3825 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

DESCRIPTION

The 3825 group is the 8-bit microcomputer based on the 740 family core technology.

The 3825 group has the LCD drive control circuit, an 8-channel A-D converter, and a Serial I/O as additional functions.

The various microcomputers in the 3825 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 3825 group, refer the section on group expansion.

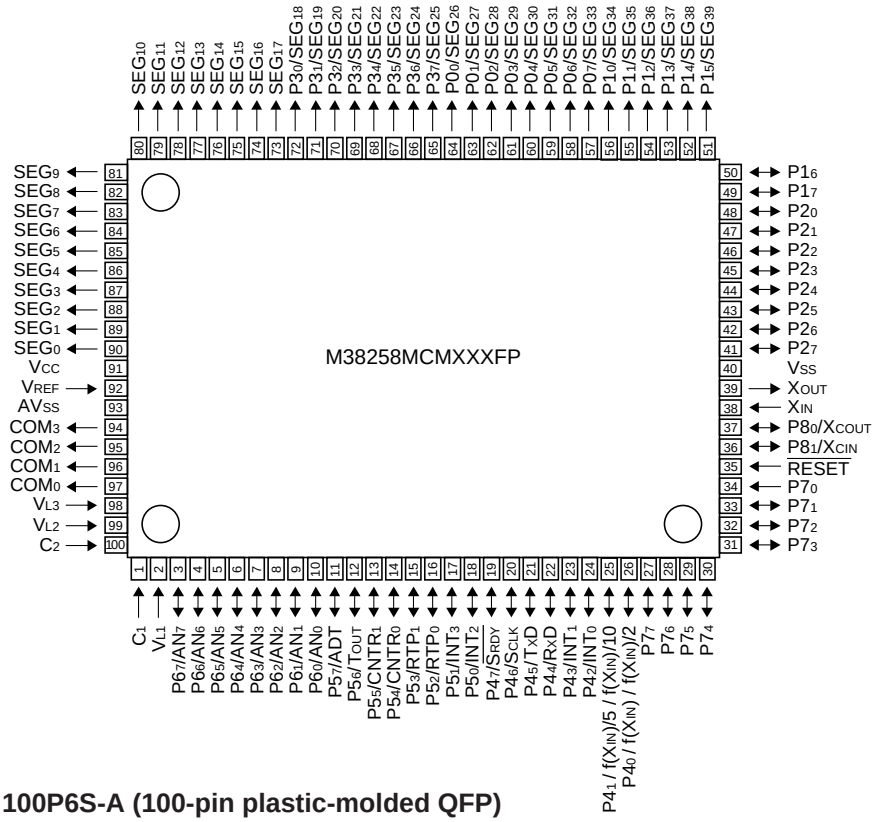
FEATURES

- Basic machine-language instructions 71
- The minimum instruction execution time ..... 0.5 µs
  (at 8MHz oscillation frequency)
- Memory size
  ROM ..... 4 K to 60 K bytes
  RAM ..... 192 to 2048 bytes
- Programmable input/output ports 43
- Software pull-up/pull-down resistors (Ports P0–P8)
- Interrupts ..... 17 sources, 16 vectors
  (includes key input interrupt)
- Timers ..... 8-bit × 3, 16-bit × 2
- Serial I/O ..... 8-bit × 1 (UART or Clock-synchronized)
- A-D converter ..... 8-bit × 8 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
  Clock (X_{IN}-X_{OUT}) ..... Internal feedback resistor
  Sub-clock (X_{CIN}-X_{COUT}) ..... Without internal feedback resistor
  (connect to external ceramic resonator or quartz-crystal oscillator)
- Power source voltage
  In high-speed mode ..... 4.0 to 5.5 V
  In middle-speed mode ..... 2.5 to 5.5 V
  (Low power source version: 2.2 V to 5.5 V)
  (Extended operating temperature version: 3.0 V to 5.5 V)
  In low-speed mode ..... 2.5 to 5.5 V
  (Low power source version: 2.2 V to 5.5 V)
  (Extended operating temperature version: 3.0 V to 5.5 V)
- Power dissipation
  In high-speed mode ..... 32 mW
  (at 8 MHz oscillation frequency, at 5 V power source voltage)
  In low-speed mode ..... 45 µW
  (at 32 kHz oscillation frequency, at 3 V power source voltage)
- Operating temperature range ..... – 20 to 85°C
  (Extended operating temperature version: –40 to 85°C)

APPLICATIONS

Camera, household appliances, consumer electronics, etc.

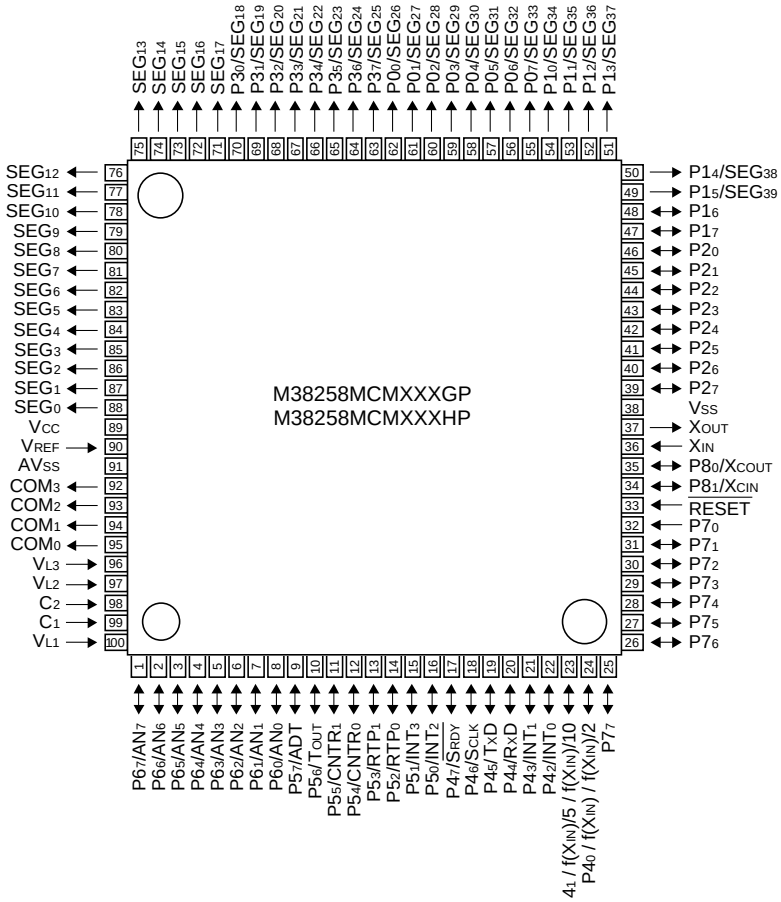
PIN CONFIGURATION (TOP VIEW)



Package type : 100P6S-A (100-pin plastic-molded QFP)

Fig. 1 Pin configuration of M38258MCMXXXFP

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 Pin configuration of M38258MCMXXXGP, M38258MCMXXXHP

FUNCTIONAL BLOCK DIAGRAM (Package : 100P6S-A)

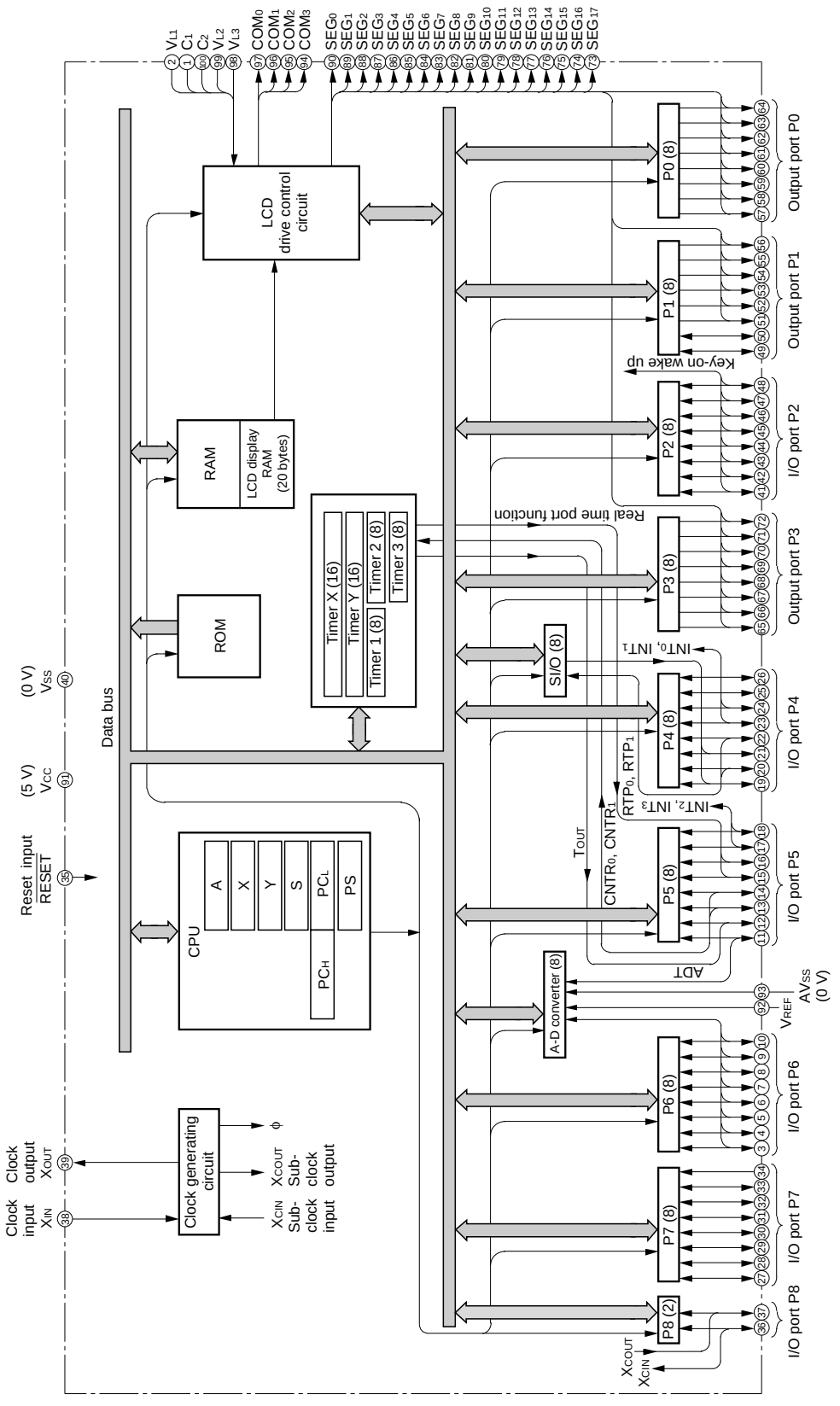


Fig. 3 Functional block diagram.

PIN DESCRIPTION

Table 1. Pin description (1)

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

Table 2. Pin description (2)

Pin	Name	Function	Function except a port function
P40/f(XIN)/ f(XIN)/2, P41/f(XIN)/5/ f(XIN)/10	I/O port P4	• 8-bit I/O port • CMOS compatible input level • CMOS 3-state output structure • I/O direction register allows each pin to be individually programmed as either input or output. • Pull-up control is enabled.	• Clock output pins
P42/INT0, P43/INT1			• Interrupt input pins
P44/RxD, P45/TxD, P46/SCLK, P47/SRDY			• Serial I/O function pins
P50/INT2, P51/INT3	I/O port P5	• 8-bit I/O port • CMOS compatible input level • CMOS 3-state output structure • I/O direction register allows each pin to be individually programmed as either input or output. • Pull-up control is enabled.	• Interrupt input pins
P52/RTP0, P53/RTP1			• Real time port function pins
P54/CNTR0, P55/CNTR1			• Timers X, Y functions pins
P56/TOUT			• Timer 2 output pin
P57/ADT			• A-D trigger input pin
P60/AN0– P67/AN7	I/O port P6	• 8-bit I/O port • CMOS compatible input level • CMOS 3-state output structure • I/O direction register allows each pin to be individually programmed as either input or output. • Pull-up control is enabled.	• A-D conversion input pins
P70	Input port P7	• 1-bit input port • CMOS compatible input level	
P71–P77	I/O port P7	• 7-bit I/O port • CMOS compatible input level • CMOS 3-state output structure • I/O direction register allows each pin to be individually programmed as either input or output. • Pull-up control is enabled.	
P80/XCOUT, P81/XCIN	I/O port P8	• 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.	•Sub-clock generating circuit I/O pins (Connect a resonator. External clock cannot be used.)

PART NUMBERING

Product M3825 **8 M C M XXX HP**

Package type
FP : 100P6S-A package
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.

Normally, using hyphen
When electrical characteristic, or division of quality identification code using alphanumeric character
– : Standard
D : Extended operating temperature version
M : Low power source 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
0 : 192 bytes
1 : 256 bytes
2 : 384 bytes
3 : 512 bytes
4 : 640 bytes
5 : 768 bytes
6 : 896 bytes
7 : 1024 bytes
8 : 1536 bytes
9 : 2048 bytes

Fig. 4 Part numbering

GROUP EXPANSION

Mitsubishi plans to expand the 3825 group as follows.

Memory Type

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

Memory Size

ROM/PROM size ..... 16 K to 60 Kbytes
RAM size ..... 640 to 2048 bytes

Packages

100PFB-A ..... 0.4 mm-pitch plastic molded TQFP
100P6Q-A ..... 0.5 mm-pitch plastic molded LQFP
100P6S-A ..... 0.65 mm-pitch plastic molded QFP
100D0 ..... Ceramic QFN (EPROM version)

Memory Expansion Plan

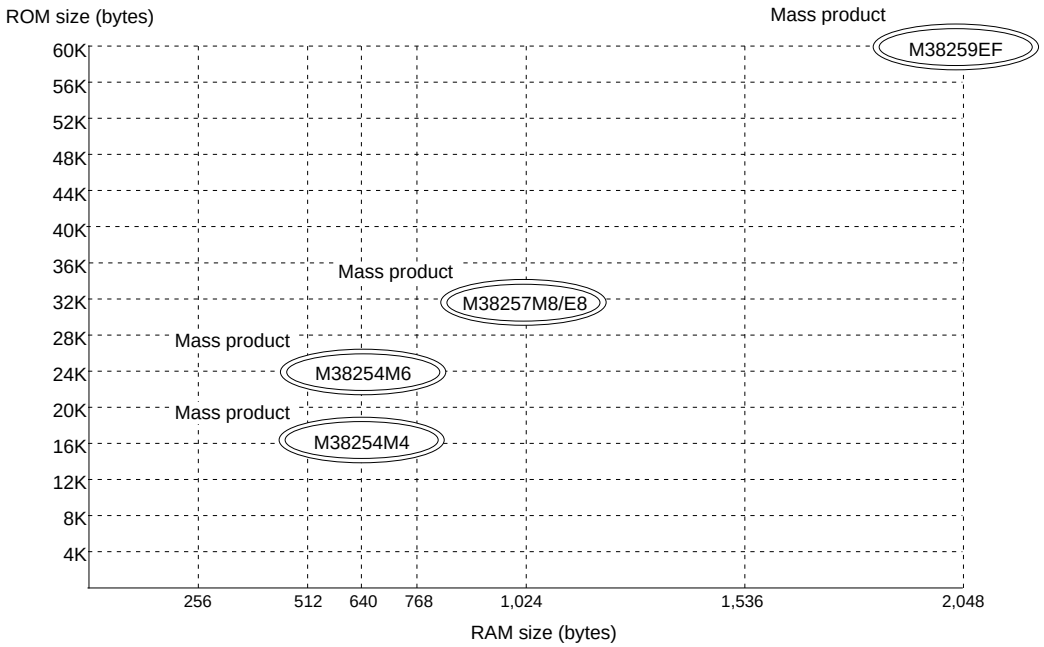


Fig. 5 Memory expansion plan

Currently supported products are listed below.

Table 3. List of supported products **As of June 1999**

Product	(P) ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M38254M4-XXXFP	16384 (16254)	640	100P6S-A	Mask ROM version
M38254M4-XXXGP			100P6Q-A	Mask ROM version
M38254M6-XXXFP	24576 (24446)	640	100P6S-A	Mask ROM version
M38254M6-XXXGP			100P6Q-A	
M38257M8-XXXFP	32768 (32638)	1024	100P6S-A	Mask ROM version
M38257E8-XXXFP				One Time PROM version
M38257E8FP				One Time PROM version (blank)
M38257M8-XXXGP			100P6Q-A	Mask ROM version
M38257E8-XXXGP				One Time PROM version
M38257E8GP				One Time PROM version (blank)
M38257E8FS			100D0	EPROM version
M38259EF-XXXFP	61440 (61310)	2048	100P6S-A	One Time PROM version
M38259EFFP				One Time PROM version (blank)
M38259EF-XXXHP			100PFB-A	One Time PROM version
M38259EFHP				One Time PROM version (blank)
M38259EF-XXXGP			100P6Q-A	One Time PROM version
M38259EFGP				One Time PROM version (blank)
M38259EFFS			100D0	EPROM version

GROUP EXPANSION (EXTENDED OPERATING TEMPERATURE VERSION)

Mitsubishi plans to expand the 3825 group (extended operating temperature version) as follows.

Memory Type

Support for mask ROM and One Time PROM versions.

Memory Size

ROM/PROM ..... 16 K to 60 Kbytes
RAM size ..... 640 to 2048 bytes

Packages

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

Memory Expansion Plan

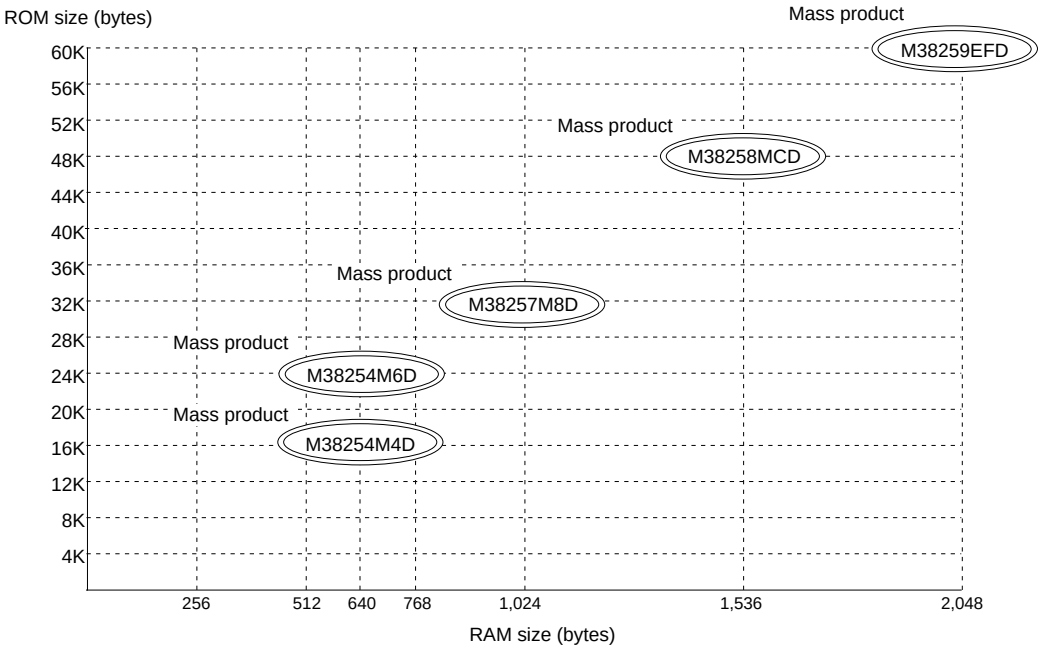


Fig. 6 Memory expansion plan for extended operating temperature version

Currently supported products are listed below.

Table 4. List of supported products for extended operating temperature version **As of June 1999**

Product	(P) ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M38254M4DXXXFP	16384 (16254)	640	100P6S-A	Mask ROM version
M38254M6DXXXFP	24576 (24446)	640		Mask ROM version
M38257M8DXXXFP	32768 (32638)	1024		Mask ROM version
M38258MCDXXXFP	49152 (49022)	1536		Mask ROM version
M38259EFDXXXFP	61440 (61310)	2048		One Time PROM version
M38259EFDFP				One Time PROM version (blank)

GROUP EXPANSION (LOW POWER SOURCE VERSION)

Mitsubishi plans to expand the 3825 group (low power source version) as follows.

Memory Type

Support for mask ROM version.

Memory Size

ROM ..... 48 Kbytes
RAM size ..... 1536 bytes

Packages

100PFB-A ..... 0.4 mm-pitch plastic molded TQFP
100P6Q-A ..... 0.5 mm-pitch plastic molded LQFP
100P6S-A ..... 0.65 mm-pitch plastic molded QFP

Memory Expansion Plan

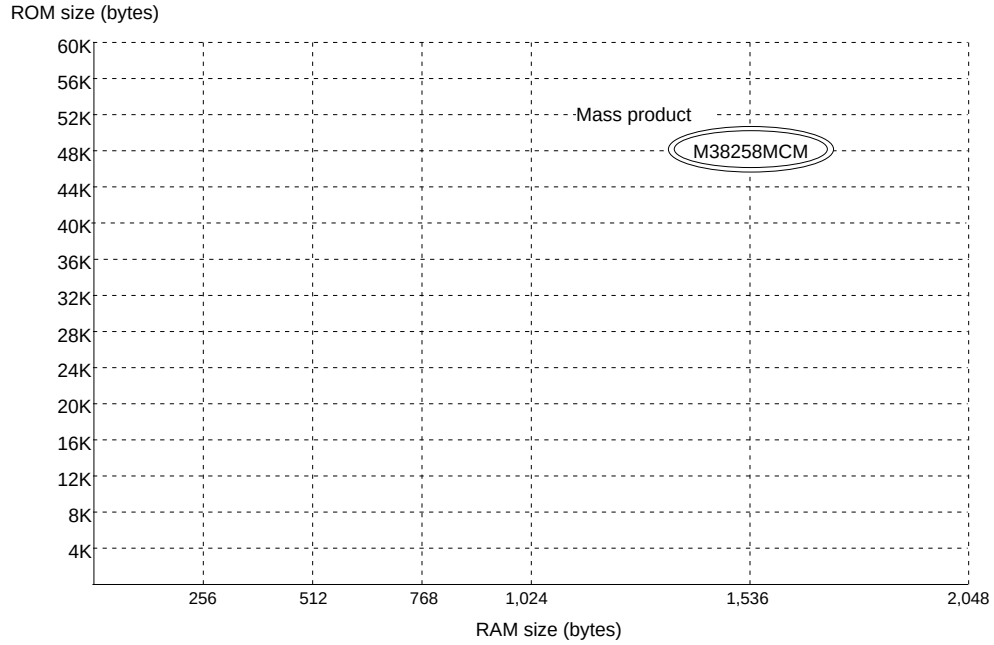


Fig. 7 Memory expansion plan for low power source version

Currently supported products are listed below.

Table 5. List of supported products for low power source version **As of June 1999**

Product	(P) ROM size (bytes) ROM size for User in ( )	RAM size (bytes)	Package	Remarks
M38258MCMXXXFP	49152 (49022)	1536	100P6S-A	Mask ROM version
M38258MCMXXXHP			100PFB-A	
M38258MCMXXXGP			100P6Q-A	

FUNCTIONAL DESCRIPTION
CENTRAL PPROCESSING UNIT (CPU)

The 3825 group uses the standard 740 family instruction set. Refer to the 740 Family Software Manual for details on the instruction set.
Machine-resident 740 family instructions are as follows:

The FST and SLW instructions cannot be used.

