 to 4.5 V (at 2.2V _{CC} -2.0 MHz oscillation frequency), 4.5 to 5.5 V (at 8 MHz oscillation frequency)	
Power dissipation		35 mW (at 8 MHz oscillation frequency)	
Input/Output characters	Input/Output voltage		5 V
	Output current		-5 to 10 mA (P0, P1, P2, P4 : CMOS tri-states)
Operating temperature range		-20 to 85°C	
Device structure		CMOS silicon gate	
Package	M37470M2/M4/M8/E4/E8-XXXSP		32-pin shrink plastic molded DIP
	M37471M2/M4/M8/E4/E8-XXXSP		42-pin shrink plastic molded DIP
	M37471M2/M4/M8/E4/E8-XXXFP		56-pin plastic molded QFP
	M37471E8SS		42-pin ceramic DIP

PIN DESCRIPTION

Pin	Name	Input/ Output	Functions
VCC, Vss	Power source voltage		Apply voltage of 2.7 to 5.5 V to VCC, and 0 V to Vss.
AVss (Note 1)	Analog power source		Ground level input pin for A-D converter. Same voltage as Vss is applied.
RESET	Reset input	Input	To enter the reset state, the reset input pin must be kept at "L" for 2 μ s or more (under normal VCC conditions).
XIN	Clock input	Input	These are I/O pins of internal clock generating circuit for main clock. To control generating frequency, an external ceramic or a quartz-crystal oscillator is connected between the XIN and XOUT pins. If an external clock is used, the clock source should be connected the XIN pin and the XOUT pin should be left open. Feedback resistor is connected between XIN and XOUT.
XOUT	Clock output	Output	
VREF	Reference voltage input	Input	Reference voltage input pin for the A-D converter.
P00–P07	I/O port P0	I/O	Port P0 is an 8-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 1-bit and a key on wake up function is provided.
P10–P17	I/O port P1	I/O	Port P1 is an 8-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 4-bit. P12, P13 are in common with timer output pins T0, T1, P14, P15, P16, P17 are in common with serial I/O pins SIN, SOUT, CLK, SRDY, respectively. The output structure of SOUT and SRDY can be changed to N-channel open drain output.
P20–P27 (Note 2)	I/O port P2	I/O	Port P2 is an 8-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 4-bit. This port is in common with analog input pins IN0–IN7.
P30–P33	Input port P3	Input	Port P3 is a 4-bit input port. P30, P31 are in common with external interrupt input pins INT0, INT1, and P32, P33 are in common with timer input pins CNTR0, CNTR1.
P40–P43 (Note 3)	I/O port P4	I/O	Port P4 is a 4-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 4-bit.
P50–P53 (Note 4)	Input port P5	Input	Port P5 is a 4-bit input port and pull-up transistor can be connected in units of 4-bit. P50, P51 are in common with input/output pins of clock for clock function XCIN, XCOUT. When P50, P51 are used as XCIN, XCOUT, connect a ceramic or a quartz-crystal oscillator between XCIN and XCOUT. If an external clock input is used, connect the clock input to the XCIN pin and open the XCOUT pin. Feedback resistor is connected between XCIN and XCOUT pins.

Notes 1 : AVss for M37471M2/M4/M8/E4/E8-XXXFP.

2 : Only P20–P23 (IN0–IN3) 4-bit for 7470 group.

3 : Only P40 and P41 2-bit for 7470 group.

4 : This port is not included in 7470 group.

FUNCTIONAL DESCRIPTION
Central Processing Unit (CPU)

The 7470/7471 group uses the standard 740 family instruction set. Refer to the table of 740 family addressing modes and machine instructions or the SERIES 740 <Software> User's Manual for details on the instruction set.

Machine-resident 740 family instructions are as follows:

The FST and SLW instruction cannot be used.

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

CPU Mode Register

The CPU mode register is allocated at address 00FB16.

This register contains the stack page selection bit.

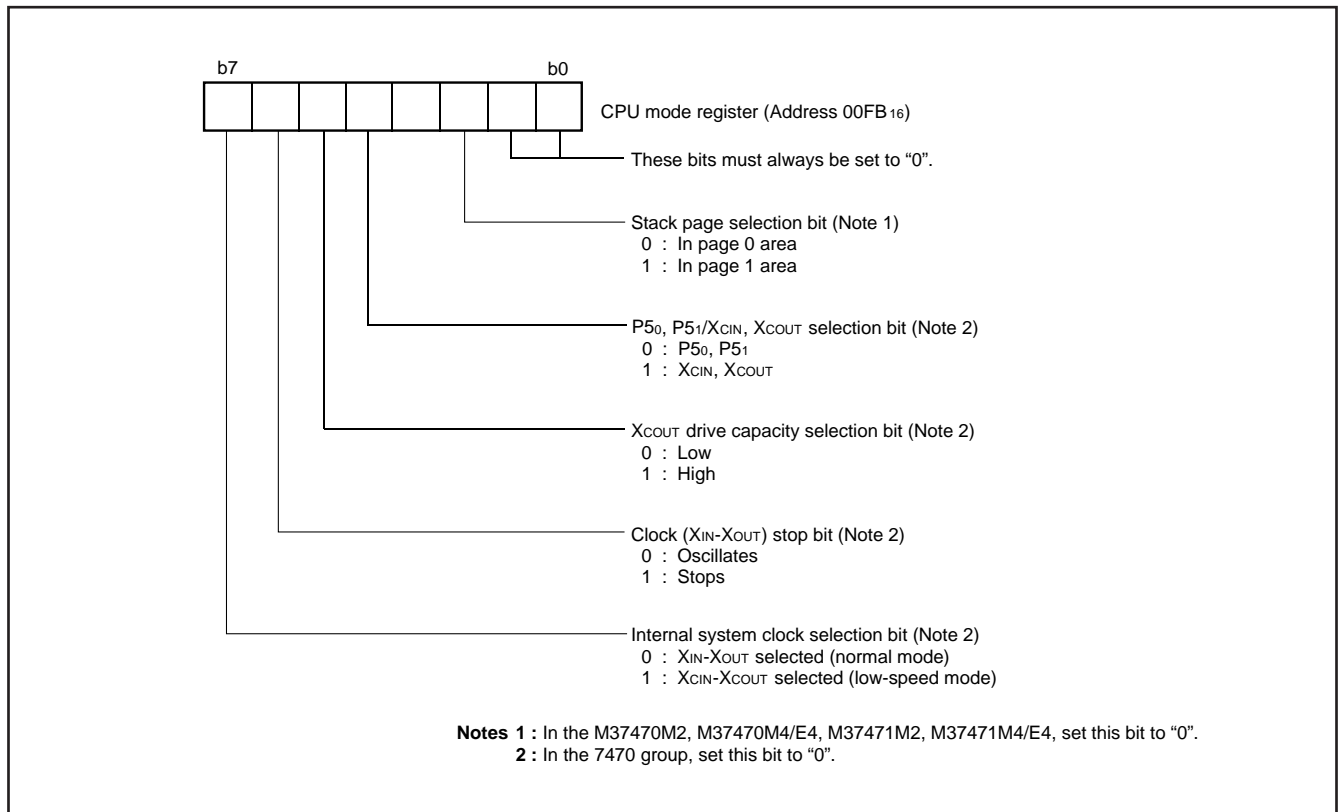


Fig. 1 Structure of CPU mode register

MEMORY

• **Special Function Register (SFR) Area**

The special function register (SFR) area contains the registers relating to functions such as I/O ports and timers.

• **RAM**

RAM is used for data storage as well as a stack area.

• **ROM**

ROM is used for storing user programs as well as the interrupt vector area.

• **Interrupt Vector Area**

The interrupt vector area is for storing jump destination addresses used at reset or when an interrupt is generated.

• **Zero Page**

Zero page addressing mode is useful because it enables access to this area with fewer instruction cycles.

• **Special Page**

Special page addressing mode is useful because it enables access to this area with fewer instruction cycles.

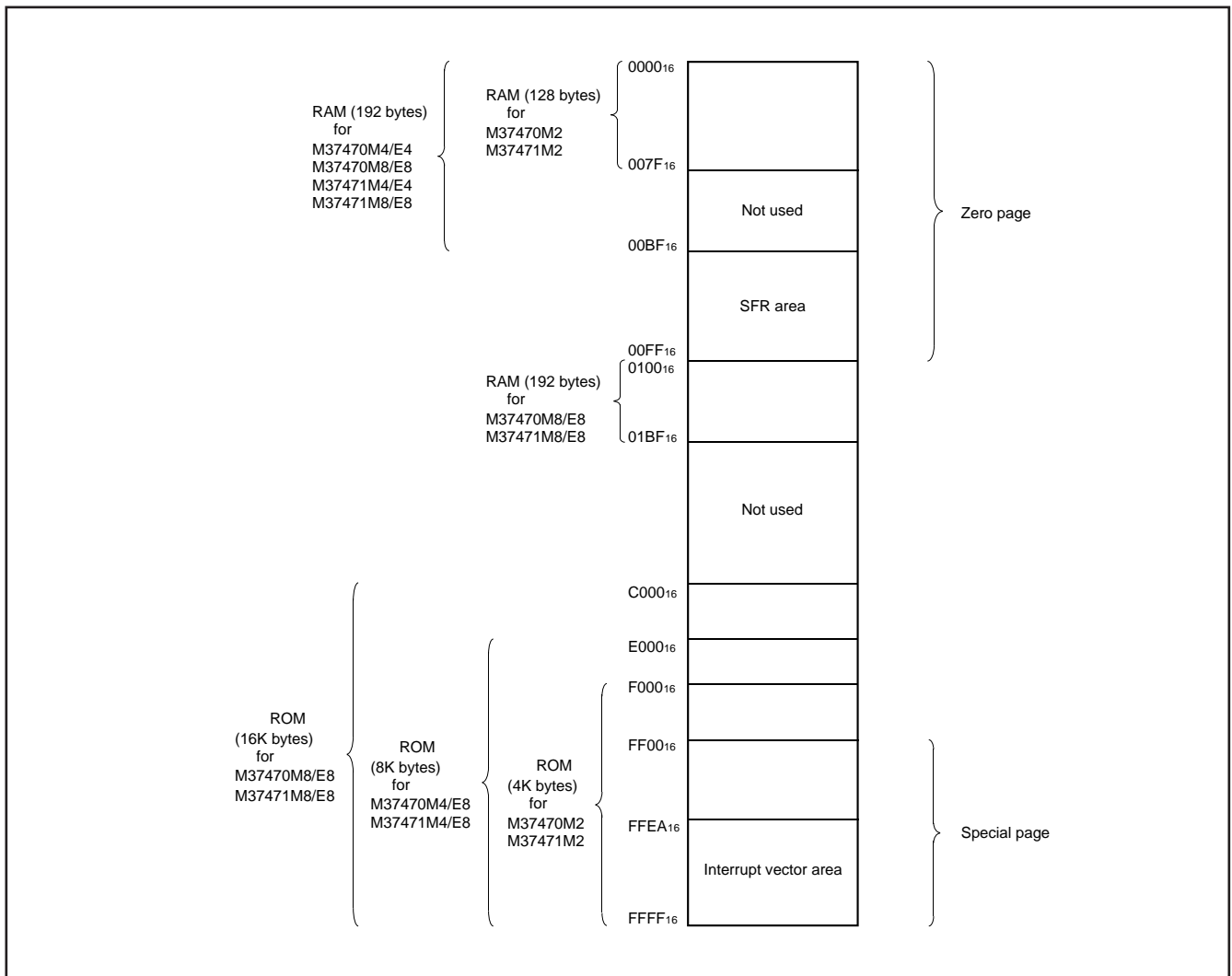


Fig. 2 Memory map

00C0 ₁₆	Port P0	00E0 ₁₆	
00C1 ₁₆	Port P0 direction register	00E1 ₁₆	
00C2 ₁₆	Port P1	00E2 ₁₆	
00C3 ₁₆	Port P1 direction register	00E3 ₁₆	
00C4 ₁₆	Port P2	00E4 ₁₆	
00C5 ₁₆	Port P2 direction register	00E5 ₁₆	
00C6 ₁₆	Port P3	00E6 ₁₆	
00C7 ₁₆		00E7 ₁₆	
00C8 ₁₆	Port P4	00E8 ₁₆	
00C9 ₁₆	Port P4 direction register	00E9 ₁₆	
00CA ₁₆	Port P5 (Note 1)	00EA ₁₆	
00CB ₁₆		00EB ₁₆	
00CC ₁₆		00EC ₁₆	
00CD ₁₆		00ED ₁₆	
00CE ₁₆		00EE ₁₆	
00CF ₁₆		00EF ₁₆	
00D0 ₁₆	P0 pull-up control register	00F0 ₁₆	Timer 1
00D1 ₁₆	P1–P5 pull-up control register (Note 2)	00F1 ₁₆	Timer 2
00D2 ₁₆		00F2 ₁₆	Timer 3
00D3 ₁₆		00F3 ₁₆	Timer 4
00D4 ₁₆	Edge polarity selection register	00F4 ₁₆	
00D5 ₁₆		00F5 ₁₆	
00D6 ₁₆	Input latch register	00F6 ₁₆	
00D7 ₁₆		00F7 ₁₆	Timer FF register
00D8 ₁₆		00F8 ₁₆	Timer 12 mode register
00D9 ₁₆	A-D control register	00F9 ₁₆	Timer 34 mode register
00DA ₁₆	A-D conversion register	00FA ₁₆	Timer mode register 2
00DB ₁₆		00FB ₁₆	CPU mode register
00DC ₁₆	Serial I/O mode register	00FC ₁₆	Interrupt request register 1
00DD ₁₆	Serial I/O register	00FD ₁₆	Interrupt request register 2
00DE ₁₆	Serial I/O counter Byte counter	00FE ₁₆	Interrupt control register 1
00DF ₁₆		00FF ₁₆	Interrupt control register 2

Notes 1 : This address is not used in the 7470 group.
 2 : This address is allocated P1–P4 pull-up control register for the 7470 group.

Fig. 3 SFR (Special Function Register) memory map

INTERRUPTS

Interrupts can be caused by 12 different sources consisting of five external, six internal, and one software sources.

Interrupts are vectored interrupts with priorities shown in Table 1. Reset is also included in the table because its operation is similar to an interrupt.

When an interrupt is accepted, the registers are pushed, interrupt disable flag I is set, and the program jumps to the address specified in the vector table. The interrupt request bit is cleared automatically. The reset and BRK instruction interrupt can never be disabled. Other interrupts are disabled when the interrupt disable flag is set.

All interrupts except the BRK instruction interrupt have an interrupt request bit and an interrupt enable bit. The interrupt request bits are in interrupt request registers 1 and 2 and the interrupt enable bits are in interrupt control registers 1 and 2. External interrupts INT₀ and INT₁ can be asserted on either the falling or rising edge as set in the edge polarity selection register. When "0" is set to this register, the interrupt is activated on the falling edge; when "1" is set to the register, the interrupt is activated on the rising edge.

When the device is put into power-down state by the STP instruction or the WIT instruction, if bit 5 in the edge polarity selection register is "1", the INT₁ interrupt becomes a key on wake up interrupt. When a key on wake up interrupt is valid, an interrupt request is generated by applying the "L" level to any pin in port P0. In this case, the port used for interrupt must have been set for the input mode.

If bit 5 in the edge polarity selection register is "0" when the device is in power-down state, the INT₁ interrupt is selected. Also, if bit 5 in the edge polarity selection register is set to "1" when the device is not in a power-down state, neither key on wake up interrupt request nor INT₁ interrupt request is generated.

The CNTR₀/CNTR₁ interrupts function in the same as INT₀ and INT₁. The interrupt input pin can be specified for either CNTR₀ or CNTR₁ pin by setting bit 4 in the edge polarity selection register.

Figure 4 shows the structure of the edge polarity selection register, interrupt request registers 1 and 2, and interrupt control registers 1 and 2.

Interrupts other than the BRK instruction interrupt and reset are accepted when the interrupt enable bit is "1", interrupt request bit is "1", and the interrupt disable flag is "0". The interrupt request bit can be reset with a program, but not set. The interrupt enable bit can be set and reset with a program.

Reset is treated as a non-maskable interrupt with the highest priority. Figure 5 shows interrupts control.

