

DESCRIPTION

The 7513 group is the 8-bit microcomputer based on the 740 family core technology.

The 7513 group has the LCD drive control circuit, the A-D/D-A converter, the UART, and the PWM as additional functions.

The various microcomputers in the 7513 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 7513 group, refer to the section on group expansion.

FEATURES

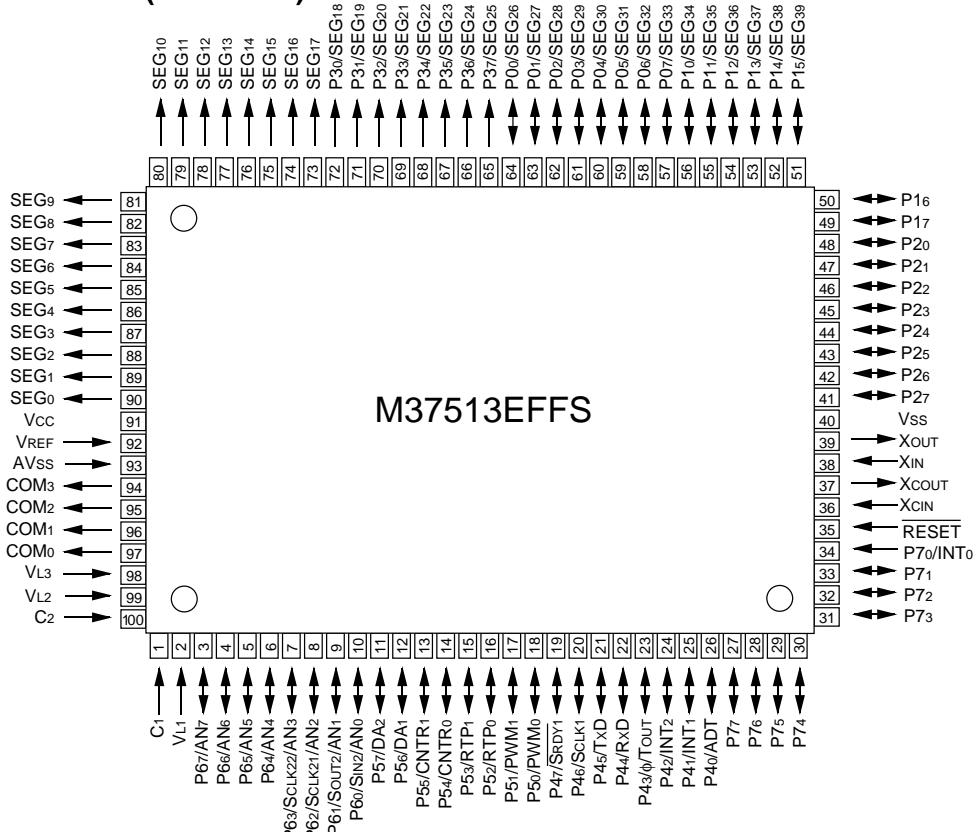
- Basic machine-language instructions 71
- The minimum instruction execution time 0.5 μ s
(at 8MHz oscillation frequency)
- Memory size
 - ROM 32 K to 60 K bytes
 - RAM 1024 to 2048 bytes
- Programmable input/output ports 55
- Output port 8
- Input port 1
- Interrupts 17 sources, 16 vectors
(includes key input interrupt)
- Timers 8-bit X 3, 16-bit X 2

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

APPLICATIONS

Camera, Wireless phone, etc.

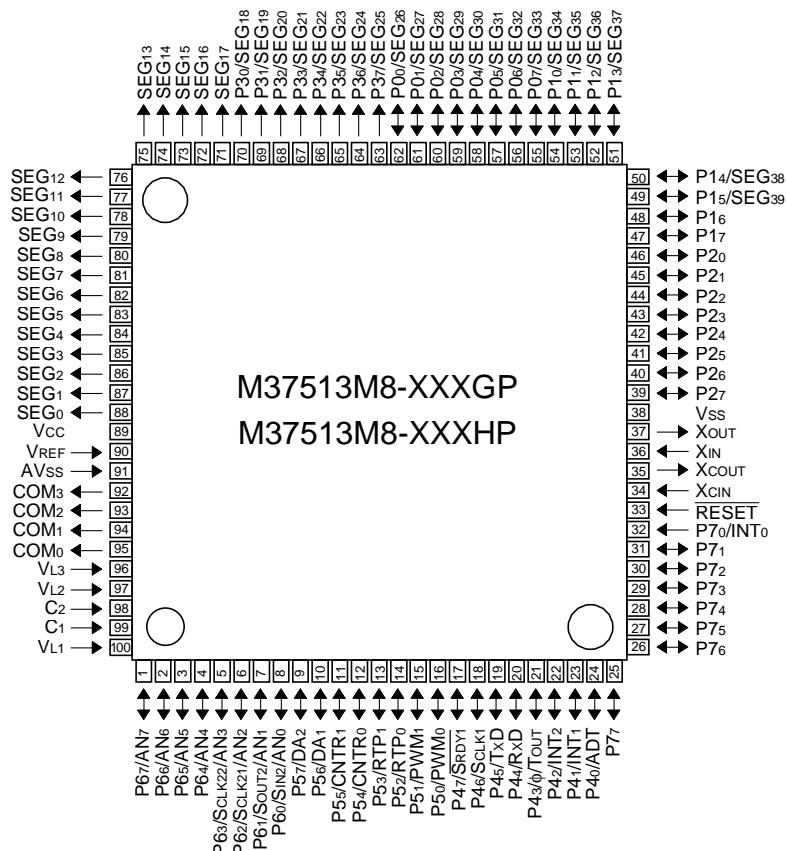
PIN CONFIGURATION (TOP VIEW)



Package type : 100D0 (Window type ceramic LCC)

Fig. 1 M37513EFFS pin configuration

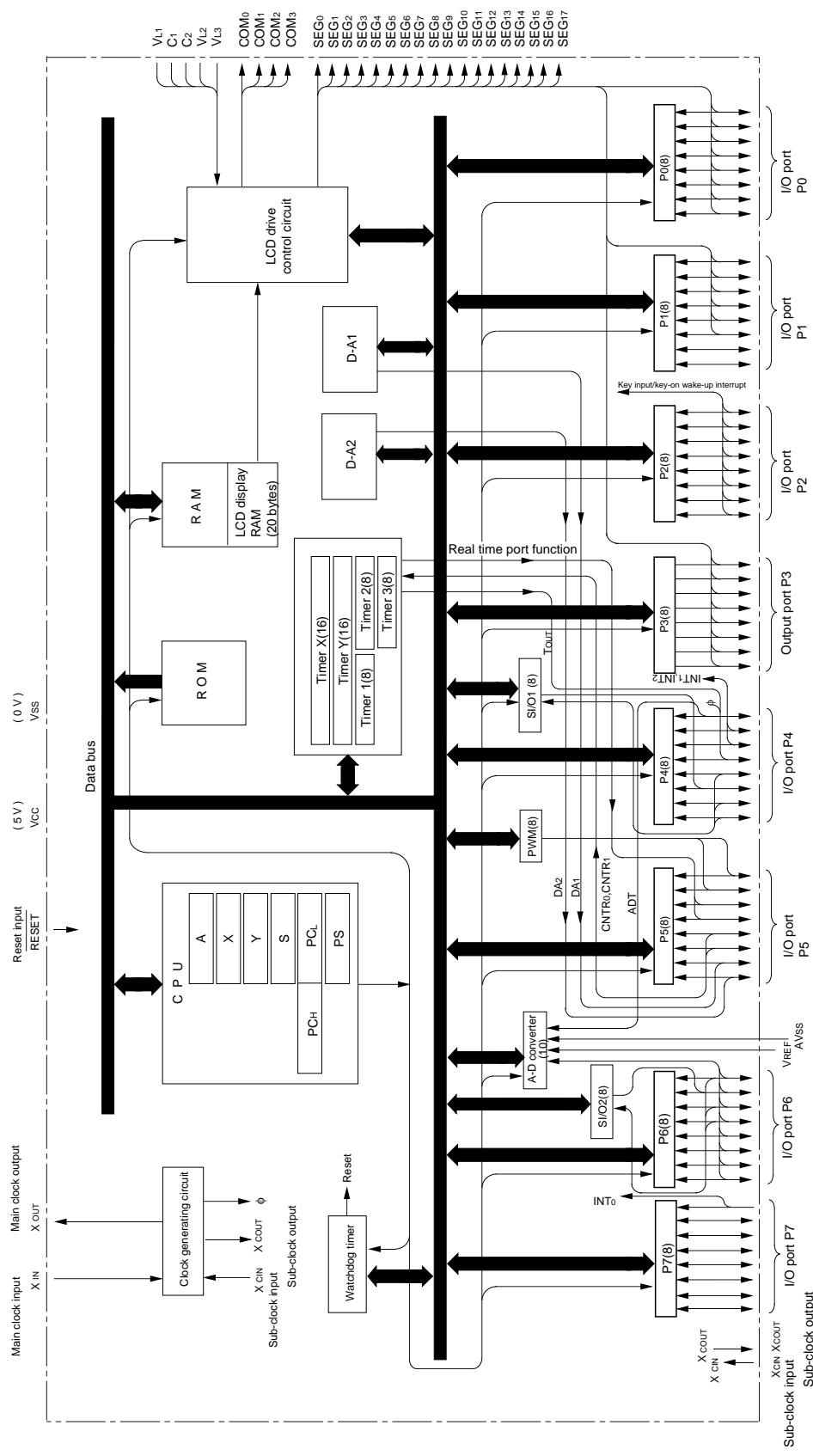
PIN CONFIGURATION (TOP VIEW)



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

Fig. 2 M37513M8-XXXGP/M37513M8-XXXHP pin configuration

FUNCTIONAL BLOCK DIAGRAM



PIN DESCRIPTION**Table 1 Pin description (1)**

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

Table 2 Pin description (2)

Pin	Name	Function	Function except a port function
P40/ADT	I/O port P4	<ul style="list-style-type: none"> •1-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •N-channel open-drain output structure. 	<ul style="list-style-type: none"> •A-D trigger input pin •Interrupt input pin
P41/INT1, P42/INT2		<ul style="list-style-type: none"> •7-bit I/O port with same function as P16 and P17. •CMOS compatible input level. 	•Interrupt input pins
P43/φ/TOUT		<ul style="list-style-type: none"> •CMOS 3-state output structure. •Pull-up control is enabled. 	<ul style="list-style-type: none"> •φ clock output pin •Timer 2 output pin
P44/RxD, P45/TxD, P46/SCLK1, P47/SRDY1			•Serial I/O1 I/O pins
P50/PWM0, P51/PWM1	I/O port P5	<ul style="list-style-type: none"> •8-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. 	•PWM function pins
P52/RTP0, P53/RTP1			•Real time port function pins
P54/CNTR0, P55/CNTR1			•Timer X, Y function pins
P56/DA1, P57/DA2			•D-A conversion output pins
P60/AN0/SIN2, P61/AN1/SOUT2, P62/AN2/SCLK21, P63/AN3/SCLK22	I/O port P6	<ul style="list-style-type: none"> •8-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •CMOS 3-state output structure. •Pull-up control is enabled. 	<ul style="list-style-type: none"> •A-D conversion input pins •Serial I/O2 I/O pins
P64/AN4– P67/AN7			•A-D conversion input pins
P70/INT0	Input port P7	<ul style="list-style-type: none"> •1-bit I/O port. •CMOS compatible input level. 	•Interrupt input pin
P71–P77	I/O port P7	<ul style="list-style-type: none"> •7-bit I/O port with same function as P16 and P17. •CMOS compatible input level. •N-channel open-drain output structure. 	
XCOUT	Sub-clock output	<ul style="list-style-type: none"> •Sub-clock generating circuit I/O pins. 	
XCIN	Sub-clock input	(Connect a resonator. External clock cannot be used.)	

PART NUMBERING

Product M37513 **M** **8** - **XXX** **HP****Package type**

HP : 100PFB-A package
GP : 100P6Q-A package
FS : 100D0 package

ROM number

Omitted in One Time PROM version
shipped in blank and EPROM version.

ROM/PROM size

1 : 4096 bytes
2 : 8192 bytes
3 : 12288 bytes
4 : 16384 bytes
5 : 20480 bytes
6 : 24576 bytes
7 : 28672 bytes
8 : 32768 bytes
9 : 36864 bytes
A : 40960 bytes
B : 45056 bytes
C : 49152 bytes
D : 53248 bytes
E : 57344 bytes
F : 61440 bytes

The first 128 bytes and the last 2 bytes of ROM
are reserved areas ; they cannot be used.

Memory type

M : Mask ROM version
E : EPROM or One Time PROM version

RAM size

M37513M8-XXXGP/HP: 1024 byte
M37513EFGP/HP/FS : 2048 bytes

Fig. 4 Part numbering

GROUP EXPANSION

Mitsubishi plans to expand the 7513 group as follows:

Memory Type

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

Memory Size

ROM/PROM size 32 K to 60 K bytes

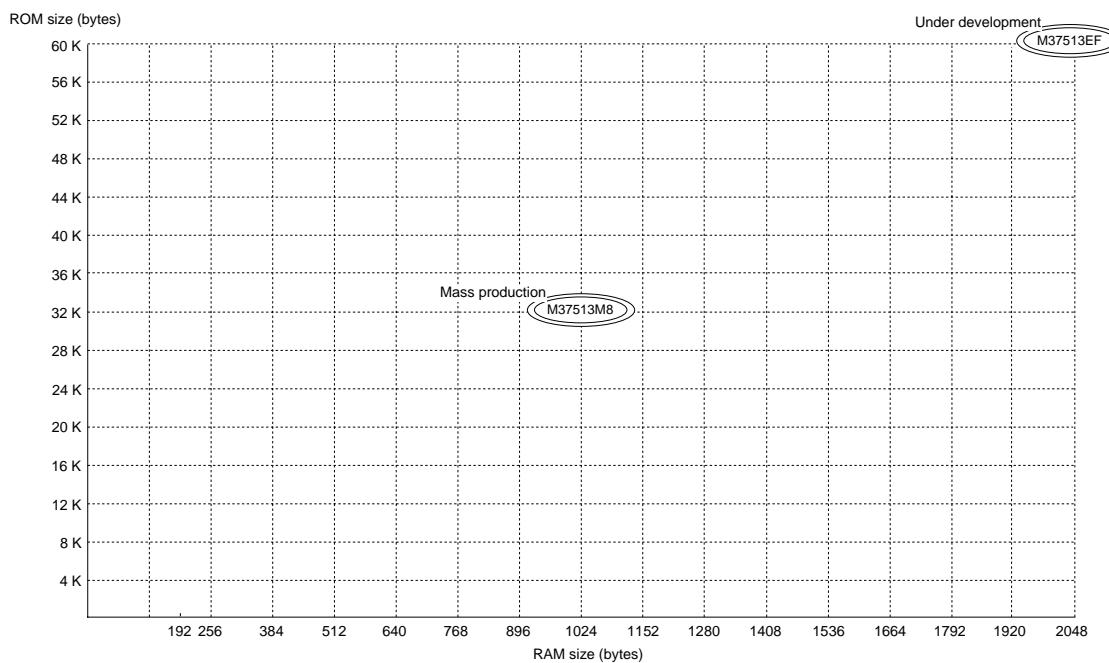
RAM size 1024 to 2048 bytes

Package

100PFB-A 0.4 mm-pitch plastic molded TQFP

100P6Q-A 0.5 mm-pitch plastic molded LQFP

100D0 Window type ceramic LCC (EPROM version)

Memory Expansion Plan

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

Fig. 5 Memory expansion plan

Currently supported products are listed below.

Table 3 List of supported products

As of Nov. 2000

Product	(P) ROM size (bytes) ROM size for User in ()	RAM size (bytes)	Package	Remarks
M37513M8-XXXHP	32768 (32638)	1024	100PFB-A	Mask ROM version
M37513M8-XXXGP			100P6Q-A	Mask ROM version
M37513EFHP	61440 (61310)	2048	100PFB-A	One Time PROM version (blank)
M37513EFGP			100P6Q-A	One Time PROM version (blank)
M37513EFFS			100D0	

FUNCTIONAL DESCRIPTION

Central Processing Unit (CPU)

The 7513 group uses the standard 740 Family instruction set. Refer to the table of 740 Series addressing modes and machine instructions or the 740 Series Software Manual for details on the instruction set.

Machine-resident 740 Series instructions are as follows:

The FST and SLW instructions cannot be used.

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

[Accumulator (A)]

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

[Index Register X (X)]

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

[Index Register Y (Y)]

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

[Stack Pointer (S)]

The stack pointer is an 8-bit register used during subroutine calls and interrupts. This register indicates start address of stored area (stack) for storing registers during subroutine calls and interrupts. The low-order 8 bits of the stack address are determined by the contents of the stack pointer. The high-order 8 bits of the stack address are determined by the stack page selection bit. If the stack page selection bit is "0", the high-order 8 bits becomes "0016". If the stack page selection bit is "1", the high-order 8 bits becomes "0116".

The operations of pushing register contents onto the stack and popping them from the stack are shown in Figure 6.

Store registers other than those described in Figure 6 with program when the user needs them during interrupts or subroutine calls.

[Program Counter (PC)]

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

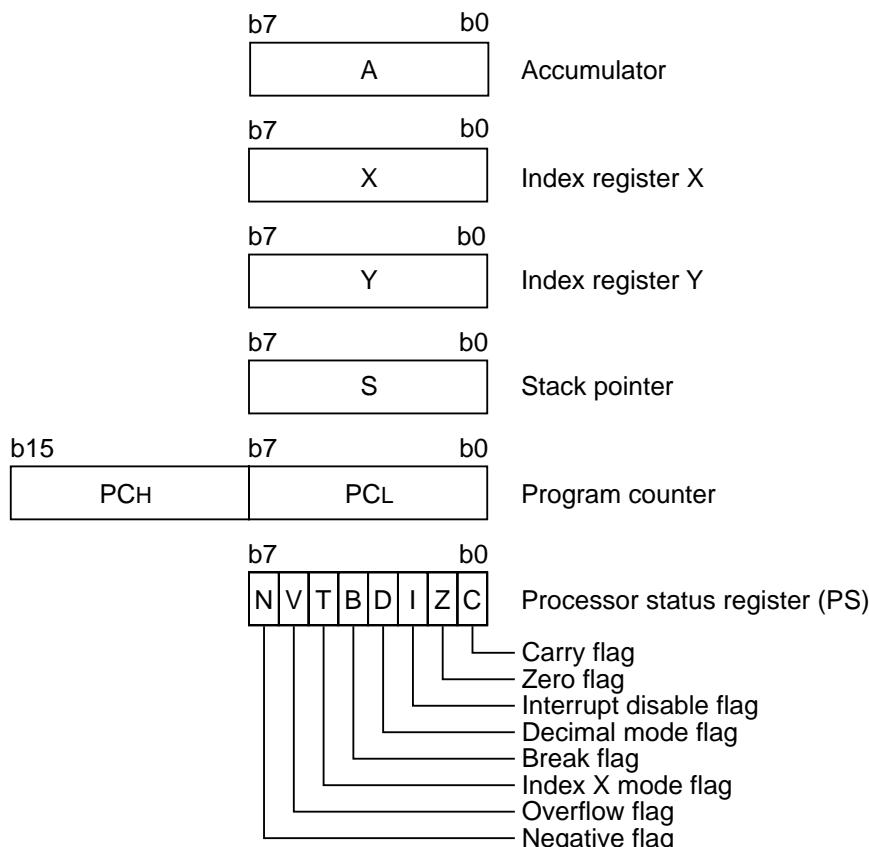


Fig. 6 740 Family CPU register structure

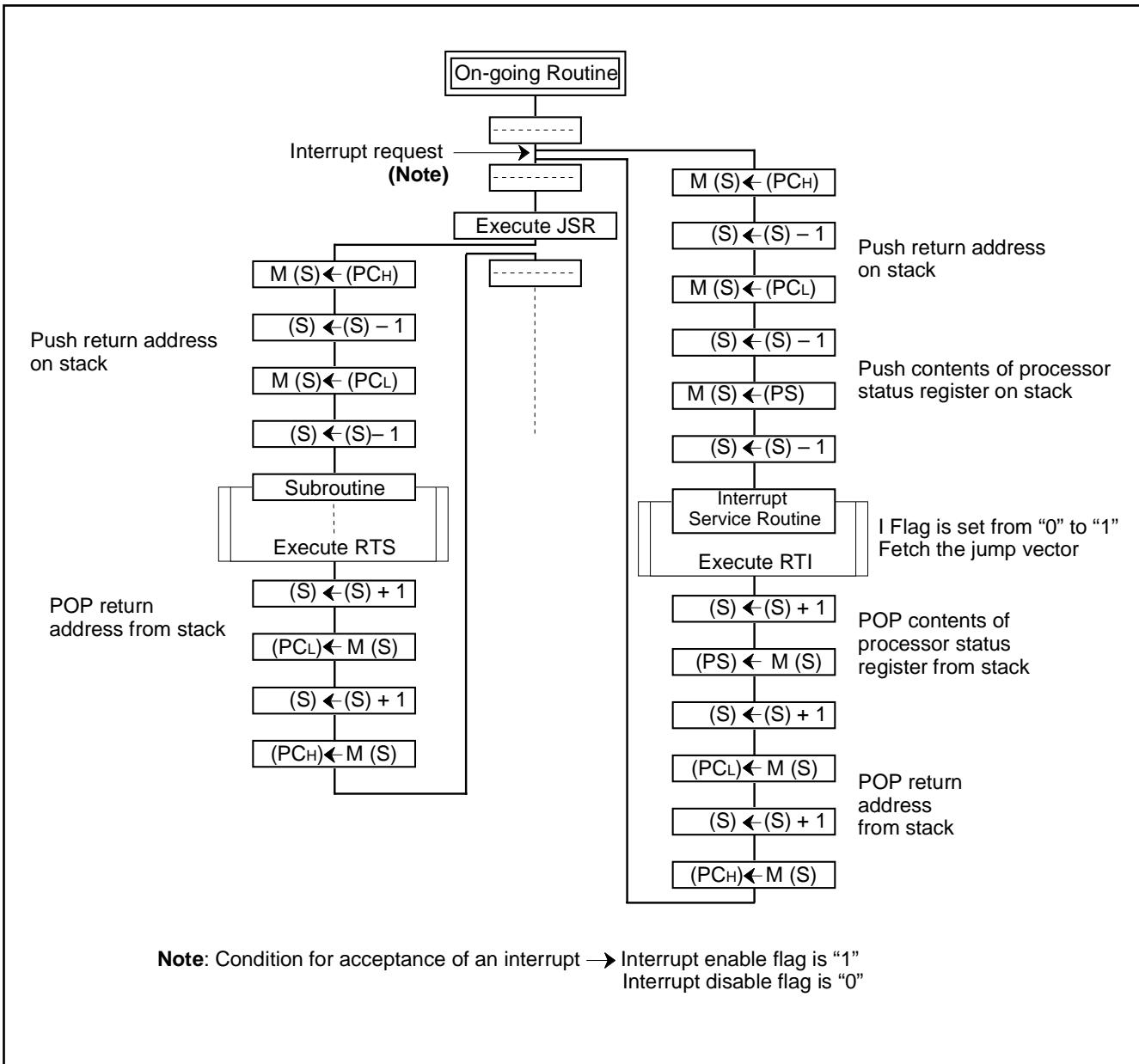


Fig. 7 Register push and pop at interrupt generation and subroutine call

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

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

[Processor status register (PS)]

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

•Bit 0: Carry flag (C)

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

•Bit 1: Zero flag (Z)

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

•Bit 2: Interrupt disable flag (I)

The I flag disables all interrupts except for the interrupt generated by the BRK instruction.

Interrupts are disabled when the I flag is "1".

•Bit 3: Decimal mode flag (D)

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

•Bit 4: Break flag (B)

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

•Bit 5: Index X mode flag (T)

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

•Bit 6: Overflow flag (V)

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

•Bit 7: Negative flag (N)

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

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

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

[CPU Mode Register (CPUM)] 003B₁₆

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

The CPU mode register is allocated at address 003B₁₆.

