

MITSUBISHI MICROCOMPUTERS 7477/7478 GROUP

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

DESCRIPTION

The 7477/7478 group is the single-chip microcomputer designed with CMOS silicon gate technology.

The single-chip microcomputer is 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.

In addition, built-in PROM type microcomputers with built-in electrically writable PROM, and additional functions equivalent to the mask ROM version are also available.

7477/7478 group products are shown noted below.

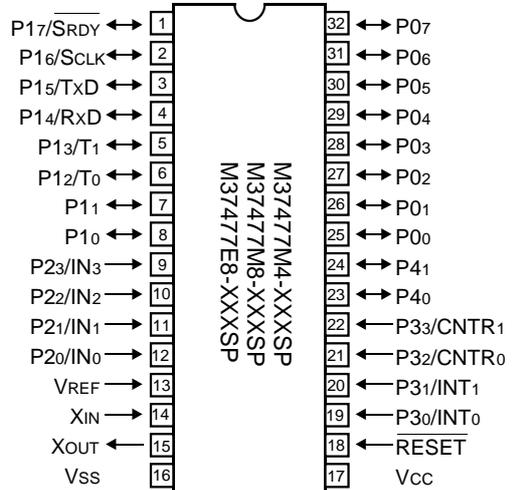
The 7477 and the 7478 differ in the number of I/O ports, package outline, and clock generating circuit only.

| Product | Version |
|-------------------|--------------------------------------------------------------|
| M37477M4-XXXSP/FP | Mask ROM version |
| M37477M8-XXXSP/FP | |
| M37477E8SP/FP | One Time PROM version (Built-in PROM type microcomputers) |
| M37477E8-XXXSP/FP | |
| M37478M4-XXXSP/FP | Mask ROM version |
| M37478M8-XXXSP/FP | |
| M37478E8SP/FP | One Time PROM version (Built-in PROM type microcomputers) |
| M37478E8-XXXSP/FP | |
| M37478E8SS | PROM version (Built-in PROM type microcomputer) |

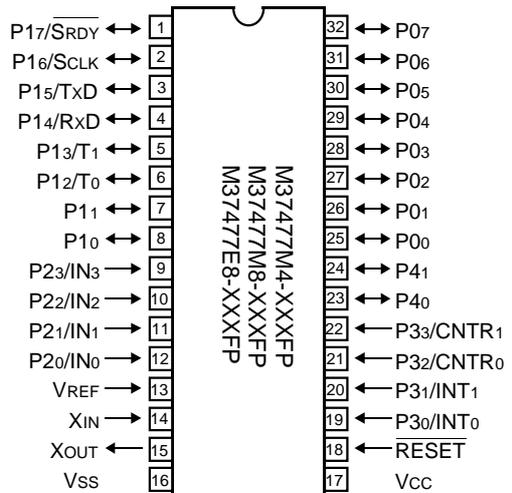
FEATURES

- Basic machine-language instructions 71
- Memory size
 - ROM 8192 bytes (M37477M4, M37478M4)
 - RAM 192 bytes (M37477M4, M37478M4)
- The minimum instruction execution time 0.5μs (at 8MHz oscillation frequency)
- Power source voltage
 - 2.7 to 4.5V (at 2.2V_{CC} – 2.0MHz oscillation frequency)
 - 4.5 to 5.5V (at 8MHz oscillation frequency)
- Power dissipation in normal mode 35mW (at 8MHz oscillation frequency)
- Subroutine nesting 96 levels max. (M37477M4, M37478M4)
- Interrupt 13 sources, 11 vectors
- 8-bit timers 4
- Programmable I/O ports
 - (Ports P0, P1, P4) 18 (7477 group)
 - 20 (7478 group)
- Input ports (Ports P2, P3) 8 (7477 group)
- 16 (7478 group)
- 8-bit serial I/O 1 (UART or clock-synchronized)
- 8-bit A-D converter 4 channels (7477 group)
- 8 channels (7478 group)

PIN CONFIGURATION (TOP VIEW)



Outline 32P4B



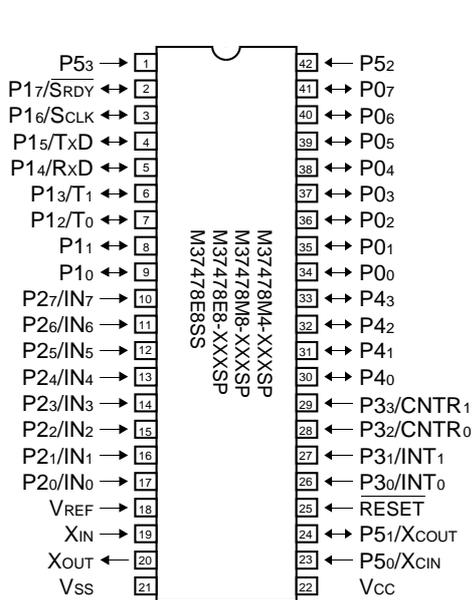
Outline 32P2W-A

Note : The only differences between the 32P4B package product and the 32P2W-A package product are package shape and absolute maximum ratings.

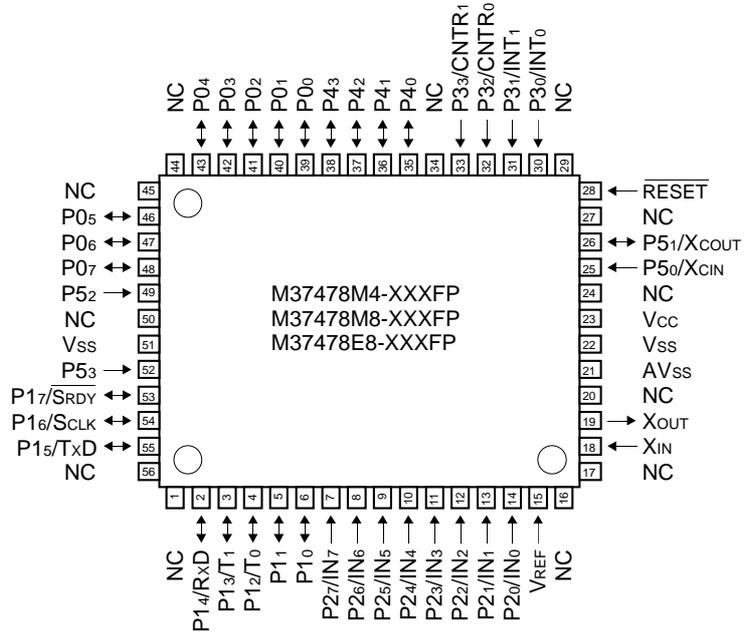
APPLICATIONS

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

PIN CONFIGURATION (TOP VIEW)

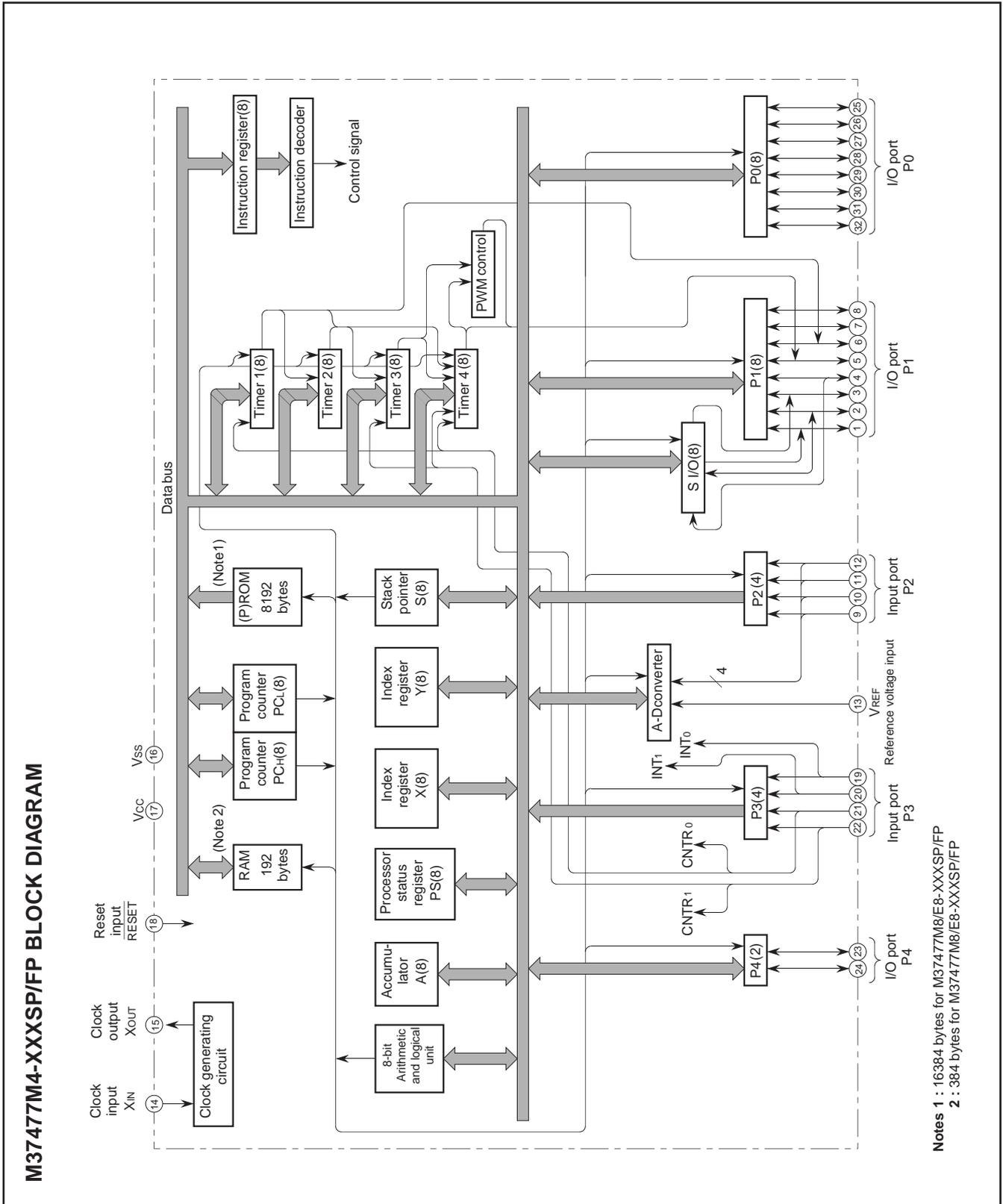


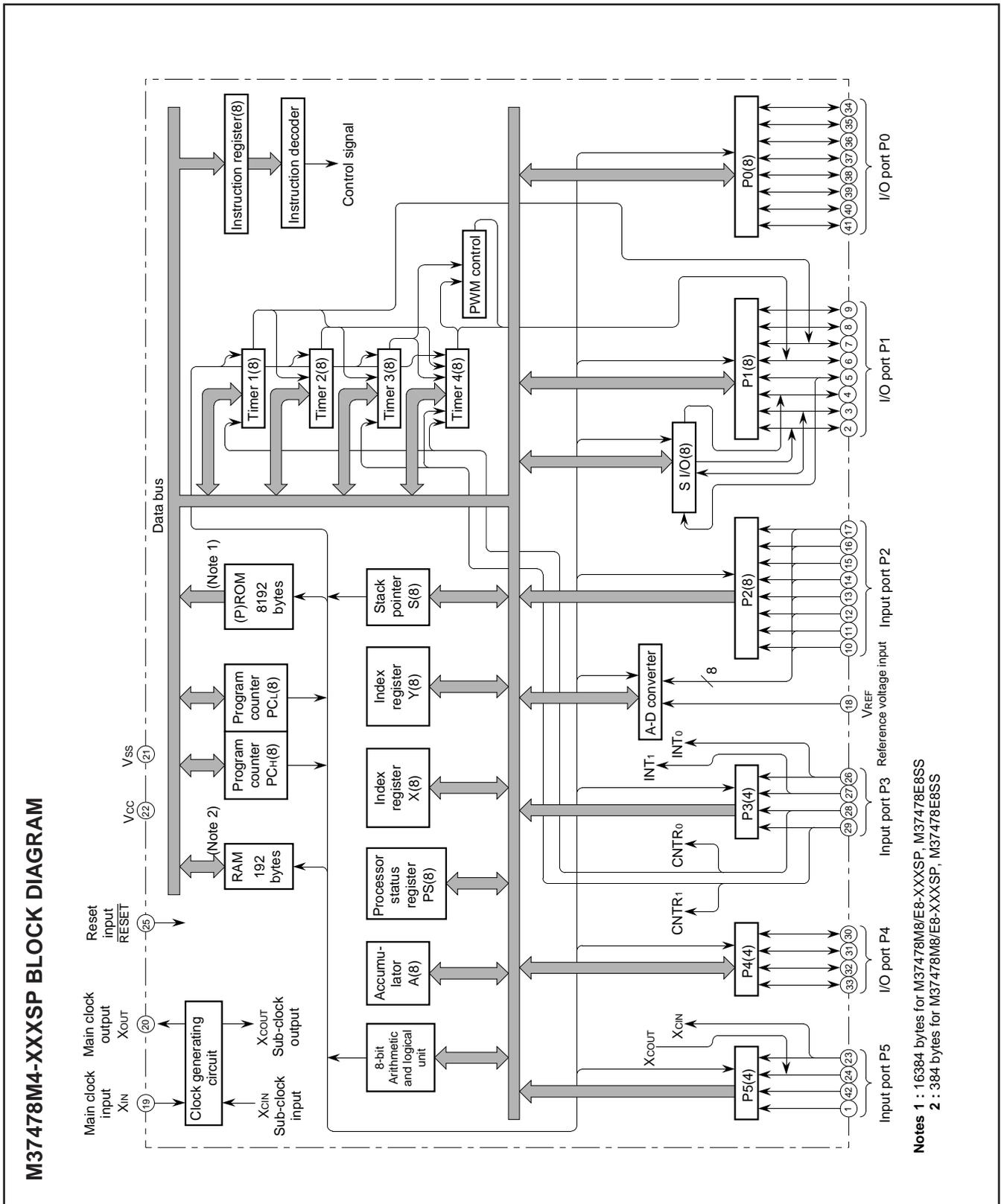
Outline 42P4B
42S1B-A (Window)



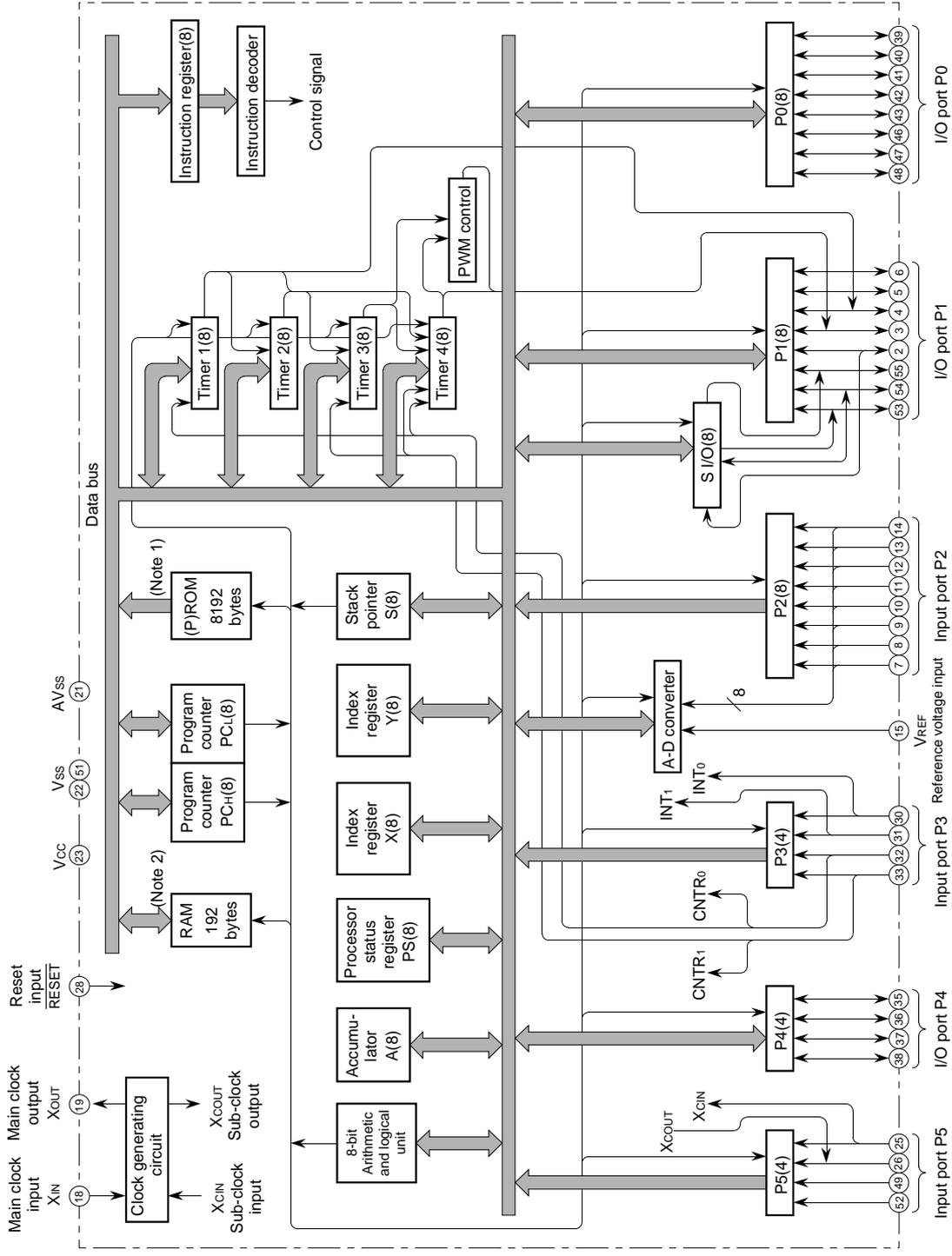
Outline 56P6N-A

Note : The only differences between the 42P4B package product and the 56P6N-A package product are package shape, absolute maximum ratings and the fact that the 56P6N-A package product has an AVss pin.