Table 1. Interrupt vector address and priority

Interrupt source	Priority	Vector addresses	Remarks
RESET	1	FFFF ₁₆ , FFFE ₁₆	Non-maskable
INT ₀ interrupt	2	FFFD ₁₆ , FFFC ₁₆	External interrupt (polarity programmable)
INT ₁ interrupt or key on wake up interrupt	3	FFFB ₁₆ , FFFA ₁₆	External interrupt (INT ₁ is polarity programmable)
CNTR ₀ interrupt or CNTR ₁ interrupt	4	FFF9 ₁₆ , FFF8 ₁₆	External interrupt (polarity programmable)
Timer 1 interrupt	5	FFF7 ₁₆ , FFF6 ₁₆	
Timer 2 interrupt	6	FFF5 ₁₆ , FFF4 ₁₆	
Timer 3 interrupt	7	FFF3 ₁₆ , FFF2 ₁₆	
Timer 4 interrupt	8	FFF1 ₁₆ , FFF0 ₁₆	
Serial I/O interrupt	9	FFEF ₁₆ , FFEE ₁₆	
A-D conversion completion interrupt	10	FFED ₁₆ , FFEC ₁₆	
BRK instruction interrupt	11	FFEB ₁₆ , FFEA ₁₆	Non-maskable software interrupt

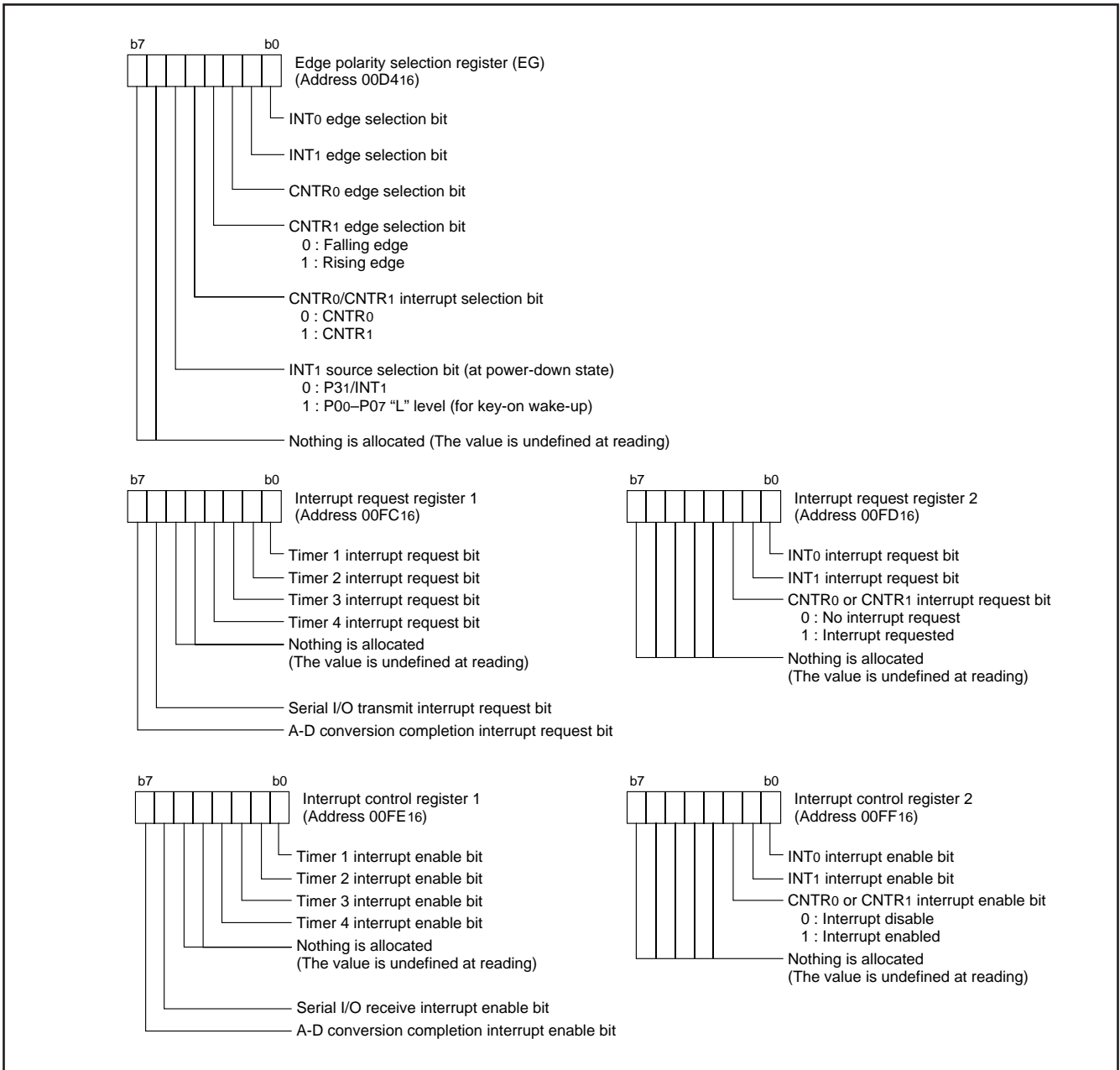


Fig. 4 Structure of registers related to interrupt

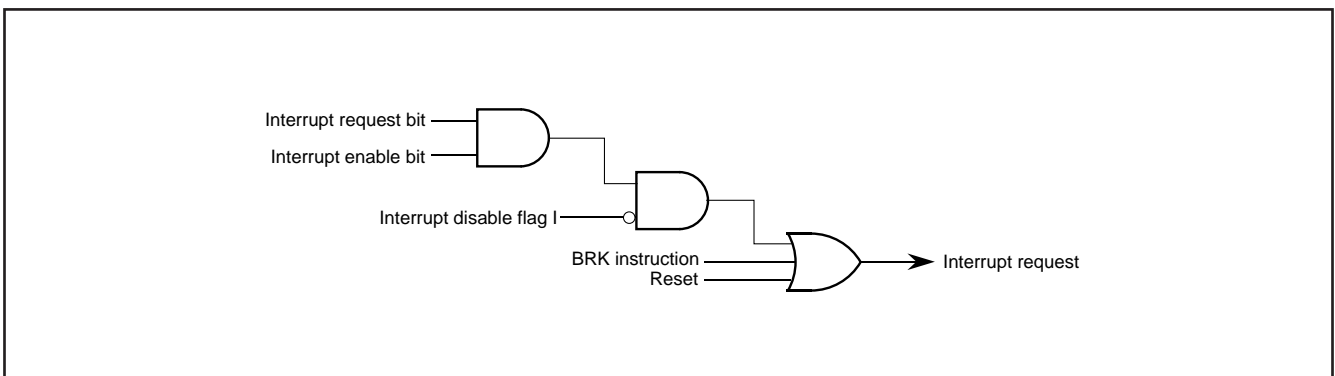


Fig. 5 Interrupt control

TIMER

The 7470/7471 group has four timers; timer 1, timer 2, timer 3, and timer 4.

A block diagram of timer 1 through 4 is shown in Figure 6.

Timer 1 can be operated in the timer mode, event count mode, or pulse output mode. Timer 1 starts counting when bit 0 in the timer 12 mode register (address 00F8₁₆) is set to "0".

The count source can be selected from the $f(X_{IN})$ divided by 16, $f(X_{CIN})$ divided by 16, $f(X_{CIN})$, or event input from P32/CNTR₀ pin. Do not select $f(X_{CIN})$ as the count source in the 7470 group. When bit 1 and bit 2 in the timer 12 mode register are "0", $f(X_{IN})$ divided by 16 or $f(X_{CIN})$ divided by 16 is selected. Selection between $f(X_{IN})$ and $f(X_{CIN})$ is done by bit 7 in the CPU mode register (address 00FB₁₆). When bit 1 in the timer 12 mode register is "0" and bit 2 is "1", $f(X_{CIN})$ is selected. And, when bit 1 in the timer 12 mode register is "1", an event input from the CNTR₀ pin is selected. Event inputs are selected depending on bit 2 in the edge polarity selection register (address 00D4₁₆). When this bit is "0", the inverted value of CNTR₀ input is selected; when the bit is "1", CNTR₀ input is selected.

When bit 3 in the timer 12 mode register is set to "1", the P12 pin becomes timer output T₀. When the direction register of P12 is set for the output mode at this time, the timer 1 overflow divided by 2 is output from T₀.

Please set the initial output value in the following procedure.

- ① Set "1" to bit 0 of the timer 12 mode register.
(Timer 1 count stop.)
- ② Set "1" to bit 0 of the timer mode register 2.
- ③ Set the output value to bit 0 of the timer FF register.
- ④ Set the count value to the timer 1.
- ⑤ Set "0" to bit 0 of the timer 12 mode register.
(Timer 1 count start.)

Timer 2 can only be operated in the timer mode. Timer 2 starts counting when bit 4 in the timer 12 mode register is set to "0".

The count source can be selected from the divide by 16, divide by 64, divide by 128, or divide by 256 frequency of $f(X_{IN})$ or $f(X_{CIN})$, and timer 1 overflow. Do not select $f(X_{CIN})$ as the count source in the 7470 group. When bit 5 in the timer 12 mode register is "0", any of the divide by 16, divide by 64, divide by 128, or divide by 256 frequency of $f(X_{IN})$ or $f(X_{CIN})$ is selected. The divide ratio is selected according to bit 6 and bit 7 in the timer 12 mode register, and selection between $f(X_{IN})$ and $f(X_{CIN})$ is made according to bit 7 in the CPU mode register. When bit 5 in the timer 12 mode register is "1", timer 1 overflow is selected as the count source.

Timer 3 can be operated in the timer mode, event count mode, or PWM mode. Timer 3 starts counting when bit 0 in the timer 34 mode register (address 00F9₁₆) is set to "0".

The count source can be selected from the $f(X_{IN})$ divided by 16, $f(X_{CIN})$ divided by 16, $f(X_{CIN})$, timer 1 or timer 2 overflow, or an event input from P33/CNTR₁ pin according to the statuses of bit 1 and bit 2 in the timer 34 mode register, bit 6 in the timer mode register 2 (address 00FA₁₆) and bit 7 in the CPU mode register. Do not select $f(X_{CIN})$ as the count source in the 7470 group. Note, however, that if timer 1 overflow or timer 2 overflow is selected for the count source of timer 3 when timer 1 overflow is selected for the count source of timer 2, timer 1 overflow is always selected regardless of the status of bit 6 in the timer mode register 2. Event inputs are selected depending on bit 3 in the edge polarity selection register. When this bit is "0", the inverted value of CNTR₁ input is selected; when the bit is "1", CNTR₁ input is selected.

Timer 4 can be operated in the timer mode, event count mode, pulse output mode, pulse width measuring mode, or PWM mode. Timer 4 starts counting when bit 3 in the timer 34 mode register is set to "0" when bit 6 in this register is "0". When bit 6 is "1", the pulse width measuring mode is selected. The count source can be selected from timer 3 overflow, $f(X_{IN})$ divided by 16, $f(X_{CIN})$ divided by 16, $f(X_{CIN})$, timer 1 or timer 2 overflow, or an event input from P33/CNTR₁ pin according to the statuses of bit 4 and bit 5 in the timer 34 mode register, bit 6 in the timer mode register 2, and bit 7 in the CPU mode register. Do not select $f(X_{CIN})$ as the count source in the 7470 group. Note, however, that if timer 1 overflow or timer 2 overflow is selected for the count source of timer 4 when timer 1 overflow is selected for the count source of timer 2, timer 1 overflow is always selected regardless of the status of bit 6 in the timer mode register 2. Event inputs are selected depending on bit 3 in the edge polarity selection register.

When this bit is "0", the inverted value of CNTR₁ input is selected; when the bit is "1", CNTR₁ input is selected.

When bit 7 in the timer 34 mode register is set to "1", the P13 pin becomes timer output T₁. When the direction register of P13 is set for the output mode at this time, the timer 4 overflow divided by 2 is output from T₁ when bit 7 in the timer mode register 2 is "0".

Please set the initial output value in the following procedure.

- ① Set "1" to bit 3 of the timer 34 mode register.
(Timer 4 count stop.)
- ② Set "1" to bit 1 of the timer mode register 2.
- ③ Set the output value to bit 1 of the timer FF register.
- ④ Set the count value to the timer 4.
- ⑤ Set "0" to bit 3 of the timer 34 mode register.
(Timer 4 count start.)

(1) Timer mode

Timer performs down count operations with the dividing ratio being $1/(n+1)$. Writing a value to the timer latch sets a value to the timer. When the value to be set to the timer latch is nn_{16} , the value to be set to a timer is nn_{16} , which is down counted at the falling edge of the count source from nn_{16} to $(nn_{16}-1)$ to $(nn_{16}-2)$ to ...01₁₆ to 00₁₆ to FF₁₆. At the falling edge of the count source immediately after timer value has reached FF₁₆, value $(nn_{16}-1)$ obtained by subtracting one from the timer latch value is set (reloaded) to the timer to continue counting. At the rising edge of the count source immediately after the timer value has reached FF₁₆, an overflow occurs and an interrupt request is generated.

(2) Event count mode

Timer operates in the same way as in the timer mode except that it counts input from the CNTR0 or CNTR1 pin.

(3) Pulse output mode

In this mode, duty 50% pulses are output from the T0 or T1 pin. When the timer overflows, the polarity of the T0 or T1 pin output level is inverted.

(4) Pulse width measuring mode

The 7470/7471 group can measure the "H" or "L" width of the CNTR0 or CNTR1 input waveform by using the pulse width measuring mode of timer 4. The pulse width measuring mode is selected by writing "1" to bit 6 in the timer 34 mode register. In the pulse width measuring mode, the timer counts the count source while the CNTR0 or CNTR1 input is "H" or "L". Whether the CNTR0 input or CNTR1 input to be measured can be specified by the status of bit 4 in the edge polarity selection register; whether the "H" width or "L" width to be measured can be specified by the status of bit 2 (CNTR0) and bit 3 (CNTR1) in the edge polarity selection register.

(5) PWM mode

The PWM mode can be entered for timer 3 and timer 4 by setting bit 7 in the timer mode register 2 to "1". In the PWM mode, the P13 pin is set for timer output T1 to output PWM waveforms by setting bit 7 in the timer 34 mode register to "1". The direction register of P13 must be set for the output mode before this can be done.

In the PWM mode, timer 3 is counting and timer 4 is idle while the PWM waveform is "L". When timer 3 overflows, the PWM waveform goes "H". At this time, timer 3 stops counting simultaneously and timer 4 starts counting. When timer 4 overflows, the PWM waveform goes "L", and timer 4 stops and timer 3 starts counting again. Consequently, the "L" duration of the PWM waveform is determined by the value of timer 3; the "H" duration of the PWM waveform is determined by the value of timer 4.

When a value is written to the timer in operation during the PWM mode, the value is only written to the timer latch, and not written to the timer. In this case, if the timer overflows, a value one less the value in the timer latch is written to the timer. When any value is written to an idle timer, the value is written to both the timer latch and the timer.

In this mode, do not select timer 3 overflow as the count source for timer 4.

INPUT LATCH FUNCTION

The 7470/7471 group can latch the P30/INT0, P31/INT1, P32/CNTR0, and P33/CNTR1 pin level into the input latch register (address 00D616) when timer 4 overflows. The polarity of each pin latched to the input latch register can be selected by using the edge polarity selection register. When bit 0 in the edge polarity selection register is "0", the inverted value of the P30/INT0 pin level is latched; when the bit is "1", the P30/INT0 pin level is latched as it is. When bit 1 in the edge polarity selection register is "0", the inverted value of the P31/INT1 pin level is latched; when the bit is "1", the P31/INT1 pin level is latched as it is. When bit 2 in the edge polarity selection register is "0", the inverted value of the P32/CNTR0 pin level is latched; when the bit is "1", the P32/CNTR0 pin level is latched as it is. When bit 3 in the edge polarity selection register is "0", the inverted value of the P33/CNTR1 pin level is latched; when the bit is "1", the P33/CNTR1 pin level is latched as it is.

