To all our customers

Regarding the change of names mentioned in the document, such as Mitsubishi Electric and Mitsubishi XX, to Renesas Technology Corp.

The semiconductor operations of Hitachi and Mitsubishi Electric were transferred to Renesas Technology Corporation on April 1st 2003. These operations include microcomputer, logic, analog and discrete devices, and memory chips other than DRAMs (flash memory, SRAMs etc.) Accordingly, although Mitsubishi Electric, Mitsubishi Electric Corporation, Mitsubishi Semiconductors, and other Mitsubishi brand names are mentioned in the document, these names have in fact all been changed to Renesas Technology Corp. Thank you for your understanding. Except for our corporate trademark, logo and corporate statement, no changes whatsoever have been made to the contents of the document, and these changes do not constitute any alteration to the contents of the document itself.

Note : Mitsubishi Electric will continue the business operations of high frequency & optical devices and power devices.

Renesas Technology Corp.
Customer Support Dept.
April 1, 2003

7560 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

DESCRIPTION

The 7560 group is the 8-bit microcomputer based on the 740 family core technology.

The 7560 group has the LCD drive control circuit, an 8-channel A-D converter, D-A converter, serial I/O and PWM as additional functions.

The various microcomputers in the 7560 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 7560 group, refer the section on group expansion.

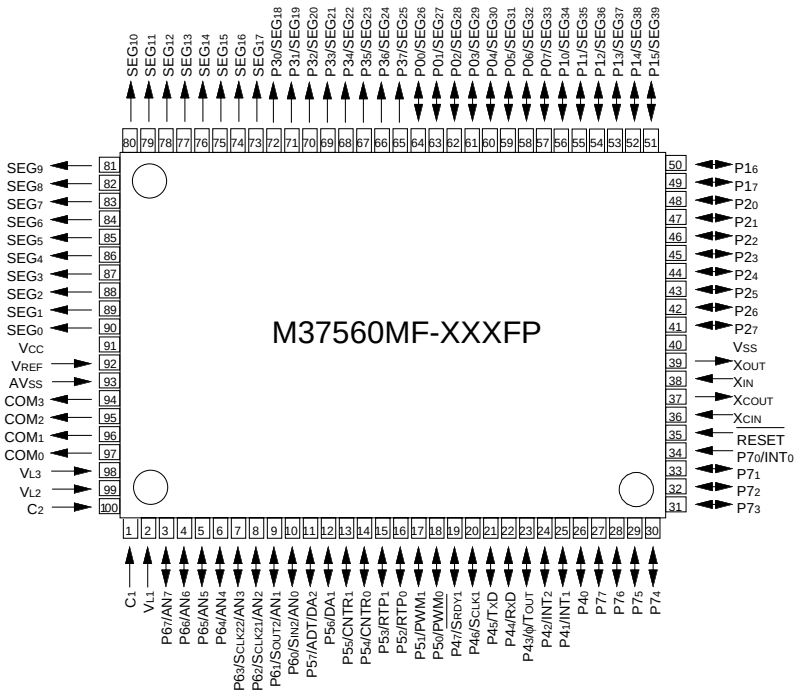
FEATURES

- Basic machine-language instructions 71
- The minimum instruction execution time ..... 0.5 µs
  (at 8 MHz oscillation frequency)
- Memory size
  ROM ..... 32 K to 60 K bytes
  RAM ..... 1024 to 2560 bytes
- Programmable input/output ports 55
- Software pull-up resistors ..... Built-in
- Output ports 8
- Input ports 1
- Interrupts ..... 17 sources, 16 vectors
  External ..... 7 sources (includes key input interrupt)
  Internal ..... 9 sources
  Software ..... 1 source
- Timers ..... 8-bit × 3, 16-bit × 2
- Serial I/O1 ..... 8-bit × 1 (UART or Clock-synchronous)
- Serial I/O2 ..... 8-bit × 1 (Clock-synchronous)
- PWM output ..... 8-bit × 1
- A-D converter ..... 10-bit × 8 channels
- D-A converter ..... 8-bit × 2 channels
- LCD drive control circuit
  Bias 1/2, 1/3
  Duty 1/2, 1/3, 1/4
  Common output 4
  Segment output 40
- 2 Clock generating circuits
  (connect to external ceramic resonator or quartz-crystal oscillator)
- Watchdog timer ..... 14-bit × 1
- Power source voltage ..... 2.2 to 5.5 V
  (EPROM and One Time PROM version: 2.5 to 5.5 V)
  (Extended operating temperature version: 3.0 to 5.5 V)
- Power dissipation
  In high-speed mode ..... 32 mW
  (at 8 MHz oscillation frequency, at 5 V power source voltage)
  In low-speed mode ..... 45 µW
  (at 32 kHz oscillation frequency, at 3 V power source voltage)
- Operating temperature range ..... – 20 to 85°C
  (Extended operating temperature version: – 40 to 85°C)

APPLICATIONS

Camera, household appliances, consumer electronics, etc.

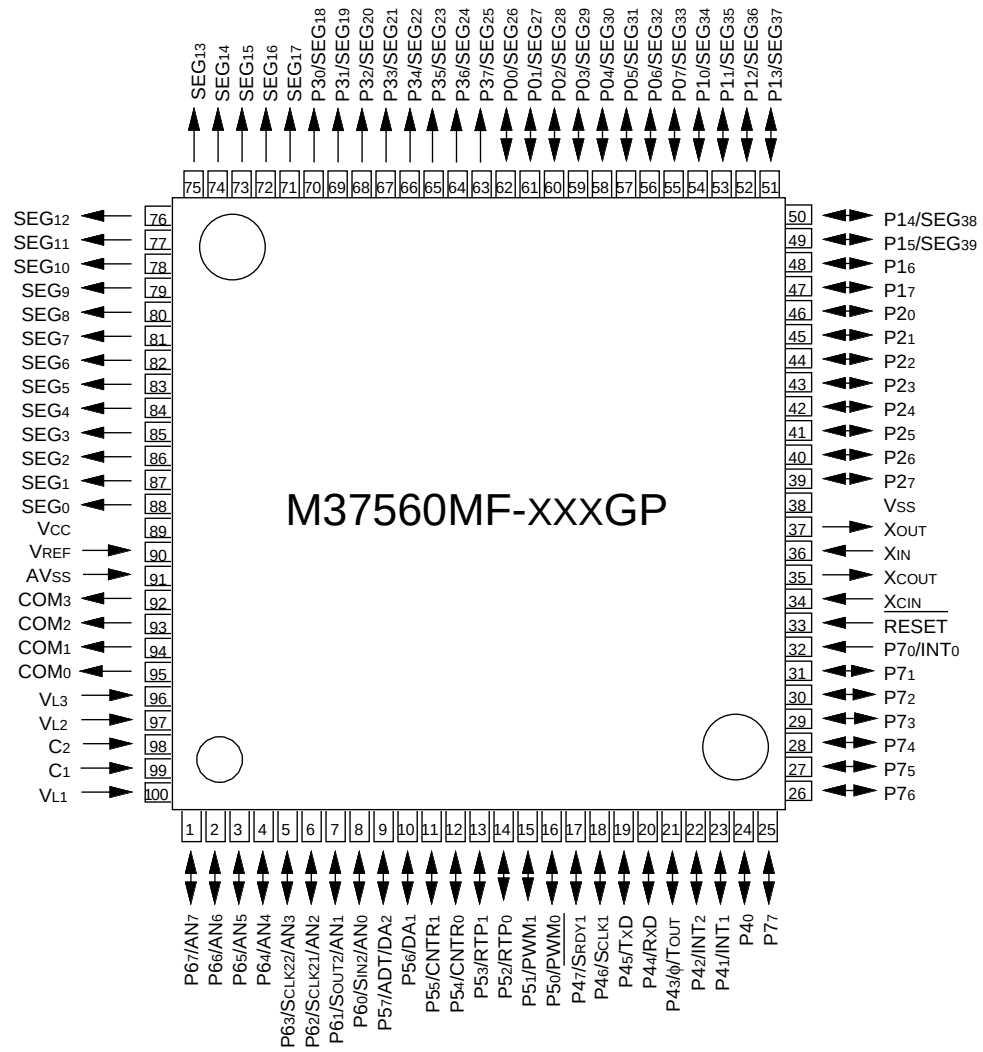
PIN CONFIGURATION (TOP VIEW)



Package type : 100P6S-A

Fig. 1 Pin configuration (Package type: 100P6S-A)

PIN CONFIGURATION (TOP VIEW)



Package type : 100P6Q-A

Fig. 2 Pin configuration (Package type: 100P6Q-A)

FUNCTIONAL BLOCK DIAGRAM (Package type: 100P6S-A)

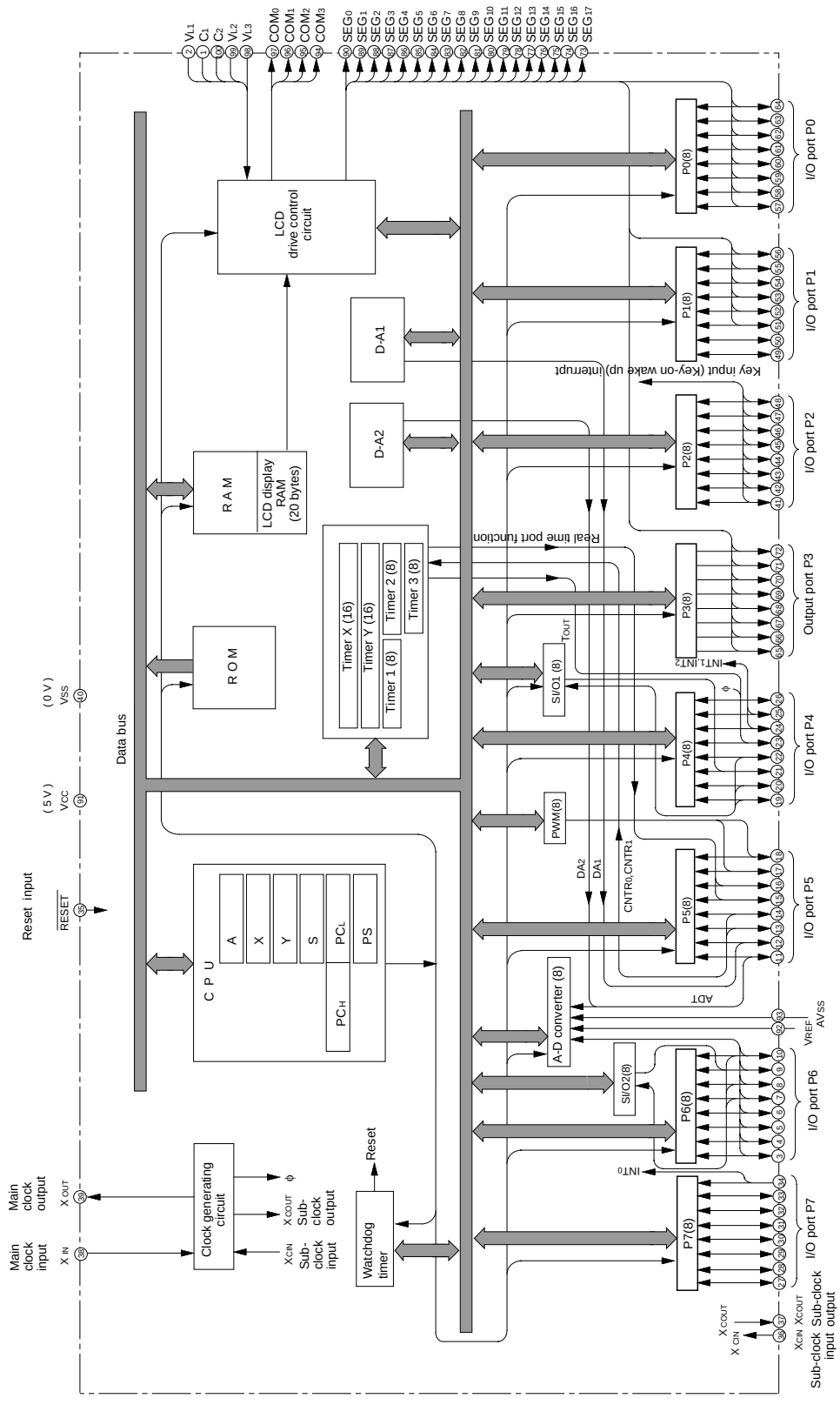


Fig. 3 Functional block diagram

PIN DESCRIPTION

Table 1 Pin description (1)

Pin	Name	Function	Function except a port function
V_{CC}, V_{SS}	Power source	•Apply voltage of 2.2 V to 5.5 V (2.5 to 5.5 V for EPROM and One Time PROM version, 3.0 to 5.5 V for extended operating temperature version) to V_{CC}, and 0 V to V_{SS}.	
V_{REF}	Analog reference voltage	•Reference voltage input pin for A-D converter and D-A converter.	
AV_{SS}	Analog power source	•GND input pin for A-D converter and D-A converter. •Connect to V_{SS}.	
$\overline{RESET}$	Reset input	•Reset input pin for active “L”.	
X_{IN}	Clock input	•Input and output pins for the main clock generating circuit. •Connect a ceramic resonator or a quartz-crystal oscillator between the X_{IN} and X_{OUT} pins to set the oscillation frequency. •If an external clock is used, connect the clock source to the X_{IN} pin and leave the X_{OUT} pin open. A feedback resistor is built-in.	
X_{OUT}	Clock output		
V_{L1}–V_{L3}	LCD power source	•Input 0 ≤ V_{L1} ≤ V_{L2} ≤ V_{L3} voltage. •Input 0 – V_{L3} voltage to LCD. (0 ≤ V_{L1} ≤ V_{L2} ≤ V_{L3} when a voltage is multiplied.)	
C_1, C_2	Charge-pump capacitor pin	•External capacitor pins for a voltage multiplier (3 times) of LCD control.	
COM_0–COM_3	Common output	•LCD common output pins. •COM_2 and COM_3 are not used at 1/2 duty ratio. •COM_3 is not used at 1/3 duty ratio.	
SEG_0–SEG_{17}	Segment output	•LCD segment output pins.	
$P0_0$/SEG_{26}–$P0_7$/SEG_{33}	I/O port P0	•8-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. •I/O direction register allows each 8-bit pin to be programmed as either input or output.	•LCD segment output pins
$P1_0$/SEG_{34}–$P1_5$/SEG_{39}	I/O port P1	•6-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. •I/O direction register allows each 6-bit pin to be programmed as either input or output.	
$P1_6$, $P1_7$		•2-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	
$P2_0$ – $P2_7$	I/O port P2	•8-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	•Key input (key-on wake-up) interrupt input pins
$P3_0$/SEG_{18} – $P3_7$/SEG_{25}	Output port P3	•8-bit output. •CMOS 3-state output structure. •Port output control is enabled.	•LCD segment output pins

Table 2 Pin description (2)

Pin	Name	Function	Function except a port function
$P4_0$	I/O port P4	•1-bit I/O port. •CMOS compatible input level. •N-channel open-drain output structure. •I/O direction register allows this pin to be individually programmed as either input or output.	
$P4_1/INT_1$, $P4_2/INT_2$		•7-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	•INT_i interrupt input pins
$P4_3/\phi/T_{OUT}$			•System clock ϕ output pin •Timer 2 output pin
$P4_4/R_XD$, $P4_5/T_XD$, $P4_6/\underline{S_{CLK1}}$, $P4_7/S_{RDY1}$			•Serial I/O1 I/O pins
$P5_0/PWM_0$, $P5_1/PWM_1$	I/O port P5	•8-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	•PWM output pins
$P5_2/RTP_0$, $P5_3/RTP_1$			•Real time port output pins
$P5_4/CNTR_0$, $P5_5/CNTR_1$			•Timer X, Y I/O pins
$P5_6/DA_1$			•D-A converter output pin
$P5_7/ADT/DA_2$			•D-A converter output pin •A-D external trigger input pin
$P6_0/S_{IN2}/AN_0$, $P6_1/S_{OUT2}/AN_1$, $P6_2/S_{CLK21}/AN_2$, $P6_3/S_{CLK22}/AN_3$	I/O port P6	•8-bit I/O port. •CMOS compatible input level. •CMOS 3-state output structure. •I/O direction register allows each pin to be individually programmed as either input or output. •Pull-up control is enabled.	•A-D converter input pins •Serial I/O2 I/O pins
$P6_4/AN_4$–$P6_7/AN_7$			•A-D converter input pins
$P7_0/INT_0$	Input port P7	•1-bit input port.	•INT_0 interrupt input pin
$P7_1$–$P7_7$	I/O port P7	•7-bit I/O port. •CMOS compatible input level. •N-channel open-drain output structure. •I/O direction register allows each pin to be individually programmed as either input or output.	
X_{COUT}	Sub-clock output	•Sub-clock generating circuit I/O pins.	
X_{CIN}	Sub-clock input	(Connect a oscillator. External clock cannot be used.)	

PART NUMBERING

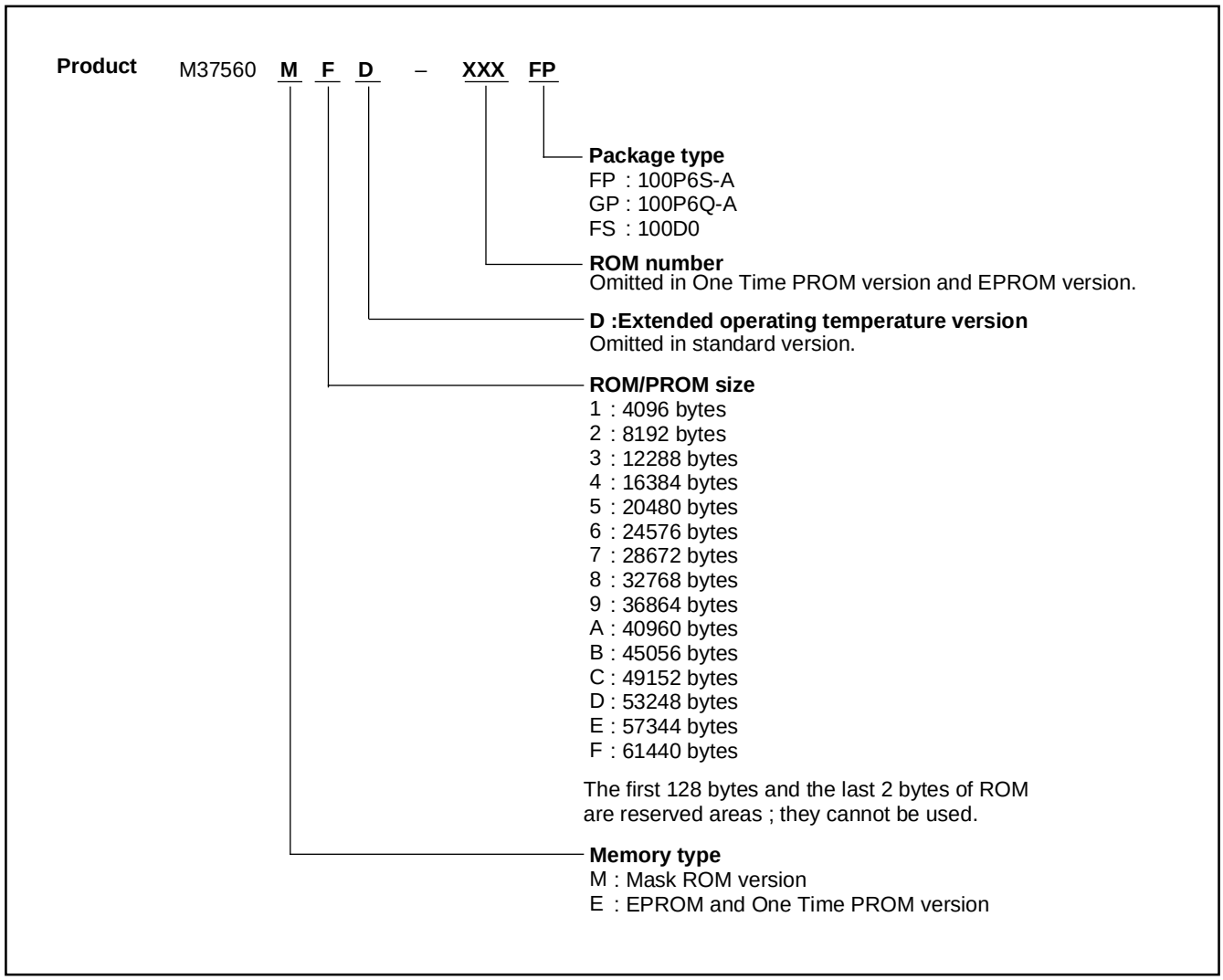


Fig. 4 Part numbering

GROUP EXPANSION

Mitsubishi expands the 7560 group as follows.

Memory Type

Support for mask ROM version.

Memory Size

ROM size ..... 32 K to 60 K bytes
RAM size ..... 1024 to 2560 bytes

Packages

100P6Q-A ..... 0.5 mm-pitch plastic molded QFP
100P6S-A ..... 0.65 mm-pitch plastic molded QFP

Memory Expansion

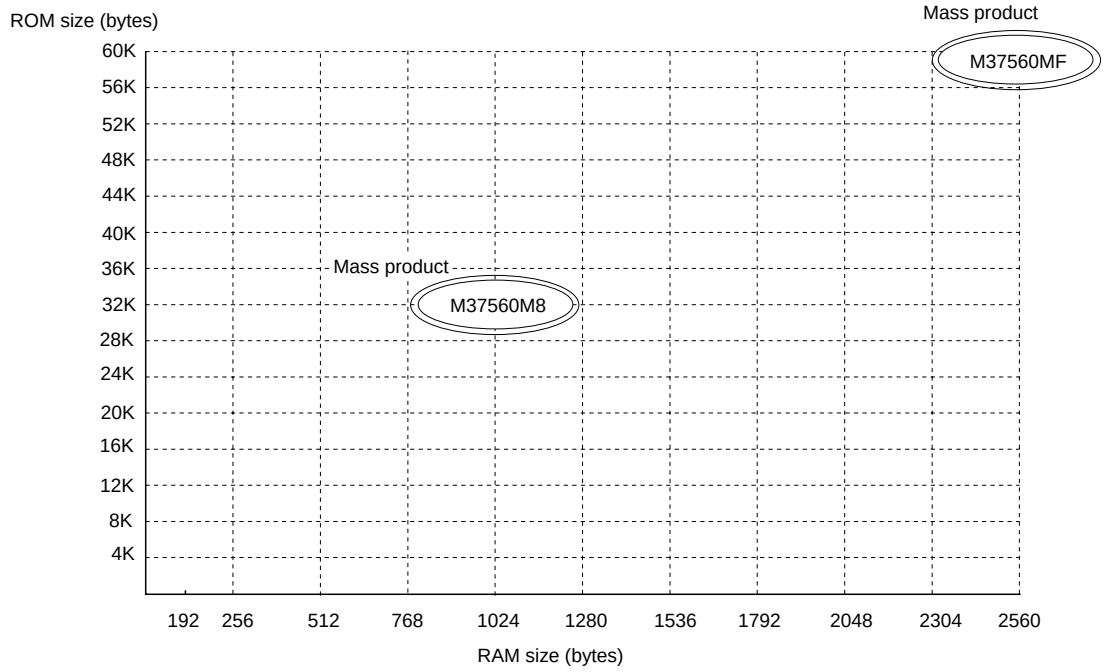


Fig. 5 Memory expansion

Currently products are listed below.

Table 3 List of products **As of Jan. 2003**

Product	ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M37560M8-XXXFP	32768 (32638)	1024	100P6S-A	Mask ROM version
M37560M8-XXXGP			100P6Q-A	Mask ROM version
M37560MF-XXXFP	61440 (61310)	2560	100P6S-A	Mask ROM version
M37560MF-XXXGP			100P6Q-A	Mask ROM version

GROUP EXPANSION (One Time and EPROM version)

Mitsubishi expands the 7560 group as follows.

Memory Type

Support for One Time and EPROM version.

Memory Size

ROM size ..... 60 K bytes
RAM size ..... 2560 bytes

Packages

100P6Q-A ..... 0.5 mm-pitch plastic molded QFP
100P6S-A ..... 0.65 mm-pitch plastic molded QFP
100D0 ..... Ceramic LCC (EPROM version)

Memory Expansion

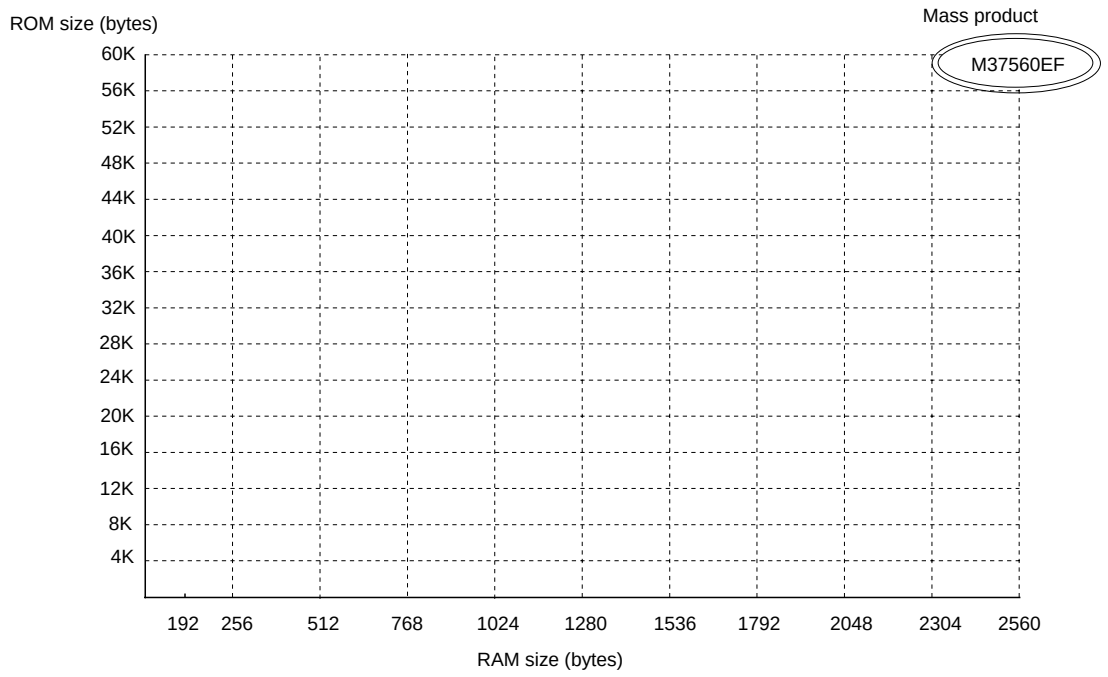


Fig. 6 Memory expansion

Currently products are listed below.

Table 4 List of products **As of Jan. 2003**

Product	ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M37560EFFP	61440 (61310)	2560	100P6S-A	One Time PROM version
M37560EFGP			100P6Q-A	One Time PROM version
M37560EFFS			100D0	EPROM version

GROUP EXPANSION (Extended operating temperature version)

Mitsubishi expands the 7560 group as follows.

Memory Type

Support for extended operating temperature version.

Memory Size

ROM size ..... 60 K bytes
RAM size ..... 2560 bytes

Packages

100P6S-A ..... 0.65 mm-pitch plastic molded QFP

Memory Expansion

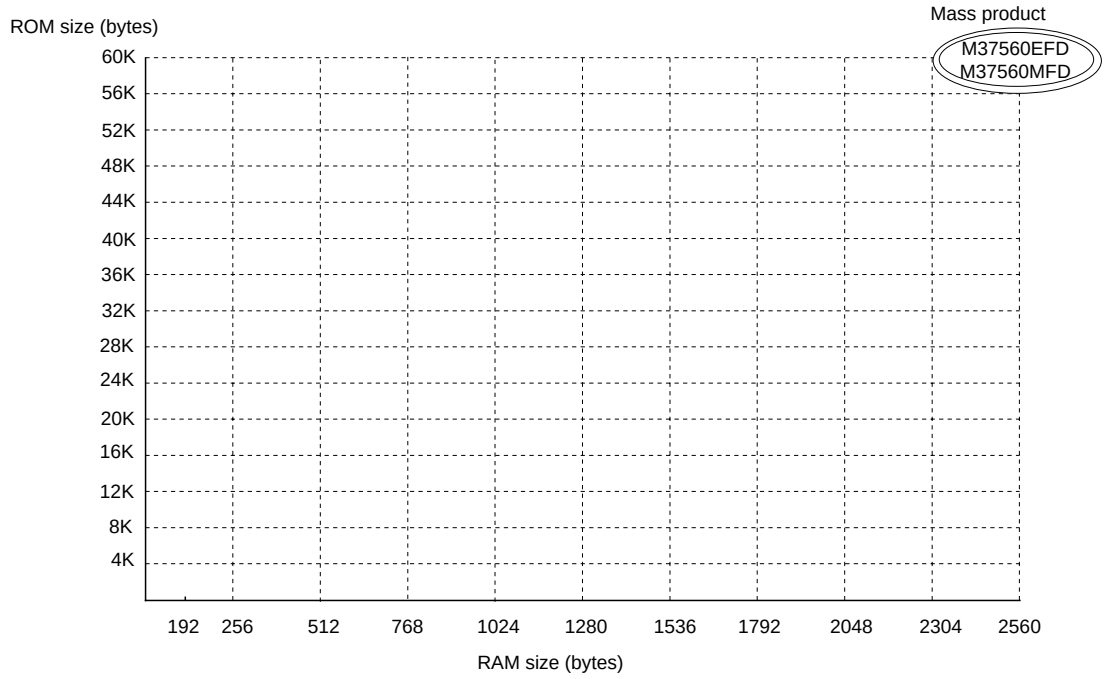


Fig. 7 Memory expansion

Currently products are listed below.

Table 5 List of products **As of Jan. 2003**

Product	ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M37560MFD-XXXFP	61440 (61310)	2560	100P6S-A	Mask ROM version (Extended operating temperature version)
M37560EFDFP				One Time PROM version (Extended operating temperature version)

FUNCTIONAL DESCRIPTION
CENTRAL PROCESSING UNIT (CPU)

The 7560 group uses the standard 740 family instruction set. Refer to the table of 740 family addressing modes and machine instructions or the 740 Family Software Manual for details on the instruction set.

Machine-resident 740 family instructions are as follows:

The FST and SLW instruction cannot be used.

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

The central processing unit (CPU) has six registers. Figure 8 shows the 740 Family CPU register structure.

[Accumulator (A)]

The accumulator is an 8-bit register. Data operations such as arithmetic 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 “00_{16}”. If the stack page selection bit is “1”, the high-order 8 bits becomes “01_{16}”.

Figure 9 shows the operations of pushing register contents onto the stack and popping them from the stack. Table 6 shows the push and pop instructions of accumulator or processor status register.

Store registers other than those described in Figure 9 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 PC_H and PC_L. It is used to indicate the address of the next instruction to be executed.