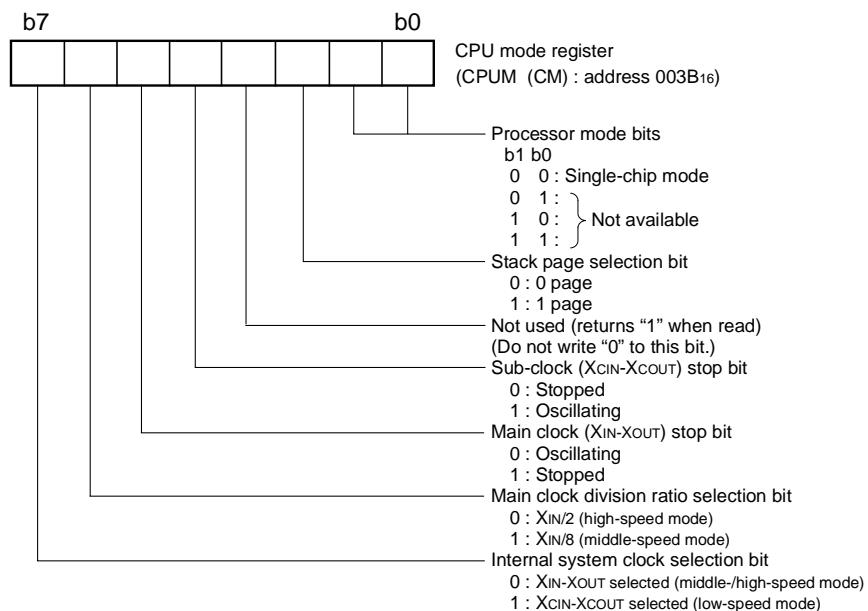


Fig. 8 Structure of CPU mode register

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

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

RAM

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

ROM

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

Interrupt Vector Area

The interrupt vector area contains reset and interrupt vectors.

Zero Page

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

Special Page

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

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

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

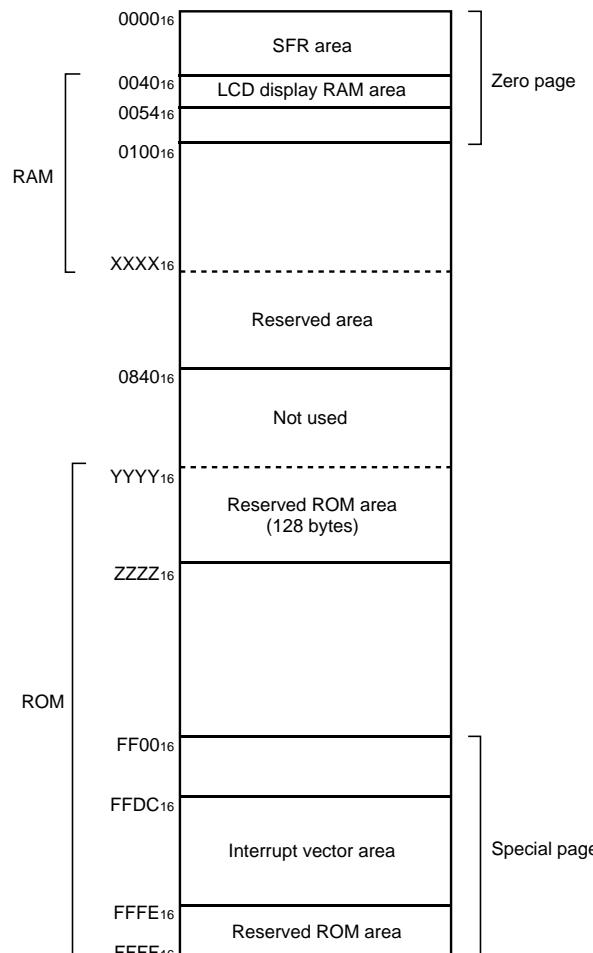


Fig. 9 Memory map diagram

0000 ₁₆	Port P0 (P0)	0020 ₁₆	Timer X (low) (TXL)
0001 ₁₆	Port P0 direction register (P0D)	0021 ₁₆	Timer X (high) (TXH)
0002 ₁₆	Port P1 (P1)	0022 ₁₆	Timer Y (low) (TYL)
0003 ₁₆	Port P1 output control register (P1D)	0023 ₁₆	Timer Y (high) (TYH)
0004 ₁₆	Port P2 (P2)	0024 ₁₆	Timer 1 (T1)
0005 ₁₆	Port P2 direction register (P2D)	0025 ₁₆	Timer 2 (T2)
0006 ₁₆	Port P3 (P3)	0026 ₁₆	Timer 3 (T3)
0007 ₁₆	Port P3 output control register (P3C)	0027 ₁₆	Timer X mode register (TXM)
0008 ₁₆	Port P4 (P4)	0028 ₁₆	Timer Y mode register (TYM)
0009 ₁₆	Port P4 direction register (P4D)	0029 ₁₆	Timer 123 mode register (T123M)
000A ₁₆	Port P5 (P5)	002A ₁₆	T _{OUT} /φ output control register (CKOUT)
000B ₁₆	Port P5 direction register (P5D)	002B ₁₆	PWM control register (PWMCON)
000C ₁₆	Port P6 (P6)	002C ₁₆	PWM prescaler (PREPWM)
000D ₁₆	Port P6 direction register (P6D)	002D ₁₆	PWM register (PWM)
000E ₁₆	Port P7 (P7)	002E ₁₆	
000F ₁₆	Port P7 direction register (P7D)	002F ₁₆	
0010 ₁₆		0030 ₁₆	
0011 ₁₆		0031 ₁₆	A-D control register (ADCON)
0012 ₁₆		0032 ₁₆	A-D conversion register (low-order) (ADL)
0013 ₁₆		0033 ₁₆	A-D conversion register (high-order) (ADH)
0014 ₁₆		0034 ₁₆	D-A1 conversion register (DA1)
0015 ₁₆	Key input control register (KIC)	0035 ₁₆	D-A2 conversion register (DA2)
0016 ₁₆	PULL register A (PULLA)	0036 ₁₆	D-A control register (Dacon)
0017 ₁₆	PULL register B (PULLB)	0037 ₁₆	Watchdog timer control register (WDTCON)
0018 ₁₆	Transmit/Receive buffer register(TB/RB)	0038 ₁₆	Segment output enable register (SEG)
0019 ₁₆	Serial I/O1 status register (SIO1STS)	0039 ₁₆	LCD mode register (LM)
001A ₁₆	Serial I/O1 control register (SIO1CON)	003A ₁₆	Interrupt edge selection register (INTEDGE)
001B ₁₆	UART control register (UARTCON)	003B ₁₆	CPU mode register (CPUM)
001C ₁₆	Baud rate generator (BRG)	003C ₁₆	Interrupt request register 1 (IREQ1)
001D ₁₆	Serial I/O2 control register (SIO2CON)	003D ₁₆	Interrupt request register 2 (IREQ2)
001E ₁₆	Reserved area	003E ₁₆	Interrupt control register 1 (ICON1)
001F ₁₆	Serial I/O2 register (SIO2)	003F ₁₆	Interrupt control register 2 (ICON2)

Fig. 10 Memory map of special function register (SFR)

I/O PORTS

Direction Registers

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

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

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

Port P3 Output Control Register

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

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

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

Pull-up Control

By setting the PULL register A (address 001616) or the PULL register B (address 001716), ports P1, 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 programmed as the output ports.

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

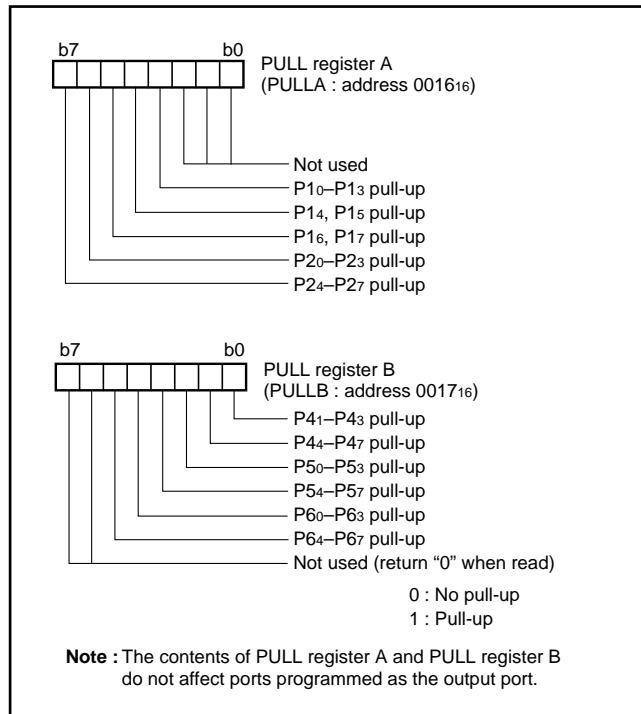


Fig. 11 Structure of PULL register A and PULL register B

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

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P00/SEG26– P07/SEG33	Port P0	Input/output, byte unit	CMOS compatible input level CMOS 3-state output	LCD segment output	Segment output enable register	(1) (2)
P10/SEG34– P15/SEG39	Port P1	Input/output, 6-bit unit	CMOS compatible input level CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(3) (4)
P16 , P17		Input/output, individual bits	CMOS compatible input level CMOS 3-state output		PULL register A	(6)
P20–P27	Port P2	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Key input (key-on wake-up) interrupt input	PULL register A Interrupt control register2 Key input control register	(6)
P30/SEG18– P37/SEG25	Port P3	Output	CMOS 3-state output	LCD segment output	Segment output enable register P3 output enable register	(5)
P40/ADT	Port P4	Input/output, individual bits	CMOS compatible input level N-channel open-drain output	A-D trigger input External interrupt input	A-D control register Interrupt edge selection register	(15)
P41/INT1, P42/INT2			CMOS compatible input level CMOS 3-state output	External interrupt input	PULL register B Interrupt edge selection register	(6)
P43/φ/TOUT				Timer output φ output	PULL register B Timer 123 mode register TOUT/φ output control register	(14)
P44/RxD, P45/TxD, P46/SCLK1, P47/SDY1				Serial I/O1 function I/O	PULL register B Serial I/O1 control register Serial I/O1 status register UART control register	(7) (8) (9) (10)
P50/PWM0, P51/PWM1	Port P5	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	PWM output	PULL register B PWM control register	(12)
P52/RTP0, P53/RTP1				Real time port function output	PULL register B Timer X mode register	(11)
P54/CNTR0				Timer X function I/O	PULL register B Timer X mode register	(13)
P55/CNTR1				Timer Y function input	PULL register B Timer Y mode register	(16)
P56/DA1				DA1 output A-D VREF input	PULL register B D-A control register A-D control register	(17)
P57/DA2				DA2 output	PULL register B D-A control register	(17)

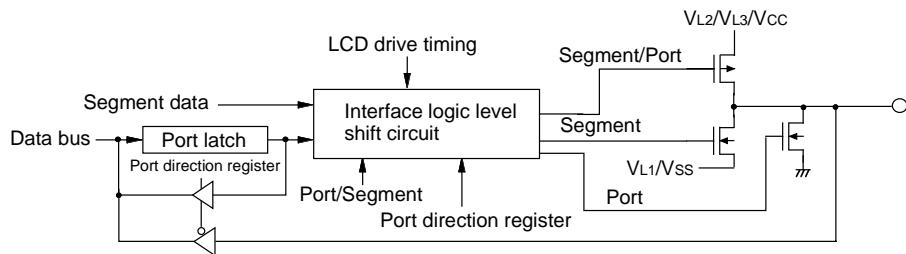
Table 7 List of I/O port function (2)

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P60/SIN2/AN0	Port P6	Input/ output, individual bits	CMOS compatible input level CMOS 3-state output	A-D conversion input Serial I/O2 function I/O	A-D control register Serial I/O2 control register	(19)
P61/SOUT2/ AN1						(20)
P62/SCLK21/ AN2						(21)
P63/SCLK22 / AN3						(22)
P64/AN4— P67/AN7						(18)
P70/INT0	Port P7	Input	CMOS compatible input level	External interrupt input	Interrupt edge selection register	(25)
P71—P77		Input/ output, individual bits	CMOS compatible input level N-channel open-drain output			(15)
COM0—COM3	Common	Output	LCD common output		LCD mode register	(23)
SEG0—SEG17	Segment	Output	LCD segment output			(24)

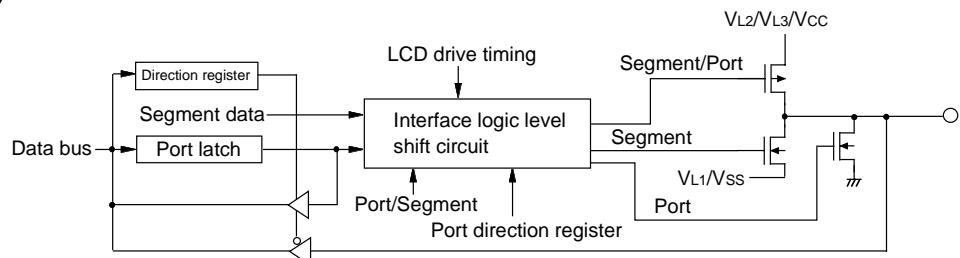
Notes1: How to use double-function ports as function I/O ports, refer to the applicable sections.

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

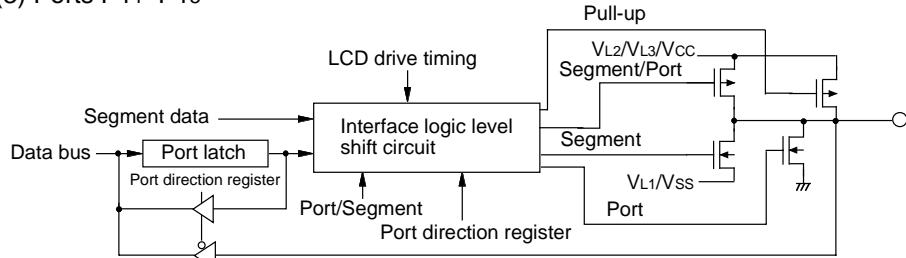
(1) Ports P01–P07



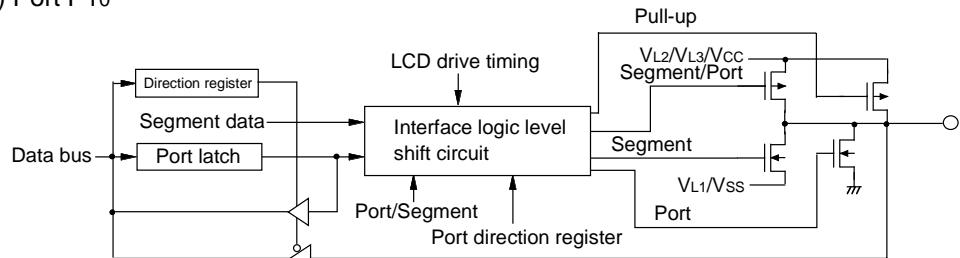
(2) Port P00



(3) Ports P11–P15



(4) Port P10



(5) Port P3

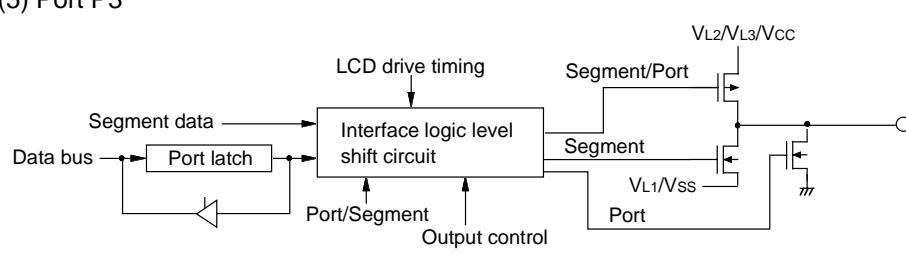
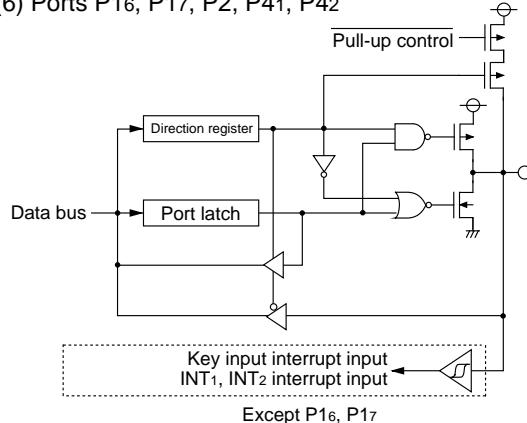
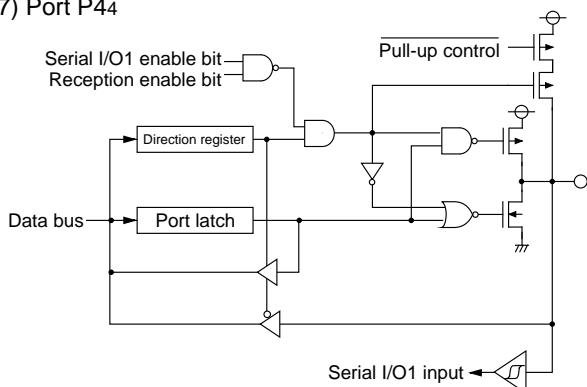


Fig. 12 Port block diagram (1)

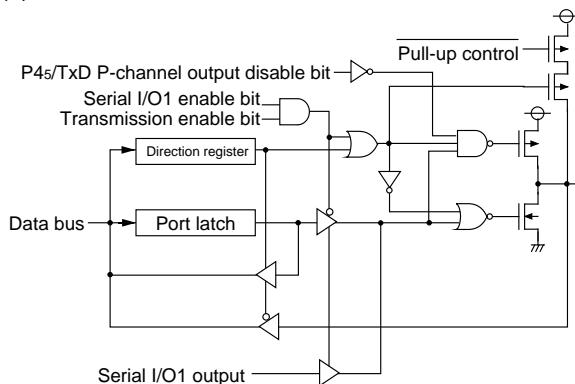
(6) Ports P16, P17, P2, P41, P42



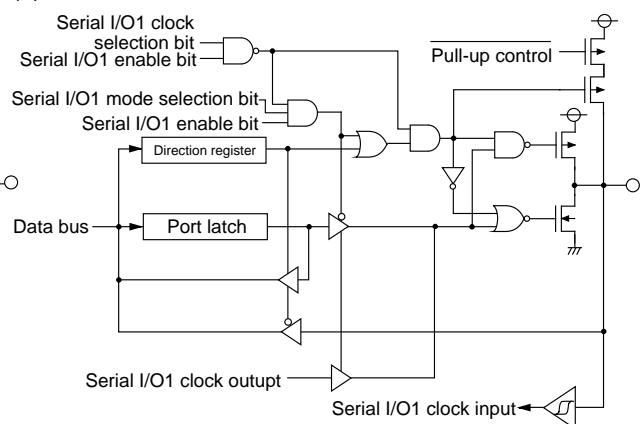
(7) Port P44



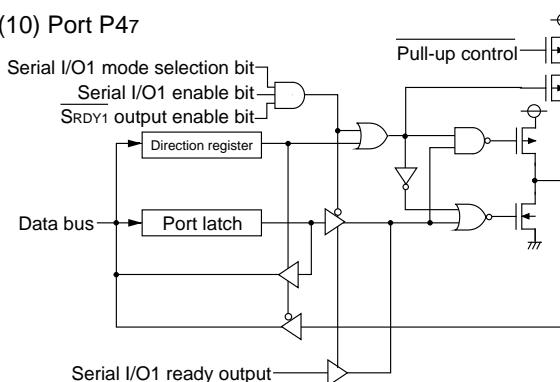
(8) Port P45



(9) Port P46



(10) Port P47



(11) Ports P52, P53

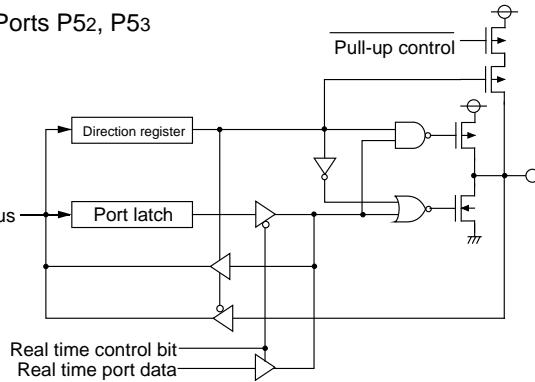


Fig. 13 Port block diagram (2)

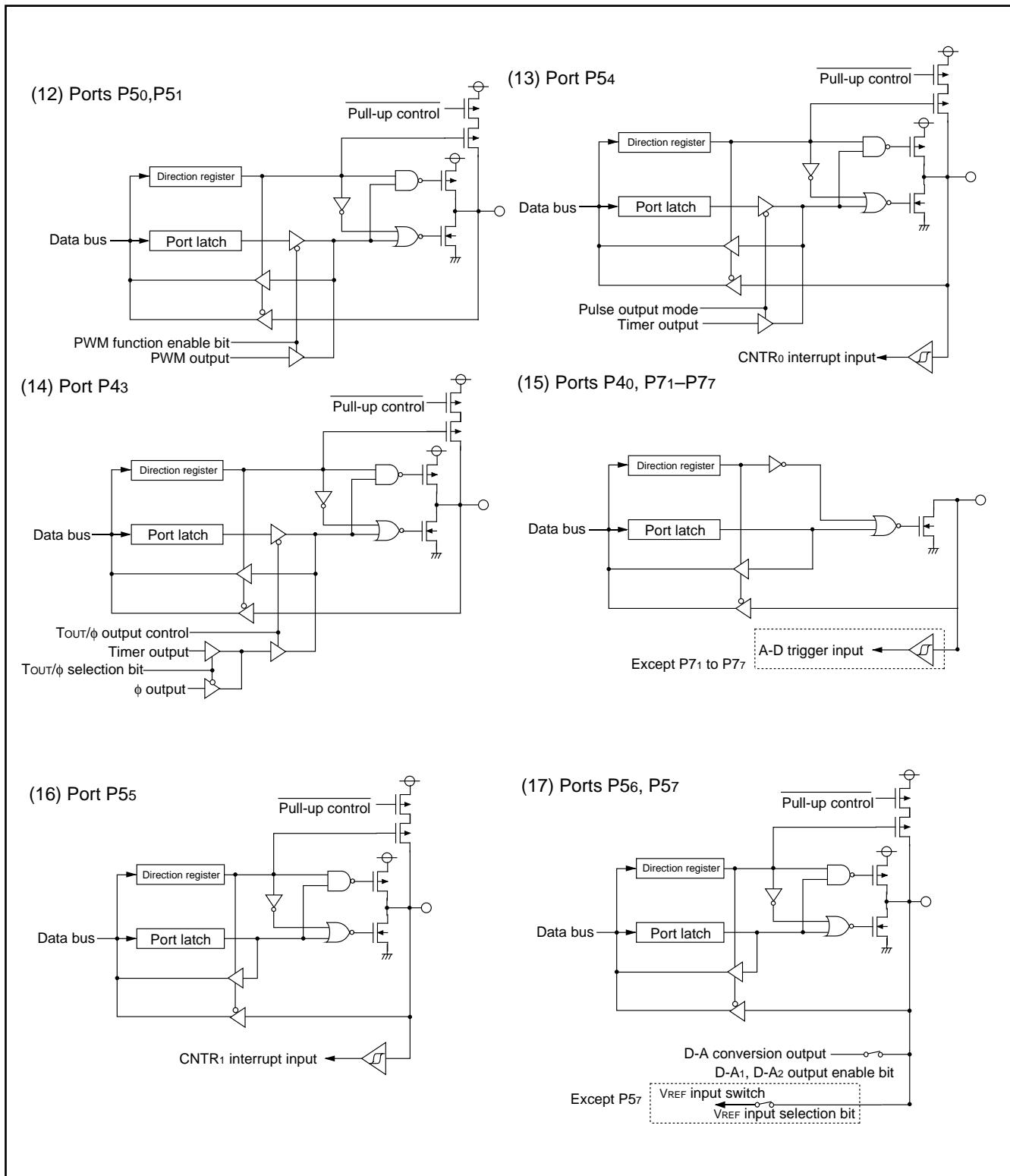


Fig. 14 Port block diagram (3)

