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Renesas Technology Corp.  
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April 1, 2003

# 38C3 Group

User's Manual

MITSUBISHI 8-BIT SINGLE-CHIP  
MICROCOMPUTER  
740 FAMILY / 38000 SERIES

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## Preface

This user's manual describes Mitsubishi's CMOS 8-bit microcomputers 38C3 Group.

After reading this manual, the user should have a thorough knowledge of the functions and features of the 38C3 Group, and should be able to fully utilize the product. The manual starts with specifications and ends with application examples.

For details of software, refer to the "740 Family Software Manual."

For details of development support tools, refer to the "DEVELOPMENT SUPPORT TOOLS FOR MICROCOMPUTERS" data book.

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# BEFORE USING THIS USER'S MANUAL

This user's manual consists of the following three chapters. Refer to the chapter appropriate to your conditions, such as hardware design or software development.

## 1. Organization

### ● CHAPTER 1 HARDWARE

This chapter describes features of the microcomputer and operation of each peripheral function.

### ● CHAPTER 2 APPLICATION

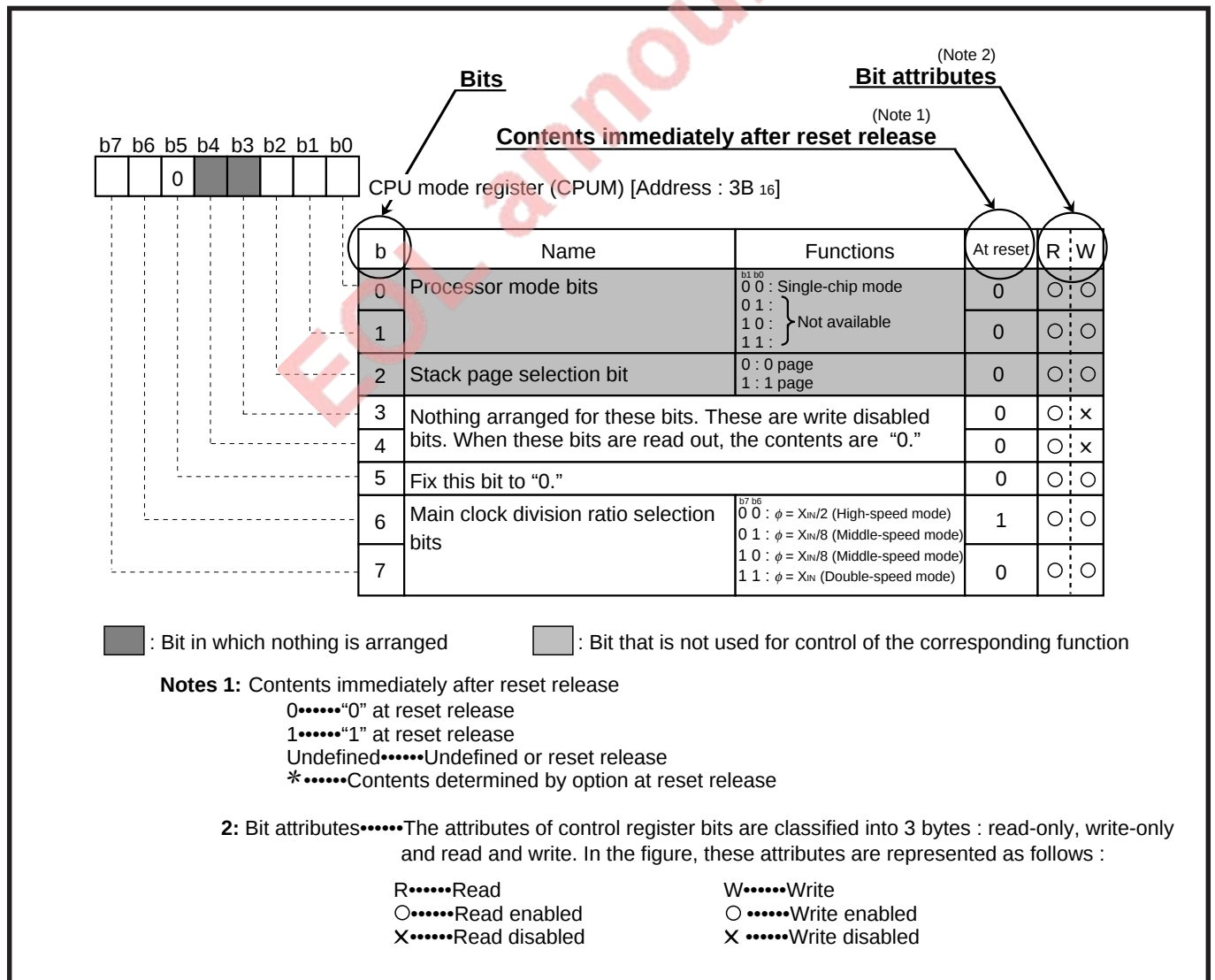
This chapter describes usage and application examples of peripheral functions, based mainly on setting examples of relevant registers.

### ● CHAPTER 3 APPENDIX

This chapter includes a list of registers, and necessary information for systems development using the microcomputer, the mask ROM confirmation (for mask ROM version), ROM programming confirmation, and the mark specifications which are to be submitted when ordering.

## 2. Structure of Register

The figure of each register structure describes its functions, contents at reset, and attributes as follows:



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# CHAPTER 1

## **HARDWARE**

DESCRIPTION  
FEATURES  
APPLICATION  
PIN CONFIGURATION  
FUNCTIONAL BLOCK  
PIN DESCRIPTION  
PART NUMBERING  
GROUP EXPANSION  
FUNCTIONAL DESCRIPTION  
NOTES ON PROGRAMMING  
NOTES ON USE  
DATA REQUIRED FOR MASK  
ORDERS  
DATA REQUIRED FOR ROM WRITING  
ORDERS  
ROM PROGRAMMING METHOD  
FUNCTIONAL DESCRIPTION  
SUPPLEMENT

# HARDWARE

## DESCRIPTION/FEATURES/APPLICATION/PIN CONFIGURATION

### DESCRIPTION

The 38C3 group is the 8-bit microcomputer based on the 740 family core technology.

The 38C3 group has a LCD drive control circuit, a 10-channel A-D converter, and a Serial I/O as additional functions.

The various microcomputers in the 38C3 group include variations of internal memory size and packaging. For details, refer to the section on part numbering.

For details on availability of microcomputers in the 38C3 group, refer to the section on group expansion.

### FEATURES

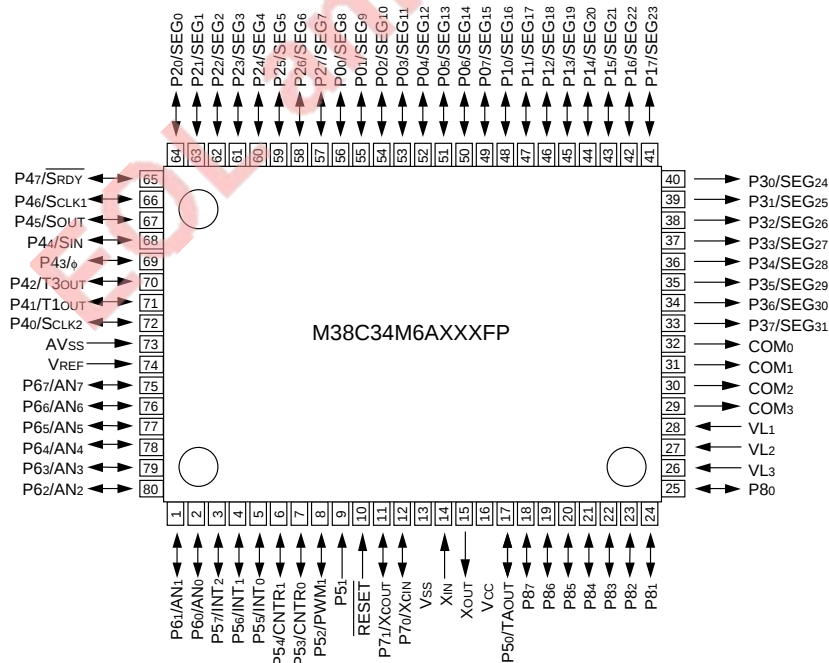
- Basic machine-language instructions ..... 71
- The minimum instruction execution time ..... 0.5  $\mu$ s  
(at 8MHz oscillation frequency)
- Memory size
  - ROM ..... 4 K to 48 K bytes
  - RAM ..... 192 to 1024 bytes
- Programmable input/output ports ..... 57
- Software pull-up/pull-down resistors  
..... (Ports P0–P8 except Port P51)
- Interrupts ..... 16 sources, 16 vectors  
(includes key input interrupt)
- Timers ..... 8-bit X 6, 16-bit X 1
- A-D converter ..... 10-bit X 8 channels
- Serial I/O ..... 8-bit X 1 (Clock-synchronized)

- LCD drive control circuit
  - Bias ..... 1/1, 1/2, 1/3
  - Duty ..... 1/1, 1/2, 1/3, 1/4
  - Common output ..... 4
  - Segment output ..... 32
- 2 Clock generating circuit  
(connect to external ceramic resonator or quartz-crystal oscillator)
- Power source voltage
  - In high-speed mode ..... 4.0 to 5.5 V
  - In middle-speed mode ..... 2.5 to 5.5 V  
(M version is 2.2\* to 5.5 V)
  - In low-speed mode ..... 2.5 to 5.5 V  
(M version is 2.2\* to 5.5 V)
- Power dissipation
  - In high-speed mode ..... 32 mW  
(at 8 MHz oscillation frequency)
  - In low-speed mode ..... 45  $\mu$ W  
(at 32 kHz oscillation frequency, at 3 V power source voltage)
- Operating temperature range ..... – 20 to 85°C
- \* Mask ROM version only

### APPLICATION

Camera, household appliances, consumer electronics, etc.

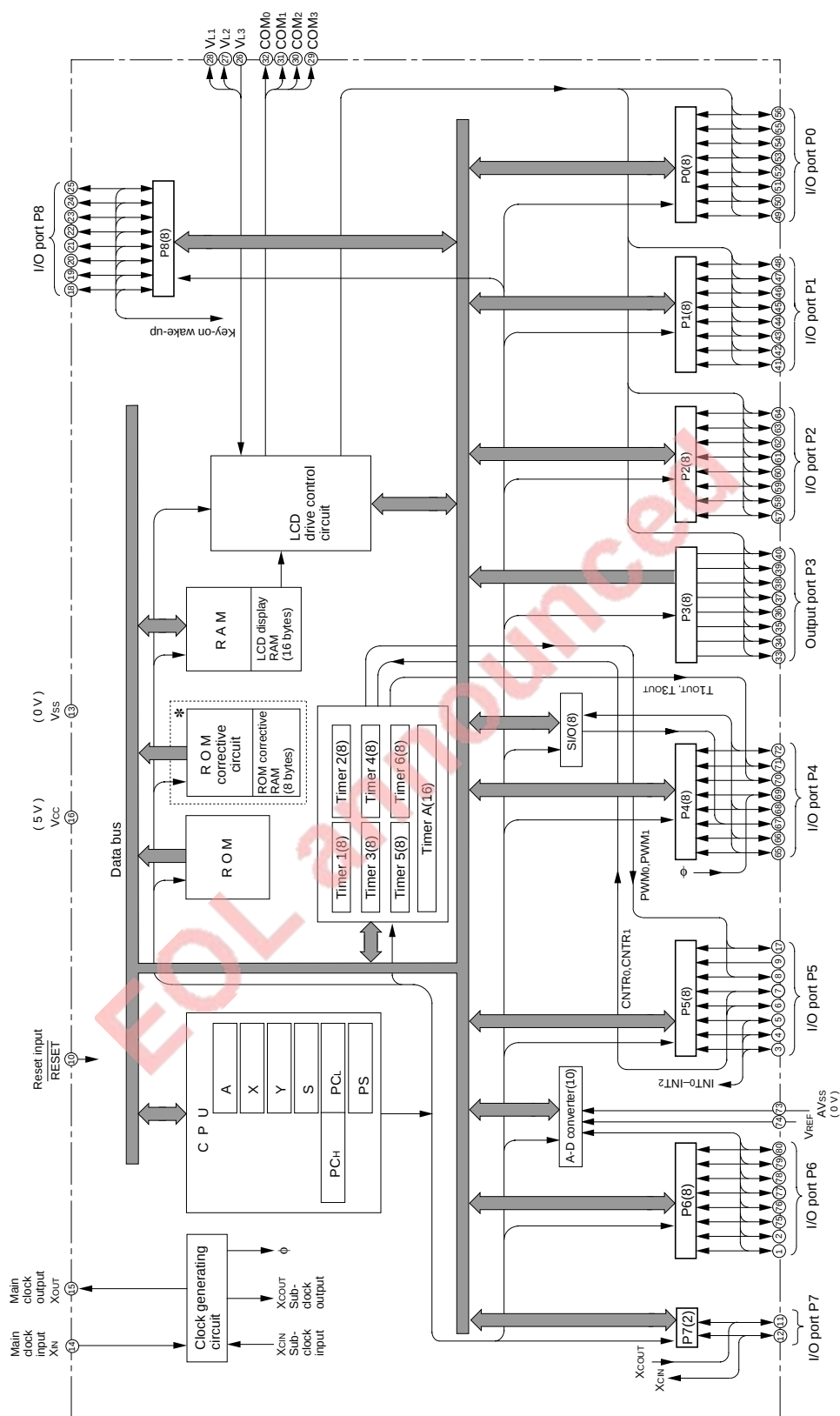
### PIN CONFIGURATION (TOP VIEW)



Package type : 80P6N-A  
80-pin plastic-molded QFP

Fig. 1 M38C34M6AXXFP pin configuration

FUNCTIONAL BLOCK DIAGRAM



\* This is valid only in mask ROM version.

Fig. 2 Functional block diagram

# HARDWARE

## PIN DESCRIPTION

### PIN DESCRIPTION

Table 1 Pin description (1)

| Pin                                    | Name                     | Function                                                                                                                                                                                                                                                                                                                                                                                                                            | Function except a port function |
|----------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| VCC, VSS                               | Power source             | • Apply voltage of 2.5* V to 5.5 V to VCC, and 0 V to VSS.                                                                                                                                                                                                                                                                                                                                                                          |                                 |
| VREF                                   | Analog reference voltage | • Reference voltage input pin for A-D converter.                                                                                                                                                                                                                                                                                                                                                                                    |                                 |
| AVSS                                   | Analog power source      | • GND input pin for A-D converter.<br>• Connect to VSS.                                                                                                                                                                                                                                                                                                                                                                             |                                 |
| $\overline{\text{RESET}}$              | Reset input              | • Reset input pin for active "L."                                                                                                                                                                                                                                                                                                                                                                                                   |                                 |
| XIN                                    | Clock input              | <ul style="list-style-type: none"> <li>Input and output pins for the main clock generating circuit.</li> <li>Feedback resistor is built in between XIN pin and XOUT pin.</li> <li>Connect a ceramic resonator or a quartz-crystal oscillator between the XIN and XOUT pins to set the oscillation frequency.</li> <li>If an external clock is used, connect the clock source to the XIN pin and leave the XOUT pin open.</li> </ul> |                                 |
| XOUT                                   | Clock output             |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| VL1 – VL3                              | LCD power source         | <ul style="list-style-type: none"> <li>Input <math>0 \leq \text{VL1} \leq \text{VL2} \leq \text{VL3} \leq \text{VCC}</math> voltage.</li> <li>Input 0 – VL3 voltage to LCD.</li> </ul>                                                                                                                                                                                                                                              |                                 |
| COM0 – COM3                            | Common output            | <ul style="list-style-type: none"> <li>LCD common output pins.</li> <li>COM1, COM2, and COM3 are not used at 1/1 duty ratio.</li> <li>COM2 and COM3 are not used at 1/2 duty ratio.</li> <li>COM3 is not used at 1/3 duty ratio.</li> </ul>                                                                                                                                                                                         |                                 |
| P00/SEG8 – P07/SEG15                   | I/O port P0              | <ul style="list-style-type: none"> <li>8-bit I/O port.</li> <li>CMOS compatible input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each port to be individually programmed as either input or output.</li> <li>Pull-down control is enabled.</li> </ul>                                                                                                                                    | • LCD segment pins              |
| P10/SEG16 – P17/SEG23                  | I/O port P1              |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| P20/SEG0 – P27/SEG7                    | I/O port P2              |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| P30/SEG24 – P37/SEG31                  | Output port P3           | <ul style="list-style-type: none"> <li>8-bit output port.</li> <li>CMOS state output.</li> <li>Pull-down control is enabled.</li> </ul>                                                                                                                                                                                                                                                                                             |                                 |
| P40/SCLK2                              | I/O port P4              | <ul style="list-style-type: none"> <li>8-bit I/O port.</li> <li>CMOS compatible input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each pin to be individually programmed as either input or output.</li> <li>Pull-up control is enabled.</li> </ul>                                                                                                                                       | • Serial I/O function pin       |
| P41/T1OUT                              |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                     | • Timer output pin              |
| P42/T3OUT                              |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                     | • Timer output pin              |
| P43/ $\phi$                            |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                     | • $\phi$ output pin             |
| P44/SIN, P45/SOUT, P46/SCLK1, P47/SRDY |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                     | • Serial I/O function pins      |

\* Mask ROM version of M version is 2.2 V to 5.5 V.

Table 2 Pin description (2)

| Pin                                | Name          | Function                                                                                                                                                                                                                                                                                      | Function except a port function                   |
|------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
|                                    |               |                                                                                                                                                                                                                                                                                               |                                                   |
| P51                                | Input port P5 | <ul style="list-style-type: none"> <li>1-bit input pin.</li> <li>CMOS compatible input level.</li> </ul>                                                                                                                                                                                      |                                                   |
| P50/TAOUT                          | I/O port P5   | <ul style="list-style-type: none"> <li>7-bit I/O port.</li> <li>CMOS compatible input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each pin to be individually programmed as either input or output.</li> <li>Pull-up control is enabled.</li> </ul> | • Timer A output pin                              |
| P52/PWM1                           |               |                                                                                                                                                                                                                                                                                               | • PWM1 output (timer output) pin                  |
| P53/CNTR0,<br>P54/CNTR1            |               |                                                                                                                                                                                                                                                                                               | • External count I/O pins                         |
| P55/INT0,<br>P56/INT1,<br>P57/INT2 |               |                                                                                                                                                                                                                                                                                               | • External interrupt input pins                   |
| P60/AN0 –<br>P67/AN7               | I/O port P6   | <ul style="list-style-type: none"> <li>8-bit I/O port.</li> <li>CMOS compatible input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each pin to be individually programmed as either input or output.</li> <li>Pull-up control is enabled.</li> </ul> | • A-D conversion input pins                       |
| P70/XCIN,<br>P71/XCOUT             | I/O port P7   | <ul style="list-style-type: none"> <li>2-bit I/O port.</li> <li>CMOS compatible input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each pin to be individually programmed as either input or output.</li> <li>Pull-up control is enabled.</li> </ul> | • Sub-clock generating circuit I/O pins           |
| P80 – P87                          | I/O port P8   | <ul style="list-style-type: none"> <li>8-bit I/O port.</li> <li>TTL input level.</li> <li>CMOS 3-state output structure.</li> <li>I/O direction register allows each pin to be individually programmed as either input or output.</li> <li>Pull-up control is enabled.</li> </ul>             | • Key input (Key-on wake-up) interrupt input pins |

# HARDWARE

## PART NUMBERING

### PART NUMBERING

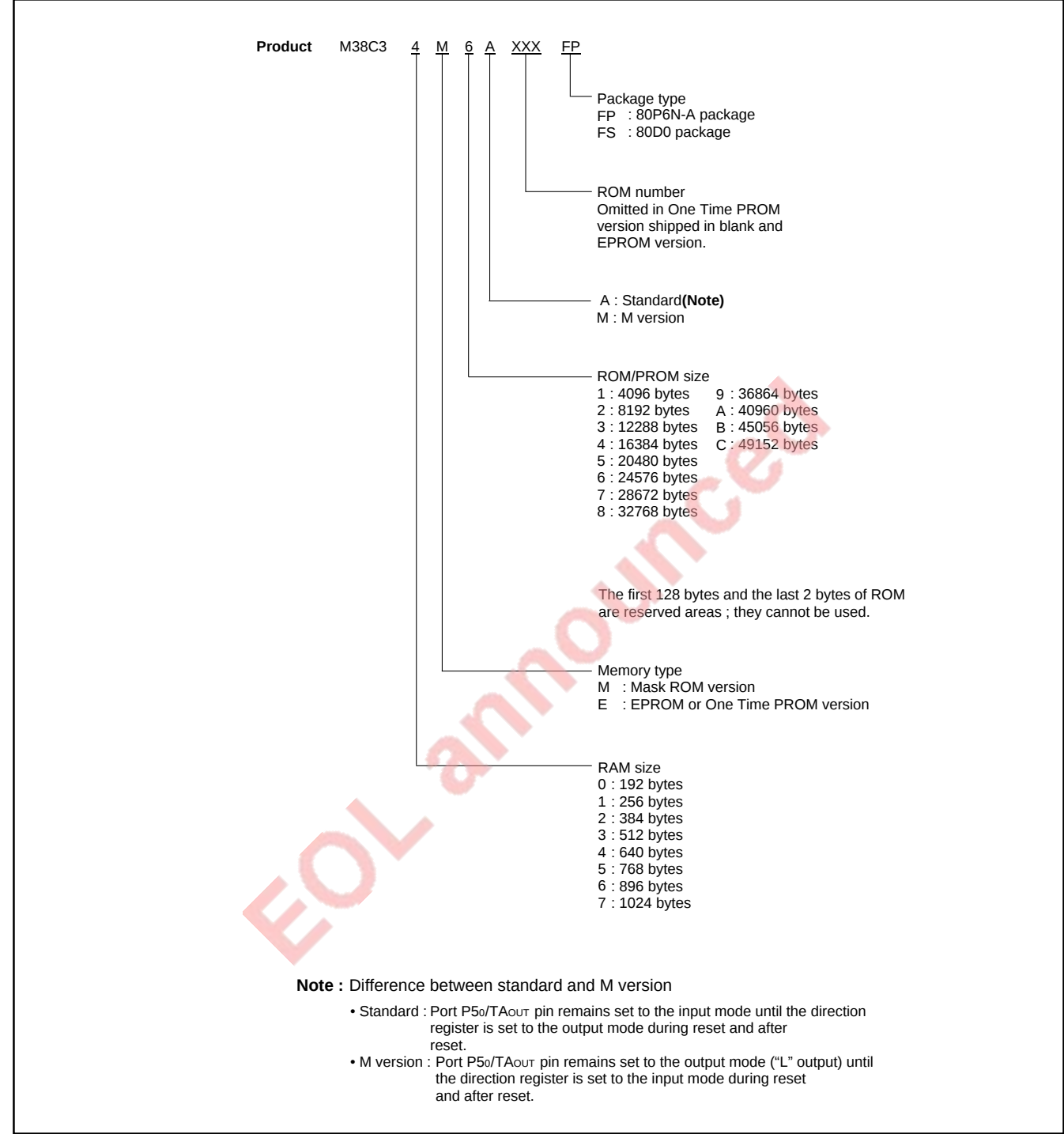


Fig. 3 Part numbering

### GROUP EXPANSION

Mitsubishi plans to expand the 38C3 group as follows.

### Memory Type

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

### Memory Size

ROM/PROM size ..... 16 K to 48 K bytes

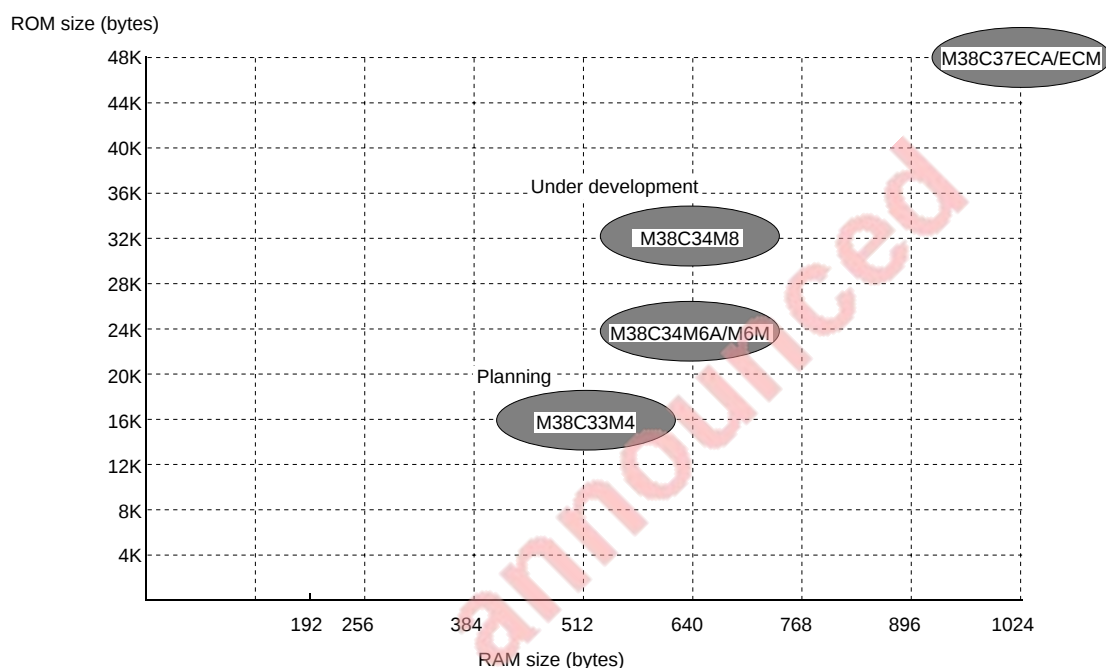
RAM size ..... 512 to 1024 bytes

### Packages

80P6N-A ..... 0.8 mm-pitch plastic molded QFP

80D0 ..... 0.8 mm-pitch ceramic LCC (EPROM version)

### Memory Expansion Plan



Products under development or planning : the development schedule and specification may be revised without notice.  
Planning products may be stopped the development.

Fig. 4 Memory expansion plan

Currently supported products are listed below.

Table 3 Support products

As of December 1998

| Product name   | (P) ROM size (bytes)<br>ROM size for User in ( ) | RAM size (bytes) | Package | Remarks                       |
|----------------|--------------------------------------------------|------------------|---------|-------------------------------|
| M38C34M6AXXXFP | 24576 (24446)                                    | 640              | 80P6N-A | Mask ROM version              |
| M38C37ECAXXXFP | 49152 (49022)                                    | 1024             |         | One Time PROM version         |
| M38C37ECAFP    |                                                  |                  |         | One Time PROM version (blank) |
| M38C37ECAFS    |                                                  |                  | 80D0    | EPROM version                 |
| M38C34M6MXXFP  | 24576 (24446)                                    | 640              | 80P6N-A | Mask ROM version              |
| M38C37ECMXXFP  | 49152 (49022)                                    | 1024             |         | One Time PROM version         |
| M38C37ECMFP    |                                                  |                  |         | One Time PROM version (blank) |
| M38C37ECMFS    |                                                  |                  | 80D0    | EPROM version                 |

# HARDWARE

## FUNCTIONAL DESCRIPTION

### FUNCTIONAL DESCRIPTION Central Processing Unit (CPU)

The 38C3 group uses the standard 740 Family instruction set. Refer to the table of 740 Family addressing modes and machine instructions or the 740 Family Software Manual for details on the instruction set.

Machine-resident 740 Family instructions are as follows:

- The FST and SLW instructions cannot be used.
- The STP, WIT, MUL, and DIV instructions can be used.

#### [Accumulator (A)]

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

#### [Index Register X (X)]

The index register X is an 8-bit register. In the index addressing modes, the value of the OPERAND is added to the contents of register X and specifies the real address.

#### [Index Register Y (Y)]

The index register Y is an 8-bit register. In partial instruction, the value of the OPERAND is added to the contents of register Y and specifies the real address.

#### [Stack Pointer (S)]

The stack pointer is an 8-bit register used during subroutine calls and interrupts. This register indicates start address of stored area (stack) for storing registers during subroutine calls and interrupts. The low-order 8 bits of the stack address are determined by the contents of the stack pointer. The high-order 8 bits of the stack address are determined by the stack page selection bit. If the stack page selection bit is "0", the high-order 8 bits becomes "0016". If the stack page selection bit is "1", the high-order 8 bits becomes "0116". The operations of pushing register contents onto the stack and popping them from the stack are shown in Figure 6. Store registers other than those described in Figure 6 with program when the user needs them during interrupts or subroutine calls.

#### [Program Counter (PC)]

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

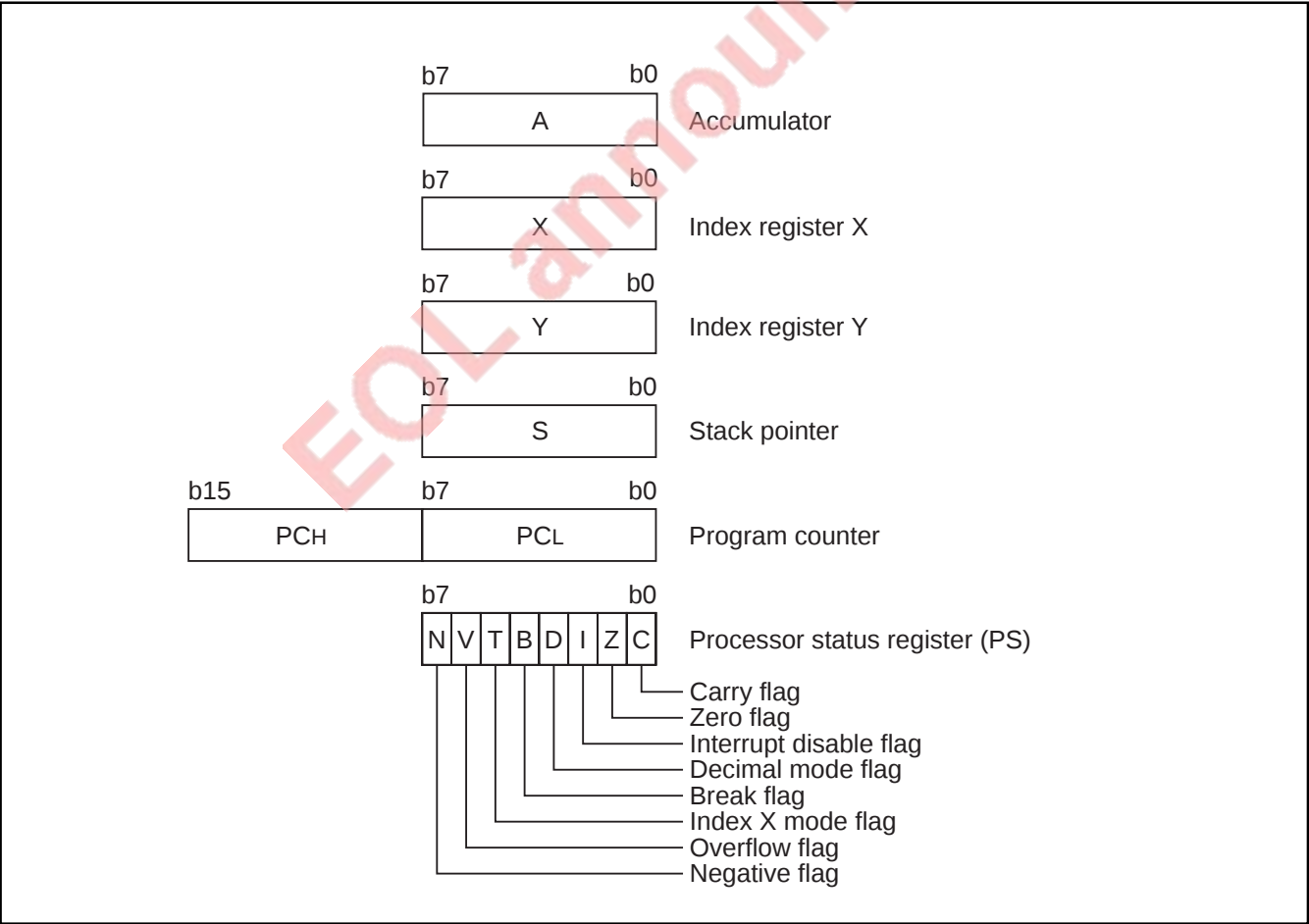


Fig. 5 740 Family CPU register structure

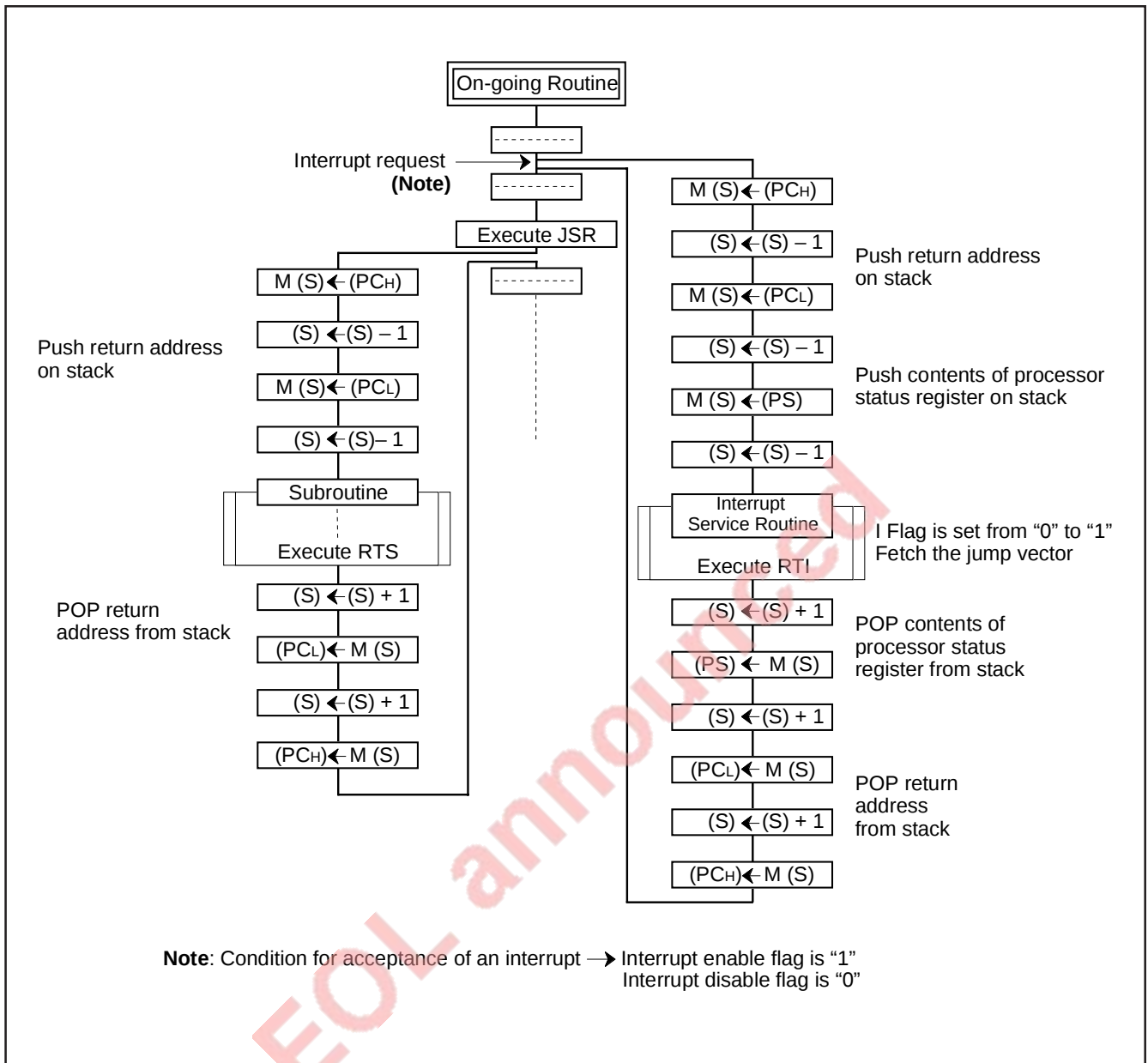


Fig. 6 Register push and pop at interrupt generation and subroutine call

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

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

# HARDWARE

## FUNCTIONAL DESCRIPTION

### [Processor status register (PS)]

The processor status register is an 8-bit register consisting of 5 flags which indicate the status of the processor after an arithmetic operation and 3 flags which decide MCU operation. Branch operations can be performed by testing the Carry (C) flag, Zero (Z) flag, Overflow (V) flag, or the Negative (N) flag. In decimal mode, the Z, V, N flags are not valid.

•Bit 0: Carry flag (C)

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

•Bit 1: Zero flag (Z)

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

•Bit 2: Interrupt disable flag (I)

The I flag disables all interrupts except for the interrupt generated by the BRK instruction. Interrupts are disabled when the I flag is "1".

•Bit 3: Decimal mode flag (D)

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

•Bit 4: Break flag (B)

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

•Bit 5: Index X mode flag (T)

When the T flag is "0", arithmetic operations are performed between accumulator and memory. When the T flag is "1", direct arithmetic operations and direct data transfers are enabled between memory locations.

•Bit 6: Overflow flag (V)

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

•Bit 7: Negative flag (N)

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

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

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

[CPU Mode Register (CPUM)] 003B16

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

The CPU mode register is allocated at address 003B16.

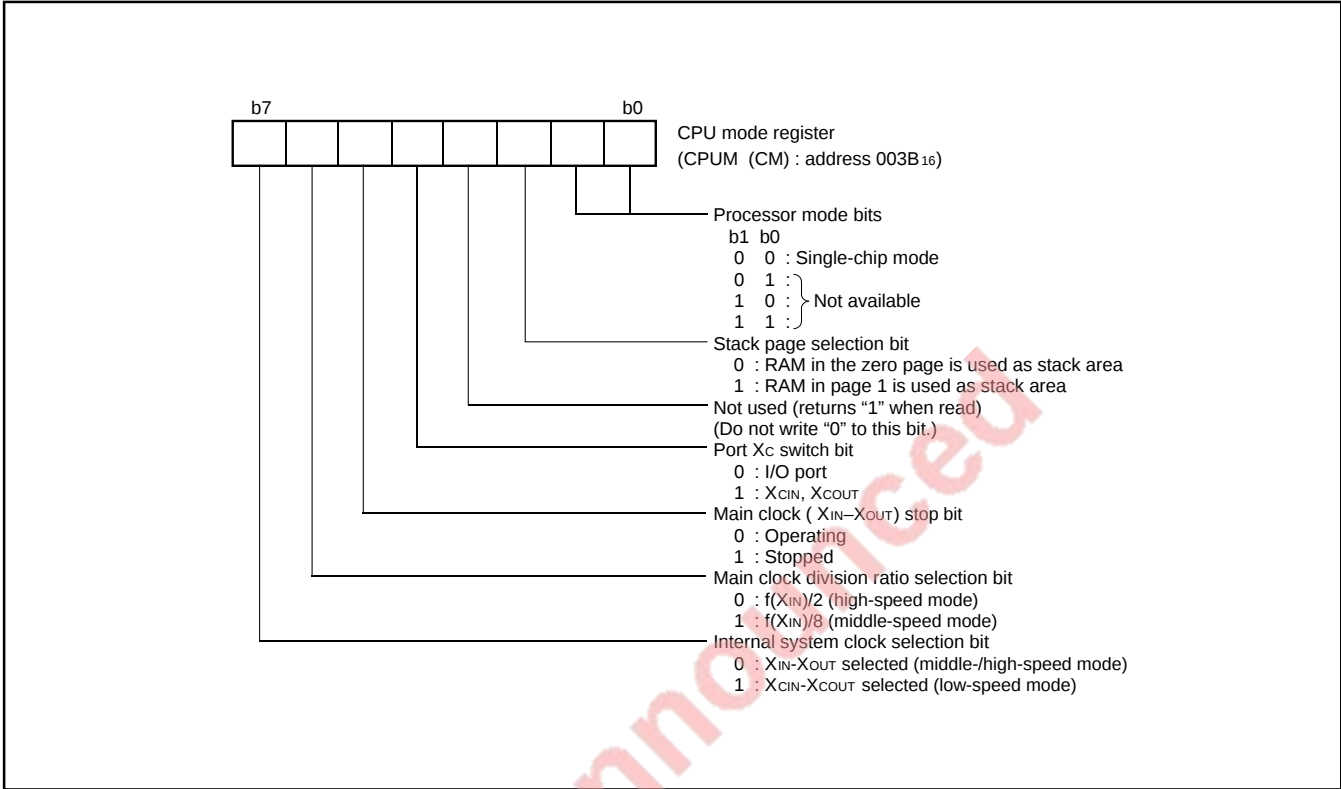


Fig. 7 Structure of CPU mode register

# HARDWARE

## FUNCTIONAL DESCRIPTION

### MEMORY

#### Special Function Register (SFR) Area

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

#### RAM

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

#### ROM

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

#### Interrupt Vector Area

The interrupt vector area contains reset and interrupt vectors.

#### Zero Page

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

#### Special Page

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

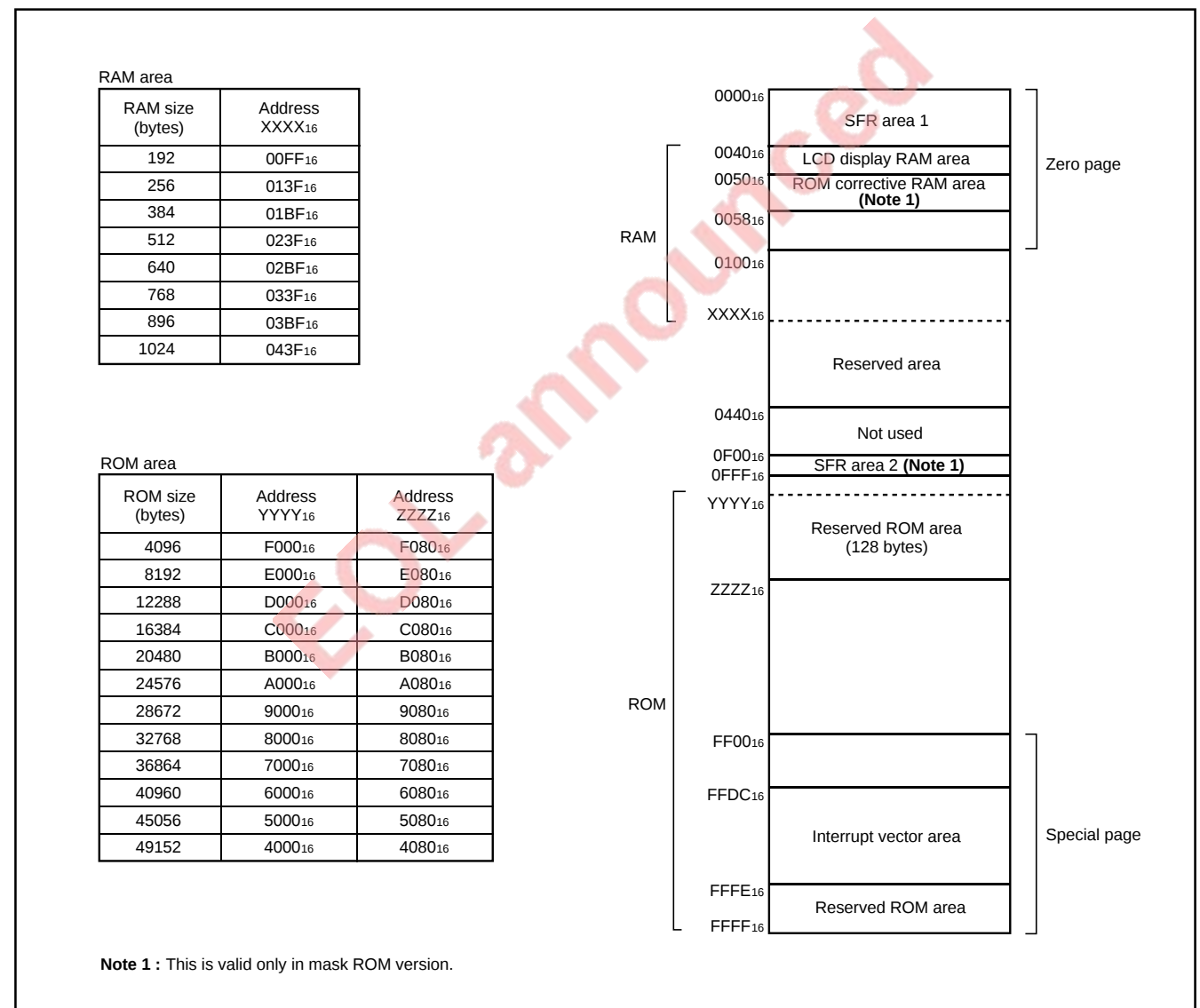


Fig. 8 Memory map diagram

|                    |                                                  |                    |                                                  |
|--------------------|--------------------------------------------------|--------------------|--------------------------------------------------|
| 0000 <sub>16</sub> | Port P0 (P0)                                     | 0020 <sub>16</sub> | Timer 1 (T1)                                     |
| 0001 <sub>16</sub> | Port P0 direction register (P0D)                 | 0021 <sub>16</sub> | Timer 2 (T2)                                     |
| 0002 <sub>16</sub> | Port P1 (P1)                                     | 0022 <sub>16</sub> | Timer 3 (T3)                                     |
| 0003 <sub>16</sub> | Port P1 direction register (P1D)                 | 0023 <sub>16</sub> | Timer 4 (T4)                                     |
| 0004 <sub>16</sub> | Port P2 (P2)                                     | 0024 <sub>16</sub> | Timer 5 (T5)                                     |
| 0005 <sub>16</sub> | Port P2 direction register (P2D)                 | 0025 <sub>16</sub> | Timer 6 (T6)                                     |
| 0006 <sub>16</sub> | Port P3 (P3)                                     | 0026 <sub>16</sub> |                                                  |
| 0007 <sub>16</sub> |                                                  | 0027 <sub>16</sub> | Timer 6 PWM register (T6PWM)                     |
| 0008 <sub>16</sub> | Port P4 (P4)                                     | 0028 <sub>16</sub> | Timer 12 mode register (T12M)                    |
| 0009 <sub>16</sub> | Port P4 direction register (P4D)                 | 0029 <sub>16</sub> | Timer 34 mode register (T34M)                    |
| 000A <sub>16</sub> | Port P5 (P5)                                     | 002A <sub>16</sub> | Timer 56 mode register (T56M)                    |
| 000B <sub>16</sub> | Port P5 direction register (P5D)                 | 002B <sub>16</sub> | φ output control register (CKOUT)                |
| 000C <sub>16</sub> | Port P6 (P6)                                     | 002C <sub>16</sub> | Timer A register (low) (TAL)                     |
| 000D <sub>16</sub> | Port P6 direction register (P6D)                 | 002D <sub>16</sub> | Timer A register (high) (TAH)                    |
| 000E <sub>16</sub> | Port P7 (P7)                                     | 002E <sub>16</sub> | Compare register (low) (CONAL)                   |
| 000F <sub>16</sub> | Port P7 direction register (P7D)                 | 002F <sub>16</sub> | Compare register (high) (CONAH)                  |
| 0010 <sub>16</sub> | Port P8 (P8)                                     | 0030 <sub>16</sub> | Timer A mode register (TAM)                      |
| 0011 <sub>16</sub> | Port P8 direction register (P8D)                 | 0031 <sub>16</sub> | Timer A control register (TACON)                 |
| 0012 <sub>16</sub> |                                                  | 0032 <sub>16</sub> | A-D control register (ADCON)                     |
| 0013 <sub>16</sub> |                                                  | 0033 <sub>16</sub> | A-D conversion register (low) (ADL)              |
| 0014 <sub>16</sub> |                                                  | 0034 <sub>16</sub> | A-D conversion register (high) (ADH)             |
| 0015 <sub>16</sub> |                                                  | 0035 <sub>16</sub> |                                                  |
| 0016 <sub>16</sub> | PULL register A (PULLA)                          | 0036 <sub>16</sub> |                                                  |
| 0017 <sub>16</sub> | PULL register B (PULLB)                          | 0037 <sub>16</sub> |                                                  |
| 0018 <sub>16</sub> | Port P8 output selection register (P8SEL)        | 0038 <sub>16</sub> | Segment output enable register (SEG)             |
| 0019 <sub>16</sub> | Serial I/O control register 1 (SIOCON1)          | 0039 <sub>16</sub> | LCD mode register (LM)                           |
| 001A <sub>16</sub> | Serial I/O control register 2 (SIOCON2)          | 003A <sub>16</sub> | Interrupt edge selection register (INTEDGE)      |
| 001B <sub>16</sub> | Serial I/O register (SIO)                        | 003B <sub>16</sub> | CPU mode register (CPUM)                         |
| 001C <sub>16</sub> |                                                  | 003C <sub>16</sub> | Interrupt request register 1 (IREQ1)             |
| 001D <sub>16</sub> |                                                  | 003D <sub>16</sub> | Interrupt request register 2 (IREQ2)             |
| 001E <sub>16</sub> |                                                  | 003E <sub>16</sub> | Interrupt control register 1 (ICON1)             |
| 001F <sub>16</sub> |                                                  | 003F <sub>16</sub> | Interrupt control register 2 (ICON2)             |
| 0F01 <sub>16</sub> | ROM correct enable register 1 (Note)             | 0F0A <sub>16</sub> | ROM correct high-order address register 5 (Note) |
| 0F02 <sub>16</sub> | ROM correct high-order address register 1 (Note) | 0F0B <sub>16</sub> | ROM correct low-order address register 5 (Note)  |
| 0F03 <sub>16</sub> | ROM correct low-order address register 1 (Note)  | 0F0C <sub>16</sub> | ROM correct high-order address register 6 (Note) |
| 0F04 <sub>16</sub> | ROM correct high-order address register 2 (Note) | 0F0D <sub>16</sub> | ROM correct low-order address register 6 (Note)  |
| 0F05 <sub>16</sub> | ROM correct low-order address register 2 (Note)  | 0F0E <sub>16</sub> | ROM correct high-order address register 7 (Note) |
| 0F06 <sub>16</sub> | ROM correct high-order address register 3 (Note) | 0F0F <sub>16</sub> | ROM correct low-order address register 7 (Note)  |
| 0F07 <sub>16</sub> | ROM correct low-order address register 3 (Note)  | 0F10 <sub>16</sub> | ROM correct high-order address register 8 (Note) |
| 0F08 <sub>16</sub> | ROM correct high-order address register 4 (Note) | 0F11 <sub>16</sub> | ROM correct low-order address register 8 (Note)  |
| 0F09 <sub>16</sub> | ROM correct low-order address register 4 (Note)  |                    |                                                  |

**Note:** This register is valid only in mask ROM version.

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

# HARDWARE

## FUNCTIONAL DESCRIPTION

### I/O PORTS

#### [Direction Registers (ports P2, P4, P50, P52–P57, and P6–P8)]

The I/O ports P2, P4, P50, P52–P57, and P6–P8 have direction registers which determine the input/output direction of each individual pin. Each bit in a direction register corresponds to one pin, each pin can be set to be input port or output port.

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

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

#### [Direction Registers (ports P0 and P1)]

Ports P0 and P1 have direction registers which determine the input/output direction of each individual port.

Each port in a direction register corresponds to one port, each port can be set to be input or output.

When “0” is written to the bit 0 of a direction register, that port becomes an input port. When “1” is written to that port, that port becomes an output port. Bits 1 to 7 of ports P0 and P1 direction registers are not used.

### Pull-up/Pull-down Control

By setting the PULL register A (address 0016<sub>16</sub>) or the PULL register B (address 0017<sub>16</sub>), ports except for ports P3 and P5<sub>1</sub> can control either pull-down or pull-up (pins that are shared with the segment output pins for LCD are pull-down; all other pins are pull-up) with a program.

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

### Port P8 Output Selection

Ports P8<sub>0</sub> to P8<sub>7</sub> can be switched to N-channel open-drain output by setting “1” to the port P8 output selection register.

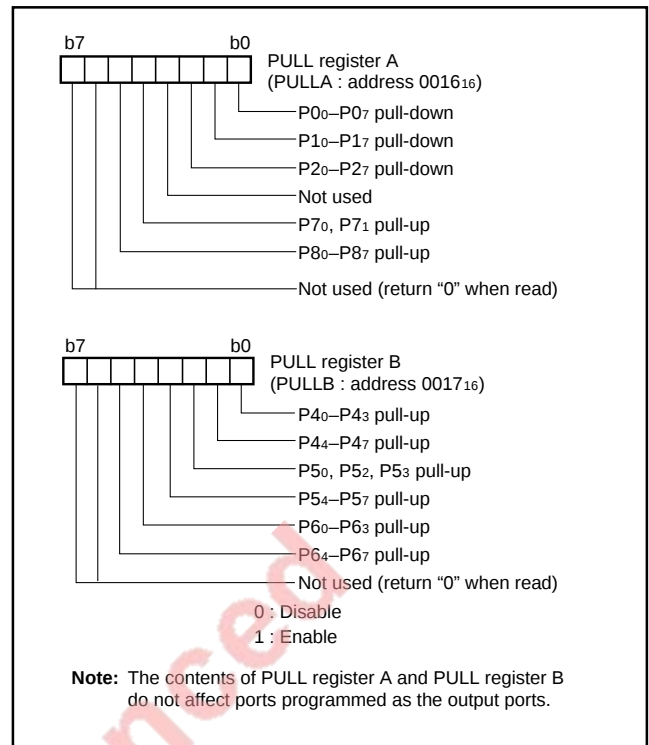


Fig. 10 Structure of PULL register A and PULL register B

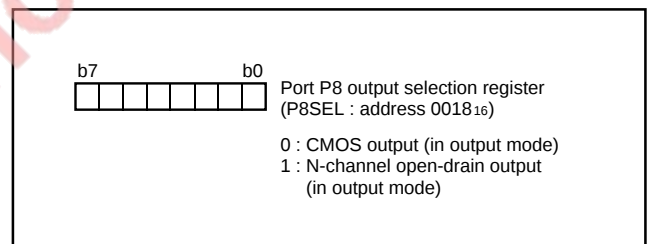


Fig. 11 Structure of port P8 output selection register

Table 6 List of I/O port function (1)

| Pin                                                                     | Name    | Input/Output                  | I/O format                                         | Non-port function  | Related SFRs                                      | Ref. No. |
|-------------------------------------------------------------------------|---------|-------------------------------|----------------------------------------------------|--------------------|---------------------------------------------------|----------|
| P0 <sub>0</sub> /SEG <sub>8</sub> – P0 <sub>7</sub> /SEG <sub>15</sub>  | Port P0 | Input/Output, port unit       | CMOS compatible input level<br>CMOS 3-state output | LCD segment output | PULL register A<br>Segment output enable register | (1)      |
| P1 <sub>0</sub> /SEG <sub>16</sub> – P1 <sub>7</sub> /SEG <sub>23</sub> | Port P1 | Input/Output, port unit       | CMOS compatible input level<br>CMOS 3-state output | LCD segment output | PULL register A<br>Segment output enable register |          |
| P2 <sub>0</sub> /SEG <sub>0</sub> – P2 <sub>7</sub> /SEG <sub>7</sub>   | Port P2 | Input/Output, individual bits | CMOS compatible input<br>CMOS 3-state output       | LCD segment output | PULL register A<br>Segment output enable register |          |
| P3 <sub>0</sub> /SEG <sub>24</sub> – P3 <sub>7</sub> /SEG <sub>31</sub> | Port P3 | Output, individual bits       | CMOS 3-state output                                | LCD segment output | Segment output enable register                    | (2)      |

**Table 7 List of I/O port function (2)**

| Pin                                          | Name    | Input/Output                  | I/O format                                         | Non-port function                          | Related SFRs                                                         | Ref. No.                 |
|----------------------------------------------|---------|-------------------------------|----------------------------------------------------|--------------------------------------------|----------------------------------------------------------------------|--------------------------|
| P40/SCLK2                                    | Port P4 | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | Serial I/O function I/O                    | Serial I/O control registers 1, 2<br>PULL register B                 | (3)                      |
| P41/T1OUT                                    |         |                               |                                                    | Timer output                               | Timer 12 mode register<br>PULL register B                            | (4)                      |
| P42/T3OUT                                    |         |                               |                                                    | Timer output                               | Timer 34 mode register<br>PULL register B                            | (4)                      |
| P43/ $\phi$                                  |         |                               |                                                    | $\phi$ clock output                        | $\phi$ output control register<br>PULL register B                    | (5)                      |
| P44/SIN<br>P45/SOUT<br>P46/SCLK1<br>P47/SRDY |         |                               |                                                    | Serial I/O function I/O                    | Serial I/O control registers 1, 2<br>PULL register B                 | (6)<br>(7)<br>(8)<br>(9) |
| P50/TAOUT                                    | Port P5 | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | Timer A output                             | Timer A mode register<br>Timer A control register<br>PULL register B | (10)                     |
| P51                                          |         | Input                         | CMOS compatible input level                        |                                            |                                                                      | (11)                     |
| P52/PWM1                                     |         | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | PWM output                                 | Timer 56 mode register<br>PULL register B                            | (4)                      |
| P53/CNTR0<br>P54/CNTR1                       |         | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | External count I/O                         | Interrupt edge selection register<br>PULL register B                 | (12)                     |
| P55/INT0<br>P56/INT1<br>P57/INT2             |         |                               |                                                    | External interrupt input                   | Interrupt edge selection register<br>PULL register B                 | (12)                     |
| P60/AN0<br>—<br>P67/AN7                      | Port P6 | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | A-D converter input                        | A-D control register<br>PULL register B                              | (13)                     |
| P70/XCIN                                     | Port P7 | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | Sub-clock generating circuit I/O           | CPU mode register<br>PULL register A                                 | (14)                     |
| P71/XCOUT                                    |         |                               |                                                    |                                            |                                                                      | (15)                     |
| P80 – P87                                    | Port P8 | Input/Output, individual bits | CMOS compatible input level<br>CMOS 3-state output | Key input (key-on wake-up) interrupt input | Interrupt control register 2<br>PULL register A                      | (17)                     |
| COM0 – COM3                                  | Common  | Output                        | LCD common output                                  |                                            | LCD mode register                                                    | (16)                     |

**Notes 1:** Make sure that the input level at each pin is either 0 V or V<sub>CC</sub> during execution of the STP instruction.

When an input level is at an intermediate potential, a current will flow from V<sub>CC</sub> to V<sub>SS</sub> through the input-stage gate.

**2:** For details of how to use double function ports as function I/O ports, refer to the applicable sections.

# HARDWARE

## FUNCTIONAL DESCRIPTION

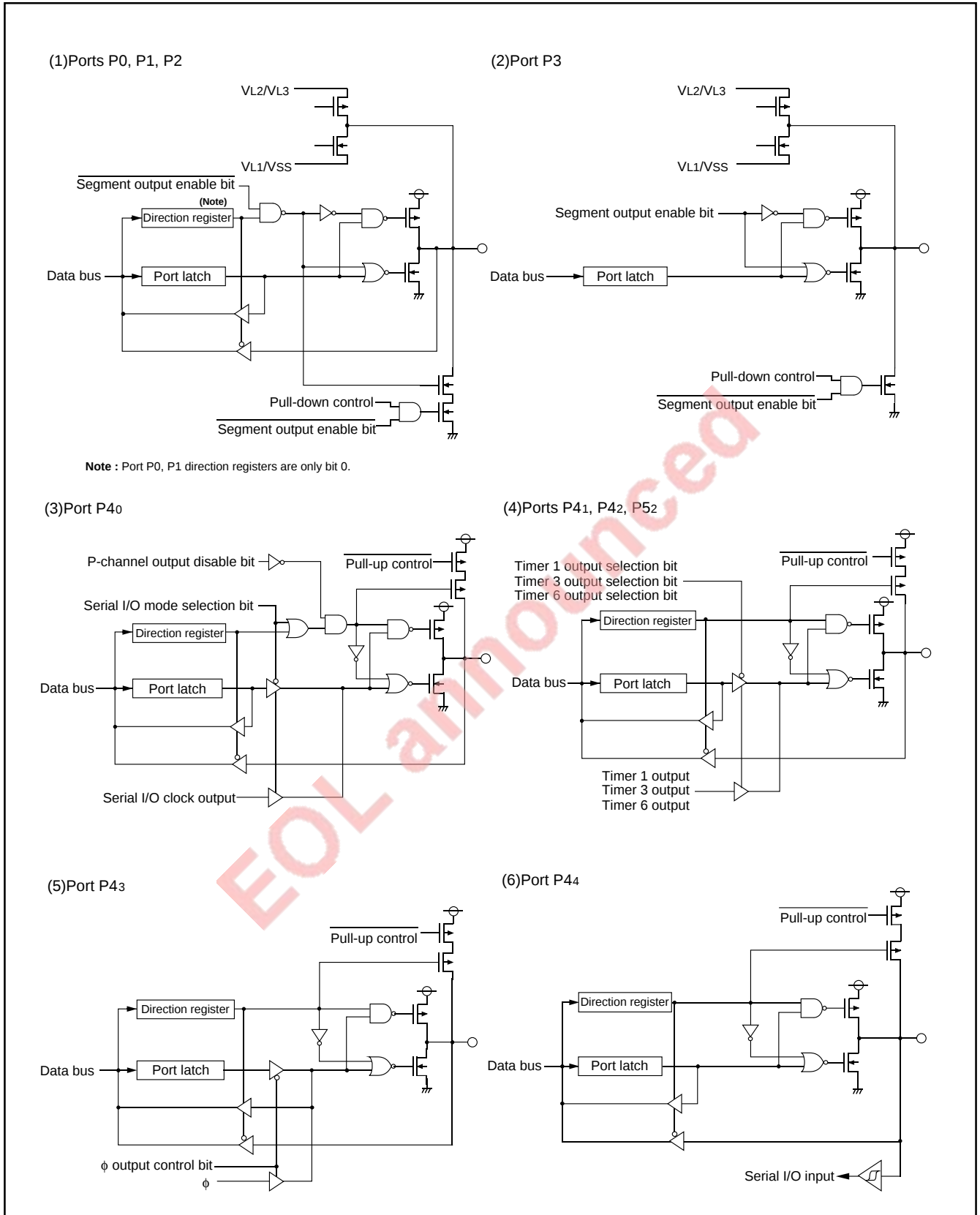


Fig. 12 Port block diagram (1)

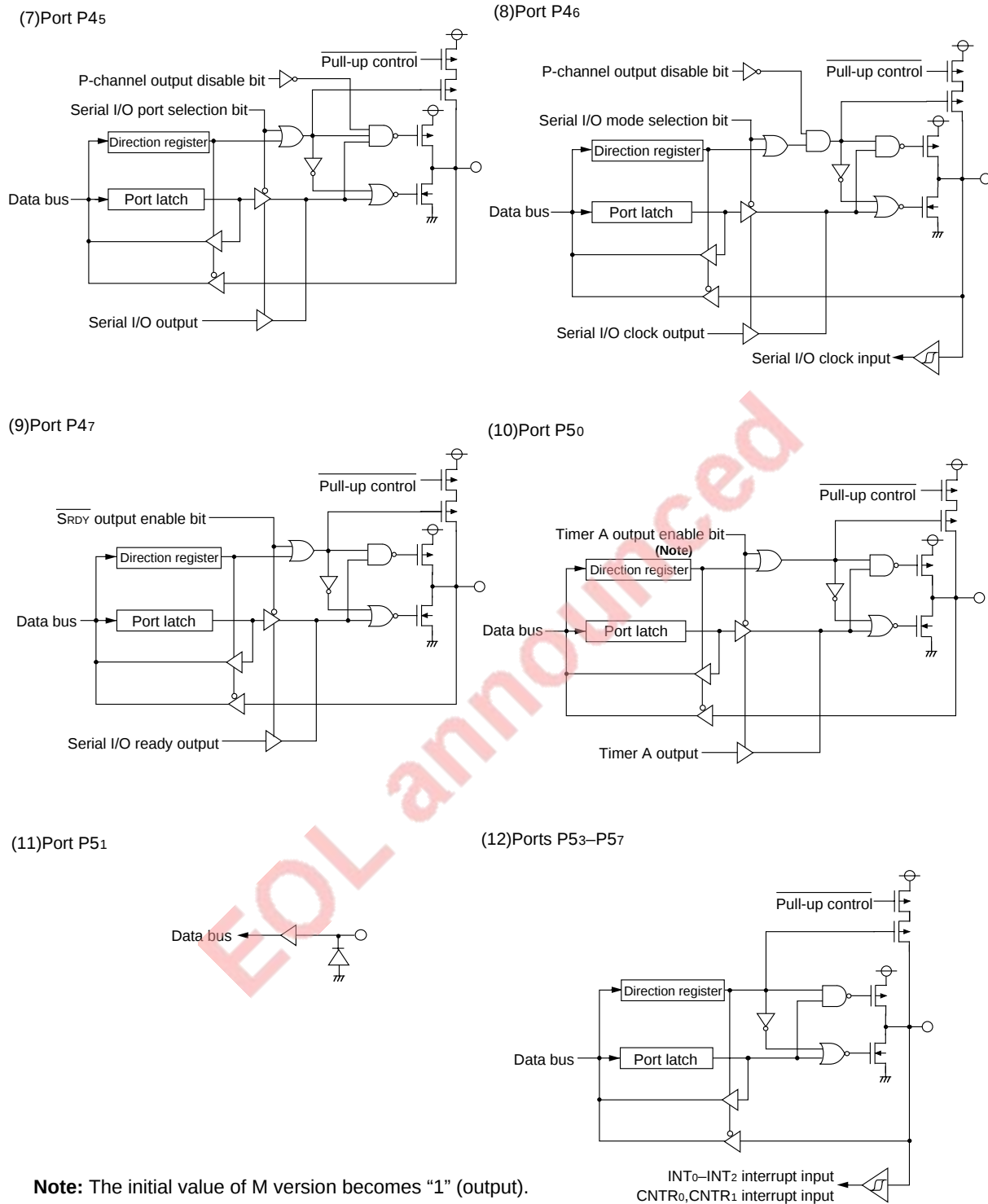


Fig. 13 Port block diagram (2)

# HARDWARE

## FUNCTIONAL DESCRIPTION

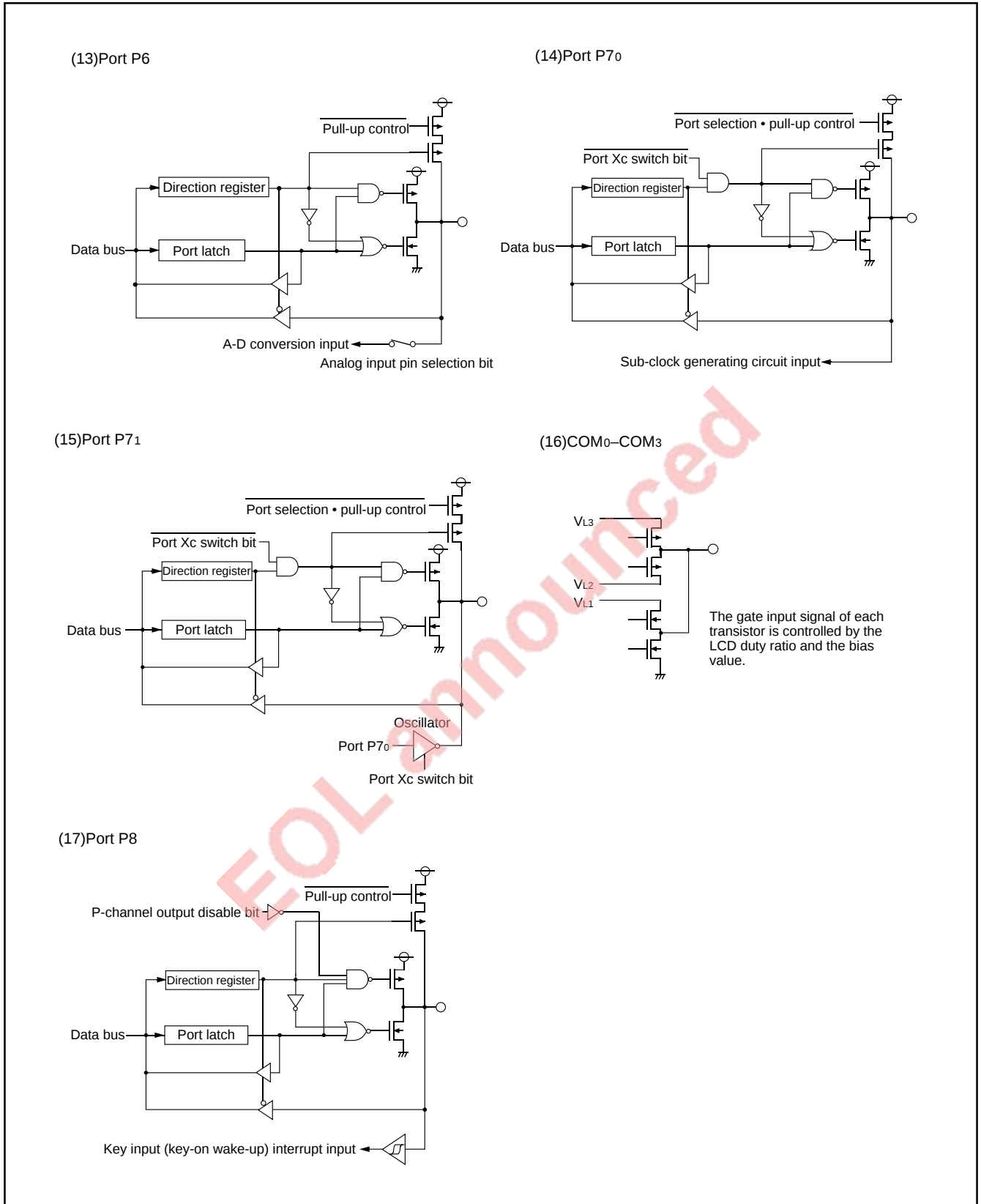


Fig. 14 Port block diagram (3)

## INTERRUPTS

Interrupts occur by sixteen sources: six external, nine internal, and one software.

### Interrupt Control

Each interrupt except the BRK instruction interrupt have both an interrupt request bit and an interrupt enable bit, and is controlled by the interrupt disable flag. An interrupt occurs if the corresponding interrupt request and enable bits are "1" and the interrupt disable flag is "0".

Interrupt enable bits can be set or cleared by software. Interrupt request bits can be cleared by software, but cannot be set by software. The BRK instruction interrupt and reset cannot be disabled with any flag or bit. The I flag disables all interrupts except the BRK instruction interrupt and reset. If several interrupts requests occurs at the same time the interrupt with highest priority is accepted first.

### Interrupt Operation

By acceptance of an interrupt, the following operations are automatically performed:

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

#### ■Notes on Interrupts

When the active edge of an external interrupt (INT0 – INT2, CNTR0 or CNTR1) is set or an vector interrupt source where several interrupt source is assigned to the same vector address is switched, the corresponding interrupt request bit may also be set. Therefore, take following sequence:

- (1) Disable the interrupt.
- (2) Change the active edge in interrupt edge selection register.
- (3) Clear the set interrupt request bit to "0."
- (4) Enable the interrupt.

# HARDWARE

## FUNCTIONAL DESCRIPTION

**Table 8** Interrupt vector addresses and priority

| Interrupt Source           | Priority | Vector Addresses ( <b>Note 1</b> ) |                    | Interrupt Request<br>Generating Conditions                   | Remarks                                         |
|----------------------------|----------|------------------------------------|--------------------|--------------------------------------------------------------|-------------------------------------------------|
|                            |          | High                               | Low                |                                                              |                                                 |
| Reset ( <b>Note 2</b> )    | 1        | FFFD <sub>16</sub>                 | FFFC <sub>16</sub> | At reset                                                     | Non-maskable                                    |
| INT0                       | 2        | FFFB <sub>16</sub>                 | FFFA <sub>16</sub> | At detection of either rising or falling edge of INT0 input  | External interrupt (active edge selectable)     |
| INT1                       | 3        | FFF9 <sub>16</sub>                 | FFF8 <sub>16</sub> | At detection of either rising or falling edge of INT1 input  | External interrupt (active edge selectable)     |
| INT2                       | 4        | FFF7 <sub>16</sub>                 | FFF6 <sub>16</sub> | At detection of either rising or falling edge of INT2 input  | External interrupt (active edge selectable)     |
| Serial I/O                 | 5        | FFF5 <sub>16</sub>                 | FFF4 <sub>16</sub> | At completion of serial I/O data transmit/receive            | Valid when serial I/O is selected               |
| Timer A                    | 6        | FFF3 <sub>16</sub>                 | FFF2 <sub>16</sub> | At timer A underflow                                         |                                                 |
| Timer 1                    | 7        | FFF1 <sub>16</sub>                 | FFF0 <sub>16</sub> | At timer 1 underflow                                         |                                                 |
| Timer 2                    | 8        | FFEF <sub>16</sub>                 | FFEE <sub>16</sub> | At timer 2 underflow                                         | STP release timer underflow                     |
| Timer 3                    | 9        | FFED <sub>16</sub>                 | FFEC <sub>16</sub> | At timer 3 underflow                                         |                                                 |
| Timer 4                    | 10       | FFEB <sub>16</sub>                 | FFEA <sub>16</sub> | At timer 4 underflow                                         |                                                 |
| Timer 5                    | 11       | FFE9 <sub>16</sub>                 | FFE8 <sub>16</sub> | At timer 5 underflow                                         |                                                 |
| Timer 6                    | 12       | FFE7 <sub>16</sub>                 | FFE6 <sub>16</sub> | At timer 6 underflow                                         |                                                 |
| CNTR0                      | 13       | FFE5 <sub>16</sub>                 | FFE4 <sub>16</sub> | At detection of either rising or falling edge of CNTR0 input | External interrupt (active edge selectable)     |
| CNTR1                      | 14       | FFE3 <sub>16</sub>                 | FFE2 <sub>16</sub> | At detection of either rising or falling edge of CNTR1 input | External interrupt (active edge selectable)     |
| Key input (Key-on wake-up) | 15       | FFE1 <sub>16</sub>                 | FFE0 <sub>16</sub> | At falling of port P8 (at input) input logical level AND     | External interrupt (falling valid)              |
| A-D conversion             | 16       | FFDF <sub>16</sub>                 | FFDE <sub>16</sub> | At completion of A-D conversion                              | Valid when A-D conversion interrupt is selected |
| BRK instruction            | 17       | FFDD <sub>16</sub>                 | FFDC <sub>16</sub> | At BRK instruction execution                                 | Non-maskable software interrupt                 |

**Notes 1:** Vector addresses contain interrupt jump destination addresses.

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

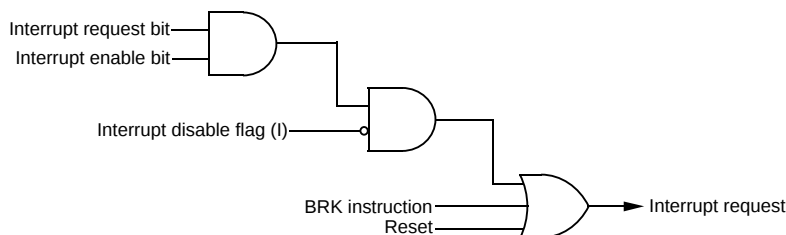


Fig. 15 Interrupt control

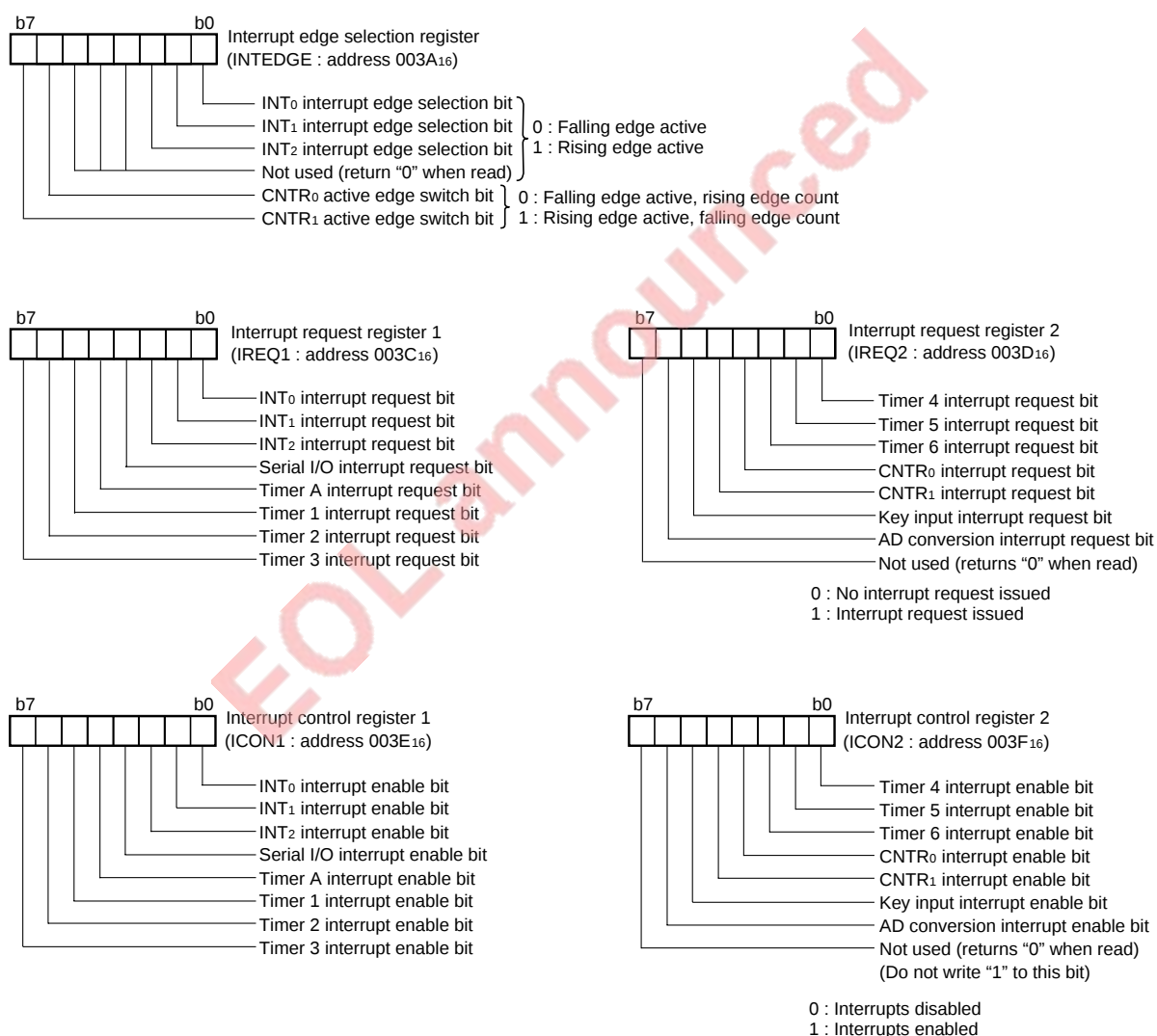


Fig. 16 Structure of interrupt-related registers

# HARDWARE

## FUNCTIONAL DESCRIPTION

### Key Input Interrupt (Key-on Wake-Up)

A key input interrupt request is generated by applying "L" level to any pin of port P8 that have been set to input mode. In other words, it is generated when AND of input level goes from "1" to "0". An example

of using a key input interrupt is shown in Figure 17, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports P80–P83.

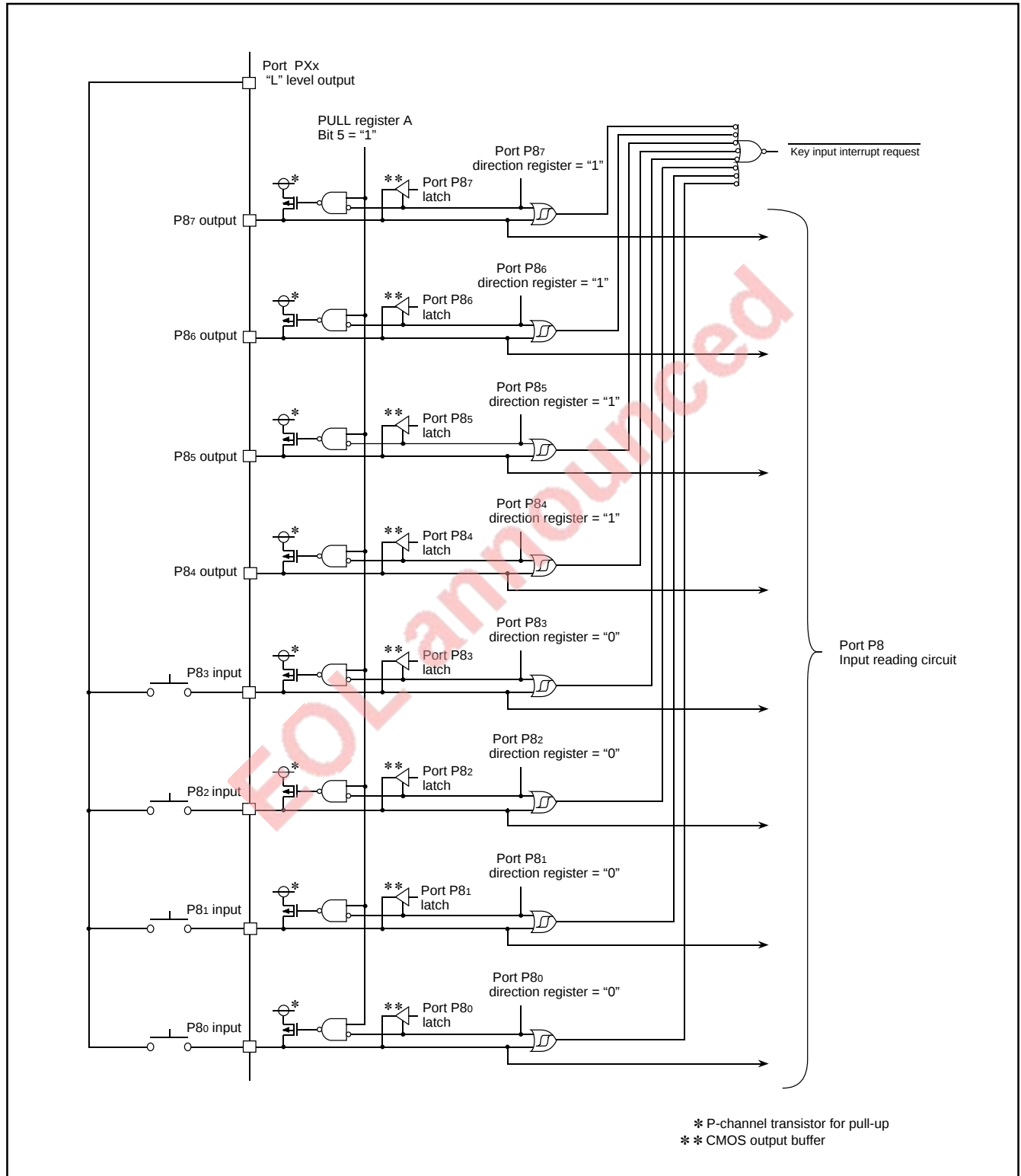


Fig. 17 Connection example when using key input interrupt and port P8 block diagram

## TIMERS

## 8-Bit Timer

The 38C3 group has six built-in timers : Timer 1, Timer 2, Timer 3, Timer 4, Timer 5, and Timer 6.

Each timer has the 8-bit timer latch. All timers are down-counters. When the timer reaches "0016," an underflow occurs with the next count pulse. Then the contents of the timer latch is reloaded into the timer and the timer continues down-counting. When a timer underflows, the interrupt request bit corresponding to that timer is set to "1."

The count can be stopped by setting the stop bit of each timer to "1." The system clock  $\phi$  can be set to either the high-speed mode or low-speed mode with the CPU mode register. At the same time, timer internal count source is switched to either  $f(X_{IN})$  or  $f(X_{CN})$ .

## ●Timer 1, Timer 2

The count sources of timer 1 and timer 2 can be selected by setting the timer 12 mode register. A rectangular waveform of timer 1 underflow signal divided by 2 is output from the P41/T1OUT pin. The waveform polarity changes each time timer 1 overflows. The active edge of the external clock CNTR0 can be switched with the bit 6 of the interrupt edge selection register.

At reset or when executing the STP instruction, all bits of the timer 12 mode register are cleared to "0," timer 1 is set to "FF16," and timer 2 is set to "0116."

## ●Timer 3, Timer 4

The count sources of timer 3 and timer 4 can be selected by setting the timer 34 mode register. A rectangular waveform of timer 3 underflow signal divided by 2 is output from the P42/T3OUT pin. The waveform polarity changes each time timer 3 overflows. The active edge of the external clock CNTR1 can be switched with the bit 7 of the interrupt edge selection register.

## ●Timer 5, Timer 6

The count sources of timer 5 and timer 6 can be selected by setting the timer 56 mode register. A rectangular waveform of timer 6 underflow signal divided by 2 can be output from the P52/PWM1 pin.

## ●Timer 6 PWM1 Mode

Timer 6 can output a rectangular waveform with "H" duty cycle  $n/(n+m)$  from the P52/PWM1 pin by setting the timer 56 mode register (refer to Figure 20). The  $n$  is the value set in timer 6 latch (address 002516) and  $m$  is the value in the timer 6 PWM register (address 002716). If  $n$  is "0," the PWM output is "L," if  $m$  is "0," the PWM output is "H" ( $n = 0$  is prior than  $m = 0$ ). In the PWM mode, interrupts occur at the rising edge of the PWM output.

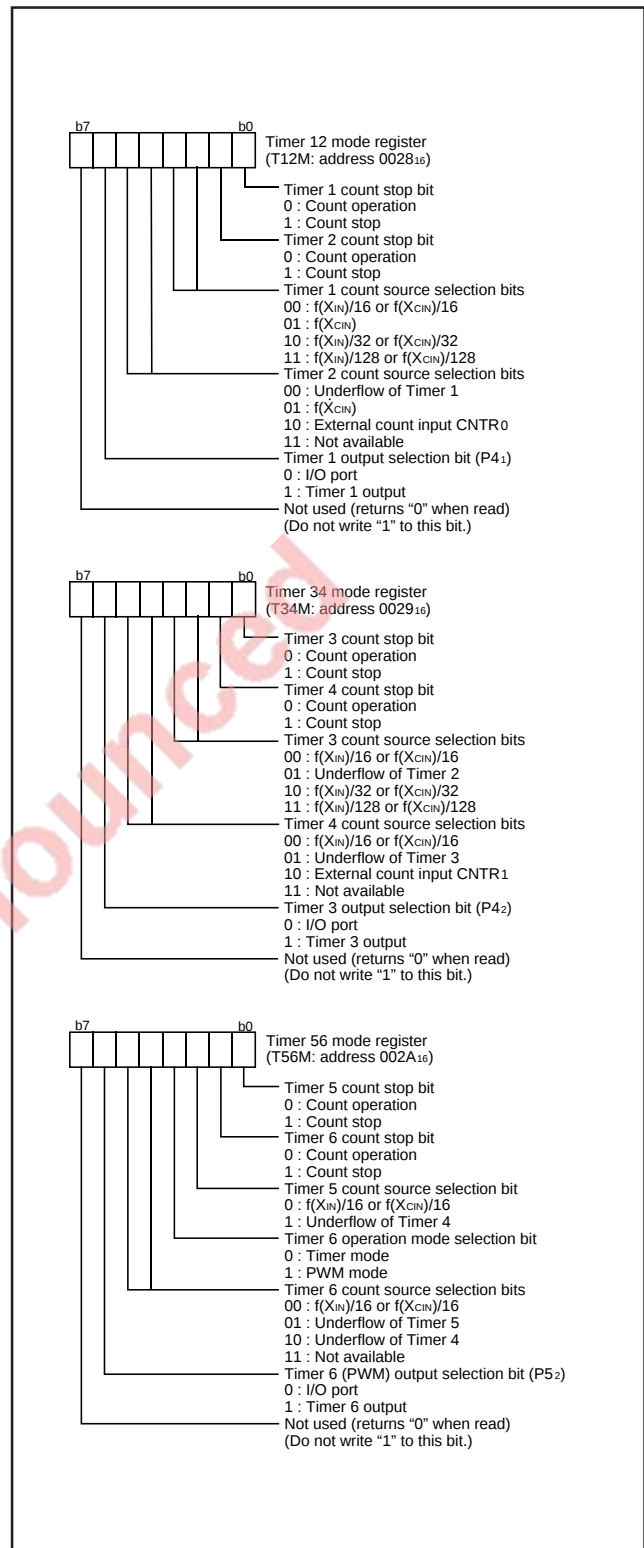


Fig. 18 Structure of timer related register

# HARDWARE

## FUNCTIONAL DESCRIPTION

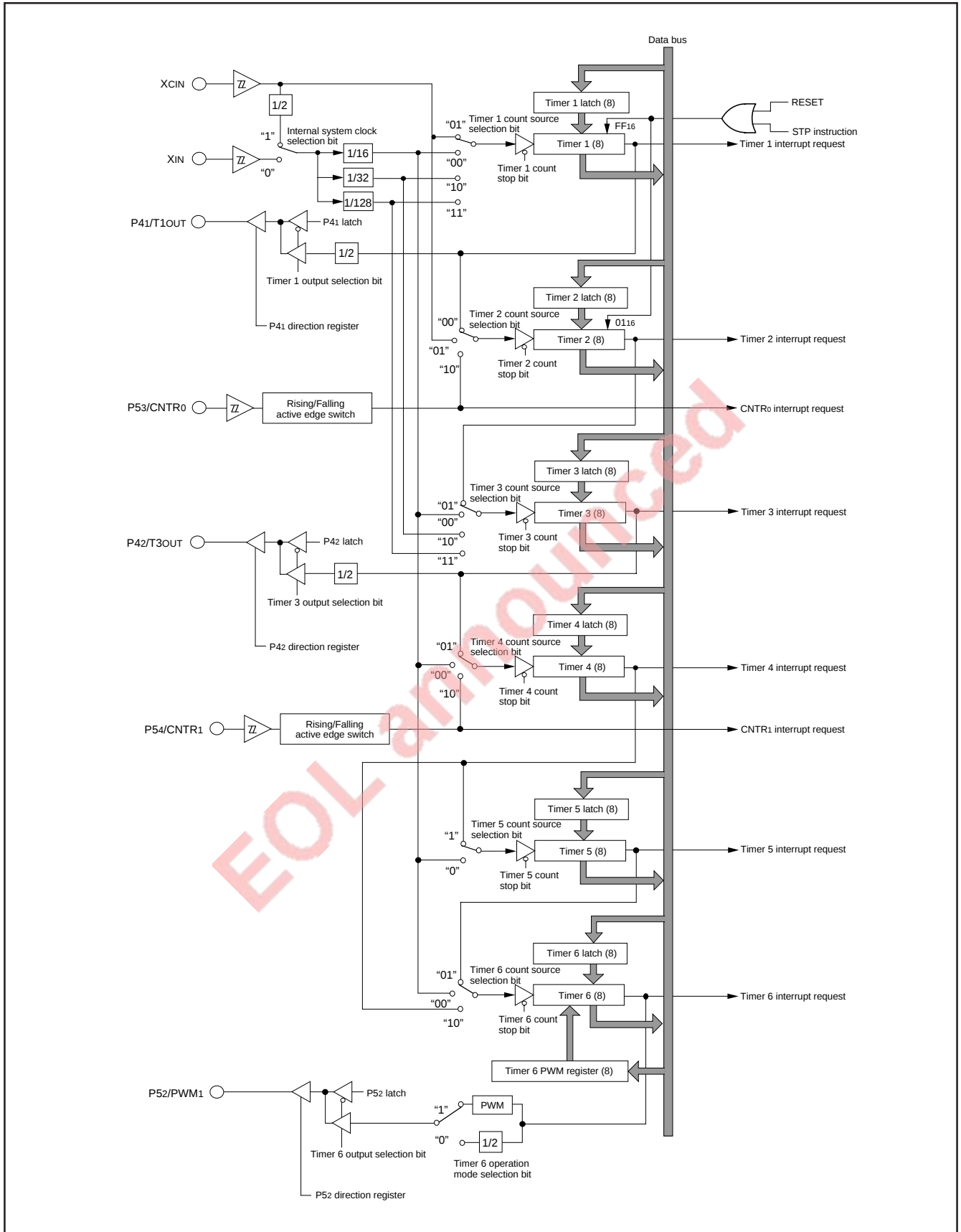


Fig. 19 Block diagram of timer

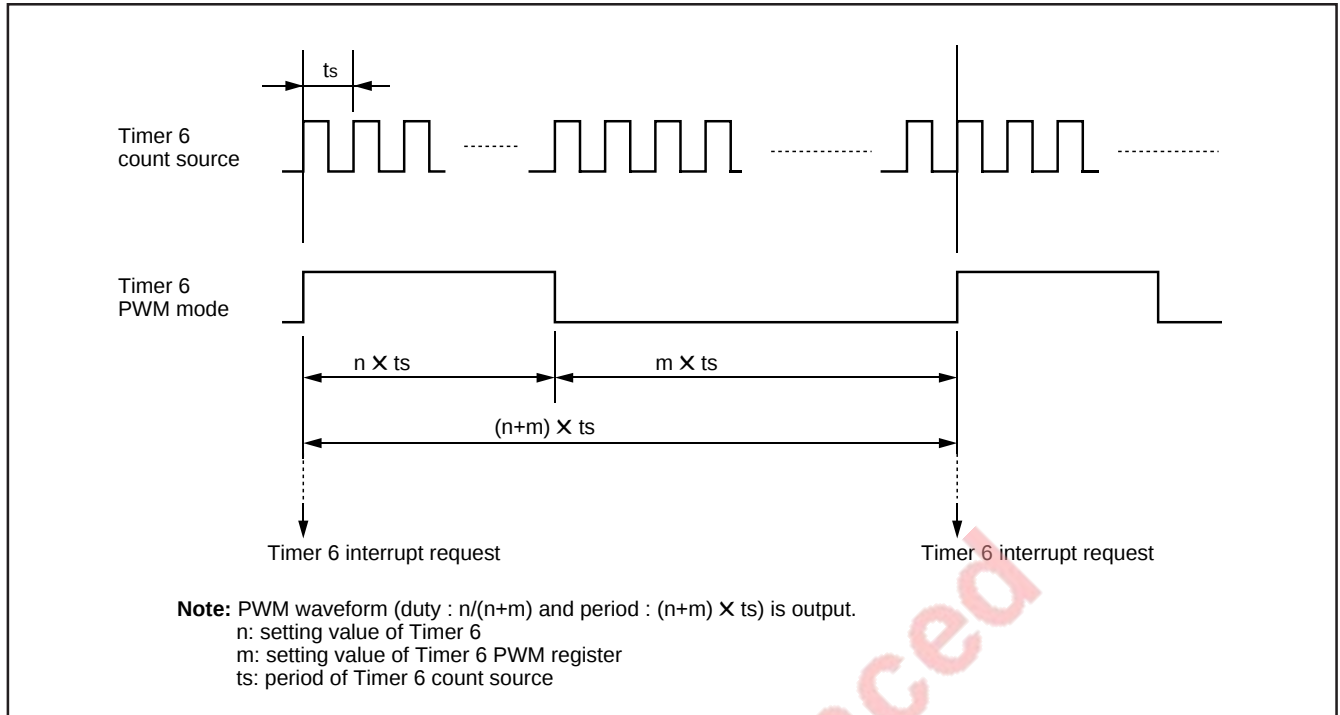


Fig. 20 Timing chart of timer 6 PWM1 mode

### 16-bit Timer

Timer A is a 16-bit timer that can be selected in one of four modes by the timer A mode register and the timer A control register.