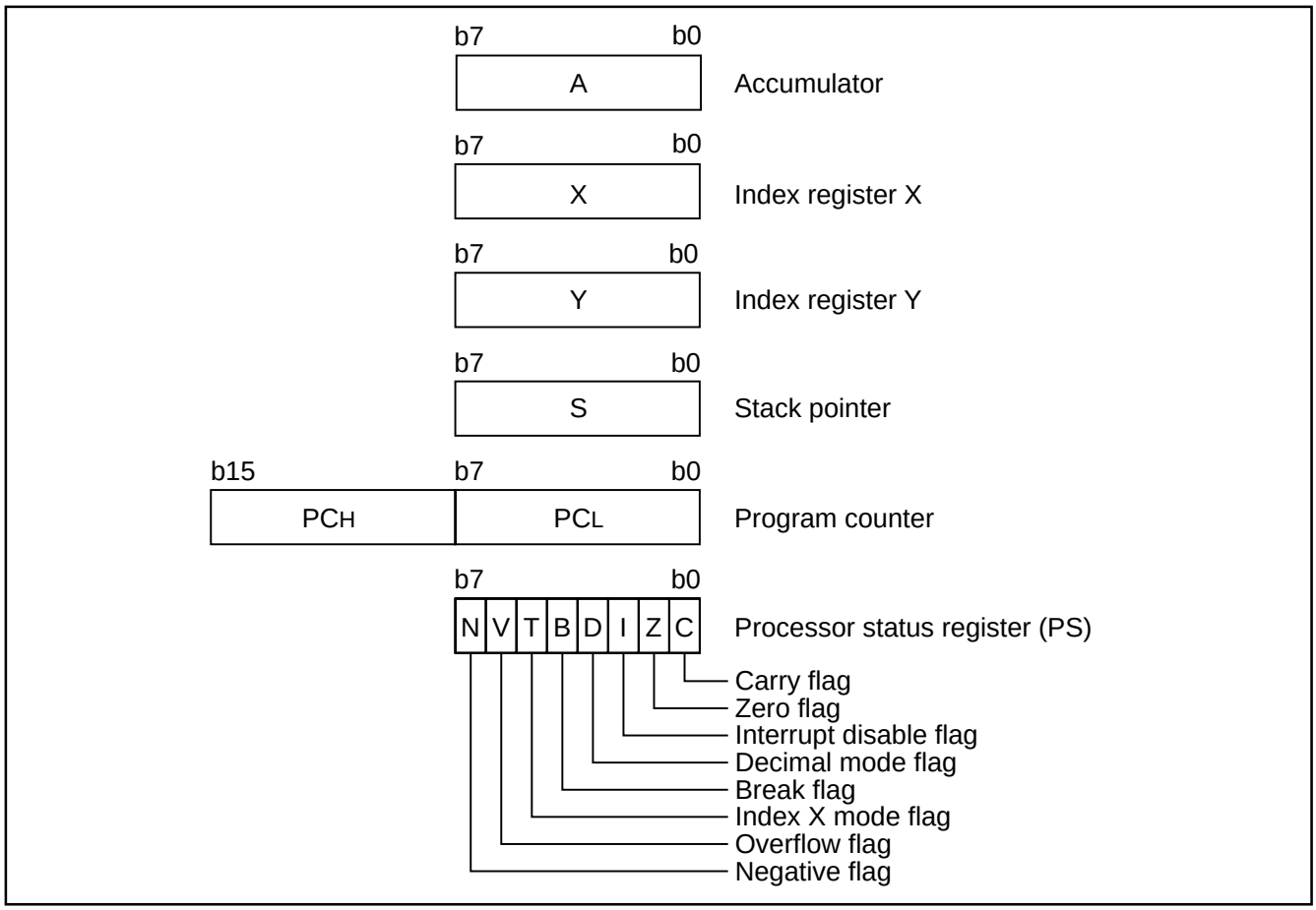


Fig. 8 740 Family CPU register structure

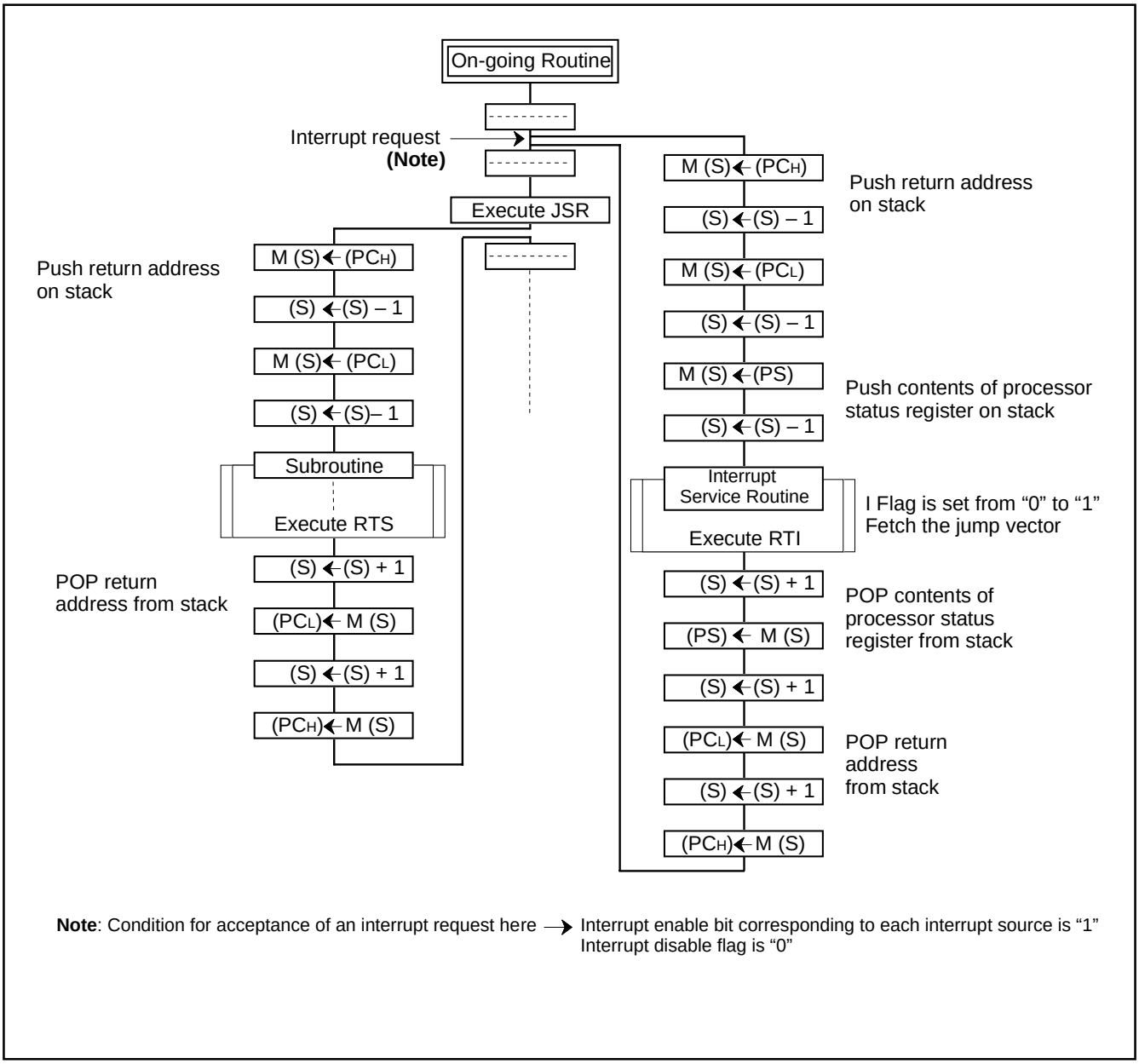


Fig. 9 Register push and pop at interrupt generation and subroutine call

Table 6 Push and pop instructions of accumulator or processor status register

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

[Processor status register (PS)]

The processor status register is an 8-bit register consisting of 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 to “1” if the result of an immediate arithmetic operation or a data transfer is “0”, and set to “0” 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. When the BRK instruction is generated, the B flag is set to “1” automatically. When the other interrupts are generated, the B flag is set to “0”, and the processor status register is pushed onto the stack.
- 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 to “1” 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 V flag.
- Bit 7: Negative flag (N)
  The N flag is set to “1” 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 7 Instructions to set each bit of processor status register to “0” or “1”

	C flag	Z flag	I flag	D flag	B flag	T flag	V flag	N flag
Instruction setting to “1”	SEC	–	SEI	SED	–	SET	–	–
Instruction setting to “0”	CLC	–	CLI	CLD	–	CLT	CLV	–

[CPU Mode Register (CPUM)] 003B16

The CPU mode register contains the stack page selection bit and the system clock control bits, etc.
The CPU mode register is allocated at address 003B16.

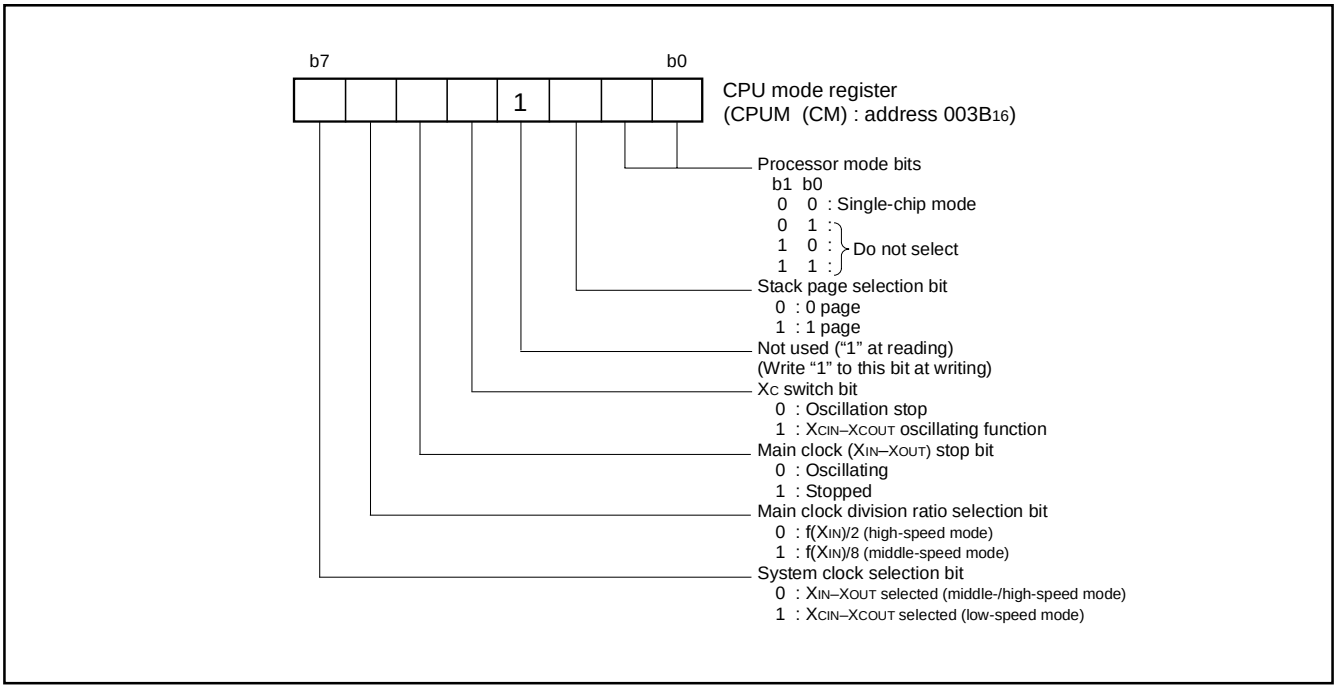


Fig. 10 Structure of CPU mode register

MEMORY

Special Function Register (SFR) Area

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

RAM

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

ROM

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

Interrupt Vector Area

The interrupt vector area contains reset and interrupt vectors.

Zero Page

The 256 bytes from addresses 0000_{16} to $00FF_{16}$ are called the zero page area. The internal RAM and the special function registers (SFR) are allocated to this area.

The zero page addressing mode can be used to specify memory and register addresses in the zero page area. Access to this area with only 2 bytes is possible in the zero page addressing mode.

Special Page

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

RAM area

RAM size (bytes)	Address $XXXX_{16}$
192	$00FF_{16}$
256	$013F_{16}$
384	$01BF_{16}$
512	$023F_{16}$
640	$02BF_{16}$
768	$033F_{16}$
896	$03BF_{16}$
1024	$043F_{16}$
1536	$063F_{16}$
2048	$083F_{16}$
2560	$0A3F_{16}$

ROM area

ROM size (bytes)	Address $YYYY_{16}$	Address $ZZZZ_{16}$
4096	$F000_{16}$	$F080_{16}$
8192	$E000_{16}$	$E080_{16}$
12288	$D000_{16}$	$D080_{16}$
16384	$C000_{16}$	$C080_{16}$
20480	$B000_{16}$	$B080_{16}$
24576	$A000_{16}$	$A080_{16}$
28672	9000_{16}	9080_{16}
32768	8000_{16}	8080_{16}
36864	7000_{16}	7080_{16}
40960	6000_{16}	6080_{16}
45056	5000_{16}	5080_{16}
49152	4000_{16}	4080_{16}
53248	3000_{16}	3080_{16}
57344	2000_{16}	2080_{16}
61440	1000_{16}	1080_{16}

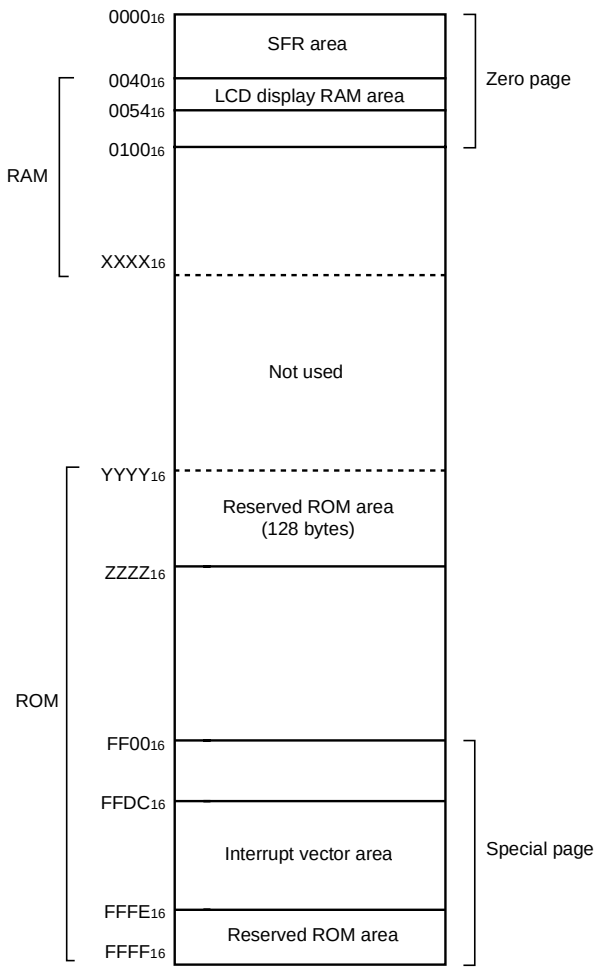


Fig. 11 Memory map diagram

0000₁₆	Port P0 register (P0)
0001₁₆	Port P0 direction register (P0D)
0002₁₆	Port P1 register (P1)
0003₁₆	Port P1 direction register (P1D)
0004₁₆	Port P2 register (P2)
0005₁₆	Port P2 direction register (P2D)
0006₁₆	Port P3 register (P3)
0007₁₆	Port P3 output control register (P3C)
0008₁₆	Port P4 register (P4)
0009₁₆	Port P4 direction register (P4D)
000A₁₆	Port P5 register (P5)
000B₁₆	Port P5 direction register (P5D)
000C₁₆	Port P6 register (P6)
000D₁₆	Port P6 direction register (P6D)
000E₁₆	Port P7 register (P7)
000F₁₆	Port P7 direction register (P7D)
0010₁₆	
0011₁₆	
0012₁₆	
0013₁₆	
0014₁₆	A-D conversion low-order register (ADL)
0015₁₆	Key input control register (KIC)
0016₁₆	PULL register A (PULLA)
0017₁₆	PULL register B (PULLB)
0018₁₆	Transmit/Receive buffer register(TB/RB)
0019₁₆	Serial I/O1 status register (SIO1STS)
001A₁₆	Serial I/O1 control register (SIO1CON)
001B₁₆	UART control register (UARTCON)
001C₁₆	Baud rate generator (BRG)
001D₁₆	Serial I/O2 control register (SIO2CON)
001E₁₆	Reserved area **(Note)**
001F₁₆	Serial I/O2 register (SIO2)

0020₁₆	Timer X low-order register (TXL)
0021₁₆	Timer X high-order register (TXH)
0022₁₆	Timer Y low-order register (TYL)
0023₁₆	Timer Y high-order register (TYH)
0024₁₆	Timer 1 register (T1)
0025₁₆	Timer 2 register (T2)
0026₁₆	Timer 3 register (T3)
0027₁₆	Timer X mode register (TXM)
0028₁₆	Timer Y mode register (TYM)
0029₁₆	Timer 123 mode register (T123M)
002A₁₆	TOUT/ϕ output control register (CKOUT)
002B₁₆	PWM control register (PWMCON)
002C₁₆	PWM prescaler (PREPWM)
002D₁₆	PWM register (PWM)
002E₁₆	Reserved area **(Note)**
002F₁₆	Reserved area **(Note)**
0030₁₆	Reserved area **(Note)**
0031₁₆	Reserved area **(Note)**
0032₁₆	D-A1 conversion register (DA1)
0033₁₆	D-A2 conversion register (DA2)
0034₁₆	A-D control register (ADCON)
0035₁₆	A-D conversion high-order register (ADH)
0036₁₆	D-A control register (DACON)
0037₁₆	Watchdog timer control register (WDTCON)
0038₁₆	Segment output enable register (SEG)
0039₁₆	LCD mode register (LM)
003A₁₆	Interrupt edge selection register (INTEDGE)
003B₁₆	CPU mode register (CPUM)
003C₁₆	Interrupt request register 1(IREQ1)
003D₁₆	Interrupt request register 2(IREQ2)
003E₁₆	Interrupt control register 1(ICON1)
003F₁₆	Interrupt control register 2(ICON2)

Note: Do not write to the addresses of reserved area.

Fig. 12 Memory map of special function register (SFR)

I/O PORTS
Direction Registers

The I/O ports (ports P0, P1, P2, P4, P5, P6, $P7_1$–$P7_7$) have direction registers. Ports $P1_6$, $P1_7$, P4, P5, P6, and $P7_1$–$P7_7$ can be set to input mode or output mode by each pin individually. $P0_0$–$P0_7$ and $P1_0$-$P1_5$ are respectively set to input mode or output mode in a lump by bit 0 of the direction registers of ports P0 and P1 (see Figure 13).

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

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

Port P3 Output Control Register

Bit 0 of the port P3 output control register (address 0007_{16}) enables control of the output of ports $P3_0$–$P3_7$.

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

When resetting, bit 0 of the port P3 output control register is set to "0" (the port output function is invalid) and pulled up.

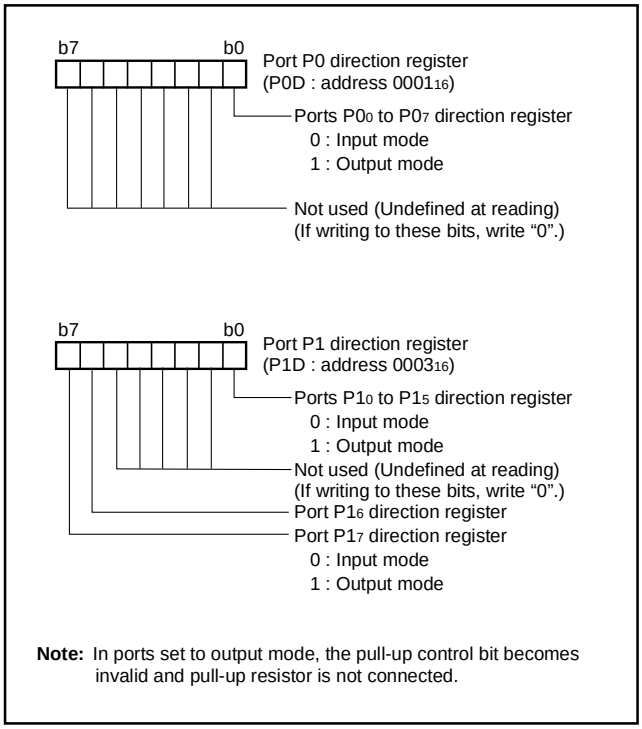


Fig. 13 Structure of port P0 direction register, port P1 direction register

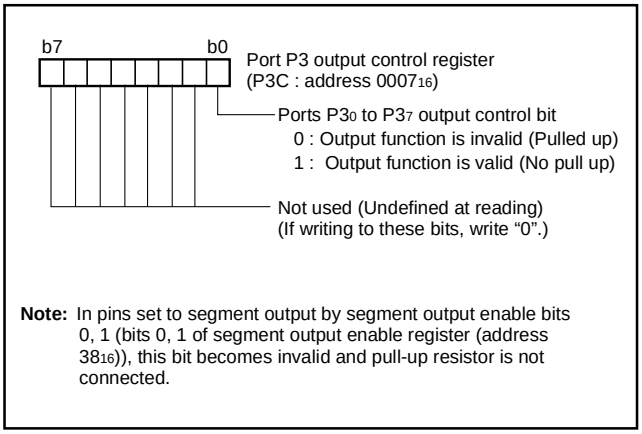
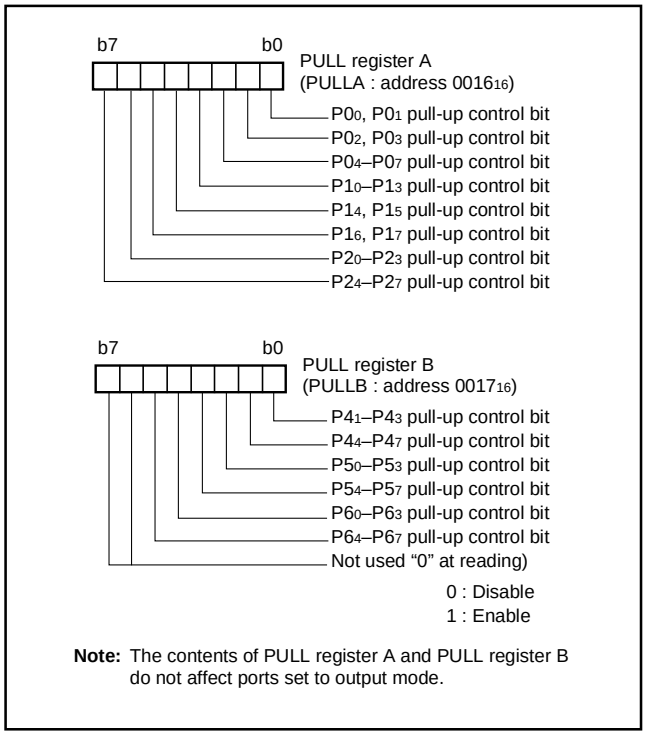


Fig. 14 Structure of port P3 output control register

Pull-up Control

By setting the PULL register A (address 0016_{16}) or the PULL register B (address 0017_{16}), ports P0 to P2, P4 to P6 can control pull-up with a program.

However, the contents of PULL register A and PULL register B do not affect ports set to output mode and the ports are no pulled up. The PULL register A setting is invalid for pins selecting segment output with the segment output enable register and the pins are not pulled up.



Note: The contents of PULL register A and PULL register B do not affect ports set to output mode.

Fig. 15 Structure of PULL register A and PULL register B

Table 8 List of I/O port function (1)

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P0$_0$/SEG$_{26}$–P0$_7$/SEG$_{33}$	Port P0	Input/output, byte unit	CMOS compatible input level CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1) (2)
P1$_0$/SEG$_{34}$–P1$_5$/SEG$_{39}$	Port P1	Input/output, 6-bit unit	CMOS compatible input level CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1) (2)
P1$_6$, P1$_7$		Input/output, individual bits	CMOS compatible input level CMOS 3-state output		PULL register A	(4)
P2$_0$–P2$_7$	Port P2	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Key input (key-on wake-up) interrupt input	PULL register A Interrupt control register 2 Key input control register	
P3$_0$/SEG$_{18}$–P3$_7$/SEG$_{25}$	Port P3	Output	CMOS 3-state output	LCD segment output	Segment output enable register Port P3 output control register	(3)
P4$_0$	Port P4	Input/output, individual bits	CMOS compatible input level N-channel open-drain output			(13)
P4$_1$/INT$_1$, P4$_2$/INT$_2$			CMOS compatible input level CMOS 3-state output	INT$_i$ interrupt input	Interrupt edge selection register	(4)
P4$_3$/ϕ/T$_{OUT}$				Timer 2 output System clock ϕ output	PULL register B Timer 123 mode register T$_{OUT}$/ϕ output control register	(12)
P4$_4$/RxD, P4$_5$/TxD, P4$_6$/S$_{CLK1}$, P4$_7$/$\overline{S_{RDY1}}$				Serial I/O1 I/O	PULL register B Serial I/O1 control register Serial I/O1 status register UART control register	(5) (6) (7) (8)
P5$_0$/PWM$_0$, P5$_1$/PWM$_1$	Port P5	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	PWM output	PULL register B PWM control register	(10)
P5$_2$/RTP$_0$, P5$_3$/RTP$_1$				Real time port output	PULL register B Timer X mode register	(9)
P5$_4$/CNTR$_0$				Timer X I/O	PULL register B Timer X mode register	(11)
P5$_5$/CNTR$_1$				Timer Y input	PULL register B Timer Y mode register	(14)
P5$_6$/DA$_1$				DA$_1$ output	PULL register B D-A control register	(15)
P5$_7$/ADT/ DA$_2$				DA$_2$ output A-D external trigger input	PULL register B D-A control register A-D control register	(15)

Table 9 List of I/O port function (2)

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

Notes 1: How to use double-function ports as function I/O pins, refer to the applicable sections.

2: Make sure that the input level at each pin is either 0 V or VCC before execution of the STP instruction. When an electric potential is at an intermediate potential, a current will flow from VCC to VSS through the input-stage gate and power source current may increase.

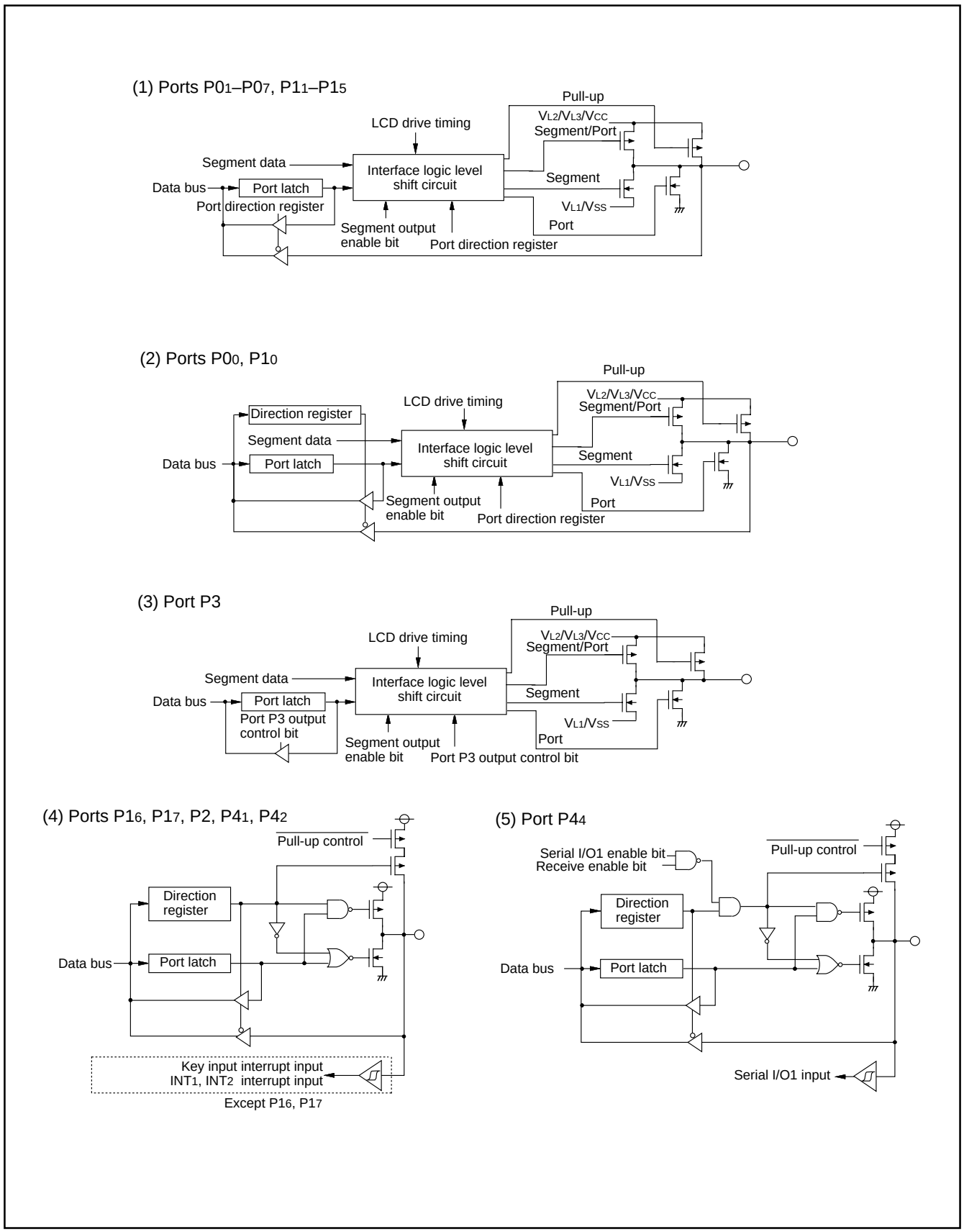


Fig. 16 Port block diagram (1)

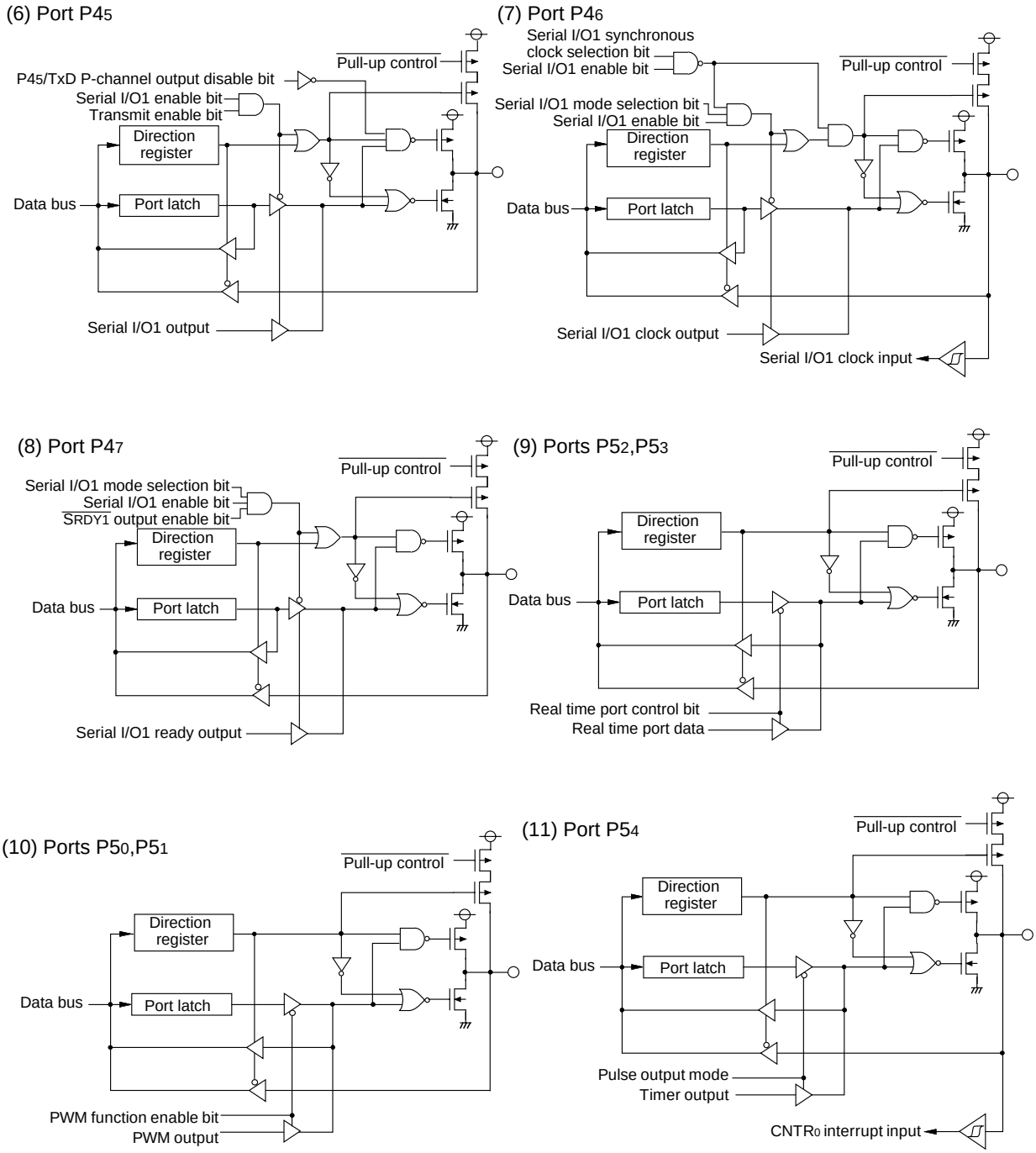


Fig. 17 Port block diagram (2)

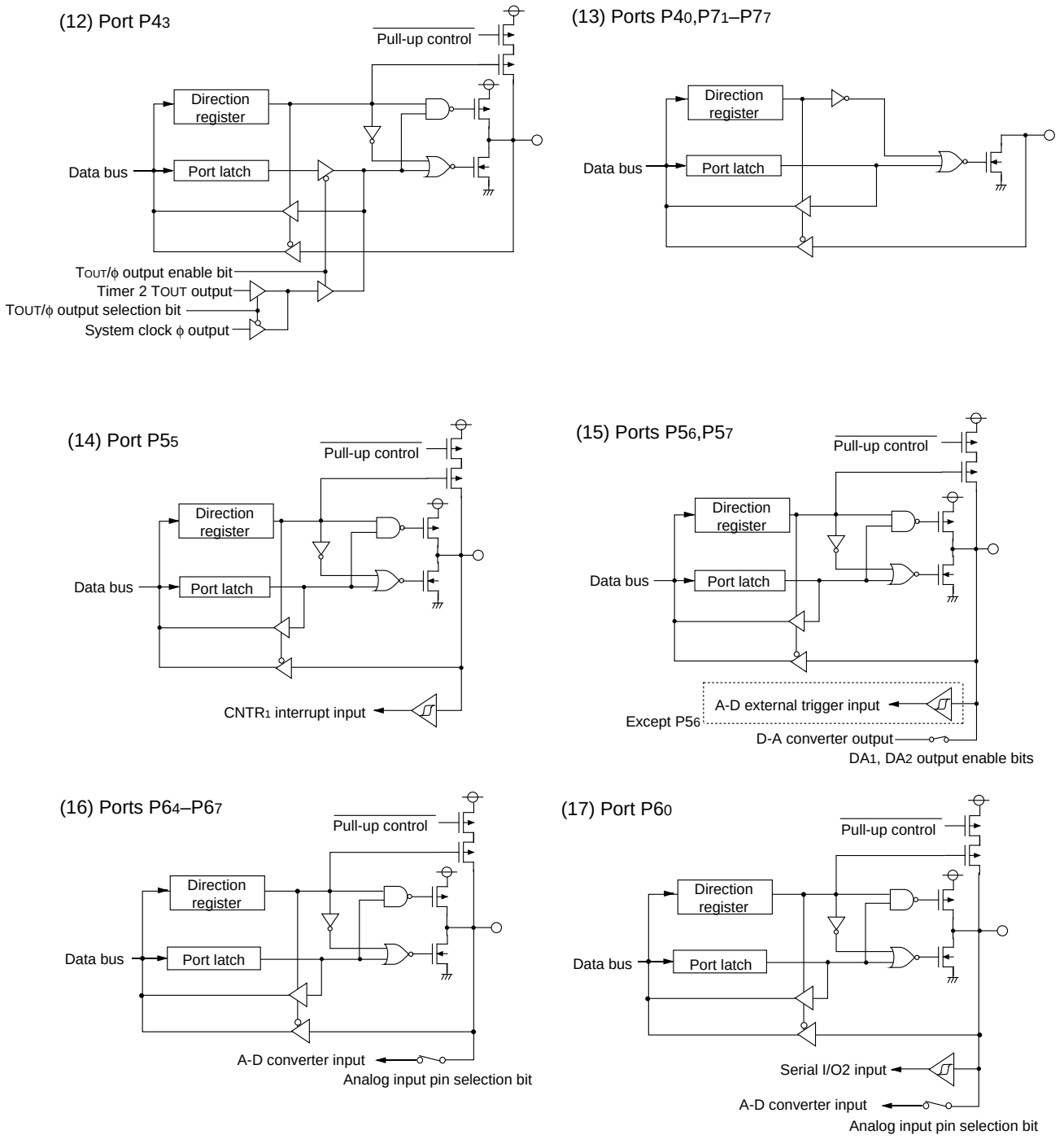


Fig. 18 Port block diagram (3)