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

[CPU Mode Register (CPUM)] 003B16

The CPU mode register is allocated at address 003B16.

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

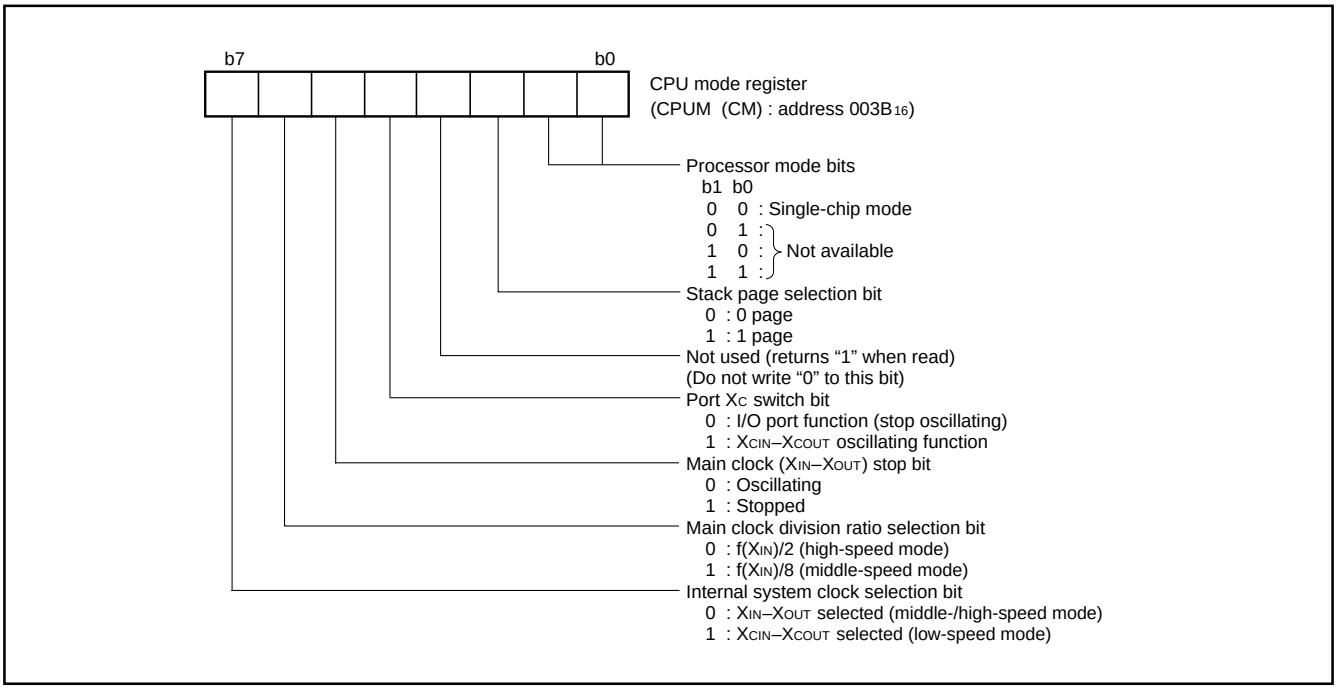


Fig. 8 Structure of CPU mode register

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

The 256 bytes from addresses 0000_{16} to $00FF_{16}$ are called the zero page area. The internal RAM and the special function registers (SFR) are allocated to this area.
The zero page addressing mode can be used to specify memory and register addresses in the zero page area. Access to this area with only 2 bytes is possible in the zero page addressing mode.

Special Page

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

RAM area

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

ROM area

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

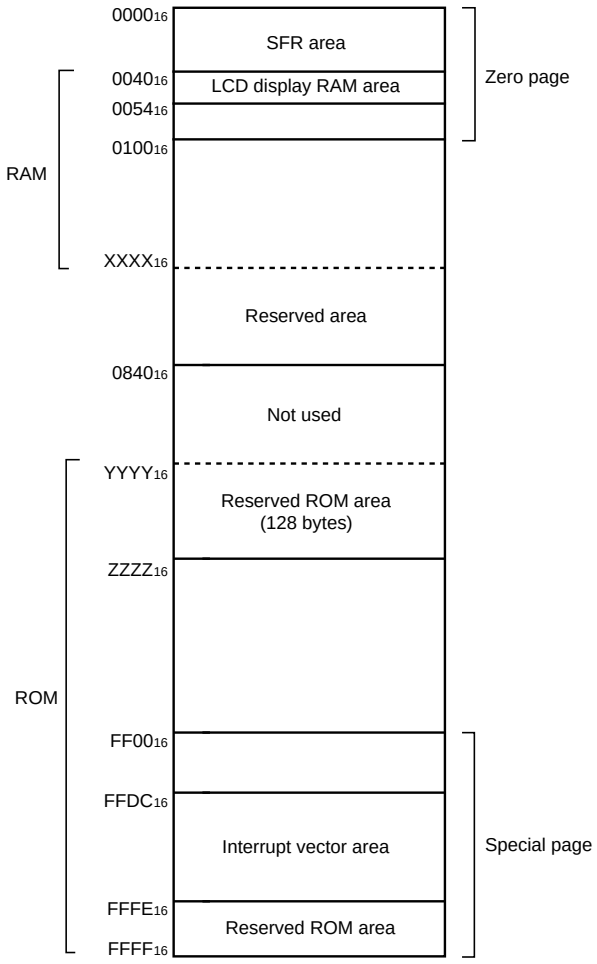


Fig. 9 Memory map diagram

0000_{16}	Port P0 (P0)	0020_{16}	Timer X (low) (TXL)
0001_{16}		0021_{16}	Timer X (high) (TXH)
0002_{16}	Port P1 (P1)	0022_{16}	Timer Y (low) (TYL)
0003_{16}	Port P1 output control register (P1C)	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}		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)	$002A_{16}$	Clock output control register (TCON)
$000B_{16}$	Port P5 direction register (P5D)	$002B_{16}$	
$000C_{16}$	Port P6 (P6)	$002C_{16}$	
$000D_{16}$	Port P6 direction register (P6D)	$002D_{16}$	
$000E_{16}$	Port P7 (P7)	$002E_{16}$	
$000F_{16}$	Port P7 direction register (P7D)	$002F_{16}$	
0010_{16}	Port P8 (P8)	0030_{16}	
0011_{16}	Port P8 direction register (P8D)	0031_{16}	
0012_{16}		0032_{16}	
0013_{16}		0033_{16}	
0014_{16}		0034_{16}	A-D control register (ADCON)
0015_{16}		0035_{16}	A-D conversion register (AD)
0016_{16}	PULL register A (PULLA)	0036_{16}	
0017_{16}	PULL register B (PULLB)	0037_{16}	
0018_{16}	Transmit/Receive buffer register(TB/RB)	0038_{16}	Segment output enable register (SEG)
0019_{16}	Serial I/O status register (SIOSTS)	0039_{16}	LCD mode register (LM)
$001A_{16}$	Serial I/O 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)
$001D_{16}$		$003D_{16}$	Interrupt request register 2(IREQ2)
$001E_{16}$		$003E_{16}$	Interrupt control register 1(ICON1)
$001F_{16}$		$003F_{16}$	Interrupt control register 2(ICON2)

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

I/O PORTS

Direction Registers

The 3825 group has 43 programmable I/O pins arranged in seven I/O ports (ports $P1_6$, $P1_7$ P2, P4–P6, $P7_1$–$P7_7$, $P8_0$ and $P8_1$). The I/O ports have direction registers which determine the input/output direction of each individual pin. (Ports $P1_6$ and $P1_7$ are shared with bits 6 and 7 of the port P1 output control register). Each bit in a direction register corresponds to one pin, and each pin can be set to be input port or output port.

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

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

Port P1 Output Control Register

Bit 0 of the port P1 output control register (address 0003_{16}) enables control of the output of ports $P1_0$ to $P1_5$.

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

In this case, setting of the PULL register A to ports $P1_0$ to $P1_5$ is invalid.

When resetting, bit 0 of the port P1 output control register is set to "0" (the port output function is invalid.)

Pull-up/Pull-down Control

By setting the PULL register A (address 0016_{16}) or the PULL register B (address 0017_{16}), ports P0 to P8 except $P7_0$ can control either pull-down or pull-up (pins that are shared with the segment output pins for LCD are pull-down; all other pins are pull-up) with a program.

However, the contents of PULL register A and PULL register B do not affect ports programmed as the output ports. (except for ports P0 and P3).

Ports P0 and P3 share the port output control function with bit 0 of the PULL register A. When set to "1", the port output function is invalid (Pull-down is valid).

When set to "0", the port output function is valid (Pull-down is invalid).

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

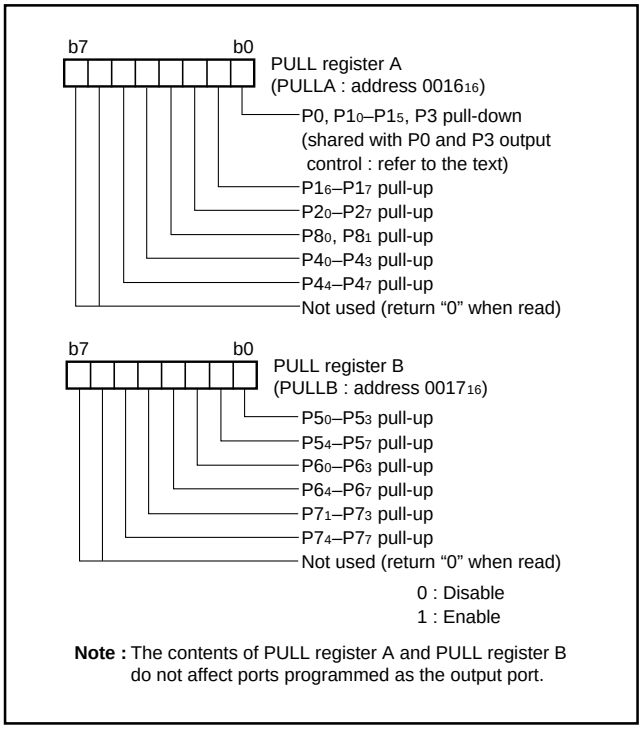


Fig. 11 Structure of PULL register A and PULL register B

Table 6. I/O ports functions

Pin	Name	Input/Output	I/O Format	Non-Port Function	Related SFRs	Diagram No.
P0$_0$/SEG$_{26}$–P0$_7$/SEG$_{33}$	Port P0	Output	CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1)
P1$_0$/SEG$_{34}$–P1$_5$/SEG$_{39}$	Port P1	Output	CMOS 3-state output	LCD segment output	PULL register A Segment output enable register Port P1 output control register	(1)
P1$_6$, P1$_7$		Input/output, individual bits	CMOS compatible input level CMOS 3-state output		PULL register A	(2)
P2$_0$–P2$_7$	Port P2	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Key-on wake up interrupt input	PULL register A Interrupt control register 2	(2)
P3$_0$/SEG$_{18}$–P3$_7$/SEG$_{25}$	Port P3	Output	CMOS 3-state output	LCD segment output	PULL register A Segment output enable register	(1)
P4$_0$/f(X$_{IN}$)/f(X$_{IN}$)/2, P4$_1$/f(X$_{IN}$)/5/f(X$_{IN}$)/10	Port P4	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Clock output	Clock output control register PULL register A	(2)
P4$_2$/INT$_0$, P4$_3$/INT$_1$				External interrupt input	PULL register A Interrupt edge selection register	(2)
P4$_4$/RxD				Serial I/O function I/O	PULL register A Serial I/O control register Serial I/O status register UART control register	(3)
P5$_4$/TxD						(4)
P4$_6$/SCLK						(5)
P4$_7$/SRDY						(6)
P5$_0$/INT$_2$, P5$_1$/INT$_3$	Port P5	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	External interrupt input	PULL register B Interrupt edge selection register	(2)
P5$_2$/RTP$_0$, P5$_3$/RTP$_1$				Real time port function output	PULL register B Timer X mode register	(7)
P5$_4$/CNTR$_0$				Timer X function I/O	PULL register B Timer X mode register	(8)
P5$_5$/CNTR$_1$				Timer Y function input	PULL register B Timer Y mode register	(9)
P5$_6$/TOUT				Timer 2 output	PULL register B Timer 123 mode register	(8)
P5$_7$/ADT				A-D trigger input	PULL register B A-D control register	(9)
P6$_0$/AN$_0$–P6$_7$/AN$_7$	Port P6	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	A-D conversion input	PULL register B A-D control register	(10)
P7$_0$	Port P7	Input	CMOS compatible input level			(11)
P7$_1$–P7$_7$		Input/output, individual bits	CMOS compatible input level CMOS 3-state output		PULL register B	(12)
P8$_0$/XCOUT	Port P8	Input/output, individual bits	CMOS compatible input level CMOS 3-state output	Sub-clock generating circuit	PULL register A CPU mode register	(13)
P8$_1$/XCIN						(14)
COM$_0$–COM$_3$	Common	Output	LCD common output		LCD mode register	(15)
SEG$_0$–SEG$_{17}$	Segment	Output	LCD segment output			(16)

Note 1: When using double-function ports as functional I/O pins, refer the method to the relevant 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 from Vcc to Vss through the input-stage gate.

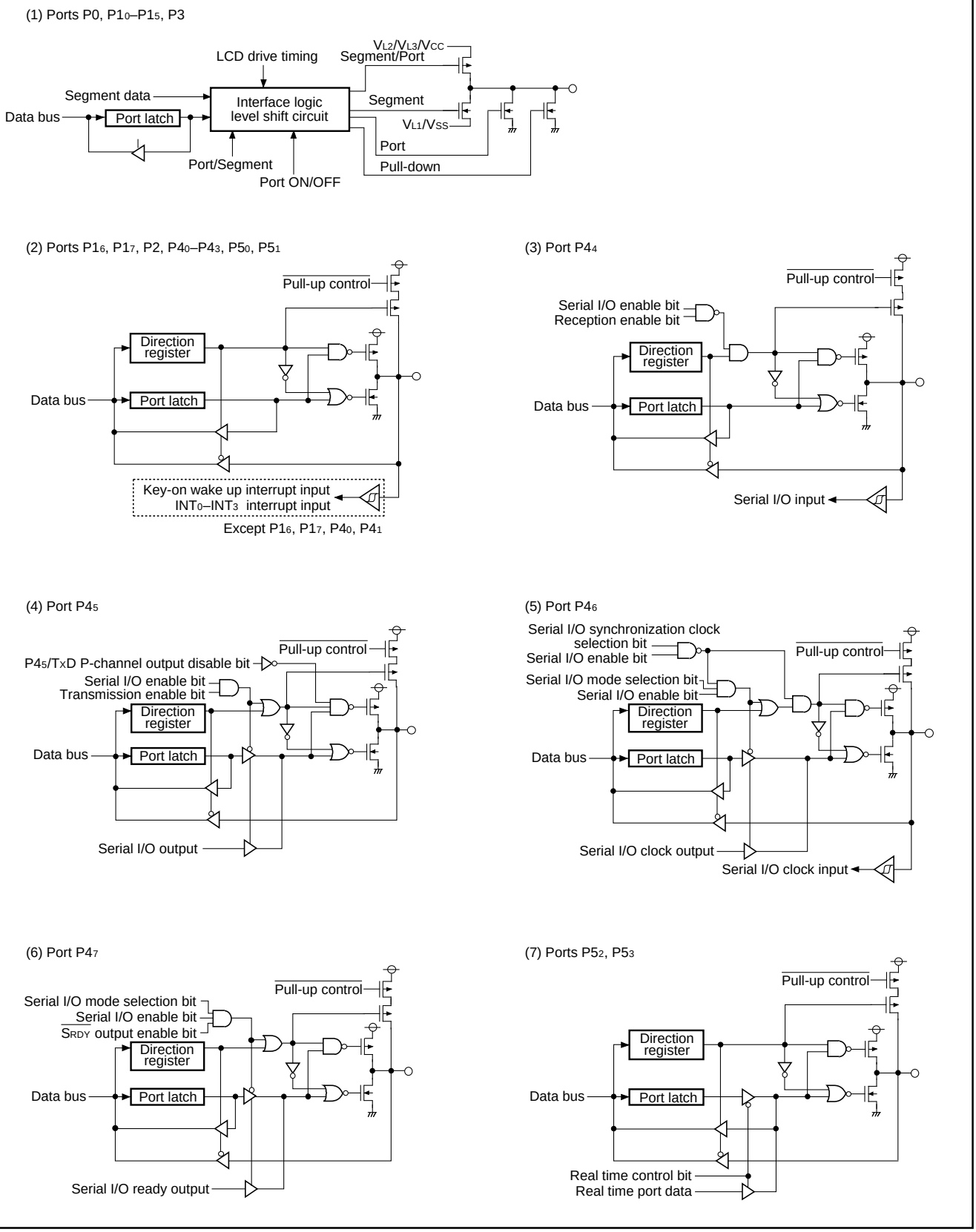
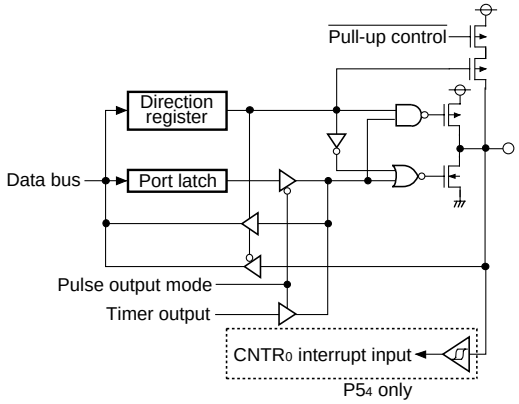
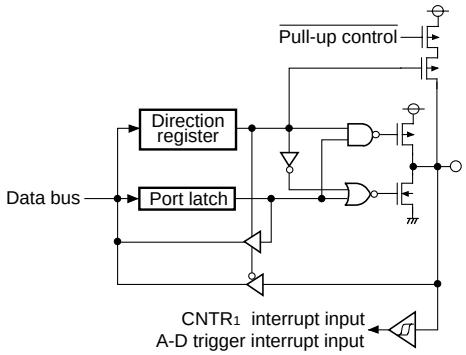


Fig. 12 Port block diagram (1)

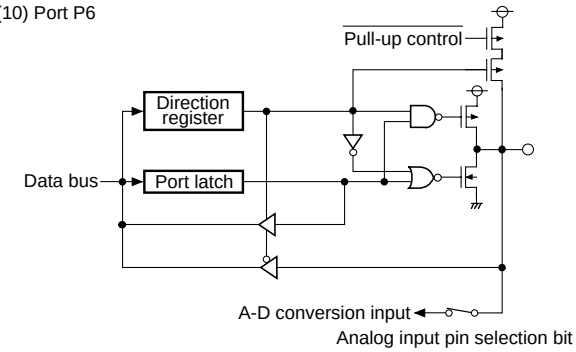
(8) Ports $P5_4$, $P5_6$



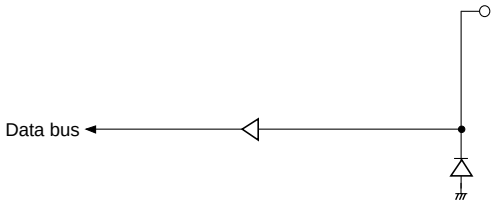
(9) Ports $P5_5$, $P5_7$



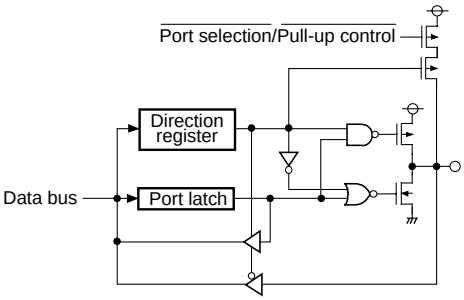
(10) Port P6



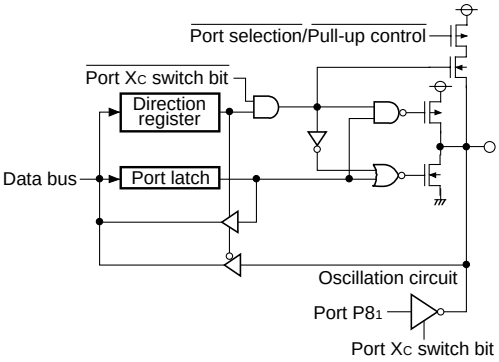
(11) Port $P7_0$



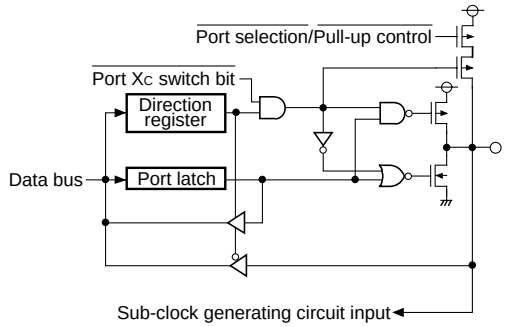
(12) Ports $P7_1$–$P7_7$



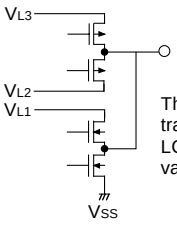
(13) Port $P8_0$



(14) Port $P8_1$

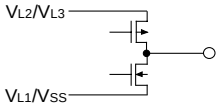


(15) COM_0–COM_3



The gate input signal of each transistor is controlled by the LCD duty ratio and the bias value.

(16) SEG_0–SEG_{17}



The voltage applied to the sources of P-channel and N-channel transistors is the controlled voltage by the bias value.

Fig. 13 Port block diagram (2)

INTERRUPTS

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

Interrupt Control

Each interrupt is controlled by an interrupt request bit, an interrupt enable bit, and the interrupt disable flag except for the software interrupt set by the BRK instruction. An interrupt 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 cannot be disabled with any flag or bit. The I flag disables all interrupts except the BRK instruction interrupt.

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

Interrupt Operation

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

1. The contents of the program counter and the processor status register are automatically pushed onto the stack.
2. The interrupt 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 the active edge of an external interrupt (INT_0–INT_3, $CNTR_0$, or $CNTR_1$) is changed, the corresponding interrupt request bit may also be set. Therefore, please take following sequence:

(1) Disable the external interrupt which is selected
(2) Change the active edge selection (use the timer X mode register for $CNTR_0$, the timer Y mode register for $CNTR_1$)
(3) Clear the interrupt request bit which is selected to “0”
(4) Enable the external interrupt which is selected.