#### ●Timer A

The timer A operates as down-count. When the timer contents reach "000016", an underflow occurs at the next count pulse and the timer latch contents are reloaded. After that, the timer continues count-down. When the timer underflows, the interrupt request bit corresponding to the timer A is set to "1".

#### (1) Timer mode

The count source can be selected by setting the timer A mode register.

#### (2) Pulse output mode

Pulses of which polarity is inverted each time the timer underflows are output from the TAOUT pin. Except for that, this mode operates just as in the timer mode.

When using this mode, set port P50 sharing the TAOUT pin to output mode.

#### (3) IGBT output mode

After dummy output from the TAOUT pin, count starts with the INT0 pin input as a trigger. When the trigger is detected or the timer A underflows, "H" is output from the TAOUT pin.

When the count value corresponds with the compare register value, the TAOUT output becomes "L". When the INT0 signal becomes "H", the TAOUT output is forced to become "L".

After noise is cleared by noise filters, judging continuous 4-time same levels with sampling clocks to be signals, the INT0 signal can use 4

types of delay time by a delay circuit.

When using this mode, set port P55 sharing the INT0 pin to input mode and set port P50 sharing the TAOUT pin to output mode.

It is possible to force the timer A output to be "L" using pins INT1 and INT2 by the timer A control register.

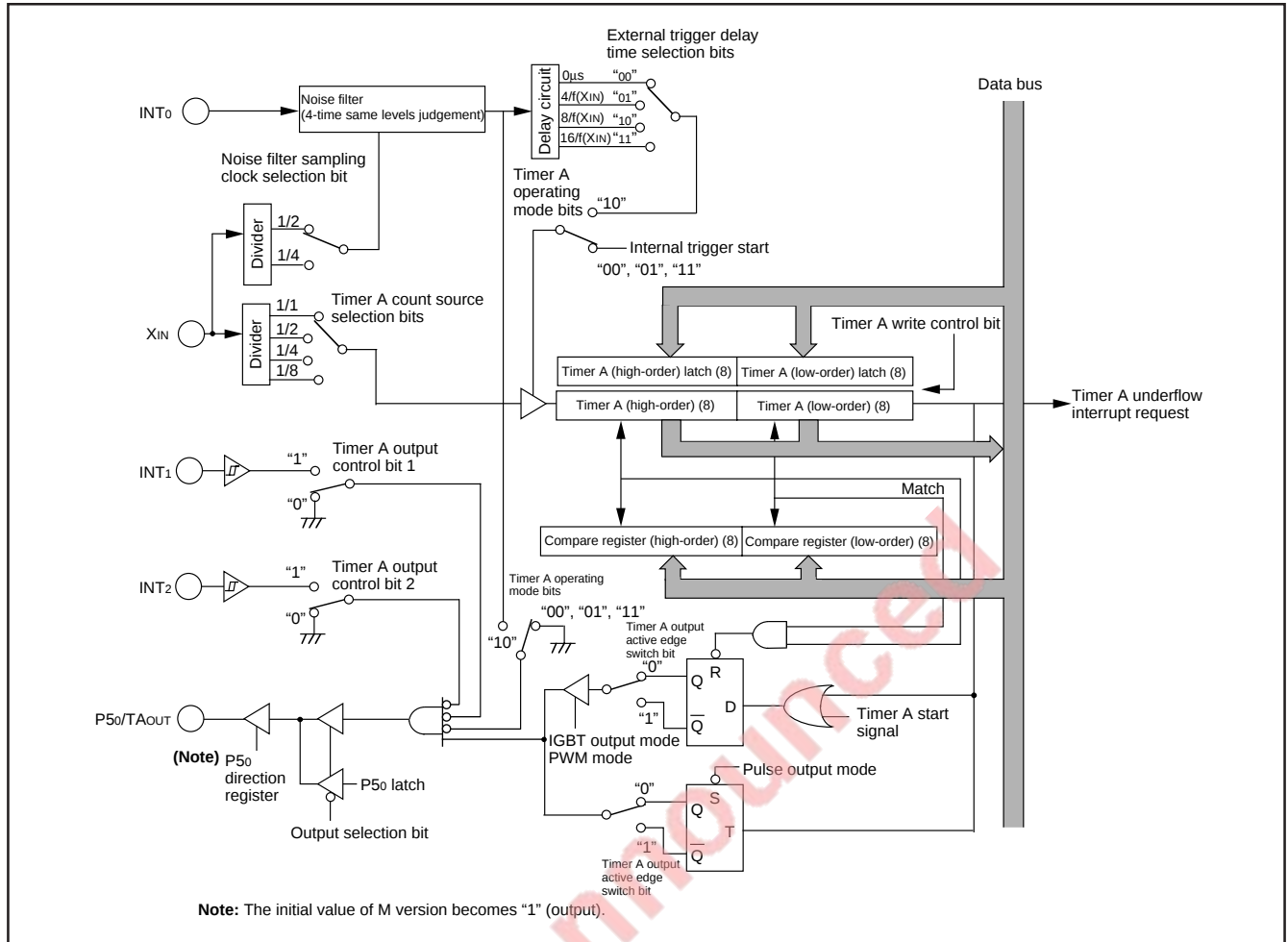
#### (4) PWM mode

IGBT dummy output, an external trigger with the INT0 pin and output control with pins INT1 and INT2 are not used. Except for those, this mode operates just as in the IGBT output mode.

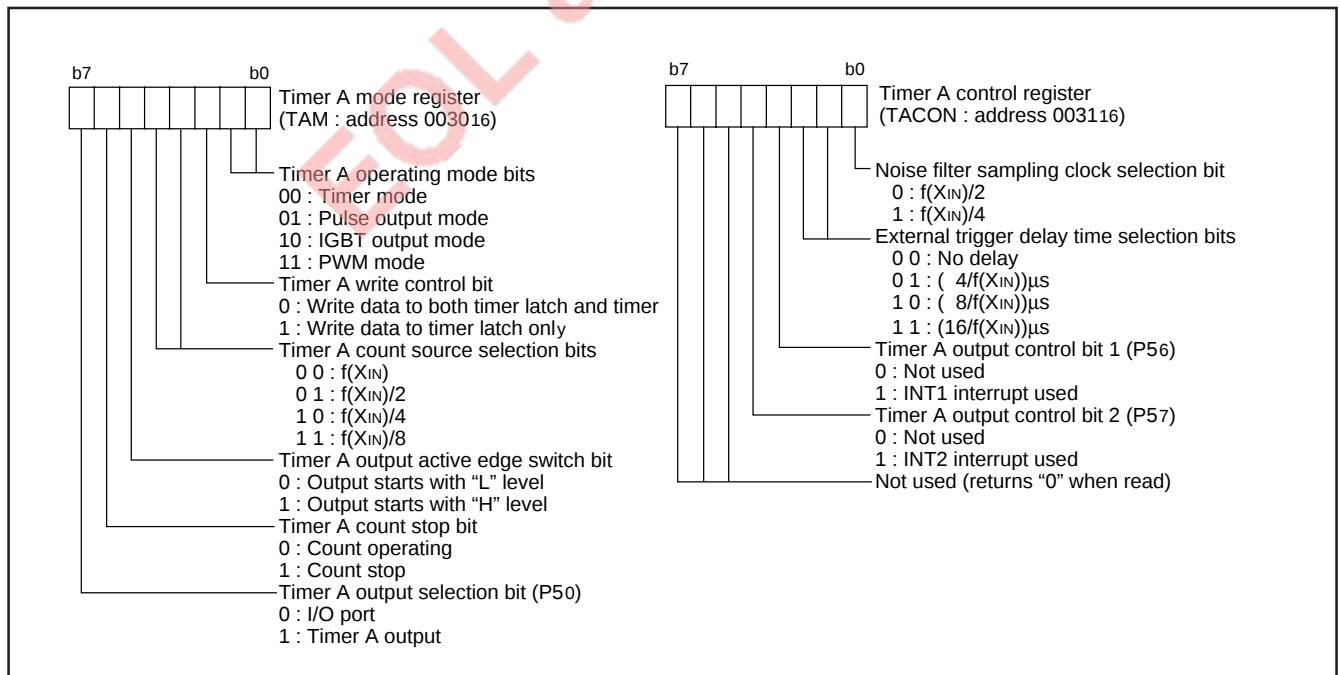
The period of PWM waveform is specified by the timer A set value. The "H" term is specified by the compare register set value.

When using this mode, set port P50 sharing the TAOUT pin to output mode.

## FUNCTIONAL DESCRIPTION



**Fig. 21 Block diagram of timer A**



**Fig. 22 Structure of timer A related registers**

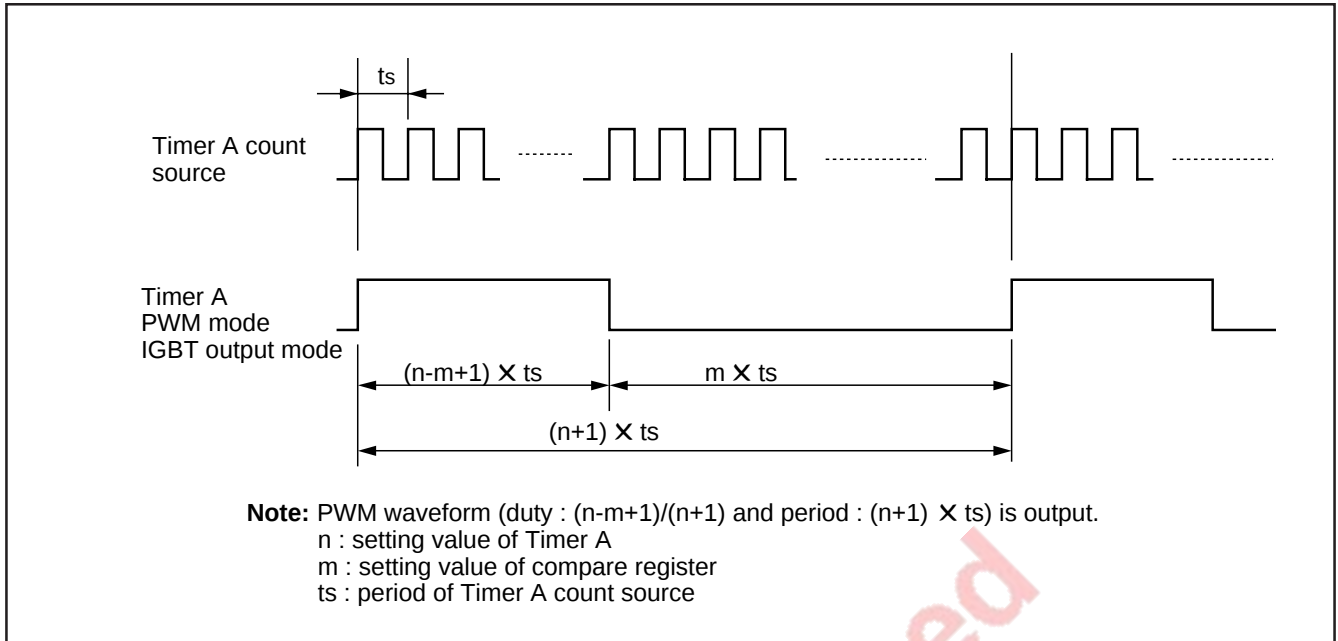


Fig. 23 Timing chart of timer A PWM, IGBT output modes

**■Notes on Timer A****(1) Write order to timer A**

- In the timer and pulse output modes, write to the timer A register (low-order) first and to the timer A register (high-order) next. Do not write to only one side.
- In the IGBT and PWM modes, write to the registers as follows:  
the compare register (high- and low-order)  
the timer A register (low-order)  
the timer A register (high-order).  
It is possible to use whichever order to write to the compare register (high- and low-order). However, write both the compare register and the timer A register at the same time.

**(2) Read order to timer A**

- In all modes, read to the timer A register (high-order) first and to the timer A register (low-order) next. Read order to the compare register is not specified.
- If reading to the timer A register during write operation or writing to it during read operation, normal operation will not be performed.

**(3) Write to timer A**

- When writing a value to the timer A address to write to the latch only, the value is set into the reload latch and the timer is updated at the next underflow. Normally, when writing a value to the timer A address, the value is set into the timer and the timer latch at the same time, because they are written at the same time.  
When writing to the latch only, if the write timing to the high-order reload latch and the underflow timing are almost the same, an expected value may be set in the high-order counter.
- Do not switch the timer count source during timer count operation. Stop the timer count before switching it. Additionally, when performing write to the latch and the timer at the same time, the timer count value may change large.

**(4) Set of timer A mode register**

Set the write control bit to "1" (write to the latch only) when setting the IGBT and PWM modes.

Output waveform simultaneously reflects the contents of both registers at the next underflow after writing to the timer A register (high-order).

**(5) Output control function of timer A**

When using the output control function (INT1 and INT2) in the IGBT mode, set the levels of INT1 and INT2 to "H" in the falling edge active or to "L" in the rising edge active before switching to the IGBT mode.

# HARDWARE

## FUNCTIONAL DESCRIPTION

### SERIAL I/O

The 38C3 group has a built-in 8-bit clock synchronous serial I/O. The

I/O pins of serial I/O also operate as I/O port P4, and their function is selected by the serial I/O control register 1 (address 001916).

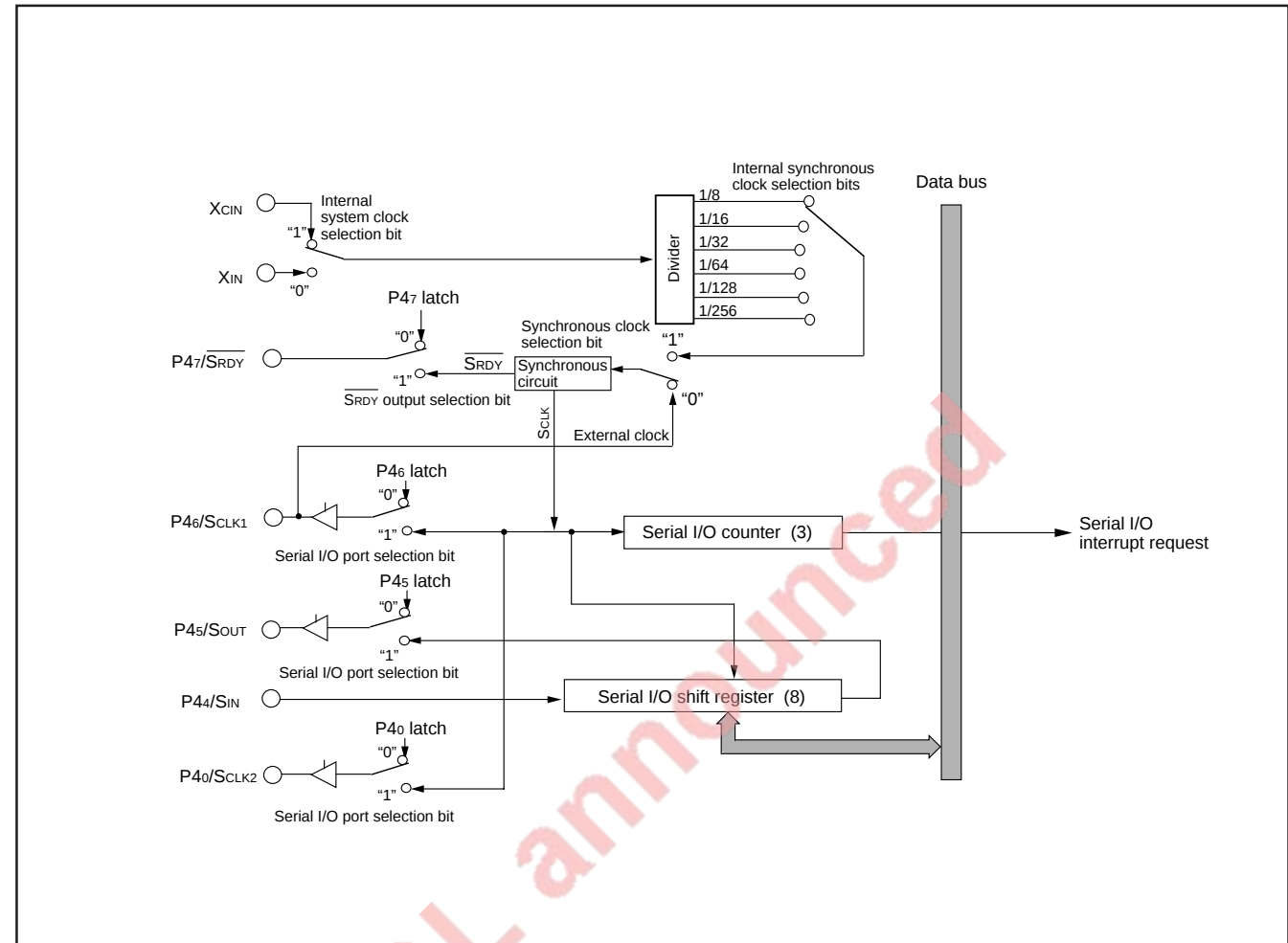


Fig. 24 Block diagram of serial I/O

### [Serial I/O Control Registers 1, 2 (SIOCON1, SIOCON2)] 001916, 001A16

Each of the serial I/O control registers 1, 2 contains 8 bits that select various control parameters of serial I/O.

#### ●Operation in serial I/O mode

Either an internal clock or an external clock can be selected as the synchronous clock for serial I/O transfer. A dedicated divider is built-in as the internal clock, giving a choice of six clocks.

When internal clock is selected, serial I/O starts to transfer by a write signal to the serial I/O register (address 001B16). After 8 bits have been transferred, the SOUT pin goes to high impedance.

When external clock is selected, the clock must be controlled externally because the contents of the serial I/O register continue to shift while the transfer clock is input. In this case, the SOUT pin does not go to high impedance at the completion of data transfer.

The interrupt request bit is set at the end of the transfer of 8 bits, regardless of whether the internal or external clock is selected.

When selecting internal clock and setting "1" to SIOCON20, the P40 pin can be also used as synchronous clock output pin SCLK2. At this time, the SCLK1 pin can be used as I/O port.

Table 9 Function of P46/SCLK1 and P40/SCLK2

| SIOCON16 | SIOCON13 | SIOCON20 | P46/SCLK1 | P40/SCLK2 |
|----------|----------|----------|-----------|-----------|
| 1        | 1        | 0        | SCLK1     | P40       |
|          |          | 1        | P46       | SCLK2     |

SIOCON13: Serial I/O port selection bit

SIOCON16: Synchronous clock selection bit

SIOCON20: Synchronous clock output pin selection bit

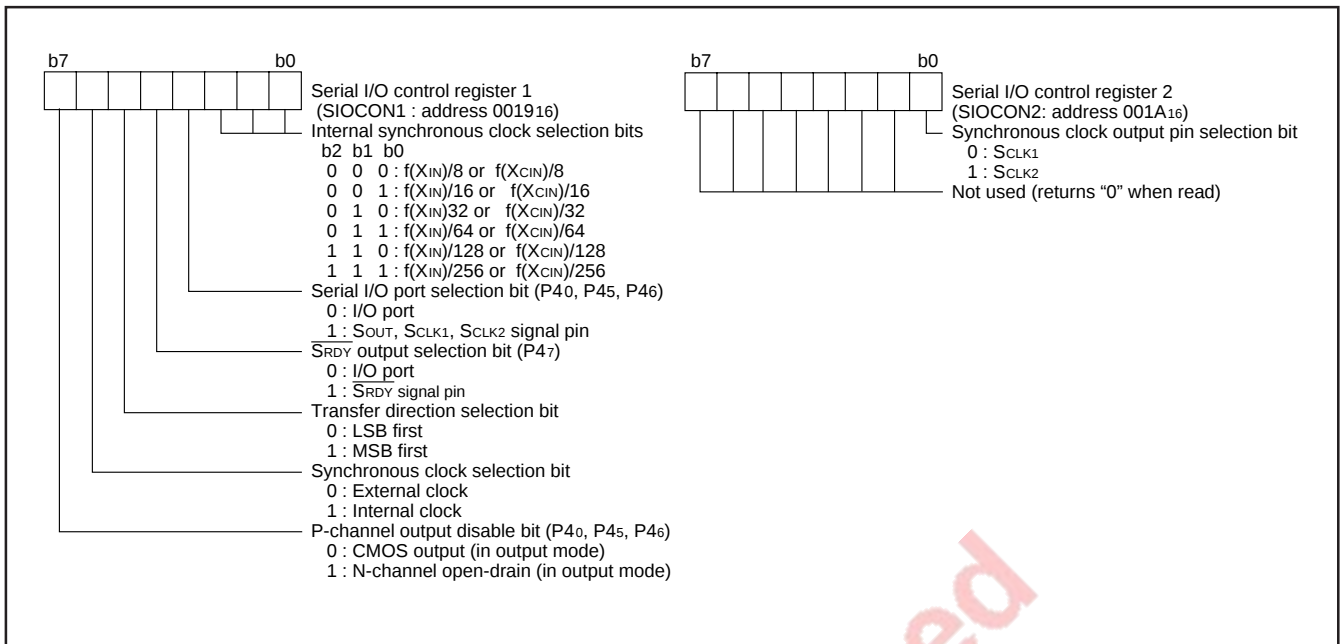


Fig. 25 Structure of serial I/O control register

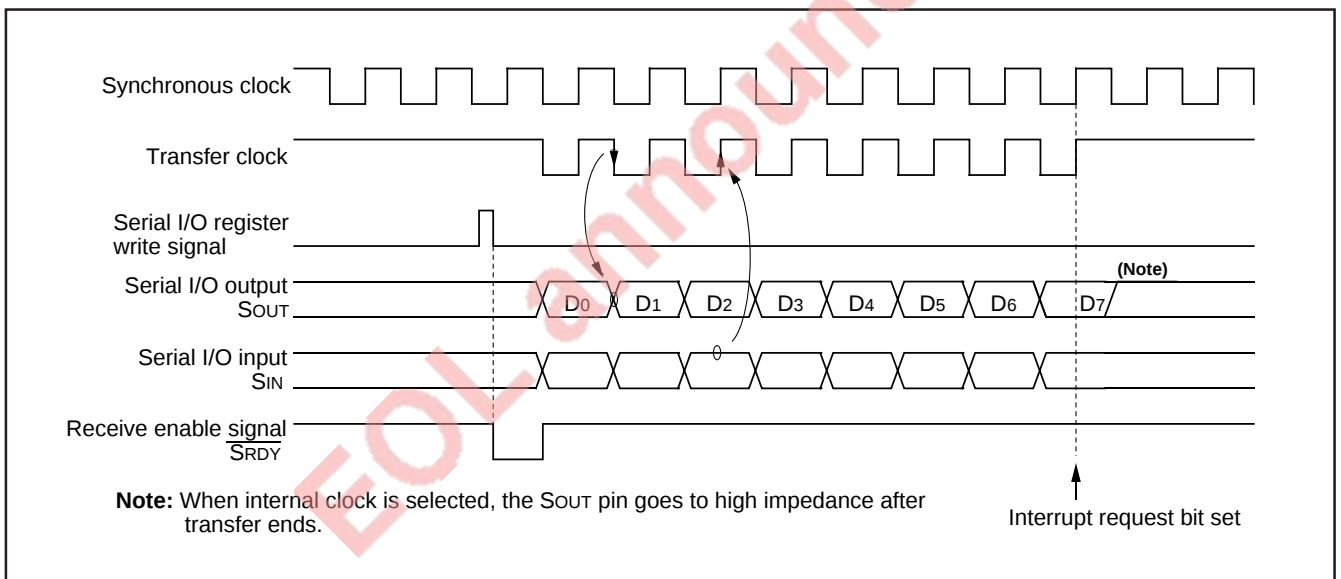


Fig. 26 Serial I/O timing (for LSB first)

# HARDWARE

## FUNCTIONAL DESCRIPTION

### A-D CONVERTER

The 38C3 group has a 10-bit A-D converter. The A-D converter performs successive approximation conversion.

#### [A-D Conversion Register (AD)] 0033<sub>16</sub>, 0034<sub>16</sub>

One of these registers is a high-order register, and the other is a low-order register. The high-order 8 bits of a conversion result is stored in the A-D conversion register (high-order) (address 0034<sub>16</sub>), and the low-order 2 bits of the same result are stored in bit 7 and bit 6 of the A-D conversion register (low-order) (address 0033<sub>16</sub>). During A-D conversion, do not read these registers.

#### [A-D Control Register (ADCON)] 0032<sub>16</sub>

This register controls A-D converter. Bits 2 to 0 are analog input pin selection bits. Bit 4 is an AD conversion completion bit and "0" during A-D conversion. This bit is set to "1" upon completion of A-D conversion.

A-D conversion is started by setting "0" in this bit.

#### [Comparison Voltage Generator]

The comparison voltage generator divides the voltage between AV<sub>SS</sub> and V<sub>REF</sub>, and outputs the divided voltages.

#### [Channel Selector]

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

#### [Comparator and Control Circuit]

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

Note that the comparator is constructed linked to a capacitor, so set  $f(X_{IN})$  to at least 500 kHz during A-D conversion. Use a CPU system clock dividing the main clock X<sub>IN</sub> as the internal system clock.

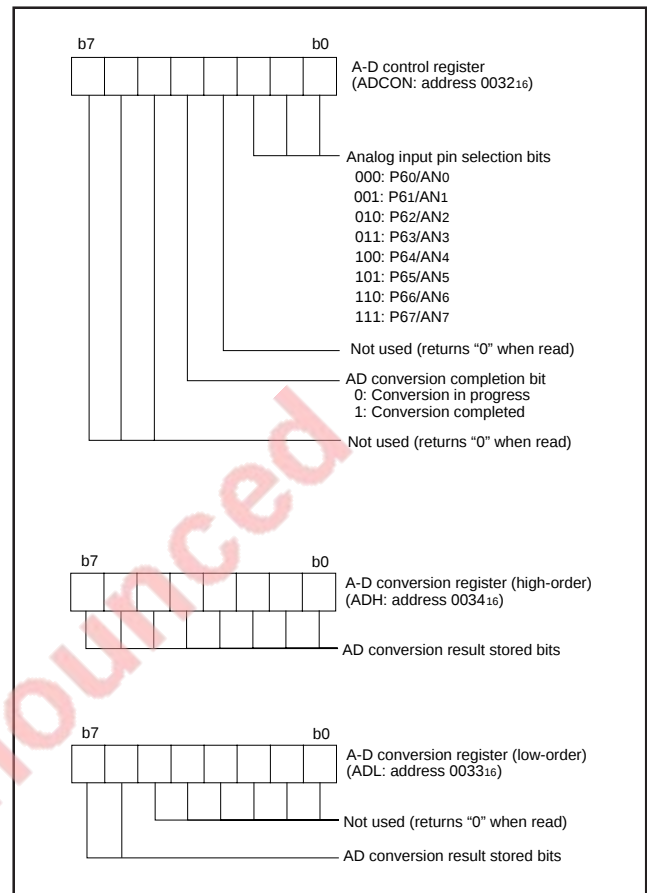


Fig. 27 Structure of A-D control register

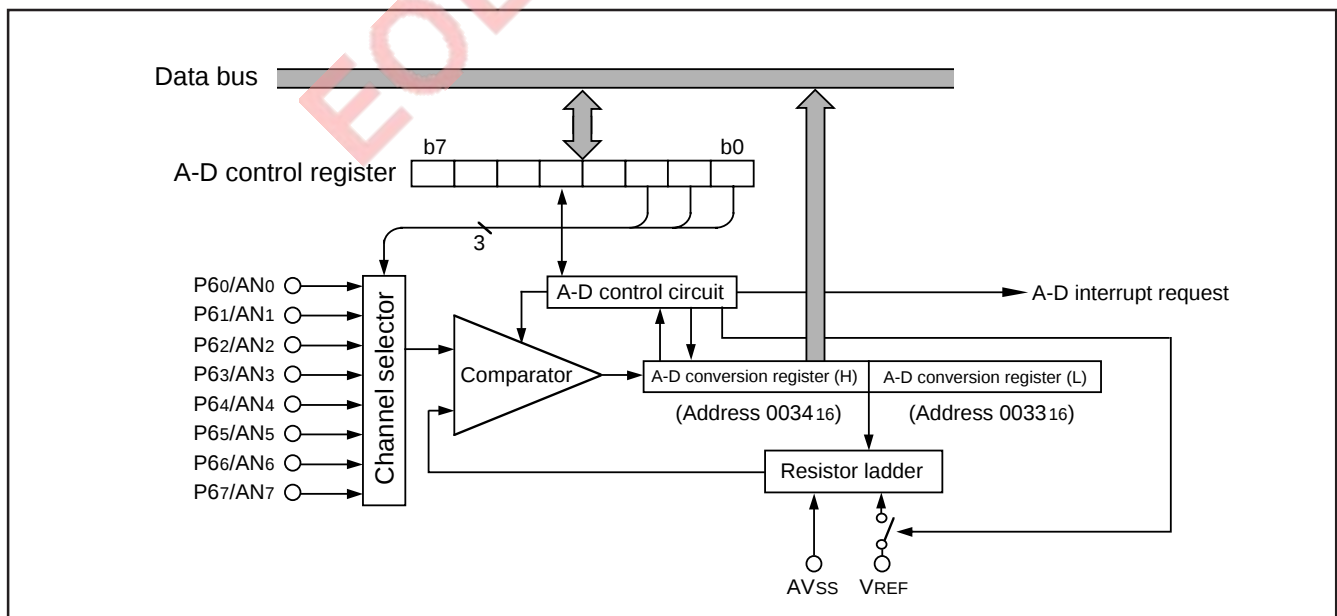


Fig. 28 Block diagram of A-D converter

## LCD DRIVE CONTROL CIRCUIT

The 38C3 group has the built-in Liquid Crystal Display (LCD) drive control circuit consisting of the following.

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

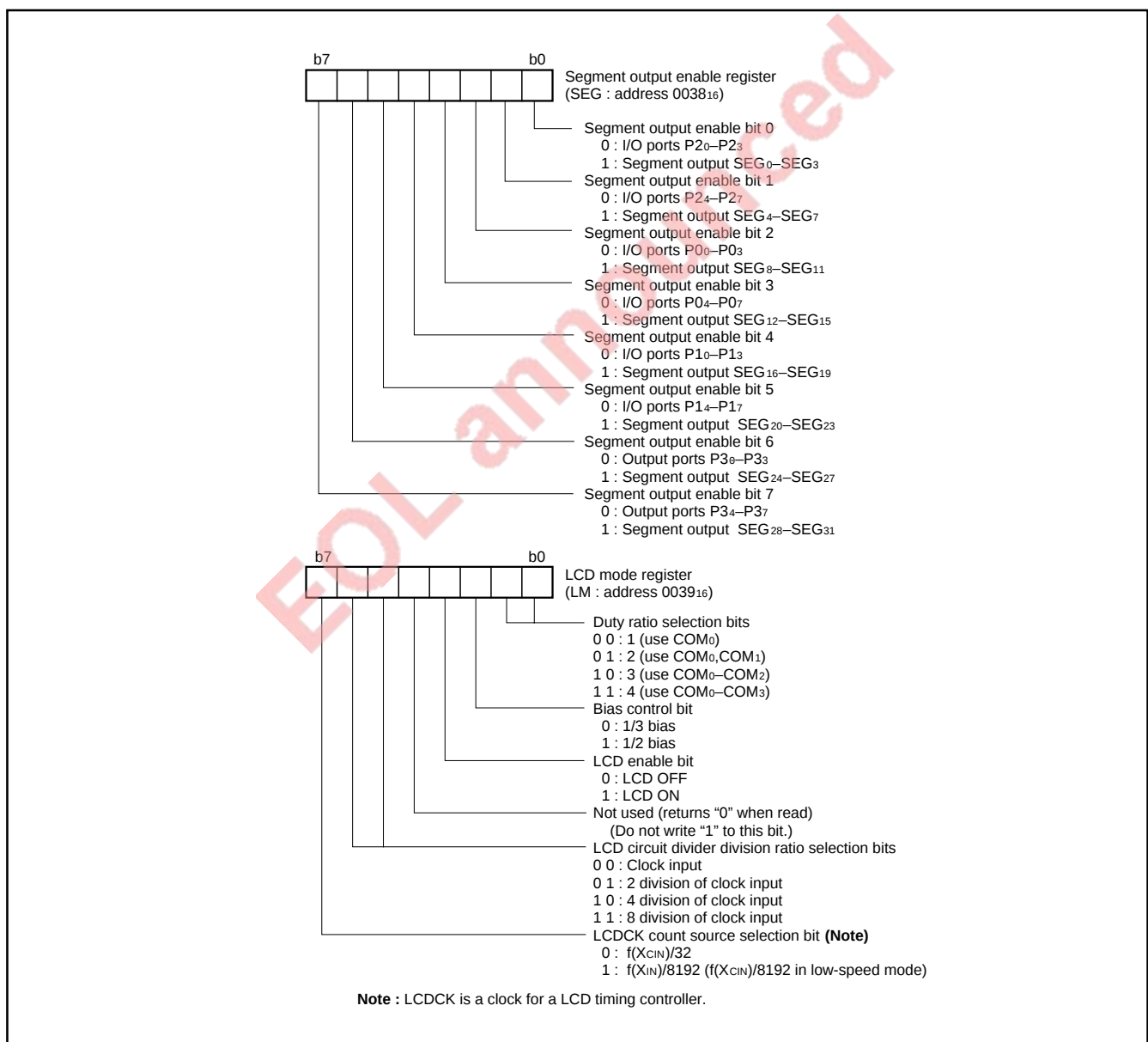
A maximum of 32 segment output pins and 4 common output pins can be used.

Up to 128 pixels can be controlled for a LCD display. When the LCD enable bit is set to "1" after data is set in the LCD mode register, the

segment output enable register, and the LCD display RAM, the LCD drive control circuit starts reading the display data automatically, performs the bias control and the duty ratio control, and displays the data on the LCD panel.

**Table 10 Maximum number of display pixels at each duty ratio**

| Duty ratio | Maximum number of display pixels       |
|------------|----------------------------------------|
| 1          | 32 dots<br>or 8 segment LCD 4 digits   |
| 2          | 64 dots<br>or 8 segment LCD 8 digits   |
| 3          | 96 dots<br>or 8 segment LCD 12 digits  |
| 4          | 128 dots<br>or 8 segment LCD 16 digits |



**Fig. 29 Structure of LCD related registers**

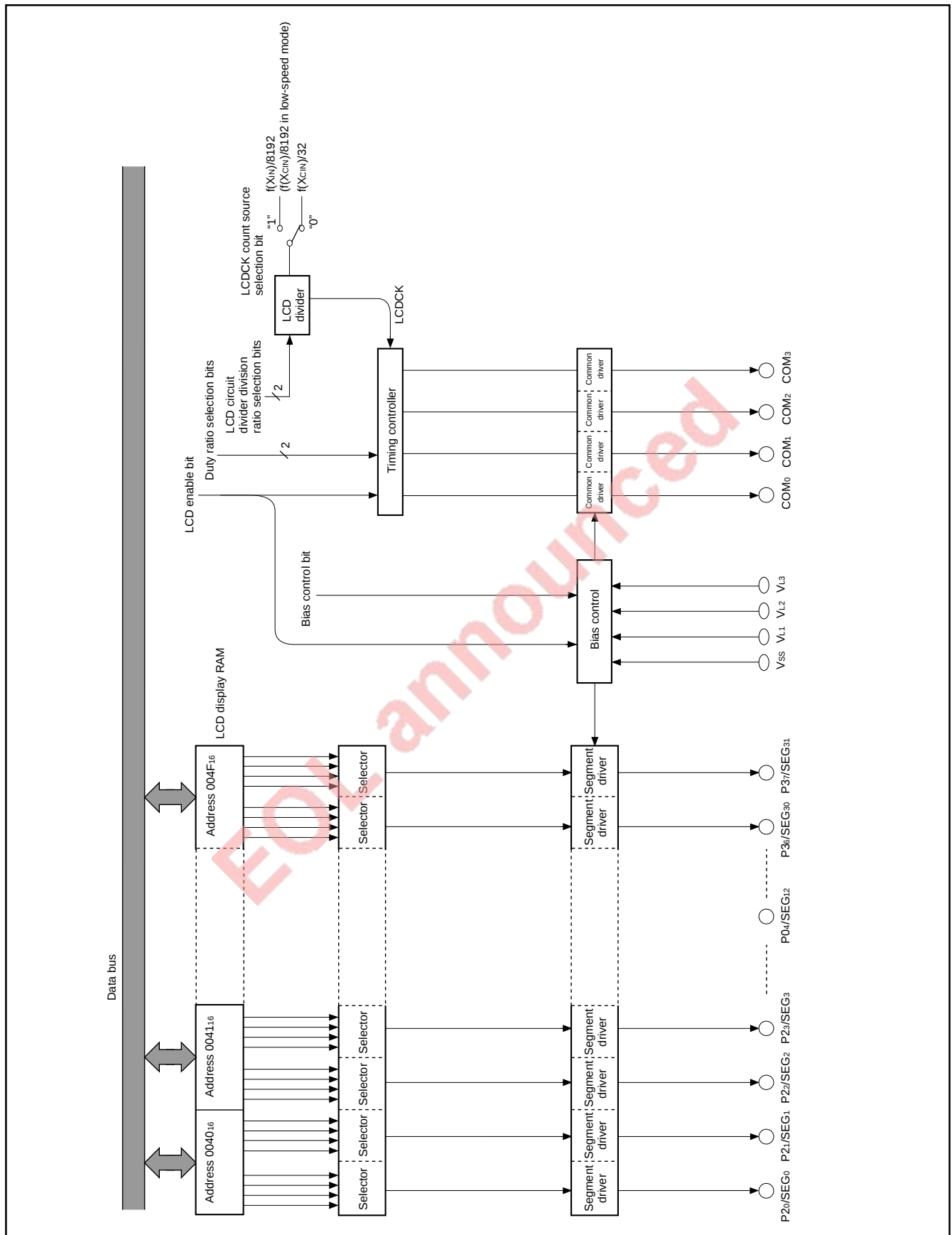


Fig. 30 Block diagram of LCD controller/driver

### Bias Control and Applied Voltage to LCD Power Input Pins

To the LCD power input pins (VL1–VL3), apply the voltage value shown in Table 11 according to the bias value.

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

### Common Pin and Duty Ratio Control

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

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

When selecting 1-duty ratio, 1/1 bias can be used.

**Table 11** Bias control and applied voltage to VL1–VL3

| Bias value                 | Voltage value                            |
|----------------------------|------------------------------------------|
| 1/3 bias                   | VL3=VLCD<br>VL2=2/3 VLCD<br>VL1=1/3 VLCD |
| 1/2 bias                   | VL3=VLCD<br>VL2=VL1=1/2 VLCD             |
| 1/1 bias<br>(1-duty ratio) | VL3=VLCD<br>VL2=VL1=VSS                  |

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

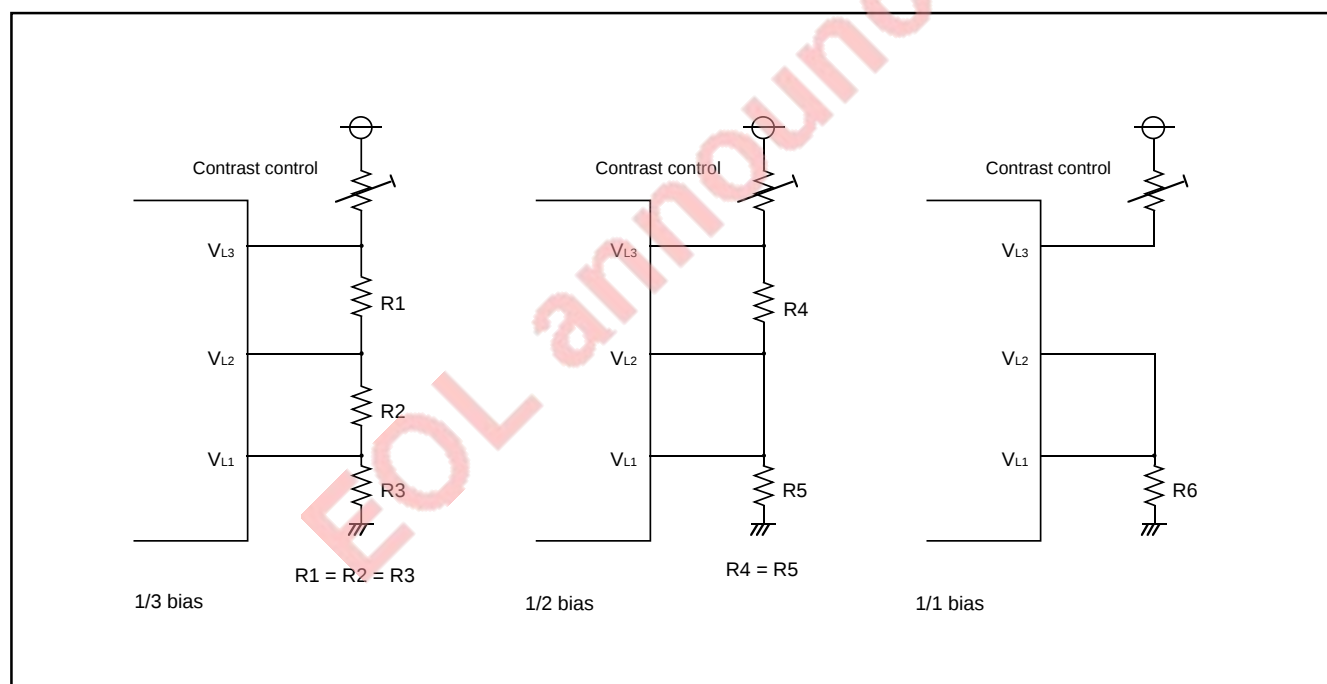
**Table 12** Duty ratio control and common pins used

| Duty ratio | Duty ratio selection bit |       | Common pins used             |
|------------|--------------------------|-------|------------------------------|
|            | Bit 1                    | Bit 0 |                              |
| 1          | 0                        | 0     | COM0 ( <b>Note 1</b> )       |
| 2          | 0                        | 1     | COM0, COM1 ( <b>Note 2</b> ) |
| 3          | 1                        | 0     | COM0–COM2 ( <b>Note 3</b> )  |
| 4          | 1                        | 1     | COM0–COM3                    |

**Notes 1:** COM1, COM2, and COM3 are open.

**2:** COM2 and COM3 are open.

**3:** COM3 is open.



**Fig. 31** Example of circuit at each bias

# HARDWARE

## FUNCTIONAL DESCRIPTION

### LCD Display RAM

Address 0040<sub>16</sub> to 004F<sub>16</sub> is the designated RAM for the LCD display. When “1” are written to these addresses, the corresponding segments of the LCD display panel are turned on.

### LCD Drive Timing

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

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

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

| Bit<br>Address     | 7                 | 6                | 5                | 4                | 3                 | 2                | 1                | 0                |
|--------------------|-------------------|------------------|------------------|------------------|-------------------|------------------|------------------|------------------|
| 0040 <sub>16</sub> | SEG <sub>1</sub>  |                  |                  |                  | SEG <sub>0</sub>  |                  |                  |                  |
| 0041 <sub>16</sub> | SEG <sub>3</sub>  |                  |                  |                  | SEG <sub>2</sub>  |                  |                  |                  |
| 0042 <sub>16</sub> | SEG <sub>5</sub>  |                  |                  |                  | SEG <sub>4</sub>  |                  |                  |                  |
| 0043 <sub>16</sub> | SEG <sub>7</sub>  |                  |                  |                  | SEG <sub>6</sub>  |                  |                  |                  |
| 0044 <sub>16</sub> | SEG <sub>9</sub>  |                  |                  |                  | SEG <sub>8</sub>  |                  |                  |                  |
| 0045 <sub>16</sub> | SEG <sub>11</sub> |                  |                  |                  | SEG <sub>10</sub> |                  |                  |                  |
| 0046 <sub>16</sub> | SEG <sub>13</sub> |                  |                  |                  | SEG <sub>12</sub> |                  |                  |                  |
| 0047 <sub>16</sub> | SEG <sub>15</sub> |                  |                  |                  | SEG <sub>14</sub> |                  |                  |                  |
| 0048 <sub>16</sub> | SEG <sub>17</sub> |                  |                  |                  | SEG <sub>16</sub> |                  |                  |                  |
| 0049 <sub>16</sub> | SEG <sub>19</sub> |                  |                  |                  | SEG <sub>18</sub> |                  |                  |                  |
| 004A <sub>16</sub> | SEG <sub>21</sub> |                  |                  |                  | SEG <sub>20</sub> |                  |                  |                  |
| 004B <sub>16</sub> | SEG <sub>23</sub> |                  |                  |                  | SEG <sub>22</sub> |                  |                  |                  |
| 004C <sub>16</sub> | SEG <sub>25</sub> |                  |                  |                  | SEG <sub>24</sub> |                  |                  |                  |
| 004D <sub>16</sub> | SEG <sub>27</sub> |                  |                  |                  | SEG <sub>26</sub> |                  |                  |                  |
| 004E <sub>16</sub> | SEG <sub>29</sub> |                  |                  |                  | SEG <sub>28</sub> |                  |                  |                  |
| 004F <sub>16</sub> | SEG <sub>31</sub> |                  |                  |                  | SEG <sub>30</sub> |                  |                  |                  |
|                    | COM <sub>3</sub>  | COM <sub>2</sub> | COM <sub>1</sub> | COM <sub>0</sub> | COM <sub>3</sub>  | COM <sub>2</sub> | COM <sub>1</sub> | COM <sub>0</sub> |

Fig. 32 LCD display RAM map

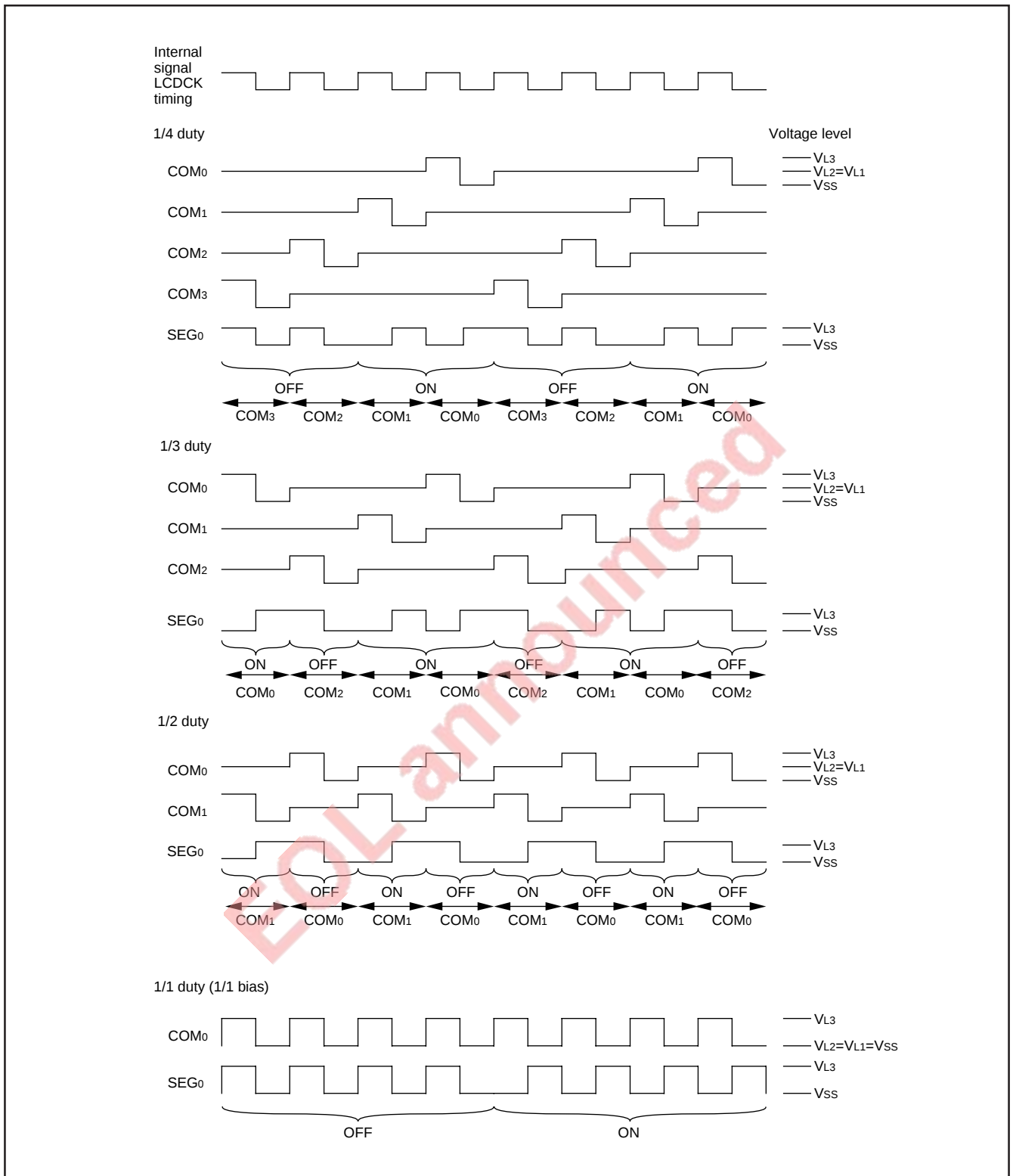


Fig. 33 LCD drive waveform (1/2 bias)

# HARDWARE

## FUNCTIONAL DESCRIPTION

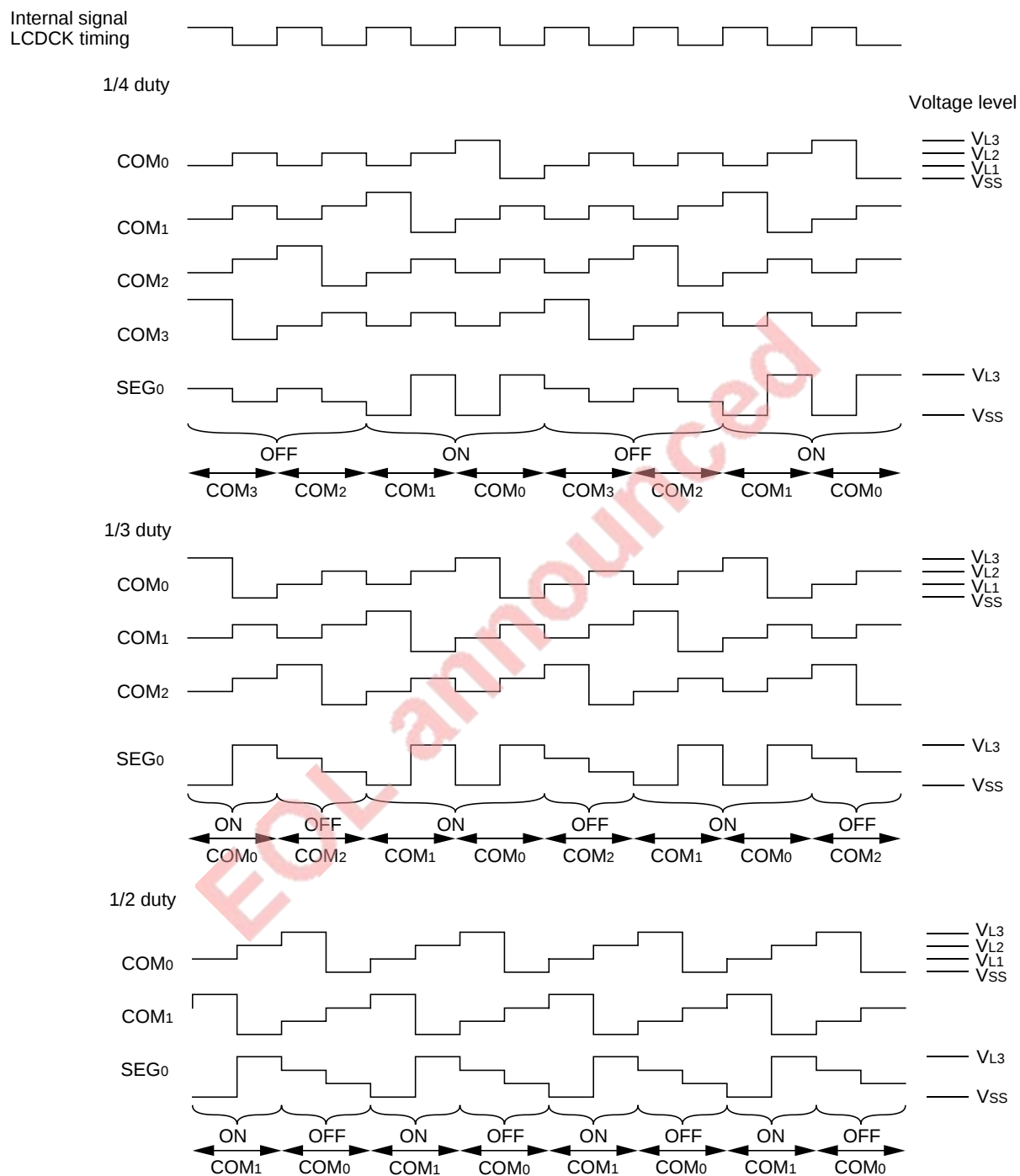


Fig. 34 LCD drive waveform (1/3 bias)

### $\phi$ CLOCK OUTPUT FUNCTION

The internal system clock  $\phi$  can be output from port P43 by setting the  $\phi$  output control register. Set "1" to bit 3 of the port P4 direction register when outputting  $\phi$  clock.

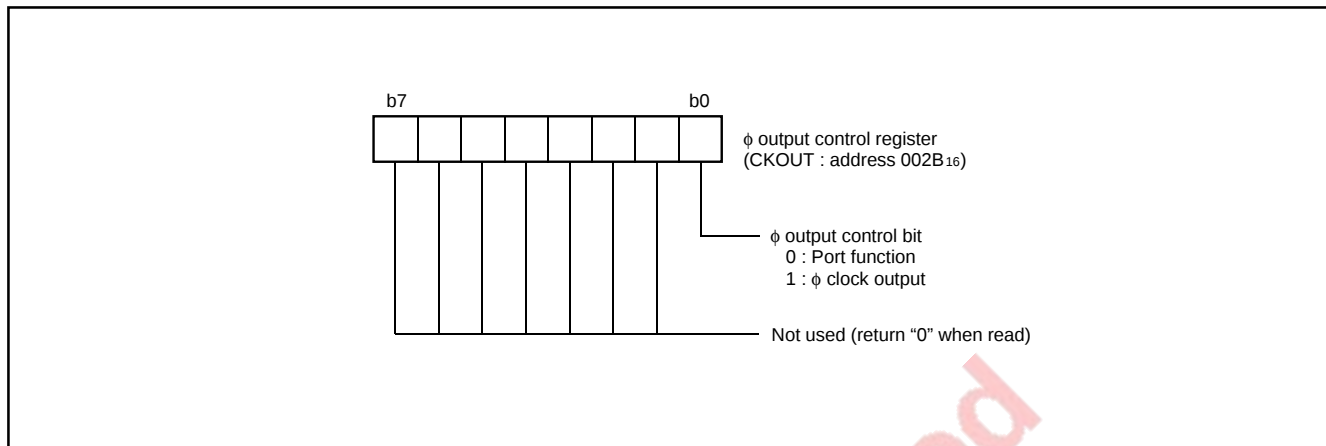


Fig. 35 Structure of  $\phi$  output control register

# HARDWARE

## FUNCTIONAL DESCRIPTION

### ROM CORRECTION FUNCTION (Mask ROM version only)

The 38C3 group has the ROM correction function correcting data at the arbitrary addresses in the ROM area.

#### [ROM correct address register] 0F02<sub>16</sub> – 0F11<sub>16</sub>

This is the register to store the address performing ROM correction. There are two types of registers to correct up to 8 addresses: one is the register to store the high-order address and the other is to store the low-order address.

#### [ROM correct enable register 1 (RC1)] 0F01<sub>16</sub>

This is the register to enable the ROM correction function. When setting the bit corresponding to the ROM correction address to "1", the ROM correction function is enabled.

It becomes invalid to the addresses of which corresponding bit is "0". All bits are "0" at the initial state.

#### [ROM correct data]

This is the register to store a correct data for the address specified by the ROM correct address register.

#### ■Notes on ROM correction function

1. To use the ROM correction function, transfer data to each ROM correct data register in the initial setting.
2. Do not specify the same addresses in the ROM correct address register.

|                    |                                           |
|--------------------|-------------------------------------------|
| 0F02 <sub>16</sub> | ROM correct high-order address register 1 |
| 0F03 <sub>16</sub> | ROM correct low-order address register 1  |
| 0F04 <sub>16</sub> | ROM correct high-order address register 2 |
| 0F05 <sub>16</sub> | ROM correct low-order address register 2  |
| 0F06 <sub>16</sub> | ROM correct high-order address register 3 |
| 0F07 <sub>16</sub> | ROM correct low-order address register 3  |
| 0F08 <sub>16</sub> | ROM correct high-order address register 4 |
| 0F09 <sub>16</sub> | ROM correct low-order address register 4  |
| 0F0A <sub>16</sub> | ROM correct high-order address register 5 |
| 0F0B <sub>16</sub> | ROM correct low-order address register 5  |
| 0F0C <sub>16</sub> | ROM correct high-order address register 6 |
| 0F0D <sub>16</sub> | ROM correct low-order address register 6  |
| 0F0E <sub>16</sub> | ROM correct high-order address register 7 |
| 0F0F <sub>16</sub> | ROM correct low-order address register 7  |
| 0F10 <sub>16</sub> | ROM correct high-order address register 8 |
| 0F11 <sub>16</sub> | ROM correct low-order address register 8  |

Fig. 36 Structure of ROM correct address register

|                    |                    |
|--------------------|--------------------|
| 0050 <sub>16</sub> | ROM correct data 1 |
| 0051 <sub>16</sub> | ROM correct data 2 |
| 0052 <sub>16</sub> | ROM correct data 3 |
| 0053 <sub>16</sub> | ROM correct data 4 |
| 0054 <sub>16</sub> | ROM correct data 5 |
| 0055 <sub>16</sub> | ROM correct data 6 |
| 0056 <sub>16</sub> | ROM correct data 7 |
| 0057 <sub>16</sub> | ROM correct data 8 |

Fig. 37 Structure of ROM correct data

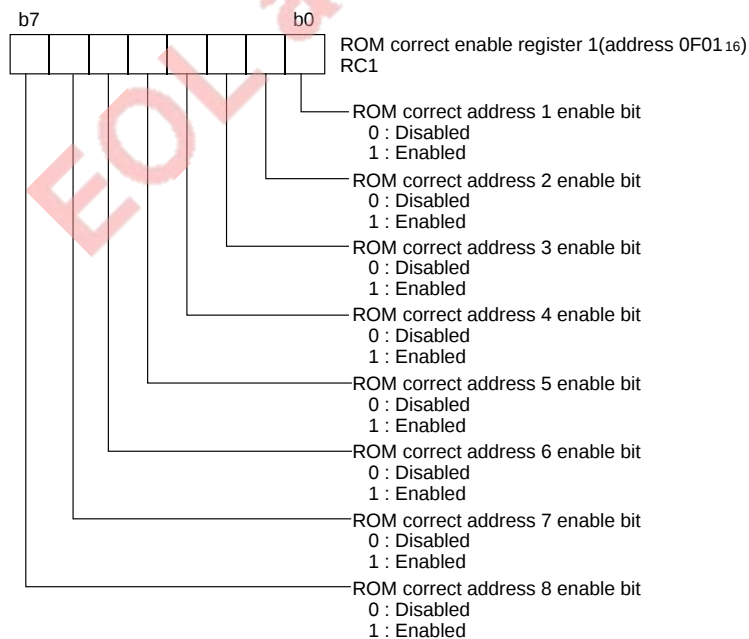


Fig. 38 Structure of ROM correct enable register 1

### RESET CIRCUIT

To reset the microcomputer,  $\overline{\text{RESET}}$  pin should be held at an "L" level for 2  $\mu\text{s}$  or more. Then the  $\overline{\text{RESET}}$  pin is returned to an "H" level (the power source voltage should be between 2.5 V and 5.5 V (M version: 2.2\* V to 5.5 V), and the oscillation should be stable), reset is released. After the reset is completed, the program starts from the address contained in address FFFD<sub>16</sub> (high-order byte) and address FFFC<sub>16</sub> (low-order byte). Make sure that the reset input voltage is less than 0.5 V for Vcc of 2.5 V (M version: less than 0.44 V for Vcc of 2.2\* V) when switching to the high-speed mode, a power source voltage must be between 4.0 V and 5.5 V.

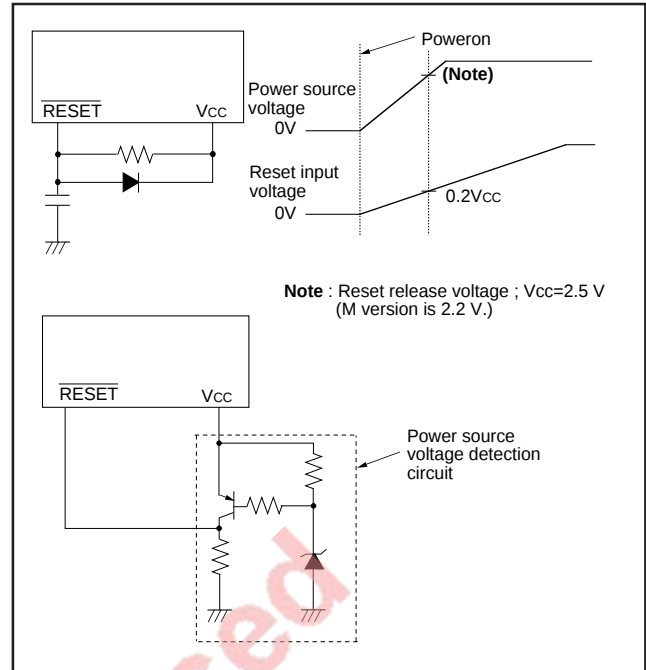


Fig. 39 Reset circuit example

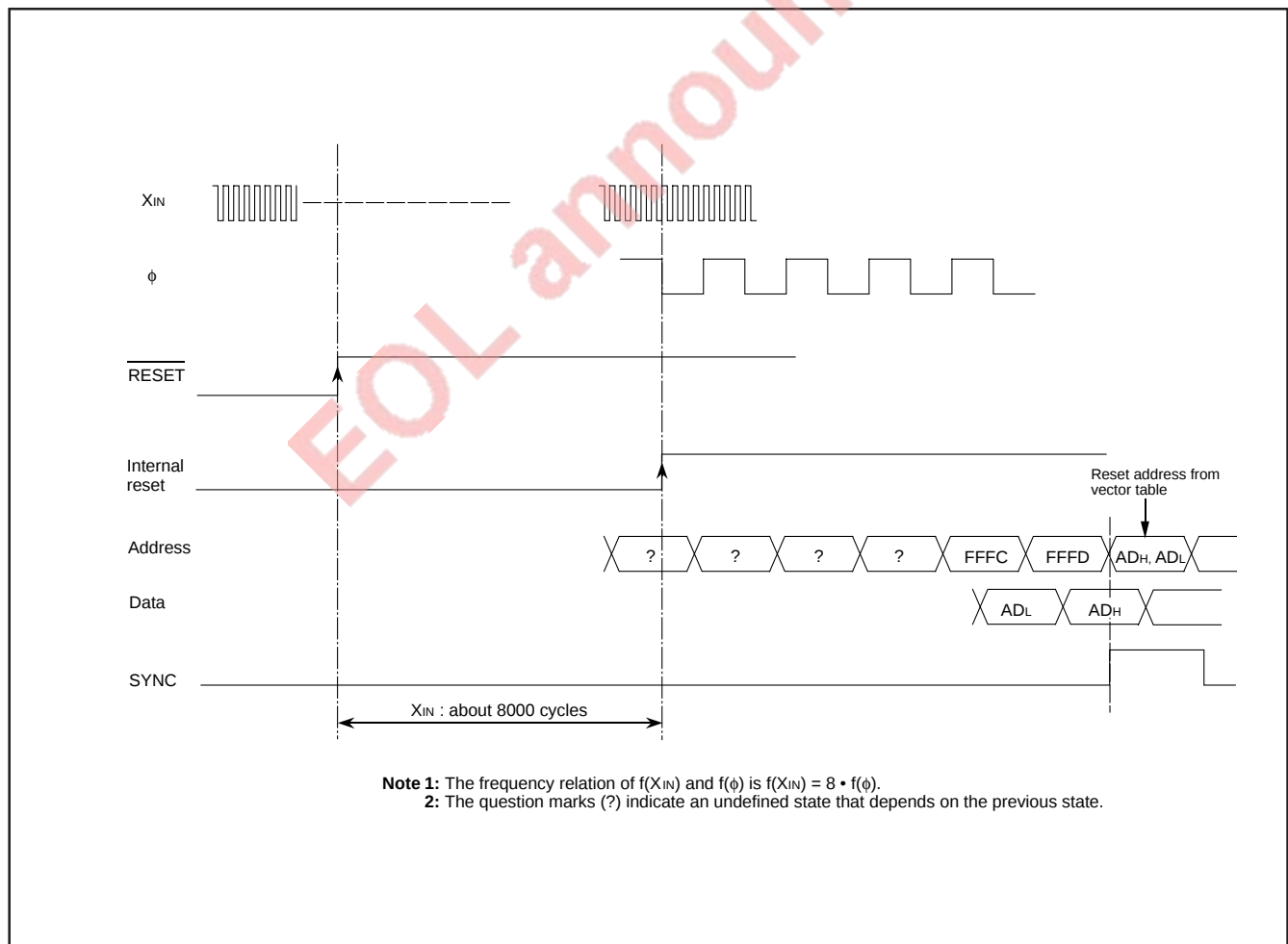


Fig. 40 Reset sequence

# HARDWARE

## FUNCTIONAL DESCRIPTION

|                                        | Address            | Register contents |                                                | Address            | Register contents           |
|----------------------------------------|--------------------|-------------------|------------------------------------------------|--------------------|-----------------------------|
| (1) Port P0                            | 0000 <sub>16</sub> | 00 <sub>16</sub>  | (34) Timer A register (high-order)             | 002D <sub>16</sub> | FF <sub>16</sub>            |
| (2) Port P0 direction register         | 0001 <sub>16</sub> | 00 <sub>16</sub>  | (35) Compare register (low-order)              | 002E <sub>16</sub> | 00 <sub>16</sub>            |
| (3) Port P1                            | 0002 <sub>16</sub> | 00 <sub>16</sub>  | (36) Compare register (high-order)             | 002F <sub>16</sub> | 00 <sub>16</sub>            |
| (4) Port P1 direction register         | 0003 <sub>16</sub> | 00 <sub>16</sub>  | (37) Timer A mode register                     | 0030 <sub>16</sub> | 00 <sub>16</sub>            |
| (5) Port P2                            | 0004 <sub>16</sub> | 00 <sub>16</sub>  | (38) Timer A control register                  | 0031 <sub>16</sub> | 00 <sub>16</sub>            |
| (6) Port P2 direction register         | 0005 <sub>16</sub> | 00 <sub>16</sub>  | (39) A-D control register                      | 0032 <sub>16</sub> | 10 <sub>16</sub>            |
| (7) Port P3                            | 0006 <sub>16</sub> | 00 <sub>16</sub>  | (40) Segment output enable register            | 0038 <sub>16</sub> | 00 <sub>16</sub>            |
| (8) Port P4                            | 0008 <sub>16</sub> | 00 <sub>16</sub>  | (41) LCD mode register                         | 0039 <sub>16</sub> | 00 <sub>16</sub>            |
| (9) Port P4 direction register         | 0009 <sub>16</sub> | 00 <sub>16</sub>  | (42) Interrupt edge selection register         | 003A <sub>16</sub> | 00 <sub>16</sub>            |
| (10) Port P5                           | 000A <sub>16</sub> | 00 <sub>16</sub>  | (43) CPU mode register                         | 003B <sub>16</sub> | 01001000                    |
| (11) Port P5 direction register        | 000B <sub>16</sub> | 00 <sub>16</sub>  | (44) Interrupt request register 1              | 003C <sub>16</sub> | 00 <sub>16</sub>            |
| (12) Port P6                           | 000C <sub>16</sub> | 00 <sub>16</sub>  | (45) Interrupt request register 2              | 003D <sub>16</sub> | 00 <sub>16</sub>            |
| (13) Port P6 direction register        | 000D <sub>16</sub> | 00 <sub>16</sub>  | (46) Interrupt control register 1              | 003E <sub>16</sub> | 00 <sub>16</sub>            |
| (14) Port P7                           | 000E <sub>16</sub> | 00 <sub>16</sub>  | (47) Interrupt control register 2              | 003F <sub>16</sub> | 00 <sub>16</sub>            |
| (15) Port P7 direction register        | 000F <sub>16</sub> | 00 <sub>16</sub>  | (48) ROM correct enable register 1             | 0F01 <sub>16</sub> | 00 <sub>16</sub>            |
| (16) Port P8                           | 0010 <sub>16</sub> | 00 <sub>16</sub>  | (49) ROM correct high-order address register 1 | 0F02 <sub>16</sub> | FF <sub>16</sub>            |
| (17) Port P8 direction register        | 0011 <sub>16</sub> | 00 <sub>16</sub>  | (50) ROM correct low-order address register 1  | 0F03 <sub>16</sub> | FF <sub>16</sub>            |
| (18) PULL register A                   | 0016 <sub>16</sub> | 0F <sub>16</sub>  | (51) ROM correct high-order address register 2 | 0F04 <sub>16</sub> | FF <sub>16</sub>            |
| (19) PULL register B                   | 0017 <sub>16</sub> | 00 <sub>16</sub>  | (52) ROM correct low-order address register 2  | 0F05 <sub>16</sub> | FF <sub>16</sub>            |
| (20) Port P8 output selection register | 0018 <sub>16</sub> | 00 <sub>16</sub>  | (53) ROM correct high-order address register 3 | 0F06 <sub>16</sub> | FF <sub>16</sub>            |
| (21) Serial I/O control register 1     | 0019 <sub>16</sub> | 00 <sub>16</sub>  | (54) ROM correct low-order address register 3  | 0F07 <sub>16</sub> | FF <sub>16</sub>            |
| (22) Serial I/O control register 2     | 001A <sub>16</sub> | 00 <sub>16</sub>  | (55) ROM correct high-order address register 4 | 0F08 <sub>16</sub> | FF <sub>16</sub>            |
| (23) Timer 1                           | 0020 <sub>16</sub> | FF <sub>16</sub>  | (56) ROM correct low-order address register 4  | 0F09 <sub>16</sub> | FF <sub>16</sub>            |
| (24) Timer 2                           | 0021 <sub>16</sub> | 01 <sub>16</sub>  | (57) ROM correct high-order address register 5 | 0F0A <sub>16</sub> | FF <sub>16</sub>            |
| (25) Timer 3                           | 0022 <sub>16</sub> | FF <sub>16</sub>  | (58) ROM correct low-order address register 5  | 0F0B <sub>16</sub> | FF <sub>16</sub>            |
| (26) Timer 4                           | 0023 <sub>16</sub> | FF <sub>16</sub>  | (59) ROM correct high-order address register 6 | 0F0C <sub>16</sub> | FF <sub>16</sub>            |
| (27) Timer 5                           | 0024 <sub>16</sub> | FF <sub>16</sub>  | (60) ROM correct low-order address register 6  | 0F0D <sub>16</sub> | FF <sub>16</sub>            |
| (28) Timer 6                           | 0025 <sub>16</sub> | FF <sub>16</sub>  | (61) ROM correct high-order address register 7 | 0F0E <sub>16</sub> | FF <sub>16</sub>            |
| (29) Timer 12 mode register            | 0028 <sub>16</sub> | 00 <sub>16</sub>  | (62) ROM correct low-order address register 7  | 0F0F <sub>16</sub> | FF <sub>16</sub>            |
| (30) Timer 34 mode register            | 0029 <sub>16</sub> | 00 <sub>16</sub>  | (63) ROM correct high-order address register 8 | 0F10 <sub>16</sub> | FF <sub>16</sub>            |
| (31) Timer 56 mode register            | 002A <sub>16</sub> | 00 <sub>16</sub>  | (64) ROM correct low-order address register 8  | 0F11 <sub>16</sub> | FF <sub>16</sub>            |
| (32) $\phi$ output control register    | 002B <sub>16</sub> | 00 <sub>16</sub>  | (65) Processor status register (PS)            |                    | XXXX1XX                     |
| (33) Timer A register (low-order)      | 002C <sub>16</sub> | FF <sub>16</sub>  | (66) Program counter (PC <sub>H</sub> )        |                    | FFFD <sub>16</sub> contents |
|                                        |                    |                   |                                                | (PC <sub>L</sub> ) | FFFC <sub>16</sub> contents |

X: Not fixed

Since the initial values for other than above mentioned registers and RAM contents are indefinite at reset, they must be set.

In the M version, bit 0 of the port P5 direction register becomes "1."

Fig. 41 Internal status at reset

### CLOCK GENERATING CIRCUIT

The 38C3 group has two built-in oscillation circuits. An oscillation circuit can be formed by connecting a resonator between XIN and XOUT (XCIN and XCOUT). Use the circuit constants in accordance with the resonator manufacturer's recommended values. No external resistor is needed between XIN and XOUT since a feedback resistor exists on-chip. However, an external feedback resistor is needed between XCIN and XCOUT.

Immediately after power on, only the XIN oscillation circuit starts oscillating, and XCIN and XCOUT pins function as I/O ports.

### Frequency control

#### (1) Middle-speed mode

The internal system clock is the frequency of XIN divided by 8. After reset, this mode is selected.

#### (2) High-speed mode

The internal system clock is the frequency of XIN divided by 2.

#### (3) Low-speed mode

The internal system clock is the frequency of XCIN divided by 2.

#### ■Notes on clock generating circuit

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

### Oscillation control

#### (1) Stop mode

If the STP instruction is executed, the internal system clock stops at an "H" level, and XIN and XCIN oscillators stop. Timer 1 is set to "FF16" and timer 2 is set to "0116."

Either XIN divided by 16 or XCIN divided by 16 is input to timer 1 as count source, and the output of timer 1 is connected to timer 2. The bits of the timer 12 mode register are cleared to "0." Set the interrupt enable bits of the timer 1 and timer 2 to disabled ("0") before executing the STP instruction. Oscillator restarts when an external interrupt is received, but the internal system clock is not supplied to the CPU until timer 2 underflows. This allows time for the clock circuit oscillation to stabilize.

#### (2) Wait mode

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

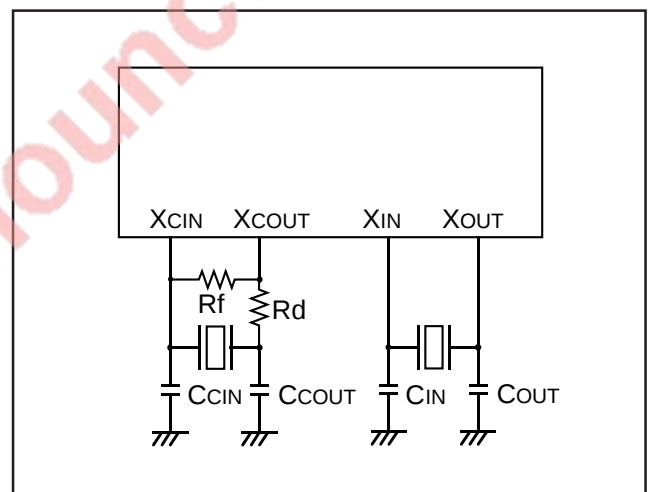


Fig. 42 Ceramic resonator circuit

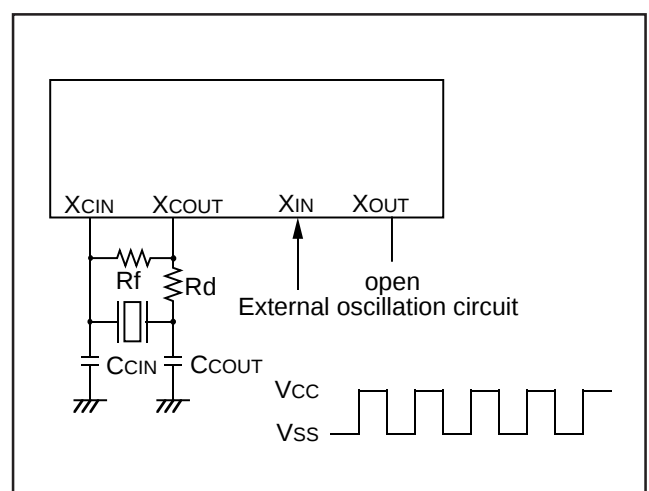
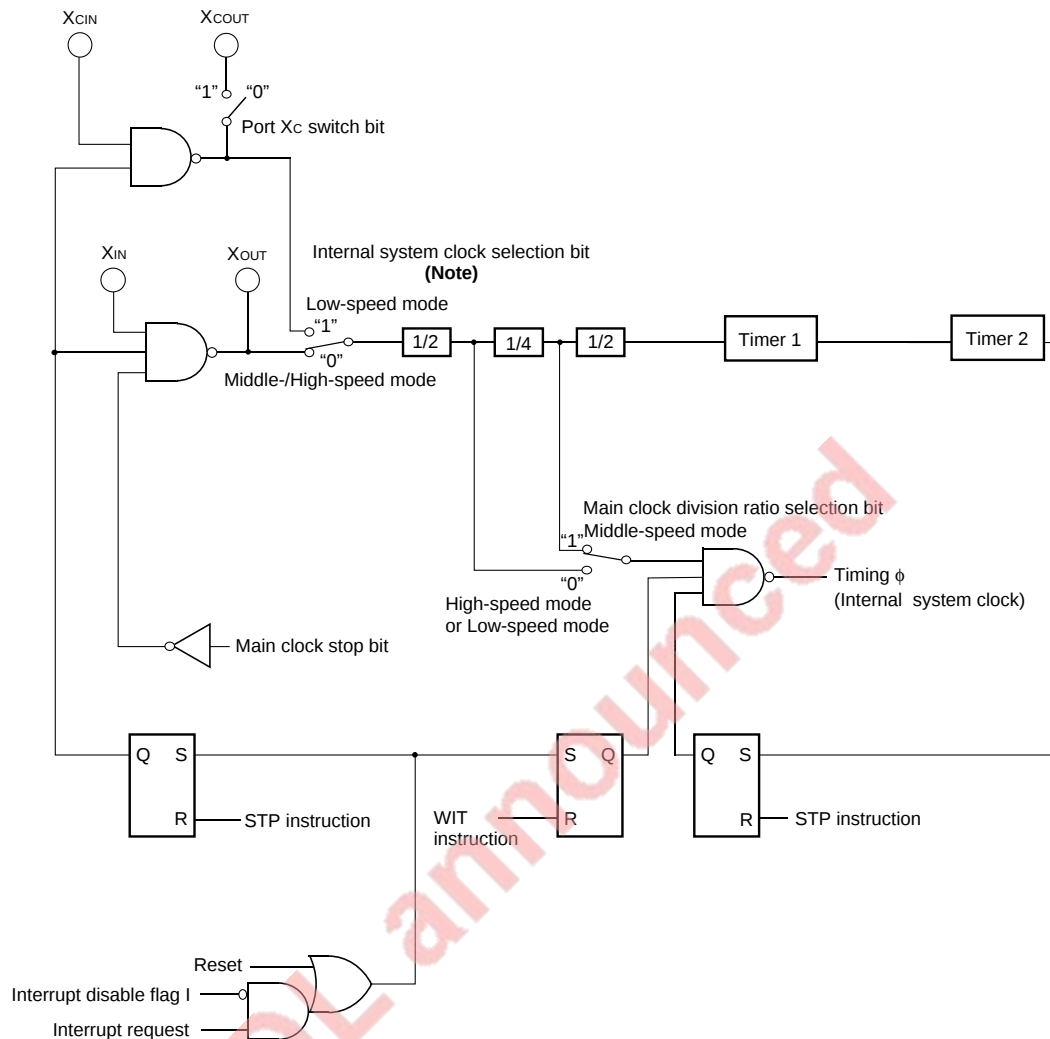


Fig. 43 External clock input circuit

# HARDWARE

## FUNCTIONAL DESCRIPTION



**Note :** When using the low-speed mode, set the port Xc switch bit to "1".

Fig. 44 Clock generating circuit block diagram

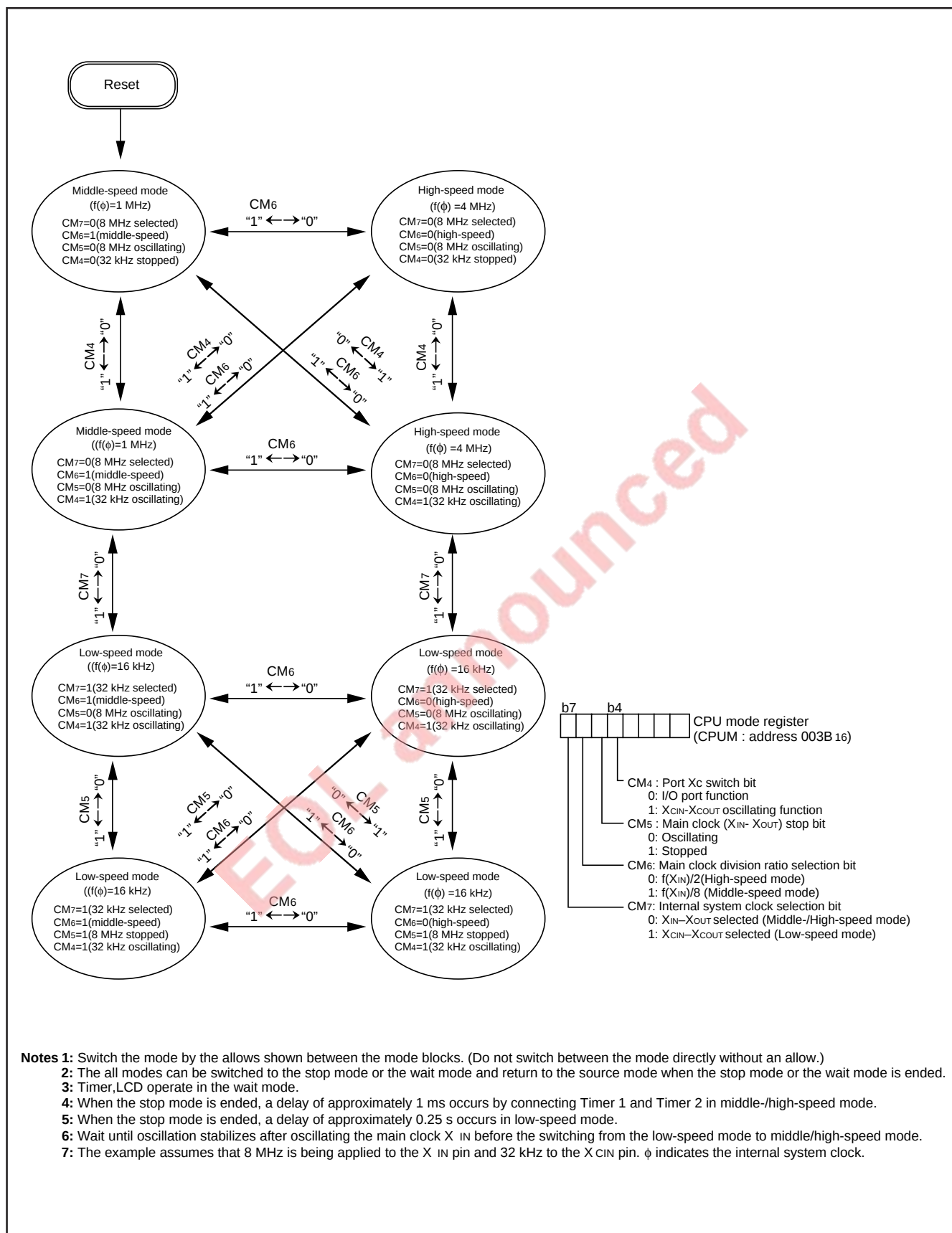


Fig. 45 State transitions of system clock

# HARDWARE

## NOTES ON PROGRAMMING/NOTES ON USE

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### NOTES ON PROGRAMMING Processor Status Register

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

### Interrupts

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

### Decimal Calculations

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

### Timers

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

### Multiplication and Division Instructions

- The index X mode (T) and the decimal mode (D) flags do not affect the MUL and DIV instruction.
- The execution of these instructions does not change the contents of the processor status register.

### Ports

The contents of the port direction registers cannot be read. The following cannot be used:

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

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

### Serial I/O

- Using an external clock

When using an external clock, input "H" to the external clock input pin and clear the serial I/O interrupt request bit before executing serial I/O transfer and serial I/O automatic transfer.

- Using an internal clock

When using an internal clock, set the synchronous clock to the internal clock, then clear the serial I/O interrupt request bit before executing a serial I/O transfer and serial I/O automatic transfer.

### A-D Converter

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

Therefore, make sure that  $f(XIN)$  is at least on 500 kHz during an A-D conversion.

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

### Instruction Execution Time

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

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

The frequency of the internal system clock is the same half of the  $XIN$  frequency in high-speed mode.

### At STP Instruction Release

At the STP instruction release, all bits of the timer 12 mode register are cleared.

### NOTES ON USE Notes on Built-in EPROM Version

The P51 pin of the One Time PROM version or the EPROM version functions as the power source input pin of the internal EPROM.

Therefore, this pin is set at low input impedance, thereby being affected easily by noise.

To prevent a malfunction due to noise, insert a resistor (approx. 5 k $\Omega$ ) in series with the P51 pin.

**DATA REQUIRED FOR MASK ORDERS AND ROM WRITING ORDERS/ROM PROGRAMMING METHOD****DATA REQUIRED FOR MASK ORDERS**

The following are necessary when ordering a mask ROM production:

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

**DATA REQUIRED FOR ROM WRITING ORDERS**

The following are necessary when ordering a ROM writing:

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

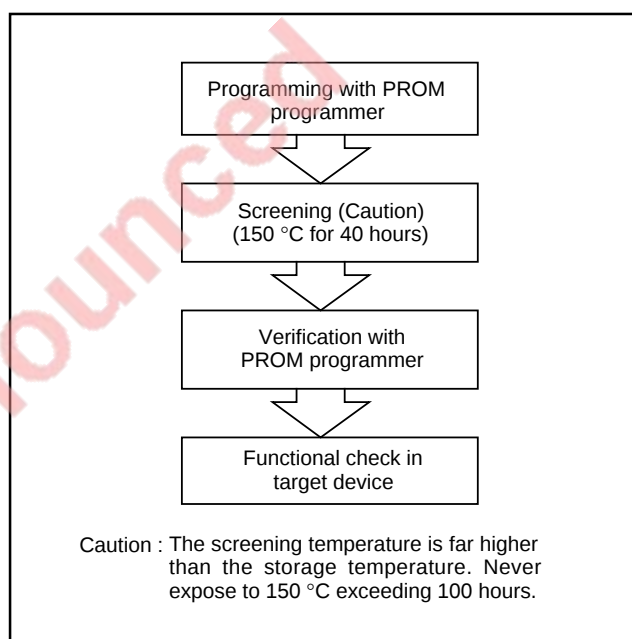
**ROM PROGRAMMING METHOD**

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

**Table 13 Programming adapter**

| Package | Name of Programming Adapter |
|---------|-----------------------------|
| 80P6N-A | PCA4738F-80A                |
| 80D0    | PCA4738L-80A                |

The PROM of the blank One Time PROM version is not tested or screened in the assembly process and following processes. To ensure proper operation after programming, the procedure shown in Figure 46 is recommended to verify programming.



**Fig. 46 Programming and testing of One Time PROM version**

# HARDWARE

## FUNCTIONAL DESCRIPTION SUPPLEMENT

### FUNCTIONAL DESCRIPTION SUPPLEMENT

#### Interrupt

38C3 group permits interrupts on the basis of 16 sources.

It is vector interrupts with a fixed priority system. Accordingly, when two or more interrupt requests occur during the same sampling, the

higher-priority interrupt is accepted first. This priority is determined by hardware, but various priority processing can be performed by software, using an interrupt enable bit and an interrupt disable flag.

For interrupt sources, vector addresses and interrupt priority, refer to Table 14.

**Table 14** Interrupt sources, vector addresses and interrupt priority

| Interrupt Source           | Priority | Vector Addresses (Note 1) |                    | Interrupt Request<br>Generating Conditions                               | Remarks                                         |
|----------------------------|----------|---------------------------|--------------------|--------------------------------------------------------------------------|-------------------------------------------------|
|                            |          | High                      | Low                |                                                                          |                                                 |
| Reset (Note 2)             | 1        | FFFD <sub>16</sub>        | FFFC <sub>16</sub> | At reset                                                                 | Non-maskable                                    |
| INT <sub>0</sub>           | 2        | FFFB <sub>16</sub>        | FFFA <sub>16</sub> | At detection of either rising or falling edge of INT <sub>0</sub> input  | External interrupt (active edge selectable)     |
| INT <sub>1</sub>           | 3        | FFF9 <sub>16</sub>        | FFF8 <sub>16</sub> | At detection of either rising or falling edge of INT <sub>1</sub> input  | External interrupt (active edge selectable)     |
| INT <sub>2</sub>           | 4        | FFF7 <sub>16</sub>        | FFF6 <sub>16</sub> | At detection of either rising or falling edge of INT <sub>2</sub> input  | External interrupt (active edge selectable)     |
| Serial I/O                 | 5        | FFF5 <sub>16</sub>        | FFF4 <sub>16</sub> | At completion of serial I/O data transmit/receive                        | Valid when serial I/O is selected               |
| Timer A                    | 6        | FFF3 <sub>16</sub>        | FFF2 <sub>16</sub> | At timer A underflow                                                     |                                                 |
| Timer 1                    | 7        | FFF1 <sub>16</sub>        | FFF0 <sub>16</sub> | At timer 1 underflow                                                     |                                                 |
| Timer 2                    | 8        | FFEF <sub>16</sub>        | FFEE <sub>16</sub> | At timer 2 underflow                                                     | STP release timer underflow                     |
| Timer 3                    | 9        | FFED <sub>16</sub>        | FFEC <sub>16</sub> | At timer 3 underflow                                                     |                                                 |
| Timer 4                    | 10       | FFEB <sub>16</sub>        | FFEA <sub>16</sub> | At timer 4 underflow                                                     |                                                 |
| Timer 5                    | 11       | FFE9 <sub>16</sub>        | FFE8 <sub>16</sub> | At timer 5 underflow                                                     |                                                 |
| Timer 6                    | 12       | FFE7 <sub>16</sub>        | FFE6 <sub>16</sub> | At timer 6 underflow                                                     |                                                 |
| CNTR <sub>0</sub>          | 13       | FFE5 <sub>16</sub>        | FFE4 <sub>16</sub> | At detection of either rising or falling edge of CNTR <sub>0</sub> input | External interrupt (active edge selectable)     |
| CNTR <sub>1</sub>          | 14       | FFE3 <sub>16</sub>        | FFE2 <sub>16</sub> | At detection of either rising or falling edge of CNTR <sub>1</sub> input | External interrupt (active edge selectable)     |
| Key input (Key-on wake-up) | 15       | FFE1 <sub>16</sub>        | FFE0 <sub>16</sub> | At falling of port P8 (at input) input logical level AND                 | External interrupt (falling valid)              |
| A-D conversion             | 16       | FFDF <sub>16</sub>        | FFDE <sub>16</sub> | At completion of A-D conversion                                          | Valid when A-D conversion interrupt is selected |
| BRK instruction            | 17       | FFDD <sub>16</sub>        | FFDC <sub>16</sub> | At BRK instruction execution                                             | Non-maskable software interrupt                 |

**Notes 1:** Vector addresses contain interrupt jump destination addresses.

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

Timing After Interrupt

The interrupt processing routine begins with the machine cycle following the completion of the instruction that is currently in execution. Figure 47 shows a timing chart after an interrupt occurs, and Figure 48 shows the time up to execution of the interrupt processing routine.