M37478M4-XXXXFP BLOCK DIAGRAM



FUNCTIONS OF 7477/7478 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 | M37477M4 | ROM | 8192 bytes |
| | M37478M4 | RAM | 192 bytes |
| | M37477M8/E8 | (P)ROM | 16384 bytes |
| | M37478M8/E8 | RAM | 384 bytes |
| Input/Output port | P0, P1 | I/O | 8-bit \times 2 |
| | P2 | Input | 8-bit \times 1 (4-bit \times 1 for the 7477 group) |
| | P3, P5 | Input | 4-bit \times 2 (Port P5 is not included in the 7477 group) |
| | P4 | I/O | 4-bit \times 1 (2-bit \times 1 for the 7477 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 the 7477 group) | |
| Subroutine nesting | M37477M4, M37478M4 | | 96 (max.) |
| | M37477M8/E8, M37478M8/E8 | | 192 (max.) |
| Interrupt | | 5 external interrupts, 7 internal interrupts, 1 software interrupt | |
| Clock generating circuit | | Built-in circuit with internal feedback resistor (a ceramic or a quartz-crystal oscillator) | |
| Power source circuit | | 2.7 to 4.5V (at 2.2V _{CC} -2.0MHz oscillation frequency), 4.5 to 5.5V (at 8MHz oscillation frequency) | |
| Power dissipation | | 35mW (at 8MHz oscillation frequency) | |
| Input/Output characters | Input/Output voltage | | 5V |
| | Output current | | -5 to 10mA (P0, P1, P4 : CMOS tri-states) |
| Operating temperature range | | -20 to 85°C | |
| Device structure | | CMOS silicon gate | |
| Package | M37477M4/M8/E8-XXXSP | | 32-pin shrink plastic molded DIP |
| | M37477M4/M8/E8-XXXFP | | 32-pin plastic molded SOP |
| | M37478M4/M8/E8-XXXSP | | 42-pin shrink plastic molded DIP |
| | M37478M4/M8/E8-XXXFP | | 56-pin plastic molded QFP |
| | M37478E8SS | | 42-pin ceramic DIP |

PIN DESCRIPTION

| Pin | Name | Input/ Output | Functions |
|-----------------------------------------------|-------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VCC, VSS | Power source | | Apply voltage of 2.7 to 5.5V to VCC, and 0V 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 2μs 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 A-D converter. |
| P0 ₀ – P0 ₇ | 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. |
| P1 ₀ – P1 ₇ | 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. P1 ₂ and P1 ₃ are in common with timer output pins T ₀ and T ₁ . P1 ₄ , P1 ₅ , P1 ₆ and P1 ₇ are in common with serial I/O pins Rx _D , Tx _D , SCLK and SRDY, respectively. |
| P2 ₀ – P2 ₇ (Note 2) | Input port P2 | Input | Port P2 is an 8-bit input port. This port is in common with analog input pins IN ₀ to IN ₇ . |
| P3 ₀ – P3 ₃ | Input port P3 | Input | Port P3 is a 4-bit input port. P3 ₀ , P3 ₁ are in common with external interrupt input pins INT ₀ , INT ₁ , and P3 ₂ , P3 ₃ are in common with timer input pins CNTR ₀ , CNTR ₁ . |
| P4 ₀ – P4 ₃ (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. |
| P5 ₀ – P5 ₃ (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. P5 ₀ , P5 ₁ are in common with input/output pins of clock for clock function XCIN, XCOUT. When P5 ₀ , P5 ₁ 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 M37478M4/M8/E8-XXXFP.
 - 2 : Only P2₀–P2₃ (IN₀–IN₃) 4-bit for the 7477 group.
 - 3 : Only P4₀ and P4₁ 2-bit for the 7477 group.
 - 4 : This port is not included in the 7477 group.

FUNCTIONAL DESCRIPTION

Central Processing Unit (CPU)

The 7477/7478 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.

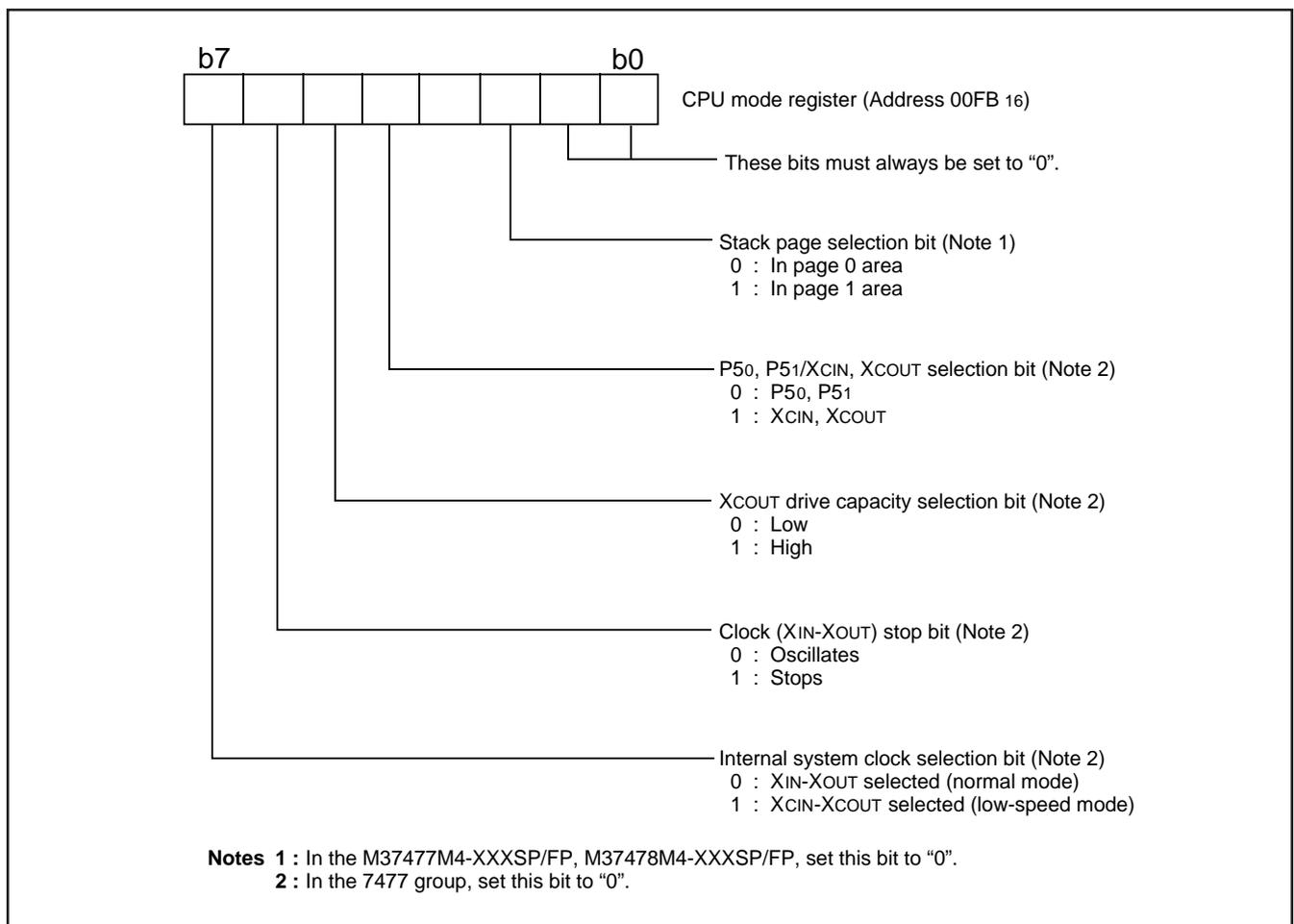


Fig. 1 Structure of CPU mode register

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.

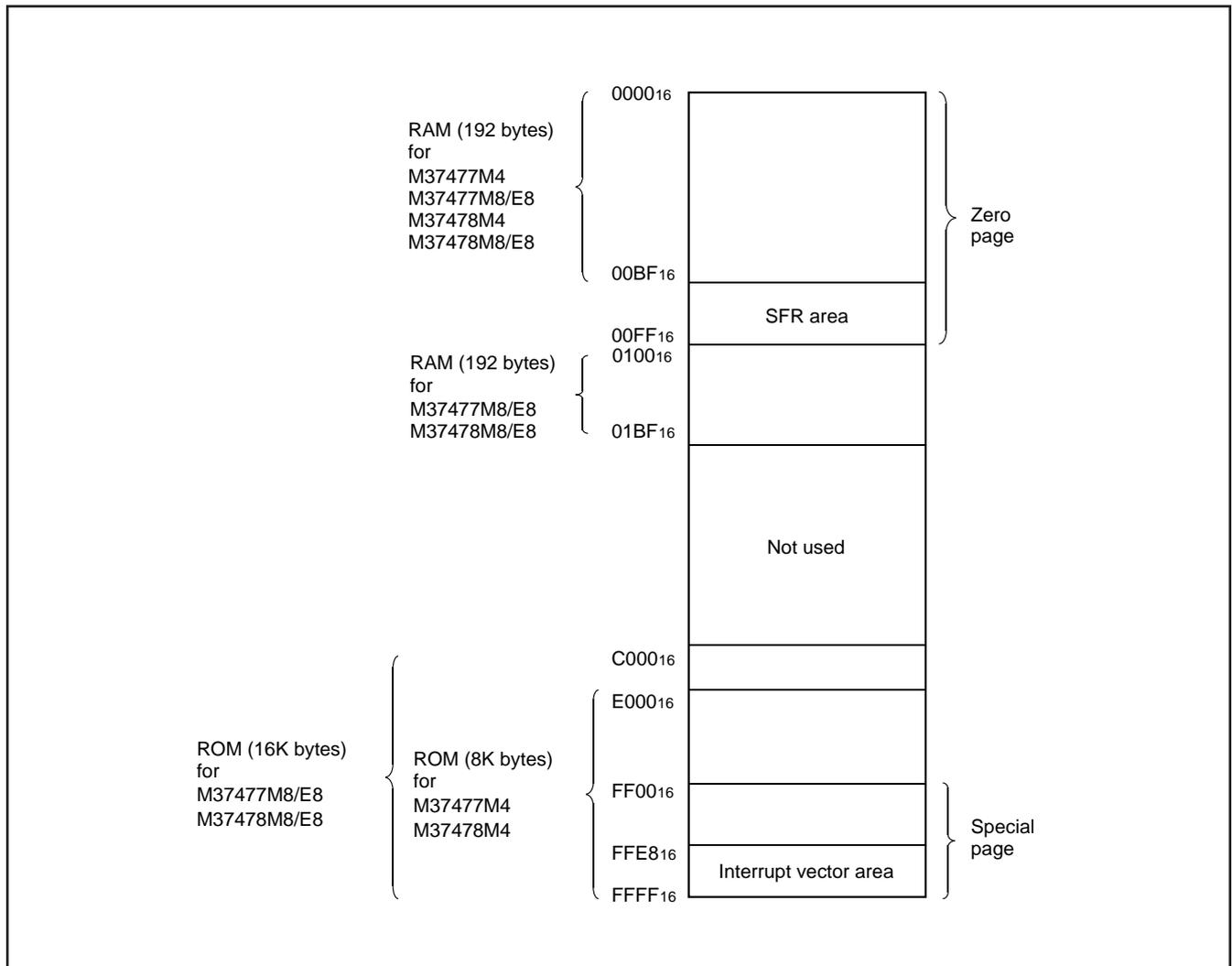


Fig. 2 Memory map

| | | | |
|--------------------|-----------------------------------------|--------------------|----------------------------------|
| 00C0 ₁₆ | Port P0 | 00E0 ₁₆ | Transmit/receive buffer register |
| 00C1 ₁₆ | Port P0 direction register | 00E1 ₁₆ | Serial I/O status register |
| 00C2 ₁₆ | Port P1 | 00E2 ₁₆ | Serial I/O control register |
| 00C3 ₁₆ | Port P1 direction register | 00E3 ₁₆ | UART control register |
| 00C4 ₁₆ | Port P2 | 00E4 ₁₆ | Baud rate generator |
| 00C5 ₁₆ | | 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 | | 00FC ₁₆ | Interrupt request register 1 |
| 00DD ₁₆ | | 00FD ₁₆ | Interrupt request register 2 |
| 00DE ₁₆ | | 00FE ₁₆ | Interrupt control register 1 |
| 00DF ₁₆ | | 00FF ₁₆ | Interrupt control register 2 |

Notes 1 : This address is not used in the 7477 group.
2 : This address is allocated P1–P4 pull-up control register for the 7477 group.

Fig. 3 SFR (Special Function Register) memory map

INTERRUPTS

Interrupts can be caused by 13 different sources consisting of five external, seven 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 receive interrupt | 9 | FFEF ₁₆ , FFEE ₁₆ | |
| Serial I/O transmit interrupt | 10 | FFED ₁₆ , FFEC ₁₆ | |
| A-D conversion completion interrupt | 11 | FFEB ₁₆ , FFEA ₁₆ | |
| BRK instruction interrupt | 12 | FFE9 ₁₆ , FFE8 ₁₆ | Non-maskable software interrupt |