Table 7. Interrupt vector addresses and priority

Interrupt Source	Priority	Vector Addresses (Note 1)		Interrupt Request Generating Conditions	Remarks
		High	Low		
Reset (Note 2)	1	$FFFD_{16}$	$FFFC_{16}$	At reset	Non-maskable
INT_0	2	$FFFB_{16}$	$FFFA_{16}$	At detection of either rising or falling edge of INT_0 input	External interrupt (active edge selectable)
INT_1	3	$FFF9_{16}$	$FFF8_{16}$	At detection of either rising or falling edge of INT_1 input	External interrupt (active edge selectable)
Serial I/O reception	4	$FFF7_{16}$	$FFF6_{16}$	At completion of serial I/O data reception	Valid when serial I/O is selected
Serial I/O transmission	5	$FFF5_{16}$	$FFF4_{16}$	At completion of serial I/O transmit shift or when transmission buffer is empty	Valid when serial I/O is selected
Timer X	6	$FFF3_{16}$	$FFF2_{16}$	At timer X underflow	
Timer Y	7	$FFF1_{16}$	$FFF0_{16}$	At timer Y underflow	
Timer 2	8	$FFEF_{16}$	$FFEE_{16}$	At timer 2 underflow	
Timer 3	9	$FFED_{16}$	$FFEC_{16}$	At timer 3 underflow	
$CNTR_0$	10	$FFEB_{16}$	$FFEA_{16}$	At detection of either rising or falling edge of $CNTR_0$ input	External interrupt (active edge selectable)
$CNTR_1$	11	$FFE9_{16}$	$FFE8_{16}$	At detection of either rising or falling edge of $CNTR_1$ input	External interrupt (active edge selectable)
Timer 1	12	$FFE7_{16}$	$FFE6_{16}$	At timer 1 underflow	
INT_2	13	$FFE5_{16}$	$FFE4_{16}$	At detection of either rising or falling edge of INT_2 input	External interrupt (active edge selectable)
INT_3	14	$FFE3_{16}$	$FFE2_{16}$	At detection of either rising or falling edge of INT_3 input	External interrupt (active edge selectable)
Key input (Key-on wake up)	15	$FFE1_{16}$	$FFE0_{16}$	At falling of conjunction of input level for port P2 (at input mode)	External interrupt (valid when an “L” level is applied)
ADT	16	$FFDF_{16}$	$FFDE_{16}$	At falling of ADT input	Valid when ADT interrupt is selected External interrupt (Valid at falling)
A-D conversion				At completion of A-D conversion	Valid when A-D interrupt is selected
BRK instruction	17	$FFDD_{16}$	$FFDC_{16}$	At BRK instruction execution	Non-maskable software interrupt

Notes 1: Vector addresses contain interrupt jump destination addresses.
2: Reset function in the same way as an interrupt with the highest priority.

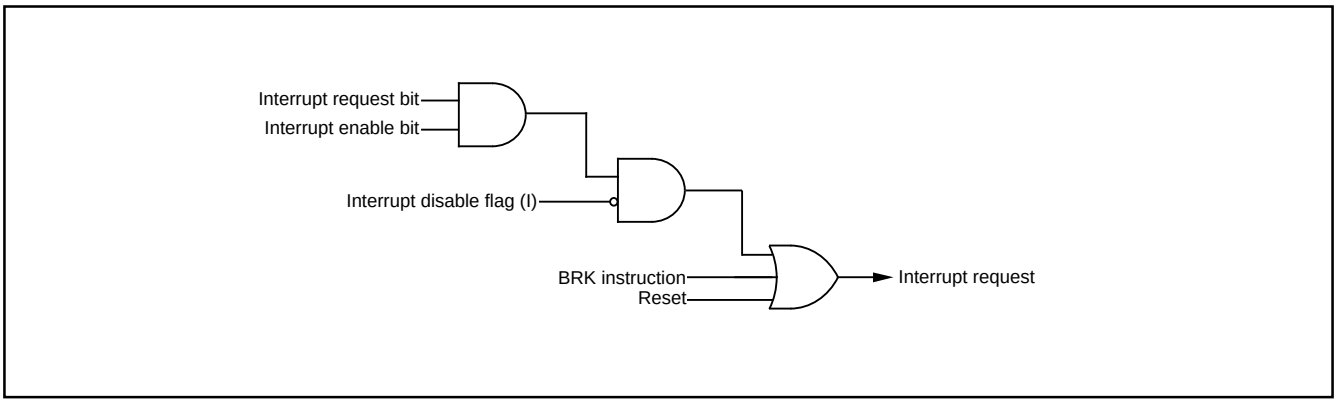


Fig. 14 Interrupt control

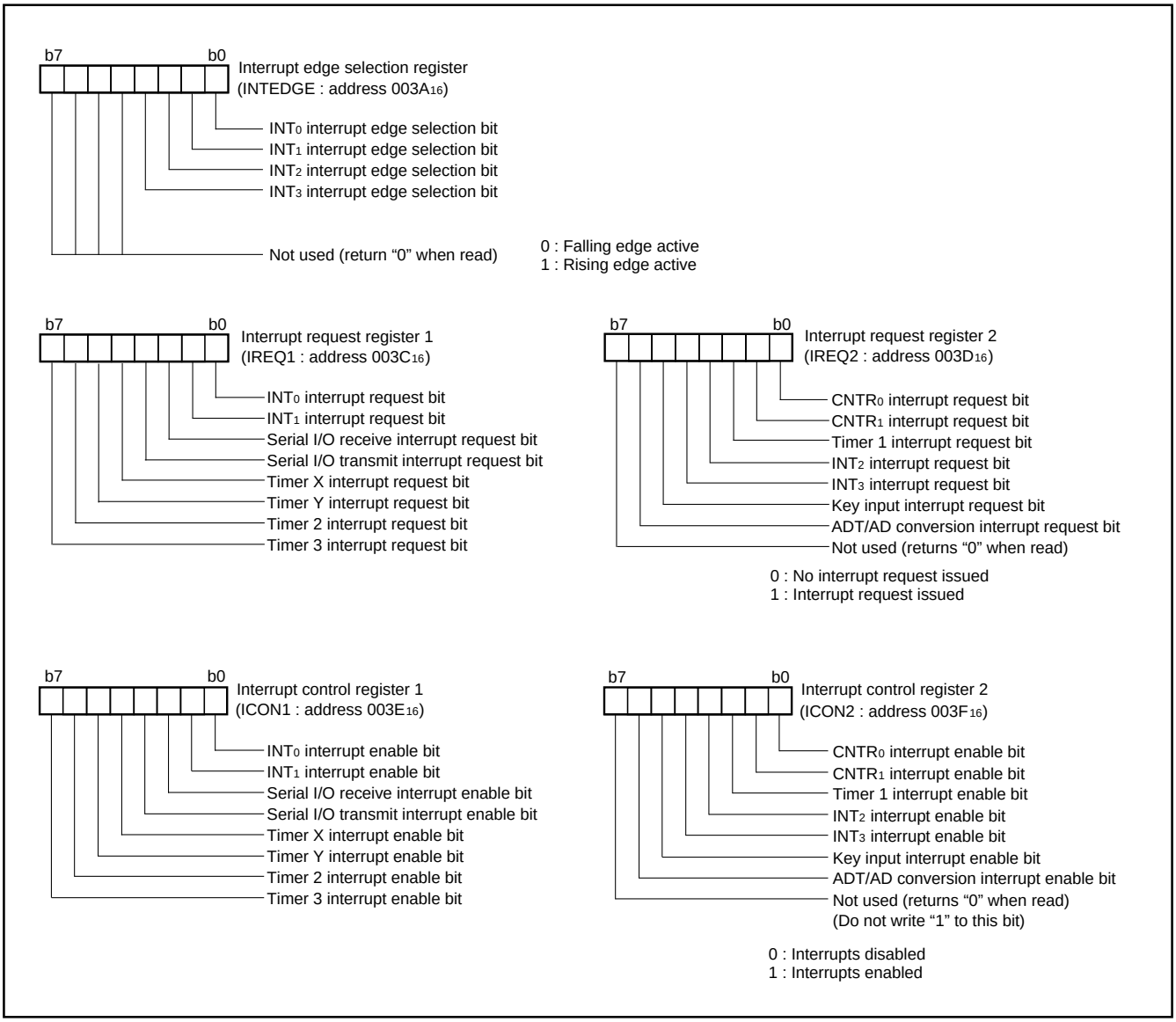


Fig. 15 Structure of interrupt-related registers

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 16, where an interrupt request is generated by pressing one of the keys consisted as an active-low key matrix which inputs to ports $P2_0$–$P2_3$.

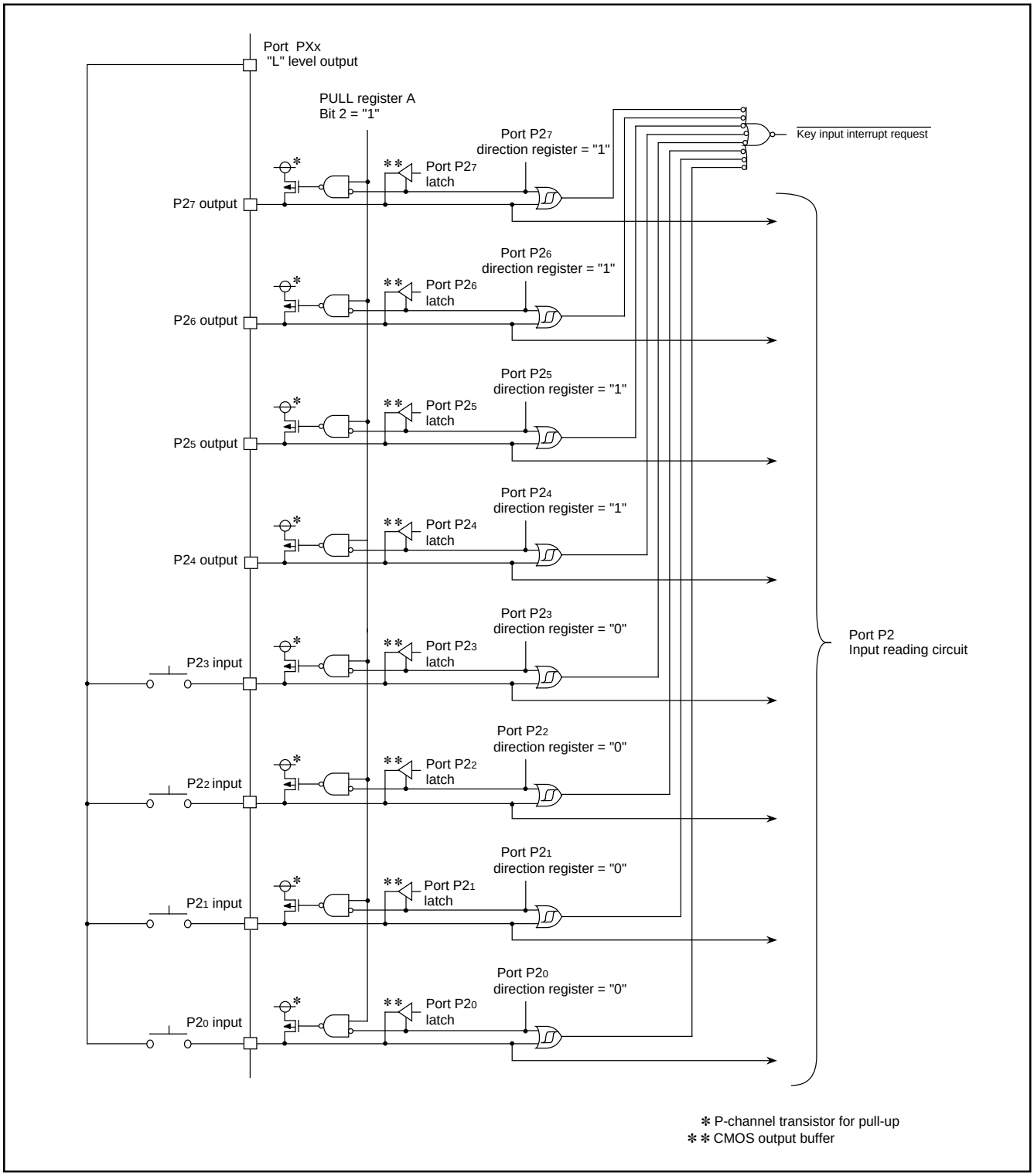


Fig. 16 Connection example when using key input interrupt and port P2 block diagram

TIMERS

The 3825 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 "00$_{16}$", an underflow occurs at the next count pulse and the corresponding timer latch is reloaded into the timer and the count is continued. When a timer underflows, the interrupt request bit corresponding to that timer is set to "1".

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.

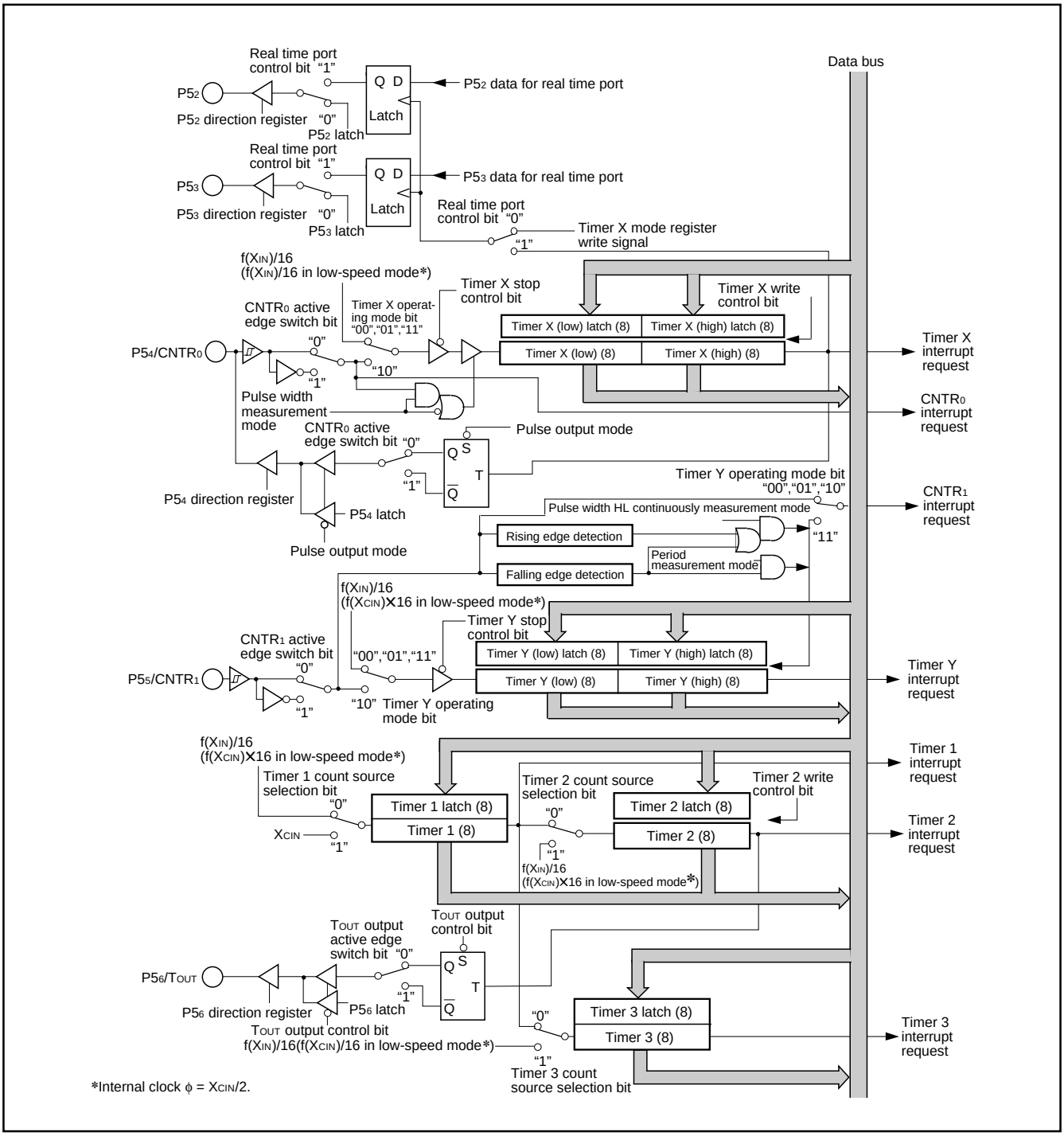


Fig. 17 Timer block diagram

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 corresponding port P54 direction register to output mode.

(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 corresponding port P54 direction register to input mode.

(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 corresponding port P54 direction register to input mode.

●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, when writing in the timer latch at the timer underflow, the value is set in the timer and the latch at one time. Additionally, 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.

●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” after set of the real time port data, data are output independent of the timer X operation.) If the data for the real time port is changed while the real time port function is valid, the changed data are output at the next underflow of timer X.
Before using this function, set the corresponding port direction registers to output mode.

■Note on CNTR0 interrupt active edge selection

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

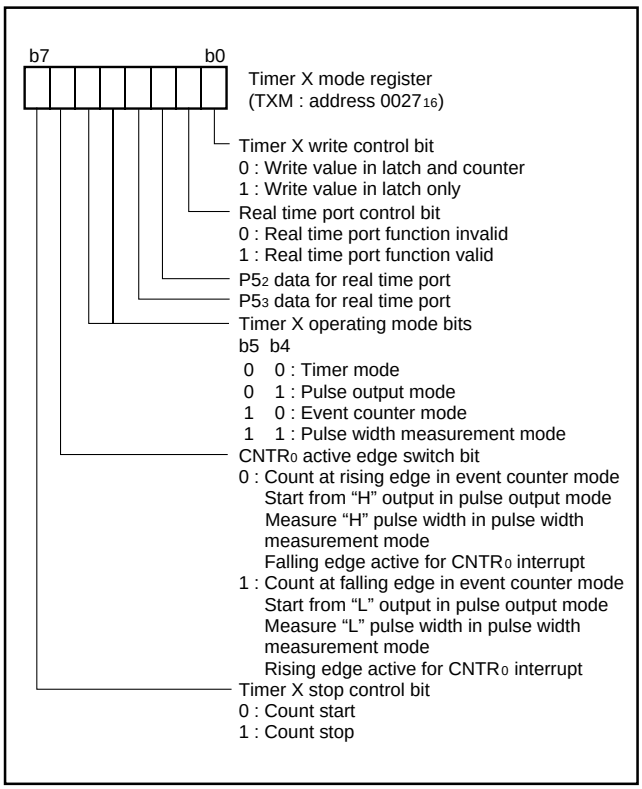


Fig. 18 Structure of timer X mode register

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 corresponding port P55 direction register to input mode.

(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 corresponding port P55 direction register to input mode.

(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 corresponding port P55 direction register to input mode.

■Note 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.

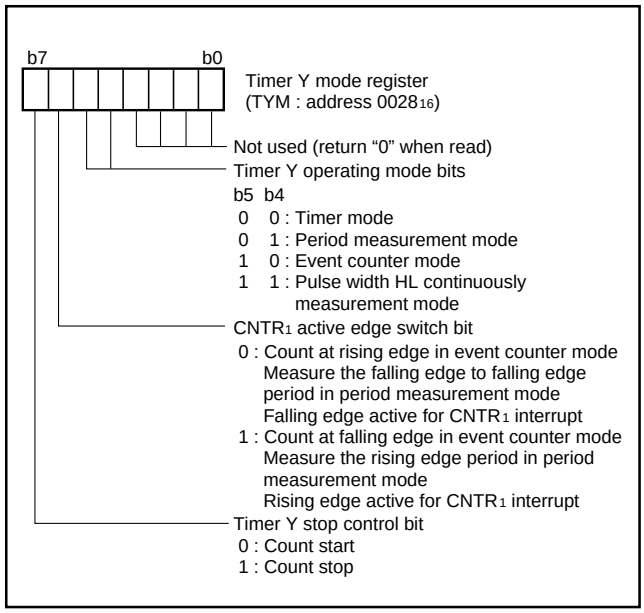


Fig. 19 Structure of timer Y mode register

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, 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 (T_{OUT}) is output enabled, an inversion signal from pin T_{OUT} is output each time timer 2 underflows.

In this case, set the port $P5_6$ shared with the T_{OUT} pin to the output mode.

■Note on Timer 1 to Timer 3

When the count source of timers 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.

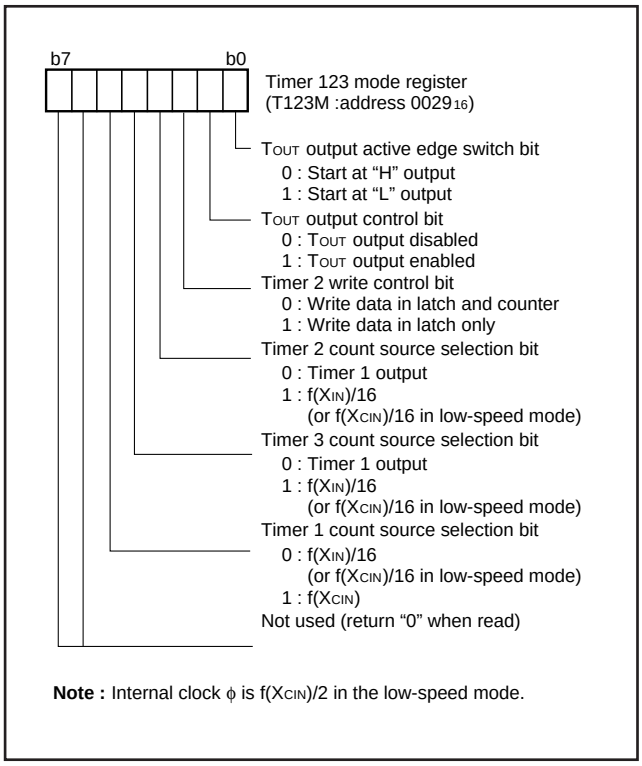


Fig. 20 Structure of timer 123 mode register

SERIAL I/O

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

(1) Clock Synchronous Serial I/O Mode

Clock synchronous serial I/O mode can be selected by setting the mode selection bit of the serial I/O control register to “1”.
For clock synchronous serial I/O, the transmitter and the receiver must use the same clock. If an internal clock is used, transfer is started by a write signal to the TB/RB (address 0018_{16}).

