

### 4-BIT SINGLE-CHIP MICROCONTROLLER

The  $\mu$ PD75P0016 replaces the  $\mu$ PD750008's internal mask ROM with a one-time PROM and features expanded ROM capacity.

Because the  $\mu$ PD75P0016 supports programming by users, it is suitable for use in prototype testing for system development using the  $\mu$ PD750004, 750006, or 750008 products, and for use in small-lot production.

Detailed information about product features and specifications can be found in the following document  
 $\mu$ PD750008 User's Manual: U10740E

#### FEATURES

- Compatible with  $\mu$ PD750008
- Memory capacity:
  - PROM : 16384  $\times$  8 bits
  - RAM : 512  $\times$  4 bits
- Can operate in same power supply voltage as the mask ROM version  $\mu$ PD750008
  - $V_{DD} = 2.2$  to 5.5 V
- ★ • Supports QTOP™ microcontroller

**Remark** QTOP Microcontroller is the general name for a total support service that includes imprinting, marking, screening, and verifying one-time PROM single-chip microcontrollers offered by NEC.

#### ORDERING INFORMATION

Part number	Package	ROM ( $\times$ 8 bits)
$\mu$ PD75P0016CU	42-pin plastic shrink DIP (600 mil, 1.778-mm pitch)	16384
$\mu$ PD75P0016GB-3BS-MTX	44-pin plastic QFP (10 $\times$ 10 mm, 0.8-mm pitch)	16384

**Caution** On-chip pull-up resistors by mask option cannot be provided.

The information in this document is subject to change without notice.

## FUNCTION LIST

Item		Function	
Instruction execution time		<ul style="list-style-type: none"> <li>• 0.95, 1.91, 3.81, 15.3 <math>\mu</math>s (main system clock: at 4.19 MHz operation)</li> <li>• 0.67, 1.33, 2.67, 10.7 <math>\mu</math>s (main system clock: at 6.0 MHz operation)</li> <li>• 122 <math>\mu</math>s (subsystem clock: at 32.768 kHz operation)</li> </ul>	
On-chip memory	PROM	16384 $\times$ 8 bits	
	RAM	512 $\times$ 4 bits	
General register		<ul style="list-style-type: none"> <li>• In 4-bit operation: 8 <math>\times</math> 4 banks</li> <li>• In 8-bit operation: 4 <math>\times</math> 4 banks</li> </ul>	
I/O port	CMOS input	8	Connection of on-chip pull-up resistor specifiable by software: 7
	CMOS I/O	18	Direct LED drive capability Connection of on-chip pull-up resistor specifiable by software: 18
	N-ch open drain I/O	8	Direct LED drive capability 13 V withstand voltage
	Total	34	
Timer		4 channels <ul style="list-style-type: none"> <li>• 8-bit timer/event counter: 1 channel</li> <li>• 8-bit timer counter: 1 channel</li> <li>• Basic interval timer/watchdog timer: 1 channel</li> <li>• Watch timer: 1 channel</li> </ul>	
Serial interface		<ul style="list-style-type: none"> <li>• 3-wire serial I/O mode ... Switching of MSB/LSB-first</li> <li>• 2-wire serial I/O mode</li> <li>• SBI mode</li> </ul>	
Bit sequential buffer (BSB)		16 bits	
Clock output (PCL)		<ul style="list-style-type: none"> <li>• <math>\Phi</math>, 524, 262, 65.5 kHz (main system clock: at 4.19 MHz operation)</li> <li>• <math>\Phi</math>, 750, 375, 93.8 kHz (main system clock: at 6.0 MHz operation)</li> </ul>	
Buzzer output (BUZ)		<ul style="list-style-type: none"> <li>• 2, 4, 32 kHz (main system clock: at 4.19 MHz operation or subsystem clock: at 32.768 kHz operation)</li> <li>• 2.93, 5.86, 46.9 kHz (main system clock: at 6.0 MHz operation)</li> </ul>	
Vectored interrupt		External: 3 Internal: 4	
Test input		External: 1 Internal: 1	
System clock oscillation circuit		<ul style="list-style-type: none"> <li>• Main system clock oscillation ceramic/crystal oscillation circuit</li> <li>• Subsystem clock oscillation crystal oscillation circuit</li> </ul>	
Standby function		STOP/HALT mode	
Operating ambient temperature		$T_A = -40$ to $+85^\circ\text{C}$	
Supply voltage		$V_{DD} = 2.2$ to $5.5$ V	
Package		42-pin plastic shrink DIP (600 mil, 1.778-mm pitch) 44-pin plastic QFP (10 $\times$ 10 mm, 0.8-mm pitch)	