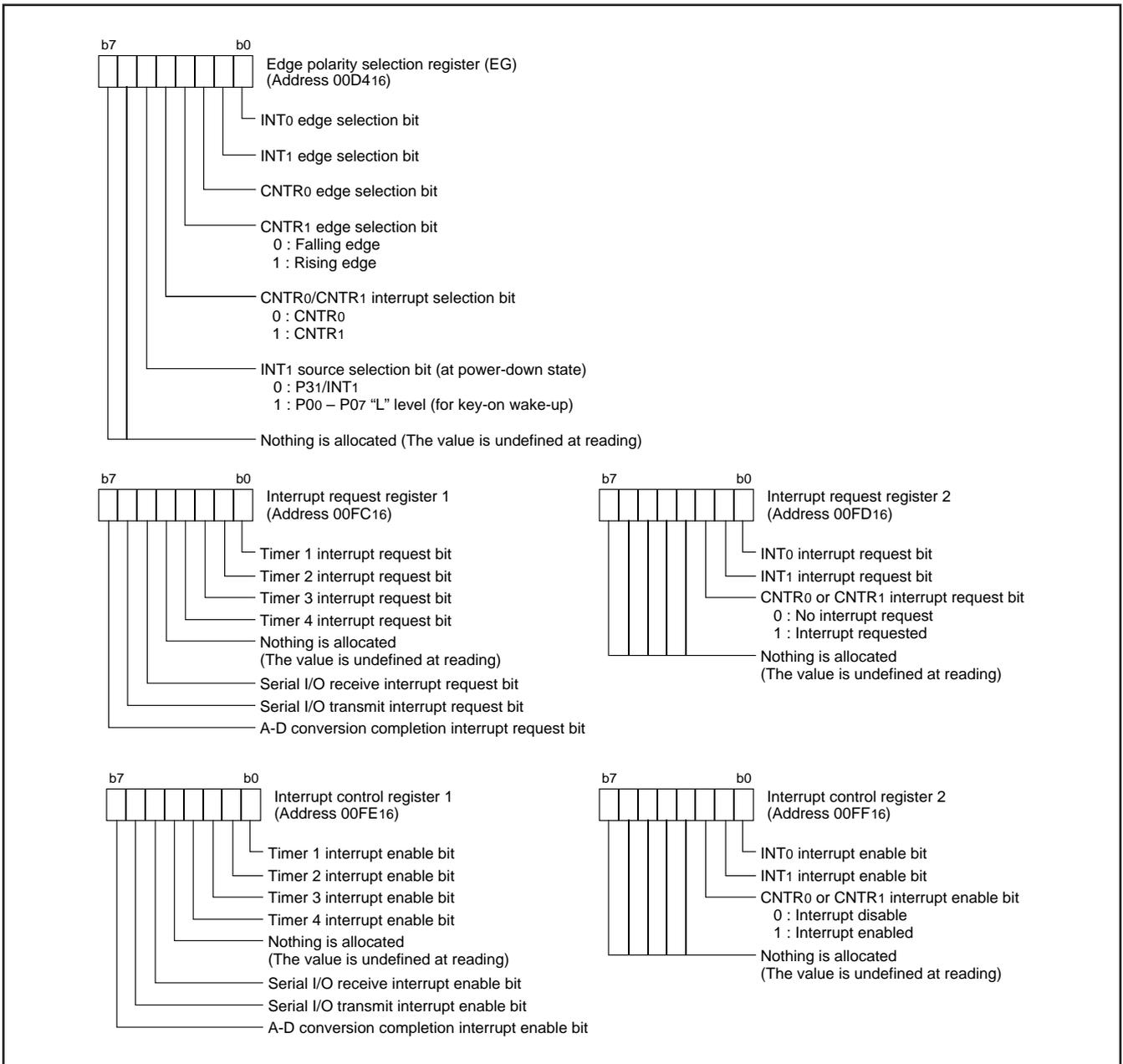


Fig. 4 Structure of registers related to interrupt

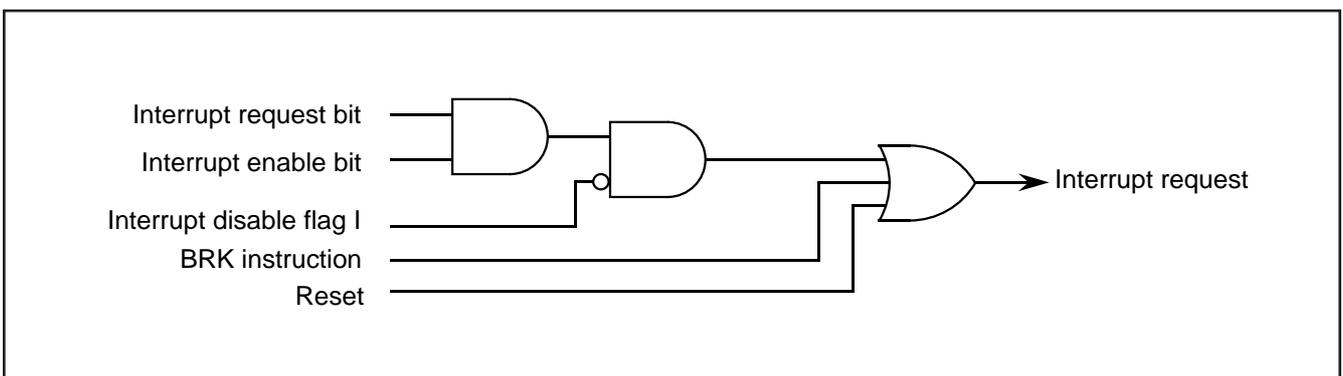


Fig. 5 Interrupt control

TIMER

The 7477/7478 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 $f(XIN)$ divided by 16, $f(XCIN)$ divided by 16, $f(XCIN)$, or event input from P32/CNTR₀ pin. Do not select $f(XCIN)$ as the count source in the 7477 group. When bit 1 and bit 2 in the timer 12 mode register are "0", $f(XIN)$ divided by 16 or $f(XCIN)$ divided by 16 is selected. Selection between $f(XIN)$ and $f(XCIN)$ 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", $f(XCIN)$ 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 $f(XIN)$ or $f(XCIN)$, and timer 1 overflow. Do not select $f(XCIN)$ as the count source in the 7477 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 $f(XIN)$ or $f(XCIN)$ is selected. The divide ratio is selected according to bit 6 and bit 7 in the timer 12 mode register, and selection between $f(XIN)$ and $f(XCIN)$ 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 $f(XIN)$ divided by 16, $f(XCIN)$ divided by 16, $f(XCIN)$, timer 1 or timer 2 overflow, or an event input from P33/CNTR₁ pins 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 $f(XCIN)$ as the count source in the 7477 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, $f(XIN)$ divided by 16, $f(XCIN)$ divided by 16, $f(XCIN)$, 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 $f(XCIN)$ as the count source in the 7477 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 ...0₁₆ 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 7477/7478 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 7477/7478 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.

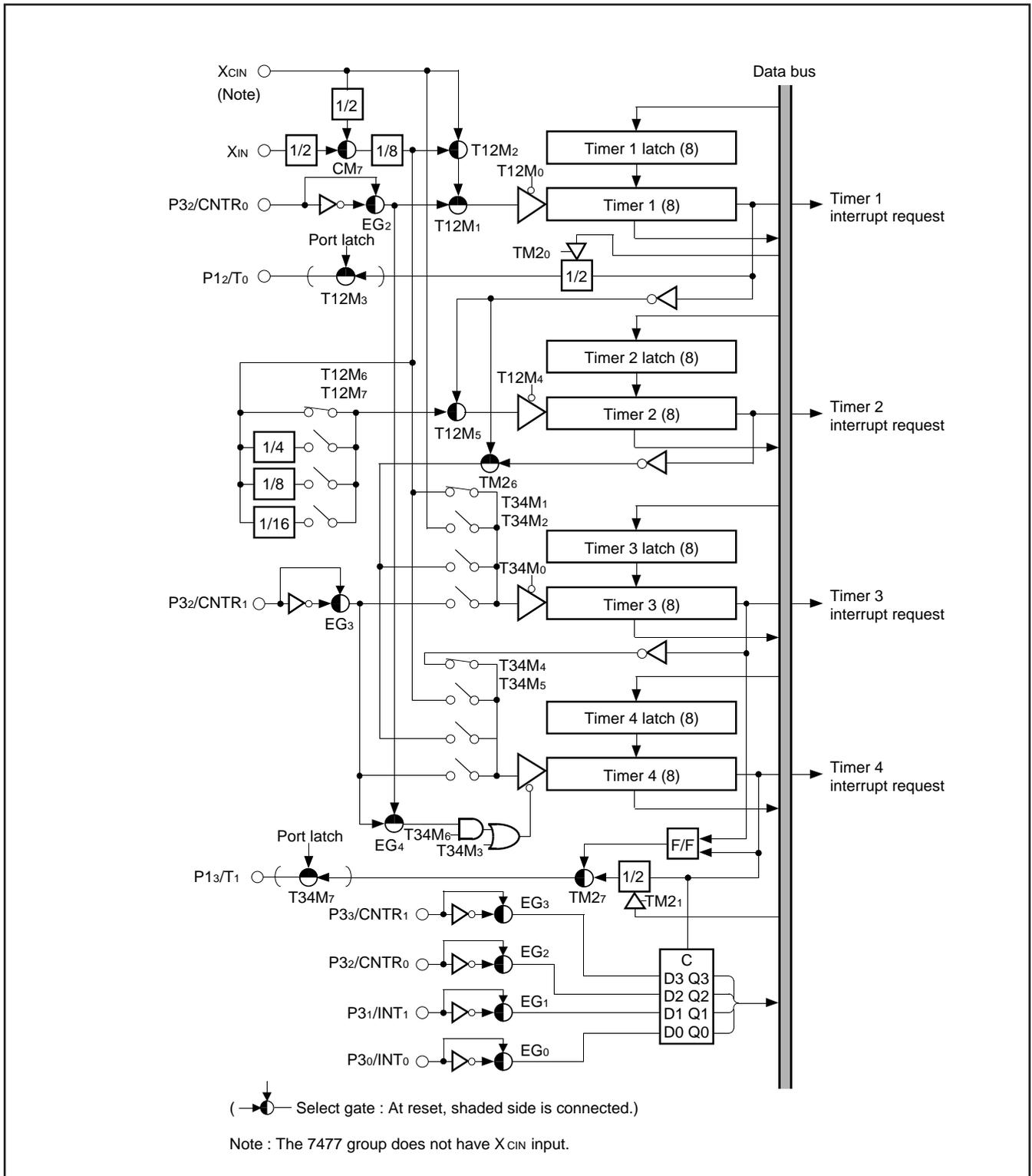


Fig. 6 Block diagram of timer 1 through 4

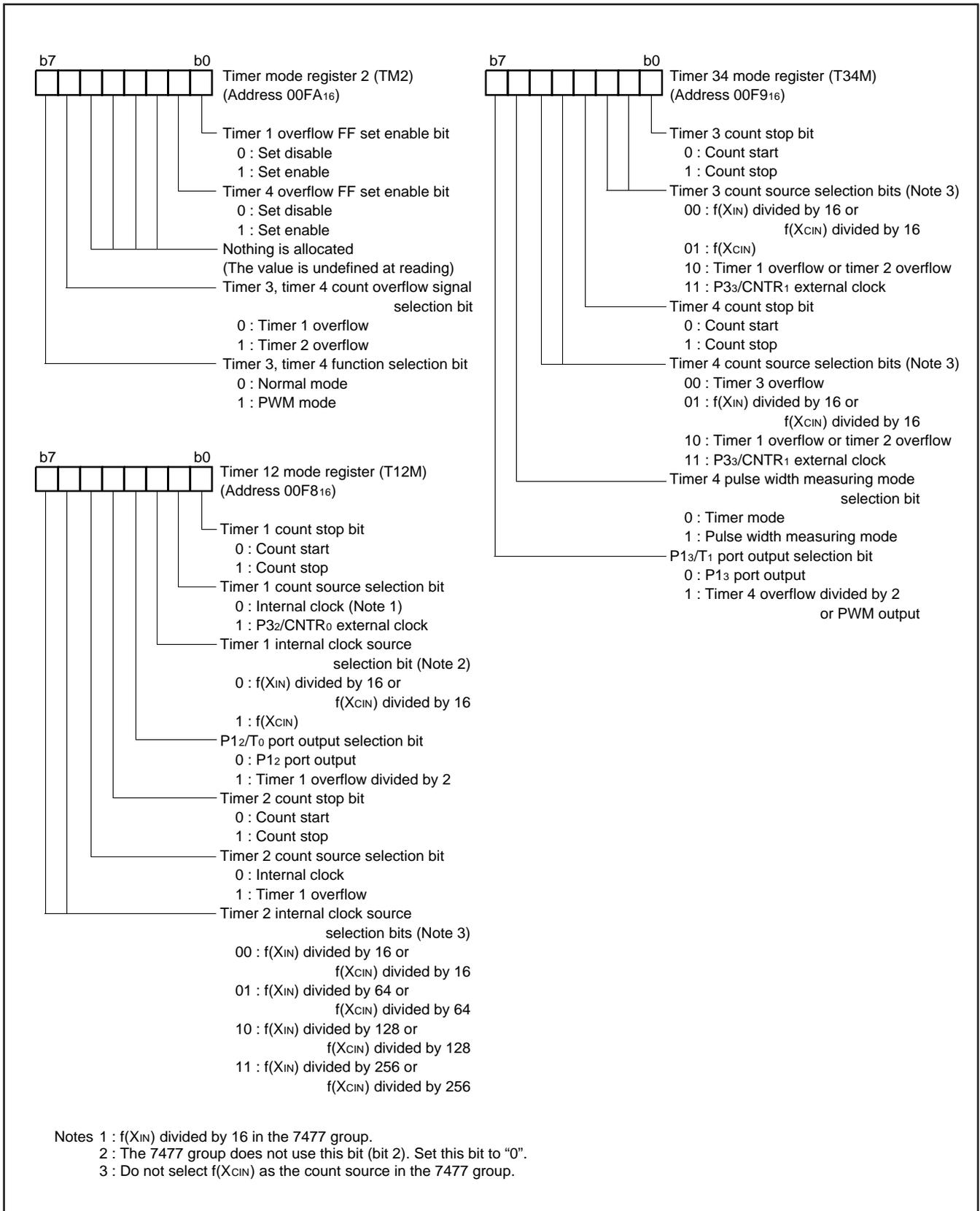


Fig. 7 Structure of timer mode registers

SERIAL I/O

Serial I/O 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.

Clock Synchronous Serial I/O Mode

Clock synchronous serial I/O mode can be selected by setting the mode selection bit of the serial I/O control register to "1". For clock synchronous serial I/O, the transmitter and the receiver must use the same clock. If an internal clock is used, transfer is started by a write signal to the transmit or receive buffer.

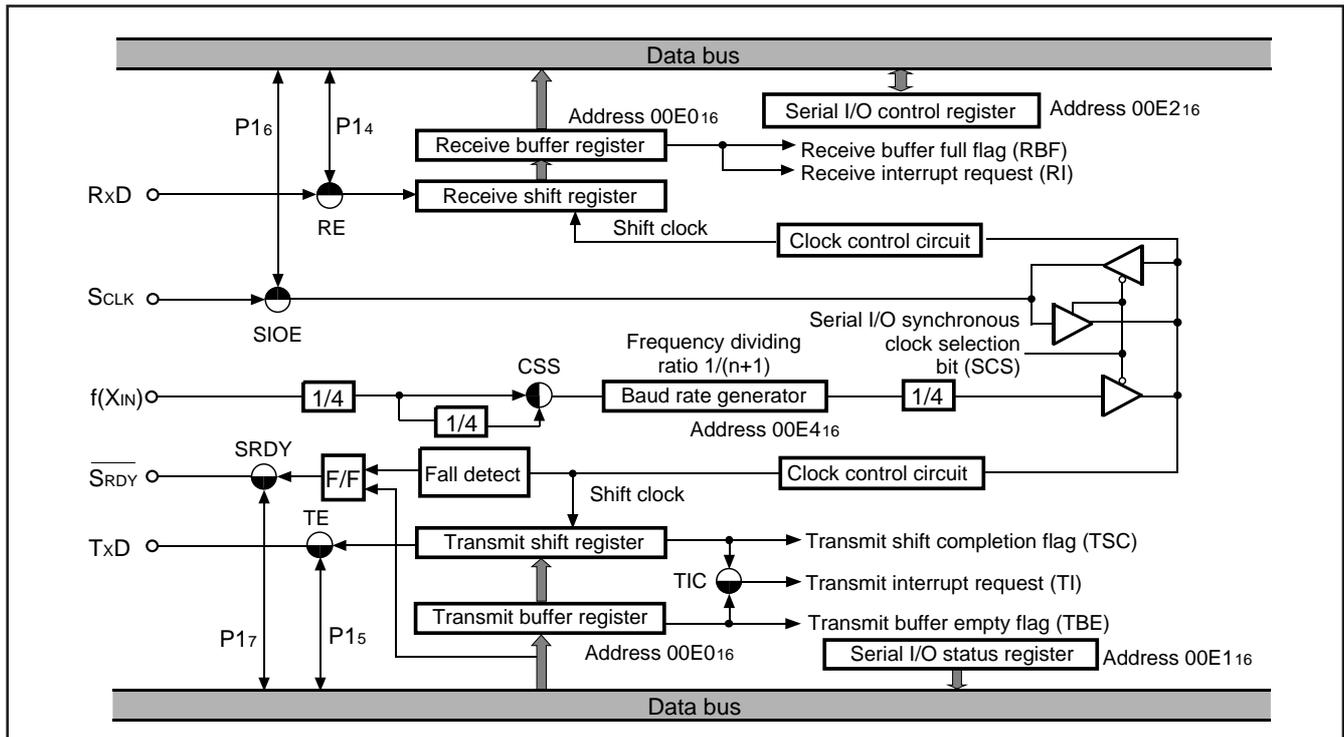


Fig. 8 Clock synchronous serial I/O block diagram

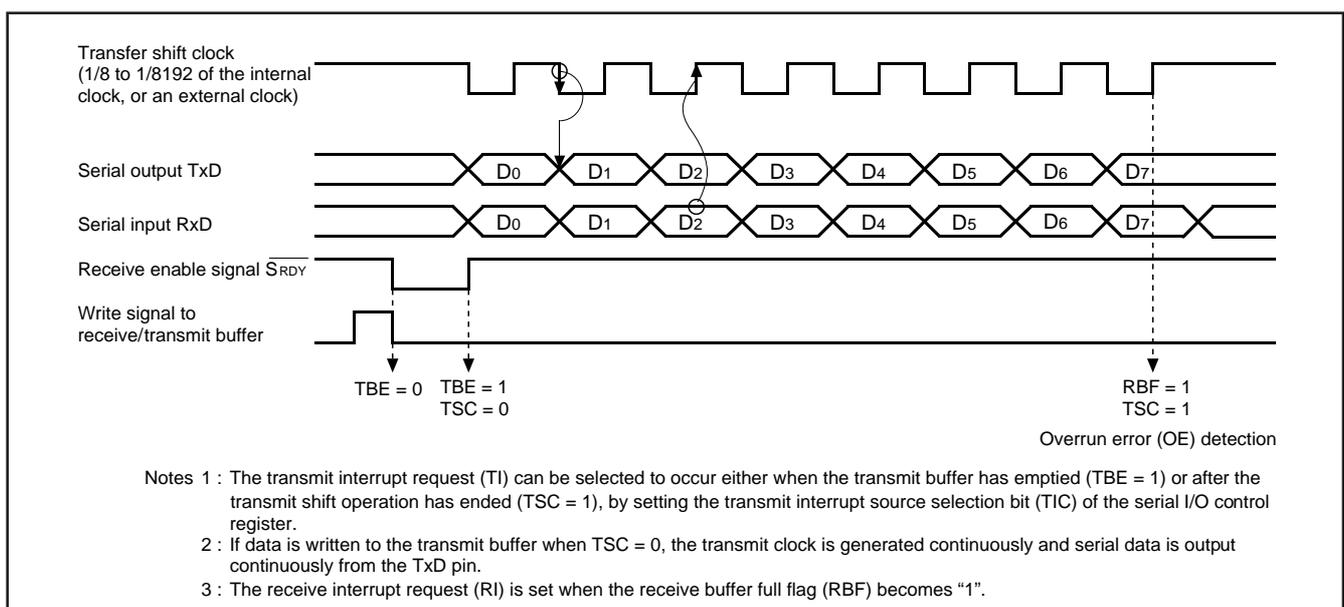


Fig. 9 Operation of clock synchronous serial I/O function

Asynchronous Serial I/O (UART) Mode

Clock asynchronous serial I/O mode (UART) can be selected by clearing the serial I/O mode selection bit of the serial I/O control register to "0".

Eight serial data transfer formats can be selected, and the transfer formats used by a transmitter and receiver must be identical. The transmit and receive shift registers each have a buffer, but the two

buffers have the same address in memory. Since the shift register cannot be written to or read from directly, transmit data is written to the transmit buffer, 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 can hold a character while the next character is being received.