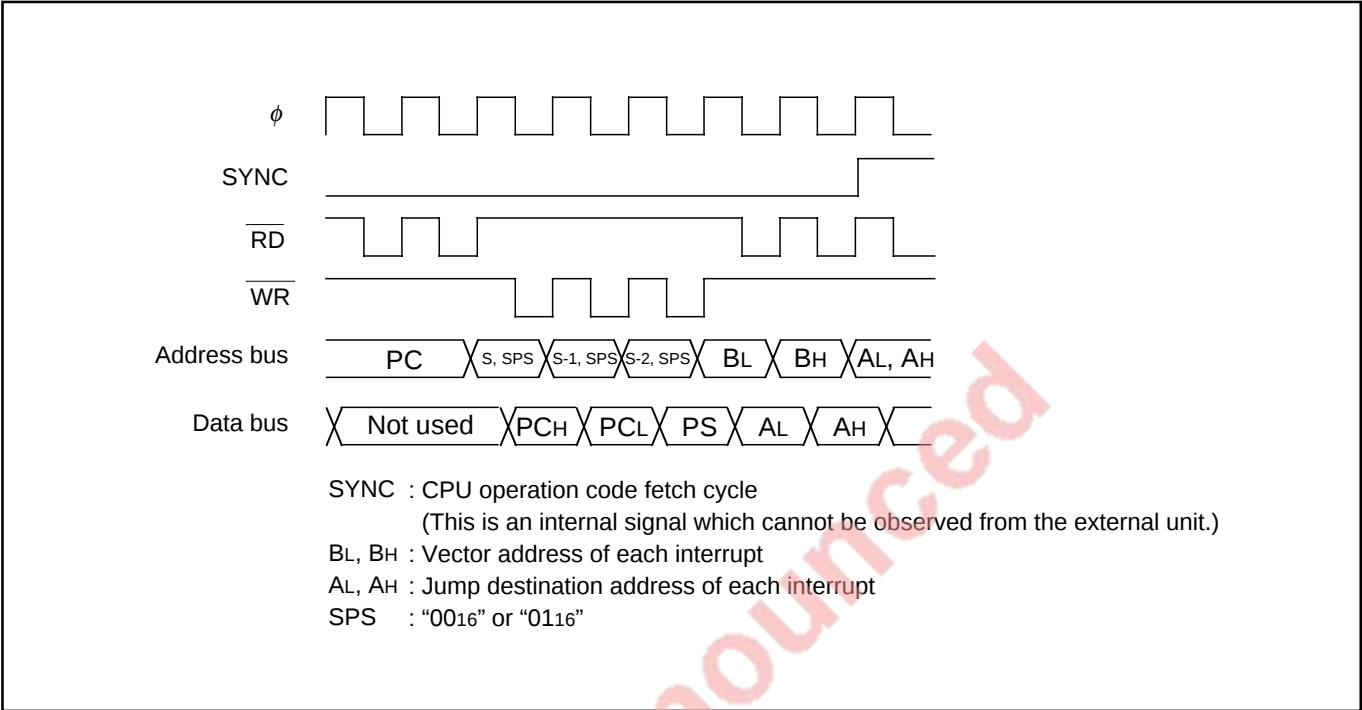


Fig. 47 Timing chart after interrupt occurs

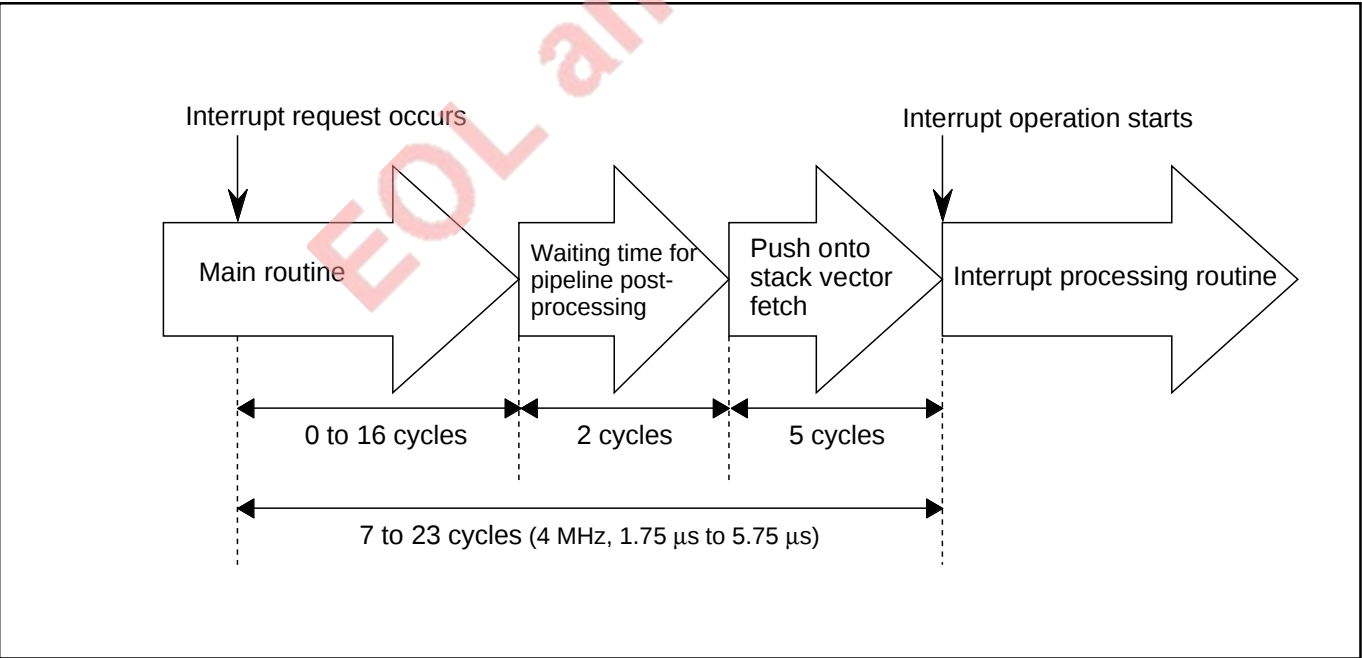


Fig. 48 Time up to execution of interrupt processing routine

# HARDWARE

## FUNCTIONAL DESCRIPTION SUPPLEMENT

### A-D Converter

A-D conversion is started by setting AD conversion completion bit to “0.” During A-D conversion, internal operations are performed as follows.

1. After the start of A-D conversion, A-D conversion register goes to “0016.”
2. The highest-order bit of A-D conversion register is set to “1,” and the comparison voltage  $V_{ref}$  is input to the comparator. Then,  $V_{ref}$  is compared with analog input voltage  $V_{IN}$ .
3. As a result of comparison, when  $V_{ref} < V_{IN}$ , the highest-order bit of A-D conversion register becomes “1.” When  $V_{ref} > V_{IN}$ , the highest-order bit becomes “0.”

By repeating the above operations up to the lowest-order bit of the A-D conversion register, an analog value converts into a digital value. A-D conversion completes at 61 clock cycles (15.25  $\mu$ s at  $f(X_{IN}) = 8$  MHz) after it is started, and the result of the conversion is stored into the A-D conversion register.

Concurrently with the completion of A-D conversion, A-D conversion interrupt request occurs, so that the AD conversion interrupt request bit is set to “1.”

**Table 15 Relative formula for a reference voltage  $V_{REF}$  of A-D converter and  $V_{ref}$**

|                      |                                           |
|----------------------|-------------------------------------------|
| When $n = 0$         | $V_{ref} = 0$                             |
| When $n = 1$ to 1023 | $V_{ref} = \frac{V_{REF}}{1024} \times n$ |

$n$ : Value of A-D converter (decimal numeral)

**Table 16 Change of A-D conversion register during A-D conversion**

|                                      | Change of A-D conversion register                            | Value of comparison voltage ( $V_{ref}$ )                                    |
|--------------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------|
| At start of conversion               | 0 0 0 0 0 0 0 0 0 0 0 0                                      | 0                                                                            |
| First comparison                     | 1 0 0 0 0 0 0 0 0 0 0 0                                      | $\frac{V_{REF}}{2}$                                                          |
| Second comparison                    | *1 1 0 0 0 0 0 0 0 0 0 0                                     | $\frac{V_{REF}}{2} \pm \frac{V_{REF}}{4}$                                    |
| Third comparison                     | *1 *2 1 0 0 0 0 0 0 0 0 0                                    | $\frac{V_{REF}}{2} \pm \frac{V_{REF}}{4} \pm \frac{V_{REF}}{8}$              |
| $\approx$                            |                                                              |                                                                              |
| After completion of tenth comparison | A result of A-D conversion<br>*1 *2 *3 *4 *5 *6 *7 *8 *9 *10 | $\frac{V_{REF}}{2} \pm \frac{V_{REF}}{4} \pm \dots \pm \frac{V_{REF}}{1024}$ |

\*1–\*10: A result of the first comparison to the tenth comparison

Figures 49 shows the A-D conversion equivalent circuit, and Figure 50 shows the A-D conversion timing chart.

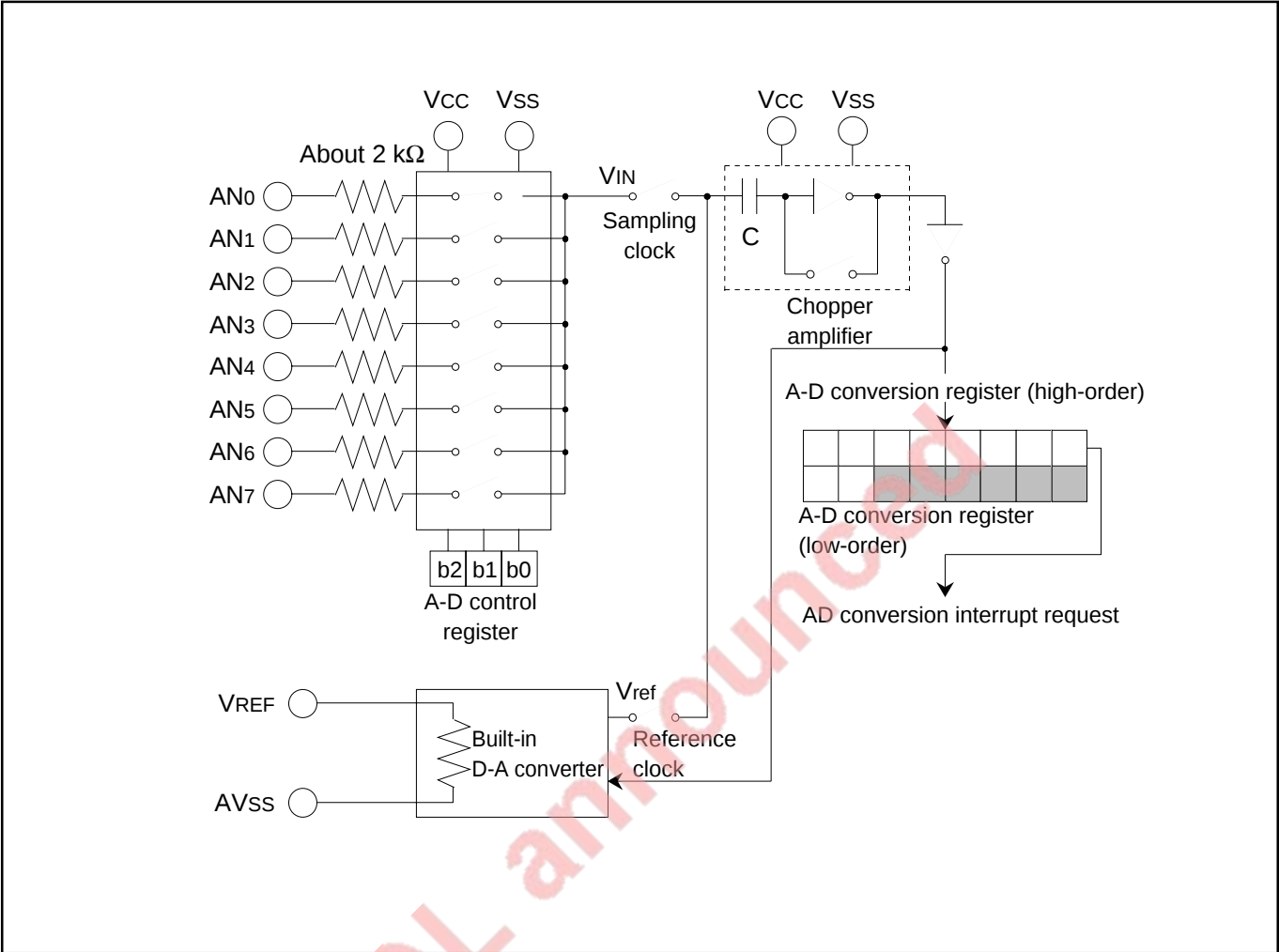


Fig. 49 A-D conversion equivalent circuit

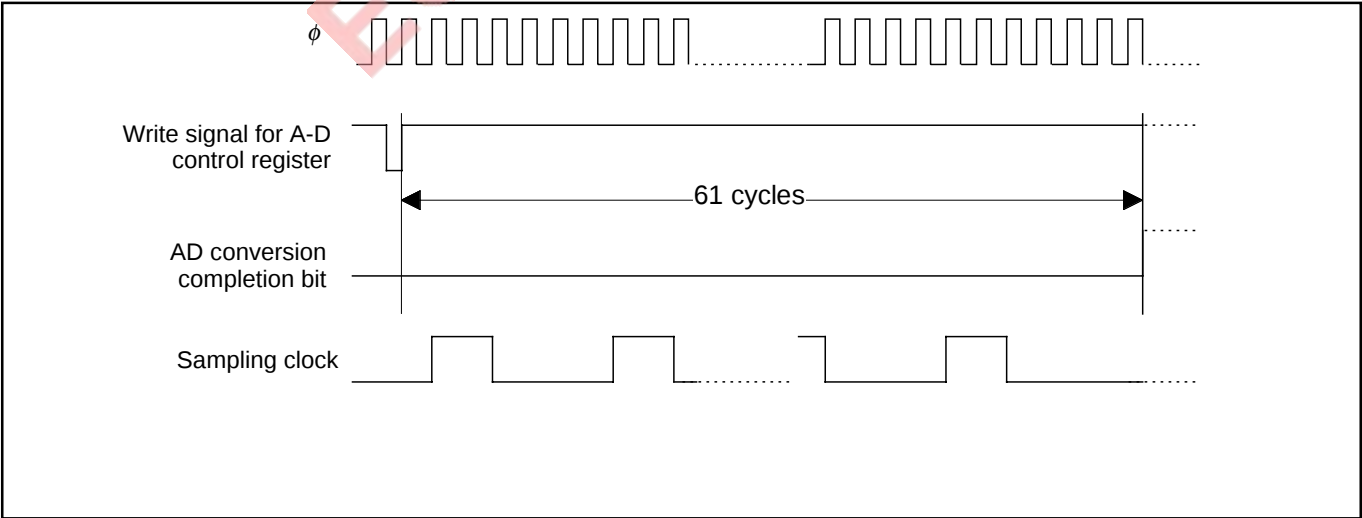


Fig. 50 A-D conversion timing chart

# HARDWARE

## FUNCTIONAL DESCRIPTION SUPPLEMENT

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### *MEMORANDUM*

EOL announced

# CHAPTER 2

## APPLICATION

- 2.1 I/O port
- 2.2 Timer
- 2.3 Serial I/O
- 2.4 LCD controller
- 2.5 A-D converter
- 2.6 ROM correct function
- 2.7 Reset circuit
- 2.8 Clock generating circuit

# APPLICATION

## 2.1 I/O port

### 2.1 I/O port

This paragraph describes the setting method of I/O port relevant registers, notes etc.

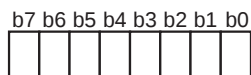
#### 2.1.1 Memory map

| Address            |                                           |
|--------------------|-------------------------------------------|
| 0000 <sub>16</sub> | Port P0 (P0)                              |
| 0001 <sub>16</sub> | Port P0 direction register (P0D)          |
| 0002 <sub>16</sub> | Port P1 (P1)                              |
| 0003 <sub>16</sub> | Port P1 direction register (P1D)          |
| 0004 <sub>16</sub> | Port P2 (P2)                              |
| 0005 <sub>16</sub> | Port P2 direction register (P2D)          |
| 0006 <sub>16</sub> | Port P3 (P3)                              |
| 0007 <sub>16</sub> |                                           |
| 0008 <sub>16</sub> | Port P4 (P4)                              |
| 0009 <sub>16</sub> | Port P4 direction register (P4D)          |
| 000A <sub>16</sub> | Port P5 (P5)                              |
| 000B <sub>16</sub> | Port P5 direction register (P5D)          |
| 000C <sub>16</sub> | Port P6 (P6)                              |
| 000D <sub>16</sub> | Port P6 direction register (P6D)          |
| 000E <sub>16</sub> | Port P7 (P7)                              |
| 000F <sub>16</sub> | Port P7 direction register (P7D)          |
| 0010 <sub>16</sub> | Port P8 (P8)                              |
| 0011 <sub>16</sub> | Port P8 direction register (P8D)          |
| ≈                  | ≈                                         |
| 0016 <sub>16</sub> | PULL register A (PULLA)                   |
| 0017 <sub>16</sub> | PULL register B (PULLB)                   |
| 0018 <sub>16</sub> | Port P8 output selection register (P8SEL) |
|                    |                                           |

Fig. 2.1.1 Memory map of I/O port relevant registers

## 2.1.2 Relevant registers

## Port Pi



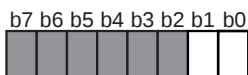
Port Pi (i = 0, 1, 2, 3, 4, 5, 6, 8)

(Pi: addresses 00<sub>16</sub>, 02<sub>16</sub>, 04<sub>16</sub>, 06<sub>16</sub>, 08<sub>16</sub>, 0A<sub>16</sub>, 0C<sub>16</sub>, 10<sub>16</sub>)

| b | Name     | Functions                                                            | At reset | R | W |
|---|----------|----------------------------------------------------------------------|----------|---|---|
| 0 | Port Pi0 | ● In output mode<br>Write ..... Port latch<br>Read ..... Port latch  | 0        | ○ | ○ |
| 1 | Port Pi1 |                                                                      | 0        | ○ | ○ |
| 2 | Port Pi2 | ● In input mode<br>Write ..... Port latch<br>Read ..... Value of pin | 0        | ○ | ○ |
| 3 | Port Pi3 |                                                                      | 0        | ○ | ○ |
| 4 | Port Pi4 | ● In input mode<br>Write ..... Port latch<br>Read ..... Value of pin | 0        | ○ | ○ |
| 5 | Port Pi5 |                                                                      | 0        | ○ | ○ |
| 6 | Port Pi6 | ● In input mode<br>Write ..... Port latch<br>Read ..... Value of pin | 0        | ○ | ○ |
| 7 | Port Pi7 |                                                                      | 0        | ○ | ○ |

Fig. 2.1.2 Structure of port Pi (i = 0, 1, 2, 3, 4, 5, 6, 8)

## Port P7



Port P7

(P7: address 0E<sub>16</sub>)

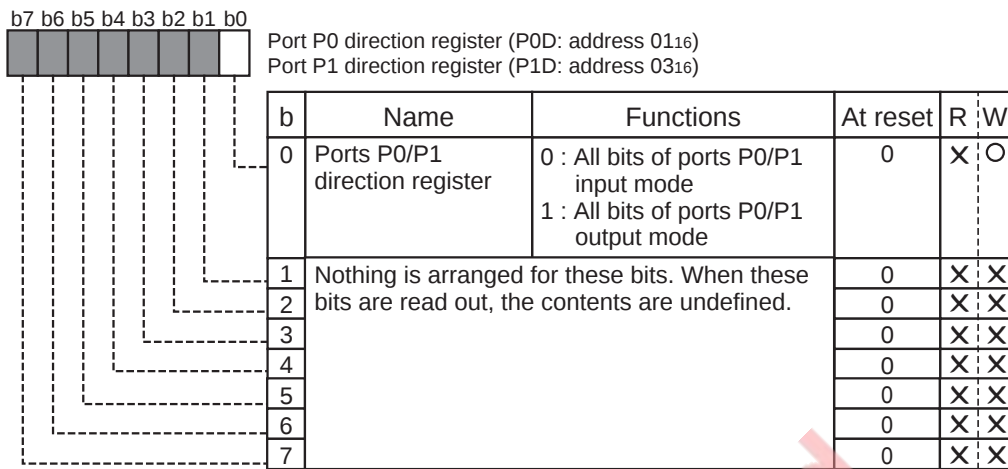
| b | Name                                                                                          | Functions                                                            | At reset | R | W |
|---|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------|---|---|
| 0 | Port P70                                                                                      | ● In output mode<br>Write ..... Port latch<br>Read ..... Port latch  | 0        | ○ | ○ |
| 1 | Port P71                                                                                      | ● In input mode<br>Write ..... Port latch<br>Read ..... Value of pin | 0        | ○ | ○ |
| 2 | Nothing is arranged for these bits. When these bits are read out, the contents are undefined. |                                                                      | 0        | × | × |
| 3 |                                                                                               |                                                                      | 0        | × | × |
| 4 |                                                                                               |                                                                      | 0        | × | × |
| 5 |                                                                                               |                                                                      | 0        | × | × |
| 6 |                                                                                               |                                                                      | 0        | × | × |
| 7 |                                                                                               |                                                                      | 0        | × | × |

Fig. 2.1.3 Structure of port P7

# APPLICATION

## 2.1 I/O port

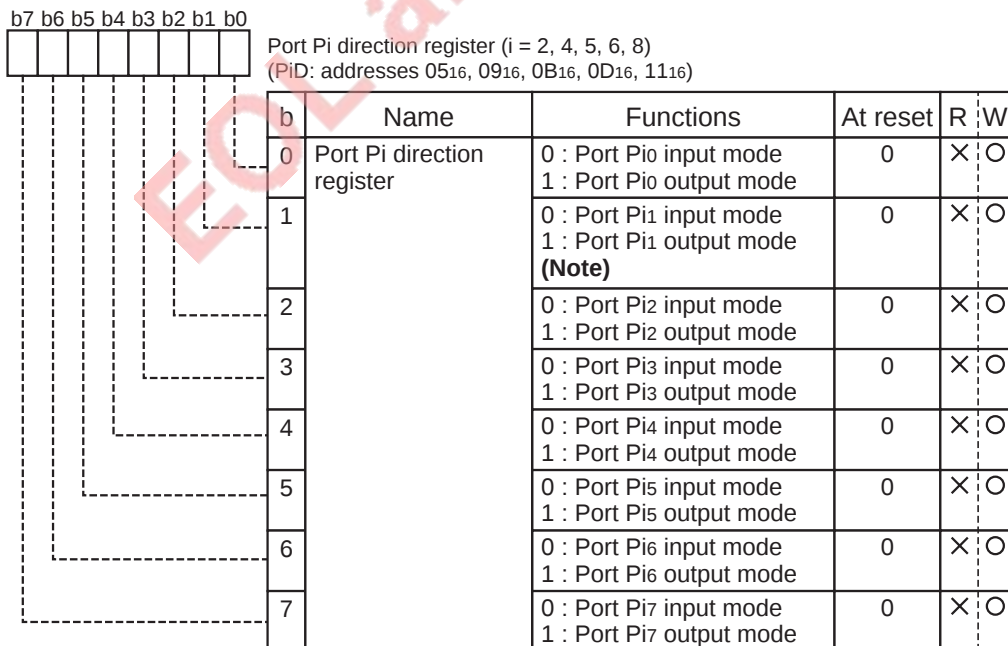
### Port P0 direction register, Port P1 direction register



**Note:** Ports P0 and P1 are switched to input and output by each port. When b0 of corresponding port direction register is set to "0", all 8 bits of port become input port. When b0 of corresponding port direction register is set to "1", all 8 bits of port become output port. Nothing is arranged for b1 to b7 of port P0 and port P1 direction registers. These are write disabled bits.

Fig. 2.1.4 Structure of Port P0 direction register and port P1 direction register

### Port Pi direction register



**Note:** Bit 1 of the port P5 direction register (address 0B16) does not have direction register function, because P51 is an input port. When writing to bit 1 of the port P5 direction register, write "0" to the bit.

Fig. 2.1.5 Structure of Port Pi direction register (i = 2, 4, 5, 6, 8)

## Port P7 direction register

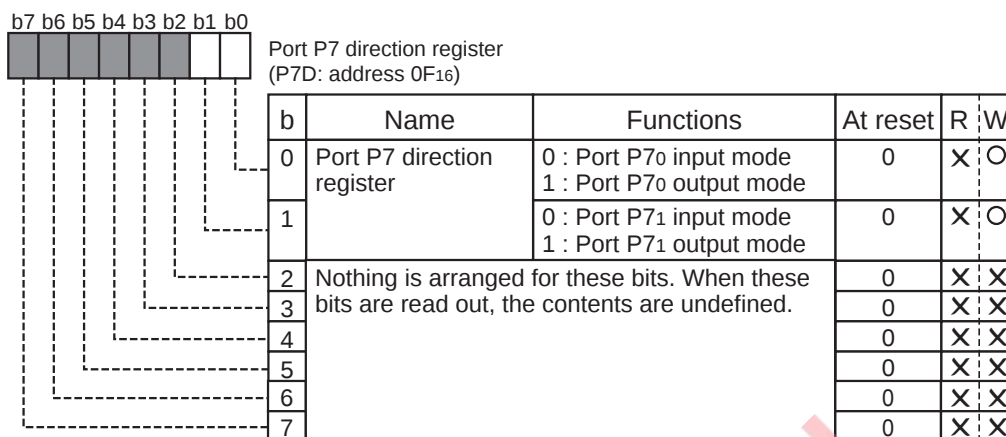
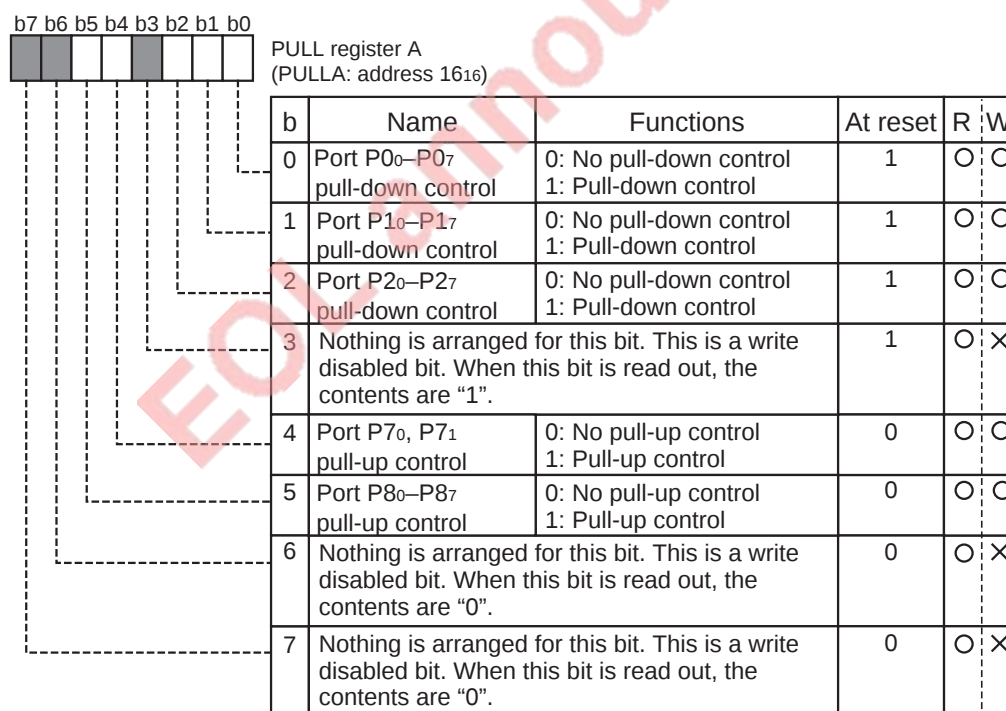


Fig. 2.1.6 Structure of Port P7 direction register

## PULL register A



**Note:** The pin which is set to output port is cut off from pull-up control.

Fig. 2.1.7 Structure of PULL register A

# APPLICATION

## 2.1 I/O port

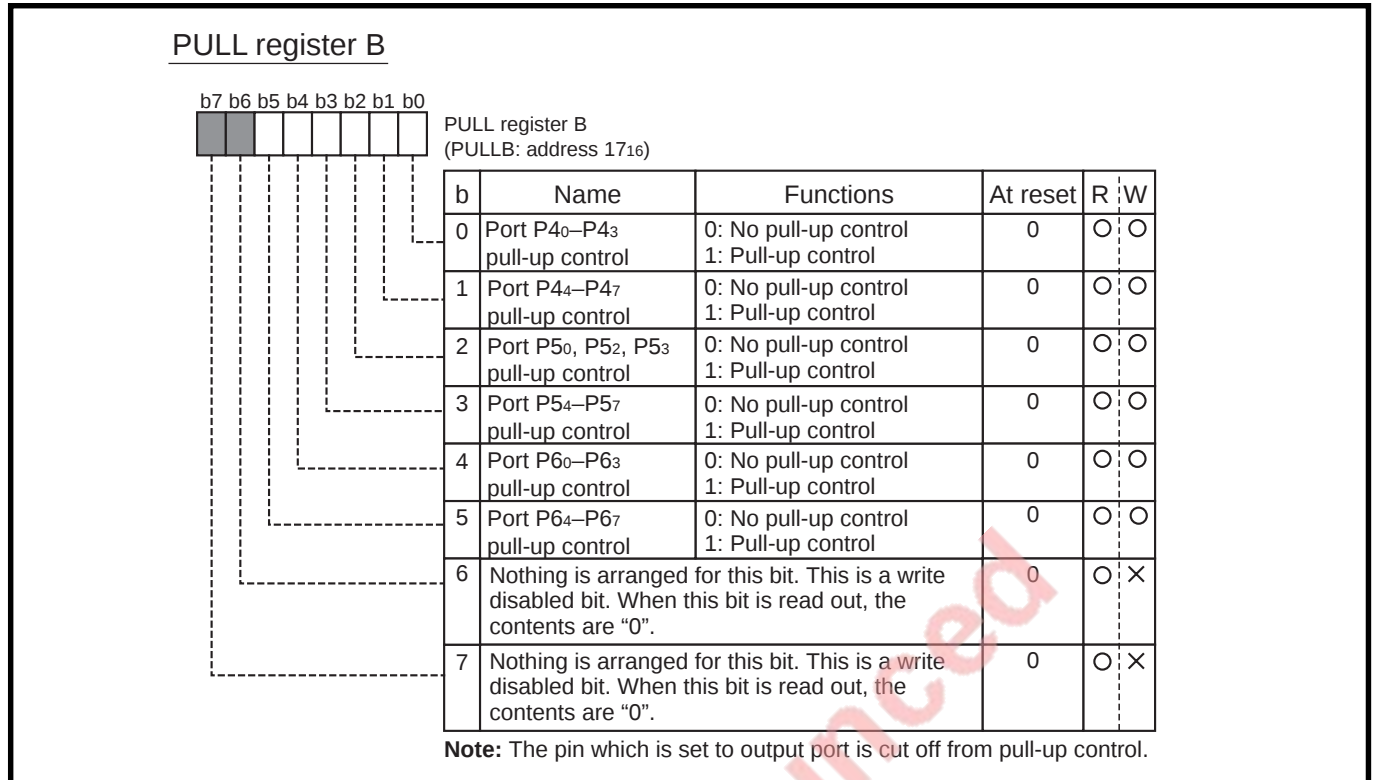


Fig. 2.1.8 Structure of PULL register B

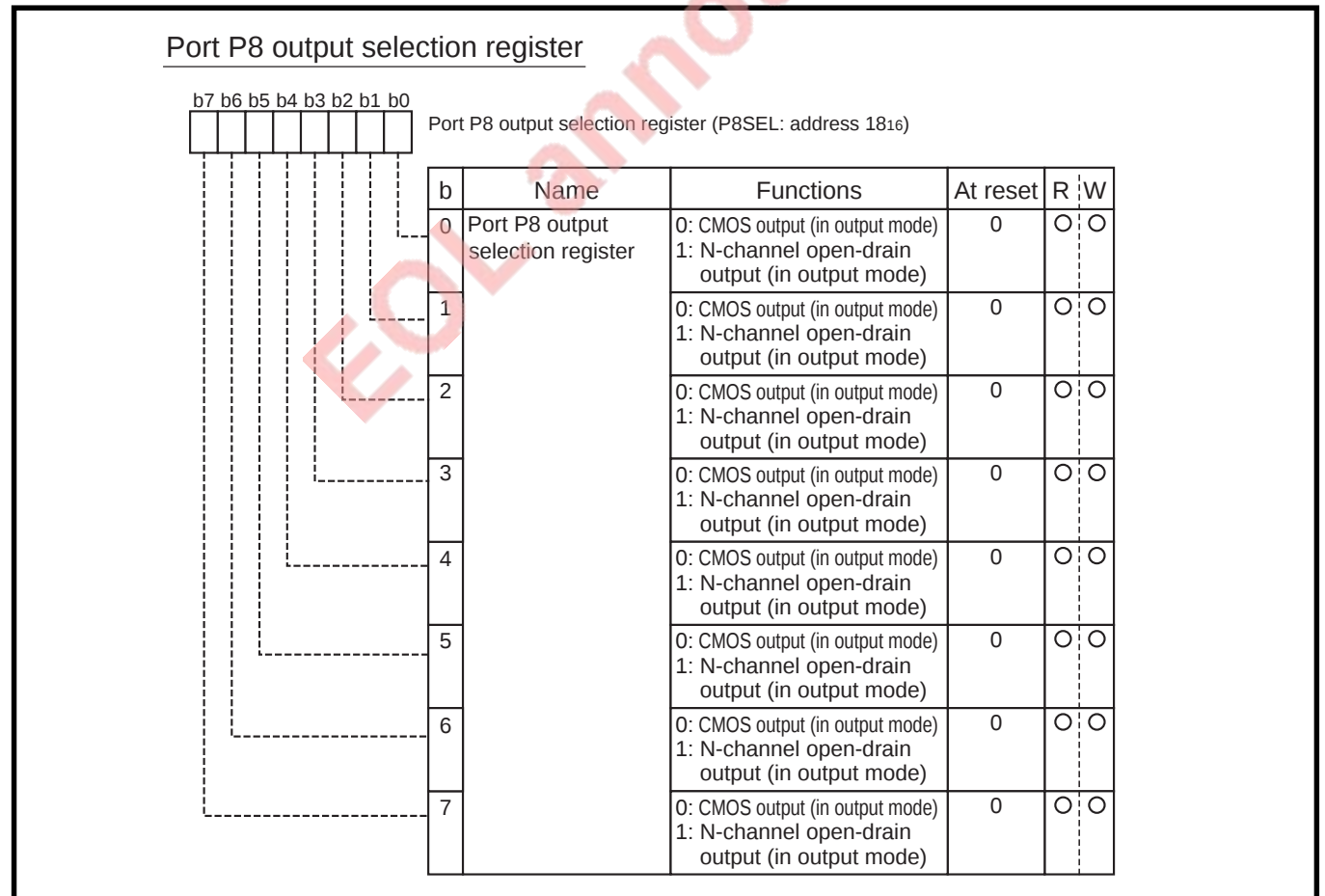


Fig. 2.1.9 Structure of Port P8 output selection register

## 2.1.3 Terminate unused pins

Table 2.1.1 Termination of unused pins

| Pins                                                                            | Termination                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P3                                                                              | Open at "H" output state.                                                                                                                                                                                                                  |
| P0, P1, P2, P4, P5 <sub>0</sub> , P5 <sub>2</sub> –P5 <sub>7</sub> , P6, P7, P8 | <ul style="list-style-type: none"> <li>• Set to the input mode and connect each to V<sub>CC</sub> or V<sub>SS</sub> through a resistor of 1 kΩ to 10 kΩ.</li> <li>• Set to the output mode and open at "L" or "H" output state.</li> </ul> |
| P5 <sub>1</sub>                                                                 | Connect to V <sub>CC</sub> or V <sub>SS</sub> through a resistor of 1 kΩ to 10 kΩ.                                                                                                                                                         |
| VL <sub>1</sub> –VL <sub>3</sub>                                                | Connect to V <sub>SS</sub> (GND).                                                                                                                                                                                                          |
| COM <sub>0</sub> –COM <sub>3</sub>                                              | Open                                                                                                                                                                                                                                       |
| V <sub>REF</sub>                                                                | Open                                                                                                                                                                                                                                       |
| X <sub>OUT</sub>                                                                | Open (only when using external clock)                                                                                                                                                                                                      |
| AV <sub>SS</sub>                                                                | Connect to V <sub>SS</sub> (GND).                                                                                                                                                                                                          |

EOL announced

# APPLICATION

## 2.1 I/O port

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### 2.1.4 Notes on I/O port

#### (1) Notes in standby state

In standby state <sup>1</sup> for low-power dissipation, do not make input levels of an input port and an I/O port “undefined”.

Pull-up (connect the port to VCC) or pull-down (connect the port to VSS) these ports through a resistor.

When determining a resistance value, note the following points:

- External circuit
- Variation of output levels during the ordinary operation

When using built-in pull-up resistor, note on varied current values:

- When setting as an input port : Fix its input level
- When setting as an output port : Prevent current from flowing out to external

#### Reason

The potential which is input to the input buffer in a microcomputer is unstable in the state that input levels of a input port and an I/O port are “undefined”. This may cause power source current.

1 standby state: stop mode by executing **STP** instruction  
wait mode by executing **WIT** instruction

#### (2) Modifying port latch of I/O port with bit managing instruction

When the port latch of an I/O port is modified with the bit managing instruction <sup>2</sup>, the value of the unspecified bit may be changed.

#### Reason

The bit managing instructions are read-modify-write form instructions for reading and writing data by a byte unit. Accordingly, when these instructions are executed on a bit of the port latch of an I/O port, the following is executed to all bits of the port latch.

- As for bit which is set for input port:  
The pin state is read in the CPU, and is written to this bit after bit managing.
- As for bit which is set for output port:  
The bit value is read in the CPU, and is written to this bit after bit managing.

Note the following:

- Even when a port which is set as an output port is changed for an input port, its port latch holds the output data.
- As for a bit of which is set for an input port, its value may be changed even when not specified with a bit managing instruction in case where the pin state differs from its port latch contents.

2 Bit managing instructions: **SEB** and **CLB** instructions

#### (3) Pull-up/Pull-down control

When each port which has built-in pull-up/pull-down resistor (P0, P1, P2, P4, P5<sub>0</sub>, P5<sub>2</sub>–P5<sub>7</sub>, P6, P7, P8) is set to output port, pull-up/pull-down control of corresponding port become invalid. (Pull-up/Pull-down cannot be set.)

#### Reason

Pull-up control is valid only when each direction register is set to the input mode.

### 2.1.5 Termination of unused pins

#### (1) Terminate unused pins

① Output ports : Open

② Input ports :

Connect each pin to Vcc or Vss through each resistor of 1 k $\Omega$  to 10 k $\Omega$ .

As for pins whose potential affects to operation modes such as pin INT or others, select the Vcc pin or the Vss pin according to their operation mode.

③ I/O ports :

- Set the I/O ports for the input mode and connect them to Vcc or Vss through each resistor of 1 k $\Omega$  to 10 k $\Omega$ .

Ports that permit the selecting of a built-in pull-up resistor can also use this resistor. Set the I/O ports for the output mode and open them at “L” or “H”.

- When opening them in the output mode, the input mode of the initial status remains until the mode of the ports is switched over to the output mode by the program after reset. Thus, the potential at these pins is undefined and the power source current may increase in the input mode. With regard to an effects on the system, thoroughly perform system evaluation on the user side.
- Since the direction register setup may be changed because of a program runaway or noise, set direction registers by program periodically to increase the reliability of program.

#### (2) Termination remarks

① Input ports and I/O ports :

Do not open in the input mode.

● Reason

- The power source current may increase depending on the first-stage circuit.
- An effect due to noise may be easily produced as compared with proper termination ② and ③ shown on the above.

② I/O ports :

When setting for the input mode, do not connect to Vcc or Vss directly.

● Reason

If the direction register setup changes for the output mode because of a program runaway or noise, a short circuit may occur between a port and Vcc (or Vss).

③ I/O ports :

When setting for the input mode, do not connect multiple ports in a lump to Vcc or Vss through a resistor.

● Reason

If the direction register setup changes for the output mode because of a program runaway or noise, a short circuit may occur between ports.

- At the termination of unused pins, perform wiring at the shortest possible distance (20 mm or less) from microcomputer pins.

# APPLICATION

## 2.2 Timer

### 2.2 Timer

This paragraph explains the registers setting method and the notes relevant to the timers.

#### 2.2.1 Memory map

|                    |                                       |
|--------------------|---------------------------------------|
| 0020 <sub>16</sub> | Timer 1 (T1)                          |
| 0021 <sub>16</sub> | Timer 2 (T2)                          |
| 0022 <sub>16</sub> | Timer 3 (T3)                          |
| 0023 <sub>16</sub> | Timer 4 (T4)                          |
| 0024 <sub>16</sub> | Timer 5 (T5)                          |
| 0025 <sub>16</sub> | Timer 6 (T6)                          |
|                    |                                       |
| 0027 <sub>16</sub> | Timer 6 PWM register (T6PWM)          |
| 0028 <sub>16</sub> | Timer 12 mode register (T12M)         |
| 0029 <sub>16</sub> | Timer 34 mode register (T34M)         |
| 002A <sub>16</sub> | Timer 56 mode register (T56M)         |
|                    |                                       |
| 002C <sub>16</sub> | Timer A register (low-order) (TAL)    |
| 002D <sub>16</sub> | Timer A register (high-order) (TAH)   |
| 002E <sub>16</sub> | Compare register (low-order) (CONAL)  |
| 002F <sub>16</sub> | Compare register (high-order) (CONAH) |
| 0030 <sub>16</sub> | Timer A mode register (TAM)           |
| 0031 <sub>16</sub> | Timer A control register (TACON)      |
|                    |                                       |
| 003C <sub>16</sub> | Interrupt request register 1 (IREQ1)  |
| 003D <sub>16</sub> | Interrupt request register 2 (IREQ2)  |
| 003E <sub>16</sub> | Interrupt control register 1 (ICON1)  |
| 003F <sub>16</sub> | Interrupt control register 2 (ICON2)  |

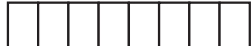
Fig. 2.2.1 Memory map of registers relevant to timers

## 2.2.2 Relevant registers

## (1) 8-bit timer

## Timer i

b7 b6 b5 b4 b3 b2 b1 b0



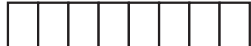
Timer i (i = 1, 3, 4, 5, 6)  
(Ti: addresses 20<sub>16</sub>, 22<sub>16</sub>, 23<sub>16</sub>, 24<sub>16</sub>, 25<sub>16</sub>)

| b | Functions                                                                                          | At reset | R | W |
|---|----------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | • Set timer i count value.                                                                         | 1        | ○ | ○ |
| 1 | • The value set in this register is written to both the timer i and the timer i latch at one time. | 1        | ○ | ○ |
| 2 |                                                                                                    | 1        | ○ | ○ |
| 3 | • When the timer i is read out, the count value of the timer i is read out.                        | 1        | ○ | ○ |
| 4 |                                                                                                    | 1        | ○ | ○ |
| 5 |                                                                                                    | 1        | ○ | ○ |
| 6 |                                                                                                    | 1        | ○ | ○ |
| 7 |                                                                                                    | 1        | ○ | ○ |

Fig. 2.2.2 Structure of Timer i (i=1, 3, 4, 5, 6)

## Timer 2

b7 b6 b5 b4 b3 b2 b1 b0



Timer 2  
(T2: address 21<sub>16</sub>)

| b | Functions                                                                                          | At reset | R | W |
|---|----------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | • Set timer 2 count value.                                                                         | 1        | ○ | ○ |
| 1 | • The value set in this register is written to both the timer 2 and the timer 2 latch at one time. | 0        | ○ | ○ |
| 2 |                                                                                                    | 0        | ○ | ○ |
| 3 | • When the timer 2 is read out, the count value of the timer 2 is read out.                        | 0        | ○ | ○ |
| 4 |                                                                                                    | 0        | ○ | ○ |
| 5 |                                                                                                    | 0        | ○ | ○ |
| 6 |                                                                                                    | 0        | ○ | ○ |
| 7 |                                                                                                    | 0        | ○ | ○ |

Fig. 2.2.3 Structure of Timer 2

# APPLICATION

## 2.2 Timer

Timer 6 PWM register

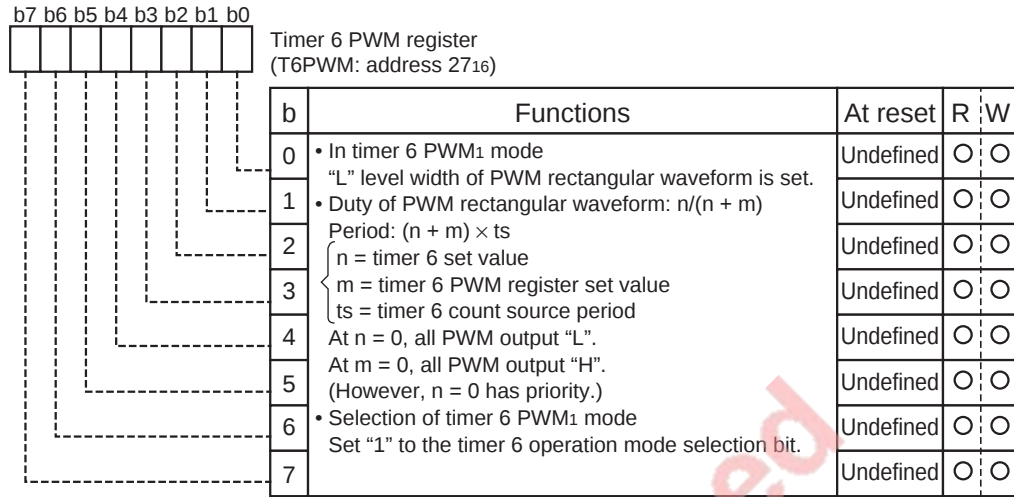


Fig. 2.2.4 Structure of Timer 6 PWM register

Timer 12 mode register

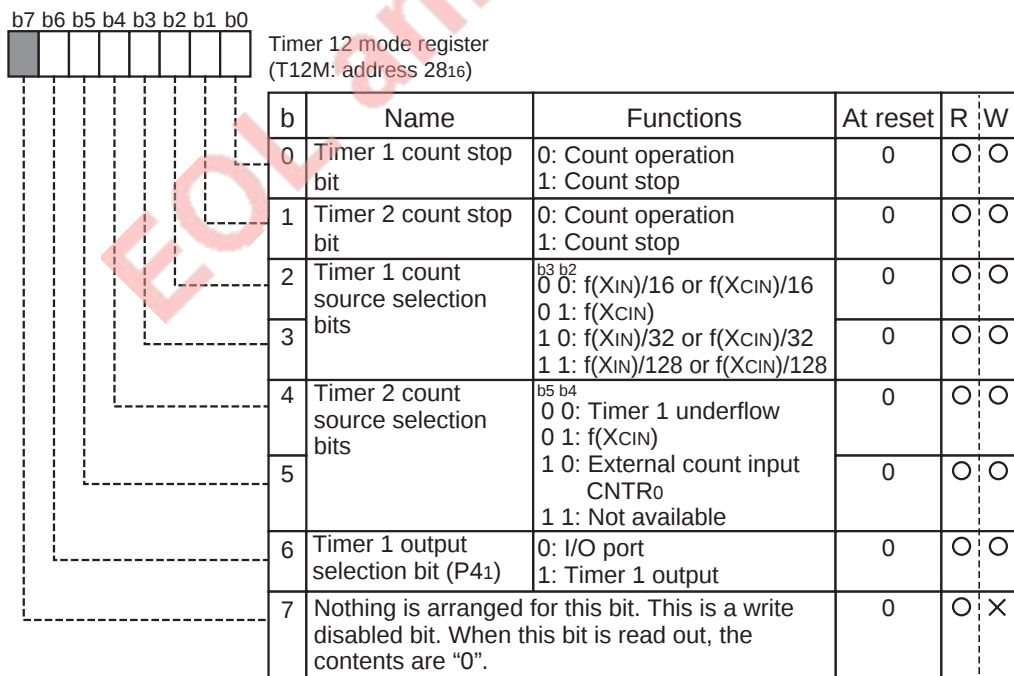


Fig. 2.2.5 Structure of Timer 12 mode register

## Timer 34 mode register

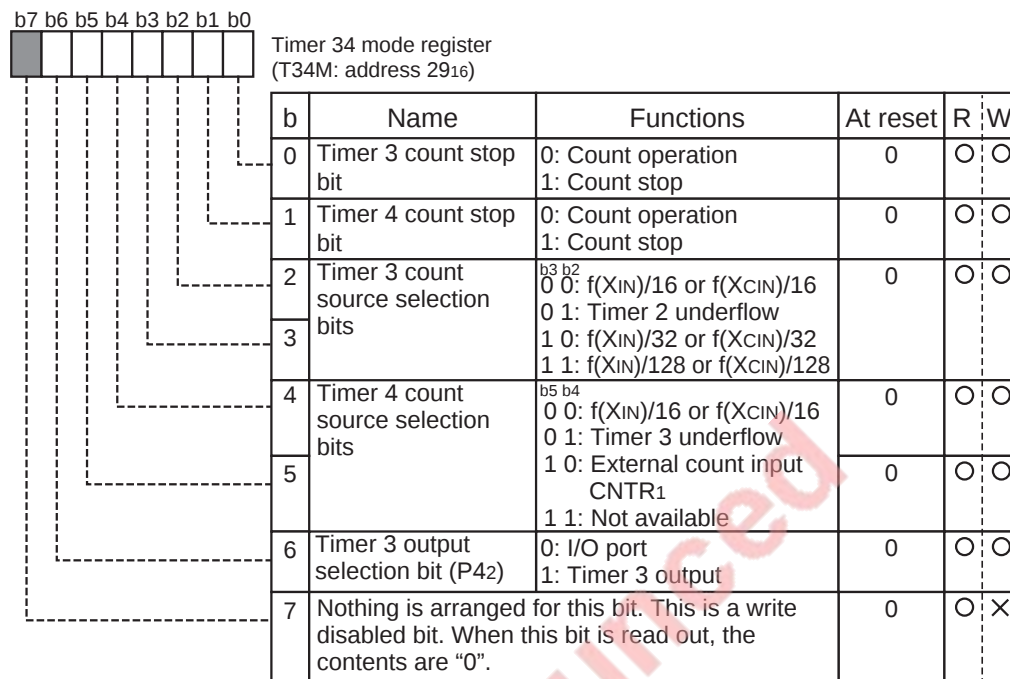


Fig. 2.2.6 Structure of Timer 34 mode register

## Timer 56 mode register

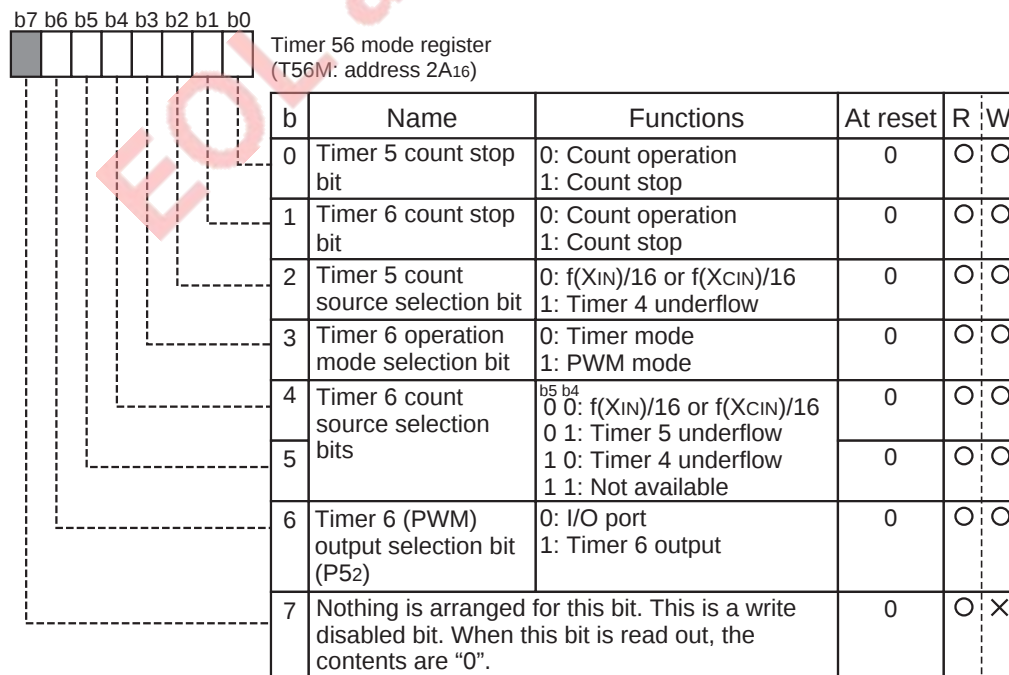


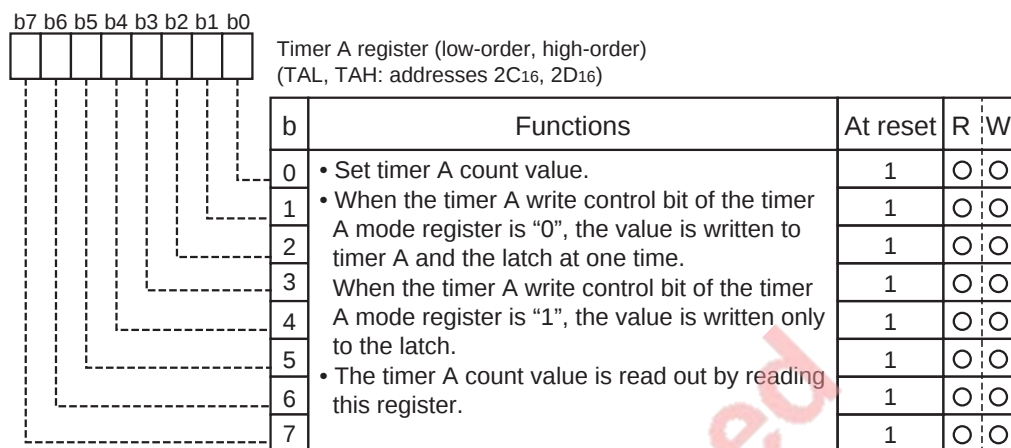
Fig. 2.2.7 Structure of Timer 56 mode register

# APPLICATION

## 2.2 Timer

### (2) 16-bit timer

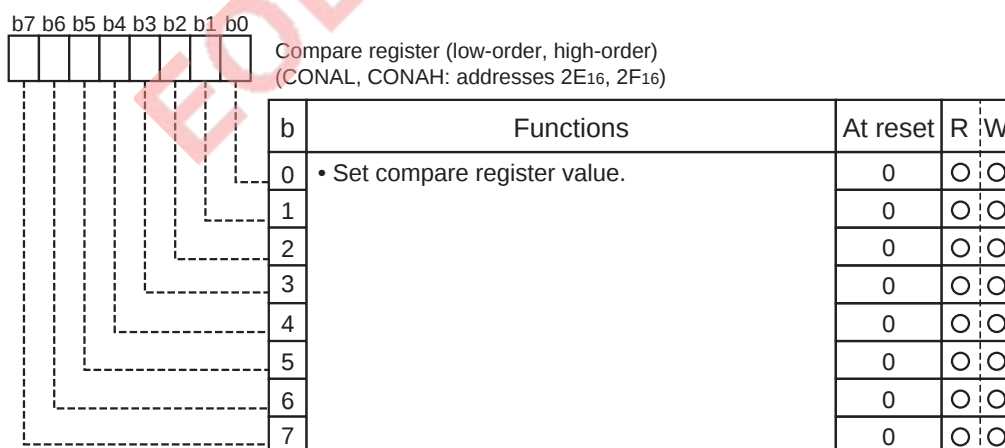
#### Timer A register (low-order, high-order)



- Notes 1:** When reading and writing, perform them to both the high-order and low-order bytes.
- 2:** Read both registers in order of TAH and TAL following.
- 3:** Write both registers in order of TAL and TAH following.
- 4:** Do not read both registers during a write, and do not write to both registers during a read.

Fig. 2.2.8 Structure of Timer A register (low-order, high-order)

#### Compare register (low-order, high-order)



**Note:** Write registers in order of CONAH, CONAL, TAL, and TAH following.

Fig. 2.2.9 Structure of Compare register (low-order, high-order)

## Timer A mode register

|    |    |    |    |    |    |    |    |                                                           |
|----|----|----|----|----|----|----|----|-----------------------------------------------------------|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |                                                           |
|    |    |    |    |    |    |    |    | Timer A mode register<br>(TAM: address 30 <sub>16</sub> ) |
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Fig. 2.2.10 Structure of Timer A mode register

## Timer A control register

|    |    |    |    |    |    |    |    |                                                                |
|----|----|----|----|----|----|----|----|----------------------------------------------------------------|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |                                                                |
|    |    |    |    |    |    |    |    | Timer A control register<br>(TACON: address 31 <sub>16</sub> ) |
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Fig. 2.2.11 Structure of Timer A control register

# APPLICATION

## 2.2 Timer

### (3) 8-bit timer, 16-bit timer

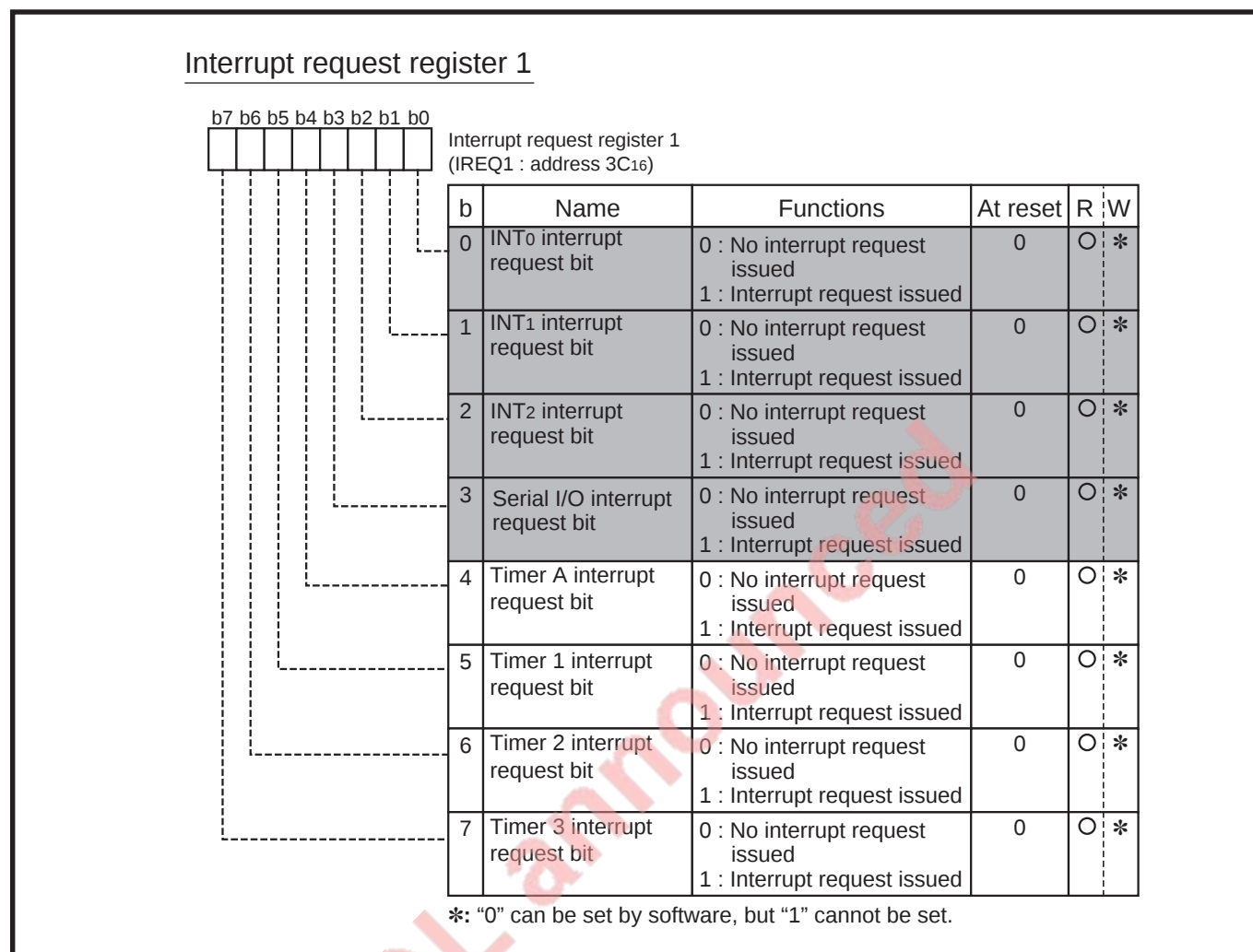


Fig. 2.2.12 Structure of Interrupt request register 1

## Interrupt request register 2

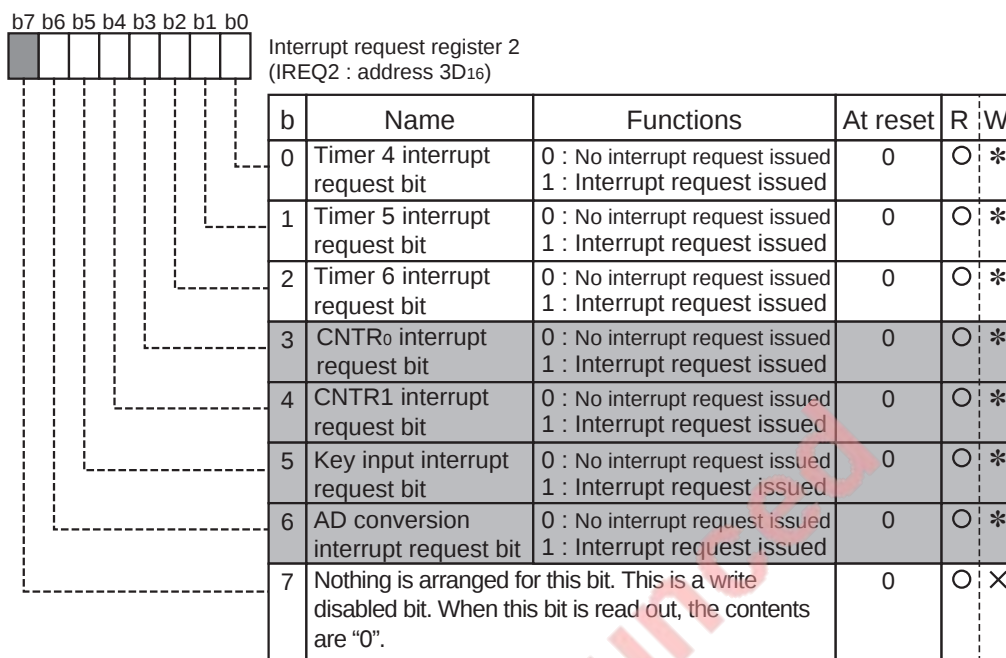


Fig. 2.2.13 Structure of Interrupt request register 2

# APPLICATION

## 2.2 Timer

Interrupt control register 1

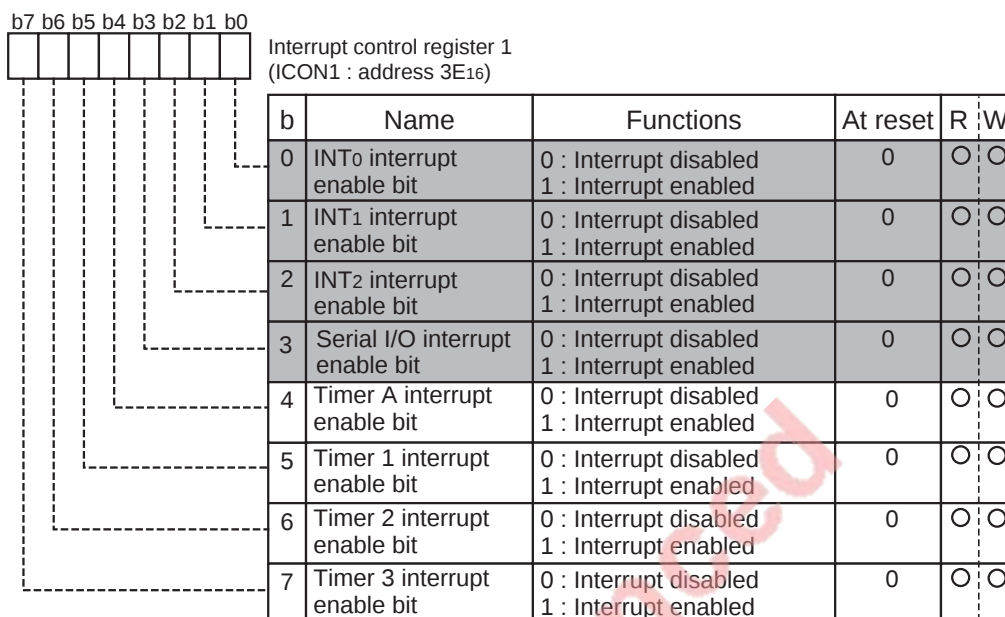


Fig. 2.2.14 Structure of Interrupt control register 1

Interrupt control register 2

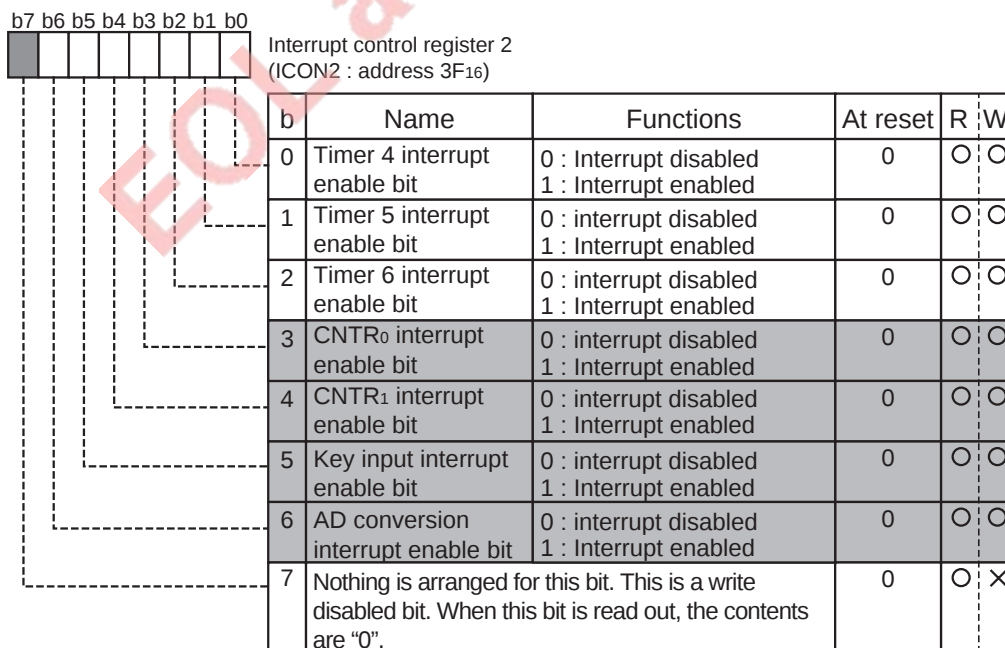


Fig. 2.2.15 Structure of Interrupt control register 2

### 2.2.3 Timer application examples

#### (1) Basic functions and uses

##### [Function 1] Control of event interval (Timer 1 to Timer 6, Timer A: timer mode)

When a certain time, by setting a count value to each timer, has passed, the timer interrupt request occurs.

<Use>

- Generating of an output signal timing
- Generating of a wait time

##### [Function 2] Control of cyclic operation (Timer 1 to Timer 6, Timer A: timer mode)

The value of the timer latch is automatically written to the corresponding timer each time the timer underflows, and each timer interrupt request occurs in cycles.

<Use>

- Generating of cyclic interrupts
- Clock function (measurement of 1 s); see "(2) Timer application example 1"
- Control of a main routine cycle

##### [Function 3] Output of rectangular waveform

(Timer 1, Timer 3, Timer 6, Timer A: pulse output mode)

The output level of the T1<sub>OUT</sub> pin, T3<sub>OUT</sub> pin, PWM<sub>1</sub> pin or TA<sub>OUT</sub> pin is inverted each time the timer underflows.

<Use>

- Piezoelectric buzzer output; see "(3) Timer application example 2"
- Generating of the remote control carrier waveforms

##### [Function 4] Count of external pulses (Timer 2, Timer 4)

External pulses input to the CNTR<sub>0</sub> pin, CNTR<sub>1</sub> pin are counted as the timer count source (in the event counter mode).

<Use>

- Frequency measurement; see "(4) Timer application example 3"
- Division of external pulses
- Generating of interrupts due to a cycle using external pulses as the count source; count of a reel pulse

##### [Function 5] Output of PWM signal (Timer 6)

"H" interval and "L" interval are specified, respectively, and the output of pulses from P5<sub>2</sub>/PWM<sub>1</sub> pin is repeated.

<Use>

- Control of electric volume

##### [Function 6] Output of IGBT control signal (Timer A: IGBT output mode)

The external signal which is input to INT<sub>0</sub> pin is used as trigger, and the period and "H" interval are specified, respectively, and the output of pulses from P5<sub>0</sub>/TA<sub>OUT</sub> pin is repeated.

<Use>

- IGBT control of IH heat equipment; see "(5) Timer application example 4"
- IGBT control to magnetron

##### [Function 7] Output of PWM signal (Timer A: PWM mode)

The cycle and "H" interval are specified, respectively, and the output of pulses from P5<sub>0</sub>/TA<sub>OUT</sub> pin is repeated.

<Use>

- Control of electric volume
- IGBT control of IH heat equipment

# APPLICATION

## 2.2 Timer

### (2) Timer application example 1: Clock function (measurement of 1 s)

**Outline:** The input clock is divided by the timer so that the clock can count up at 1 s intervals.

**Specifications:** •The clock  $f(X_{IN}) = 4.19 \text{ MHz}$  ( $2^{22} \text{ Hz}$ ) is divided by the timer.

- The timer 3 interrupt request bit is checked in main routine, and if the interrupt request is issued, the clock is counted up.
- The timer 1 interrupt occurs every  $244 \mu\text{s}$  to execute processing of other interrupts.

Figure 2.2.16 shows the timers connection and setting of division ratios; Figure 2.2.17 shows the relevant registers setting; Figure 2.2.18 shows the control procedure.

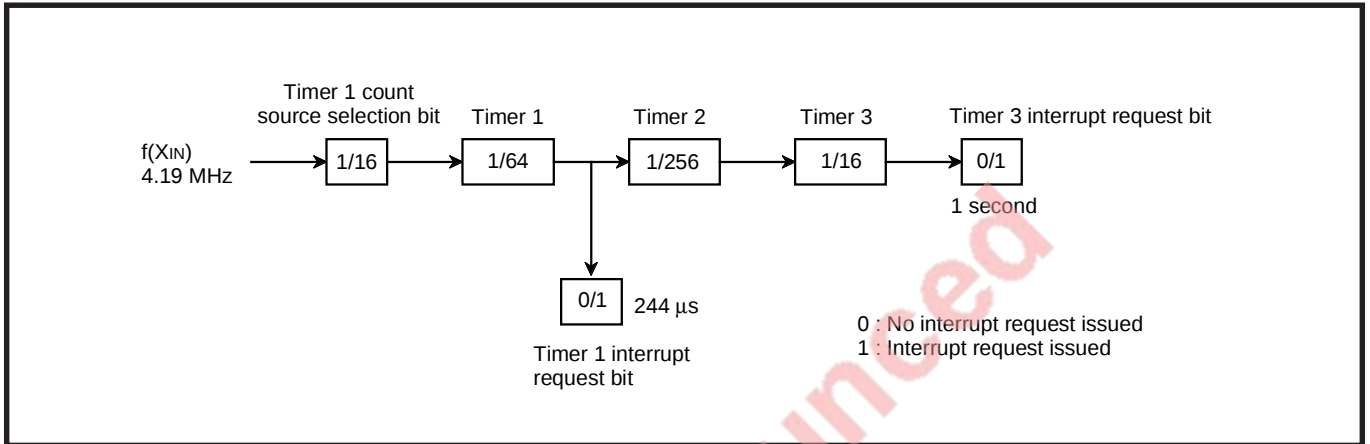


Fig. 2.2.16 Timers connection and setting of division ratios

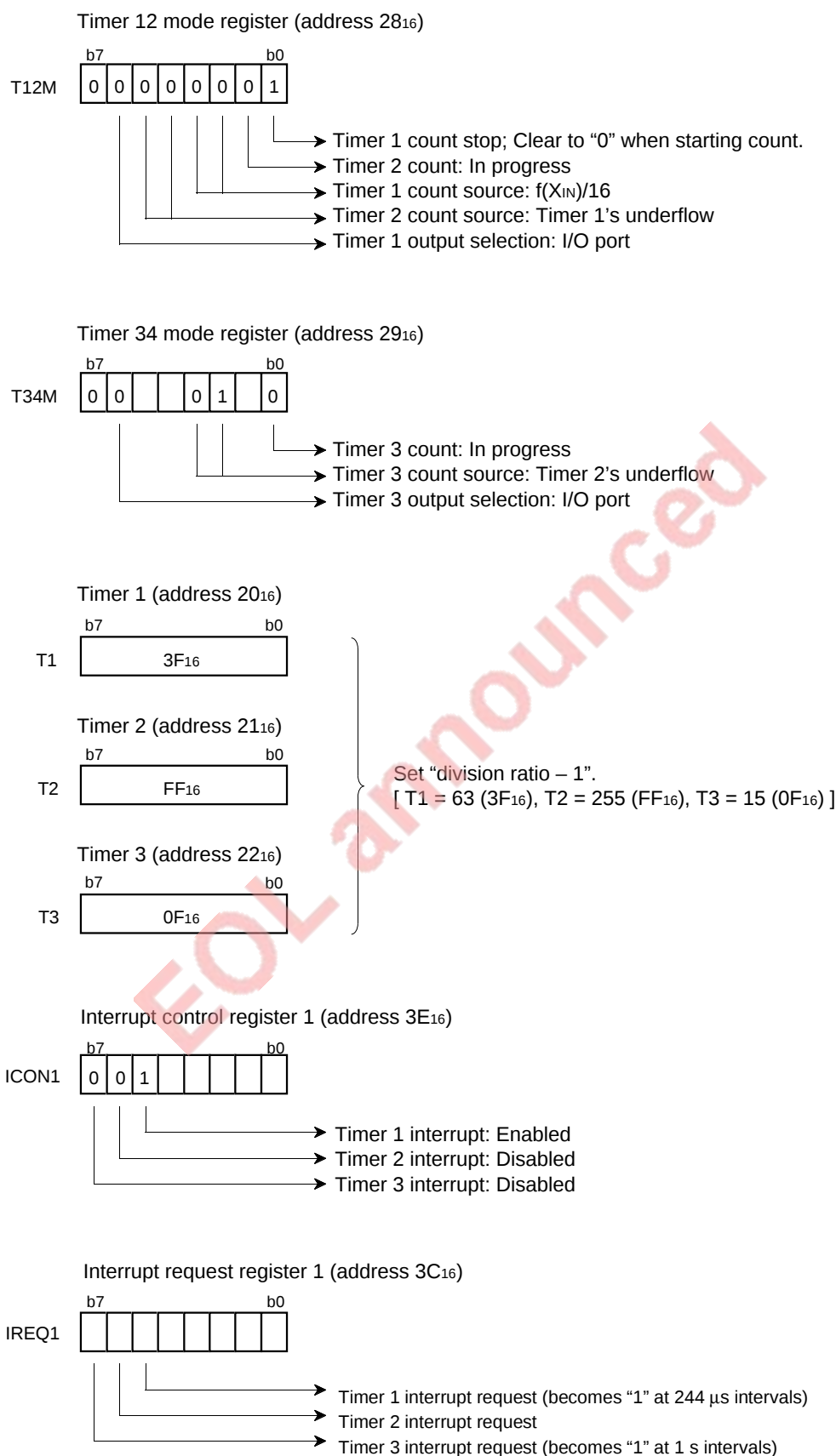


Fig. 2.2.17 Relevant registers setting

# APPLICATION

## 2.2 Timer

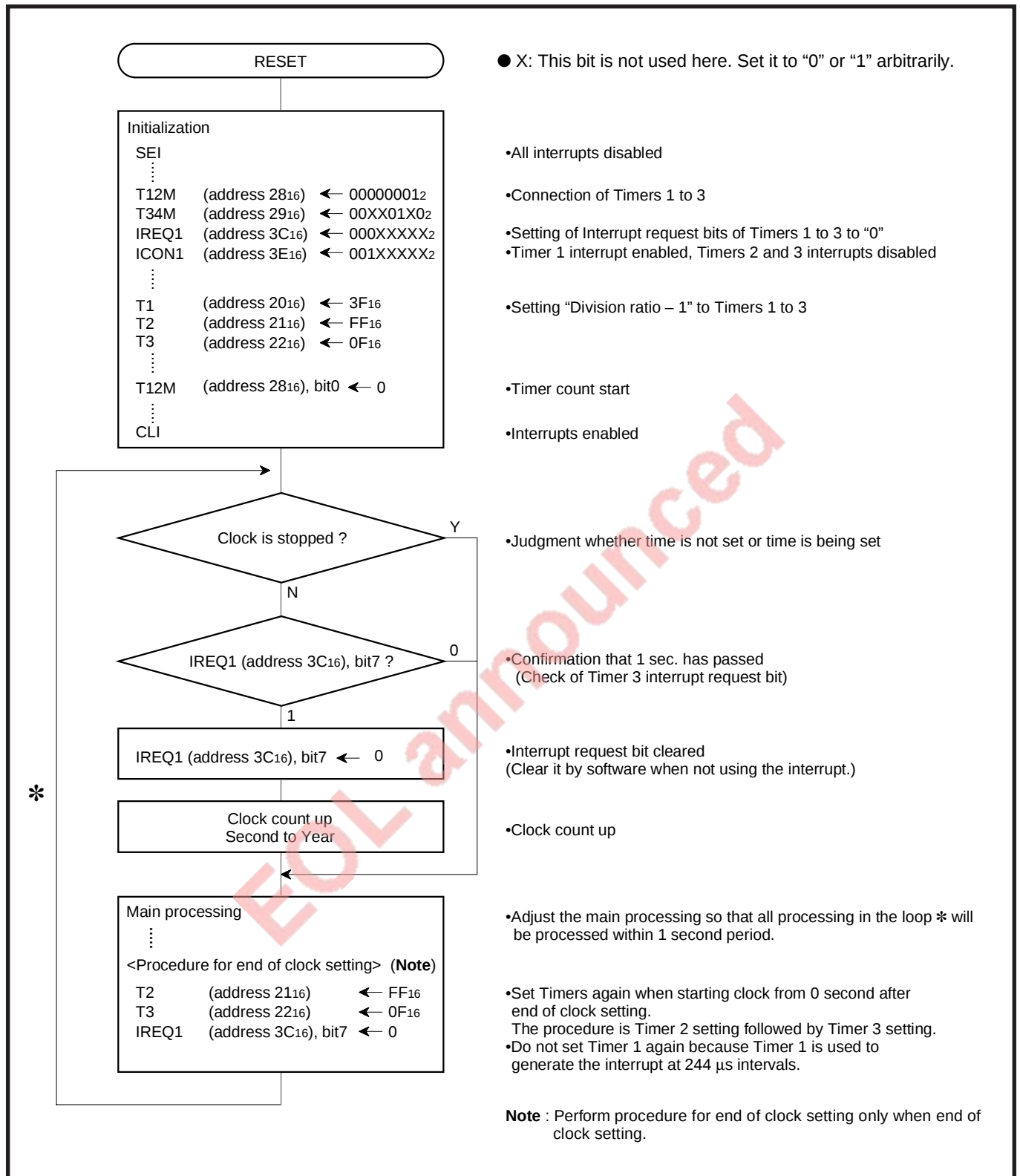


Fig. 2.2.18 Control procedure

### (3) Timer application example 2: Piezoelectric buzzer output

**Outline:** The rectangular waveform output function of the timer is applied for a piezoelectric buzzer output.

**Specifications:**

- The rectangular waveform, dividing the clock  $f(X_{IN}) = 4.19 \text{ MHz}$  ( $2^{22} \text{ Hz}$ ) into about 2 kHz (2048 Hz), is output from the P4<sub>2</sub>/T3<sub>OUT</sub> pin.
- The level of the P4<sub>2</sub>/T3<sub>OUT</sub> pin is fixed to "H" while a piezoelectric buzzer output stops.

Figure 2.2.19 shows a peripheral circuit example, and Figure 2.2.20 shows the timers connection and setting of division ratios. Figures 2.2.21 shows the relevant registers setting, and Figure 2.2.22 shows the control procedure.

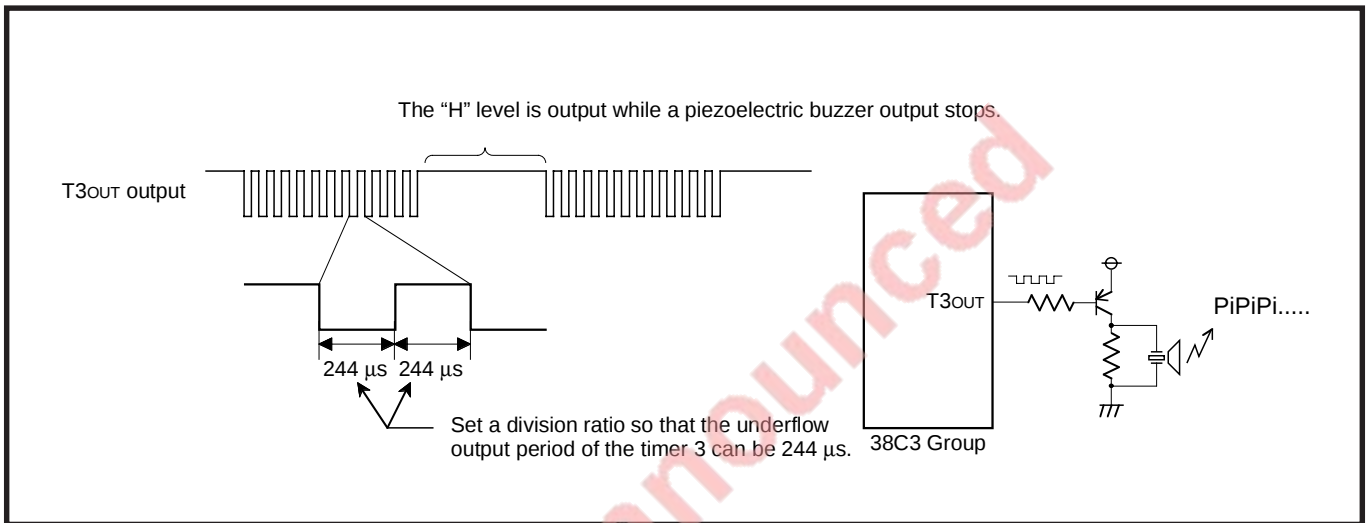


Fig. 2.2.19 Peripheral circuit example

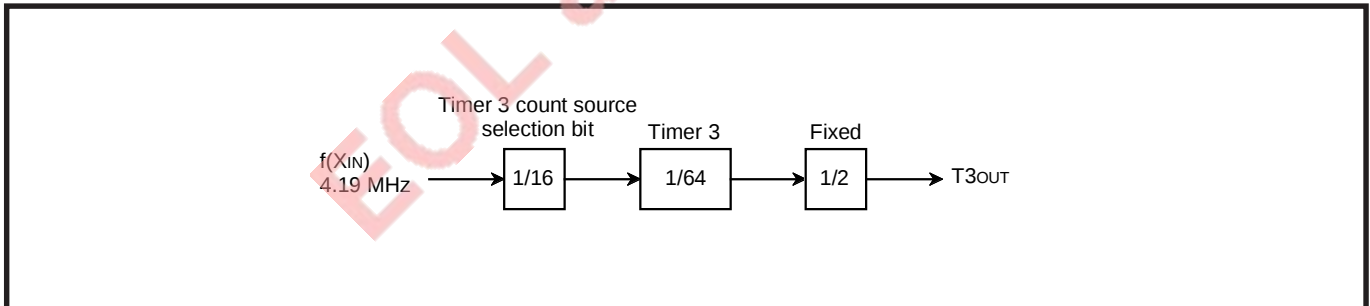


Fig. 2.2.20 Timers connection and setting of division ratios

## 2.2 Timer



**(4) Timer application example 3: Frequency measurement**

**Outline:** The following two values are compared to judge whether the frequency is within a valid range.

- A value by counting pulses input to P5<sub>4</sub>/CNTR<sub>1</sub> pin with the timer.
- A reference value

**Specifications:** •The pulse is input to the P5<sub>4</sub>/CNTR<sub>1</sub> pin and counted by the timer 4.

- A count value of timer 4 is read out at about 2 ms intervals, the timer 1 interrupt interval. When the count value is 28 to 40, it is judged that the input pulse is valid.
- Because the timer is a down-counter, the count value is compared with 227 to 215 (**Note**).

**Note:** 227 to 215 = {255 (initial value of counter) – 28} to {255 – 40}; 28 to 40 means the number of valid count.

Figure 2.2.23 shows the judgment method of valid/invalid of input pulses; Figure 2.2.24 shows the relevant registers setting; Figure 2.2.25 shows the control procedure.

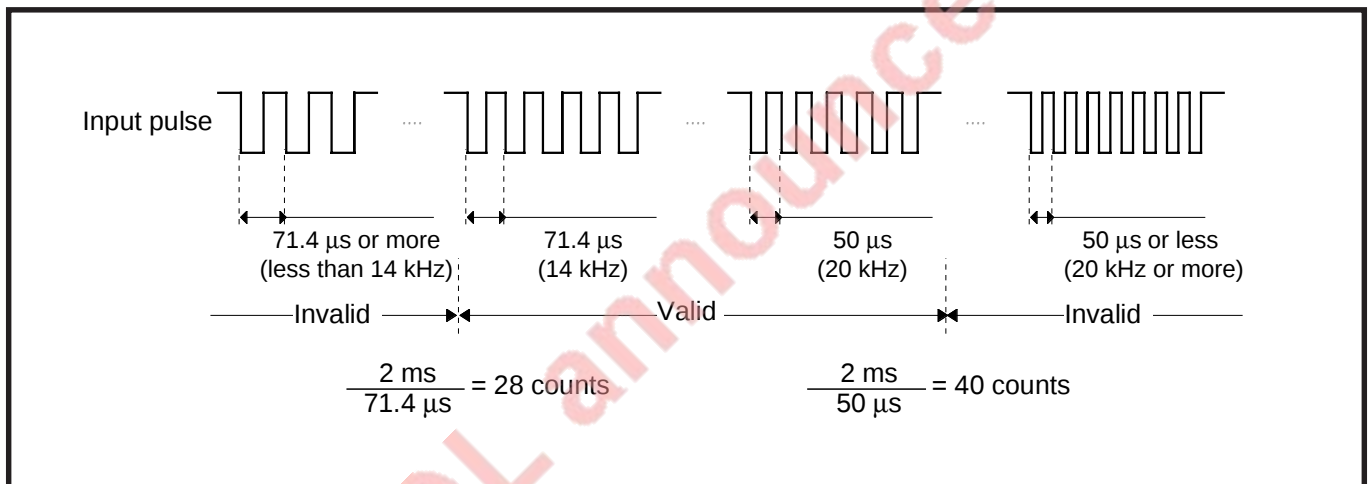


Fig. 2.2.23 Judgment method of valid/invalid of input pulses

# APPLICATION

## 2.2 Timer

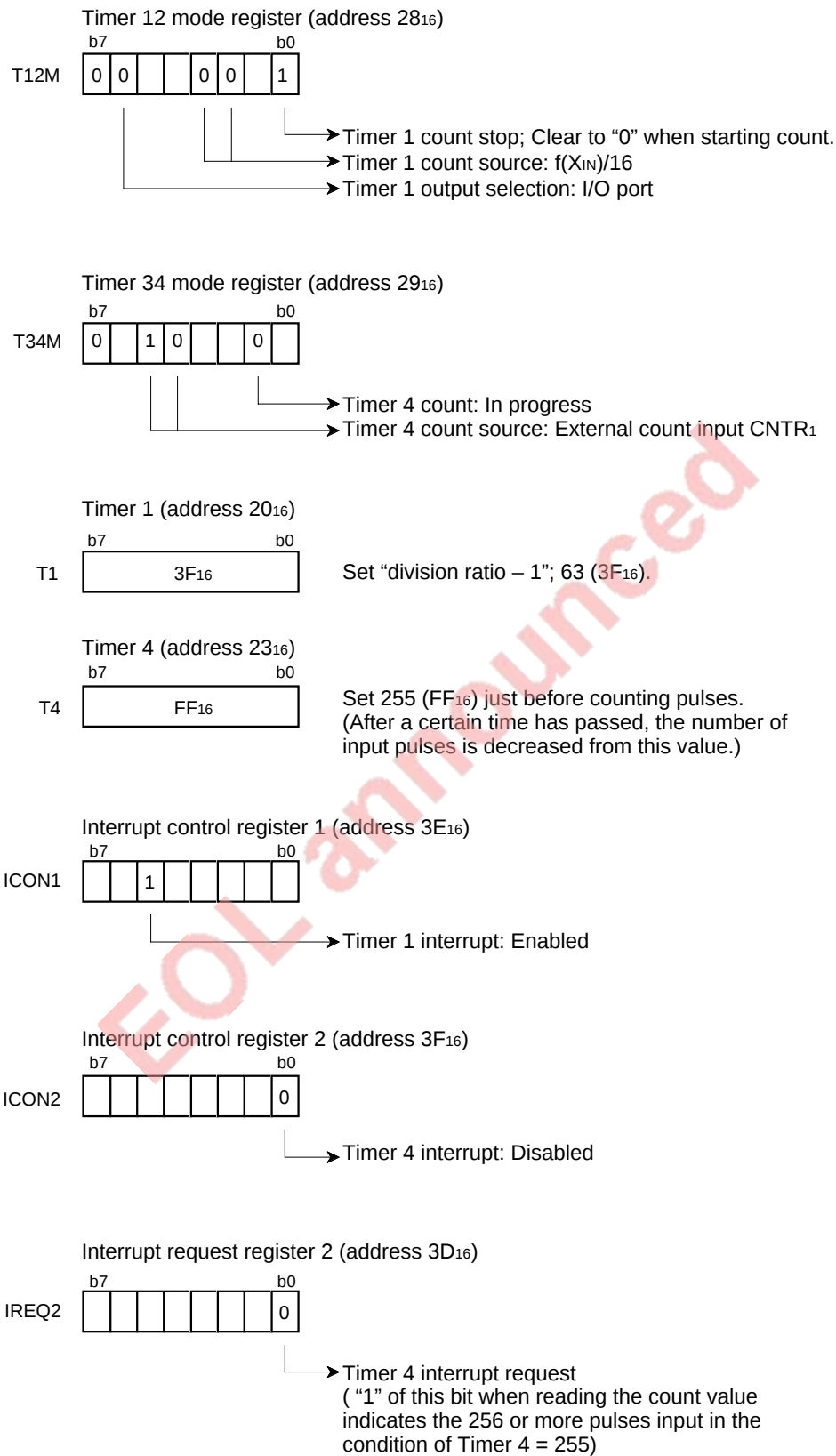


Fig. 2.2.24 Relevant registers setting

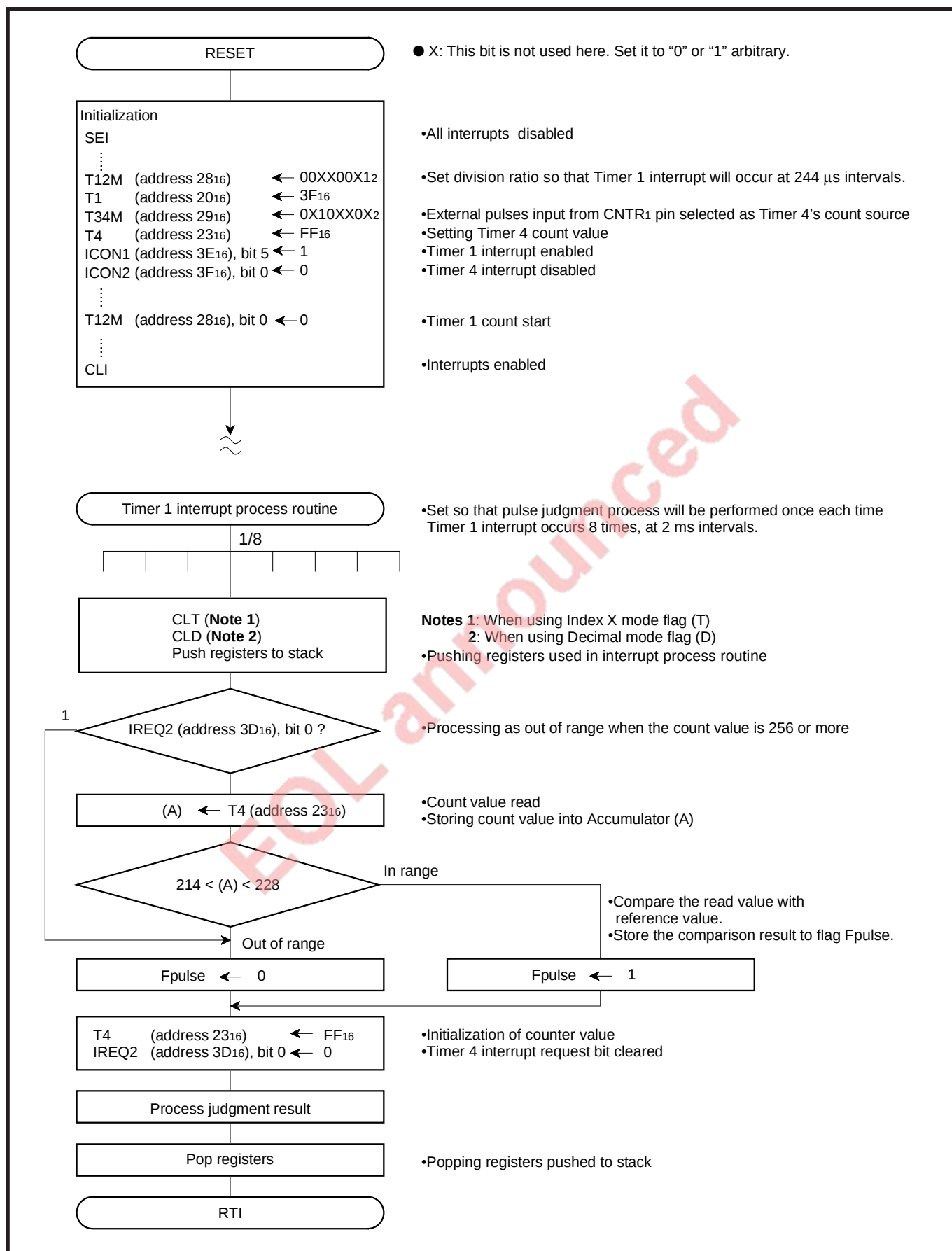


Fig. 2.2.25 Control procedure

# APPLICATION

## 2.2 Timer

### (5) Timer application example 4: Output of IGBT control signal

**Outline:** Synchronized variable PWM signal is output in “H” term.

When a signal is input to INT<sub>0</sub> pin before timer underflow during “L” output, timer restarts.