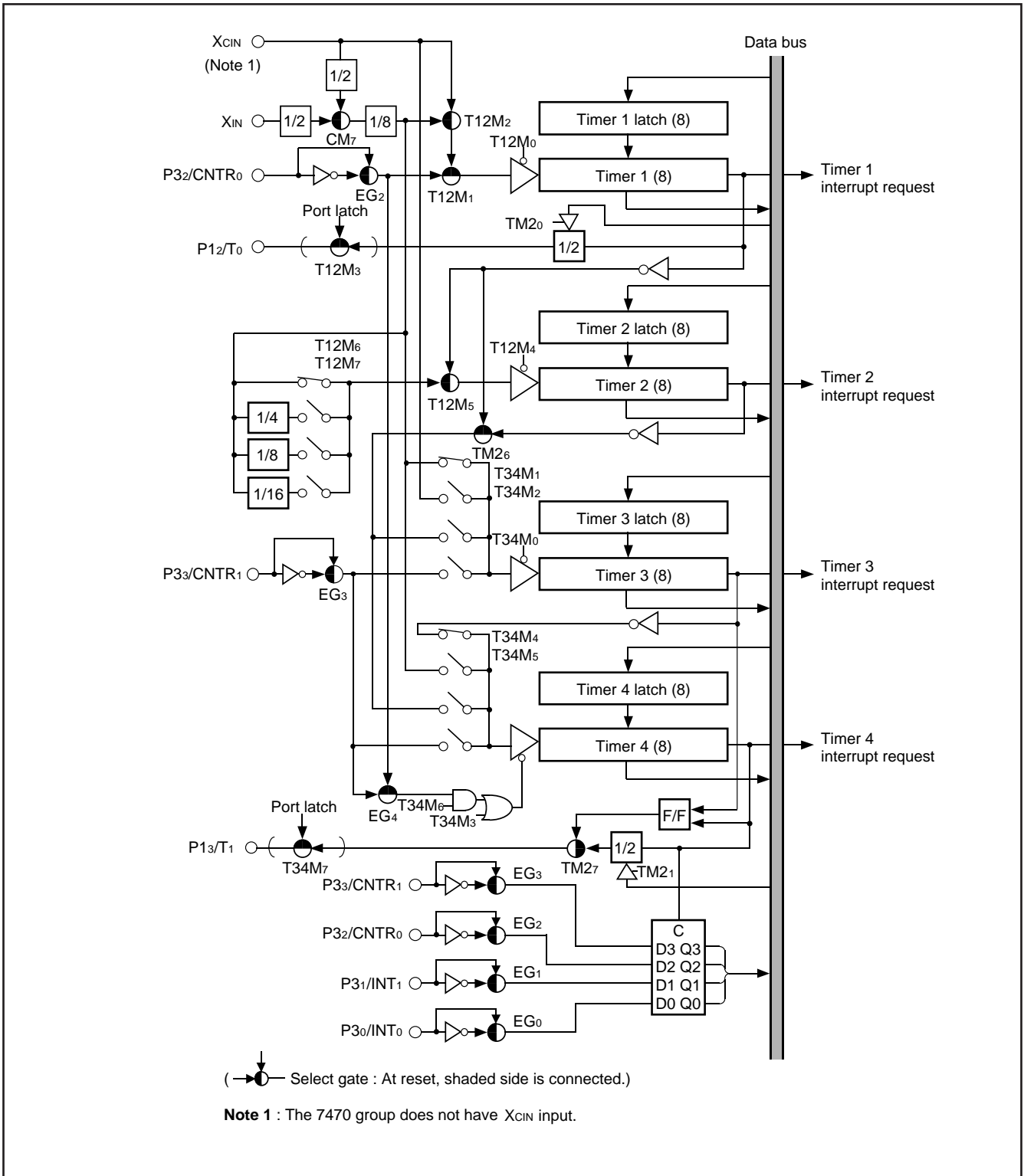


Fig. 6 Block diagram of timer 1 through 4

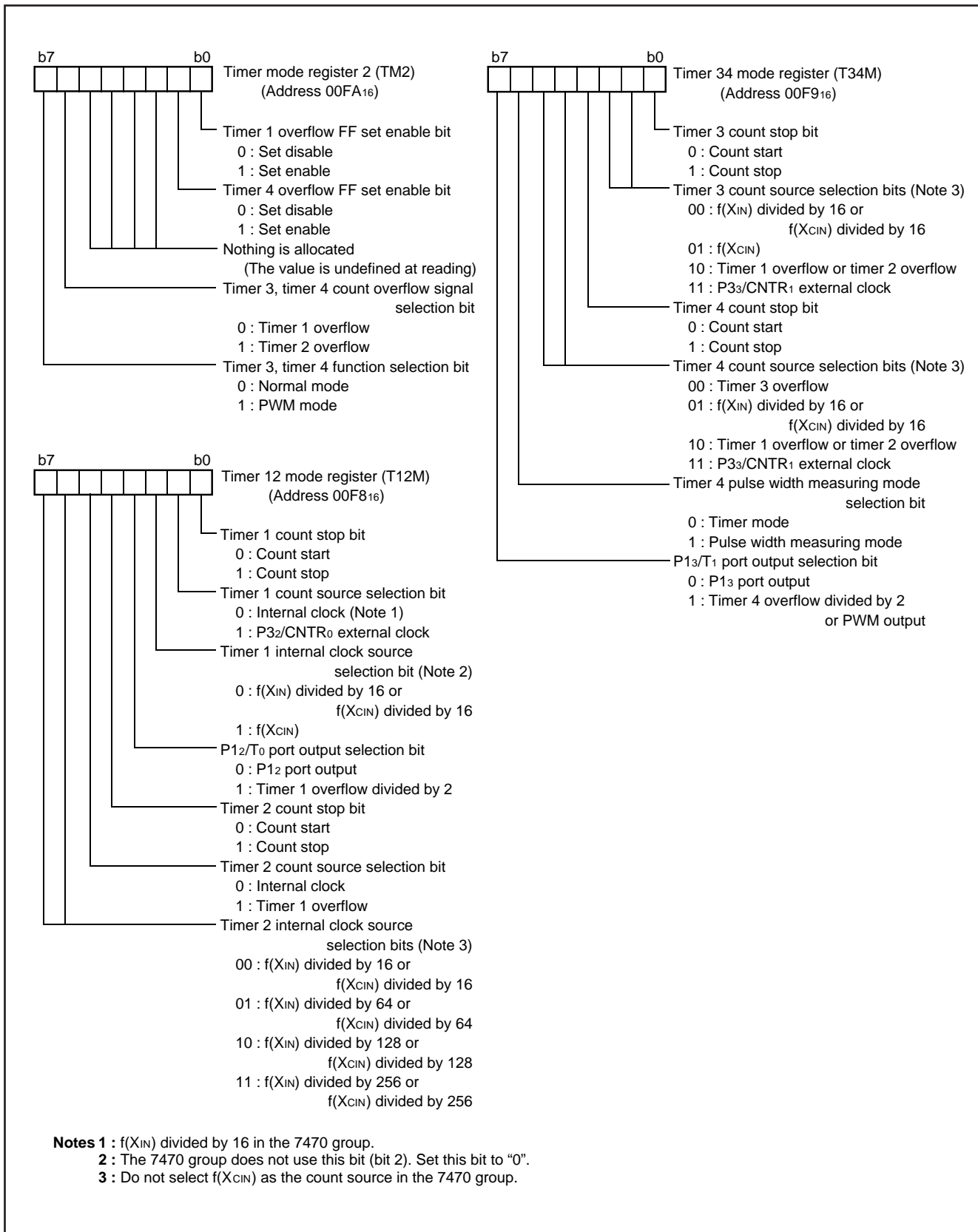


Fig. 7 Structure of timer mode registers

SERIAL I/O

The block diagram of serial I/O is shown in Figure 8. In the serial I/O mode, the receive ready signal ($\overline{\text{SRDY}}$), synchronous input/output clock (CLK), and the serial I/O (SOUT, SIN) pins are used as P17, P16, P15, and P14, respectively.

The serial I/O mode register (address 00DC16) is an 8-bit register. Bit 2 of this register is used to select a synchronous clock source. When this bit is "0", an external clock from P16 is selected. When this bit is "1", an internal clock is selected.

The internal clock can be selected from among the divide by 8, divide by 16, divide by 32, divide by 512 frequency of the oscillator frequency $f(\text{XIN})$ or $f(\text{XCIN})$. Do not select $f(\text{XCIN})$ as the count source in the 7470 group. The divide ratio is selected according to bit 0 and bit 1 in the serial I/O mode register, and selection be-

tween $f(\text{XIN})$ and $f(\text{XCIN})$ is mode according to bit 7 in the CPU mode register.

Bits 3 and 4 decide whether parts of P1 will be used as a serial I/O or not. When bit 3 is "1", P16 becomes an I/O pin of the synchronous clock. When an internal synchronous clock is selected, the clock is output from P16. If the external synchronous clock is selected, the clock is input to P16.

And P15 will be a serial output. To use P14 as a serial input, set the direction register bit which corresponds to P14, to "0". For more information on the direction register, refer to the I/O pin section.

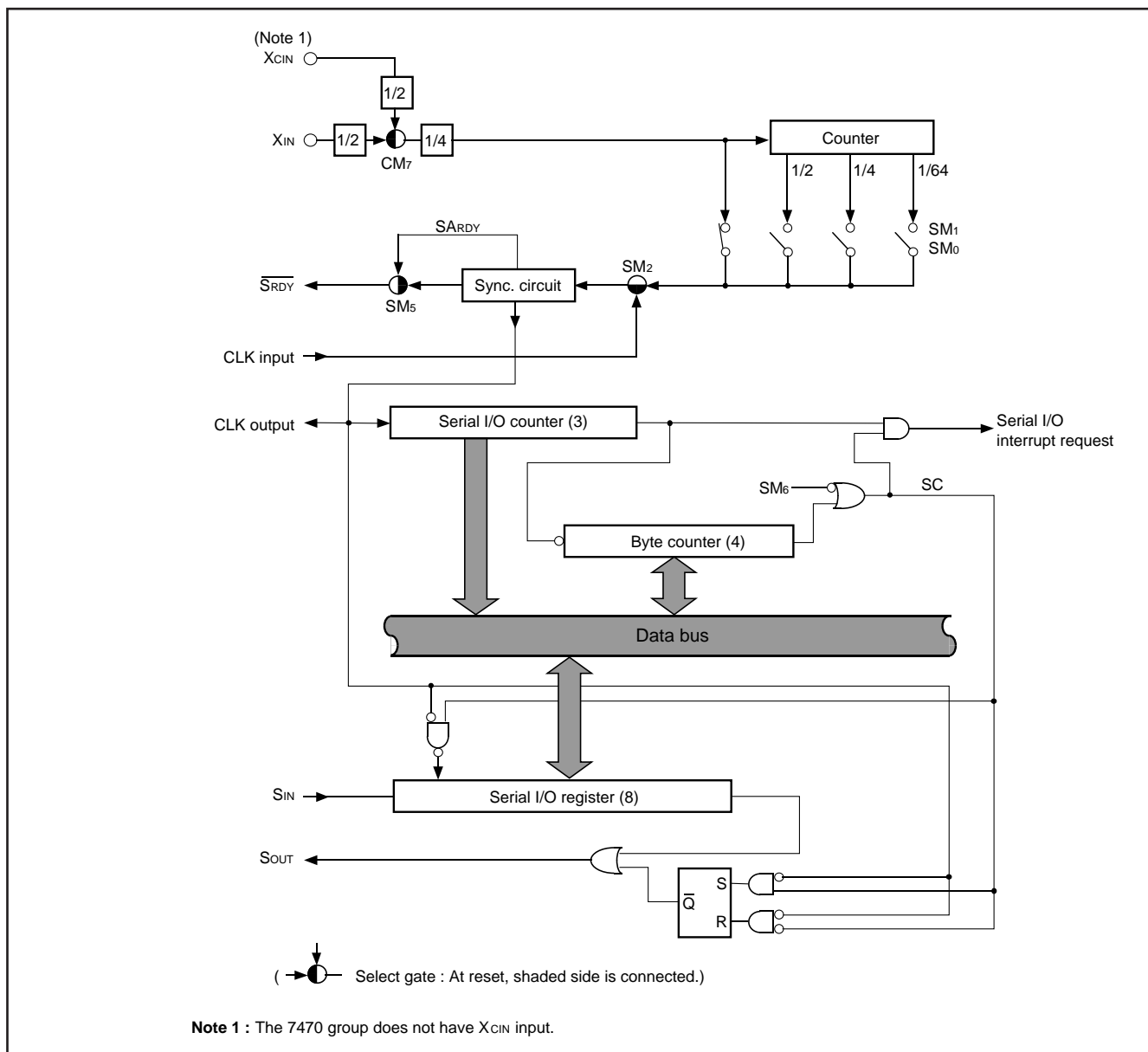


Fig. 8 Block diagram of serial I/O

Bit 4 determines if P17 is used as an output pin for the receive ready signal (bit 4="1", $\overline{\text{SRDY}}$) or used as a normal I/O pin (bit 4="0").

When the P17 pin is used as the $\overline{\text{SRDY}}$ output pin, output signal can be selected between $\overline{\text{SRDY}}$ signal and $\overline{\text{SARDY}}$ signal by using bit 5 in the serial I/O mode register. The $\overline{\text{SRDY}}$ signal is driven "L" by a signal written into the serial I/O register to inform that the device is ready to receive. Then, the $\overline{\text{SRDY}}$ signal is driven "H" on the first falling edge of the transfer clock.

The $\overline{\text{SARDY}}$ signal is driven "H" by a signal written into the serial I/O register, and driven "L" on the last rising edge of the transfer clock.

The function of serial I/O differs depending on the clock source; external clock or internal clock.

Internal Clock – The serial I/O counter is set to 7 when data is stored in the serial I/O register. At each falling edge of the transfer clock, serial data is output to P15. During the rising edge of this clock, data can be input from P14 and the data in the serial I/O register will be shifted 1 bit. Data is output starting with the LSB. After the transfer clock has counted 8 times, the serial I/O register will be empty and the transfer clock will remain at a high level. At this time the interrupt request bit will be set.

External Clock – If an external clock is used, the interrupt request bit will be set after the transfer clock has counted 8 times but the transfer clock will not stop. Due to this reason, the external clock must be controlled from the outside.

Timing diagrams are shown in Figure 9.

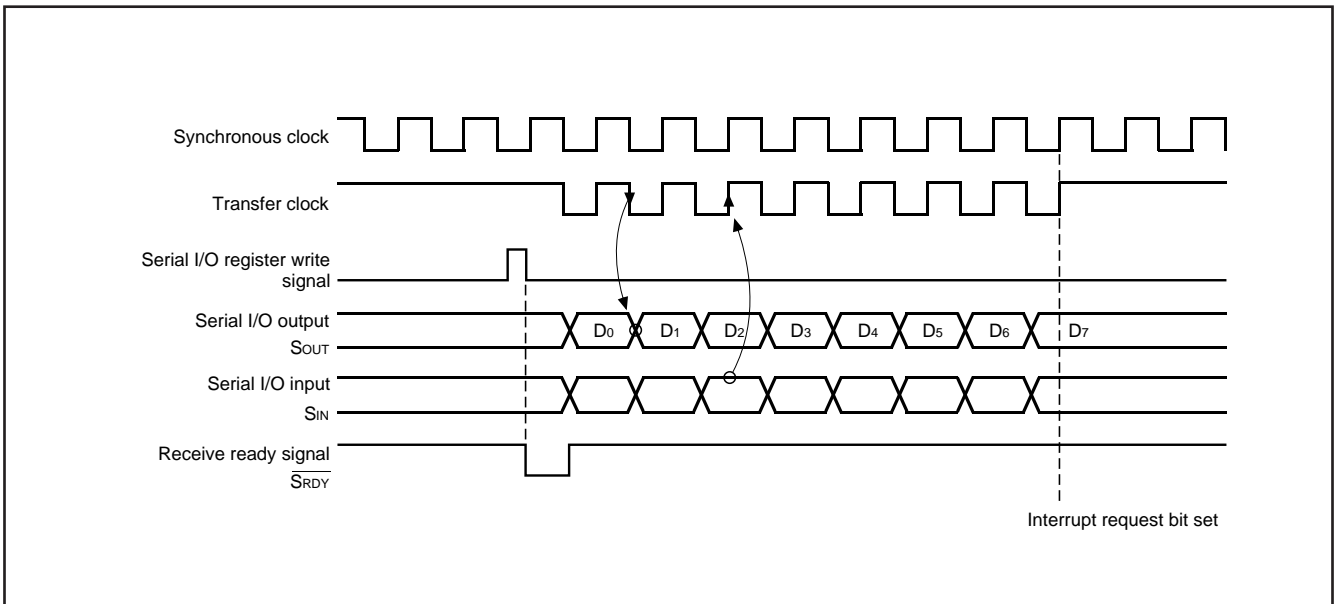


Fig. 9 Serial I/O timing

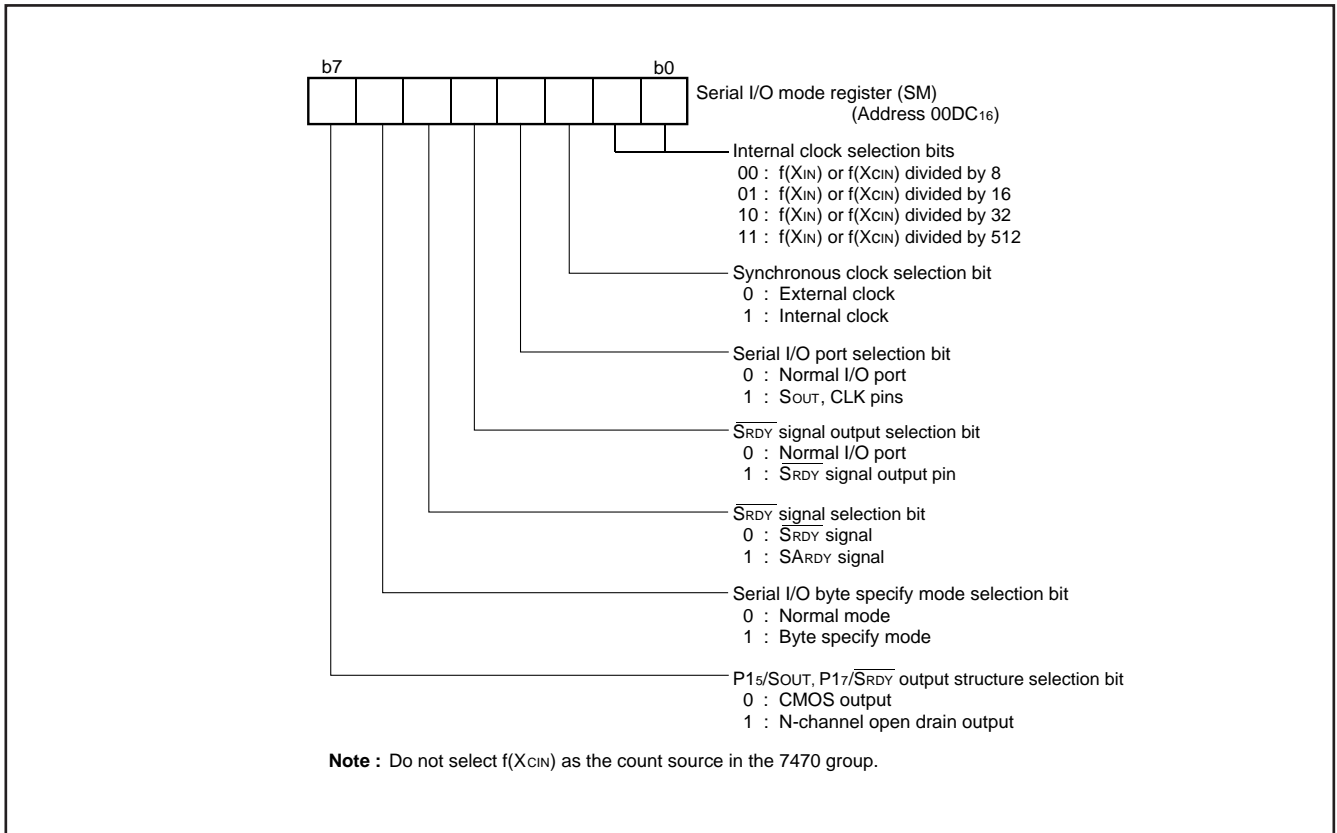


Fig. 10 Structure of serial I/O mode register

BYTE SPECIFY MODE

The serial I/O has a byte specify mode that allows one specific byte data to be selected for transmission or reception when serial I/O circuits of two or more microcomputers are connected to send or receive data through one bus. The data to be sent or received can be specified by writing a value into the byte counter. The value written in the byte counter is decremented by one each time eight cycles of transfer clock are input. When the value in the byte counter becomes "0", serial transmission/reception is done by the next eight cycles of transfer clock. When the value in the byte counter is not "0", the output on the SOUT pin is driven "H" by the falling edge of the first transfer clock pulse to inhibit transmission/reception.

Serial I/O interrupt requests are generated only when serial transmission/reception is done after the value in the byte counter is decremented to "0". When the SARDY signal output is selected, the SARDY signal is driven "L" by the last rising edge of the transfer clock after the value in the byte counter is decremented to "0".

Note that in the byte mode, an external clock must be used as the sync. clock for the purpose of the mode.

A-D CONVERTER

The A-D conversion uses an 8-bit successive comparison method. Figure 11 shows a block diagram of the A-D conversion circuit. Conversion is automatically carried out once started by the program.

There are eight analog input pins which are shared with P20 to P27 of port P2 (Only P20 to P23 4-bit for 7470 group. Which analog inputs are to be A-D converted is specified by using bit 2 to bit 0 in the A-D control register (address 00D9₁₆). Pins for inputs to be A-D converted must be set for input by setting the direction register bit to "0". Bit 3 in the A-D control register is an A-D conversion end bit. This is "0" during A-D conversion; it is set to "1" when the conversion is terminated. Therefore, it is possible to know whether A-D conversion is terminated by checking this bit. Bit 4 in the A-D control register is a VREF connection selection bit.

During A-D conversion, this bit must be set "1" for the ladder resistor and VREF pin to be connected; after the A-D conversion is terminated, this bit can be reset to "0" to separate the ladder resistor from the VREF pin. In this way, power consumption in the ladder resistor can be suppressed while no A-D conversion is performed. Figure 13 shows the relationship between the contents of A-D control register and the selected input pins.

The A-D conversion register (address 00DA₁₆) contains information on the results of conversion, so that it is possible to know the results of conversion by reading the contents of this register.

The following explains the procedure to execute A-D conversion. First, set values to bit 2 to bit 0 in the A-D control register to select the pins that you want to execute A-D conversion. Next, clear the A-D conversion end bit to "0".

When the above is done, A-D conversion is initiated. The A-D conversion is completed after an elapse of 50 machine cycles (12.5 μs when f(XIN)= 8 MHz), the A-D conversion end bit is set to "1", and the interrupt request bit is set to "1". The results of conversion are contained in the A-D conversion register.