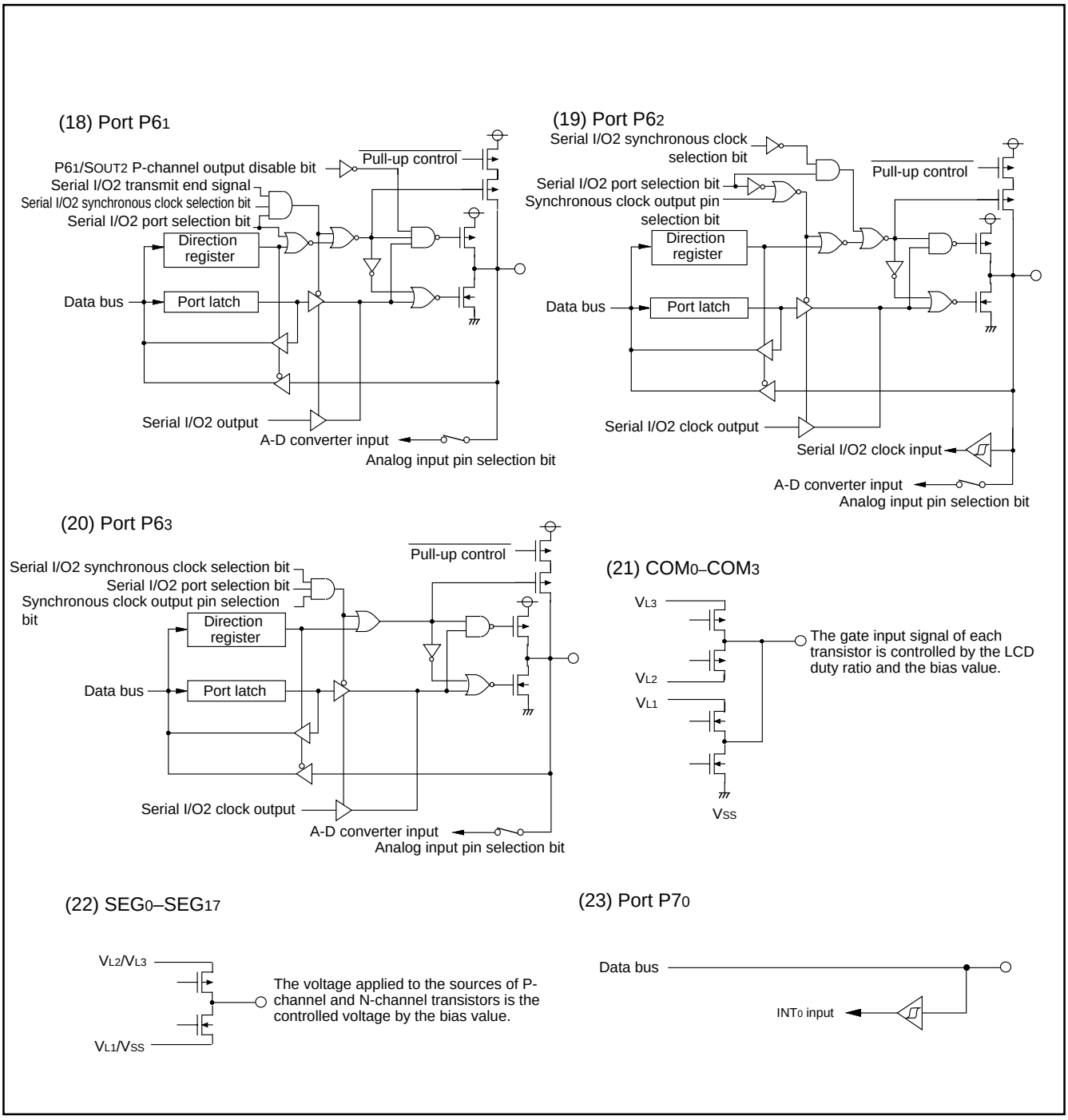


Fig. 19 Port block diagram (4)

INTERRUPTS

Interrupts occur by seventeen sources: seven external, nine internal, and one software. When an interrupt request is accepted, the program branches to the interrupt jump destination address set in the vector address (see Figure 10).

Interrupt Control

Each interrupt is controlled by an interrupt request bit, an interrupt enable bit, and the interrupt disable flag except for the software interrupt set by the BRK instruction. An interrupt is accepted if the corresponding interrupt request and enable bits are “1” and the interrupt disable flag is “0”.

Interrupt enable bits can be set to “0” or “1” by program.

Interrupt request bits can be set to “0” by program, but cannot be set to “1” by program.

The BRK instruction interrupt and reset cannot be disabled with any flag or bit. When the interrupt disable (I) flag is set to “1”, all interrupt requests except the BRK instruction interrupt and reset are not accepted.

When several interrupt requests occur at the same time, the interrupts are received according to priority.

Interrupt Operation

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

1. The contents of the program counter and the processor status register are automatically pushed onto the stack.
2. The interrupt jump destination address is read from the vector table into the program counter.
3. The interrupt disable flag is set to “1” and the corresponding interrupt request bit is set to “0”.

Table 10 Interrupt vector addresses and priority

Interrupt Source	Priority	Vector Addresses **(Note 1)**		Interrupt Request Generating Conditions	Remarks
		High	Low		
Reset **(Note 2)**	1	$FFFD_{16}$	$FFFC_{16}$	At reset	Non-maskable
INT_0	2	$FFFB_{16}$	$FFFA_{16}$	At detection of either rising or falling edge of INT_0 input	External interrupt (active edge selectable)
INT_1	3	$FFF9_{16}$	$FFF8_{16}$	At detection of either rising or falling edge of INT_1 input	External interrupt (active edge selectable)
Serial I/O1 reception	4	$FFF7_{16}$	$FFF6_{16}$	At completion of serial I/O1 data reception	Valid when serial I/O1 is selected
Serial I/O1 transmission	5	$FFF5_{16}$	$FFF4_{16}$	At completion of serial I/O1 transmit shift or when transmission buffer is empty	Valid when serial I/O1 is selected
Timer X	6	$FFF3_{16}$	$FFF2_{16}$	At timer X underflow	
Timer Y	7	$FFF1_{16}$	$FFF0_{16}$	At timer Y underflow	
Timer 2	8	$FFEF_{16}$	$FFEE_{16}$	At timer 2 underflow	
Timer 3	9	$FFED_{16}$	$FFEC_{16}$	At timer 3 underflow	
$CNTR_0$	10	$FFEB_{16}$	$FFEA_{16}$	At detection of either rising or falling edge of $CNTR_0$ input	External interrupt (active edge selectable)
$CNTR_1$	11	$FFE9_{16}$	$FFE8_{16}$	At detection of either rising or falling edge of $CNTR_1$ input	External interrupt (active edge selectable)
Timer 1	12	$FFE7_{16}$	$FFE6_{16}$	At timer 1 underflow	
INT_2	13	$FFE5_{16}$	$FFE4_{16}$	At detection of either rising or falling edge of INT_2 input	External interrupt (active edge selectable)
Serial I/O2	14	$FFE3_{16}$	$FFE2_{16}$	At completion of serial I/O2 data transmission or reception	Valid when serial I/O2 is selected
Key input (Key-on wake-up)	15	$FFE1_{16}$	$FFE0_{16}$	At falling of conjunction of input level for port P2 (at input mode)	External interrupt (valid at falling)
ADT	16	$FFDF_{16}$	$FFDE_{16}$	At falling edge of ADT input	Valid when ADT interrupt is selected External interrupt (valid at falling)
A-D conversion				At completion of A-D conversion	Valid when A-D interrupt is selected
BRK instruction	17	$FFDD_{16}$	$FFDC_{16}$	At BRK instruction execution	Non-maskable software interrupt

Notes1: Vector addresses contain interrupt jump destination addresses.
2: Reset is not an interrupt. Reset has the higher priority than all interrupts.

■Notes on interrupts

When setting the followings, the interrupt request bit may be set to "1".

•When switching external interrupt active edge
Related register: Interrupt edge selection register (address $3A_{16}$)
Timer X mode register (address 27_{16})
Timer Y mode register (address 28_{16})

•When switching interrupt sources of an interrupt vector address where two or more interrupt sources are allocated
Related register: Interrupt source selection bit of A-D control register (bit 6 of address 34_{16})

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

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

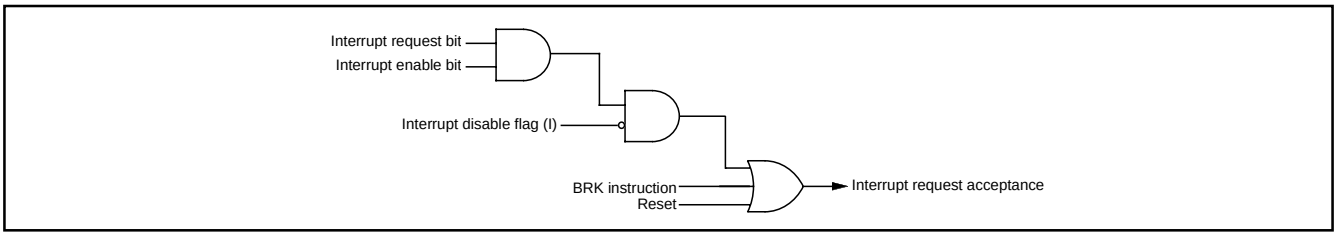


Fig. 20 Interrupt control

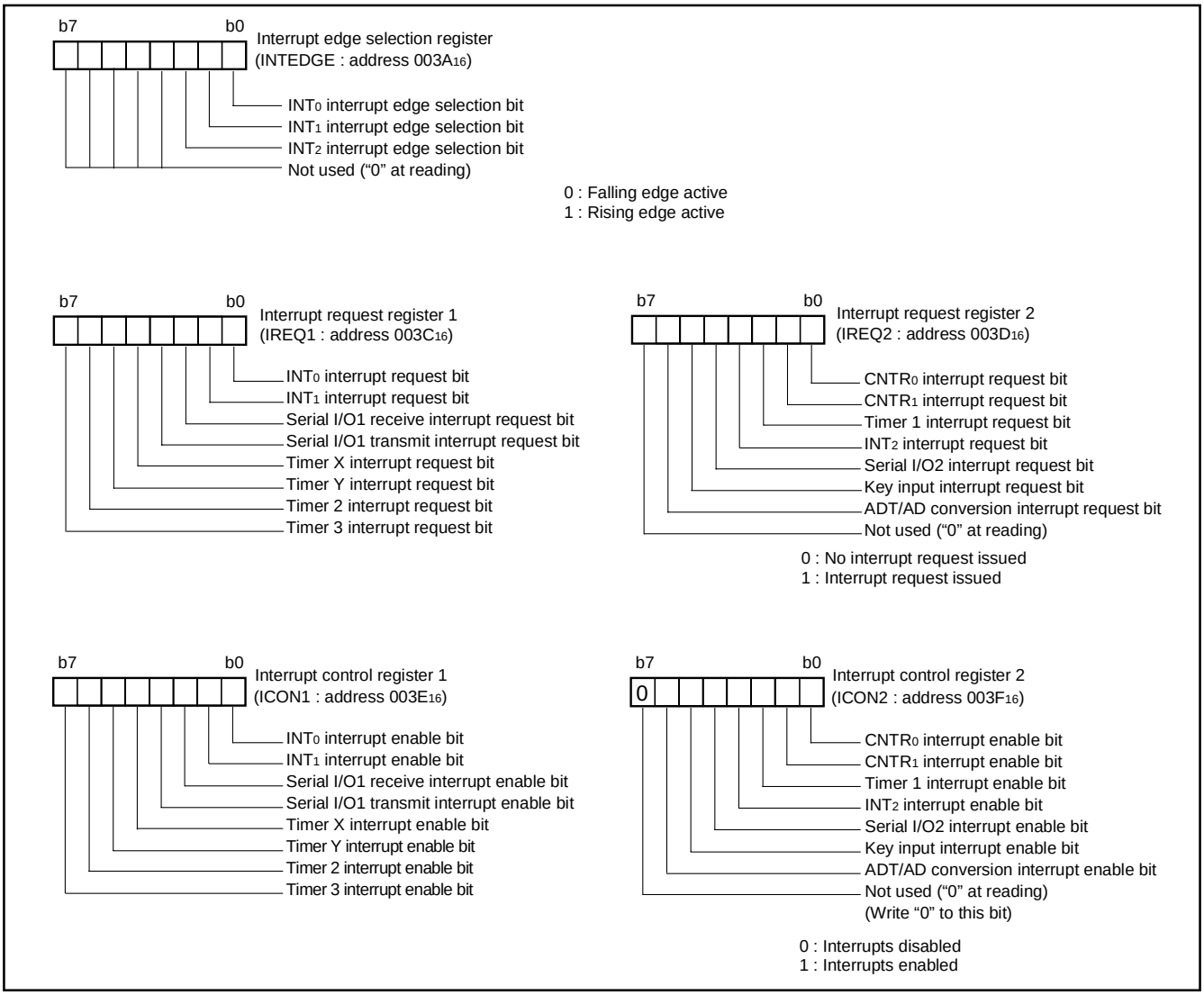


Fig. 21 Structure of interrupt-related registers

Key Input Interrupt (Key-on Wake Up)

The key input interrupt is enabled when any of port P2 is set to input mode and the bit corresponding to key input control register is set to “1”.

A Key input interrupt request is generated by applying “L” level voltage to any pin of port P2 of which key input interrupt is enabled. In other words, it is generated when AND of input level goes from “1” to “0”. A connection example of using a key input interrupt is shown in Figure 22, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports $P2_0$–$P2_3$.

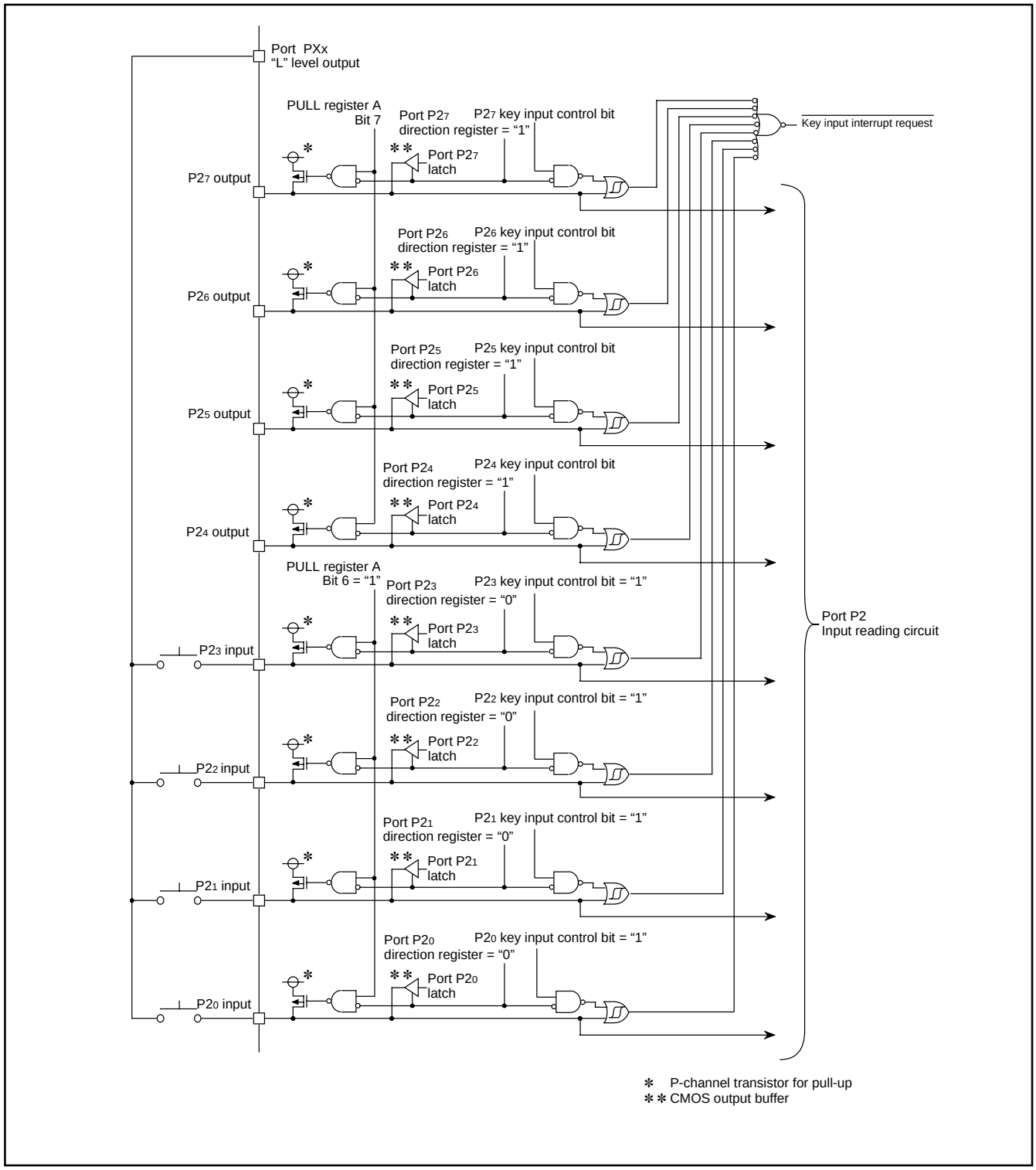


Fig. 22 Connection example when using key input interrupt and port P2 block diagram

The key input interrupt is controlled by the key input control register and the port direction register. When enabling the key input interrupt, set “1” to the key input control bit. A key input can be accepted from pins set as the input mode in ports $P2_0$–$P2_7$.

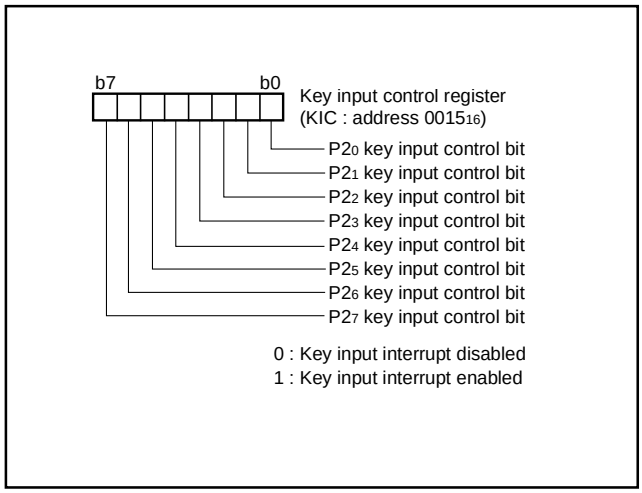


Fig. 23 Structure of key input control register

TIMERS

The 7560 group has five timers: timer X, timer Y, timer 1, timer 2, and timer 3. Timer X and timer Y are 16-bit timers, and timer 1, timer 2, and timer 3 are 8-bit timers.

All timers are down count timers. When the timer reaches “0”, an underflow occurs at the next count pulse and the corresponding timer latch is reloaded into the timer and the count is continued. When a timer underflows, the interrupt request bit corresponding to that timer is set to “1”.

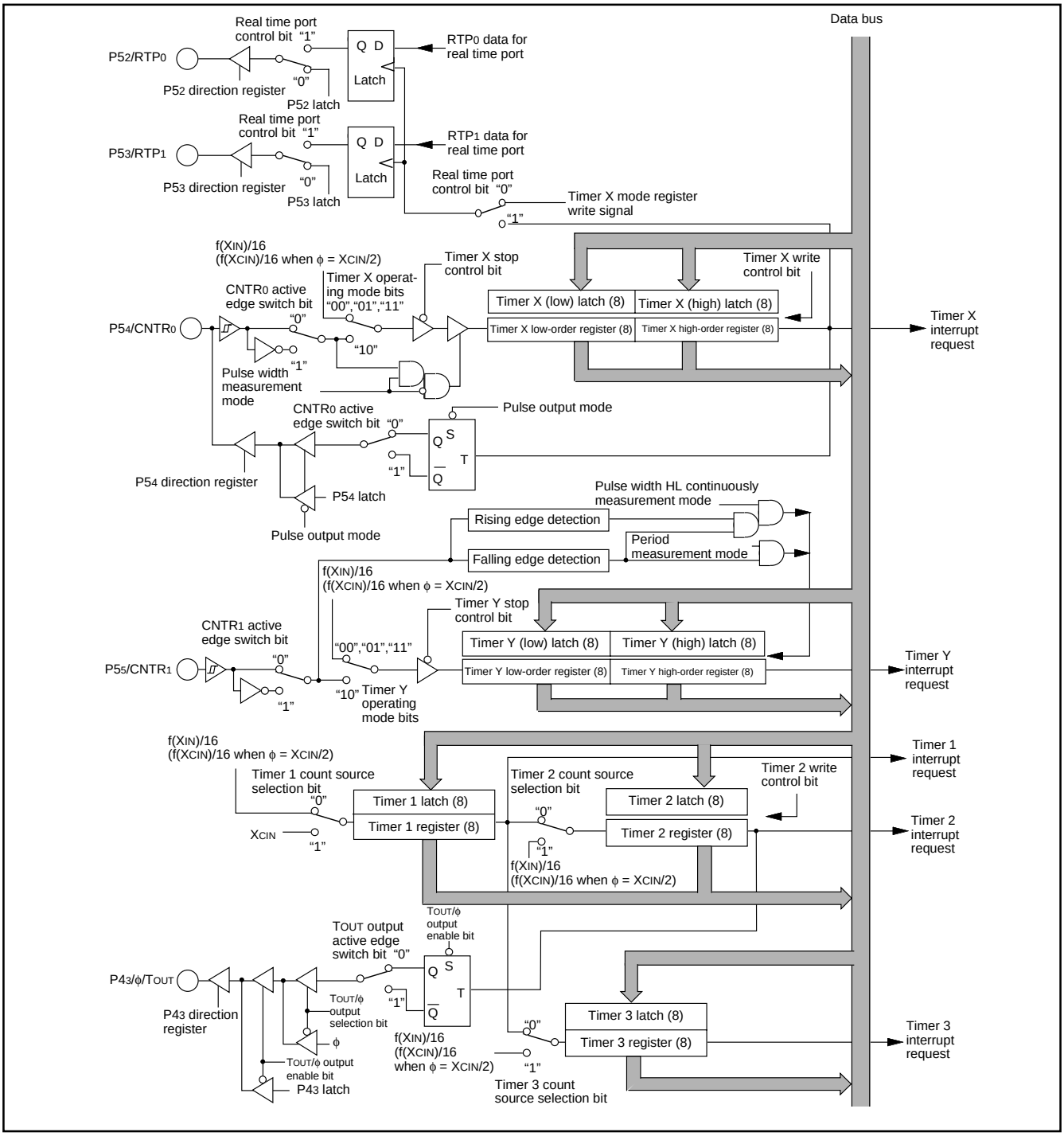


Fig. 24 Timer block diagram

Timer X

Timer X is a 16-bit timer and is equipped with the timer latch. The division ratio of timer X is given by 1/(n+1), where n is the value in the timer latch. Timer X is a down-counter. When the contents of timer X reach "0000_{16}", an underflow occurs at the next count pulse and the contents of the timer latch are reloaded into the timer and the count is continued. When the timer underflows, the timer X interrupt request bit is set to "1".

Timer X can be selected in one of four modes by the timer X mode register and can be controlled the timer X write and the real time port.

(1) Timer mode

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

(2) Pulse output mode

Each time the timer underflows, a signal output from the $CNTR_0$ pin is inverted. Except for this, the operation in pulse output mode is the same as in timer mode. When using a timer in this mode, set the $P5_4$/$CNTR_0$ pin to output mode (set "1" to bit 4 of port P5 direction register).

(3) Event counter mode

The timer counts signals input through the $CNTR_0$ pin.

Except for this, the operation in event counter mode is the same as in timer mode. When using a timer in this mode, set the $P5_4$/$CNTR_0$ pin to input mode (set "0" to bit 4 of port P5 direction register).

(4) Pulse width measurement mode

The count source is f(X_{IN})/16 (or f(X_{CIN})/16 in low-speed mode). If $CNTR_0$ active edge switch bit is "0", the timer counts while the input signal of $CNTR_0$ pin is at "H". If it is "1", the timer counts while the input signal of $CNTR_0$ pin is at "L". When using a timer in this mode, set the $P5_4$/$CNTR_0$ pin to input mode (set "0" to bit 4 of port P5 direction register).

●Read and write to timer X high-order, low-order registers

When reading and writing to the timer X high-order and low-order registers, be sure to read/write both the timer X high- and low-order registers.

When reading the timer X high-order and low-order registers, read the high-order register first. When writing to the timer X high-order and low-order registers, write the low-order register first. The timer X cannot perform the correct operation if the next operation is performed.

- Write operation to the high- or low-order register before reading the timer X low-order register
- Read operation from the high- or low-order register before writing to the timer X high-order register

●Timer X Write Control

Which write control can be selected by the timer X write control bit (bit 0) of the timer X mode register (address 0027_{16}), writing data to both the latch and the timer at the same time or writing data only to the latch. When the operation "writing data only to the latch" is selected, the value is set to the timer latch by writing data to the timer X register and the timer is updated at next underflow. After reset, the operation "writing data to both the latch and the timer at the same time" is selected, and the value is set to both the latch and the timer at the same time by writing data to the timer X register. The write operation is independent of timer X count operation, operating or stopping.

When the value is written in latch only, a value is simultaneously set to the timer X and the timer X latch if the writing in the high-order register and the underflow of timer X are performed at the same timing. Unexpected value may be set in the high-order timer on this occasion.

●Real Time Port Control

While the real time port function is valid, data for the real time port are output from ports $P5_2$ and $P5_3$ each time the timer X underflows. (However, if the real time port control bit is changed from "0" to "1" after set of the real time port data, data are output independent of the timer X operation.) If the data for the real time port is changed while the real time port function is valid, the changed data are output at the next underflow of timer X.

Before using this function, set the $P5_2$/RTP_0, $P5_3$/RTP_1 pins to output mode (set "1" to bits 2, 3 of port P5 direction register).

■Note on $CNTR_0$ interrupt active edge selection

$CNTR_0$ interrupt active edge depends on the $CNTR_0$ active edge switch bit.

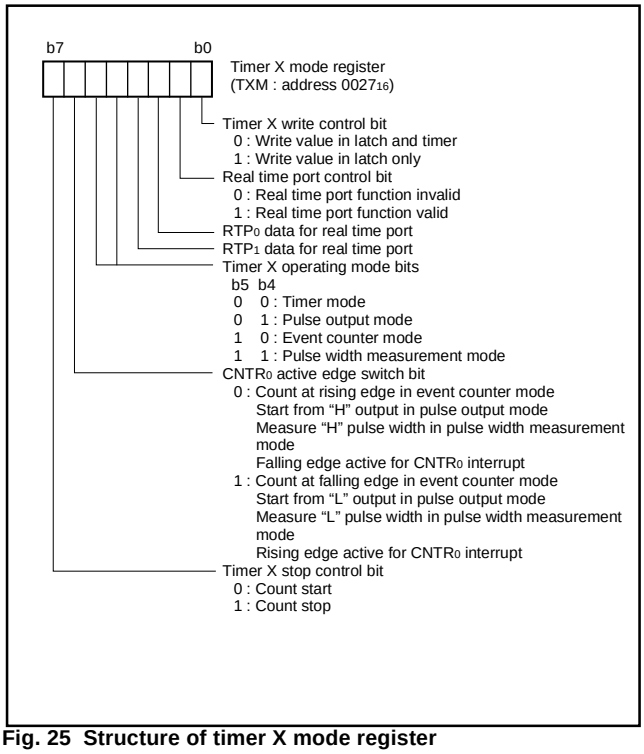


Fig. 25 Structure of timer X mode register

Timer Y

Timer Y is a 16-bit timer and is equipped with the timer latch. The division ratio of timer Y is given by 1/(n+1), where n is the value in the timer latch. Timer Y is a down-counter. When the contents of timer Y reach "0000_{16}", an underflow occurs at the next count pulse and the contents of the timer latch are reloaded into the timer and the count is continued. When the timer underflows, the timer Y interrupt request bit is set to "1".

Timer Y can be selected in one of four modes by the timer Y mode register.

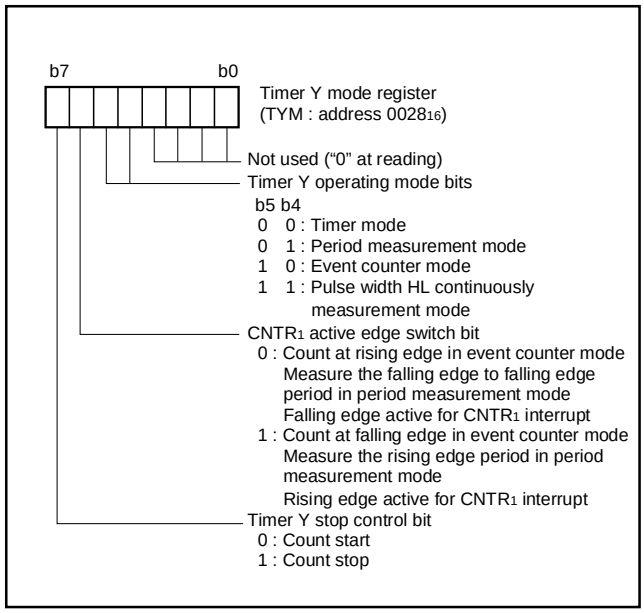


Fig. 26 Structure of timer Y mode register

(1) Timer mode

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

(2) Period measurement mode

$CNTR_1$ interrupt request is generated at rising or falling edge of $CNTR_1$ pin input signal. Simultaneously, the value in timer Y latch is reloaded in timer Y and timer Y continues counting down. Except for this, the operation in period measurement mode is the same as in timer mode.

The timer value just before the reloading at rising or falling of $CNTR_1$ pin input signal is retained until the next valid edge is input.

The rising or falling timing of $CNTR_1$ pin input signal can be discriminated by $CNTR_1$ interrupt. When using a timer in this mode, set the $P5_5$/$CNTR_1$ pin to input mode (set "0" to bit 5 of port P5 direction register).

(3) Event counter mode

The timer counts signals input through the $CNTR_1$ pin.

Except for this, the operation in event counter mode is the same as in timer mode. When using a timer in this mode, set the $P5_5$/$CNTR_1$ pin to input mode (set "0" to bit 5 of port P5 direction register).

(4) Pulse width HL continuously measurement mode

$CNTR_1$ interrupt request is generated at both rising and falling edges of $CNTR_1$ pin input signal. Except for this, the operation in pulse width HL continuously measurement mode is the same as in period measurement mode. When using a timer in this mode, set the $P5_5$/$CNTR_1$ pin to input mode (set "0" to bit 5 of port P5 direction register).

■Note on $CNTR_1$ interrupt active edge selection

$CNTR_1$ interrupt active edge depends on the value of the $CNTR_1$ active edge switch bit. However, in pulse width HL continuously measurement mode, $CNTR_1$ interrupt request is generated at both rising and falling edges of $CNTR_1$ pin input signal regardless of the value of $CNTR_1$ active edge switch bit.

Timer 1, Timer 2, Timer 3

Timer 1, timer 2, and timer 3 are 8-bit timers and is equipped with the timer latch. The count source for each timer can be selected by the timer 123 mode register.

The division ratio of each timer is given by 1/(n+1), where n is the value in the timer latch. All timers are down-counters. When the contents of the timer reach "00_{16}", an underflow occurs at the next count pulse and the contents of the timer latch are reloaded into the timer and the count is continued. When the timer underflows, the interrupt request bit corresponding to that timer is set to "1".

When a value is written to the timer 1 register and the timer 3 register, a value is simultaneously set as the timer latch and the timer. When the timer 1 register, the timer 2 register, or the timer 3 register is read, the count value of the timer can be read.

●Timer 2 Write Control

Which write can be selected by the timer 2 write control bit (bit 2) of the timer 123 mode register (address 0029_{16}), writing data to both the latch and the timer at the same time or writing data only to the latch. When the operation "writing data only to the latch" is selected, the value is set to the timer 2 latch by writing data to the timer 2 register and the timer 2 is updated at next underflow. After reset, the operation "writing data to both the latch and the timer at the same time" is selected, and the value is set to both the timer 2 latch and the timer 2 at the same time by writing data to the timer 2 register.