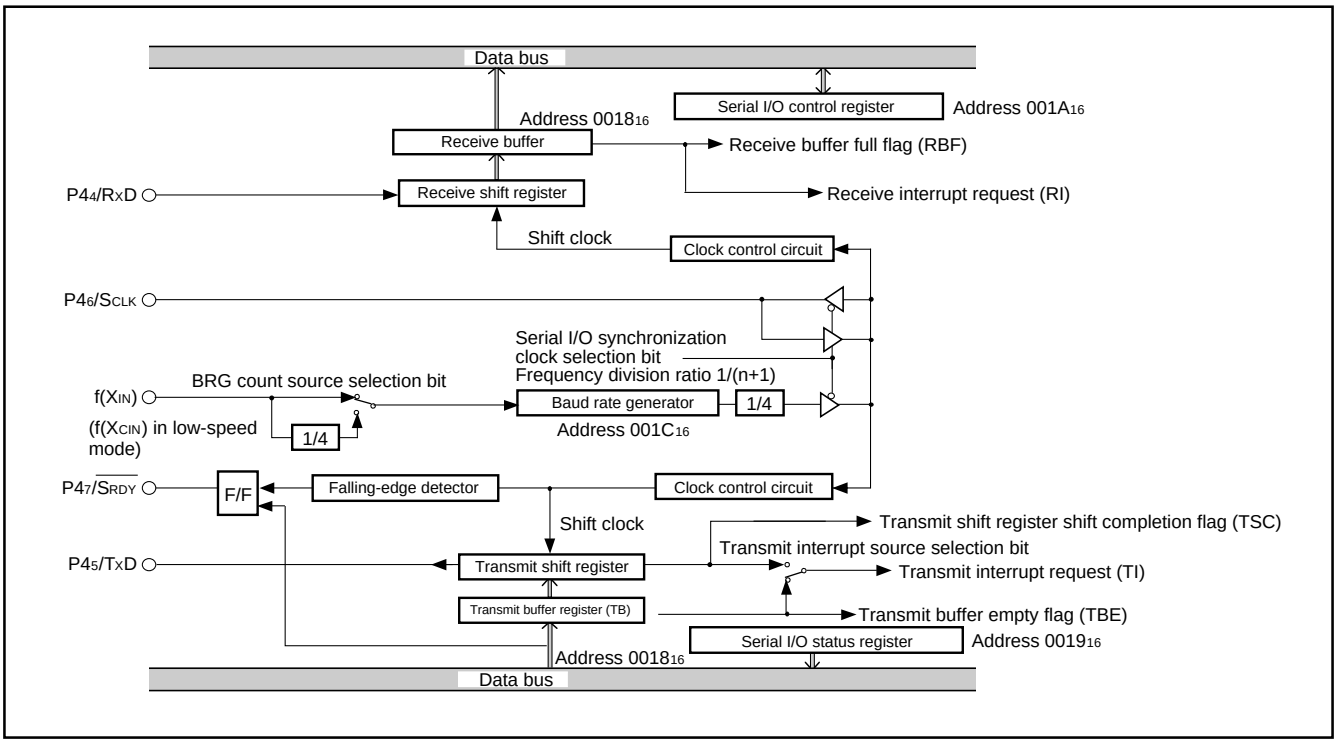
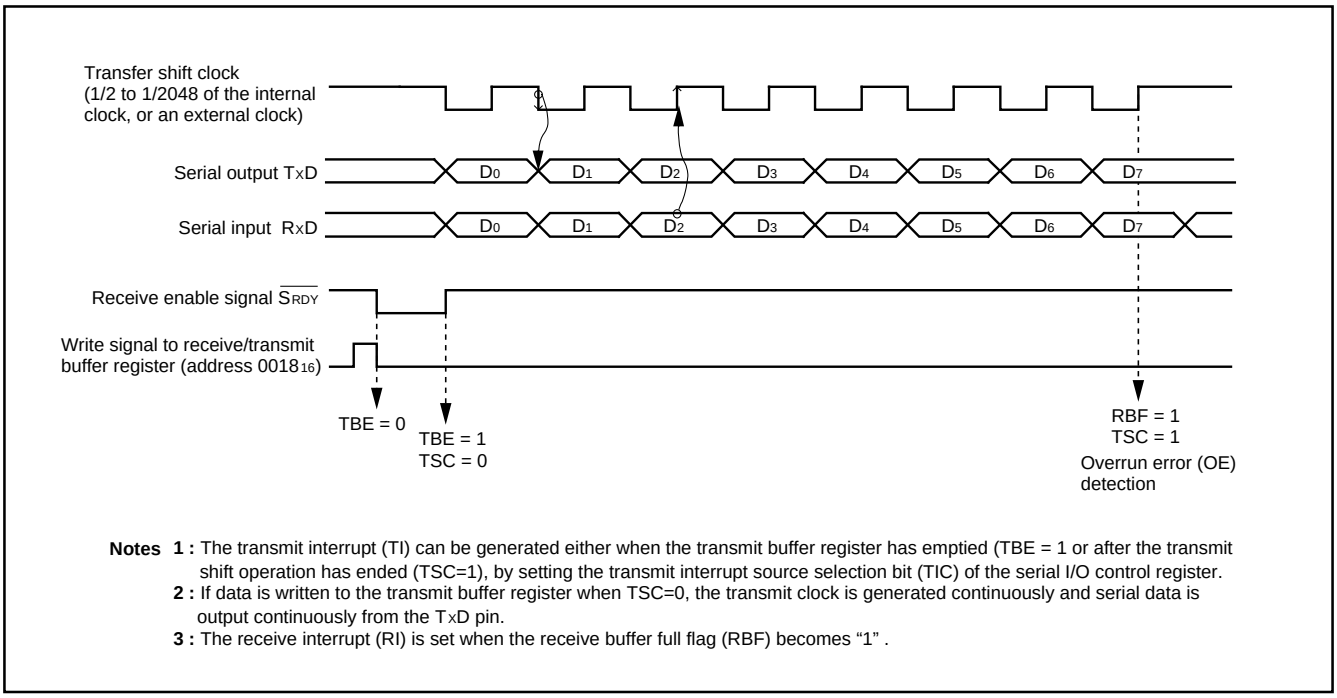


Fig. 21 Block diagram of clock synchronous serial I/O



Notes
1 : The transmit interrupt (TI) can be generated either when the transmit buffer register has emptied (TBE = 1 or after the transmit shift operation has ended (TSC=1), by setting the transmit interrupt source selection bit (TIC) of the serial I/O control register.
2 : If data is written to the transmit buffer register when TSC=0, the transmit clock is generated continuously and serial data is output continuously from the TxD pin.
3 : The receive interrupt (RI) is set when the receive buffer full flag (RBF) becomes “1” .

Fig. 22 Operation of clock synchronous serial I/O 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/O control register to “0”.

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

The transmit and receive shift registers each have a buffer register, 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.

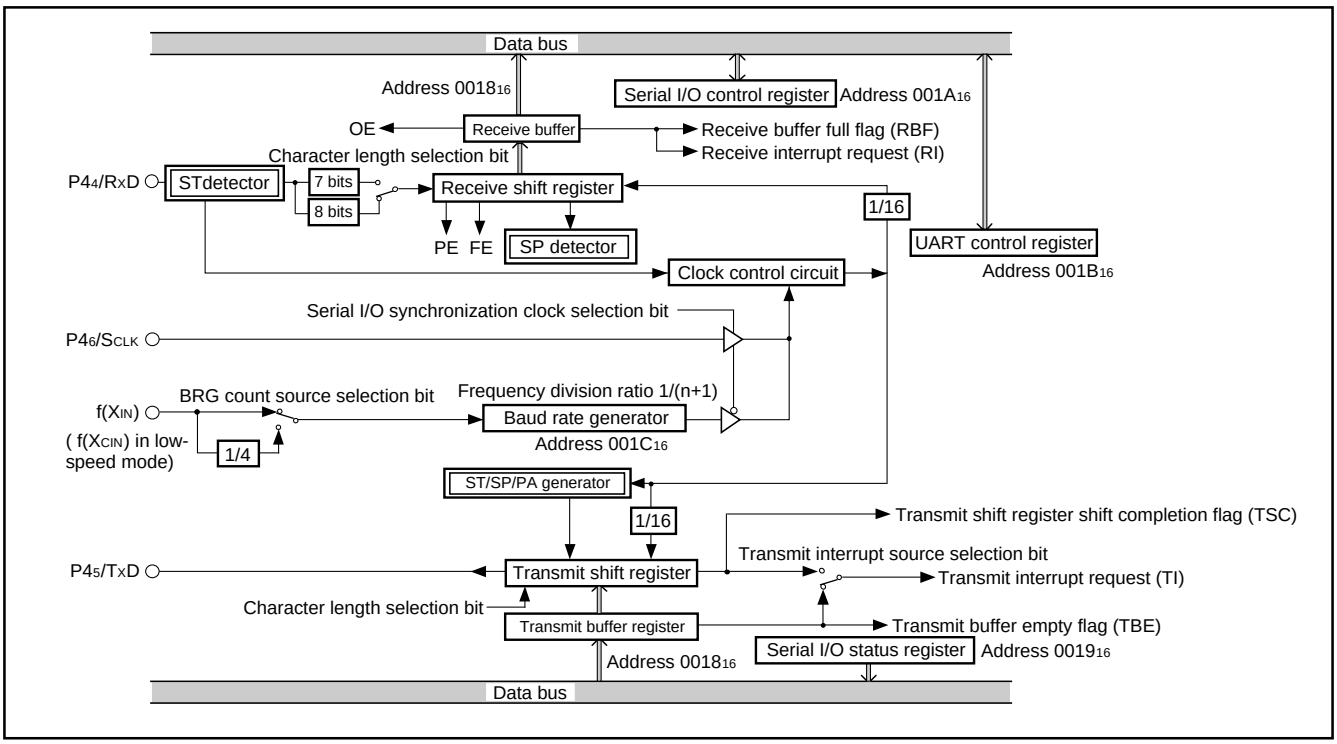
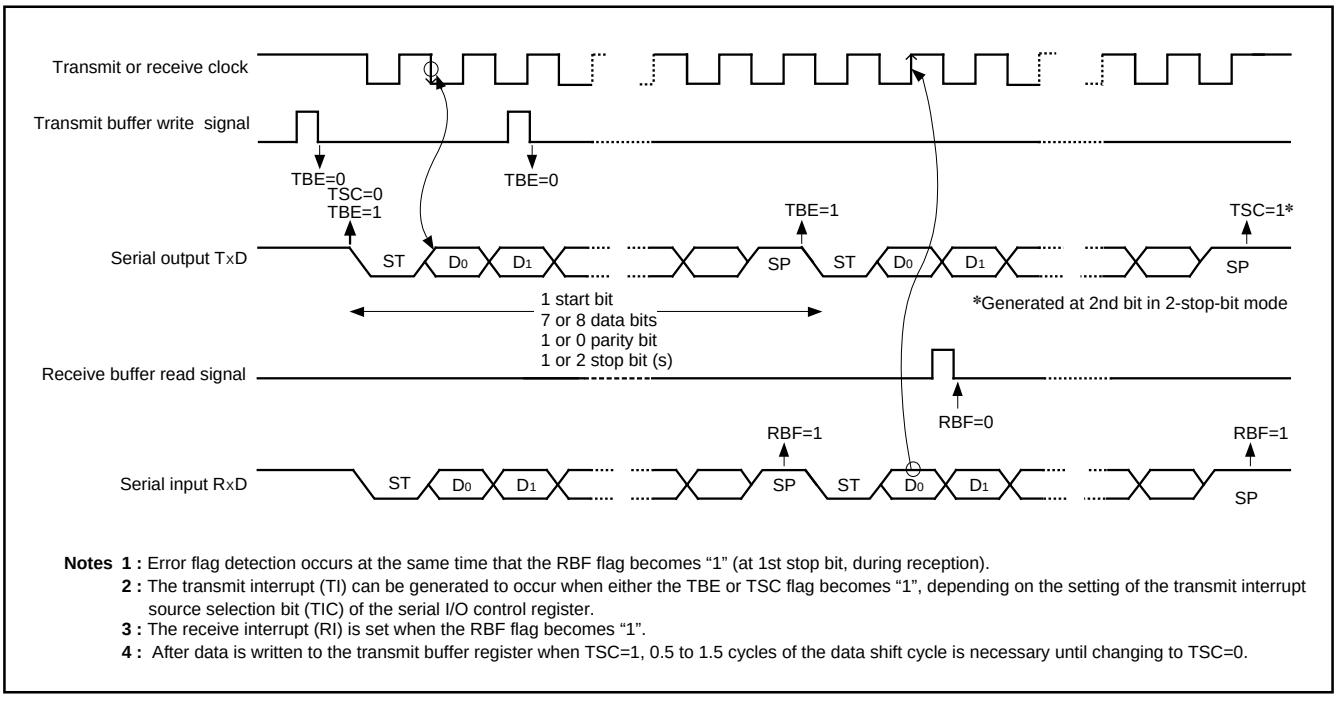


Fig. 23 Block diagram of UART serial I/O



Notes 1 : Error flag detection occurs at the same time that the RBF flag becomes “1” (at 1st stop bit, during reception).
2 : The transmit interrupt (TI) can be generated to occur when either the TBE or TSC flag becomes “1”, depending on the setting of the transmit interrupt source selection bit (TIC) of the serial I/O control register.
3 : The receive interrupt (RI) is set when the RBF flag becomes “1”.
4 : After data is written to the transmit buffer register when TSC=1, 0.5 to 1.5 cycles of the data shift cycle is necessary until changing to TSC=0.

Fig. 24 Operation of UART serial I/O function

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

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

[Serial I/O Status Register (SIOSTS)] 0019$_{16}$

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

Three of the flags (bits 4 to 6) are valid only in 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/O status register clears all the error flags OE, PE, FE, and SE (bit 3 to bit 6, respectively). Writing “0” to the serial I/O enable bit SIOE (bit 7 of the Serial I/O Control Register) also clears all the status flags, including the error flags.

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

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

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

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

The UART control register consists of four control bits (bits 0 to 3) which are valid when asynchronous serial I/O is selected and set the data format of an data transfer. One bit in this register (bit 4) is always valid and sets the output structure of the P4$_5$/TxD pin.

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

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

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

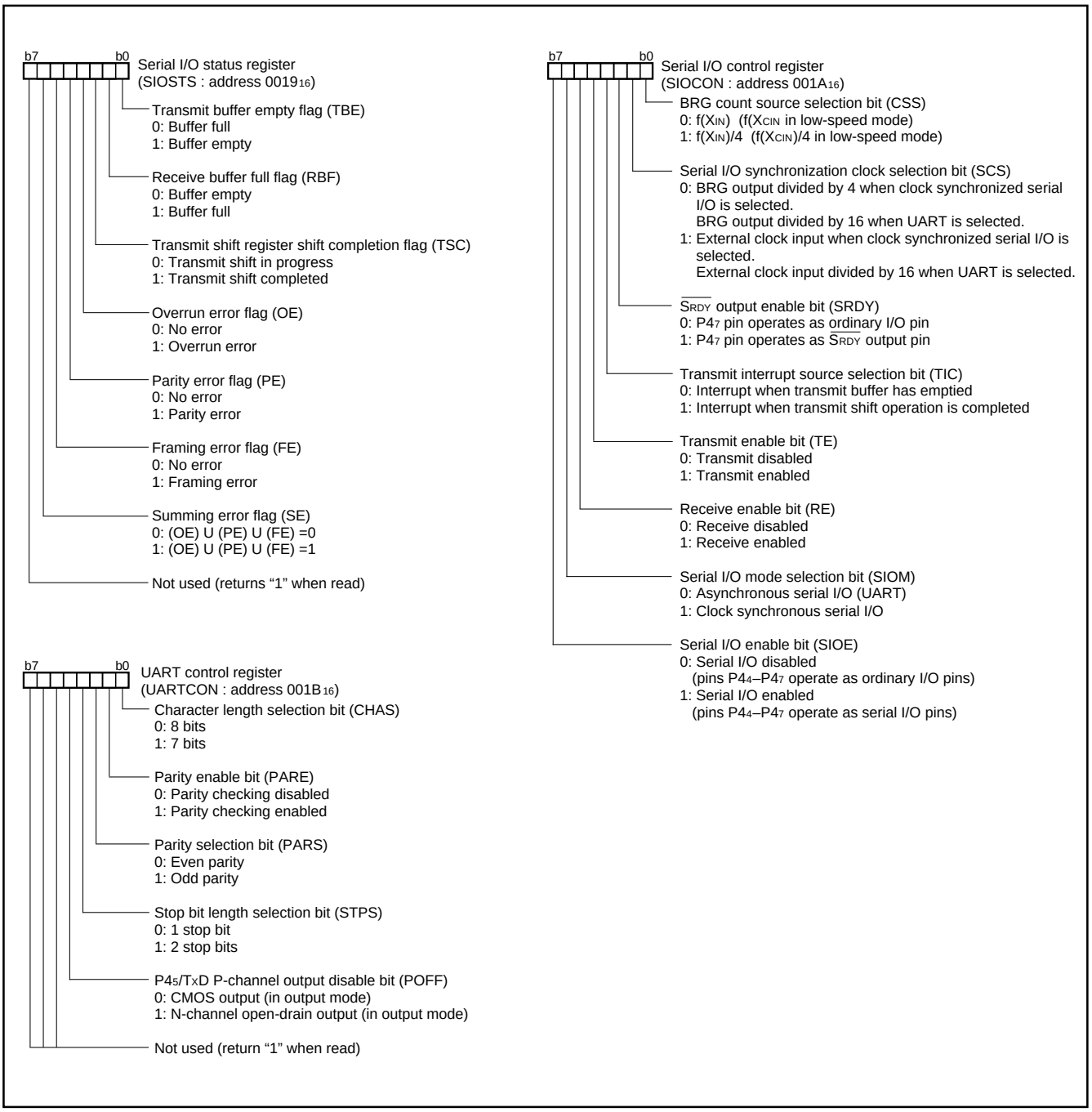


Fig. 25 Structure of serial I/O control registers

A-D CONVERTER

The functional blocks of the A-D converter are described below.

[A-D Conversion Register (AD)] 003516

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

[A-D Control Register (ADCON)] 003416

The A-D control register controls the A-D conversion process. Bits 0 to 2 of this register select specific analog input pins. Bit 3 signals the completion of an A-D conversion. The value of this bit remains at “0” during an 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”, this bit enables A-D conversion even by a falling edge of an ADT input. Set ports which share with ADT pins to input when using an A-D external trigger.

Comparison Voltage Generator

The comparison voltage generator divides the voltage between AVSS and VREF by 256, and outputs the divided voltages.

Channel Selector

The channel selector selects one of the input ports P67/AN7–P60/AN0.

Comparator and Control Circuit

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

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

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

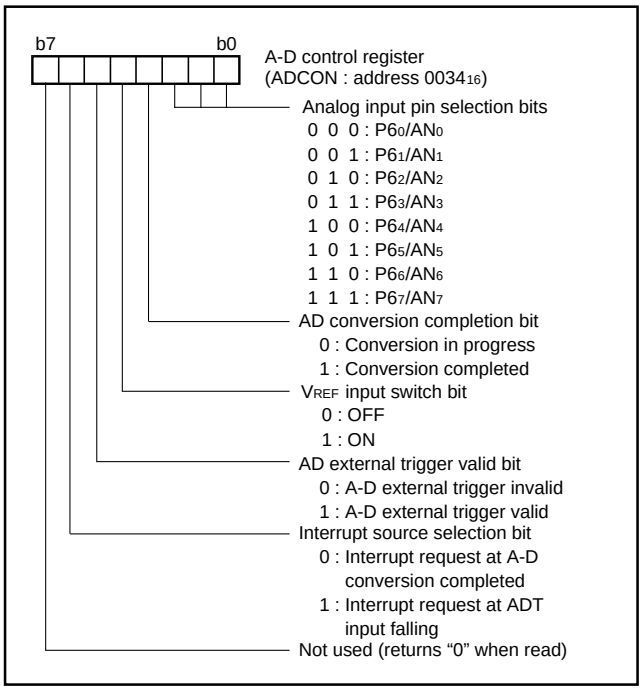


Fig. 26 Structure of A-D control register

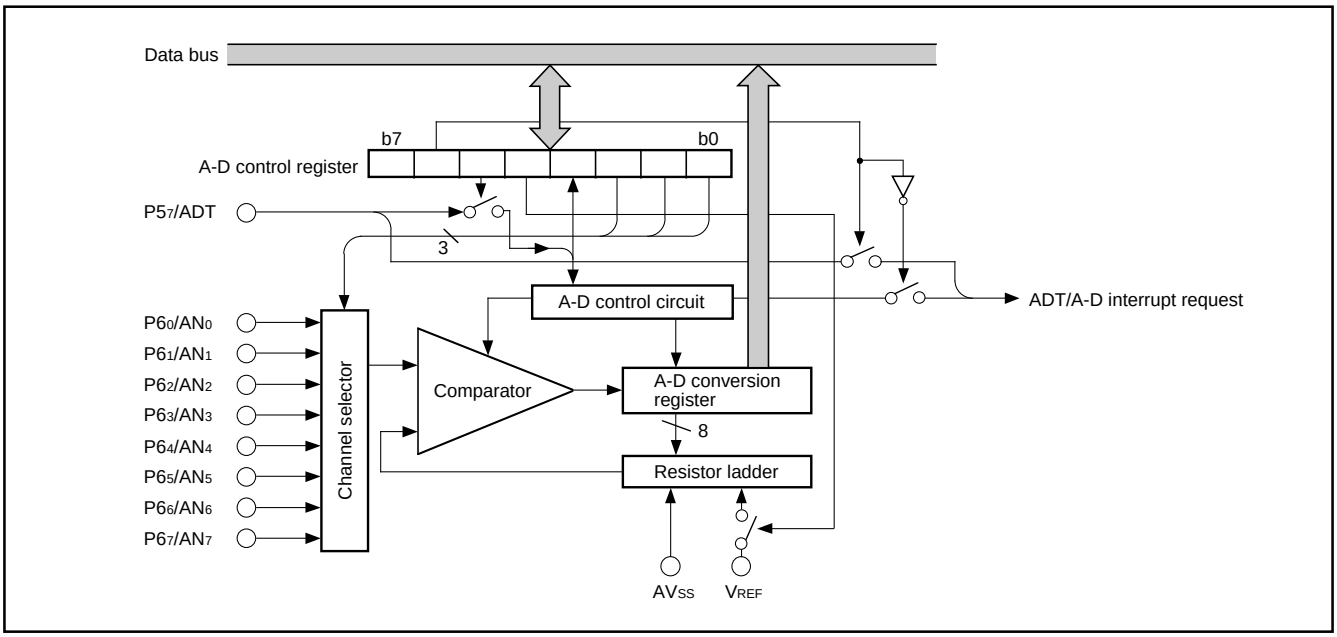


Fig. 27 A-D converter block diagram

LCD DRIVE CONTROL CIRCUIT

The 3825 group has the built-in Liquid Crystal Display (LCD) drive control circuit consisting of the following.

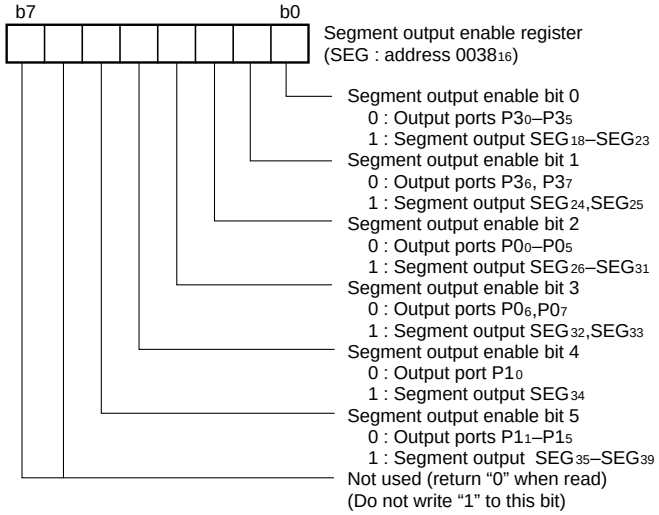
- LCD display RAM
- Segment output enable register
- LCD mode register
- Voltage multiplier
- Selector
- Timing controller
- Common driver
- Segment driver
- Bias control circuit

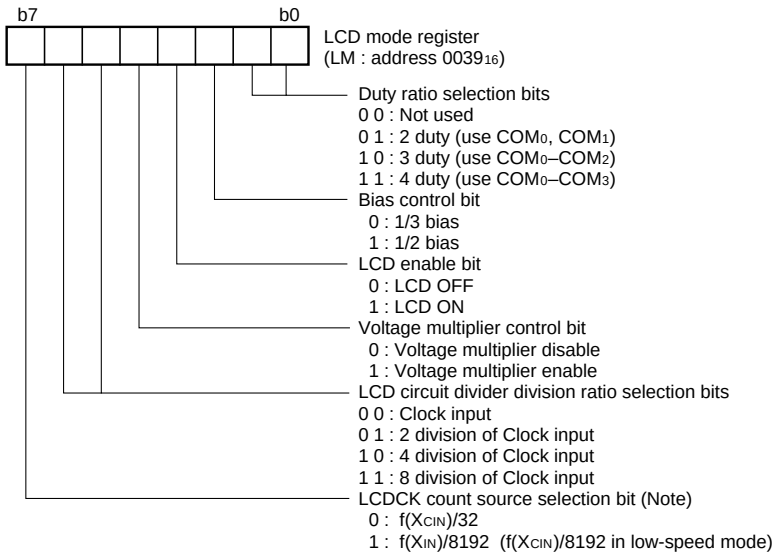
A maximum of 40 segment output pins and 4 common output pins can be used.