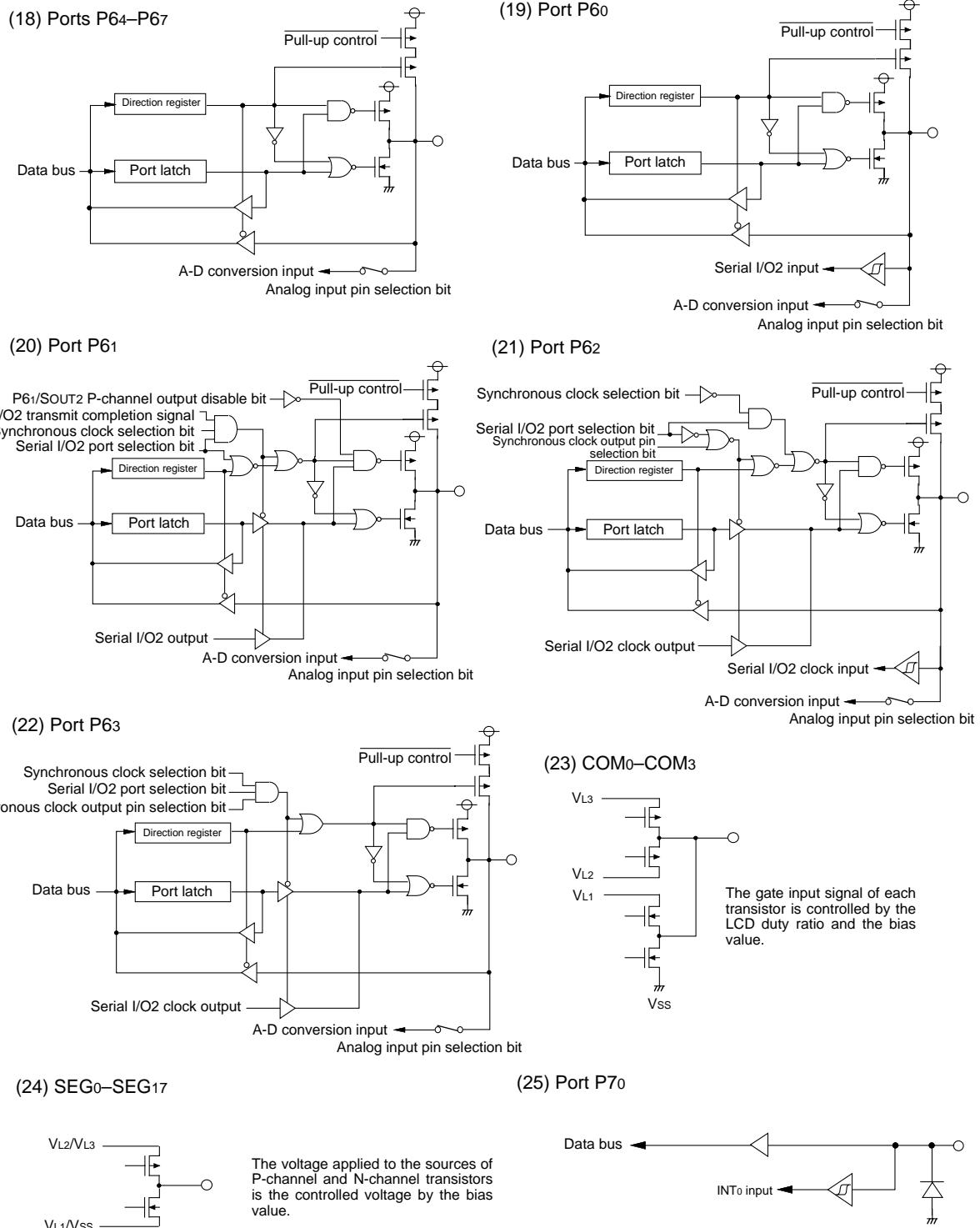


Fig. 15 Port block diagram (4)

INTERRUPTS

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

Interrupt Control

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

Interrupt Operation

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

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

■Notes

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

- When setting external interrupt active edge

Related register: Interrupt edge selection register (address 3A16)
Timer X mode register (address 2716)
Timer Y mode register (address 2816)

- When switching interrupt sources of an interrupt vector address where two or more interrupt sources are allocated

Related register: A-D control register (address 003116)

Table 8 Interrupt vector addresses and priority

Interrupt Source	Priority	Vector Addresses (Note 1)		Interrupt Request Generating Conditions	Remarks
		High	Low		
Reset (Note 2)	1	FFFD16	FFFC16	At reset	Non-maskable
INT0	2	FFFB16	FFFA16	At detection of either rising or falling edge of INT0 input	External interrupt (active edge selectable)
INT1	3	FFF916	FFF816	At detection of either rising or falling edge of INT1 input	External interrupt (active edge selectable)
Serial I/O1 reception	4	FFF716	FFF616	At completion of serial I/O1 data reception	Valid when serial I/O1 is selected
Serial I/O1 transmission	5	FFF516	FFF416	At completion of serial I/O1 transmit shift or when transmission buffer is empty	Valid when serial I/O1 is selected
Timer X	6	FFF316	FFF216	At timer X underflow	
Timer Y	7	FFF116	FFF016	At timer Y underflow	
Timer 2	8	FFEF16	FFEE16	At timer 2 underflow	
Timer 3	9	FFED16	FFEC16	At timer 3 underflow	
CNTR0	10	FFEB16	FFEA16	At detection of either rising or falling edge of CNTR0 input	External interrupt (active edge selectable)
CNTR1	11	FFE916	FFE816	At detection of either rising or falling edge of CNTR1 input	External interrupt (active edge selectable)
Timer 1	12	FFE716	FFE616	At timer 1 underflow	
INT2	13	FFE516	FFE416	At detection of either rising or falling edge of INT2 input	External interrupt (active edge selectable)
Serial I/O2	14	FFE316	FFE216	At completion of serial I/O2 data transmission or reception	Valid when serial I/O2 is selected
Key input (Key-on wake-up)	15	FFE116	FFE016	At falling of conjunction of input level for port P2 (at input mode)	External interrupt (valid at falling)
ADT	16	FFDF16	FFDE16	At either rising or falling edge of ADT input	External interrupt (Valid when ADT interrupt is selected)
A-D conversion				At completion of A-D conversion	Valid when A-D interrupt is selected
BRK instruction	17	FFDD16	FFDC16	At BRK instruction execution	Non-maskable software interrupt

Notes1: Vector addresses contain interrupt jump destination addresses.

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

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

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

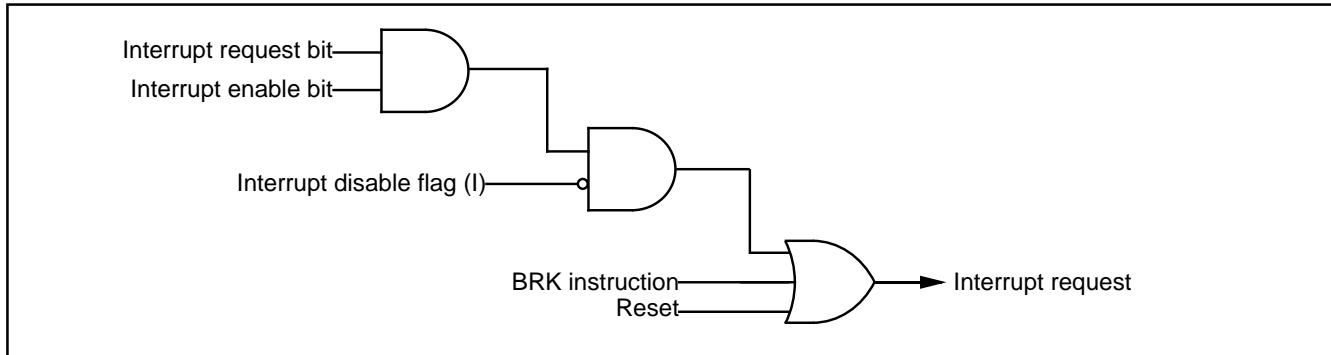


Fig. 16 Interrupt control

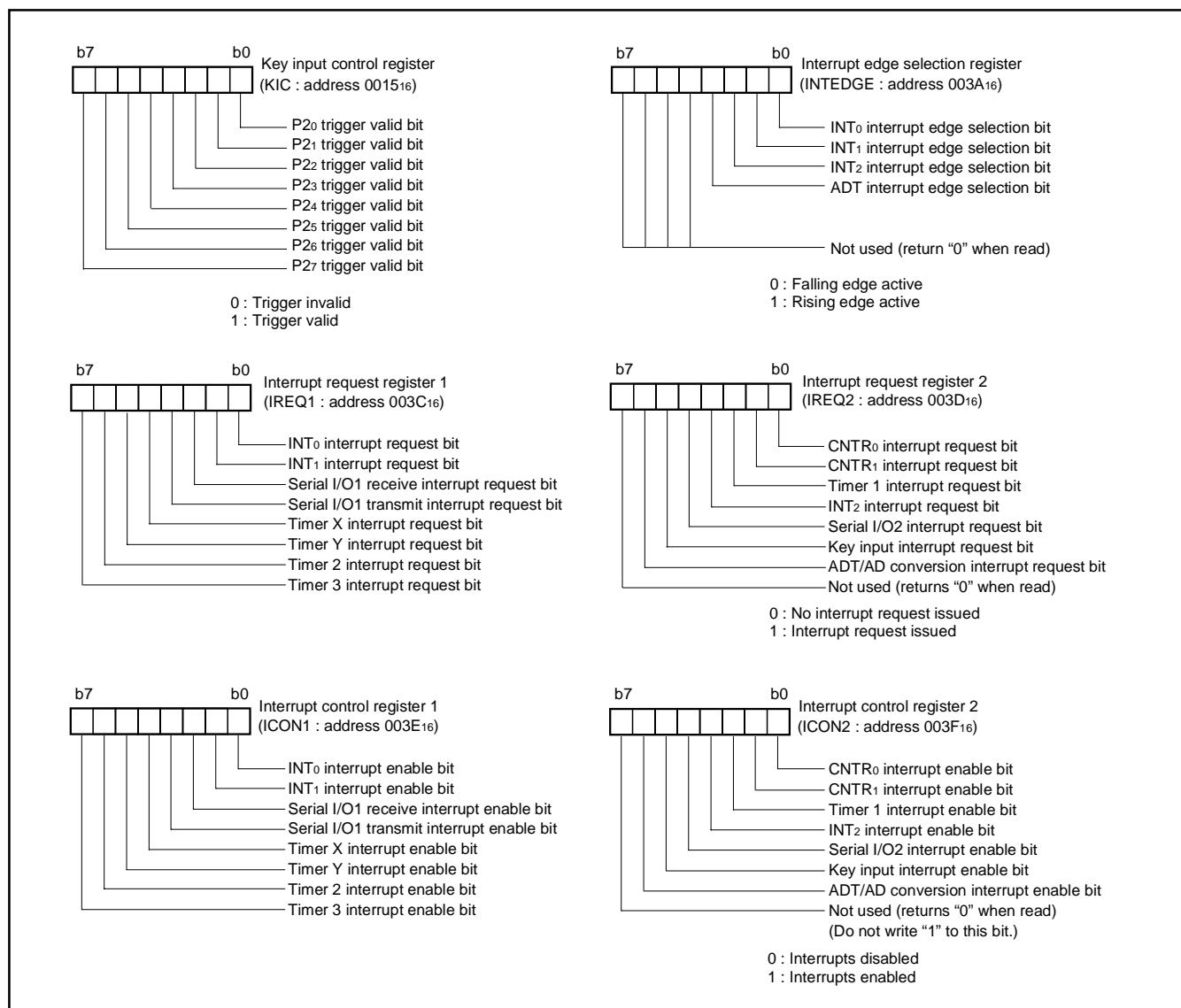


Fig. 17 Structure of interrupt-related registers

Key Input Interrupt (Key-on wake-up)

A Key-on wake up interrupt request is generated by applying a falling edge to any pin of port P2 that have been set to input mode. In other words, it is generated when AND of input level goes from

"1" to "0". An example of using a key input interrupt is shown in Figure 18, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports P20-P23.

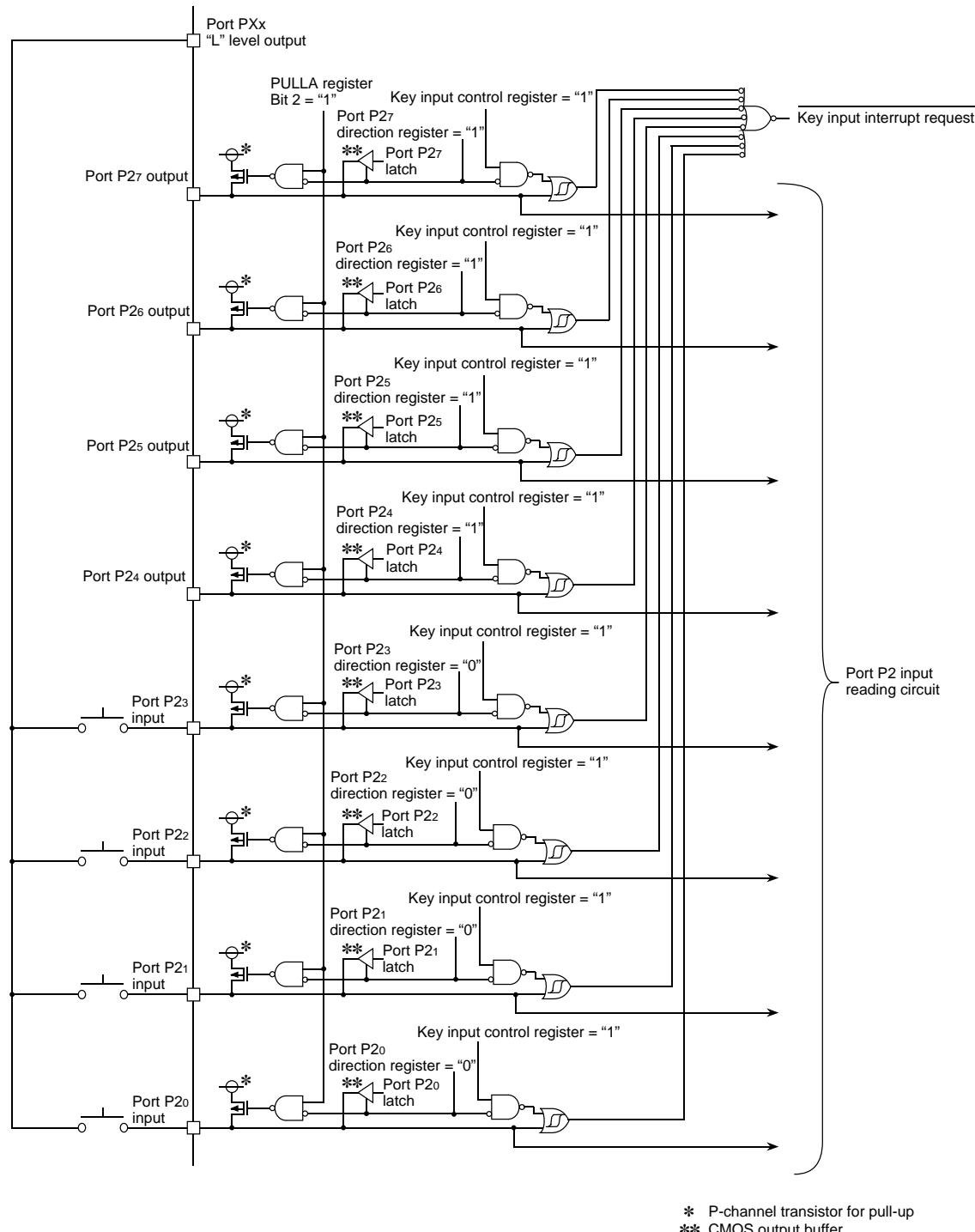


Fig. 18 Connection example when using key input interrupt and port P2 block diagram

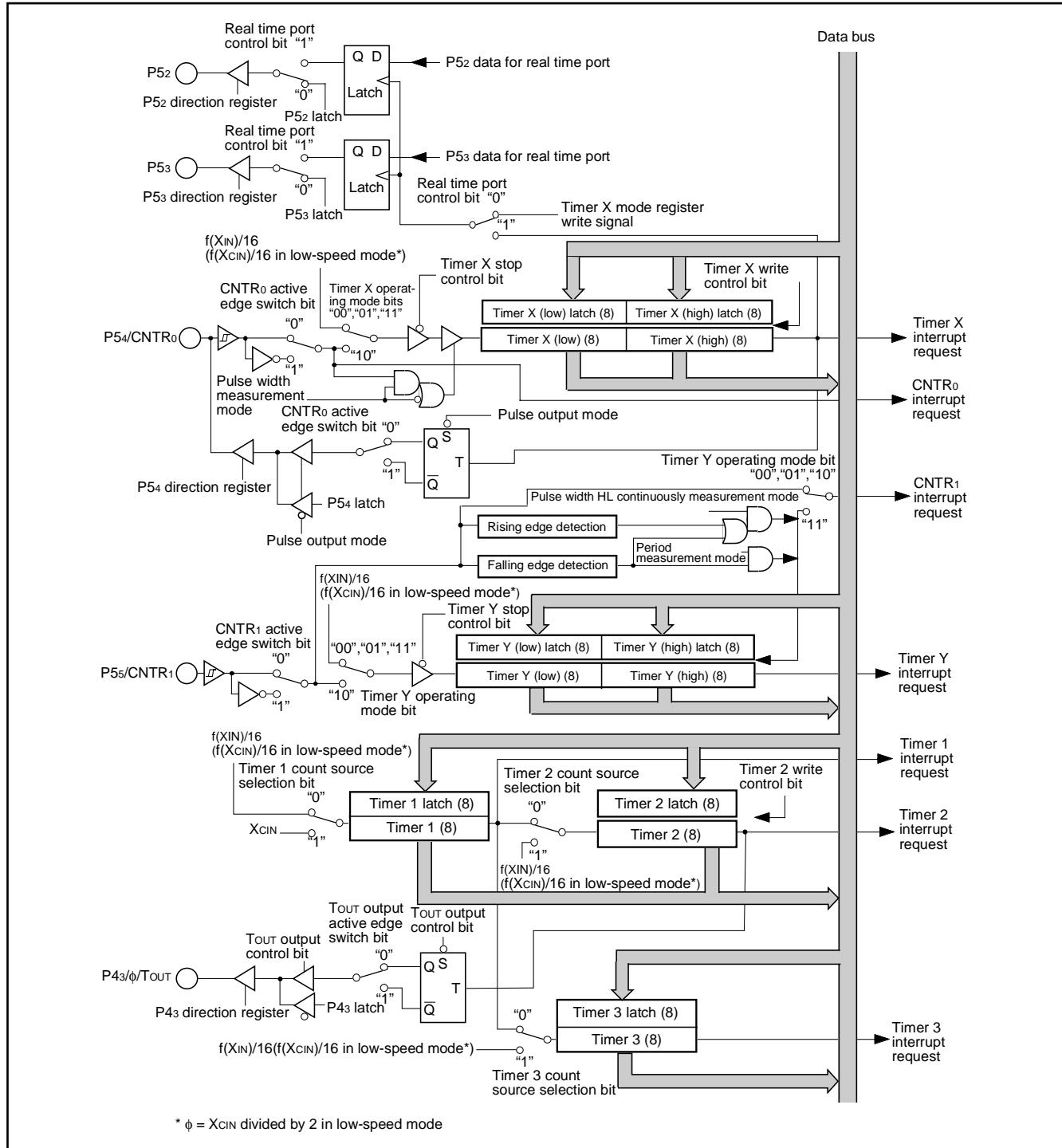
TIMERS

The 7513 group has five timers: timer X, timer Y, timer 1, timer 2, and timer 3. Timer X and timer Y are 16-bit timers, and timer 1, timer 2, and timer 3 are 8-bit timers.

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

responding to that timer is set to "1".

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



* $\phi = X_{CIN}$ divided by 2 in low-speed mode

Fig. 19 Timer block diagram

Timer X

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

(1) Timer Mode

The timer counts $f(XIN)/16$ (or $f(XCIN)/16$ in low-speed mode).

(2) Pulse Output Mode

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

(3) Event Counter Mode

The timer counts signals input through the CNTR0 pin.

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

(4) Pulse Width Measurement Mode

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

●Timer X write control

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

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

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

■Notes on CNTR0 interrupt active edge selection

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

●Real time port control

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

Before using this function, set the corresponding port direction registers to output mode.

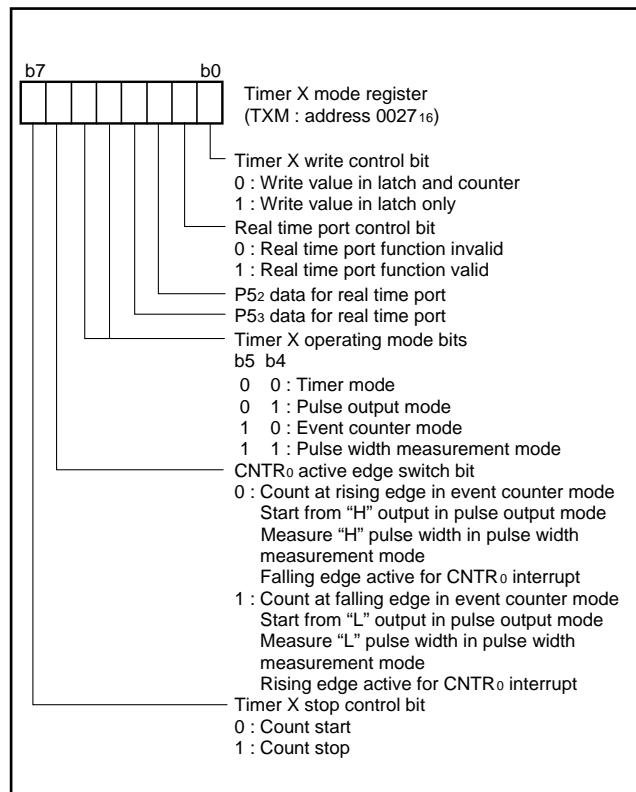


Fig. 20 Structure of timer X mode register

Timer Y

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

(1) Timer Mode

The timer counts $f(Xin)/16$ (or $f(XCIN)/16$ in low-speed mode).

(2) Period Measurement Mode

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

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

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

(3) Event Counter Mode

The timer counts signals input through the CNTR1 pin.

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

(4) Pulse Width HL Continuously Measurement Mode

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

■Notes on CNTR1 interrupt active edge selection

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

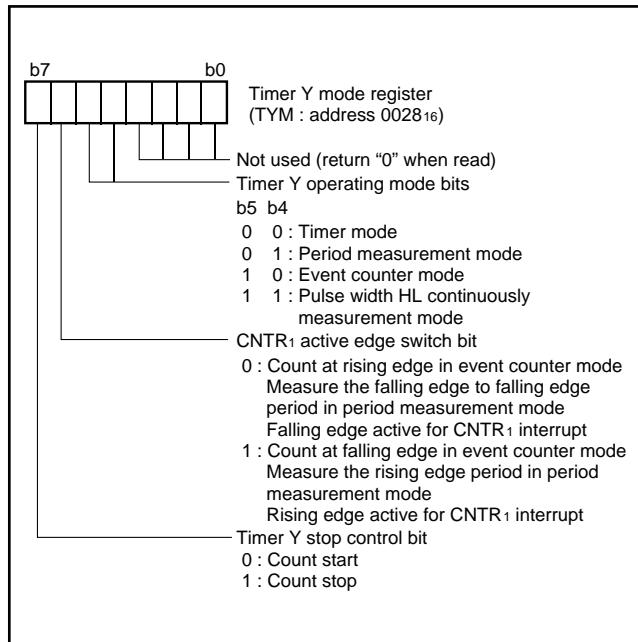


Fig. 21 Structure of timer Y mode register

Timer 1, Timer 2, Timer 3

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

●Timer 2 write control

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

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

●Timer 2 output control

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

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

■Notes on timer 1 to timer 3

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

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

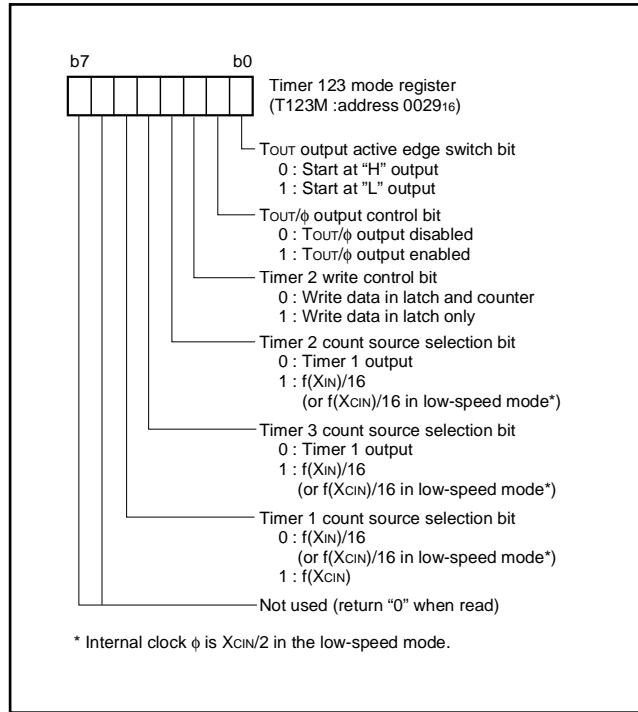


Fig. 22 Structure of timer 123 mode register

SERIAL I/O**Serial I/O1**

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

(1) Clock Synchronous Serial I/O Mode

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

For clock synchronous serial I/O1, the transmitter and the receiver must use the same clock. If an internal clock is used, transfer is started by a write signal to the transmit/receive buffer registers.