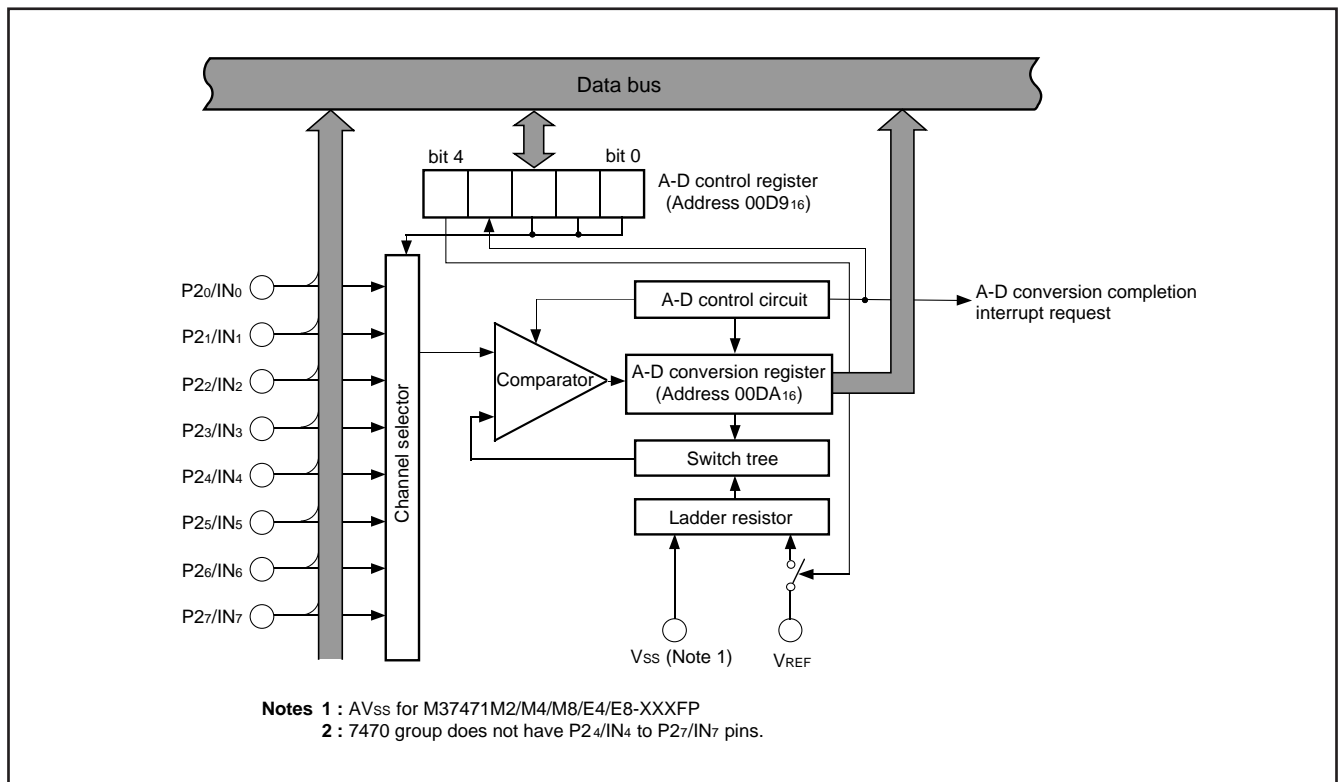


Fig. 11 A-D converter circuit

KEY ON WAKE UP

“Key on wake up” is one way of returning from a power down state caused by the STP or WIT instruction. If any terminal of port P0 has “L” level applied, after bit 5 of the edge polarity selection register (EG5) is set to “1”, an interrupt is generated and the microcomputer is returned to the normal operating state. A key matrix can be connected to port P0 and the microcomputer can be returned to a normal state by pushing any key.

The key on wake up interrupt is common with the $\overline{\text{INT1}}$ interrupt. When EG5 is set to “1”, the key on wake up function is selected. However, key on wake up cannot be used in the normal operating state. When the microcomputer is in the normal operating state, both key on wake up and $\overline{\text{INT1}}$ are invalid.

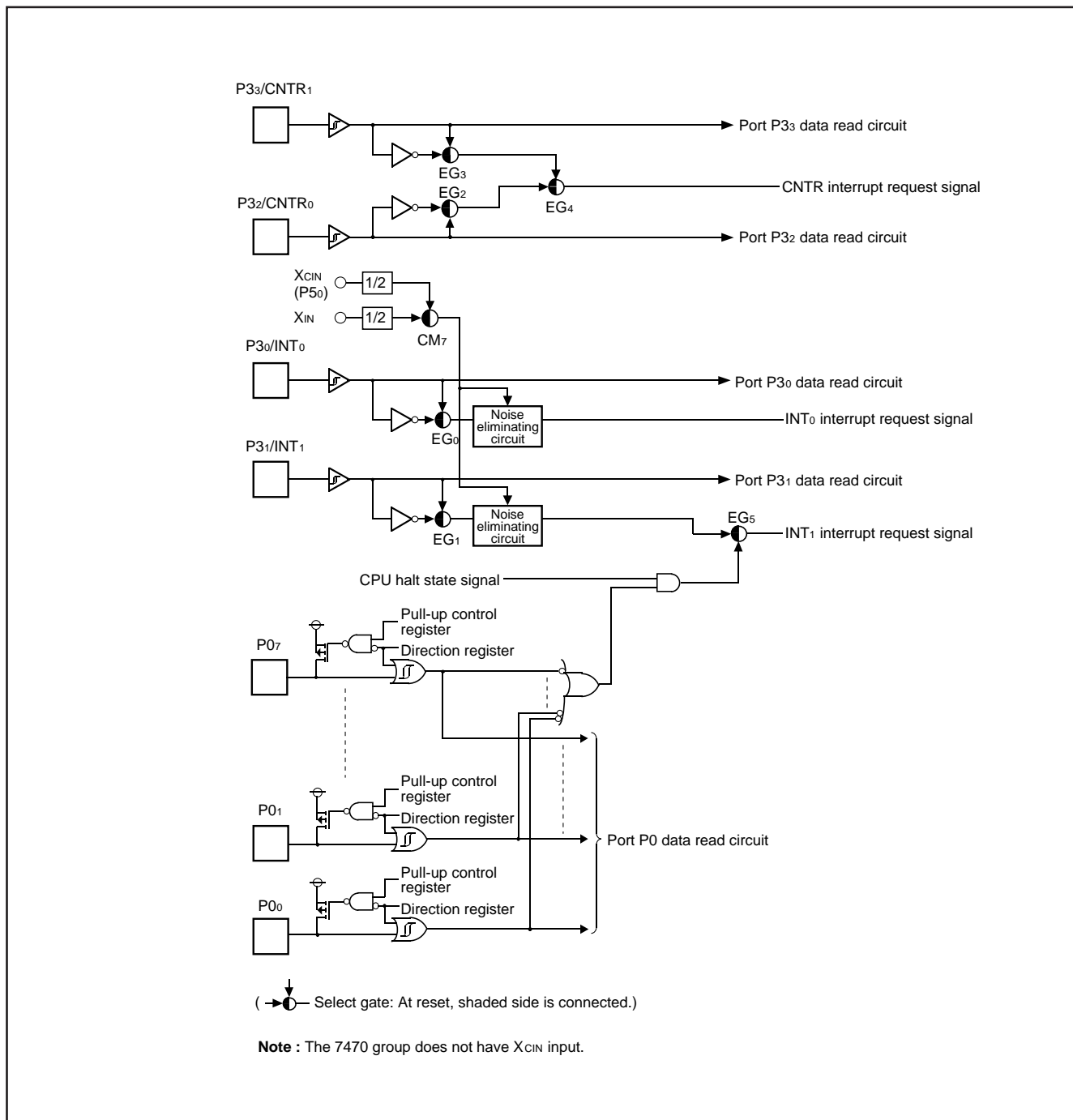


Fig. 13 Block diagram of interrupt input and key on wake up circuit

RESET CIRCUIT

The 7470/7471 group are reset according to the sequence shown in Figure 15. It starts the program from the address formed by using the content of address FFFF₁₆ as the high order address and the content of the address FFFE₁₆ as the low order address, when the RESET pin is held at "L" level for no less than 2 μs while the power voltage is in the recommended operating condition and then returned to "H" level.

The internal initializations following reset are shown in Figure 16. Example of reset circuit is Figure 14. Immediately after reset, timer 3 and timer 4 are connected, and counts the f(X_{IN}) divided by 16. At this time, FF₁₆ is set to timer 3, and 07₁₆ is set to timer 4. The reset is cleared when timer 4 overflows.

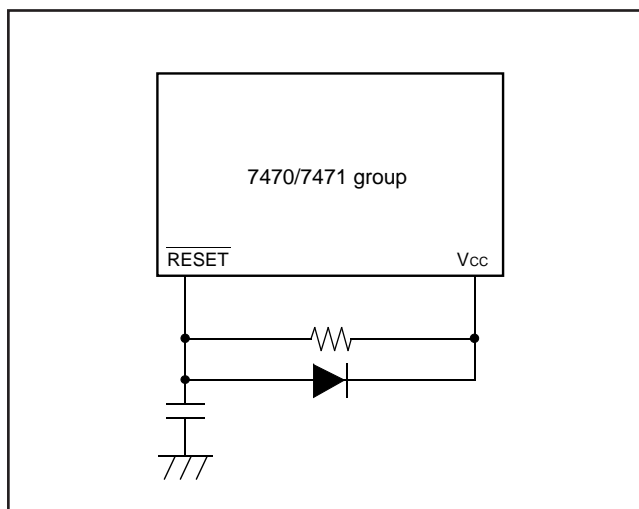


Fig. 14 Example of reset circuit

	Address	
(1) Port P0 direction register (C1 ₁₆) ...	00 ₁₆	
(2) Port P1 direction register (C3 ₁₆) ...	00 ₁₆	
(3) Port P2 direction register (C5 ₁₆) ...	00 ₁₆	
(4) Port P4 direction register (C9 ₁₆) ...	0000	
(5) P0 pull-up control register (D0 ₁₆) ...	00 ₁₆	
(6) P1–P5 pull-up control register (Note 1)(D1 ₁₆) ...	000000	
(7) Edge selection register (EG) (D4 ₁₆) ...	000000	
(8) A-D control register (D9 ₁₆) ...	001000	
(9) Serial I/O mode register (SM) (DC ₁₆) ...	00 ₁₆	
(10) Timer 12 mode register (T12M) (F8 ₁₆) ...	00 ₁₆	
(11) Timer 34 mode register (T34M) (F9 ₁₆) ...	00 ₁₆	
(12) Timer mode register 2 (TM2) (FA ₁₆) ...	000000	
(13) CPU mode register (CM) (FB ₁₆) ...	00000000	
(14) Interrupt request register 1 (FC ₁₆) ...	00000000	
(15) Interrupt request register 2 (FD ₁₆) ...	0000	
(16) Interrupt control register 1 (FE ₁₆) ...	00000000	
(17) Interrupt control register 2 (FF ₁₆) ...	0000	
(18) Program counter (PC _H) ...	Contents of address FFFF ₁₆	
(PC _L) ...	Contents of address FFFE ₁₆	
(19) Processor status register (PS) ...	1	

Notes
 1 : This address is allocated P1–P4 pull-up control register for 7470 group. Bit 6 is not used.
 2 : Since the contents of both registers other than those listed above (including timers and the serial I/O register) are undefined at reset, it is necessary to set initial values.

Fig. 16 Internal state of microcomputer at reset

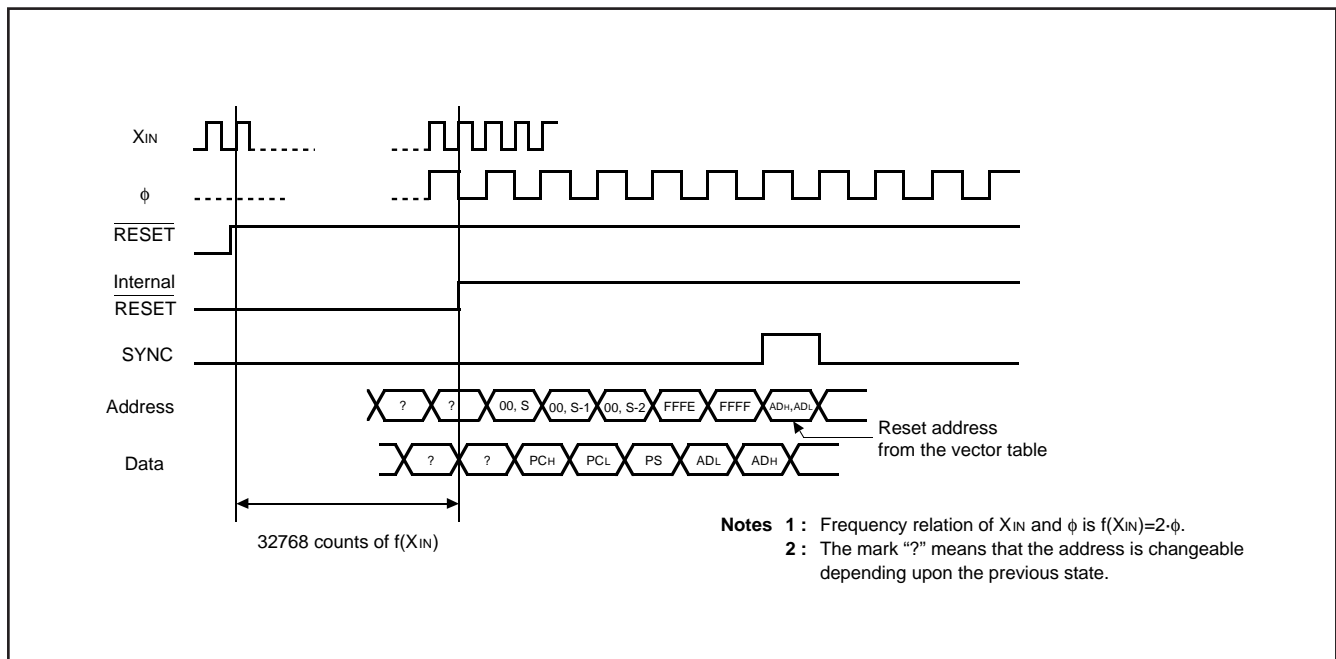


Fig. 15 Timing diagram at reset

I/O PORTS**(1) Port P0**

Port P0 is an 8-bit I/O port with CMOS outputs. As shown in Figure 2, P0 can be accessed as memory through zero page address 00C0₁₆. Port P0's direction register allows each bit to be programmed individually as input or output. The direction register (zero page address 00C1₁₆) can be programmed as input with "0", or as output with "1". When in the output mode, the data to be output is latched to the port latch and output. When data is read from the output port, the output pin level is not read, only the latched data of the port latch is read. Therefore, a previously output value can be read correctly even though the output voltage level has been shifted up or down. Port pins set as input are in the high impedance state so the signal level can be read. When data is written into the input port, the data is latched only to the output latch and the pin still remains in the high impedance state. Following the execution of STP or WIT instruction, key matrix with port P0 can be used to generate the interrupt to bring the microcomputer back in its normal state. When this port is selected for input, pull-up transistor can be connected in units of 1-bit.

(2) Port P1

Port P1 has the same function as port P0. P12–P17 serve dual functions, and the desired function can be selected by the program. When this port is selected for input, pull-up transistor can be connected in units of 4-bit.

(3) Port P2

Port P2 has the same function as port P0. In the 7470 group, this port is P20–P23, a 4-bit I/O port. This port can also be used as the analog voltage input pins. When this port is selected for input, pull-up transistor can be connected in units of 4-bit.

(4) Port P3

Port P3 is a 4-bit input port.

(5) Port P4

Port P4 is a 4-bit I/O port and has basically the same functions as port P0. In the 7470 group, this port is P40 and P41, a 2-bit I/O port. When this port is selected for input, pull-up transistor can be connected in units of 4-bit .

(6) Port P5

Port P5 is a 4-bit input port and pull-up transistor can be connected in units of 4-bit. P50 and P51 are shared with clock generating circuit input/output pins.

The 7470 group does not have this port.

(7) INT0 pin (P30/INT0 pin)

This is an interrupt input pin, and is shared with port P30. When "H" to "L" or "L" to "H" transition input is applied to this pin, the INT0 interrupt request bit (bit 0 of address 00FD₁₆) is set to "1".

(8) INT1 pin (P31/INT1 pin)

This is an interrupt input pin, and is shared with port P31. When "H" to "L" or "L" to "H" transition input is applied to this pin, the INT1 interrupt request bit (bit 1 of address 00FD₁₆) is set to "1".

(9) Counter input CNTR0 pin (P32/CNTR0 pin)

This is a timer input pin, and is shared with port P32.

When this pin is selected to CNTR0 or CNTR1 interrupt input pin and "H" to "L" or "L" to "H" transition input is applied to this pin, the CNTR0 or CNTR1 interrupt request bit (bit 2 of address 00FD₁₆) is set to "1".

(10) Counter input CNTR1 pin (P33/CNTR1 pin)

This is a timer input pin, and is shared with port P33.

When this pin is selected to CNTR0 or CNTR1 interrupt input pin and "H" to "L" or "L" to "H" transition input is applied to this pin, the CNTR0 or CNTR1 interrupt request bit (bit 2 of address 00FD₁₆) is set to "1".