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 8. 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. 28 Structure of segment output enable register and LCD mode register

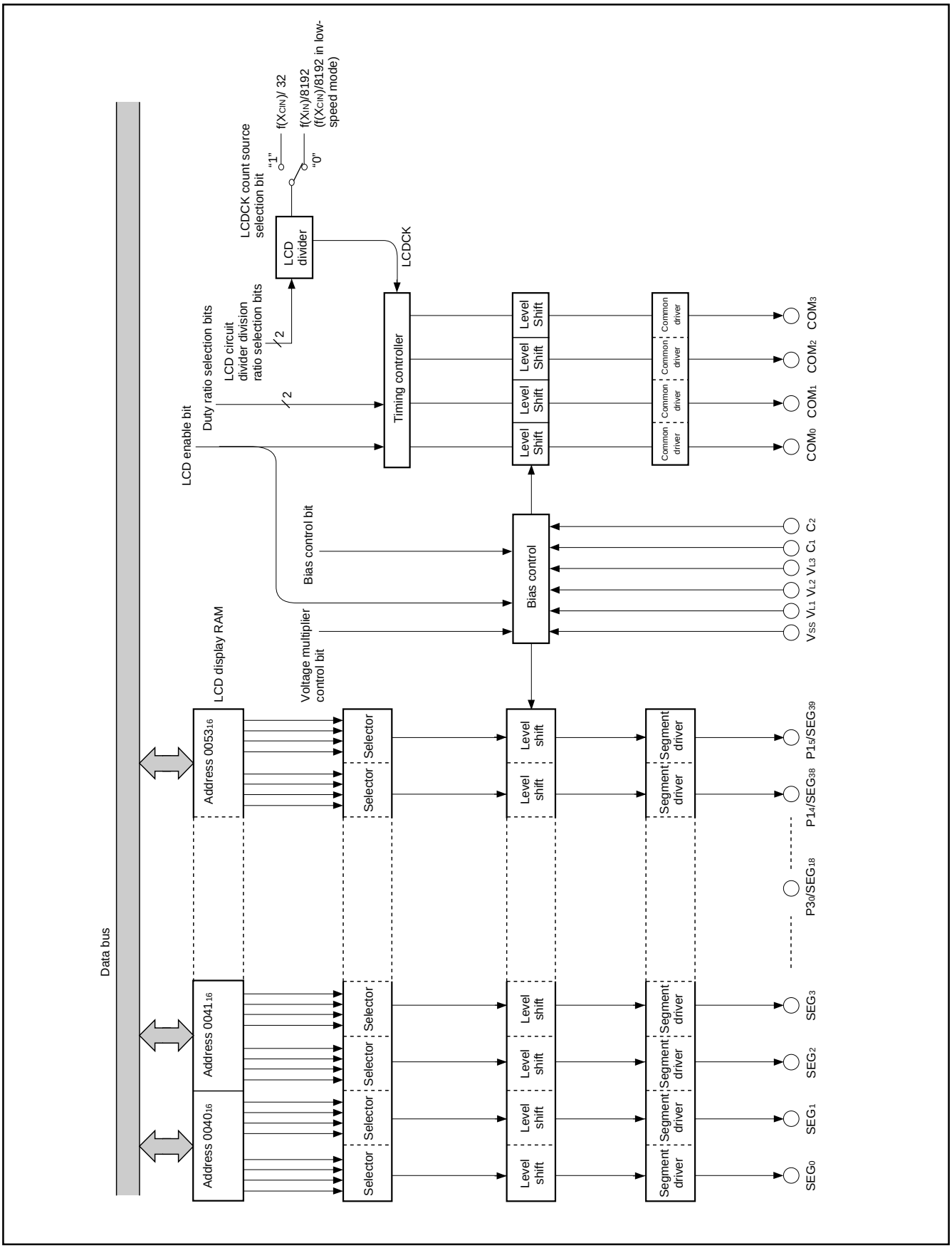


Fig. 29 Block diagram of LCD controller/driver

Voltage Multiplier (3 Times)

The voltage multiplier performs threefold boosting. This circuit inputs a reference voltage for boosting from LCD power input pin V_{L1}. (However, when using a 1/2 bias, connect V_{L1} and V_{L2} and apply voltage by external resistor division.)

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

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

When using the voltage multiplier; after applying 1.3 V ≤ Voltage ≤ 2.3 V to the V_{L1} pin, set the voltage multiplier control bit to "1" to select the voltage multiplier enable.

When not using the voltage multiplier, apply proper voltage to the LCD power input pins (V_{L1}–V_{L3}).

Bias Control and Applied Voltage to LCD Power Input Pins

To the LCD power input pins (V_{L1}–V_{L3}), apply the voltage shown in Table 9 according to the bias value.

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

Common Pin and Duty Ratio Control

The common pins (COM_0–COM_3) to be used are determined by duty ratio.

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

Table 9. Bias control and applied voltage to V_{L1}–V_{L3}

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

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

Table 10. 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

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

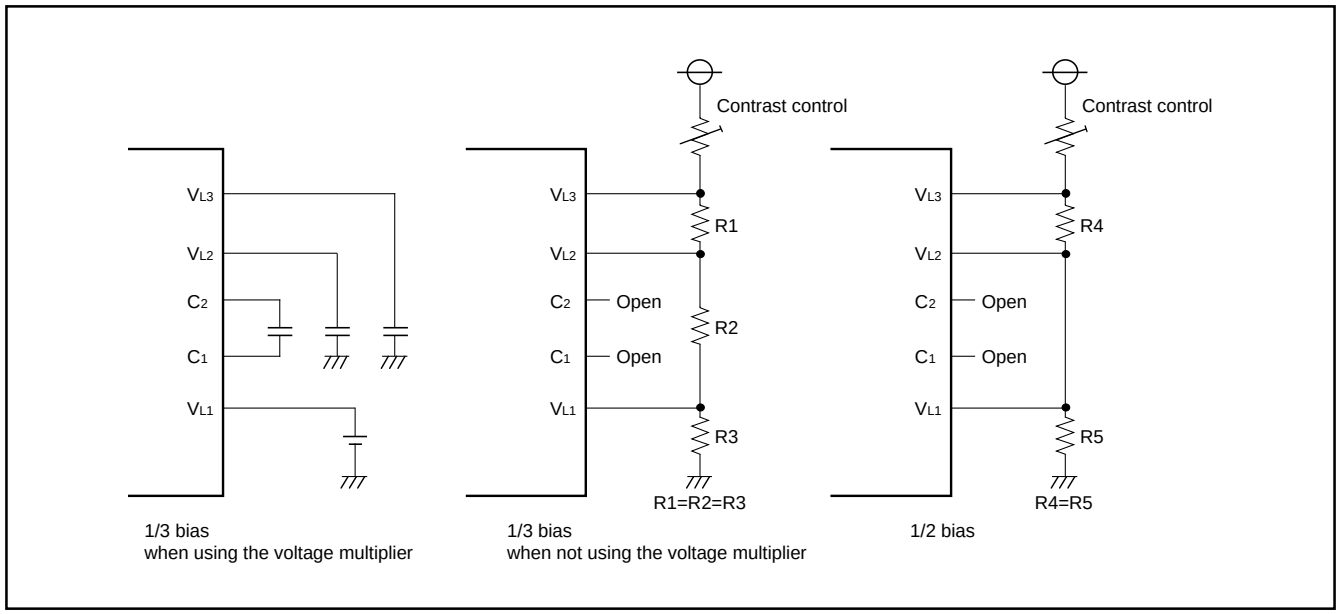


Fig. 30 Example of circuit at each bias

LCD Display RAM

Address 0040_{16} to 0053_{16} 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;

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

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

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

Fig. 31 LCD display RAM map

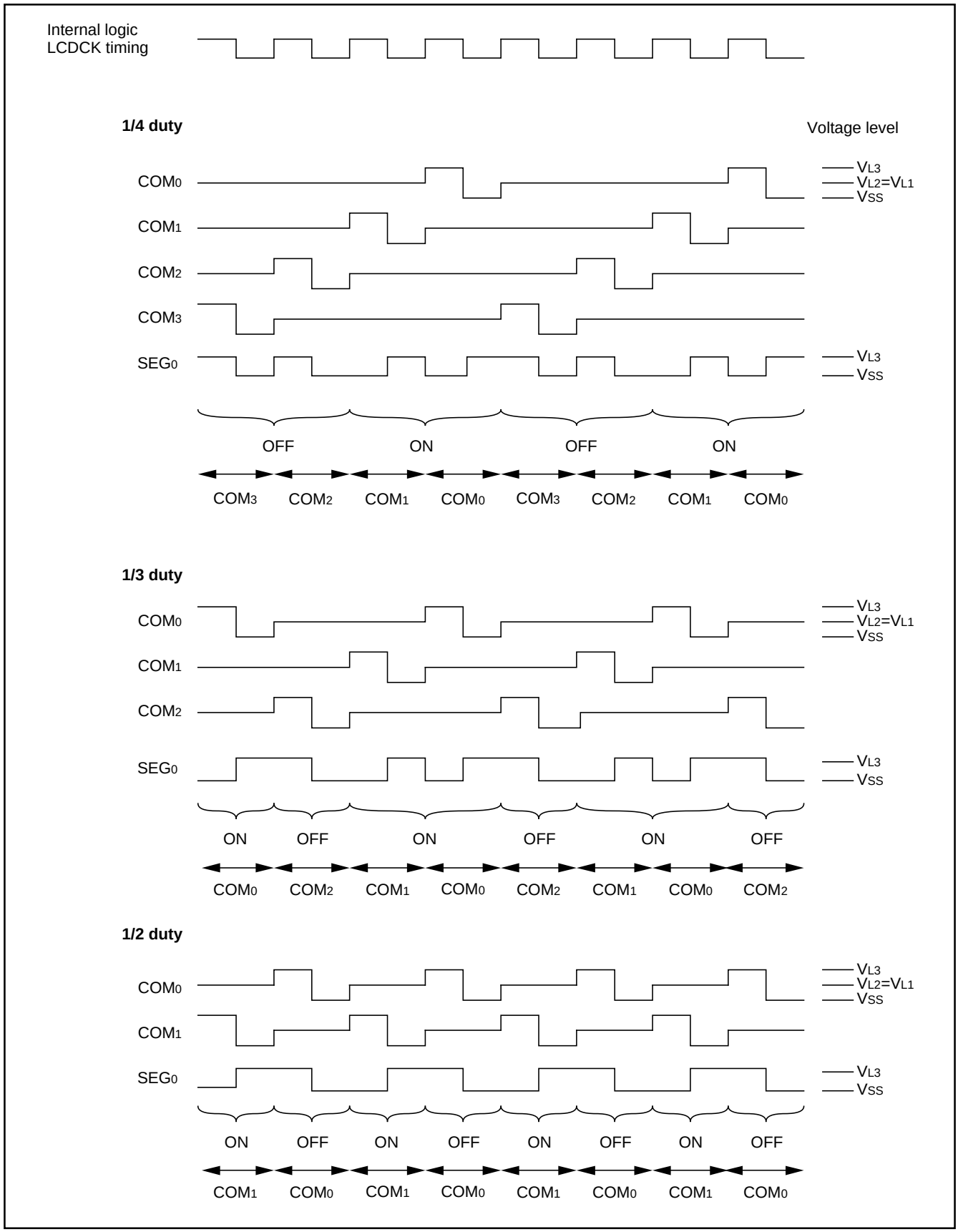


Fig. 32 LCD drive waveform (1/2 bias)

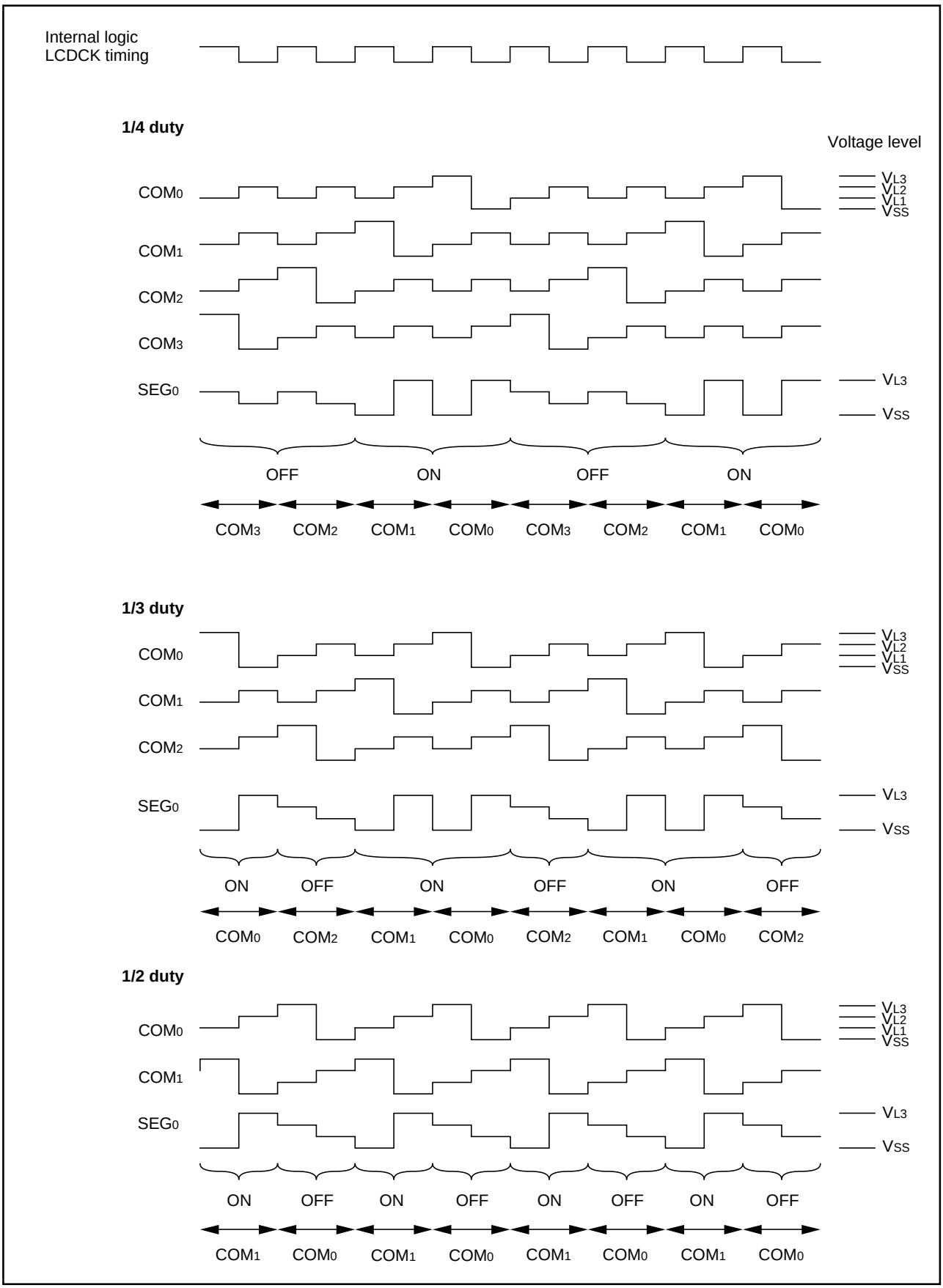


Fig. 33 LCD drive waveform (1/3 bias)

CLOCK OUTPUT FUNCTION

Input/output ports $P4_0$ and $P4_1$ can output clock. The input/output ports and clock output function are put under double function controlled by the clock output control register (address $002A_{16}$).

Selection of Input/Output Ports and Clock Output Function

Bits 0 and 1 of the clock output control register can select between the input/output ports and the clock output function.

When selecting the clock output function, clocks are output while the direction register of ports $P4_0$ and $P4_1$ are set to output.

At the next cycle of rewriting the clock output control bit, $P4_0$ is switched between the port output and the clock output.

In synchronization with the fall of the clock (resulting from dividing X_{IN} by 5) on rewriting the clock output control bit, $P4_1$ is switched between the port output and the clock output.

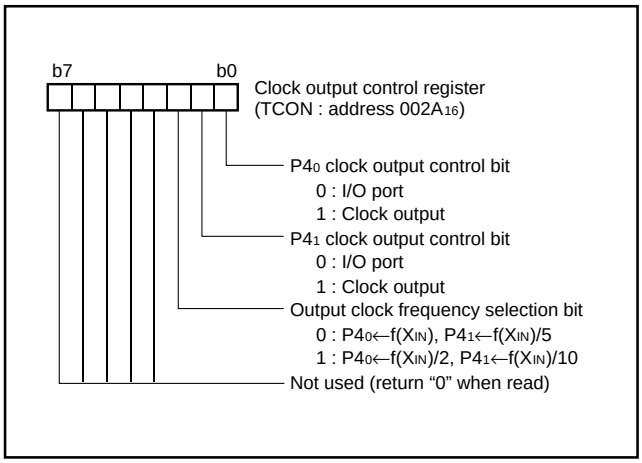


Fig. 34 Structure of clock output control register

Selection of Output Clock Frequency

Bit 2 (output clock frequency selection bit) of the clock output control register selects an output clock frequency.

When setting the output clock frequency selection bit to "0", port $P4_0$ becomes the frequency of $f(X_{IN})$ and port $P4_1$ becomes the frequency of $f(X_{IN})/5$.

At this time, the output pulse of port $P4_0$ depends on the X_{IN} input pulse, while the output pulse of port $P4_1$ has duty ratio of about 40%.

When setting the output clock frequency selection bit to "1", port $P4_0$ becomes the frequency of $f(X_{IN})/2$ and port $P4_1$ becomes the frequency of $f(X_{IN})/10$. At this time, the output pulses of both ports $P4_0$ and $P4_1$ have duty ratio of 50%.

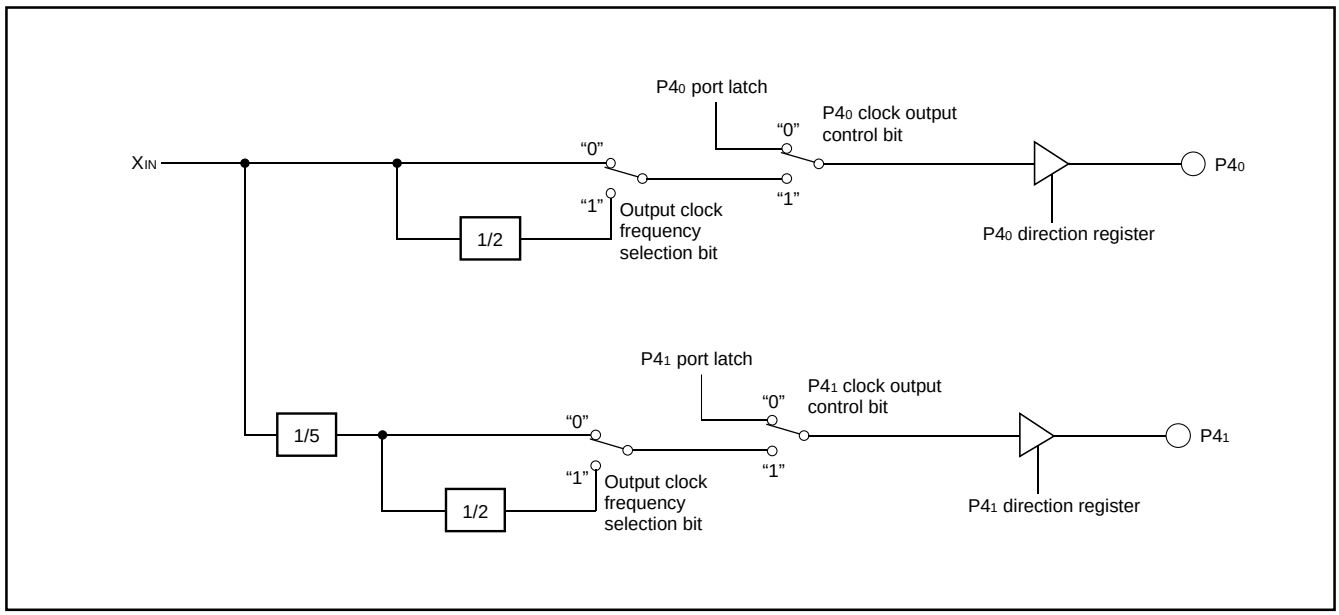


Fig. 35 Clock output function block diagram

RESET CIRCUIT

To reset the microcomputer, $\overline{\text{RESET}}$ pin should be held at an “L” level for 2 μs or more. Then the $\overline{\text{RESET}}$ 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), and 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 for V_{CC} (Min.).