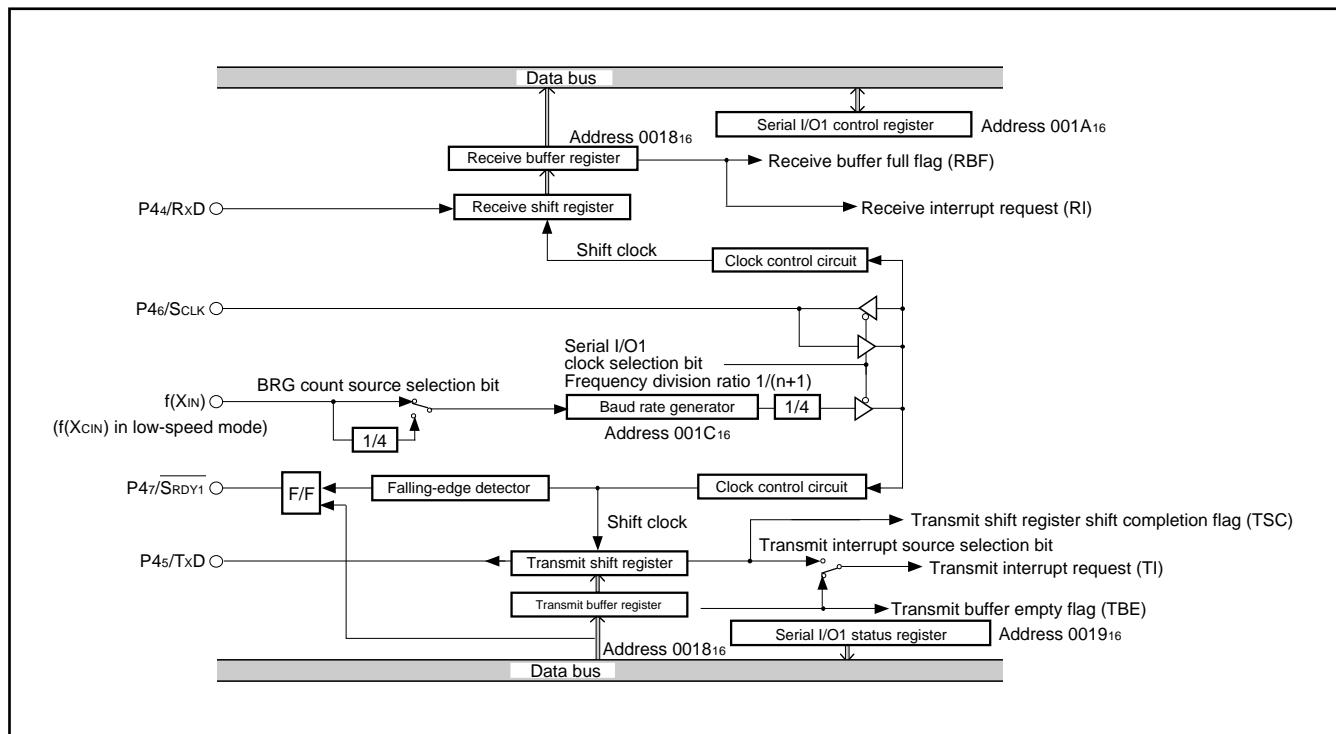


Fig. 23 Block diagram of clock synchronous serial I/O1

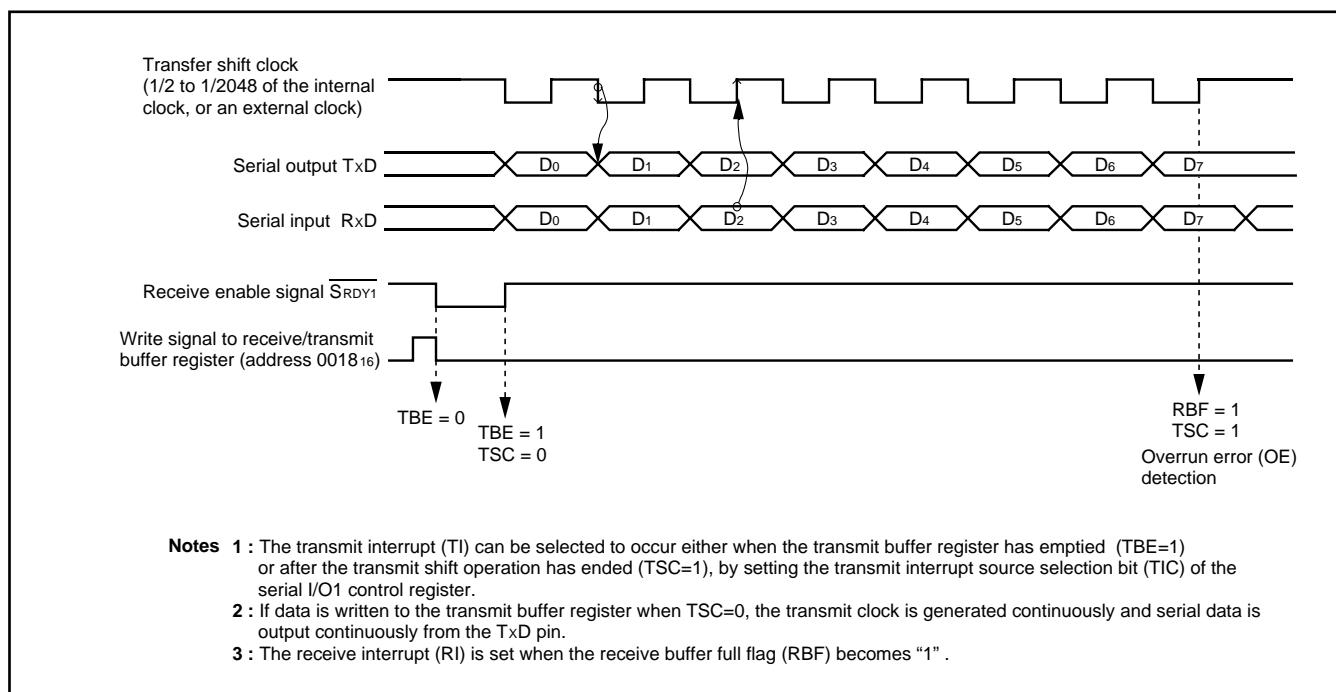


Fig. 24 Operation of clock synchronous serial I/O1 function

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

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

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

The transmit and receive shift registers each have a buffer regis-

ter, but the two buffers have the same address in memory. Since the shift register cannot be written to or read from directly, transmit data is written to the transmit buffer, and receive data is read from the receive buffer.

The transmit buffer can also hold the next data to be transmitted, and the receive buffer register can hold a character while the next character is being received.

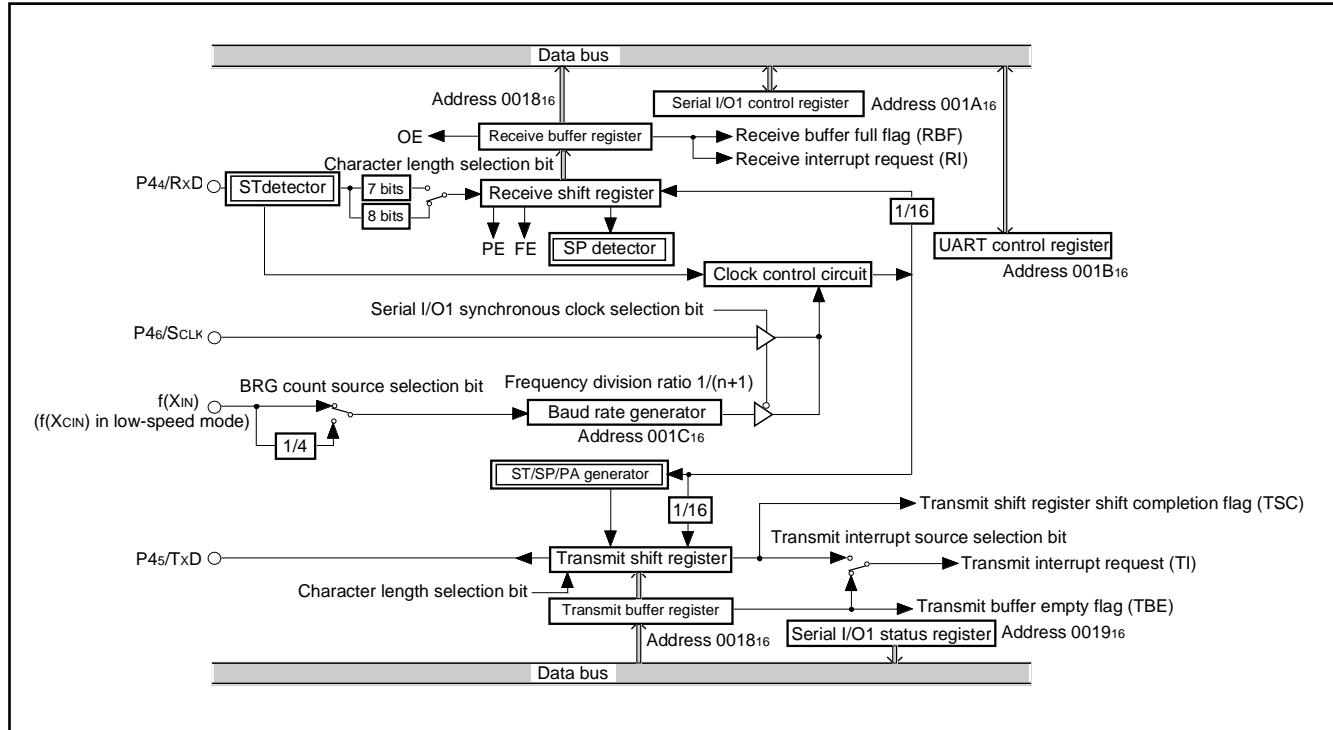


Fig. 25 Block diagram of UART serial I/O1

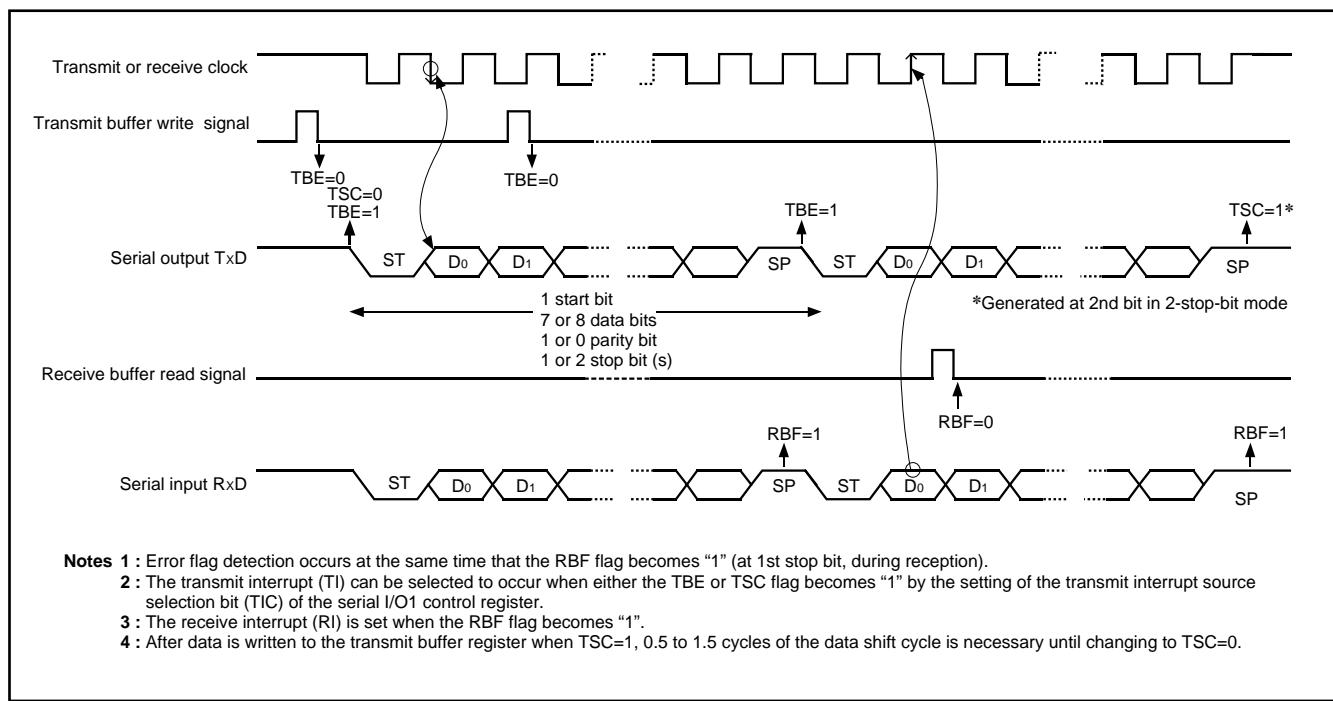


Fig. 26 Operation of UART serial I/O1 function

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

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

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

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

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

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

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

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

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

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

[UART Control Register (UARTCON)] 001B16

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

[Baud Rate Generator(BRG)] 001616

The baud rate generator determines the baud rate for serial transfer.

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

■ Notes

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 synchronized with the transmission enabled, take the following sequence.

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

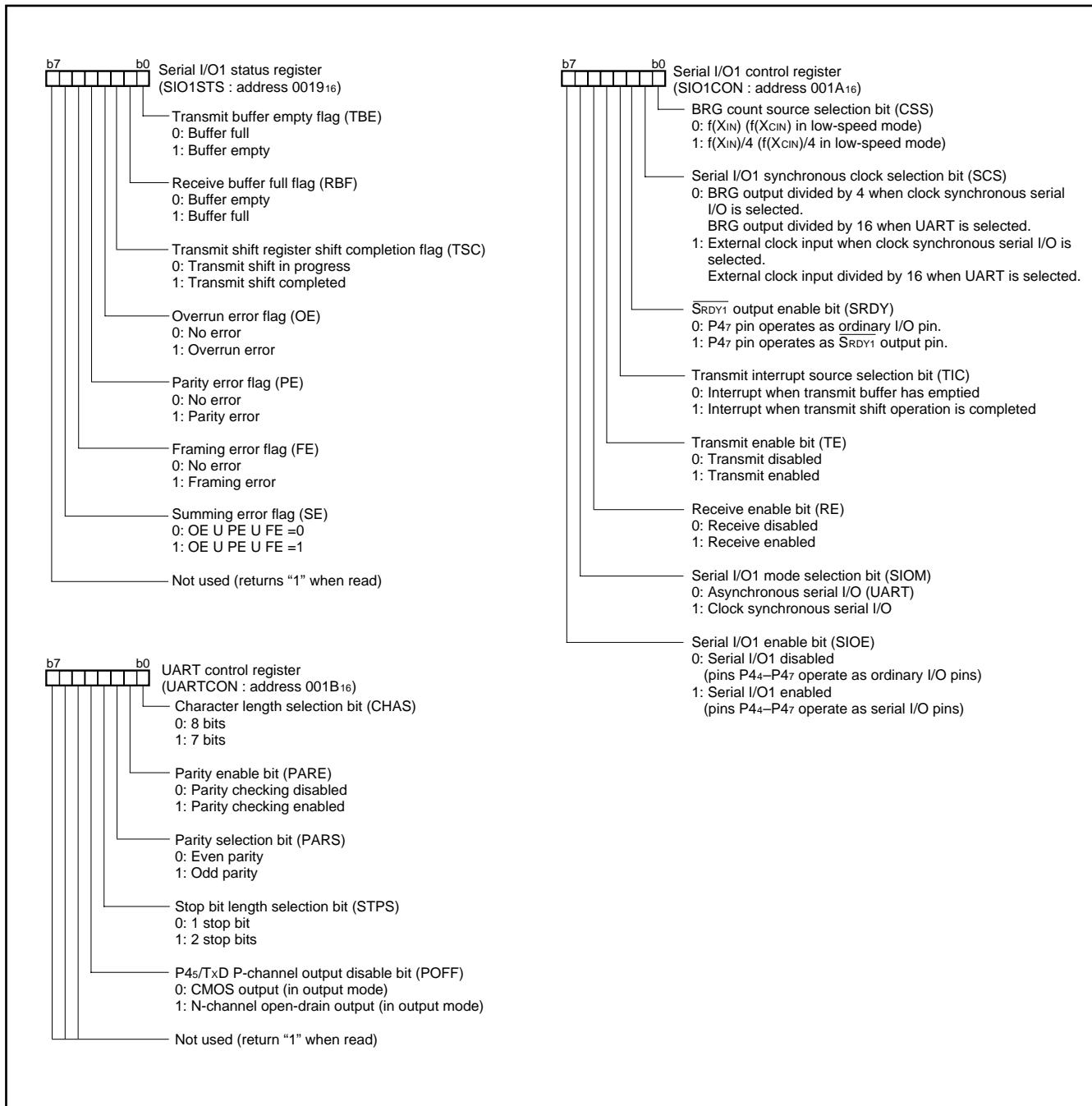


Fig. 27 Structure of serial I/O1 control registers

Serial I/O2

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

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

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

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

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

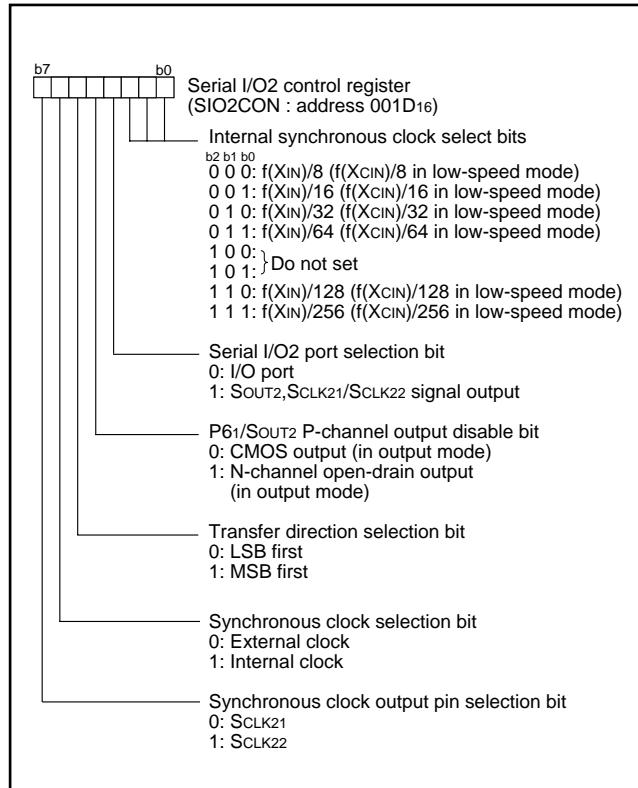


Fig. 28 Structure of serial I/O2 control register

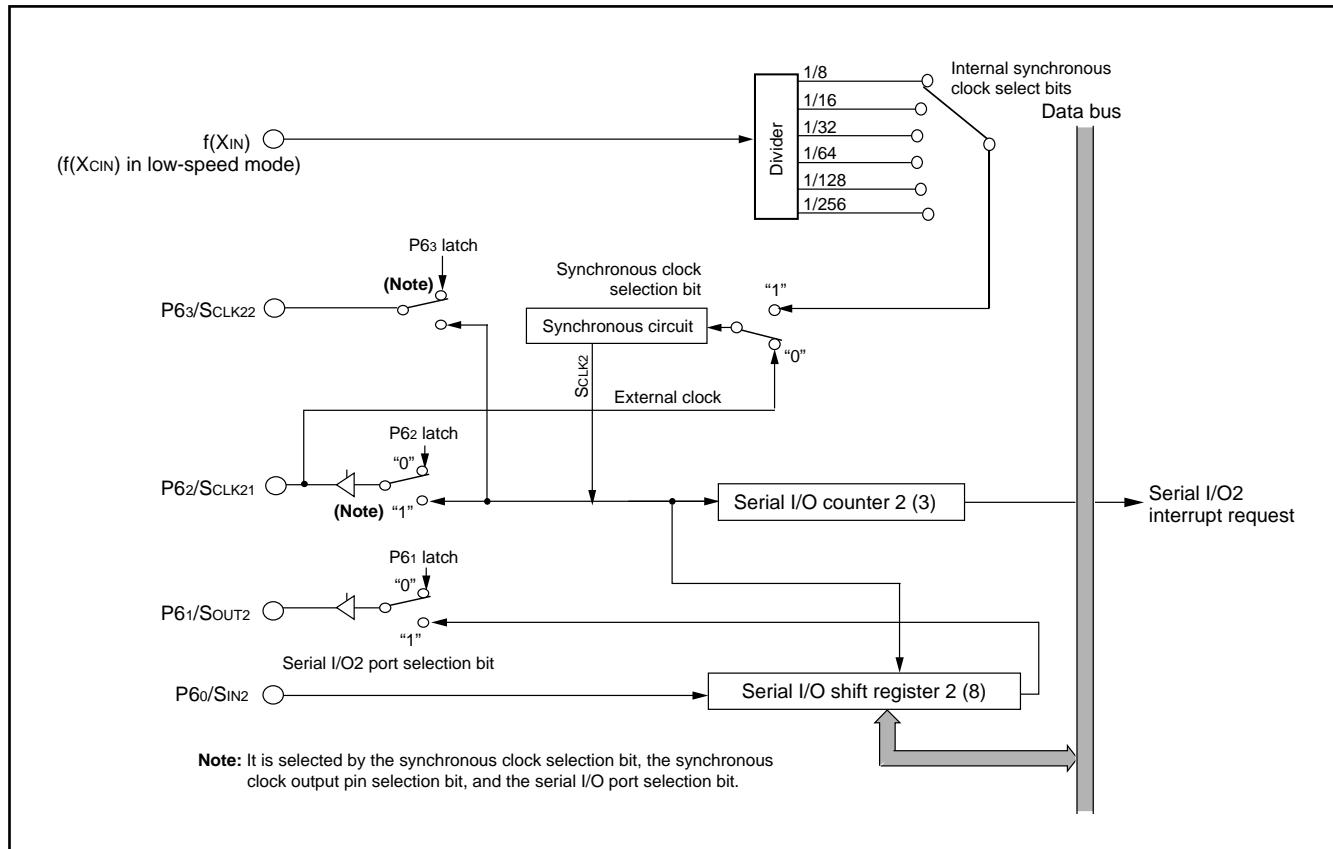


Fig. 29 Block diagram of serial I/O2 function

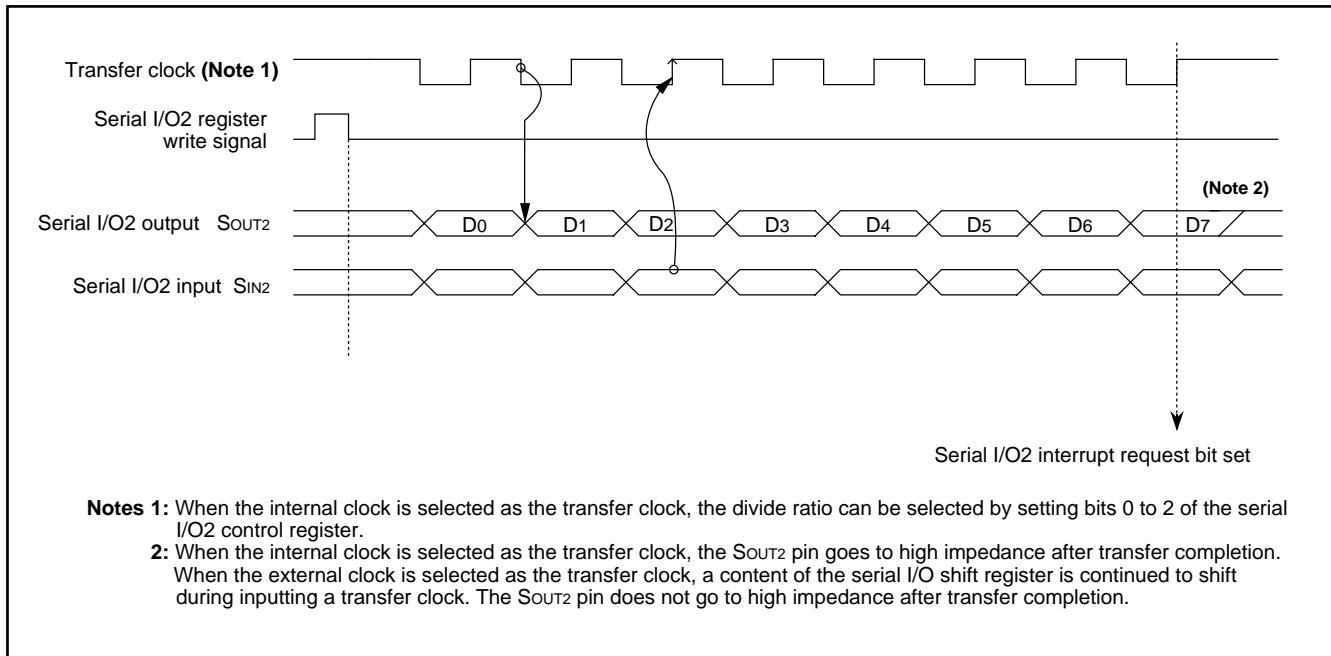


Fig. 30 Timing of serial I/O2 function

PULSE WIDTH MODULATION (PWM)

The 7513 group has a PWM function with an 8-bit resolution, based on a signal that is the clock input XIN or that clock input divided by 2.