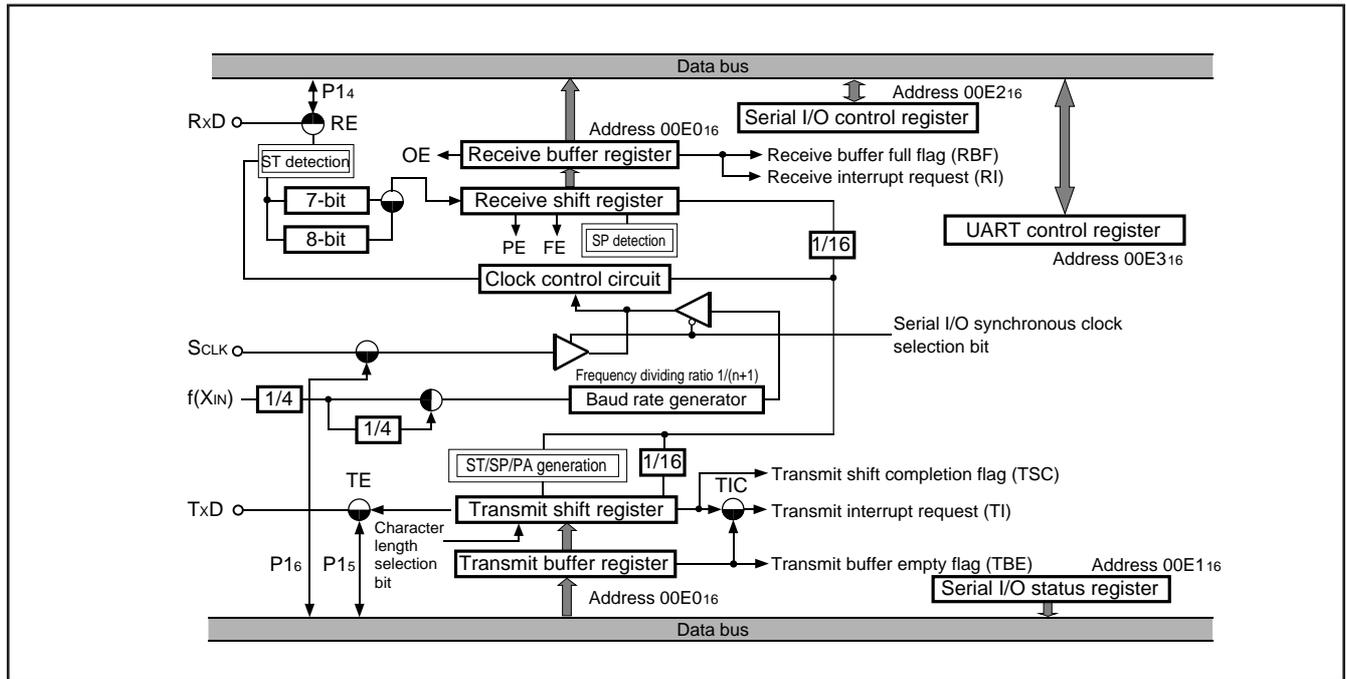


Fig. 10 UART serial I/O block diagram

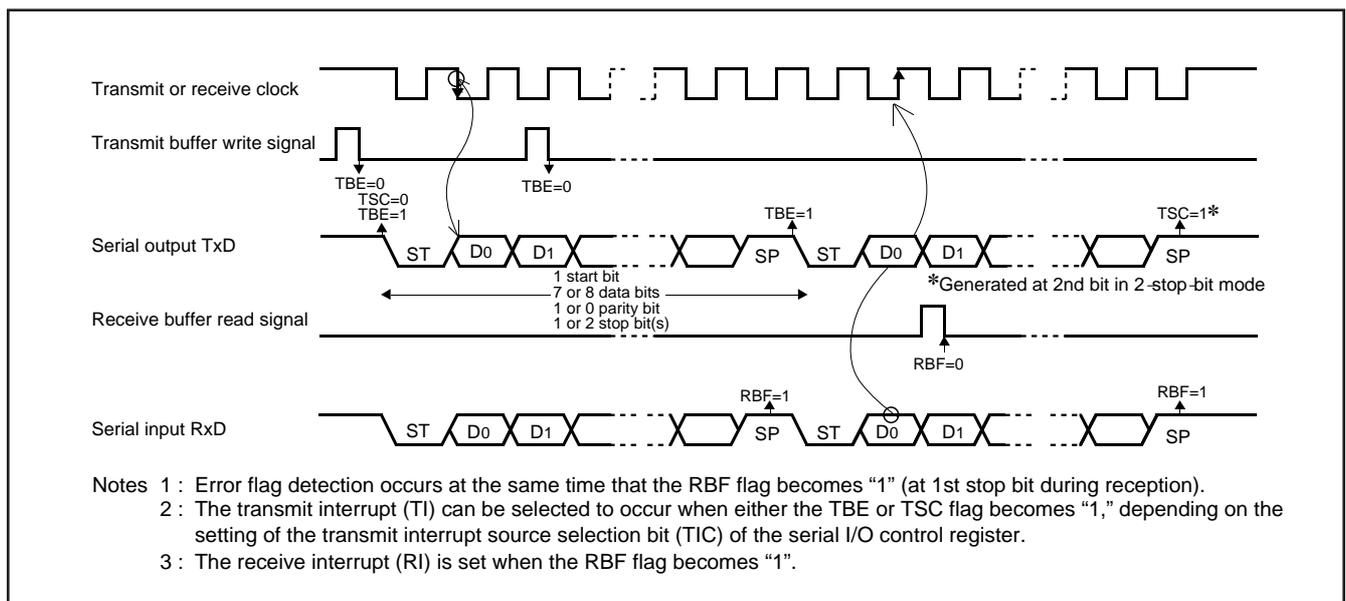


Fig. 11 Operation of UART serial I/O function

Serial I/O Control Register SIOCON

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

UART Control Register UARTCON

The UART control register consists of four control bits (bits 0 to 3) which are valid when asynchronous serial I/O is selected and set the data format of a data transfer.

Serial I/O Status Register SIOSTS

The read-only serial I/O status register consists of seven flags (bits 0 to 6) which indicate the operating status of the serial I/O function and various errors.

Three of the flags (bits 4 to 6) are valid only in selected UART.

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, and the receive buffer full flag is set. Writing to the serial I/O status register clears all the error flags OE, PE, FE, and SE (bit 3 to bit 6, respectively). Writing "0" to the serial I/O enable bit SIOE (bit 7 of the serial I/O control register) also clears all the status flags, including the error flags.

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

Transmit Buffer/Receive Buffer TB/RB

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

Baud Rate Generator BRG

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.

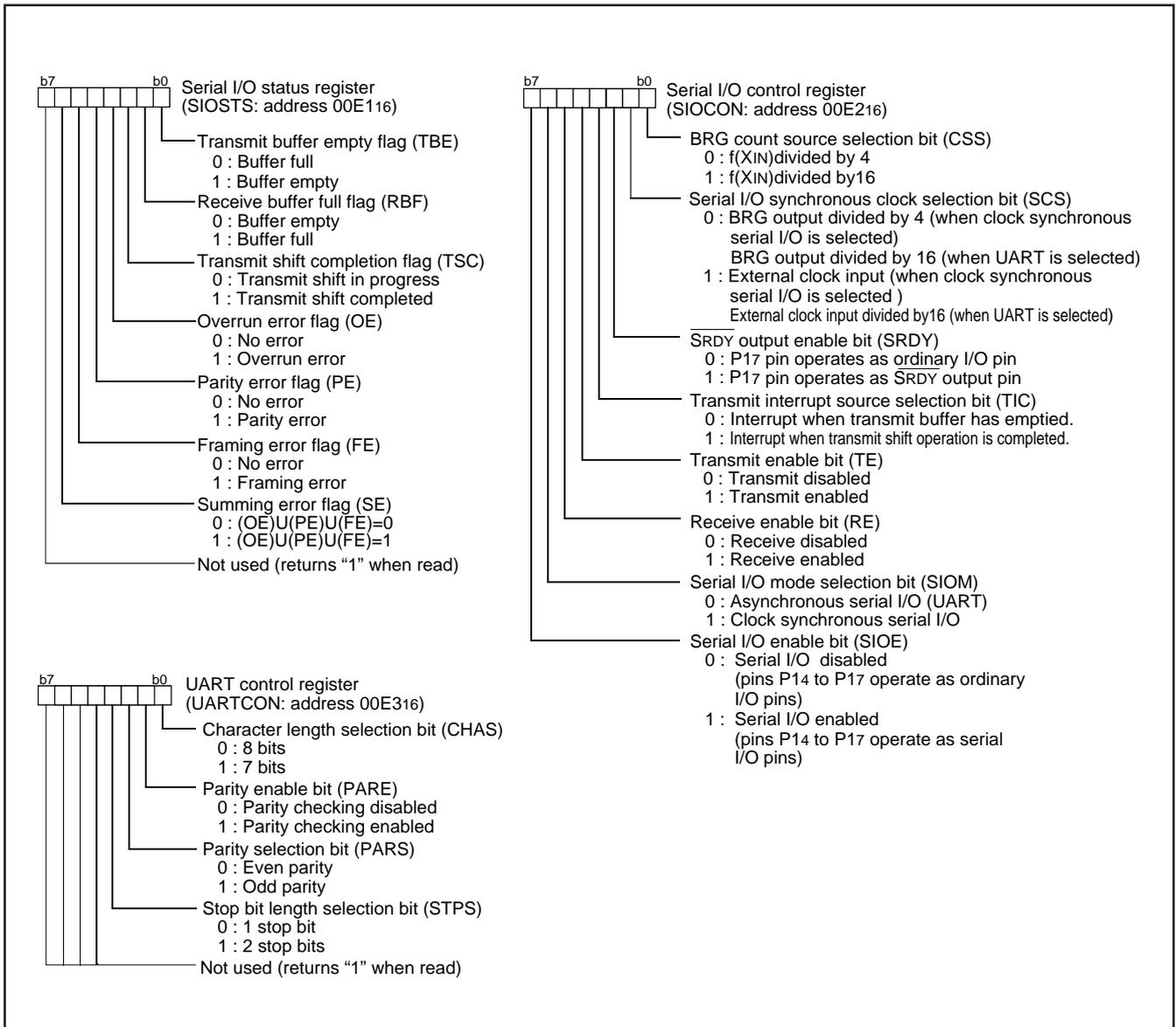


Fig. 12 Structure of serial I/O control registers

A-D CONVERTER

The A-D conversion uses an 8-bit successive comparison method. Figure 13 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 7477 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.

Figure 14 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 μ s when $f(X_{IN}) = 8\text{MHz}$), 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.

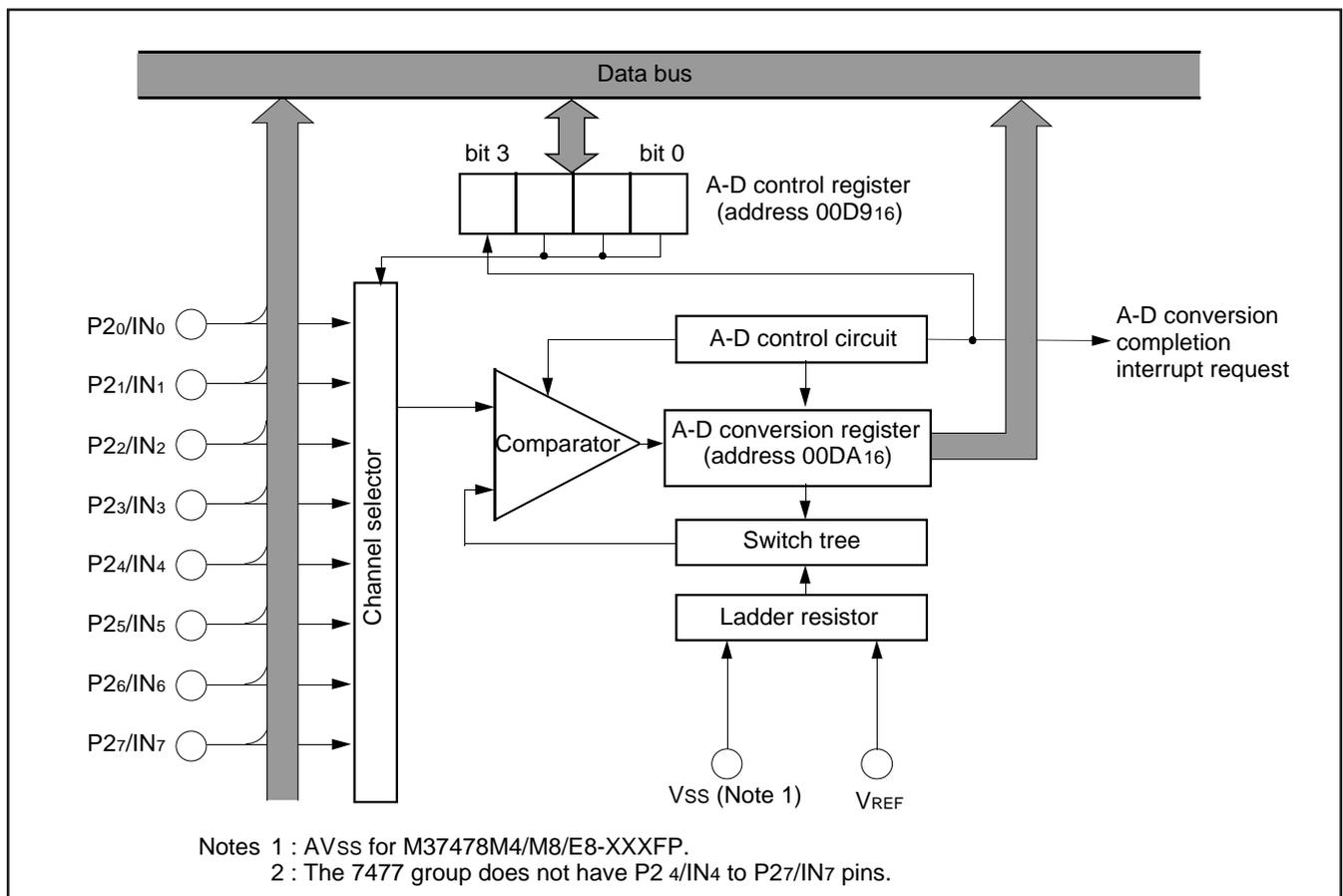


Fig. 13 A-D converter circuit

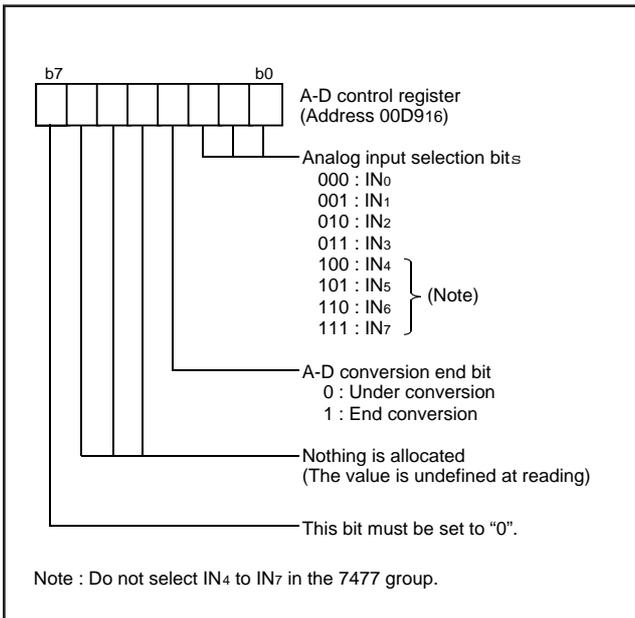


Fig. 14 Structure of A-D control register

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 $\overline{\text{INT}}_1$ 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 $\overline{\text{INT}}_1$ are invalid.

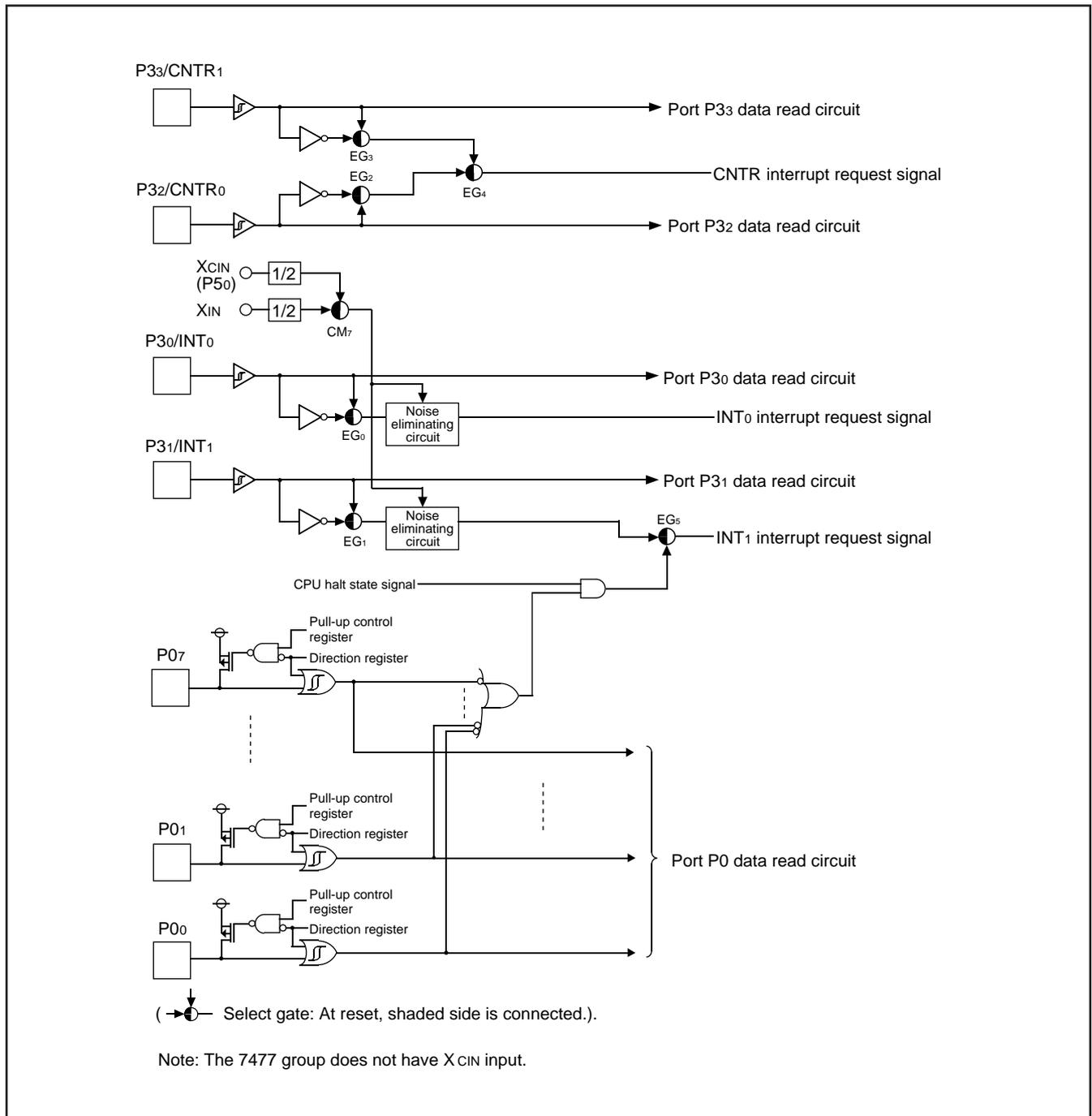


Fig. 15 Block diagram of interrupt input and key on wake up circuit

RESET CIRCUIT

The 7477/7478 group is reset according to the sequence shown in Figure 18. 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 $\overline{\text{RESET}}$ pin is held at "L" level for no less than 2 μ s 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 17. Example of reset circuit is Figure 16. 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.