If the value is written in latch only, a value is simultaneously set to the timer 2 and the timer 2 latch when the writing in the high-order register and the underflow of timer 2 are performed at the same timing.

●Timer 2 Output Control

When the timer 2 (T_{OUT}) output is enabled by the T_{OUT}/ϕ output enable bit and the T_{OUT}/ϕ output selection bit, an inversion signal from the T_{OUT} pin is output each time timer 2 underflows.

In this case, set the P43/ϕ/T_{OUT} pin to output mode (set "1" to bit 3 of port P4 direction register).

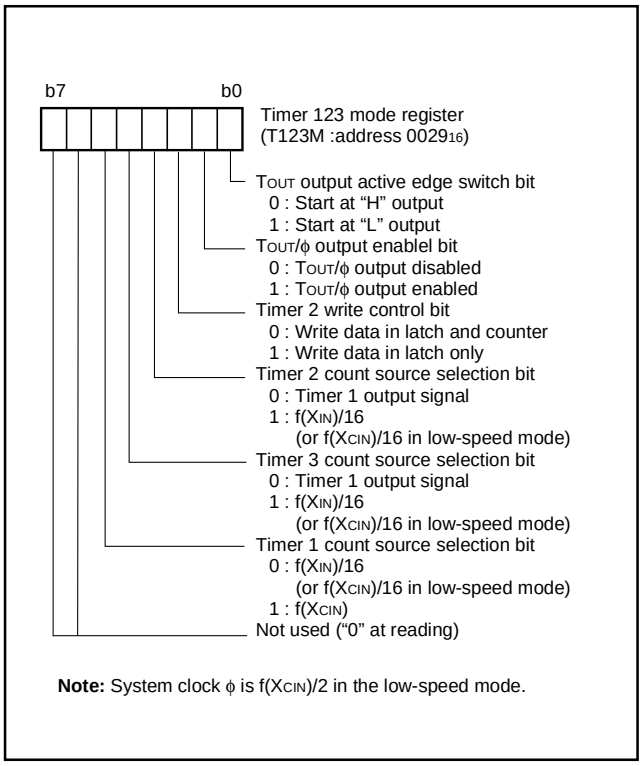


Fig. 27 Structure of timer 123 mode register

■Note on Timer 1 to Timer 3

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

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

SERIAL I/O
Serial I/O1

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

(1) Clock Synchronous Serial I/O Mode

Clock synchronous serial I/O mode is selected by setting the serial I/O1 mode selection bit of the serial I/O1 control register to "1". For clock synchronous serial I/O mode, the transmitter and the receiver must use the same clock as an operation clock.

When an internal clock is selected as an operation clock, transmit or receive is started by a write signal to the transmit buffer register.

When an external clock is selected as an operation clock, serial I/O1 becomes the state where transmit or receive can be performed by a write signal to the transmit buffer register. Transmit and receive are started by input of an external clock.

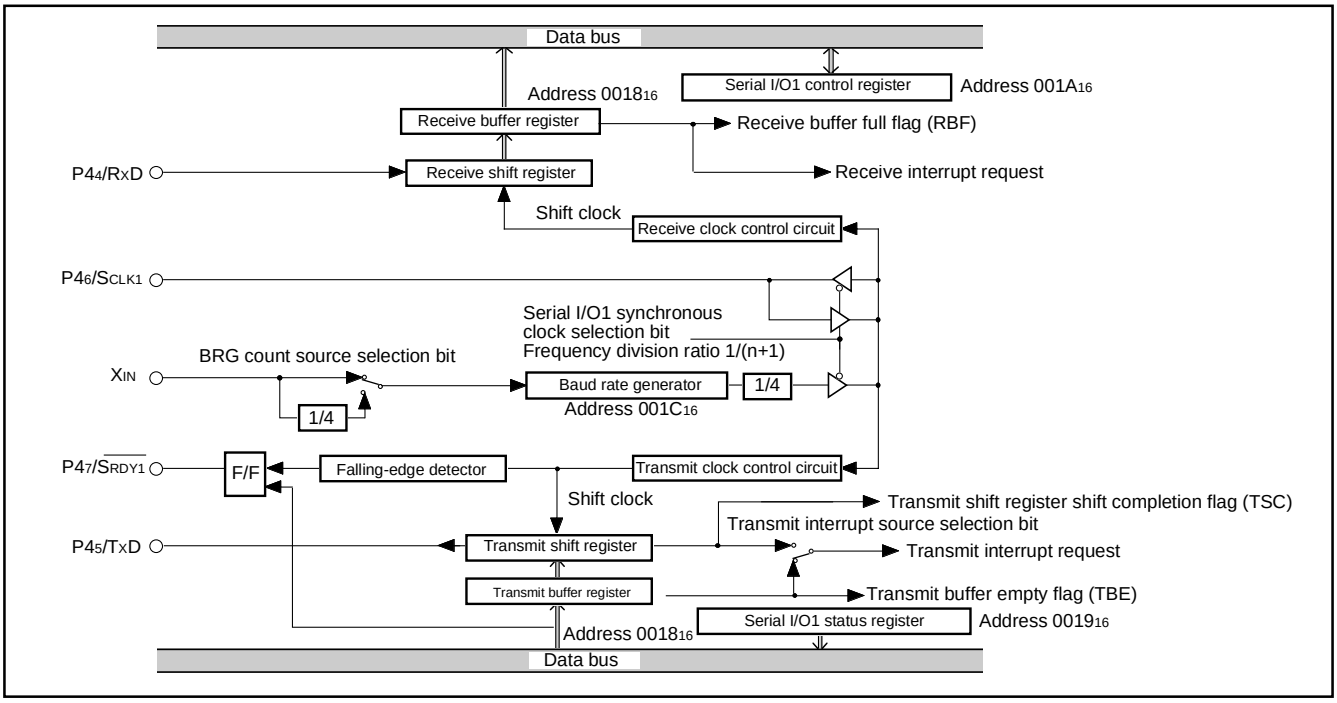
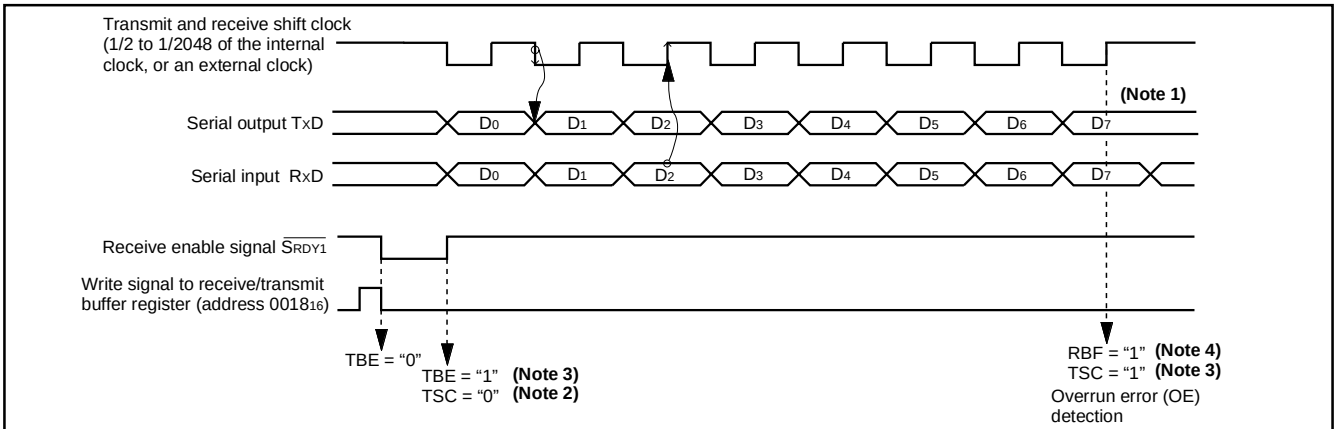


Fig. 28 Block diagram of clock synchronous serial I/O1



Notes
1 : After data transferring, the TxD pin keeps D7 output value.
2 : If data is written to the transmit buffer register when TSC = "0", the transmit clock is generated continuously and serial data can be output continuously from the TxD pin.
3 : Select the serial I/O1 transmit interrupt request factor between when the transmit buffer register has emptied (TBE = "1") or after the transmit shift operation has ended (TSC = "1"), by setting the transmit interrupt source selection bit (TIC) of the serial I/O1 control register.
4 : The serial I/O1 receive interrupt request occurs when the receive buffer full flag (RBF) becomes "1".

Fig. 29 Operation of clock synchronous serial I/O1 function

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

Clock asynchronous serial I/O mode (UART) is selected by setting the serial I/O1 mode selection bit of the serial I/O1 control register to "0".

Eight serial data transfer formats can be selected, and the transfer formats used by a transmitter and receiver must be identical.

The transmit and receive shift registers each have a buffer register, but the two buffers have the same address (0018_{16}) in memory. Since the shift register cannot be written to or read from directly, transmit data is written to the transmit buffer, and receive data is read from the receive buffer.

The transmit buffer can also hold the next data to be transmitted during transmitting, and the receive buffer register can hold received one-byte data while the next one-byte data is being received.

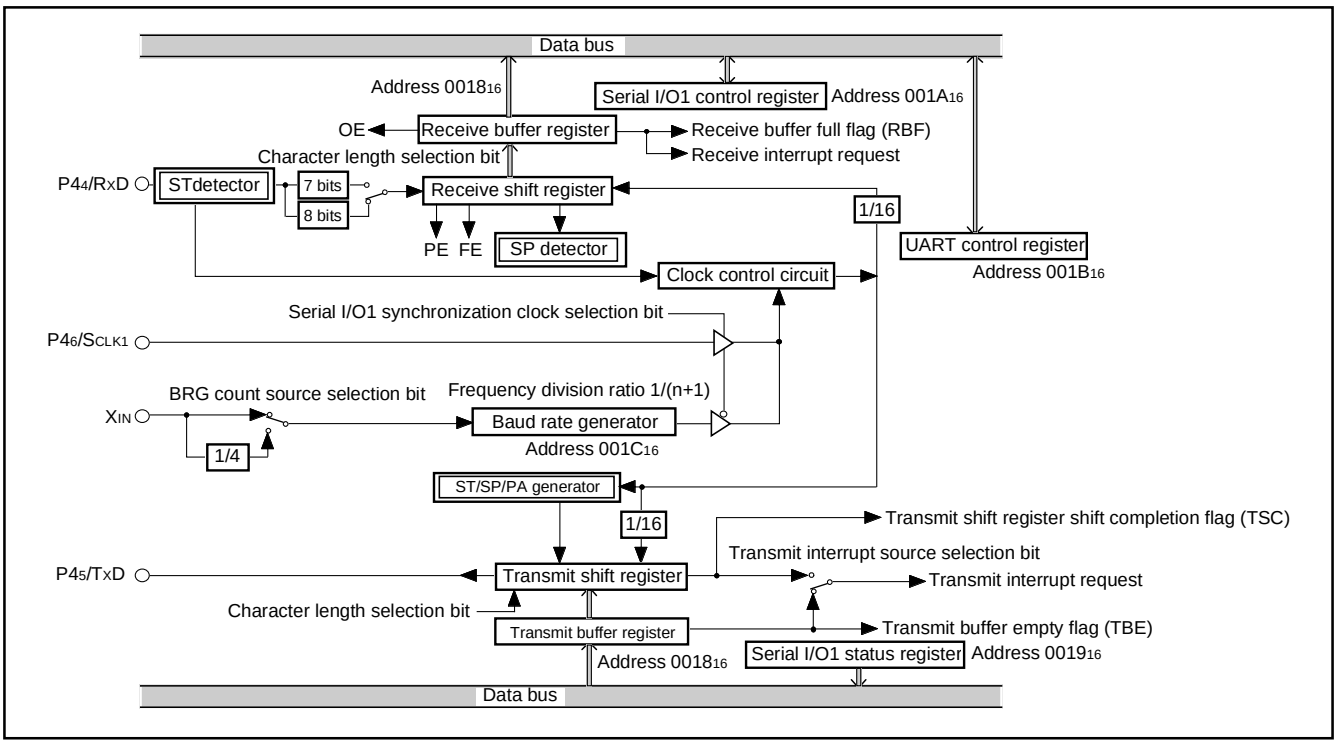
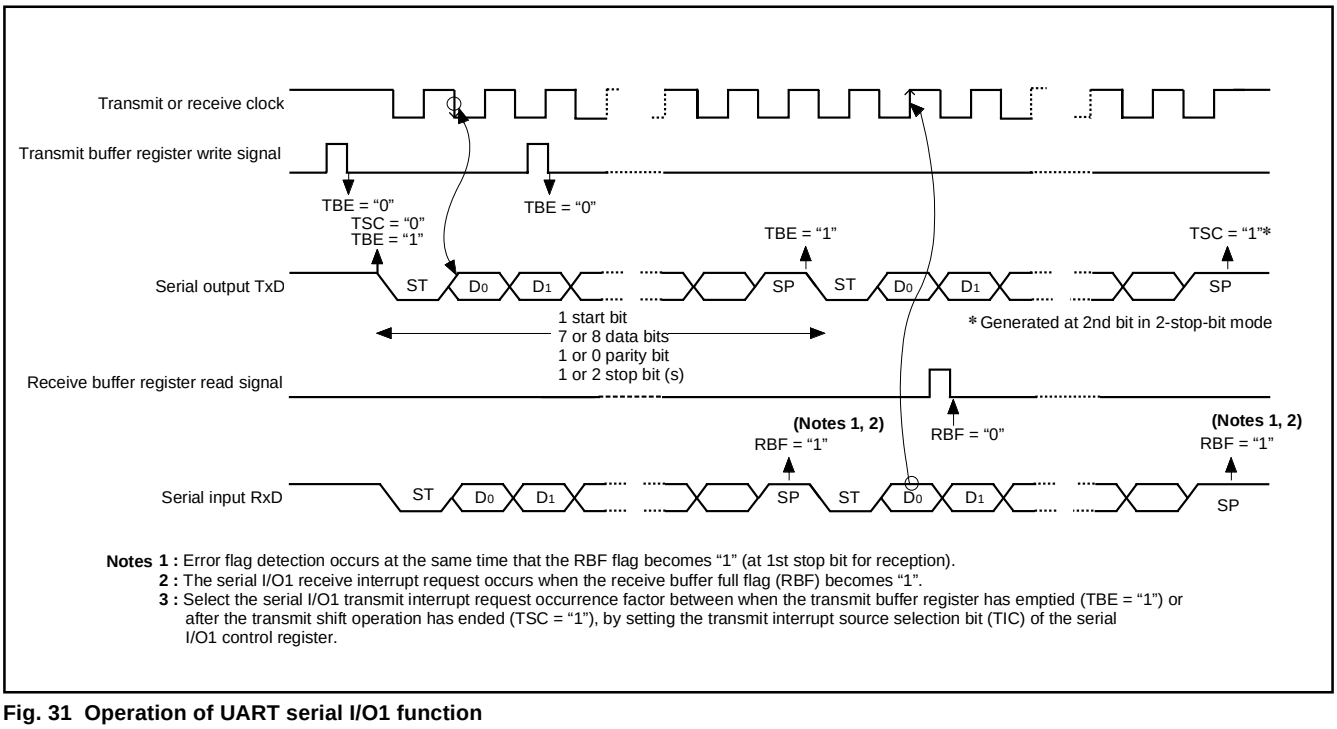


Fig. 30 Block diagram of UART serial I/O1



Notes 1 : Error flag detection occurs at the same time that the RBF flag becomes "1" (at 1st stop bit for reception).
2 : The serial I/O1 receive interrupt request occurs when the receive buffer full flag (RBF) becomes "1".
3 : Select the serial I/O1 transmit interrupt request occurrence factor between when the transmit buffer register has emptied (TBE = "1") or after the transmit shift operation has ended (TSC = "1"), by setting the transmit interrupt source selection bit (TIC) of the serial I/O1 control register.

Fig. 31 Operation of UART serial I/O1 function

[Transmit Buffer/Receive Buffer Register (TB/RB)] 0018$_{16}$

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

[Serial I/O1 Status Register (SIO1STS)] 0019$_{16}$

The read-only serial I/O1 status register consists of seven flags (bits 0 to 6) which indicate the operating status of the serial I/O1 function and various errors.

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

The receive buffer full flag (bit 1) is set to "0" when the receive buffer register is read.

If there is an error, it is detected at the same time that data is transferred from the receive shift register to the receive buffer register, and the receive buffer full flag is set to "1". A write signal to the serial I/O1 status register sets all the error flags (OE, PE, FE, and SE) (bit 3 to bit 6, respectively) to "0". Writing "0" to the serial I/O1 enable bit (SIOE) also sets all the status flags to "0", including the error flags.

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

[Serial I/O1 Control Register (SIO1CON)] 001A$_{16}$

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

[UART Control Register (UARTCON)] 001B$_{16}$

The UART control register consists of the bits which set the data format of an data transmit and receive, and the bit which sets the output structure of the P45/TxD pin.

[Baud Rate Generator (BRG)] 001C$_{16}$

The baud rate generator is the 8-bit counter equipped with a reload register. Set the division value of the BRG count source to the baud rate generator.

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

■Notes on serial I/O

When setting the transmit enable bit to "1", the serial I/O1 transmit interrupt request bit is automatically set to "1". When not requiring the interrupt occurrence synchronous with the transmission enabled, take the following sequence.

①Set the serial I/O1 transmit interrupt enable bit to "0" (disabled).
②Set the transmit enable bit to "1".
③Set the serial I/O1 transmit interrupt request bit to "0" after 1 or more instructions have been executed.
④Set the serial I/O1 transmit interrupt enable bit to "1" (enabled).

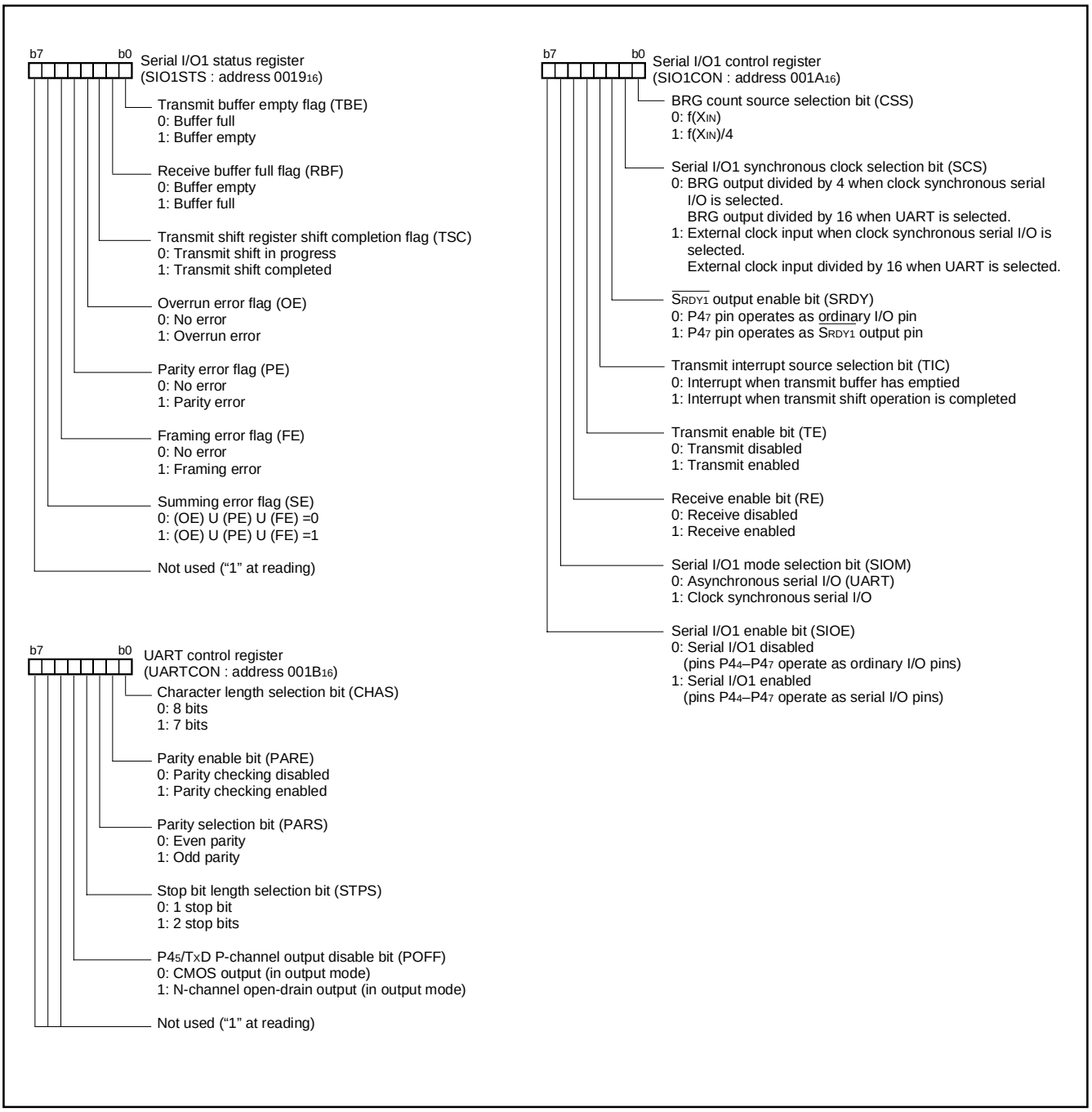


Fig. 32 Structure of serial I/O1 control registers

Serial I/O2

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

For serial I/O2, the transmitter and the receiver must use the same clock as a synchronous clock. When an internal clock is selected as a synchronous clock, the serial I/O2 is initialized and, transmit and receive is started by a write signal to the serial I/O2 register.

When an external clock is selected as an synchronous clock, the serial I/O2 counter is initialized by a write signal to the serial I/O2 register, serial I/O2 becomes the state where transmission or reception can be performed. Write to the serial I/O2 register while SCLK21 is "H" state when an external clock is selected as an synchronous clock.

Either P62/SCLK21 or P63/SCLK22 pin can be selected as an output pin of the synchronous clock. In this case, the pin that is not selected as an output pin of the synchronous clock functions as a I/O port.

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

The serial I/O2 control register contains eight control bits for the serial I/O2 functions. After setting to this register, write data to the serial I/O2 register and start transmit and receive.

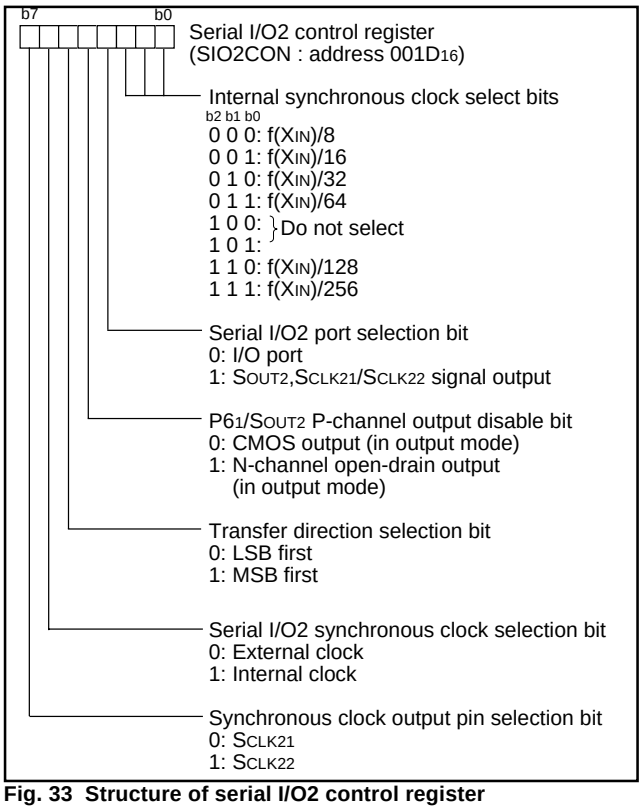


Fig. 33 Structure of serial I/O2 control register

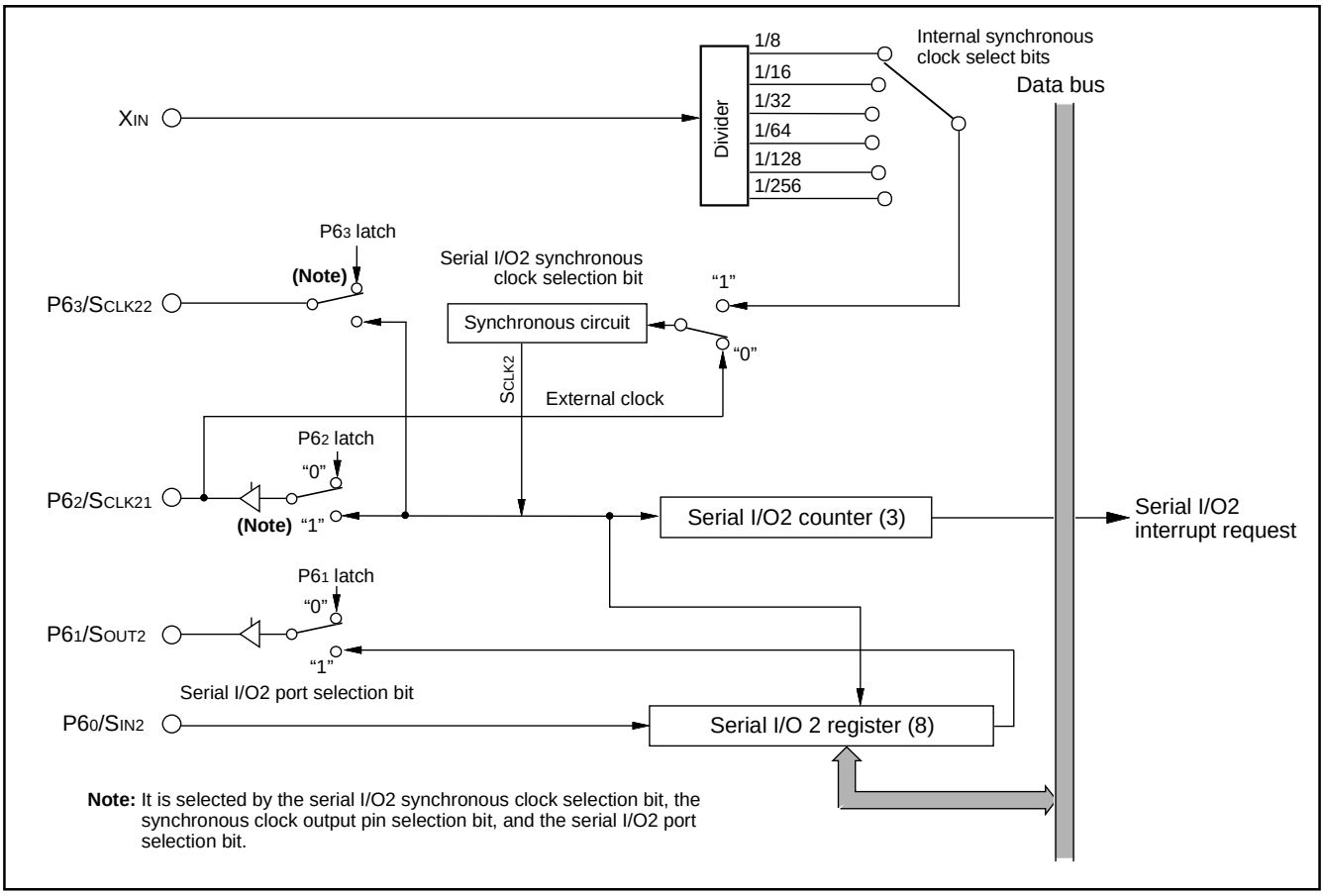


Fig. 34 Block diagram of serial I/O2 function

●Serial I/O2 Operating

The serial I/O2 counter is initialized to “7” by writing to the serial I/O2 register.

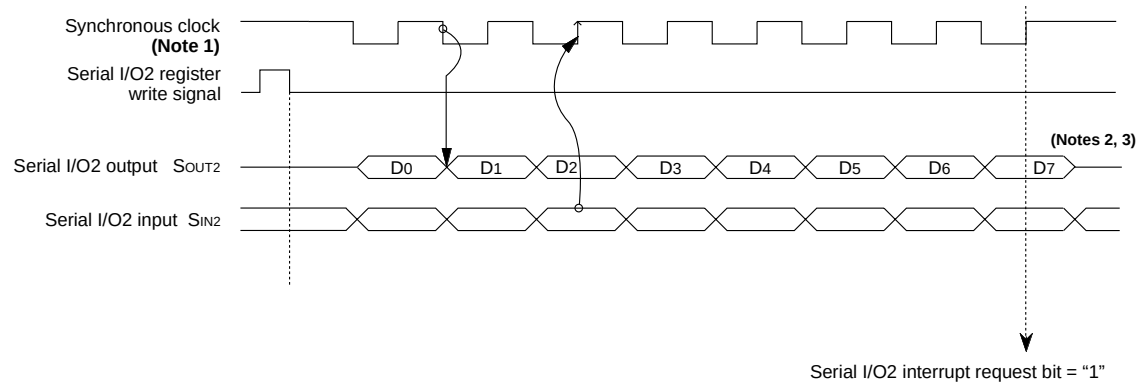
After writing, whenever a synchronous clock changes from “H” to “L”, data is output from the SOUT2 pin. Moreover, whenever a synchronous clock changes from “L” to “H”, data is taken in from the SIN2 pin, and 1 bit shift of the serial I/O2 register is carried out simultaneously.

When the internal clock is selected as a synchronous clock, it is as follows if a synchronous clock is counted 8 times.

- Serial I/O2 counter = “0”
- Synchronous clock stops in “H” state
- Serial I/O2 interrupt request bit = “1”

The SOUT2 pin is in a high impedance state after transfer is completed.

When the external clock is selected as a synchronous clock, if a synchronous clock is counted 8 times, the serial I/O2 interrupt request bit is set to “1”, and the SOUT2 pin holds the output level of D7. However, if a synchronous clock continues being input, the shift of the serial I/O2 register is continued and transmission data continues being output from the SOUT2 pin.



Notes 1: When the internal clock is selected as the synchronous clock, the divide ratio can be selected by setting bits 0 to 2 of the serial I/O2 control register.
2: When the internal clock is selected as the synchronous clock, the SOUT2 pin goes to high impedance after transfer completion.
3: When the external clock is selected as the synchronous clock, the SOUT2 pin keeps D7 output level after transfer completion. However, if synchronous clocks input are carried on, the transmit data will be output continuously from the SOUT2 pin because shifts of serial I/O2 shift register is continued as long as synchronous clocks are input.

Fig. 35 Timing of serial I/O2 function

PULSE WIDTH MODULATION (PWM)

The 7560 group has a PWM function with an 8-bit resolution, using f(XIN) or f(XIN)/2 as a count source.

Data Setting

The PWM output pins are shared with ports P50 and P51. Set the PWM period by the PWM prescaler, and set the period during which the output pulse is an "H" by the PWM register.

If PWM count source is f(XIN) and the value in the PWM prescaler is n and the value in the PWM register is m (where n = 0 to 255 and m = 0 to 255) :

PWM period = 255 × (n+1)/f(XIN)

= 31.875 × (n+1) µs (when f(XIN) = 8 MHz)

Output pulse "H" period = PWM period × m/255

= 0.125 × (n+1) × m µs

(when f(XIN) = 8 MHz)

PWM Operation

When either bit 1 (PWM0 function enable bit) or bit 2 (PWM1 function enable bit) of the PWM control register or both bits are enabled, operation starts from initializing status, and pulses are output starting at "H". When one PWM output is enabled and that the other PWM output is enabled, PWM output which is enabled to output later starts pulse output from halfway of PWM period (see Figure 39).