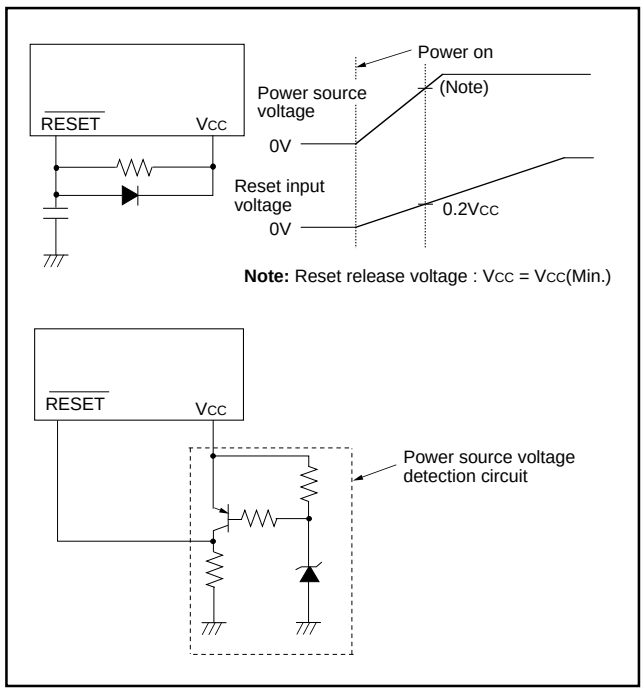


Fig. 36 Example of reset circuit

		Address	Register contents
(1)	Port P0	0000 16	00 16
(2)	Port P1	0002 16	00 16
(3)	Port P1 output control register	0003 16	00 16
(4)	Port P2	0004 16	00 16
(5)	Port P2 direction register	0005 16	00 16
(6)	Port P3	0006 16	00 16
(7)	Port P4	0008 16	00 16
(8)	Port P4 direction register	0009 16	00 16
(9)	Port P5	000A 16	00 16
(10)	Port P5 direction register	000B 16	00 16
(11)	Port P6	000C 16	00 16
(12)	Port P6 direction register	000D 16	00 16
(13)	Port P7	000E 16	00 16
(14)	Port P7 direction register	000F 16	00 16
(15)	Port P8	0010 16	00 16
(16)	Port P8 direction register	0011 16	00 16
(17)	PULL register A	0016 16	01 16
(18)	PULL register B	0017 16	00 16
(19)	Serial I/O status register	0019 16	1 0 0 0 0 0 0 0
(20)	Serial I/O control register	001A 16	00 16
(21)	UART control register	001B 16	1 1 1 0 0 0 0 0
(22)	Timer X (low)	0020 16	FF16
(23)	Timer X (high)	0021 16	FF16
(24)	Timer Y (low)	0022 16	FF16
(25)	Timer Y (high)	0023 16	FF16
(26)	Timer 1	0024 16	FF16
(27)	Timer 2	0025 16	01 16
(28)	Timer 3	0026 16	FF16
(29)	Timer X mode register	0027 16	00 16
(30)	Timer Y mode register	0028 16	00 16
(31)	Timer 123 mode register	0029 16	00 16
(32)	Clock output control register	002A 16	00 16
(33)	A-D control register	0034 16	0 0 0 0 1 0 0 0
(34)	Segment output enable register	0038 16	00 16
(35)	LCD mode register	0039 16	00 16
(36)	Interrupt edge selection register	003A 16	00 16
(37)	CPU mode register	003B 16	0 1 0 0 1 0 0 0
(38)	Interrupt request register 1	003C 16	00 16
(39)	Interrupt request register 2	003D 16	00 16
(40)	Interrupt control register 1	003E 16	00 16
(41)	Interrupt control register 2	003F 16	00 16
(42)	Processor status register	(P S)	X X X X X 1 X X
(43)	Program counter	(P C H)	Contents of address FFFD 16
		(P C L)	Contents of address FFFC 16

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

Fig. 37 Internal state of microcomputer immediately after reset

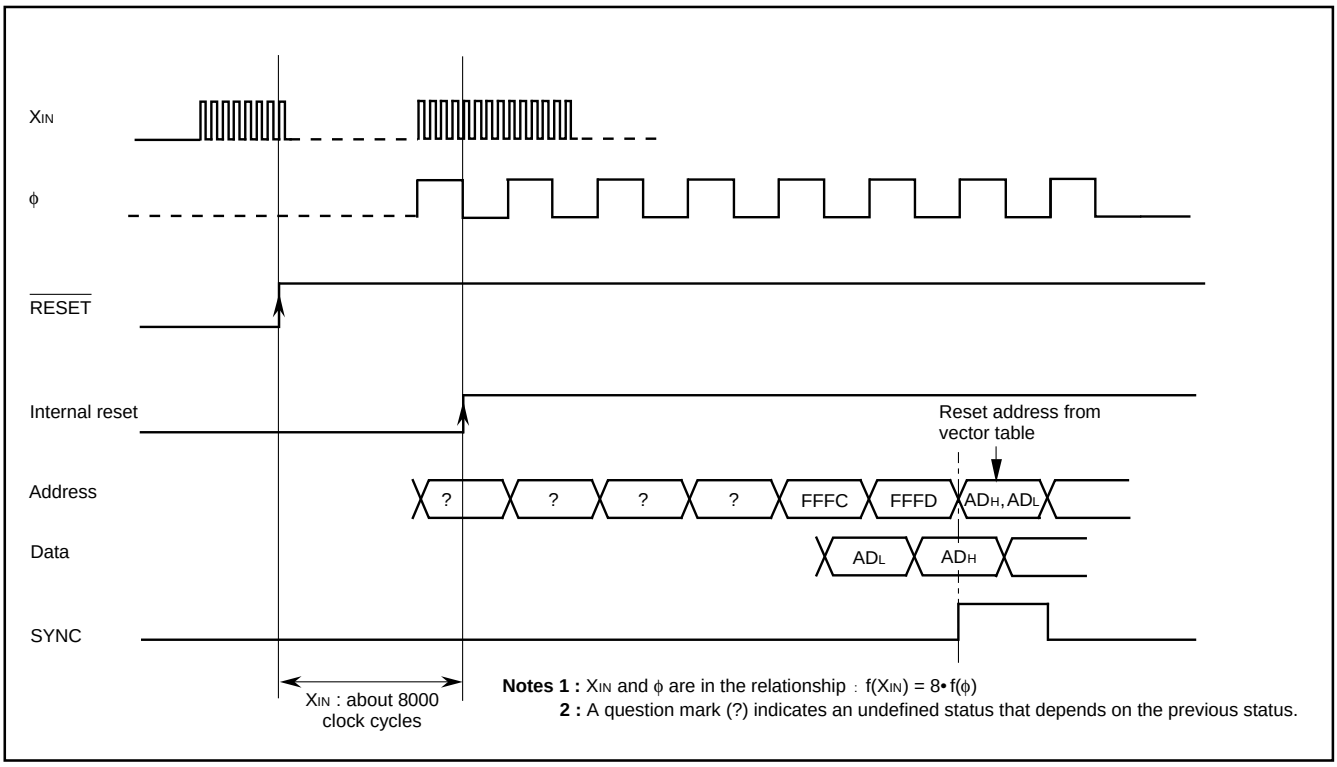


Fig. 38 Reset sequence

CLOCK GENERATING CIRCUIT

The 3825 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 function as I/O ports. The pull-up resistor of XCIN and XCOUT pins must be made invalid to use the sub-clock.

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

Oscillation Control
(1) Stop mode

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

Either XIN 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 time 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.

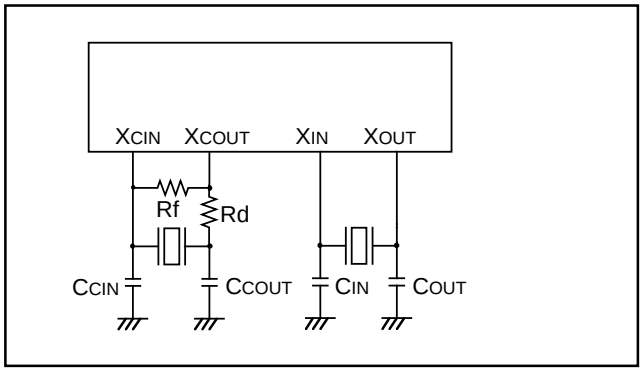


Fig. 39 Ceramic resonator circuit

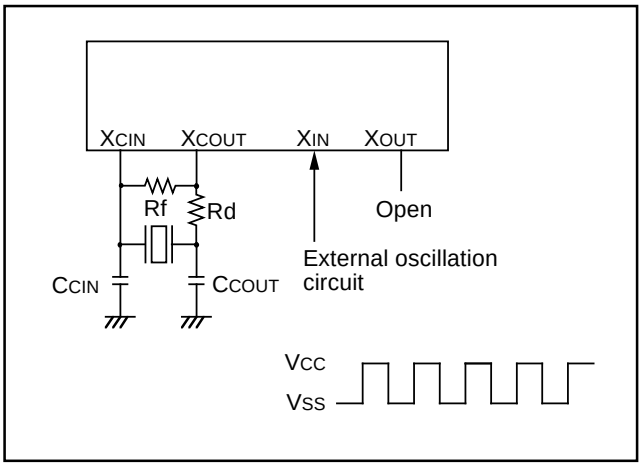
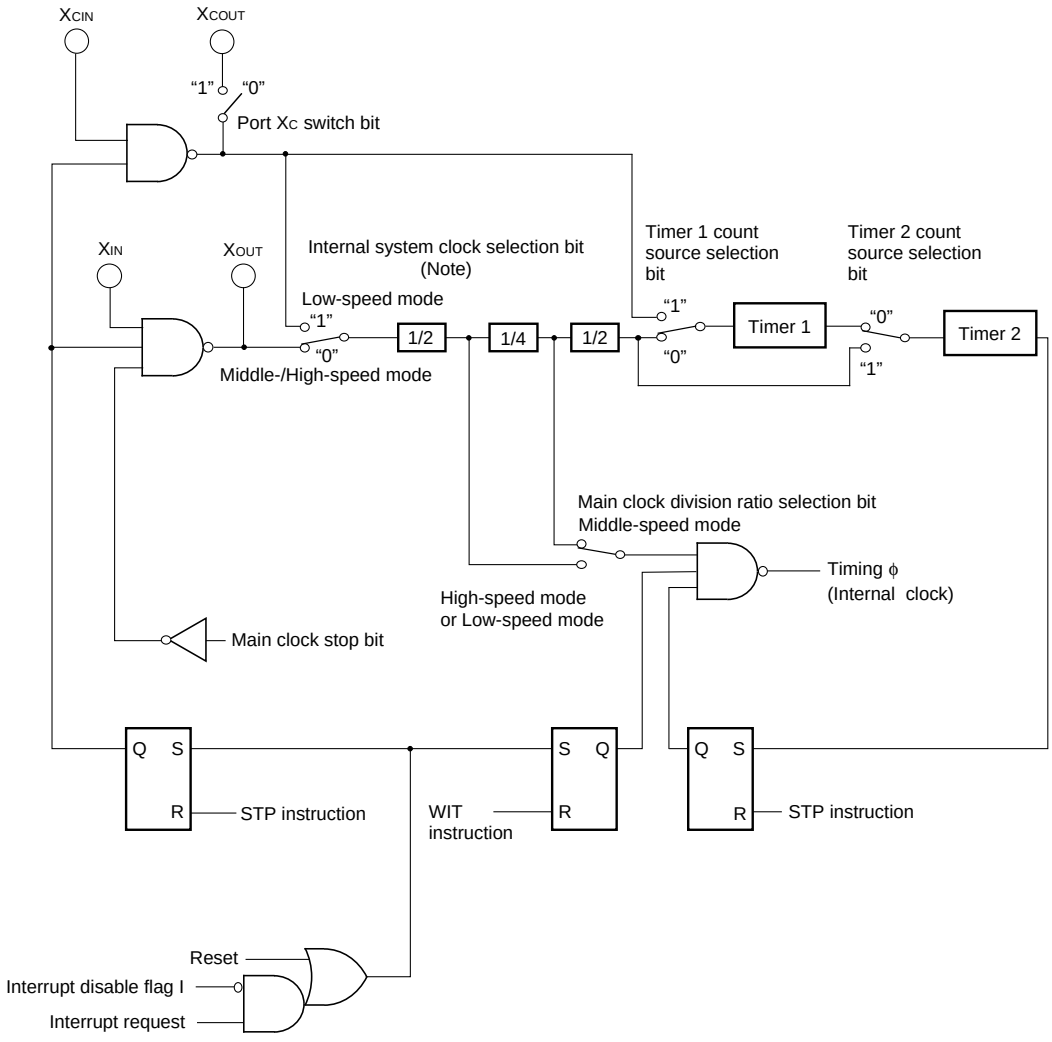
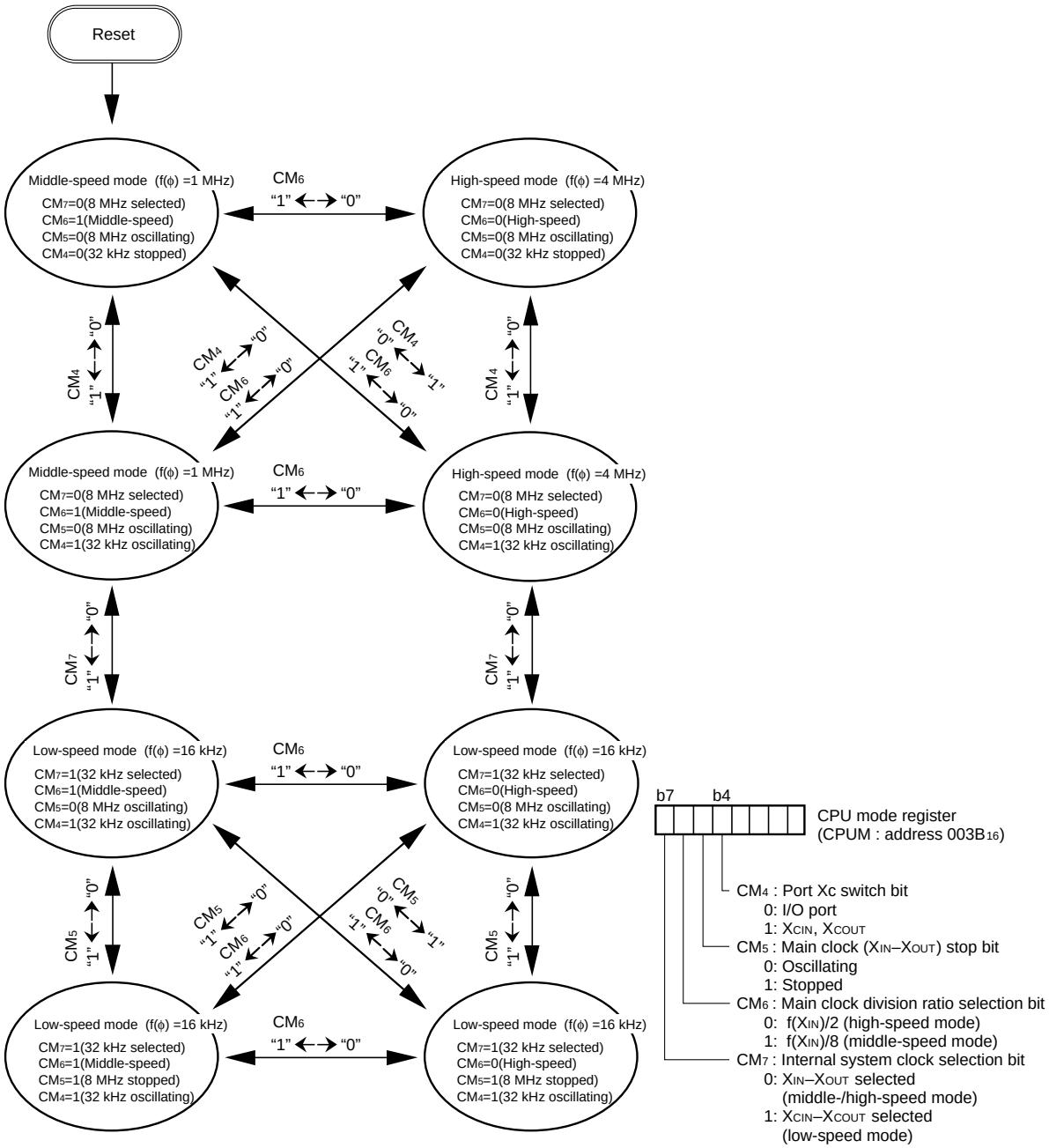


Fig. 40 External clock input circuit



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

Fig. 41 Clock generating circuit block diagram



Notes 1 : Switch the mode by the allows shown between the mode blocks. (Do not switch between the mode directly without an allow.)
2 : The all modes can be switched to the stop mode or the wait mode and returned to the source mode when the stop mode or the wait mode is ended.
3 : Timer and LCD operate in the wait mode.
4 : When the stop mode is ended, a delay of approximately 1 ms occurs automatically by timer 1 and timer 2 in middle-/high-speed mode.
5 : When the stop mode is ended, a delay of approximately 0.25 s occurs automatically by timer 1 and timer 2 in low-speed mode.
6 : Wait until oscillation stabilizes after oscillating the main clock X_{IN} before the switching from the low-speed mode to middle-/high-speed mode.
7 : The example assumes that 8 MHz is being applied to the X_{IN} pin and 32 kHz to the X_{CIN} pin. φ indicates the internal clock.

Fig. 42 State transitions of internal clock φ

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. Only the ADC and SBC instructions yield proper decimal results. 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.
The carry flag can be used to indicate whether a carry or borrow has occurred. Initialize the carry flag before each calculation. Clear the carry flag before an ADC and set the flag before an SBC.

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 $\overline{\text{SRDY}}$ signal, set the transmit enable bit, the receive enable bit, and the $\overline{\text{SRDY}}$ output enable bit to "1".
Serial I/O continues to output the final bit from the TxD pin 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 500kHz 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. Mark Specification Form
3. Data to be written to ROM, in EPROM form (three identical copies) or one floppy disk

DATA REQUIRED FOR ROM WRITING ORDERS

The following are necessary when ordering a ROM writing:

1. ROM Writing Confirmation Form
2. Mark Specification Form
3. Data to be written to ROM, in EPROM form (three identical copies) or 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 11. Programming adapter

Package	Name of Programming Adapter
100PFB-A	PCA4738H-100A
100P6Q-A	PCA4738G-100A
100P6S-A	PCA4738F-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 43 is recommended to verify programming.

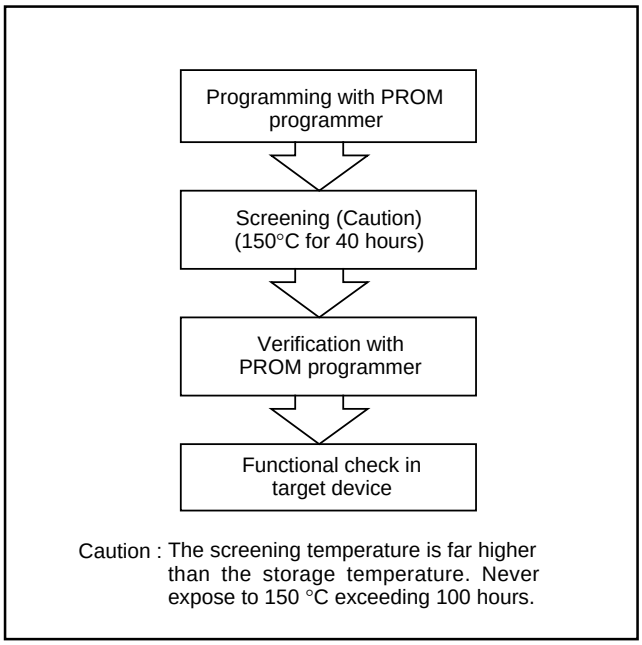


Fig. 43 Programming and testing of One Time PROM version

ELECTRICAL CHARACTERISTICS

Table 12. 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 $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage $P7_0$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3}		V_{L2} to 7.0	V
V_I	Input voltage C_1, C_2		–0.3 to 7.0	V
V_I	Input voltage $\overline{RESET}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C_1, C_2		–0.3 to 7.0	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3}		–0.3 to 7.0	V
V_O	Output voltage V_{L2}, SEG_0–SEG_{17}		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	T_a = 25°C	300	mW
Topr	Operating temperature		–20 to 85	°C
Tstg	Storage temperature		–40 to 125	°C

Table 13. Recommended operating conditions (V_{CC} = 2.5 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	V
		Middle-speed mode f(X_{IN}) = 8 MHz	2.5	5.0	5.5	
		Low-speed mode	2.5	5.0	5.5	
V_{SS}	Power source voltage			0		V
V_{REF}	A-D conversion reference voltage		2.0		V_{CC}	V
AV_{SS}	Analog power source voltage			0		V
V_{IA}	Analog input voltage AN_0–AN_7		AV_{SS}		V_{CC}	V
V_{IH}	“H” input voltage	$P1_6$, $P1_7$, $P4_0$, $P4_1$, $P4_5$, $P4_7$, $P5_2$, $P5_3$, $P5_6$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$ (CM_4=0)	0.7V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$P2_0$–$P2_7$, $P4_2$–$P4_4$, $P4_6$, $P5_0$, $P5_1$, $P5_4$, $P5_5$, $P5_7$,	0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$\overline{RESET}$	0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	X_{IN}	0.8V_{CC}		V_{CC}	V
V_{IL}	“L” input voltage	$P1_6$, $P1_7$, $P4_0$, $P4_1$, $P4_5$, $P4_7$, $P5_2$, $P5_3$, $P5_6$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$ (CM_4=0)	0		0.3V_{CC}	V
V_{IL}	“L” input voltage	$P2_0$–$P2_7$, $P4_2$–$P4_4$, $P4_6$, $P5_0$, $P5_1$, $P5_4$, $P5_5$, $P5_7$	0		0.2V_{CC}	V
V_{IL}	“L” input voltage	$\overline{RESET}$	0		0.2V_{CC}	V
V_{IL}	“L” input voltage	X_{IN}	0		0.2V_{CC}	V

Table 14. Recommended operating conditions

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

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 1)			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P7_1$–$P7_7$ (Note 1)			40	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$,$P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 1)			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P7_1$–$P7_7$ (Note 1)			20	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			–0.5	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			10	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			–0.1	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			–2.5	mA
$I_{OL(avg)}$	"L" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 3)			2.5	mA
$I_{OL(avg)}$	"L" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			5.0	mA
$f(CNTR_0)$ $f(CNTR_1)$	Input frequency for timers X and Y (duty cycle 50%)	(4.0 V ≤ V_{CC} ≤ 5.5 V)			4.0	MHz
		(V_{CC} ≤ 4.0 V)			(2×V_{CC}) –4	MHz
$f(X_{IN})$	Main clock input oscillation frequency (Note 4)	High-speed mode (4.0 V ≤ V_{CC} ≤ 5.5 V)			8.0	MHz
		High-speed mode (V_{CC} ≤ 4.0 V)			(4×V_{CC}) –8	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency (Note 4, 5)			32.768	50	kHz

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

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

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

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

5: When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

Table 15. Electrical characteristics (V_{CC} =4.0 to 5.5 V, T_a = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
V_{OH}	"H" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –0.1 mA	V_{CC}–2.0			V
			I_{OH} = –25 μA V_{CC} = 2.5 V	V_{CC}–1.0			V
V_{OH}	"H" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OH} = –5 mA	V_{CC}–2.0			V
			I_{OH} = –1.25 mA	V_{CC}–0.5			V
			I_{OH} = –1.25 mA V_{CC} = 2.5 V	V_{CC}–1.0			V
V_{OL}	"L" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
			I_{OL} = 1.25 mA			0.5	V
			I_{OL} = 1.25 mA V_{CC} = 2.5 V			1.0	V
V_{OL}	"L" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OL} = 10 mA			2.0	V
			I_{OL} = 2.5 mA			0.5	V
			I_{OL} = 2.5 mA V_{CC} = 2.5 V			1.0	V
V_{T+} – V_{T-}	Hysteresis	INT_0–INT_3, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis	S_{CLK}, R_XD			0.5		V
V_{T+} – V_{T-}	Hysteresis	$\overline{RESET}$	$\overline{RESET}$: V_{CC}=2.5 V to 5.5 V		0.5		V
I_{IH}	"H" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{CC}			5.0	μA
I_{IH}	"H" input current	$\overline{RESET}$	V_I = V_{CC}			5.0	μA
I_{IH}	"H" input current	X_{IN}	V_I = V_{CC}		4.0		μA
I_{IL}	"L" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{SS} Pull-ups "off"			–5.0	μA
			V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–30	–70	–140	μA
			V_{CC} = 3 V, V_I = V_{SS} Pull-ups "on"	–6.0	–25	–45	μA
I_{IL}	"L" input current	$P7_0$				–5.0	μA
I_{IL}	"L" input current	$\overline{RESET}$	V_I = V_{SS}			–5.0	μA
I_{IL}	"L" input current	X_{IN}	V_I = V_{SS}		–4.0		μA
I_{LOAD}	Output load current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	30	70	140	μA
			V_{CC} = 3.0 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	6.0	25	45	μA
I_{LEAK}	Output leak current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_O = V_{CC}, Pull-downs "off" Output transistors "off"			5.0	μA
			V_O = V_{SS}, Pull-downs "off" Output transistors "off"			–5.0	μA

Note: When "1" is set to port X_C switch bit (bit 4 of address $003B_{16}$) of CPU mode register, the drive ability of port $P8_0$ is different from the value above mentioned.