**Specifications:** •The signal, of which “H” level width is 5 μs and cycle is 20 μs, is output from the P5<sub>0</sub>/TA<sub>OUT</sub> pin.

However, if “H” is input to INT<sub>0</sub> pin during “L” output, timer restarts from “H” output.

<Example>

When  $f(X_{IN}) = 8 \text{ MHz}$ , the count source is 125 ns.

Figure 2.2.26 shows the timers connection and setting of division ratio; Figure 2.2.27 shows the relevant registers setting; Figure 2.2.28 shows the control procedure.

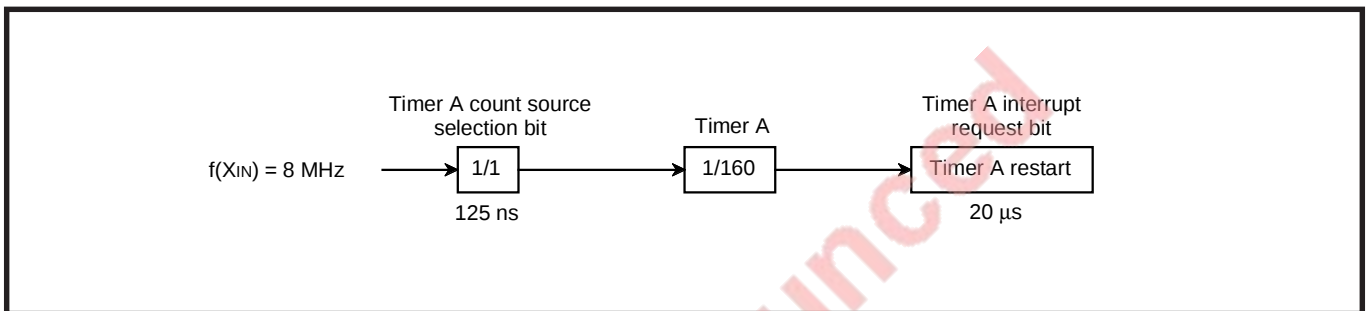
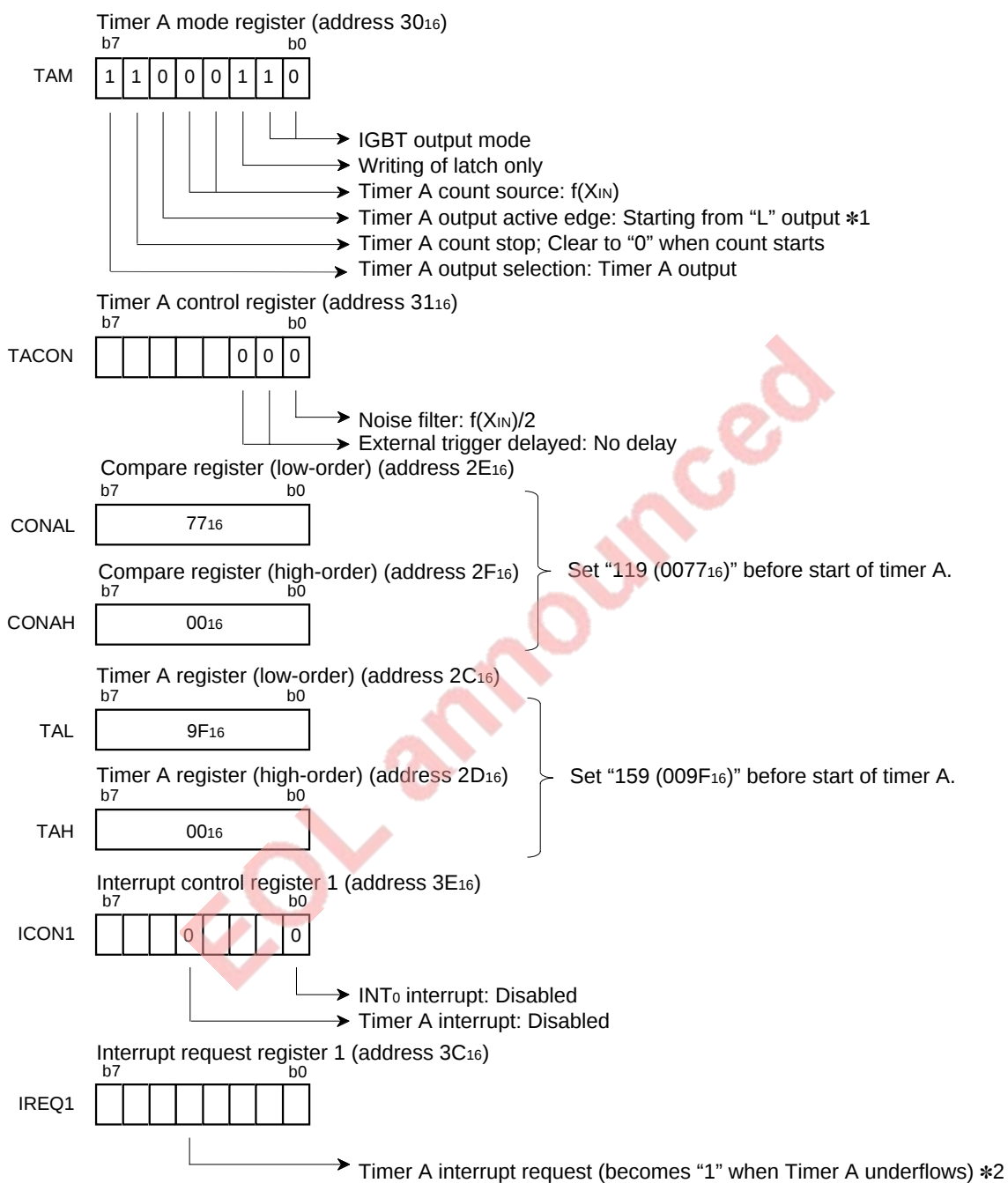


Fig. 2.2.26 Timers connection and setting of division ratios



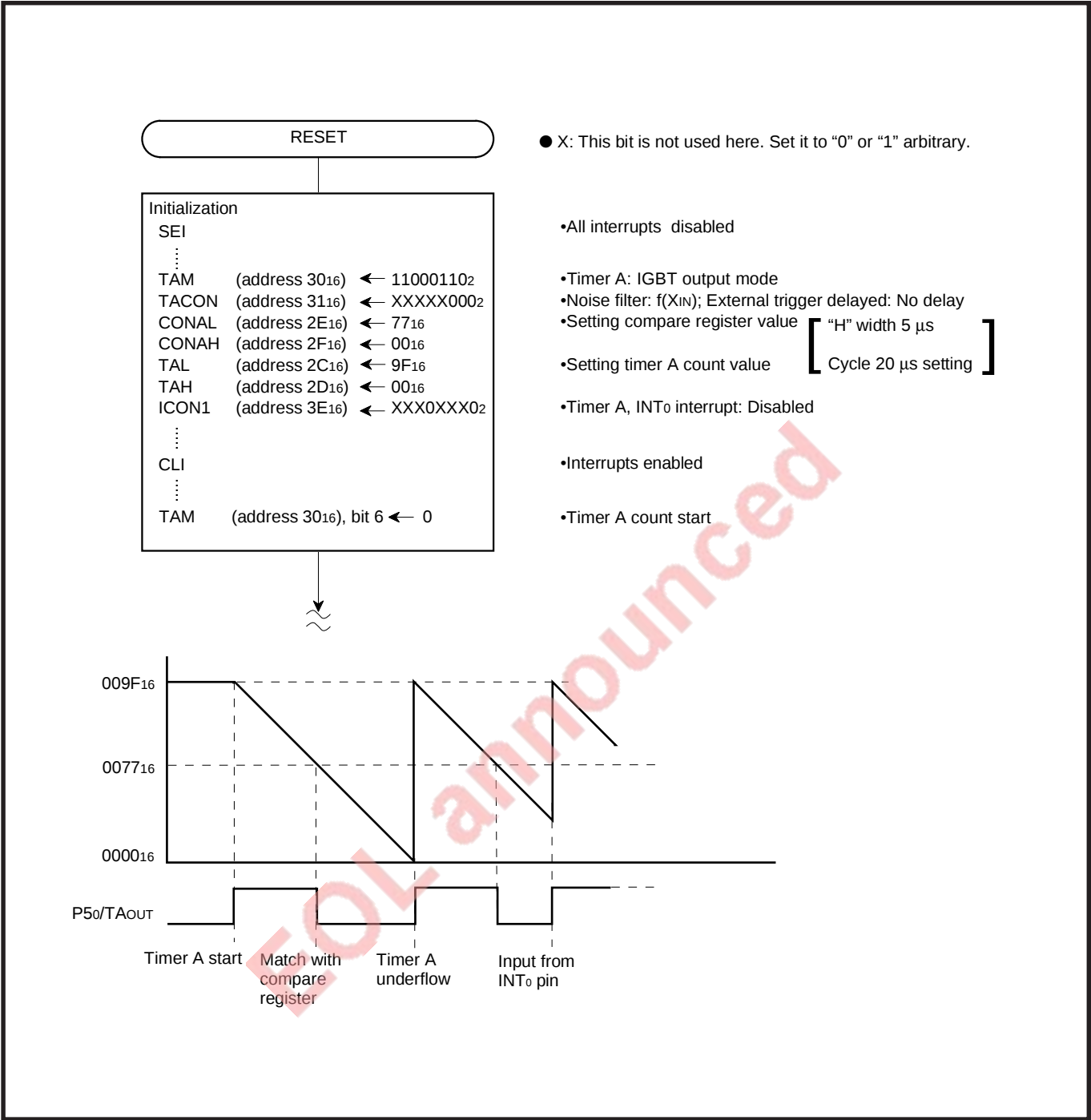
\*1 Use this bit with "0" (start from "L" output) in the IGBT output mode.

\*2 This bit becomes "1" even when a signal is input from the INT<sub>0</sub> pin in the IGBT output mode.

Fig. 2.2.27 Relevant registers setting

# APPLICATION

## 2.2 Timer



### 2.2.4 Notes on timer A (PWM mode and IGBT output mode)

#### (1) When timer starts first or last value of compare register is "0000<sub>16</sub>"

After "L" level (timer A output active edge switch bit is "0"; when starting from "L" output) is output during 2 cycles (until timer underflows two times), PWM output or IGBT output starts.

**Reason:** When data is written to timer A and compare register, value of timer A and value of compare register are renewed at timer underflow. In case of this, compare register value and timer value are compared before renewal, so that they are judged to be equal, and TA<sub>OUT</sub> output becomes "L". (Timer A output active edge switch bit = "0": when starting from "L" output)

Timer A underflow should cause "H" output, but the match have the priority. (see "Figure 2.2.29")

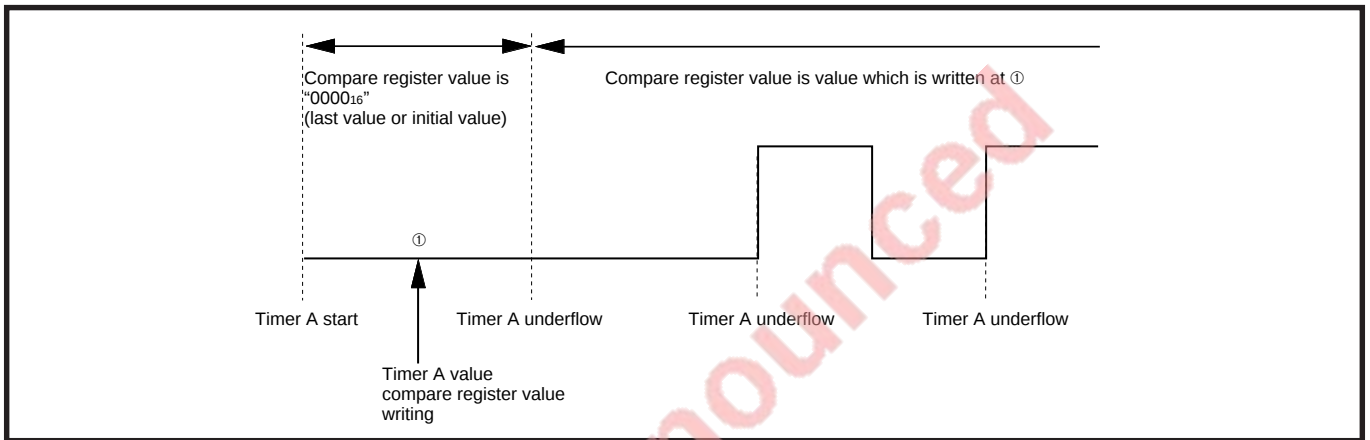


Fig. 2.2.29 PWM output and IGBT output (1)

#### (2) When compare register is set to "0000<sub>16</sub>" (last value is except "0000<sub>16</sub>")

Next 1 cycle of the cycle in which data is written to timer A and compare register is output "H", and "L" is output from the next cycle. (timer A output active edge switch bit = "0": when starting from "L" output)

(see "Figure 2.2.30")

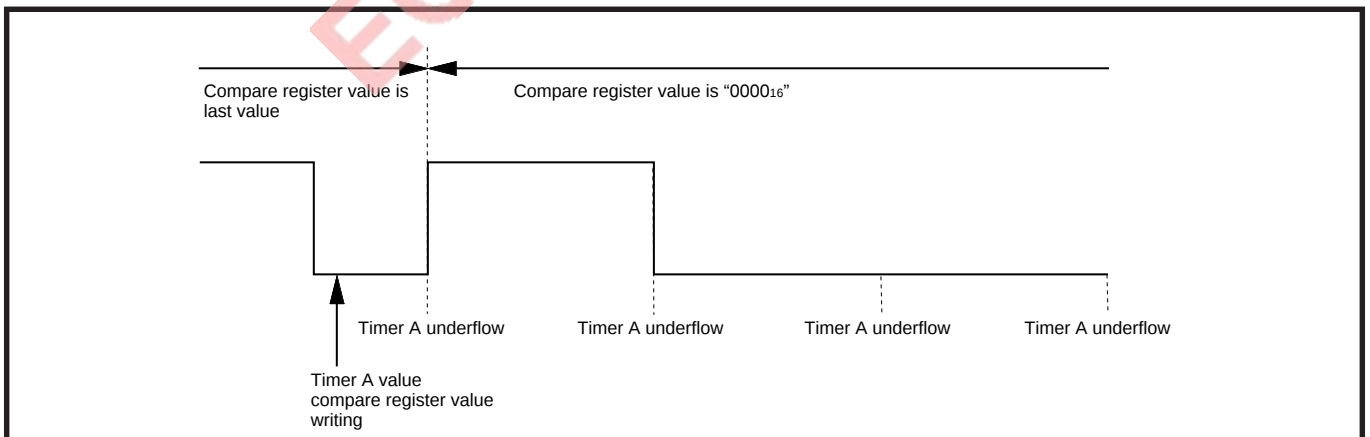


Fig. 2.2.30 PWM output and IGBT output (2)

# APPLICATION

## 2.2 Timer

### (3) When timer A and compare register have same value

TA<sub>OUT</sub> output becomes “H” with underflow immediately after data is written to timer A and compare register. TA<sub>OUT</sub> output becomes “L” when timer A is reloaded and the value matches with compare register. This “H” output width becomes 1 count of timer A count source. (timer A output active edge switch bit =“0”: when starting from “L” output) (see “Figure 2.2.31”)

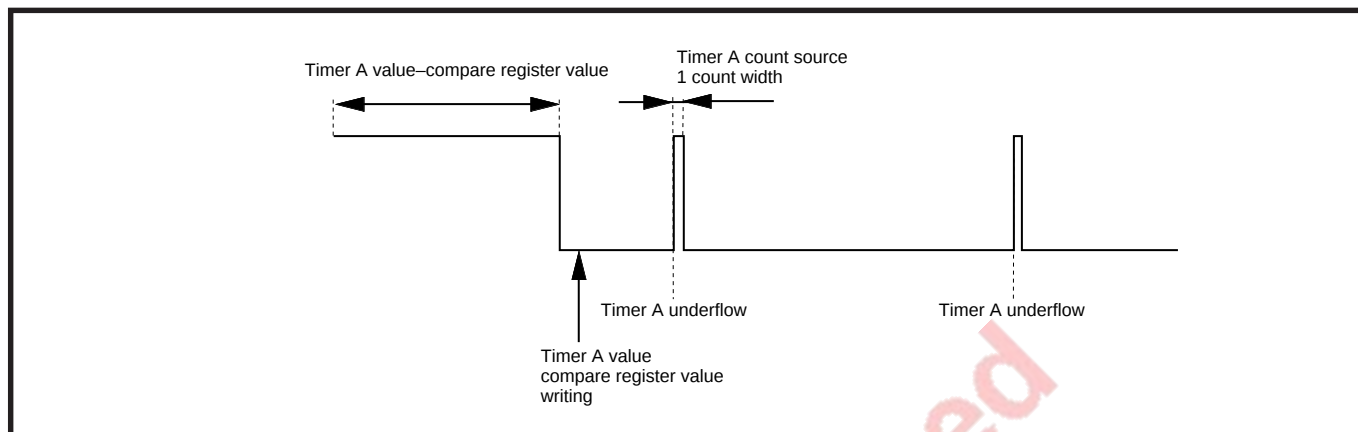


Fig. 2.2.31 PWM output and IGBT output (3)

## 2.3 Serial I/O

This paragraph explains the registers setting method and the notes relevant to the serial I/O.

### 2.3.1 Memory map

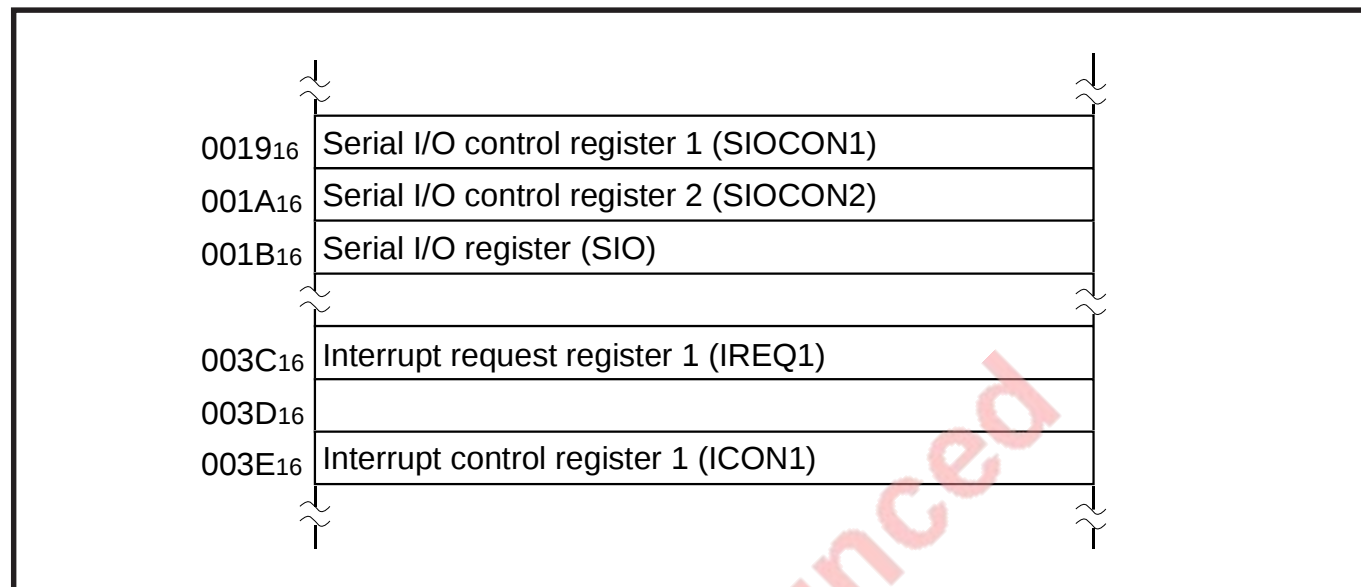


Fig. 2.3.1 Memory map of registers relevant to Serial I/O

### 2.3.2 Relevant registers

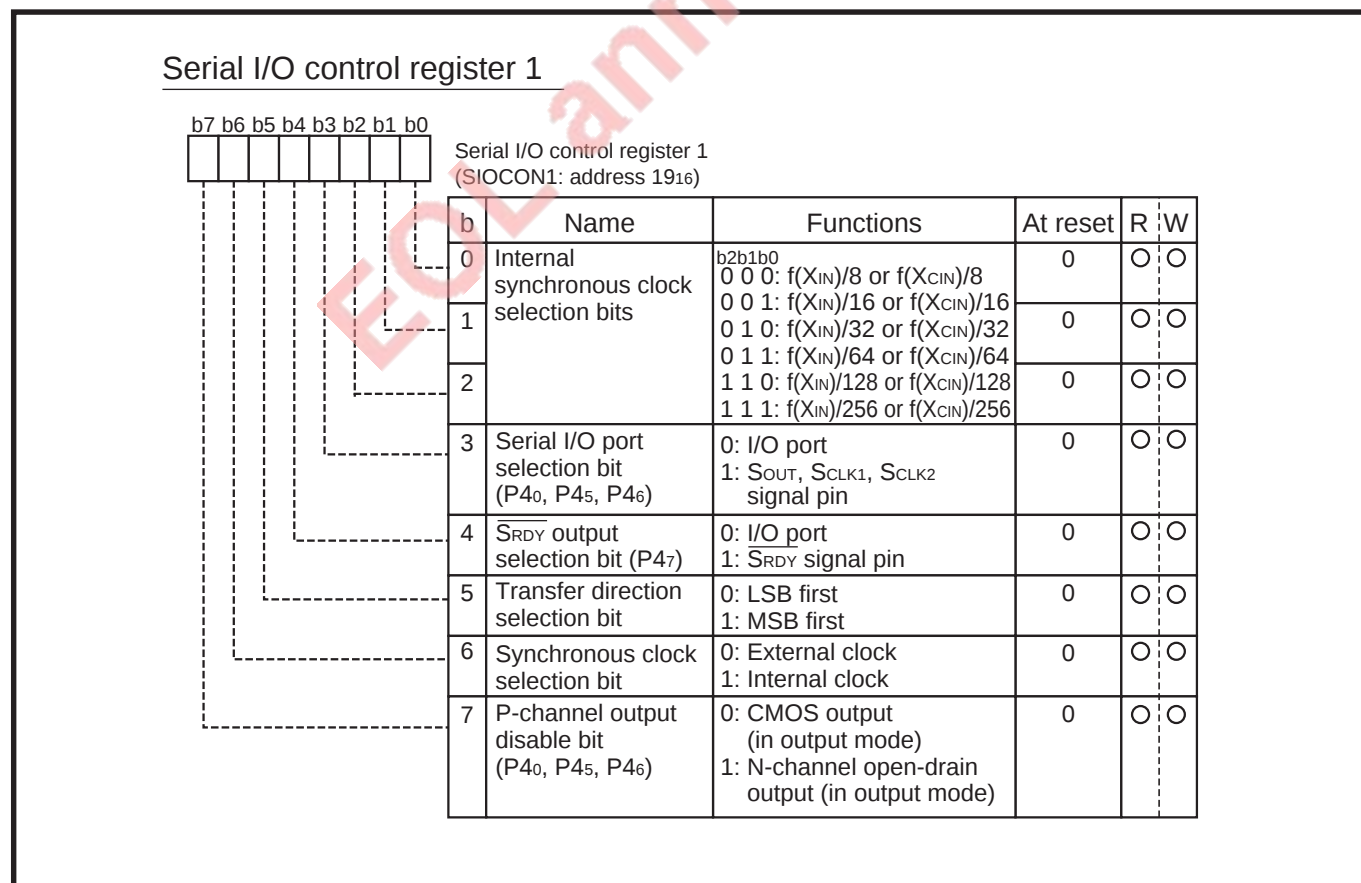


Fig. 2.3.2 Structure of Serial I/O control register 1

# APPLICATION

## 2.3 Serial I/O

### Serial I/O control register 2

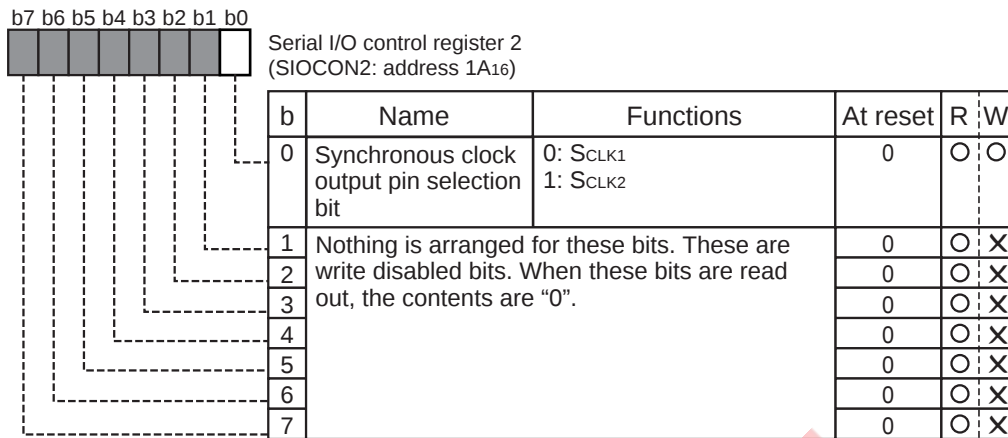
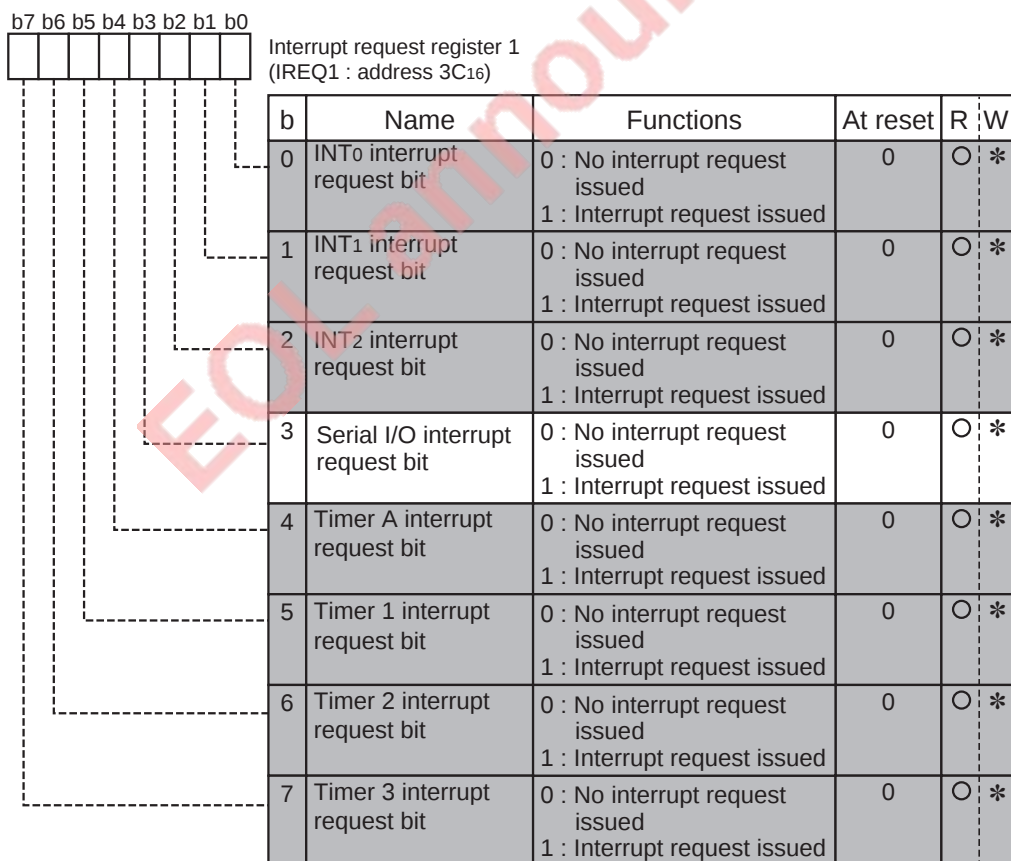


Fig. 2.3.3 Structure of Serial I/O control register 2

### Interrupt request register 1



\*: "0" can be set by software, but "1" cannot be set.

Fig. 2.3.4 Structure of Interrupt request register 1

### Interrupt control register 1

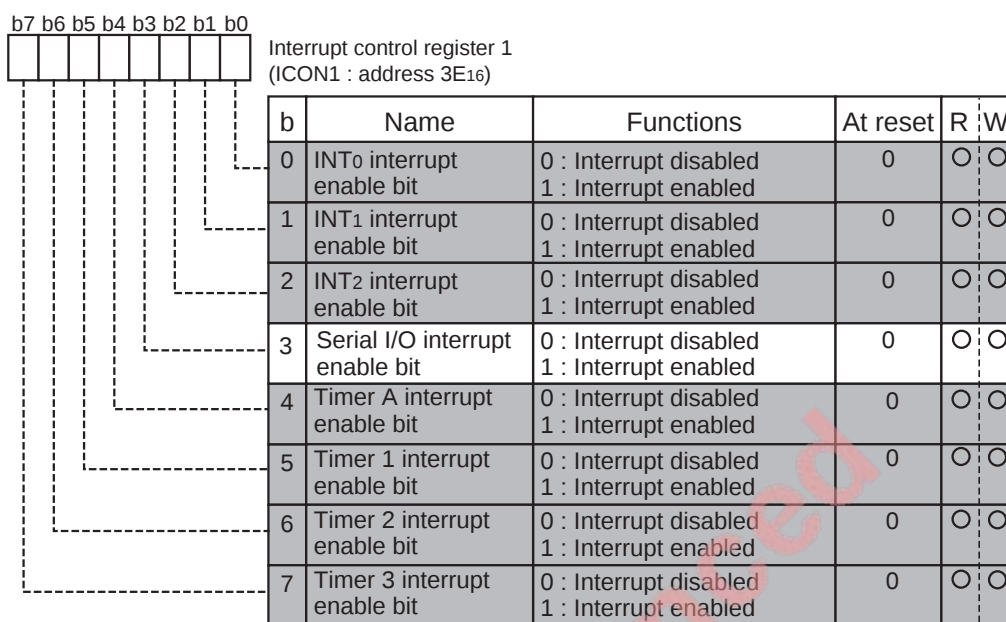


Fig. 2.3.5 Structure of Interrupt control register 1

# APPLICATION

## 2.3 Serial I/O

### 2.3.3 Serial I/O connection examples

#### (1) Control of peripheral IC equipped with CS pin

Figure 2.3.6 shows connection examples with peripheral ICs equipped with the CS pin.

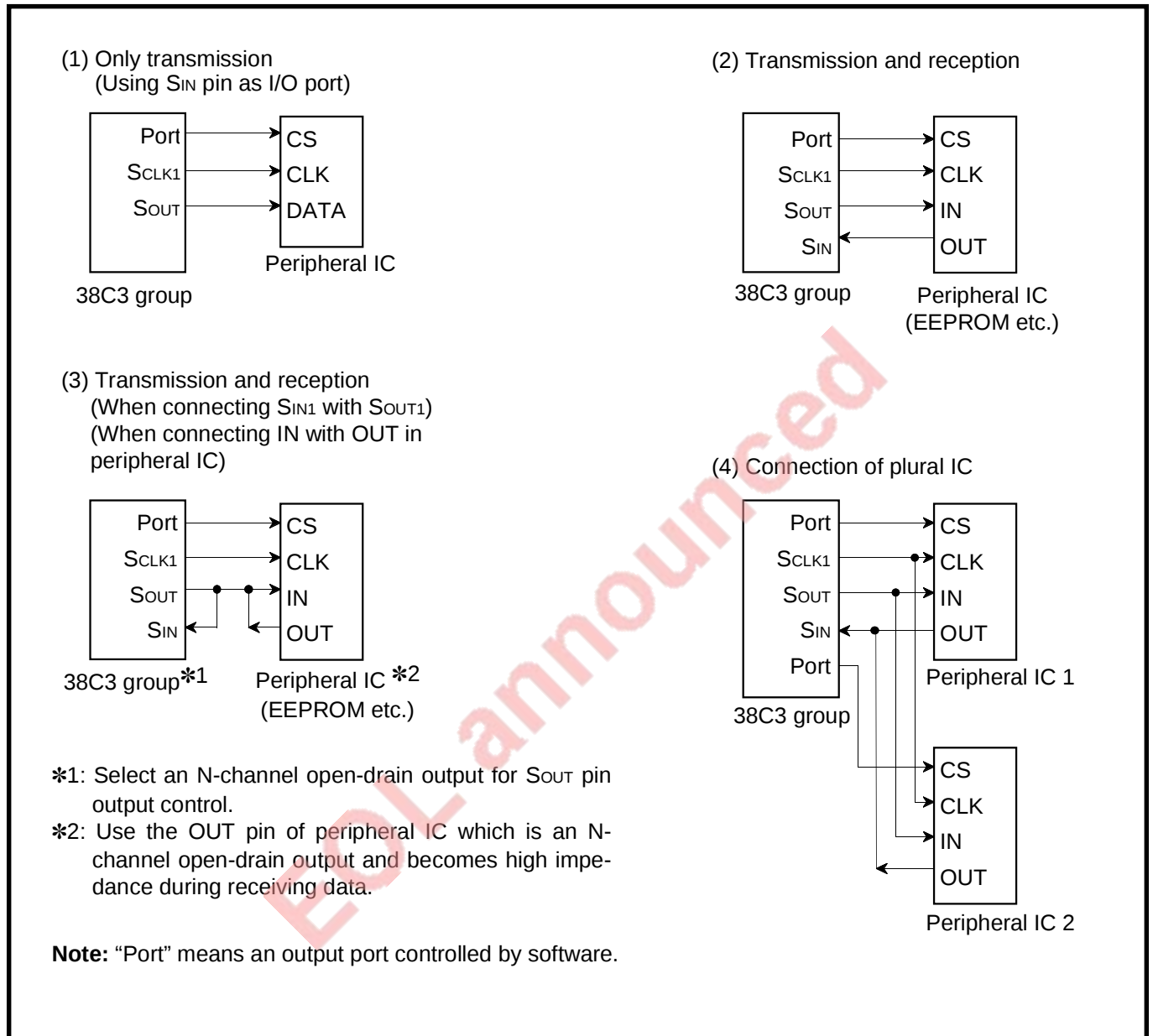


Fig. 2.3.6 Serial I/O connection examples (1)

**(2) Connection with microcomputer**

Figure 2.3.7 shows connection examples with another microcomputer.

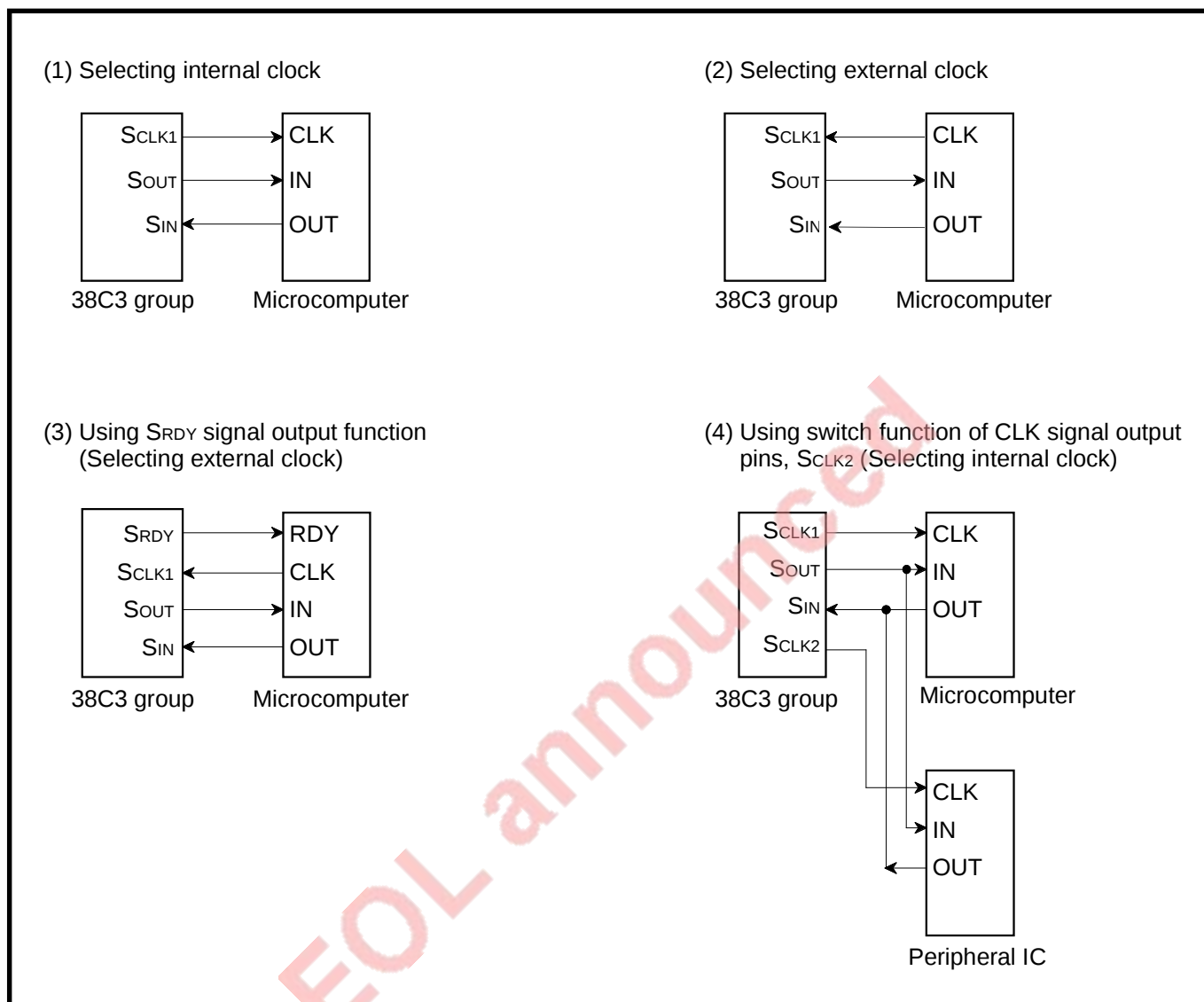


Fig. 2.3.7 Serial I/O connection examples (2)

# APPLICATION

## 2.3 Serial I/O

### 2.3.4 Serial I/O's modes

38C3 Group can use clock synchronous serial I/O.

Figure 2.3.8 shows the serial I/O's modes.

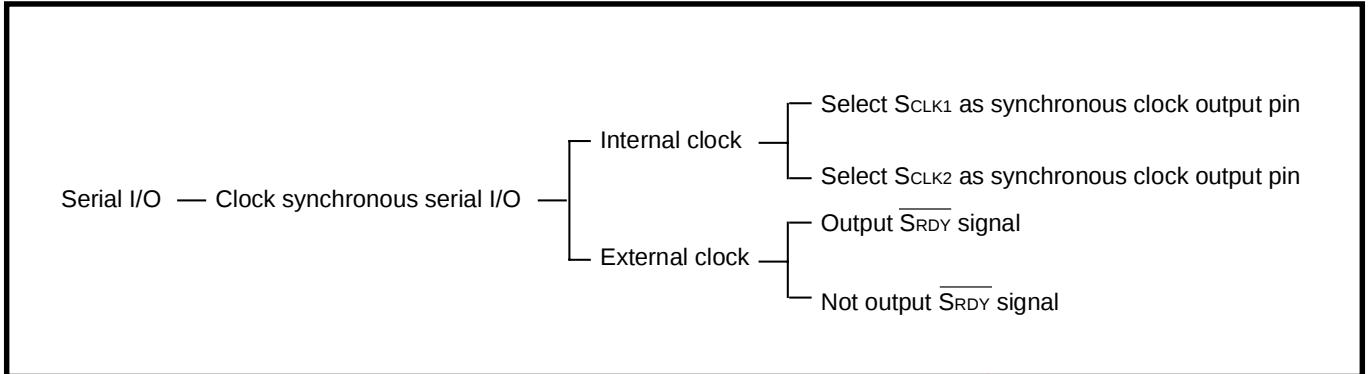


Fig. 2.3.8 Serial I/O's modes

### 2.3.5 Serial I/O application examples

#### (1) Communication (transmission/reception) using clock synchronous serial I/O

**Outline :** 2-byte data is transmitted and received, using the clock synchronous serial I/O.  
The  $S_{RDY}$  signal is used for communication control.

Figure 2.3.9 shows a connection diagram, and Figure 2.3.10 shows a timing chart.

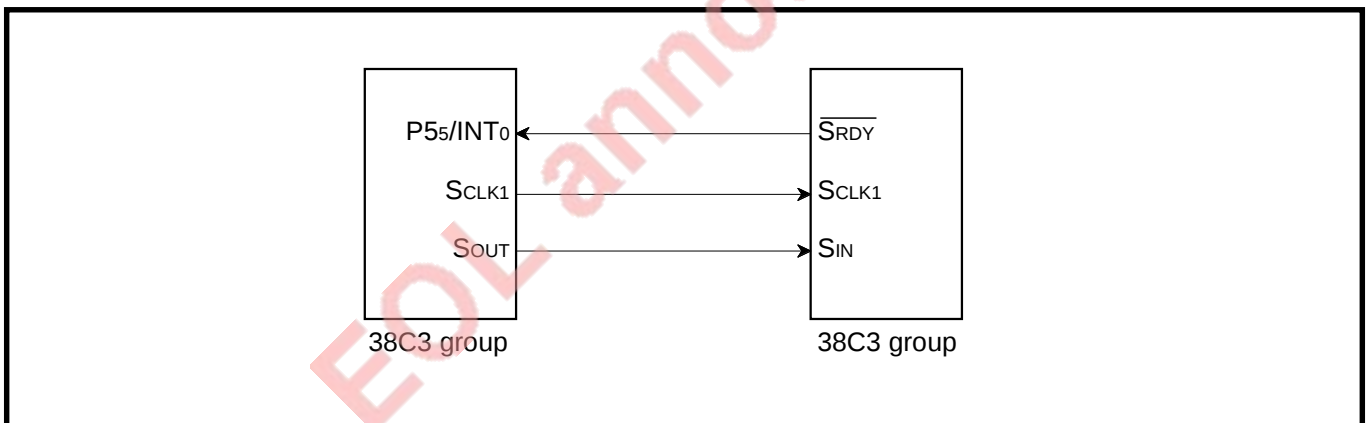


Fig. 2.3.9 Connection diagram

**Specifications :** • Use of serial I/O in clock synchronous serial I/O

- Synchronous clock frequency : 125 kHz ( $f(X_{IN}) = 4 \text{ MHz}$  is divided by 32)
- Use of  $S_{RDY}$  (receivable signal) \_\_\_\_\_
- The reception side outputs the  $S_{RDY}$  signal at intervals of 2 ms (generated by the timer), and 2-byte data is transferred from the transmission side to the reception side.

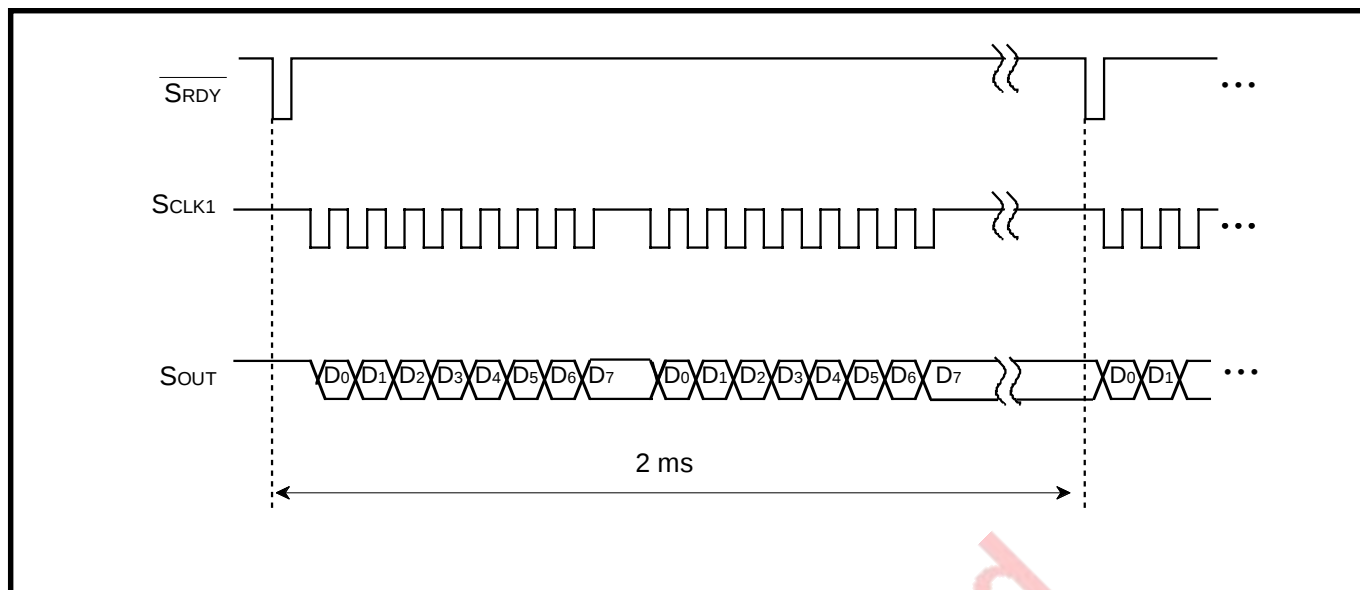


Fig. 2.3.10 Timing chart

# APPLICATION

## 2.3 Serial I/O

Figure 2.3.11 shows the registers setting relevant to the transmission side, and Figure 2.3.12 shows the registers setting relevant to the reception side.

Transmission side

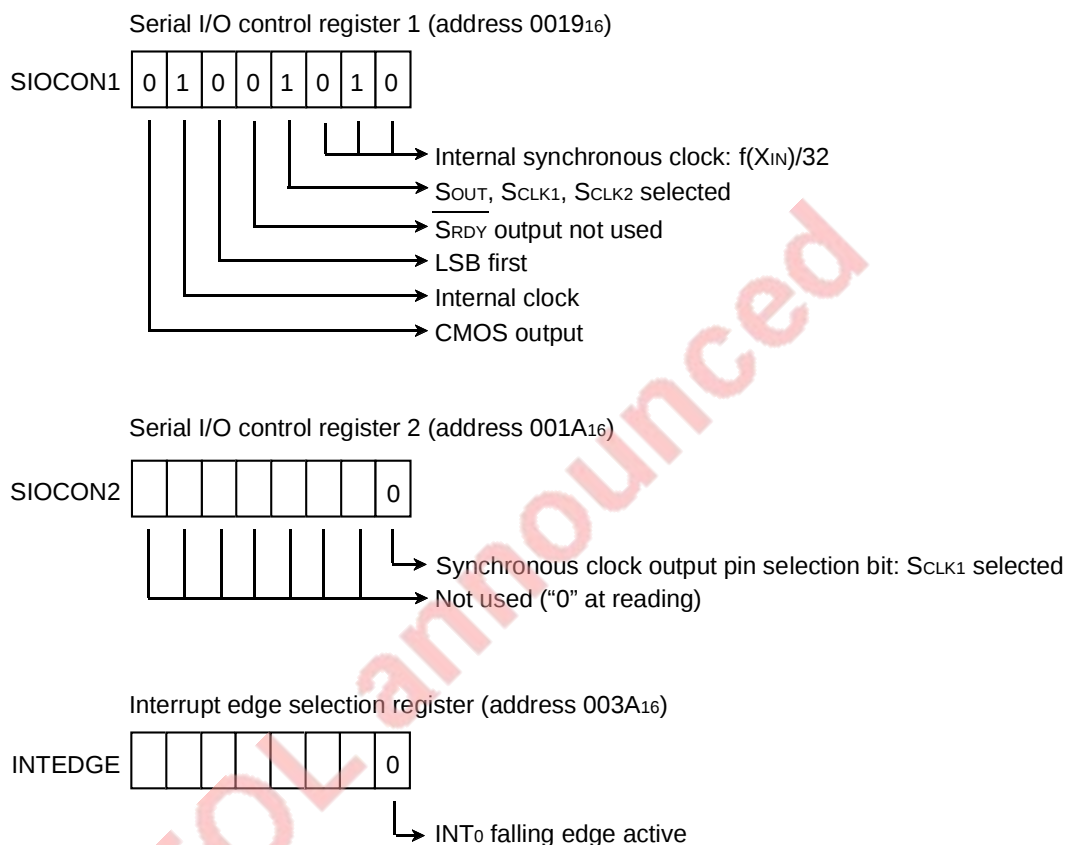


Fig. 2.3.11 Registers setting relevant to transmission side

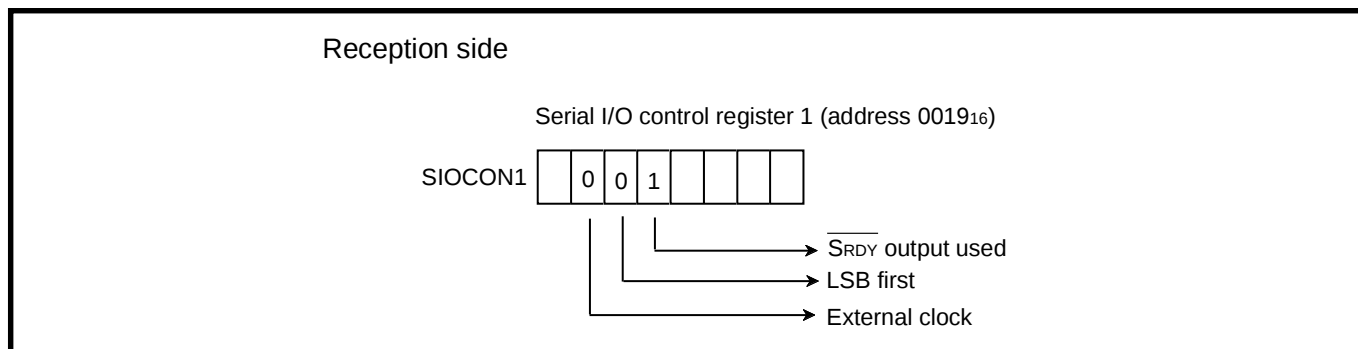


Fig. 2.3.12 Registers setting relevant to reception side

Figure 2.3.13 shows a control procedure of the transmission side, and Figure 2.3.14 shows a control procedure of the reception side.

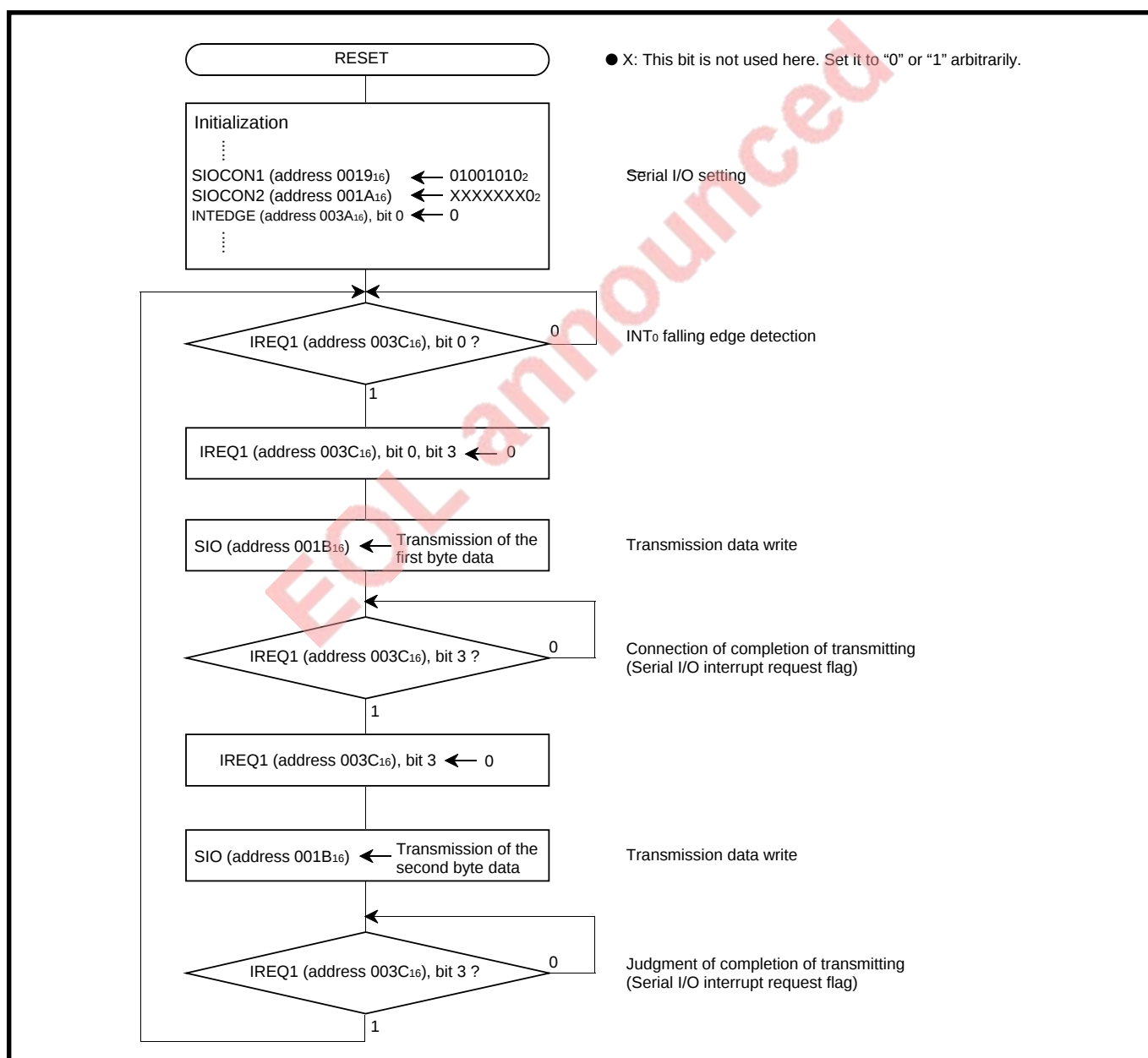


Fig. 2.3.13 Control procedure of transmission side

# APPLICATION

## 2.3 Serial I/O

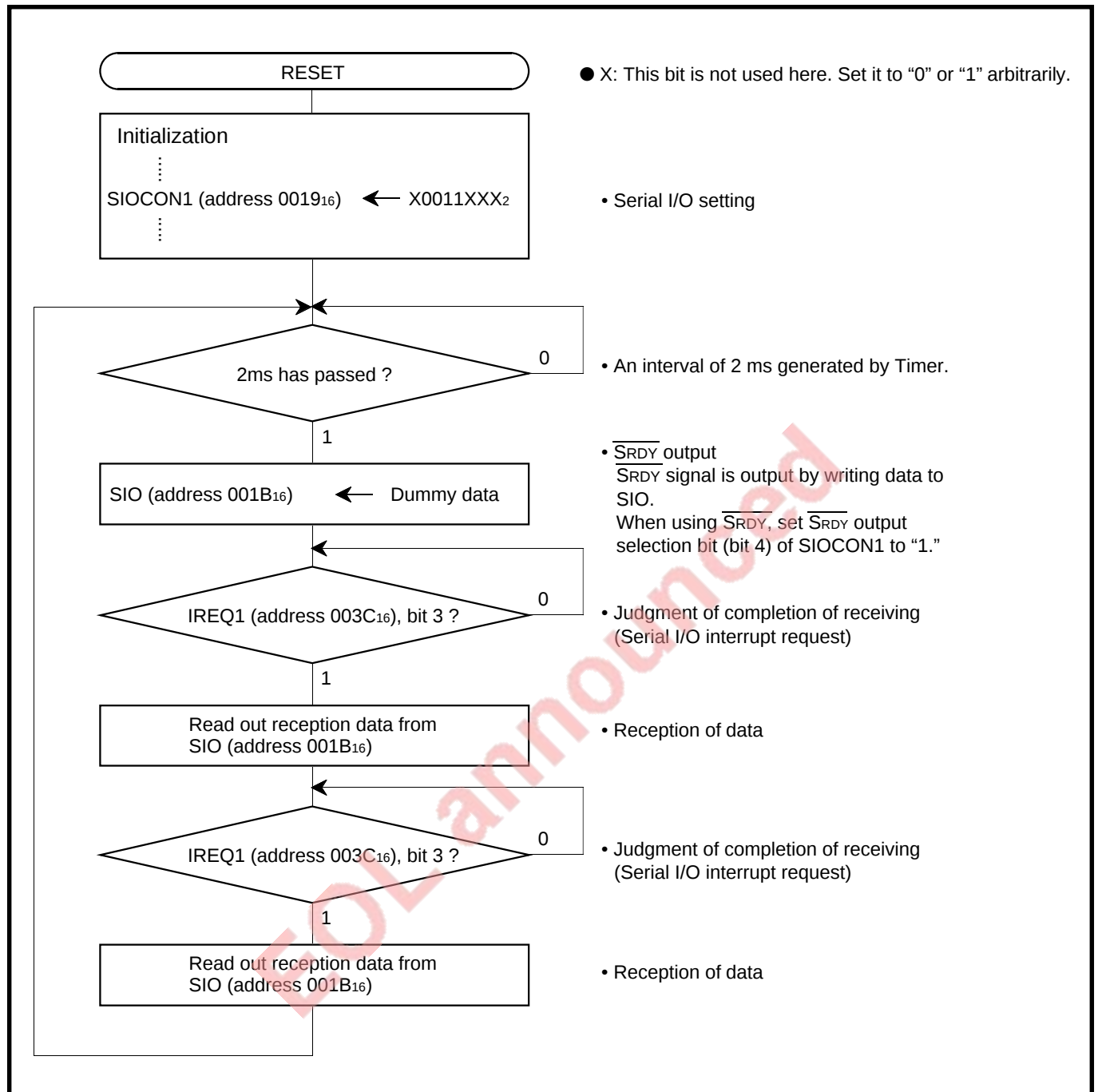


Fig. 2.3.14 Control procedure of reception side

**(2) Output of serial data (control of peripheral IC)**

**Outline :** Serial communication is performed, connecting port P5<sub>7</sub> with the  $\overline{\text{CS}}$  pin of a peripheral IC.

Figure 2.3.15 shows a connection diagram, and Figure 2.3.16 shows a timing chart.

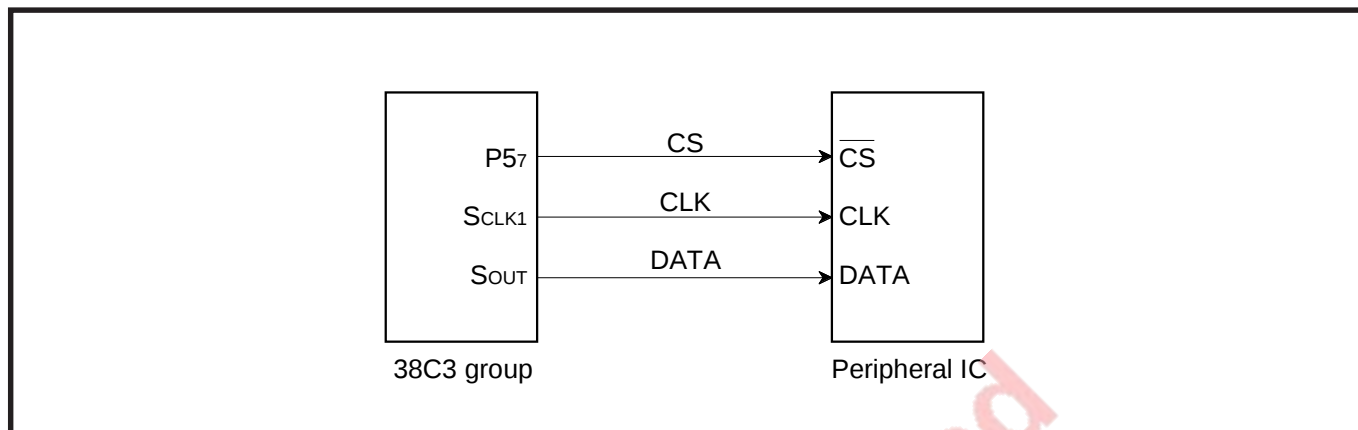


Fig. 2.3.15 Connection diagram

**Specifications :** • Use of serial I/O in clock synchronous serial I/O

- Synchronous clock frequency : 125 kHz ( $f(X_{IN}) = 4 \text{ MHz}$  is divided by 32)
- Transfer direction : LSB first
- Not use of serial I/O interrupt
- Port P5<sub>7</sub> is connected with the  $\overline{\text{CS}}$  pin ("L" active) of the peripheral IC for transmission control; the output level of port P5<sub>7</sub> is controlled by software.

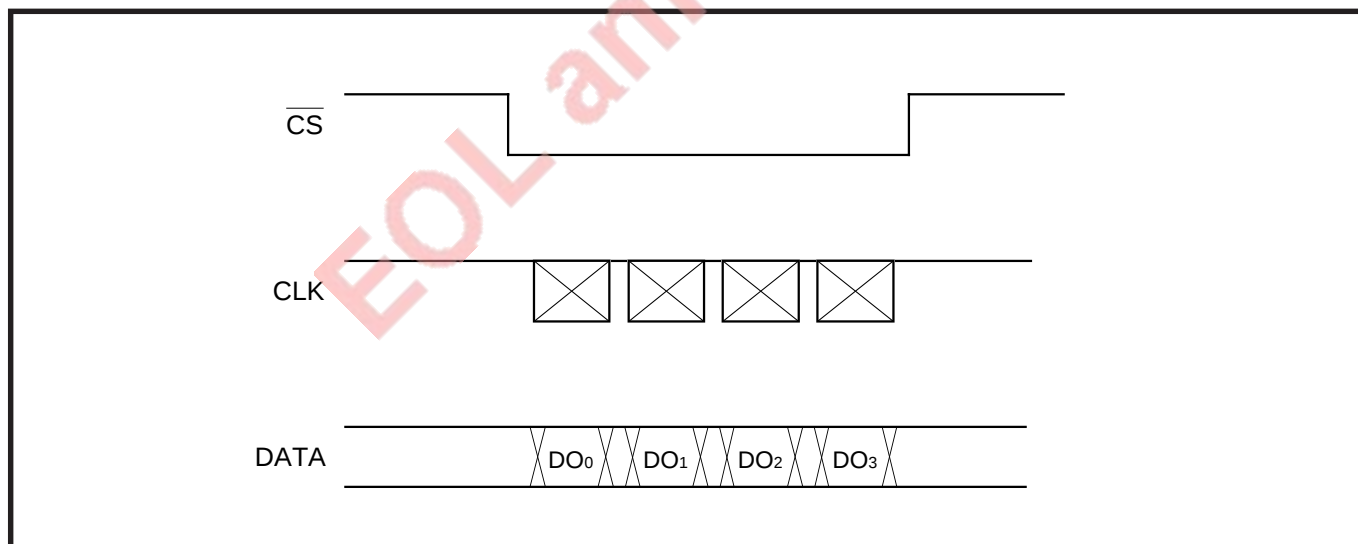


Fig. 2.3.16 Timing chart

# APPLICATION

## 2.3 Serial I/O

Figure 2.3.17 shows the relevant registers setting and Figure 2.3.18 shows the setting of transmission data.

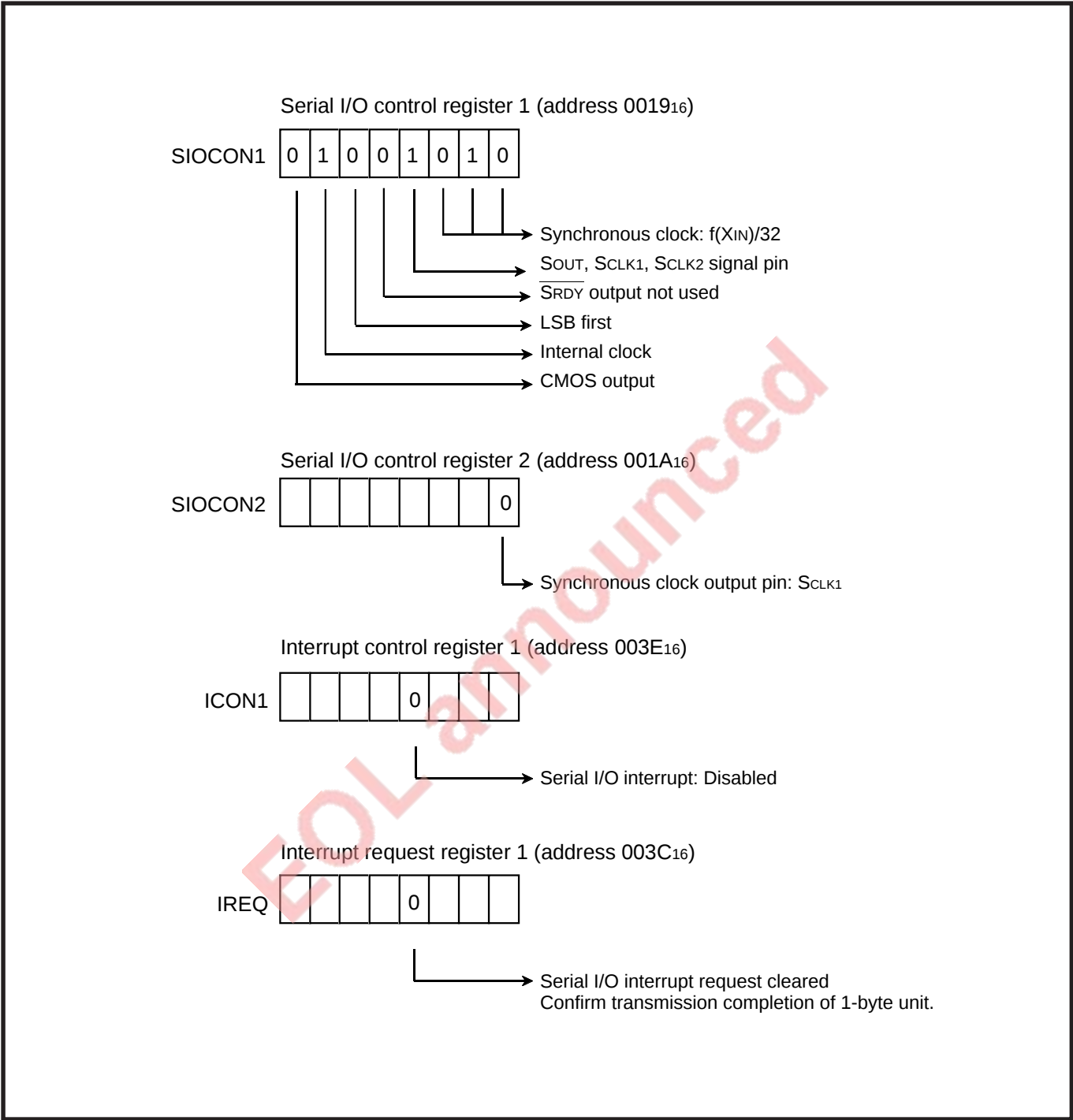


Fig. 2.3.17 Relevant registers setting

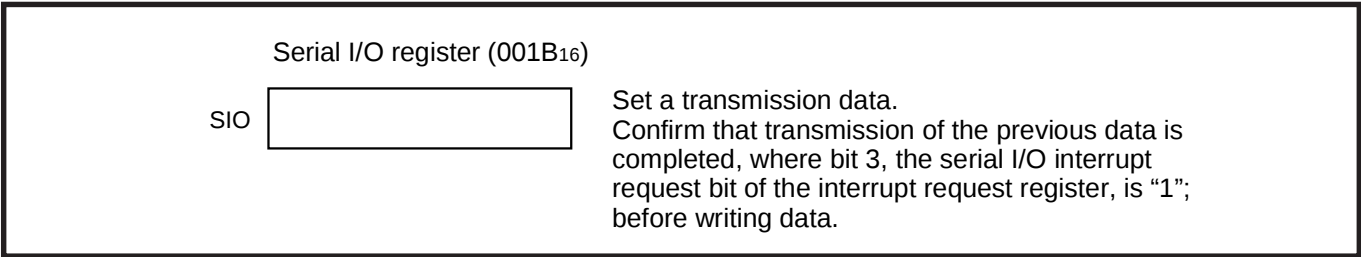


Fig. 2.3.18 Setting of transmission data

Figure 2.3.19 shows a control procedure.

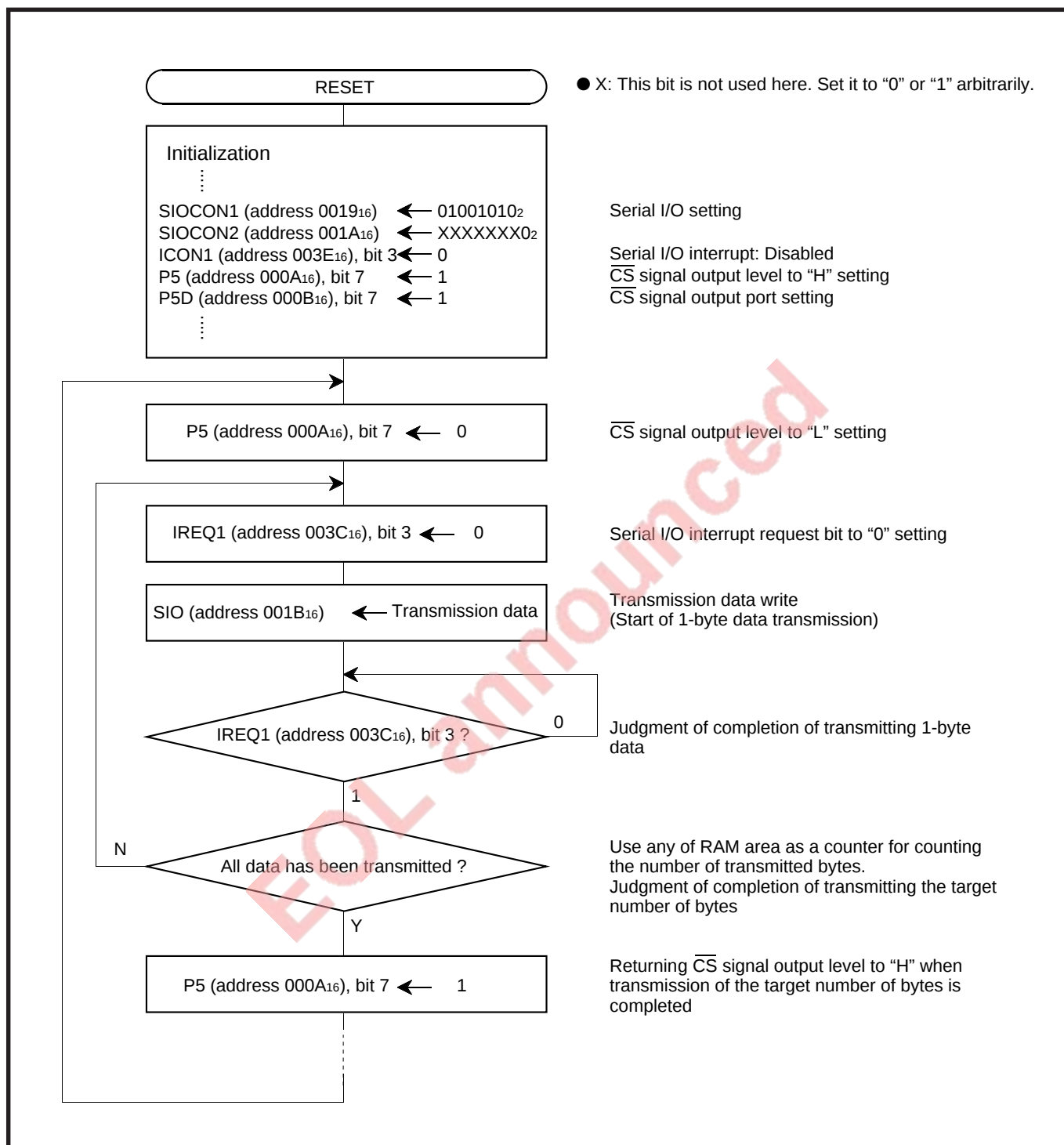


Fig. 2.3.19 Control procedure

# APPLICATION

## 2.3 Serial I/O

### (3) Cyclic transmission or reception of block data (data of specified number of bytes) between two microcomputers

**Outline :** When the clock synchronous serial I/O is used for communication, synchronization of the clock and the data between the transmitting and receiving sides may be lost because of noise included in the synchronous clock. It is necessary to correct that constantly, using “heading adjustment”.

This “heading adjustment” is carried out by using the interval between blocks in this example.

Figure 2.3.20 shows a connection diagram.

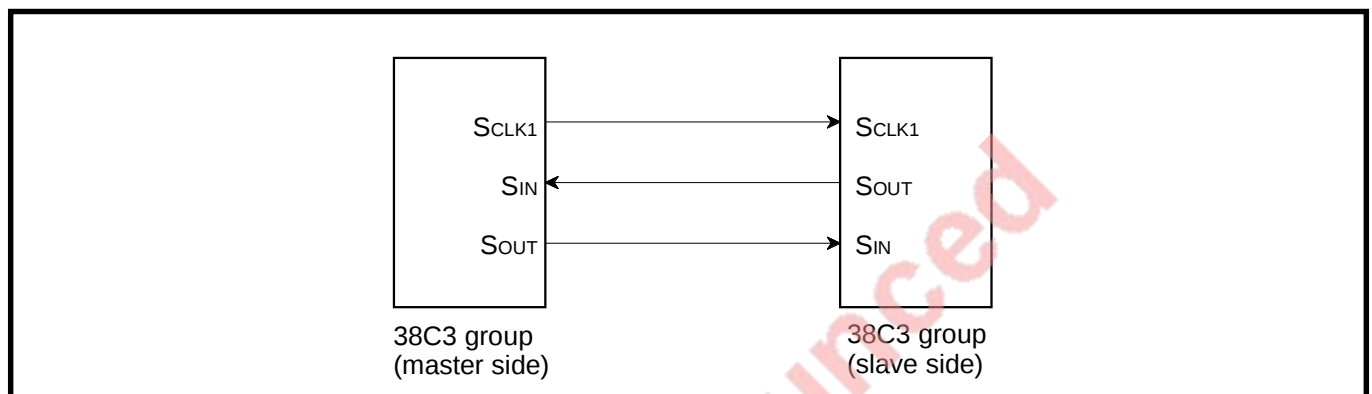


Fig. 2.3.20 Connection diagram

- Specifications:**
- Synchronous clock frequency : 131 kHz ( $f(X_{IN}) = 4.19 \text{ MHz}$  is divided by 32.)
  - Byte cycle: 488  $\mu\text{s}$
  - Number of bytes for transmission or reception : 8 bytes/block each
  - Block transfer cycle : 16 ms
  - Block transfer term : 3.5 ms
  - Interval between blocks : 12.5 ms
  - Heading adjustment time : 8 ms
  - Transfer direction : LSB first

**Limitations of the specifications:**

- Reading of the reception data and setting of the next transmission data must be completed within the time obtained from “byte cycle – time for transferring 1-byte data” (in this example, the time taken from generating of the serial I/O interrupt request to input of the next synchronous clock is 431  $\mu\text{s}$ ).
- “Heading adjustment time < interval between blocks” must be satisfied.

The communication is performed according to the timing shown in Figure 2.3.21. In the slave unit, when a synchronous clock is not input within a certain time (heading adjustment time), the next clock input is processed as the beginning (heading) of a block.

When a clock is input again after one block (8 bytes) is received, the clock is ignored.

Figure 2.3.22 shows the relevant registers setting in the master unit and Figure 2.3.23 shows the relevant registers setting in the slave unit.

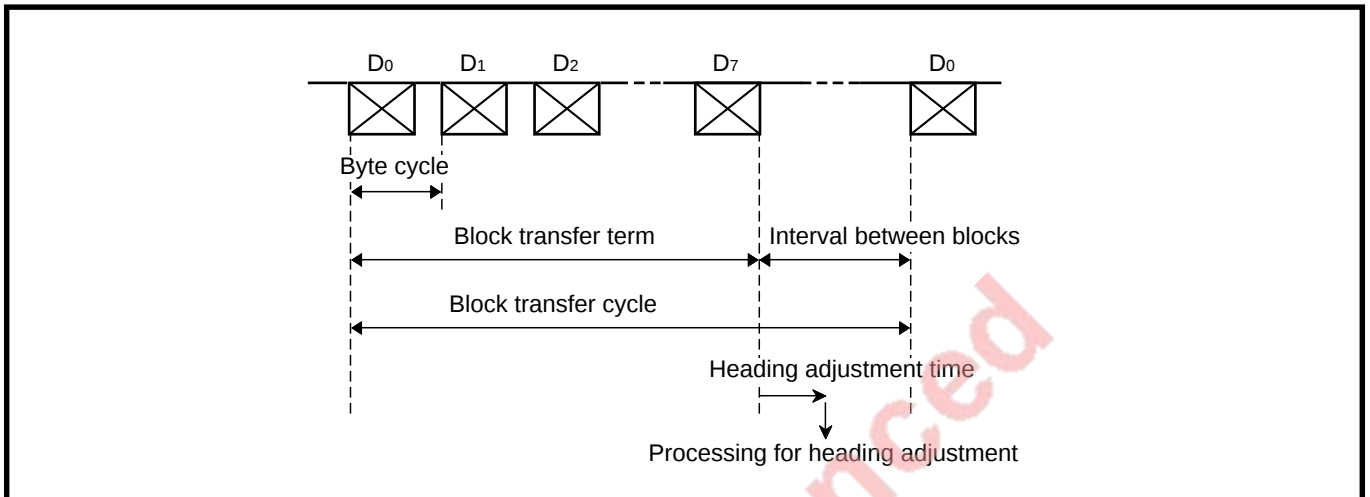


Fig. 2.3.21 Timing chart

# APPLICATION

## 2.3 Serial I/O

### Master unit

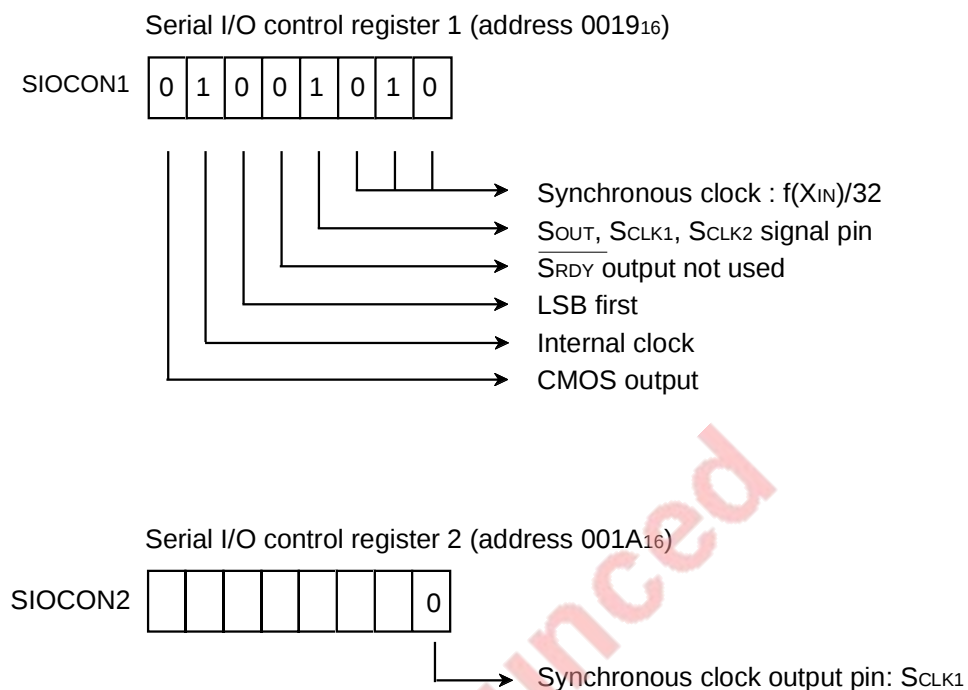


Fig. 2.3.22 Relevant registers setting in master unit

### Slave unit

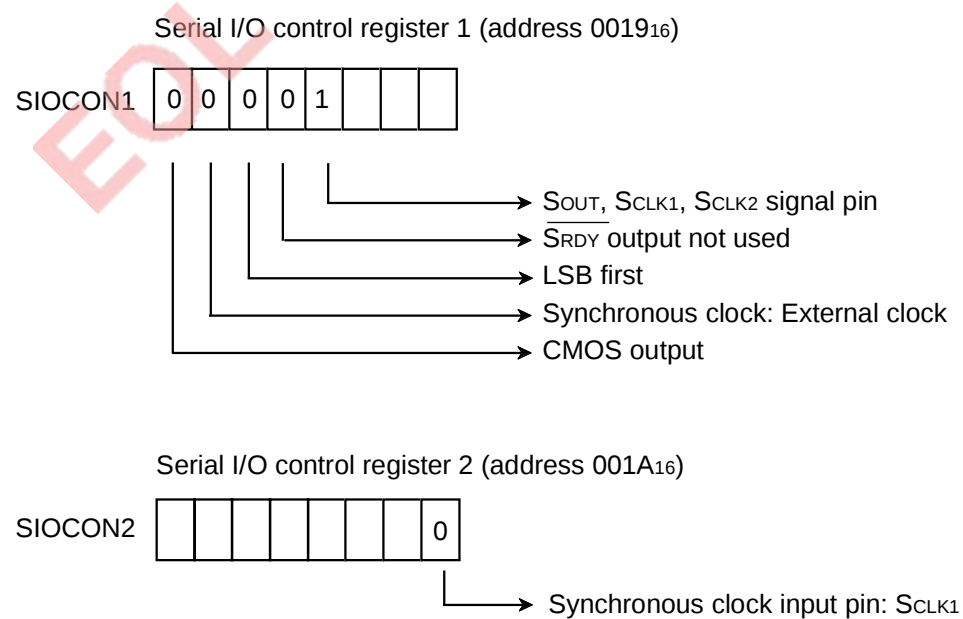


Fig. 2.3.23 Relevant registers setting in slave unit

**Control procedure by software:**

## ● Control in the master unit

After setting the relevant registers shown in Figure 2.3.22, the master unit starts transmission or reception of 1-byte data by writing transmission data to the serial I/O register.

To perform the communication in the timing shown in Figure 2.3.21, take the timing into account and write transmission data. Additionally, read out the reception data when the serial I/O interrupt request bit is set to "1," or before the next transmission data is written to the serial I/O register.

Figure 2.3.24 shows a control procedure of the master unit using timer interrupts.

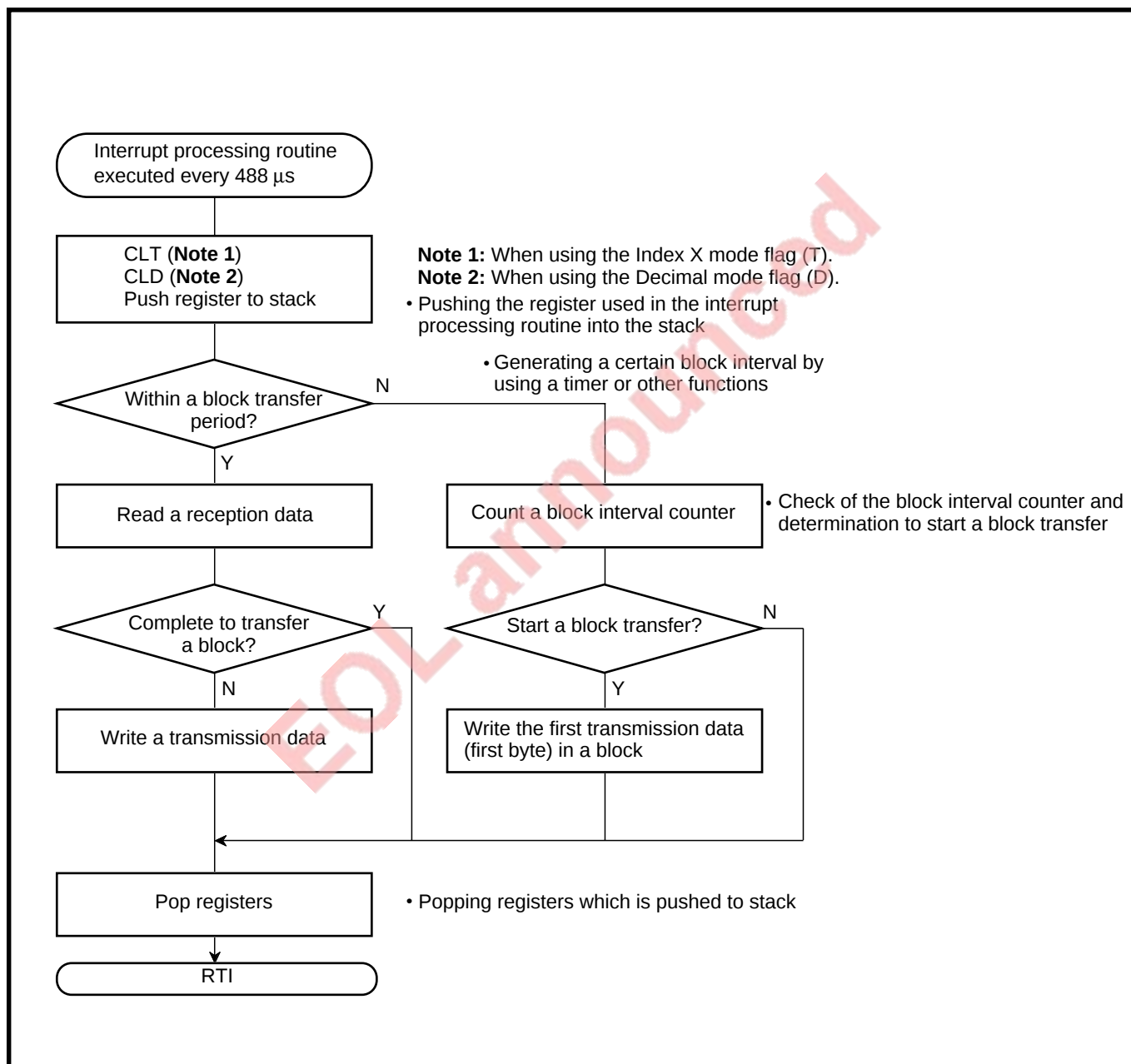


Fig. 2.3.24 Control procedure of master unit

# APPLICATION

## 2.3 Serial I/O

### ● Control in the slave unit

After setting the relevant registers as shown in Figure 2.3.23, the slave unit becomes the state where a synchronous clock can be received at any time, and the serial I/O interrupt occurs each time an 8-bit synchronous clock is received.

In the serial I/O interrupt processing routine, the data to be transmitted next is written to the serial I/O register after the received data is read out.

However, if no serial I/O interrupt occurs for a certain time (heading adjustment time or more), the following processing will be performed.

1. The first 1-byte data of the transmission data in the block is written into the serial I/O register.
  2. The data to be received next is processed as the first 1 byte of the received data in the block.
- Figure 2.3.25 shows a control procedure of the slave unit using the serial I/O interrupt and any timer interrupt (for heading adjustment).

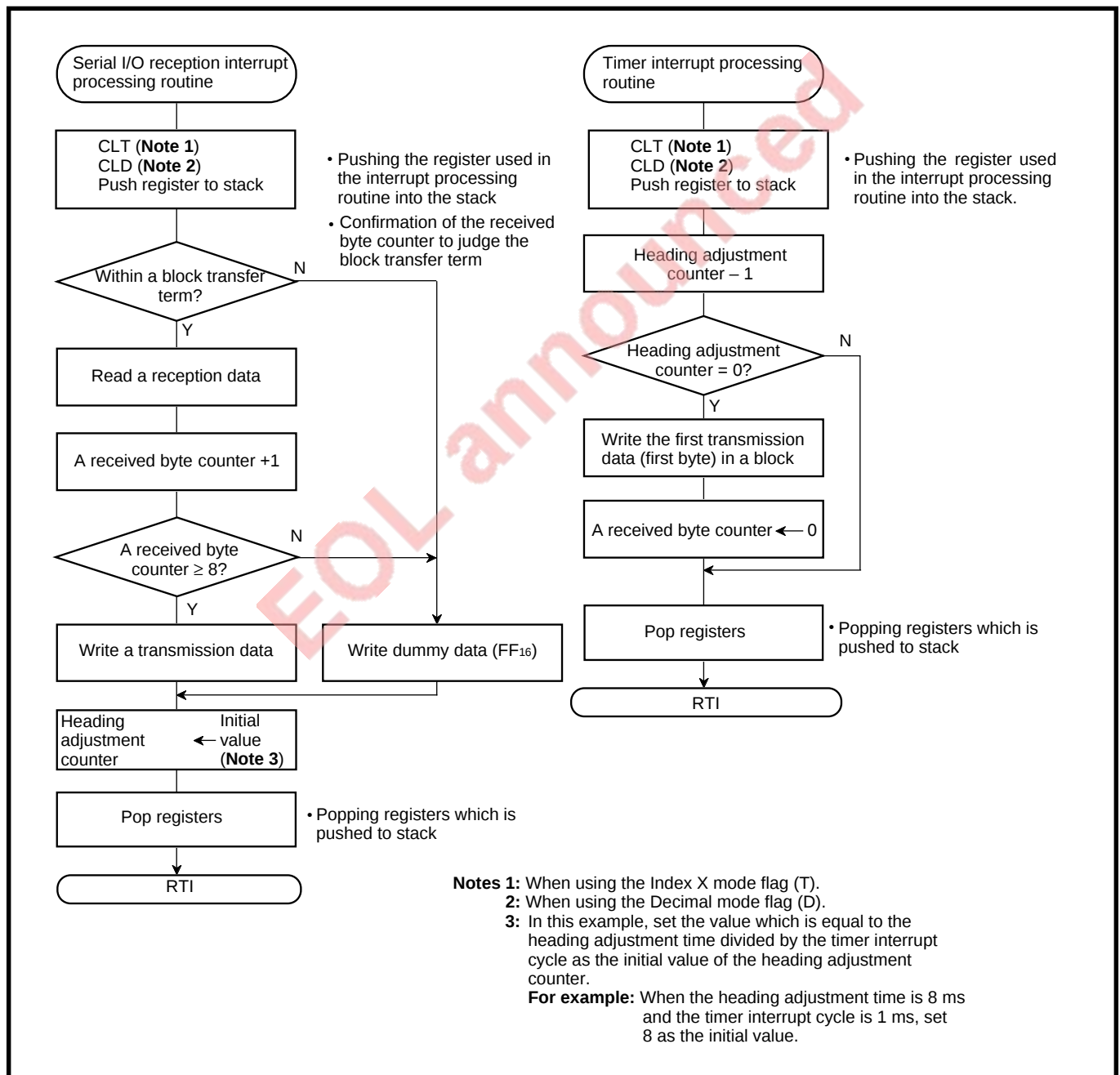


Fig. 2.3.25 Control procedure of slave unit

### 2.3.6 Notes on serial I/O

**(1) Selecting external synchronous clock**

When an external synchronous clock is selected, the contents of serial I/O register are being shifted continually while the transfer clock is input to the serial I/O1 clock pin. In this case, control the clock externally.

**(2) Transmission data wiring**

When an external clock is used as the synchronous clock, write the transmit data to the serial I/O shift register at "H" level of transfer clock input.

EOL announced

# APPLICATION

## 2.4 LCD controller

### 2.4 LCD controller

This paragraph explains the registers setting method and the notes relevant to the LCD controller.