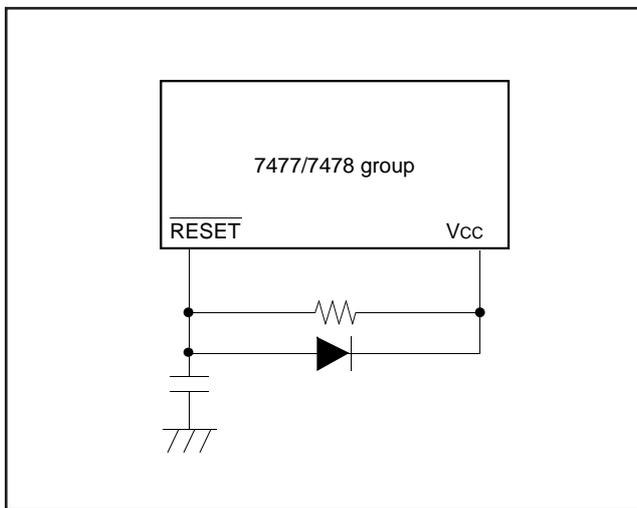


Fig. 16 Example of reset circuit

| | Address | |
|---------------------------------------------|-------------------------|----------------------------------------|
| (1) Port P0 direction register | (C1 ₁₆) ... | 00 ₁₆ |
| (2) Port P1 direction register | (C3 ₁₆) ... | 00 ₁₆ |
| (3) Port P4 direction register | (C9 ₁₆) ... | 0 0 0 0 |
| (4) P0 pull-up control register | (D0 ₁₆) ... | 00 ₁₆ |
| (5) P1-P5 pull-up control register (Note 1) | (D1 ₁₆) ... | 0 0 0 0 0 0 |
| (6) Edge selection register (EG) | (D4 ₁₆) ... | 0 0 0 0 0 0 0 |
| (7) A-D control register | (D9 ₁₆) ... | 0 1 0 0 0 |
| (8) Serial I/O status register | (E1 ₁₆) ... | 0 0 0 0 0 0 0 |
| (9) Serial I/O control register | (E2 ₁₆) ... | 00 ₁₆ |
| (10) UART control register | (E3 ₁₆) ... | 0 0 0 0 |
| (11) Timer 12 mode register (T12M) | (F8 ₁₆) ... | 00 ₁₆ |
| (12) Timer 34 mode register (T34M) | (F9 ₁₆) ... | 00 ₁₆ |
| (13) Timer mode register 2 (TM2) | (FA ₁₆) ... | 0 0 0 0 0 0 |
| (14) CPU mode register (CM) | (FB ₁₆) ... | 0 0 0 0 0 0 0 |
| (15) Interrupt request register 1 | (FC ₁₆) ... | 0 0 0 0 0 0 |
| (16) Interrupt request register 2 | (FD ₁₆) ... | 0 0 0 0 |
| (17) Interrupt control register 1 | (FE ₁₆) ... | 0 0 0 0 0 0 |
| (18) Interrupt control register 2 | (FF ₁₆) ... | 0 0 0 0 |
| (19) Program counter | (PCH) ... | Contents of address FFFF ₁₆ |
| | (PCL) ... | Contents of address FFFE ₁₆ |
| (20) Processor status register | (PS) ... | 1 |

Notes 1 : This address is allocated P1-P4 pull-up control register for the 7477 group. Bit 6 is not used.
2 : Since the contents of both registers other than those listed above (including timers and the transmit/receive buffer register) are undefined at reset, it is necessary to set initial values.

Fig. 17 Internal state of microcomputer at reset

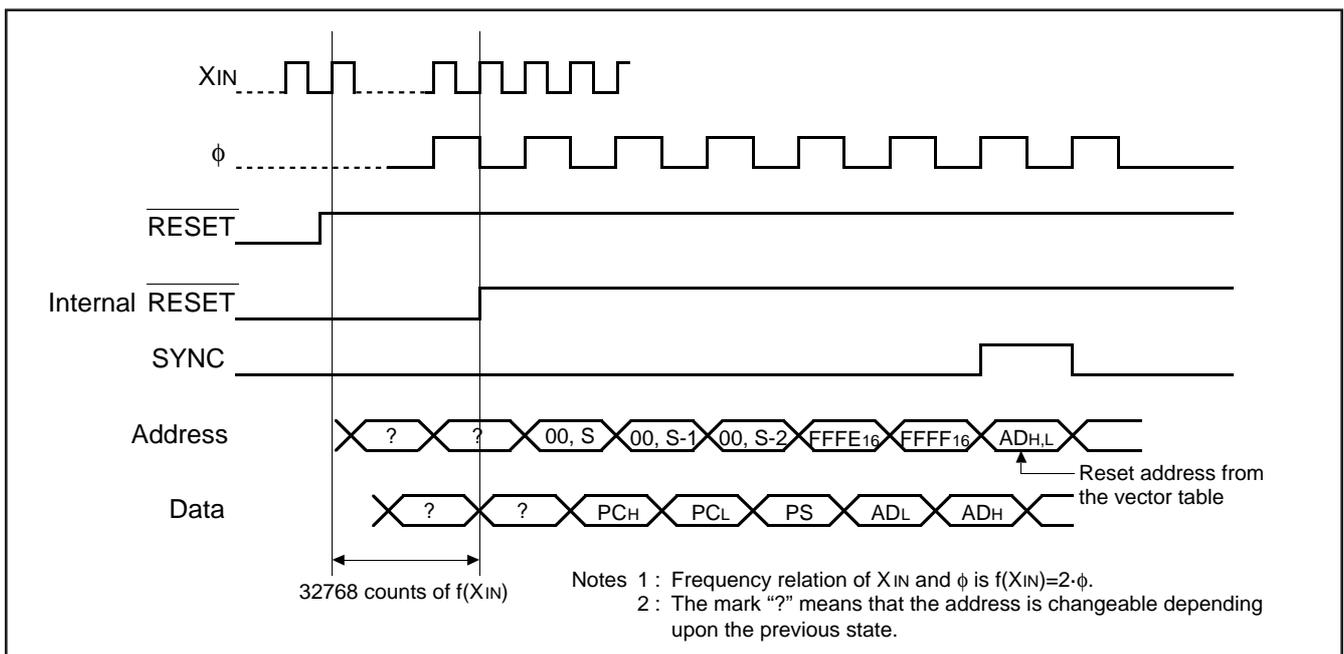


Fig. 18 Timing diagram at reset

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 is an 8-bit input port. In the 7477 group, this port is P20 – P23, a 4-bit input port. This port can also be used as the analog voltage input pins.

(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 7477 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 7477 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".

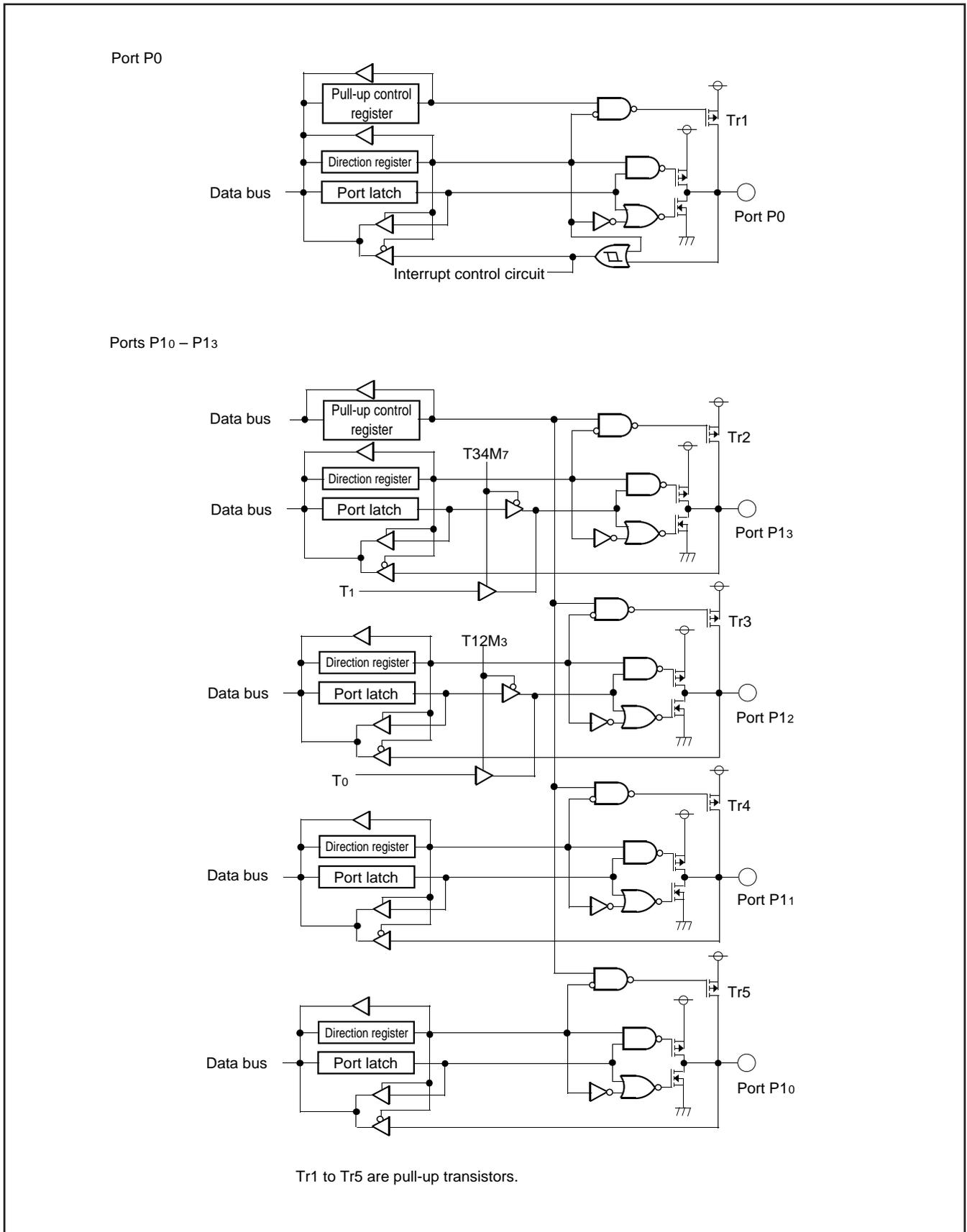
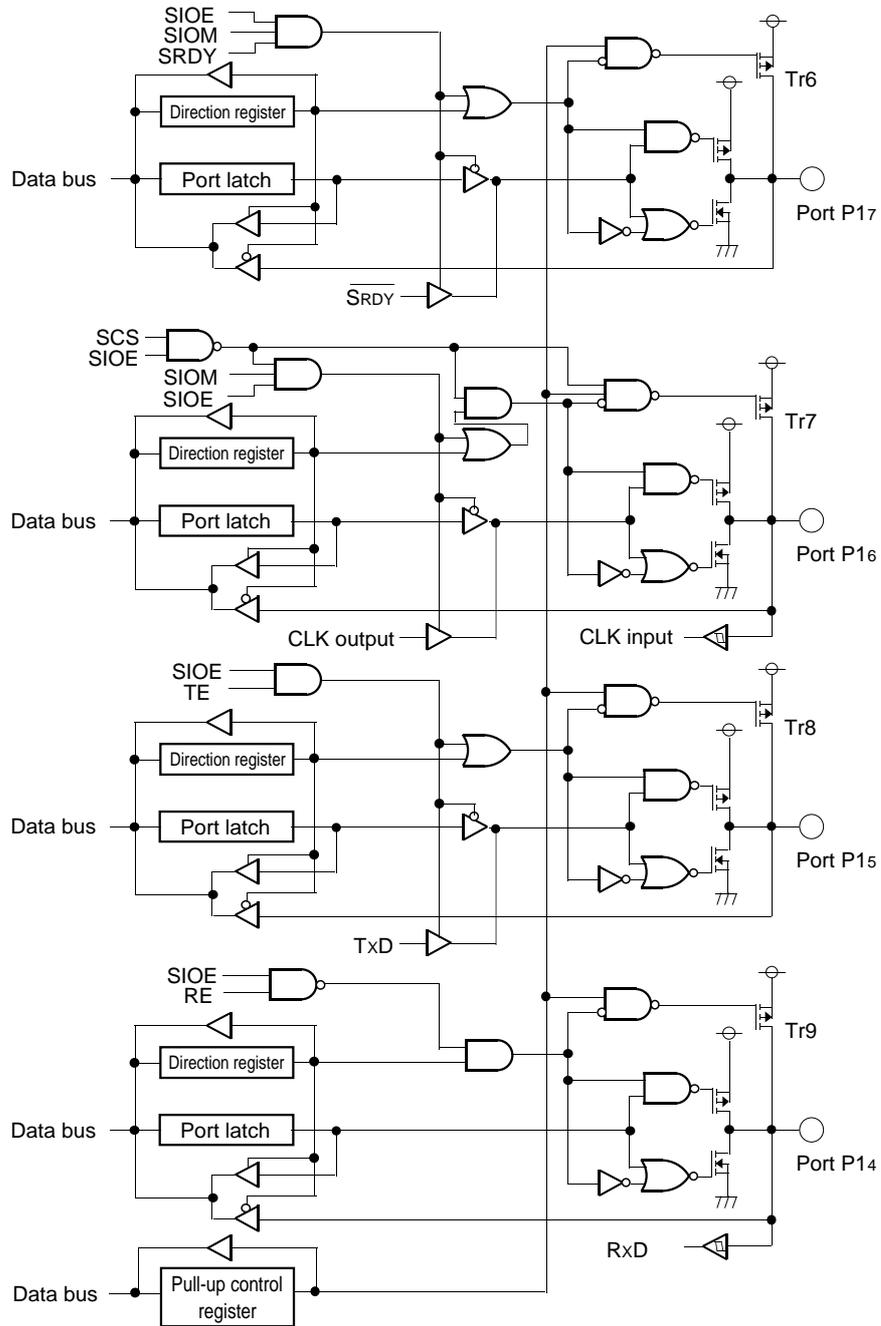


Fig. 19 Block diagram of ports P0, P10-P13

Ports P14 – P17



Tr6 to Tr9 are pull-up transistors.