Table 16. Electrical characteristics

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

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode	2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating		6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating		1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”		25	36	µA
		• Low-speed mode, V_{CC} = 5 V, T_a = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”		7.0	14	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”		15	22	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 25°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”		4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off” T_a = 25 °C		0.1	1.0	µA
		All oscillation stopped (in STP state) Output transistors “off” T_a = 85 °C			10	
V_{L1}	Power source voltage	When using voltage multiplier	1.3	1.8	2.3	V
I_{L1}	Power source current (V_{L1}) (Note)	V_{L1} = 1.8 V		3.0	6.0	µA
		V_{L1} < 1.3 V		10	50	

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

Table 17. A-D converter characteristics

(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –20 to 85°C, 4 MHz ≤ f(X_{IN}) ≤ 8 MHz, in middle-/high-speed mode, unless otherwise noted.)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 5 V			±2	LSB
t_{CONV}	Conversion time	f(X_{IN}) = 8 MHz		12.5 (Note)		μs
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference input current	V_{REF} = 5 V	50	150	200	μA
I_{IA}	Analog port input current				5.0	μA

Note : When an internal trigger is used in middle-speed mode, it is 14 μs.

Table 18. Timing requirements 1 (V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	80			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	800			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	370			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	370			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	220			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	100			ns

Note : When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

Table 19. Timing requirements 2 (V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	500/ (V_{CC}–2)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	250/ (V_{CC}–2)–20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	250/ (V_{CC}–2)–20			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	230			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	2000			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	950			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	950			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	400			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	200			ns

Note: When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{wH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{c(SCLK)}$/2–30			ns
$t_{wL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{c(SCLK)}$/2–30			ns
$t_{d(SCLK-TxD)}$	Serial I/O output delay time (Note 1)			140	ns
$t_{v(SCLK-TxD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			30	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			30	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		10	30	ns

Notes 1 : 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 21. Switching characteristics 2 (V_{CC} = 2.5 to 4.0 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{wH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{c(SCLK)}$/2–50			ns
$t_{wL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{c(SCLK)}$/2–50			ns
$t_{d(SCLK-TxD)}$	Serial I/O output delay time (Note 1)			350	ns
$t_{v(SCLK-TxD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			50	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		20	50	ns

Notes 1 : 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.

ELECTRICAL CHARACTERISTICS (Extended Operating Temperature Version)

Table 22. Absolute maximum ratings (Extended operating temperature version)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 7.0	V
V_I	Input voltage P1$_6$, P1$_7$, P2$_0$–P2$_7$, P4$_0$–P4$_7$, P5$_0$–P5$_7$, P6$_0$–P6$_7$, P8$_0$, P8$_1$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage P7$_0$–P7$_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3}		V_{L2} to 7.0	V
V_I	Input voltage C$_1$, C$_2$		–0.3 to 7.0	V
V_I	Input voltage $\overline{\text{RESET}}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C$_1$, C$_2$		–0.3 to 7.0	V
V_O	Output voltage P0$_0$–P0$_7$, P1$_0$–P1$_5$, P3$_0$–P3$_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage P1$_6$, P1$_7$, P2$_0$–P2$_7$, P4$_0$–P4$_7$, P5$_0$–P5$_7$, P6$_0$–P6$_7$, P7$_1$–P7$_7$ P8$_0$, P8$_1$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3}		–0.3 to 7.0	V
V_O	Output voltage V_{L2}, SEG$_0$–SEG$_{17}$		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	T_a = 25°C	300	mW
Topr	Operating temperature		–40 to 85	°C
Tstg	Storage temperature		–65 to 150	°C

Table 23. Recommended operating conditions (Extended operating temperature version)

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

Symbol	Parameter			Limits			Unit
				Min.	Typ.	Max.	
V_{CC}	Power source voltage	High-speed mode f(X_{IN})=8 MHz		4.0	5.0	5.5	
		Middle-speed mode f(X_{IN}) = 8 MHz	T_a = –20 to 85°C	2.5	5.0	5.5	
			T_a = –40 to –20°C	3.0	5.0	5.5	
		Low-speed mode	T_a = –20 to 85°C	2.5	5.0	5.5	
			T_a = –40 to –20°C	3.0	5.0	5.5	
V_{SS}	Power source voltage				0		V
V_{REF}	A-D conversion reference voltage			2.0		V_{CC}	V
AV_{SS}	Analog power source voltage				0		V
V_{IA}	Analog input voltage	AN$_0$–AN$_7$		AV_{SS}		V_{CC}	V
V_{IH}	“H” input voltage	P1$_6$, P1$_7$, P4$_0$, P4$_1$, P4$_5$, P4$_7$, P5$_2$, P5$_3$, P5$_6$, P6$_0$–P6$_7$, P7$_0$–P7$_7$, P8$_0$, P8$_1$ (CM$_4$=0)		0.7V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	P2$_0$–P2$_7$, P4$_2$–P4$_4$, P4$_6$, P5$_0$, P5$_1$, P5$_4$, P5$_5$, P5$_7$		0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$\overline{\text{RESET}}$		0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	X_{IN}		0.8V_{CC}		V_{CC}	V
V_{IL}	“L” input voltage	P1$_6$, P1$_7$, P4$_0$, P4$_1$, P4$_5$, P4$_7$, P5$_2$, P5$_3$, P5$_6$, P6$_0$–P6$_7$, P7$_0$–P7$_7$, P8$_0$, P8$_1$ (CM$_4$=0)		0		0.3V_{CC}	V
V_{IL}	“L” input voltage	P2$_0$–P2$_7$, P4$_2$–P4$_4$, P4$_6$, P5$_0$, P5$_1$, P5$_4$, P5$_5$, P5$_7$		0		0.2V_{CC}	V
V_{IL}	“L” input voltage	$\overline{\text{RESET}}$		0		0.2V_{CC}	V
V_{IL}	“L” input voltage	X_{IN}		0		0.2V_{CC}	V

Table 24. Recommended operating conditions (Extended operating temperature version)

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

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 1)			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P7_1$–$P7_7$ (Note 1)			40	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_1$, $P8_0$, $P8_1$ (Note 1)			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P7_1$–$P7_7$ (Note 1)			20	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			–0.5	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			10	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 3)			–0.1	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			–2.5	mA
$I_{OL(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 3)			2.5	mA
$I_{OL(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			5.0	mA
$f(CNTR_0)$ $f(CNTR_1)$	Input frequency for timers X and Y (duty cycle 50%)	($4.0\ V \le V_{CC} \le 5.5\ V$)			4.0	MHz
		($V_{CC} \le 4.0\ V$)			$(2 \times V_{CC}) - 4$	MHz
$f(X_{IN})$	Main clock input oscillation frequency (Note 4)	High-speed mode ($4.0\ V \le V_{CC} \le 5.5\ V$)			8.0	MHz
		High-speed mode ($V_{CC} \le 4.0\ V$)			$(4 \times V_{CC}) - 8$	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency (Note 4, 5)			32.768	50	kHz

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

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

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

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

5 : When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

Table 25. Electrical characteristics (Extended operating temperature version) (1)

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

Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
V_{OH}	"H" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –2.5 mA	V_{CC}–2.0			V
			I_{OH} = –0.6 mA V_{CC} = 3.0 V	V_{CC}–0.9			V
V_{OH}	"H" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OH} = –5 mA	V_{CC}–2.0			V
			I_{OH} = –1.25 mA	V_{CC}–0.5			V
			I_{OH} = –1.25 mA V_{CC} = 3.0 V	V_{CC}–0.9			V
V_{OL}	"L" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
			I_{OL} = 1.25 mA			0.5	V
			I_{OL} = 1.25 mA V_{CC} = 3.0 V			1.1	V
V_{OL}	"L" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OL} = 10 mA			2.0	V
			I_{OL} = 2.5 mA			0.5	V
			I_{OL} = 2.5 mA V_{CC} = 3.0 V			1.1	V
V_{T+} – V_{T-}	Hysteresis	INT_0–INT_3, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis	S_{CLK}, R_XD			0.5		V
V_{T+} – V_{T-}	Hysteresis	$\overline{RESET}$	$\overline{RESET}$: V_{CC}=2.5 V to 5.5 V		0.5		V
I_{IH}	"H" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current	$\overline{RESET}$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current	X_{IN}	V_I = V_{CC}		4.0		µA
I_{IL}	"L" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$,$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{SS} Pull-ups "off"			–5.0	µA
			V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–30	–70	–140	µA
			V_{CC} = 3 V, V_I = V_{SS} Pull-ups "on"	–6.0	–25	–45	µA
I_{IL}	"L" input current	$P7_0$				–5.0	µA
I_{IL}	"L" input current	$\overline{RESET}$	V_I = V_{SS}			–5.0	µA
I_{IL}	"L" input current	X_{IN}	V_I = V_{SS}		–4.0		µA
I_{LOAD}	Output load current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	30	70	170	µA
			V_{CC} = 3.0 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	6.0	25	55	µA
I_{LEAK}	Output leak current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_O = V_{CC}, Pull-downs "off" Output transistors "off"			5.0	µA
			V_O = V_{SS}, Pull-downs "off" Output transistors "off"			–5.0	µA

Note : When "1" is set to port X_C switch bit (bit 4 of address $003B_{16}$) of CPU mode register, the drive ability of port $P8_0$ is different from the value above mentioned.

Table 26. Electrical characteristics (Extended operating temperature version)

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

Symbol	Parameter	Test conditions		Limits			Unit
				Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode		2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating			6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating			1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			25	36	µA
		• Low-speed mode, V_{CC} = 5 V, T_a = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			7.0	14	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”			15	22	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 25°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”			4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off”	T_a = 25°C		0.1	1.0	µA
			T_a = 85°C			10	
V_{L1}	Power source voltage	When using voltage multiplier		1.3	1.8	2.3	V
I_{L1}	Power source current (V_{L1}) (Note)	V_{L1} = 1.8 V			3.0	6.0	µA
		V_{L1} < 1.3 V			10	50	

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

Table 27. A-D converter characteristics (Extended operating temperature version)

(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –40 to 85°C, 4 MHz ≤ $f(X_{IN})$ ≤ 8 MHz, in middle-/high-speed mode, unless otherwise noted.)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 5 V			±2	LSB
t_{CONV}	Conversion time	$f(X_{IN})$ = 8 MHz		12.5 (Note)		µs
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog iinput current				5.0	µA

Note : When an internal trigger is used in middle-speed mode, it is 14 µs.

Table 28. Timing reguirements 1 (Extended operating temperature version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	80			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	800			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	370			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	370			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	220			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	100			ns

Note : When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

Table 29. Timing reguirements 2 (Extended operating temperature version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	500/ (V_{CC}–2)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	250/ (V_{CC}–2)–20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	250/ (V_{CC}–2)–20			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	230			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	2000			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	950			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	950			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	400			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	200			ns

Note: When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

Table 30. Switching characteristics 1 (Extended operating temperature version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{C(SCLK)}$/2–30			ns
$t_{WL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{C(SCLK)}$/2–30			ns
$t_{d(SCLK-TXD)}$	Serial I/O output delay time (Note 1)			140	ns
$t_{v(SCLK-TXD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			30	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			30	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		10	30	ns

Notes 1 : When the P45/TXD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is “0”.

2 : X_{OUT} and X_{COUT} pins are excluded.

Table 31. Switching characteristics 2 (Extended operating temperature version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{WH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{C(SCLK)}$/2–50			ns
$t_{WL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{C(SCLK)}$/2–50			ns
$t_{d(SCLK-TXD)}$	Serial I/O output delay time (Note 1)			350	ns
$t_{v(SCLK-TXD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			50	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		20	50	ns

Notes 1 : When the P45/TXD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is “0”.

2 : X_{OUT} and X_{COUT} pins are excluded.

ELECTRICAL CHARACTERISTICS (Low Power Source Version)

Table 32. Absolute maximum ratings (Low power source version)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 7.0	V
V_I	Input voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage $P7_0$–$P7_7$		–0.3 to V_{CC} +0.3	V
V_I	Input voltage V_{L1}		–0.3 to V_{L2}	V
V_I	Input voltage V_{L2}		V_{L1} to V_{L3}	V
V_I	Input voltage V_{L3}		V_{L2} to 7.0	V
V_I	Input voltage C_1, C_2		–0.3 to 7.0	V
V_I	Input voltage $\overline{RESET}$, X_{IN}		–0.3 to V_{CC} +0.3	V
V_O	Output voltage C_1, C_2		–0.3 to 7.0	V
V_O	Output voltage $P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	At output port	–0.3 to V_{CC}	V
		At segment output	–0.3 to V_{L3}	V
V_O	Output voltage $P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$ $P8_0$, $P8_1$		–0.3 to V_{CC} +0.3	V
V_O	Output voltage V_{L3}		–0.3 to 7.0	V
V_O	Output voltage V_{L2}, SEG_0–SEG_{17}		–0.3 to V_{L3}	V
V_O	Output voltage X_{OUT}		–0.3 to V_{CC} +0.3	V
Pd	Power dissipation	T_a = 25°C	300	mW
Topr	Operating temperature		–20 to 85	°C
Tstg	Storage temperature		–40 to 125	°C

Table 33. Recommended operating conditions (Low power source version)

(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	V
		Middle-speed mode, f(X_{IN}) = 8 MHz	2.2	5.0	5.5	
		Low-speed mode	2.2	5.0	5.5	
V_{SS}	Power source voltage			0		V
V_{REF}	A-D conversion reference voltage		2.0		V_{CC}	V
AV_{SS}	Analog power source voltage			0	V_{CC}	V
V_{IA}	Analog input voltage	AN_0–AN_7	AV_{SS}		V_{CC}	V
V_{IH}	“H” input voltage	$P1_6$, $P1_7$, $P4_0$, $P4_1$, $P4_5$, $P4_7$, $P5_2$, $P5_3$, $P5_6$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$ (CM_4=0)	0.7V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$P2_0$–$P2_7$, $P4_2$–$P4_4$, $P4_6$, $P5_0$, $P5_1$, $P5_4$, $P5_5$, $P5_7$	0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	$\overline{RESET}$	0.8V_{CC}		V_{CC}	V
V_{IH}	“H” input voltage	X_{IN}	0.8V_{CC}		V_{CC}	V
V_{IL}	“L” input voltage	$P1_6$, $P1_7$, $P4_0$, $P4_1$, $P4_5$, $P4_7$, $P5_2$, $P5_3$, $P5_6$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$ (CM_4=0)	0		0.3V_{CC}	V
V_{IL}	“L” input voltage	$P2_0$–$P2_7$, $P4_2$–$P4_4$, $P4_6$, $P5_0$, $P5_1$, $P5_4$, $P5_5$, $P5_7$	0		0.2V_{CC}	V
V_{IL}	“L” input voltage	$\overline{RESET}$	0		0.2V_{CC}	V
V_{IL}	“L” input voltage	X_{IN}	0		0.2V_{CC}	V

Table 34. Recommended operating conditions (Low power source version)

(V_{CC} = 2.2 to 5.5 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–20	mA
$\Sigma I_{OH(peak)}$	"H" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 1)			–20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P4_0$–$P4_7$,$P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			20	mA
$\Sigma I_{OL(peak)}$	"L" total peak output current	$P7_1$–$P7_7$ (Note 1)			40	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			–10	mA
$\Sigma I_{OH(avg)}$	"H" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_1$, $P8_0$, $P8_1$ (Note 1)			–10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$–$P3_7$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P8_0$, $P8_1$ (Note 1)			10	mA
$\Sigma I_{OL(avg)}$	"L" total average output current	$P7_1$–$P7_7$ (Note 1)			20	mA
$I_{OH(peak)}$	"H" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			–0.5	mA
$I_{OH(peak)}$	"H" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			–5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 2)			5.0	mA
$I_{OL(peak)}$	"L" peak output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 2)			10	mA
$I_{OH(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 3)			–0.1	mA
$I_{OH(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			–2.5	mA
$I_{OL(avg)}$	"H" average output current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$ (Note 3)			2.5	mA
$I_{OL(avg)}$	"H" average output current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note 3)			5.0	mA
$f(CNTR_0)$ $f(CNTR_1)$	Input frequency for timers X and Y (duty cycle 50%)	(4.0 V ≤ V_{CC} ≤ 5.5 V)			4.0	MHz
		(2.2 V ≤ V_{CC} ≤ 4.0 V)			(10 × V_{CC} – 4) / 9	MHz
$f(X_{IN})$	Main clock input oscillation frequency (Note 4)	High-speed mode (4.0 V ≤ V_{CC} ≤ 5.5 V)			8.0	MHz
		High-speed mode (2.2 V ≤ V_{CC} ≤ 4.0 V)			(20 × V_{CC} – 8) / 9	MHz
		Middle-speed mode			8.0	MHz
$f(X_{CIN})$	Sub-clock input oscillation frequency (Note 4, 5)			32.768	50	kHz

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

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

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

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

5 : When using the microcomputer in low-speed mode, make sure that the sub-clock input oscillation frequency on condition that $f(X_{CIN}) < f(X_{IN})/3$.

Table 35. Electrical characteristics (Low power source version)

(V_{CC} = 2.2 to 5.5 V, T_a = –20 to 85°C, unless otherwise noted)

Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
V_{OH}	"H" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OH} = –2.5 mA	V_{CC}–2.0			V
			I_{OH} = –0.25 mA V_{CC} = 2.2 V	V_{CC}–0.8			V
V_{OH}	"H" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OH} = –5 mA	V_{CC}–2.0			V
			I_{OH} = –1.25 mA	V_{CC}–0.5			V
			I_{OH} = –1.25 mA V_{CC} = 2.2 V	V_{CC}–0.8			V
V_{OL}	"L" output voltage	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	I_{OL} = 5 mA			2.0	V
			I_{OL} = 1.25 mA			0.5	V
			I_{OL} = 1.25 mA V_{CC} = 2.2 V			0.8	V
V_{OL}	"L" output voltage	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$ (Note)	I_{OL} = 10 mA			2.0	V
			I_{OL} = 2.5 mA			0.5	V
			I_{OL} = 2.5 mA V_{CC} = 2.2 V			0.8	V
V_{T+} – V_{T-}	Hysteresis	INT_0–INT_3, ADT, $CNTR_0$, $CNTR_1$, $P2_0$–$P2_7$			0.5		V
V_{T+} – V_{T-}	Hysteresis	S_{CLK}, R_XD			0.5		V
V_{T+} – V_{T-}	Hysteresis	$\overline{RESET}$	$\overline{RESET}$: V_{CC}=2.2 V to 5.5 V		0.5		V
I_{IH}	"H" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_0$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current	$\overline{RESET}$	V_I = V_{CC}			5.0	µA
I_{IH}	"H" input current	X_{IN}	V_I = V_{CC}		4.0		µA
I_{IL}	"L" input current	$P1_6$, $P1_7$, $P2_0$–$P2_7$, $P4_0$–$P4_7$, $P5_0$–$P5_7$, $P6_0$–$P6_7$, $P7_1$–$P7_7$, $P8_0$, $P8_1$	V_I = V_{SS} Pull-ups "off"			–5.0	µA
			V_{CC} = 5 V, V_I = V_{SS} Pull-ups "on"	–30	–70	–140	µA
			V_{CC} = 2.2 V, V_I = V_{SS} Pull-ups "on"	–6.0	–25	–45	µA
I_{IL}	"L" input current	$P7_0$				–5.0	µA
I_{IL}	"L" input current	$\overline{RESET}$	V_I = V_{SS}			–5.0	µA
I_{IL}	"L" input current	X_{IN}	V_I = V_{SS}		–4.0		µA
I_{LOAD}	Output load current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_{CC} = 5.0 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	30	70	140	µA
			V_{CC} = 2.2 V, V_O = V_{CC}, Pull-downs "on" Output transistors "off"	6.0	25	45	µA
I_{LEAK}	Output leak current	$P0_0$–$P0_7$, $P1_0$–$P1_5$, $P3_0$–$P3_7$	V_O = V_{CC}, Pull-downs "off" Output transistors "off"			5.0	µA
			V_O = V_{SS}, Pull-downs "off" Output transistors "off"			–5.0	µA

Note : When "1" is set to port X_C switch bit (bit 4 of address $003B_{16}$) of CPU mode register, the drive ability of port $P8_0$ is different from the value above mentioned.

Table 36. Electrical characteristics (Low power source version)

(V_{CC} = 2.2 to 5.5 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
V_{RAM}	RAM retention voltage	At clock stop mode	2.0		5.5	V
I_{CC}	Power source current	• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating		6.4	13	mA
		• High-speed mode, V_{CC} = 5 V $f(X_{IN})$ = 8 MHz (in WIT state) $f(X_{CIN})$ = 32.768 kHz Output transistors “off” A-D converter in operating		1.6	3.2	mA
		• Low-speed mode, V_{CC} = 5 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”		25	36	µA
		• Low-speed mode, V_{CC} = 5 V, T_a = 25°C $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”		7.0	14	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 55°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz Output transistors “off”		15	22	µA
		• Low-speed mode, V_{CC} = 3 V, $T_a \leq 25°C$ $f(X_{IN})$ = stopped $f(X_{CIN})$ = 32.768 kHz (in WIT state) Output transistors “off”		4.5	9.0	µA
		All oscillation stopped (in STP state) Output transistors “off” — T_a = 25°C		0.1	1.0	µA
		All oscillation stopped (in STP state) Output transistors “off” — T_a = 85°C			10	µA
V_{L1}	Power source voltage	When using voltage multiplier	1.3	1.8	2.3	V
I_{L1}	Power source current (V_{L1}) (Note)	V_{L1} = 1.8 V		3.0	6.0	µA
		V_{L1} < 1.3 V		10	50	µA

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

Table 37. A-D converter characteristics (Low power source version)

(V_{CC} = 4.0 to 5.5 V, V_{SS} = 0 V, T_a = –20 to 85°C, 4 MHz ≤ $f(X_{IN})$ ≤ 8 MHz, in middle-/high-speed mode, unless otherwise noted.)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
–	Resolution				8	Bits
–	Absolute accuracy (excluding quantization error)	V_{CC} = V_{REF} = 5 V			±2	LSB
t_{CONV}	Conversion time	$f(X_{IN})$ = 8 MHz		12.5 (Note)		µs
R_{LADDER}	Ladder resistor		12	35	100	kΩ
I_{VREF}	Reference input current	V_{REF} = 5 V	50	150	200	µA
I_{IA}	Analog iinput current				5.0	µA

Note : When an internal trigger is used in middle-speed mode, it is 14 µs.