Data Setting

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

If PWM count source is $f(XIN)$ 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) :

$$\begin{aligned} \text{PWM period} &= 255 \times (n+1)/f(XIN) \\ &= 51 \times (n+1) \mu\text{s} \quad (\text{when } f(XIN) = 5 \text{ MHz}) \\ \text{Output pulse "H" period} &= \text{PWM period} \times m/255 \\ &= 0.2 \times (n+1) \times m \mu\text{s} \\ &\quad (\text{when } f(XIN) = 5 \text{ MHz}) \end{aligned}$$

PWM Operation

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

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

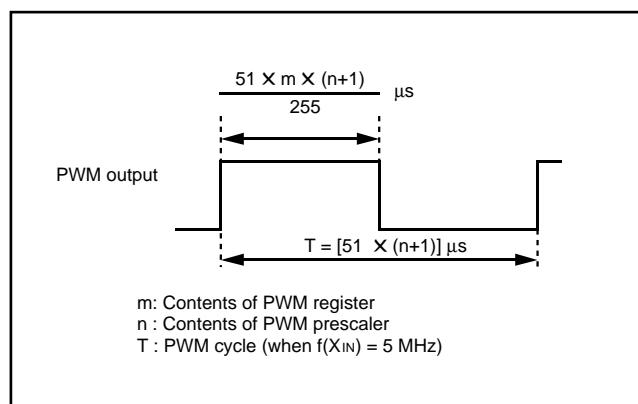


Fig. 31 Timing of PWM cycle

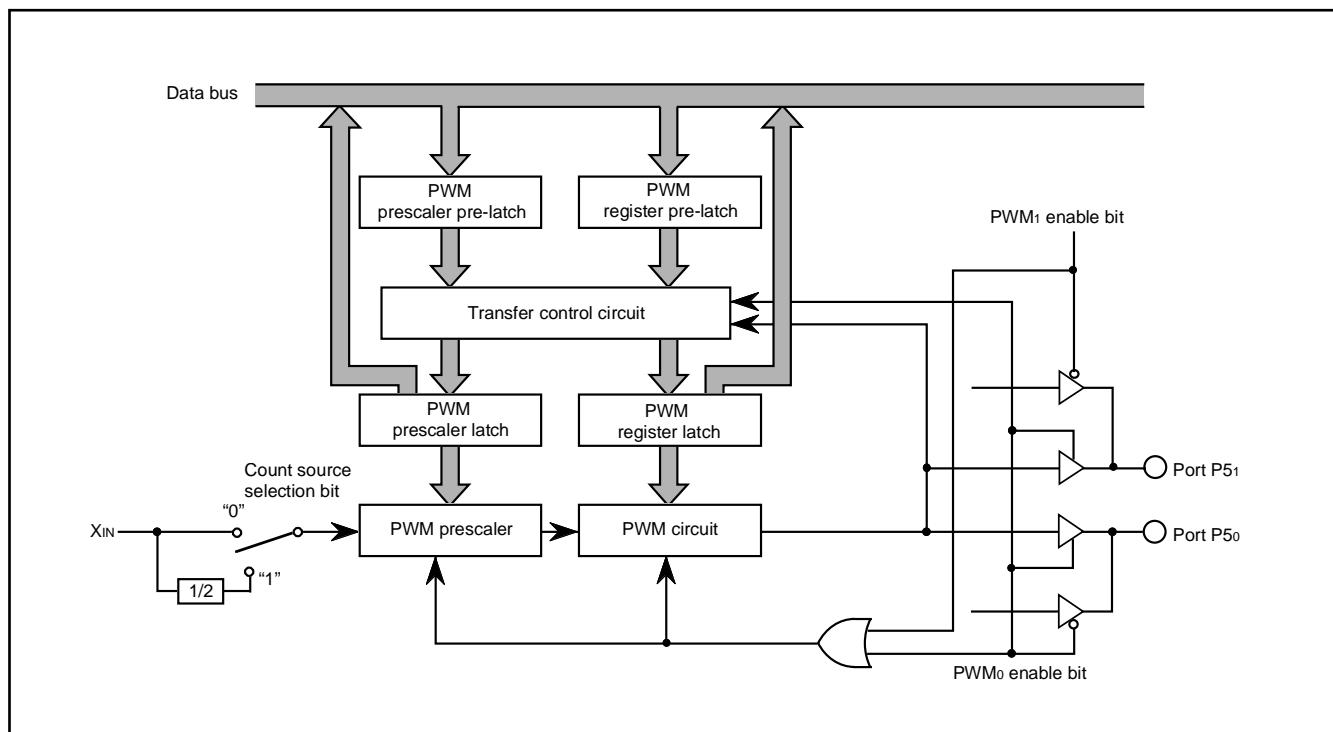


Fig. 32 Block diagram of PWM function

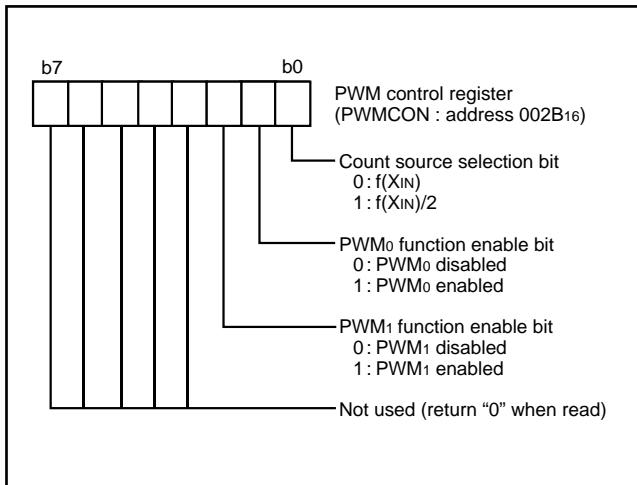


Fig. 33 Structure of PWM control register

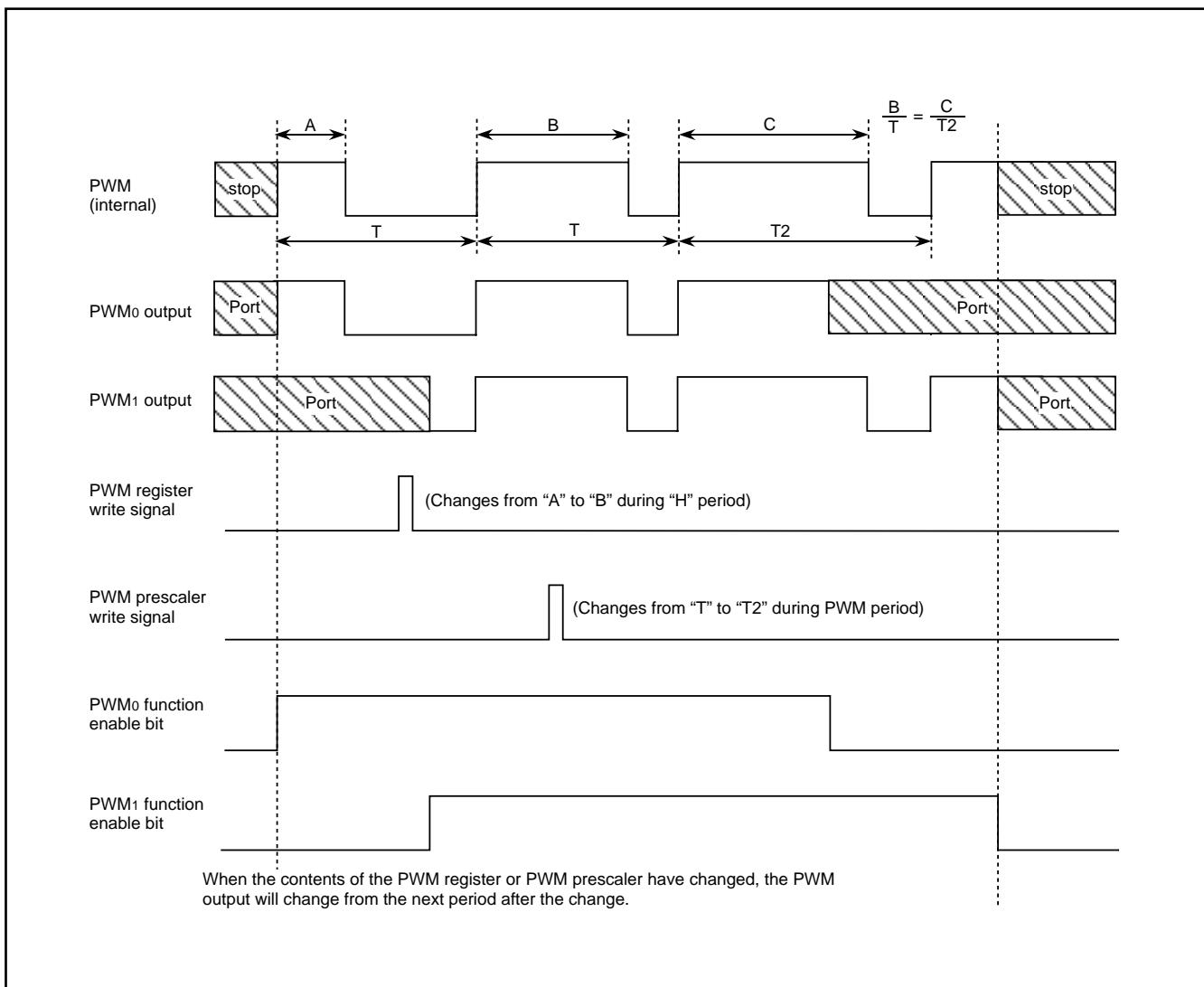


Fig. 34 PWM output timing when PWM register or PWM prescaler is changed

A-D CONVERTER**[A-D Conversion Registers (ADL, ADH)]**
003216, 003316

The A-D conversion registers are read-only registers that contain the result of an A-D conversion. During A-D conversion, do not read these registers.

[A-D Control Register (ADCON)] 003116

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

[Comparison Voltage Generator]

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

[Channel Selector]

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

[Comparator and Control Circuit]

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

Note that the comparator is constructed linked to a capacitor, so set f(XIN) to at least 500 kHz during A-D conversion.

Use a clock divided the main clock XIN as the internal clock ϕ .

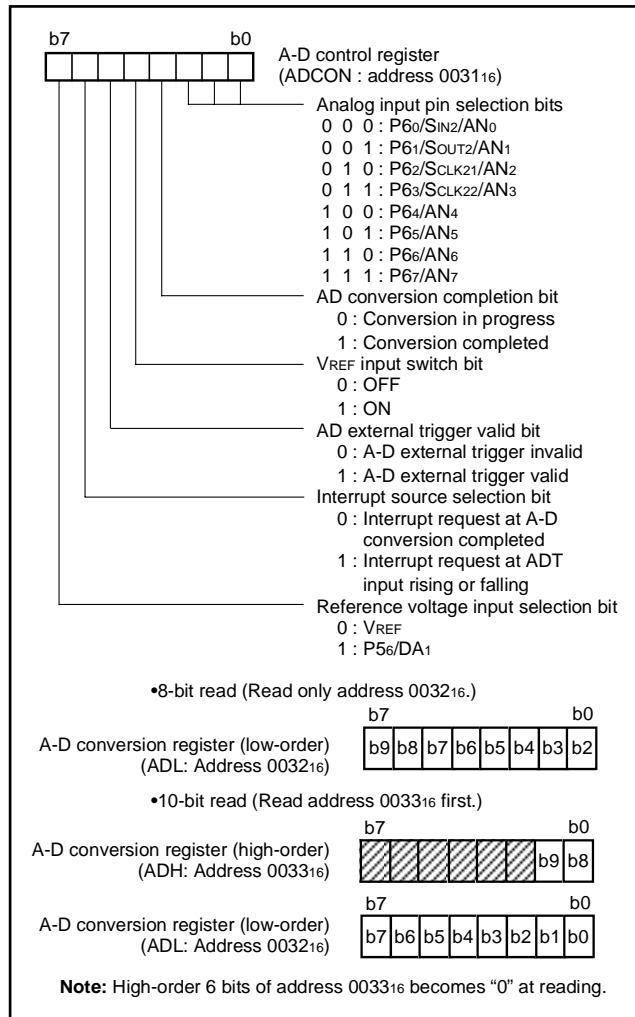


Fig. 35 Structure of A-D control register

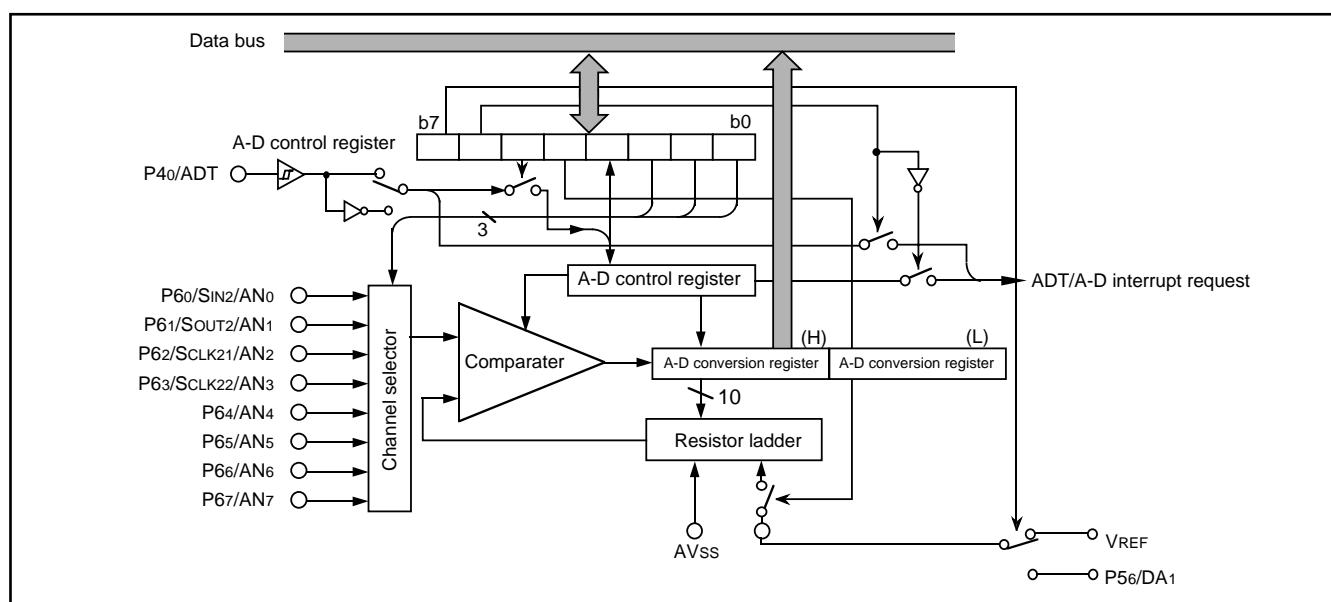


Fig. 36 A-D converter block diagram

D-A CONVERTER

The 7513 group has an on-chip D-A converter with 8-bit resolution and 2 channels (DAi (i=1, 2)). The D-A converter is performed by setting the value in the D-A conversion register. The result of D-A converter is output from DAi pin. When using the D-A converter, the corresponding port direction register bit (P56/DA1, P57/DA2) should be set to "0" (input status).

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

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

Where V_{REF} is the reference voltage.

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

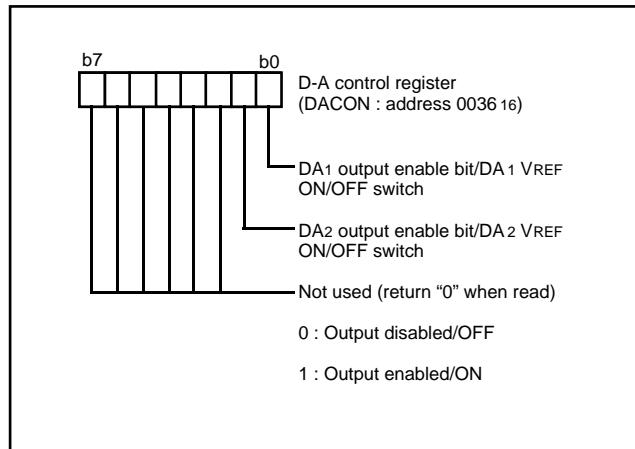


Fig. 37 Structure of D-A control register

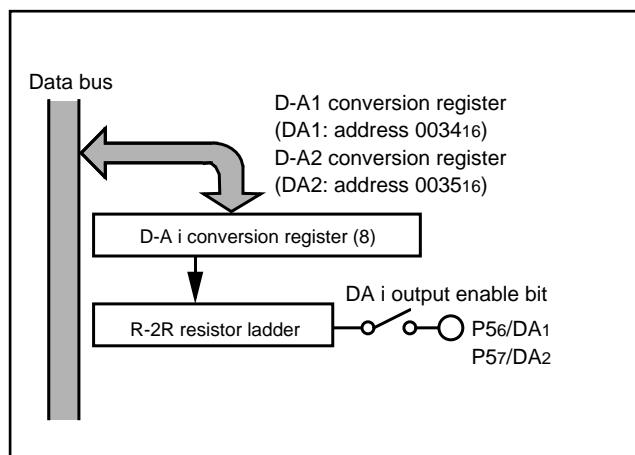


Fig. 38 Block diagram of D-A converter

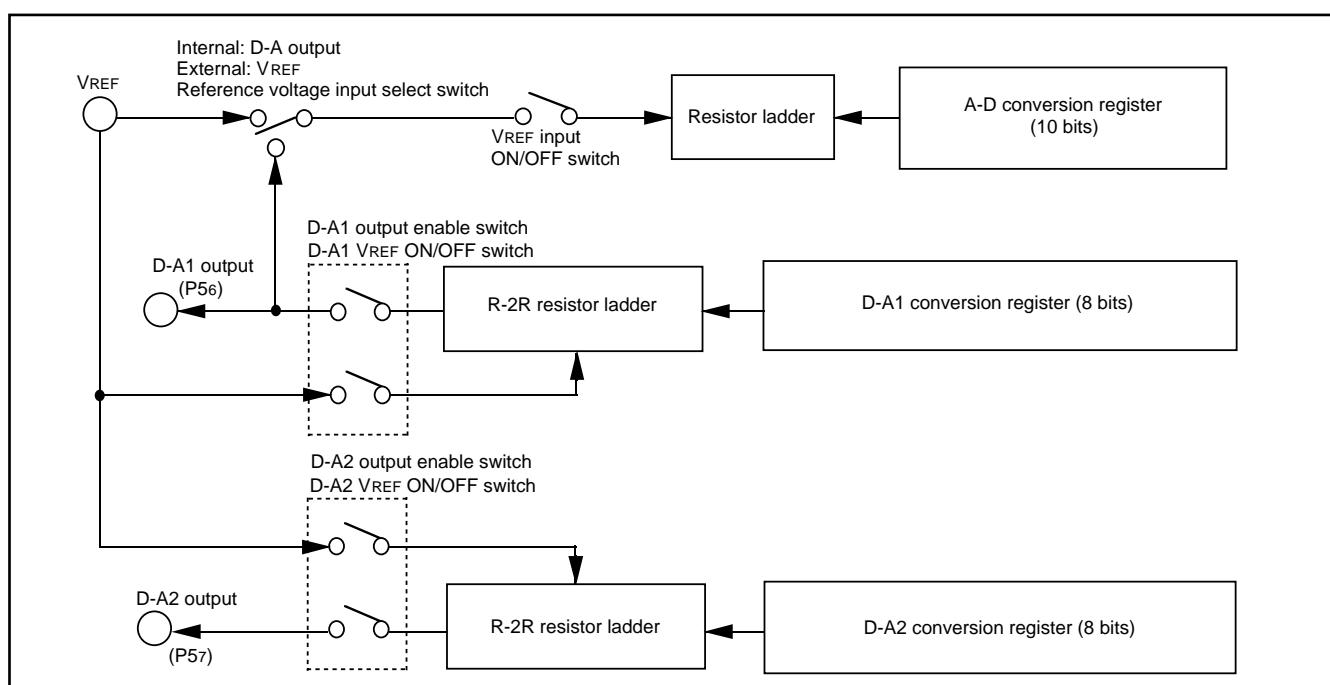


Fig. 39 A-D converter, D-A converter block diagram

LCD DRIVE CONTROL CIRCUIT

The 7513 group has the built-in Liquid Crystal Display (LCD) drive control circuit consisting of the following.