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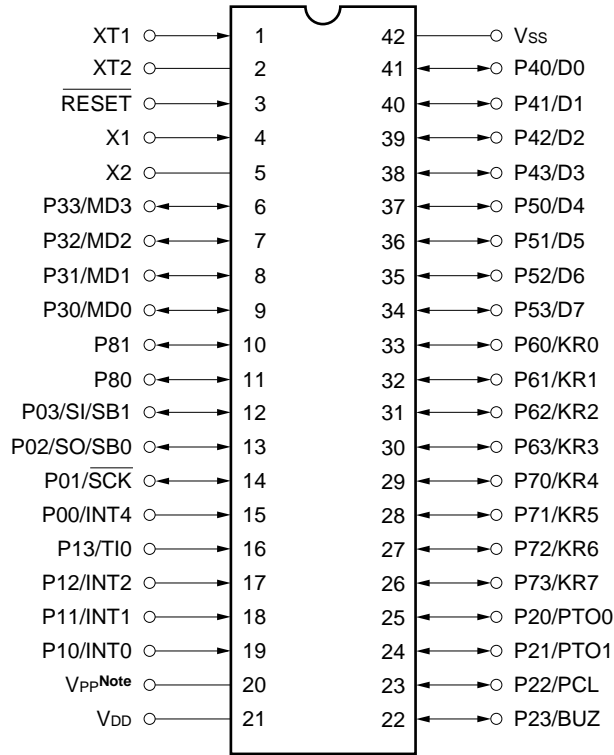
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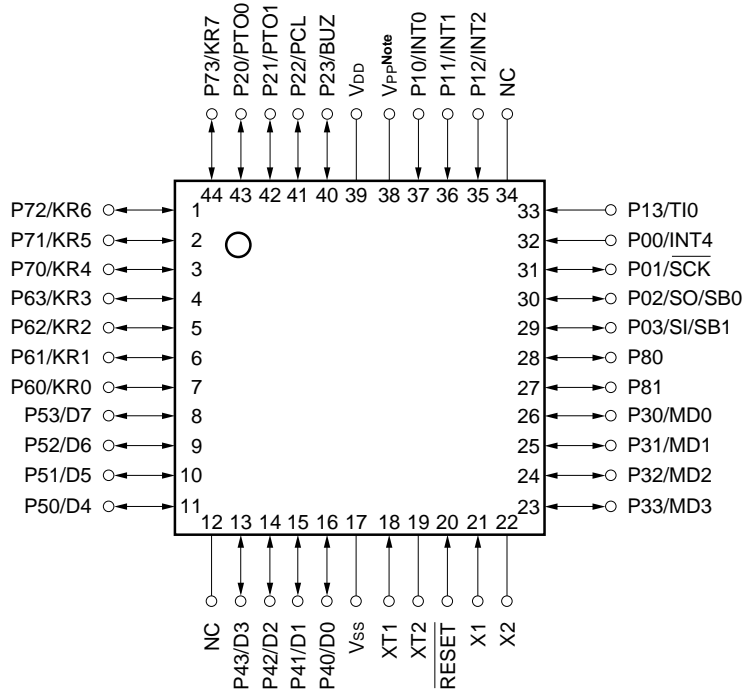
### 1. PIN CONFIGURATION (Top View)