#### 2.4.1 Memory map

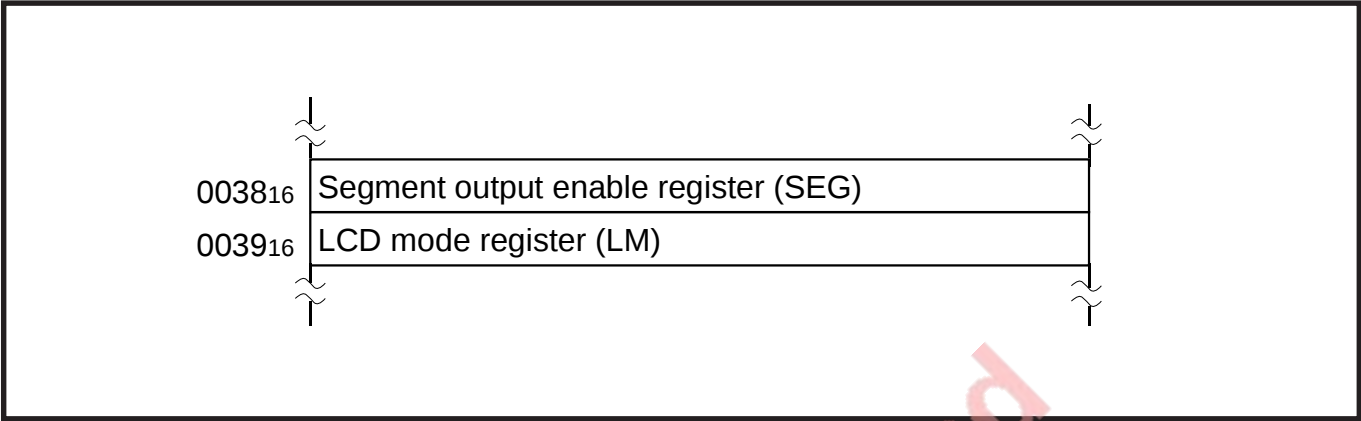


Fig. 2.4.1 Memory map of registers relevant to LCD controller

## 2.4.2 Relevant registers

## Segment output enable register

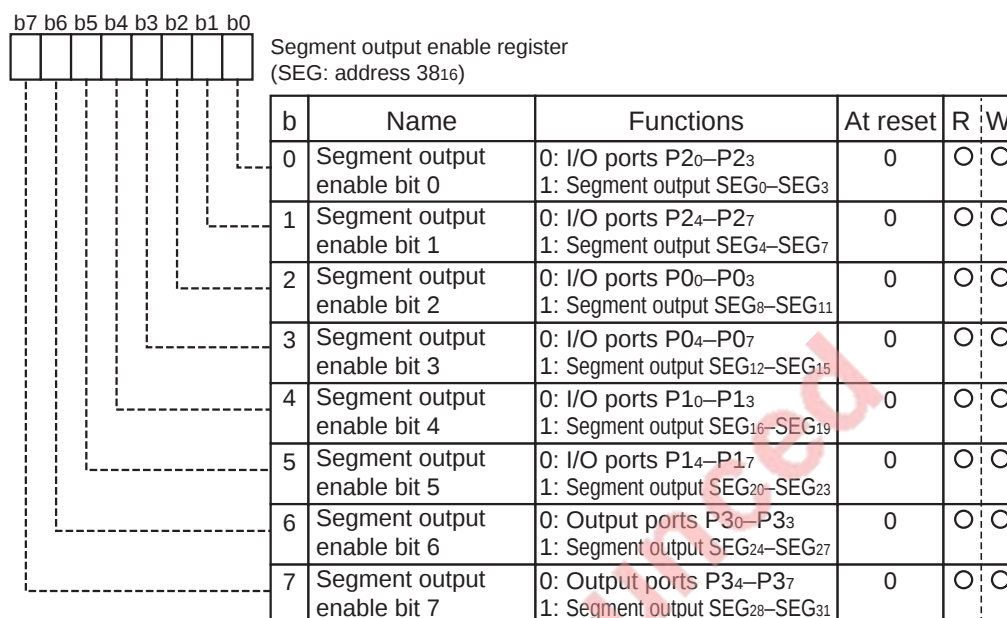
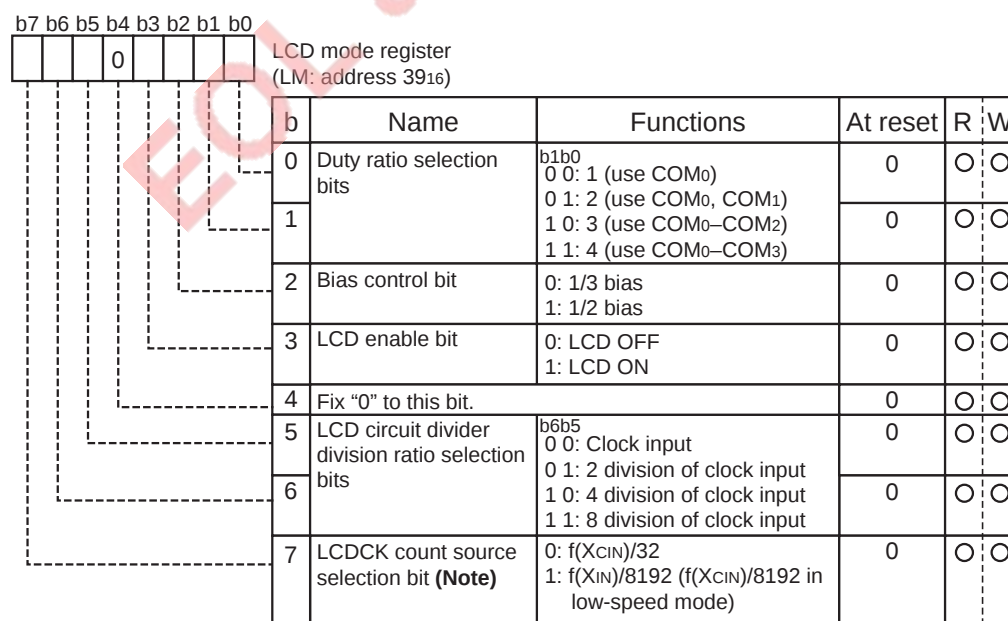


Fig. 2.4.2 Structure of Segment output enable register

## LCD mode register



**Note:** LCDCK is a clock for a LCD timing controller.

Fig. 2.4.3 Structure of LCD mode register

# APPLICATION

## 2.4 LCD controller

### 2.4.3 LCD controller application examples

**Outline:** A LCD panel display data by using the LCD controller.

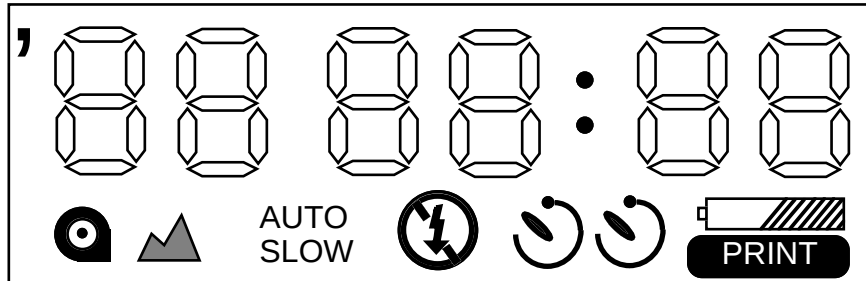


Fig. 2.4.4 LCD panel

- Specifications:**
- Use of segment output SEG<sub>0</sub> to SEG<sub>13</sub>
  - Setting of port P1 to I/O port, setting of port P3 to output
  - Frame frequency = 61 Hz
  - Duty ratio number = 4, Bias value = 1/3

Figure 2.4.5 shows the segment allocation example.

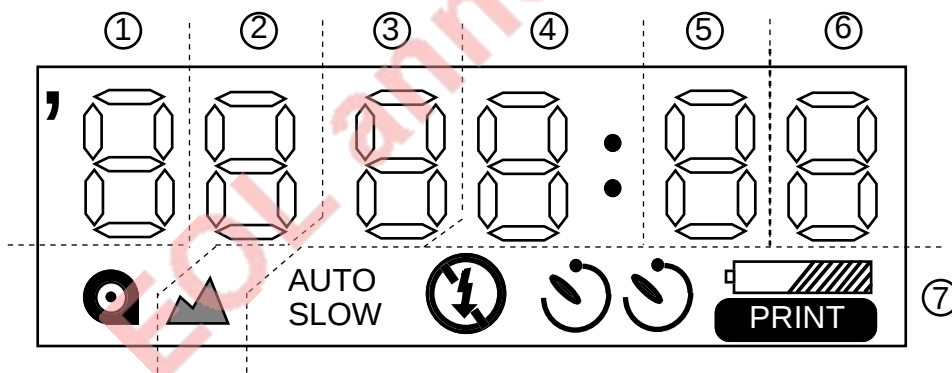


Fig. 2.4.5 Segment allocation example

## Setting of LCD display RAM:

| Bit                | 7     | 6    | 5    | 4    | 3     | 2    | 1    | 0    |
|--------------------|-------|------|------|------|-------|------|------|------|
| Address            | COM3  | COM2 | COM1 | COM0 | COM3  | COM2 | COM1 | COM0 |
| 0040 <sub>16</sub> | SEG1  |      |      |      | SEG0  |      |      |      |
| 0041 <sub>16</sub> | SEG3  |      |      |      | SEG2  |      |      |      |
| 0042 <sub>16</sub> | SEG5  |      |      |      | SEG4  |      |      |      |
| 0043 <sub>16</sub> | SEG7  |      |      |      | SEG6  |      |      |      |
| 0044 <sub>16</sub> | SEG9  |      |      |      | SEG8  |      |      |      |
| 0045 <sub>16</sub> | SEG11 |      |      |      | SEG10 |      |      |      |
| 0046 <sub>16</sub> | SEG13 |      |      |      | SEG12 |      |      |      |
| 0047 <sub>16</sub> | SEG15 |      |      |      | SEG14 |      |      |      |
| 0048 <sub>16</sub> | SEG17 |      |      |      | SEG16 |      |      |      |
| 0049 <sub>16</sub> | SEG19 |      |      |      | SEG18 |      |      |      |
| 004A <sub>16</sub> | SEG21 |      |      |      | SEG20 |      |      |      |
| 004B <sub>16</sub> | SEG23 |      |      |      | SEG22 |      |      |      |
| 004C <sub>16</sub> | SEG25 |      |      |      | SEG24 |      |      |      |
| 004D <sub>16</sub> | SEG27 |      |      |      | SEG26 |      |      |      |
| 004E <sub>16</sub> | SEG29 |      |      |      | SEG28 |      |      |      |
| 004F <sub>16</sub> | SEG31 |      |      |      | SEG30 |      |      |      |

Fig. 2.4.6 LCD display RAM map

| Bit                | 7    | 6    | 5    | 4    | 3    | 2    | 1     | 0    |
|--------------------|------|------|------|------|------|------|-------|------|
| Address            | COM3 | COM2 | COM1 | COM0 | COM3 | COM2 | COM1  | COM0 |
| 0040 <sub>16</sub> | ,    | g    | f    | e    | d    | c    | b     | a    |
| 0041 <sub>16</sub> | ⊙    | g    | f    | e    | d    | c    | b     | a    |
| 0042 <sub>16</sub> | ▲    | g    | f    | e    | d    | c    | b     | a    |
| 0043 <sub>16</sub> | :    | g    | f    | e    | d    | c    | b     | a    |
| 0044 <sub>16</sub> |      | g    | f    | e    | d    | c    | b     | a    |
| 0045 <sub>16</sub> |      | g    | f    | e    | d    | c    | b     | a    |
| 0046 <sub>16</sub> | SLOW | AUTO | ⚡    | ↺    | ↻    | ↻    | PRINT | 🔋    |

➔ ①  
➔ ②  
➔ ③  
➔ ④  
➔ ⑤  
➔ ⑥  
➔ ⑦

Fig. 2.4.7 LCD display RAM setting

# APPLICATION

## 2.4 LCD controller

Figure 2.4.8 shows the relevant registers setting.

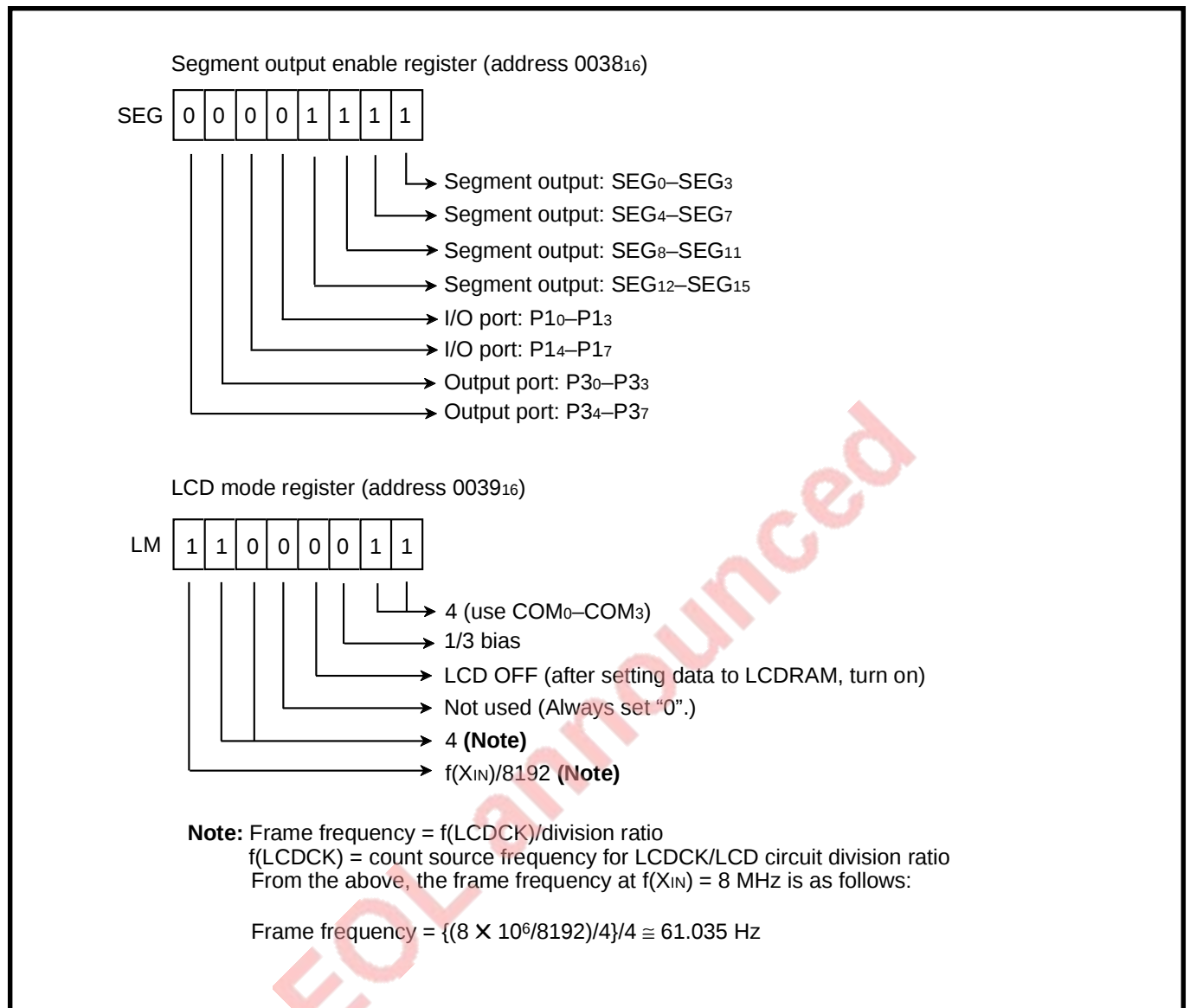


Fig. 2.4.8 Relevant registers setting

**Control procedure:** Figure 2.4.9 shows the control procedure of relevant registers to turn on all the LCD display in Figure 2.4.4.

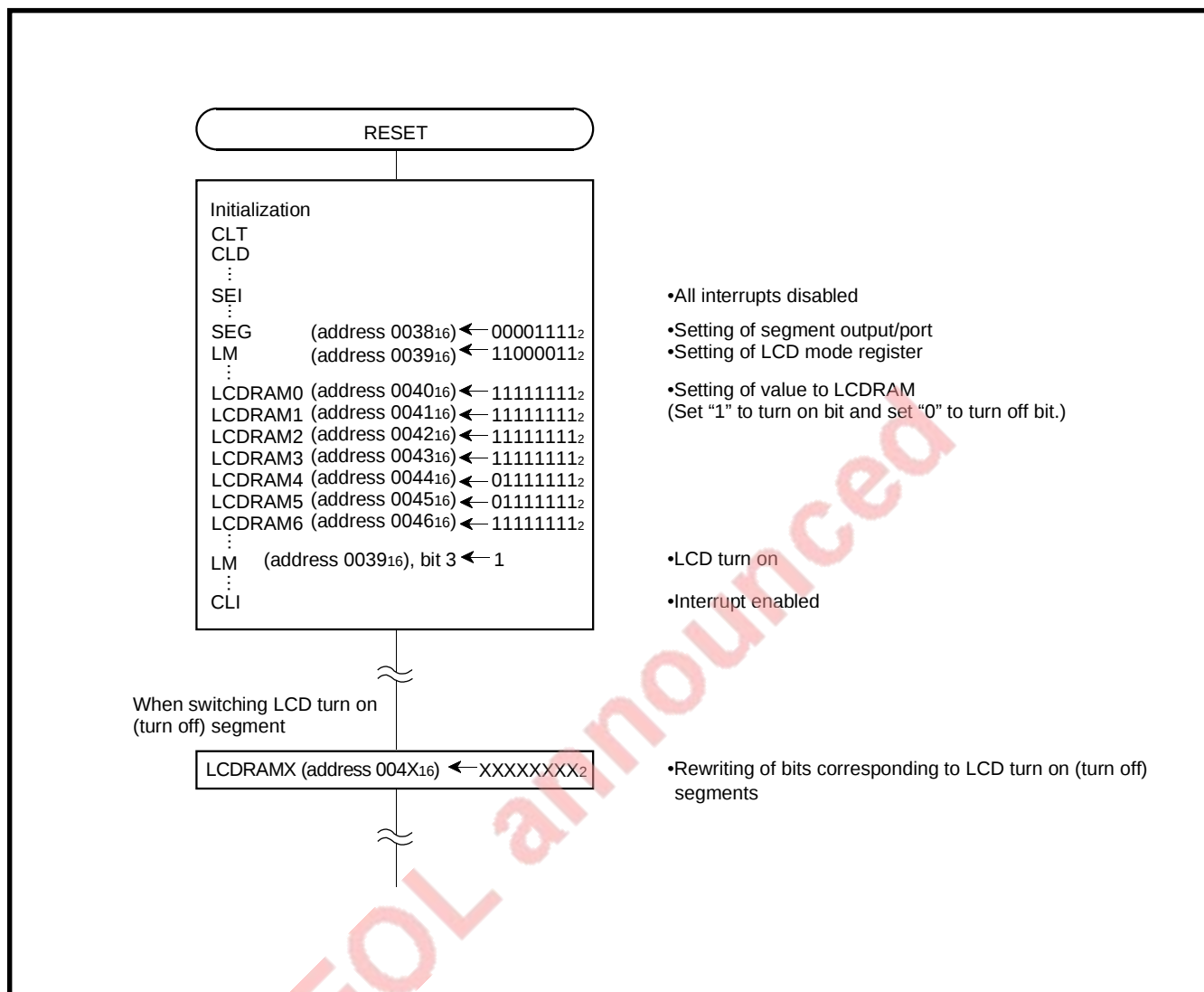


Fig. 2.4.9 Control procedure

# APPLICATION

## 2.4 LCD controller

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### 2.4.4 Notes on LCD controller

- When switching from the high-speed or middle-speed mode to the low-speed mode, switch the mode in the following order:
  - (1) 32 kHz oscillation selected (bit 4 of CPU mode register (address 003B<sub>16</sub>) = "1")
  - (2) Count source for LCDCK =  $f(X_{CIN})/32$  (bit 7 of LCD mode register (address 0039<sub>16</sub>) = "0")
  - (3) Internal system clock:  $X_{CIN}-X_{COUT}$  selected (bit 7 of CPU mode register (address 003B<sub>16</sub>) = "1")
  - (4) Main clock  $X_{IN}-X_{OUT}$  stopped (bit 5 of CPU mode register (address 003B<sub>16</sub>) = "1")Execute the setting (2) after the oscillation at 32 kHz (setting (1)) becomes completely stable.
- If the STP instruction is executed while the LCD is turned on by setting bit 3 of the LCD mode register (address 0039<sub>16</sub>) to "1", a DC voltage is applied to the LCD. For this reason, do not execute the STP instruction while the LCD is lighting.
- When the LCD is not used, open the segment and the common pins.  
Connect  $V_{L1}-V_{L3}$  to  $V_{SS}$ .
- For the following products, if the LCD enable bit of the LCD mode register (bit 3 of address 0039<sub>16</sub>) is set to "0", all LCDs cannot be turned off. To turn off all LCDs, set "0" (turn off) to all corresponding LCD display RAM.  
**Corresponding products:** M38C34M6AXXXFP, M38C34M6MXXXXFP, M38C37ECAXXXFP, M38C37ECMXXXXFP, M38C37ECAFP, M38C37ECMFP, M38C37ECAFS, M38C37ECMFS, M38C37RFS, M38C37RMFS

## 2.5 A-D converter

This paragraph describes the setting method of A-D converter relevant registers, notes etc.

### 2.5.1 Memory map

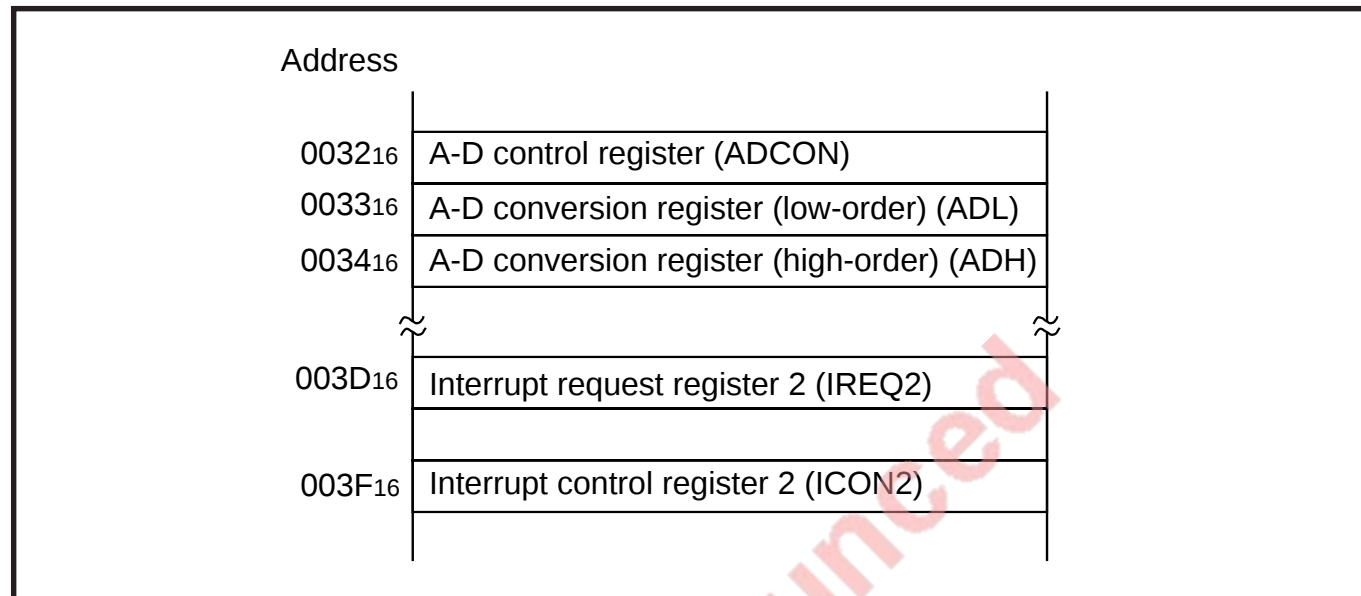


Fig. 2.5.1 Memory map of A-D converter relevant registers

### 2.5.2 Relevant registers

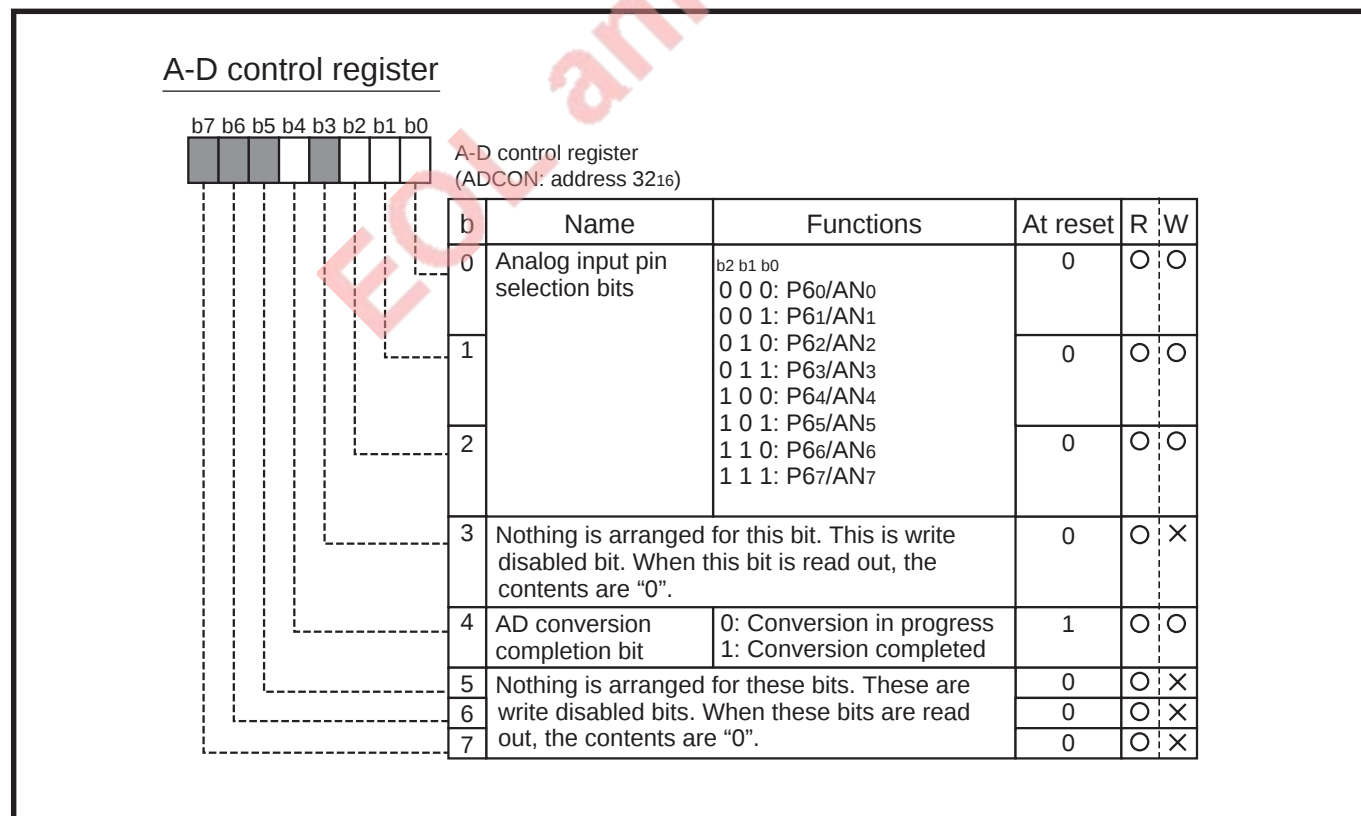


Fig. 2.5.2 Structure of A-D control register

# APPLICATION

## 2.5 A-D converter

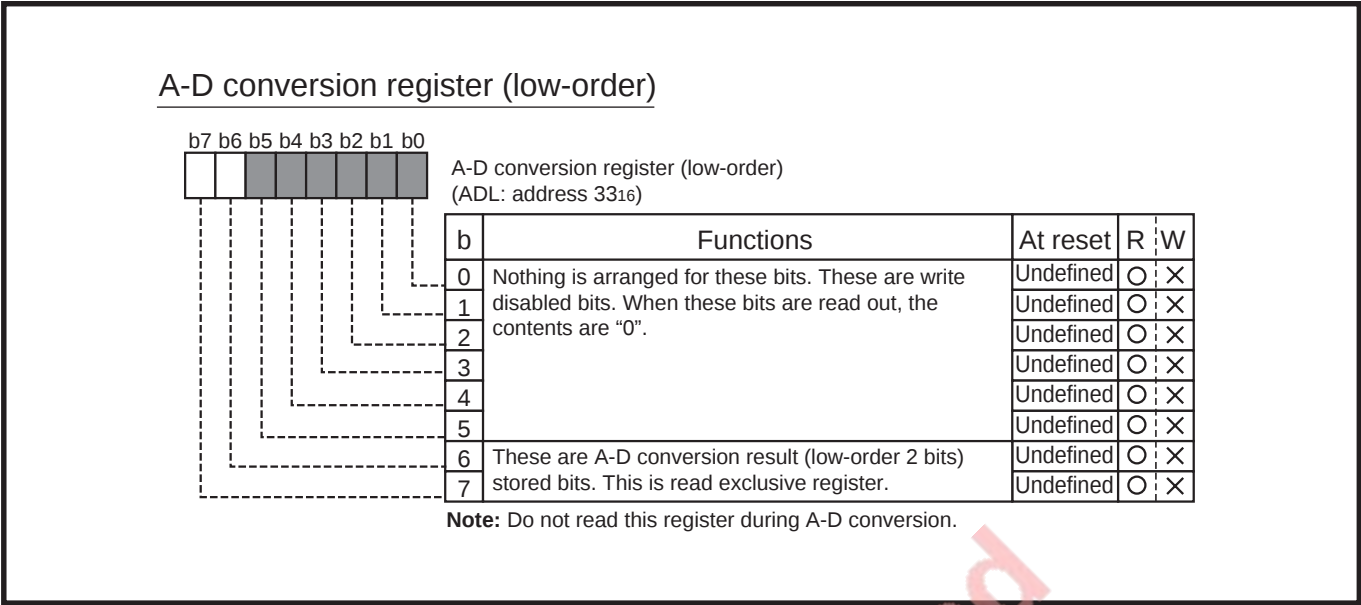


Fig. 2.5.3 Structure of A-D conversion register (low-order)

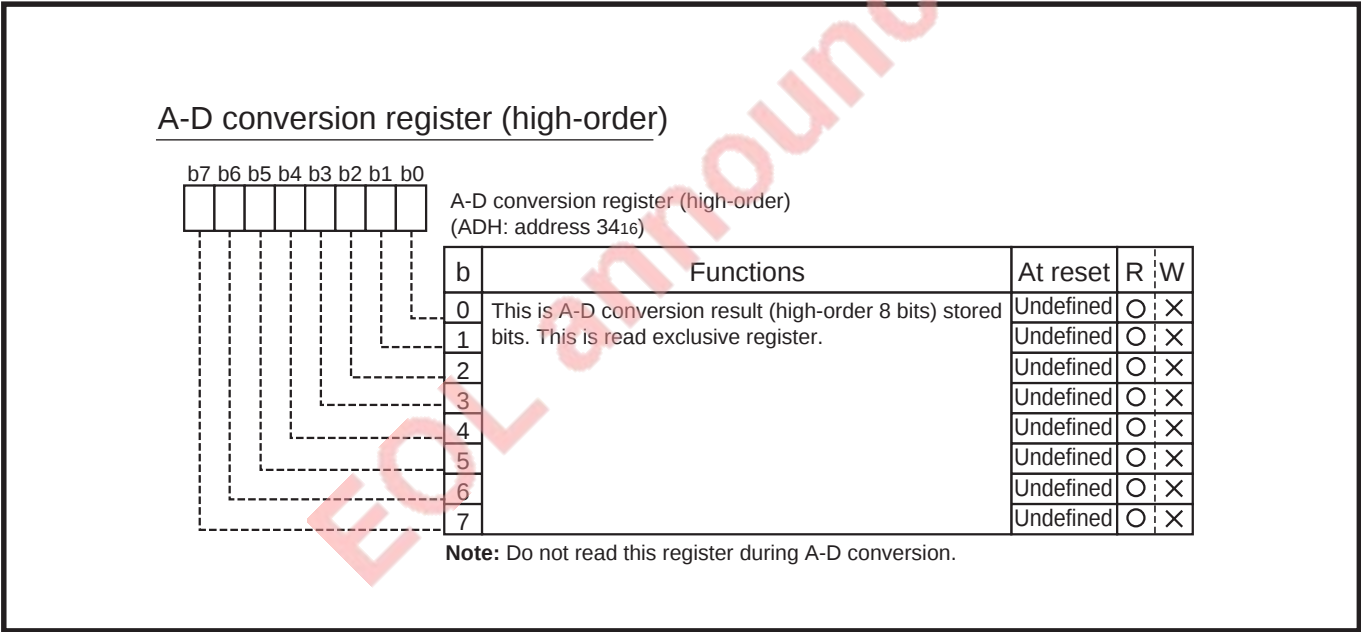


Fig. 2.5.4 Structure of A-D conversion register (high-order)

## Interrupt request register 2

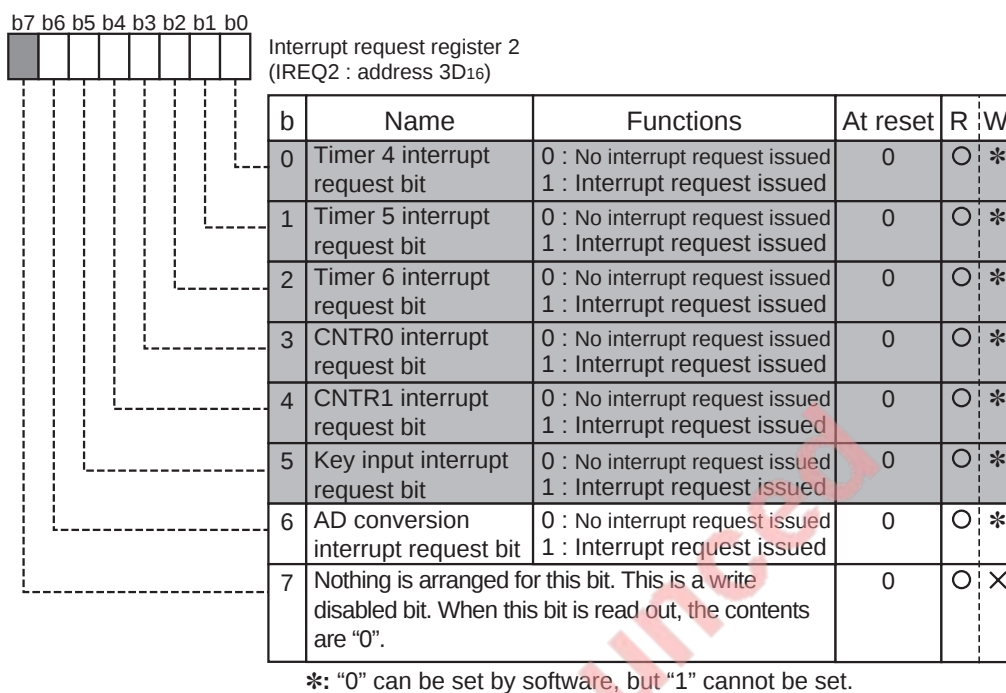


Fig. 2.5.5 Structure of Interrupt request register 2

## Interrupt control register 2

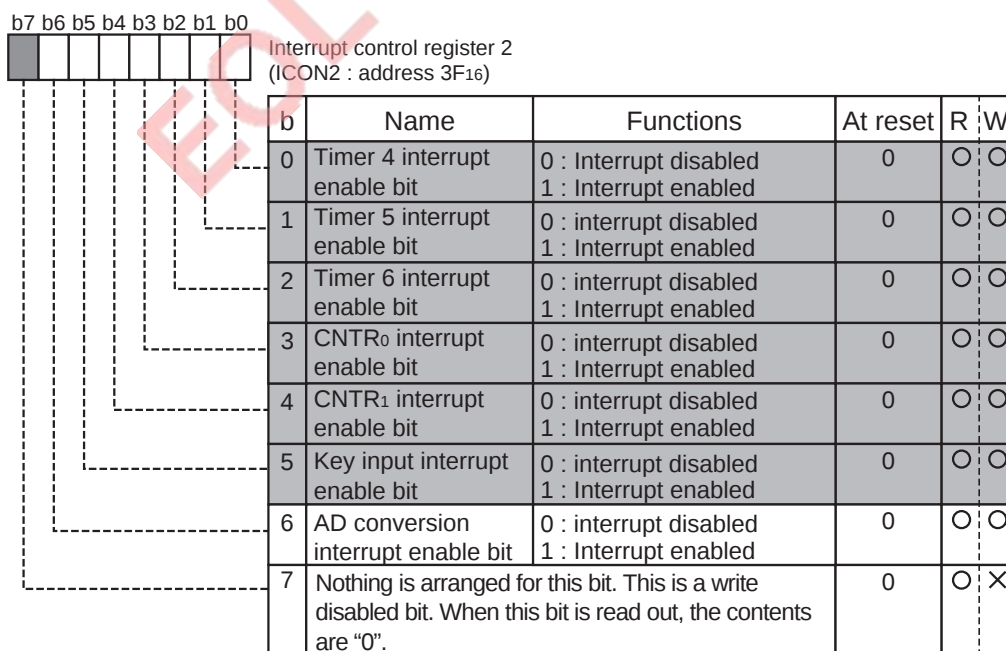


Fig. 2.5.6 Structure of Interrupt control register 2

# APPLICATION

## 2.5 A-D converter

### 2.5.3 A-D converter application examples

#### (1) Read-in of analog signal

**Outline:** The analog input voltage from a sensor is converted to digital values.

Figure 2.5.7 shows a connection diagram, and Figure 2.5.8 shows the setting of relevant registers.

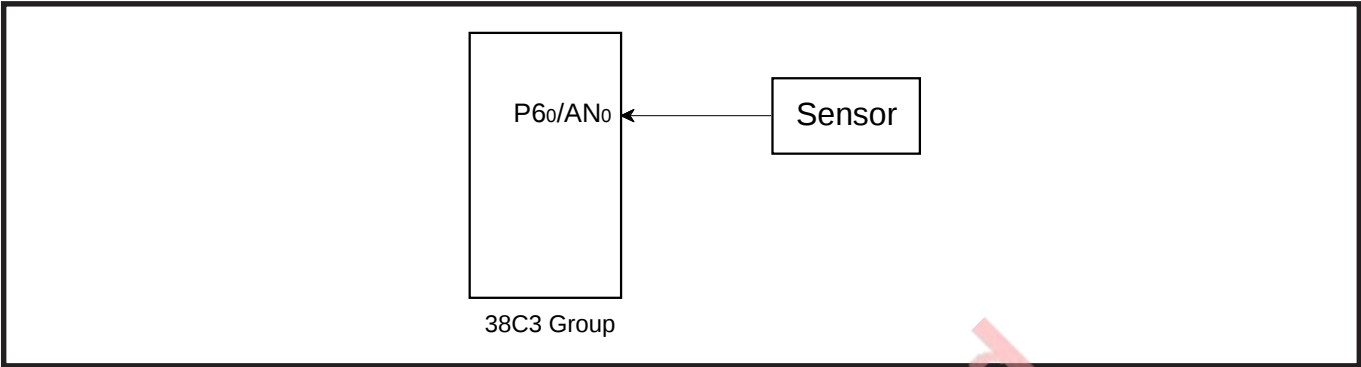


Fig. 2.5.7 Connection diagram

**Specifications:**

- Conversion of analog input voltage input from sensor to digital values
- Use of P60/AN0 pin as analog input pin

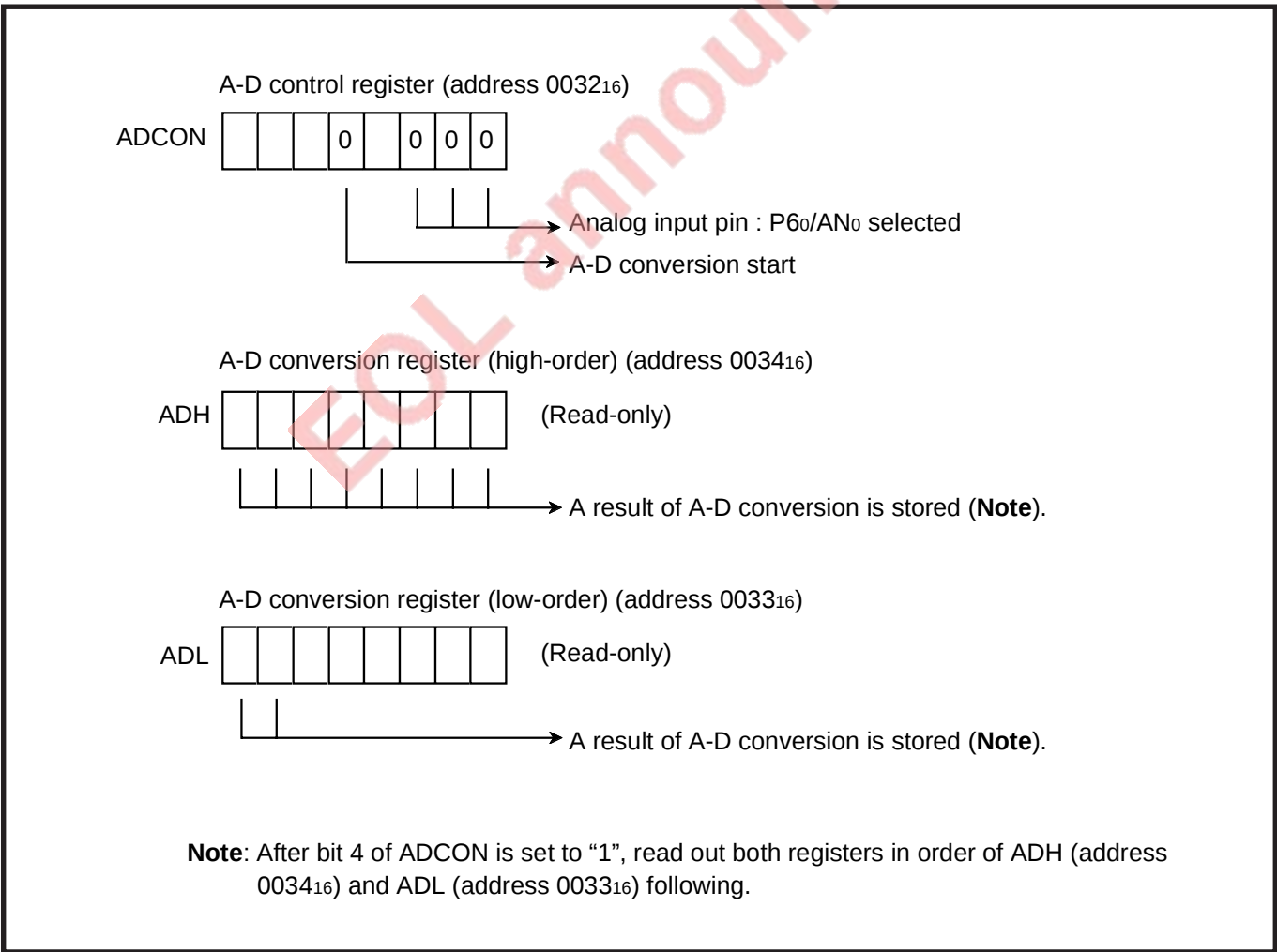


Fig. 2.5.8 Setting of relevant registers

**Control procedure:** A-D converter is started by performing register setting shown Figure 2.5.8. Figure 2.5.9 shows the control procedure.

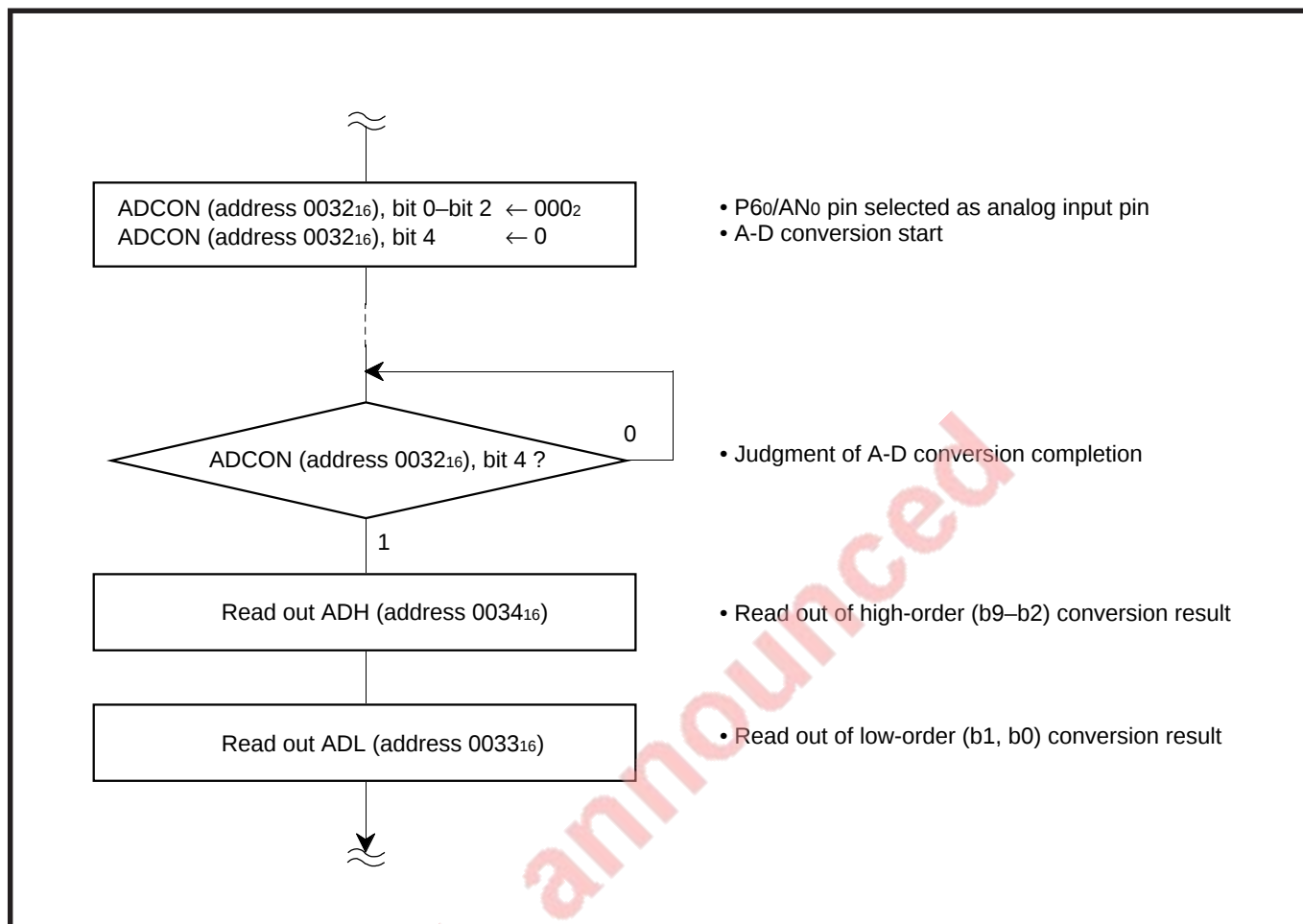


Fig. 2.5.9 Control procedure

# APPLICATION

## 2.5 A-D converter

---

### 2.5.4 Notes on A-D converter

#### (1) Analog input pin

- Make the signal source impedance for analog input low, or equip an analog input pin with an external capacitor of 0.01  $\mu\text{F}$  to 1  $\mu\text{F}$ . Further, be sure to verify the operation of application products on the user side.

#### ● Reason

An analog input pin includes the capacitor for analog voltage comparison. Accordingly, when signals from signal source with high impedance are input to an analog input pin, charge and discharge noise generates. This may cause the A-D conversion precision to be worse.

#### (2) A-D converter power source pin

The AVss pin is A-D converter power source pin. Regardless of using the A-D conversion function or not, connect it as following :

- AVss : Connect to the Vss line.

#### ● Reason

If the AVss pin is opened, the microcomputer may have a failure because of noise or others.

#### (3) Clock frequency during A-D conversion

The comparator consists of a capacity coupling, and a charge of the capacity will be lost if the clock frequency is too low. Thus, make sure the following during an A-D conversion.

- $f(X_{IN})$  is 500 kHz or more.
- Use clock divided by main clock ( $f(X_{IN})$ ) as internal system clock.
- Do not execute the **STP** instruction and **WIT** instruction.

## 2.6 ROM correct function

This paragraph describes the setting method of ROM correct function relevant registers, notes etc.

### 2.6.1 Memory map

| Address            |                                                  |
|--------------------|--------------------------------------------------|
| 0050 <sub>16</sub> | ROM correct data 1                               |
| 0051 <sub>16</sub> | ROM correct data 2                               |
| 0052 <sub>16</sub> | ROM correct data 3                               |
| 0053 <sub>16</sub> | ROM correct data 4                               |
| 0054 <sub>16</sub> | ROM correct data 5                               |
| 0055 <sub>16</sub> | ROM correct data 6                               |
| 0056 <sub>16</sub> | ROM correct data 7                               |
| 0057 <sub>16</sub> | ROM correct data 8                               |
| ≈                  | ≈                                                |
| 0F01 <sub>16</sub> | ROM correct enable register 1 (RC1) (Note)       |
| 0F02 <sub>16</sub> | ROM correct high-order address register 1 (Note) |
| 0F03 <sub>16</sub> | ROM correct low-order address register 1 (Note)  |
| 0F04 <sub>16</sub> | ROM correct high-order address register 2 (Note) |
| 0F05 <sub>16</sub> | ROM correct low-order address register 2 (Note)  |
| 0F06 <sub>16</sub> | ROM correct high-order address register 3 (Note) |
| 0F07 <sub>16</sub> | ROM correct low-order address register 3 (Note)  |
| 0F08 <sub>16</sub> | ROM correct high-order address register 4 (Note) |
| 0F09 <sub>16</sub> | ROM correct low-order address register 4 (Note)  |
| 0F0A <sub>16</sub> | ROM correct high-order address register 5 (Note) |
| 0F0B <sub>16</sub> | ROM correct low-order address register 5 (Note)  |
| 0F0C <sub>16</sub> | ROM correct high-order address register 6 (Note) |
| 0F0D <sub>16</sub> | ROM correct low-order address register 6 (Note)  |
| 0F0E <sub>16</sub> | ROM correct high-order address register 7 (Note) |
| 0F0F <sub>16</sub> | ROM correct low-order address register 7 (Note)  |
| 0F10 <sub>16</sub> | ROM correct high-order address register 8 (Note) |
| 0F11 <sub>16</sub> | ROM correct low-order address register 8 (Note)  |

**Note:** This register is valid only in mask ROM version.

Fig. 2.6.1 Memory map of ROM correct function relevant registers

# APPLICATION

## 2.6 ROM correct function

### 2.6.2 Relevant registers

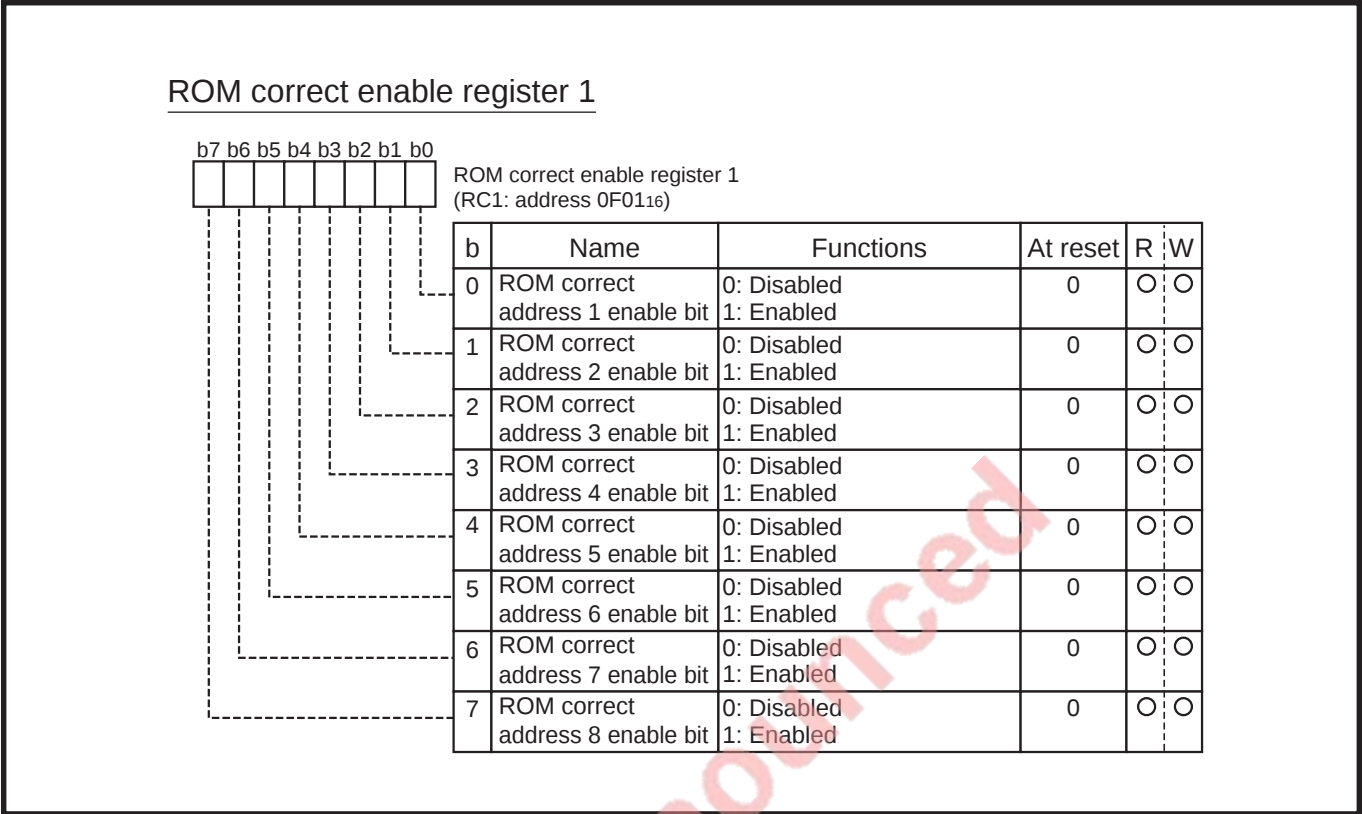


Fig. 2.6.2 Structure of ROM correct enable register 1

### 2.6.3 ROM correct function application examples

**Outline:** When the contents of ROM would be corrected, the contents of ROM can be changed artificially by connecting E<sup>2</sup>PROM to the externals and storing the contents (correct address, correct data) to the ROM correct function relevant registers.

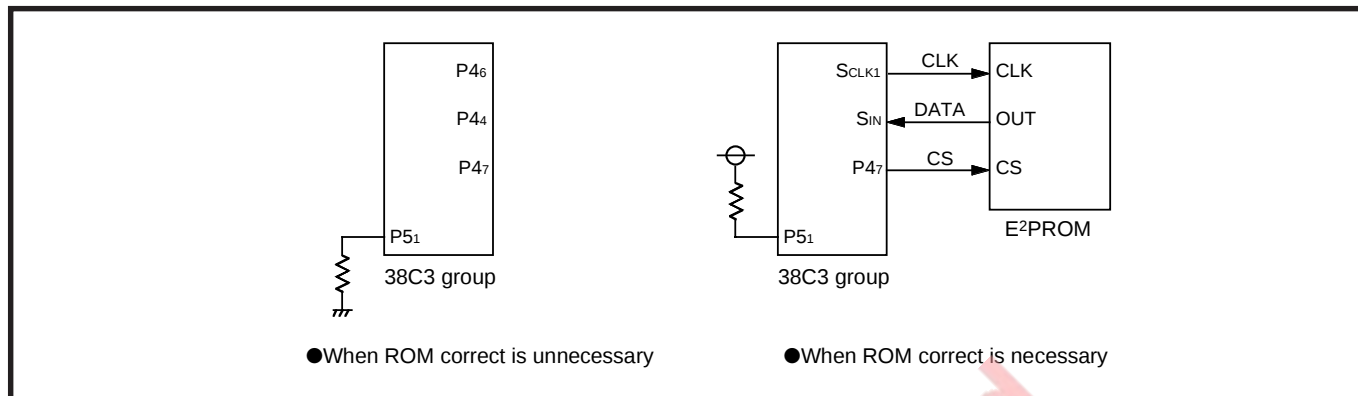


Fig. 2.6.3 Connection diagram

**Specifications:** ●If ROM correct is necessary, make P5<sub>1</sub> pull-up. If ROM correct is unnecessary, make P5<sub>1</sub> pull-down.

- Use of serial I/O as communication with E<sup>2</sup>PROM
- Connection of clock and S<sub>CLK1</sub>, connection of CS pin and P4<sub>7</sub>

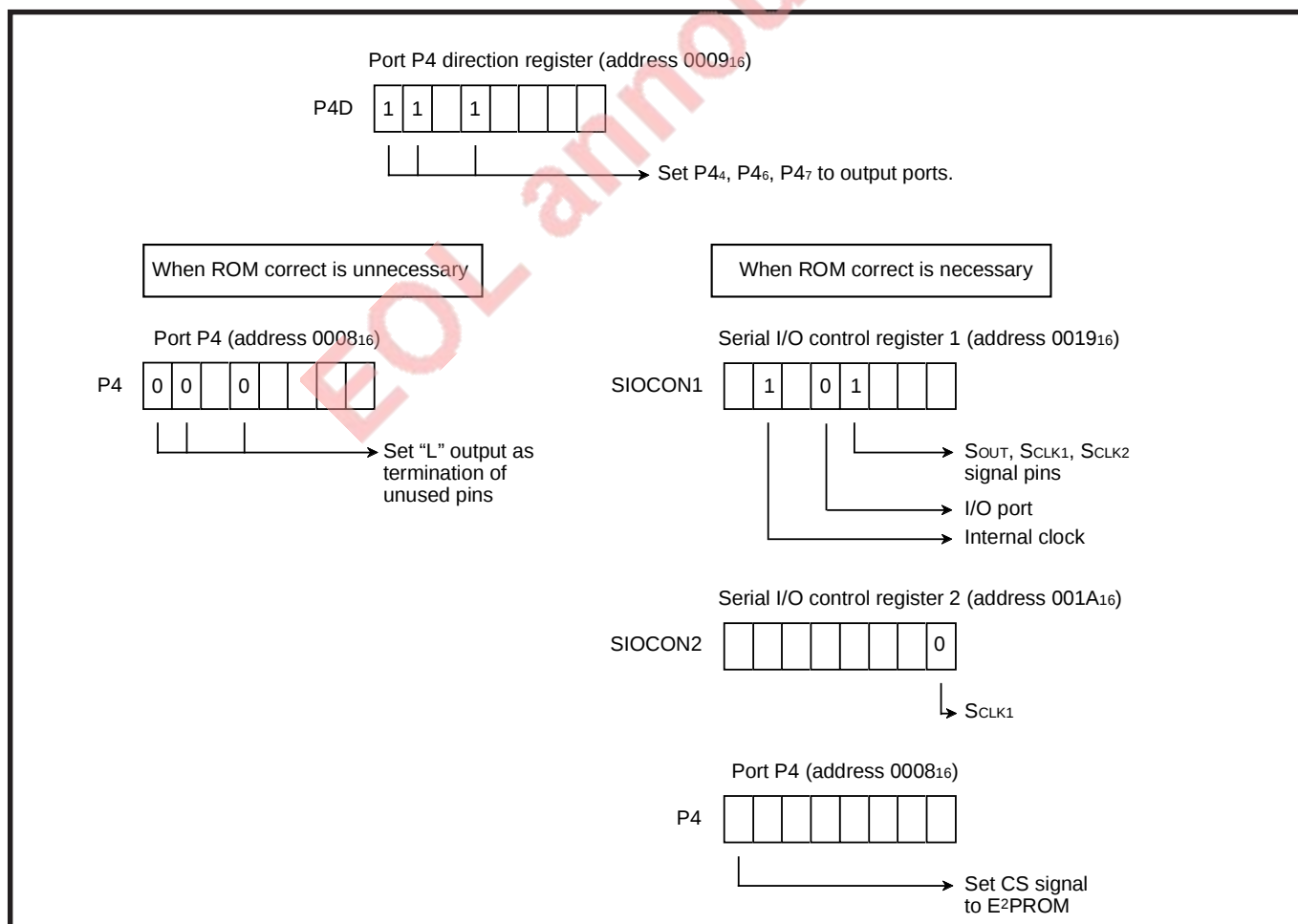


Fig. 2.6.4 Setting of relevant registers

# APPLICATION

## 2.6 ROM correct function

Control procedure:

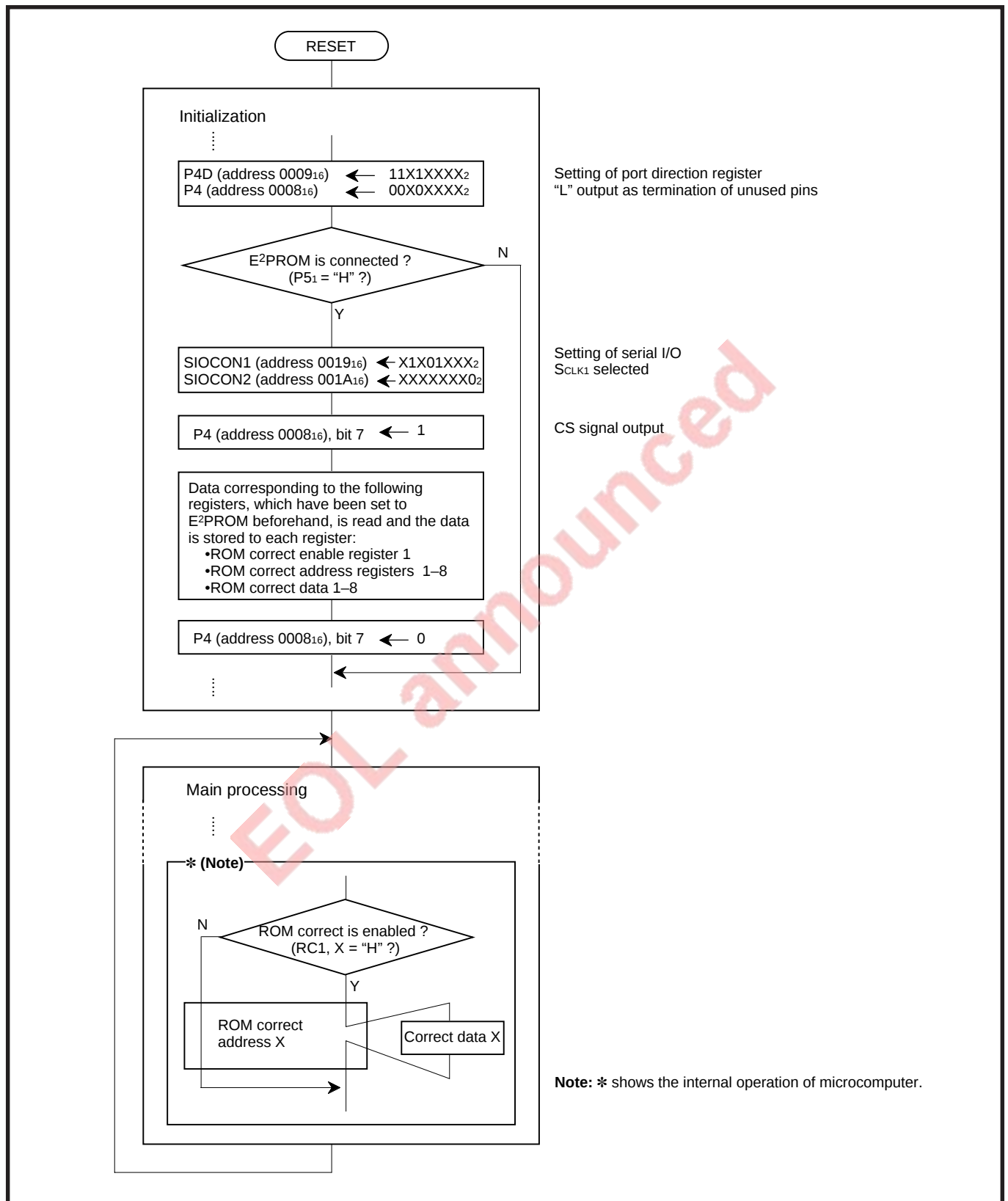


Fig. 2.6.5 Control procedure

## 2.7 Reset circuit

The reset state is caused by applying an “L” level to the  $\overline{\text{RESET}}$  pin. After that, the reset state is released by applying an “H” level to the  $\overline{\text{RESET}}$  pin, so that the program is executed in the middle-speed mode from the contents of the reset vector address.

### 2.7.1 Connection example of reset IC

Figure 2.7.1 shows the example of power-on reset circuit. Figure 2.7.2 shows the system example which switches to the RAM backup mode by detecting a drop of the system power source voltage with the INT interrupt.

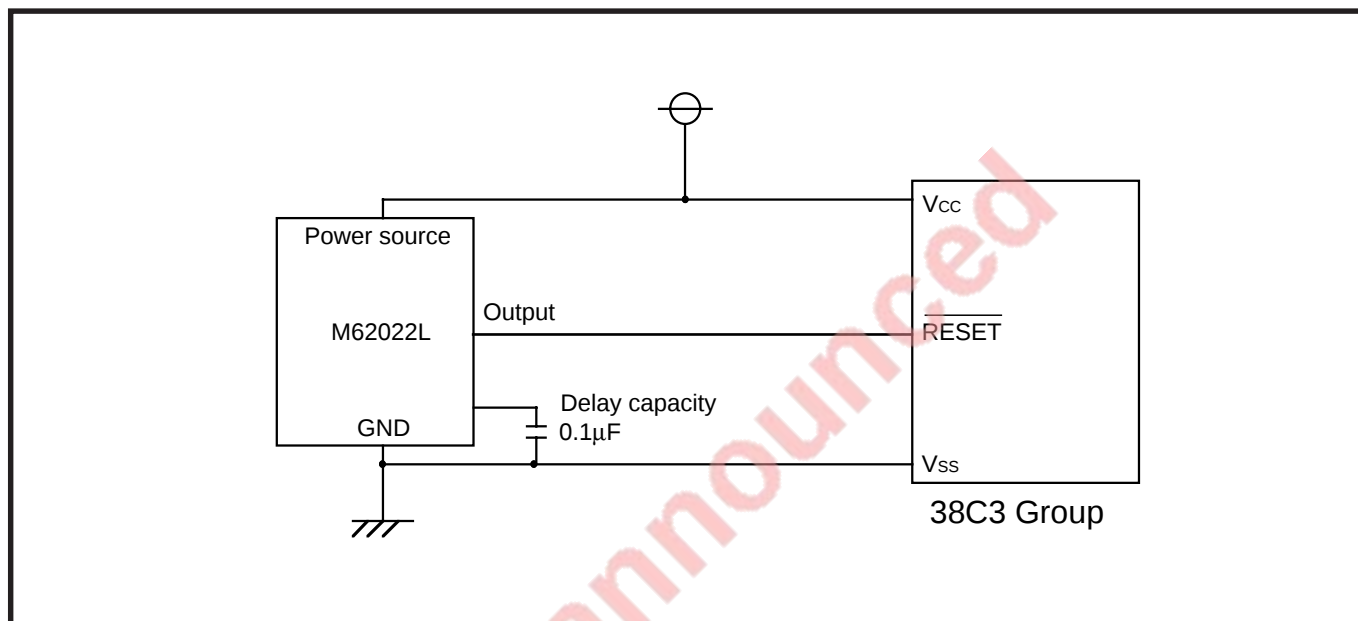


Fig. 2.7.1 Example of power-on reset circuit

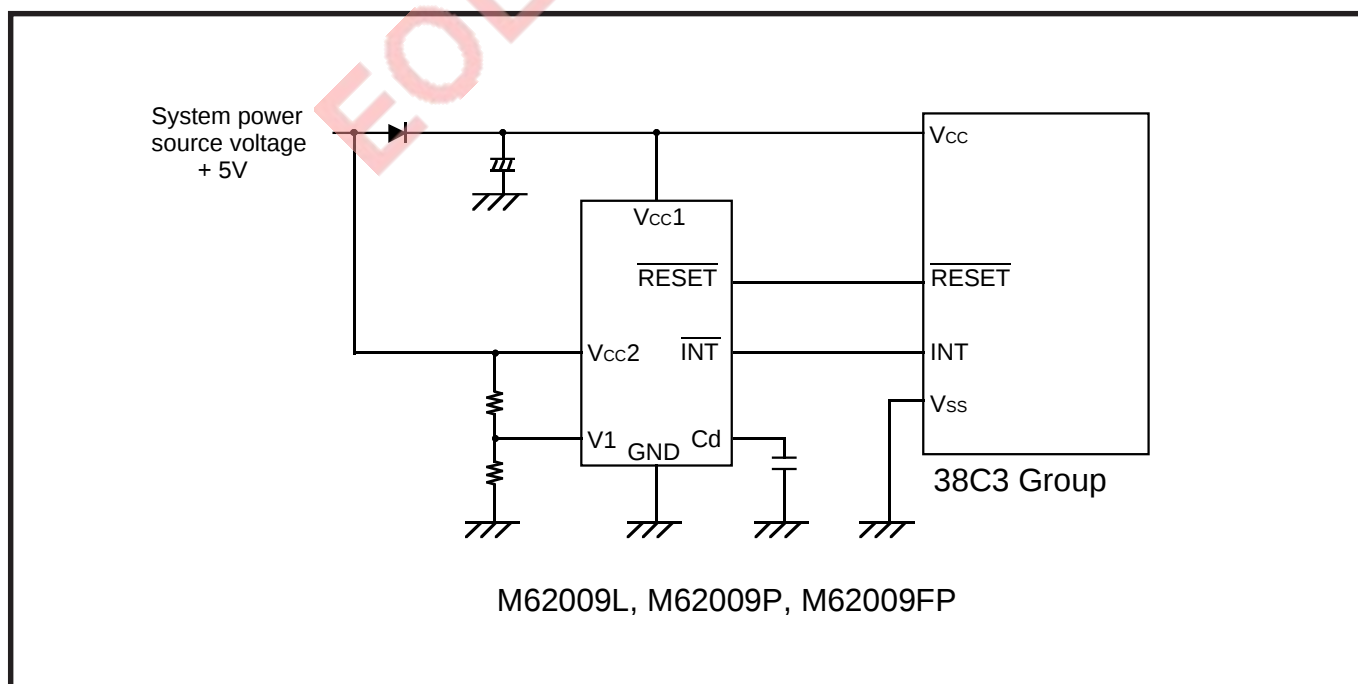


Fig. 2.7.2 RAM backup system example

# APPLICATION

## 2.7 Reset circuit

---

### 2.7.2 Notes on reset circuit

#### (1) Reset input voltage control

Make sure that the reset input voltage is 0.5 V or less for V<sub>CC</sub> of 2.5 V (**Note**).

Perform switch to the high-speed mode when power source voltage is within 4.0 to 5.5 V.

**Note:** M version of mask ROM version is 2.2 V.

#### (2) Countermeasure when $\overline{\text{RESET}}$ signal rise time is long

In case where the  $\overline{\text{RESET}}$  signal rise time is long, connect a ceramic capacitor or others across the  $\overline{\text{RESET}}$  pin and the V<sub>SS</sub> pin. And use a 1000 pF or more capacitor for high frequency use. When connecting the capacitor, note the following :

- Make the length of the wiring which is connected to a capacitor as short as possible.
- Be sure to verify the operation of application products on the user side.

#### ● Reason

If the several nanosecond or several ten nanosecond impulse noise enters the  $\overline{\text{RESET}}$  pin, it may cause a microcomputer failure.

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## 2.8 Clock generating circuit

This paragraph describes the setting method of clock generating circuit relevant registers, application examples etc.

### 2.8.1 Relevant register

Figure 2.8.1 shows the structure of the CPU mode register.

CPU mode register

| CPU mode register<br>(CPUM, CM: address 3B16) |                                         |                                                                                                                  |          |    |    |    |    |
|-----------------------------------------------|-----------------------------------------|------------------------------------------------------------------------------------------------------------------|----------|----|----|----|----|
| b7                                            | b6                                      | b5                                                                                                               | b4       | b3 | b2 | b1 | b0 |
|                                               |                                         |                                                                                                                  |          |    |    |    |    |
| b                                             | Name                                    | Functions                                                                                                        | At reset | R  | W  |    |    |
| 0                                             | Processor mode bits                     | <sup>b1 b0</sup><br>00 : Single-chip mode                                                                        | 0        | ○  | ○  |    |    |
| 1                                             |                                         | 01 :<br>10 :<br>11 : } Not available                                                                             | 0        | ○  | ○  |    |    |
| 2                                             |                                         | 0 : Page 0<br>1 : Page 1                                                                                         | 0        | ○  | ○  |    |    |
| 3                                             |                                         | Nothing is arranged for this bit. When this bit is read out, the contents are "1". Do not write "0" to this bit. | 1        | ○  | ○  |    |    |
| 4                                             | Port Xc switch bit                      | 0: I/O port function<br>1: XCIN-XCOUT oscillation function                                                       | 0        | ○  | ○  |    |    |
| 5                                             | Main clock (XIN-XOUT) stop bit          | 0: Oscillating<br>1: Stopped                                                                                     | 0        | ○  | ○  |    |    |
| 6                                             | Main clock division ratio selection bit | 0: f(XIN)/2 (high-speed mode)<br>1: f(XIN)/8 (middle-speed mode)                                                 | 1        | ○  | ○  |    |    |
| 7                                             | Internal system clock selection bit     | 0: XIN-XOUT selection (middle-/high-speed mode)<br>1: XCIN-XCOUT selection (low-speed mode)                      | 0        | ○  | ○  |    |    |

Fig. 2.8.1 Structure of CPU mode register

# APPLICATION

## 2.8 Clock generating circuit

### 2.8.2 Clock generating circuit application examples

#### (1) Status transition during power failure

**Outline:** The clock is counted up every one second by using the timer interrupt during a power failure.

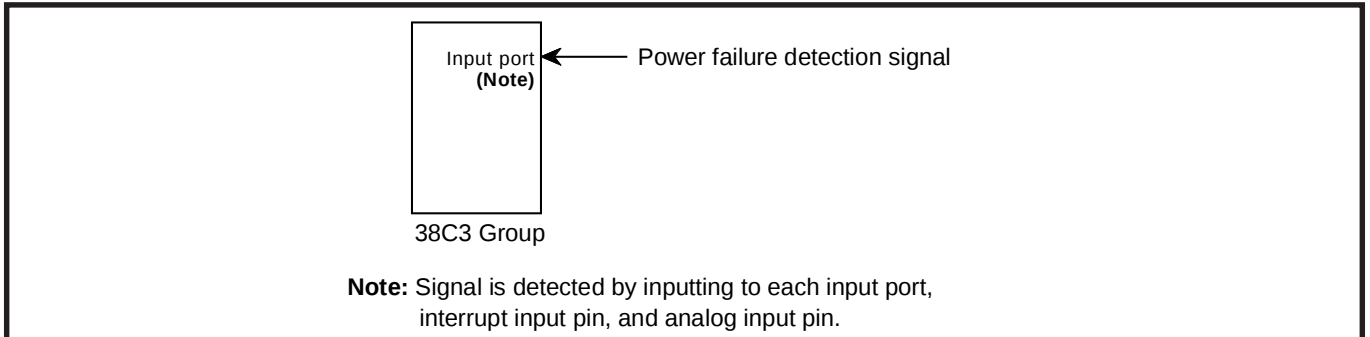


Fig. 2.8.2 Connection diagram

- Specifications:**
- Reducing power dissipation as low as possible while maintaining clock function
  - Clock:  $f(X_{IN}) = 8 \text{ MHz}$ ,  $f(X_{CIN}) = 32.768 \text{ kHz}$
  - Port processing
    - Input port: Fixed to "H" or "L" level on the external
    - Output port: Fixed to output level that does not cause current flow to the external  
(Example) When a circuit turns on LED at "L" output level, fix the output level to "H".
  - I/O port: Input port → Fixed to "H" or "L" level on the external  
Output port → Output of data that does not consume current
  - $V_{REF}$ : Stop to supply to reference voltage input pin by external circuit

Figure 2.8.3 shows the status transition diagram during power failure and Figure 2.8.4 shows the setting of relevant registers.

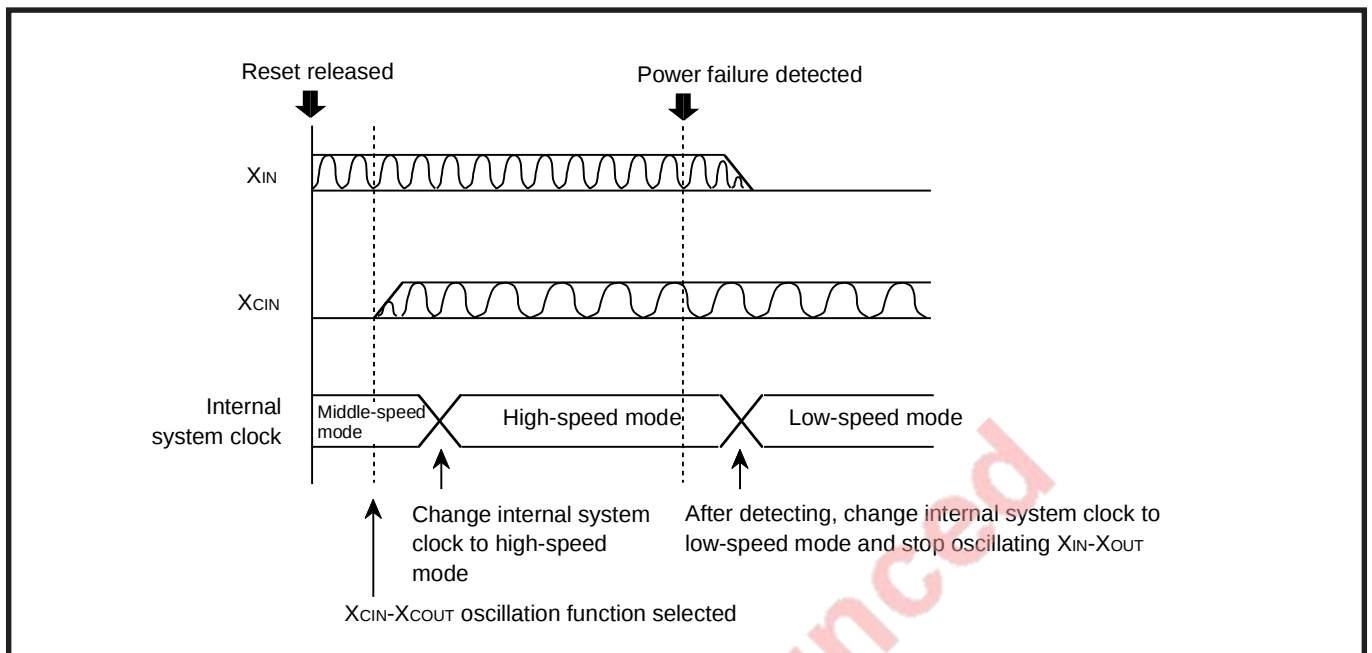
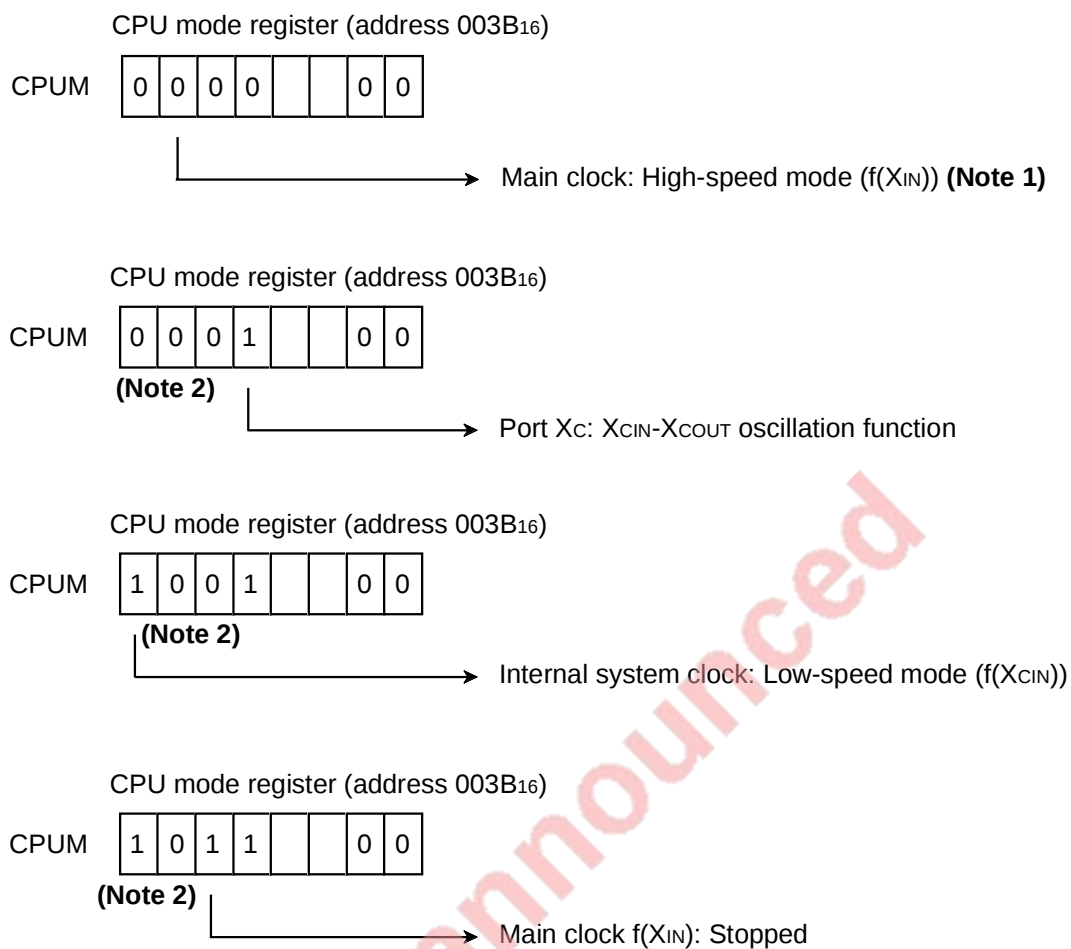


Fig. 2.8.3 Status transition diagram during power failure

# APPLICATION

## 2.8 Clock generating circuit



**Notes 1:** This setting is necessary only when selecting the high-speed mode.

**2:** When selecting the middle-speed mode, bit 6 is "1".

Fig. 2.8.4 Setting of relevant registers

**Control procedure:** Set the relevant registers in the order shown below to prepare for a power failure.

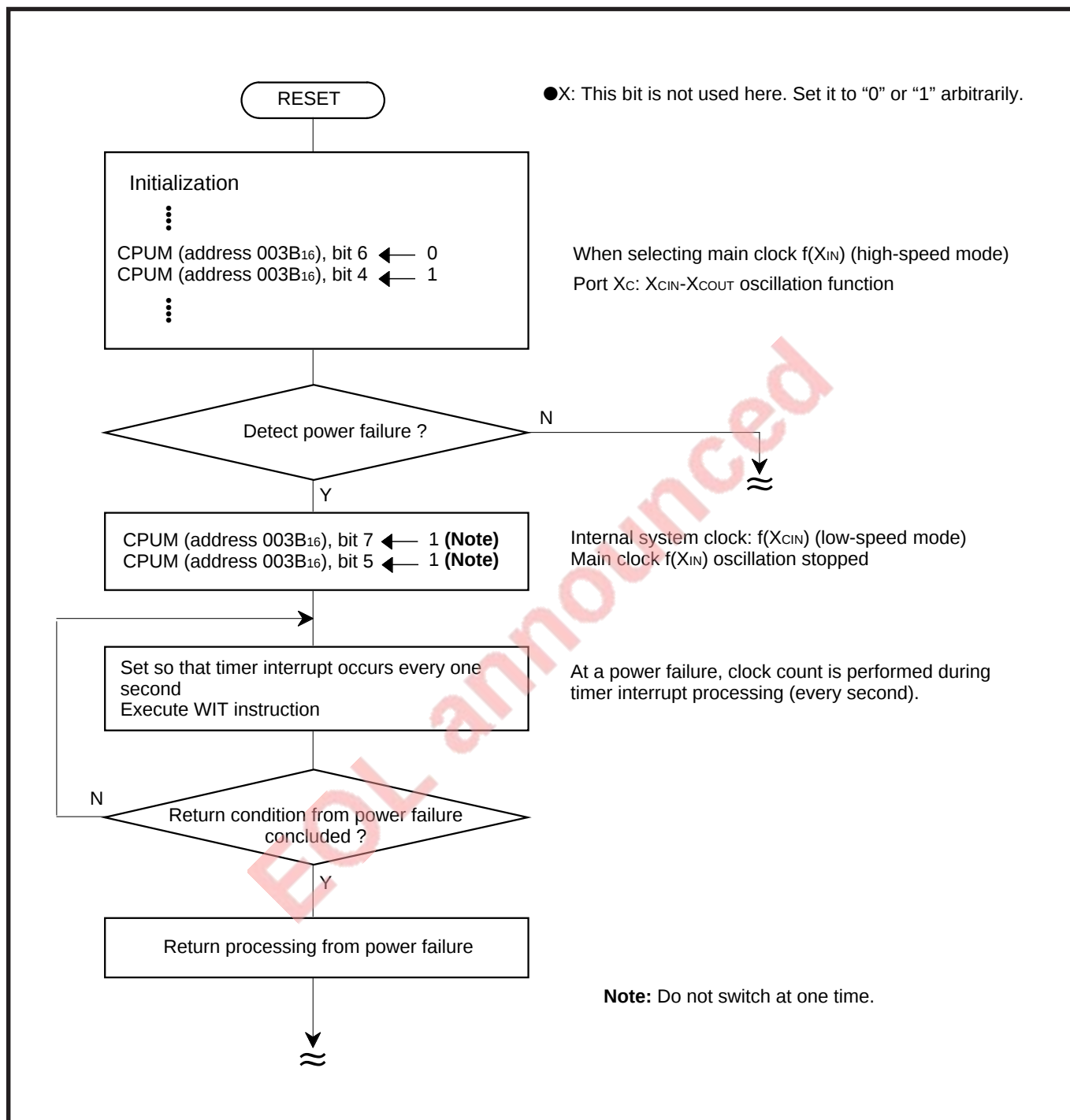


Fig. 2.8.5 Control procedure

# APPLICATION

## 2.8 Clock generating circuit

### (2) Counting without clock error during power failure

**Outline:** It keeps counting without clock error during a power failure.

**Specifications:** •Reducing power consumption as low as possible while maintaining clock function

•Clock:  $f(X_{IN}) = 4.19 \text{ MHz}$

•Sub clock:  $f(X_{CIN}) = 32.768 \text{ kHz}$

•Use of Timer 3 interrupt

For the peripheral circuit and the status transition during a power failure, refer to “**Figures 2.8.2 and 2.8.3**”.

Figure 2.8.6 shows the structure of clock counter, Figures 2.8.7 and 2.8.8 show the setting of relevant registers.