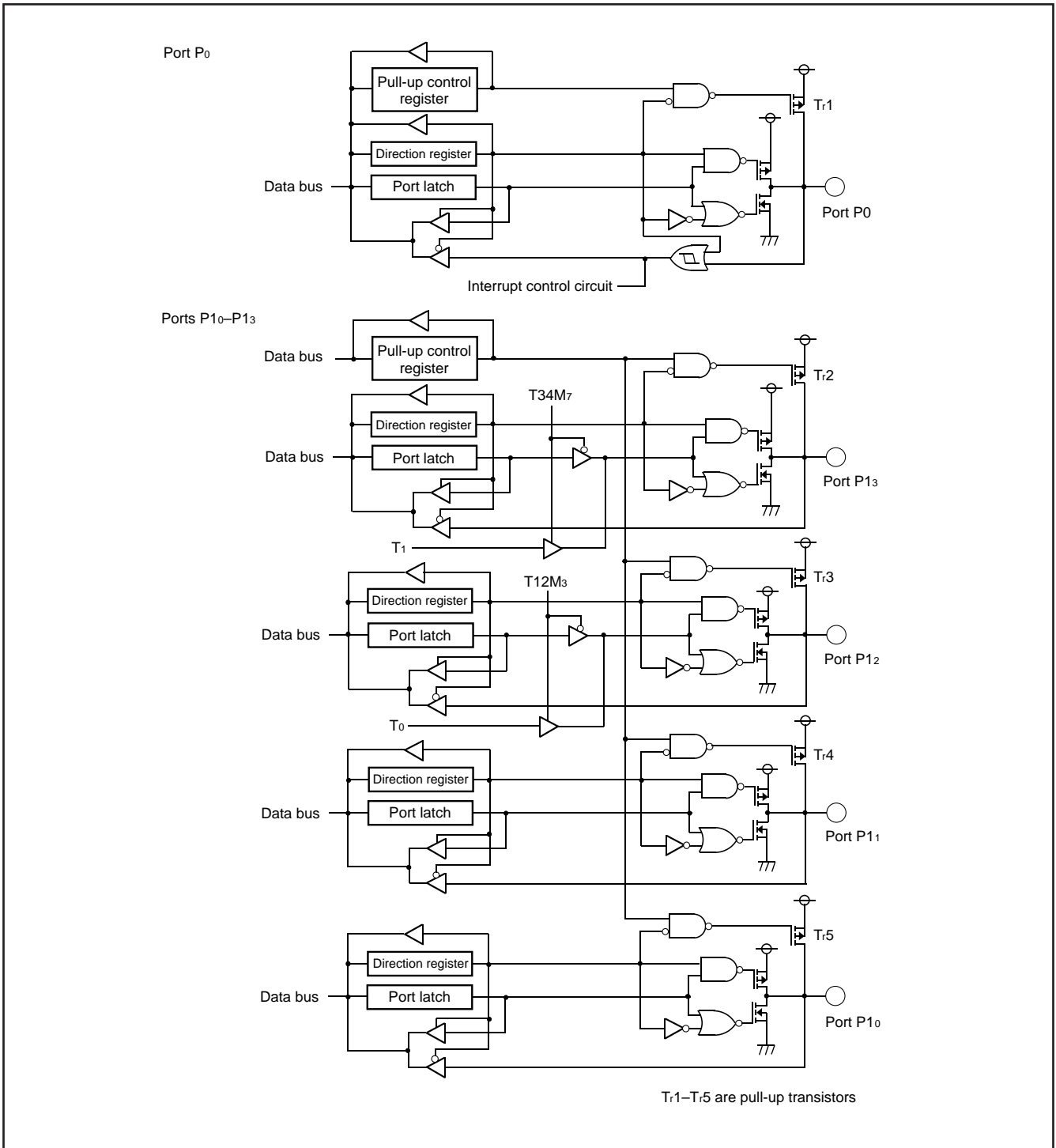


Fig. 17 Block diagram of ports P₀, P₁₀-P₁₃

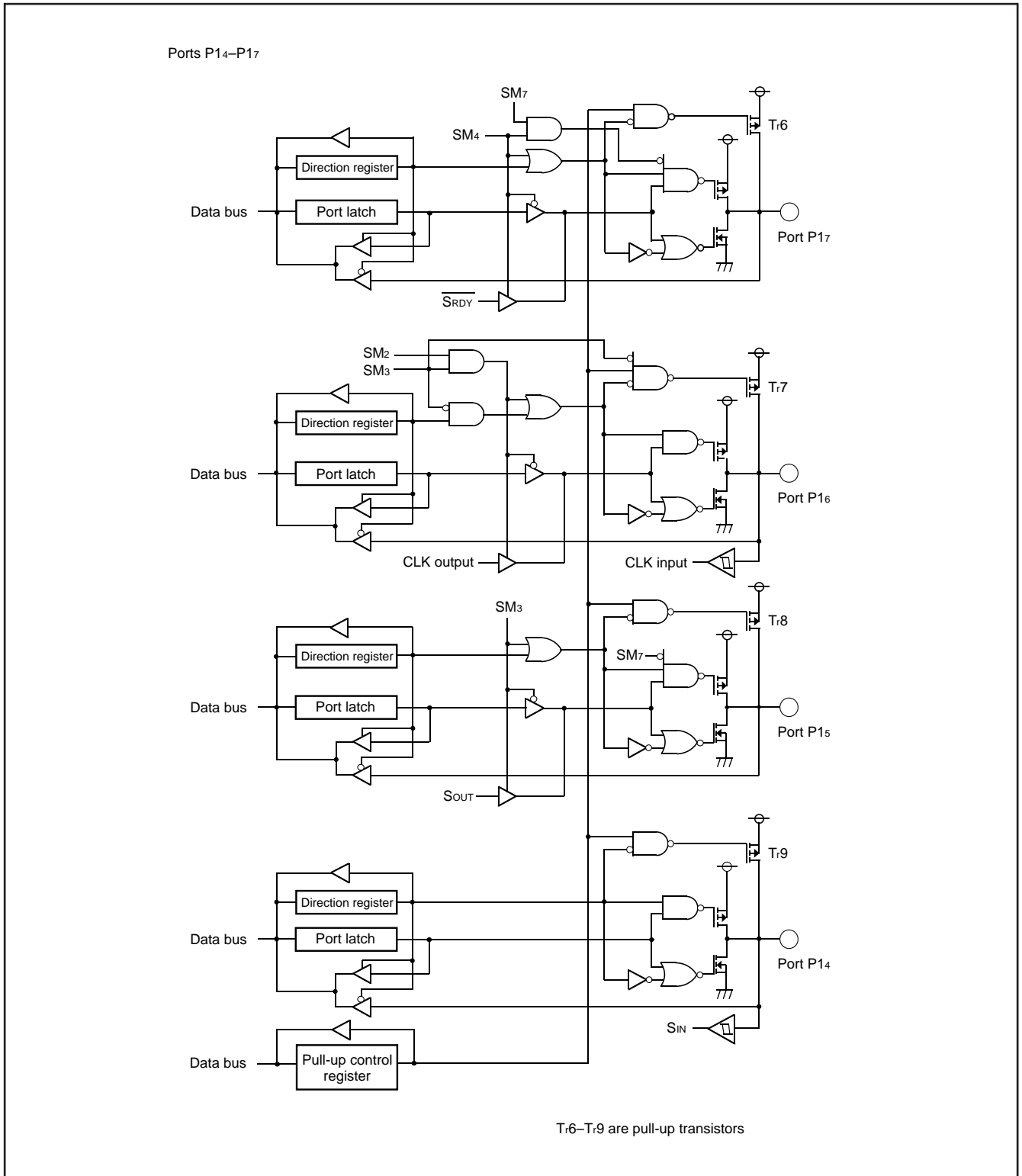


Fig. 18 Block diagram of ports P14-P17

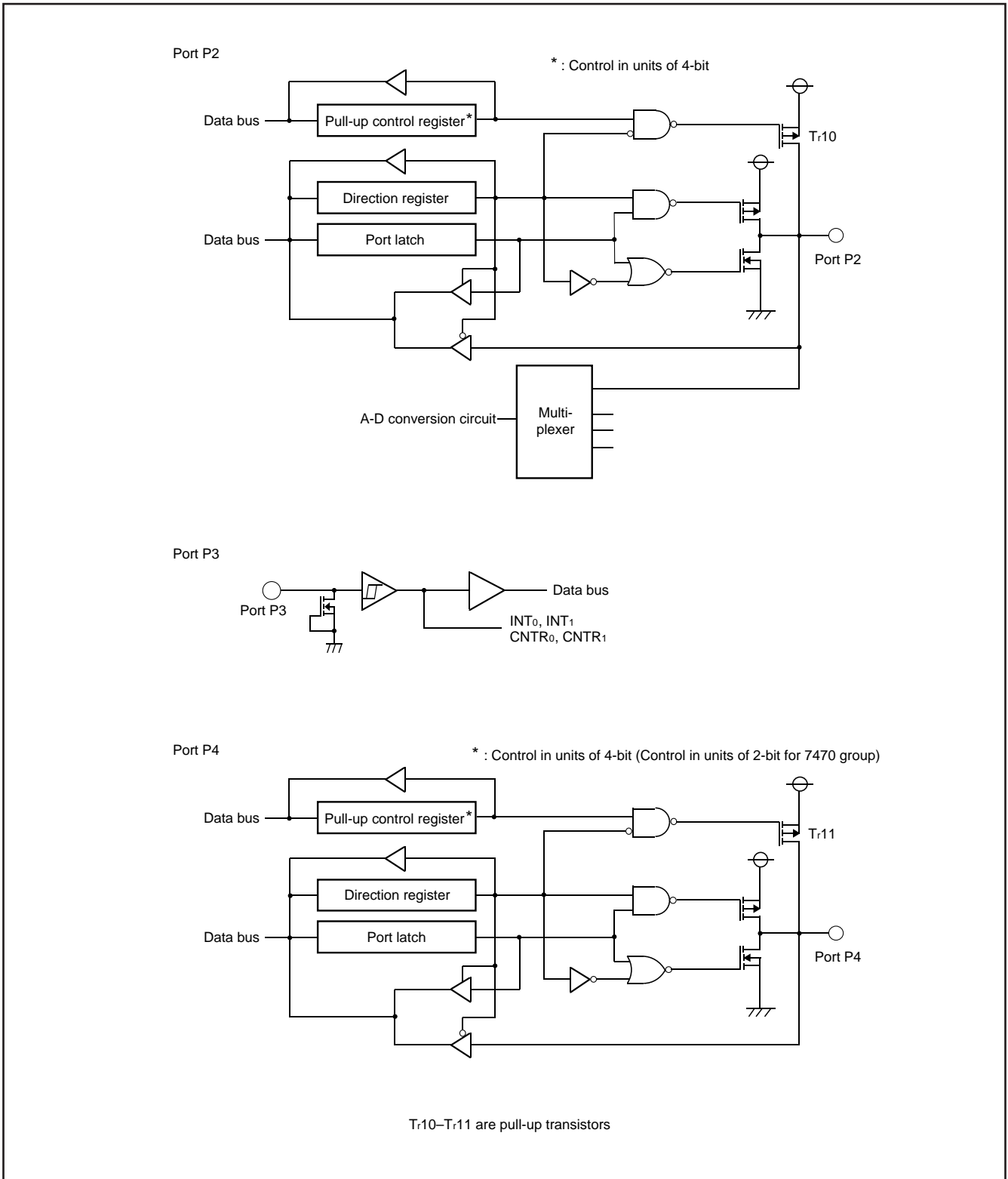


Fig. 19 Block diagram of ports P2-P4

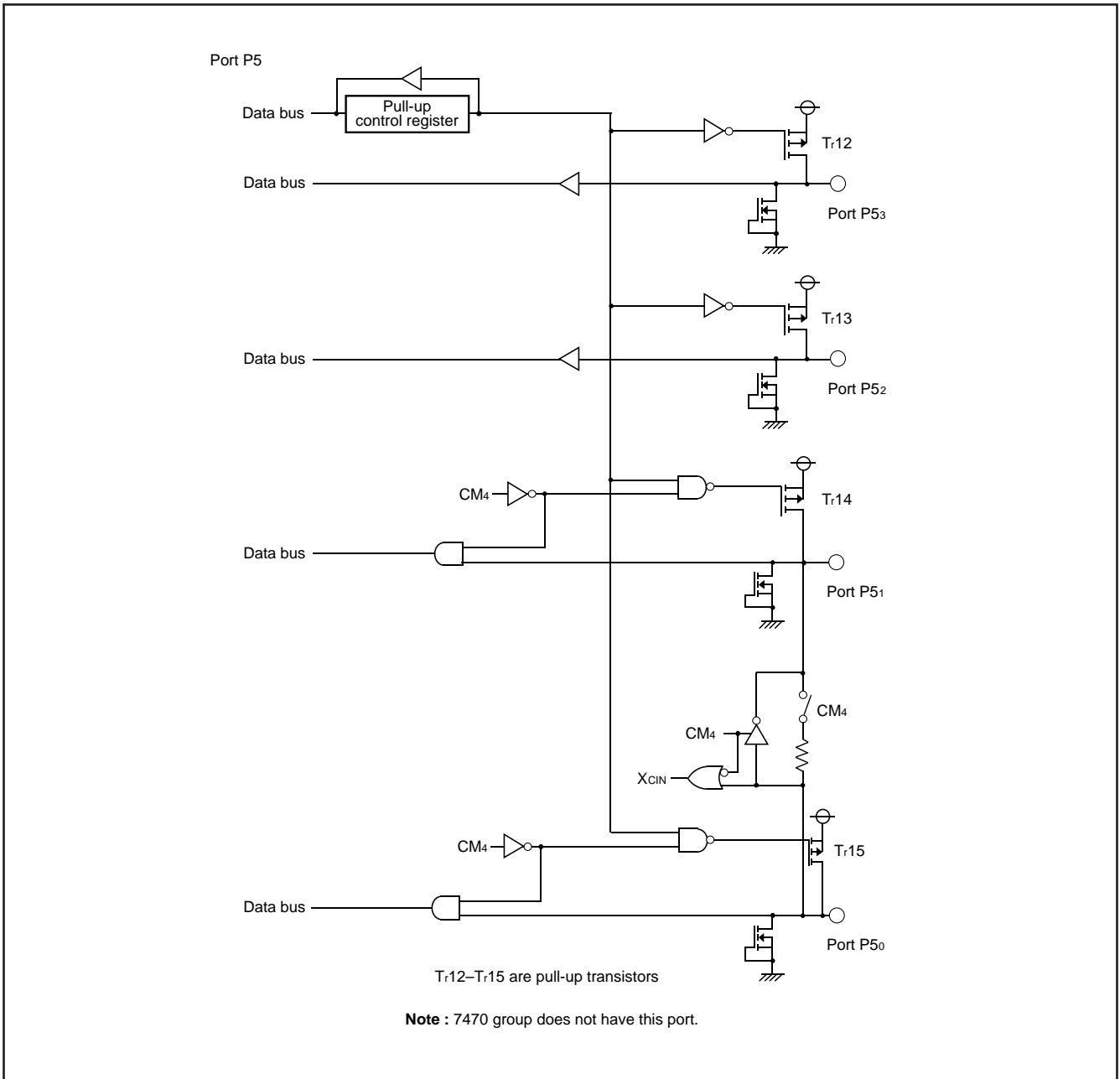


Fig. 20 Block diagram of port P5

CLOCK GENERATING CIRCUIT

The 7470 group has one internal clock generating circuit and 7471 group has two internal clock generating circuits.

Figure 25 shows a block diagram of the clock generating circuit. Normally, the frequency applied to the clock input pin X_{IN} divided by two is used as the internal clock ϕ . Bit 7 of CPU mode register can be used to switch the internal clock ϕ to 1/2 the frequency applied to the clock input pin X_{CIN} in the 7471 group.

Figure 21, 22 show a circuit example using a ceramic resonator (or a quartz-crystal oscillator). Use the manufacturer's recommended values for constants such as capacitance which will differ depending on each oscillator. When using an external clock signal, input from the $X_{IN}(X_{CIN})$ pin and leave the $X_{OUT}(X_{COUT})$ pin open. A circuit example is shown in Figure 23, 24.

The 7470/7471 group has two low power dissipation modes; stop and wait. The microcomputer enters a stop mode when the STP instruction is executed. The oscillator (both X_{IN} clock and X_{CIN} clock) stops with the internal clock ϕ held at "H" level. In this case timer 3 and timer 4 are forcibly connected and FF16 is automatically set in timer 3 and 0716 in timer 4.

Although oscillation is restarted when an external interrupt is accepted, the internal clock ϕ remains in the "H" state until timer 4 overflows. In other words, the internal clock ϕ is not supplied until timer 4 overflows. This is because when a ceramic or similar other oscillator is used, a finite time is required until stable oscillation is obtained after restart.

The microcomputer enters an wait mode when the WIT instruction is executed. The internal clock ϕ stops at "H" level, but the oscillator does not stop. ϕ is re-supplied (wait mode release) when the microcomputer receives an interrupt.

Instructions can be executed immediately because the oscillator is not stopped. The interrupt enable bit of the interrupt used to reset the wait mode or the stop mode must be set to "1" before executing the WIT or the STP instruction.

Low power dissipation operation is also achieved when the X_{IN} clock is stopped and the internal clock ϕ is generated from the X_{CIN} clock (30 μ A typ. at $f(X_{CIN}) = 32$ kHz). This operation is only 7471 group. X_{IN} clock oscillation is stopped when the bit 6 of CPU mode register is set and restarted when it is cleared. However, the wait time until the oscillation stabilizes must be generated with a program when restarting. Figure 27 shows the transition of states for the system clock.

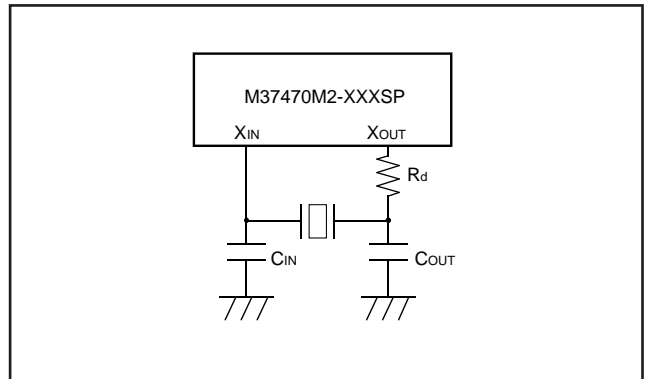


Fig. 21 Example of ceramic resonator circuit (7470 group)

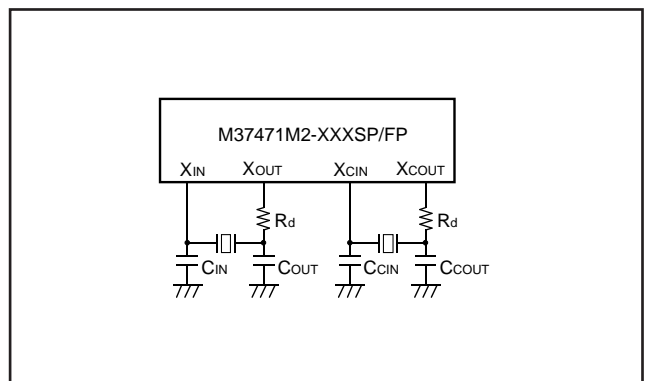


Fig. 22 Example of ceramic resonator circuit (7471 group)

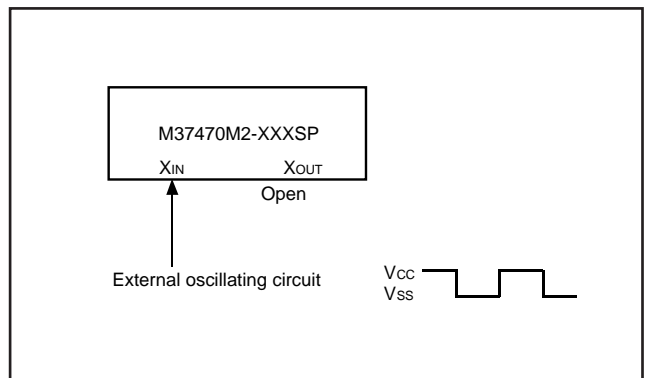


Fig. 23 External clock input circuit (7470 group)