Table 38. Timing reguirements 1 (Low power source Version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	250			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	105			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	105			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	80			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	80			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	800			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	370			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	370			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	220			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	100			ns

Note : When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

Table 39. Timing reguirements 2 (Low power source Version)

(V_{CC} = 2.2 to 4.0 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{w(\overline{RESET})}$	Reset input “L” pulse width	2			µs
$t_{c(X_{IN})}$	Main clock input cycle time (X_{IN} input)	125			ns
$t_{wH(X_{IN})}$	Main clock input “H” pulse width	45			ns
$t_{wL(X_{IN})}$	Main clock input “L” pulse width	40			ns
$t_{c(CNTR)}$	$CNTR_0$, $CNTR_1$ input cycle time	900 / (V_{CC} – 0.4)			ns
$t_{wH(CNTR)}$	$CNTR_0$, $CNTR_1$ input “H” pulse width	450 / (V_{CC} – 0.4) – 20			ns
$t_{wL(CNTR)}$	$CNTR_0$, $CNTR_1$ input “L” pulse width	450 / (V_{CC} – 0.4) – 20			ns
$t_{wH(INT)}$	INT_0 to INT_3 input “H” pulse width	230			ns
$t_{wL(INT)}$	INT_0 to INT_3 input “L” pulse width	230			ns
$t_{c(S_{CLK})}$	Serial I/O clock input cycle time (Note)	2000			ns
$t_{wH(S_{CLK})}$	Serial I/O clock input “H” pulse width (Note)	950			ns
$t_{wL(S_{CLK})}$	Serial I/O clock input “L” pulse width (Note)	950			ns
$t_{su(R_{XD}–S_{CLK})}$	Serial I/O input set up time	400			ns
$t_{h(S_{CLK}–R_{XD})}$	Serial I/O input hold time	200			ns

Note: When f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “1” (Clock synchronous).
Divide this value by four when f(X_{IN}) = 8 MHz and bit 6 of address $001A_{16}$ is “0” (UART).

Table 40. Switching characteristics 1 (Low power source version)

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

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{wH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{c(SCLK)}$/2–30			ns
$t_{wL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{c(SCLK)}$/2–30			ns
$t_{d(SCLK-TxD)}$	Serial I/O output delay time (Note 1)			140	ns
$t_{v(SCLK-TxD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			30	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			30	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		10	30	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		10	30	ns

Notes 1 : When the P45/TxD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is “0”.
2 : X_{OUT} and X_{COUT} pins are excluded.

Table 41. Switching characteristics 2 (Low power source version)

(V_{CC} = 2.2 to 4.0 V, V_{SS} = 0 V, T_a = –20 to 85°C, unless otherwise noted.)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
$t_{wH(SCLK)}$	Serial I/O clock output “H” pulse width	$t_{c(SCLK)}$/2–50			ns
$t_{wL(SCLK)}$	Serial I/O clock output “L” pulse width	$t_{c(SCLK)}$/2–50			ns
$t_{d(SCLK-TxD)}$	Serial I/O output delay time (Note 1)			350	ns
$t_{v(SCLK-TxD)}$	Serial I/O output valid time (Note 1)	–30			ns
$t_{r(SCLK)}$	Serial I/O clock output rising time			50	ns
$t_{f(SCLK)}$	Serial I/O clock output falling time			50	ns
$t_{r(CMOS)}$	CMOS output rising time (Note 2)		20	50	ns
$t_{f(CMOS)}$	CMOS output falling time (Note 2)		20	50	ns

Notes 1 : When the P45/TxD P-channel output disable bit of the UART control register (bit 4 of address 001B16) is “0”.
2 : X_{OUT} and X_{COUT} pins are excluded.

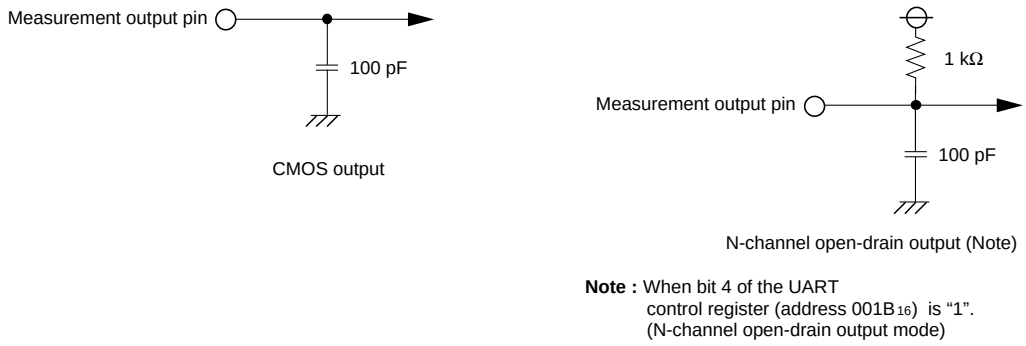


Fig. 44 Circuit for measuring output switching characteristics

TIMING DIAGRAM

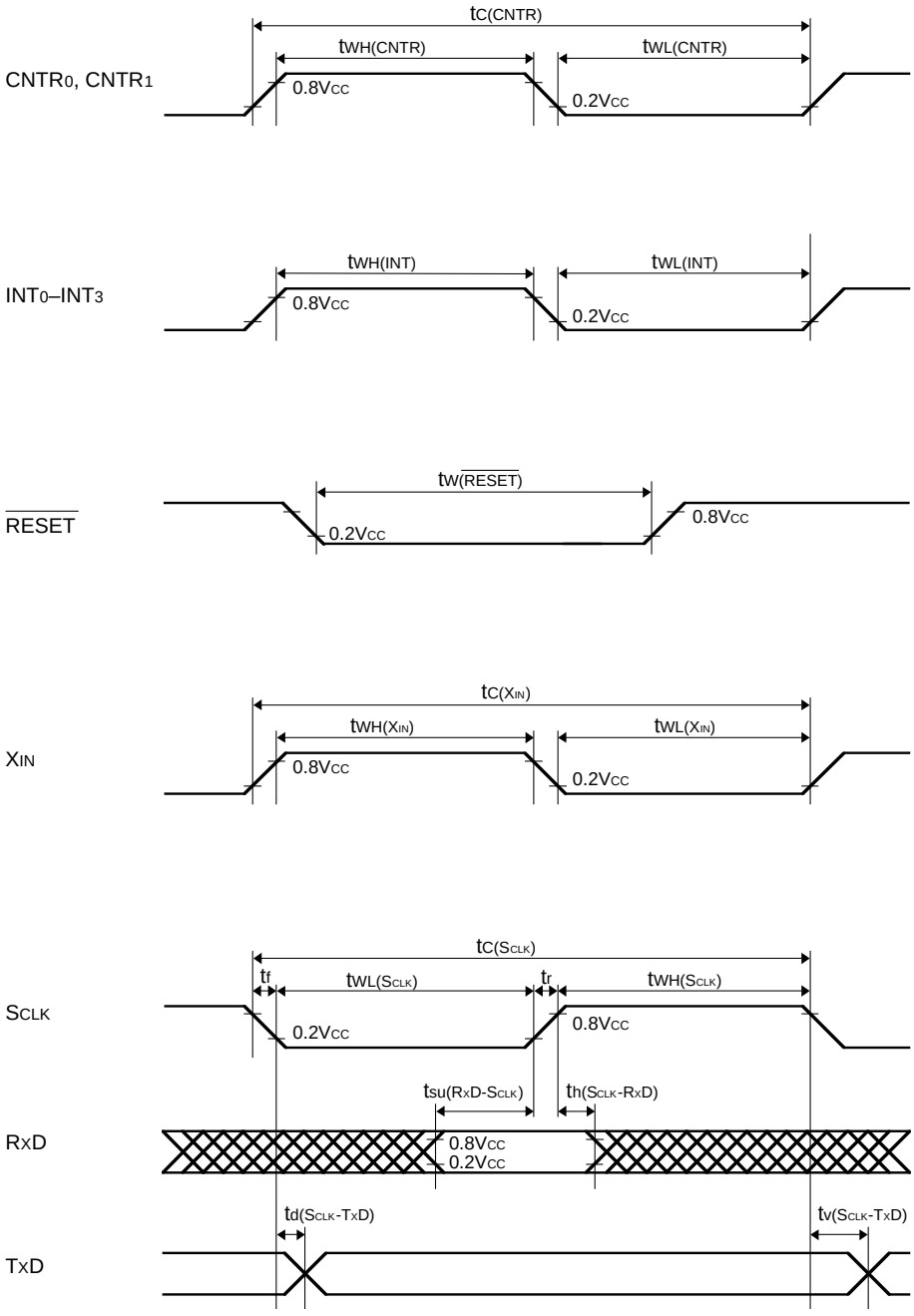


Fig. 45 Timing diagram

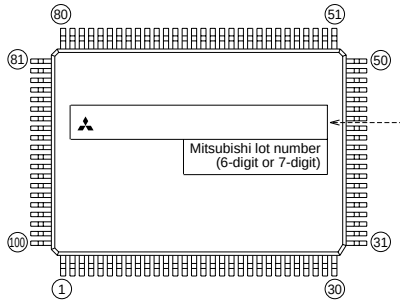
MARK SPECIFICATION FORM

100P6S (100-PIN QFP) MARK SPECIFICATION FORM

Mitsubishi IC catalog name

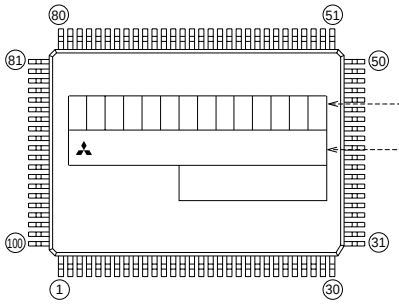
Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

A. Standard Mitsubishi Mark



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B. Customer's Parts Number + Mitsubishi catalog name



Customer's Parts Number

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Note1 : The mark field should be written right aligned.

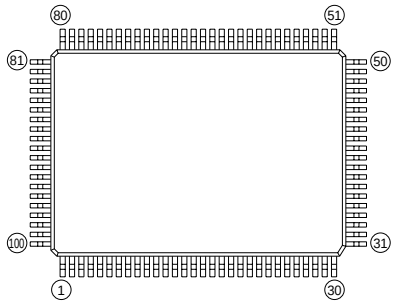
2 : The fonts and size of characters are standard Mitsubishi type.

3 : Customer's Parts Number can be up to 14 characters : Only 0 ~ 9, A ~ Z, +, –, /, (,), &, ©, . (periods), , (commas) are usable.

4 : If the Mitsubishi logo is not required, check the box below.

Mitsubishi logo is not required ☐

C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.
Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.

2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.
Please submit a clean original of the logo.
For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

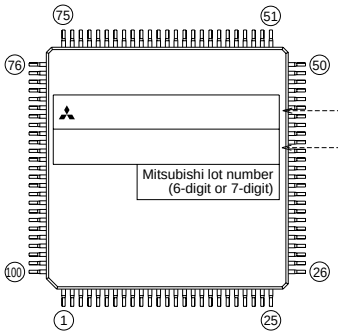
Special logo required ☐

100P6Q (100-PIN LQFP) MARK SPECIFICATION FORM

Mitsubishi IC catalog name

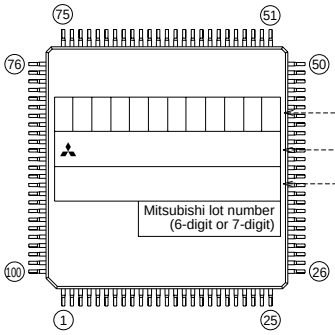
Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

A. Standard Mitsubishi Mark



Mitsubishi IC catalog name
Mitsubishi IC catalog name

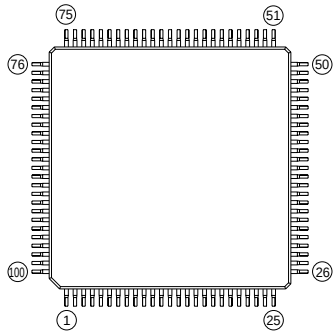
B. Customer's Parts Number + Mitsubishi catalog name



Customer's Parts Number
Note : The fonts and size of characters are standard Mitsubishi type.
Mitsubishi IC catalog name
Note1 : The mark field should be written right aligned.
2 : The fonts and size of characters are standard Mitsubishi type.
3 : Customer's Parts Number can be up to 12 characters : Only 0 ~ 9, A ~ Z, +, –, /, (,), &, ©, . (periods), , (commas) are usable.
4 : If the Mitsubishi logo is not required, check the box below.

Mitsubishi logo is not required ☐

C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.
Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.
2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.
Please submit a clean original of the logo.
For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

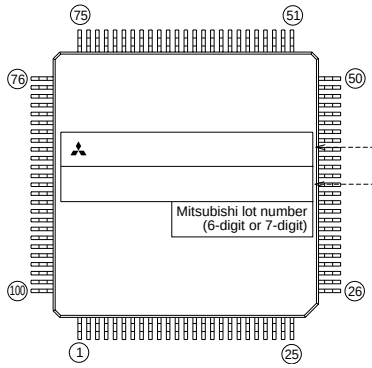
Special logo required ☐

100PFB (100-PIN TQFP) MARK SPECIFICATION FORM

Mitsubishi IC catalog name

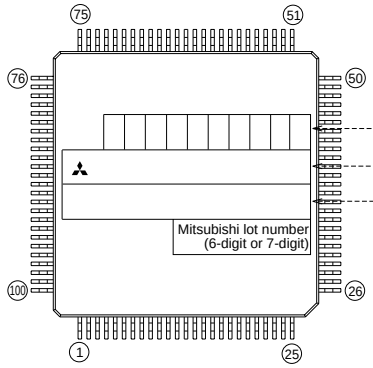
Please choose one of the marking types below (A, B, C), and enter the Mitsubishi catalog name and the special mark (if needed).

A. Standard Mitsubishi Mark



Mitsubishi IC catalog name
Mitsubishi IC catalog name

B. Customer's Parts Number + Mitsubishi catalog name

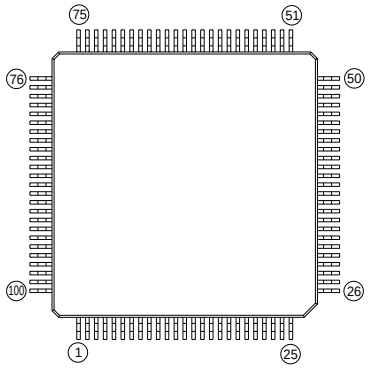


Customer's Parts Number
Note : The fonts and size of characters are standard Mitsubishi type.
Mitsubishi IC catalog name
Note1 : The mark field should be written right aligned.
2 : The fonts and size of characters are standard Mitsubishi type.
3 : Customer's Parts Number can be up to 10 characters : Only 0 ~ 9, A ~ Z, +, –, /, (,), &, ©, . (periods), , (commas) are usable.
4 : If the Mitsubishi logo is not required, check the box below.

Mitsubishi logo is not required ☐

5 : The allocation of Mitsubishi IC catalog name and Mitsubishi Product number depend on the Mitsubishi IC catalog name's characters, and requiring Mitsubishi logo or not.

C. Special Mark Required



Note1 : If the Special Mark is to be Printed, indicate the desired layout of the mark in the left figure. The layout will be duplicated as close as possible.
Mitsubishi lot number (6-digit or 7-digit) and Mask ROM number (3-digit) are always marked.
2 : If the customer's trade mark logo must be used in the Special Mark, check the box below.
Please submit a clean original of the logo.
For the new special character fonts a clean font original (ideally logo drawing) must be submitted.

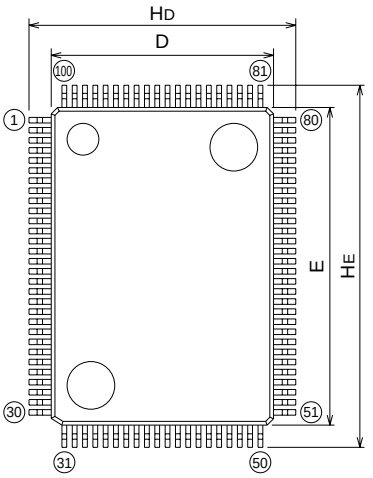
Special logo required ☐

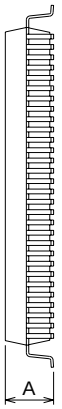
PACKAGE OUTLINES

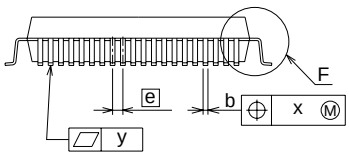
100P6S-A

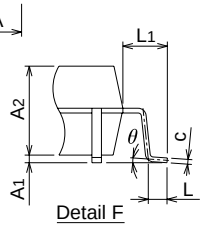
Plastic 100pin 14×20mm body QFP

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

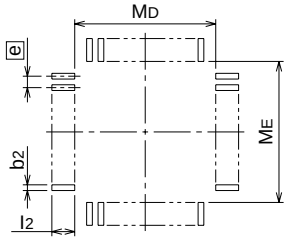








Detail F



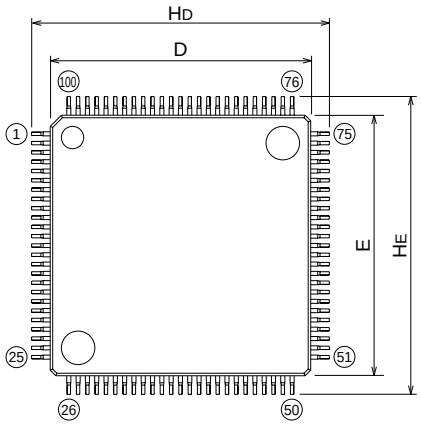
Recommended Mount Pad

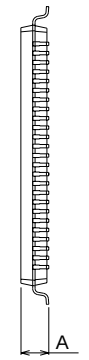
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	3.05
A1	0	0.1	0.2
A2	–	2.8	–
b	0.25	0.3	0.4
c	0.13	0.15	0.2
D	13.8	14.0	14.2
E	19.8	20.0	20.2
e	–	0.65	–
HD	16.5	16.8	17.1
HE	22.5	22.8	23.1
L	0.4	0.6	0.8
L1	–	1.4	–
x	–	–	0.13
y	–	–	0.1
θ	0°	–	10°
b2	–	0.35	–
l2	1.3	–	–
MD	–	14.6	–
ME	–	20.6	–

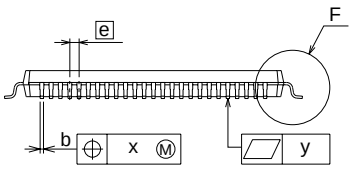
100P6Q-A

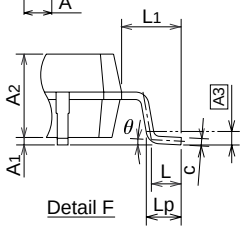
Plastic 100pin 14×14mm body LQFP

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

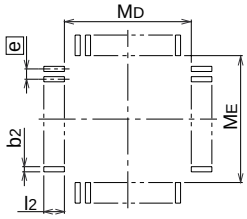








Detail F



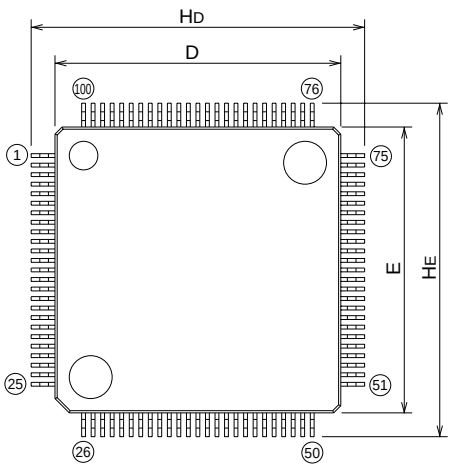
Recommended Mount Pad

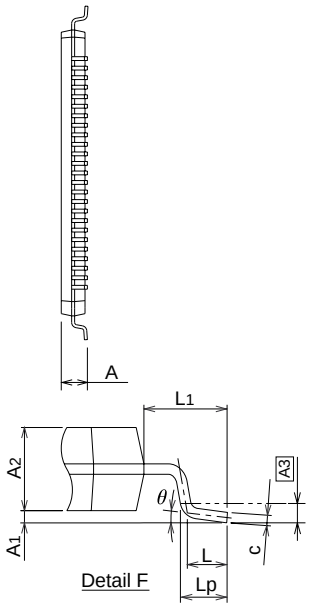
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	1.7
A1	0	0.1	0.2
A2	–	1.4	–
b	0.13	0.18	0.28
c	0.105	0.125	0.175
D	13.9	14.0	14.1
E	13.9	14.0	14.1
e	–	0.5	–
HD	15.8	16.0	16.2
HE	15.8	16.0	16.2
L	0.3	0.5	0.7
L1	–	1.0	–
Lp	0.45	0.6	0.75
A3	–	0.25	–
x	–	–	0.08
y	–	–	0.1
θ	0°	–	10°
b2	–	0.225	–
l2	0.9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

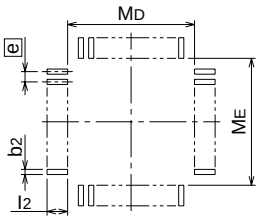
100PFB-A

Plastic 100pin 12×12mm body TQFP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
TQFP100-P-1212-0.40	–	0.37	Cu Alloy







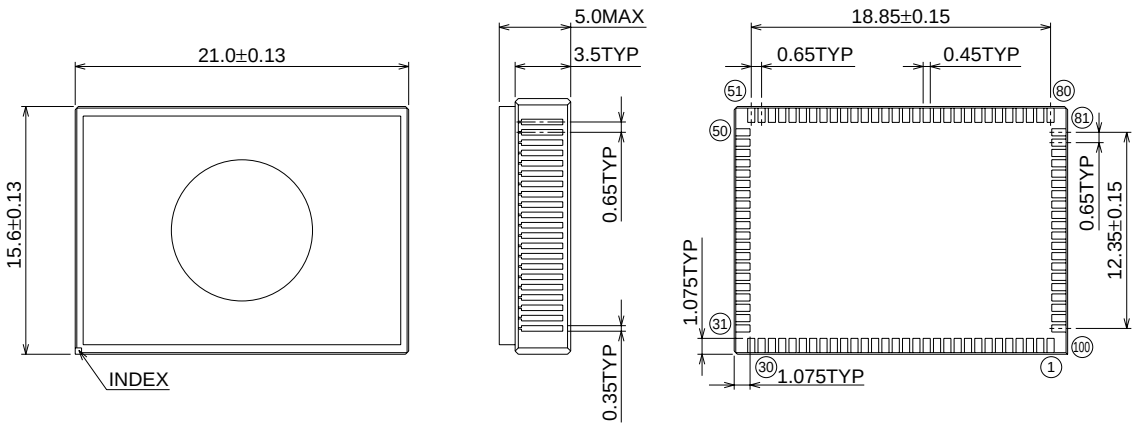
Recommended Mount Pad

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
θ	0°	–	10°
b2	–	0.225	–
l2	1.0	–	–
MD	–	12.4	–
ME	–	12.4	–

100D0

Glass seal 100pin QFN

EIAJ Package Code	JEDEC Code	Weight(g)
–	–	



3825 Group

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

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REVISION DESCRIPTION LIST	3825 GROUP DATA SHEET

Rev. No.	Revision Description	Rev. date
1.0	First Edition	980123
2.0	Low power source version is added.	980515
2.1	The followings are mainly revised: On pages 7 to 10; the group expansion On page 17; (11) Port $P7_0$ of port block diagram On page 43; the name in Table 11 On pages 53 and 59; the “L” input current parameter of I_{IL} in Tables 25 and 35 is not $P7_0$–$P7_7$ but $P7_1$–$P7_7$.	990713