Fig. 20 Block diagram of ports P14 – P17

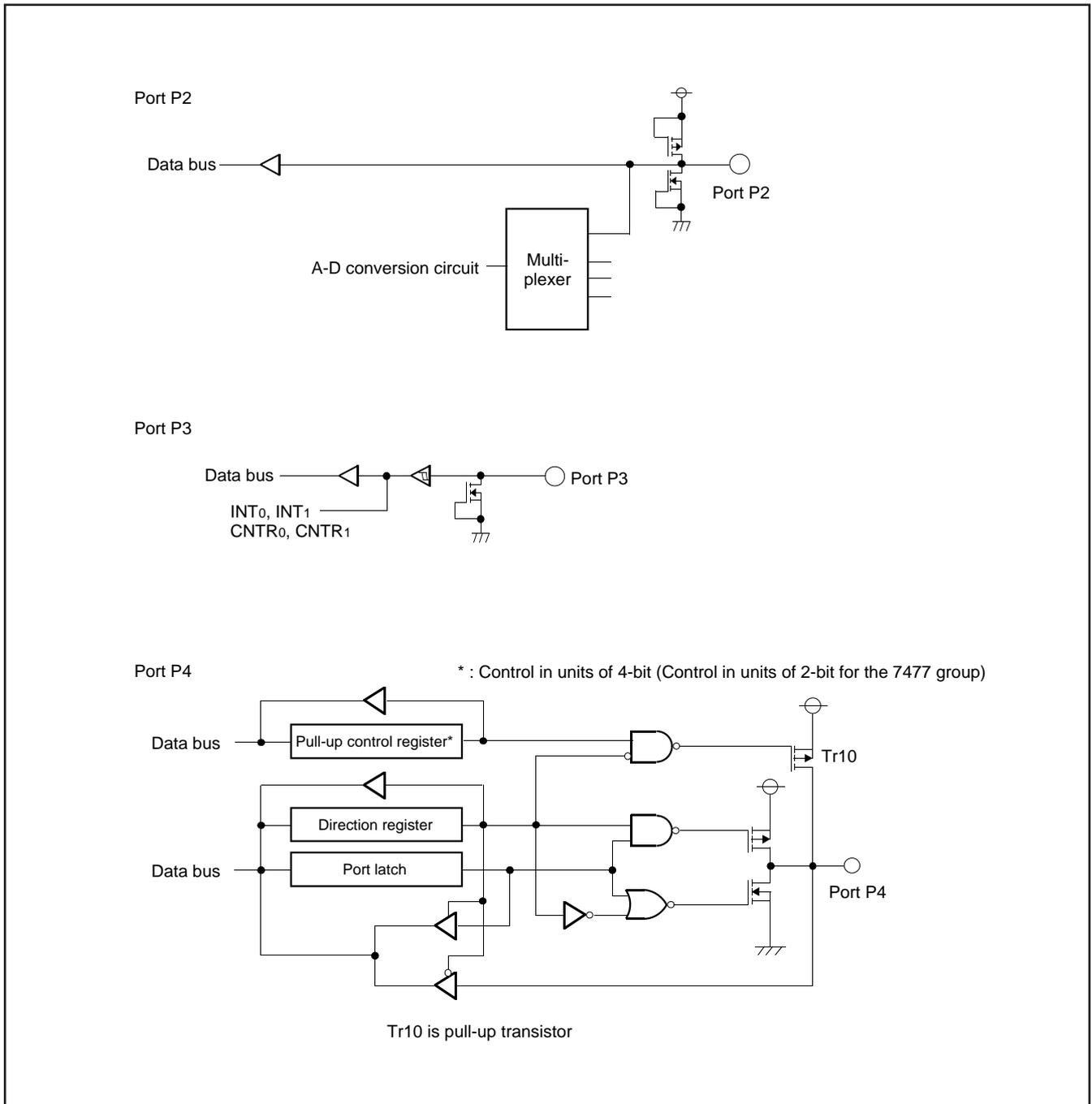


Fig. 21 Block diagram of ports P2 – P4

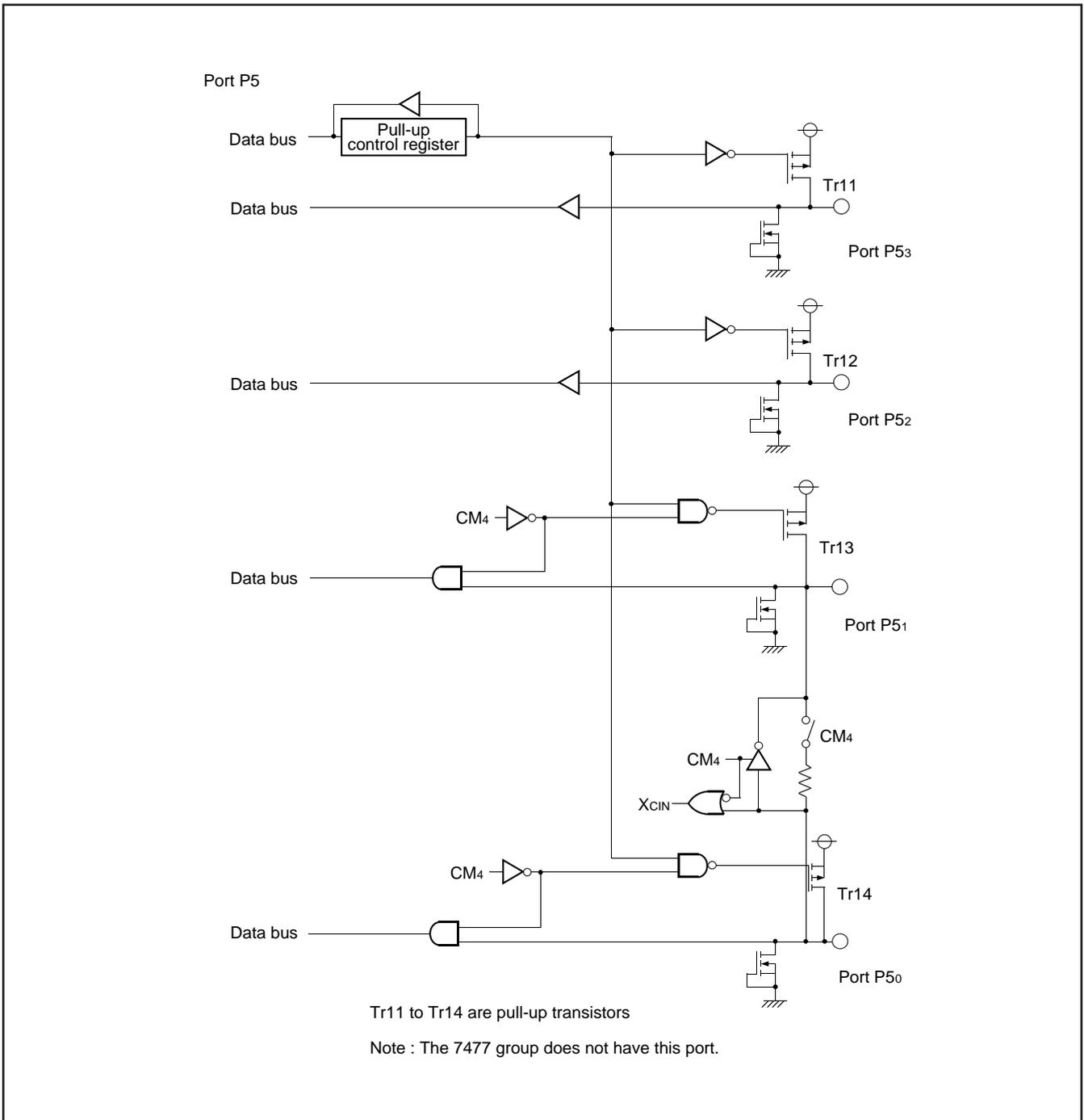


Fig. 22 Block diagram of port P5

CLOCK GENERATING CIRCUIT

The 7477 group has one internal clock generating circuit and 7478 group has two internal clock generating circuits.

Figure 27 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 7478 group.

Figure 23, 24 show a circuit example using a ceramic resonator (or 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_{COU}T) pin open. A circuit example is shown in Figure 25, 26.

The 7477/7478 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}) = 32kHz). This operation is only 7478 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 29 shows the transition of states for the system clock.

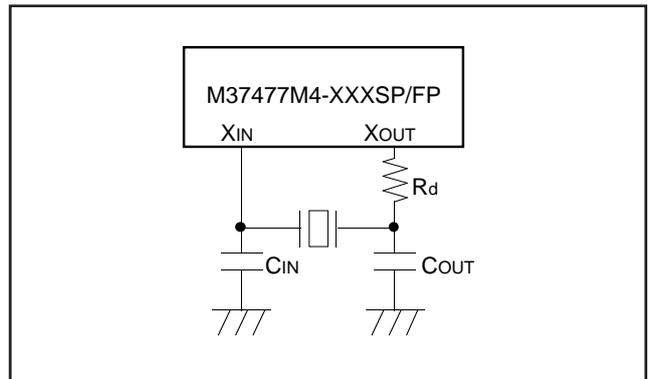


Fig. 23 Example of ceramic resonator circuit (7477 group)

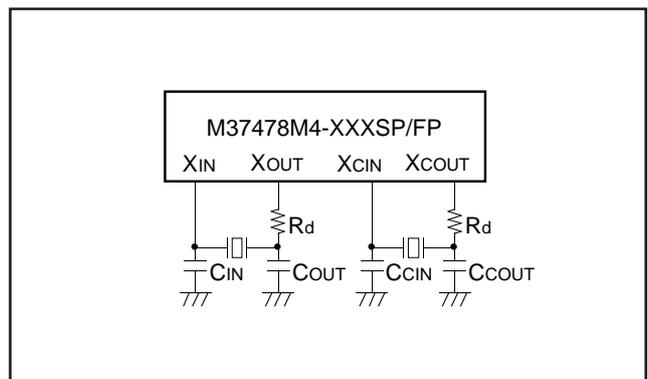


Fig. 24 Example of ceramic resonator circuit (7478 group)

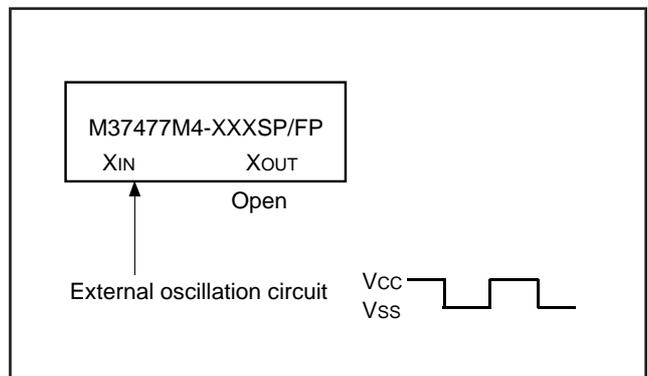


Fig. 25 External clock input circuit (7477 group)

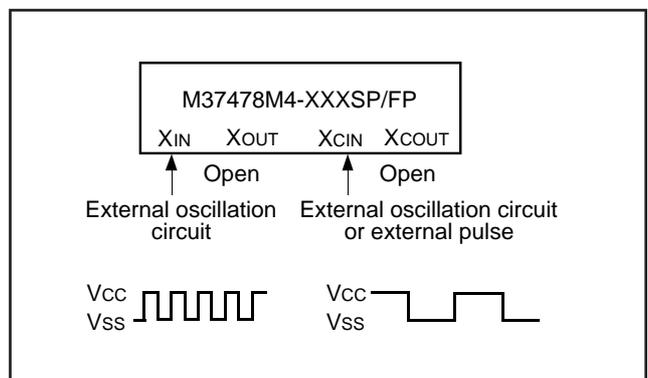


Fig. 26 External clock input circuit (7478 group)