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

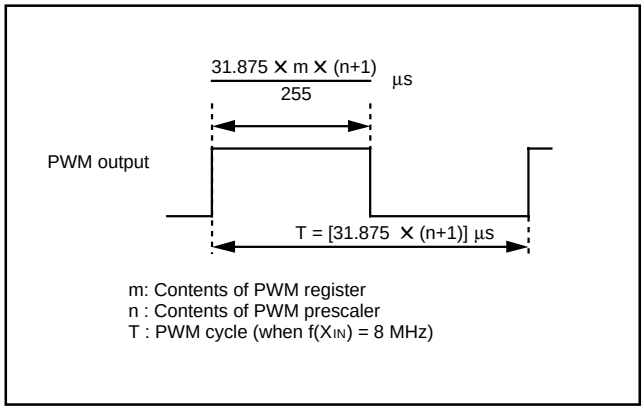


Fig. 36 Timing of PWM cycle

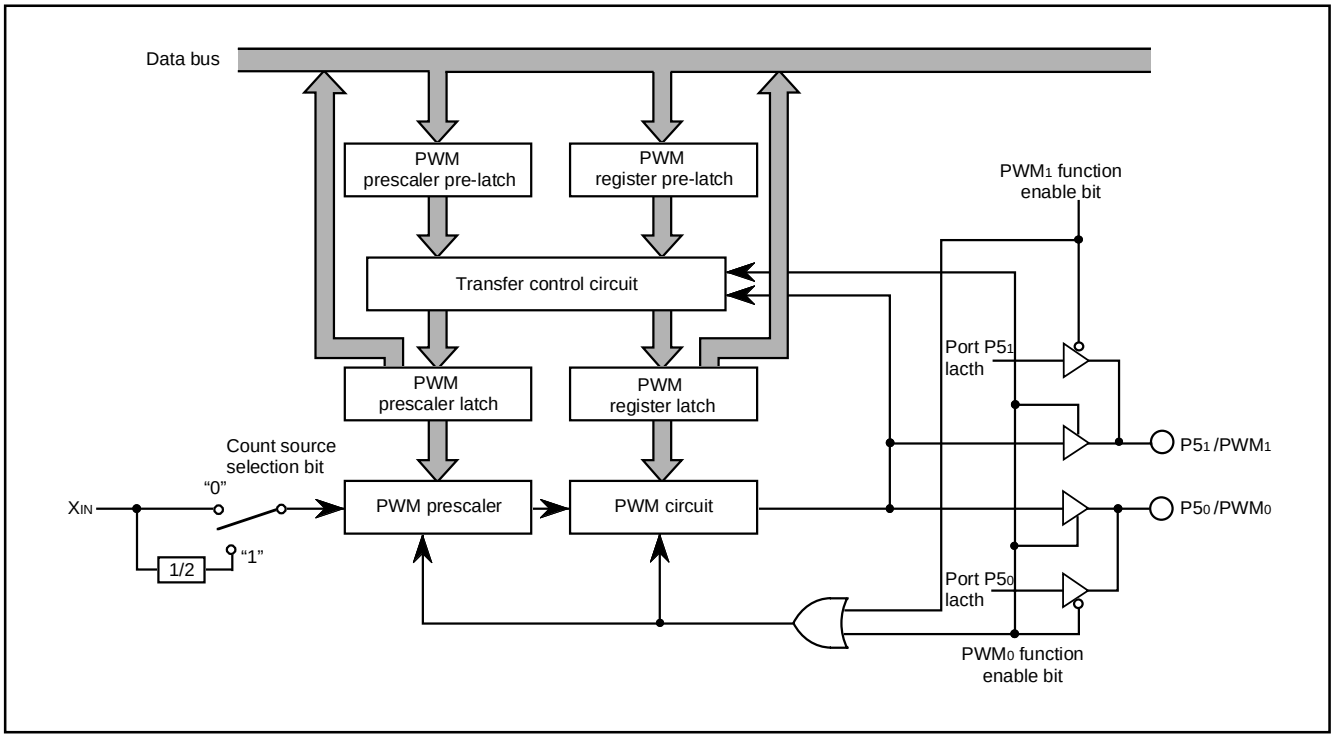


Fig. 37 Block diagram of PWM function

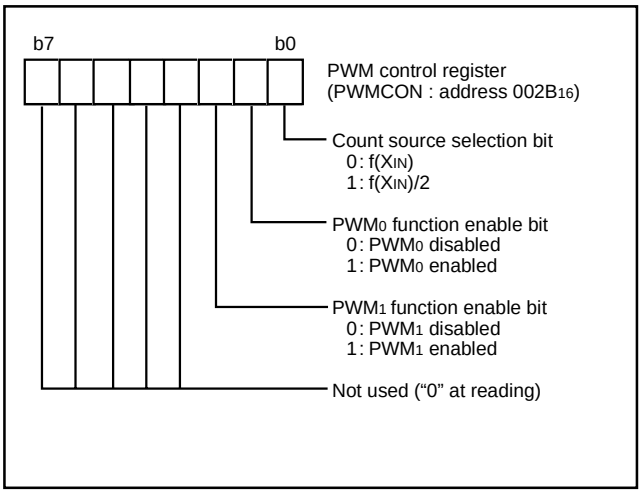


Fig. 38 Structure of PWM control register

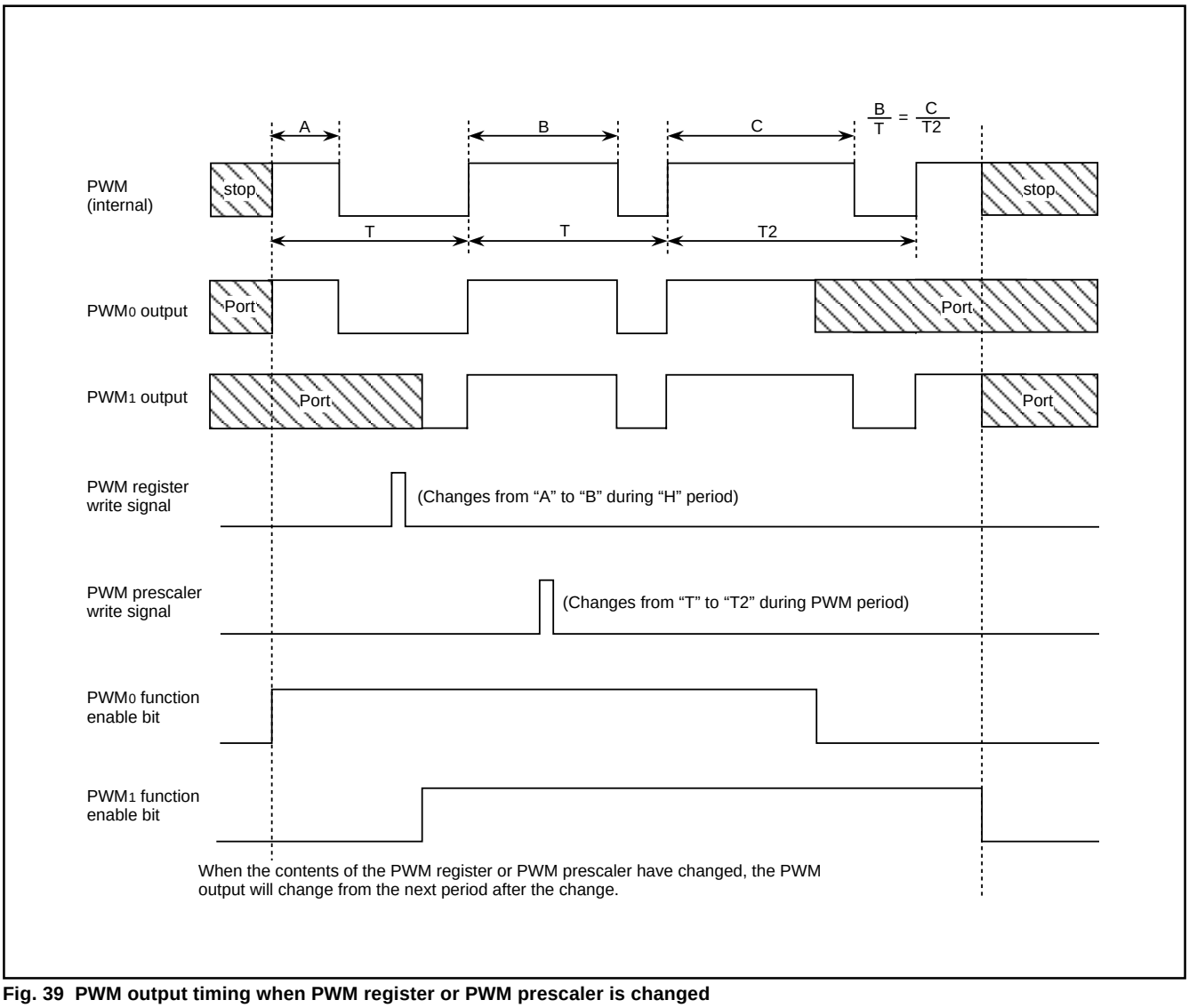


Fig. 39 PWM output timing when PWM register or PWM prescaler is changed

A-D CONVERTER

[A-D Conversion Low-Order Register (ADL)] 0014$_{16}$

[A-D Conversion High-Order Register (ADH)] 0035$_{16}$

The A-D conversion registers are read-only registers that store the result of an A-D conversion . When reading this register during an A-D conversion, the previous conversion result is read.

The high-order 8 bits of a conversion result is stored in the A-D conversion high-order register (address 0035$_{16}$), and the low-order 2 bits of the same result are stored in bit 7 and bit 6 of the A-D conversion low-order register (address 0014$_{16}$).

Bit 0 of the A-D conversion low-order register is the conversion mode selection bit. When this bit is set to “0”, that becomes the 10-bit A-D mode. When this bit is set to “1”, that becomes the 8-bit A-D mode.

[A-D Control Register (ADCON)] 0034$_{16}$

The A-D control register controls the A-D conversion process. Bits 0 to 2 of this register select specific analog input pins. Bit 3 indicates the completion of an A-D conversion. The value of this bit remains at “0” during an A-D conversion, then it is set to “1” when the A-D conversion is completed. Writing “0” to this bit starts the A-D conversion.

Bit 4 is the V_{REF} input switch bit which controls connection of the resistor ladder and the reference voltage input pin (V_{REF}). The resistor ladder is always connected to V_{REF} when bit 4 is set to “1”. When bit 4 is set to “0”, the resistor ladder is cut off from V_{REF} except for A-D conversion performed. When bit 5, which is the AD external trigger valid bit, is set to “1”, A-D conversion starts also by a falling edge of an ADT input. When using an A-D external trigger, set the P5$_7$/ADT pin to input mode (set “0” to bit 7 of port P5 direction register).

Comparison Voltage Generator

The comparison voltage generator divides the voltage between AV_{SS} and V_{REF} by 256 (when 8-bit A-D mode) or 1024 (when 10-bit A-D mode), and outputs the divided voltages.

Channel Selector

The channel selector selects one of the input ports P6$_7$/AN$_7$–P6$_0$/AN$_0$.

Comparator and Control Circuit

The comparator and control circuit compare an analog input voltage with the comparison voltage and store 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 converter interrupt request bit to “1”.

Note that because the comparator consists of a capacitor coupling, set f(X_{IN}) to 500 kHz or more during an A-D conversion. Use the clock divided from the main clock f(X_{IN}) as the system clock ϕ.

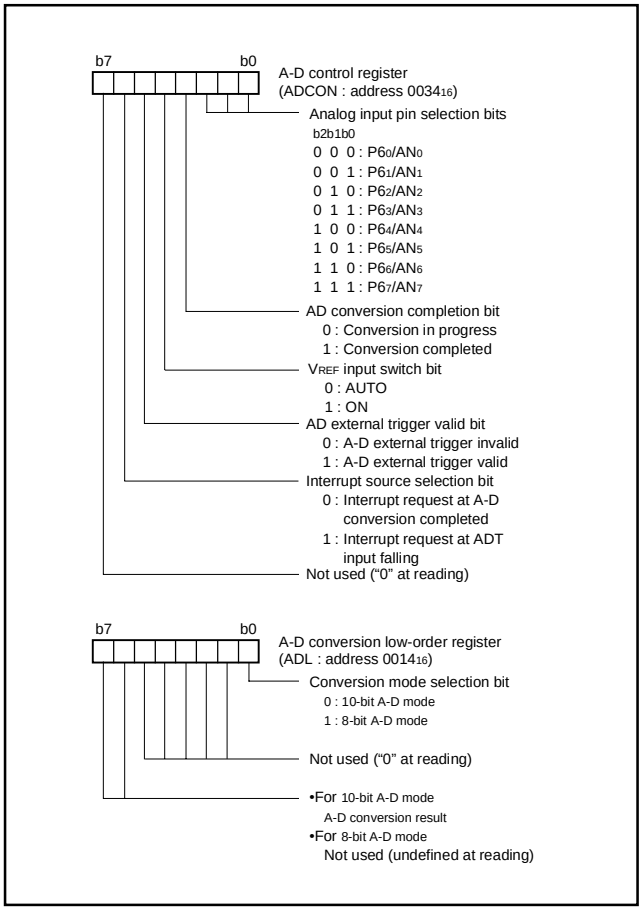


Fig. 40 Structure of A-D converter-related registers

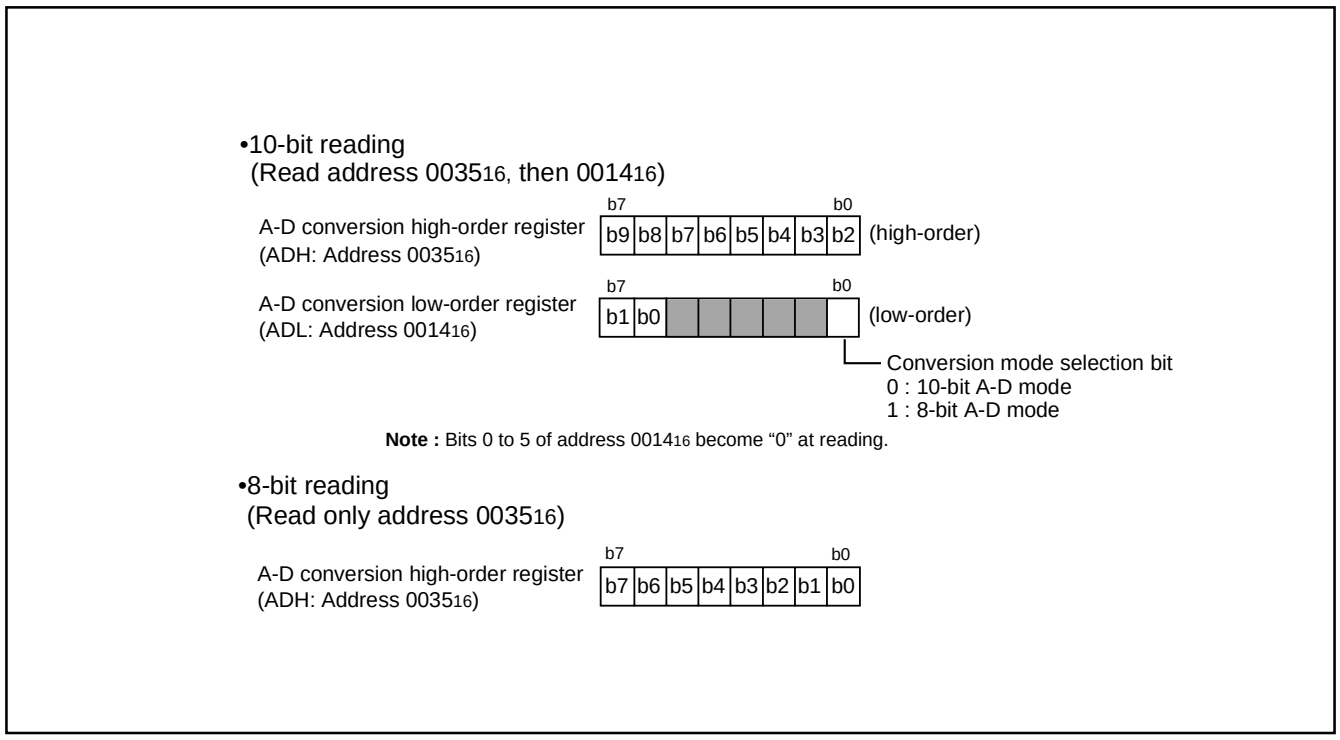


Fig. 41 Read of A-D conversion register

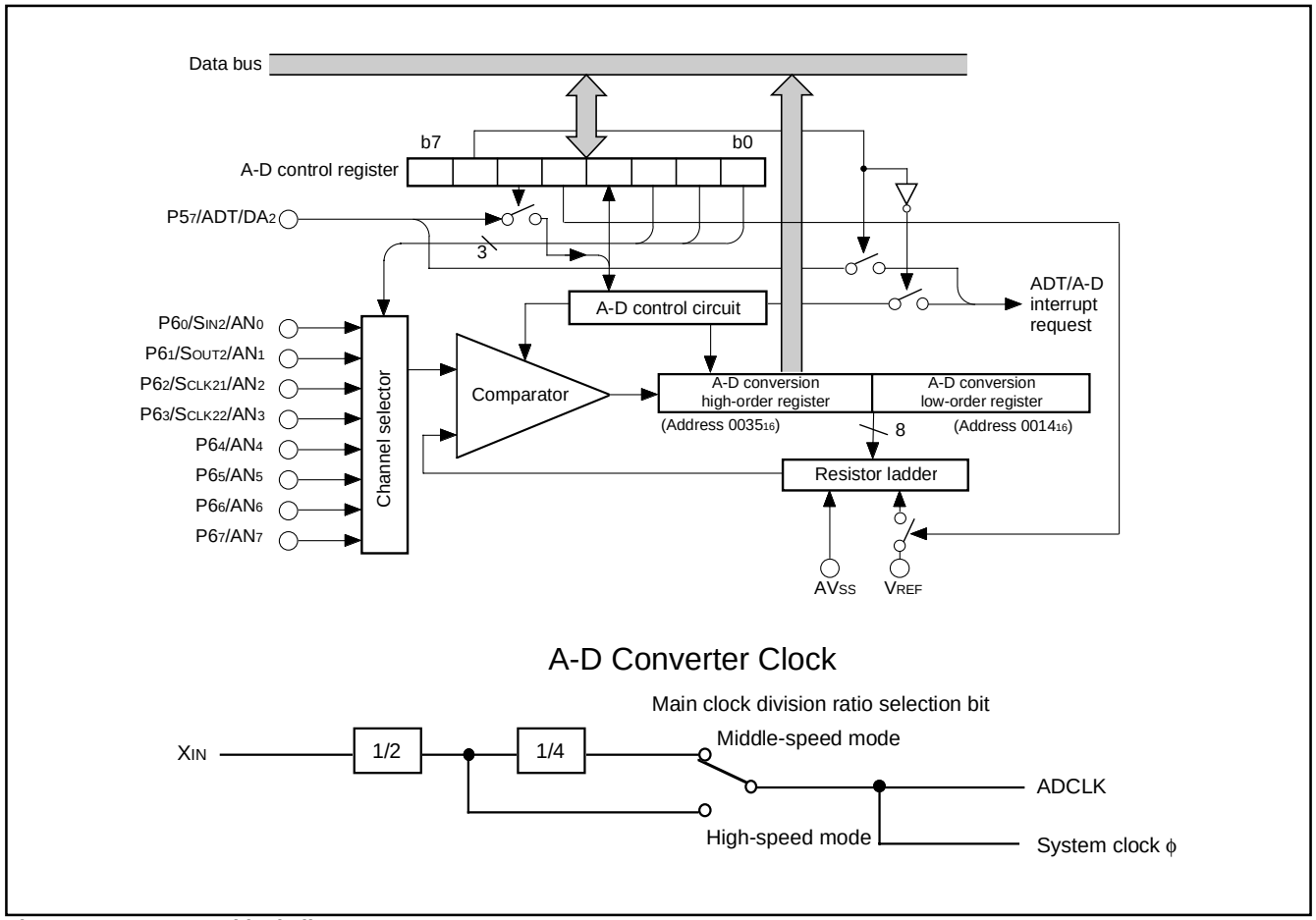


Fig. 42 A-D converter block diagram

D-A Converter

The 7560 group has a D-A converter with 8-bit resolution and 2 channels (DA_1, DA_2).

The D-A converter is started by setting the value in the D-A conversion register. When the DA_1 output enable bit or the DA_2 output enable bit is set to "1", the result of D-A conversion is output from the corresponding DA pin. When using the D-A converter, set the $P5_6/DA_1$ pin and the $P5_7/DA_2$ pin to input mode (set "0" to bits 6, 7 of port P5 direction register) and the pull-up resistor should be in the OFF state (set "0" to bit 3 of PULL register B) previously.

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

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

Where V_{REF} is the reference voltage.

At reset, the D-A conversion registers are set to "00_{16}", the DA_1 output enable bit and the DA_2 output enable bit are set to "0", and the $P5_6/DA_1$ pin and the $P5_7/DA_2$ pin goes to high impedance state. The DA converter is not buffered, so connect an external buffer when driving a low-impedance load.

■ Note on applied voltage to V_{REF} pin

When these pins are used as D-A conversion output pins, the Vcc level is recommended for the applied voltage to V_{REF} pin.

When the voltage below Vcc level is applied, the D-A conversion accuracy may be worse.

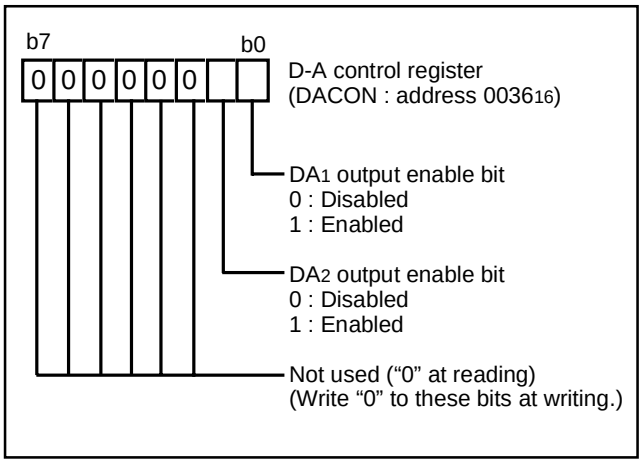


Fig. 43 Structure of D-A control register

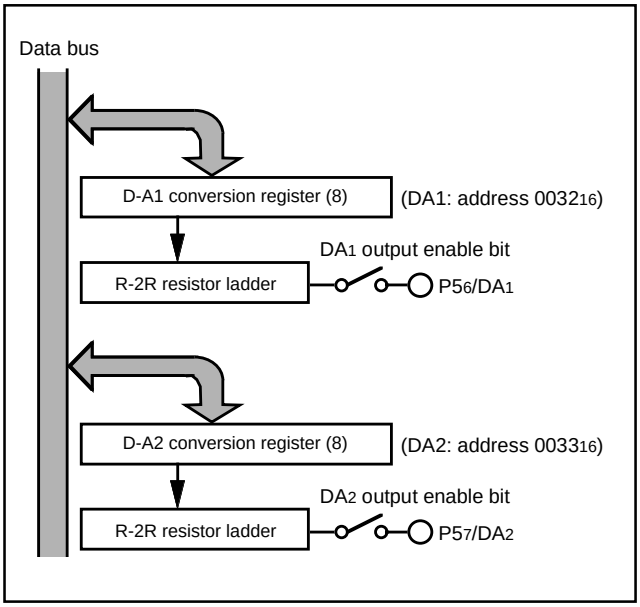


Fig. 44 Block diagram of D-A converter

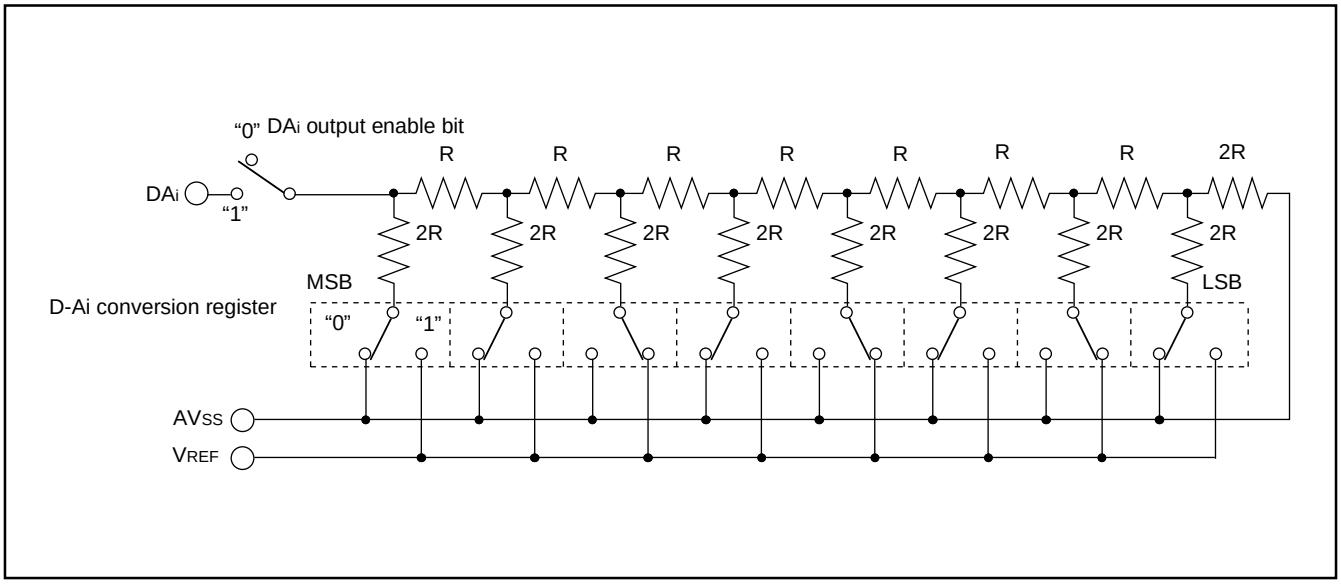


Fig. 45 Equivalent connection circuit of D-A converter

LCD DRIVE CONTROL CIRCUIT

The 7560 group has the Liquid Crystal Display (LCD) drive control circuit consisting of the following.

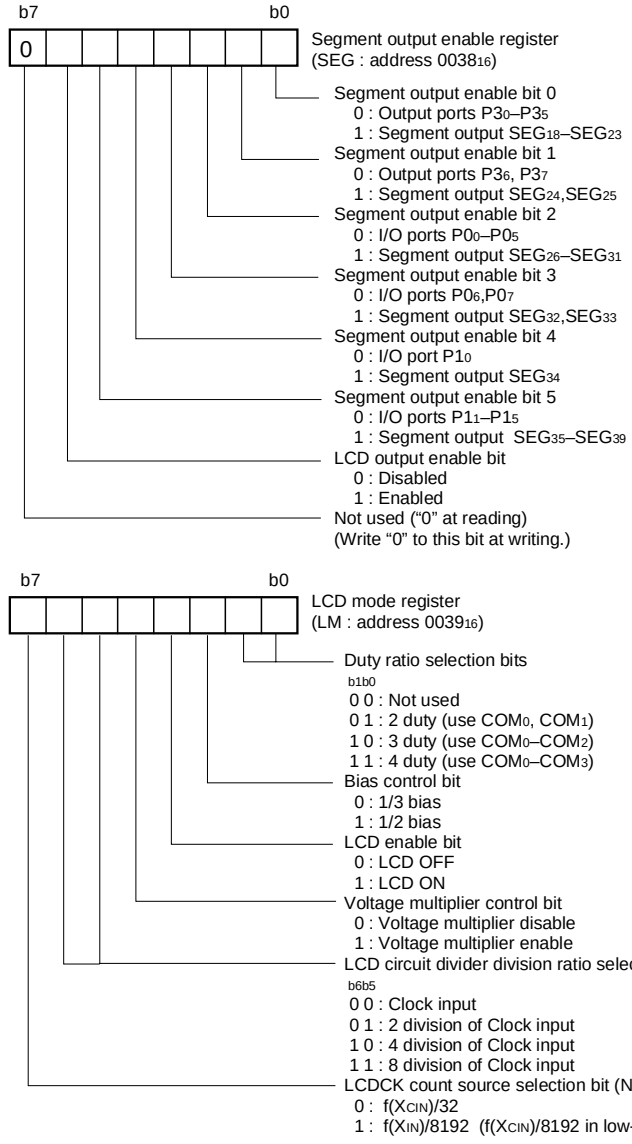
- LCD display RAM
- Segment output enable register
- LCD mode register
- Voltage multiplier
- Selector
- Timing controller
- Common driver
- Segment driver
- Bias control circuit

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

Up to 160 pixels can be controlled for LCD display. When the LCD enable bit is set to "1" (LCD ON) 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 11 Maximum number of display pixels at each duty ratio

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



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

Fig. 46 Structure of segment output enable register and LCD mode register

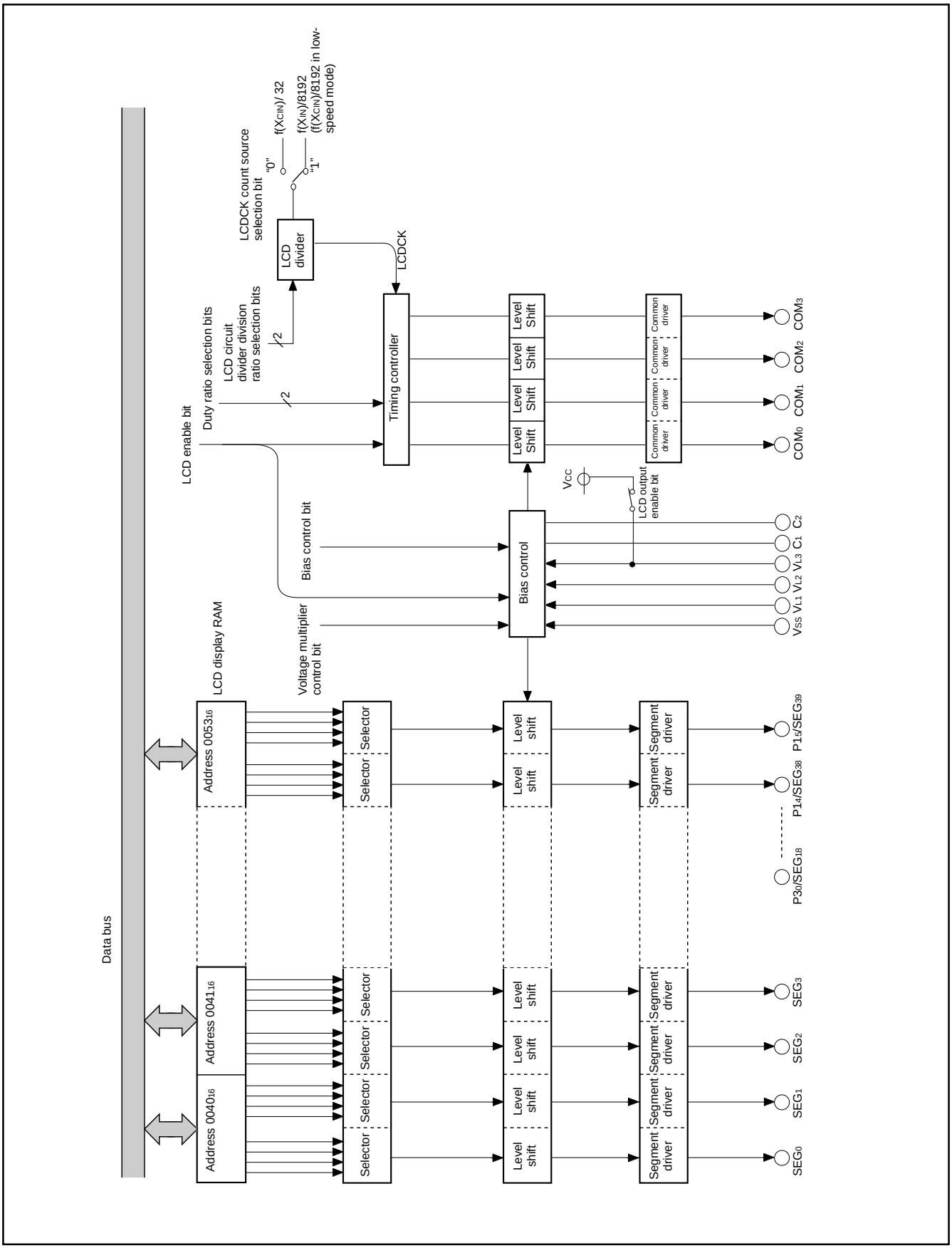


Fig. 47 Block diagram of LCD controller/driver

Voltage Multiplier (3 Times)

The voltage multiplier performs threefold boosting. This circuit inputs a reference voltage for boosting from LCD power input pin V_{L1}.

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

1. Set the segment output enable bits (bits 0 to 5) of the segment output enable register to “0” or “1”.
2. Set the duty ratio selection bits (bits 0 and 1), the bias control bit (bit 2), the LCD circuit divider division ratio selection bits (bits 5 and 6), and the LCDCK count source selection bit (bit 7) of the LCD mode register to “0” or “1”.
3. Set the LCD output enable bit (bit 6) of the segment output enable register to “1”. Apply the limit voltage or less to the V_{L1} pin.
4. Set the voltage multiplier control bit (bit 4) of the LCD mode register to “1”. However, be sure to select 1/3 bias for bias control.

When voltage is input to the V_{L1} pin during operating the voltage multiplier, voltage that is twice as large as V_{L1} occurs at the V_{L2} pin, and voltage that is three times as large as V_{L1} occurs at the V_{L3} pin.

■Notes on Voltage Multiplier

When using the voltage multiplier, apply the limit voltage or less to the V_{L1} pin, then set the voltage multiplier control bit to “1” (enabled).

When not using the voltage multiplier, set the LCD output enable bit to “1”, then apply proper voltage to the LCD power input pins (V_{L1}–V_{L3}).

When the LCD output enable bit is set to “0” (disabled), the V_{CC} voltage is applied to the V_{L3} pin inside of this microcomputer.

Bias Control and Applied Voltage to LCD Power Input Pins

To the LCD power input pins (V_{L1}–V_{L3}), apply the voltage shown in Table 12 according to the bias value.

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

Table 12 Bias control and applied voltage to V_{L1}–V_{L3}

Bias value	Voltage value
1/3 bias	$V_{L3}=V_{LCD}$ $V_{L2}=2/3\ V_{LCD}$ $V_{L1}=1/3\ V_{LCD}$
1/2 bias	$V_{L3}=V_{LCD}$ $V_{L2}=V_{L1}=1/2\ V_{LCD}$

Note : V_{LCD} is the maximum value of supplied voltage for the LCD panel.