- 42-pin plastic shrink DIP (600 mil, 1.778-mm pitch)  
μPD75P0016CU



**Note** Directly connect V<sub>PP</sub> to V<sub>DD</sub> in the normal operation mode.

- 44-pin plastic QFP (10 × 10 mm, 0.8-mm pitch)  
μPD75P0016GB-3BS-MTX

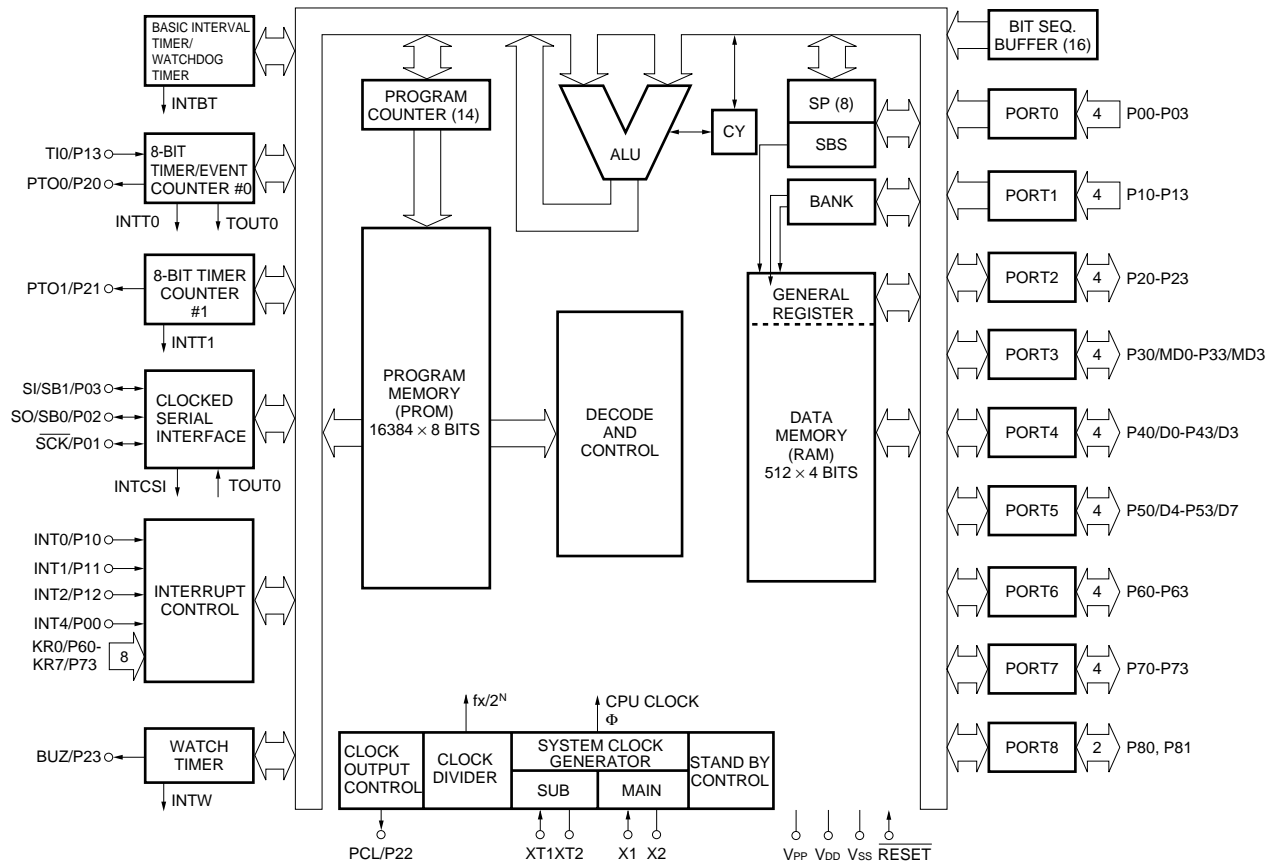


**Note** Directly connect V<sub>PP</sub> to V<sub>DD</sub> in the normal operation mode.

## PIN IDENTIFICATIONS

P00-P03	: Port0	$\overline{\text{SCK}}$	: Serial Clock
P10-P13	: Port1	SI	: Serial Input
P20-P23	: Port2	SO	: Serial Output
P30-P33	: Port3	SB0, SB1	: Serial Data Bus 0,1
P40-P43	: Port4	$\overline{\text{RESET}}$	: Reset
P50-P53	: Port5	TI0	: Timer Input 0
P60-P63	: Port6	PTO0, PTO1	: Programmable Timer Output 0, 1
P70-P73	: Port7	BUZ	: Buzzer Clock
P80, P81	: Port8	PCL	: Programmable Clock
KR0-KR7	: Key Return 0-7	INT0, 1, 4	: External Vectored Interrupt 0, 1, 4
V <sub>DD</sub>	: Positive Power Supply	INT2	: External Test Input 2
V <sub>SS</sub>	: Ground	X1, X2	: Main System Clock Oscillation 1, 2
V <sub>PP</sub>	: Programming Power Supply	XT1, XT2	: Subsystem Clock Oscillation 1, 2
NC	: No Connection	MD0-MD3	: Mode Selection 0-3
		D0-D7	: Data Bus 0-7