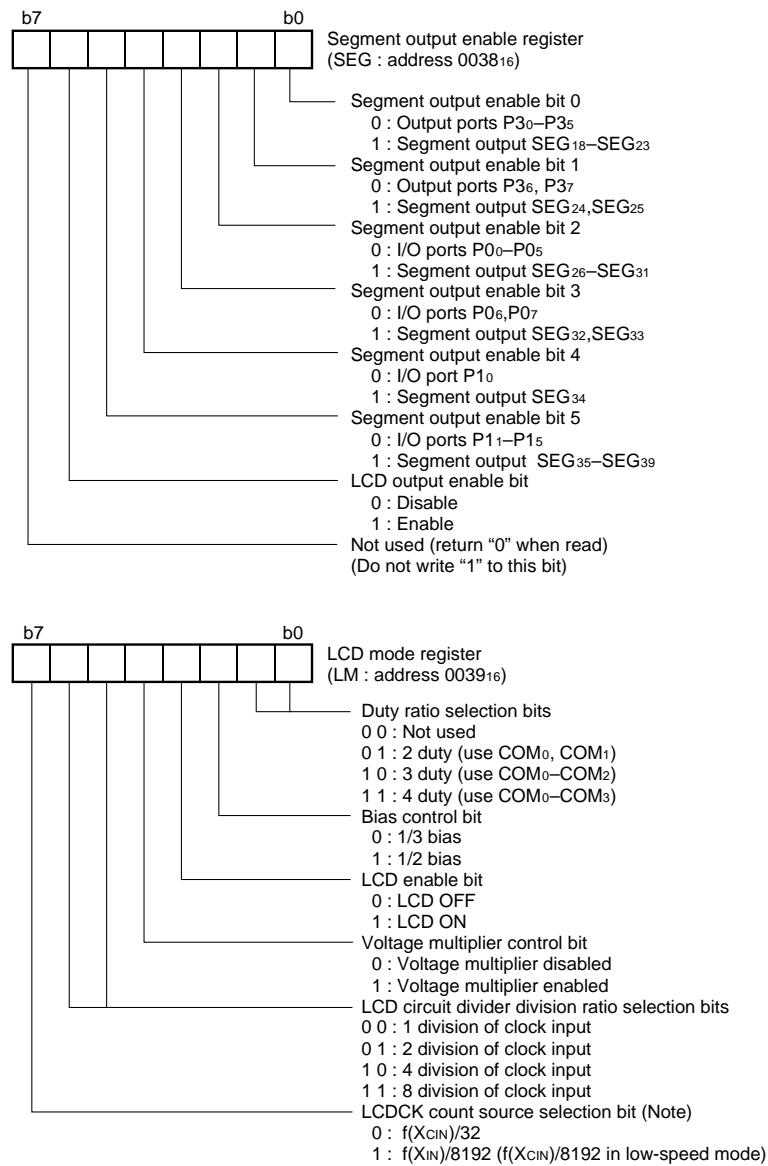
- LCD display RAM
- Segment output enable register
- LCD mode register
- Voltage multiplier
- Selector
- Timing controller
- Common driver
- Segment driver
- Bias control circuit

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

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

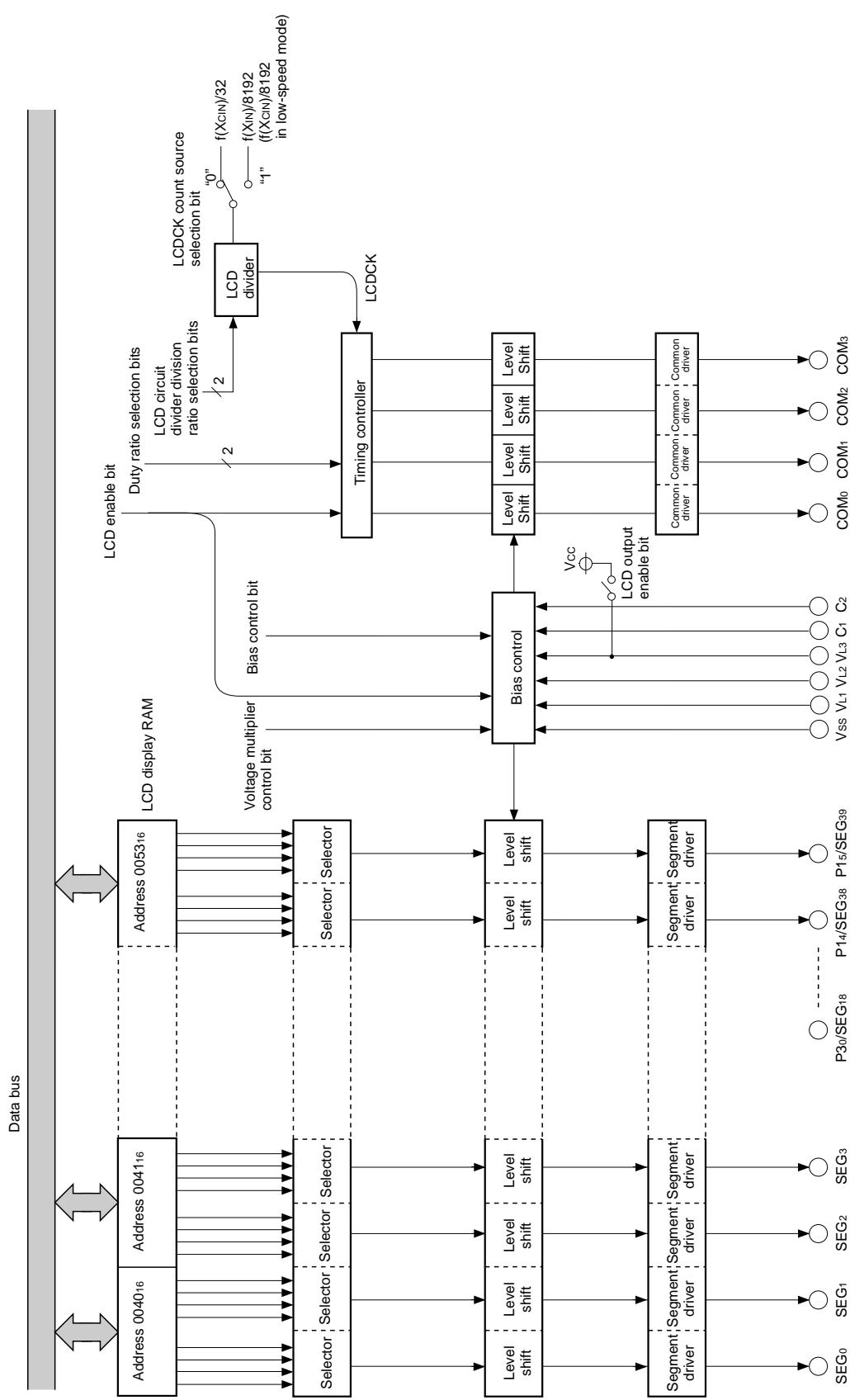
Table 9 Maximum number of display pixels at each duty ratio

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. 40 Structure of LCD mode register



Voltage Multiplier (3 Times)

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

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

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

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

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

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

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

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

Bias Control and Applied Voltage to LCD Power Input Pins

To the LCD power input pins (VL1–VL3), apply the voltage shown in Table 10 according to the bias value.

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

Table 10 Bias control and applied voltage to VL1–VL3

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

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

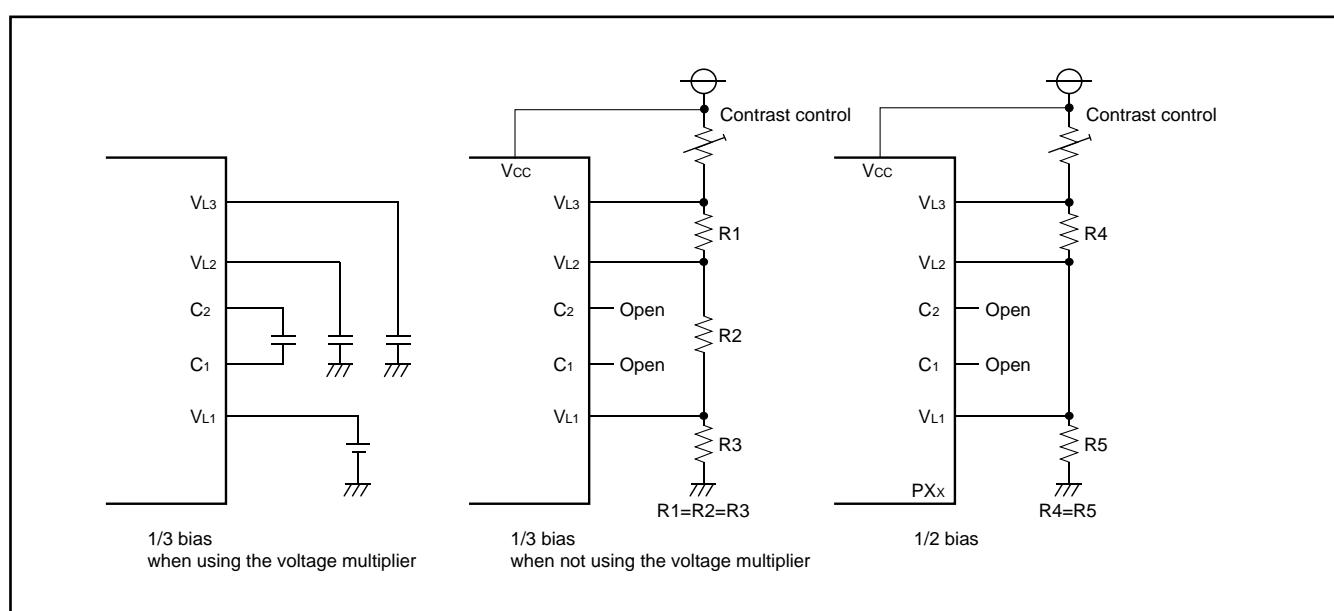


Fig. 42 Example of circuit at each bias

Common Pin and Duty Ratio Control

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

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

When releasing from reset, the Vcc (VL₃) voltage is output from the common pins.

ment/output port pins are the high impedance condition. The segment/I/O port pins(SEG₂₆–SEG₃₃). are set to input ports, and the high impedance condition. The segment/I/O port pins(SEG₃₄–SEG₃₉). are set to input ports, and Vcc (=VL₃) is applied to them by pull-up resistor.

LCD Display RAM

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

LCD Drive Timing

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

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

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

Table 11 Duty ratio control and common pins used

Duty ratio	Duty ratio selection bit		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

Notes1: COM₂ and COM₃ are open.

2: COM₃ is open.

Segment Signal Output Pin

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

Segment signals are output according to the bit data of the LCD RAM corresponding to the duty ratio. After reset release, a Vcc (=VL₃) voltage is output to the segment-only pins and the seg-

Bit address \	7	6	5	4	3	2	1	0
004016	SEG1				SEG0			
004116	SEG3				SEG2			
004216	SEG5				SEG4			
004316	SEG7				SEG6			
004416	SEG9				SEG8			
004516	SEG ₁₁				SEG ₁₀			
004616	SEG ₁₃				SEG ₁₂			
004716	SEG ₁₅				SEG ₁₄			
004816	SEG ₁₇				SEG ₁₆			
004916	SEG ₁₉				SEG ₁₈			
004A16	SEG ₂₁				SEG ₂₀			
004B16	SEG ₂₃				SEG ₂₂			
004C16	SEG ₂₅				SEG ₂₄			
004D16	SEG ₂₇				SEG ₂₆			
004E16	SEG ₂₉				SEG ₂₈			
004F16	SEG ₃₁				SEG ₃₀			
005016	SEG ₃₃				SEG ₃₂			
005116	SEG ₃₅				SEG ₃₄			
005216	SEG ₃₇				SEG ₃₆			
005316	SEG ₃₉				SEG ₃₈			
	COM ₃	COM ₂	COM ₁	COM ₀	COM ₃	COM ₂	COM ₁	COM ₀

Fig. 43 LCD display RAM map

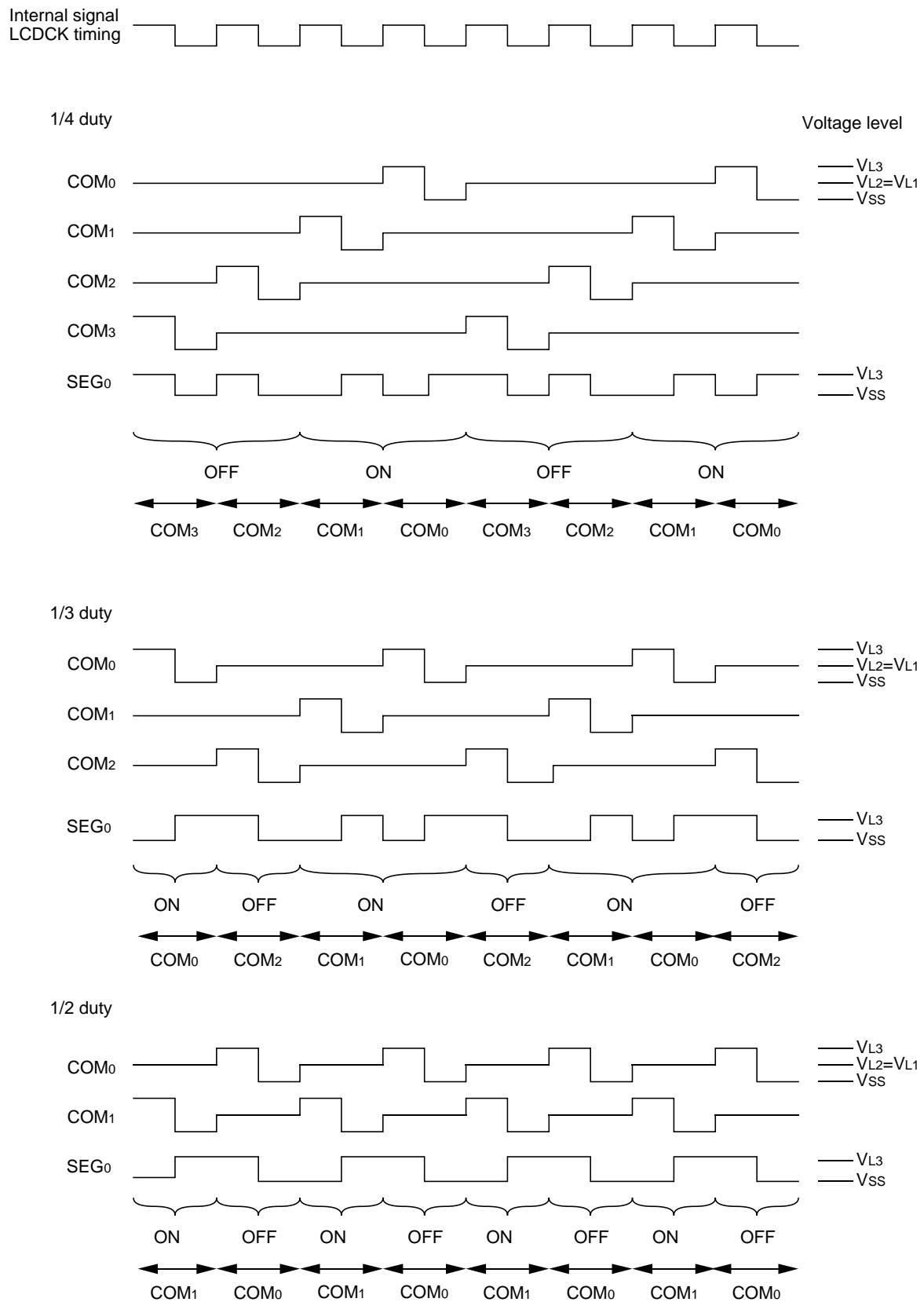


Fig. 44 LCD drive waveform (1/2 bias)

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

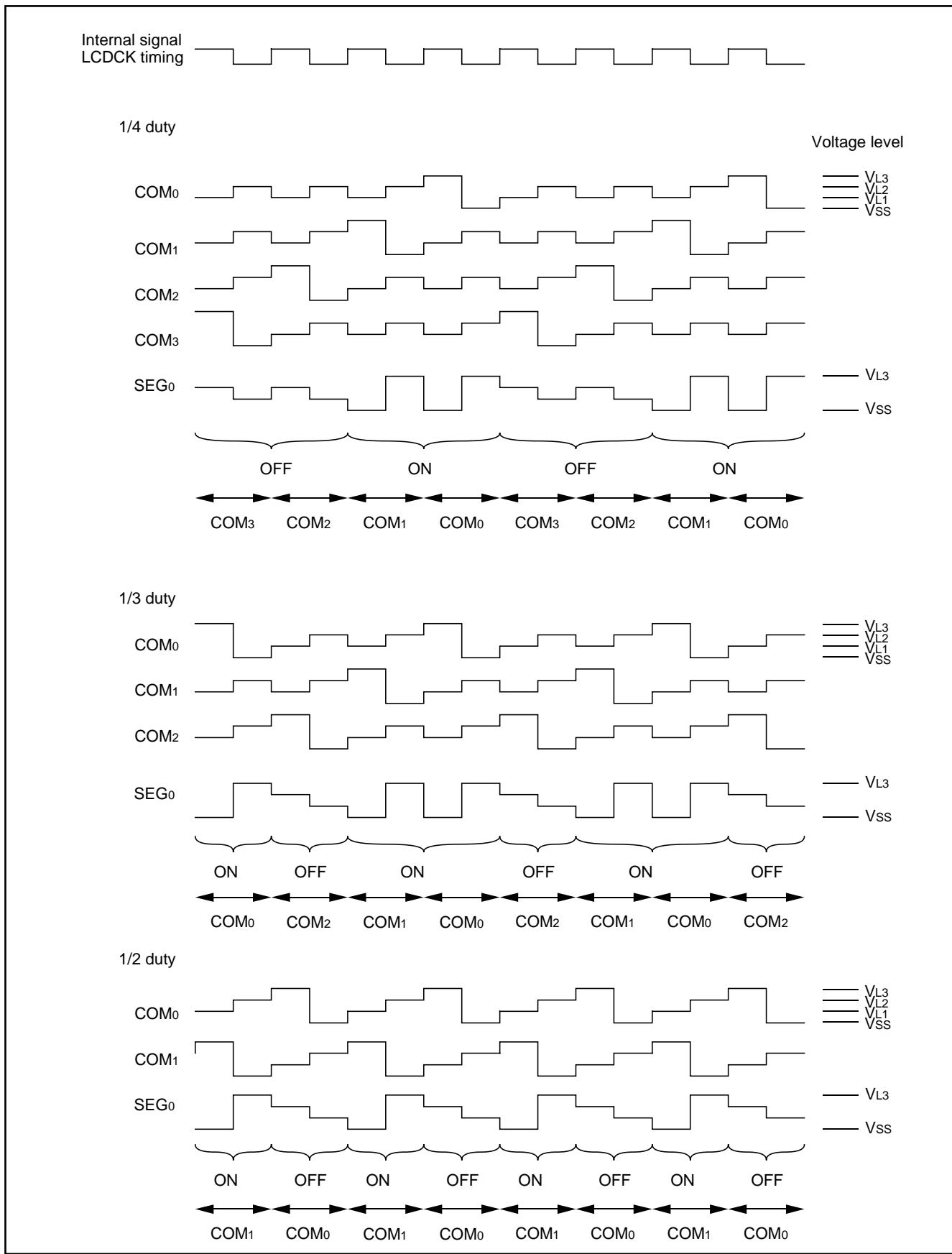


Fig. 45 LCD drive waveform (1/3 bias)

WATCHDOG TIMER

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

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

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

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

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

The count source of the watchdog timer becomes the system clock ϕ divided by 8. The detection time in this case is set to 8.19 s at $f(XCIN) = 32$ kHz and 65.536 ms at $f(XIN) = 4$ MHz.

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

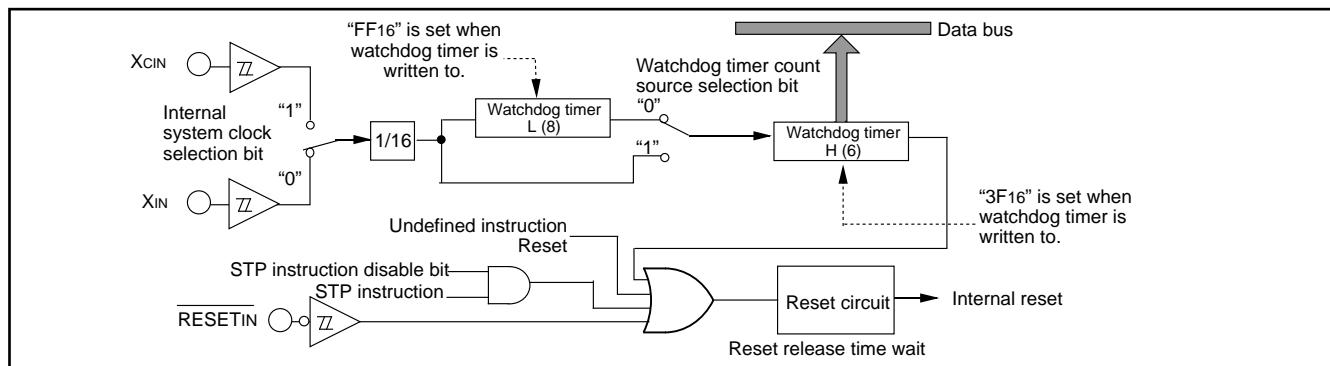


Fig. 46 Block diagram of watchdog timer

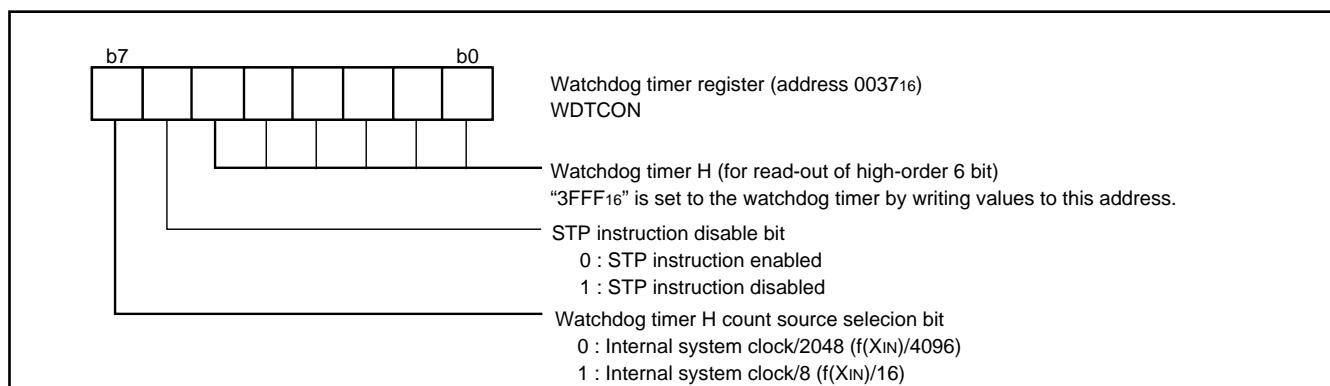


Fig. 47 Structure of watchdog timer control register

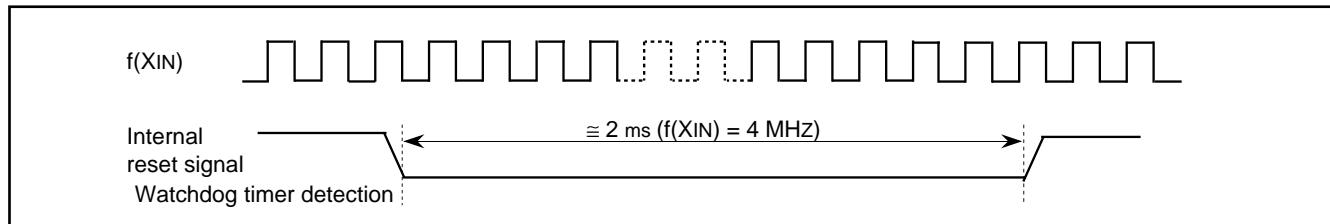
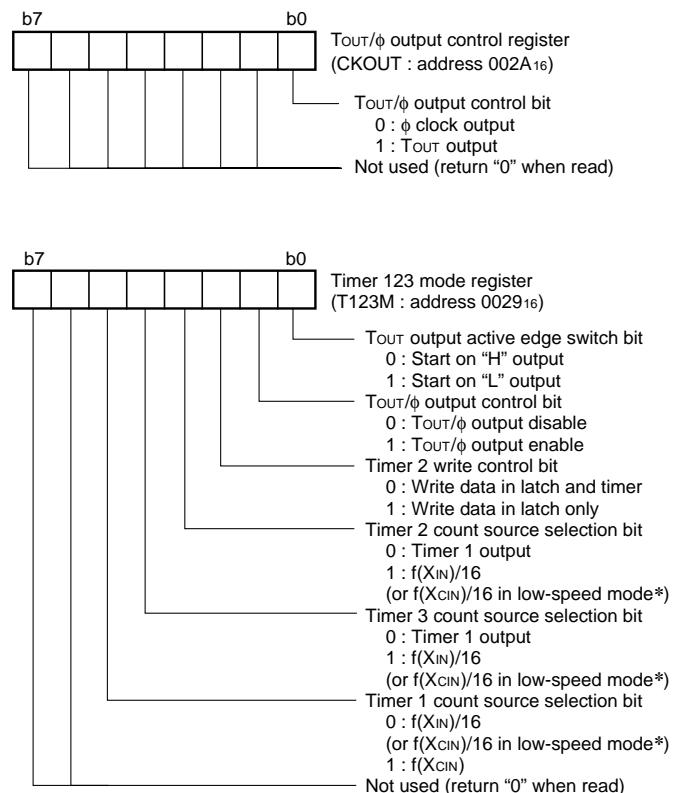


Fig. 48 Timing of reset output

Tout/ ϕ CLOCK OUTPUT FUNCTION

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



* : Internal clock ϕ is $f(X_{CIN})/2$ in low-speed mode.

Fig. 49 Structure of Tout/f output-related register

RESET CIRCUIT

To reset the microcomputer, RESET pin should be held at an "L" level for 2 μ s or more. Then the RESET pin is returned to an "H" level (the power source voltage should be between $V_{CC(min.)}$ and 5.5 V, and the oscillation should be stable), reset is released. After the reset is completed, the program starts from the address contained in address FFFD16 (high-order byte) and address FFFC16 (low-order byte). Make sure that the reset input voltage is less than 0.2 V_{CC} for V_{CC} of V_{CC} (min.).