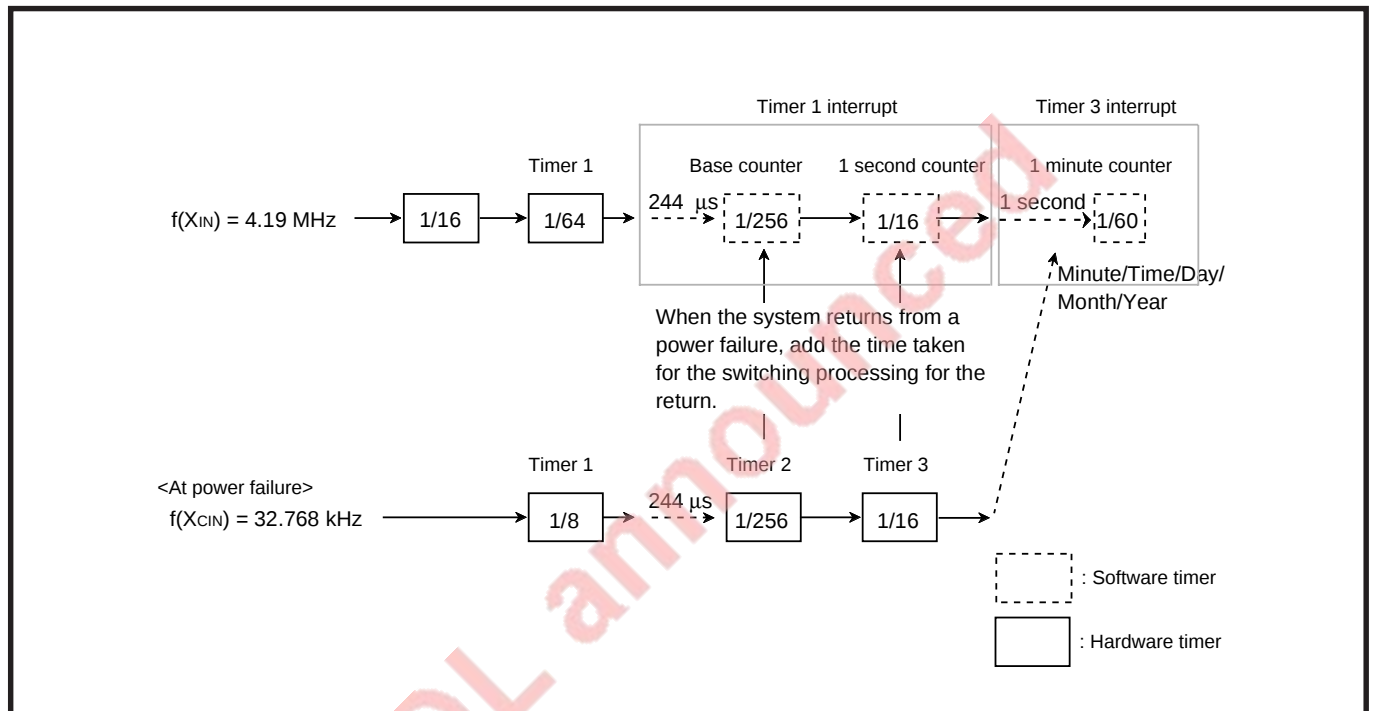


Fig. 2.8.6 Structure of clock counter

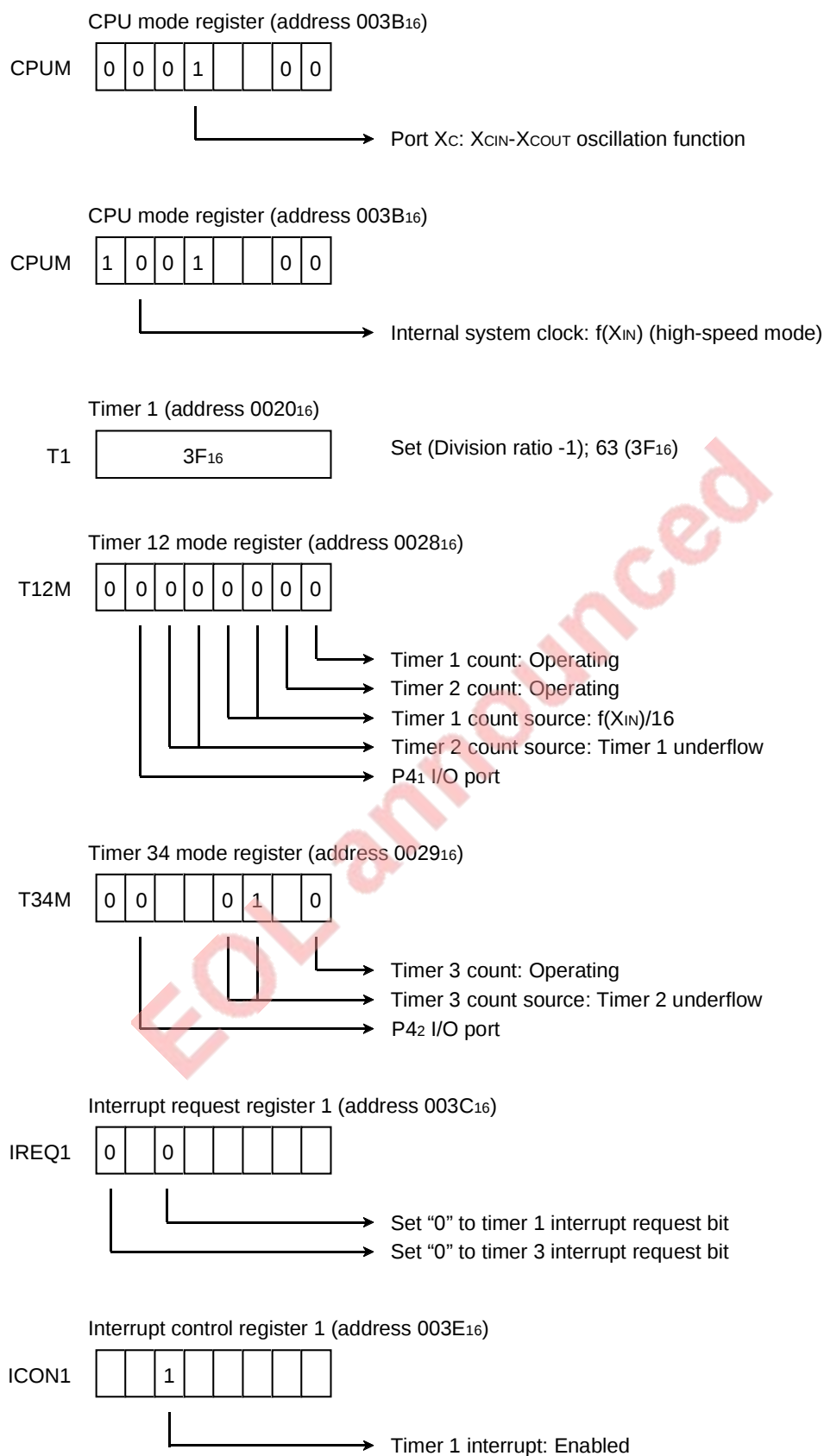


Fig. 2.8.7 Initial setting of relevant registers

# APPLICATION

## 2.8 Clock generating circuit

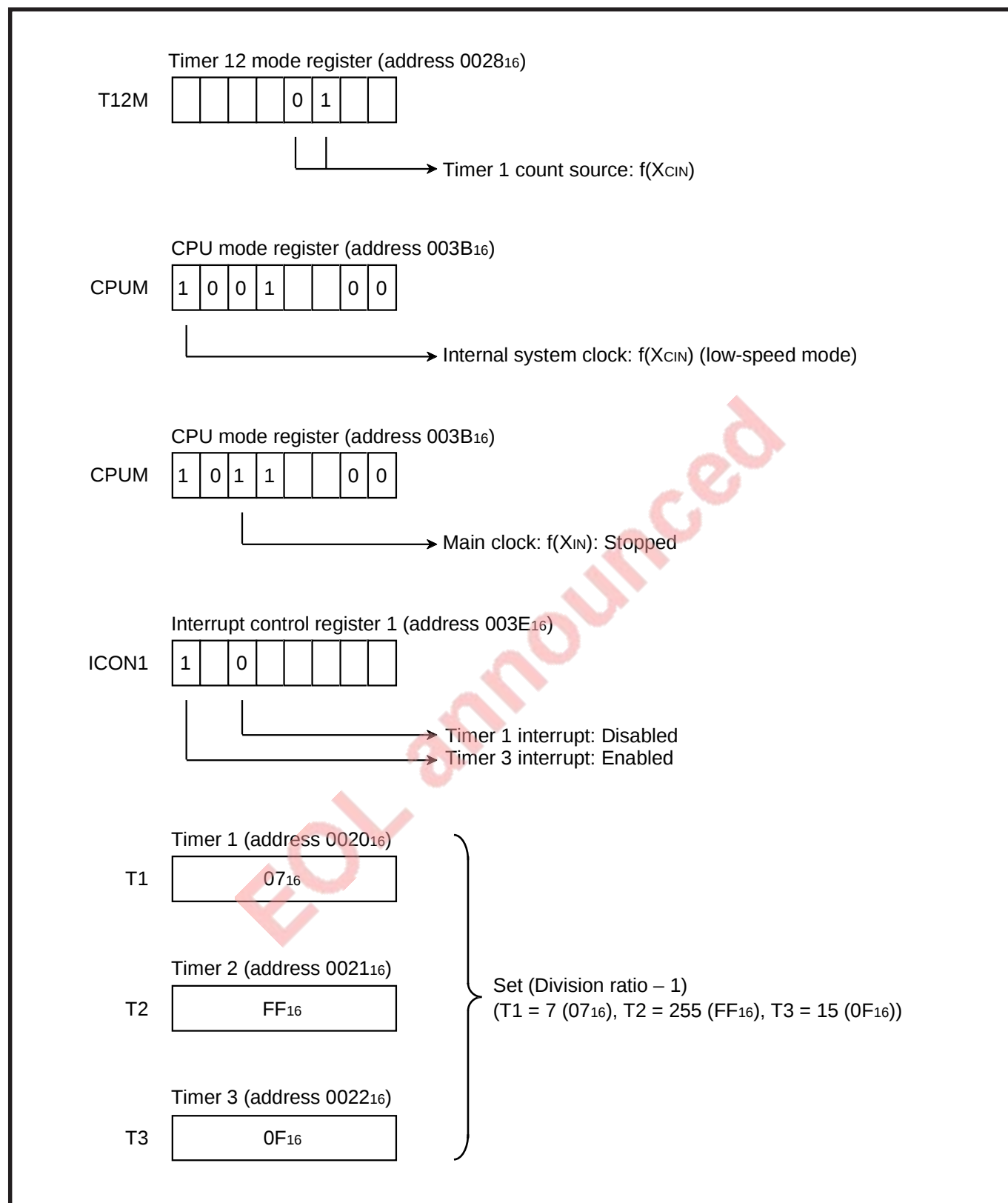


Fig. 2.8.8 Setting of relevant registers after detecting power failure

**Control procedure:** Set the relevant registers in the order shown below to prepare for a power failure.

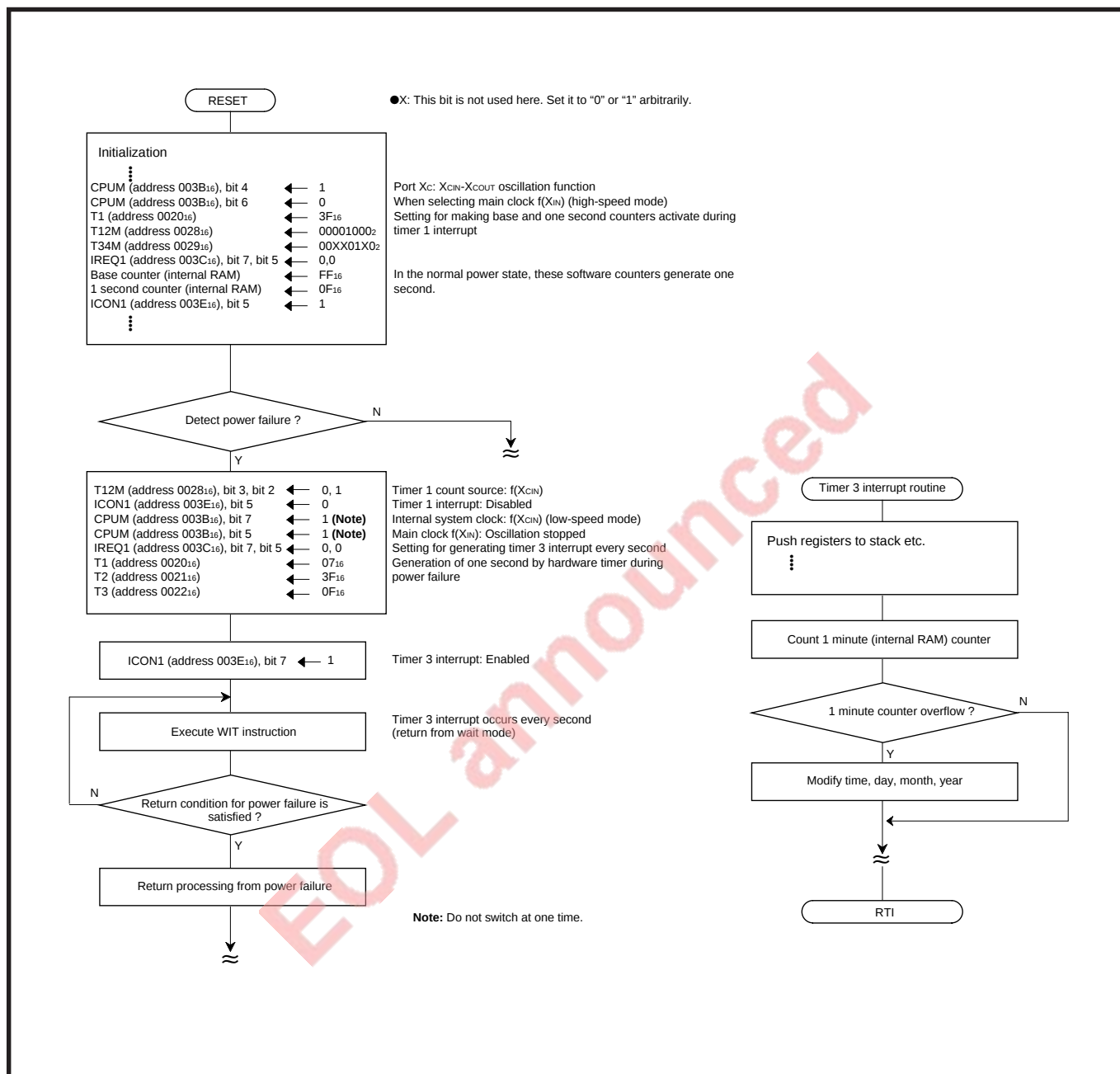


Fig. 2.8.9 Control procedure

# APPLICATION

## 2.8 Clock generating circuit

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### *MEMORANDUM*

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## CHAPTER 3

# APPENDIX

- 3.1 Electrical characteristics
- 3.2 Standard characteristics
- 3.3 Notes on use
- 3.4 Countermeasures against noise
- 3.5 Control registers
- 3.6 Mask ROM confirmation form
- 3.7 ROM programming confirmation form
- 3.8 Mark specification form
- 3.9 Package outline
- 3.10 Machine instructions
- 3.11 List of instruction code
- 3.12 SFR memory map
- 3.13 Pin configuration

# APPENDIX

## 3.1 Electrical characteristics

### 3.1 Electrical characteristics

#### 3.1.1 Absolute maximum ratings

**Table 3.1.1 Absolute maximum ratings**

| Symbol           | Parameter                                                                             | Conditions                                                                  | Ratings                                 | Unit |
|------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------|------|
| V <sub>CC</sub>  | Power source voltage                                                                  | All voltages are based on V <sub>SS</sub> . Output transistors are cut off. | –0.3 to 7.0                             | V    |
| V <sub>I</sub>   | Input voltage P00–P07, P10–P17, P20–P27, P40–P47, P50–P57, P60–P67, P70, P71, P80–P87 |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>I</sub>   | Input voltage V <sub>L1</sub>                                                         |                                                                             | –0.3 to V <sub>L2</sub>                 | V    |
| V <sub>I</sub>   | Input voltage V <sub>L2</sub>                                                         |                                                                             | V <sub>L1</sub> to V <sub>L3</sub>      | V    |
| V <sub>I</sub>   | Input voltage V <sub>L3</sub>                                                         |                                                                             | V <sub>L2</sub> to V <sub>CC</sub> +0.3 | V    |
| V <sub>I</sub>   | Input voltage RESET, X <sub>IN</sub>                                                  |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage P00–P07, P10–P17, P20–P27, P30–P37                                     | At output port                                                              | –0.3 to V <sub>CC</sub> +0.3            | V    |
|                  |                                                                                       | At segment output                                                           | –0.3 to V <sub>L3</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage COM0–COM3                                                              |                                                                             | –0.3 to V <sub>L3</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage P40–P47, P50, P52–P57, P60–P67, P70, P71, P80–P87                      |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage X <sub>OUT</sub>                                                       |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| P <sub>d</sub>   | Power dissipation                                                                     | T <sub>a</sub> = 25°C                                                       | 300                                     | mW   |
| T <sub>opr</sub> | Operating temperature                                                                 |                                                                             | –20 to 85                               | °C   |
| T <sub>stg</sub> | Storage temperature                                                                   |                                                                             | –40 to 125                              | °C   |

#### 3.1.2 Recommended operating conditions

**Table 3.1.2 Recommended operating conditions**

(V<sub>CC</sub> = 2.5 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol           | Parameter                       |                                               | Limits             |      |                     | Unit |
|------------------|---------------------------------|-----------------------------------------------|--------------------|------|---------------------|------|
|                  |                                 |                                               | Min.               | Typ. | Max.                |      |
| V <sub>CC</sub>  | Power source voltage            | High-speed mode f(X <sub>IN</sub> ) = 8 MHz   | 4.0                | 5.0  | 5.5                 | V    |
|                  |                                 | Middle-speed mode f(X <sub>IN</sub> ) = 8 MHz | 2.5                | 5.0  | 5.5                 | V    |
|                  |                                 | Low-speed mode                                | 2.5                | 5.0  | 5.5                 | V    |
| V <sub>SS</sub>  | Power source voltage            |                                               |                    | 0    |                     | V    |
| V <sub>REF</sub> | A-D converter reference voltage |                                               | 2.0                |      | V <sub>CC</sub>     | V    |
| AV <sub>SS</sub> | Analog power source voltage     |                                               |                    | 0    |                     | V    |
| V <sub>IA</sub>  | Analog input voltage AN0–AN7    |                                               | AV <sub>SS</sub>   |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub>  | "H" input voltage               | P00–P07, P10–P17, P20–P27                     | 0.7V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub>  | "H" input voltage               | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub>  | "H" input voltage               | P80–P87                                       | 0.4V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub>  | "H" input voltage               | RESET                                         | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub>  | "H" input voltage               | X <sub>IN</sub>                               | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IL</sub>  | "L" input voltage               | P00–P07, P10–P17, P20–P27                     | 0                  |      | 0.3V <sub>CC</sub>  | V    |
| V <sub>IL</sub>  | "L" input voltage               | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0                  |      | 0.2V <sub>CC</sub>  | V    |
| V <sub>IL</sub>  | "L" input voltage               | P80–P87                                       | 0                  |      | 0.16V <sub>CC</sub> | V    |
| V <sub>IL</sub>  | "L" input voltage               | RESET                                         | 0                  |      | 0.2V <sub>CC</sub>  | V    |
| V <sub>IL</sub>  | "L" input voltage               | X <sub>IN</sub>                               | 0                  |      | 0.2V <sub>CC</sub>  | V    |

## 3.1 Electrical characteristics

**Table 3.1.3 Recommended operating conditions**(V<sub>CC</sub> = 2.5 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol     | Parameter                                                                                                | Limits |      |      | Unit |
|------------|----------------------------------------------------------------------------------------------------------|--------|------|------|------|
|            |                                                                                                          | Min.   | Typ. | Max. |      |
| ΣIOH(peak) | "H" total peak output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37<br>P80–P87, P50    |        |      | –60  | mA   |
| ΣIOH(peak) | "H" total peak output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                   |        |      | –30  | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                    |        |      | 40   | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P80–P87, P50                                          |        |      | 80   | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                   |        |      | 40   | mA   |
| ΣIOH(avg)  | "H" total average output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37<br>P80–P87, P50 |        |      | –30  | mA   |
| ΣIOH(avg)  | "H" total average output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                |        |      | –15  | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                 |        |      | 20   | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P80–P87, P50                                       |        |      | 40   | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                |        |      | 20   | mA   |
| IOH(peak)  | "H" peak output current ( <b>Note 2</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                          |        |      | –4.0 | mA   |
| IOH(peak)  | "H" peak output current ( <b>Note 2</b> )<br>P40–P47, P50, P52–P57, P60–P67, P70, P71<br>P80–P87         |        |      | –10  | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                          |        |      | 5.0  | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                         |        |      | 10   | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P80–P87, P50                                                |        |      | 30   | mA   |
| IOH(avg)   | "H" average output current ( <b>Note 3</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                       |        |      | –2.0 | mA   |
| IOH(avg)   | "H" average output current ( <b>Note 3</b> )<br>P40–P47, P50, P52–P57, P60–P67, P70, P71<br>P80–P87      |        |      | –5.0 | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                       |        |      | 2.5  | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                      |        |      | 5.0  | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P80–P87, P50                                             |        |      | 15   | mA   |

**Notes 1:** The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.

**2:** The peak output current is the peak current flowing in each port.

**3:** The average output current is average value measured over 100 ms.

# APPENDIX

## 3.1 Electrical characteristics

**Table 3.1.4 Recommended operating conditions**

(V<sub>CC</sub> = 2.5 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                | Parameter                                          |                                                      | Limits |        |                        | Unit |
|-----------------------|----------------------------------------------------|------------------------------------------------------|--------|--------|------------------------|------|
|                       |                                                    |                                                      | Min.   | Typ.   | Max.                   |      |
| f(CNTR <sub>0</sub> ) | Input frequency (duty cycle 50%)                   | (4.0 V ≤ V <sub>CC</sub> ≤ 5.5 V)                    |        |        | 4.0                    | MHz  |
| f(CNTR <sub>1</sub> ) |                                                    | (V <sub>CC</sub> ≤ 4.0 V)                            |        |        | (2×V <sub>CC</sub> )–4 | MHz  |
| f(X <sub>IN</sub> )   | Main clock input oscillation frequency (Note 4)    | High-speed mode<br>(4.0 V ≤ V <sub>CC</sub> ≤ 5.5 V) |        |        | 8.0                    | MHz  |
|                       |                                                    | High-speed mode<br>(V <sub>CC</sub> ≤ 4.0 V)         |        |        | (4×V <sub>CC</sub> )–8 | MHz  |
|                       |                                                    | Middle-speed mode                                    |        |        | 8.0                    | MHz  |
| f(X <sub>CIN</sub> )  | Sub-clock input oscillation frequency (Notes 4, 5) |                                                      |        | 32.768 | 50                     | kHz  |

**Notes 4:** When the oscillation frequency has a duty cycle of 50%.

**5:** When using the microcomputer in low-speed mode, set the sub-clock input oscillation frequency on condition that f(X<sub>CIN</sub>) < f(X<sub>IN</sub>)/3.

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## 3.1.3 Electrical characteristics

Table 3.1.5 Electrical characteristics

(V<sub>CC</sub> = 4.0 to 5.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol                           | Parameter                                                                     | Test conditions                                                             | Limits               |      |      | Unit |
|----------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------|------|------|------|
|                                  |                                                                               |                                                                             | Min.                 | Typ. | Max. |      |
| V <sub>OH</sub>                  | “H” output voltage<br>P00–P07, P10–P17, P20–P27,<br>P30–P37                   | I <sub>OH</sub> = -2.0 mA                                                   | V <sub>CC</sub> -2.0 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -0.6 mA                                                   | V <sub>CC</sub> -1.0 |      |      | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OH</sub>                  | “H” output voltage<br>P40–P47, P50, P52–P57,<br>P60–P67, P70, P71,<br>P80–P87 | I <sub>OH</sub> = -5 mA                                                     | V <sub>CC</sub> -2.0 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -1.25 mA                                                  | V <sub>CC</sub> -0.5 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -1.25 mA                                                  | V <sub>CC</sub> -1.0 |      |      | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage<br>P00–P07, P10–P17, P20–P27,<br>P30–P37                   | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 2.0  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 1.25 mA                                                   |                      |      | 0.5  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 1.25 mA                                                   |                      |      | 1.0  | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage<br>P40–P47, P52–P57, P60–P67,<br>P70, P71                  | I <sub>OL</sub> = 5.0 mA                                                    |                      |      | 2.0  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 0.5  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 1.0  | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage P80–P87, P50                                               | I <sub>OL</sub> = 15 mA                                                     |                      |      | 2.0  | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis<br>INT0–INT2, CNTR0, CNTR1, P80–P87                                |                                                                             |                      | 0.5  |      | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis SCLK1, SIN                                                         |                                                                             |                      | 0.5  |      | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis RESET                                                              | RESET:<br>V <sub>CC</sub> = 2.5 V – 5.5 V                                   |                      | 0.5  |      | V    |
| I <sub>IH</sub>                  | “H” input current<br>P00–P07, P10–P17, P20–P27                                | V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “off”                         |                      |      | 5.0  | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 5.0 V, V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “on” | 30                   | 70   | 140  | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 3.0 V, V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “on” | 6.0                  | 25   | 45   | μA   |
|                                  |                                                                               |                                                                             |                      |      |      |      |
| I <sub>IH</sub>                  | “H” input current<br>P40–P47, P50–P57, P60–P67,<br>P70, P71, P80–P87          | V <sub>I</sub> = V <sub>CC</sub>                                            |                      |      | 5.0  | μA   |
| I <sub>IH</sub>                  | “H” input current RESET                                                       | V <sub>I</sub> = V <sub>CC</sub>                                            |                      |      | 5.0  | μA   |
| I <sub>IH</sub>                  | “H” input current XIN                                                         | V <sub>I</sub> = V <sub>CC</sub>                                            |                      | 4.0  |      | μA   |
| I <sub>IL</sub>                  | “L” input current<br>P00–P07, P10–P17, P20–P27, P51                           |                                                                             |                      |      | -5.0 | μA   |
| I <sub>IL</sub>                  | “L” input current<br>P40–P47, P50, P52–P57,<br>P60–P67, P70, P71, P80–P87     | V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “off”                           |                      |      | -5.0 | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 5.0 V, V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “on”   | -30                  | -70  | -140 | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 3.0 V, V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “on”   | -6                   | -25  | -45  | μA   |
|                                  |                                                                               |                                                                             |                      |      |      |      |
| I <sub>IL</sub>                  | “L” input current RESET                                                       | V <sub>I</sub> = V <sub>SS</sub>                                            |                      |      | -5   | μA   |
| I <sub>IL</sub>                  | “L” input current XIN                                                         | V <sub>I</sub> = V <sub>SS</sub>                                            |                      | -4   |      | μA   |

**Note:** When “1” is set to the port Xc switch bit (bit 4 of address 003B16) of the CPU mode register, the drive ability of Port P71 is different from the value above mentioned.

# APPENDIX

## 3.1 Electrical characteristics

**Table 3.1.6 Electrical characteristics**

(V<sub>CC</sub> = 2.5 to 5.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol          | Parameter            | Test conditions                                                                                                                                                                      | Limits                 |      |      | Unit |
|-----------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|------|------|
|                 |                      |                                                                                                                                                                                      | Min.                   | Typ. | Max. |      |
| VRAM            | RAM hold voltage     | When clock is stopped                                                                                                                                                                | 2.0                    |      | 5.5  | V    |
| I <sub>CC</sub> | Power source current | High-speed mode, V <sub>CC</sub> = 5 V<br>f(X <sub>IN</sub> ) = 8 MHz<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off",<br>A-D converter in operating                |                        | 6.4  | 13   | mA   |
|                 |                      | High-speed mode, V <sub>CC</sub> = 5 V<br>f(X <sub>IN</sub> ) = 8 MHz (in WIT state)<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off",<br>A-D converter stopped      |                        | 1.6  | 3.2  | mA   |
|                 |                      | Low-speed mode, V <sub>CC</sub> = 3 V,<br>T <sub>a</sub> ≤ 55 °C<br>f(X <sub>IN</sub> ) = stopped<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off"                   |                        | 15   | 22   | μA   |
|                 |                      | Low-speed mode, V <sub>CC</sub> = 3 V,<br>T <sub>a</sub> = 25 °C<br>f(X <sub>IN</sub> ) = stopped<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>(in WIT state)<br>Output transistors "off" |                        | 4.5  | 9.0  | μA   |
|                 |                      | All oscillation stopped<br>(in STP state)                                                                                                                                            | T <sub>a</sub> = 25 °C | 0.1  | 1.0  | μA   |
|                 |                      | Output transistors "off"                                                                                                                                                             | T <sub>a</sub> = 85 °C |      | 10   | μA   |

## 3.1.4 A-D converter characteristics

**Table 3.1.7 A-D converter characteristics**(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = -20 to 85°C, 4 MHz ≤ f(X<sub>IN</sub>) ≤ 8 MHz, in middle-speed/high-speed mode)

| Symbol            | Parameter                                        | Test conditions                             | Limits |      |      | Unit  |
|-------------------|--------------------------------------------------|---------------------------------------------|--------|------|------|-------|
|                   |                                                  |                                             | Min.   | Typ. | Max. |       |
| —                 | Resolution                                       |                                             |        |      | 10   | Bits  |
| —                 | Absolute accuracy (excluding quantization error) | V <sub>CC</sub> = V <sub>REF</sub> = 5.12 V |        | ±1   | ±2.5 | LSB   |
| T <sub>conv</sub> | Conversion time                                  |                                             | 61     |      | 62   | tc(φ) |
| I <sub>VREF</sub> | Reference input current                          | V <sub>REF</sub> = 5 V                      | 50     | 150  | 200  | μA    |
| I <sub>IA</sub>   | Analog port input current                        |                                             |        | 0.5  | 5.0  | μA    |
| RLADDER           | Ladder resistor                                  |                                             |        | 35   |      | kΩ    |

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# APPENDIX

## 3.1 Electrical characteristics

### 3.1.5 Timing requirements and switching characteristics

**Table 3.1.8 Timing requirements 1**

(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits |      |      | Unit |
|----------------------------|-----------------------------------------|--------|------|------|------|
|                            |                                         | Min.   | Typ. | Max. |      |
| t <sub>w</sub> (RESET)     | Reset input “L” pulse width             | 2      |      |      | μs   |
| t <sub>c</sub> (XIN)       | Main clock input cycle time (XIN input) | 125    |      |      | ns   |
| t <sub>wH</sub> (XIN)      | Main clock input “H” pulse width        | 45     |      |      | ns   |
| t <sub>wL</sub> (XIN)      | Main clock input “L” pulse width        | 40     |      |      | ns   |
| t <sub>c</sub> (CNTR)      | CNTR0, CNTR1 input cycle time           | 250    |      |      | ns   |
| t <sub>wH</sub> (CNTR)     | CNTR0, CNTR1 input “H” pulse width      | 105    |      |      | ns   |
| t <sub>wL</sub> (CNTR)     | CNTR0, CNTR1 input “L” pulse width      | 105    |      |      | ns   |
| t <sub>wH</sub> (INT)      | INT0–INT2 input “H” pulse width         | 80     |      |      | ns   |
| t <sub>wL</sub> (INT)      | INT0–INT2 input “L” pulse width         | 80     |      |      | ns   |
| t <sub>c</sub> (SCLK)      | Serial I/O clock input cycle time       | 800    |      |      | ns   |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock input “H” pulse width  | 370    |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock input “L” pulse width  | 370    |      |      | ns   |
| t <sub>su</sub> (SIN–SCLK) | Serial I/O input setup time             | 220    |      |      | ns   |
| t <sub>h</sub> (SCLK–SIN)  | Serial I/O input hold time              | 100    |      |      | ns   |

**Table 3.1.9 Timing requirements 2**

(V<sub>CC</sub> = 2.5 to 4.0 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                      |      |      | Unit |
|----------------------------|-----------------------------------------|-----------------------------|------|------|------|
|                            |                                         | Min.                        | Typ. | Max. |      |
| t <sub>w</sub> (RESET)     | Reset input “L” pulse width             | 2                           |      |      | μs   |
| t <sub>c</sub> (XIN)       | Main clock input cycle time (XIN input) | 125                         |      |      | ns   |
| t <sub>wH</sub> (XIN)      | Main clock input “H” pulse width        | 45                          |      |      | ns   |
| t <sub>wL</sub> (XIN)      | Main clock input “L” pulse width        | 40                          |      |      | ns   |
| t <sub>c</sub> (CNTR)      | CNTR0, CNTR1 input cycle time           | 500/(V <sub>CC</sub> –2)    |      |      | ns   |
| t <sub>wH</sub> (CNTR)     | CNTR0, CNTR1 input “H” pulse width      | 250/(V <sub>CC</sub> –2)–20 |      |      | ns   |
| t <sub>wL</sub> (CNTR)     | CNTR0, CNTR1 input “L” pulse width      | 250/(V <sub>CC</sub> –2)–20 |      |      | ns   |
| t <sub>wH</sub> (INT)      | INT0–INT2 input “H” pulse width         | 230                         |      |      | ns   |
| t <sub>wL</sub> (INT)      | INT0–INT2 input “L” pulse width         | 230                         |      |      | ns   |
| t <sub>c</sub> (SCLK)      | Serial I/O clock input cycle time       | 2000                        |      |      | ns   |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock input “H” pulse width  | 950                         |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock input “L” pulse width  | 950                         |      |      | ns   |
| t <sub>su</sub> (SIN–SCLK) | Serial I/O input setup time             | 400                         |      |      | ns   |
| t <sub>h</sub> (SCLK–SIN)  | Serial I/O input hold time              | 200                         |      |      | ns   |

## 3.1 Electrical characteristics

**Table 3.1.10 Switching characteristics 1**(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                     |      |      | Unit |
|----------------------------|-----------------------------------------|----------------------------|------|------|------|
|                            |                                         | Min.                       | Typ. | Max. |      |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock output "H" pulse width | t <sub>c</sub> (SCLK)/2–30 |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock output "L" pulse width | t <sub>c</sub> (SCLK)/2–30 |      |      | ns   |
| t <sub>d</sub> (SCLK-SOUT) | Serial I/O output delay time (Note 1)   |                            |      | 140  | ns   |
| t <sub>v</sub> (SCLK-SOUT) | Serial I/O output valid time (Note 1)   | –30                        |      |      | ns   |
| t <sub>r</sub> (SCLK)      | Serial I/O clock output rising time     |                            |      | 30   | ns   |
| t <sub>f</sub> (SCLK)      | Serial I/O clock output falling time    |                            |      | 30   | ns   |
| t <sub>r</sub> (CMOS)      | CMOS output rising time (Note 2)        |                            | 10   | 30   | ns   |
| t <sub>f</sub> (CMOS)      | CMOS output falling time (Note 2)       |                            | 10   | 30   | ns   |

**Notes 1:** When the P-channel output disable bit (bit 7 of address 001916) is "0."**2:** The XOUT, XCOUT pins are excluded.**Table 3.1.11 Switching characteristics 2**(V<sub>CC</sub> = 2.5 to 4.0 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                     |      |      | Unit |
|----------------------------|-----------------------------------------|----------------------------|------|------|------|
|                            |                                         | Min.                       | Typ. | Max. |      |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock output "H" pulse width | t <sub>c</sub> (SCLK)/2–50 |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock output "L" pulse width | t <sub>c</sub> (SCLK)/2–50 |      |      | ns   |
| t <sub>d</sub> (SCLK-SOUT) | Serial I/O output delay time (Note 1)   |                            |      | 350  | ns   |
| t <sub>v</sub> (SCLK-SOUT) | Serial I/O output valid time (Note 1)   | –30                        |      |      | ns   |
| t <sub>r</sub> (SCLK)      | Serial I/O clock output rising time     |                            |      | 50   | ns   |
| t <sub>f</sub> (SCLK)      | Serial I/O clock output falling time    |                            |      | 50   | ns   |
| t <sub>r</sub> (CMOS)      | CMOS output rising time (Note 2)        |                            | 20   | 50   | ns   |
| t <sub>f</sub> (CMOS)      | CMOS output falling time (Note 2)       |                            | 20   | 50   | ns   |

**Notes 1:** When the P-channel output disable bit (bit 7 of address 001916) is "0."**2:** The XOUT, XCOUT pins are excluded.

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## 3.1 Electrical characteristics

### 3.1.6 Absolute maximum ratings (M version)

**Table 3.1.12 Absolute maximum ratings (M version)**

| Symbol           | Parameter                                                                             | Conditions                                                                  | Ratings                                 | Unit |
|------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------|------|
| V <sub>CC</sub>  | Power source voltage                                                                  | All voltages are based on V <sub>SS</sub> . Output transistors are cut off. | –0.3 to 7.0                             | V    |
| V <sub>I</sub>   | Input voltage P00–P07, P10–P17, P20–P27, P40–P47, P50–P57, P60–P67, P70, P71, P80–P87 |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>I</sub>   | Input voltage V <sub>L1</sub>                                                         |                                                                             | –0.3 to V <sub>L2</sub>                 | V    |
| V <sub>I</sub>   | Input voltage V <sub>L2</sub>                                                         |                                                                             | V <sub>L1</sub> to V <sub>L3</sub>      | V    |
| V <sub>I</sub>   | Input voltage V <sub>L3</sub>                                                         |                                                                             | V <sub>L2</sub> to V <sub>CC</sub> +0.3 | V    |
| V <sub>I</sub>   | Input voltage RESET, X <sub>IN</sub>                                                  |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage P00–P07, P10–P17, P20–P27, P30–P37                                     | At output port                                                              | –0.3 to V <sub>CC</sub> +0.3            | V    |
|                  |                                                                                       | At segment output                                                           | –0.3 to V <sub>L3</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage COM0–COM3                                                              |                                                                             | –0.3 to V <sub>L3</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage P40–P47, P50, P52–P57, P60–P67, P70, P71, P80–P87                      |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| V <sub>O</sub>   | Output voltage X <sub>OUT</sub>                                                       |                                                                             | –0.3 to V <sub>CC</sub> +0.3            | V    |
| P <sub>d</sub>   | Power dissipation                                                                     | T <sub>a</sub> = 25°C                                                       | 300                                     | mW   |
| T <sub>opr</sub> | Operating temperature                                                                 |                                                                             | –20 to 85                               | °C   |
| T <sub>stg</sub> | Storage temperature                                                                   |                                                                             | –40 to 125                              | °C   |

### 3.1.7 Recommended operating conditions (M version)

**Table 3.1.13 Recommended operating conditions (M version)**

(V<sub>CC</sub> = 2.2 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol           | Parameter                       |                                               | Limits           |      |                 | Unit |
|------------------|---------------------------------|-----------------------------------------------|------------------|------|-----------------|------|
|                  |                                 |                                               | Min.             | Typ. | Max.            |      |
| V <sub>CC</sub>  | Power source voltage            | High-speed mode f(X <sub>IN</sub> ) = 8 MHz   | 4.0              | 5.0  | 5.5             | V    |
|                  |                                 | Middle-speed mode f(X <sub>IN</sub> ) = 8 MHz | 2.2              | 5.0  | 5.5             | V    |
|                  |                                 | Low-speed mode                                | 2.2              | 5.0  | 5.5             | V    |
| V <sub>SS</sub>  | Power source voltage            |                                               |                  | 0    |                 | V    |
| V <sub>REF</sub> | A-D converter reference voltage |                                               | 2.0              |      | V <sub>CC</sub> | V    |
| AV <sub>SS</sub> | Analog power source voltage     |                                               |                  | 0    |                 | V    |
| V <sub>IA</sub>  | Analog input voltage AN0–AN7    |                                               | AV <sub>SS</sub> |      | V <sub>CC</sub> | V    |

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**Table 3.1.14 Recommended operating conditions (M version)**(V<sub>CC</sub> = 2.5 to 5.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol          | Parameter         |                                               | Limits             |      |                     | Unit |
|-----------------|-------------------|-----------------------------------------------|--------------------|------|---------------------|------|
|                 |                   |                                               | Min.               | Typ. | Max.                |      |
| V <sub>IH</sub> | "H" input voltage | P00–P07, P10–P17, P20–P27                     | 0.7V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | P80–P87                                       | 0.4V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | $\overline{\text{RESET}}$                     | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | X <sub>IN</sub>                               | 0.8V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IL</sub> | "L" input voltage | P00–P07, P10–P17, P20–P27                     | 0                  |      | 0.3V <sub>CC</sub>  | V    |
| V <sub>IL</sub> | "L" input voltage | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0                  |      | 0.2V <sub>CC</sub>  | V    |
| V <sub>IL</sub> | "L" input voltage | P80–P87                                       | 0                  |      | 0.16V <sub>CC</sub> | V    |
| V <sub>IL</sub> | "L" input voltage | $\overline{\text{RESET}}$                     | 0                  |      | 0.2V <sub>CC</sub>  | V    |
| V <sub>IL</sub> | "L" input voltage | X <sub>IN</sub>                               | 0                  |      | 0.2V <sub>CC</sub>  | V    |

**Table 3.1.15 Recommended operating conditions (M version)**(V<sub>CC</sub> = 2.2 to 2.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol          | Parameter         |                                               | Limits              |      |                     | Unit |
|-----------------|-------------------|-----------------------------------------------|---------------------|------|---------------------|------|
|                 |                   |                                               | Min.                | Typ. | Max.                |      |
| V <sub>IH</sub> | "H" input voltage | P00–P07, P10–P17, P20–P27                     | 0.8V <sub>CC</sub>  |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0.95V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | P80–P87                                       | 0.5V <sub>CC</sub>  |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | $\overline{\text{RESET}}$                     | 0.95V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IH</sub> | "H" input voltage | X <sub>IN</sub>                               | 0.95V <sub>CC</sub> |      | V <sub>CC</sub>     | V    |
| V <sub>IL</sub> | "L" input voltage | P00–P07, P10–P17, P20–P27                     | 0                   |      | 0.2V <sub>CC</sub>  | V    |
| V <sub>IL</sub> | "L" input voltage | P40–P47, P50–P57, P60–P67, P70, P71 (CM4 = 0) | 0                   |      | 0.05V <sub>CC</sub> | V    |
| V <sub>IL</sub> | "L" input voltage | P80–P87                                       | 0                   |      | 0.1V <sub>CC</sub>  | V    |
| V <sub>IL</sub> | "L" input voltage | $\overline{\text{RESET}}$                     | 0                   |      | 0.05V <sub>CC</sub> | V    |
| V <sub>IL</sub> | "L" input voltage | X <sub>IN</sub>                               | 0                   |      | 0.05V <sub>CC</sub> | V    |

# APPENDIX

## 3.1 Electrical characteristics

**Table 3.1.16 Recommended operating conditions (M version)**

(V<sub>CC</sub> = 2.2 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol     | Parameter                                                                                                | Limits |      |      | Unit |
|------------|----------------------------------------------------------------------------------------------------------|--------|------|------|------|
|            |                                                                                                          | Min.   | Typ. | Max. |      |
| ΣIOH(peak) | "H" total peak output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37<br>P80–P87, P50    |        |      | –60  | mA   |
| ΣIOH(peak) | "H" total peak output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                   |        |      | –30  | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                    |        |      | 40   | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P80–P87, P50                                          |        |      | 80   | mA   |
| ΣIOL(peak) | "L" total peak output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                   |        |      | 40   | mA   |
| ΣIOH(avg)  | "H" total average output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37<br>P80–P87, P50 |        |      | –30  | mA   |
| ΣIOH(avg)  | "H" total average output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                |        |      | –15  | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                 |        |      | 20   | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P80–P87, P50                                       |        |      | 40   | mA   |
| ΣIOL(avg)  | "L" total average output current ( <b>Note 1</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                |        |      | 20   | mA   |
| IOH(peak)  | "H" peak output current ( <b>Note 2</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                          |        |      | –4.0 | mA   |
| IOH(peak)  | "H" peak output current ( <b>Note 2</b> )<br>P40–P47, P50, P52–P57, P60–P67, P70, P71<br>P80–P87         |        |      | –10  | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                          |        |      | 5.0  | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                         |        |      | 10   | mA   |
| IOL(peak)  | "L" peak output current ( <b>Note 2</b> )<br>P80–P87, P50                                                |        |      | 30   | mA   |
| IOH(avg)   | "H" average output current ( <b>Note 3</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                       |        |      | –2.0 | mA   |
| IOH(avg)   | "H" average output current ( <b>Note 3</b> )<br>P40–P47, P50, P52–P57, P60–P67, P70, P71<br>P80–P87      |        |      | –5.0 | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P00–P07, P10–P17, P20–P27, P30–P37                       |        |      | 2.5  | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P40–P47, P52–P57, P60–P67, P70, P71                      |        |      | 5.0  | mA   |
| IOL(avg)   | "L" average output current ( <b>Note 3</b> )<br>P80–P87, P50                                             |        |      | 15   | mA   |

**Notes 1:** The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.

**2:** The peak output current is the peak current flowing in each port.

**3:** The average output current is average value measured over 100 ms.

**Table 3.1.17 Recommended operating conditions (M version)**(V<sub>CC</sub> = 2.2 to 5.5 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                | Parameter                                          |                                                      | Limits |        |                        | Unit |
|-----------------------|----------------------------------------------------|------------------------------------------------------|--------|--------|------------------------|------|
|                       |                                                    |                                                      | Min.   | Typ.   | Max.                   |      |
| f(CNTR <sub>0</sub> ) | Input frequency (duty cycle 50%)                   | (4.0 V ≤ V <sub>CC</sub> ≤ 5.5 V)                    |        |        | 4.0                    | MHz  |
| f(CNTR <sub>1</sub> ) |                                                    | (2.2 V ≤ V <sub>CC</sub> ≤ 4.0 V)                    |        |        | (2×V <sub>CC</sub> )–4 | MHz  |
| f(X <sub>IN</sub> )   | Main clock input oscillation frequency (Note 4)    | High-speed mode<br>(4.0 V ≤ V <sub>CC</sub> ≤ 5.5 V) |        |        | 8.0                    | MHz  |
|                       |                                                    | High-speed mode<br>(2.2 V ≤ V <sub>CC</sub> ≤ 4.0 V) |        |        | (4×V <sub>CC</sub> )–8 | MHz  |
|                       |                                                    | Middle-speed mode                                    |        |        | 8.0                    | MHz  |
| f(X <sub>CIN</sub> )  | Sub-clock input oscillation frequency (Notes 4, 5) |                                                      |        | 32.768 | 50                     | kHz  |

**Notes 4:** When the oscillation frequency has a duty cycle of 50%.**5:** When using the microcomputer in low-speed mode, set the sub-clock input oscillation frequency on condition that f(X<sub>CIN</sub>) < f(X<sub>IN</sub>)/3.

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# APPENDIX

## 3.1 Electrical characteristics

### 3.1.8 Electrical characteristics (M version)

**Table 3.1.18 Electrical characteristics (M version)**

(V<sub>CC</sub> = 4.0 to 5.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol                           | Parameter                                                                     | Test conditions                                                             | Limits               |      |      | Unit |
|----------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------|------|------|------|
|                                  |                                                                               |                                                                             | Min.                 | Typ. | Max. |      |
| V <sub>OH</sub>                  | “H” output voltage<br>P00–P07, P10–P17, P20–P27,<br>P30–P37                   | I <sub>OH</sub> = -2.0 mA                                                   | V <sub>CC</sub> -2.0 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -0.6 mA                                                   | V <sub>CC</sub> -1.0 |      |      | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OH</sub>                  | “H” output voltage<br>P40–P47, P50, P52–P57,<br>P60–P67, P70, P71,<br>P80–P87 | I <sub>OH</sub> = -5 mA                                                     | V <sub>CC</sub> -2.0 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -1.25 mA                                                  | V <sub>CC</sub> -0.5 |      |      | V    |
|                                  |                                                                               | I <sub>OH</sub> = -1.25 mA                                                  | V <sub>CC</sub> -1.0 |      |      | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage<br>P00–P07, P10–P17, P20–P27,<br>P30–P37                   | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 2.0  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 1.25 mA                                                   |                      |      | 0.5  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 1.25 mA                                                   |                      |      | 1.0  | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage<br>P40–P47, P52–P57, P60–P67,<br>P70, P71                  | I <sub>OL</sub> = 5.0 mA                                                    |                      |      | 2.0  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 0.5  | V    |
|                                  |                                                                               | I <sub>OL</sub> = 2.5 mA                                                    |                      |      | 1.0  | V    |
|                                  |                                                                               | V <sub>CC</sub> = 2.5 V                                                     |                      |      |      |      |
| V <sub>OL</sub>                  | “L” output voltage P80–P87, P50                                               | I <sub>OL</sub> = 15 mA                                                     |                      |      | 2.0  | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis<br>INT0–INT2, CNTR0, CNTR1, P80–P87                                |                                                                             |                      | 0.5  |      | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis SCLK1, SIN                                                         |                                                                             |                      | 0.5  |      | V    |
| V <sub>T+</sub> –V <sub>T-</sub> | Hysteresis RESET                                                              | RESET:<br>V <sub>CC</sub> = 2.2 V – 5.5 V                                   |                      | 0.5  |      | V    |
| I <sub>IH</sub>                  | “H” input current<br>P00–P07, P10–P17, P20–P27                                | V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “off”                         |                      |      | 5.0  | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 5.0 V, V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “on” | 30                   | 70   | 140  | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 3.0 V, V <sub>I</sub> = V <sub>CC</sub><br>Pull-down “on” | 6.0                  | 25   | 45   | μA   |
|                                  |                                                                               |                                                                             |                      |      |      |      |
| I <sub>IH</sub>                  | “H” input current<br>P40–P47, P50–P57, P60–P67,<br>P70, P71, P80–P87          | V <sub>I</sub> = V <sub>CC</sub>                                            |                      |      | 5.0  | μA   |
| I <sub>IH</sub>                  | “H” input current RESET                                                       | V <sub>I</sub> = V <sub>CC</sub>                                            |                      |      | 5.0  | μA   |
| I <sub>IH</sub>                  | “H” input current XIN                                                         | V <sub>I</sub> = V <sub>CC</sub>                                            |                      | 4.0  |      | μA   |
| I <sub>IL</sub>                  | “L” input current<br>P00–P07, P10–P17, P20–P27, P51                           |                                                                             |                      |      | -5.0 | μA   |
| I <sub>IL</sub>                  | “L” input current<br>P40–P47, P50, P52–P57,<br>P60–P67, P70, P71, P80–P87     | V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “off”                           |                      |      | -5.0 | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 5.0 V, V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “on”   | -30                  | -70  | -140 | μA   |
|                                  |                                                                               | V <sub>CC</sub> = 3.0 V, V <sub>I</sub> = V <sub>SS</sub><br>Pull-up “on”   | -6                   | -25  | -45  | μA   |
|                                  |                                                                               |                                                                             |                      |      |      |      |
| I <sub>IL</sub>                  | “L” input current RESET                                                       | V <sub>I</sub> = V <sub>SS</sub>                                            |                      |      | -5   | μA   |
| I <sub>IL</sub>                  | “L” input current XIN                                                         | V <sub>I</sub> = V <sub>SS</sub>                                            |                      | -4   |      | μA   |

**Note:** When “1” is set to the port Xc switch bit (bit 4 of address 003B16) of the CPU mode register, the drive ability of Port P71 is different from the value above mentioned.

## 3.1 Electrical characteristics

**Table 3.1.19 Electrical characteristics (M version)**(V<sub>CC</sub> = 2.2 to 5.5 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol          | Parameter            | Test conditions                                                                                                                                                                      | Limits                 |      |      | Unit |
|-----------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|------|------|
|                 |                      |                                                                                                                                                                                      | Min.                   | Typ. | Max. |      |
| VRAM            | RAM hold voltage     | When clock is stopped                                                                                                                                                                | 2.0                    |      | 5.5  | V    |
| I <sub>CC</sub> | Power source current | High-speed mode, V <sub>CC</sub> = 5 V<br>f(X <sub>IN</sub> ) = 8 MHz<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off",<br>A-D converter in operating                |                        | 6.4  | 13   | mA   |
|                 |                      | High-speed mode, V <sub>CC</sub> = 5 V<br>f(X <sub>IN</sub> ) = 8 MHz (in WIT state)<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off",<br>A-D converter stopped      |                        | 1.6  | 3.2  | mA   |
|                 |                      | Low-speed mode, V <sub>CC</sub> = 3 V,<br>T <sub>a</sub> ≤ 55 °C<br>f(X <sub>IN</sub> ) = stopped<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>Output transistors "off"                   |                        | 15   | 22   | μA   |
|                 |                      | Low-speed mode, V <sub>CC</sub> = 3 V,<br>T <sub>a</sub> = 25 °C<br>f(X <sub>IN</sub> ) = stopped<br>f(X <sub>CIN</sub> ) = 32.768 kHz<br>(in WIT state)<br>Output transistors "off" |                        | 4.5  | 9.0  | μA   |
|                 |                      | All oscillation stopped<br>(in STP state)                                                                                                                                            | T <sub>a</sub> = 25 °C | 0.1  | 1.0  | μA   |
|                 |                      | Output transistors "off"                                                                                                                                                             | T <sub>a</sub> = 85 °C |      | 10   | μA   |

# APPENDIX

## 3.1 Electrical characteristics

### 3.1.9 A-D converter characteristics (M version)

**Table 3.1.20 A-D converter characteristics (M version)**

(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, 4 MHz ≤ f(X<sub>IN</sub>) ≤ 8 MHz, in middle-speed/high-speed mode)

| Symbol            | Parameter                                        | Test conditions                             | Limits |      |      | Unit  |
|-------------------|--------------------------------------------------|---------------------------------------------|--------|------|------|-------|
|                   |                                                  |                                             | Min.   | Typ. | Max. |       |
| —                 | Resolution                                       |                                             |        |      | 10   | Bits  |
| —                 | Absolute accuracy (excluding quantization error) | V <sub>CC</sub> = V <sub>REF</sub> = 5.12 V |        | ±1   | ±2.5 | LSB   |
| T <sub>conv</sub> | Conversion time                                  |                                             | 61     |      | 62   | tc(φ) |
| I <sub>VREF</sub> | Reference input current                          | V <sub>REF</sub> = 5 V                      | 50     | 150  | 200  | μA    |
| I <sub>IA</sub>   | Analog port input current                        |                                             |        | 0.5  | 5.0  | μA    |
| RLADDER           | Ladder resistor                                  |                                             |        | 35   |      | kΩ    |

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## 3.1 Electrical characteristics

## 3.1.10 Timing requirements and switching characteristics (M version)

Table 3.1.21 Timing requirements 1 (M version)

(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits |      |      | Unit |
|----------------------------|-----------------------------------------|--------|------|------|------|
|                            |                                         | Min.   | Typ. | Max. |      |
| t <sub>w</sub> (RESET)     | Reset input "L" pulse width             | 2      |      |      | μs   |
| t <sub>c</sub> (XIN)       | Main clock input cycle time (XIN input) | 125    |      |      | ns   |
| t <sub>wH</sub> (XIN)      | Main clock input "H" pulse width        | 45     |      |      | ns   |
| t <sub>wL</sub> (XIN)      | Main clock input "L" pulse width        | 40     |      |      | ns   |
| t <sub>c</sub> (CNTR)      | CNTR0, CNTR1 input cycle time           | 250    |      |      | ns   |
| t <sub>wH</sub> (CNTR)     | CNTR0, CNTR1 input "H" pulse width      | 105    |      |      | ns   |
| t <sub>wL</sub> (CNTR)     | CNTR0, CNTR1 input "L" pulse width      | 105    |      |      | ns   |
| t <sub>wH</sub> (INT)      | INT0-INT2 input "H" pulse width         | 80     |      |      | ns   |
| t <sub>wL</sub> (INT)      | INT0-INT2 input "L" pulse width         | 80     |      |      | ns   |
| t <sub>c</sub> (SCLK)      | Serial I/O clock input cycle time       | 800    |      |      | ns   |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock input "H" pulse width  | 370    |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock input "L" pulse width  | 370    |      |      | ns   |
| t <sub>su</sub> (SIN-SCLK) | Serial I/O input setup time             | 220    |      |      | ns   |
| t <sub>h</sub> (SCLK-SIN)  | Serial I/O input hold time              | 100    |      |      | ns   |

Table 3.1.22 Timing requirements 2 (M version)

(V<sub>CC</sub> = 2.2 to 4.0 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = -20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                      |      |      | Unit |
|----------------------------|-----------------------------------------|-----------------------------|------|------|------|
|                            |                                         | Min.                        | Typ. | Max. |      |
| t <sub>w</sub> (RESET)     | Reset input "L" pulse width             | 2                           |      |      | μs   |
| t <sub>c</sub> (XIN)       | Main clock input cycle time (XIN input) | 125                         |      |      | ns   |
| t <sub>wH</sub> (XIN)      | Main clock input "H" pulse width        | 45                          |      |      | ns   |
| t <sub>wL</sub> (XIN)      | Main clock input "L" pulse width        | 40                          |      |      | ns   |
| t <sub>c</sub> (CNTR)      | CNTR0, CNTR1 input cycle time           | 500/(V <sub>CC</sub> -2)    |      |      | ns   |
| t <sub>wH</sub> (CNTR)     | CNTR0, CNTR1 input "H" pulse width      | 250/(V <sub>CC</sub> -2)-20 |      |      | ns   |
| t <sub>wL</sub> (CNTR)     | CNTR0, CNTR1 input "L" pulse width      | 250/(V <sub>CC</sub> -2)-20 |      |      | ns   |
| t <sub>wH</sub> (INT)      | INT0-INT2 input "H" pulse width         | 230                         |      |      | ns   |
| t <sub>wL</sub> (INT)      | INT0-INT2 input "L" pulse width         | 230                         |      |      | ns   |
| t <sub>c</sub> (SCLK)      | Serial I/O clock input cycle time       | 2000                        |      |      | ns   |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock input "H" pulse width  | 950                         |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock input "L" pulse width  | 950                         |      |      | ns   |
| t <sub>su</sub> (SIN-SCLK) | Serial I/O input setup time             | 400                         |      |      | ns   |
| t <sub>h</sub> (SCLK-SIN)  | Serial I/O input hold time              | 200                         |      |      | ns   |

# APPENDIX

## 3.1 Electrical characteristics

**Table 3.1.23 Switching characteristics 1 (M version)**

(V<sub>CC</sub> = 4.0 to 5.5 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                     |      |      | Unit |
|----------------------------|-----------------------------------------|----------------------------|------|------|------|
|                            |                                         | Min.                       | Typ. | Max. |      |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock output "H" pulse width | t <sub>c</sub> (SCLK)/2–30 |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock output "L" pulse width | t <sub>c</sub> (SCLK)/2–30 |      |      | ns   |
| t <sub>d</sub> (SCLK-SOUT) | Serial I/O output delay time (Note 1)   |                            |      | 140  | ns   |
| t <sub>v</sub> (SCLK-SOUT) | Serial I/O output valid time (Note 1)   | –30                        |      |      | ns   |
| t <sub>r</sub> (SCLK)      | Serial I/O clock output rising time     |                            |      | 30   | ns   |
| t <sub>f</sub> (SCLK)      | Serial I/O clock output falling time    |                            |      | 30   | ns   |
| t <sub>r</sub> (CMOS)      | CMOS output rising time (Note 2)        |                            | 10   | 30   | ns   |
| t <sub>f</sub> (CMOS)      | CMOS output falling time (Note 2)       |                            | 10   | 30   | ns   |

**Notes 1:** When the P-channel output disable bit (bit 7 of address 001916) is "0."

**2:** The XOUT, Xcout pins are excluded.

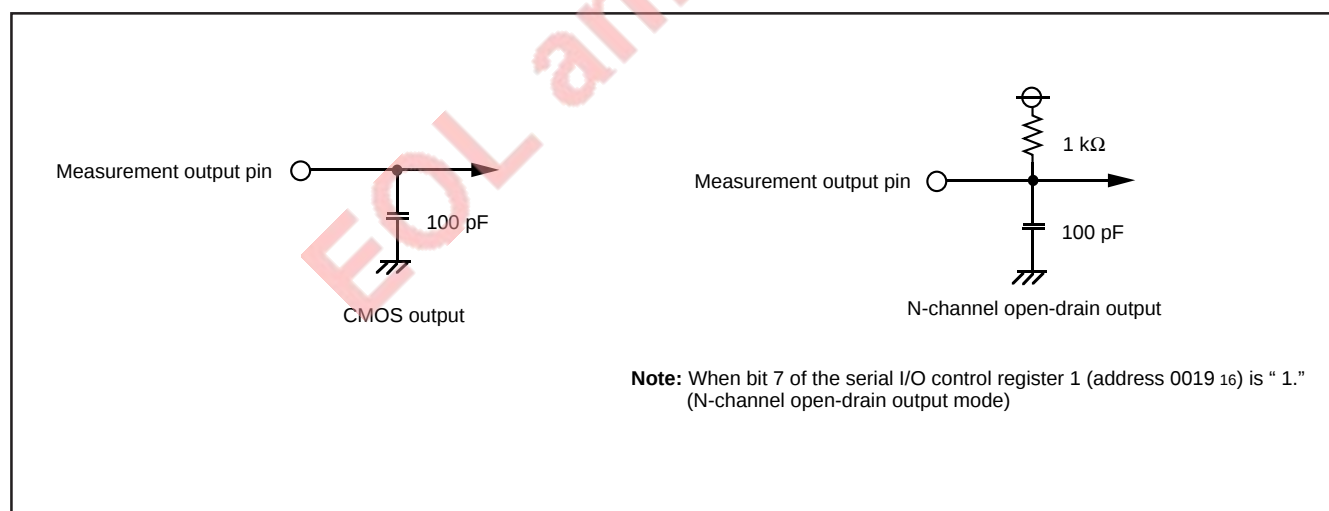
**Table 3.1.24 Switching characteristics 2 (M version)**

(V<sub>CC</sub> = 2.2 to 4.0 V, V<sub>SS</sub> = 0 V, T<sub>a</sub> = –20 to 85°C, unless otherwise noted)

| Symbol                     | Parameter                               | Limits                     |      |      | Unit |
|----------------------------|-----------------------------------------|----------------------------|------|------|------|
|                            |                                         | Min.                       | Typ. | Max. |      |
| t <sub>wH</sub> (SCLK)     | Serial I/O clock output "H" pulse width | t <sub>c</sub> (SCLK)/2–50 |      |      | ns   |
| t <sub>wL</sub> (SCLK)     | Serial I/O clock output "L" pulse width | t <sub>c</sub> (SCLK)/2–50 |      |      | ns   |
| t <sub>d</sub> (SCLK-SOUT) | Serial I/O output delay time (Note 1)   |                            |      | 350  | ns   |
| t <sub>v</sub> (SCLK-SOUT) | Serial I/O output valid time (Note 1)   | –30                        |      |      | ns   |
| t <sub>r</sub> (SCLK)      | Serial I/O clock output rising time     |                            |      | 50   | ns   |
| t <sub>f</sub> (SCLK)      | Serial I/O clock output falling time    |                            |      | 50   | ns   |
| t <sub>r</sub> (CMOS)      | CMOS output rising time (Note 2)        |                            | 20   | 50   | ns   |
| t <sub>f</sub> (CMOS)      | CMOS output falling time (Note 2)       |                            | 20   | 50   | ns   |

**Notes 1:** When the P-channel output disable bit (bit 7 of address 001916) is "0."

**2:** The XOUT, Xcout pins are excluded.



**Fig. 3.1.1 Circuit for measuring output switching characteristics**

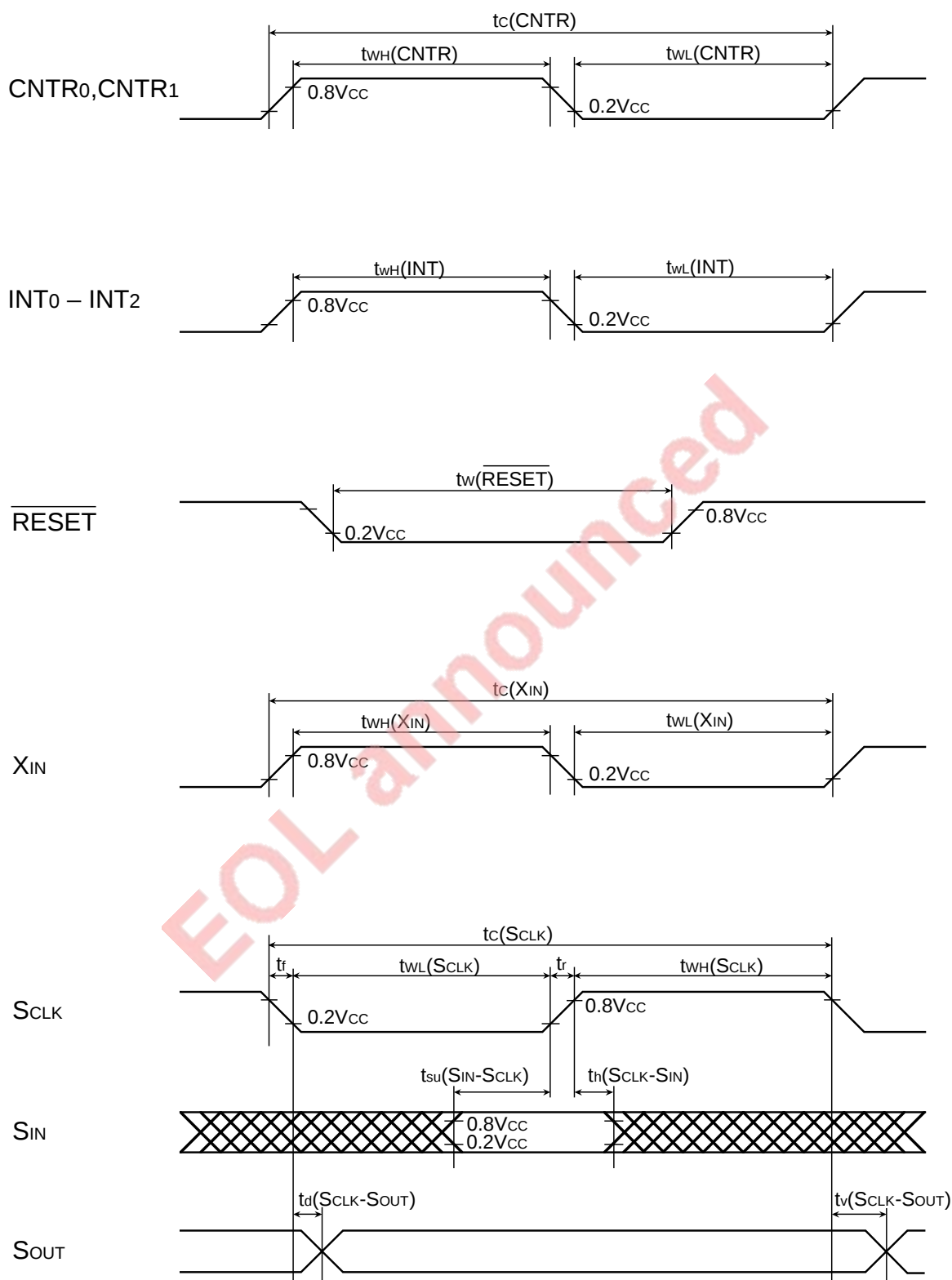


Fig. 3.1.2 Timing chart

# APPENDIX

## 3.2 Standard characteristics

### 3.2 Standard characteristics

#### 3.2.1 Power source current standard characteristics

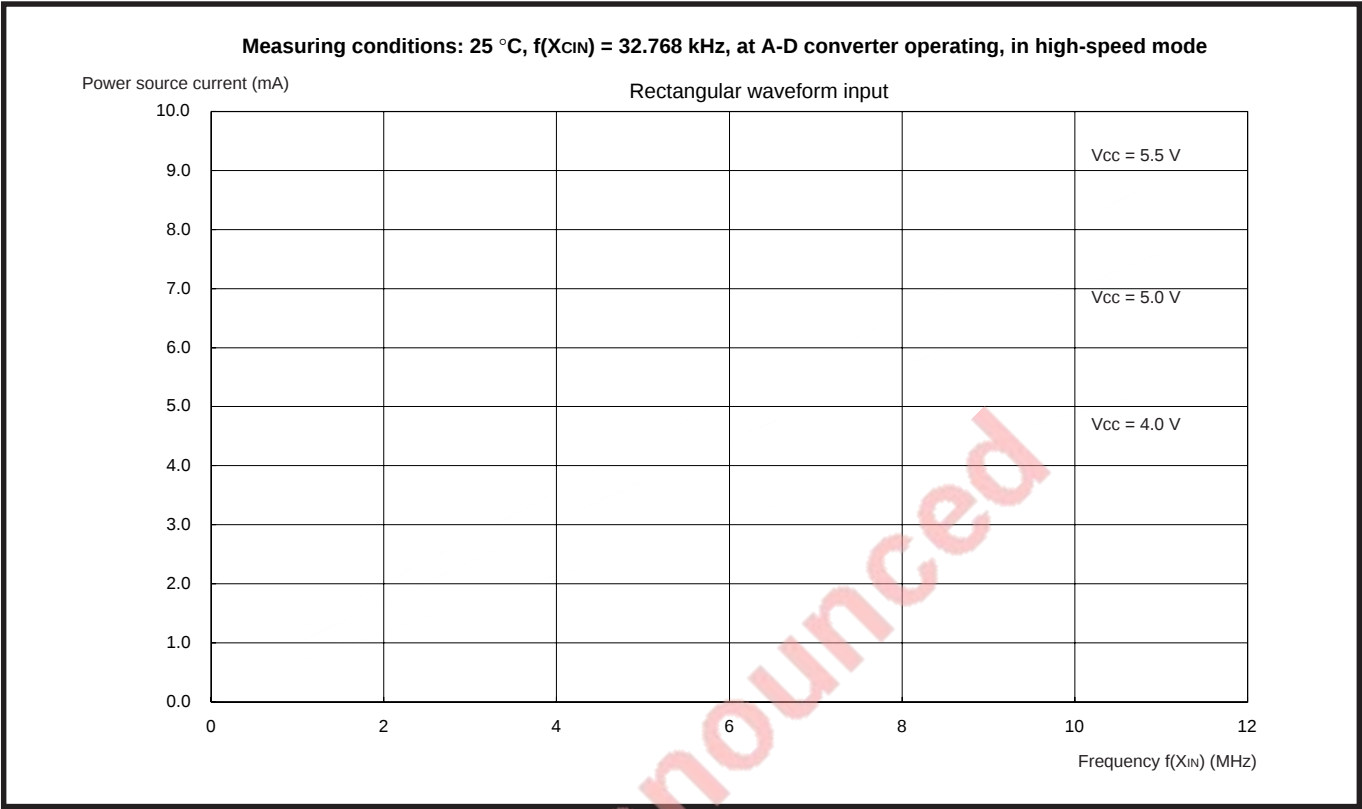


Fig. 3.2.1 Power source current standard characteristics

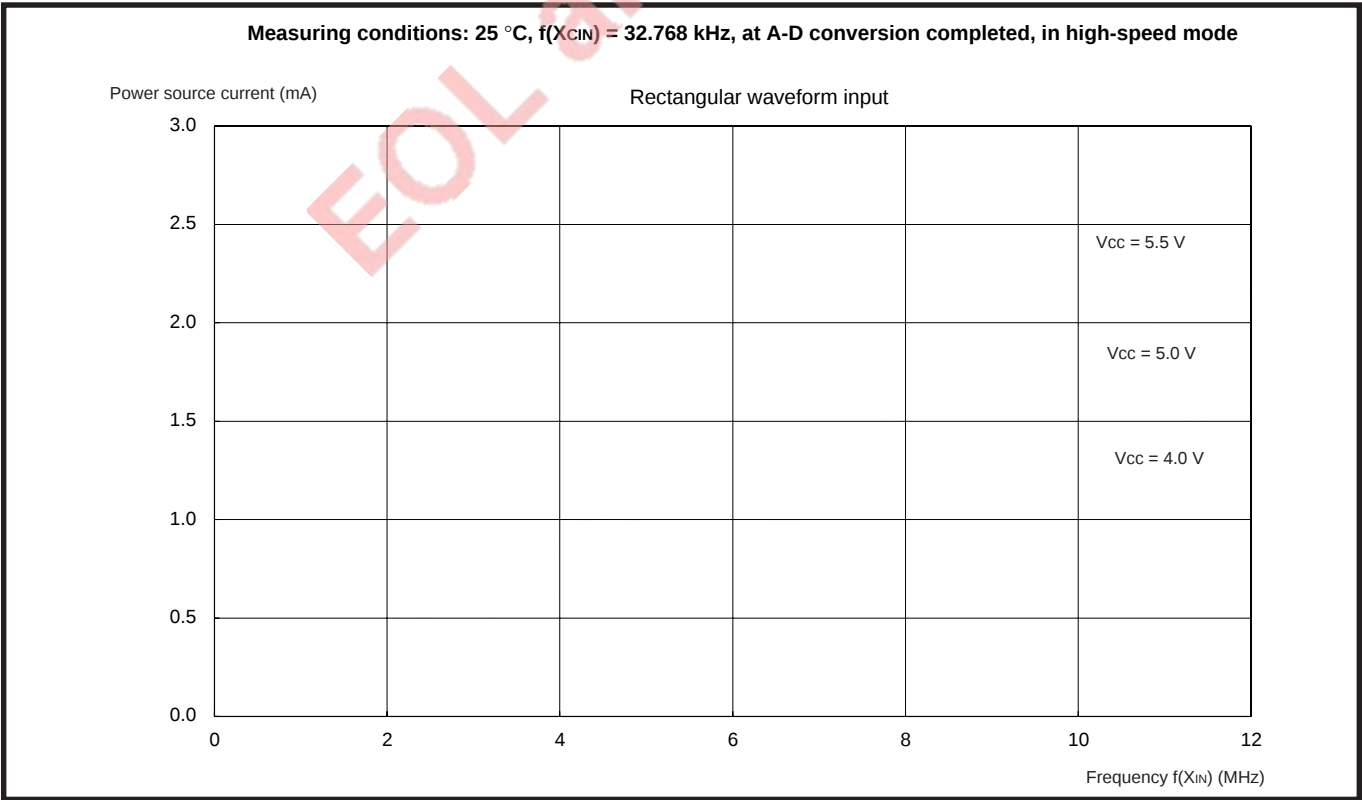


Fig. 3.2.2 Power source current standard characteristics (in wait mode)

## 3.2.2 Port standard characteristics

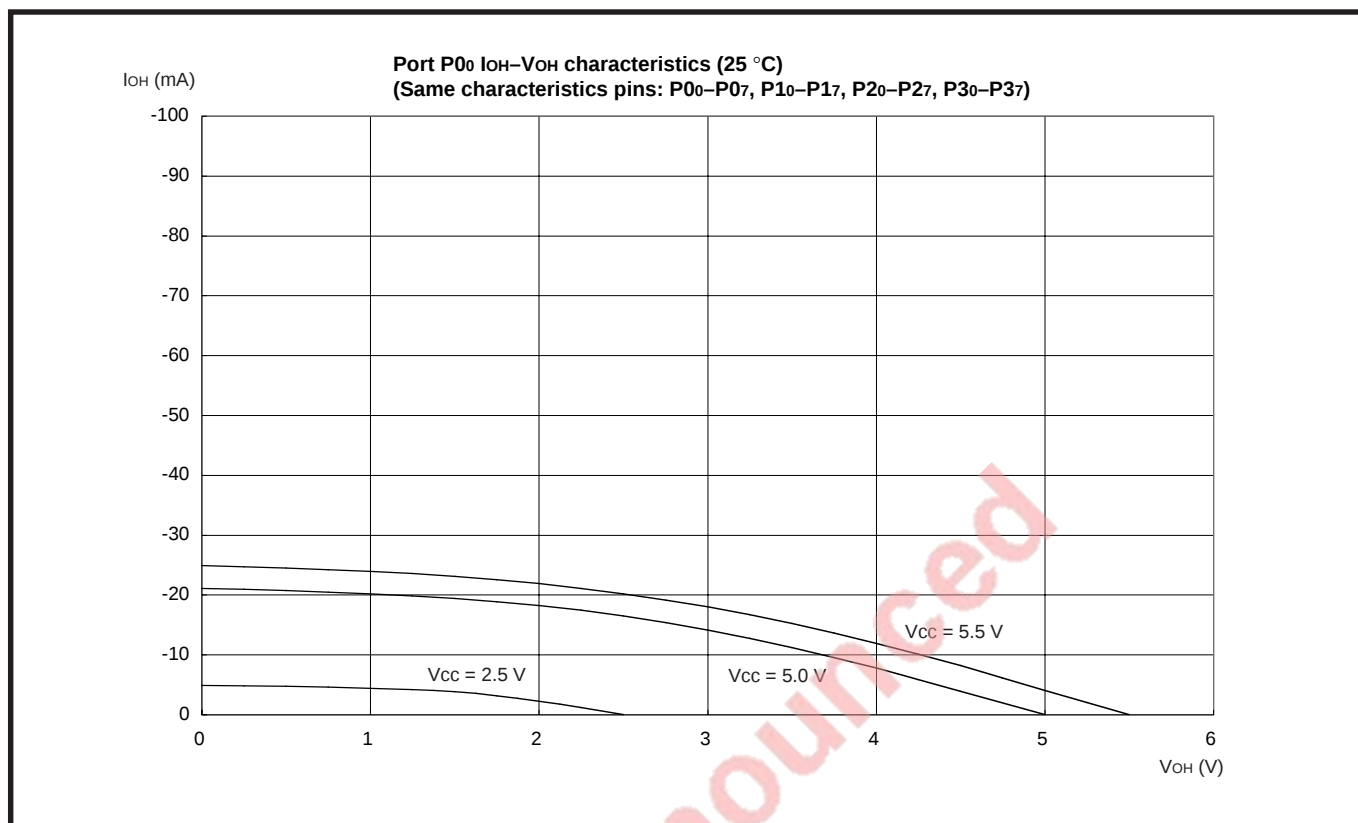


Fig. 3.2.3 CMOS output port (P0, P1, P2, P3) P-channel side characteristics (25 °C)

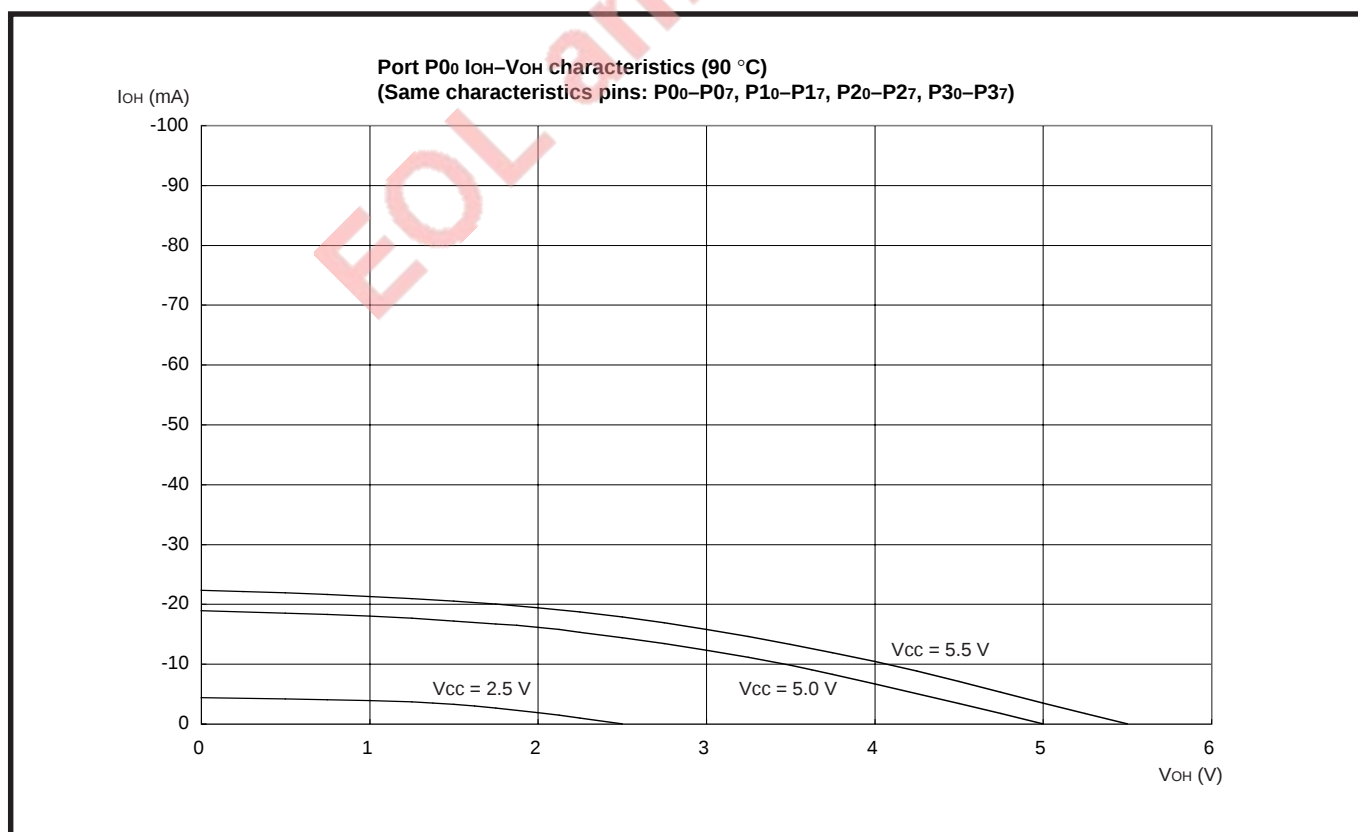


Fig. 3.2.4 CMOS output port (P0, P1, P2, P3) P-channel side characteristics (90 °C)

# APPENDIX

## 3.2 Standard characteristics

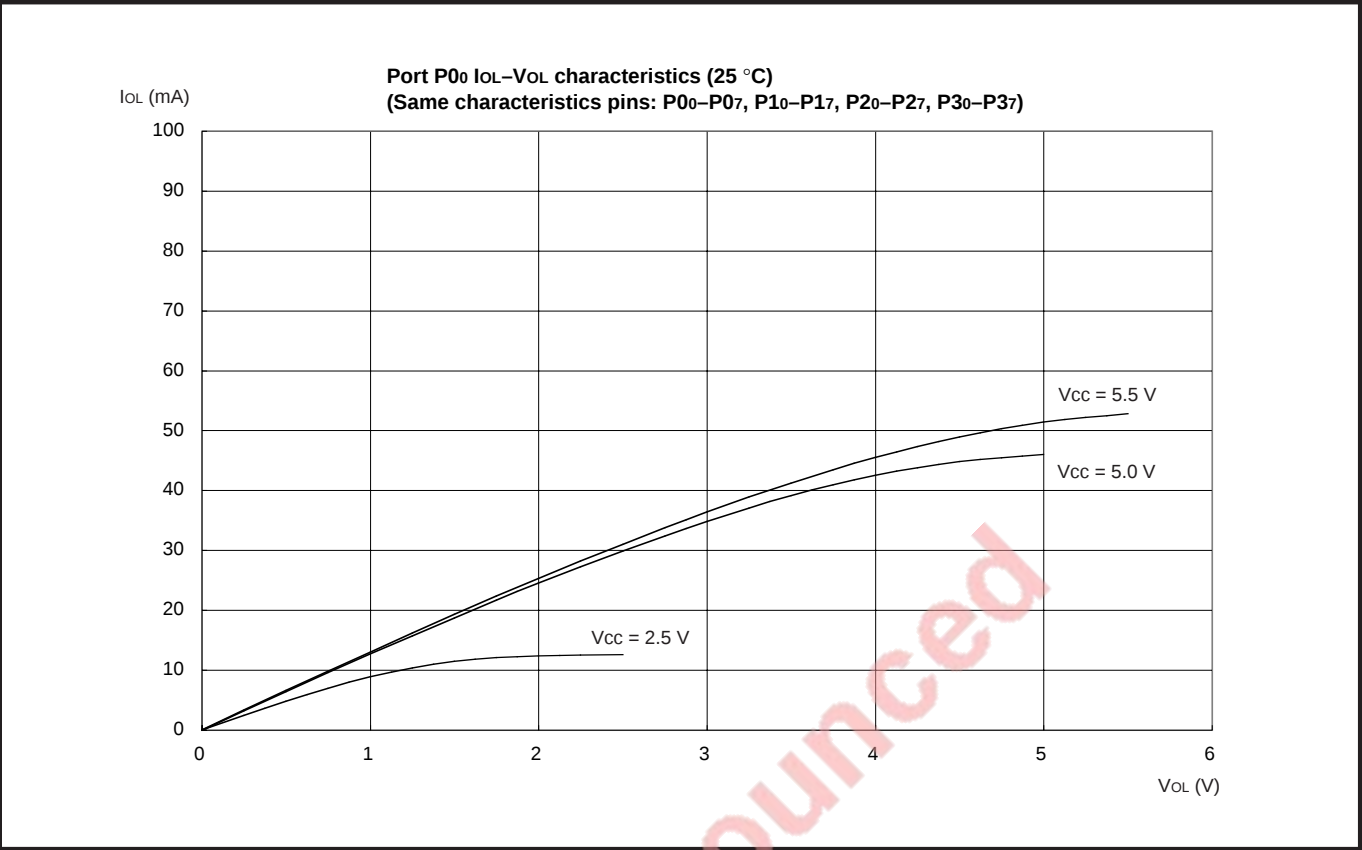


Fig. 3.2.5 CMOS output port (P0, P1, P2, P3) P-channel side characteristics (25 °C)

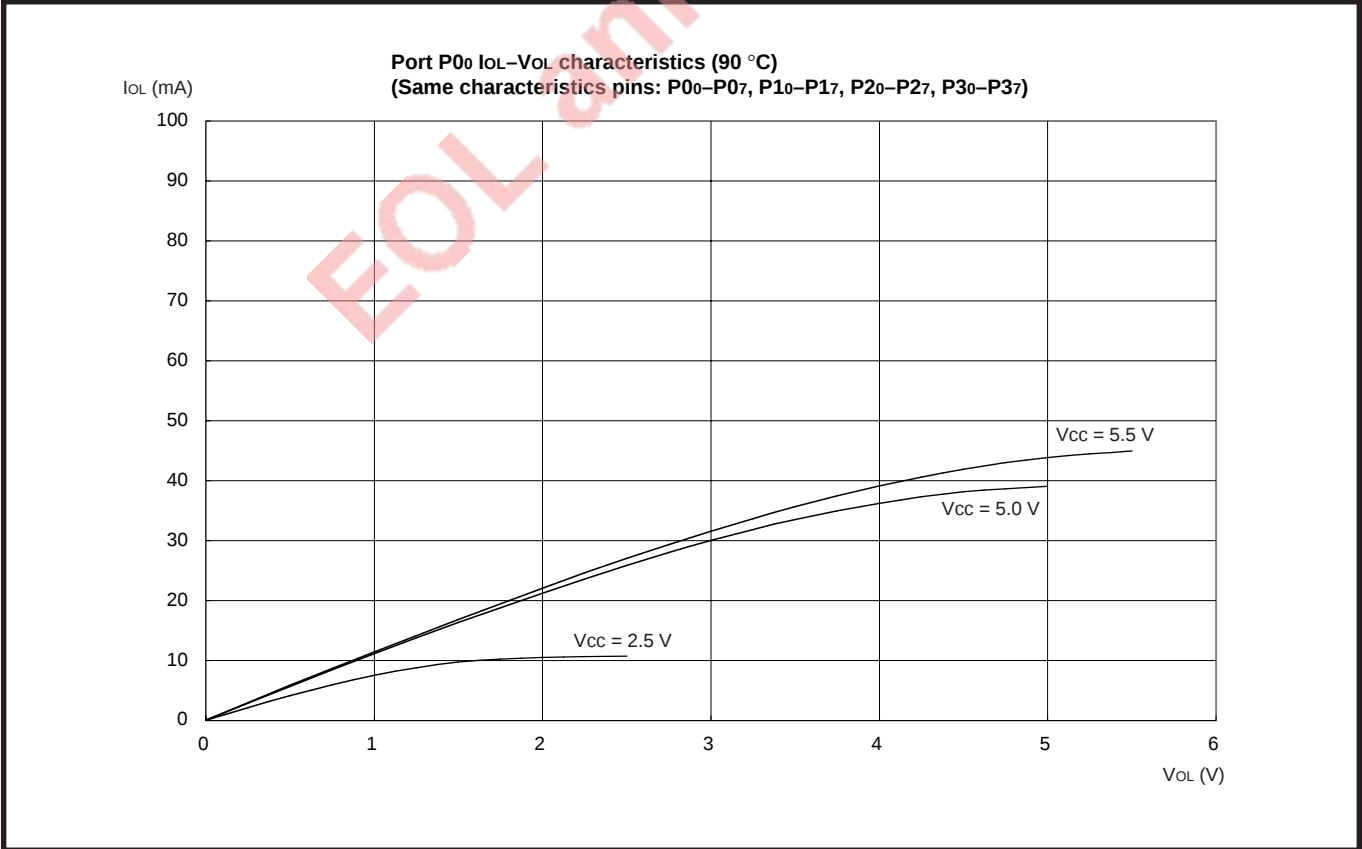


Fig. 3.2.6 CMOS output port (P0, P1, P2, P3) N-channel side characteristics (90 °C)

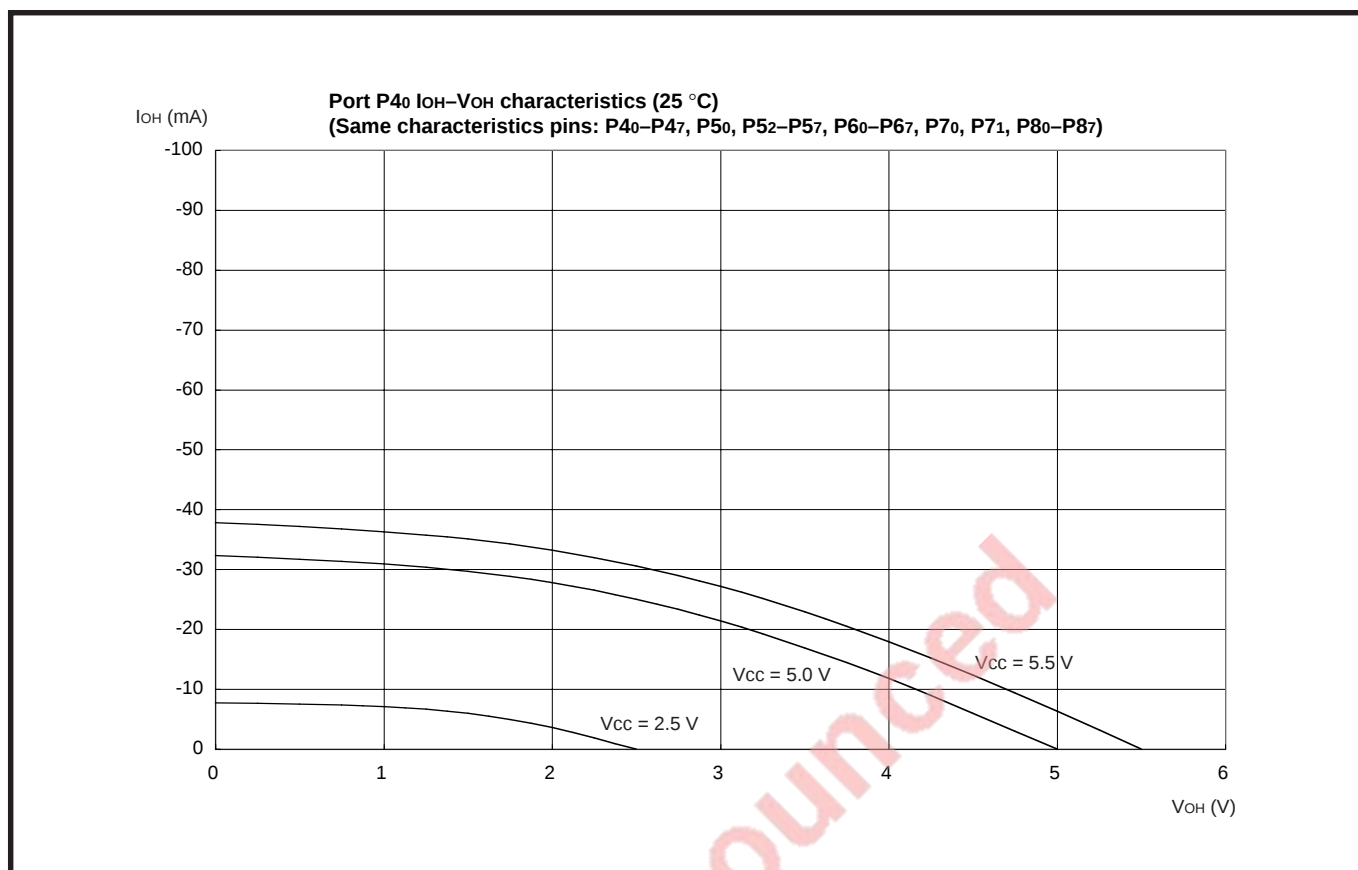


Fig. 3.2.7 CMOS output port (P4, P50, P52-P57, P6, P70, P71, P8) P-channel side characteristics (25 °C)

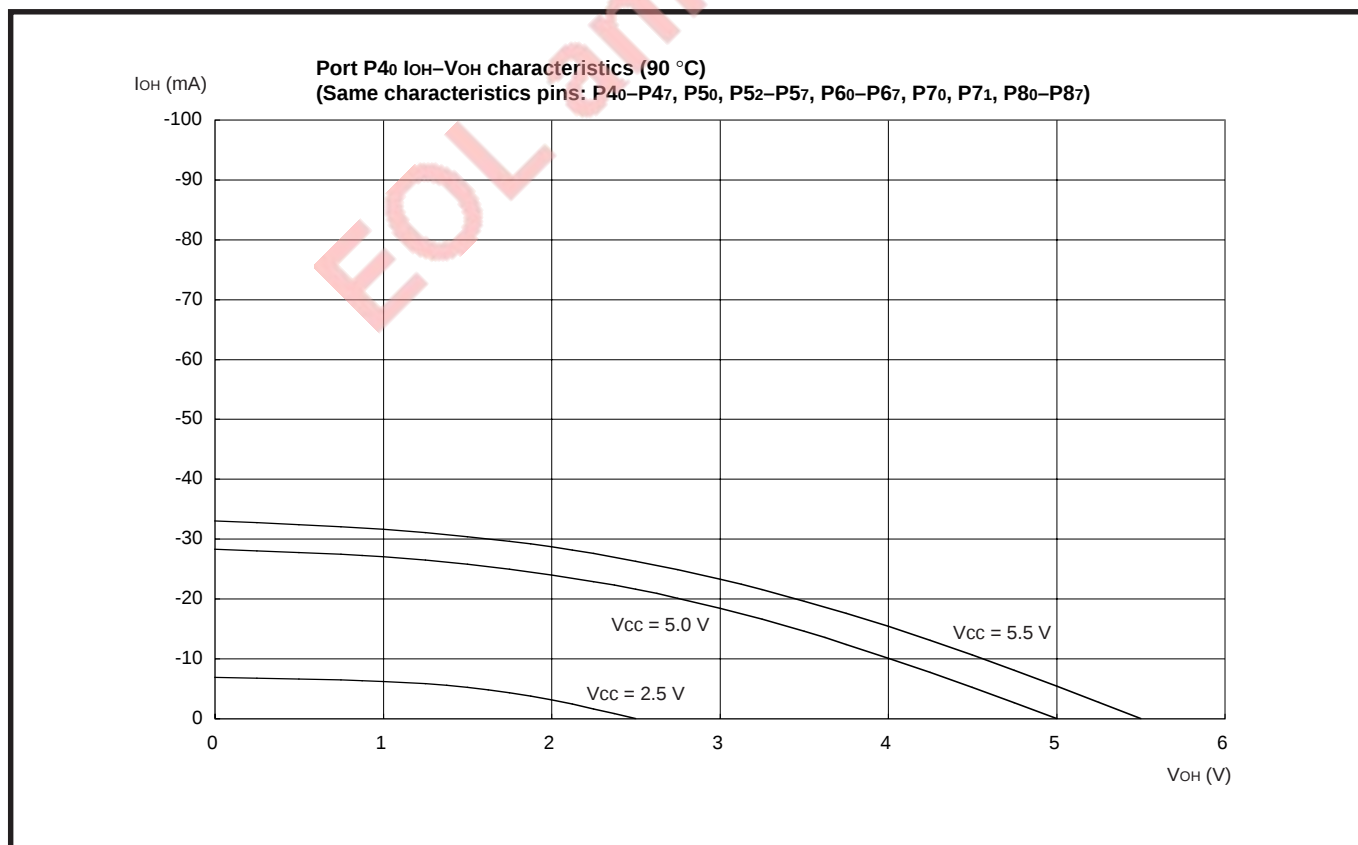


Fig. 3.2.8 CMOS output port (P4, P50, P52-P57, P6, P70, P71, P8) P-channel side characteristics (90 °C)

# APPENDIX

## 3.2 Standard characteristics

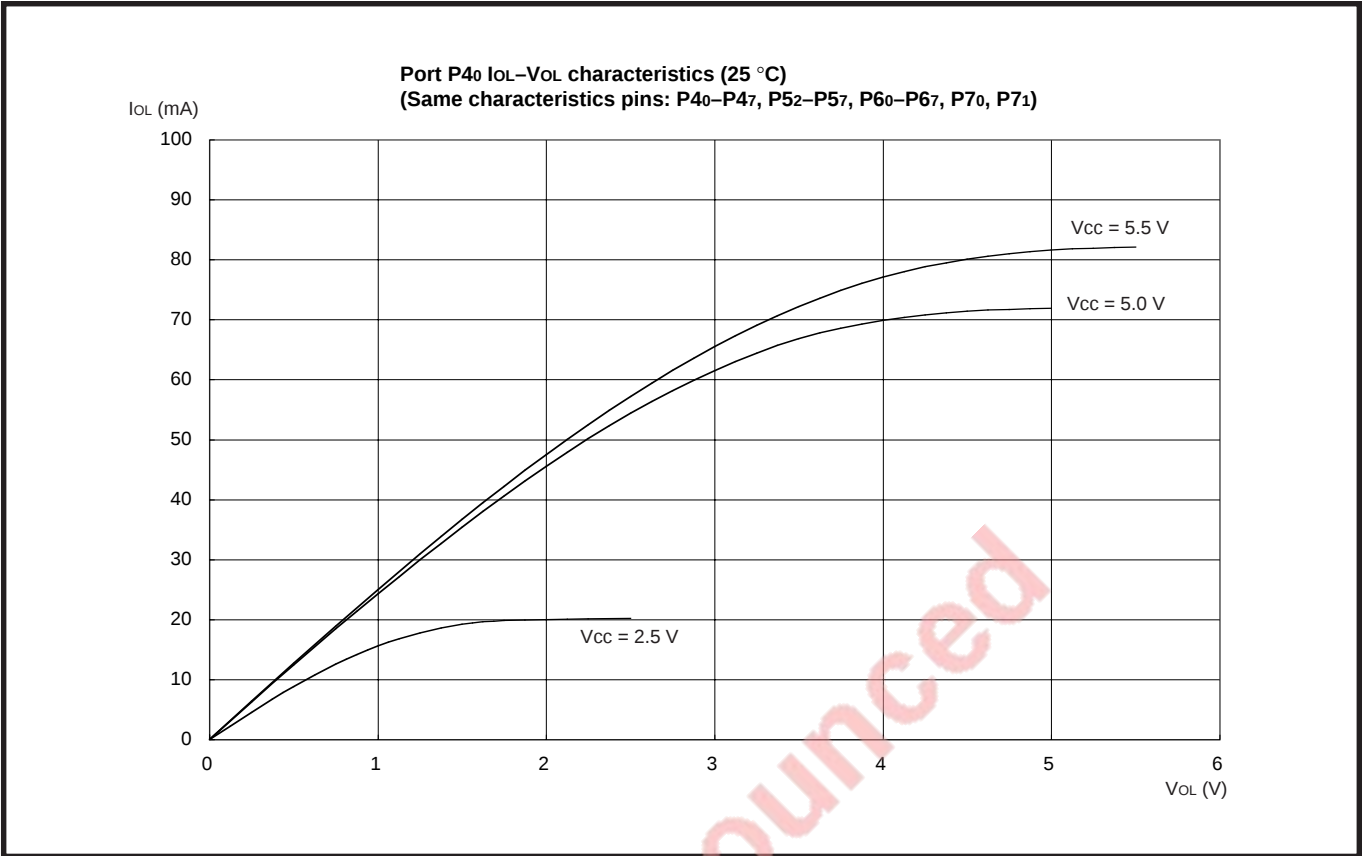


Fig. 3.2.9 CMOS output port (P4, P5<sub>2</sub>-P5<sub>7</sub>, P6, P7<sub>0</sub>, P7<sub>1</sub>) N-channel side characteristics (25 °C)

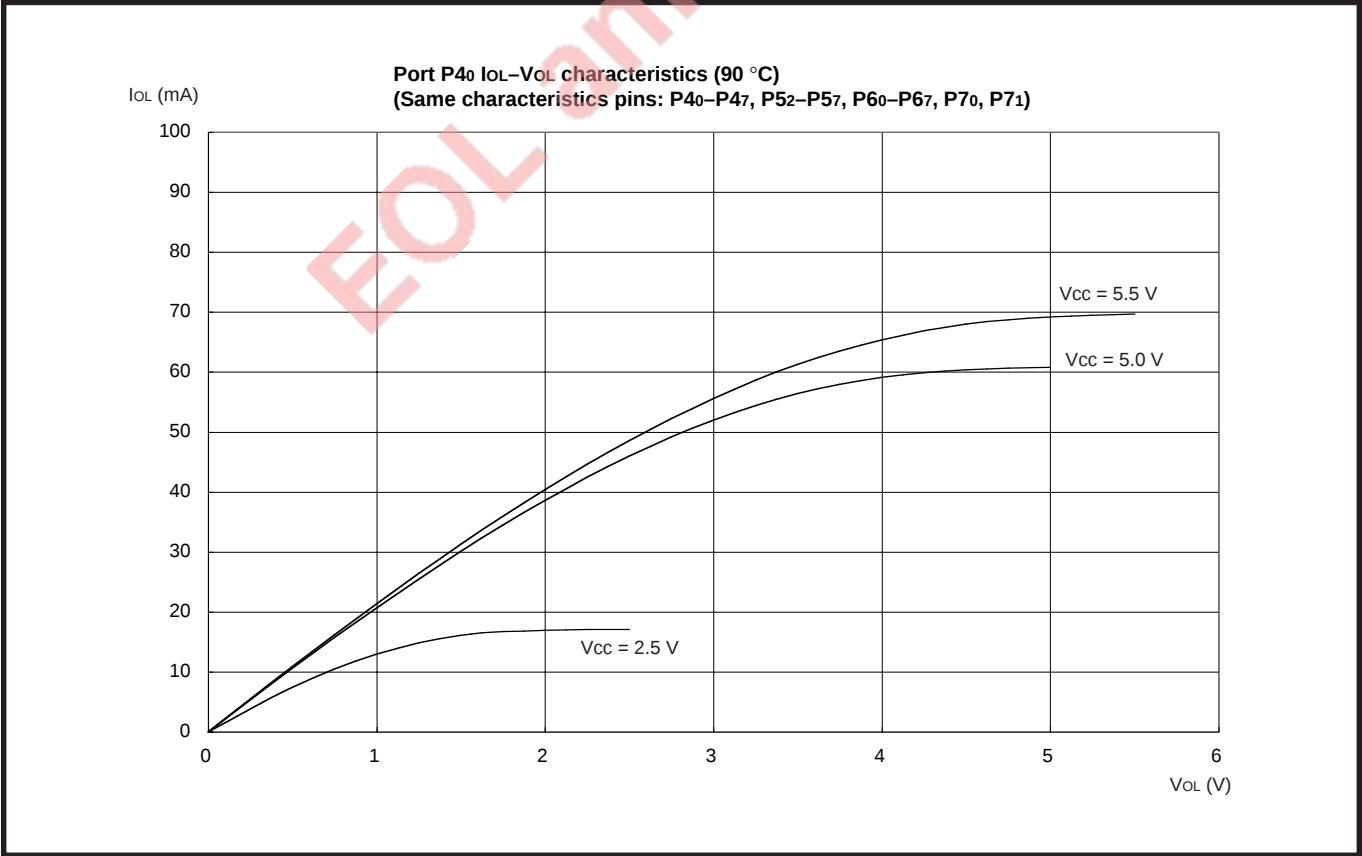


Fig. 3.2.10 CMOS output port (P4, P5<sub>2</sub>-P5<sub>7</sub>, P6, P7<sub>0</sub>, P7<sub>1</sub>) N-channel side characteristics (90 °C)

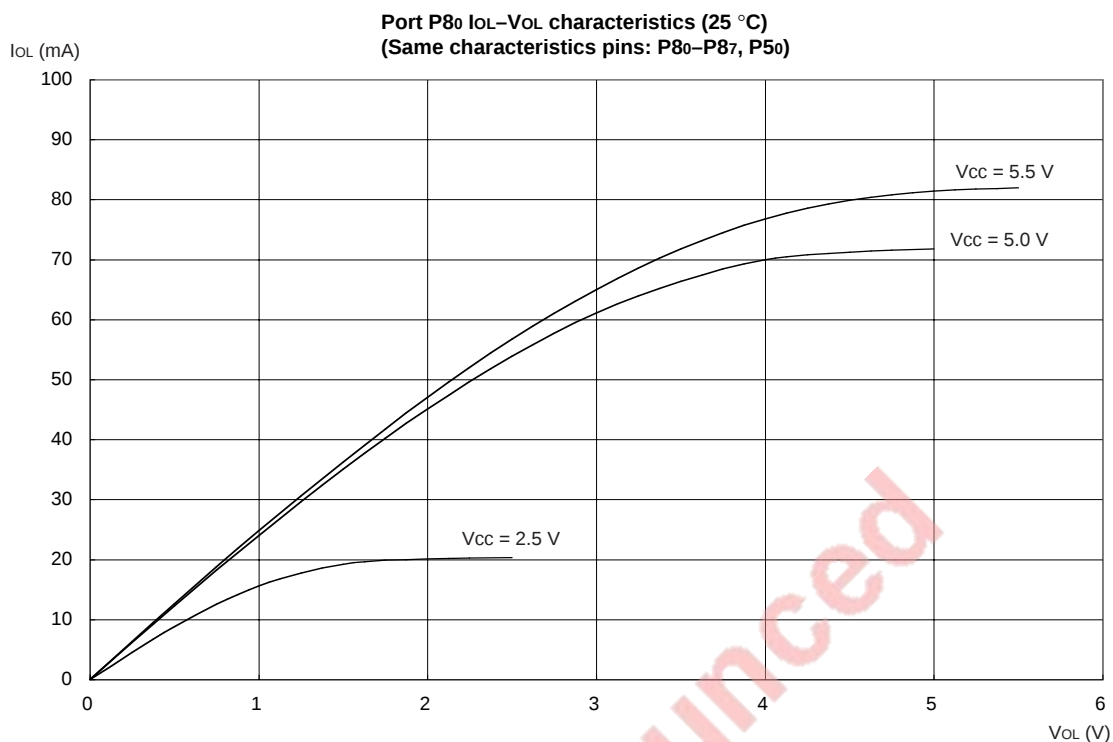


Fig. 3.2.11 CMOS output port (P5<sub>0</sub>, P8) N-channel side characteristics (25 °C)

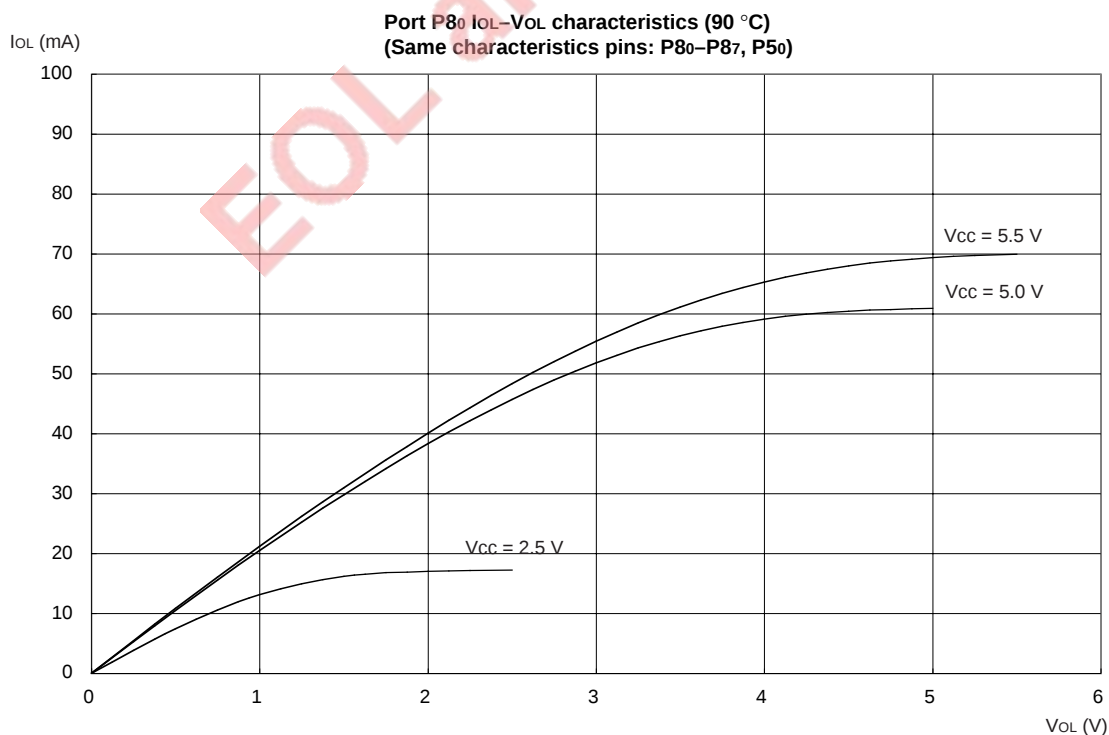


Fig. 3.2.12 CMOS output port (P5<sub>0</sub>, P8) N-channel side characteristics (90 °C)

# APPENDIX

## 3.3 Notes on use

### 3.3 Notes on use

#### 3.3.1 Notes on interrupts

##### (1) Switching external interrupt detection edge

For the products able to switch the external interrupt detection edge, switch it as the following sequence.