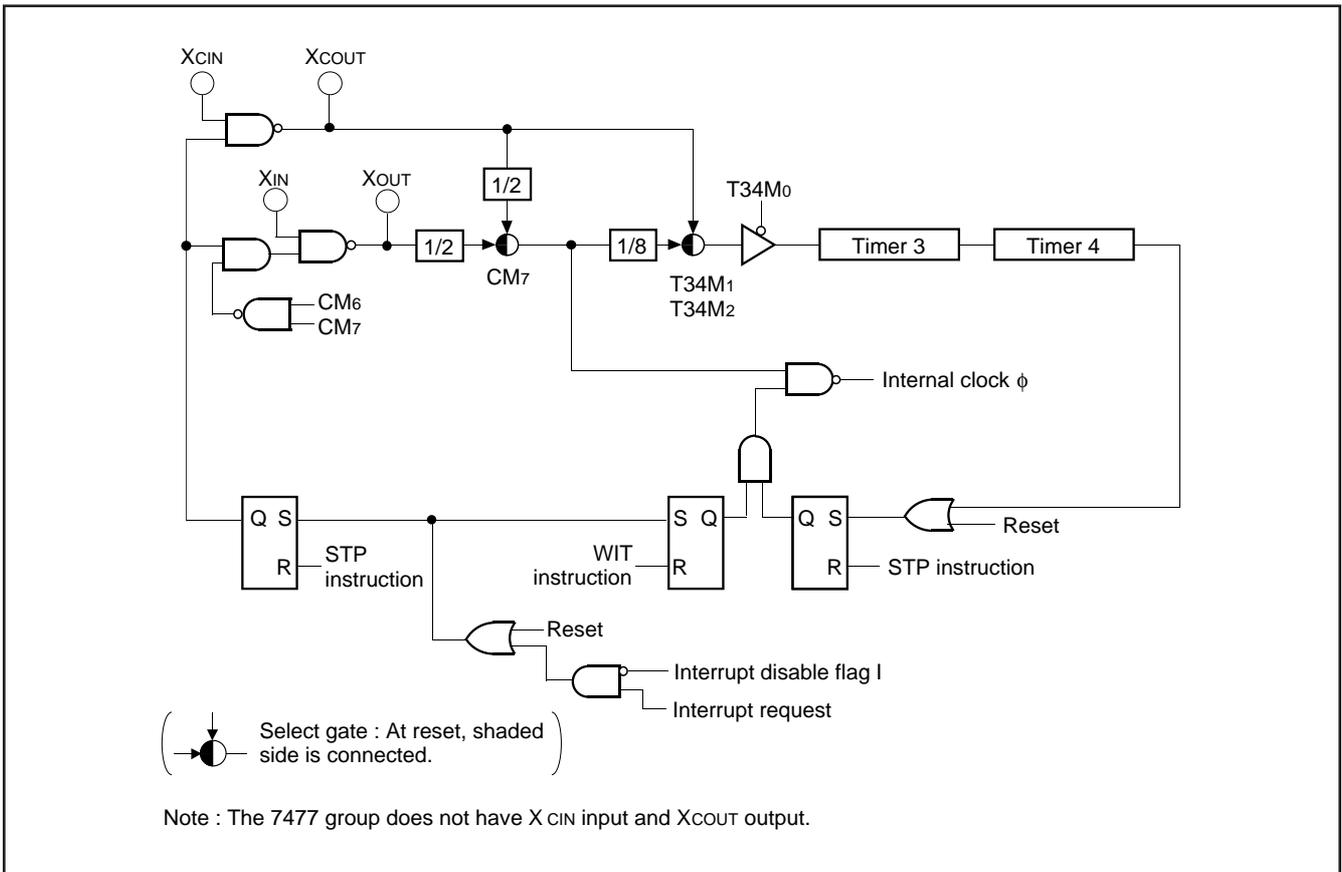


Fig. 27 Block diagram of clock generating circuit

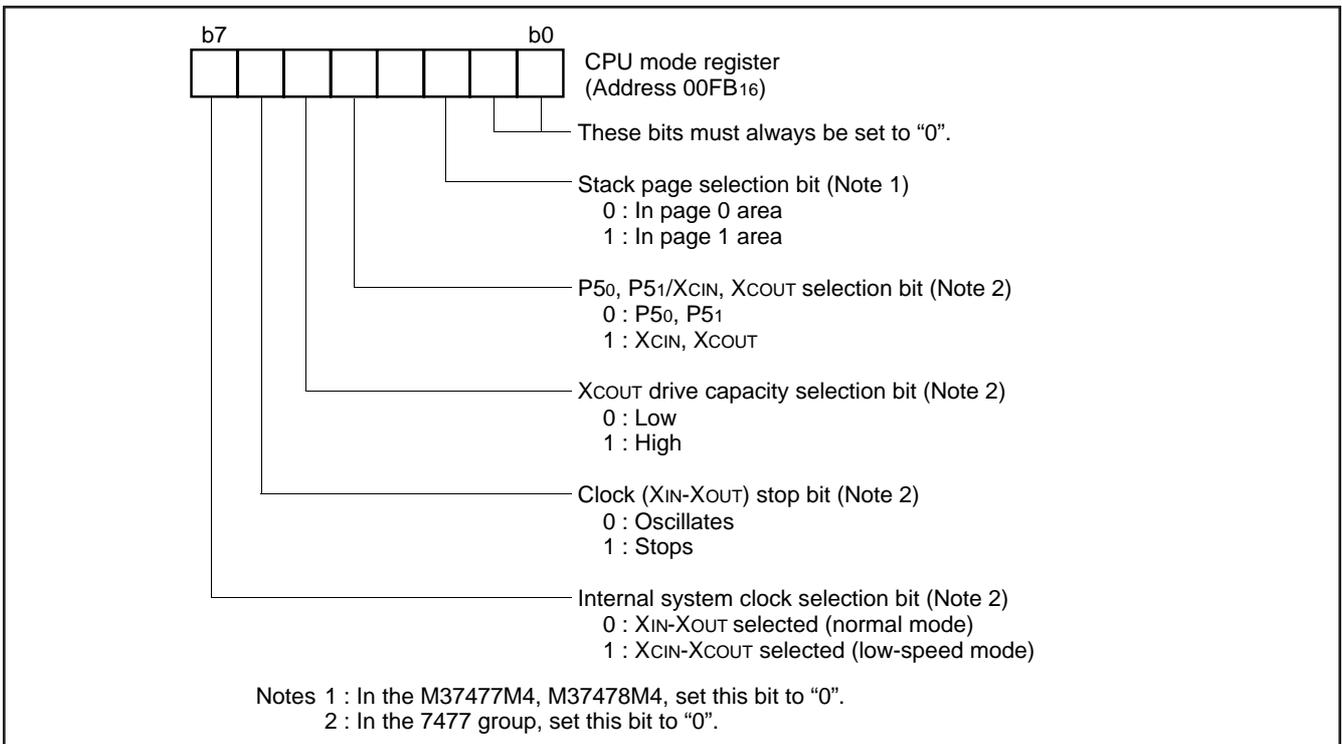


Fig. 28 Structure of CPU mode register

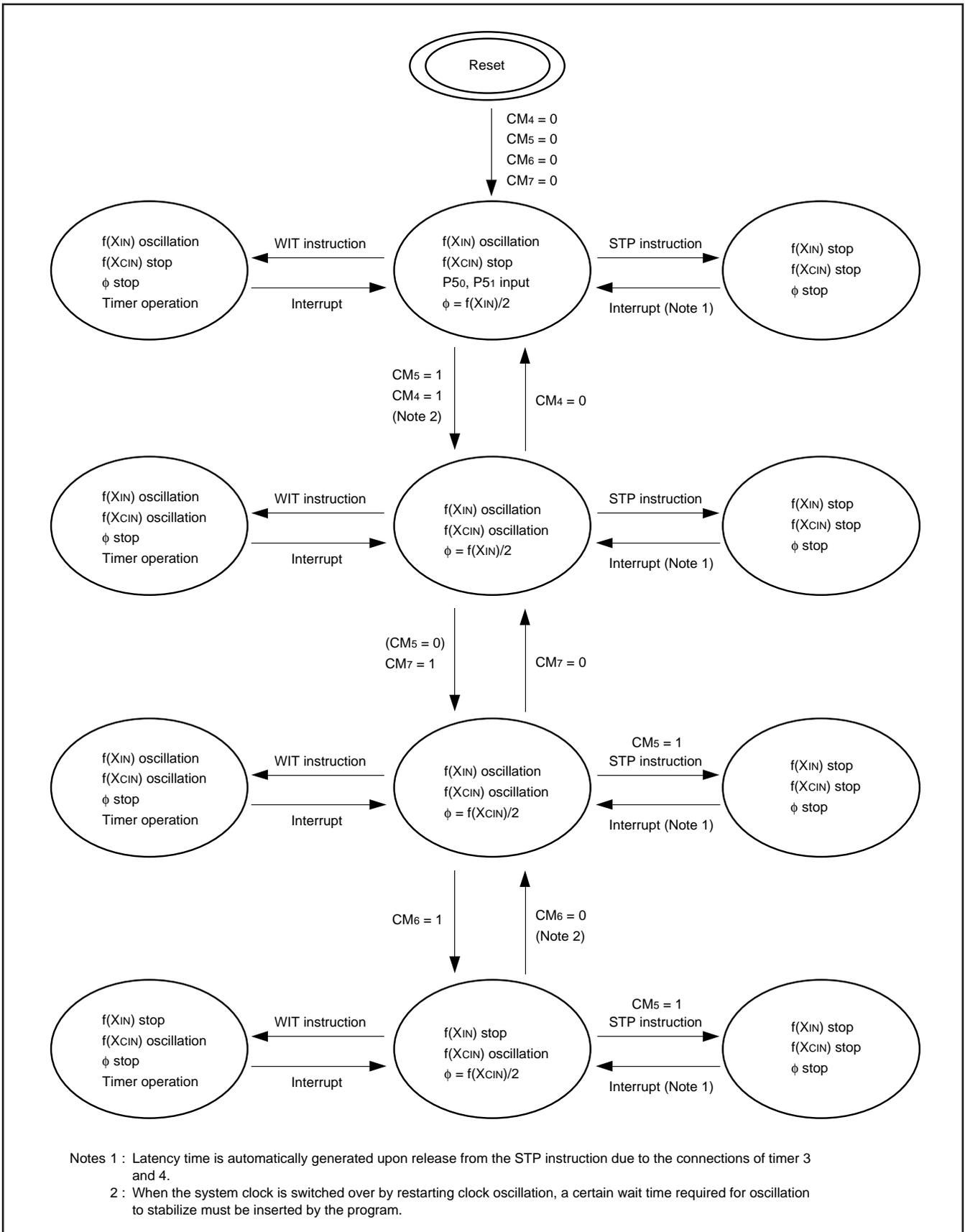
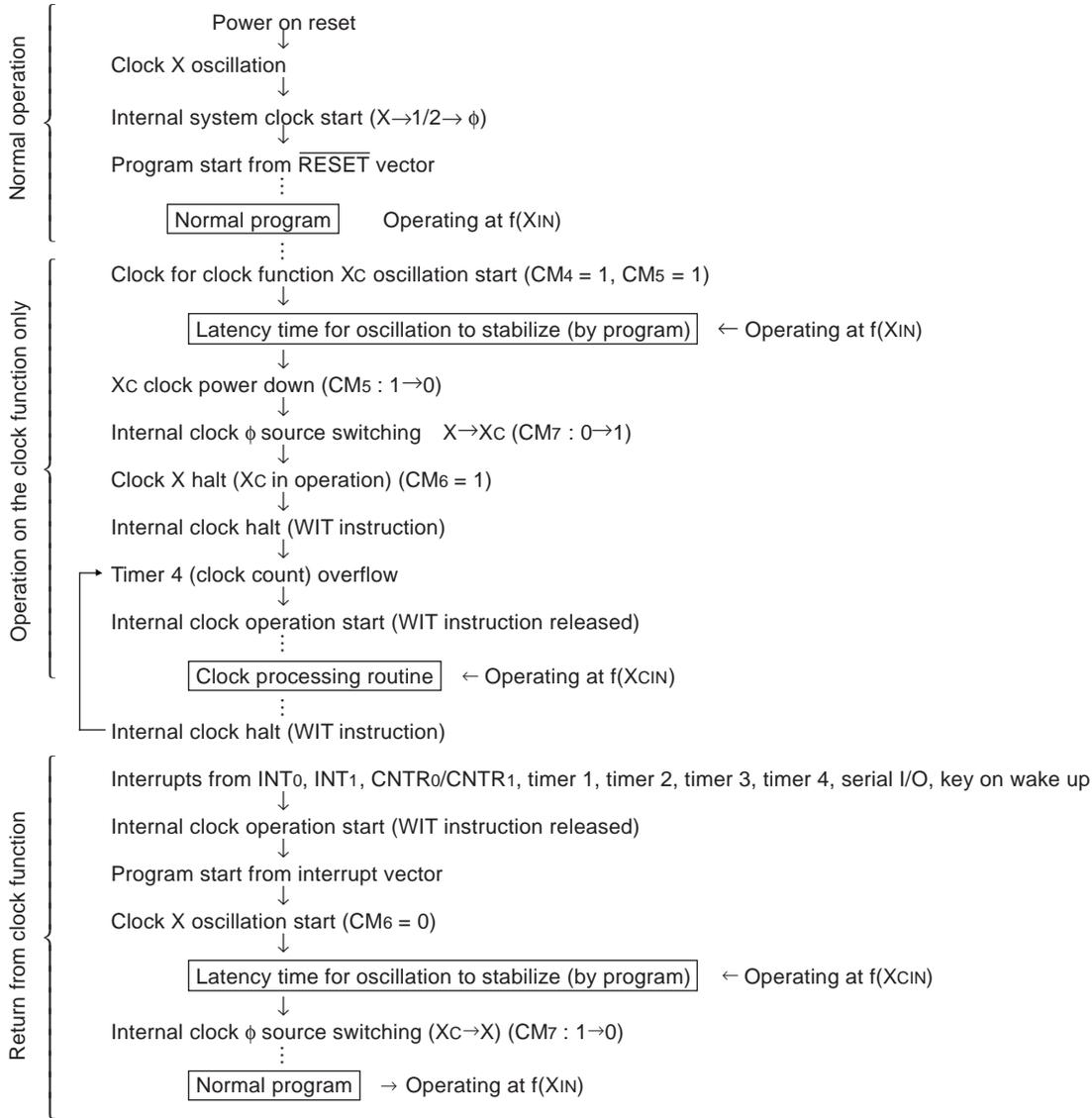
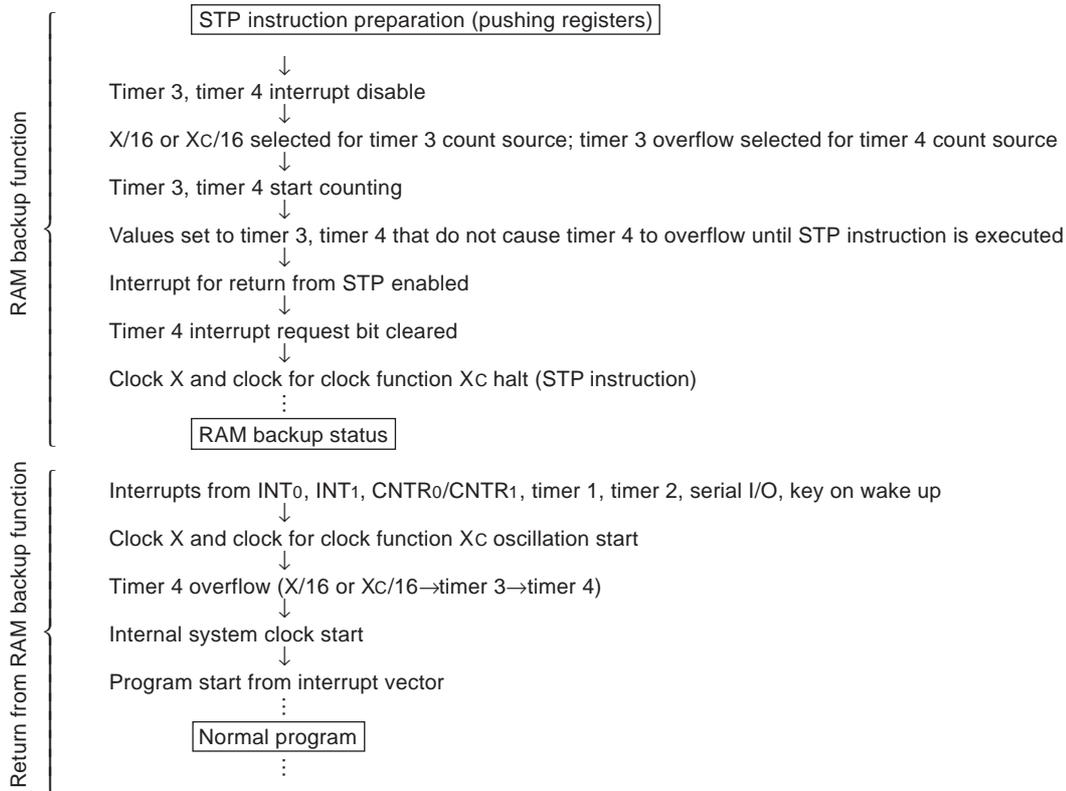


Fig. 29 Transition of states for the system clock.

<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 | | Apply voltage of 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. |
| $\overline{\text{RESET}}$ | 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 | 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 | Single-chip /EPROM | 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 $\overline{\text{CE}}$ input. |
| P0 – 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 I/O D0–D7 | I/O | Port P0 works as an 8-bit data bus (D0 to 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 and P13 are in common with timer output pins T0, T1. P14, P15, P16 and P17 are in common with serial I/O pins RxD, TxD, SCLK, SRDY, respectively. |
| | EPROM | Address input A4–A10 | Input | P11 to P17 works as the 7-bit address input (A4 to A10). P10 must be opened. |
| P20 – P27 (Note 2) | Single-chip | Input port P2 | Input | Port P2 is an 8-bit input port. This port is in common with analog input pins IN0 to IN7. |
| | EPROM | Address input A0–A3 | Input | P20 to P23 works as the lower 4-bit address input (A0 to A3). P24 to P27 must be opened. |
| P30 – P33 | Single-chip | Input port P3 | Input | Port P3 is a 4-bit input port. P30 and 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 $\overline{\text{OE}}$ 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 and P41 works as the higher 2-bit address input (A13, A14). P42 and 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, 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. |
| | EPROM | | Open. | |

Notes 1 : AVSS for M37478M4/M8/E8-XXXFP.

2 : Only P20–P23 (IN0–IN3) 4-bit for the 7477 group.

3 : Only P40 and P41 2-bit for the 7477group.

4 : This port is not included in the 7477 group.

EPROM MODE

The M37477E8, M37478E8 feature an EPROM mode in addition to its normal modes. When the 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 to P17, P20 to P23, P3, P40, P41 and VREF are used for the PROM (equivalent to the M5L27C256). 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 M5L27C256K. 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

| | M37477E8, M37478E8 | M5L27C256K |
|-----------------|------------------------------------------------|-----------------|
| 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{CE} | VREF | \overline{CE} |
| \overline{OE} | P32 | \overline{OE} |