2. BLOCK DIAGRAM



### 3. PIN FUNCTIONS

#### 3.1 Port Pins

Pin name	I/O	Shared by	Function	8-bit I/O	When reset	I/O circuit type <small>Note 1</small>
P00	I	INT4	This is a 4-bit input port (PORT0). For P01 to P03, on-chip pull-up resistor connections are software-specifiable in 3-bit units.	×	Input	<B>
P01	I/O	$\overline{\text{SCK}}$				<F>-A
P02	I/O	SO/SB0				<F>-B
P03	I/O	SI/SB1				<M>-C
P10	I	INT0	This is a 4-bit input port (PORT1). On-chip pull-up resistor connections are software-specifiable in 4-bit units. P10/INT0 can select noise elimination circuit.	×	Input	<B>-C
P11		INT1				
P12		INT2				
P13		T10				
P20	I/O	PTO0	This is a 4-bit I/O port (PORT2). On-chip pull-up resistor connections are software-specifiable in 4-bit units.	×	Input	E-B
P21		PTO1				
P22		PCL				
P23		BUZ				
P30	I/O	MD0	This is a programmable 4-bit I/O port (PORT3). Input and output can be specified in single-bit units. On-chip pull-up resistor connections are software-specifiable in 4-bit units.	×	Input	E-B
P31		MD1				
P32		MD2				
P33		MD3				
★ P40 <small>Note 2</small>	I/O	D0	This is an N-ch open-drain 4-bit I/O port (PORT4). In the open-drain mode, withstands up to 13 V.	○	High impedance	M-E
P41 <small>Note 2</small>		D1				
P42 <small>Note 2</small>		D2				
P43 <small>Note 2</small>		D3				
★ P50 <small>Note 2</small>	I/O	D4	This is an N-ch open-drain 4-bit I/O port (PORT5). In the open-drain mode, withstands up to 13 V.	○	High impedance	M-E
P51 <small>Note 2</small>		D5				
P52 <small>Note 2</small>		D6				
P53 <small>Note 2</small>		D7				
P60	I/O	KR0	This is a programmable 4-bit I/O port (PORT6). Input and output can be specified in single-bit units. On-chip pull-up resistor connections are software-specifiable in 4-bit units.	○	Input	<F>-A
P61		KR1				
P62		KR2				
P63		KR3				
P70	I/O	KR4	This is a 4-bit I/O port (PORT7). On-chip pull-up resistor connections are software-specifiable in 4-bit units.	○	Input	<F>-A
P71		KR5				
P72		KR6				
P73		KR7				
P80	I/O	—	This is a 2-bit I/O port (PORT8). On-chip pull-up resistor connections are software-specifiable in 2-bit units.	×	Input	E-B
P81		—				