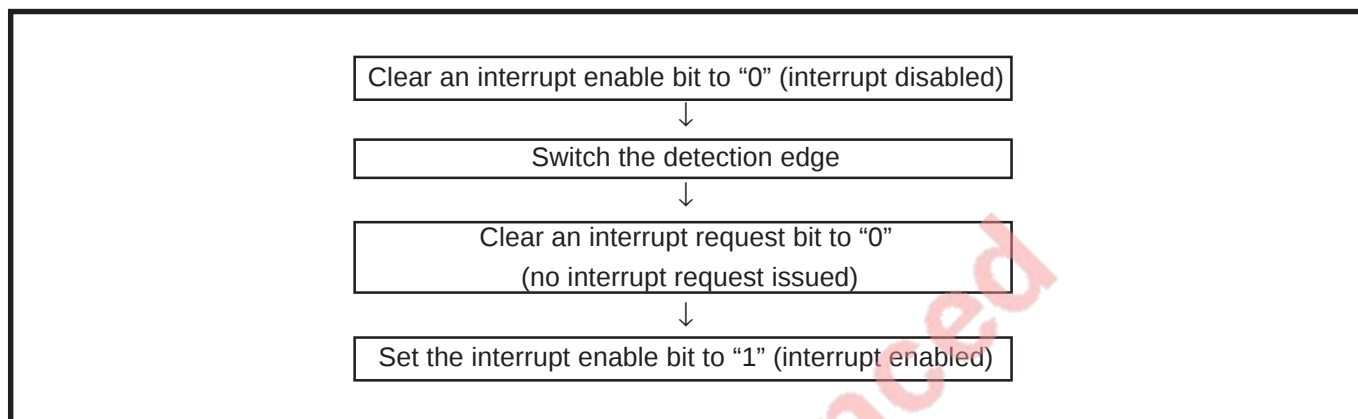


Fig. 3.3.1 Sequence of switch detection edge

##### ■ Reason

The interrupt circuit recognizes the switching of the detection edge as the change of external input signals. This may cause an unnecessary interrupt.

##### (2) Check of interrupt request bit

- When executing the **BBC** or **BBS** instruction to an interrupt request bit of an interrupt request register immediately after this bit is set to "0" by using a data transfer instruction, execute one or more instructions before executing the **BBC** or **BBS** instruction.

##### ■ Reason

If the **BBC** or **BBS** instruction is executed immediately after an interrupt request bit of an interrupt request register is cleared to "0", the value of the interrupt request bit before being cleared to "0" is read.

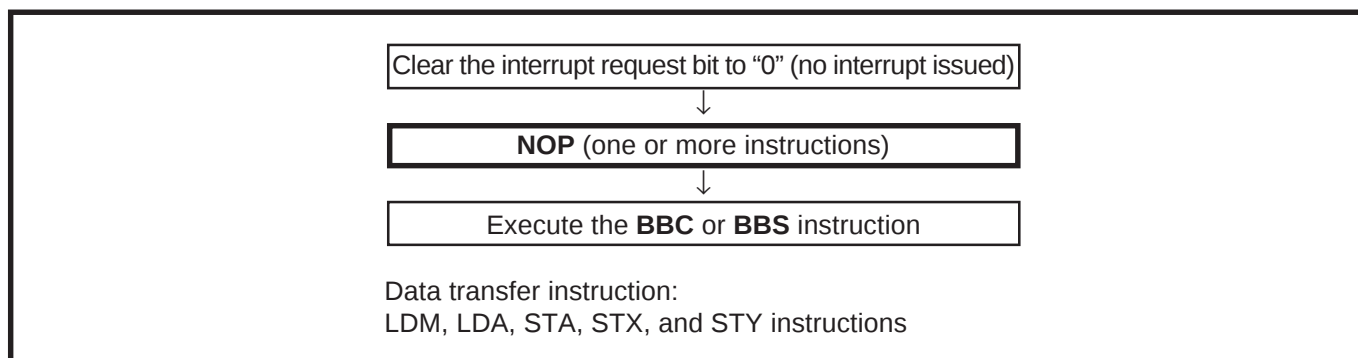


Fig. 3.3.2 Sequence of check of interrupt request bit

### (3) Structure of interrupt control register 2

Fix the bit 7 of the interrupt control register 2 to "0". Figure 3.3.3 shows the structure of the interrupt control register 2.

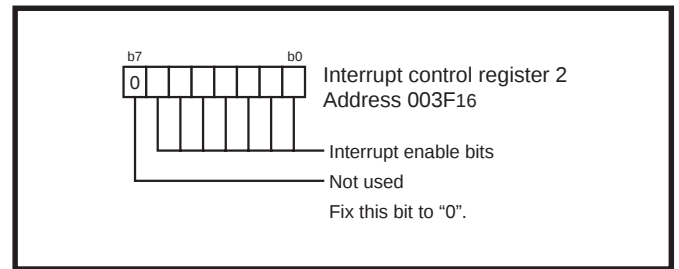


Fig. 3.3.3 Structure of interrupt control register 2

### 3.3.2 Notes on timer A (PWM mode and IGBT output mode)

#### (1) When timer starts first or last value of compare register is "0000<sub>16</sub>"

After "L" level (timer A output active edge switch bit is "0"; when starting from "L" output) is output during 2 cycles (until timer underflows two times), start PWM output or IGBT output.

**Reason:** When data is written to timer A and compare register, value of timer A and value of compare register are renewed at timer underflow. In case of this, compare register value and timer value are compared before renewal so that they are judged to be equal, and TA<sub>OUT</sub> output becomes "L". (Timer A output switch bit = "0": when starting from "L" output) Timer A underflow should be "H" output, but the match have the priority. (see "Figure 3.3.4")

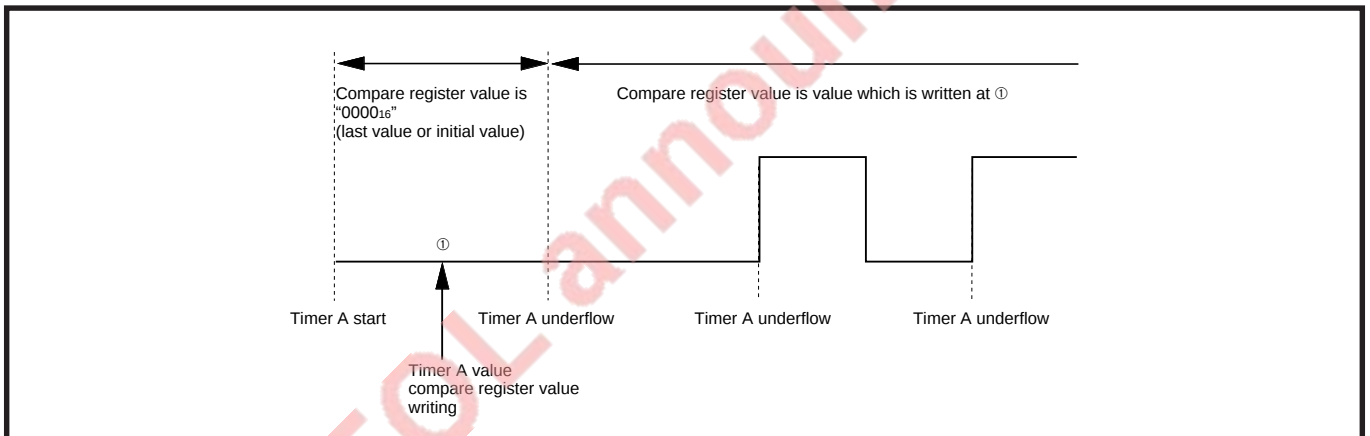


Fig. 3.3.4 PWM output and IGBT output (1)

# APPENDIX

## 3.3 Notes on use

### (2) When compare register is set to “0000<sub>16</sub>” (last value is except “0000<sub>16</sub>”)

Next 1 cycle of the cycle which data is written to timer A and compare register is output “H”, and “L” is output from the next cycle. (timer A output switch bit = “0”: when starting from “L” output) (see “Figure 3.3.5”)

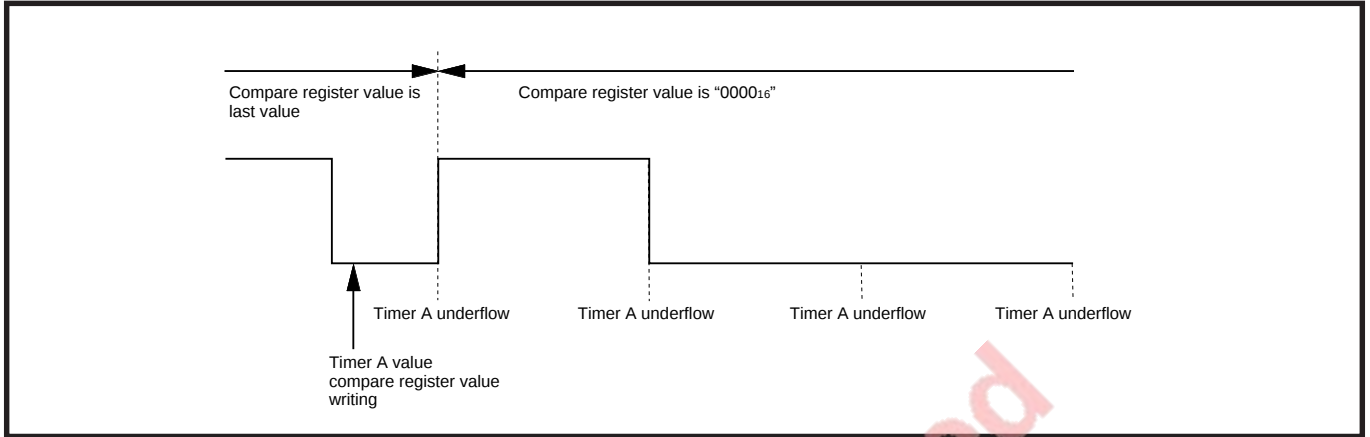


Fig. 3.3.5 PWM output and IGBT output (2)

### (3) When timer A and compare register are same value

TA<sub>OUT</sub> output becomes “H” with underflow immediately after data is written to timer A and compare register. And TA<sub>OUT</sub> output becomes “L” when timer A is reloaded and the value matches with compare register. This “H” output width becomes 1 count of timer A count source. (timer A output switch bit = “0”: when starting from “L” output) (see “Figure 3.3.6”)

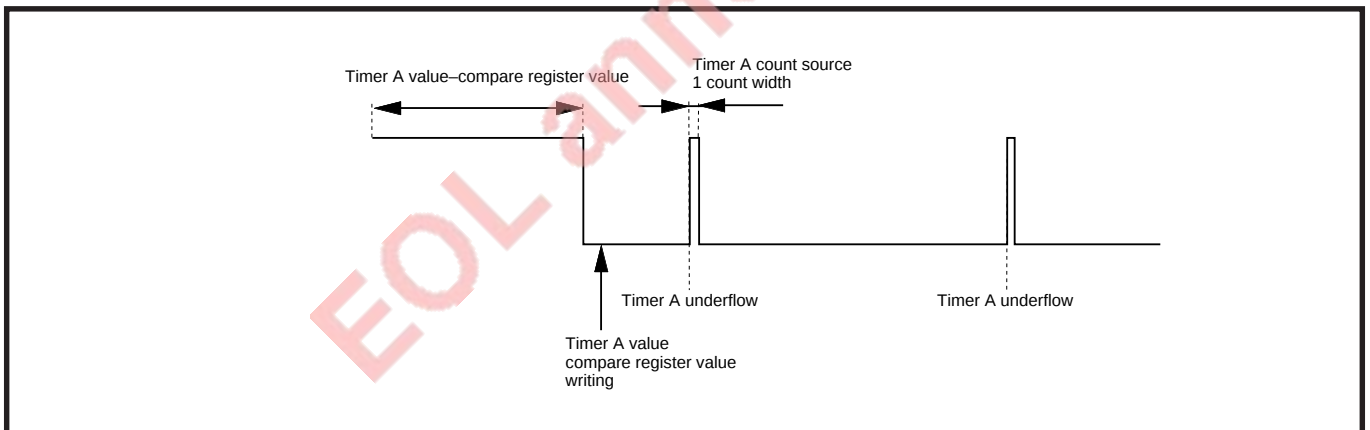


Fig. 3.3.6 PWM output and IGBT output (3)

## 3.3.3 Notes on serial I/O

## (1) Selecting external synchronous clock

When an external synchronous clock is selected, the contents of serial I/O register are being shifted continually while the transfer clock is input to the serial I/O1 clock pin. In this case, control the clock externally.

## (2) Transmission data writing

When an external clock is used as the synchronous clock, write the transmit data to the serial I/O shift register at "H" level of transfer clock input.

## 3.3.4 Notes on LCD controller

- When switching from the high-speed or middle-speed mode to the low-speed mode, switch the mode in the following order:

- (1) 32 kHz oscillation selected (bit 4 of CPU mode register (address 003B<sub>16</sub>) = "1")
  - (2) Count source for LCDCK =  $f(X_{CIN})/32$  (bit 7 of LCD mode register (address 0039<sub>16</sub>) = "0")
  - (3) Internal system clock:  $X_{CIN}-X_{COUT}$  selected (bit 7 of CPU mode register (address 003B<sub>16</sub>) = "1")
  - (4) Main clock  $X_{IN}-X_{OUT}$  stopped (bit 5 of CPU mode register (address 003B<sub>16</sub>) = "1")
- Execute the setting (2) after the oscillation at 32 kHz (setting (1)) becomes completely stable.

- If the STP instruction is executed while the LCD is turned on by setting bit 3 of the LCD mode register (address 0039<sub>16</sub>) to "1", a DC voltage is applied to the LCD. For this reason, do not execute the STP instruction while the LCD is lighting.

- When the LCD is not used, open the segment and the common pins.  
Connect  $V_{L1}$  to  $V_{L3}$  to  $V_{SS}$ .

- For the following products, if the LCD enable bit of the LCD mode register (bit 3 of address 0039<sub>16</sub>) is set to "0", all LCDs cannot be turned off. When all LCDs are turned off, set "0" (turn off) to all corresponding LCD display RAM.

**Corresponding products:** M38C34M6AXXXFP, M38C34M6MXXFP, M38C37ECAXXXFP, M38C37ECMXXFP, M38C37ECAFP, M38C37ECMFP, M38C37ECAFS, M38C37ECMFS, M38C37RFS, M38C37RMFS

# APPENDIX

## 3.3 Notes on use

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### 3.3.5 Notes on A-D converter

#### (1) Analog input pin

- Make the signal source impedance for analog input low, or equip an analog input pin with an external capacitor of 0.01  $\mu\text{F}$  to 1  $\mu\text{F}$ . Further, be sure to verify the operation of application products on the user side.

#### ● Reason

An analog input pin includes the capacitor for analog voltage comparison. Accordingly, when signals from signal source with high impedance are input to an analog input pin, charge and discharge noise generates. This may cause the A-D conversion precision to be worse.

#### (2) A-D converter power source pin

The AVss pin is A-D converter power source pin. Regardless of using the A-D conversion function or not, connect it as following :

- AVss : Connect to the Vss line.

#### ● Reason

If the AVss pin is opened, the microcomputer may have a failure because of noise or others.

#### (3) Clock frequency during A-D conversion

The comparator consists of a capacity coupling, and a charge of the capacity will be lost if the clock frequency is too low. Thus, make sure the following during an A-D conversion.

- $f(X_{IN})$  is 500 kHz or more.
- Use clock divided by main clock ( $f(X_{IN})$ ) as internal system clock.
- Do not execute the **STP** instruction and **WIT** instruction.

### 3.3.6 Notes on reset circuit

#### (1) Reset input voltage control

Make sure that the reset input voltage is 0.5 V or less for Vcc of 2.5 V (**Note**).

Perform switch to the high-speed mode when power source voltage is within 4.0 to 5.5 V.

**Note:** M version of mask ROM version is 2.2 V.

#### (2) Countermeasure when RESET signal rise time is long

In case where the RESET signal rise time is long, connect a ceramic capacitor or others across the RESET pin and the Vss pin. And use a 1000 pF or more capacitor for high frequency use. When connecting the capacitor, note the following :

- Make the length of the wiring which is connected to a capacitor as short as possible.
- Be sure to verify the operation of application products on the user side.

#### ● Reason

If the several nanosecond or several ten nanosecond impulse noise enters the RESET pin, it may cause a microcomputer failure.

### 3.4 Countermeasures against noise

Countermeasures against noise are described below. The following countermeasures are effective against noise in theory, however, it is necessary not only to take measures as follows but to evaluate before actual use.

#### 3.4.1 Shortest wiring length

The wiring on a printed circuit board can function as an antenna which feeds noise into the microcomputer. The shorter the total wiring length (by mm unit), the less the possibility of noise insertion into a microcomputer.

##### (1) Package

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

##### ● Reason

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

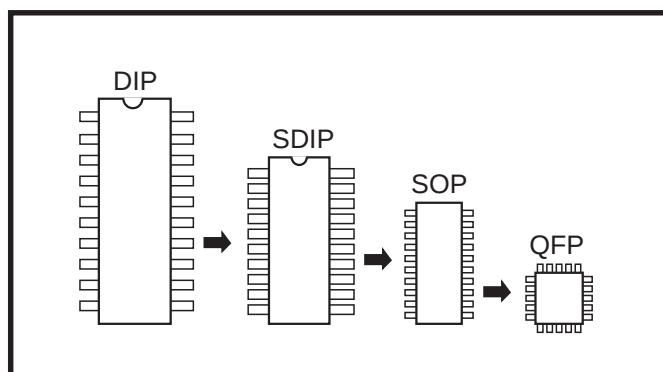


Fig. 3.4.1 Selection of packages

##### (2) Wiring for RESET pin

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

##### ● Reason

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

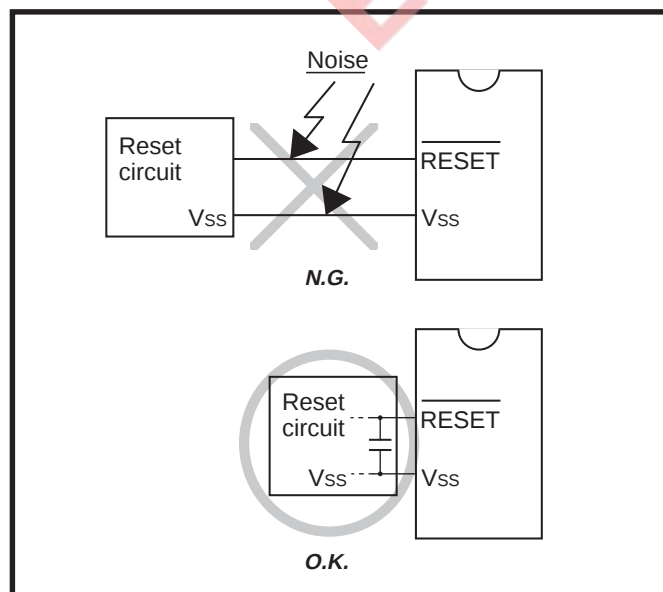


Fig. 3.4.2 Wiring for the RESET pin

# APPENDIX

## 3.4 Countermeasures against noise

### (3) Wiring for clock input/output pins

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

#### ● Reason

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

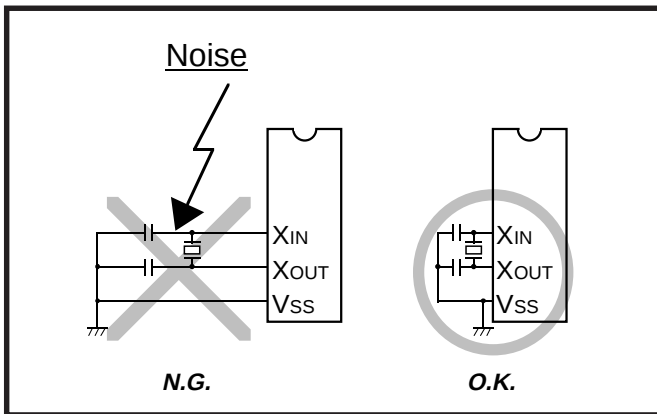


Fig. 3.4.3 Wiring for clock I/O pins

**(4) Wiring to VPP pin of One Time PROM version and EPROM version**

Connect an approximately 5 kΩ resistor to the VPP pin the shortest possible in series. When not connecting the resistor, make the length of wiring between the VPP pin and the Vss pin the shortest possible.

**Note:** Even when a circuit which included an approximately 5 kΩ resistor is used in the Mask ROM version, the microcomputer operates correctly.

**● Reason**

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

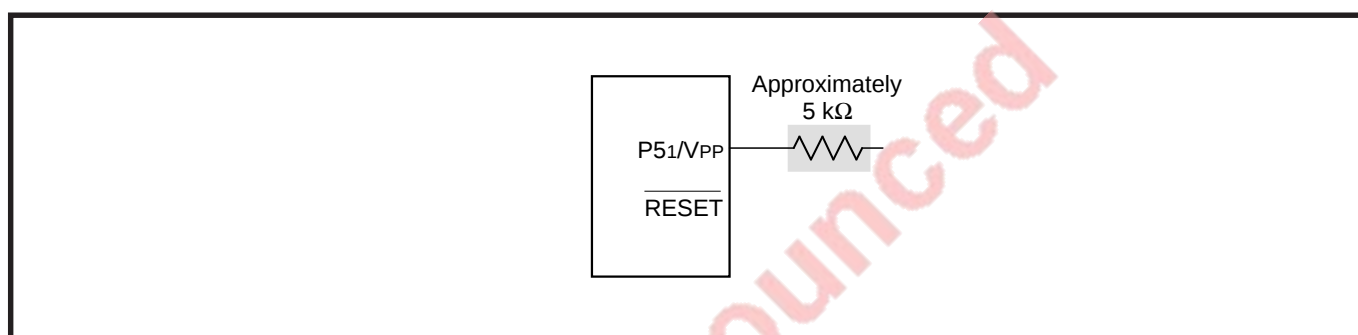


Fig. 3.4.4 Wiring for the VPP pin of the One Time PROM and the EPROM version

**3.4.2 Connection of bypass capacitor across Vss line and Vcc line**

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

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

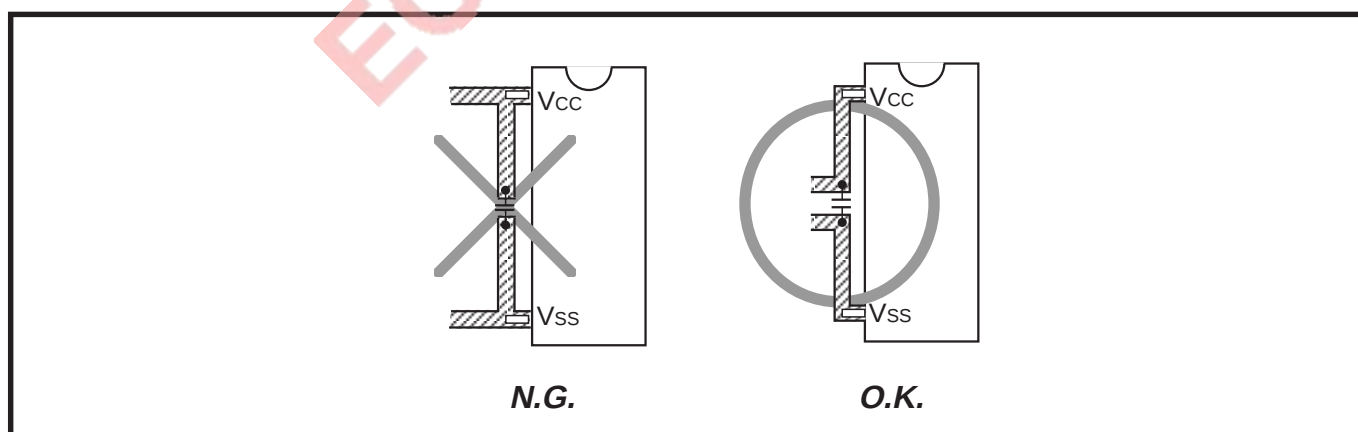


Fig. 3.4.5 Bypass capacitor across the Vss line and the Vcc line

# APPENDIX

## 3.4 Countermeasures against noise

### 3.4.3 Wiring to analog input pins

- Connect an approximately  $100\ \Omega$  to  $1\ \text{k}\Omega$  resistor to an analog signal line which is connected to an analog input pin in series. Besides, connect the resistor to the microcomputer as close as possible.
- Connect an approximately  $1000\ \text{pF}$  capacitor across the  $V_{SS}$  pin and the analog input pin. Besides, connect the capacitor to the  $V_{SS}$  pin as close as possible. Also, connect the capacitor across the analog input pin and the  $V_{SS}$  pin at equal length.

#### ● Reason

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

If a capacitor between an analog input pin and the  $V_{SS}$  pin is grounded at a position far away from the  $V_{SS}$  pin, noise on the GND line may enter a microcomputer through the capacitor.

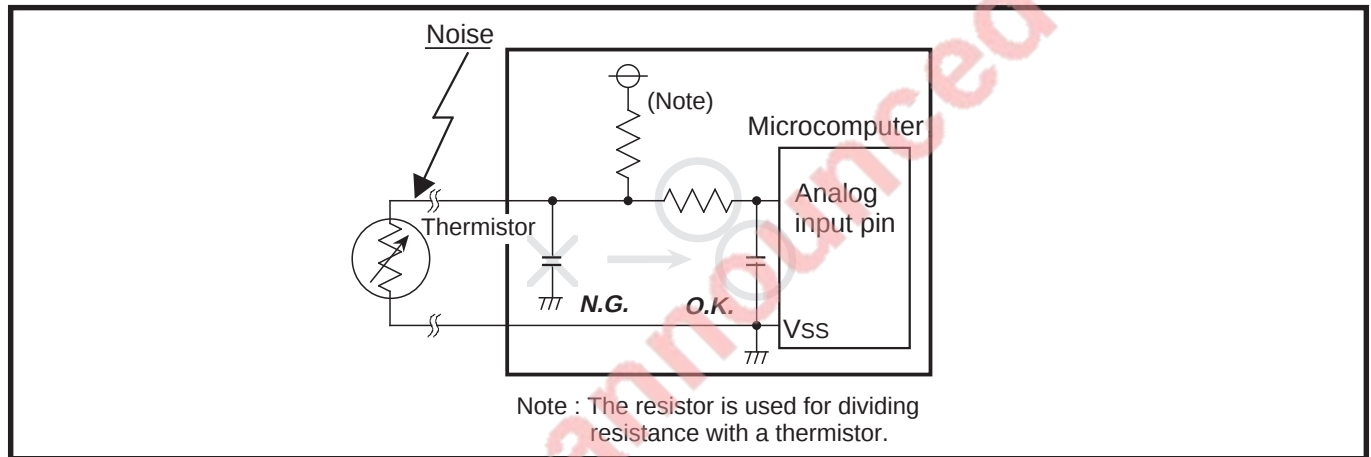


Fig. 3.4.6 Analog signal line and a resistor and a capacitor

### 3.4.4 Oscillator concerns

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

#### (1) Keeping oscillator away from large current signal lines

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

#### ● Reason

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

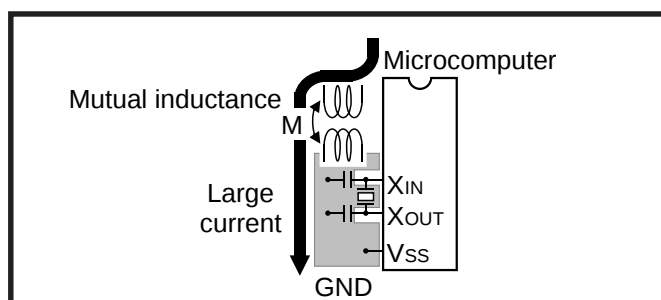


Fig. 3.4.7 Wiring for a large current signal line

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

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

**● Reason**

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

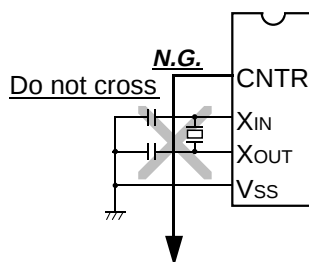


Fig. 3.4.8 Wiring of signal lines where potential levels change frequently

**(3) Oscillator protection using Vss pattern**

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

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

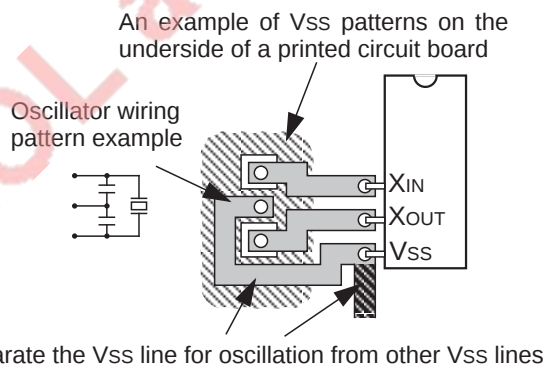


Fig. 3.4.9 Vss pattern on the underside of an oscillator

# APPENDIX

## 3.4 Countermeasures against noise

### 3.4.5 Setup for I/O ports

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

#### <Hardware>

- Connect a resistor of 100  $\Omega$  or more to an I/O port in series.

#### <Software>

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

**Note:** When a direction register is set for input port again at fixed periods, a several-nanosecond short pulse may be output from this port. If this is undesirable, connect a capacitor to this port to remove the noise pulse.

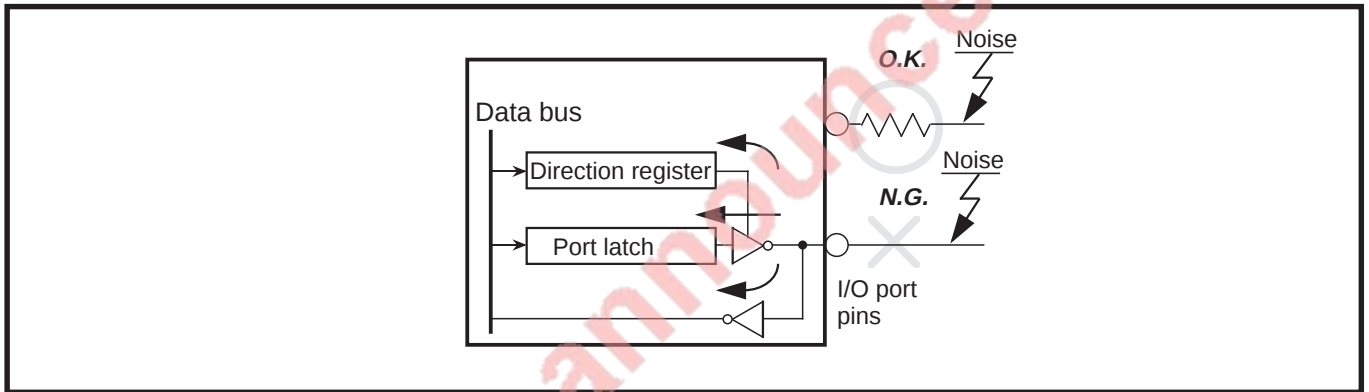


Fig. 3.4.10 Setup for I/O ports

### 3.4.6 Providing of watchdog timer function by software

If a microcomputer runs away because of noise or others, it can be detected by a software watchdog timer and the microcomputer can be reset to normal operation. This is equal to or more effective than program runaway detection by a hardware watchdog timer. The following shows an example of a watchdog timer provided by software.

In the following example, to reset a microcomputer to normal operation, the main routine detects errors of the interrupt processing routine and the interrupt processing routine detects errors of the main routine. This example assumes that interrupt processing is repeated multiple times in a single main routine processing.

#### <The main routine>

- Assigns a single byte of RAM to a software watchdog timer (SWDT) and writes the initial value N in the SWDT once at each execution of the main routine. The initial value N should satisfy the following condition:  

$$N+1 \geq (\text{Counts of interrupt processing executed in each main routine})$$
 As the main routine execution cycle may change because of an interrupt processing or others, the initial value N should have a margin.
- Watches the operation of the interrupt processing routine by comparing the SWDT contents with counts of interrupt processing after the initial value N has been set.
- Detects that the interrupt processing routine has failed and determines to branch to the program initialization routine for recovery processing in the following case:  
 If the SWDT contents do not change after interrupt processing.

#### <The interrupt processing routine>

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

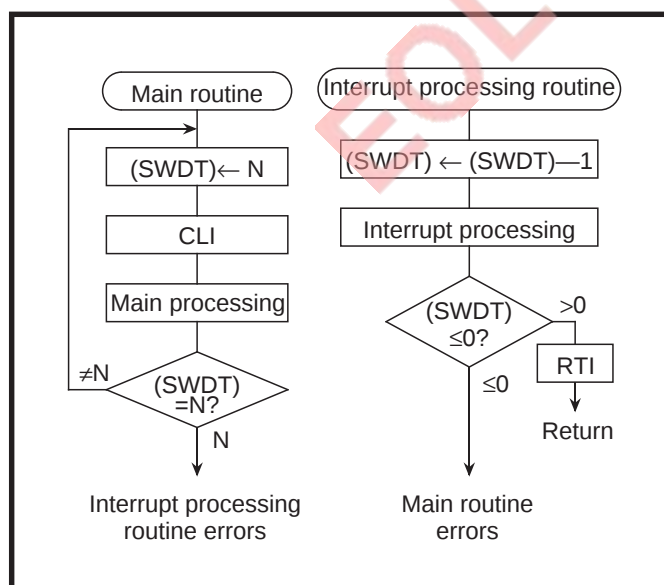


Fig. 3.4.11 Watchdog timer by software

# APPENDIX

## 3.5 Control registers

### 3.5 Control registers

#### Port Pi

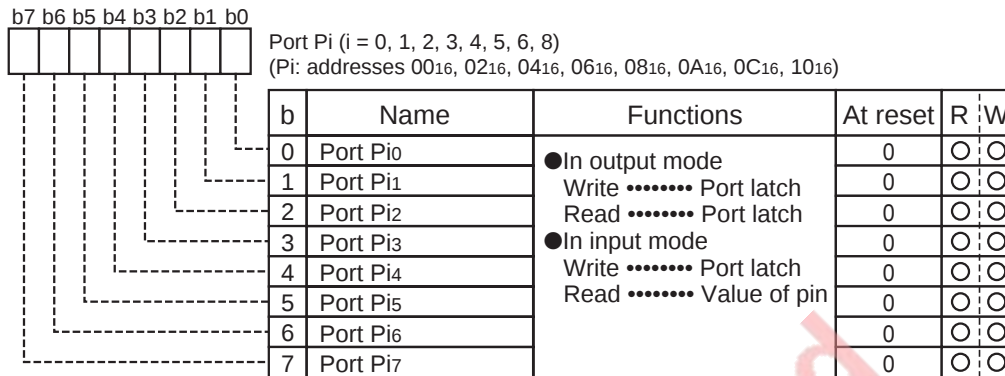
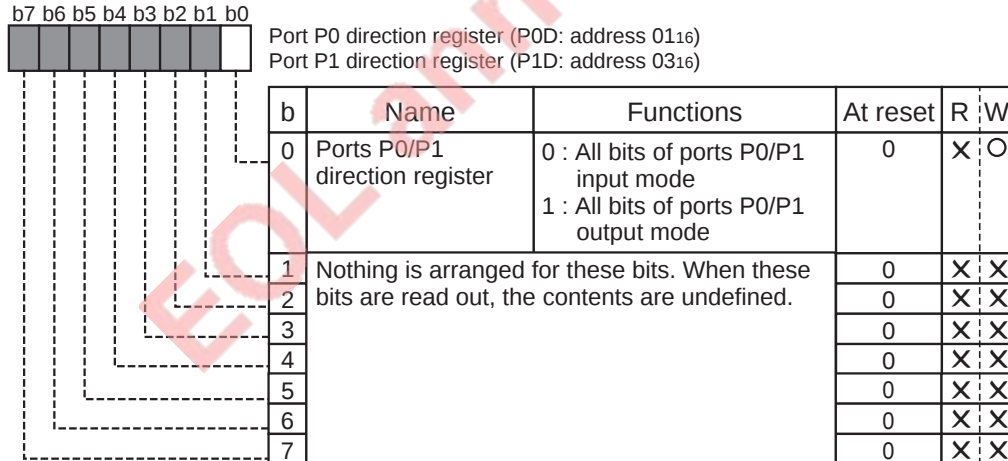


Fig. 3.5.1 Structure of Port Pi

#### Port P0 direction register, Port P1 direction register



**Note:** Ports P0 and P1 are switched to input and output by each port. When b0 of corresponding port direction register is set to "0", all 8 bits of port become input port. When b0 of corresponding port direction register is set to "1", all 8 bits of port become output port. Nothing is arranged for b1 to b7 of port P0 and port P1 direction registers. These are write disabled bits.

Fig. 3.5.2 Structure of Port P0 direction register and Port P1 direction register

## Port Pi direction register

| b7                                                                                              | b6                         | b5                                                                                         | b4       | b3 | b2 | b1 | b0 |
|-------------------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------|----------|----|----|----|----|
|                                                                                                 |                            |                                                                                            |          |    |    |    |    |
| Port Pi direction register (i = 2, 4, 5, 6, 8)<br>(PiD: addresses 0516, 0916, 0B16, 0D16, 1116) |                            |                                                                                            |          |    |    |    |    |
| b                                                                                               | Name                       | Functions                                                                                  | At reset | R  | W  |    |    |
| 0                                                                                               | Port Pi direction register | 0 : Port P <sub>0</sub> input mode<br>1 : Port P <sub>0</sub> output mode                  | 0        | X  | O  |    |    |
| 1                                                                                               |                            | 0 : Port P <sub>1</sub> input mode<br>1 : Port P <sub>1</sub> output mode<br><b>(Note)</b> | 0        | X  | O  |    |    |
| 2                                                                                               |                            | 0 : Port P <sub>2</sub> input mode<br>1 : Port P <sub>2</sub> output mode                  | 0        | X  | O  |    |    |
| 3                                                                                               |                            | 0 : Port P <sub>3</sub> input mode<br>1 : Port P <sub>3</sub> output mode                  | 0        | X  | O  |    |    |
| 4                                                                                               |                            | 0 : Port P <sub>4</sub> input mode<br>1 : Port P <sub>4</sub> output mode                  | 0        | X  | O  |    |    |
| 5                                                                                               |                            | 0 : Port P <sub>5</sub> input mode<br>1 : Port P <sub>5</sub> output mode                  | 0        | X  | O  |    |    |
| 6                                                                                               |                            | 0 : Port P <sub>6</sub> input mode<br>1 : Port P <sub>6</sub> output mode                  | 0        | X  | O  |    |    |
| 7                                                                                               |                            | 0 : Port P <sub>7</sub> input mode<br>1 : Port P <sub>7</sub> output mode                  | 0        | X  | O  |    |    |

**Note:** Bit 1 of the port P5 direction register (address 0B16) does not have direction register function, because P5<sub>1</sub> is an input port. When writing to bit 1 of the port P5 direction register, write "0" to the bit.

Fig. 3.5.3 Structure of Port Pi direction register

## Port P7

|                               |                                                                                               |                                                                      |          |    |    |    |    |
|-------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------|----|----|----|----|
| b7                            | b6                                                                                            | b5                                                                   | b4       | b3 | b2 | b1 | b0 |
|                               |                                                                                               |                                                                      |          |    |    |    |    |
| Port P7<br>(P7: address 0E16) |                                                                                               |                                                                      |          |    |    |    |    |
| b                             | Name                                                                                          | Functions                                                            | At reset | R  | W  |    |    |
| 0                             | Port P7 <sub>0</sub>                                                                          | ● In output mode<br>Write ..... Port latch<br>Read ..... Port latch  | 0        | ○  | ○  |    |    |
| 1                             | Port P7 <sub>1</sub>                                                                          | ● In input mode<br>Write ..... Port latch<br>Read ..... Value of pin | 0        | ○  | ○  |    |    |
| 2                             | Nothing is arranged for these bits. When these bits are read out, the contents are undefined. |                                                                      | 0        | ×  | ×  |    |    |
| 3                             |                                                                                               |                                                                      | 0        | ×  | ×  |    |    |
| 4                             |                                                                                               |                                                                      | 0        | ×  | ×  |    |    |
| 5                             |                                                                                               |                                                                      | 0        | ×  | ×  |    |    |
| 6                             |                                                                                               |                                                                      | 0        | ×  | ×  |    |    |
| 7                             |                                                                                               |                                                                      | 0        | ×  | ×  |    |    |

Fig. 3.5.4 Structure of Port P7

# APPENDIX

## 3.5 Control registers

### Port P7 direction register

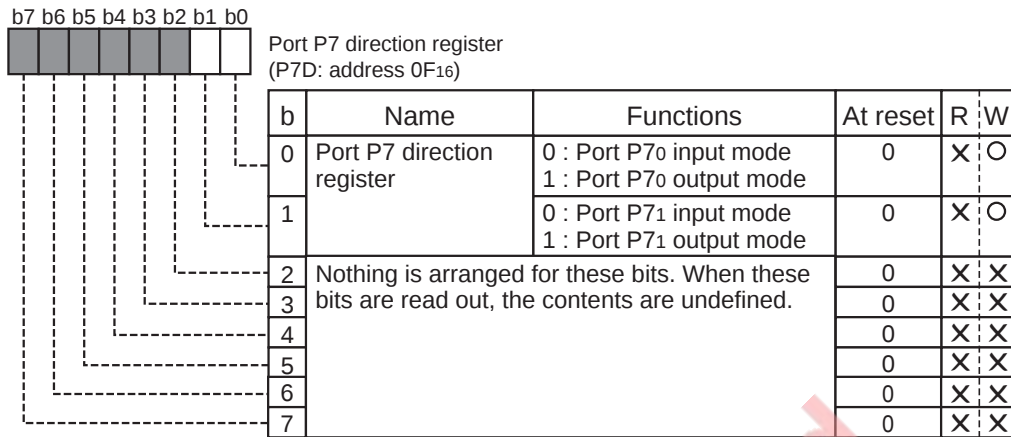
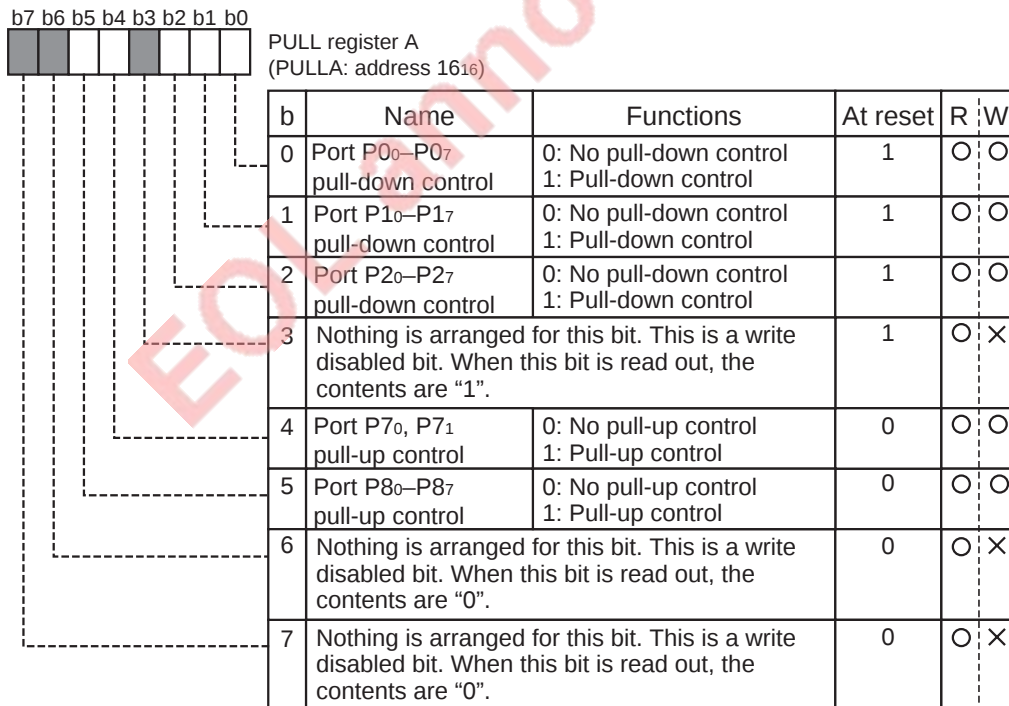


Fig. 3.5.5 Structure of Port P7 direction register

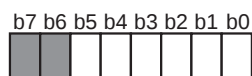
### PULL register A



**Note:** The pin which is set to output port is cut off from pull-up control.

Fig. 3.5.6 Structure of PULL register A

## PULL register B



PULL register B  
(PULLB: address 17<sub>16</sub>)

| b | Name                                                                                                             | Functions                                   | At reset | R | W |
|---|------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------|---|---|
| 0 | Port P4 <sub>0</sub> –P4 <sub>3</sub><br>pull-up control                                                         | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 1 | Port P4 <sub>4</sub> –P4 <sub>7</sub><br>pull-up control                                                         | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 2 | Port P5 <sub>0</sub> , P5 <sub>2</sub> , P5 <sub>3</sub><br>pull-up control                                      | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 3 | Port P5 <sub>4</sub> –P5 <sub>7</sub><br>pull-up control                                                         | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 4 | Port P6 <sub>0</sub> –P6 <sub>3</sub><br>pull-up control                                                         | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 5 | Port P6 <sub>4</sub> –P6 <sub>7</sub><br>pull-up control                                                         | 0: No pull-up control<br>1: Pull-up control | 0        | ○ | ○ |
| 6 | Nothing is arranged for this bit. This is a write disabled bit. When this bit is read out, the contents are "0". |                                             | 0        | ○ | × |
| 7 | Nothing is arranged for this bit. This is a write disabled bit. When this bit is read out, the contents are "0". |                                             | 0        | ○ | × |

**Note:** The pin which is set to output port is cut off from pull-up control.

Fig. 3.5.7 Structure of PULL register B

# APPENDIX

## 3.5 Control registers

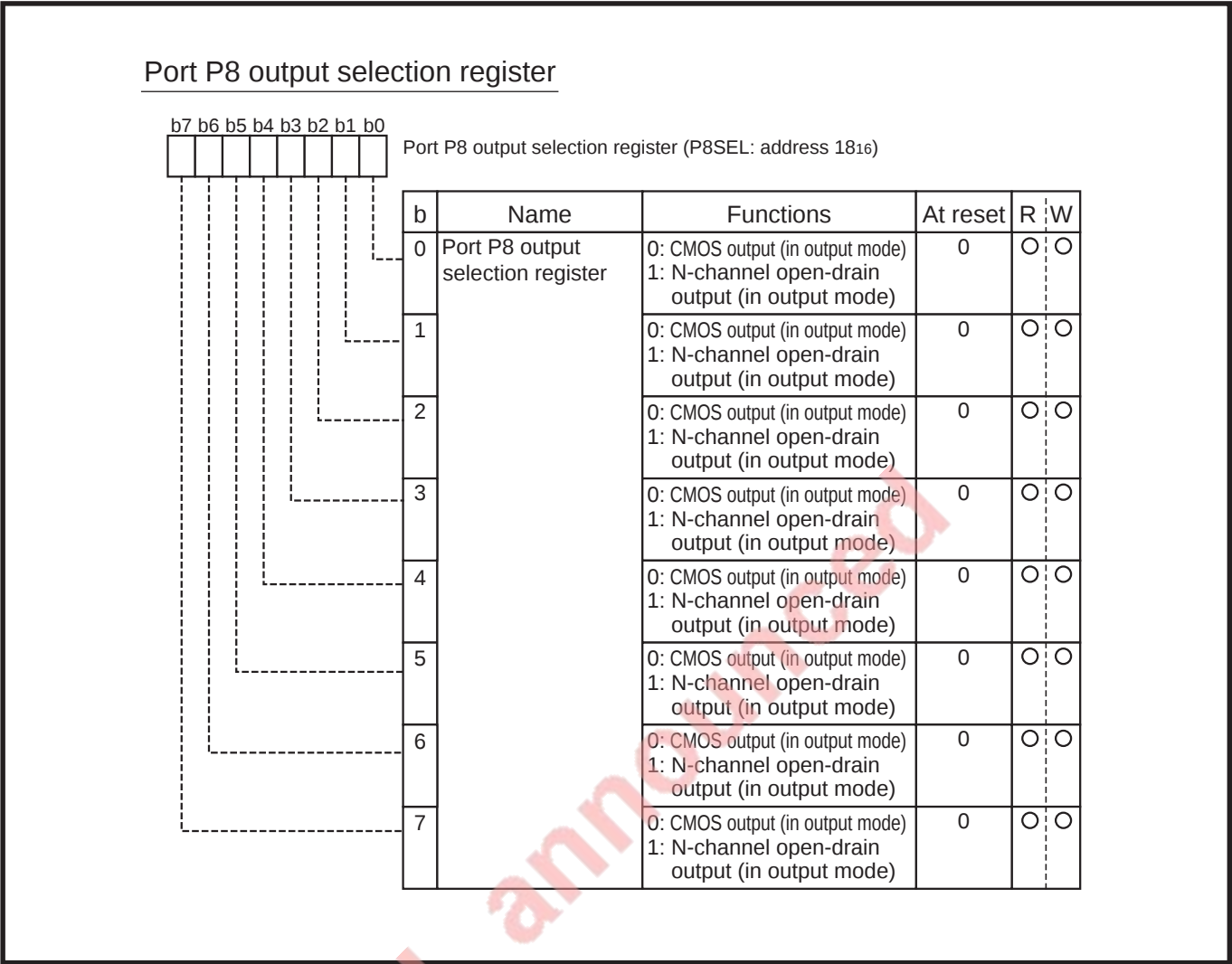


Fig. 3.5.8 Structure of Port P8 output selection register

## Serial I/O control register 1

b7

b6

b5

b4

b3

b2

b1

b0

Serial I/O control register 1

(SIOCON1: address 19<sub>16</sub>)

| b | Name                                                                                 | Functions                                                                                                                | At reset | R | W |
|---|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | Internal synchronous clock selection bits                                            | b2b1b0<br>0 0 0: f(X <sub>IN</sub> )/8 or f(X <sub>CIN</sub> )/8                                                         | 0        | ○ | ○ |
| 1 |                                                                                      | 0 0 1: f(X <sub>IN</sub> )/16 or f(X <sub>CIN</sub> )/16                                                                 | 0        | ○ | ○ |
|   |                                                                                      | 0 1 0: f(X <sub>IN</sub> )/32 or f(X <sub>CIN</sub> )/32                                                                 |          |   |   |
|   |                                                                                      | 0 1 1: f(X <sub>IN</sub> )/64 or f(X <sub>CIN</sub> )/64                                                                 |          |   |   |
| 2 |                                                                                      | 1 1 0: f(X <sub>IN</sub> )/128 or f(X <sub>CIN</sub> )/128<br>1 1 1: f(X <sub>IN</sub> )/256 or f(X <sub>CIN</sub> )/256 | 0        | ○ | ○ |
| 3 | Serial I/O port selection bit (P4 <sub>0</sub> , P4 <sub>5</sub> , P4 <sub>6</sub> ) | 0: I/O port<br>1: S <sub>OUT</sub> , S <sub>CLK1</sub> , S <sub>CLK2</sub> signal pin                                    | 0        | ○ | ○ |
| 4 | $\overline{SRDY}$ output selection bit (P4 <sub>7</sub> )                            | 0: I/O port<br>1: $\overline{SRDY}$ signal pin                                                                           | 0        | ○ | ○ |
| 5 | Transfer direction selection bit                                                     | 0: LSB first<br>1: MSB first                                                                                             | 0        | ○ | ○ |
| 6 | Synchronous clock selection bit                                                      | 0: External clock<br>1: Internal clock                                                                                   | 0        | ○ | ○ |
| 7 | P-channel output disable bit (P4 <sub>0</sub> , P4 <sub>5</sub> , P4 <sub>6</sub> )  | 0: CMOS output (in output mode)<br>1: N-channel open-drain output (in output mode)                                       | 0        | ○ | ○ |

Fig. 3.5.9 Structure of Serial I/O control register 1

# APPENDIX

## 3.5 Control registers

### Serial I/O control register 2

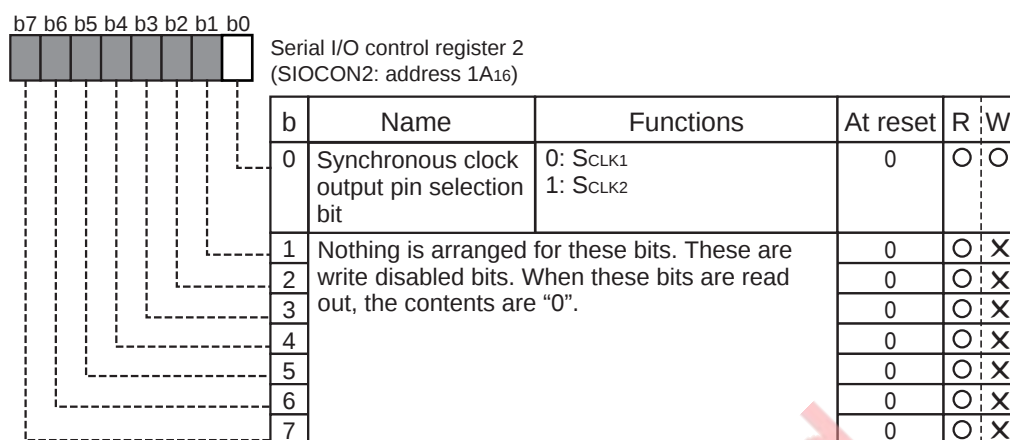


Fig. 3.5.10 Structure of Serial I/O control register 2

### Serial I/O register

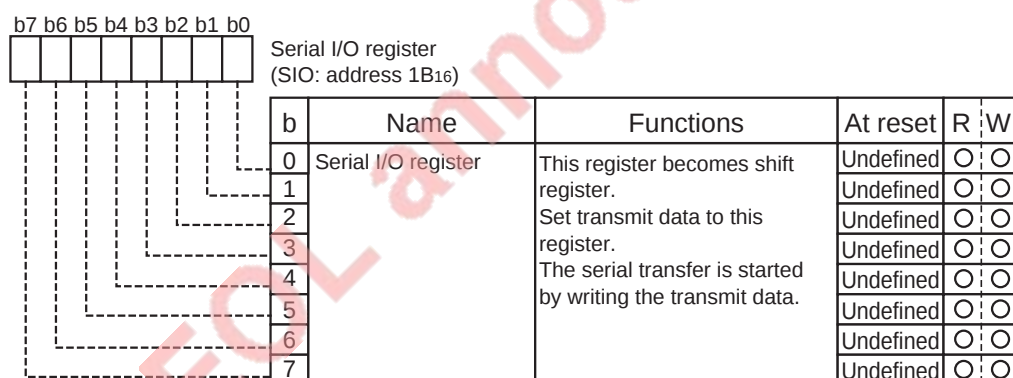


Fig. 3.5.11 Structure of Serial I/O register

Timer i

b7 b6 b5 b4 b3 b2 b1 b0



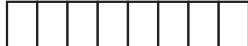
Timer i (i = 1, 3, 4, 5, 6)  
(Ti: addresses 20<sub>16</sub>, 22<sub>16</sub>, 23<sub>16</sub>, 24<sub>16</sub>, 25<sub>16</sub>)

| b | Functions                                                                                          | At reset | R | W |
|---|----------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | • Set timer i count value.                                                                         | 1        | ○ | ○ |
| 1 | • The value set in this register is written to both the timer i and the timer i latch at one time. | 1        | ○ | ○ |
| 2 |                                                                                                    | 1        | ○ | ○ |
| 3 | • When the timer i is read out, the count value of the timer i is read out.                        | 1        | ○ | ○ |
| 4 |                                                                                                    | 1        | ○ | ○ |
| 5 |                                                                                                    | 1        | ○ | ○ |
| 6 |                                                                                                    | 1        | ○ | ○ |
| 7 |                                                                                                    | 1        | ○ | ○ |

Fig. 3.5.12 Structure of Timer i

Timer 2

b7 b6 b5 b4 b3 b2 b1 b0



Timer 2  
(T2: address 21<sub>16</sub>)

| b | Functions                                                                                          | At reset | R | W |
|---|----------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | • Set timer 2 count value.                                                                         | 1        | ○ | ○ |
| 1 | • The value set in this register is written to both the timer 2 and the timer 2 latch at one time. | 0        | ○ | ○ |
| 2 |                                                                                                    | 0        | ○ | ○ |
| 3 | • When the timer 2 is read out, the count value of the timer 2 is read out.                        | 0        | ○ | ○ |
| 4 |                                                                                                    | 0        | ○ | ○ |
| 5 |                                                                                                    | 0        | ○ | ○ |
| 6 |                                                                                                    | 0        | ○ | ○ |
| 7 |                                                                                                    | 0        | ○ | ○ |

Fig. 3.5.13 Structure of Timer 2

# APPENDIX

## 3.5 Control registers

Timer 6 PWM register

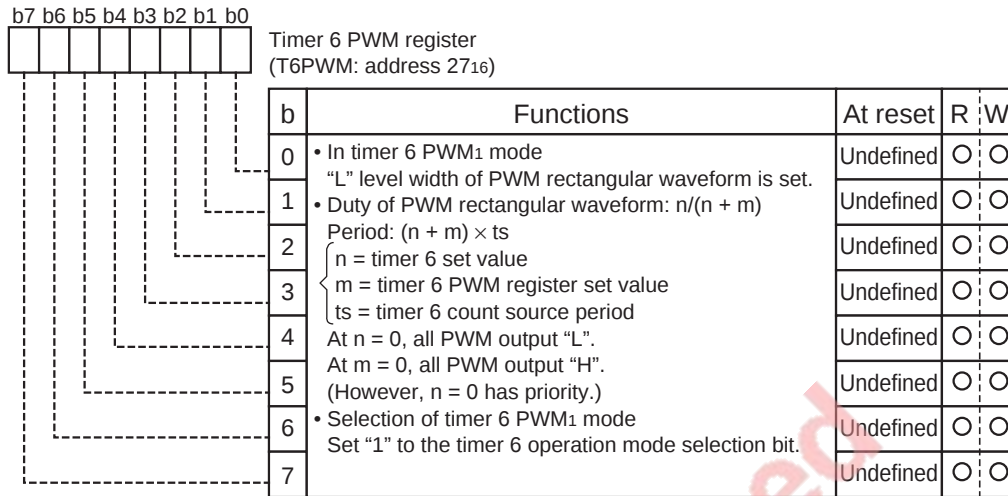


Fig. 3.5.14 Structure of Timer 6 PWM register

Timer 12 mode register

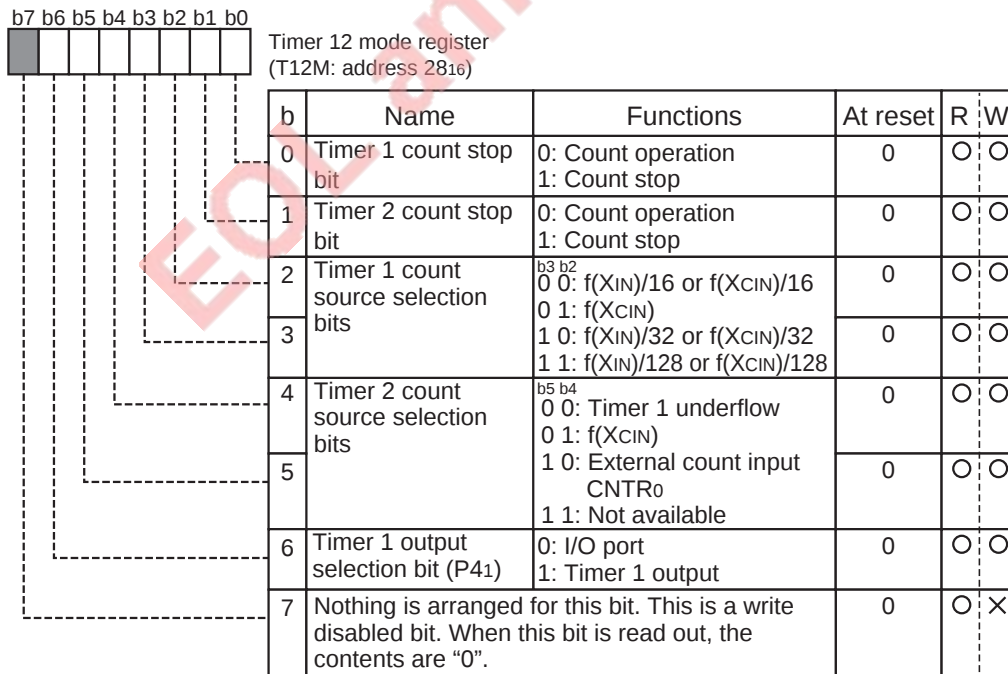


Fig. 3.5.15 Structure of Timer 12 mode register

### Timer 34 mode register

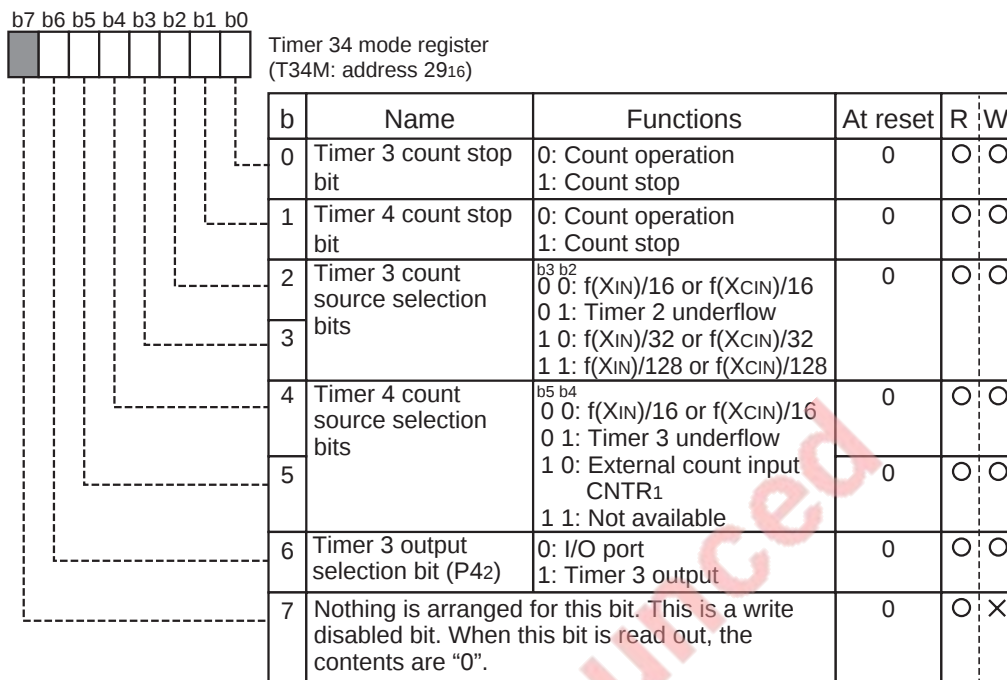


Fig. 3.5.16 Structure of Timer 34 mode register

### Timer 56 mode register

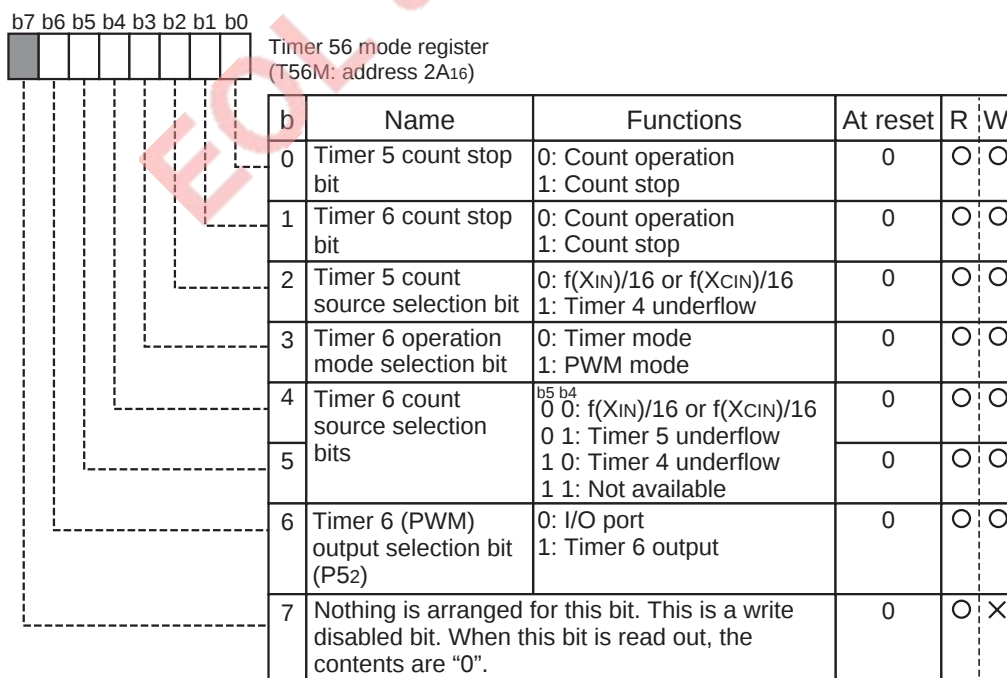


Fig. 3.5.17 Structure of Timer 56 mode register

# APPENDIX

## 3.5 Control registers

### $\phi$ output control register

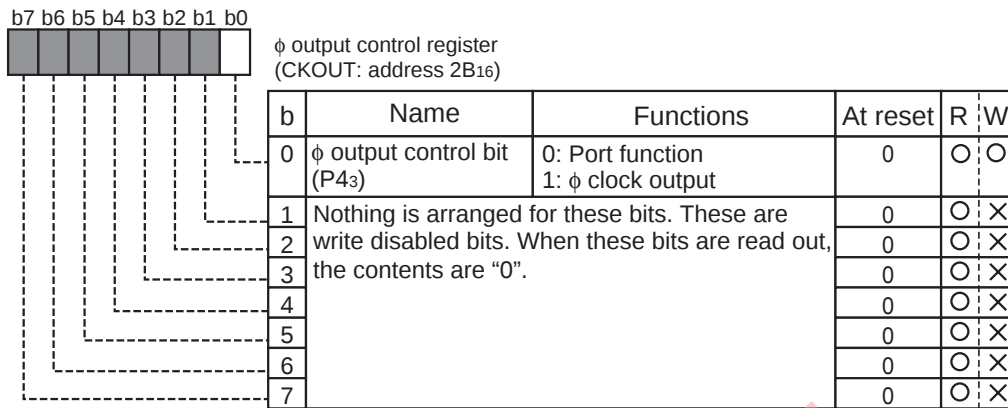
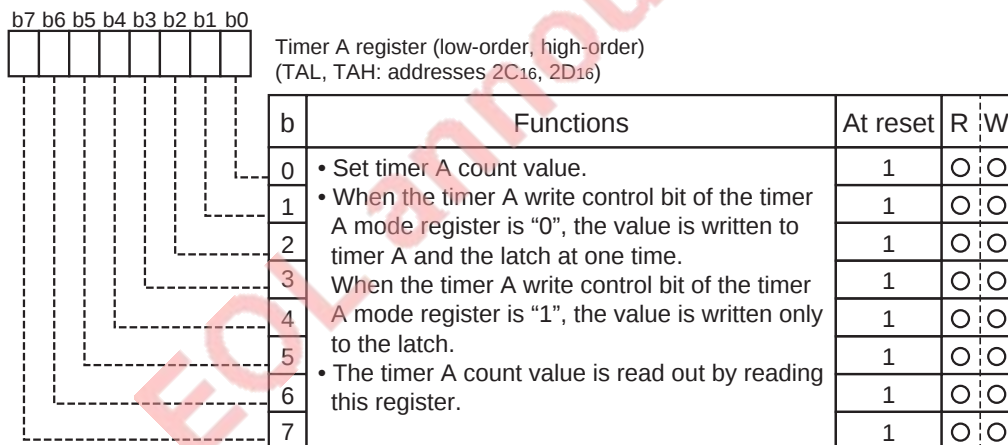


Fig. 3.5.18 Structure of  $\phi$  output control register

### Timer A register (low-order, high-order)



- Notes 1:** When reading and writing, perform them to both the high-order and low-order bytes.
- 2:** Read both registers in order of TAH and TAL following.
- 3:** Write both registers in order of TAL and TAH following.
- 4:** Do not read both registers during a write, and do not write to both registers during a read.

Fig. 3.5.19 Structure of Timer A register (low-order, high-order)

### Compare register (low-order, high-order)

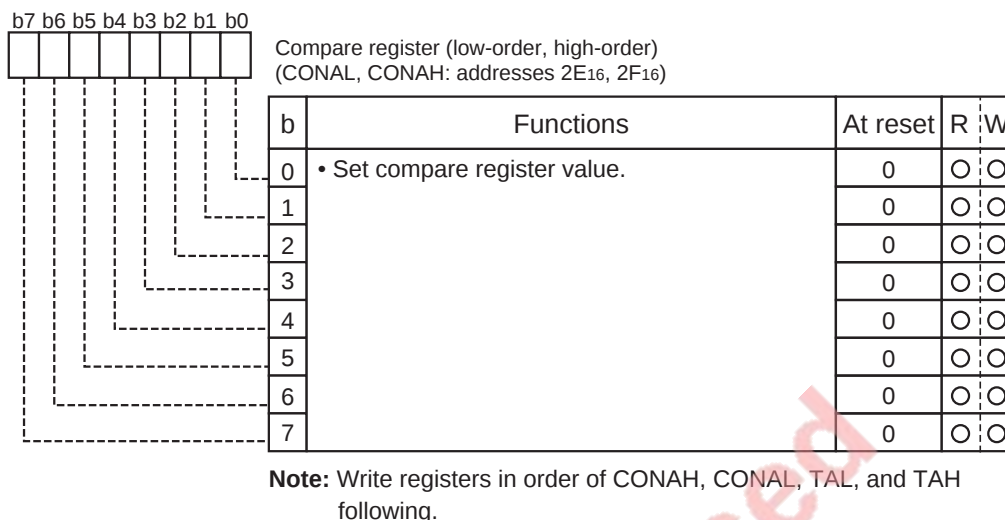


Fig. 3.5.20 Structure of Compare register (low-order, high-order)

### Timer A mode register

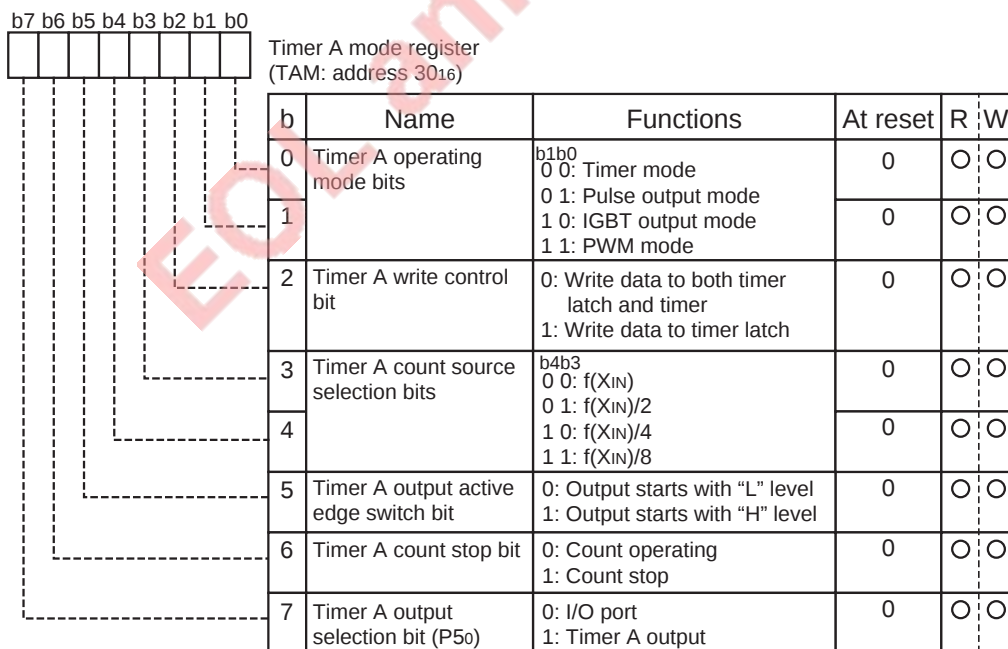


Fig. 3.5.21 Structure of Timer A mode register

# APPENDIX

## 3.5 Control registers

Timer A control register

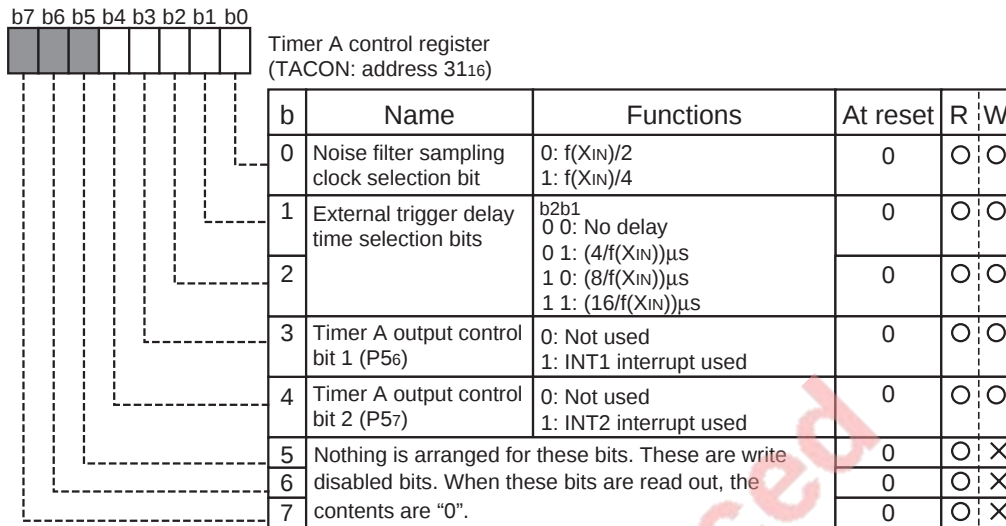


Fig. 3.5.22 Structure of Timer A control register

A-D control register

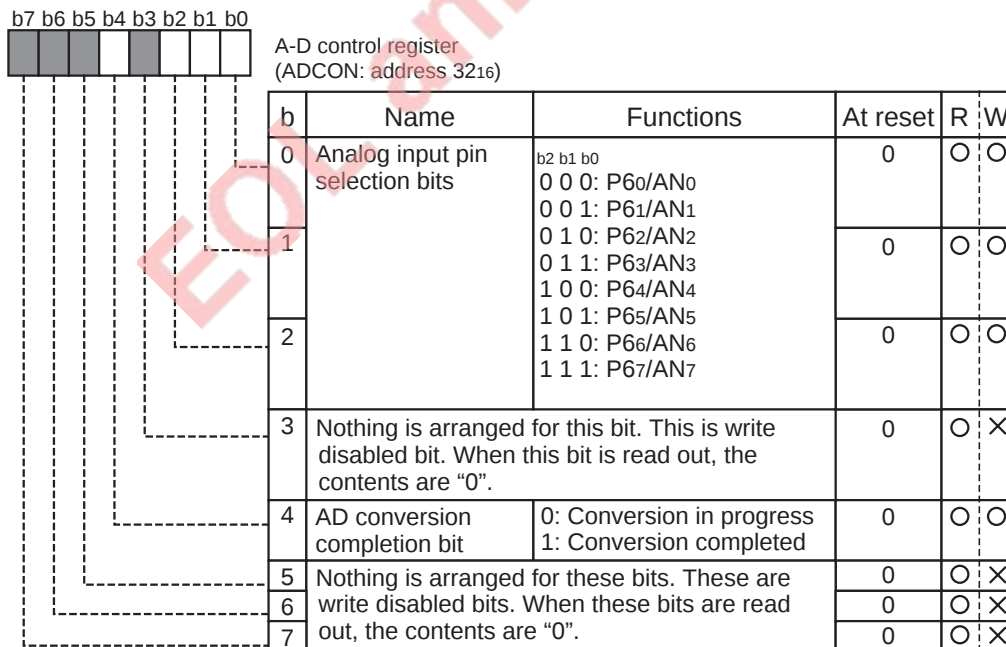


Fig. 3.5.23 Structure of A-D control register

## A-D conversion register (low-order)

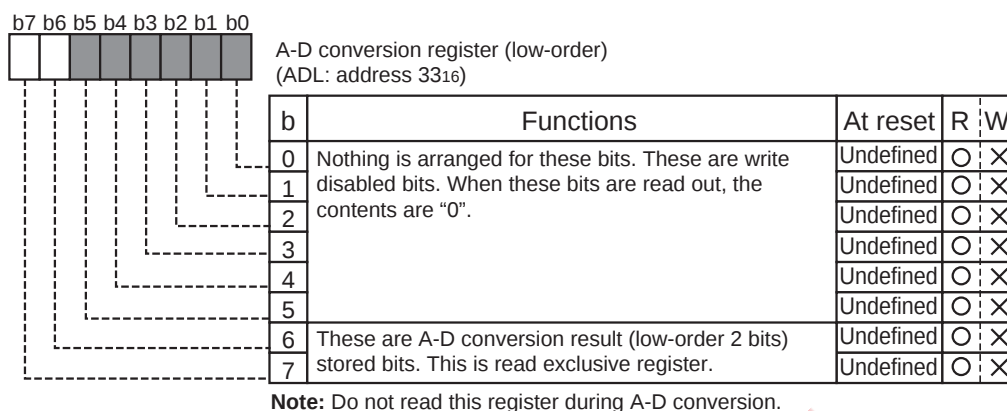


Fig. 3.5.24 Structure of A-D conversion register (low-order)

## A-D conversion register (high-order)

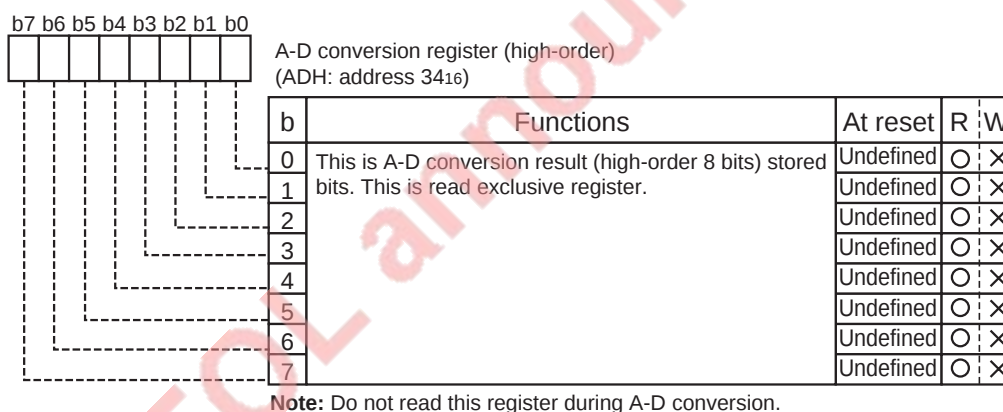


Fig. 3.5.25 Structure of A-D conversion register (high-order)

# APPENDIX

## 3.5 Control registers

### Segment output enable register

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|----|----|----|----|----|----|----|----|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
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Fig. 3.5.26 Structure of Segment output enable register

### LCD mode register

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|    |    |    | 0  |    |    |    |    |

LCD mode register  
(LM: address 39<sub>16</sub>)

| b | Name                                              | Functions                                                                                                                                                                                           | At reset | R | W |
|---|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|---|
| 0 | Duty ratio selection bits                         | b1b0<br>0 0: 1 (use COM <sub>0</sub> )<br>0 1: 2 (use COM <sub>0</sub> , COM <sub>1</sub> )<br>1 0: 3 (use COM <sub>0</sub> –COM <sub>2</sub> )<br>1 1: 4 (use COM <sub>0</sub> –COM <sub>3</sub> ) | 0        | ○ | ○ |
| 1 |                                                   |                                                                                                                                                                                                     | 0        | ○ | ○ |
| 2 | Bias control bit                                  | 0: 1/3 bias<br>1: 1/2 bias                                                                                                                                                                          | 0        | ○ | ○ |
| 3 | LCD enable bit                                    | 0: LCD OFF<br>1: LCD ON                                                                                                                                                                             | 0        | ○ | ○ |
| 4 | Fix "0" to this bit.                              |                                                                                                                                                                                                     | 0        | ○ | ○ |
| 5 | LCD circuit divider division ratio selection bits | b6b5<br>0 0: Clock input<br>0 1: 2 division of clock input<br>1 0: 4 division of clock input<br>1 1: 8 division of clock input                                                                      | 0        | ○ | ○ |
| 6 |                                                   |                                                                                                                                                                                                     | 0        | ○ | ○ |
| 7 | LCDCK count source selection bit (Note)           | 0: f(X <sub>CIN</sub> )/32<br>1: f(X <sub>IN</sub> )/8192 (f(X <sub>CIN</sub> )/8192 in low-speed mode)                                                                                             | 0        | ○ | ○ |

**Note:** LCDCK is a clock for a LCD timing controller.

Fig. 3.5.27 Structure of LCD mode register

## Interrupt edge selection register

|    |    |    |    |    |    |    |    |                                                               |                                                                                                                        |                                                                                                        |          |   |   |
|----|----|----|----|----|----|----|----|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------|---|---|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Interrupt edge selection register<br>(INTEDEGE: address 3A16) |                                                                                                                        |                                                                                                        |          |   |   |
|    |    |    |    |    |    |    |    | b                                                             | Name                                                                                                                   | Functions                                                                                              | At reset | R | W |
|    |    |    |    |    |    |    |    | 0                                                             | INT <sub>0</sub> interrupt edge selection bit                                                                          | 0: Falling edge active<br>1: Rising edge active                                                        | 0        | ○ | ○ |
|    |    |    |    |    |    |    |    | 1                                                             | INT <sub>1</sub> interrupt edge selection bit                                                                          | 0: I/O ports P2 <sub>4</sub> –P2 <sub>7</sub><br>1: Segment output SEG <sub>4</sub> –SEG <sub>7</sub>  | 0        | ○ | ○ |
|    |    |    |    |    |    |    |    | 2                                                             | INT <sub>2</sub> interrupt edge selection bit                                                                          | 0: I/O ports P0 <sub>0</sub> –P0 <sub>3</sub><br>1: Segment output SEG <sub>8</sub> –SEG <sub>11</sub> | 0        | ○ | ○ |
|    |    |    |    |    |    |    |    | 3                                                             | Nothing is arranged for these bits. These are write disabled bits. When these bits are read out, the contents are "0". |                                                                                                        | 0        | ○ | × |
|    |    |    |    |    |    |    |    | 4                                                             |                                                                                                                        | 0                                                                                                      | ○        | × |   |
|    |    |    |    |    |    |    |    | 5                                                             |                                                                                                                        | 0                                                                                                      | ○        | × |   |
|    |    |    |    |    |    |    |    | 6                                                             | CNTR <sub>0</sub> active edge switch bit                                                                               | 0: Falling edge active, rising edge count<br>1: Rising edge active, falling edge count                 | 0        | ○ | ○ |
|    |    |    |    |    |    |    |    | 7                                                             | CNTR <sub>1</sub> active edge switch bit                                                                               | 0: Falling edge active, rising edge count<br>1: Rising edge active, falling edge count                 | 0        | ○ | ○ |

Fig. 3.5.28 Structure of Interrupt edge selection register

## CPU mode register

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|    |    |    |    |    |    |    |    |

CPU mode register  
(CPUM, CM: address 3B16)

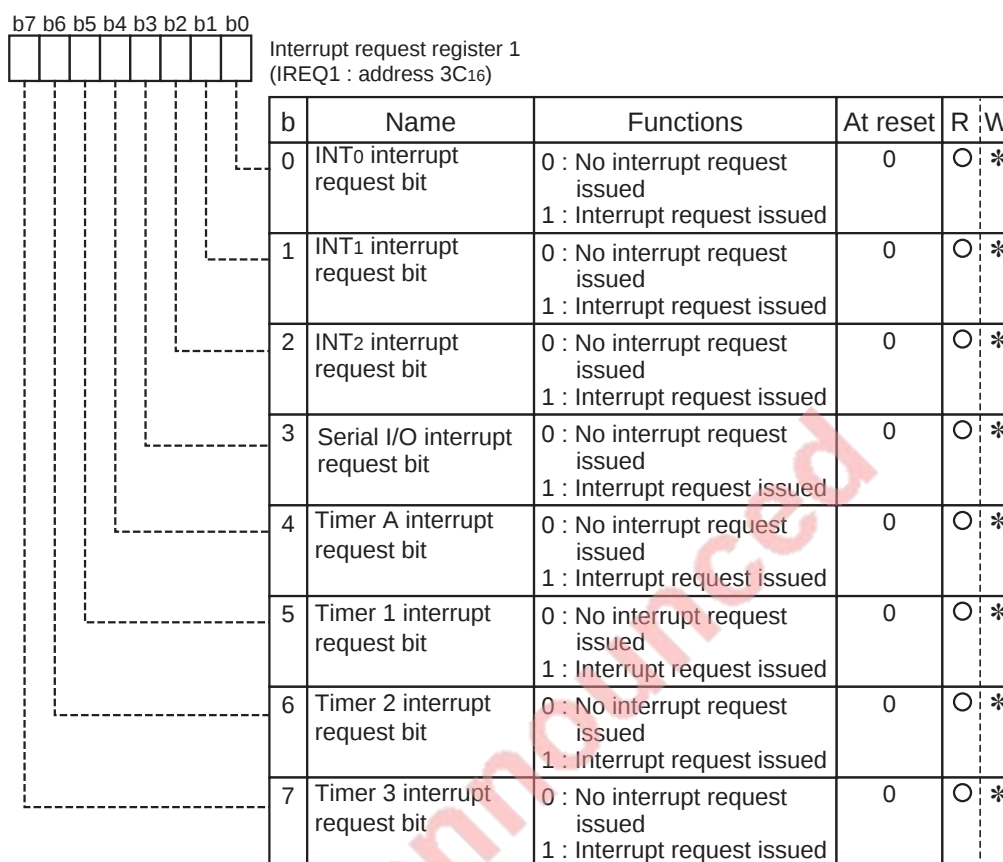
| b | Name                                    | Functions                                                                                                       | At reset                 | R | W |   |
|---|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------------------|---|---|---|
| 0 | Processor mode bits                     | b1 b0<br>00 : Single-chip mode                                                                                  | 0                        | ○ | ○ |   |
| 1 |                                         | 01 :<br>10 :<br>11 : } Not available                                                                            | 0                        | ○ | ○ |   |
| 2 |                                         | Stack page selection bit                                                                                        | 0 : Page 0<br>1 : Page 1 | 0 | ○ | ○ |
| 3 |                                         | Nothing is arranged for this bit. When this bit is read out, the contents is "1". Do not write "0" to this bit. |                          | 1 | ○ | ○ |
| 4 | Port Xc switch bit                      | 0: I/O port function<br>1: XCIN–XCOUT oscillation function                                                      | 0                        | ○ | ○ |   |
| 5 | Main clock (XIN–XOUT) stop bit          | 0: Oscillating<br>1: Stopped                                                                                    | 0                        | ○ | ○ |   |
| 6 | Main clock division ratio selection bit | 0: f(XIN)/2 (high-speed mode)<br>1: f(XIN)/8 (middle-speed mode)                                                | 1                        | ○ | ○ |   |
| 7 | Internal system clock selection bit     | 0: XIN–XOUT selection (middle-/high-speed mode)<br>1: XCIN–XCOUT selection (low-speed mode)                     | 0                        | ○ | ○ |   |

Fig. 3.5.29 Structure of CPU mode register

# APPENDIX

## 3.5 Control registers

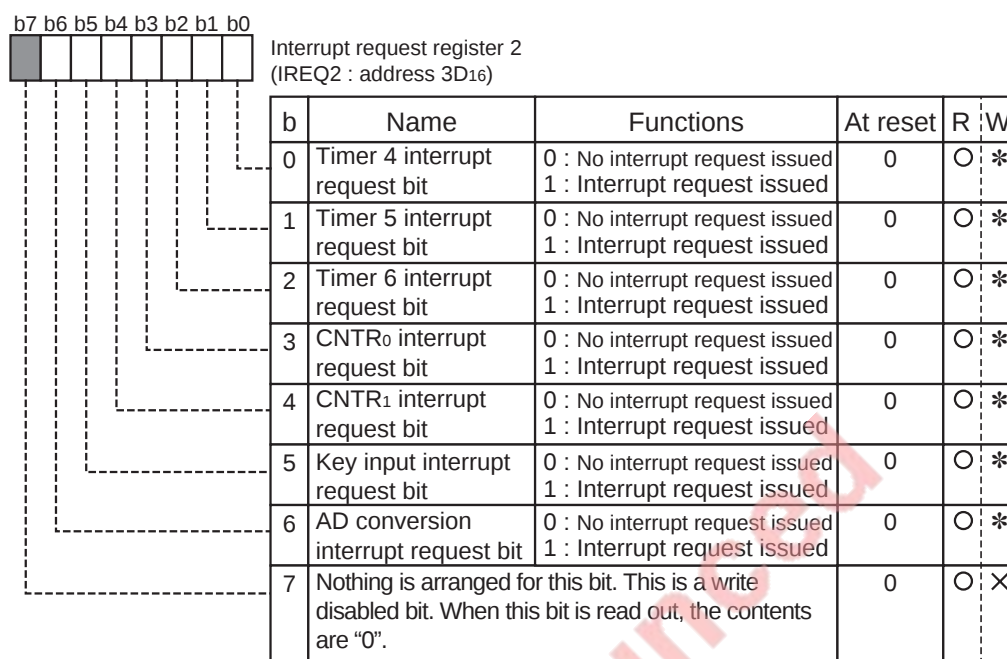
### Interrupt request register 1



\*: "0" can be set by software, but "1" cannot be set.