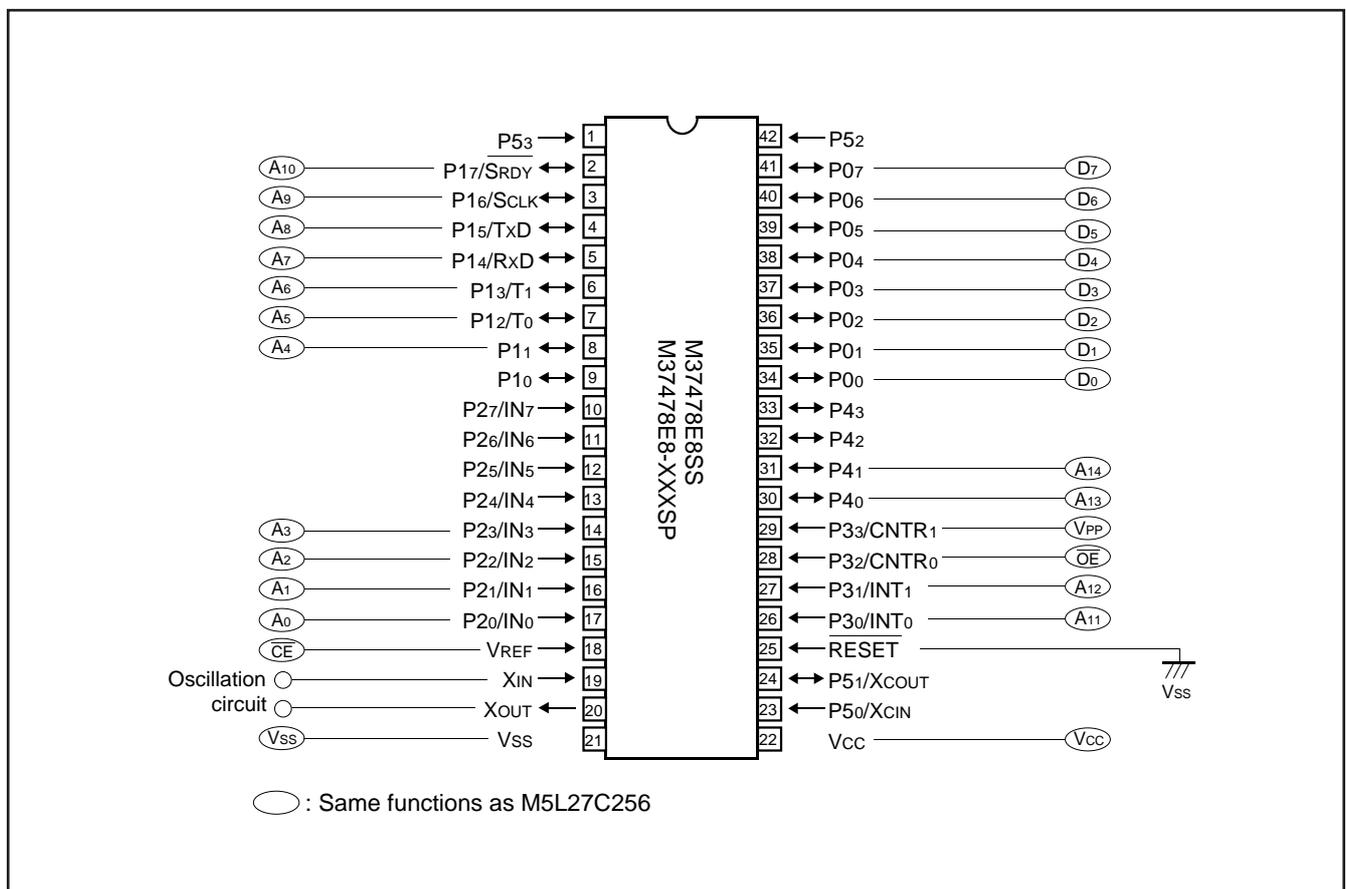


Fig. 30 Pin connection in EPROM mode

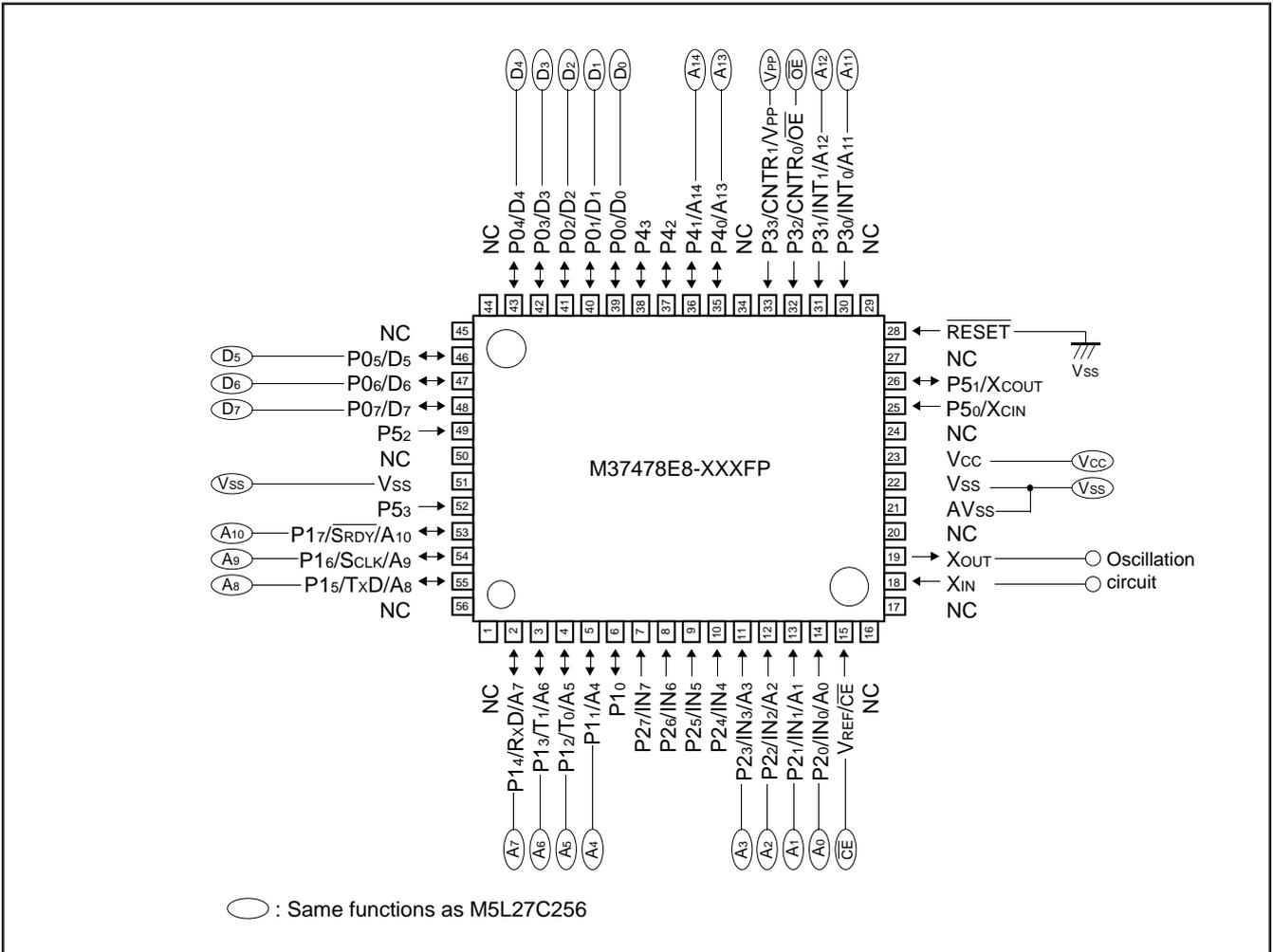


Fig. 31 Pin connection in EPROM mode

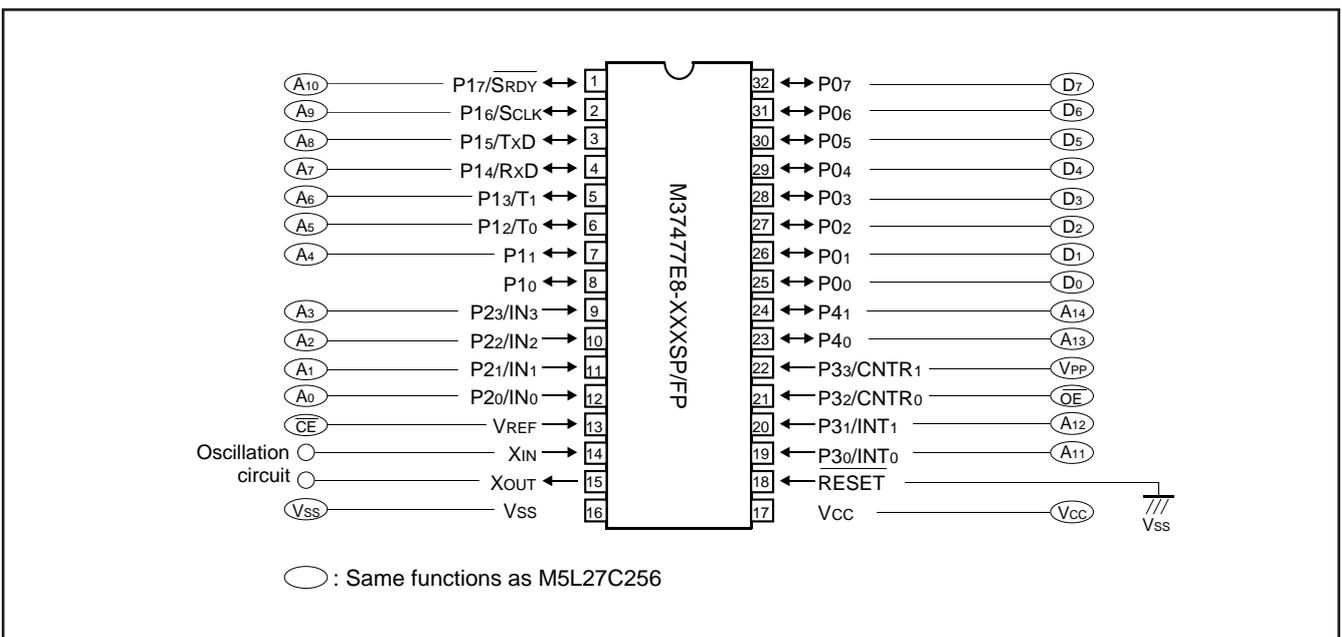


Fig. 32 Pin connection in EPROM mode

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 to A14) to be read and the data will be output to the I/O pins (D0 to 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 VPP is applied to the VPP pin. The address to be written to is selected with pins A0 to A14, and the data to be written is input to pins D0 to D7. Set the \overline{CE} pin to "L" level to begin writing.

Note on Writing

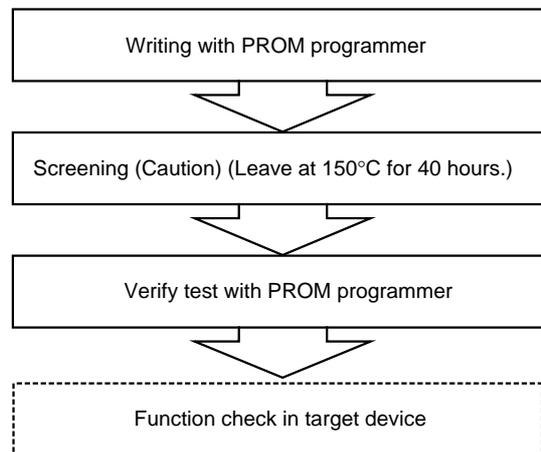
When using a PROM programmer, the address range should be between 4000₁₆ and 7FFF₁₆. When data is written between addresses 0000₁₆ and 7FFF₁₆, fill addresses 0000₁₆ to 3FFF₁₆ with FF₁₆.

Erasing

Data can only be erased on the M37478E8SS 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 (12.5V) 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} | VPP | VCC | 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 an "L" and an "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 7477 group, 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

M37477M4/M8/E8-XXXSP/FP
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 P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P2 ₀ – P2 ₃ , P3 ₀ – P3 ₃ , P4 ₀ , P4 ₁ , V _{REF} , RESET | | -0.3 to V _{CC} +0.3 | V |
| V _O | Output voltage P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P4 ₀ , P4 ₁ , X _{OUT} | | -0.3 to V _{CC} +0.3 | V |
| P _d | Power dissipation | T _a = 25°C | 1000 (Note) | mW |
| T _{opr} | Operating temperature | | -20 to 85 | °C |
| T _{stg} | Storage temperature | | -40 to 150 | °C |

Note : 500mW for M37477M4/M8/E8-XXXXFP

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 | 5.5 | |
| V _{SS} | Power source voltage | | 0 | | | V |
| V _{IH} | “H” input voltage P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P3 ₀ – P3 ₃ , RESET, X _{IN} | | 0.8 V _{CC} | | V _{CC} | V |
| V _{IH} | “H” input voltage P2 ₀ – P2 ₃ , P4 ₀ , P4 ₁ | | 0.7 V _{CC} | | V _{CC} | V |
| V _{IL} | “L” input voltage P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P3 ₀ – P3 ₃ | | 0 | | 0.2 V _{CC} | V |
| V _{IL} | “L” input voltage P2 ₀ – P2 ₃ , P4 ₀ , P4 ₁ | | 0 | | 0.25 V _{CC} | V |
| V _{IL} | “L” input voltage RESET | | 0 | | 0.12 V _{CC} | V |
| V _{IL} | “L” input voltage X _{IN} | | 0 | | 0.16 V _{CC} | V |
| I _{OH(sum)} | “H” sum output current P0 ₀ – P0 ₇ , P4 ₀ , P4 ₁ | | | | -30 | mA |
| I _{OH(sum)} | “H” sum output current P1 ₀ – P1 ₇ | | | | -30 | mA |
| I _{OL(sum)} | “L” sum output current P0 ₀ – P0 ₇ , P4 ₀ , P4 ₁ | | | | 60 | mA |
| I _{OL(sum)} | “L” sum output current P1 ₀ – P1 ₇ | | | | 60 | mA |
| I _{OH(peak)} | “H” peak output current P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P4 ₀ , P4 ₁ | | | | -10 | mA |
| I _{OL(peak)} | “L” peak output current P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P4 ₀ , P4 ₁ | | | | 20 | mA |
| I _{OH(avg)} | “H” average output current P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P4 ₀ , P4 ₁ (Note 1) | | | | -5 | mA |
| I _{OL(avg)} | “L” average output current P0 ₀ – P0 ₇ , P1 ₀ – P1 ₇ , P4 ₀ , P4 ₁ (Note1) | | | | 10 | mA |
| f(CNTR) | Timer input frequency CNTR ₀ (P3 ₂), CNTR ₁ (P3 ₃) (Note 2) | | f(X _{IN}) = 4 MHz | | 1 | MHz |
| | | | f(X _{IN}) = 8 MHz | | 2 | |
| f(SCLK) | Serial I/O clock input frequency SCLK (P1 ₆) (Note 2) | Use as clock synchronous serial I/O mode | f(X _{IN}) = 4 MHz | | 250 | kHz |
| | | | f(X _{IN}) = 8 MHz | | 500 | |
| | Use as UART mode | f(X _{IN}) = 4 MHz | | 1 | MHz | |
| | | f(X _{IN}) = 8 MHz | | 2 | | |
| f(X _{IN}) | Clock input oscillation frequency (Note 2) | | V _{CC} = 2.7 to 4.5 V | | 2.2V _{CC} – 2 | MHz |
| | | | V _{CC} = 4.5 to 5.5 V | | 8 | |

Notes 1 : The average output current I_{OH} (avg) and I_{OL} (avg) are the average value during a 100ms.

2 : Oscillation frequency is at 50% duty cycle.

M37477M4/M8/E8-XXXSP/FP

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, 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, 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/SCLK | use as SCLK input | VCC = 5 V | | 0.5 | | V | |
| | | | VCC = 3 V | | 0.3 | | | |
| IIL | "H" 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 | VCC = 5 V | | | –5 | μA | |
| | | | VCC = 3 V | | | –3 | | |
| 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 | 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)=8MHz | VCC = 5 V | | 7 | 14 | mA |
| | | | | VCC = 3 V | | 3.5 | 7 | |
| | | | f(XIN)=4MHz | VCC = 5 V | | 7.5 | 15 | |
| | | | | VCC = 3 V | | 4 | 8 | |
| | | At wait mode. | f(XIN)=8MHz | VCC = 5 V | | 2 | 4 | mA |
| | | | | VCC = 3 V | | 2 | 4 | |
| | | | f(XIN)=4MHz | VCC = 5 V | | 1 | 2 | |
| | | | | VCC = 3 V | | 0.5 | 1 | |
| At stop mode, f(XIN)=0, VCC=5V | | | Ta = 25°C | | 0.1 | 1 | μA | |
| | | | Ta = 85°C | | 1 | 10 | | |
| VRAM | RAM retention voltage | Stop all oscillation | | 2 | | | V | |

M37477M4/M8/E8-XXXSP/FP

A-D CONVERSION 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. | |
| — | Resolution | | | | 8 | bits |
| — | Absolute accuracy | | | | ±3 | LSB |
| T _{CONV} | Conversion time | V _{CC} = 2.7 to 5.5 V, f(X _{IN}) = 4 MHz | | | 25 | μs |
| | | V _{CC} = 4.5 to 5.5 V, f(X _{IN}) = 8 MHz | | | 12.5 | |
| V _{REF} | Reference input voltage | | 0.5 V _{CC} | | V _{CC} | V |
| RLADDER | Ladder resistance value | | 2 | 5 | 10 | kΩ |
| V _{IA} | Analog input voltage | | 0 | | V _{REF} | V |

M37478M4/M8/E8-XXXSP/FP, M37478E8SS
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 P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₂₀ – P ₂₇ , P ₃₀ – P ₃₃ , P ₄₀ – P ₄₃ , P ₅₀ – P ₅₃ , V _{REF} , RESET | | -0.3 to V _{CC} +0.3 | V |
| V _O | Output voltage P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₄₀ – P ₄₃ , X _{OUT} | | -0.3 to V _{CC} +0.3 | V |
| P _d | Power dissipation | T _a = 25°C | 1000 (Note) | mW |
| T _{opr} | Operating temperature | | -20 to 85 | °C |
| T _{stg} | Storage temperature | | -40 to 150 | °C |

Note : 500mW for M37478M4/M8/E8-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 P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₃₀ – P ₃₃ , $\overline{\text{RESET}}$, X _{IN} | | 0.8 V _{CC} | | V _{CC} | V | |
| V _{IH} | “H” input voltage P ₂₀ – P ₂₇ , P ₄₀ – P ₄₃ , P ₅₀ – P ₅₃ (Note 1) | | 0.7 V _{CC} | | V _{CC} | V | |
| V _{IL} | “L” input voltage P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₃₀ – P ₃₃ | | 0 | | 0.2 V _{CC} | V | |
| V _{IL} | “L” input voltage P ₂₀ – P ₂₇ , P ₄₀ – P ₄₃ , P ₅₀ –P ₅₃ (Note 1) | | 0 | | 0.25 V _{CC} | V | |
| V _{IL} | “L” input voltage $\overline{\text{RESET}}$ | | 0 | | 0.12 V _{CC} | V | |
| V _{IL} | “L” input voltage X _{IN} | | 0 | | 0.16 V _{CC} | V | |
| I _{OH} (sum) | “H” sum output current P ₀₀ – P ₀₇ , P ₄₀ – P ₄₃ | | | | - 30 | mA | |
| I _{OH} (sum) | “H” sum output current P ₁₀ – P ₁₇ | | | | - 30 | mA | |
| I _{OL} (sum) | “L” sum output current P ₀₀ – P ₀₇ , P ₄₀ – P ₄₃ | | | | 60 | mA | |
| I _{OL} (sum) | “L” sum output current P ₁₀ – P ₁₇ | | | | 60 | mA | |
| I _{OH} (peak) | “H” peak output current P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₄₀ – P ₄₃ | | | | - 10 | mA | |
| I _{OL} (peak) | “L” peak output current P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₄₀ – P ₄₃ | | | | 20 | mA | |
| I _{OH} (avg) | “H” average output current P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₄₀ – P ₄₃ (Note 2) | | | | - 5 | mA | |
| I _{OL} (avg) | “L” average output current P ₀₀ – P ₀₇ , P ₁₀ – P ₁₇ , P ₄₀ – P ₄₃ (Note 2) | | | | 10 | mA | |
| 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(SCLK) | Serial I/O clock input frequency SCLK (P16) (Note 2) | Use as clock synchronous serial I/O mode | f(X _{IN}) = 4 MHz | | | 250 | kHz |
| | | | f(X _{IN}) = 8 MHz | | | 500 | |
| | | Use as UART mode | 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 | 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 100ms.

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.

M37478M4/M8/E8-XXXSP/FP, M37478E8SS

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, 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, 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/SCLK | used as SCLK 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 | VCC = 5 V | | | –5 | μA | |
| | | | VCC = 3 V | | | –3 | | |
| 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 | 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)=8MHz | VCC = 5 V | | 7 | 14 | mA |
| | | | f(XIN)=4MHz | VCC = 3 V | | 3.5 | 7 | |
| | | At normal mode, A-D conversion is executed. | f(XIN)=8MHz | VCC = 5 V | | 7.5 | 15 | mA |
| | | | f(XIN)=4MHz | VCC = 3 V | | 4 | 8 | |
| | | At low-speed mode, Ta=25°C, f(XIN)=0, f(XCIN)=32kHz, low-power mode, A-D conversion is not executed. | | VCC = 5 V | | 30 | 80 | μA |
| | | | | VCC = 3 V | | 15 | 40 | |
| | | At wait mode. | f(XIN)=8MHz | VCC = 5 V | | 2 | 4 | mA |
| | | | f(XIN)=4MHz | VCC = 3 V | | 1 | 2 | |
| | | At wait mode, Ta=25°C, f(XIN)=0, f(XCIN)=32kHz, low-power mode | | VCC = 5 V | | 3 | 12 | μA |
| | | | | VCC = 3 V | | 2 | 8 | |
| At stop mode, f(XIN)=0, f(XCIN)=0, VCC=5V | | Ta = 25°C | | 0.1 | 1 | μA | | |
| | | Ta = 85°C | | 1 | 10 | | | |
| VRAM | RAM retention voltage | Stop all oscillation | | 2 | | | V | |

M37478M4/M8/E8-XXXSP/FP, M37478E8SS**A-D CONVERTER 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. | |
| — | Resolution | | | | 8 | bits |
| — | Absolute accuracy | | | | ±3 | LSB |
| T _{CONV} | Conversion time | V _{CC} = 2.7 to 5.5 V, f(X _{IN}) = 4 MHz | | | 25 | μs |
| | | V _{CC} = 4.5 to 5.5 V, f(X _{IN}) = 8 MHz | | | 12.5 | |
| V _{REF} | Reference input voltage | | 0.5 V _{CC} | | V _{CC} | V |
| RLADDER | Ladder resistance value | | 2 | 5 | 10 | kΩ |
| V _{IA} | Analog input voltage | | 0 | | V _{REF} | V |

Keep safety first in your circuit designs!

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