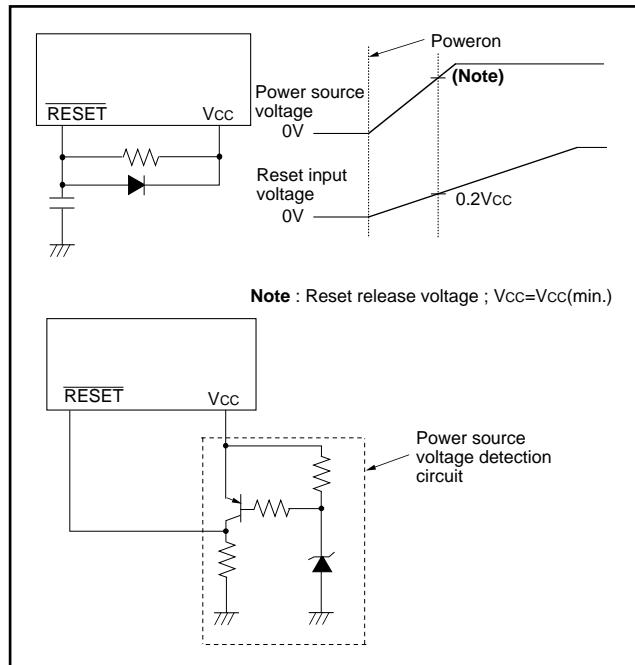


Fig. 50 Reset Circuit Example

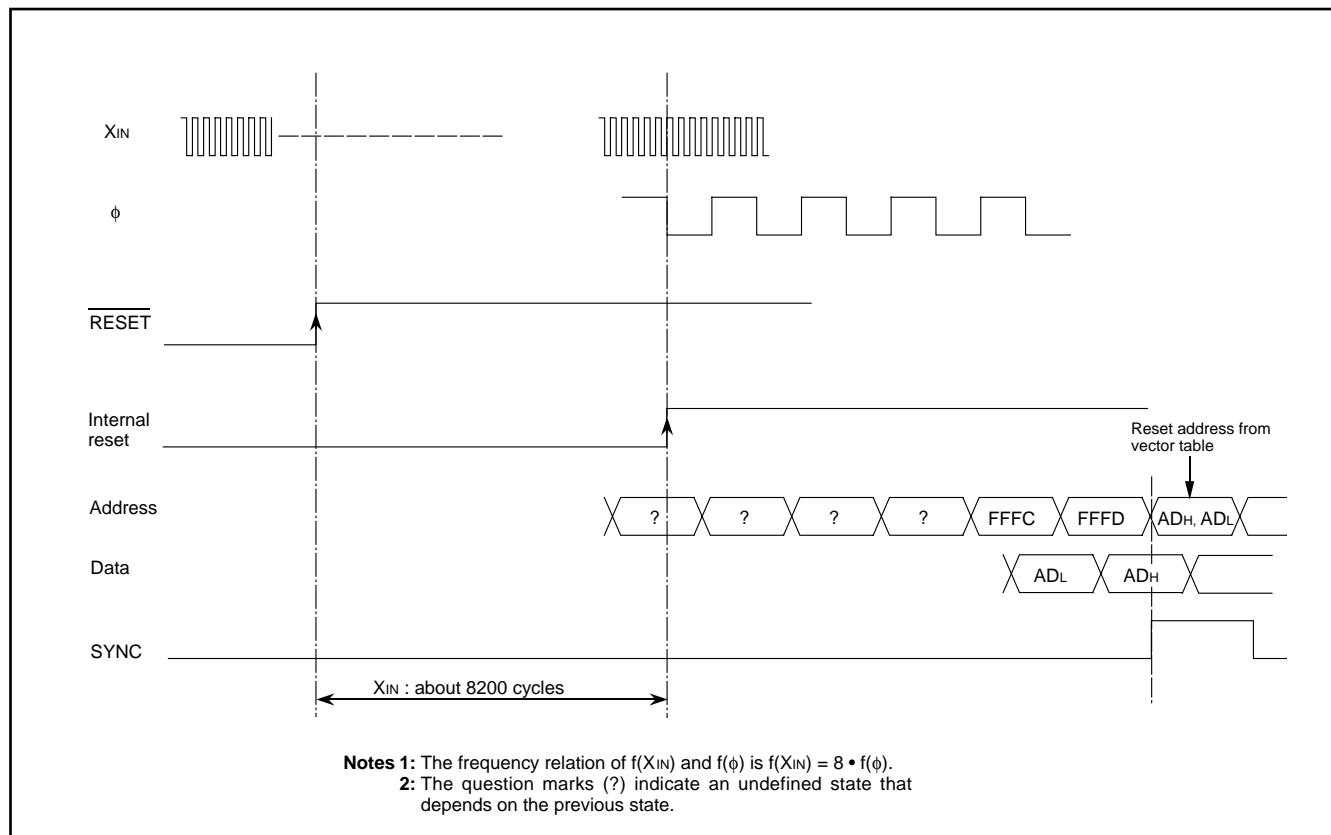


Fig. 51 Reset Sequence

	Address	Register contents		Address	Register contents
(1) Port P0 direction register	0001 ₁₆	00 ₁₆	(28) A-D control register	0031 ₁₆	08 ₁₆
(2) Port P1 direction register	0003 ₁₆	00 ₁₆	(29) A-D conversion register (low-order)	0032 ₁₆	XX ₁₆
(3) Port P2 direction register	0005 ₁₆	00 ₁₆	(30) A-D conversion register (high-order)	0033 ₁₆	XX ₁₆
(4) Port P3 output control register	0007 ₁₆	00 ₁₆	(31) D-A1 conversion register	0034 ₁₆	00 ₁₆
(5) Port P4 direction register	0009 ₁₆	00 ₁₆	(32) D-A2 conversion register	0035 ₁₆	00 ₁₆
(6) Port P5 direction register	000B ₁₆	00 ₁₆	(33) D-A control register	0036 ₁₆	00 ₁₆
(7) Port P6 direction register	000D ₁₆	00 ₁₆	(34) Watchdog timer control register	0037 ₁₆	0011111111
(8) Port P7 direction register	000F ₁₆	00 ₁₆	(35) Segment output enable register	0038 ₁₆	00 ₁₆
(9) Key input control register	0015 ₁₆	00 ₁₆	(36) LCD mode register	0039 ₁₆	00 ₁₆
(10) PULL register A	0016 ₁₆	3F ₁₆	(37) Interrupt edge selection register	003A ₁₆	00 ₁₆
(11) PULL register B	0017 ₁₆	00 ₁₆	(38) CPU mode register	003B ₁₆	01001000
(12) Serial I/O1 status register	0019 ₁₆	10000000	(39) Interrupt request register 1	003C ₁₆	00 ₁₆
(13) Serial I/O1 control register	001A ₁₆	00 ₁₆	(40) Interrupt request register 2	003D ₁₆	00 ₁₆
(14) UART control register	001B ₁₆	11000000	(41) Interrupt control register 1	003E ₁₆	00 ₁₆
(15) Serial I/O2 control register	001D ₁₆	00 ₁₆	(42) Interrupt control register 2	003F ₁₆	00 ₁₆
(16) Timer X (low-order)	0020 ₁₆	FF ₁₆	(43) Processor status register	(PS)	XXXXX1XX
(17) Timer X (high-order)	0021 ₁₆	FF ₁₆	(44) Program counter	(PC _H)	Contents of address FFFD ₁₆
(18) Timer Y (low-order)	0022 ₁₆	FF ₁₆		(PC _L)	Contents of address FFFC ₁₆
(19) Timer Y (high-order)	0023 ₁₆	FF ₁₆	(45) Watchdog timer (high-order)		3F ₁₆
(20) Timer 1	0024 ₁₆	FF ₁₆	(46) Watchdog timer (low-order)		FF ₁₆
(21) Timer 2	0025 ₁₆	01 ₁₆			
(22) Timer 3	0026 ₁₆	FF ₁₆			
(23) Timer X mode register	0027 ₁₆	00 ₁₆			
(24) Timer Y mode register	0028 ₁₆	00 ₁₆			
(25) Timer 123 mode register	0029 ₁₆	00 ₁₆			
(26) TOUT/φ output control register	002A ₁₆	00 ₁₆			
(27) PWM control register	002B ₁₆	00 ₁₆			

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

Fig. 52 Initial status at reset

CLOCK GENERATING CIRCUIT

The 7513 group has two built-in oscillation circuits. An oscillation circuit can be formed by connecting a resonator between XIN and XOUT (XCIN and XCOUT). Use the circuit constants in accordance with the resonator manufacturer's recommended values. No external resistor is needed between XIN and XOUT since a feed-back resistor exists on-chip. However, an external feed-back resistor is needed between XCIN and XCOUT.

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

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

Frequency Control

(1) Middle-speed Mode

The internal clock ϕ is the frequency of XIN divided by 8.

After reset, this mode is selected.

(2) High-speed Mode

The internal clock ϕ is half the frequency of XIN.

(3) Low-speed Mode

● The internal clock ϕ is half the frequency of XCIN.

● A low-power consumption operation can be realized by stopping the main clock XIN in this mode. To stop the main clock, set bit 5 of the CPU mode register to "1".

When the main clock XIN is restarted, set enough time for oscillation to stabilize by programming.

Note: If you switch the mode between middle/high-speed and low-speed, stabilize both 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 on condition that $f(XIN) > 3f(XCIN)$.

Oscillation Control

(1) Stop Mode

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

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

(2) Wait Mode

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

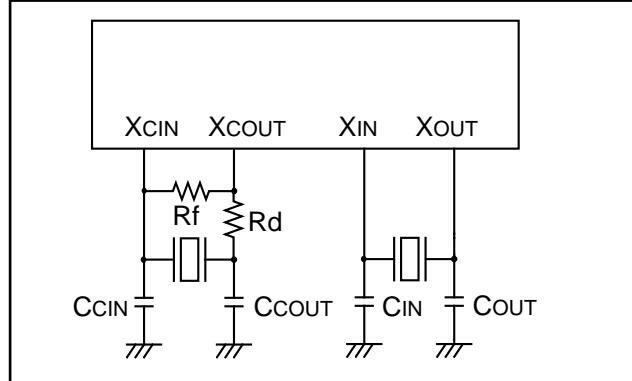


Fig. 53 Ceramic resonator circuit

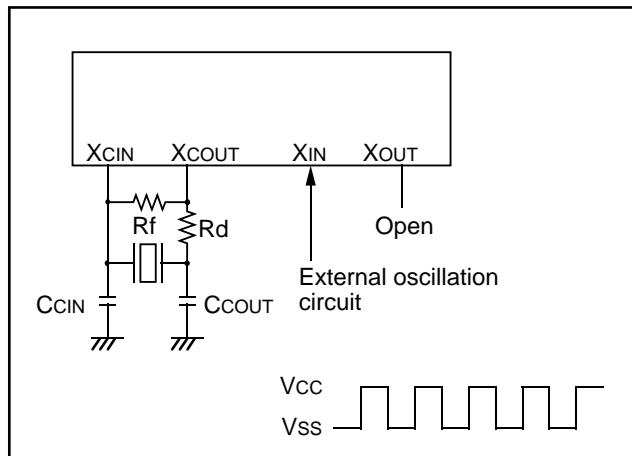


Fig. 54 External clock input circuit

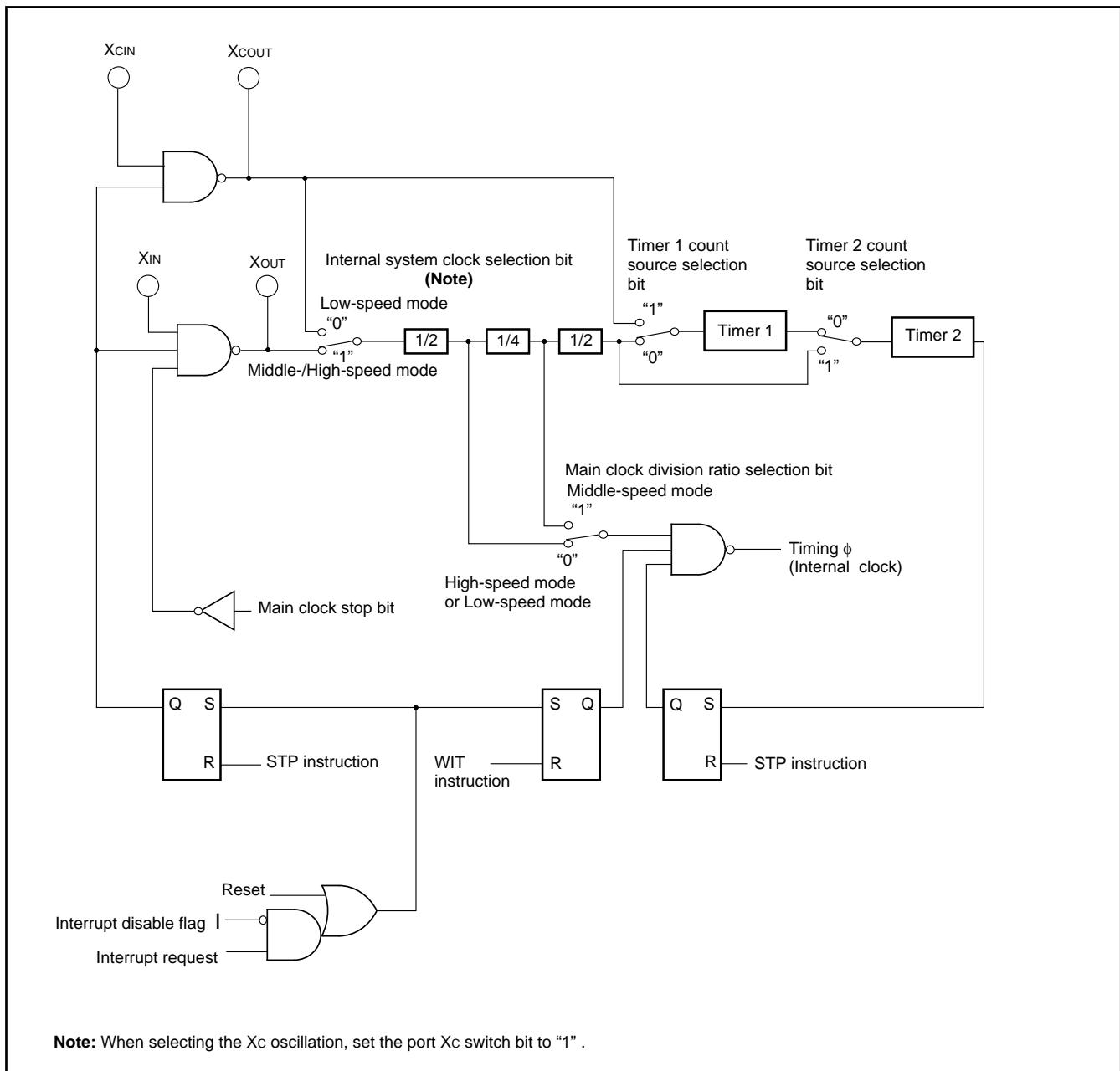


Fig. 55 Clock generating circuit block diagram

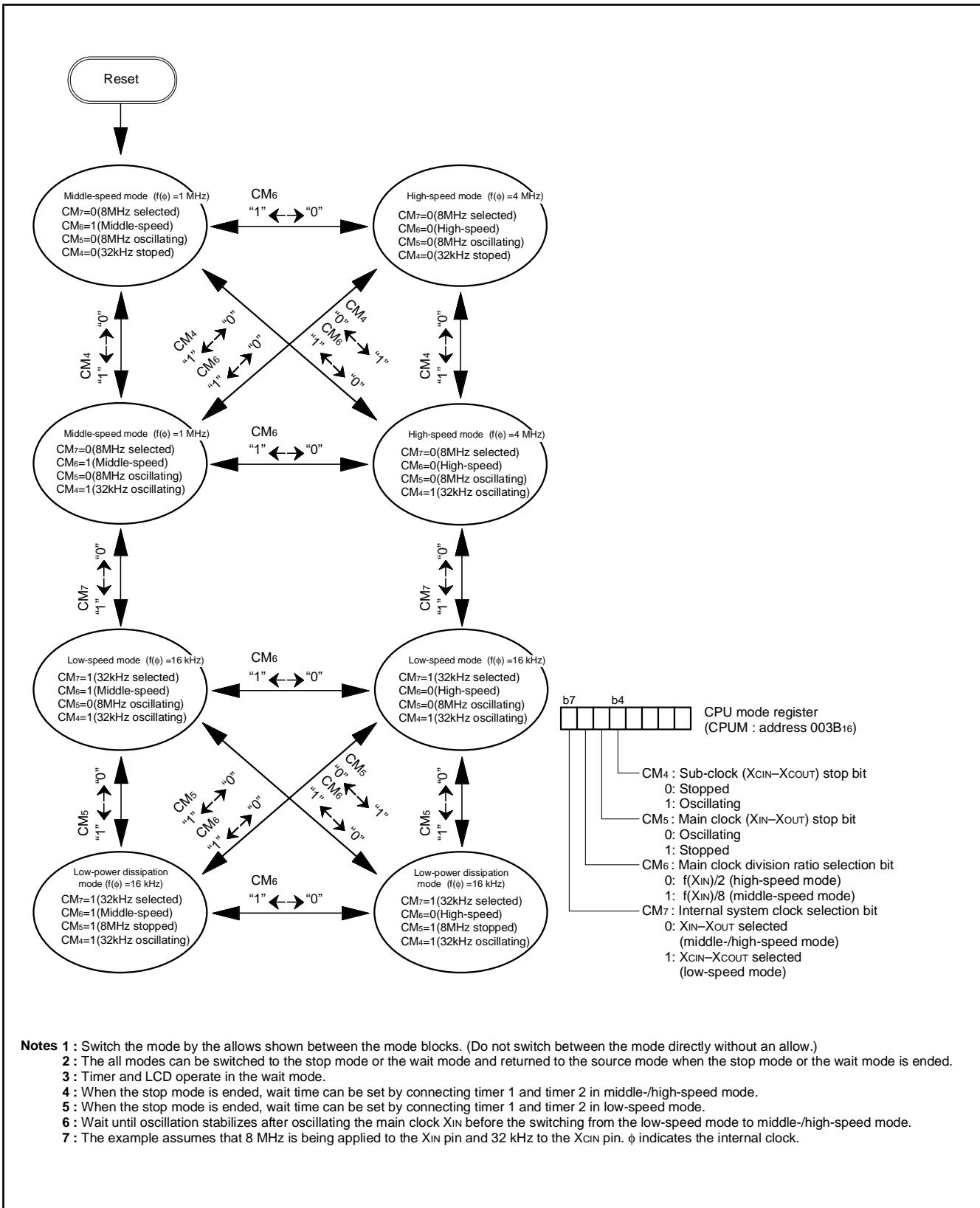


Fig. 56 State transitions of system clock

NOTES ON PROGRAMMING

Processor Status Register

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

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

Interrupt

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

Decimal Calculations

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

Timers

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

Multiplication and Division Instructions

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

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

Ports

The contents of the port direction registers cannot be read.

The following cannot be used:

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

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

Serial I/O

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

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

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

A-D Converter

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

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

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

Instruction Execution Time

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

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

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

DATA REQUIRED FOR MASK ORDERS

The following are necessary when ordering a mask ROM production:

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

ROM PROGRAMMING METHOD

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

Table 12 Special programming adapter

Package	Name of Programming Adapter
100PFB-A	PCA4738H-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 57 is recommended to verify programming.

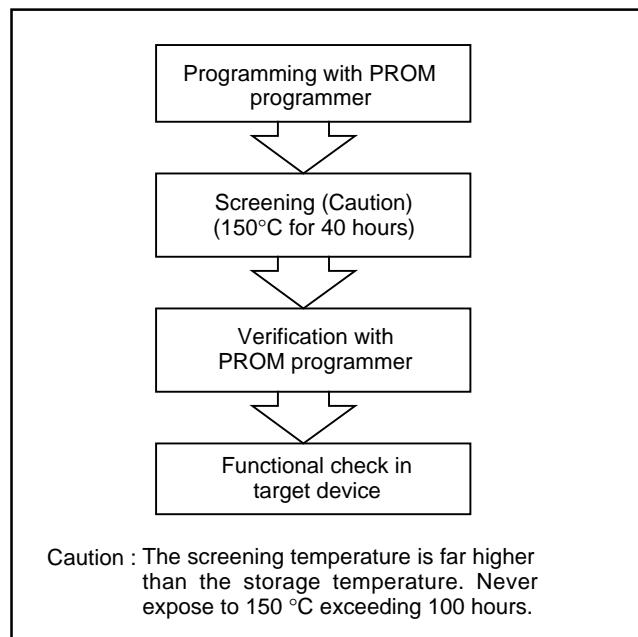


Fig. 57 Programming and testing of One Time PROM version

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

Table 13 Absolute maximum ratings

Symbol	Parameter	Conditions	Ratings	Unit
V _{CC}	Power source voltage	All voltages are based on V _{SS} . Output transistors are cut off.	-0.3 to 7.0	V
V _I	Input voltage P ₀₀ –P ₀₇ , P ₁₀ –P ₁₇ , P ₂₀ –P ₂₇ , P ₄₁ –P ₄₇ , P ₅₀ –P ₅₇ , P ₆₀ –P ₆₇		-0.3 to V _{CC} +0.3	V
V _I	Input voltage P ₄₀ , P ₇₁ –P ₇₇		-0.3 to 7.0	V
V _I	Input voltage P ₇₀		-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 <u>RESET</u> , 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 P ₀₀ –P ₀₇ , P ₁₀ –P ₁₅ , P ₃₀ –P ₃₇	At output port	-0.3 to V _{CC}	V
		At segment output	-0.3 to V _{L3}	V
V _O	Output voltage P ₁₆ , P ₁₇ , P ₂₀ –P ₂₇ , P ₄₁ –P ₄₇ , P ₅₀ –P ₅₇ , P ₆₀ –P ₆₇		-0.3 to V _{CC} +0.3	V
V _O	Output voltage P ₄₀ , P ₇₁ –P ₇₇		-0.3 to 7.0	V
V _O	Output voltage V _{L3} , SEG ₀ –SEG ₁₇ , COM ₀ –COM ₃		-0.3 to 7.0	V
V _O	Output voltage V _{L2}		-0.3 to V _{L3}	V
V _O	Output voltage X _{OUT}		-0.3 to V _{CC} +0.3	V
P _d	Power dissipation	T _a = 25°C	300	mW
T _{opr}	Operating temperature		-20 to 85	°C
T _{stg}			-40 to 125	°C

RECOMMENDED OPERATING CONDITIONS

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
V _{CC}	Power source voltage	High-speed mode f(X _{IN}) = 8 MHz	4.0	5.0	5.5
		Middle-speed mode f(X _{IN}) = 8 MHz	2.2	5.0	5.5
		Low-speed mode	2.2	5.0	5.5
V _{SS}	Power source voltage		0		V
V _{REF}	A-D, D-A conversion reference voltage		2.7		V _{CC} +0.3
AV _{SS}	Analog power source voltage		0		V
V _{IA}	Analog input voltage A _{N0} –A _{N7}		AV _{SS}		V _{CC}
V _{IH}	"H" input voltage P ₀₀ –P ₀₇ , P ₁₀ –P ₁₇ , P ₄₀ , P ₄₃ , P ₄₅ , P ₄₇ , P ₅₀ –P ₅₃ , P ₅₆ , P ₆₁ , P ₆₄ –P ₆₇ , P ₇₁ –P ₇₇	0.7 V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage P ₂₀ –P ₂₇ , P ₄₁ , P ₄₂ , P ₄₄ , P ₄₆ , P ₅₄ , P ₅₅ , P ₅₇ , P ₆₀ , P ₆₂ , P ₆₃ , P ₇₀	0.8 V _{CC}		V _{CC}	V
V _{IH}	"H" input voltage <u>RESET</u>	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 P ₀₀ –P ₀₇ , P ₁₀ –P ₁₇ , P ₄₀ , P ₄₃ , P ₄₅ , P ₄₇ , P ₅₀ –P ₅₃ , P ₅₆ , P ₆₁ , P ₆₄ –P ₆₇ , P ₇₁ –P ₇₇	0		0.3 V _{CC}	V
V _{IL}	"L" input voltage P ₂₀ –P ₂₇ , P ₄₁ , P ₄₂ , P ₄₄ , P ₄₆ , P ₅₄ , P ₅₅ , P ₅₇ , P ₆₀ , P ₆₂ , P ₆₃ , P ₇₀	0		0.2 V _{CC}	V
V _{IL}	"L" input voltage <u>RESET</u>	0		0.2 V _{CC}	V
V _{IL}	"L" input voltage X _{IN}	0		0.2 V _{CC}	V

Table 15 Recommended operating conditions (V_{CC} = 2.2 to 5.5 V, T_A = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$\Sigma I_{OH}(\text{peak})$	"H" total peak output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			-20	mA
$\Sigma I_{OH}(\text{peak})$	"H" total peak output current P41–P47, P50–P57, P60–P67 (Note 1)			-20	mA
$\Sigma I_{OL}(\text{peak})$	"L" total peak output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			20	mA
$\Sigma I_{OL}(\text{peak})$	"L" total peak output current P41–P47, P50–P57, P60–P67 (Note 1)			20	mA
$\Sigma I_{OL}(\text{peak})$	"L" total peak output current P40, P71–P77 (Note 1)			80	mA
$\Sigma I_{OH}(\text{avg})$	"H" total average output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			-10	mA
$\Sigma I_{OH}(\text{avg})$	"H" total average output current P41–P47, P50–P57, P60–P67 (Note 1)			-10	mA
$\Sigma I_{OL}(\text{avg})$	"L" total average output current P00–P07, P10–P17, P20–P27, P30–P37 (Note 1)			10	mA
$\Sigma I_{OL}(\text{avg})$	"L" total average output current P41–P47, P50–P57, P60–P67 (Note 1)			10	mA
$\Sigma I_{OL}(\text{avg})$	"L" total average output current P40, P71–P77 (Note 1)			40	mA
$I_{OH}(\text{peak})$	"H" peak output current P00–P07, P10–P15, P30–P37 (Note 2)			-1.0	mA
$I_{OH}(\text{peak})$	"H" peak output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 2)			-5.0	mA
$I_{OL}(\text{peak})$	"L" peak output current P00–P07, P10–P15, P30–P37 (Note 2)			5.0	mA
$I_{OL}(\text{peak})$	"L" peak output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 2)			10	mA
$I_{OL}(\text{peak})$	"L" peak output current P40, P71–P77 (Note 2)			20	mA
$I_{OH}(\text{avg})$	"H" average output current P00–P07, P10–P15, P30–P37 (Note 3)			-0.5	mA
$I_{OH}(\text{avg})$	"H" average output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67			-2.5	mA
$I_{OL}(\text{avg})$	"L" average output current P00–P07, P10–P15, P30–P37 (Note 3)			2.5	mA
$I_{OL}(\text{avg})$	"L" average output current P16, P17, P20–P27, P41–P47, P50–P57, P60–P67 (Note 3)			5.0	mA
$I_{OL}(\text{avg})$	"L" average output current P40, P71–P77 (Note 3)			10	mA

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

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

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

Table 16 Recommended operating conditions (Vcc = 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 ≤ Vcc ≤ 5.5 V)			4.0	MHz
		(2.2 V ≤ Vcc ≤ 4.0 V)			(10×Vcc -4)/9	MHz
f(XIN)	Main clock input oscillation frequency (Note 1)	High-speed mode (4.0 V ≤ Vcc ≤ 5.5 V)			8.0	MHz
		High-speed mode (2.2 V ≤ Vcc ≤ 4.0 V)			(20×Vcc -8)/9	MHz
		Middle-speed mode			8.0	MHz
f(XCIN)	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 $f(XCIN) < f(XIN)/3$.