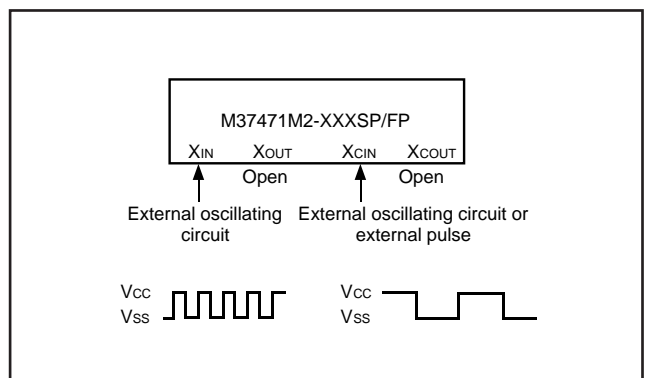


Fig. 24 External clock input circuit (7471 group)

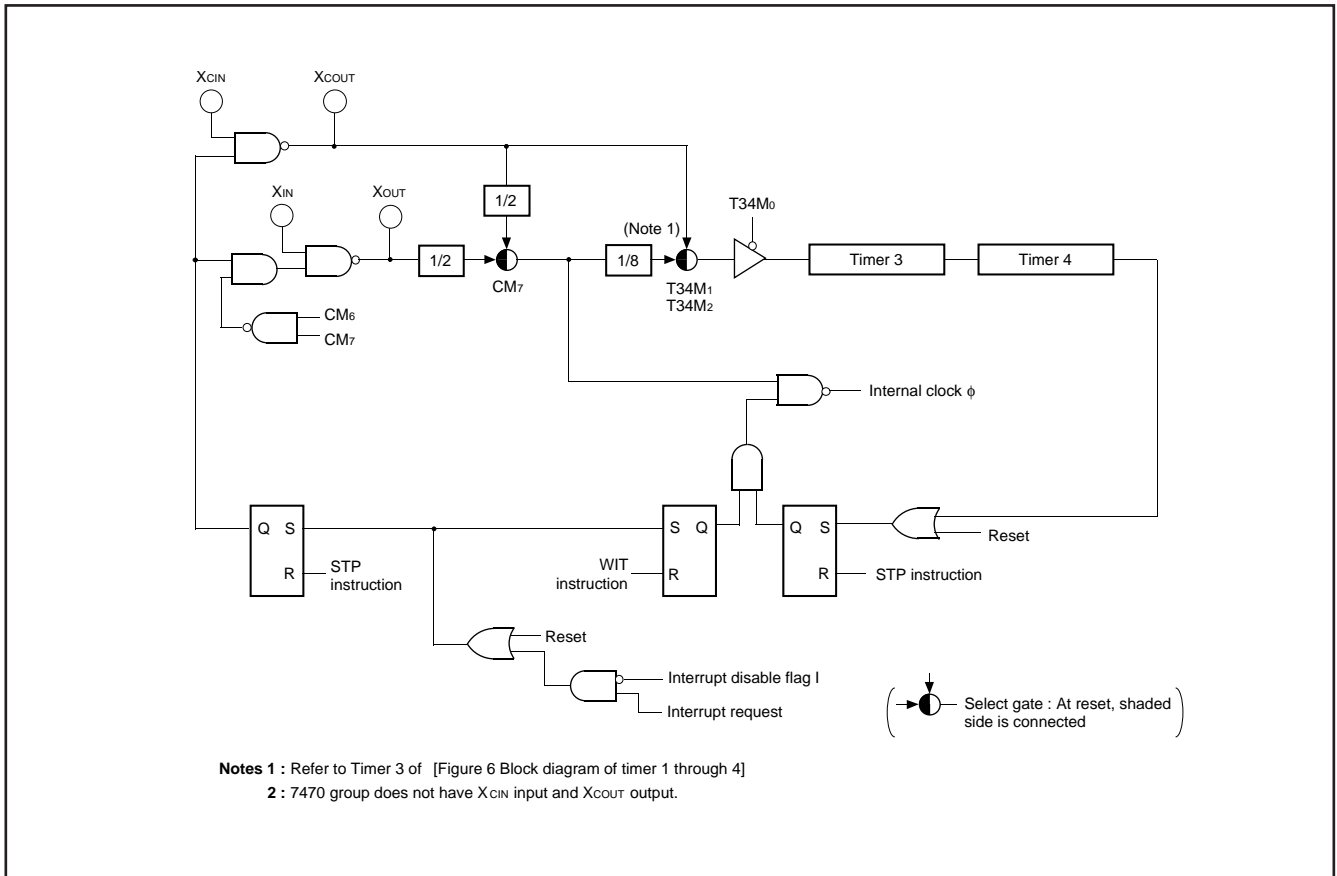


Fig. 25 Block diagram of clock generating circuit

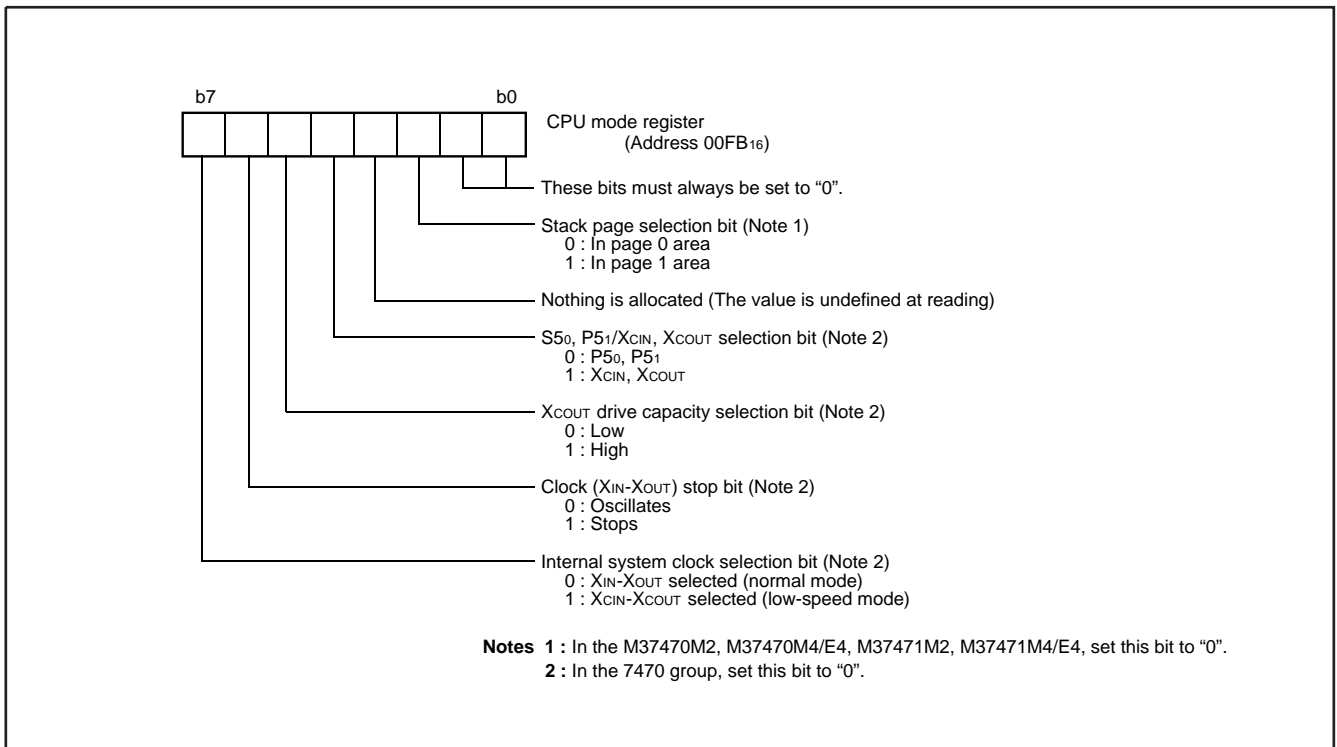


Fig. 26 Structure of CPU mode register

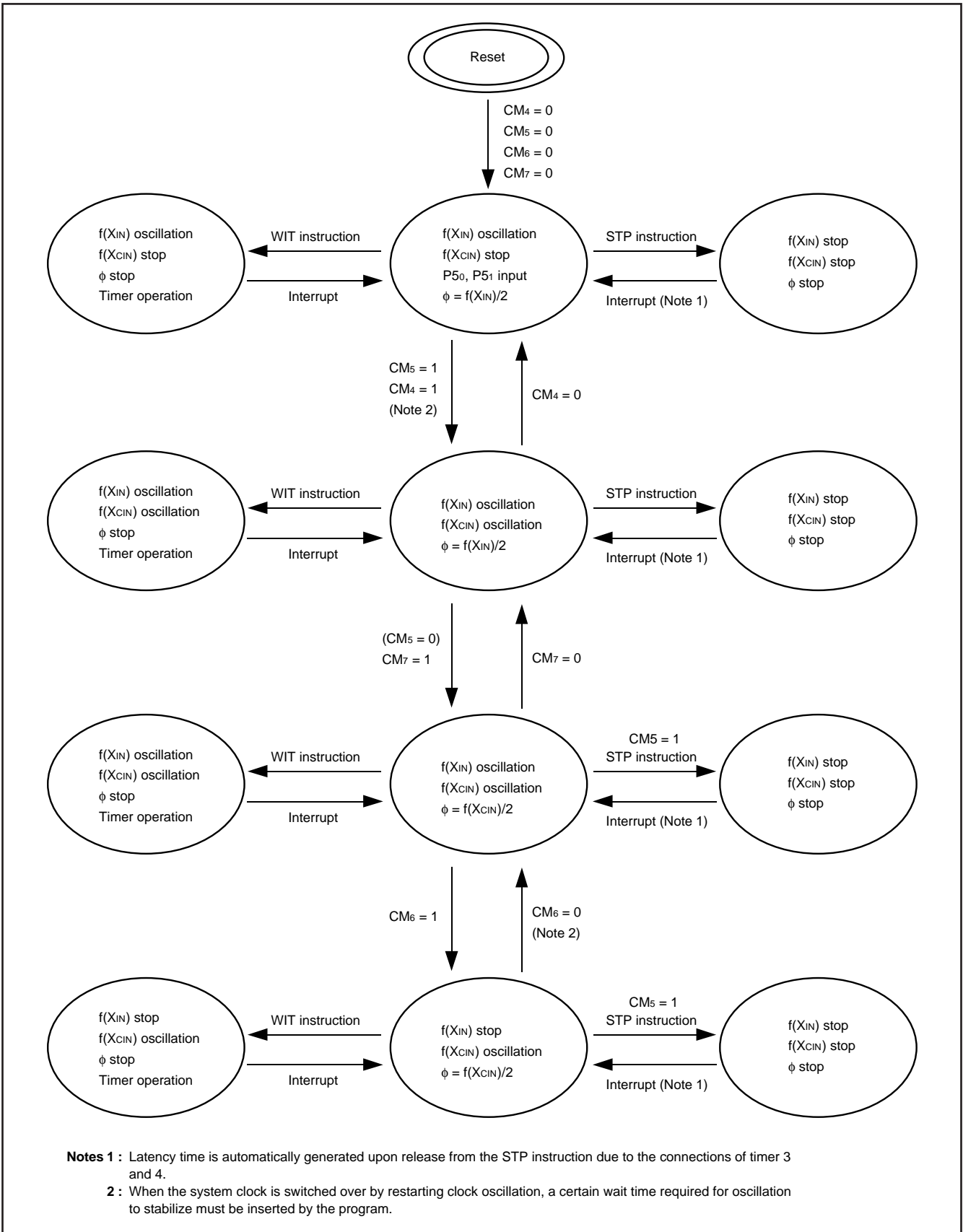
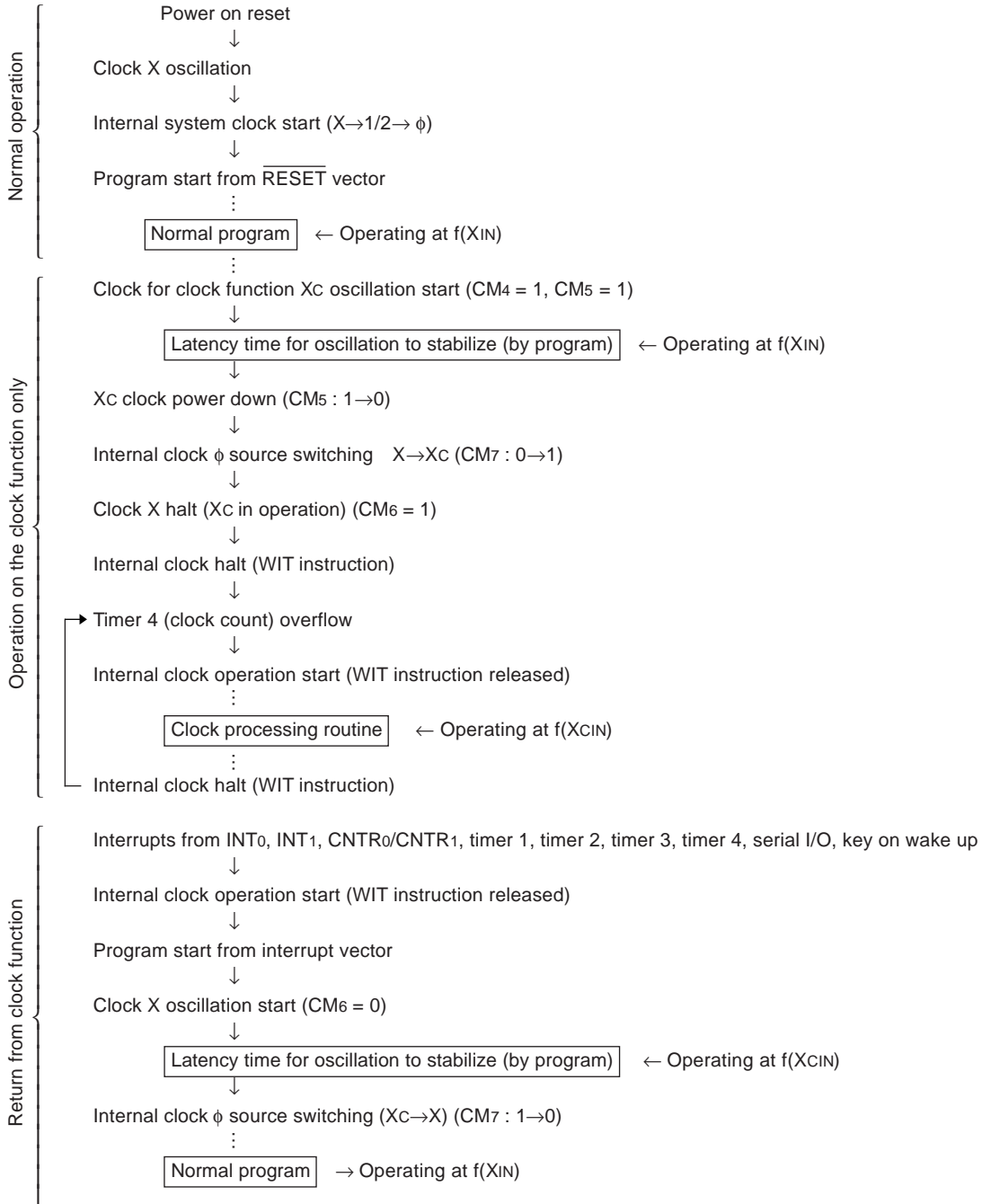
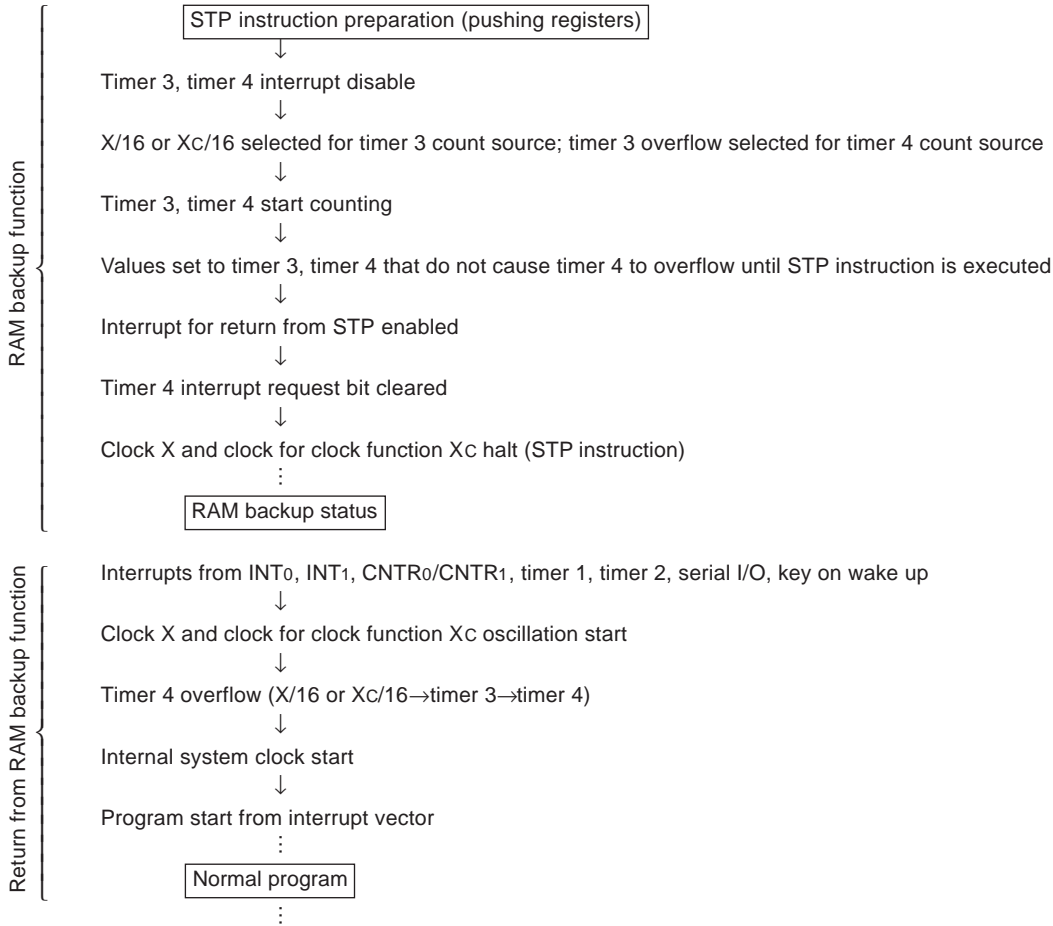