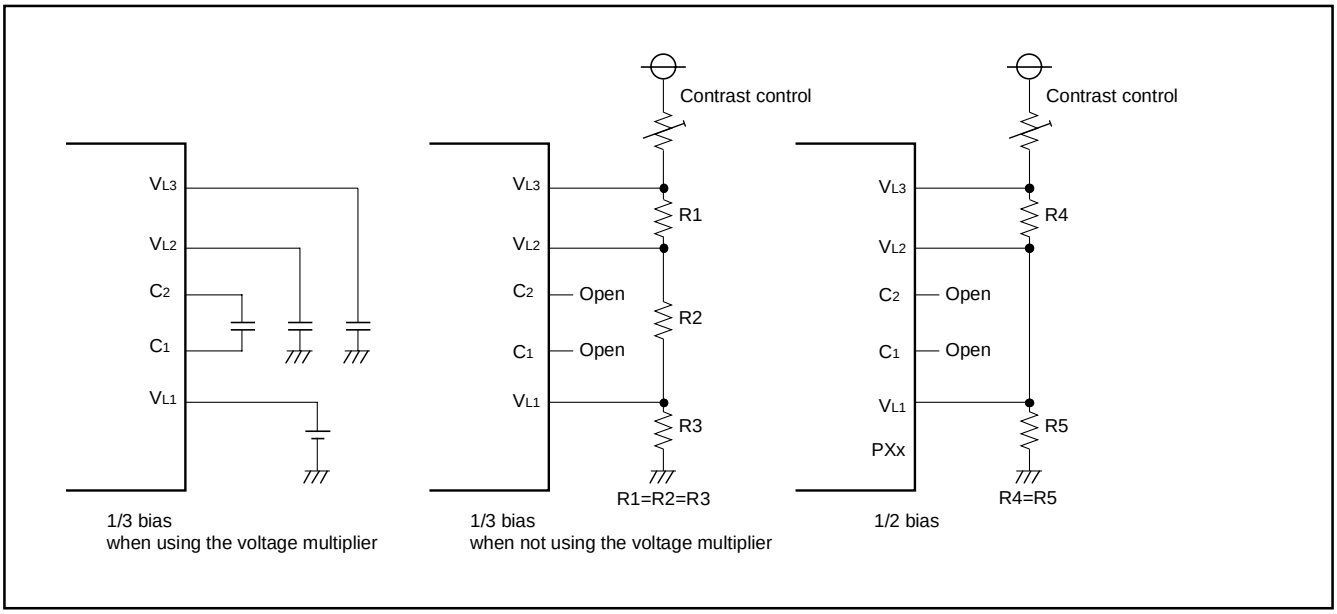


Fig. 48 Example of circuit at each bias

Common Pin and Duty Ratio Control

The common pins (COM_0–COM_3) 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).

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

Table 13 Duty ratio control and common pins used

Duty ratio	Duty ratio selection bits		Common pins used
	Bit 1	Bit 0	
2	0	1	COM_0, COM_1 (Note 1)
3	1	0	COM_0–COM_2 (Note 2)
4	1	1	COM_0–COM_3

Notes 1: COM_2 and COM_3 are open.
2: COM_3 is open.

Segment Signal Output Pins

Segment signal output pins are classified into the segment-only pins (SEG_0–SEG_{17}), the segment or output port pins (SEG_{18}–SEG_{25}), and the segment or I/O port pins (SEG_{26}–SEG_{39}).

Segment signals are output according to the bit data of the LCD RAM corresponding to the duty ratio. After reset, a V_{CC} (=V_{L3}) voltage is output to the segment-only pins and the segment/output port pins are the high impedance condition and pulled up to V_{CC} (=V_{L3}) voltage.

Also, the segment/I/O port pins(SEG_{26}–SEG_{39}) are set to input mode as I/O ports, and V_{CC} (=V_{L3}) is applied to them by pull-up resistor.

LCD Display RAM

Addresses 0040_{16} to 0053_{16} are 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 frequency of internal signal LCDCK decided LCD drive timing and the frame frequency can be determined with the following equation:

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

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

Address \ Bit	7	6	5	4	3	2	1	0
	COM_3	COM_2	COM_1	COM_0	COM_3	COM_2	COM_1	COM_0
0040_{16}	SEG_1				SEG_0			
0041_{16}	SEG_3				SEG_2			
0042_{16}	SEG_5				SEG_4			
0043_{16}	SEG_7				SEG_6			
0044_{16}	SEG_9				SEG_8			
0045_{16}	SEG_{11}				SEG_{10}			
0046_{16}	SEG_{13}				SEG_{12}			
0047_{16}	SEG_{15}				SEG_{14}			
0048_{16}	SEG_{17}				SEG_{16}			
0049_{16}	SEG_{19}				SEG_{18}			
$004A_{16}$	SEG_{21}				SEG_{20}			
$004B_{16}$	SEG_{23}				SEG_{22}			
$004C_{16}$	SEG_{25}				SEG_{24}			
$004D_{16}$	SEG_{27}				SEG_{26}			
$004E_{16}$	SEG_{29}				SEG_{28}			
$004F_{16}$	SEG_{31}				SEG_{30}			
0050_{16}	SEG_{33}				SEG_{32}			
0051_{16}	SEG_{35}				SEG_{34}			
0052_{16}	SEG_{37}				SEG_{36}			
0053_{16}	SEG_{39}				SEG_{38}			

Fig. 49 LCD display RAM map

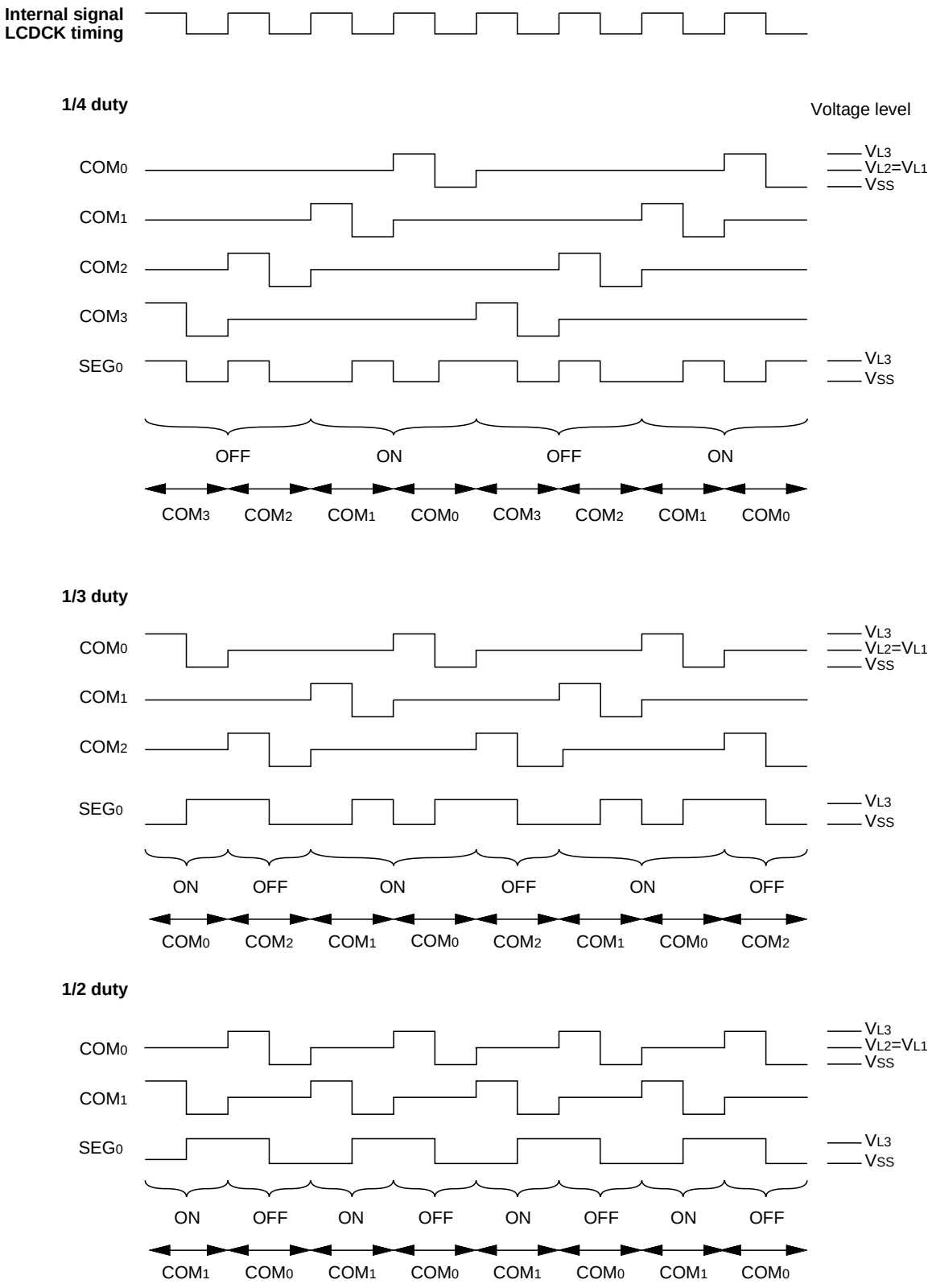


Fig. 50 LCD drive waveform (1/2 bias)

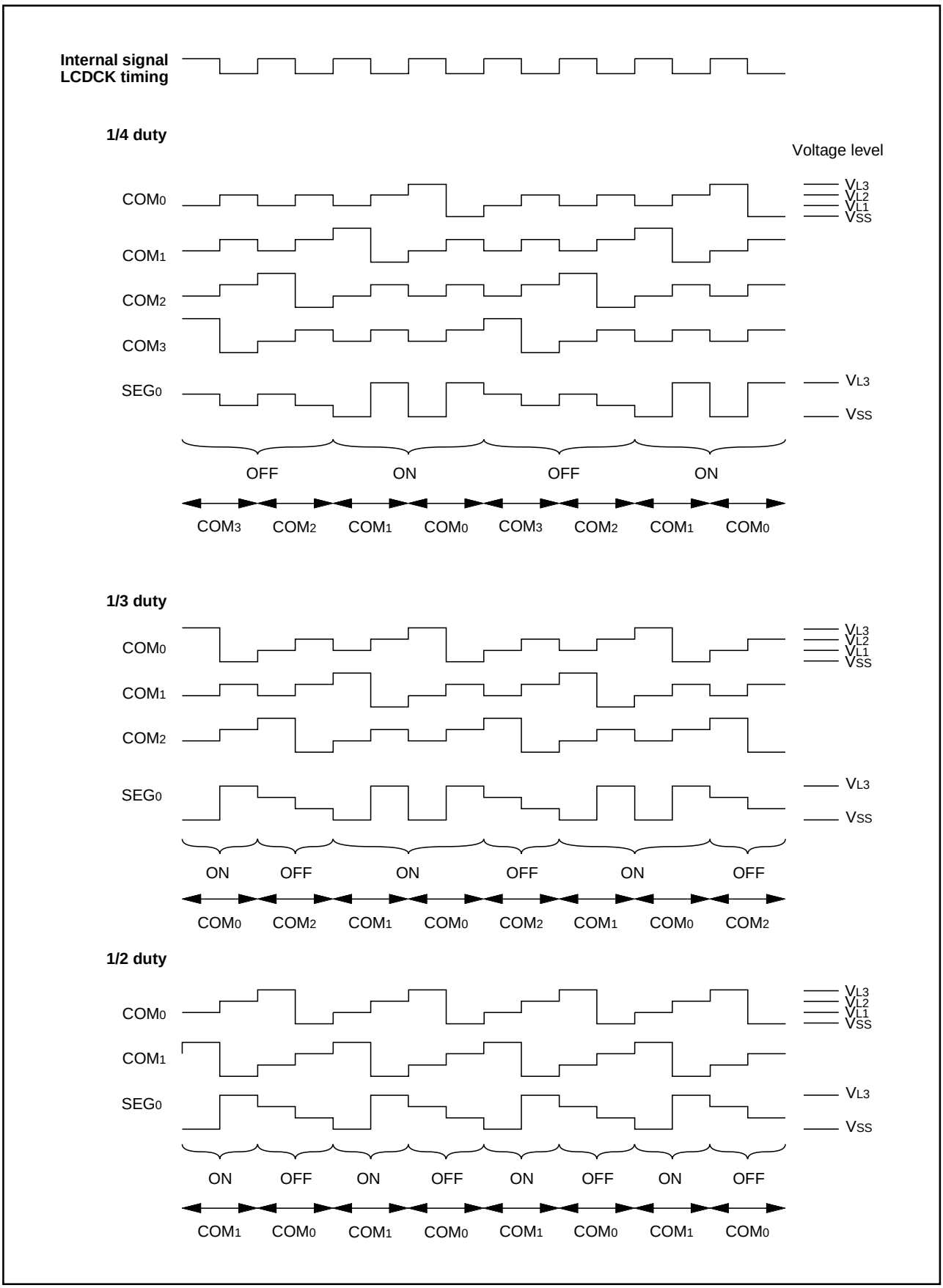


Fig. 51 LCD drive waveform (1/3 bias)

Watchdog Timer

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

The watchdog timer consists of an 8-bit watchdog timer L and a 6-bit watchdog timer H. At reset or writing to the watchdog timer control register (address 0037_{16}), the watchdog timer is set to "$3FFF_{16}$". When any data is not written to the watchdog timer control register (address 0037_{16}) after reset, the watchdog timer is stopped. The watchdog timer starts to count down from "$3FFF_{16}$" by writing to the watchdog timer control register and an internal reset occurs at an underflow. Accordingly, when using the watchdog timer function, write the watchdog timer control register before an underflow. The watchdog timer does not function when writing to the watchdog timer control register has not been done after reset. When not using the watchdog timer, do not write to it. When the watchdog timer control register is read, the following values are read:

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

When the STP instruction disable bit is "0", the STP instruction is enabled. The STP instruction is disabled when this bit is set to "1". If the STP instruction which is disabled is executed, it is processed as an undefined instruction, so that a reset occurs internally.

This bit can be set to "1" but cannot be set to "0" by program. This bit is "0" after reset.

When the watchdog timer H count source selection bit is "0", the detection time is set to 8.19 s at f(XCIN) = 32 kHz and 32.768 ms at f(XIN) = 8 MHz.

When the watchdog timer H count source selection bit is "0", the detection time is set to 32 ms at f(XCIN) = 32 kHz and 128 µs at f(XIN) = 8 MHz. There is no difference in the detection time between the middle-speed mode and the high-speed mode.

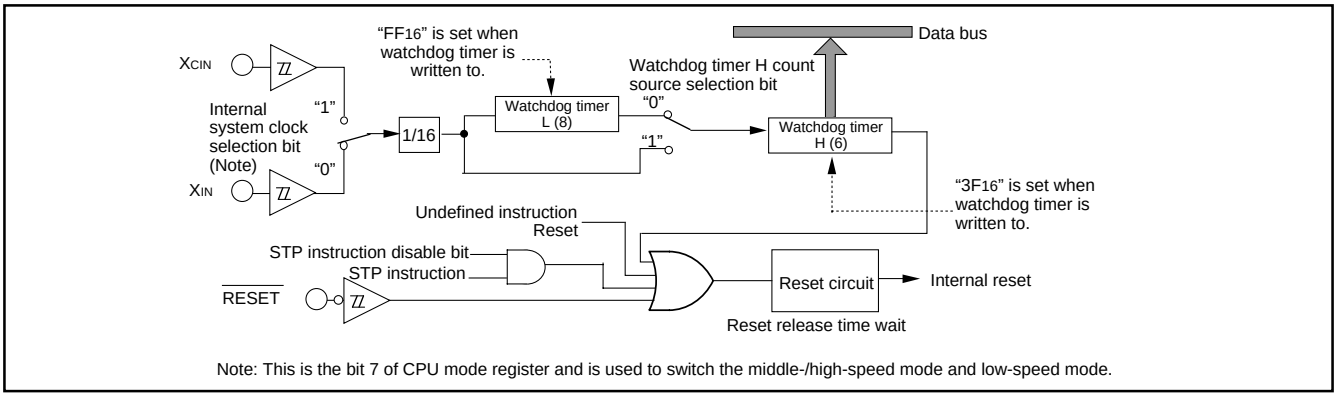


Fig. 52 Block diagram of watchdog timer

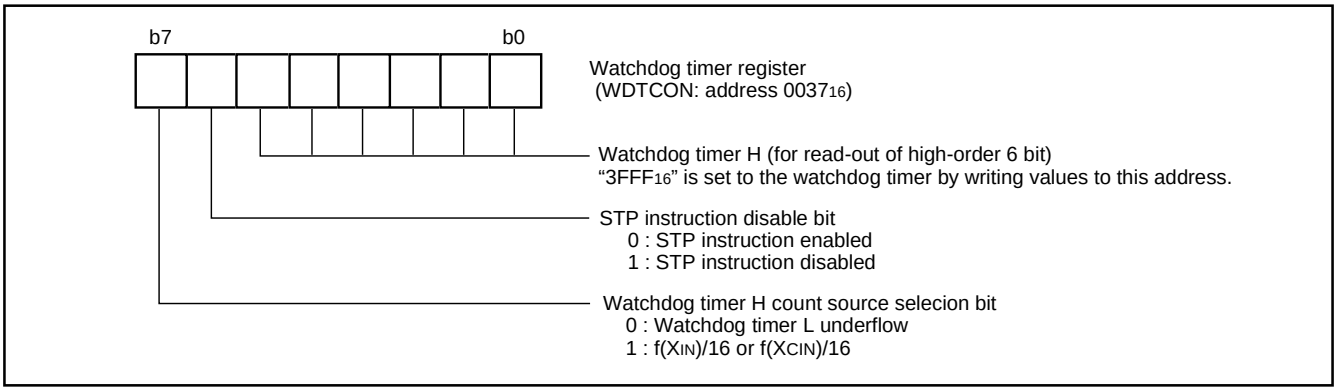


Fig. 53 Structure of watchdog timer control register

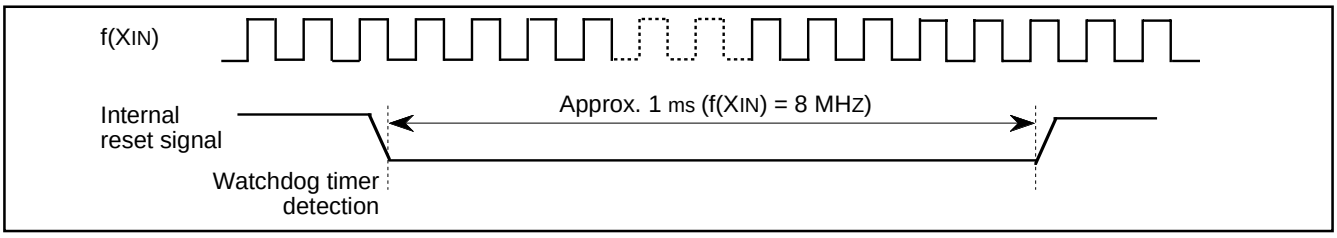


Fig. 54 Timing of reset output

TOUT/ϕ OUTPUT FUNCTION

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

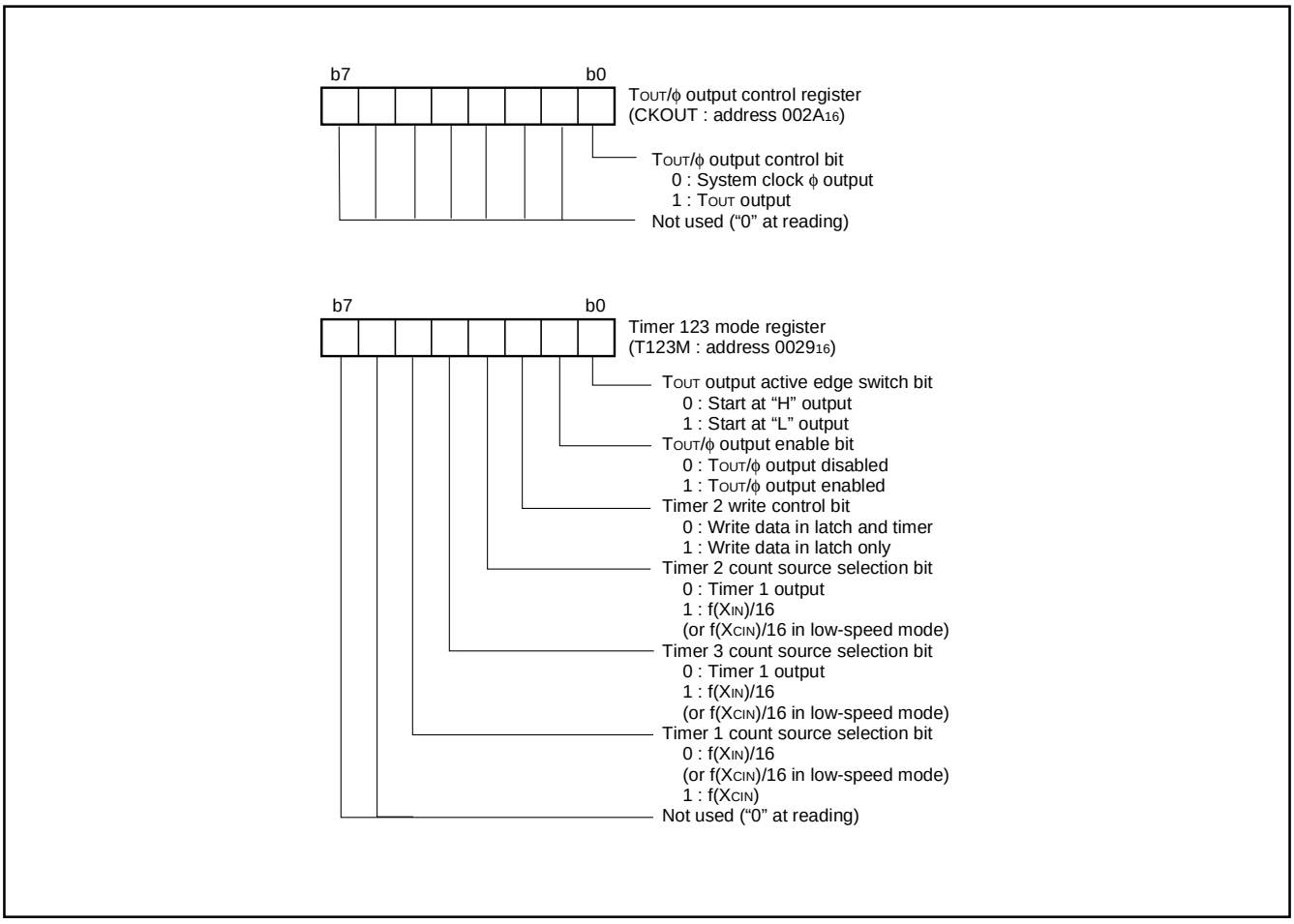


Fig. 55 Structure of TOUT/ϕ output-related registers

RESET CIRCUIT

When the power source voltage is within limits, and main clock XIN-XOUT is stable, or a stabilized clock is input to the XIN pin, if the RESET pin is held at an "L" level for 2 μs or more, the microcomputer is in an internal reset state. Then the RESET pin is returned to an "H" level, reset is released after approximate 8200 cycles of f(XIN), the program in address FFFD16 (high-order byte) and address FFFC16 (low-order byte). Make sure that the reset input voltage is less than 0.2 VCC(min.) for the power source voltage of VCC(min.).

*VCC(min.) = Minimum value of power supply voltage limits applied to VCC pin

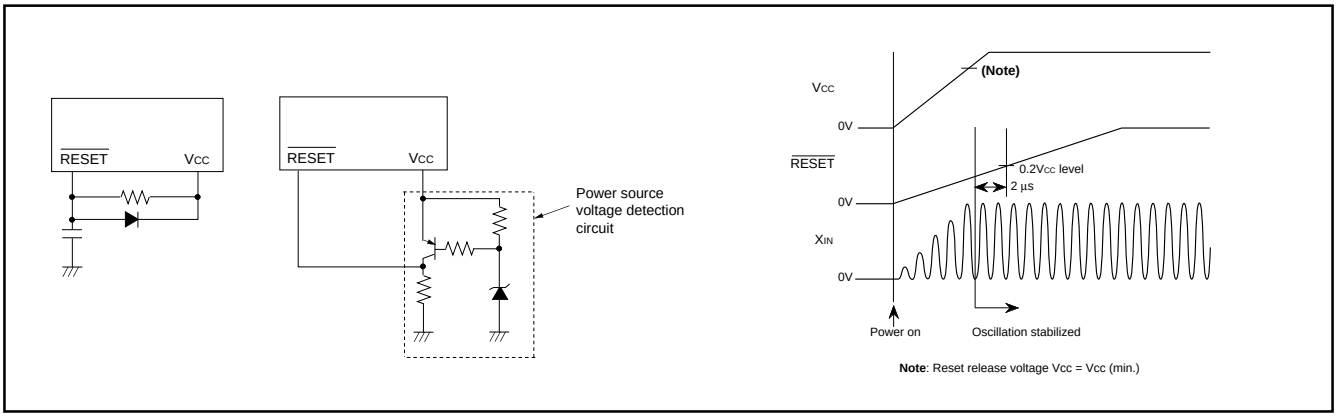


Fig. 56 Example of reset circuit

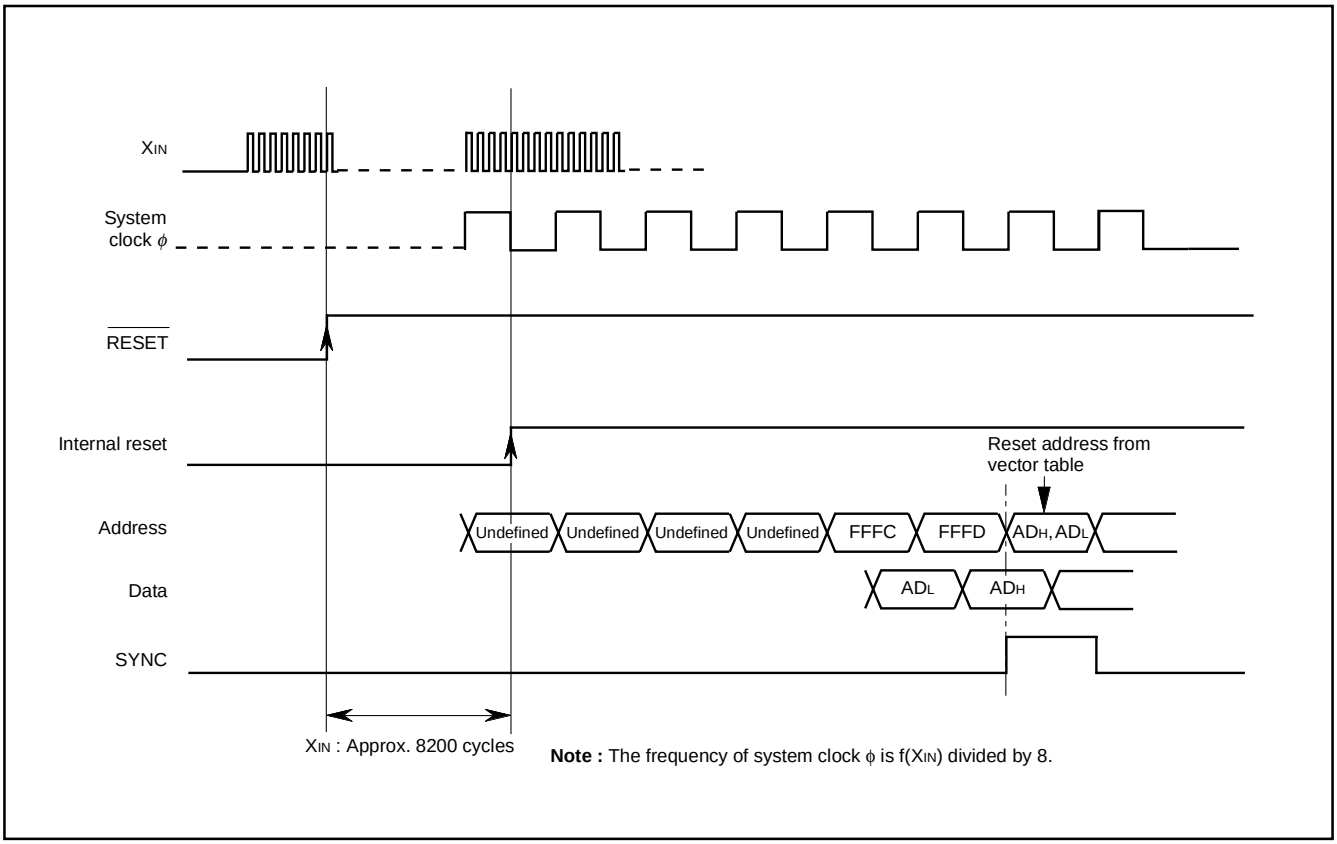


Fig. 57 Reset Sequence

		Address	Register contents
(1)	Port P0 direction register	0001_{16}	00_{16}
(2)	Port P1 direction register	0003_{16}	00_{16}
(3)	Port P2 direction register	0005_{16}	00_{16}
(4)	Port P3 output control register	0007_{16}	00_{16}
(5)	Port P4 direction register	0009_{16}	00_{16}
(6)	Port P5 direction register	$000B_{16}$	00_{16}
(7)	Port P6 direction register	$000D_{16}$	00_{16}
(8)	Port P7 direction register	$000F_{16}$	00_{16}
(9)	AD conversion low-order register	0014_{16}	X X 0 0 0 0 0 1
(10)	Key input control register	0015_{16}	00_{16}
(11)	PULL register A	0016_{16}	$3F_{16}$
(12)	PULL register B	0017_{16}	00_{16}
(13)	Serial I/O1 status register	0019_{16}	1 0 0 0 0 0 0 0
(14)	Serial I/O1 control register	$001A_{16}$	00_{16}
(15)	UART control register	$001B_{16}$	1 1 1 0 0 0 0 0
(16)	Serial I/O2 control register	$001D_{16}$	00_{16}
(17)	Timer X low-order register	0020_{16}	FF_{16}
(18)	Timer X high-order register	0021_{16}	FF_{16}
(19)	Timer Y low-order register	0022_{16}	FF_{16}
(20)	Timer Y high-order register	0023_{16}	FF_{16}
(21)	Timer 1 register	0024_{16}	FF_{16}
(22)	Timer 2 register	0025_{16}	01_{16}
(23)	Timer 3 register	0026_{16}	FF_{16}
(24)	Timer X mode register	0027_{16}	00_{16}
(25)	Timer Y mode register	0028_{16}	00_{16}
(26)	Timer 123 mode register	0029_{16}	00_{16}
(27)	T_{OUT}/ϕ output control register	$002A_{16}$	00_{16}
(28)	PWM control register	$002B_{16}$	00_{16}
(29)	D-A1 conversion register	0032_{16}	00_{16}
(30)	D-A2 conversion register	0033_{16}	00_{16}
(31)	A-D control register	0034_{16}	0 0 0 0 1 0 0 0
(32)	D-A control register	0036_{16}	00_{16}
(33)	Watchdog timer control register	0037_{16}	0 0 1 1 1 1 1 1
(34)	Segment output enable register	0038_{16}	00_{16}
(35)	LCD mode register	0039_{16}	00_{16}
(36)	Interrupt edge selection register	$003A_{16}$	00_{16}
(37)	CPU mode register	$003B_{16}$	0 1 0 0 1 0 0 0
(38)	Interrupt request register 1	$003C_{16}$	00_{16}
(39)	Interrupt request register 2	$003D_{16}$	00_{16}
(40)	Interrupt control register 1	$003E_{16}$	00_{16}
(41)	Interrupt control register 2	$003F_{16}$	00_{16}
(42)	Processor status register	(PS)	X X X X X 1 X X
(43)	Program counter	(PC_H)	Contents of address $FFFD_{16}$
		(PC_L)	Contents of address $FFFC_{16}$
(44)	Watchdog timer (high-order)		$3F_{16}$
(45)	Watchdog timer (low-order)		FF_{16}

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

Fig. 58 Internal state of microcomputer immediately after reset

CLOCK GENERATING CIRCUIT

The 7560 group has two built-in oscillation circuits: main clock XIN-XOUT oscillation circuit and sub-clock XCIN-XCOUT oscillation circuit. An oscillation circuit can be formed by connecting an oscillator between XIN and XOUT (XCIN and XCOUT). Use the circuit constants in accordance with the oscillator manufacturer's recommended values. No external resistor is needed between XIN and XOUT since a feed-back resistor exists on-chip. However, an external feed-back resistor is needed between XCIN and XCOUT since a resistor does not exist between them.

To supply a clock signal externally, input it to the XIN pin and make the XOUT pin open. The sub-clock oscillation circuit cannot directly input clocks that are externally generated. Accordingly, be sure to cause an external oscillator to oscillate.

Immediately after poweron, only the XIN oscillation circuit starts oscillating, and XCIN and XCOUT pins go to high-impedance state.

Frequency Control
(1) Middle-speed mode

The clock input to the XIN pin is divided by 8 and it is used as the system clock ϕ.

After reset, this mode is selected.

(2) High-speed mode

The clock input to the XIN pin is divided by 2 and it is used as the system clock ϕ.

(3) Low-speed mode

- The clock input to the XCIN pin is divided by 2 and it is used as the system clock ϕ.
- A low-power consumption operation can be realized by stopping the main clock in this mode. To stop the main clock, set the main clock stop bit of the CPU mode register to "1".
  When the main clock is restarted, after setting the main clock stop bit to "0", set enough time for oscillation to stabilize by program.

Note: 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 poweron and at returning from stop mode. When switching the mode between middle/high-speed and low-speed, set the frequency in the condition that f(XIN) > 3•f(XCIN).

Oscillation Control
(1) Stop mode

If the STP instruction is executed, the system clock ϕ stops at an "H" level, and main and sub clock oscillators stop.

In this time, values set previously to timer 1 latch and timer 2 latch are loaded automatically to timer 1 and timer 2. Before the STP instruction, set the values to generate the wait time required for oscillation stabilization to timer 1 latch and timer 2 latch (low-order 8 bits are set to timer 1, high-order 8 bits are set to timer 2). Either f(XIN) or f(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 123 mode register except bit 4 are set to "0". Set the timer 1 and timer 2 interrupt enable bits to "0" before executing the STP instruction.