Fig. 3.5.30 Structure of Interrupt request register 1

## Interrupt request register 2



\*: "0" can be set by software, but "1" cannot be set.

Fig. 3.5.31 Structure of Interrupt request register 2

# APPENDIX

## 3.5 Control registers

Interrupt control register 1

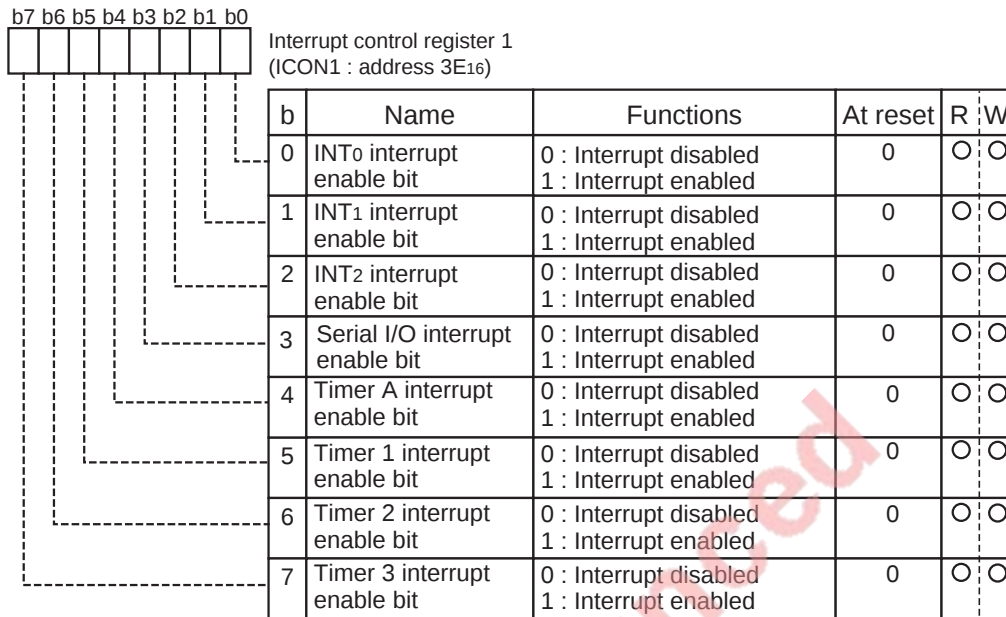


Fig. 3.5.32 Structure of Interrupt control register 1

Interrupt control register 2

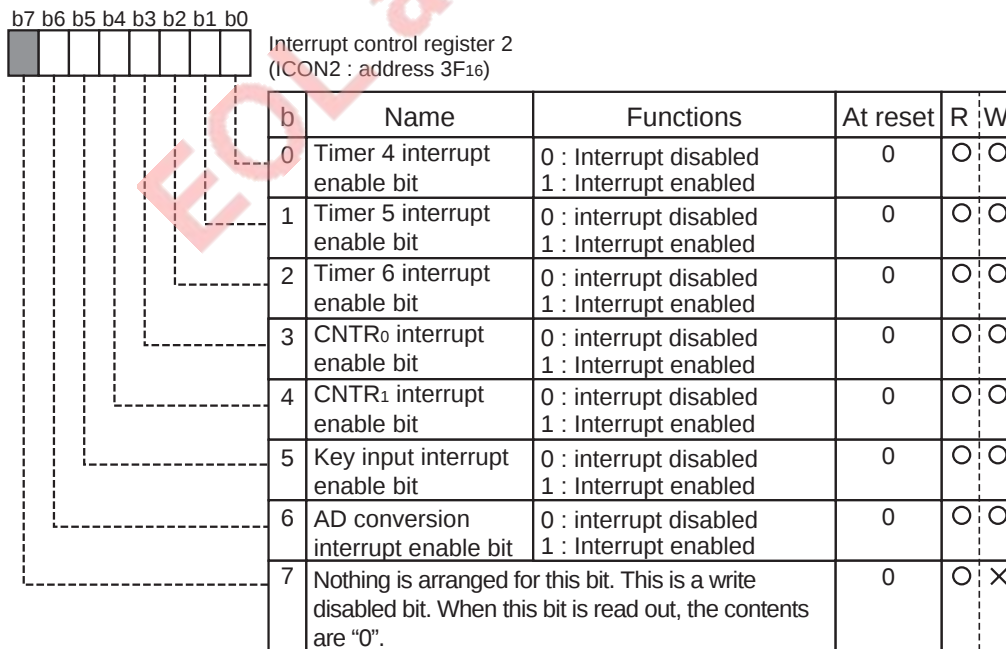


Fig. 3.5.33 Structure of Interrupt control register 2

## ROM correct enable register 1

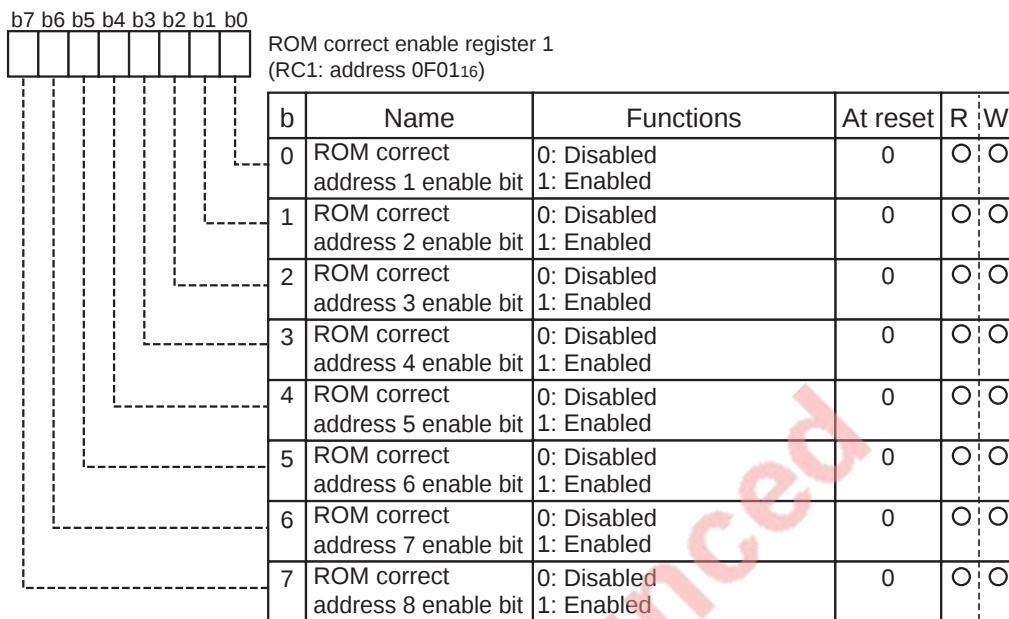


Fig. 3.5.34 Structure of ROM correct enable register 1

# APPENDIX

## 3.6 Mask ROM confirmation form

### 3.6 Mask ROM confirmation form

GZZ-SH56-24B<91A0>

|                 |  |
|-----------------|--|
| Mask ROM number |  |
|-----------------|--|

#### 740 FAMILY MASK ROM CONFIRMATION FORM SINGLE-CHIP MICROCOMPUTER M38C34M6AXXXFP MITSUBISHI ELECTRIC

|         |                        |                      |
|---------|------------------------|----------------------|
| Receipt | Date:                  |                      |
|         | Section head signature | Supervisor signature |
|         |                        |                      |

Note : Please fill in all items marked \*.

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

#### \* 1. Confirmation

Three EPROMs are required for each pattern if this order is performed by EPROMs.

One floppy disk is required for each pattern if this order is performed by a floppy disk.

Microcomputer name: ☐ M38C34M6AXXXFP

#### ☐ Ordering by EPROMs

Specify the type of EPROMs submitted.

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

Checksum code for entire EPROM 

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

 (hexadecimal notation)

EPROM type (indicate the type used)

| <input type="checkbox"/> 27256              | <input type="checkbox"/> 27512              |
|---------------------------------------------|---------------------------------------------|
| EPROM address                               | EPROM address                               |
| 0000 <sub>16</sub>                          | 0000 <sub>16</sub>                          |
| 000F <sub>16</sub>                          | 000F <sub>16</sub>                          |
| 0010 <sub>16</sub>                          | 0010 <sub>16</sub>                          |
| 207F <sub>16</sub>                          | A07F <sub>16</sub>                          |
| 2080 <sub>16</sub>                          | A080 <sub>16</sub>                          |
| 7FFD <sub>16</sub>                          | FFFD <sub>16</sub>                          |
| 7FFE <sub>16</sub>                          | FFFE <sub>16</sub>                          |
| 7FFF <sub>16</sub>                          | FFFF <sub>16</sub>                          |
| Product name<br>ASCII code :<br>'M38C34M6A' | Product name<br>ASCII code :<br>'M38C34M6A' |
| data<br>ROM (24K-130) bytes                 | data<br>ROM (24K-130) bytes                 |

In the address space of the microcomputer, the internal ROM area is from address A080<sub>16</sub> to FFFD<sub>16</sub>. The reset vector is stored in addresses FFFC<sub>16</sub> and FFFD<sub>16</sub>.

- (1) Set the data in the unused area (the shaded area of the diagram) to "FF<sub>16</sub>".
- (2) The ASCII codes of the product name "M38C34M6A" must be entered in addresses 0000<sub>16</sub> to 0008<sub>16</sub>. And set the data "FF<sub>16</sub>" in addresses 0009<sub>16</sub> to 000F<sub>16</sub>. The ASCII codes and addresses are listed to the right in hexadecimal notation.

| Address            |                        | Address            |                        |
|--------------------|------------------------|--------------------|------------------------|
| 0000 <sub>16</sub> | 'M' = 4D <sub>16</sub> | 0008 <sub>16</sub> | 'A' = 41 <sub>16</sub> |
| 0001 <sub>16</sub> | '3' = 33 <sub>16</sub> | 0009 <sub>16</sub> | FF <sub>16</sub>       |
| 0002 <sub>16</sub> | '8' = 38 <sub>16</sub> | 000A <sub>16</sub> | FF <sub>16</sub>       |
| 0003 <sub>16</sub> | 'C' = 43 <sub>16</sub> | 000B <sub>16</sub> | FF <sub>16</sub>       |
| 0004 <sub>16</sub> | '3' = 33 <sub>16</sub> | 000C <sub>16</sub> | FF <sub>16</sub>       |
| 0005 <sub>16</sub> | '4' = 34 <sub>16</sub> | 000D <sub>16</sub> | FF <sub>16</sub>       |
| 0006 <sub>16</sub> | 'M' = 4D <sub>16</sub> | 000E <sub>16</sub> | FF <sub>16</sub>       |
| 0007 <sub>16</sub> | '6' = 36 <sub>16</sub> | 000F <sub>16</sub> | FF <sub>16</sub>       |

(1/2)

GZZ-SH56-24B&lt;91A0&gt;

Mask ROM number

**740 FAMILY MASK ROM CONFIRMATION FORM**  
**SINGLE-CHIP MICROCOMPUTER M38C34M6AXXFP**  
**MITSUBISHI ELECTRIC**

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000<sub>16</sub> to 0008<sub>16</sub> of EPROM.

| EPROM type         | 27256                                            | 27512                                            |
|--------------------|--------------------------------------------------|--------------------------------------------------|
| The pseudo-command | *= $\Delta$ \$8000<br>.BYTE $\Delta$ 'M38C34M6A' | *= $\Delta$ \$0000<br>.BYTE $\Delta$ 'M38C34M6A' |

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

☐ Ordering by floppy disk

We will produce masks based on the mask files generated by the mask file generating utility. We shall assume the responsibility for errors only if the mask ROM data on the products we produce differs from this mask file. Thus, extreme care must be taken to verify the mask file in the submitted floppy disk.

The submitted floppy disk must be 3.5-inch 2HD type and DOS/V format. And the number of the mask files must be 1 in one floppy disk.

File code

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

(hexadecimal notation)

Mask file name

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

.MSK (equal or less than eight characters)

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate mark specification form (80P6N for M38C34M6AXXFP) and attach it to the mask ROM confirmation form.

※ 3. Usage conditions

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

(1) How will you use the X<sub>IN</sub>-X<sub>OUT</sub> oscillator?

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

At what frequency?

f(X<sub>IN</sub>) =  MHz

(2) Which function will you use the pins P70/X<sub>CIN</sub> and P71/X<sub>COU</sub>T as P70 and P71, or X<sub>CIN</sub> and X<sub>COU</sub>T ?

- ☐ Ports P70 and P71 function      ☐ X<sub>CIN</sub> and X<sub>COU</sub>T function (external resonator)

※ 4. Comments

APPENDIX

3.6 Mask ROM confirmation form

GZZ-SH56-25B<91A0>

Mask ROM number

740 FAMILY MASK ROM CONFIRMATION FORM

SINGLE-CHIP MICROCOMPUTER M38C34M6MXXXFP

MITSUBISHI ELECTRIC

Receipt

Date:

Section head signature

Supervisor signature

Note : Please fill in all items marked \*.

\* Customer

Company name

TEL (       )

Date issued

Date:

Issuance signature

Submitted by

Supervisor

\* 1. Confirmation  
Three EPROMs are required for each pattern if this order is performed by EPROMs.  
One floppy disk is required for each pattern if this order is performed by a floppy disk.

Microcomputer name:      ☐ M38C34M6MXXXFP

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

Checksum code for entire EPROM       (hexadecimal notation)

EPROM type (indicate the type used)

☐ 27256

☐ 27512

EPROM address

000016

Product name  
ASCII code :  
'M38C34M6M'

000F16

001016

207F16

208016

data  
ROM (24K-130) bytes

7FFD16

7FFE16

7FFF16

EPROM address

000016

Product name  
ASCII code :  
'M38C34M6M'

000F16

001016

A07F16

A08016

data  
ROM (24K-130) bytes

FFFD16

FFFE16

FFFF16

In the address space of the microcomputer, the internal ROM area is from address A08016 to FFFD16. The reset vector is stored in addresses FFFC16 and FFFD16.

- (1) Set the data in the unused area (the shaded area of the diagram) to "FF16".

(2) The ASCII codes of the product name "M38C34M6M" must be entered in addresses 000016 to 000816. And set the data "FF16" in addresses 000916 to 000F16. The ASCII codes and addresses are listed to the right in hexadecimal notation.

Address

000016

'M' = 4D16

000116

'3' = 3316

000216

'8' = 3816

000316

'C' = 4316

000416

'3' = 3316

000516

'4' = 3416

000616

'M' = 4D16

000716

'6' = 3616

Address

000816

'M' = 4D16

000916

FF16

000A16

FF16

000B16

FF16

000C16

FF16

000D16

FF16

000E16

FF16

000F16

FF16

(1/2)

3-60

38C3 Group User's Manual

GZZ-SH56-25B&lt;91A0&gt;

Mask ROM number

**740 FAMILY MASK ROM CONFIRMATION FORM**  
**SINGLE-CHIP MICROCOMPUTER M38C34M6MXXXFP**  
**MITSUBISHI ELECTRIC**

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000<sub>16</sub> to 0008<sub>16</sub> of EPROM.

| EPROM type         | 27256                            | 27512                            |
|--------------------|----------------------------------|----------------------------------|
| The pseudo-command | *= △\$8000<br>.BYTE △'M38C34M6M' | *= △\$0000<br>.BYTE △'M38C34M6M' |

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

☐ Ordering by floppy disk

We will produce masks based on the mask files generated by the mask file generating utility. We shall assume the responsibility for errors only if the mask ROM data on the products we produce differs from this mask file. Thus, extreme care must be taken to verify the mask file in the submitted floppy disk.

The submitted floppy disk must be 3.5-inch 2HD type and DOS/V format. And the number of the mask files must be 1 in one floppy disk.

File code

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

(hexadecimal notation)

Mask file name

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

.MSK (equal or less than eight characters)

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate mark specification form (80P6N for M38C34M6MXXXFP) and attach it to the mask ROM confirmation form.

※ 3. Usage conditions

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

(1) How will you use the X<sub>IN</sub>-X<sub>OUT</sub> oscillator?

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

At what frequency?

f(X<sub>IN</sub>) =  MHz

(2) Which function will you use the pins P70/X<sub>CIN</sub> and P71/X<sub>COU</sub>T as P70 and P71, or X<sub>CIN</sub> and X<sub>COU</sub>T ?

- ☐ Ports P70 and P71 function      ☐ X<sub>CIN</sub> and X<sub>COU</sub>T function (external resonator)

※ 4. Comments

APPENDIX

3.7 ROM programming confirmation form

3.7 ROM programming confirmation form

GZZ-SH56-29B<91A0>

ROM number

740 FAMILY WRITING TO PROM CONFIRMATION FORM  
SINGLE-CHIP 8-BIT MICROCOMPUTER M38C37ECAXXXFP  
MITSUBISHI ELECTRIC

|         |                        |                      |
|---------|------------------------|----------------------|
| Receipt | Date:                  |                      |
|         | Section head signature | Supervisor signature |
|         |                        |                      |

Note : Please fill in all items marked \*.

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

\* 1. Confirmation

Three EPROMs are required for each pattern if this order is performed by EPROMs.  
One floppy disk is required for each pattern if this order is performed by a floppy disk.

☐ Ordering by EPROMs

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

EPROM address

Checksum code for entire EPROM

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

(hexadecimal notation)

EPROM type (indicate the type used)

|                          |                                             |
|--------------------------|---------------------------------------------|
| <input type="checkbox"/> | <b>27512</b>                                |
| EPROM address            |                                             |
| 0000 <sub>16</sub>       | Product name<br>ASCII code :<br>'M38C37ECA' |
| 000F <sub>16</sub>       |                                             |
| 0010 <sub>16</sub>       |                                             |
| 407F <sub>16</sub>       | Data<br>ROM 48K-130 bytes                   |
| 4080 <sub>16</sub>       |                                             |
| FFFD <sub>16</sub>       |                                             |
| FFFE <sub>16</sub>       |                                             |
| FFFF <sub>16</sub>       |                                             |

In the address space of the microcomputer, the internal ROM area is from address 4080<sub>16</sub> to FFFD<sub>16</sub>. The reset vector is stored in addresses FFFC<sub>16</sub> and FFFD<sub>16</sub>.

- (1) Set the data in the unused area (the shaded area of the diagram) to "FF<sub>16</sub>".
- (2) The ASCII codes of the product name "M38C37ECA" must be entered in addresses 0000<sub>16</sub> to 0008<sub>16</sub>. And set the data "FF<sub>16</sub>" in addresses 0009<sub>16</sub> to 000F<sub>16</sub>. The ASCII codes and addresses are listed to the right in hexadecimal notation.

(1/2)

| Address            |                        | Address            |                        |
|--------------------|------------------------|--------------------|------------------------|
| 0000 <sub>16</sub> | 'M' = 4D <sub>16</sub> | 0008 <sub>16</sub> | 'A' = 41 <sub>16</sub> |
| 0001 <sub>16</sub> | '3' = 33 <sub>16</sub> | 0009 <sub>16</sub> | FF <sub>16</sub>       |
| 0002 <sub>16</sub> | '8' = 38 <sub>16</sub> | 000A <sub>16</sub> | FF <sub>16</sub>       |
| 0003 <sub>16</sub> | 'C' = 43 <sub>16</sub> | 000B <sub>16</sub> | FF <sub>16</sub>       |
| 0004 <sub>16</sub> | '3' = 33 <sub>16</sub> | 000C <sub>16</sub> | FF <sub>16</sub>       |
| 0005 <sub>16</sub> | '7' = 37 <sub>16</sub> | 000D <sub>16</sub> | FF <sub>16</sub>       |
| 0006 <sub>16</sub> | 'E' = 45 <sub>16</sub> | 000E <sub>16</sub> | FF <sub>16</sub>       |
| 0007 <sub>16</sub> | 'C' = 43 <sub>16</sub> | 000F <sub>16</sub> | FF <sub>16</sub>       |

## 3.7 ROM programming confirmation form

GZZ-SH56-29B&lt;91A0&gt;

ROM number

**740 FAMILY WRITING TO PROM CONFIRMATION FORM**  
**SINGLE-CHIP 8-BIT MICROCOMPUTER M38C37ECAXXFP**  
**MITSUBISHI ELECTRIC**

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000<sub>16</sub> to 0008<sub>16</sub> of EPROM.

|                    |                                  |
|--------------------|----------------------------------|
| EPROM type         | 27512                            |
| The pseudo-command | *= Δ\$0000<br>.BYTE Δ'M38C37ECA' |

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

☐ Ordering by floppy disk

We will produce writing to PROM based on the mask files generated by the mask file generating utility. We shall assume the responsibility for errors only if the written PROM data on the products we produce differs from this mask file. Thus, extreme care must be taken to verify the mask file in the submitted floppy disk.

The submitted floppy disk must be 3.5-inch 2HD type and DOS/V format. And the number of the mask files must be 1 in one floppy disk.

File code

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

(hexadecimal notation)

Mask file name

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

.MSK (equal or less than eight characters)

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate 80P6N mark specification form and attach it to the writing to PROM confirmation form.

※ 3. Usage conditions

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

(1) How will you use the X<sub>IN</sub>-X<sub>OUT</sub> oscillator?

- |                                               |                                           |
|-----------------------------------------------|-------------------------------------------|
| <input type="checkbox"/> Ceramic resonator    | <input type="checkbox"/> Quartz crystal   |
| <input type="checkbox"/> External clock input | <input type="checkbox"/> Other (        ) |

At what frequency?

f(X<sub>IN</sub>) =  MHz

(2) Which function will you use the pins P70/X<sub>CIN</sub> and P71/X<sub>COU</sub>T as P70 and P71, or X<sub>CIN</sub> and X<sub>COU</sub>T ?

- |                                                     |                                                                                                |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Ports P70 and P71 function | <input type="checkbox"/> X <sub>CIN</sub> and X <sub>COU</sub> T function (external resonator) |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------|

※ 4. Comments

# APPENDIX

## 3.7 ROM programming confirmation form

GZZ-SH56-30B<91A0>

ROM number

740 FAMILY WRITING TO PROM CONFIRMATION FORM  
SINGLE-CHIP 8-BIT MICROCOMPUTER M38C37ECMXXFP  
MITSUBISHI ELECTRIC

Receipt

Date:

Section head signature

Supervisor signature

Note : Please fill in all items marked \*.

|            |              |                  |                    |              |            |
|------------|--------------|------------------|--------------------|--------------|------------|
| * Customer | Company name | TEL<br>(       ) | Issuance signature | Submitted by | Supervisor |
|            | Date issued  | Date:            |                    |              |            |

- \* 1. Confirmation
- Three EPROMs are required for each pattern if this order is performed by EPROMs.  
One floppy disk is required for each pattern if this order is performed by a floppy disk.
- ☐ Ordering by EPROMs
- If at least two of the three sets of EPROMs submitted contain identical data, we will produce writing to PROM based on this data. We shall assume the responsibility for errors only if the written PROM data on the products we produce differs from this data. Thus, extreme care must be taken to verify the data in the submitted EPROMs.

EPROM address

Checksum code for entire EPROM

(hexadecimal notation)

EPROM type (indicate the type used)

☐ 27512

EPROM address

0000<sub>16</sub>

000F<sub>16</sub>

0010<sub>16</sub>

407F<sub>16</sub>

4080<sub>16</sub>

FFFD<sub>16</sub>

FFFE<sub>16</sub>

FFFF<sub>16</sub>

Product name  
ASCII code :  
'M38C37ECM'

Data  
ROM 48K-130 bytes

In the address space of the microcomputer, the internal ROM area is from address 4080<sub>16</sub> to FFFD<sub>16</sub>. The reset vector is stored in addresses FFFC<sub>16</sub> and FFFD<sub>16</sub>.

|                                                                                                                                                                                                                                                                                                         |                    |                        |                    |                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------|--------------------|--------------------------|
| (1) Set the data in the unused area (the shaded area of the diagram) to "FF <sub>16</sub> ".                                                                                                                                                                                                            | Address            |                        | Address            |                          |
|                                                                                                                                                                                                                                                                                                         | 0000 <sub>16</sub> | 'M' = 4D <sub>16</sub> | 0008 <sub>16</sub> | ' M ' = 4D <sub>16</sub> |
| (2) The ASCII codes of the product name "M38C37ECM" must be entered in addresses 0000 <sub>16</sub> to 0008 <sub>16</sub> . And set the data "FF <sub>16</sub> " in addresses 0009 <sub>16</sub> to 000F <sub>16</sub> . The ASCII codes and addresses are listed to the right in hexadecimal notation. | 0001 <sub>16</sub> | '3' = 33 <sub>16</sub> | 0009 <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0002 <sub>16</sub> | '8' = 38 <sub>16</sub> | 000A <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0003 <sub>16</sub> | 'C' = 43 <sub>16</sub> | 000B <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0004 <sub>16</sub> | '3' = 33 <sub>16</sub> | 000C <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0005 <sub>16</sub> | '7' = 37 <sub>16</sub> | 000D <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0006 <sub>16</sub> | 'E' = 45 <sub>16</sub> | 000E <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         | 0007 <sub>16</sub> | 'C' = 43 <sub>16</sub> | 000F <sub>16</sub> | FF <sub>16</sub>         |
|                                                                                                                                                                                                                                                                                                         |                    |                        |                    |                          |
|                                                                                                                                                                                                                                                                                                         |                    |                        |                    |                          |
|                                                                                                                                                                                                                                                                                                         |                    |                        |                    |                          |

(1/2)

3-64

38C3 Group User's Manual

## 3.7 ROM programming confirmation form

GZZ-SH56-30B&lt;91A0&gt;

ROM number

**740 FAMILY WRITING TO PROM CONFIRMATION FORM**  
**SINGLE-CHIP 8-BIT MICROCOMPUTER M38C37ECMXXXFP**  
**MITSUBISHI ELECTRIC**

We recommend the use of the following pseudo-command to set the start address of the assembler source program because ASCII codes of the product name are written to addresses 0000<sub>16</sub> to 0008<sub>16</sub> of EPROM.

|                    |                                  |
|--------------------|----------------------------------|
| EPROM type         | 27512                            |
| The pseudo-command | *= Δ\$0000<br>.BYTE Δ'M38C37ECM' |

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

☐ Ordering by floppy disk

We will produce writing to PROM based on the mask files generated by the mask file generating utility. We shall assume the responsibility for errors only if the written PROM data on the products we produce differs from this mask file. Thus, extreme care must be taken to verify the mask file in the submitted floppy disk.

The submitted floppy disk must be 3.5-inch 2HD type and DOS/V format. And the number of the mask files must be 1 in one floppy disk.

File code

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

(hexadecimal notation)

Mask file name

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

.MSK (equal or less than eight characters)

※ 2. Mark specification

Mark specification must be submitted using the correct form for the package being ordered. Fill out the appropriate 80P6N mark specification form and attach it to the writing to PROM confirmation form.

※ 3. Usage conditions

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

(1) How will you use the X<sub>IN</sub>-X<sub>OUT</sub> oscillator?

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

At what frequency?

f(X<sub>IN</sub>) =  MHz

(2) Which function will you use the pins P70/X<sub>CIN</sub> and P71/X<sub>COUT</sub> as P70 and P71, or X<sub>CIN</sub> and X<sub>COUT</sub> ?

- ☐ Ports P70 and P71 function      ☐ X<sub>CIN</sub> and X<sub>COUT</sub> function (external resonator)

※ 4. Comments

APPENDIX

3.8 Mark specification form

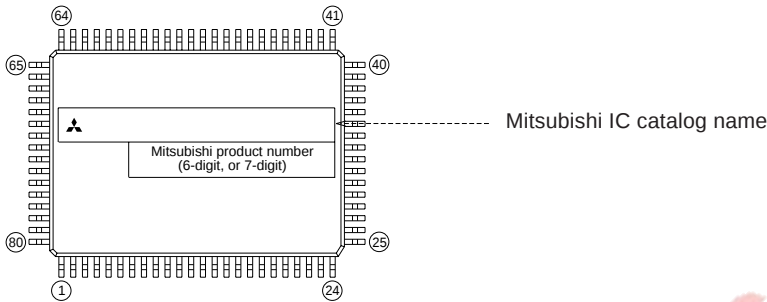
3.8 Mark specification form

80P6N (80-PIN QFP) MARK SPECIFICATION FORM

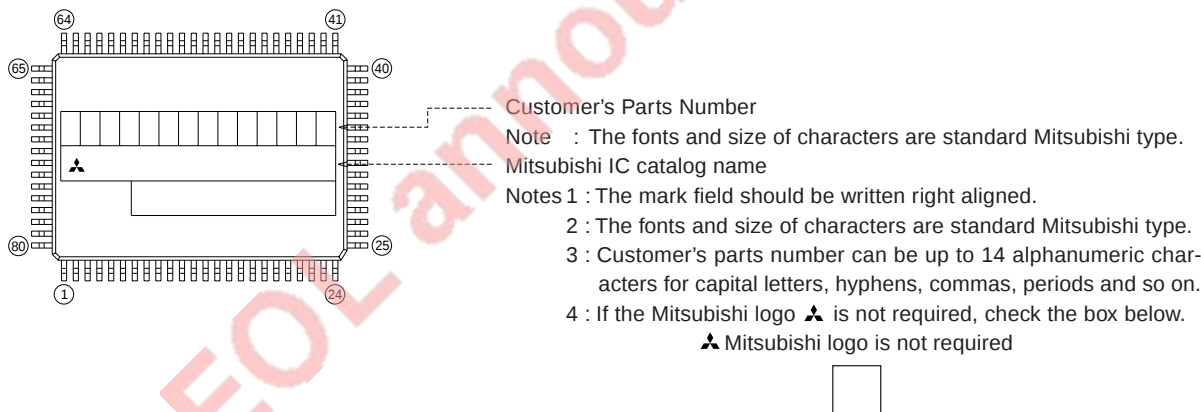
Mitsubishi IC catalog name

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

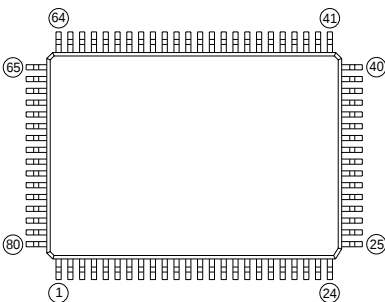
A. Standard Mitsubishi Mark



B. Customer's Parts Number + Mitsubishi IC Catalog Name



C. Special Mark Required



Notes1 : If special mark is to be printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated technically as close as possible.  
Mitsubishi product number (6-digit, or 7-digit) and Mask ROM number (3-digit) are always marked for sorting the products.  
2 : If special character fonts (e.g., customer's trade mark logo) must be used in Special Mark, check the box below.  
For the new special character fonts, a clean font original (ideally logo drawing) must be submitted.

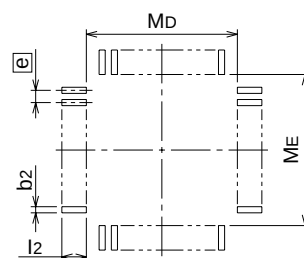
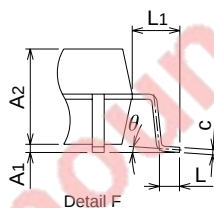
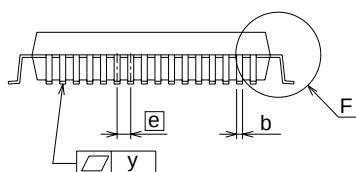
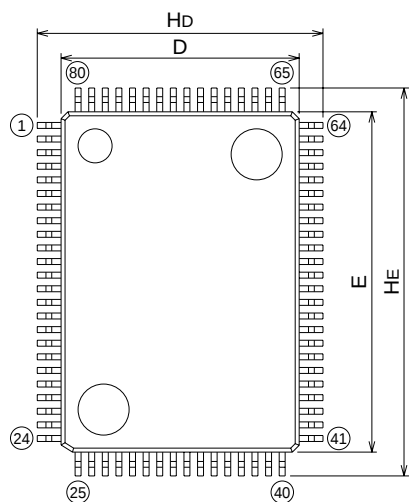
Special character fonts required ☐

## 3.9 Package outline

## 80P6N-A

Plastic 80pin 14X20mm body QFP

| EIAJ Package Code | JEDEC Code | Weight(g) | Lead Material |
|-------------------|------------|-----------|---------------|
| QFP80-P-1420-0.80 | —          | 1.58      | Alloy 42      |



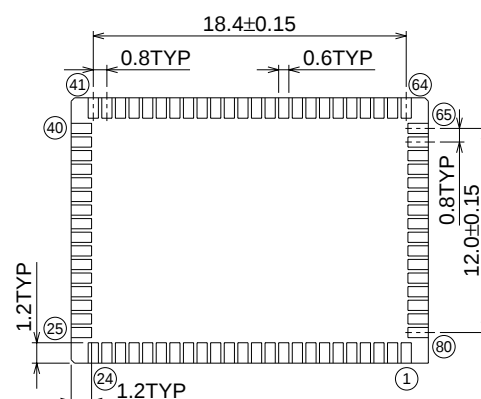
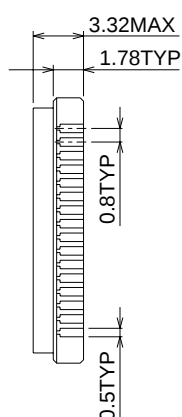
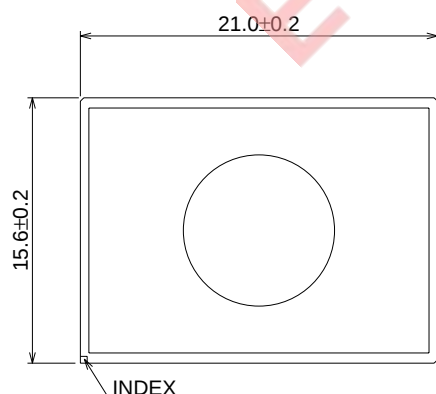
Recommended Mount Pad

| Symbol | Dimension in Millimeters |      |      |
|--------|--------------------------|------|------|
|        | Min                      | Nom  | Max  |
| A      | —                        | —    | 3.05 |
| A1     | 0                        | 0.1  | 0.2  |
| A2     | —                        | 2.8  | —    |
| b      | 0.3                      | 0.35 | 0.45 |
| c      | 0.13                     | 0.15 | 0.2  |
| D      | 13.8                     | 14.0 | 14.2 |
| E      | 19.8                     | 20.0 | 20.2 |
| e      | —                        | 0.8  | —    |
| Hd     | 16.5                     | 16.8 | 17.1 |
| HE     | 22.5                     | 22.8 | 23.1 |
| L      | 0.4                      | 0.6  | 0.8  |
| L1     | —                        | 1.4  | —    |
| y      | —                        | —    | 0.1  |
| θ      | 0°                       | —    | 10°  |
| b2     | —                        | 0.5  | —    |
| l2     | 1.3                      | —    | —    |
| MD     | —                        | 14.6 | —    |
| ME     | —                        | 20.6 | —    |

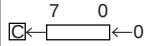
## 80D0

Glass seal 80pin QFN

| EIAJ Package Code | JEDEC Code | Weight(g) |
|-------------------|------------|-----------|
| —                 | —          | —         |



3.10 Machine instructions

| Symbol                      | Function                                                                                     | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Addressing mode |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |
|-----------------------------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|-----|---|---|----|---|---|-----------|---|---|----|---|---|------------|---|---|
|                             |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IMP             |   |   | IMM |   |   | A  |   |   | BIT, A, R |   |   | ZP |   |   | BIT, ZP, R |   |   |
|                             |                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                               | OP              | n | # | OP  | n | # | OP | n | # | OP        | n | # | OP | n | # | OP         | n | # |
| ADC<br>(Note 1)<br>(Note 5) | When T = 0<br>$A \leftarrow A + M + C$<br><br>When T = 1<br>$M(X) \leftarrow M(X) + M + C$   | When T = 0, this instruction adds the contents M, C, and A; and stores the results in A and C. When T = 1, this instruction adds the contents of M(X), M and C; and stores the results in M(X) and C. When T=1, the contents of A remain unchanged, but the contents of status flags are changed.<br>M(X) represents the contents of memory where is indicated by X.                                                                                          |                 |   |   | 69  | 2 | 2 |    |   |   |           |   |   | 65 | 3 | 2 |            |   |   |
| AND<br>(Note 1)             | When T = 0<br>$A \leftarrow A \wedge M$<br><br>When T = 1<br>$M(X) \leftarrow M(X) \wedge M$ | When T = 0, this instruction transfers the contents of A and M to the ALU which performs a bit-wise AND operation and stores the result back in A.<br>When T = 1, this instruction transfers the contents M(X) and M to the ALU which performs a bit-wise AND operation and stores the results back in M(X). When T = 1, the contents of A remain unchanged, but status flags are changed.<br>M(X) represents the contents of memory where is indicated by X. |                 |   |   | 29  | 2 | 2 |    |   |   |           |   |   | 25 | 3 | 2 |            |   |   |
| ASL                         |             | This instruction shifts the content of A or M by one bit to the left, with bit 0 always being set to 0 and bit 7 of A or M always being contained in C.                                                                                                                                                                                                                                                                                                       |                 |   |   |     |   |   | 0A | 2 | 1 |           |   |   | 06 | 5 | 2 |            |   |   |
| BBC<br>(Note 4)             | Ai or Mi = 0?                                                                                | This instruction tests the designated bit i of M or A and takes a branch if the bit is 0. The branch address is specified by a relative address. If the bit is 1, next instruction is executed.                                                                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   | 13<br>20i | 4 | 2 |    |   |   | 17<br>20i  | 5 | 3 |
| BBS<br>(Note 4)             | Ai or Mi = 1?                                                                                | This instruction tests the designated bit i of the M or A and takes a branch if the bit is 1. The branch address is specified by a relative address. If the bit is 0, next instruction is executed.                                                                                                                                                                                                                                                           |                 |   |   |     |   |   |    |   |   | 03<br>20i | 4 | 2 |    |   |   | 07<br>20i  | 5 | 3 |
| BCC<br>(Note 4)             | C = 0?                                                                                       | This instruction takes a branch to the appointed address if C is 0. The branch address is specified by a relative address. If C is 1, the next instruction is executed.                                                                                                                                                                                                                                                                                       |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |
| BCS<br>(Note 4)             | C = 1?                                                                                       | This instruction takes a branch to the appointed address if C is 1. The branch address is specified by a relative address. If C is 0, the next instruction is executed.                                                                                                                                                                                                                                                                                       |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |
| BEQ<br>(Note 4)             | Z = 1?                                                                                       | This instruction takes a branch to the appointed address when Z is 1. The branch address is specified by a relative address. If Z is 0, the next instruction is executed.                                                                                                                                                                                                                                                                                     |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |
| BIT                         | $A \wedge M$                                                                                 | This instruction takes a bit-wise logical AND of A and M contents; however, the contents of A and M are not modified.<br>The contents of N, V, Z are changed, but the contents of A, M remain unchanged.                                                                                                                                                                                                                                                      |                 |   |   |     |   |   |    |   |   |           |   |   | 24 | 3 | 2 |            |   |   |
| BMI<br>(Note 4)             | N = 1?                                                                                       | This instruction takes a branch to the appointed address when N is 1. The branch address is specified by a relative address. If N is 0, the next instruction is executed.                                                                                                                                                                                                                                                                                     |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |
| BNE<br>(Note 4)             | Z = 0?                                                                                       | This instruction takes a branch to the appointed address if Z is 0. The branch address is specified by a relative address. If Z is 1, the next instruction is executed.                                                                                                                                                                                                                                                                                       |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |            |   |   |

| Addressing mode |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   | Processor status register |   |    |     |   |   |    |    |   |   |   |   |   |   |   |   |   |
|-----------------|---|---|-------|---|---|-----|---|---|--------|---|---|--------|---|---|-----|---|---|---------|---|---|--------|---|---|---------------------------|---|----|-----|---|---|----|----|---|---|---|---|---|---|---|---|---|
| ZP, X           |   |   | ZP, Y |   |   | ABS |   |   | ABS, X |   |   | ABS, Y |   |   | IND |   |   | ZP, IND |   |   | IND, X |   |   | IND, Y                    |   |    | REL |   |   | SP |    |   | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| OP              | n | # | OP    | n | # | OP  | n | # | OP     | n | # | OP     | n | # | OP  | n | # | OP      | n | # | OP     | n | # | OP                        | n | #  | OP  | n | # | N  | V  | T | B | D | I | Z | C |   |   |   |
| 75              | 4 | 2 |       |   |   | 6D  | 4 | 3 | 7D     | 5 | 3 | 79     | 5 | 3 |     |   |   |         |   |   | 61     | 6 | 2 | 71                        | 6 | 2  |     |   |   | N  | V  | • | • | • | • | Z | C |   |   |   |
| 35              | 4 | 2 |       |   |   | 2D  | 4 | 3 | 3D     | 5 | 3 | 39     | 5 | 3 |     |   |   |         |   |   | 21     | 6 | 2 | 31                        | 6 | 2  |     |   |   | N  | •  | • | • | • | • | Z | • |   |   |   |
| 16              | 6 | 2 |       |   |   | 0E  | 6 | 3 | 1E     | 7 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |                           |   |    |     |   | N | •  | •  | • | • | • | Z | C |   |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   |    |     |   |   | •  | •  | • | • | • | • | • | • |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   |    |     |   |   | •  | •  | • | • | • | • | • | • |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   |    |     |   |   | •  | •  | • | • | • | • | • | • |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   | 90 | 2   | 2 |   |    | •  | • | • | • | • | • | • | • |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   | B0 | 2   | 2 |   |    | •  | • | • | • | • | • | • | • |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   | F0 | 2   | 2 |   |    | •  | • | • | • | • | • | • | • |   |   |
|                 |   |   |       |   |   | 2C  | 4 | 3 |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   |    |     |   |   | M7 | M6 | • | • | • | • | Z | • |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   | 30 | 2   | 2 |   |    | •  | • | • | • | • | • | • | • |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |                           |   | D0 | 2   | 2 |   |    | •  | • | • | • | • | • | • | • |   |   |

### 3.10 Machine instructions

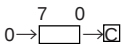
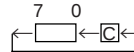
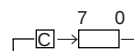
| Symbol          | Function                                                                                                                                    | Details                                                                                                                                                                                                                                                                                                                                                                            | Addressing mode |   |   |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|-----|---|---|----|---|---|-----------|---|---|----|---|---|-----------|---|---|
|                 |                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                    | IMP             |   |   | IMM |   |   | A  |   |   | BIT, A    |   |   | ZP |   |   | BIT, ZP   |   |   |
|                 |                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                    | OP              | n | # | OP  | n | # | OP | n | # | OP        | n | # | OP | n | # | OP        | n | # |
| BPL<br>(Note 4) | N = 0?                                                                                                                                      | This instruction takes a branch to the appointed address if N is 0. The branch address is specified by a relative address. If N is 1, the next instruction is executed.                                                                                                                                                                                                            |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| BRA             | PC ← PC ± offset                                                                                                                            | This instruction branches to the appointed address. The branch address is specified by a relative address.                                                                                                                                                                                                                                                                         |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| BRK             | B ← 1<br>(PC) ← (PC) + 2<br>M(S) ← PCH<br>S ← S - 1<br>M(S) ← PCL<br>S ← S - 1<br>M(S) ← PS<br>S ← S - 1<br>I ← 1<br>PCL ← ADL<br>PCH ← ADH | When the BRK instruction is executed, the CPU pushes the current PC contents onto the stack. The BADRS designated in the interrupt vector table is stored into the PC.                                                                                                                                                                                                             | 00              | 7 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| BVC<br>(Note 4) | V = 0?                                                                                                                                      | This instruction takes a branch to the appointed address if V is 0. The branch address is specified by a relative address. If V is 1, the next instruction is executed.                                                                                                                                                                                                            |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| BVS<br>(Note 4) | V = 1?                                                                                                                                      | This instruction takes a branch to the appointed address when V is 1. The branch address is specified by a relative address. When V is 0, the next instruction is executed.                                                                                                                                                                                                        |                 |   |   |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CLB             | Ai or Mi ← 0                                                                                                                                | This instruction clears the designated bit i of A or M.                                                                                                                                                                                                                                                                                                                            |                 |   |   |     |   |   |    |   |   | 1B<br>20i | 2 | 1 |    |   |   | 1F<br>20i | 5 | 2 |
| CLC             | C ← 0                                                                                                                                       | This instruction clears C.                                                                                                                                                                                                                                                                                                                                                         | 18              | 2 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CLD             | D ← 0                                                                                                                                       | This instruction clears D.                                                                                                                                                                                                                                                                                                                                                         | D8              | 2 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CLI             | I ← 0                                                                                                                                       | This instruction clears I.                                                                                                                                                                                                                                                                                                                                                         | 58              | 2 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CLT             | T ← 0                                                                                                                                       | This instruction clears T.                                                                                                                                                                                                                                                                                                                                                         | 12              | 2 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CLV             | V ← 0                                                                                                                                       | This instruction clears V.                                                                                                                                                                                                                                                                                                                                                         | B8              | 2 | 1 |     |   |   |    |   |   |           |   |   |    |   |   |           |   |   |
| CMP<br>(Note 3) | When T = 0<br>A - M<br>When T = 1<br>M(X) - M                                                                                               | When T = 0, this instruction subtracts the contents of M from the contents of A. The result is not stored and the contents of A or M are not modified.<br>When T = 1, the CMP subtracts the contents of M from the contents of M(X). The result is not stored and the contents of X, M, and A are not modified.<br>M(X) represents the contents of memory where is indicated by X. |                 |   |   | C9  | 2 | 2 |    |   |   |           |   |   | C5 | 3 | 2 |           |   |   |
| COM             | M ← $\overline{M}$                                                                                                                          | This instruction takes the one's complement of the contents of M and stores the result in M.                                                                                                                                                                                                                                                                                       |                 |   |   |     |   |   |    |   |   |           |   |   | 44 | 5 | 2 |           |   |   |
| CPX             | X - M                                                                                                                                       | This instruction subtracts the contents of M from the contents of X. The result is not stored and the contents of X and M are not modified.                                                                                                                                                                                                                                        |                 |   |   | E0  | 2 | 2 |    |   |   |           |   |   | E4 | 3 | 2 |           |   |   |
| CPY             | Y - M                                                                                                                                       | This instruction subtracts the contents of M from the contents of Y. The result is not stored and the contents of Y and M are not modified.                                                                                                                                                                                                                                        |                 |   |   | C0  | 2 | 2 |    |   |   |           |   |   | C4 | 3 | 2 |           |   |   |
| DEC             | A ← A - 1 or<br>M ← M - 1                                                                                                                   | This instruction subtracts 1 from the contents of A or M.                                                                                                                                                                                                                                                                                                                          |                 |   |   |     |   |   | 1A | 2 | 1 |           |   |   | C6 | 5 | 2 |           |   |   |

### 3.10 Machine instructions

| Addressing mode |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   | Processor status register |   |   |        |   |   |        |   |   |     |   |   |    |   |   |   |   |   |   |   |   |   |   |
|-----------------|---|---|-------|---|---|-----|---|---|--------|---|---|--------|---|---|-----|---|---|---------------------------|---|---|--------|---|---|--------|---|---|-----|---|---|----|---|---|---|---|---|---|---|---|---|---|
| ZP, X           |   |   | ZP, Y |   |   | ABS |   |   | ABS, X |   |   | ABS, Y |   |   | IND |   |   | ZP, IND                   |   |   | IND, X |   |   | IND, Y |   |   | REL |   |   | SP |   |   | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| OP              | n | # | OP    | n | # | OP  | n | # | OP     | n | # | OP     | n | # | OP  | n | # | OP                        | n | # | OP     | n | # | OP     | n | # | OP  | n | # | N  | V | T | B | D | I | Z | C |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | 1 | . | 1 | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | . | . | 0 |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | 0 | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | . | . | . | 0 | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | . | 0 | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | .  | 0 | . | . | . | . | . | . |   |   |   |
| D5              | 4 | 2 |       |   |   | CD  | 4 | 3 | DD     | 5 | 3 | D9     | 5 | 3 |     |   |   |                           |   |   |        |   |   |        |   |   |     |   | N | .  | . | . | . | . | . | Z | C |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   |    |   |   |   |   |   |   |   |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   |   | N  | . | . | . | . | . | . | Z | . |   |   |
|                 |   |   |       |   |   | EC  | 4 | 3 |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   | N | .  | . | . | . | . | . | Z | C |   |   |   |
|                 |   |   |       |   |   | CC  | 4 | 3 |        |   |   |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   | N | .  | . | . | . | . | . | Z | C |   |   |   |
| D6              | 6 | 2 |       |   |   | CE  | 6 | 3 | DE     | 7 | 3 |        |   |   |     |   |   |                           |   |   |        |   |   |        |   |   |     |   | N | .  | . | . | . | . | . | Z | . |   |   |   |

| Symbol          | Function                                                                                                                                                                                                                                                                                                                                                                                   | Details                                                                                                                                                                                                                                                                                                                                                                                                                                          | Addressing mode |   |   |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|-----|---|---|----|---|---|--------|---|---|----|---|---|---------|---|---|
|                 |                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | IMP             |   |   | IMM |   |   | A  |   |   | BIT, A |   |   | ZP |   |   | BIT, ZP |   |   |
|                 |                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                  | OP              | n | # | OP  | n | # | OP | n | # | OP     | n | # | OP | n | # | OP      | n | # |
| DEX             | $X \leftarrow X - 1$                                                                                                                                                                                                                                                                                                                                                                       | This instruction subtracts one from the current contents of X.                                                                                                                                                                                                                                                                                                                                                                                   | CA              | 2 | 1 |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| DEY             | $Y \leftarrow Y - 1$                                                                                                                                                                                                                                                                                                                                                                       | This instruction subtracts one from the current contents of Y.                                                                                                                                                                                                                                                                                                                                                                                   | 88              | 2 | 1 |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| DIV             | $A \leftarrow (M(zz + X + 1), M(zz + X)) / A$<br>$M(S) \leftarrow \text{one's complement of Remainder}$<br>$S \leftarrow S - 1$                                                                                                                                                                                                                                                            | This instruction divides the 16-bit data in $M(zz+(X))$ (low-order byte) and $M(zz+(X)+1)$ (high-order byte) by the contents of A. The quotient is stored in A and the one's complement of the remainder is pushed onto the stack.                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| EOR<br>(Note 1) | When $T = 0$<br>$A \leftarrow A \vee M$<br><br>When $T = 1$<br>$M(X) \leftarrow M(X) \vee M$                                                                                                                                                                                                                                                                                               | When $T = 0$ , this instruction transfers the contents of the M and A to the ALU which performs a bit-wise Exclusive OR, and stores the result in A.<br>When $T = 1$ , the contents of $M(X)$ and M are transferred to the ALU, which performs a bit-wise Exclusive OR and stores the results in $M(X)$ . The contents of A remain unchanged, but status flags are changed.<br>$M(X)$ represents the contents of memory where is indicated by X. |                 |   |   | 49  | 2 | 2 |    |   |   |        |   |   | 45 | 3 | 2 |         |   |   |
| INC             | $A \leftarrow A + 1$ or<br>$M \leftarrow M + 1$                                                                                                                                                                                                                                                                                                                                            | This instruction adds one to the contents of A or M.                                                                                                                                                                                                                                                                                                                                                                                             |                 |   |   |     |   |   | 3A | 2 | 1 |        |   |   | E6 | 5 | 2 |         |   |   |
| INX             | $X \leftarrow X + 1$                                                                                                                                                                                                                                                                                                                                                                       | This instruction adds one to the contents of X.                                                                                                                                                                                                                                                                                                                                                                                                  | E8              | 2 | 1 |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| INY             | $Y \leftarrow Y + 1$                                                                                                                                                                                                                                                                                                                                                                       | This instruction adds one to the contents of Y.                                                                                                                                                                                                                                                                                                                                                                                                  | C8              | 2 | 1 |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| JMP             | If addressing mode is ABS<br>$PCL \leftarrow ADL$<br>$PCH \leftarrow ADH$<br>If addressing mode is IND<br>$PCL \leftarrow M(ADH, ADL)$<br>$PCH \leftarrow M(ADH, ADL + 1)$<br>If addressing mode is ZP, IND<br>$PCL \leftarrow M(00, ADL)$<br>$PCH \leftarrow M(00, ADL + 1)$                                                                                                              | This instruction jumps to the address designated by the following three addressing modes:<br>Absolute<br>Indirect Absolute<br>Zero Page Indirect Absolute                                                                                                                                                                                                                                                                                        |                 |   |   |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| JSR             | $M(S) \leftarrow PCH$<br>$S \leftarrow S - 1$<br>$M(S) \leftarrow PCL$<br>$S \leftarrow S - 1$<br>After executing the above,<br>if addressing mode is ABS,<br>$PCL \leftarrow ADL$<br>$PCH \leftarrow ADH$<br>if addressing mode is SP,<br>$PCL \leftarrow ADL$<br>$PCH \leftarrow FF$<br>If addressing mode is ZP, IND,<br>$PCL \leftarrow M(00, ADL)$<br>$PCH \leftarrow M(00, ADL + 1)$ | This instruction stores the contents of the PC in the stack, then jumps to the address designated by the following addressing modes:<br>Absolute<br>Special Page<br>Zero Page Indirect Absolute                                                                                                                                                                                                                                                  |                 |   |   |     |   |   |    |   |   |        |   |   |    |   |   |         |   |   |
| LDA<br>(Note 2) | When $T = 0$<br>$A \leftarrow M$<br>When $T = 1$<br>$M(X) \leftarrow M$                                                                                                                                                                                                                                                                                                                    | When $T = 0$ , this instruction transfers the contents of M to A.<br>When $T = 1$ , this instruction transfers the contents of M to $(M(X))$ . The contents of A remain unchanged, but status flags are changed.<br>$M(X)$ represents the contents of memory where is indicated by X.                                                                                                                                                            |                 |   |   | A9  | 2 | 2 |    |   |   |        |   |   | A5 | 3 | 2 |         |   |   |
| LDM             | $M \leftarrow nn$                                                                                                                                                                                                                                                                                                                                                                          | This instruction loads the immediate value in M.                                                                                                                                                                                                                                                                                                                                                                                                 |                 |   |   |     |   |   |    |   |   |        |   |   | 3C | 4 | 3 |         |   |   |
| LDX             | $X \leftarrow M$                                                                                                                                                                                                                                                                                                                                                                           | This instruction loads the contents of M in X.                                                                                                                                                                                                                                                                                                                                                                                                   |                 |   |   | A2  | 2 | 2 |    |   |   |        |   |   | A6 | 3 | 2 |         |   |   |
| LDY             | $Y \leftarrow M$                                                                                                                                                                                                                                                                                                                                                                           | This instruction loads the contents of M in Y.                                                                                                                                                                                                                                                                                                                                                                                                   |                 |   |   | A0  | 2 | 2 |    |   |   |        |   |   | A4 | 3 | 2 |         |   |   |

| Addressing mode |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   | Processor status register |    |   |    |   |   |   |   |   |   |   |   |   |   |
|-----------------|----|---|-------|---|---|-----|---|---|--------|---|---|--------|---|---|-----|---|---|---------|---|---|--------|---|---|--------|---|---|---------------------------|----|---|----|---|---|---|---|---|---|---|---|---|---|
| ZP, X           |    |   | ZP, Y |   |   | ABS |   |   | ABS, X |   |   | ABS, Y |   |   | IND |   |   | ZP, IND |   |   | IND, X |   |   | IND, Y |   |   | REL                       |    |   | SP |   |   | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| OP              | n  | # | OP    | n | # | OP  | n | # | OP     | n | # | OP     | n | # | OP  | n | # | OP      | n | # | OP     | n | # | OP     | n | # | OP                        | n  | # | N  | V | T | B | D | I | Z | C |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |
| E2              | 16 | 2 |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   | •  | • | • | • | • | • | • | • | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
| 55              | 4  | 2 |       |   |   | 4D  | 4 | 3 | 5D     | 5 | 3 | 59     | 5 | 3 |     |   |   |         |   |   | 41     | 6 | 2 | 51     | 6 | 2 |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
| F6              | 6  | 2 |       |   |   | EE  | 6 | 3 | FE     | 7 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    | N | • | • | • | • | • | • | Z | • |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    | N | • | • | • | • | • | • | Z | • |   |
|                 |    |   |       |   |   | 4C  | 3 | 3 |        |   |   |        |   |   | 6C  | 5 | 3 | B2      | 4 | 2 |        |   |   |        |   |   |                           |    |   |    | • | • | • | • | • | • | • | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
|                 |    |   |       |   |   | 20  | 6 | 3 |        |   |   |        |   |   |     |   |   | 02      | 7 | 2 |        |   |   |        |   |   |                           | 22 | 5 | 2  | • | • | • | • | • | • | • | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
| B5              | 4  | 2 |       |   |   | AD  | 4 | 3 | BD     | 5 | 3 | B9     | 5 | 3 |     |   |   |         |   |   | A1     | 6 | 2 | B1     | 6 | 2 |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    |   |   |   |   |   |   |   |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    | • | • | • | • | • | • | • | • |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   |    | N | • | • | • | • | • | • | Z | • |   |
| B4              | 4  | 2 |       |   |   | AC  | 4 | 3 | BC     | 5 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |                           |    |   | N  | • | • | • | • | • | • | Z | • |   |   |

| Symbol          | Function                                                                                                                                       | Details                                                                                                                                                                                                                                                                                                                                                                                                                     | Addressing mode |   |   |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|-----|---|---|----|----|---|--------|---|---|----|----|---|---------|---|---|--|
|                 |                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                             | IMP             |   |   | IMM |   |   | A  |    |   | BIT, A |   |   | ZP |    |   | BIT, ZP |   |   |  |
|                 |                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                             | OP              | n | # | OP  | n | # | OP | n  | # | OP     | n | # | OP | n  | # | OP      | n | # |  |
| LSR             |                                                               | This instruction shifts either A or M one bit to the right such that bit 7 of the result always is set to 0, and the bit 0 is stored in C.                                                                                                                                                                                                                                                                                  |                 |   |   |     |   |   |    | 4A | 2 | 1      |   |   |    | 46 | 5 | 2       |   |   |  |
| MUL             | $M(S) \bullet A \leftarrow A * M(zz + X)$<br>$S \leftarrow S - 1$                                                                              | This instruction multiply Accumulator with the memory specified by the Zero Page X address mode and stores the high-order byte of the result on the Stack and the low-order byte in A.                                                                                                                                                                                                                                      |                 |   |   |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| NOP             | $PC \leftarrow PC + 1$                                                                                                                         | This instruction adds one to the PC but does no otheroperation.                                                                                                                                                                                                                                                                                                                                                             | EA              | 2 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| ORA<br>(Note 1) | When T = 0<br>$A \leftarrow A \vee M$<br><br>When T = 1<br>$M(X) \leftarrow M(X) \vee M$                                                       | When T = 0, this instruction transfers the contents of A and M to the ALU which performs a bit-wise "OR", and stores the result in A.<br>When T = 1, this instruction transfers the contents of M(X) and the M to the ALU which performs a bit-wise OR, and stores the result in M(X). The contents of A remain unchanged, but status flags are changed.<br>M(X) represents the contents of memory where is indicated by X. |                 |   |   | 09  | 2 | 2 |    |    |   |        |   |   |    | 05 | 3 | 2       |   |   |  |
| PHA             | $M(S) \leftarrow A$<br>$S \leftarrow S - 1$                                                                                                    | This instruction pushes the contents of A to the memory location designated by S, and decrements the contents of S by one.                                                                                                                                                                                                                                                                                                  | 48              | 3 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| PHP             | $M(S) \leftarrow PS$<br>$S \leftarrow S - 1$                                                                                                   | This instruction pushes the contents of PS to the memory location designated by S and decrements the contents of S by one.                                                                                                                                                                                                                                                                                                  | 08              | 3 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| PLA             | $S \leftarrow S + 1$<br>$A \leftarrow M(S)$                                                                                                    | This instruction increments S by one and stores the contents of the memory designated by S in A.                                                                                                                                                                                                                                                                                                                            | 68              | 4 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| PLP             | $S \leftarrow S + 1$<br>$PS \leftarrow M(S)$                                                                                                   | This instruction increments S by one and stores the contents of the memory location designated by S in PS.                                                                                                                                                                                                                                                                                                                  | 28              | 4 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| ROL             |                                                             | This instruction shifts either A or M one bit left through C. C is stored in bit 0 and bit 7 is stored in C.                                                                                                                                                                                                                                                                                                                |                 |   |   |     |   |   | 2A | 2  | 1 |        |   |   |    | 26 | 5 | 2       |   |   |  |
| ROR             |                                                             | This instruction shifts either A or M one bit right through C. C is stored in bit 7 and bit 0 is stored in C.                                                                                                                                                                                                                                                                                                               |                 |   |   |     |   |   | 6A | 2  | 1 |        |   |   |    | 66 | 5 | 2       |   |   |  |
| RRF             |                                                             | This instruction rotates 4 bits of the M content to the right.                                                                                                                                                                                                                                                                                                                                                              |                 |   |   |     |   |   |    |    |   |        |   |   |    | 82 | 8 | 2       |   |   |  |
| RTI             | $S \leftarrow S + 1$<br>$PS \leftarrow M(S)$<br>$S \leftarrow S + 1$<br>$PCL \leftarrow M(S)$<br>$S \leftarrow S + 1$<br>$PCH \leftarrow M(S)$ | This instruction increments S by one, and stores the contents of the memory location designated by S in PS. S is again incremented by one and stores the contents of the memory location designated by S in PCL. S is again incremented by one and stores the contents of memory location designated by S in PCH.                                                                                                           | 40              | 6 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |
| RTS             | $S \leftarrow S + 1$<br>$PCL \leftarrow M(S)$<br>$S \leftarrow S + 1$<br>$PCH \leftarrow M(S)$<br>$(PC) \leftarrow (PC) + 1$                   | This instruction increments S by one and stores the contents of the memory location designated by S in PCL. S is again incremented by one and the contents of the memory location is stored in PCH. PC is incremented by 1.                                                                                                                                                                                                 | 60              | 6 | 1 |     |   |   |    |    |   |        |   |   |    |    |   |         |   |   |  |

| Addressing mode |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     | Processor status register |                        |    |   |   |   |   |   |   |   |   |   |   |
|-----------------|----|---|-------|---|---|-----|---|---|--------|---|---|--------|---|---|-----|---|---|---------|---|---|--------|---|---|--------|---|---|-----|---------------------------|------------------------|----|---|---|---|---|---|---|---|---|---|---|
| ZP, X           |    |   | ZP, Y |   |   | ABS |   |   | ABS, X |   |   | ABS, Y |   |   | IND |   |   | ZP, IND |   |   | IND, X |   |   | IND, Y |   |   | REL |                           |                        | SP |   |   | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| OP              | n  | # | OP    | n | # | OP  | n | # | OP     | n | # | OP     | n | # | OP  | n | # | OP      | n | # | OP     | n | # | OP     | n | # | OP  | n                         | #                      | N  | V | T | B | D | I | Z | C |   |   |   |
| 56              | 6  | 2 |       |   |   | 4E  | 6 | 3 | 5E     | 7 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | 0                      | .  | . | . | . | . | . | Z | C |   |   |   |
| 62              | 15 | 2 |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
| 15              | 4  | 2 |       |   |   | 0D  | 4 | 3 | 1D     | 5 | 3 | 19     | 5 | 3 |     |   |   |         |   |   | 01     | 6 | 2 | 11     | 6 | 2 |     |                           | N                      | .  | . | . | . | . | . | Z | . |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | N                      | .  | . | . | . | . | . | Z | . |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | (Value saved in stack) |    |   |   |   |   |   |   |   |   |   |   |
| 36              | 6  | 2 |       |   |   | 2E  | 6 | 3 | 3E     | 7 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | N                      | .  | . | . | . | . | . | Z | C |   |   |   |
| 76              | 6  | 2 |       |   |   | 6E  | 6 | 3 | 7E     | 7 | 3 |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | N                      | .  | . | . | . | . | . | Z | C |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | (Value saved in stack) |    |   |   |   |   |   |   |   |   |   |   |
|                 |    |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |        |   |   |        |   |   |     |                           | .                      | .  | . | . | . | . | . | . | . | . |   |   |

| Symbol                      | Function                                                                                                         | Details                                                                                                                                                                                                                                                                                                                                                                                             | Addressing mode |   |   |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
|-----------------------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|---|-----|---|---|----|---|---|--------|-----------|---|----|---|---|---------|-----------|---|---|
|                             |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                     | IMP             |   |   | IMM |   |   | A  |   |   | BIT, A |           |   | ZP |   |   | BIT, ZP |           |   |   |
|                             |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                     | OP              | n | # | OP  | n | # | OP | n | # | OP     | n         | # | OP | n | # | OP      | n         | # |   |
| SBC<br>(Note 1)<br>(Note 5) | When T = 0<br>$A \leftarrow A - M - \overline{C}$<br><br>When T = 1<br>$M(X) \leftarrow M(X) - M - \overline{C}$ | When T = 0, this instruction subtracts the value of M and the complement of C from A, and stores the results in A and C.<br>When T = 1, the instruction subtracts the contents of M and the complement of C from the contents of M(X), and stores the results in M(X) and C.<br>A remain unchanged, but status flag are changed.<br>M(X) represents the contents of memory where is indicated by X. |                 |   |   | E9  | 2 | 2 |    |   |   |        |           |   | E5 | 3 | 2 |         |           |   |   |
| SEB                         | $A_i$ or $M_i \leftarrow 1$                                                                                      | This instruction sets the designated bit i of A or M.                                                                                                                                                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   |        | 0B<br>20i | 2 | 1  |   |   |         | 0F<br>20i | 5 | 2 |
| SEC                         | $C \leftarrow 1$                                                                                                 | This instruction sets C.                                                                                                                                                                                                                                                                                                                                                                            | 38              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| SED                         | $D \leftarrow 1$                                                                                                 | This instruction set D.                                                                                                                                                                                                                                                                                                                                                                             | F8              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| SEI                         | $I \leftarrow 1$                                                                                                 | This instruction set I.                                                                                                                                                                                                                                                                                                                                                                             | 78              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| SET                         | $T \leftarrow 1$                                                                                                 | This instruction set T.                                                                                                                                                                                                                                                                                                                                                                             | 32              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| STA                         | $M \leftarrow A$                                                                                                 | This instruction stores the contents of A in M.<br>The contents of A does not change.                                                                                                                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   |        |           |   | 85 | 4 | 2 |         |           |   |   |
| STP                         |                                                                                                                  | This instruction resets the oscillation control F/ F and the oscillation stops. Reset or interrupt input is needed to wake up from this mode.                                                                                                                                                                                                                                                       | 42              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| STX                         | $M \leftarrow X$                                                                                                 | This instruction stores the contents of X in M.<br>The contents of X does not change.                                                                                                                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   |        |           |   | 86 | 4 | 2 |         |           |   |   |
| STY                         | $M \leftarrow Y$                                                                                                 | This instruction stores the contents of Y in M.<br>The contents of Y does not change.                                                                                                                                                                                                                                                                                                               |                 |   |   |     |   |   |    |   |   |        |           |   | 84 | 4 | 2 |         |           |   |   |
| TAX                         | $X \leftarrow A$                                                                                                 | This instruction stores the contents of A in X.<br>The contents of A does not change.                                                                                                                                                                                                                                                                                                               | AA              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| TAY                         | $Y \leftarrow A$                                                                                                 | This instruction stores the contents of A in Y.<br>The contents of A does not change.                                                                                                                                                                                                                                                                                                               | A8              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| TST                         | $M = 0?$                                                                                                         | This instruction tests whether the contents of M are "0" or not and modifies the N and Z.                                                                                                                                                                                                                                                                                                           |                 |   |   |     |   |   |    |   |   |        |           |   | 64 | 3 | 2 |         |           |   |   |
| TSX                         | $X \leftarrow S$                                                                                                 | This instruction transfers the contents of S in X.                                                                                                                                                                                                                                                                                                                                                  | BA              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| TXA                         | $A \leftarrow X$                                                                                                 | This instruction stores the contents of X in A.                                                                                                                                                                                                                                                                                                                                                     | 8A              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| TXS                         | $S \leftarrow X$                                                                                                 | This instruction stores the contents of X in S.                                                                                                                                                                                                                                                                                                                                                     | 9A              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| TYA                         | $A \leftarrow Y$                                                                                                 | This instruction stores the contents of Y in A.                                                                                                                                                                                                                                                                                                                                                     | 98              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |
| WIT                         |                                                                                                                  | The WIT instruction stops the internal clock but not the oscillation of the oscillation circuit is not stopped.<br>CPU starts its function after the Timer X over flows (comes to the terminal count). All registers or internal memory contents except Timer X will not change during this mode. (Of course needs VDD).                                                                            | C2              | 2 | 1 |     |   |   |    |   |   |        |           |   |    |   |   |         |           |   |   |

Notes 1 : The number of cycles "n" is increased by 3 when T is 1.  
2 : The number of cycles "n" is increased by 2 when T is 1.  
3 : The number of cycles "n" is increased by 1 when T is 1.  
4 : The number of cycles "n" is increased by 2 when branching has occurred.  
5 : N, V, and Z flags are invalid in decimal operation mode.

| Addressing mode |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   | Processor status register |   |   |        |   |   |     |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----------------|---|---|-------|---|---|-----|---|---|--------|---|---|--------|---|---|-----|---|---|---------|---|---|---------------------------|---|---|--------|---|---|-----|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZP, X           |   |   | ZP, Y |   |   | ABS |   |   | ABS, X |   |   | ABS, Y |   |   | IND |   |   | ZP, IND |   |   | IND, X                    |   |   | IND, Y |   |   | REL |   |   | SP |   |   | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |   |   |   |
| OP              | n | # | OP    | n | # | OP  | n | # | OP     | n | # | OP     | n | # | OP  | n | # | OP      | n | # | OP                        | n | # | OP     | n | # | OP  | n | # | OP | n | # | N | V | T | B | D | I | Z | C |   |   |   |
| F5              | 4 | 2 |       |   |   | ED  | 4 | 3 | FD     | 5 | 3 | F9     | 5 | 3 |     |   |   |         |   |   | E1                        | 6 | 2 | F1     | 6 | 2 |     |   |   |    |   |   | N | V | . | . | . | . | Z | C |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | 1 |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
| 95              | 5 | 2 |       |   |   | 8D  | 5 | 3 | 9D     | 6 | 3 | 99     | 6 | 3 |     |   |   |         |   |   | 81                        | 7 | 2 | 91     | 7 | 2 |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . |   |   |
| 94              | 5 | 2 |       |   |   | 8C  | 5 | 3 |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    | . | . | . | . | . | . | . | . | . | . |   |   |   |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | N | . | . | . | . | . | . | . | . | . | Z | . |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | N | . | . | . | . | . | . | . | . | . | Z | . |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | N | . | . | . | . | . | . | . | . | . | Z | . |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . | . | . |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | N | . | . | . | . | . | . | . | . | . | Z | . |
|                 |   |   |       |   |   |     |   |   |        |   |   |        |   |   |     |   |   |         |   |   |                           |   |   |        |   |   |     |   |   |    |   | . | . | . | . | . | . | . | . | . | . | . | . |

# APPENDIX

## 3.10 Machine instructions

| Symbol     | Contents                                    | Symbol      | Contents                                                                                                         |
|------------|---------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------|
| IMP        | Implied addressing mode                     | +           | Addition                                                                                                         |
| IMM        | Immediate addressing mode                   | −           | Subtraction                                                                                                      |
| A          | Accumulator or Accumulator addressing mode  | *           | Multiplication                                                                                                   |
| BIT, A     | Accumulator bit addressing mode             | /           | Division                                                                                                         |
| BIT, A, R  | Accumulator bit relative addressing mode    | Λ           | Logical OR                                                                                                       |
| ZP         | Zero page addressing mode                   | V           | Logical AND                                                                                                      |
| BIT, ZP    | Zero page bit addressing mode               | ∨           | Logical exclusive OR                                                                                             |
| BIT, ZP, R | Zero page bit relative addressing mode      | —           | Negation                                                                                                         |
| ZP, X      | Zero page X addressing mode                 | ←           | Shows direction of data flow                                                                                     |
| ZP, Y      | Zero page Y addressing mode                 | X           | Index register X                                                                                                 |
| ABS        | Absolute addressing mode                    | Y           | Index register Y                                                                                                 |
| ABS, X     | Absolute X addressing mode                  | S           | Stack pointer                                                                                                    |
| ABS, Y     | Absolute Y addressing mode                  | PC          | Program counter                                                                                                  |
| IND        | Indirect absolute addressing mode           | PS          | Processor status register                                                                                        |
|            |                                             | PCH         | 8 high-order bits of program counter                                                                             |
| ZP, IND    | Zero page indirect absolute addressing mode | PCL         | 8 low-order bits of program counter                                                                              |
|            |                                             | ADH         | 8 high-order bits of address                                                                                     |
| IND, X     | Indirect X addressing mode                  | ADL         | 8 low-order bits of address                                                                                      |
| IND, Y     | Indirect Y addressing mode                  | FF          | FF in Hexadecimal notation                                                                                       |
| REL        | Relative addressing mode                    | nn          | Immediate value                                                                                                  |
| SP         | Special page addressing mode                | zz          | Zero page address                                                                                                |
| C          | Carry flag                                  | M           | Memory specified by address designation of any addressing mode                                                   |
| Z          | Zero flag                                   | M(X)        | Memory of address indicated by contents of index register X                                                      |
| I          | Interrupt disable flag                      | M(S)        | Memory of address indicated by contents of stack pointer                                                         |
| D          | Decimal mode flag                           | M(ADH, ADL) | Contents of memory at address indicated by ADH and ADL, in ADH is 8 high-order bits and ADL is 8 low-order bits. |
| B          | Break flag                                  | M(00, ADL)  | Contents of address indicated by zero page ADL                                                                   |
| T          | X-modified arithmetic mode flag             | Ai          | Bit i (i = 0 to 7) of accumulator                                                                                |
| V          | Overflow flag                               | Mi          | Bit i (i = 0 to 7) of memory                                                                                     |
| N          | Negative flag                               | OP          | Opcode                                                                                                           |
|            |                                             | n           | Number of cycles                                                                                                 |
|            |                                             | #           | Number of bytes                                                                                                  |

## 3.11 List of instruction code

| D3 – D0<br>D7 – D4 | Hexadecimal<br>notation | 0000       | 0001          | 0010           | 0011        | 0100         | 0101         | 0110         | 0111         | 1000 | 1001          | 1010     | 1011        | 1100          | 1101          | 1110          | 1111         |
|--------------------|-------------------------|------------|---------------|----------------|-------------|--------------|--------------|--------------|--------------|------|---------------|----------|-------------|---------------|---------------|---------------|--------------|
|                    |                         | 0          | 1             | 2              | 3           | 4            | 5            | 6            | 7            | 8    | 9             | A        | B           | C             | D             | E             | F            |
| 0000               | 0                       | BRK        | ORA<br>IND, X | JSR<br>ZP, IND | BBS<br>0, A | —            | ORA<br>ZP    | ASL<br>ZP    | BBS<br>0, ZP | PHP  | ORA<br>IMM    | ASL<br>A | SEB<br>0, A | —             | ORA<br>ABS    | ASL<br>ABS    | SEB<br>0, ZP |
| 0001               | 1                       | BPL        | ORA<br>IND, Y | CLT            | BBC<br>0, A | —            | ORA<br>ZP, X | ASL<br>ZP, X | BBC<br>0, ZP | CLC  | ORA<br>ABS, Y | DEC<br>A | CLB<br>0, A | —             | ORA<br>ABS, X | ASL<br>ABS, X | CLB<br>0, ZP |
| 0010               | 2                       | JSR<br>ABS | AND<br>IND, X | JSR<br>SP      | BBS<br>1, A | BIT<br>ZP    | AND<br>ZP    | ROL<br>ZP    | BBS<br>1, ZP | PLP  | AND<br>IMM    | ROL<br>A | SEB<br>1, A | BIT<br>ABS    | AND<br>ABS    | ROL<br>ABS    | SEB<br>1, ZP |
| 0011               | 3                       | BMI        | AND<br>IND, Y | SET            | BBC<br>1, A | —            | AND<br>ZP, X | ROL<br>ZP, X | BBC<br>1, ZP | SEC  | AND<br>ABS, Y | INC<br>A | CLB<br>1, A | LDM<br>ZP     | AND<br>ABS, X | ROL<br>ABS, X | CLB<br>1, ZP |
| 0100               | 4                       | RTI        | EOR<br>IND, X | STP            | BBS<br>2, A | COM<br>ZP    | EOR<br>ZP    | LSR<br>ZP    | BBS<br>2, ZP | PHA  | EOR<br>IMM    | LSR<br>A | SEB<br>2, A | JMP<br>ABS    | EOR<br>ABS    | LSR<br>ABS    | SEB<br>2, ZP |
| 0101               | 5                       | BVC        | EOR<br>IND, Y | —              | BBC<br>2, A | —            | EOR<br>ZP, X | LSR<br>ZP, X | BBC<br>2, ZP | CLI  | EOR<br>ABS, Y | —        | CLB<br>2, A | —             | EOR<br>ABS, X | LSR<br>ABS, X | CLB<br>2, ZP |
| 0110               | 6                       | RTS        | ADC<br>IND, X | MUL<br>ZP, X   | BBS<br>3, A | TST<br>ZP    | ADC<br>ZP    | ROR<br>ZP    | BBS<br>3, ZP | PLA  | ADC<br>IMM    | ROR<br>A | SEB<br>3, A | JMP<br>IND    | ADC<br>ABS    | ROR<br>ABS    | SEB<br>3, ZP |
| 0111               | 7                       | BVS        | ADC<br>IND, Y | —              | BBC<br>3, A | —            | ADC<br>ZP, X | ROR<br>ZP, X | BBC<br>3, ZP | SEI  | ADC<br>ABS, Y | —        | CLB<br>3, A | —             | ADC<br>ABS, X | ROR<br>ABS, X | CLB<br>3, ZP |
| 1000               | 8                       | BRA        | STA<br>IND, X | RRF<br>ZP      | BBS<br>4, A | STY<br>ZP    | STA<br>ZP    | STX<br>ZP    | BBS<br>4, ZP | DEY  | —             | TXA      | SEB<br>4, A | STY<br>ABS    | STA<br>ABS    | STX<br>ABS    | SEB<br>4, ZP |
| 1001               | 9                       | BCC        | STA<br>IND, Y | —              | BBC<br>4, A | STY<br>ZP, X | STA<br>ZP, X | STX<br>ZP, Y | BBC<br>4, ZP | TYA  | STA<br>ABS, Y | TXS      | CLB<br>4, A | —             | STA<br>ABS, X | —             | CLB<br>4, ZP |
| 1010               | A                       | LDY<br>IMM | LDA<br>IND, X | LDX<br>IMM     | BBS<br>5, A | LDY<br>ZP    | LDA<br>ZP    | LDX<br>ZP    | BBS<br>5, ZP | TAY  | LDA<br>IMM    | TAX      | SEB<br>5, A | LDY<br>ABS    | LDA<br>ABS    | LDX<br>ABS    | SEB<br>5, ZP |
| 1011               | B                       | BCS        | LDA<br>IND, Y | JMP<br>ZP, IND | BBC<br>5, A | LDY<br>ZP, X | LDA<br>ZP, X | LDX<br>ZP, Y | BBC<br>5, ZP | CLV  | LDA<br>ABS, Y | TSX      | CLB<br>5, A | LDY<br>ABS, X | LDA<br>ABS, X | LDX<br>ABS, Y | CLB<br>5, ZP |
| 1100               | C                       | CPY<br>IMM | CMP<br>IND, X | WIT            | BBS<br>6, A | CPY<br>ZP    | CMP<br>ZP    | DEC<br>ZP    | BBS<br>6, ZP | INY  | CMP<br>IMM    | DEX      | SEB<br>6, A | CPY<br>ABS    | CMP<br>ABS    | DEC<br>ABS    | SEB<br>6, ZP |
| 1101               | D                       | BNE        | CMP<br>IND, Y | —              | BBC<br>6, A | —            | CMP<br>ZP, X | DEC<br>ZP, X | BBC<br>6, ZP | CLD  | CMP<br>ABS, Y | —        | CLB<br>6, A | —             | CMP<br>ABS, X | DEC<br>ABS, X | CLB<br>6, ZP |
| 1110               | E                       | CPX<br>IMM | SBC<br>IND, X | DIV<br>ZP, X   | BBS<br>7, A | CPX<br>ZP    | SBC<br>ZP    | INC<br>ZP    | BBS<br>7, ZP | INX  | SBC<br>IMM    | NOP      | SEB<br>7, A | CPX<br>ABS    | SBC<br>ABS    | INC<br>ABS    | SEB<br>7, ZP |
| 1111               | F                       | BEQ        | SBC<br>IND, Y | —              | BBC<br>7, A | —            | SBC<br>ZP, X | INC<br>ZP, X | BBC<br>7, ZP | SED  | SBC<br>ABS, Y | —        | CLB<br>7, A | —             | SBC<br>ABS, X | INC<br>ABS, X | CLB<br>7, ZP |

 : 3-byte instruction

 : 2-byte instruction

 : 1-byte instruction

# APPENDIX

## 3.12 SFR memory map

### 3.12 SFR memory map

|                    |                                           |
|--------------------|-------------------------------------------|
| 0000 <sub>16</sub> | Port P0 (P0)                              |
| 0001 <sub>16</sub> | Port P0 direction register (P0D)          |
| 0002 <sub>16</sub> | Port P1 (P1)                              |
| 0003 <sub>16</sub> | Port P1 direction register (P1D)          |
| 0004 <sub>16</sub> | Port P2 (P2)                              |
| 0005 <sub>16</sub> | Port P2 direction register (P2D)          |
| 0006 <sub>16</sub> | Port P3 (P3)                              |
| 0007 <sub>16</sub> |                                           |
| 0008 <sub>16</sub> | Port P4 (P4)                              |
| 0009 <sub>16</sub> | Port P4 direction register (P4D)          |
| 000A <sub>16</sub> | Port P5 (P5)                              |
| 000B <sub>16</sub> | Port P5 direction register (P5D)          |
| 000C <sub>16</sub> | Port P6 (P6)                              |
| 000D <sub>16</sub> | Port P6 direction register (P6D)          |
| 000E <sub>16</sub> | Port P7 (P7)                              |
| 000F <sub>16</sub> | Port P7 direction register (P7D)          |
| 0010 <sub>16</sub> | Port P8 (P8)                              |
| 0011 <sub>16</sub> | Port P8 direction register (P8D)          |
| 0012 <sub>16</sub> |                                           |
| 0013 <sub>16</sub> |                                           |
| 0014 <sub>16</sub> |                                           |
| 0015 <sub>16</sub> |                                           |
| 0016 <sub>16</sub> | PULL register A (PULLA)                   |
| 0017 <sub>16</sub> | PULL register B (PULLB)                   |
| 0018 <sub>16</sub> | Port P8 output selection register (P8SEL) |
| 0019 <sub>16</sub> | Serial I/O control register 1 (SIOCON1)   |
| 001A <sub>16</sub> | Serial I/O control register 2 (SIOCON2)   |
| 001B <sub>16</sub> | Serial I/O register (SIO)                 |
| 001C <sub>16</sub> |                                           |
| 001D <sub>16</sub> |                                           |
| 001E <sub>16</sub> |                                           |
| 001F <sub>16</sub> |                                           |

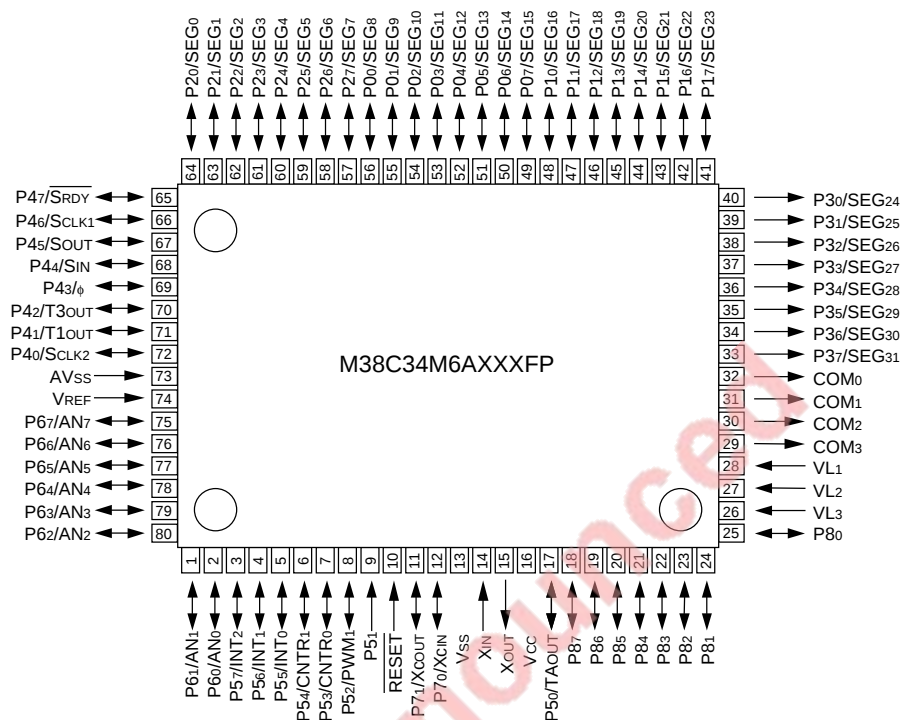
|                    |                                                         |
|--------------------|---------------------------------------------------------|
| 0F01 <sub>16</sub> | ROM correct enable register 1 <b>(Note)</b>             |
| 0F02 <sub>16</sub> | ROM correct high-order address register 1 <b>(Note)</b> |
| 0F03 <sub>16</sub> | ROM correct low-order address register 1 <b>(Note)</b>  |
| 0F04 <sub>16</sub> | ROM correct high-order address register 2 <b>(Note)</b> |
| 0F05 <sub>16</sub> | ROM correct low-order address register 2 <b>(Note)</b>  |
| 0F06 <sub>16</sub> | ROM correct high-order address register 3 <b>(Note)</b> |
| 0F07 <sub>16</sub> | ROM correct low-order address register 3 <b>(Note)</b>  |
| 0F08 <sub>16</sub> | ROM correct high-order address register 4 <b>(Note)</b> |
| 0F09 <sub>16</sub> | ROM correct low-order address register 4 <b>(Note)</b>  |

|                    |                                             |
|--------------------|---------------------------------------------|
| 0020 <sub>16</sub> | Timer 1 (T1)                                |
| 0021 <sub>16</sub> | Timer 2 (T2)                                |
| 0022 <sub>16</sub> | Timer 3 (T3)                                |
| 0023 <sub>16</sub> | Timer 4 (T4)                                |
| 0024 <sub>16</sub> | Timer 5 (T5)                                |
| 0025 <sub>16</sub> | Timer 6 (T6)                                |
| 0026 <sub>16</sub> |                                             |
| 0027 <sub>16</sub> | Timer 6 PWM register (T6PWM)                |
| 0028 <sub>16</sub> | Timer 12 mode register (T12M)               |
| 0029 <sub>16</sub> | Timer 34 mode register (T34M)               |
| 002A <sub>16</sub> | Timer 56 mode register (T56M)               |
| 002B <sub>16</sub> | φ output control register (CKOUT)           |
| 002C <sub>16</sub> | Timer A register (low) (TAL)                |
| 002D <sub>16</sub> | Timer A register (high) (TAH)               |
| 002E <sub>16</sub> | Compare register (low) (CONAL)              |
| 002F <sub>16</sub> | Compare register (high) (CONAH)             |
| 0030 <sub>16</sub> | Timer A mode register (TAM)                 |
| 0031 <sub>16</sub> | Timer A control register (TACON)            |
| 0032 <sub>16</sub> | A-D control register (ADCON)                |
| 0033 <sub>16</sub> | A-D conversion register (low) (ADL)         |
| 0034 <sub>16</sub> | A-D conversion register (high) (ADH)        |
| 0035 <sub>16</sub> |                                             |
| 0036 <sub>16</sub> |                                             |
| 0037 <sub>16</sub> |                                             |
| 0038 <sub>16</sub> | Segment output enable register (SEG)        |
| 0039 <sub>16</sub> | LCD mode register (LM)                      |
| 003A <sub>16</sub> | Interrupt edge selection register (INTEDGE) |
| 003B <sub>16</sub> | CPU mode register (CPUM)                    |
| 003C <sub>16</sub> | Interrupt request register 1 (IREQ1)        |
| 003D <sub>16</sub> | Interrupt request register 2 (IREQ2)        |
| 003E <sub>16</sub> | Interrupt control register 1 (ICON1)        |
| 003F <sub>16</sub> | Interrupt control register 2 (ICON2)        |

|                    |                                                         |
|--------------------|---------------------------------------------------------|
| 0F0A <sub>16</sub> | ROM correct high-order address register 5 <b>(Note)</b> |
| 0F0B <sub>16</sub> | ROM correct low-order address register 5 <b>(Note)</b>  |
| 0F0C <sub>16</sub> | ROM correct high-order address register 6 <b>(Note)</b> |
| 0F0D <sub>16</sub> | ROM correct low-order address register 6 <b>(Note)</b>  |
| 0F0E <sub>16</sub> | ROM correct high-order address register 7 <b>(Note)</b> |
| 0F0F <sub>16</sub> | ROM correct low-order address register 7 <b>(Note)</b>  |
| 0F10 <sub>16</sub> | ROM correct high-order address register 8 <b>(Note)</b> |
| 0F11 <sub>16</sub> | ROM correct low-order address register 8 <b>(Note)</b>  |

**Note:** This register is valid only in mask ROM version.

## 3.13 Pin configuration



(Top view)

Package type: 80P6N-A  
80-pin plastic molded QFP

# APPENDIX

## 3.13 Pin configuration

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### MEMORANDUM

EOL announced

EOL announced

**MITSUBISHI SEMICONDUCTORS  
USER'S MANUAL  
38C3 Group**

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EOL announced

**38C3 Group  
User's Manual**



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