Fig. 27 Transition of states for the system clock

<An example of flow for system>





BUILT-IN PROM TYPE MICROCOMPUTERS PIN DESCRIPTION

Pin	Mode	Name	Input/ Output	Functions
VCC,VSS	Single-chip /EPROM	Power source		Power source voltage inputs 2.7 to 5.5 V to VCC and 0 V to VSS.
AVSS (Note 1)	Single-chip /EPROM	Analog power source		Ground level input pin for A-D converter. Same voltage as VSS is applied.
RESE \bar{T}	Single-chip	Reset input	Input	To enter the reset state, the reset input pin must be kept at a "L" for 2 μ s or more (under normal VCC conditions).
	EPROM	Reset input		Connect to VSS.
XIN	Single-chip /EPROM	Clock input	Input	These are I/O pins of internal clock generating circuit for main clock. To control generating frequency, an external ceramic or a quartz-crystal oscillator is connected between the XIN and XOUT pins. If an external clock is used, the clock source should be connected the XIN pin and the XOUT pin should be left open. Feedback resistor is connected between XIN and XOUT.
XOUT		Clock output	Output	
VREF	Single-chip	Reference voltage input	Input	Reference voltage input pin for the A-D converter.
	EPROM	Select mode	Input	VREF works as $\bar{C}E$ input.
P00–P07	Single-chip	I/O port P0	I/O	Port P0 is an 8-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 1-bit and a key on wake up function is provided.
	EPROM	Data input/output D0–D7	I/O	Port P0 works as an 8-bit data bus (D0–D7).
P10–P17	Single-chip	I/O port P1	I/O	Port P1 is an 8-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 4-bit. P12, P13 are in common with timer output pins T0, T1. P14, P15, P16, P17 are in common with serial I/O pins SIN, SOUT, CLK, $\bar{S}RDY$, respectively. The output structure of SOUT and $\bar{S}RDY$ can be changed to N-channel open drain output.
	EPROM	Address input A4–A10	Input	P11–P17 works as the 7-bit address input (A4–A10). P10 must be opened.
P20–P27 (Note 2)	Single-chip	I/O port P2	I/O	Port P2 is an 8-bit input port. This port is in common with analog input pins IN0–IN7.
	EPROM	Address input A0–A3	Input	P20–P23 works as the lower 4-bit address input (A0–A3). P24–P27 must be opened.
P30–P33	Single-chip	Input port P3	Input	Port P3 is a 4-bit input port. P30, P31 are in common with external interrupt input pins INT0, INT1 and P32, P33 are in common with timer input pins CNTR0, CNTR1.
	EPROM	Address input A11, A12 Select mode VPP input	Input	P30, P31 works as the 2-bit address input (A11, A12). P32 works as $\bar{O}E$ input. Connect to P33 to VPP when programming or verifying.
P40–P43 (Note 3)	Single-chip	I/O port P4	I/O	Port P4 is a 4-bit I/O port. The output structure is CMOS output. When this port is selected for input, pull-up transistor can be connected in units of 4-bit.
	EPROM	Address input A13, A14	Input	P40, P41 works as the higher 2-bit address input (A13, A14). P42, P43 must be opened.
P50–P53 (Note 4)	Single-chip	Input port P5	Input	Port P5 is a 4-bit input port and pull-up transistor can be connected in units of 4-bit. P50, P51 are in common with input/output pins of clock for clock function XCIN, XCOU \bar{T} . When P50, P51 are used as XCIN, XCOU \bar{T} , connect a ceramic or a quartz-crystal oscillator between XCIN and XCOU \bar{T} . If an external clock input is used, connect the clock input to the XCIN pin and open the XCOU \bar{T} pin. Feedback resistor is connected between XCIN and XCOU \bar{T} pins.
	EPROM		Open.	

Notes 1 : AVSS for M37471M2/M4/M8/E4/E8-XXXFP.

2 : Only P20–P23 (IN0–IN3) 4-bit for the 7470 group.

3 : Only P40 and P41 2-bit for the 7470 group.

4 : This port is not included in the 7470 group.

EPROM MODE

The M37470E4/E8, M37471E4/E8 feature an EPROM mode in addition to its normal modes. When the $\overline{\text{RESET}}$ signal level is low ("L"), the chip automatically enters the EPROM mode. Table 2 lists the correspondence between pins and Figure 30 to 32 give the pin connection in the EPROM mode. When in the EPROM mode, ports P0, P11–P17, P20–P23, P3, P40, P41, VREF are used for the PROM (equivalent to the M5L27256). When in this mode, the built-in PROM can be written to or read from using these pins in the same way as with the M5L27256. The oscillator should be connected to the XIN and XOUT pins, or external clock should be connected to the XIN pin.

Table 2. Pin function in EPROM mode

	M37470E4/E8, M37471E4/E8	M5L27256
Vcc	Vcc	Vcc
VPP	P33	VPP
VSS	VSS	VSS
Address input	Ports P11–P17, P20–P23, P30, P31, P40, P41	A0–A14
Data I/O	Port P0	D0–D7
$\overline{\text{CE}}$	VREF	$\overline{\text{CE}}$
$\overline{\text{OE}}$	P32	$\overline{\text{OE}}$

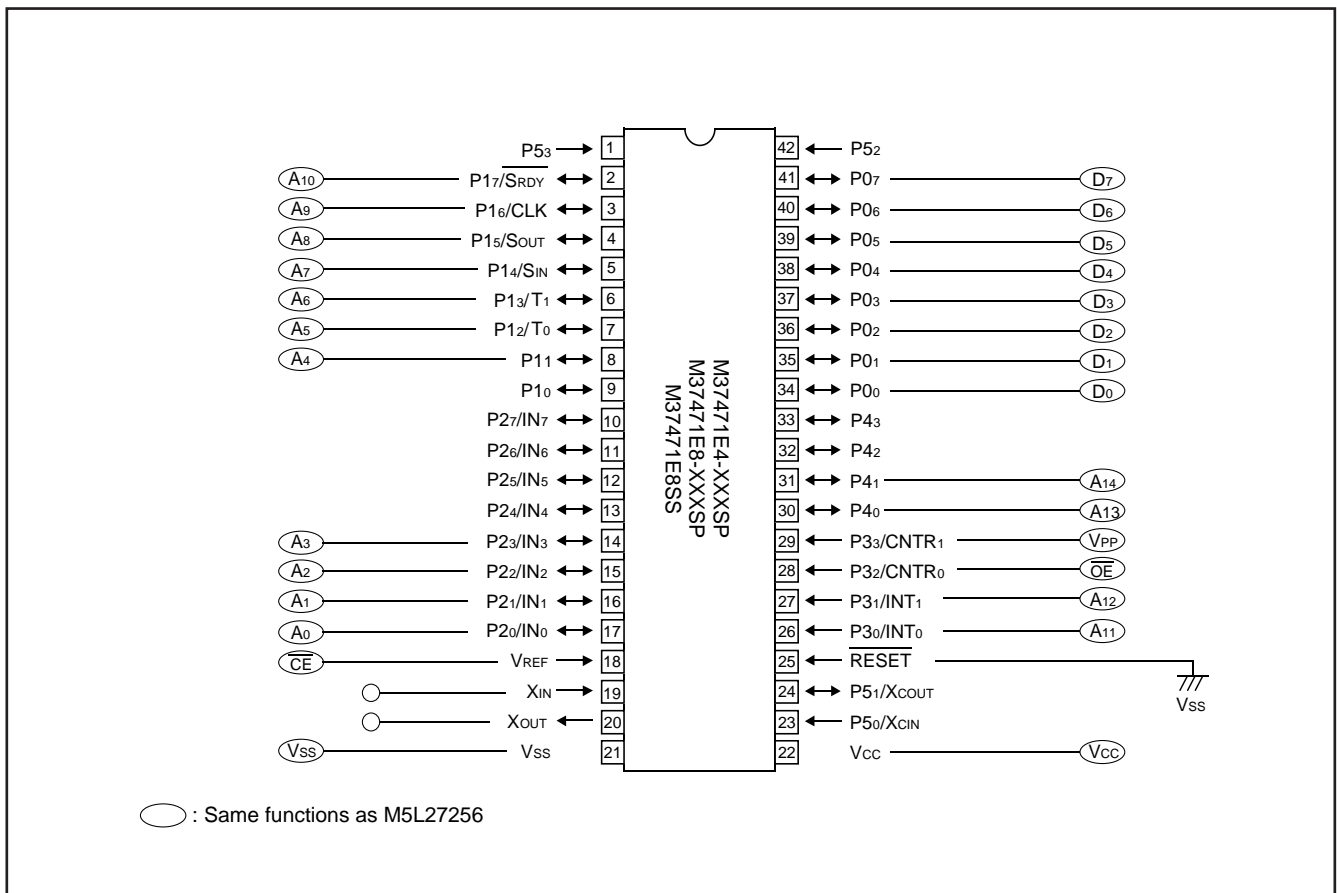


Fig. 28 Pin connection in EPROM mode

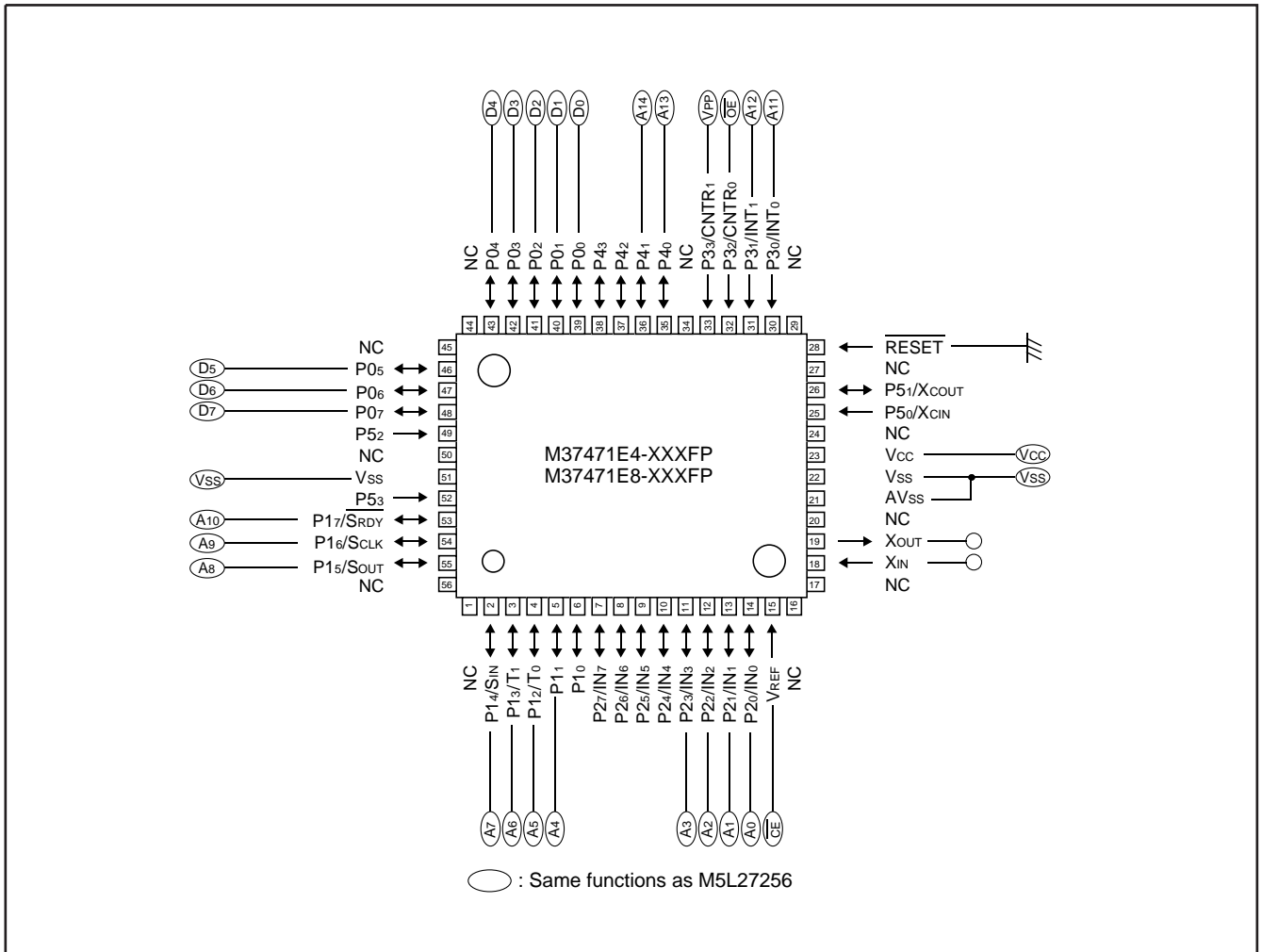


Fig. 29 Pin connection in EPROM mode

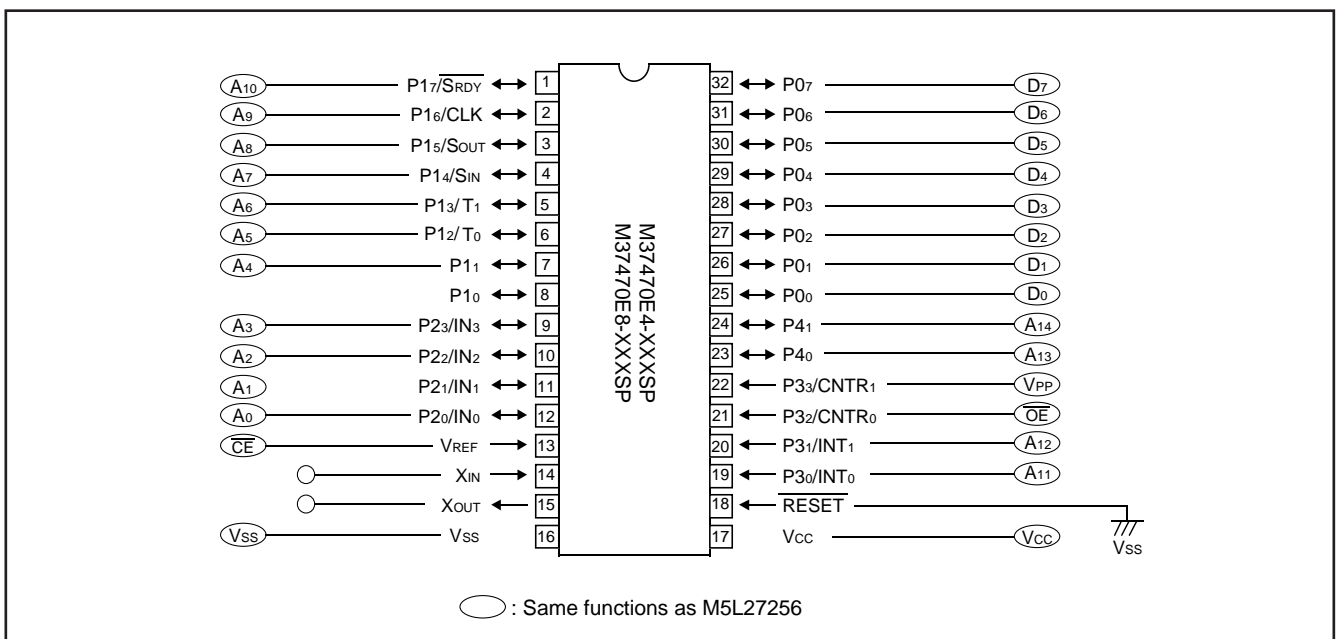


Fig. 30 Pin connection in EPROM mode

PROM READING AND WRITING

Reading

To read the PROM, set the \overline{CE} and \overline{OE} pins to "L" level. Input the address of the data (A₀–A₁₄) to be read and the data will be output to the I/O pins (D₀–D₇). The data I/O pins will be floating when either the \overline{CE} or \overline{OE} pin is in the "H" state.

Writing

To write to the PROM, set the \overline{OE} pin to "H" level. The CPU will enter the program mode when V_{PP} is applied to the V_{PP} pin. The address to be written to is selected with pins A₀–A₁₄, and the data to be written is input to pins D₀–D₇. Set the \overline{CE} pin to "L" level to begin writing.

Notes on Writing

- M37470E4, M37471E4

When using a PROM programmer, the address range should be between 6000₁₆ and 7FFF₁₆. Addresses 0000₁₆ to 5FFF₁₆ cannot be written to or read from correctly.

- M37470E8, M37471E8

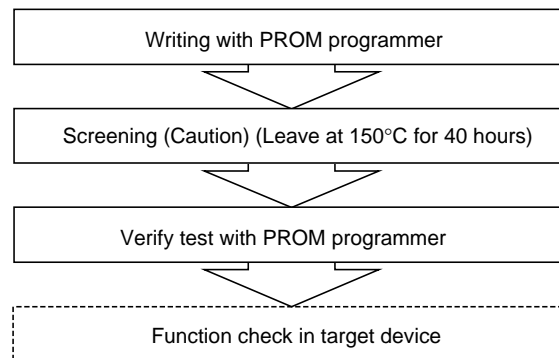
When using a PROM programmer, the address range should be between 4000₁₆ and 7FFF₁₆. When data is written between addresses 0000₁₆ and 7FFF₁₆, fill addresses 0000₁₆ to 3FFF₁₆ with FF₁₆.

Erasing

Data can only be erased on the M37471E8SS ceramic package, which includes a window. To erase data on this chip, use an ultraviolet light source with a 2537 Angstrom wave length. The minimum radiation power necessary for erasing is 15W-s/cm².

NOTES ON HANDLING

- (1) Sunlight and fluorescent light contain wave lengths capable of erasing data. For ceramic package types, cover the transparent window with a seal (provided) when this chip is in use. However, this seal must not contact the lead pins.
- (2) Before erasing, the glass should be cleaned and stains such as finger prints should be removed thoroughly. If these stains are not removed, complete erasure of the data could be prevented.
- (3) Since a high voltage (12.5 V) is used to write data, care should be taken when turning on the PROM programmer's power.
- (4) For the programmable microcomputer (shipped in One Time PROM version), Mitsubishi does not perform PROM write test and screening in the assembly process and following processes. To improve reliability after write, performing write and test according to the flow below before use is recommended.



Caution : Since the screening temperature is higher than storage temperature, never expose to 150°C exceeding 100 hours.

Table 3. I/O signal in each mode

Mode	Pin	\overline{CE}	\overline{OE}	V _{PP}	V _{CC}	Data I/O
Read-out		V _{IL}	V _{IL}	V _{CC}	V _{CC}	Output
Output disable		V _{IL}	V _{IH}	V _{CC}	V _{CC}	Floating
Programming		V _{IL}	V _{IH}	V _{PP}	V _{CC}	Input
Programming verify		V _{IH}	V _{IL}	V _{PP}	V _{CC}	Output
Program disable		V _{IH}	V _{IH}	V _{PP}	V _{CC}	Floating

Note : V_{IL} and V_{IH} indicate a "L" and "H" input voltage, respectively.