Oscillation restarts at reset or when an external interrupt is received, but the system clock ϕ is not supplied to the CPU until timer 2 underflows. This allows time for the clock circuit oscillation to stabilize when a ceramic resonator is used.

(2) Wait mode

If the WIT instruction is executed, only the system clock ϕ stops at an "H" state. The states of main clock and sub clock are the same as the state before the executing the WIT instruction, and oscillation does not stop. Since supply of internal clock ϕ is started immediately after the interrupt is received, the instruction can be executed immediately.

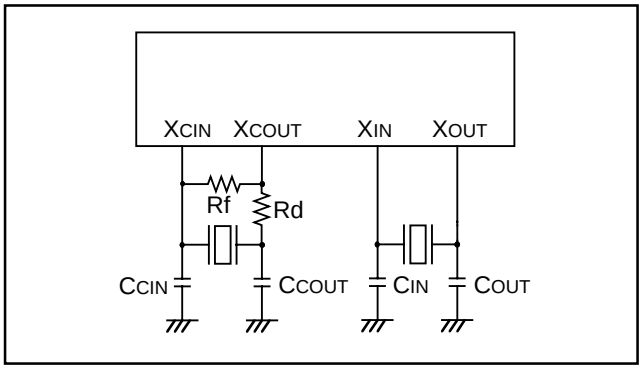


Fig. 59 Oscillator circuit

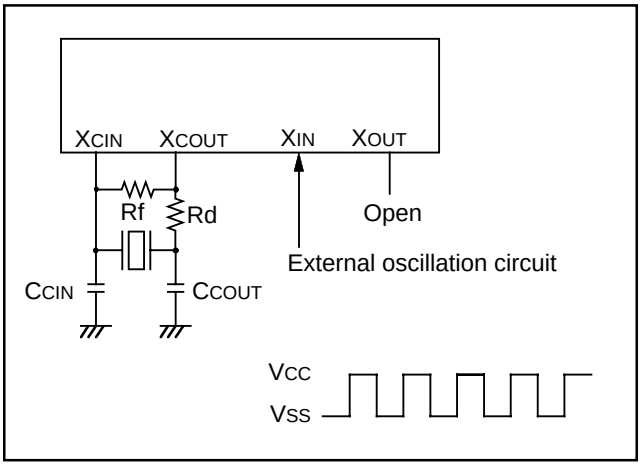
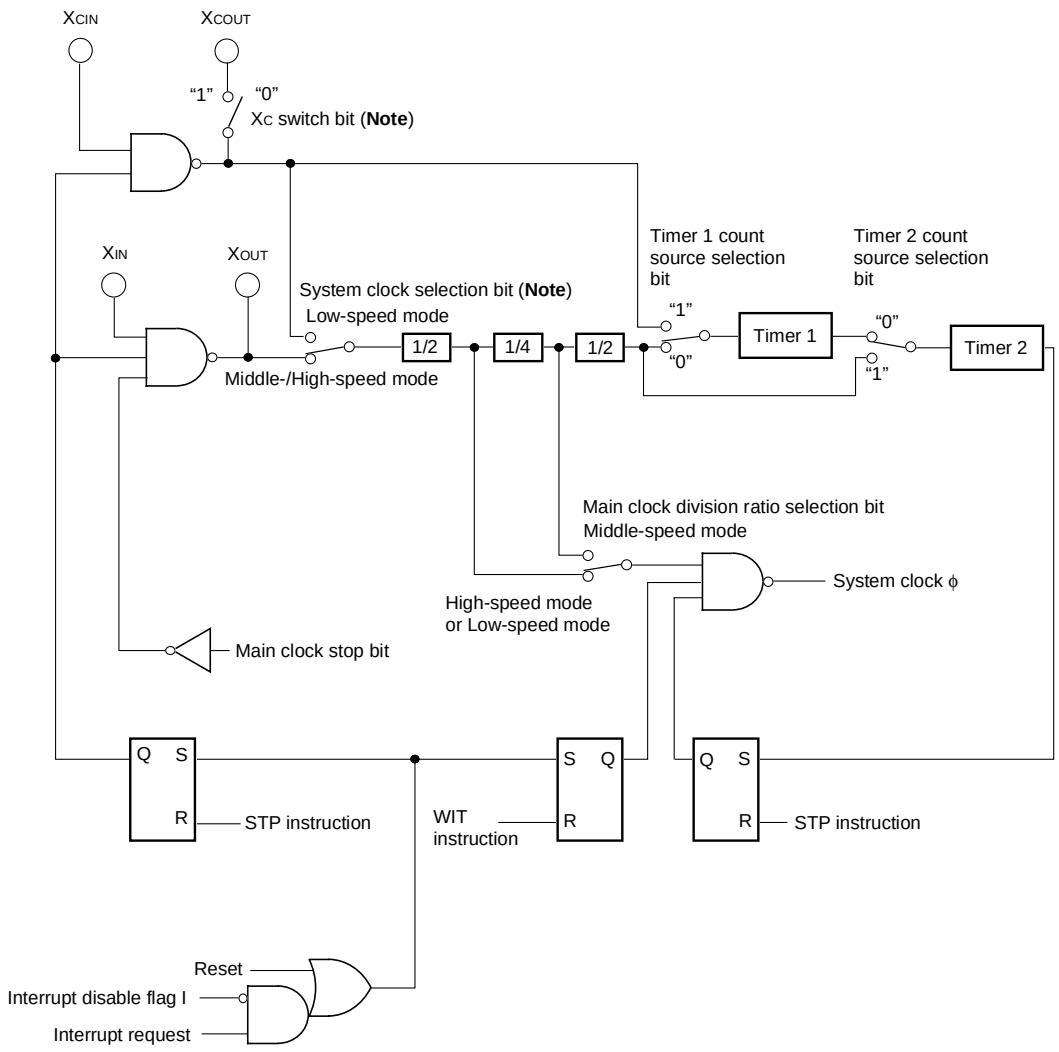
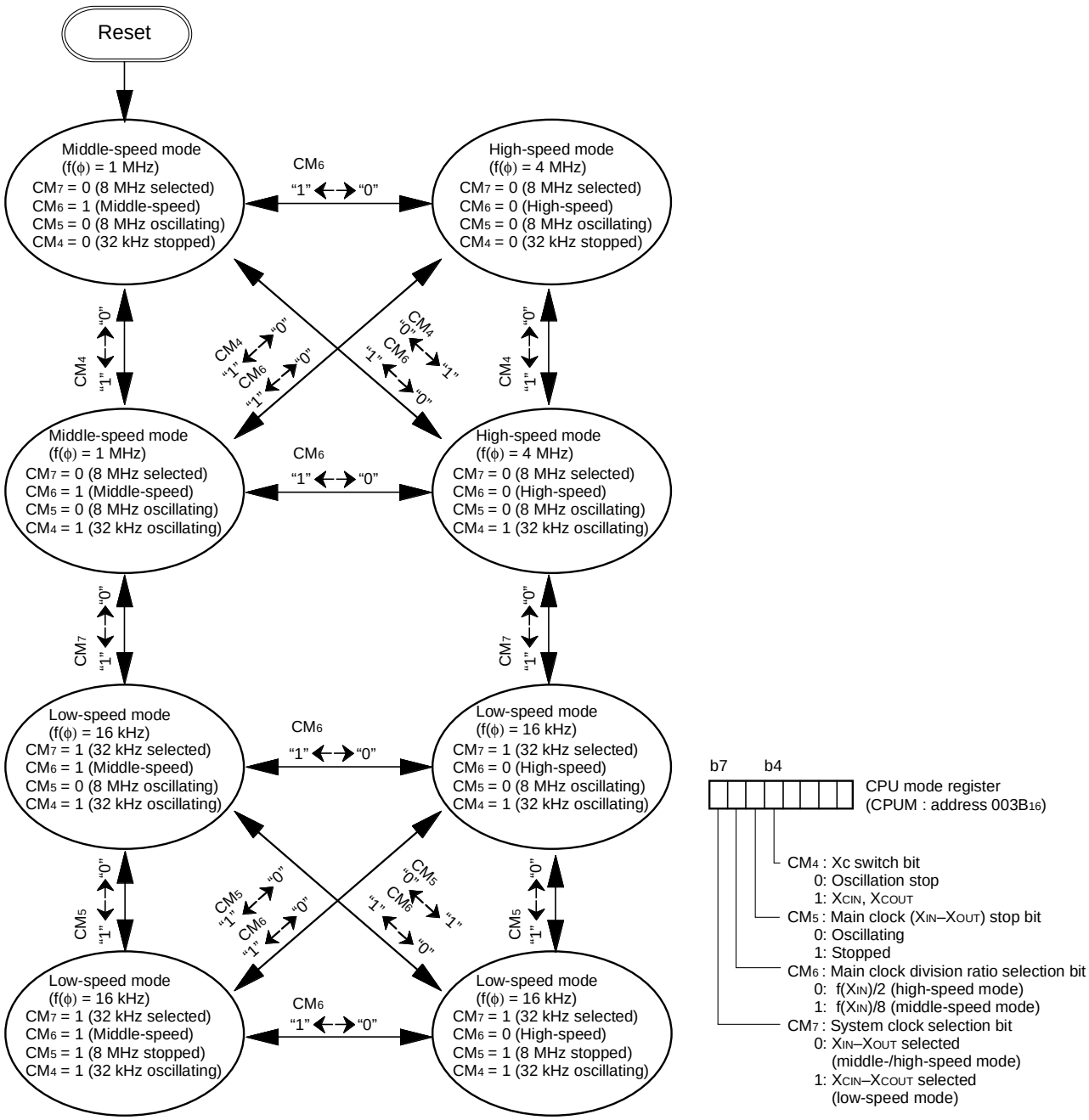


Fig. 60 External clock input circuit



Note: When using the sub clock for the system clock ϕ, set the XC switch bit to "1".

Fig. 61 Clock generating circuit block diagram



Notes 1: Switch the mode according to the arrows shown between the mode blocks. (Do not switch between the mode directly without an arrow.)
2: The all modes can be switched to the stop mode or the wait mode and returned to the source mode when the stop mode or the wait mode is ended.
3: When the stop mode is ended, a delay time can be set by timer 1 and timer 2.
4: Timer and LCD operate in the wait mode.
5: Wait until oscillation stabilizes after oscillating the main clock before the switching from the low-speed mode to middle-/high-speed mode.
6: The example assumes that 8 MHz is being applied to the X_{IN} pin and 32 kHz to the X_{CIN} pin. ϕ indicates the system clock.

Fig. 62 State transitions of system clock

NOTES ON PROGRAMMING
Processor Status Register

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

Interrupt

When the contents of an interrupt request bits are changed by the program, execute a BBC or BBS instruction after at least one instruction. This is for preventing executing a BBC or BBS instruction to the contents before change.

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.

Multiplication and Division Instructions

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

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

Ports

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

The contents of the port direction registers cannot be read.

The following cannot be used:

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

Serial I/O

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

The TxD pin of serial I/O1 retains the level then after transmission is completed.

In serial I/O2 selecting an internal clock, the SOUT2 pin goes to high impedance state after transmission is completed.

In serial I/O2 selecting an external clock, the SOUT2 pin retains the level then after transmission is completed.

A-D Converter

The input to the comparator is combined by internal capacitors. Therefore, since conversion accuracy may be worse by losing of an electric charge when the conversion speed is not enough, make sure that f(XIN) is at least 500 kHz during an A-D conversion.

The normal operation of A-D conversion cannot be guaranteed when performing the next operation:

- When writing to CPU mode register during A-D conversion operation
- When writing to A-D control register during A-D conversion operation
- When executing STP instruction or WIT instruction during A-D conversion operation

Instruction Execution Time

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

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

The frequency of the system clock ϕ depends on the main clock division ratio selection bit and the system clock selection bit.

NOTES ON USE
Countermeasures Against Noise

(1) Shortest wiring length

① Wiring for $\overline{\text{RESET}}$ pin

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

● Reason

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

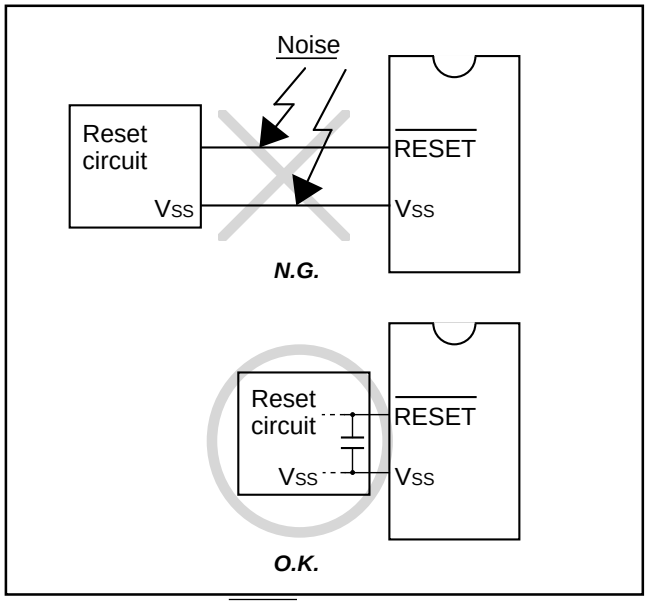


Fig. 63 Wiring for the $\overline{\text{RESET}}$ pin

② 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.

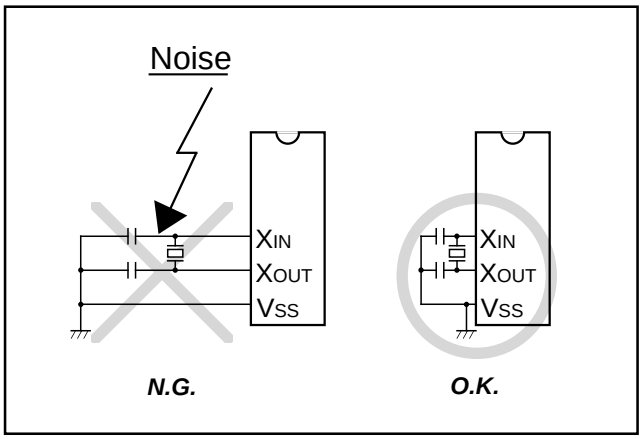


Fig. 64 Wiring for clock I/O pins

(2) Connection of bypass capacitor across Vss line and Vcc line

In order to stabilize the system operation and avoid the latch-up, 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.

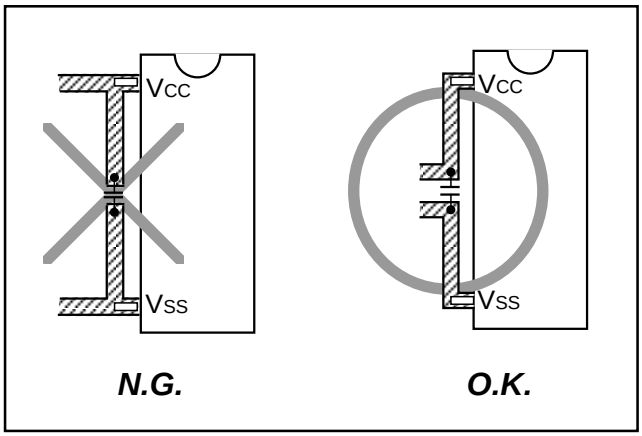


Fig. 65 Bypass capacitor across the Vss line and the Vcc line

(3) Oscillator concerns

In order to obtain the stabilized operation clock on the user system and its condition, contact the oscillator manufacturer and select the oscillator and oscillation circuit constants. Be careful especially when range of voltage or/and temperature is wide.

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

① Keeping oscillator away from large current signal lines

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

● Reason

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

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

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

● Reason

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

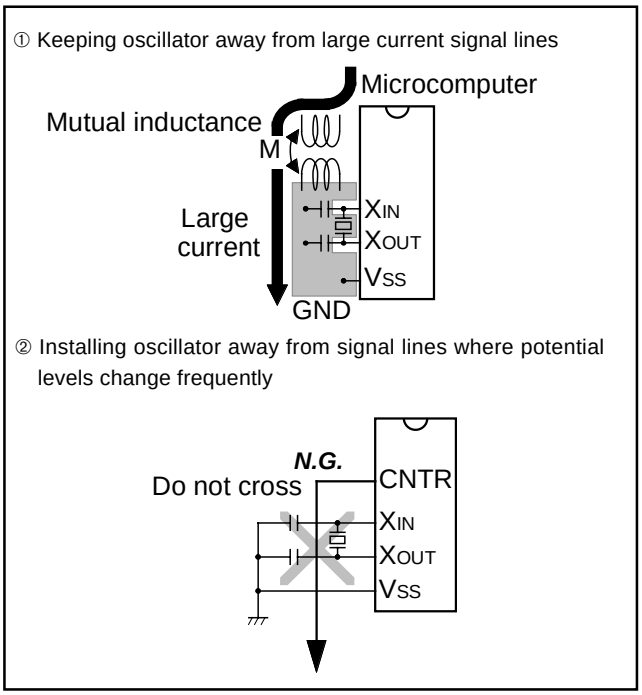


Fig. 66 Wiring for a large current signal line/Wiring of signal lines where potential levels change frequently

(4) Analog input

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

(5) Difference of memory type and size

When Mask ROM and PROM version and memory size differ in one group, actual values such as an electrical characteristics, A-D conversion accuracy, and the amount of proof of noise incorrect operation may differ from the ideal values.

When these products are used switching, perform system evaluation for each product of every after confirming product specification.

(6) Wiring to V_{PP} pin of One Time PROM version and EPROM version

Connect an approximately 5 kΩ resistor to the V_{PP} pin the shortest possible in series.

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

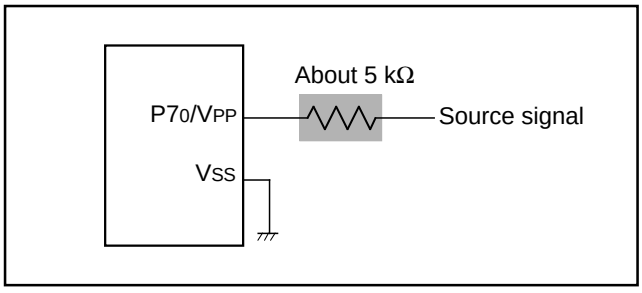


Fig. 67 Wiring for the V_{PP} pin of One Time PROM

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) or one floppy disk.

*For the mask ROM confirmation and the mark specifications, refer to the "Mitsubishi MCU Technical Information" Homepage (http://www.infomicom.maec.co.jp/indexe.htm).

ROM PROGRAMMING METHOD

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

Table 14 Special programming adapter

Package	Name of Programming Adapter
100P6S-A	PCA4738F-100A
100P6Q-A	PCA4738G-100A
100D0	PCA4738L-100A

The PROM of the blank One Time PROM version is not tested or screened in the assembly process and following processes. To ensure proper operation after programming, the procedure shown in Figure 68 is recommended to verify programming.

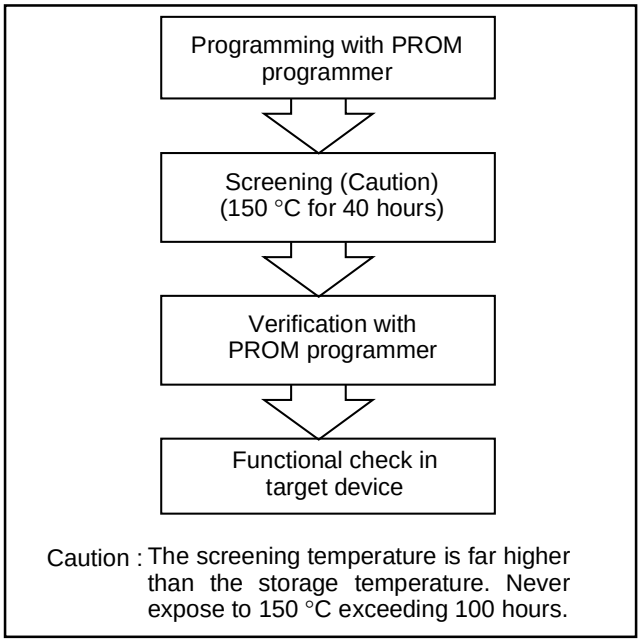


Fig. 68 State transitions of system clock

ELECTRICAL CHARACTERISTICS
ABSOLUTE MAXIMUM RATINGS

Table 15 Absolute maximum ratings

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 6.5	V
V_I	Input voltage $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage $P7_0$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3}		V_{L2} to 6.5	V
V_I	Input voltage C_1, C_2		–0.3 to 6.5	V
V_I	Input voltage $\overline{RESET}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C_1, C_2		–0.3 to 6.5	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3}		–0.3 to 6.5	V
V_O	Output voltage V_{L2}, SEG_0–SEG_{17}		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	Ta = 25°C	300	mW
Topr	Operating temperature		–20 to 85	°C
Tstg	Storage temperature		–40 to 125	°C

RECOMMENDED OPERATING CONDITIONS

Table 16 Recommended operating conditions (1) (V_{CC} = 2.2 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V_{CC}	Power source voltage	High-speed mode f(X_{IN}) = 8 MHz	4.0	5.0	5.5	V
		Middle-speed mode f(X_{IN}) = 8 MHz	2.2	5.0	5.5	
		Low-speed mode	2.2	5.0	5.5	
V_{SS}	Power source voltage			0		V
V_{REF}	A-D, D-A conversion reference voltage		2.0		V_{CC}	V
AV_{SS}	Analog power source voltage			0		V
V_{IA}	Analog input voltage AN_0–AN_7		AV_{SS}		V_{CC}	V

Table 17 Recommended operating conditions (2) (V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V_{IH}	"H" input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0.7 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0.8 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	$\overline{RESET}$	0.8 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	X_{IN}	0.8 V_{CC}		V_{CC}	V
V_{IL}	"L" input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0		0.3 V_{CC}	V
V_{IL}	"L" input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0		0.2 V_{CC}	V
V_{IL}	"L" input voltage	$\overline{RESET}$	0		0.2 V_{CC}	V
V_{IL}	"L" input voltage	X_{IN}	0		0.2 V_{CC}	V

Table 18 Recommended operating conditions (3) (V_{CC} = 2.2 to 2.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V_{IH}	"H" input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0.8 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0.95 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	$\overline{RESET}$	0.95 V_{CC}		V_{CC}	V
V_{IH}	"H" input voltage	X_{IN}	0.95 V_{CC}		V_{CC}	V
V_{IL}	"L" input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0		0.2 V_{CC}	V
V_{IL}	"L" input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0		0.05 V_{CC}	V
V_{IL}	"L" input voltage	$\overline{RESET}$	0		0.05 V_{CC}	V
V_{IL}	"L" input voltage	X_{IN}	0		0.05 V_{CC}	V

Table 19 Recommended operating conditions (4) (V_{CC} = 2.2 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			80	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			40	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			–1.0	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			10	mA
$I_{OL(peak)}$	"L" peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 2)**			20	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			–0.5	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			–2.5	mA
$I_{OL(avg)}$	"L" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			2.5	mA
$I_{OL(avg)}$	"L" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			5.0	mA
$I_{OL(avg)}$	"L" average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 3)**			10	mA

Notes1: The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.

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

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

Table 20 Recommended operating conditions (5) (V_{CC} = 2.2 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

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

Notes1: When the oscillation frequency has a duty cycle of 50%.
2: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that f(X_{CIN}) < f(X_{IN})/3.

Table 21 Electrical characteristics (1) (V_{CC} =4.0 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{OH}	"H" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –1 mA	V_{CC}–2.0			V
		I_{OH} = –0.25 mA V_{CC} = 2.2 V	V_{CC}–0.8			V
V_{OH}	"H" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**	I_{OH} = –5 mA	V_{CC}–2.0			V
		I_{OH} = –1.5 mA	V_{CC}–0.5			V
		I_{OH} = –1.25 mA V_{CC} = 2.2 V	V_{CC}–0.8			V
V_{OL}	"L" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
		I_{OL} = 1.5 mA			0.5	V
		I_{OL} = 1.25 mA V_{CC} = 2.2 V			0.8	V
V_{OL}	"L" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	I_{OL} = 10 mA			2.0	V
		I_{OL} = 3.0 mA			0.5	V
		I_{OL} = 2.5 mA V_{CC} = 2.2 V			0.8	V
V_{OL}	"L" output voltage $P4_0$, $P7_1$–$P7_7$	I_{OL} = 10 mA			0.5	V
		I_{OL} = 5 mA V_{CC} = 2.2 V			0.3	V
V_{T+} – V_{T-}	Hysteresis INT_0–INT_2, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis S_{CLK}, R_XD, S_{IN2}			0.5		V
V_{T+} – V_{T-}	Hysteresis $\overline{RESET}$			0.5		V
I_{IH}	"H" input current $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current $\overline{RESET}$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current X_{IN}	V_I = V_{CC}		4.0		µA
I_{IL}	"L" input current $P0_0$–$P0_7$,$P1_0$–$P1_7$, $P2_0$–$P2_7$,$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	V_I = V_{SS} Pull-ups "off"			–5.0	µA
		V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–60.0	–120.0	–240.0	µA
		V_{CC} = 2.2 V, V_I = V_{SS} Pull-ups "on"	–5.0	–20.0	–40.0	µA
I_{IL}	"L" input current $P4_0$, $P7_0$–$P7_7$				–5.0	µA
I_{IL}	"L" input current $\overline{RESET}$	V_I = V_{SS}			–5.0	µA
I_{IL}	"L" input current X_{IN}	V_I = V_{SS}		–4.0		µA
I_{LOAD}	Output load current $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pullup ON Output transistors "off"	–60.0	–120.0	–240.0	µA
		V_{CC} = 2.2 V,V_O = V_{CC}, Pullup ON Output transistors "off"	–5.0	–20.0	–40.0	µA
I_{LEAK}	Output leak current $P3_0$–$P3_7$	V_O = V_{CC}, Pullup OFF Output transistors "off"			5.0	µA
		V_O = V_{SS}, Pullup OFF Output transistors "off"			–5.0	µA

Table 22 Electrical characteristics (2) (V_{CC} =2.2 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode		2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating			6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter stop			1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			35	70	µA
		• Low-speed mode, V_{CC} = 5 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			20	40	µA
		• Low-speed mode, V_{CC} = 3 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			15	22	µA
		• Low-speed mode, V_{CC} = 3 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off”	Ta = 25 °C		0.1	1.0	µA
			Ta = 85 °C			10	
V_{L1}	Power source voltage	When using voltage multiplier		1.3	1.8	2.1	V
I_{L1}	Power source current (V_{L1}) **(Note)**	V_{L1} = 1.8 V			4.0		µA

Note: When the voltage multiplier control bit of the LCD mode register (bit 4 at address 0039_{16}) is “1”.

Table 23 A-D converter characteristics
(V_{CC} = 2.7 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)
8-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "1")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 2.7 to 5.5 V			±2	LSB
t_{CONV}	Conversion time		49		50	tc(ADCLK) **(Note)**
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog port input current				5.0	µA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

Table 24 A-D converter characteristics
(V_{CC} = 2.7 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)
10-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "0")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				10	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 2.7 to 5.5 V			±4	LSB
t_{CONV}	Conversion time		61		62	tc(ADCLK) **(Note)**
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog port input current				5.0	µA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

Table 25 D-A converter characteristics
(V_{CC} = 2.7 to 5.5 V, V_{CC} = V_{REF}, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy	V_{CC} = V_{REF} = 5 V			1.0	%
		V_{CC} = V_{REF} = 2.7 V			2.0	%
t_{su}	Setting time			3		µs
R_O	Output resistor		1	2.5	4	kΩ
I_{VREF}	Reference power source input current	**(Note)**			3.2	mA

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

Table 26 Timing requirements 1 (V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	80			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	800			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	370			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	370			ns
$t_{su(R_xD–S_{CLK1})}$	Serial I/O1 input set up time	220			ns
$t_{h(S_{CLK1}–R_xD)}$	Serial I/O1 input hold time	100			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	1000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	400			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	400			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	200			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	200			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

Table 27 Timing requirements 2 (V_{CC} = 2.2 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	900/(V_{CC}-0.4)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	$t_{c(CNTR)}$/2–20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	$t_{c(CNTR)}$/2–20			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	230			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	950			ns
$t_{su(R_xD–S_{CLK1})}$	Serial I/O1 input set up time	400			ns
$t_{h(S_{CLK1}–R_xD)}$	Serial I/O1 input hold time	200			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	950			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	400			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	300			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

Table 28 Switching characteristics 1 (V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	t_C (S_{CLK1})/2–30			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	t_C (S_{CLK1})/2–30			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			140	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			30	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			30	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	t_C (S_{CLK2})/2–160			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	t_C (S_{CLK2})/2–160			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X t_C (S_{CLK2})	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			40	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		10	30	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.

Table 29 Switching characteristics 2 (V_{CC} = 2.2 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	t_C (S_{CLK1})/2–50			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	t_C (S_{CLK1})/2–50			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			350	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			50	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			50	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	t_C (S_{CLK2})/2–240			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	t_C (S_{CLK2})/2–240			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X t_C (S_{CLK2})	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		20	50	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.

ELECTRICAL CHARACTERISTICS (EPROM or One Time PROM version)
ABSOLUTE MAXIMUM RATINGS (EPROM or One Time PROM version)

Table 30 Absolute maximum ratings (EPROM or One Time PROM version)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 7.0	V
V_I	Input voltage $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage $P7_0$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3}		V_{L2} to 7.0	V
V_I	Input voltage C_1, C_2		–0.3 to 7.0	V
V_I	Input voltage $\overline{RESET}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C_1, C_2		–0.3 to 7.0	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3}		–0.3 to 7.0	V
V_O	Output voltage V_{L2}, SEG_0–SEG_{17}		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	Ta = 25°C	300	mW
Topr	Operating temperature		–20 to 85	°C
Tstg	Storage temperature		–40 to 125	°C

RECOMMENDED OPERATING CONDITIONS (EPROM or One Time PROM version)

Table 31 Recommended operating conditions (1) (EPROM or One Time PROM version)

(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V_{CC}	Power source voltage	High-speed mode f(X_{IN}) = 8 MHz	4.0	5.0	5.5	V
		Middle-speed mode f(X_{IN}) = 8 MHz	2.5	5.0	5.5	
		Low-speed mode	2.5	5.0	5.5	
V_{SS}	Power source voltage			0		V
V_{REF}	A-D, D-A conversion reference voltage		2.0		V_{CC}	V
AV_{SS}	Analog power source voltage			0		V
V_{IA}	Analog input voltage AN_0–AN_7		AV_{SS}		V_{CC}	V
V_{IH}	“H” input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0.7 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0.8 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$\overline{RESET}$	0.8 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	X_{IN}	0.8 V_{CC}		V_{CC}	V
V_{IL}	“L” input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$	0		0.3 V_{CC}	V
V_{IL}	“L” input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$	0		0.2 V_{CC}	V
V_{IL}	“L” input voltage	$\overline{RESET}$	0		0.2 V_{CC}	V
V_{IL}	“L” input voltage	X_{IN}	0		0.2 V_{CC}	V

Table 32 Recommended operating conditions (2) (EPROM or One Time PROM version)
(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			80	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			40	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			–1.0	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			10	mA
$I_{OL(peak)}$	"L" peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 2)**			20	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			–0.5	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			–2.5	mA
$I_{OL(avg)}$	"L" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			2.5	mA
$I_{OL(avg)}$	"L" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			5.0	mA
$I_{OL(avg)}$	"L" average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 3)**			10	mA

Notes1: The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.
2: The peak output current is the peak current flowing in each port.
3: The average output current is an average value measured over 100 ms.