Table 17 Electrical characteristics (Vcc = 4.0 to 5.5 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
VOH	"H" output voltage P00-P07, P10-P15, P30-P37	IOH = -1 mA	Vcc-2.0			V
		IOH = -0.25 mA VCC = 2.2 V	Vcc-0.8			V
VOH	"H" output voltage P16, P17, P20-P27, P41-P47, P50-P57, P60-P67 (Note 1)	IOH = -5 mA	Vcc-2.0			V
		IOH = -1.5 mA	Vcc-0.5			V
		IOH = -1.25 mA VCC = 2.2 V	Vcc-0.8			V
VOL	"L" output voltage P00-P07, P10-P15, P30-P37	IOL = 5 mA			2.0	V
		IOL = 1.5 mA			0.5	V
		IOL = 1.25 mA VCC = 2.2 V			0.8	V
VOL	"L" output voltage P16, P17, P20-P27, P41-P47, P50-P57, P60-P67	IOL = 10 mA			2.0	V
		IOL = 3.0 mA			0.5	V
		IOL = 2.5 mA VCC = 2.2 V			0.8	V
VOL	"L" output voltage P40, P71-P77	IOL = 10 mA			0.5	V
		IOL = 5 mA VCC = 2.2 V			0.3	V
VT+ - VT-	Hysteresis INT0-INT2, ADT, CNTR0, CNTR1, P20-P27			0.5		V
VT+ - VT-	Hysteresis SCLK, RxD			0.5		V
VT+ - VT-	Hysteresis RESET			0.5		V
I _{IIH}	"H" input current P00-P07, P10-P17, P20-P27, P40-P47, P50-P57, P60-P67, P70-P77	VI = VCC			5.0	µA
I _{IIH}	"H" input current RESET	VI = VCC			5.0	µA
I _{IIH}	"H" input current XIN	VI = VCC		4.0		µA
I _{IIL}	"L" input current P10-P17, P20-P27, P40-P47, P50-P57, P60-P67, P70-P77	VI = VSS Pull-ups "off"			-5.0	µA
		VCC = 5 V, VI = VSS Pull-ups "on"	-60.0	-120.0	-240.0	µA
		VCC = 2.2 V, VI = VSS Pull-ups "on"	-5.0	-20.0	-40.0	µA
I _{IIL}	"L" input current P00-P07, P70				-5.0	µA
I _{IIL}	"L" input current RESET	VI = VSS			-5.0	µA
I _{IIL}	"L" input current XIN	VI = VSS		-4.0		µA
I _{LEAK}	Output load current P30-P37	VO = VCC Output transistors "off"			5.0	µA
		VO = VSS Output transistors "off"			-5.0	µA

Table 18 Electrical characteristics (Vcc = 2.2 to 5.5 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
VRAM	RAM retention voltage	At clock stop mode	2.0		5.5	V
ICC	Power source current	• High-speed mode, Vcc = 5 V f(XIN) = 8 MHz f(XCIN) = 32.768 kHz Output transistors "off" A-D converter in operating		6.4	13	mA
		• High-speed mode, Vcc = 5 V f(XIN) = 8 MHz (in WIT state) f(XCIN) = 32.768 kHz Output transistors "off" A-D converter in operating		1.6	3.2	mA
		• Low-speed mode, Vcc = 5 V, Ta ≤ 55°C f(XIN) = stopped f(XCIN) = 32.768 kHz Output transistors "off"		35	70	μA
		• Low-speed mode, Vcc = 5 V, Ta = 25°C f(XIN) = stopped f(XCIN) = 32.768 kHz (in WIT state) Output transistors "off"		20	40	μA
		• Low-speed mode, Vcc = 3 V, Ta ≤ 55°C f(XIN) = stopped f(XCIN) = 32.768 kHz Output transistors "off"		15.0	22.0	μA
		• Low-speed mode, Vcc = 3 V, Ta ≤ 25°C f(XIN) = stopped f(XCIN) = 32.768 kHz (in WIT state) Output transistors "off"		4.5	9.0	μA
		All oscillation stopped (in STP state)	Ta = 25 °C	0.1	1.0	μA
		Output transistors "off"	Ta = 85 °C		10.0	
VL1	Power source voltage	When using voltage multiplier	1.3	1.8	2.3	V
IL1	Power source current (VL1) (Note)	VL1 = 1.8 V		3.0	6.0	μA
		VL1 < 1.3 V		10.0	50.0	

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

Table 19 A-D converter characteristics(V_{CC} = 2.7 to 5.5 V, V_{SS} = 0 V, Ta = -20 to 85°C, 4 MHz ≤ f(XIN) ≤ 8 MHz, in middle/high-speed mode unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
-	Resolution				10	Bits
-	Absolute accuracy (excluding quantization error)	V _{CC} = V _{REF} = 4 V			±2.5	LSB
		V _{CC} = V _{REF} = 2.7 V (Note 2)			±4.0	LSB
t _{CONV}	Conversion time	f(XIN) = 4 MHz	30.5		31 (Note 1)	μs
R _{LADDER}	Ladder resistor			35		kΩ
I _{VREF}	Reference power source input current	V _{REF} = 5 V	50	150	200	μA
I _{IA}	Analog port input current			0.5	5.0	μA

Notes1: When an internal trigger is used in middle-speed mode, it is 34 ms.

2: 4 MHz ≤ f(XIN) ≤ 5.1 MHz in high-speed mode.

Table 20 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)			6.0	mA

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

Table 21 Timing requirements 1 (Vcc = 4.0 to 5.5 V, Vss = 0 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
tw(RESET)	Reset input "L" pulse width	2			μs
tc(XIN)	Main clock input cycle time (XIN input)	125			ns
twH(XIN)	Main clock input "H" pulse width	45			ns
twL(XIN)	Main clock input "L" pulse width	40			ns
tc(CNTR)	CNTR0, CNTR1 input cycle time	250			ns
twH(CNTR)	CNTR0, CNTR1 input "H" pulse width	105			ns
twL(CNTR)	CNTR0, CNTR1 input "L" pulse width	105			ns
twH(INT)	INT0 to INT2 input "H" pulse width	80			ns
twL(INT)	INT0 to INT2 input "L" pulse width	80			ns
tc(SCLK1)	Serial I/O1 clock input cycle time (Note)	800			ns
twH(SCLK1)	Serial I/O1 clock input "H" pulse width (Note)	370			ns
twL(SCLK1)	Serial I/O1 clock input "L" pulse width (Note)	370			ns
tsu(RxD-SCLK1)	Serial I/O1 input set up time	220			ns
th(SCLK1-RxD)	Serial I/O1 input hold time	100			ns
tc(SCLK2)	Serial I/O2 clock input cycle time (Note)	1000			ns
twH(SCLK2)	Serial I/O2 clock input "H" pulse width (Note)	400			ns
twL(SCLK2)	Serial I/O2 clock input "L" pulse width (Note)	400			ns
tsu(SIN2-SCLK2)	Serial I/O2 input set up time	200			ns
th(SCLK2-SIN2)	Serial I/O2 input hold time	200			ns

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

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

Table 22 Timing requirements 2 (Vcc = 2.2 to 4.0 V, Vss = 0 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
tw(RESET)	Reset input "L" pulse width	2			μs
tc(XIN)	Main clock input cycle time (XIN input)	125			ns
twH(XIN)	Main clock input "H" pulse width	45			ns
twL(XIN)	Main clock input "L" pulse width	40			ns
tc(CNTR)	CNTR0, CNTR1 input cycle time	900/(Vcc-0.4)			ns
twH(CNTR)	CNTR0, CNTR1 input "H" pulse width	tc(CNTR)/2-20			ns
twL(CNTR)	CNTR0, CNTR1 input "L" pulse width	tc(CNTR)/2-20			ns
twH(INT)	INT0 to INT2 input "H" pulse width	230			ns
twL(INT)	INT0 to INT2 input "L" pulse width	230			ns
tc(SCLK1)	Serial I/O1 clock input cycle time (Note)	2000			ns
twH(SCLK1)	Serial I/O1 clock input "H" pulse width (Note)	950			ns
twL(SCLK1)	Serial I/O1 clock input "L" pulse width (Note)	950			ns
tsu(RxD-SCLK1)	Serial I/O1 input set up time	400			ns
th(SCLK1-RxD)	Serial I/O1 input hold time	200			ns
tc(SCLK2)	Serial I/O2 clock input cycle time (Note)	2000			ns
twH(SCLK2)	Serial I/O2 clock input "H" pulse width (Note)	950			ns
twL(SCLK2)	Serial I/O2 clock input "L" pulse width (Note)	950			ns
tsu(SIN2-SCLK2)	Serial I/O2 input set up time	400			ns
th(SCLK2-SIN2)	Serial I/O2 input hold time	300			ns

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

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

Table 23 Switching characteristics 1 (Vcc = 4.0 to 5.5 V, Vss = 0 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
twH(SCLK1)	Serial I/O1 clock output "H" pulse width	tc (SCLK1)/2-30			ns
twL(SCLK1)	Serial I/O1 clock output "L" pulse width	tc (SCLK1)/2-30			ns
td(SCLK1-TxD)	Serial I/O1 output delay time (Note 1)			140	ns
tv(SCLK1-TxD)	Serial I/O1 output valid time (Note 1)	-30			ns
tr(SCLK1)	Serial I/O1 clock output rising time			30	ns
tf(SCLK1)	Serial I/O1 clock output falling time			30	ns
twH(SCLK2)	Serial I/O2 clock output "H" pulse width	tc (SCLK2)/2-160			ns
twL(SCLK2)	Serial I/O2 clock output "L" pulse width	tc (SCLK2)/2-160			ns
td(SCLK2-SOUT2)	Serial I/O2 output delay time			0.2 X tc (SCLK2)	ns
tv(SCLK2-SOUT2)	Serial I/O2 output valid time	0			ns
tf(SCLK2)	Serial I/O2 clock output falling time			40	ns
tr(CMOS)	CMOS output rising time (Note 2)			10	ns
tf(CMOS)	CMOS output falling time (Note 2)			10	ns

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

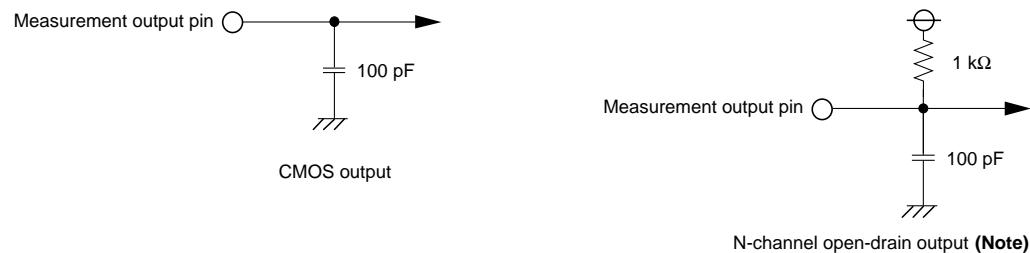
2: XOUT and XCOUT pins are excluded.

Table 24 Switching characteristics 2 (Vcc = 2.2 to 4.0 V, Vss = 0 V, Ta = -20 to 85°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
twH(SCLK1)	Serial I/O1 clock output "H" pulse width	tc (SCLK1)/2-50			ns
twL(SCLK1)	Serial I/O1 clock output "L" pulse width	tc (SCLK1)/2-50			ns
td(SCLK1-TxD)	Serial I/O1 output delay time (Note 1)			350	ns
tv(SCLK1-TxD)	Serial I/O1 output valid time (Note 1)	-30			ns
tr(SCLK1)	Serial I/O1 clock output rising time			50	ns
tf(SCLK1)	Serial I/O1 clock output falling time			50	ns
twH(SCLK2)	Serial I/O2 clock output "H" pulse width	tc (SCLK2)/2-240			ns
twL(SCLK2)	Serial I/O2 clock output "L" pulse width	tc (SCLK2)/2-240			ns
td(SCLK2-SOUT2)	Serial I/O2 output delay time			0.2 X tc (SCLK2)	ns
tv(SCLK2-SOUT2)	Serial I/O2 output valid time	0			ns
tf(SCLK2)	Serial I/O2 clock output falling time			50	ns
tr(CMOS)	CMOS output rising time (Note 2)			20	ns
tf(CMOS)	CMOS output falling time (Note 2)			20	ns

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

2: XOUT and XCOUT pins are excluded.



Note : When bit 4 of the UART control register (address 001B₁₆) is "1".
(N-channel open-drain output mode)

Fig. 58 Circuit for measuring output switching characteristics

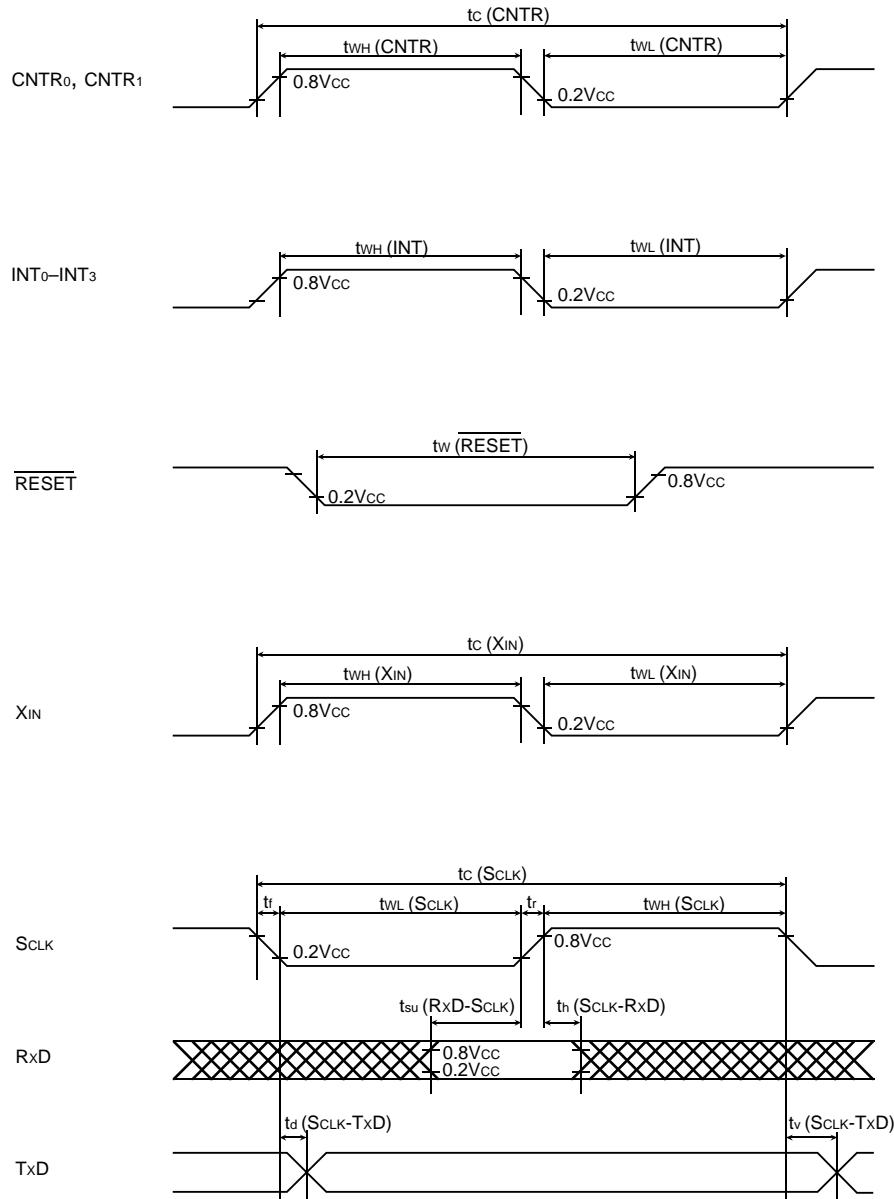
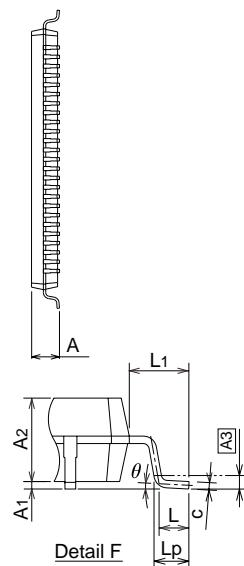
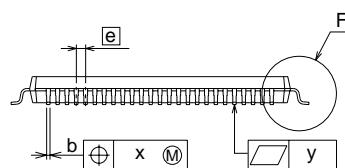
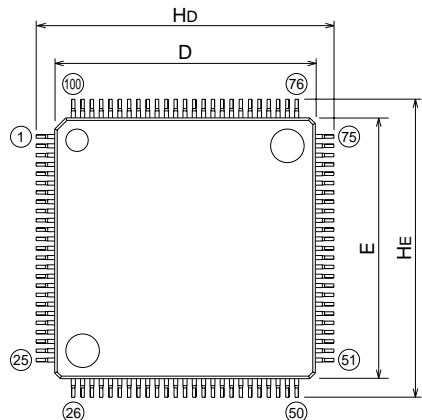


Fig. 59 Timing diagram

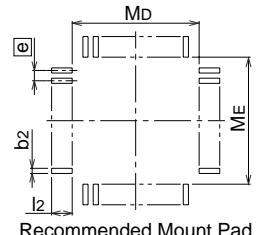
PACKAGE OUTLINE

100P6Q-A (MMP)

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



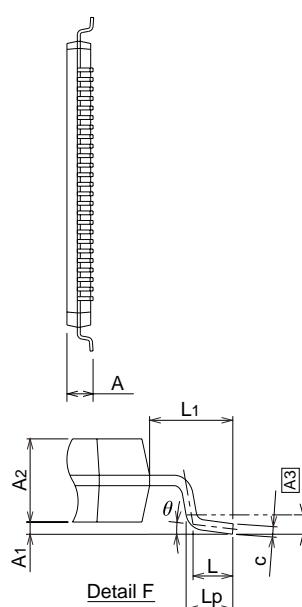
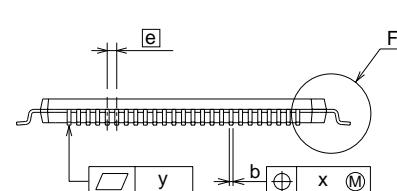
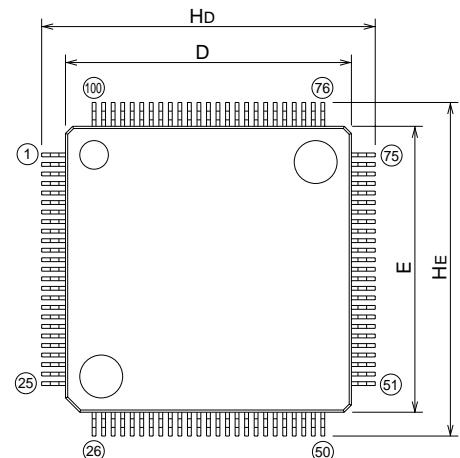
Plastic 100pin 14X14mm body LQFP



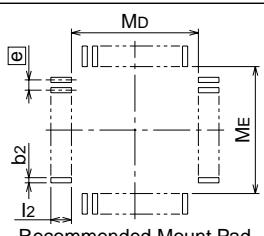
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	-	-	1.7
A1	0	0.1	0.2
A2	-	1.4	-
b	0.13	0.18	0.28
c	0.105	0.125	0.175
D	13.9	14.0	14.1
E	13.9	14.0	14.1
[e]	-	0.5	-
HD	15.8	16.0	16.2
HE	15.8	16.0	16.2
L	0.3	0.5	0.7
L1	-	1.0	-
Lp	0.45	0.6	0.75
[A3]	-	0.25	-
x	-	-	0.08
y	-	-	0.1
theta	0°	-	10°
b2	-	0.225	-
l2	0.9	-	-
MD	-	14.4	-
ME	-	14.4	-

100PFB-A (MMP)

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
LQFP100-P-1212-0.40	-	0.37	Cu Alloy



Plastic 100pin 12X12mm body TQFP

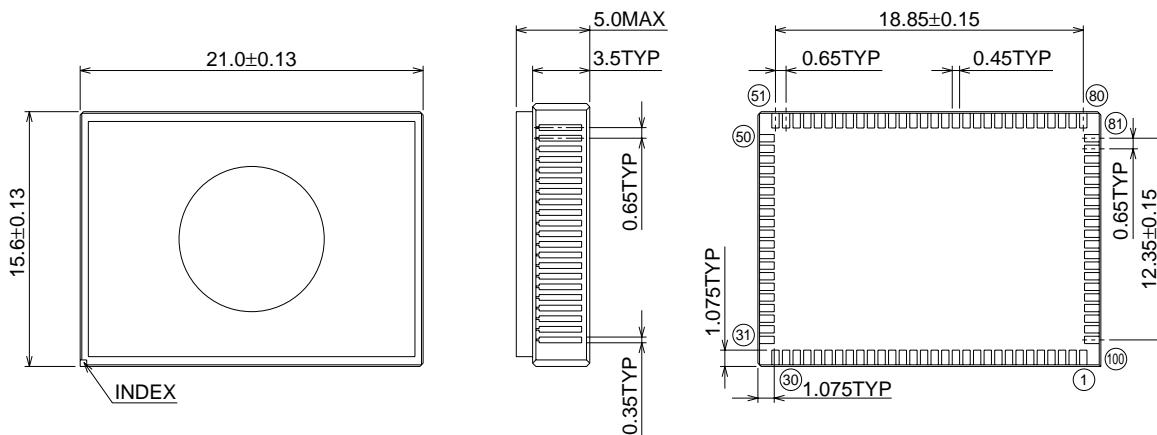


Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	-	-	1.2
A1	0.05	0.1	0.15
A2	-	1.0	-
b	0.13	0.18	0.23
c	0.105	0.125	0.175
D	11.9	12.0	12.1
E	11.9	12.0	12.1
[e]	-	0.4	-
HD	13.8	14.0	14.2
HE	13.8	14.0	14.2
L	0.4	0.5	0.6
L1	-	1.0	-
Lp	0.45	0.6	0.75
[A3]	-	0.25	-
x	-	-	0.07
y	-	-	0.08
theta	0°	-	10°
b2	-	0.225	-
l2	1.0	-	-
MD	-	12.4	-
ME	-	12.4	-

100D0

EIAJ Package Code	JEDEC Code	Weight(g)
—	—	

Glass seal 100pin QFN



- Keep safety first in your circuit designs!

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

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