PROGRAMMING NOTES

- (1) The frequency ratio of the timer is 1/(n+1).
- (2) The contents of the interrupt request bits are not modified immediately after they have been written. After writing to an interrupt request register, execute at least one instruction before executing a BBC or BBS instruction.
- (3) To calculate in decimal notation, set the decimal mode flag (D) to "1", then execute an ADC or SBC instruction. Only the ADC and SBC instruction yield proper decimal results. After executing an ADC or SBC instruction, execute at least one instruction before executing a SEC, CLC, or CLD instruction.
- (4) An NOP instruction must be used after the execution of a PLP instruction.
- (5) Do not execute the STP instruction during A-D conversion.
- (6) In the M37470, set bit 0, bit 1, and bit 3-bit 7 to "0" of the CPU mode register.
- (7) Multiply/Divide instructions
 The index X mode (T) and the decimal mode (D) flag do not affect the MUL and DIV instruction.
 The execution of these instructions does not modify the contents of the processor status register.

DATA REQUIRED FOR MASK ORDERING

Please send the following data for mask orders.

- (1) mask ROM confirmation form
- (2) mark specification form
- (3) ROM data EPROM 3 sets

M37470M2/M4/M8-XXXSP, M37470E4/E8-XXXSP
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	V
V _I	Input voltage X _{IN}		-0.3 to V _{CC} +0.3	V
V _I	Input voltage P00-P07, P10-P17, P20-P23, P30-P33, P40, P41, VREF, RESET		-0.3 to V _{CC} +0.3	V
V _O	Output voltage P00-P07, P10-P17, P20-P23, P40, P41, X _{OUT}		-0.3 to V _{CC} +0.3	V
P _d	Power dissipation	T _a = 25°C	1000	mW
T _{opr}	Operating temperature		-20 to 85	°C
T _{stg}	Storage temperature		-40 to 150	°C

RECOMMENDED OPERATING CONDITIONS (V_{CC} = 2.7 to 5.5 V, V_{SS} = 0 V, T_a = -20 to 85°C unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
V _{CC}	Power source voltage	f(X _{IN}) = 2.2V _{CC} -2.0 MHz	2.7	4.5	V
		f(X _{IN}) = 8 MHz	4.5	5	
V _{SS}	Power source voltage		0		V
V _{IH}	"H" input voltage P00-P07, P10-P17, P30-P33, RESET, X _{IN}		0.8V _{CC}	V _{CC}	V
V _{IH}	"H" input voltage P20-P23, P40, P41		0.7V _{CC}	V _{CC}	V
V _{IL}	"L" input voltage P00-P07, P10-P17, P30-P33		0	0.2V _{CC}	V
V _{IL}	"L" input voltage P20-P23, P40, P41		0	0.25V _{CC}	V
V _{IL}	"L" input voltage RESET		0	0.12V _{CC}	V
V _{IL}	"L" input voltage X _{IN}		0	0.16V _{CC}	V
I _{OH(sum)}	"H" sum output current P00-P07, P40, P41			-30	mA
I _{OH(sum)}	"H" sum output current P10-P17, P20-P23			-30	mA
I _{OL(sum)}	"L" sum output current P00-P07, P40, P41			60	mA
I _{OL(sum)}	"L" sum output current P10-P17, P20-P23			60	mA
I _{OH(peak)}	"H" peak output current P00-P07, P10-P17, P20-P23, P40, P41			-10	mA
I _{OL(peak)}	"L" peak output current P00-P07, P10-P17, P20-P23, P40, P41			20	mA
I _{OH(avg)}	"H" average output current P00-P07, P10-P17, P20-P23, P40, P41 (Note 2)			-5	mA
I _{OL(avg)}	"L" average output current P00-P07, P10-P17, P20-P23, P40, P41 (Note 2)			10	mA
f(CNTR)	Timer input frequency CNTR0 (P32), CNTR1 (P33) (Note 1)	f(X _{IN}) = 4 MHz		1	MHz
		f(X _{IN}) = 8 MHz		2	
f(CLK)	Serial I/O clock input frequency SCLK (P16) (Note 1)	f(X _{IN}) = 4 MHz		1	MHz
		f(X _{IN}) = 8 MHz		2	
f(X _{IN})	Clock input oscillation frequency (Note 1)	V _{CC} = 2.7 to 4.5 V		2.2V _{CC} - 2.0	MHz
		V _{CC} = 4.5 to 5.5 V		8	

Notes 1 : Oscillation frequency is at 50% duty cycle.

2 : The average output current I_{OH} (avg) and I_{OL} (avg) are the average value during a 100 ms.

M37470M2/M4/M8-XXXSP, M37470E4/E8-XXXSP

ELECTRICAL CHARACTERISTICS ($V_{CC} = 2.7$ to 5.5 V, $V_{SS} = 0$ V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test Conditions		Limits			Unit		
				Min.	Typ.	Max.			
VOH	“H” output voltage P00–P07, P10–P17, P20–P23, P40, P41	VCC = 5 V, IOH = –5 mA		3			V		
		VCC = 3 V, IOH = –1.5 mA		2					
VOL	“L” output voltage P00–P07, P10–P17, P20–P23, P40, P41	VCC = 5 V, IOL = 10 mA				2	V		
		VCC = 3 V, IOL = 3 mA				1			
VT+ – VT–	Hysteresis P00 – P07, P30 – P33	VCC = 5 V			0.5		V		
		VCC = 3 V			0.3				
VT+ – VT–	Hysteresis $\overline{\text{RESET}}$	VCC = 5 V			0.5		V		
		VCC = 3 V			0.3				
VT+ – VT–	Hysteresis P16/CLK	use as CLK input	VCC = 5 V		0.5		V		
			VCC = 3 V		0.3				
IIL	“L” input current P00–P07, P10–P17, P30–P32, P40–P41	Vi = 0 V, not use pull-up transistor	VCC = 5 V			–5	μA		
			VCC = 3 V			–3			
		Vi = 0 V, use pull-up transistor	VCC = 5 V	–0.25	–0.5	–1.0	mA		
			VCC = 3 V	–0.08	–0.18	–0.35			
IIL	“L” input current P33	Vi = 0 V	VCC = 5 V			–5	μA		
			VCC = 3 V			–3			
IIL	“L” input current P20–P23	Vi = 0 V, not use as analog input, not use pull-up transistor	VCC = 5 V			–5	μA		
			VCC = 3 V			–3			
		Vi = 0 V, not use as analog input, use pull-up transistor	VCC = 5 V	–0.25	–0.5	–1.0	mA		
			VCC = 3 V	–0.08	–0.18	–0.35			
IIL	“L” input current $\overline{\text{RESET}}$, XIN	Vi = 0 V (XIN is at stop mode)	VCC = 5 V			–5	μA		
			VCC = 3 V			–3			
IIH	“H” input current P00–P07, P10–P17, P30–P32, P40, P41	Vi = VCC, not use pull-up transistor	VCC = 5 V			5	μA		
			VCC = 3 V			3			
IIH	“H” input current P33	Vi = VCC	VCC = 5 V			5	μA		
			VCC = 3 V			3			
IIH	“H” input current P20–P23	Vi = VCC, not use as analog input, not use pull-up transistor	VCC = 5 V			5	μA		
			VCC = 3 V			3			
IIH	“H” input current $\overline{\text{RESET}}$, XIN	Vi = VCC, (XIN is at stop mode)	VCC = 5 V			5	μA		
			VCC = 3 V			3			
ICC	Power source current	At normal mode, A-D conversion is not executed.	f(XIN)=8 MHz	VCC = 5 V		7	14	mA	
			f(XIN)=4 MHz			3.5	7		
			At normal mode, A-D conversion is executed.	f(XIN)=8 MHz	VCC = 5 V		7.5	15	mA
				f(XIN)=4 MHz			4	8	
		At wait mode.	f(XIN)=8 MHz	VCC = 5 V		2	4	mA	
			f(XIN)=4 MHz			1	2		
		At stop mode, f(XIN)=0, VCC=5 V			Ta = 25°C		0.1	1	μA
					Ta = 85°C		1	10	
VRAM	RAM retention voltage	Stop all oscillation			2		5.5	V	

A-D CONVERTER CHARACTERISTICS

(VCC = 2.7 to 5.5 V, VSS = 0 V, Ta = -20 to 85°C, f(XIN)=4 MHz, unless otherwise noted)

Symbol	Parameter	Test Conditions	Limits			Unit
			Min.	Typ.	Max.	
-	Resolution				8	bits
-	Non-linearity error				±2	LSB
-	Differential non-linearity error				±0.9	LSB
VOT	Zero transition error	VCC = VREF = 5.12 V, IOL(sum) = 0 mA			2	LSB
		VCC = VREF = 3.072 V, IOL(sum) = 0 mA			3	
VFST	Full-scale transition error	VCC = VREF = 5.12 V			4	LSB
		VCC = VREF = 3.072 V			7	
tCONV	Conversion time	VCC = 2.7 to 5.5 V, f(XIN) = 4 MHz			25	µs
		VCC = 4.5 to 5.5 V, f(XIN) = 8 MHz			12.5	
VREF	Reference input voltage		0.5VCC		VCC	V
RLADDER	Ladder resistance value		2	5	10	kΩ
VIA	Analog input voltage		0		VREF	V

M37471M2/M4/M8-XXXSP/FP, M37471E4/E8-XXXSP/FP, M37471E8SS
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	V
V _I	Input voltage X _{IN}		-0.3 to V _{CC} +0.3	V
V _I	Input voltage P00-P07, P10-P17, P20-P27, P30-P33, P40-P43, P50-P53, V _{REF} , RESET		-0.3 to V _{CC} +0.3	V
V _O	Output voltage P00-P07, P10-P17, P20-P27, P40-P43, X _{OUT}		-0.3 to V _{CC} +0.3	V
P _d	Power dissipation	T _a = 25°C	1000 (Note 1)	mW
T _{opr}	Operating temperature		-20 to 85	°C
T _{stg}	Storage temperature		-40 to 150	°C

Note 1 : 500 mW for M37471M2/M4/M8-XXXFP.

RECOMMENDED OPERATING CONDITIONS (V_{CC} = 2.7 to 5.5 V, V_{SS} = AV_{SS} = 0 V, T_a = -20 to 85°C unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V _{CC}	Power source voltage	f(X _{IN}) = 2.2V _{CC} - 2.0 MHz	2.7		4.5	V
		f(X _{IN}) = 8 MHz	4.5	5	5.5	
V _{SS}	Power source voltage			0		V
AV _{SS}	Analog power source voltage			0		V
V _{IH}	"H" input voltage P00-P07, P10-P17, P30-P33, RESET, X _{IN}		0.8V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage P20-P27, P40-P43, P50-P53 (Note 1)		0.7V _{CC}		V _{CC}	V
V _{IL}	"L" input voltage P00-P07, P10-P17, P30-P33		0		0.2V _{CC}	V
V _{IL}	"L" input voltage P20-P27, P40-P43, P50-P53 (Note 1)		0		0.25V _{CC}	V
V _{IL}	"L" input voltage RESET		0		0.12V _{CC}	V
V _{IL}	"L" input voltage X _{IN}		0		0.16V _{CC}	V
I _{OH} (sum)	"H" sum output current P00-P07, P40-P43				-30	mA
I _{OH} (sum)	"H" sum output current P10-P17, P20-P27				-30	
I _{OL} (sum)	"L" sum output current P00-P07, P40-P43				60	mA
I _{OL} (sum)	"L" sum output current P10-P17, P20-P27				60	
I _{OH} (peak)	"H" peak output current P00-P07, P10-P17, P20-P27, P40-P43				-10	mA
I _{OL} (peak)	"L" peak output current P00-P07, P10-P17, P20-P27, P40-P43				20	
I _{OH} (avg)	"H" average output current P00-P07, P10-P17, P20-P27, P40-P43 (Note 2)				-5	mA
I _{OL} (avg)	"L" average output current P00-P07, P10-P17, P20-P27, P40-P43 (Note 2)				10	
f(CNTR)	Timer input frequency CNTR ₀ (P32), CNTR ₁ (P33) (Note 3)	f(X _{IN}) = 4 MHz			1	MHz
		f(X _{IN}) = 8 MHz			2	
f(CLK)	Serial I/O clock input frequency SCLK (P16) (Note 3)	f(X _{IN}) = 4 MHz			1	MHz
		f(X _{IN}) = 8 MHz			2	
f(X _{IN})	Main clock input oscillation frequency (Note 3)	V _{CC} = 2.7 to 4.5 V			2.2V _{CC} - 2.0	MHz
		V _{CC} = 4.5 to 5.5 V			8	
f(X _{CIN})	Sub-clock input oscillation frequency for clock function (Note 3, 4)		32	50	kHz	

Notes 1 : It is except to use P50 as X_{CIN}.

2 : The average output current I_{OH} (avg) and I_{OL} (avg) are the average value during a 100 ms.

3 : Oscillation frequency is at 50% duty cycle.

4 : When used in the low-speed mode, the clock oscillation frequency for clock function should be f(X_{CIN}) < f(X_{IN}) / 3.

M37471M2/M4/M8-XXXSP/FP, M37471E4/E8-XXXSP/FP, M37471E8SS

ELECTRICAL CHARACTERISTICS ($V_{CC} = 2.7$ to 5.5 V, $V_{SS} = AV_{SS} = 0$ V, $T_a = -20$ to 85°C , unless otherwise noted)

Symbol	Parameter	Test Conditions		Limits			Unit	
				Min.	Typ.	Max.		
VOH	"H" output voltage P00-P07, P10-P17, P20-P27, P40-P43	VCC = 5 V, IOH = -5 mA		3			V	
		VCC = 3 V, IOH = -1.5 mA		2				
VOL	"L" output voltage P00-P07, P10-P17, P20-P27, P40-P43	VCC = 5 V, IOL = 10 mA				2	V	
		VCC = 3 V, IOL = 3 mA				1		
VT+ - VT-	Hysteresis P00-P07, P30-P33	VCC = 5 V			0.5		V	
		VCC = 3 V			0.3			
VT+ - VT-	Hysteresis $\overline{\text{RESET}}$	VCC = 5 V			0.5		V	
		VCC = 3 V			0.3			
VT+ - VT-	Hysteresis P16/CLK	used as CLK input	VCC = 5 V		0.5		V	
			VCC = 3 V		0.3			
IIL	"L" input current P00-P07, P10-P17, P30-P32, P40-P43, P50-P53	VI = 0 V, not use pull-up transistor	VCC = 5 V			-5	μA	
			VCC = 3 V			-3		
		VI = 0 V, use pull-up transistor	VCC = 5 V	-0.25	-0.5	-1.0	mA	
			VCC = 3 V	-0.08	-0.18	-0.35		
IIL	"L" input current P33	VI = 0 V	VCC = 5 V			-5	μA	
			VCC = 3 V			-3		
IIL	"L" input current P20-P27	VI = 0 V, not use as analog input, not use pull-up transistor	VCC = 5 V			-5	μA	
			VCC = 3 V			-3		
		VI = 0 V, not use as analog input, use pull-up transistor	VCC = 5 V	-0.25	-0.5	-1.0	mA	
			VCC = 3 V	-0.08	-0.18	-0.35		
IIL	"L" input current $\overline{\text{RESET}}$, XIN	VI = 0 V (XIN is at stop mode)	VCC = 5 V			-5	μA	
			VCC = 3 V			-3		
IIH	"H" input current P00-P07, P10-P17, P30-P32, P40-P43, P50-P53	VI = VCC, not use pull-up transistor	VCC = 5 V			5	μA	
			VCC = 3 V			3		
IIH	"H" input current P33	VI = VCC	VCC = 5 V			5	μA	
			VCC = 3 V			3		
IIH	"H" input current P20-P27	VI = VCC, not use as analog input, not use pull-up transistor	VCC = 5 V			5	μA	
			VCC = 3 V			3		
IIH	"H" input current $\overline{\text{RESET}}$, XIN	VI = VCC, (XIN is at stop mode)	VCC = 5 V			5	μA	
			VCC = 3 V			3		
ICC	Power source current	At normal mode, A-D conversion is not executed.	f(XIN)=8 MHz	VCC = 5 V		7	14	mA
				VCC = 3 V		3.5	7	
			f(XIN)=4 MHz	VCC = 5 V		1.8	3.6	
				VCC = 3 V		1.8	3.6	
		At normal mode, A-D conversion is executed.	f(XIN)=8 MHz	VCC = 5 V		7.5	15	mA
				VCC = 3 V		4	8	
			f(XIN)=4 MHz	VCC = 5 V		2	4	
				VCC = 3 V		2	4	
		At low-speed mode, Ta=25°C, f(XIN)=0, f(XCIN)=32 kHz, XCOUT drive capacity is low, A-D conversion is not executed.		VCC = 5 V		30	80	μA
				VCC = 3 V		15	40	
		At wait mode.	f(XIN)=8 MHz	VCC = 5 V		2	4	mA
				VCC = 3 V		1	2	
f(XIN)=4 MHz	VCC = 5 V		0.5	1				
	VCC = 3 V		0.5	1				
At wait mode, XIN = 0 Hz, XCIN = 32 kHz, XCOUT is low-power mode, Ta=25°C		VCC = 5 V		3	12	μA		
		VCC = 3 V		2	8			
Stop all oscillation VCC = 5 V		Ta = 25°C		0.1	1	μA		
		Ta = 85°C		1	10			
VRAM	RAM retention voltage	Stop all oscillation		2			V	

A-D CONVERTER CHARACTERISTICS

(VCC = 2.7 to 5.5 V, VSS = AVSS = 0 V, Ta = -20 to 85°C, f(XIN) = 4 MHz, unless otherwise noted)

Symbol	Parameter	Test Conditions	Limits			Unit
			Min.	Typ.	Max.	
-	Resolution				8	bits
-	Non-linearity error				±2	LSB
-	Differential non-linearity error				±0.9	LSB
VOT	Zero transition error	VCC = VREF = 5.12 V, IOL(sum) = 0 mA			2	LSB
		VCC = VREF = 3.072 V, IOL(sum) = 0 mA			3	
VFST	Full-scale transition error	VCC = VREF = 5.12 V			4	LSB
		VCC = VREF = 3.072 V			7	
tCONV	Conversion time	VCC = 2.7 to 5.5 V, f(XIN) = 4 MHz			25	µs
		VCC = 4.5 to 5.5 V, f(XIN) = 8 MHz			12.5	
VREF	Reference input voltage		0.5VCC		VCC	V
RLADDER	Ladder resistance value		2	5	10	kΩ
VIA	Analog input voltage		0		VREF	V

Keep safety first in your circuit designs!

- Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

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REVISION DESCRIPTION LIST

7470/7471 GROUP DATA SHEET

Rev. No.	Revision Description	Rev. date
1.0	First Edition	980110