Table 33 Recommended operating conditions (3) (EPROM or One Time PROM version)
(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$f(CNTR_0)$ $f(CNTR_1)$	Input frequency for timers X and Y (duty cycle 50%)	(4.0 V ≤ V_{CC} ≤ 5.5 V)			4.0	MHz
		(V_{CC} ≤ 4.0 V)			(2×V_{CC}) –4	MHz
$f(X_{IN})$	Main clock input oscillation frequency **(Note 1)**	High-speed mode (4.0 V ≤ V_{CC} ≤ 5.5 V)			8.0	MHz
		High-speed mode (2.5 V ≤ V_{CC} ≤ 4.0 V)			(4×V_{CC}) –8	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency **(Notes 1, 2)**			32.768	50	kHz

Notes1: When the oscillation frequency has a duty cycle of 50%.
2: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

ELECTRICAL CHARACTERISTICS (EPROM or One Time PROM version)

Table 34 Electrical characteristics (1) (EPROM or One Time PROM version)

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

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{OH}	"H" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –1 mA	V_{CC}–2.0			V
		I_{OH} = –0.25 mA V_{CC} = 2.5 V	V_{CC}–0.8			V
V_{OH}	"H" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**	I_{OH} = –5 mA	V_{CC}–2.0			V
		I_{OH} = –1.5 mA	V_{CC}–0.5			V
		I_{OH} = –1.25 mA V_{CC} = 2.5 V	V_{CC}–0.8			V
V_{OL}	"L" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
		I_{OL} = 1.5 mA			0.5	V
		I_{OL} = 1.25 mA V_{CC} = 2.5 V			0.8	V
V_{OL}	"L" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	I_{OL} = 10 mA			2.0	V
		I_{OL} = 3.0 mA			0.5	V
		I_{OL} = 2.5 mA V_{CC} = 2.5 V			0.8	V
V_{OL}	"L" output voltage $P4_0$, $P7_1$–$P7_7$	I_{OL} = 10 mA			0.5	V
		I_{OL} = 5 mA V_{CC} = 2.5 V			0.3	V
V_{T+} – V_{T-}	Hysteresis INT_0–INT_2, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis S_{CLK}, R_XD, S_{IN2}			0.5		V
V_{T+} – V_{T-}	Hysteresis $\overline{RESET}$			0.5		V
I_{IH}	"H" input current $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current $\overline{RESET}$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current X_{IN}	V_I = V_{CC}		4.0		µA
I_{IL}	"L" input current $P0_0$–$P0_7$,$P1_0$–$P1_7$, $P2_0$–$P2_7$,$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	V_I = V_{SS} Pull-ups "off"			–5.0	µA
		V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–60.0	–120.0	–240.0	µA
		V_{CC} = 2.5 V, V_I = V_{SS} Pull-ups "on"	–6.0	–25.0	–45.0	µA
I_{IL}	"L" input current $P4_0$, $P7_0$–$P7_7$				–5.0	µA
I_{IL}	"L" input current $\overline{RESET}$	V_I = V_{SS}			–5.0	µA
I_{IL}	"L" input current X_{IN}	V_I = V_{SS}		–4.0		µA
I_{LOAD}	Output load current $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pullup ON Output transistors "off"	–60.0	–120.0	–240.0	µA
		V_{CC} = 2.5 V,V_O = V_{CC}, Pullup ON Output transistors "off"	–6.0	–25.0	–45.0	µA
I_{LEAK}	Output leak current $P3_0$–$P3_7$	V_O = V_{CC}, Pullup OFF Output transistors "off"			5.0	µA
		V_O = V_{SS}, Pullup OFF Output transistors "off"			–5.0	µA

Table 35 Electrical characteristics (2) (EPROM or One Time PROM version)
(V_{CC} =2.5 to 5.5 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode		2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating			6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter stop			1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			35	70	µA
		• Low-speed mode, V_{CC} = 5 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			20	40	µA
		• Low-speed mode, V_{CC} = 3 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			15	22	µA
		• Low-speed mode, V_{CC} = 3 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off”	Ta = 25 °C		0.1	1.0	µA
			Ta = 85 °C			10	
V_{L1}	Power source voltage	When using voltage multiplier		1.3	1.8	2.3	V
I_{L1}	Power source current (V_{L1}) **(Note)**	V_{L1} = 1.8 V			4.0		µA

Note: When the voltage multiplier control bit of the LCD mode register (bit 4 at address 0039_{16}) is “1”.

A-D CONVERTER CHARACTERISTICS (EPROM or One Time PROM version)

Table 36 A-D converter characteristics (EPROM or One Time PROM version)

(V_{CC} = 2.7 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)

8-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "1")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 2.7 to 5.5 V			±2	LSB
t_{CONV}	Conversion time		49		50	tc(ADCLK) (Note)
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	μA
I_{IA}	Analog port input current				5.0	μA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

Table 37 A-D converter characteristics (EPROM or One Time PROM version)

(V_{CC} = 2.7 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)

10-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "0")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				10	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 2.7 to 5.5 V			±4	LSB
t_{CONV}	Conversion time		61		62	tc(ADCLK) (Note)
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	μA
I_{IA}	Analog port input current				5.0	μA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

D-A CONVERTER CHARACTERISTICS (EPROM or One Time PROM version)

Table 38 D-A converter characteristics (EPROM or One Time PROM version)

(V_{CC} = 2.7 to 5.5 V, V_{CC} = V_{REF}, V_{SS} = AV_{SS} = 0 V, Ta = –20 to 85°C, in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy	V_{CC} = V_{REF} = 5 V			1.0	%
		V_{CC} = V_{REF} = 2.7 V			2.0	%
t_{su}	Setting time			3		μs
R_O	Output resistor		1	2.5	4	kΩ
I_{VREF}	Reference power source input current	**(Note)**			3.2	mA

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

TIMING REQUIREMENTS (EPROM or One Time PROM version)

Table 39 Timing requirements 1 (EPROM or One Time PROM version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	80			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	800			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	370			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	370			ns
$t_{su(R_{xD}–S_{CLK1})}$	Serial I/O1 input set up time	220			ns
$t_{h(S_{CLK1}–R_{xD})}$	Serial I/O1 input hold time	100			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	1000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	400			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	400			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	200			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	200			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

Table 40 Timing requirements 2 (EPROM or One Time PROM version)

(V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	500/(V_{CC}-2)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	250/(V_{CC}-2)–20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	250/(V_{CC}-2)–20			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	230			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	950			ns
$t_{su(R_{xD}–S_{CLK1})}$	Serial I/O1 input set up time	400			ns
$t_{h(S_{CLK1}–R_{xD})}$	Serial I/O1 input hold time	200			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	950			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	400			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	300			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

SWITCHING CHARACTERISTICS (EPROM or One Time PROM version)

Table 41 Switching characteristics 1 (EPROM or One Time PROM version)
(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	t_C (S_{CLK1})/2–30			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	t_C (S_{CLK1})/2–30			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			140	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			30	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			30	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	t_C (S_{CLK2})/2–160			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	t_C (S_{CLK2})/2–160			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X t_C (S_{CLK2})	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			40	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		10	30	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.

Table 42 Switching characteristics 2 (EPROM or One Time PROM version)
(V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	t_C (S_{CLK1})/2–50			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	t_C (S_{CLK1})/2–50			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			350	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			50	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			50	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	t_C (S_{CLK2})/2–240			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	t_C (S_{CLK2})/2–240			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X t_C (S_{CLK2})	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		20	50	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.

ELECTRICAL CHARACTERISTICS (Extended operating temperature version)
ABSOLUTE MAXIMUM RATINGS (Extended operating temperature version)

Table 43 Absolute maximum ratings (Extended operating temperature version)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage (Note 1)	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 6.5	V
V_I	Input voltage $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage $P7_0$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3} (Note 2)		V_{L2} to 6.5	V
V_I	Input voltage C_1, C_2 (Note 1)		–0.3 to 6.5	V
V_I	Input voltage $\overline{RESET}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C_1, C_2 (Note 1)		–0.3 to 6.5	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3} (Note 1)		–0.3 to 6.5	V
V_O	Output voltage V_{L2}, SEG_0–SEG_{17}		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	Ta = 25°C	300	mW
Topr	Operating temperature		–40 to 85	°C
Tstg	Storage temperature		–65 to 150	°C

Notes 1: –0.3 V to 7.0 V for M37560EFD.
2: V_{L2} to 7.0 V for M37560EFD

RECOMMENDED OPERATING CONDITIONS (Extended operating temperature version)

Table 44 Recommended operating conditions (1) (Extended operating temperature version)

(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, and V_{CC} = 3.0 to 5.5 V, Ta = –40 to –20 °C unless otherwise noted)

Symbol	Parameter			Limits			Unit
				Min.	Typ.	Max.	
V_{CC}	Power source voltage	High-speed mode f(X_{IN}) = 8 MHz		4.0	5.0	5.5	V
		Middle-speed mode f(X_{IN}) = 8 MHz	Ta = –20 to 85 °C	2.5	5.0	5.5	
			Ta = –40 to –20 °C	3.0	5.0	5.5	
		Low-speed mode	Ta = –20 to 85 °C	2.5	5.0	5.5	
			Ta = –40 to –20 °C	3.0	5.0	5.5	
V_{SS}	Power source voltage				0		V
V_{REF}	A-D, D-A conversion reference voltage			2.0		V_{CC}	V
AV_{SS}	Analog power source voltage				0		V
V_{IA}	Analog input voltage AN_0–AN_7			AV_{SS}		V_{CC}	V
V_{IH}	“H” input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$		0.7 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$		0.8 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$\overline{RESET}$		0.8 V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	X_{IN}		0.8 V_{CC}		V_{CC}	V
V_{IL}	“L” input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P4_0$, $P4_3$, $P4_5$, $P4_7$, $P5_0$–$P5_3$, $P5_6$, $P6_1$, $P6_4$–$P6_7$, $P7_1$–$P7_7$		0		0.3 V_{CC}	V
V_{IL}	“L” input voltage	$P2_0$–$P2_7$, $P4_1$, $P4_2$, $P4_4$, $P4_6$, $P5_4$, $P5_5$, $P5_7$, $P6_0$, $P6_2$, $P6_3$, $P7_0$		0		0.2 V_{CC}	V
V_{IL}	“L” input voltage	$\overline{RESET}$		0		0.2 V_{CC}	V
V_{IL}	“L” input voltage	X_{IN}		0		0.2 V_{CC}	V

Table 45 Recommended operating conditions (2) (Extended operating temperature version)
(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, and V_{CC} = 3.0 to 5.5 V, Ta = –40 to –20 °C, unless otherwise noted)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			80	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 1)**			40	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			–1.0	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 2)**			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 2)**			10	mA
$I_{OL(peak)}$	"L" peak output current	$P4_0$, $P7_1$–$P7_7$ **(Note 2)**			20	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			–0.5	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			–2.5	mA
$I_{OL(avg)}$	"L" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ **(Note 3)**			2.5	mA
$I_{OL(avg)}$	"L" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 3)**			5.0	mA
$I_{OL(avg)}$	"L" average output current	$P4_0$, $P7_1$–$P7_7$ **(Note 3)**			10	mA

Notes1: The total output current is the sum of all the currents flowing through all the applicable ports. The total average current is an average value measured over 100 ms. The total peak current is the peak value of all the currents.
2: The peak output current is the peak current flowing in each port.
3: The average output current is an average value measured over 100 ms.

Table 46 Recommended operating conditions (3) (Extended operating temperature version)
(V_{CC} = 2.5 to 5.5 V, Ta = –20 to 85°C, and V_{CC} = 3.0 to 5.5 V, Ta = –40 to –20 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
$f(CNTR_0)$ $f(CNTR_1)$	Input frequency for timers X and Y (duty cycle 50%)	(4.0 V ≤ V_{CC} ≤ 5.5 V)			4.0	MHz
		(V_{CC} ≤ 4.0 V)			($2 \times V_{CC}$) –4	MHz
$f(X_{IN})$	Main clock input oscillation frequency **(Note 1)**	High-speed mode (4.0 V ≤ V_{CC} ≤ 5.5 V)			8.0	MHz
		High-speed mode (V_{CC} ≤ 4.0 V)			($4 \times V_{CC}$) –8	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency **(Notes 1, 2)**			32.768	50	kHz

Notes1: When the oscillation frequency has a duty cycle of 50%.
2: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

ELECTRICAL CHARACTERISTICS (Extended operating temperature version)

Table 47 Electrical characteristics (1) (V_{CC} =4.0 to 5.5 V, Ta = –40 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{OH}	"H" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –1 mA	V_{CC}–2.0			V
		I_{OH} = –0.25 mA V_{CC} = 3.0 V	V_{CC}–1.0			V
V_{OH}	"H" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$ **(Note 1)**	I_{OH} = –5 mA	V_{CC}–2.0			V
		I_{OH} = –1.5 mA	V_{CC}–0.5			V
		I_{OH} = –1.25 mA V_{CC} = 3.0 V	V_{CC}–1.0			V
V_{OL}	"L" output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
		I_{OL} = 1.5 mA			0.5	V
		I_{OL} = 1.25 mA V_{CC} = 3.0 V			1.0	V
V_{OL}	"L" output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	I_{OL} = 10 mA			2.0	V
		I_{OL} = 3.0 mA			0.5	V
		I_{OL} = 3.0 mA V_{CC} = 3.0 V			1.0	V
V_{OL}	"L" output voltage $P4_0$, $P7_1$–$P7_7$	I_{OL} = 10 mA			0.5	V
		I_{OL} = 5 mA V_{CC} = 3.0 V			0.4	V
V_{T+} – V_{T-}	Hysteresis INT_0–INT_2, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis S_{CLK}, R_XD, S_{IN2}			0.5		V
V_{T+} – V_{T-}	Hysteresis $\overline{RESET}$			0.5		V
I_{IH}	"H" input current $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current $\overline{RESET}$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current X_{IN}	V_I = V_{CC}		4.0		µA
I_{IL}	"L" input current $P0_0$–$P0_7$,$P1_0$–$P1_7$, $P2_0$–$P2_7$,$P4_1$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$	V_I = V_{SS} Pull-ups "off"			–5.0	µA
		V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–60.0	–120.0	–240.0	µA
		V_{CC} = 3.0 V, V_I = V_{SS} Pull-ups "on"	–7.0	–30.0	–55.0	µA
I_{IL}	"L" input current $P4_0$, $P7_0$–$P7_7$				–5.0	µA
I_{IL}	"L" input current $\overline{RESET}$	V_I = V_{SS}			–5.0	µA
I_{IL}	"L" input current X_{IN}	V_I = V_{SS}		–4.0		µA
I_{LOAD}	Output load current $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pullup ON Output transistors "off"	–60.0	–120.0	–240.0	µA
		V_{CC} = 3.0 V,V_O = V_{CC}, Pullup ON Output transistors "off"	–7.0	–30.0	–55.0	µA
I_{LEAK}	Output leak current $P3_0$–$P3_7$	V_O = V_{CC}, Pullup OFF Output transistors "off"			5.0	µA
		V_O = V_{SS}, Pullup OFF Output transistors "off"			–5.0	µA

Table 48 Electrical characteristics (2) (Extended operating temperature version)
(V_{CC} =2.5 to 5.5 V, Ta = –20 to 85°C, and V_{CC} =3.0 to 5.5 V, Ta = –40 to –20°C, unless otherwise noted)

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode		2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating			6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter stop			1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			35	70	µA
		• Low-speed mode, V_{CC} = 5 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			20	40	µA
		• Low-speed mode, V_{CC} = 3 V, Ta ≤ 55°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			15	22	µA
		• Low-speed mode, V_{CC} = 3 V, Ta = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off”	Ta = 25 °C		0.1	1.0	µA
			Ta = 85 °C			10	
V_{L1}	Power source voltage	When using voltage multiplier	M37560MFD	1.3	1.8	2.1	V
			M37560EFD	1.3	1.8	2.3	
I_{L1}	Power source current (V_{L1}) **(Note)**	V_{L1} = 1.8 V			4.0		µA

Note: When the voltage multiplier control bit of the LCD mode register (bit 4 at address 0039_{16}) is “1”.

A-D CONVERTER CHARACTERISTICS (Extended operating temperature version)

Table 49 A-D converter characteristics (Extended operating temperature version)

(V_{CC} = 3.0 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –40 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)

8-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "1")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 3.0 to 5.5 V			±2	LSB
t_{CONV}	Conversion time		49		50	tc(ADCLK) (Note)
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog port input current				5.0	µA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

Table 50 A-D converter characteristics (Extended operating temperature version)

(V_{CC} = 3.0 to 5.5 V, V_{SS} = AV_{SS} = 0 V, Ta = –40 to 85°C, f(X_{IN}) = 500 kHz to 8 MHz, in middle/high-speed mode unless otherwise noted)

10-bit A-D mode (when conversion mode selection bit (bit 0 of address 001416) is "0")

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				10	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 3.0 to 5.5 V			±4	LSB
t_{CONV}	Conversion time		61		62	tc(ADCLK) (Note)
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference power source input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog port input current				5.0	µA

Note: ADCLK is the control clock of the A-D converter. System clock ϕ is used.

D-A CONVERTER CHARACTERISTICS (Extended operating temperature version)

Table 51 D-A converter characteristics (Extended operating temperature version)

(V_{CC} = 3.0 to 5.5 V, V_{CC} = V_{REF}, V_{SS} = AV_{SS} = 0 V, Ta = –40 to 85°C, in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy	V_{CC} = V_{REF} = 5 V			1.0	%
		V_{CC} = V_{REF} = 3.0 V			2.0	%
t_{su}	Setting time			3		µs
R_O	Output resistor		1	2.5	4	kΩ
I_{VREF}	Reference power source input current	**(Note)**			3.2	mA

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

TIMING REQUIREMENTS (Extended operating temperature version)

Table 52 Timing requirements 1 (Extended operating temperature version)

(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –40 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	80			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	800			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	370			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	370			ns
$t_{su(R_{XD}–S_{CLK1})}$	Serial I/O1 input set up time	220			ns
$t_{h(S_{CLK1}–R_{XD})}$	Serial I/O1 input hold time	100			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	1000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	400			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	400			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	200			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	200			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

Table 53 Timing requirements 2 (Extended operating temperature version)

(V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, and V_{CC} = 3.0 to 5.5 V, Ta = –40 to –20°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	500/(V_{CC}-2)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	250/(V_{CC}-2)–20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	250/(V_{CC}-2)–20			ns
$t_{wH(INT)}$	INT_0 to INT_2 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_2 input “L” pulse width	230			ns
$t_{c(S_{CLK1})}$	Serial I/O1 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK1})}$	Serial I/O1 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK1})}$	Serial I/O1 clock input “L” pulse width **(Note)**	950			ns
$t_{su(R_{XD}–S_{CLK1})}$	Serial I/O1 input set up time	400			ns
$t_{h(S_{CLK1}–R_{XD})}$	Serial I/O1 input hold time	200			ns
$t_{c(S_{CLK2})}$	Serial I/O2 clock input cycle time **(Note)**	2000			ns
$t_{wH(S_{CLK2})}$	Serial I/O2 clock input “H” pulse width **(Note)**	950			ns
$t_{wL(S_{CLK2})}$	Serial I/O2 clock input “L” pulse width **(Note)**	950			ns
$t_{su(S_{IN2}–S_{CLK2})}$	Serial I/O2 input set up time	400			ns
$t_{h(S_{CLK2}–S_{IN2})}$	Serial I/O2 input hold time	300			ns

Note: When bit 6 of address $001A_{16}$ is “1”.
Divide this value by four when bit 6 of address $001A_{16}$ is “0”.

SWITCHING CHARACTERISTICS (Extended operating temperature version)

Table 54 Switching characteristics 1 (Extended operating temperature version)
(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, Ta = –40 to 85°C, unless otherwise noted)

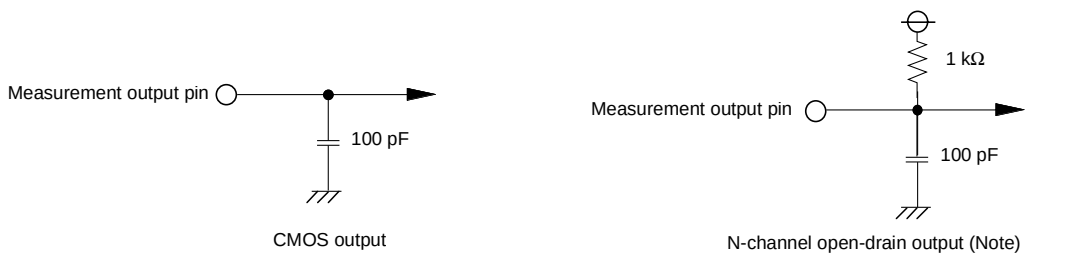
Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	$t_{C(SCLK1)}$/2–30			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	$t_{C(SCLK1)}$/2–30			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			140	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			30	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			30	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	$t_{C(SCLK2)}$/2–160			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	$t_{C(SCLK2)}$/2–160			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X $t_{C(SCLK2)}$	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			40	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		10	30	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.

Table 55 Switching characteristics 2 (Extended operating temperature version)
(V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, Ta = –20 to 85°C, and V_{CC} = 3.0 to 5.5 V, Ta = –40 to –20°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK1)}$	Serial I/O1 clock output “H” pulse width	$t_{C(SCLK1)}$/2–50			ns
$t_{WL(SCLK1)}$	Serial I/O1 clock output “L” pulse width	$t_{C(SCLK1)}$/2–50			ns
$t_{d(SCLK1–TXD)}$	Serial I/O1 output delay time **(Note 1)**			350	ns
$t_{v(SCLK1–TXD)}$	Serial I/O1 output valid time **(Note 1)**	–30			ns
$t_{r(SCLK1)}$	Serial I/O1 clock output rising time			50	ns
$t_{f(SCLK1)}$	Serial I/O1 clock output falling time			50	ns
$t_{WH(SCLK2)}$	Serial I/O2 clock output “H” pulse width	$t_{C(SCLK2)}$/2–240			ns
$t_{WL(SCLK2)}$	Serial I/O2 clock output “L” pulse width	$t_{C(SCLK2)}$/2–240			ns
$t_{d(SCLK2–SOUT2)}$	Serial I/O2 output delay time			0.2 X $t_{C(SCLK2)}$	ns
$t_{v(SCLK2–SOUT2)}$	Serial I/O2 output valid time	0			ns
$t_{f(SCLK2)}$	Serial I/O2 clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time **(Note 2)**		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time **(Note 2)**		20	50	ns

Notes1: When the $P4_5$/TxD P-channel output disable bit of the UART control register (bit 4 of address $001B_{16}$) is “0”.
2: X_{OUT} and X_{COUT} pins are excluded.



Note: When $P7_1$–$P7_7$, $P4_0$ and bit 4 of the UART control register (address $001B_{16}$) is “1” (N-channel open-drain output mode).

Fig. 69 Circuit for measuring output switching characteristics

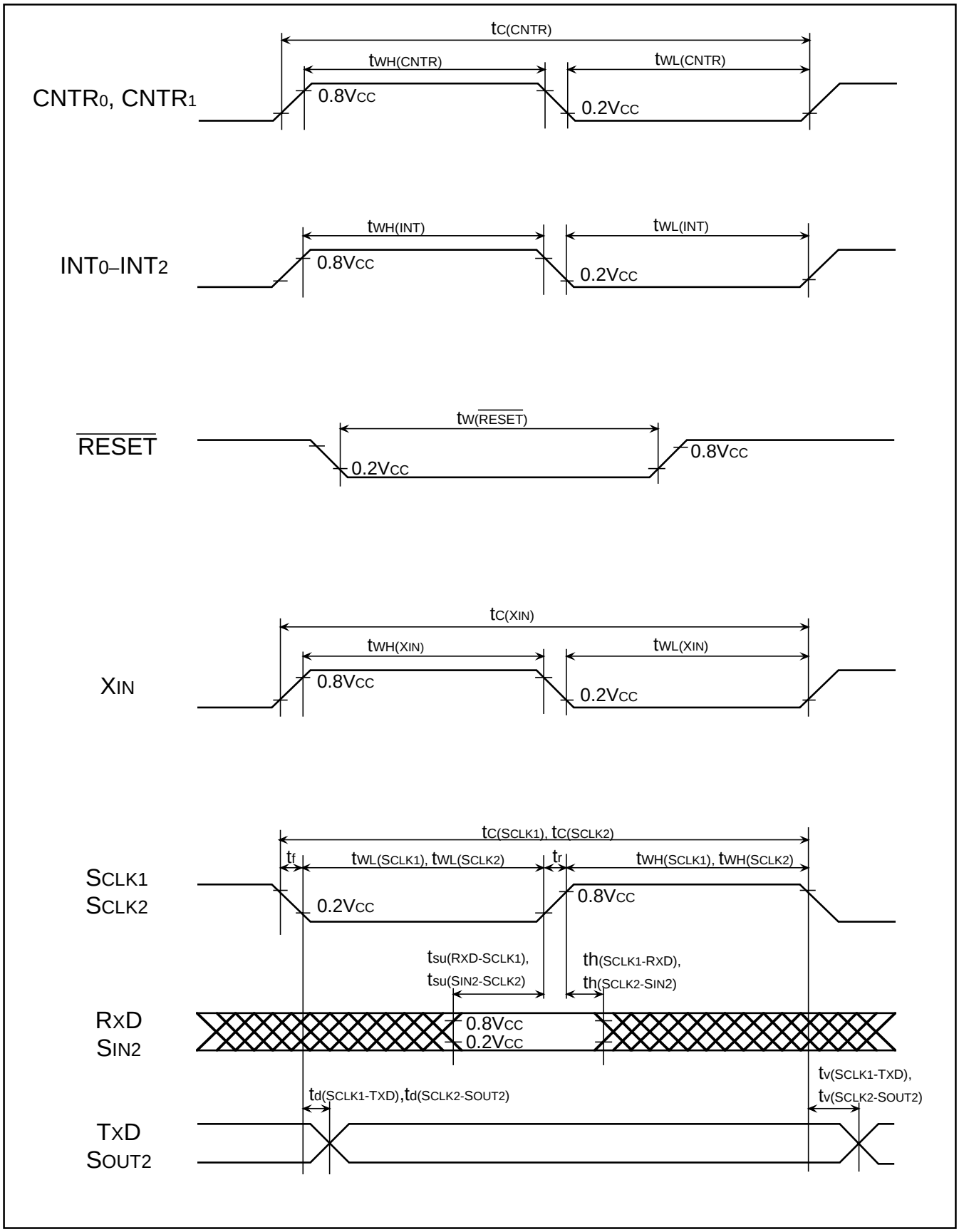


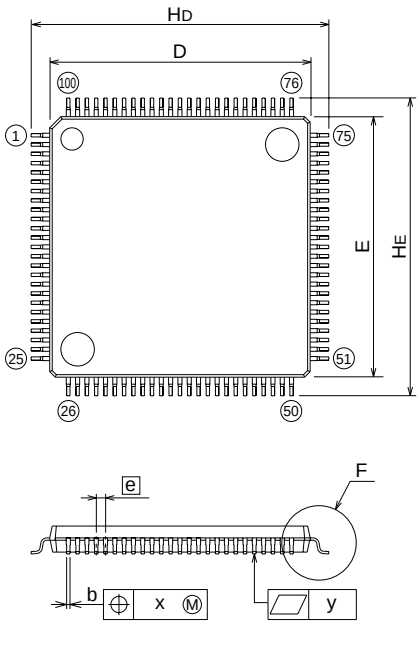
Fig. 70 Timing diagram

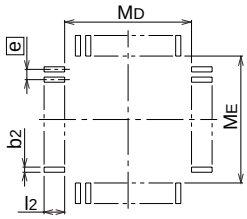
PACKAGE OUTLINE

100P6Q-A (MMP)

Plastic 100pin 14X14mm body LQFP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
LQFP100-P-1414-0.50	–	0.63	Cu Alloy





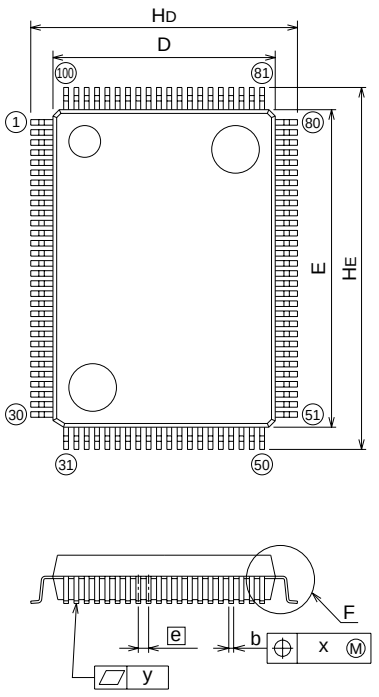
Recommended Mount Pad

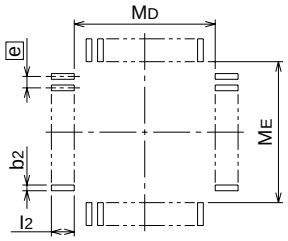
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	1.7
A1	0	0.1	0.2
A2	–	1.4	–
b	0.13	0.18	0.28
c	0.105	0.125	0.175
D	13.9	14.0	14.1
E	13.9	14.0	14.1
e	–	0.5	–
HD	15.8	16.0	16.2
HE	15.8	16.0	16.2
L	0.3	0.5	0.7
L1	–	1.0	–
Lp	0.45	0.6	0.75
A3	–	0.25	–
x	–	–	0.08
y	–	–	0.1
θ	0°	–	10°
b2	–	0.225	–
I2	0.9	–	–
MD	–	14.4	–
ME	–	14.4	–

100P6S-A (MMP)

Plastic 100pin 14X20mm body QFP

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





Recommended Mount Pad

Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	3.05
A1	0	0.1	0.2
A2	–	2.8	–
b	0.25	0.3	0.4
c	0.13	0.15	0.2
D	13.8	14.0	14.2
E	19.8	20.0	20.2
e	–	0.65	–
HD	16.5	16.8	17.1
HE	22.5	22.8	23.1
L	0.4	0.6	0.8
L1	–	1.4	–
x	–	–	0.13
y	–	–	0.1
θ	0°	–	10°
b2	–	0.35	–
I2	1.3	–	–
MD	–	14.6	–
ME	–	20.6	–

7560 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

Renesas Technology Corp.
Nippon Bldg.,6-2,Otemachi 2-chome,Chiyoda-ku,Tokyo,100-0004 Japan

RENESAS
Renesas Technology Corp.

REVISION HISTORY	7560 GROUP DATA SHEET

Rev.	Date	Description	
		Page	Summary
1.0	03/28/01		First Edition
1.1	06/08/01	52	Table 13 V_{REF} Min. V_{CC}+0.3 → V_{CC}
1.2	12/05/01	1	• A-D converter; 8 bits → 10 bits • Power source voltage; value at EPROM and One Time PROM version and at extended operating temperature version added. • Power dissipation; In high-speed mode: 40 → 32 mW, In low-speed mode: 60 → 45 μW • Operating temperature range; value at extended temperature version added.
		4	Table 1; V_{CC}, V_{SS}: voltage valued at EPROM and One Time PROM version and at extended operating temperature version added.
		6	Fig. 4; Description about EPROM and One Time PROM version and extended operating temperature version added.
		7	Fig. 5; Under development → Mass product
		8	GROUP EXPANSION for EPROM and One Time PROM version added.
		9	GROUP EXPANSION for extended operating temperature version added.
		15	Fig. 12; Reserved area: Note added. Address 001416: Reserved area → A-D conversion register (ADL). Address 003516: A-D conversion register (AD) → A-D conversion register (ADH)
		26	Fig. 21; $P52$, $P53$, $P43$ revised.
		38	[A-D Conversion Register (ADH, ADL)] 003516, 001416 revised. Comparison Voltage Generator revised. Fig. 38 revised.
		42	Voltage Multiplier; 2.1 V → 2.1 V (2.3 V for EPROM and One Time PROM version)
		49	Fig. 53; (9) AD conversion register (low-order) added.
		50	Oscillation Control; (1) Stop mode revised.
		54	DATA REQUIRED FOR MASK ORDERS; URL: mesc → maec ROM PROGRAMMING METHOD added.
		57	I_{OH} (avg); (Note 3) added.
		60	Table 22; I_{CC} value revised.
		61	Table 23; Note added. Conversion time revised. Table 24; A-D converter characteristics at 10-bit A-D mode added.
		62	Table 27; tc (CNTR) revised.
		64 to 77	ELECTRICAL CHARACTERISTICS (EPROM and One Time PROM version) and ELECTRICAL CHARACTERISTICS (Extended operating temperature version) added.
2.0	01/28/03	1	"●Interrupts" of "FEATURES" is partly added.
		4	Table 1 is partly revised.
		5	Table 2 is partly revised.
		14	Figure 11 is partly revised.

Rev.	Date	Description	
		Page	Summary
2.0	01/28/03	15	Figure 12 is partly revised.
		16	Explanations of “Direcion Registers” of “I/O PORTS” are partly revised.
		16	Explanations of “Pull-up Control” of “I/O PORTS” are partly revised.
		16	Figure 13 is added.
		16	Figure 14 is added.
		20	Figure 16 is partly revised.
		21	Figure 17 is partly revised.
		22	Figure 18 is partly revised.
		23	Figure 19 is partly revised.
		24	Explanations of “INTERRUPTS” are partly added.
		25	Explanations of “■Notes on interrupts” are partly revised.
		26	Explanations of “Key Input Interrupt (Key-on Wake Up)” are partly revised.
		26	Figure 22 is partly revised.
		27	Explanations of “Key Input Interrupt (Key-on Wake Up)” are added.
		27	Figure 23 is added.
		28	Figure 24 is partly revised.
		29	Explanations of “Timer X” are partly added.
		30	Explanations of “Timer Y” are partly added.
		30	Explanations of “(2) Period measurement mode” of “Timer Y” are partly revised.
		31	Explanations of “Timer 1, Timer 2, Timer 3” are partly added.
		31	Explanations of “●Timer 2 Write Control” are partly added,
		32	Explanations of “(1) Clock Synchronous Serial I/O Mode” are partly added.
		32	Note of Figure 29 is partly added.
		34	Explanations of “[UART Control Register (UARTON)] are partly revised.
		36	Explanations of “Serial I/O2” are partly added.
		36	Explanations of “[Serial I/O2 Control Register (SIO2CON)]” are partly added.
		37	“●Serial I/O2 Operating” is added.
		40	Explanations of “[A-D Control Register (ADCON)]” are partly added.
		40	Figure 40 is partly added.
		41	Figure 42 is partly added.
		42	Figure 44 is partly added.
		43	Figure 45 is added.
		46	Explanations of “Voltage Multiplier (3 Times)” are partly revised.
		50	Explanation of “Watchdog Timer” are partly revised.
		51	Figure 55 is partly revised.
		52	Explanations of “RESET CIRCUIT” are partly revised.
		52	Figure 56 is partly revised.
		54	Explanations of “(2) Wait mode” are partly revised.
		55	Figure 61 is partly revised.

Rev.	Date	Description	
		Page	Summary
2.0	01/28/03	56	Figure 62 is partly revised.
		57	Explanations of “Interrupt” of “NOTES ON PROGRAMMING” are partly revised.
		57	“Timers” of “NOTES ON PROGRAMMING”of Rev. 1.2 is eliminated.
		58, 59	“Countermeasures Against Noise” is added.
		67	Table 23 is partly revised.
		67	Table 24 is partly revised.
		74	Table 36 is partly revised.
		74	Table 37 is partly revised.
		81	Table 49 is partly revised.
		81	Table 50 is partly revised.
		All pages	Text expressions are improved.