**Notes 1.** Circuit types enclosed in brackets indicate Schmitt triggered inputs.

**2.** Low-level input current leakage increases when input instructions or bit manipulation instructions are executed.

3.2 Non-port Pins

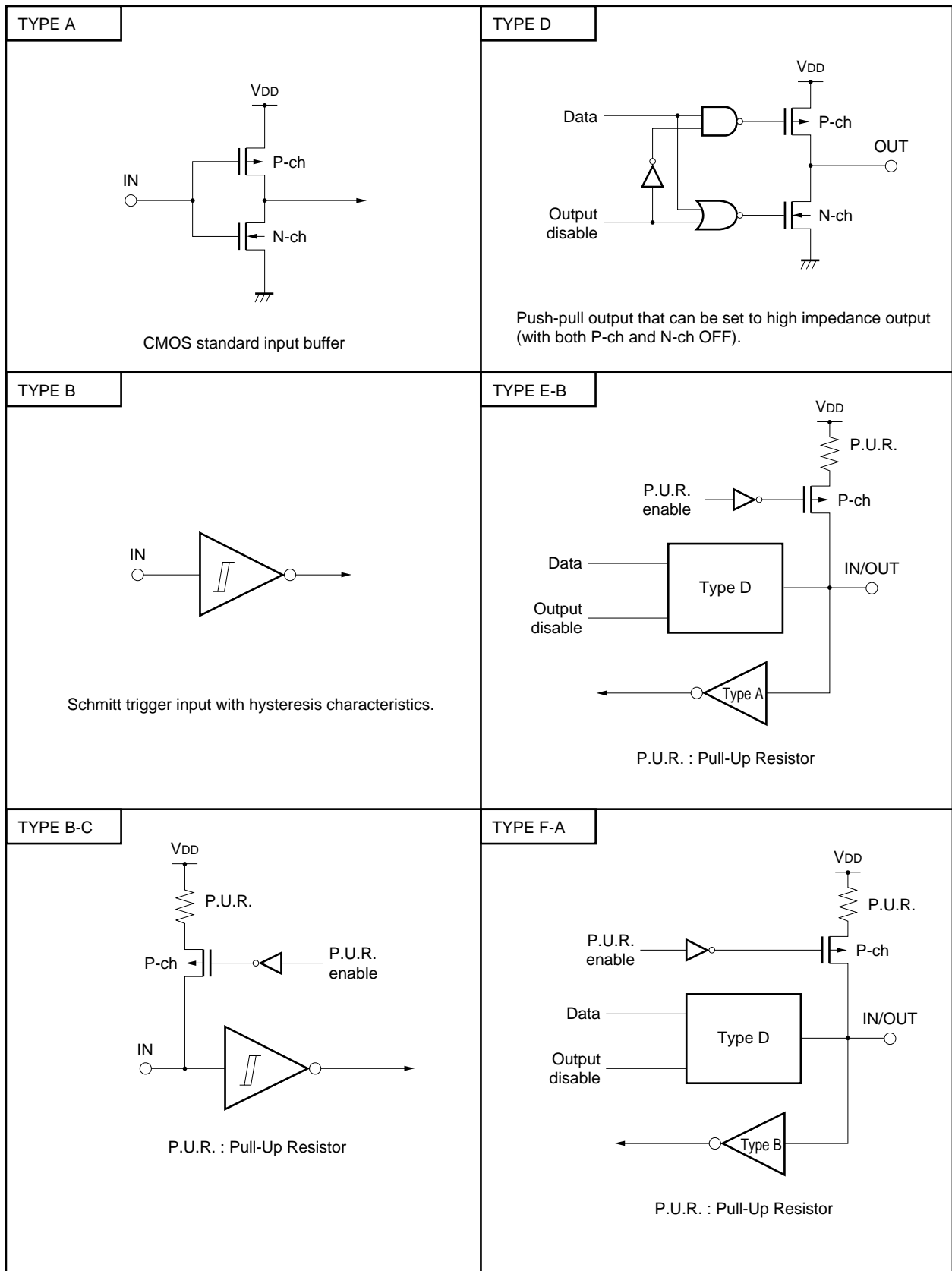
Pin name	I/O	Shared by	Function	When reset	I/O circuit type <b>Note 1</b>
TI0	I	P13	External event pulse input to timer/event counter	Input	<B>-C
PTO0	O	P20	Timer/event counter output	Input	E-B
PTO1		P21	Timer counter output		
PCL		P22	Clock output		
BUZ		P23	Outputs any frequency (for buzzer or system clock trimming)		
$\overline{\text{SCK}}$	I/O	P01	Serial clock I/O	Input	<F>-A
SO/SB0		P02	Serial data output Serial data bus I/O		<F>-B
SI/SB1		P03	Serial data input Serial data bus I/O		<M>-C
INT4		P00	Edge-triggered vectored interrupt input (Detects both rising and falling edges).		<B>
INT0	I	P10	Edge-triggered vectored interrupt input (detected edge is selectable). INT0/P10 can select noise elimination circuit.	Input	<B>-C
INT1		P11	Asynch		
INT2		P12	Rising edge-triggered testable input Asynch		
KR0-KR3	I	P60-P63	Falling edge-triggered testable input	Input	<F>-A
KR4-KR7	I	P70-P73	Falling edge-triggered testable input	Input	<F>-A
X1	I	—	Ceramic/crystal resonator connection for main system clock. If using an external clock, input it to X1 and input the inverted clock to X2.	—	—
X2	—				
XT1	I	—	Crystal resonator connection for subsystem clock. If using an external clock, input it to XT1 and input the inverted clock to X2. XT1 can be used as a 1-bit (test) input.	—	—
XT2	—				
$\overline{\text{RESET}}$	I	—	System reset input (low level active)	—	<B>
MD0-MD3	I	P30-P33	Mode selection for program memory (PROM) write/verify.	Input	E-B
★ D0-D3	I/O	P40-P43	Data bus pin for program memory (PROM) write/verify.	Input	M-E
★ D4-D7		P50-P53			
$V_{PP}$ <b>Note 2</b>	—	—	Programmable voltage supply in program memory (PROM) write/verify mode. In normal operation mode, connect directly to $V_{DD}$ . Apply +12.5 V in PROM write/verify mode.	—	—
$V_{DD}$	—	—	Positive power supply	—	—
$V_{SS}$	—	—	Ground potential	—	—

- Notes**
1. Circuit types enclosed in brackets indicate Schmitt triggered inputs.
  2. During normal operation, the  $V_{PP}$  pin will not operate normally unless connected to  $V_{DD}$  pin.

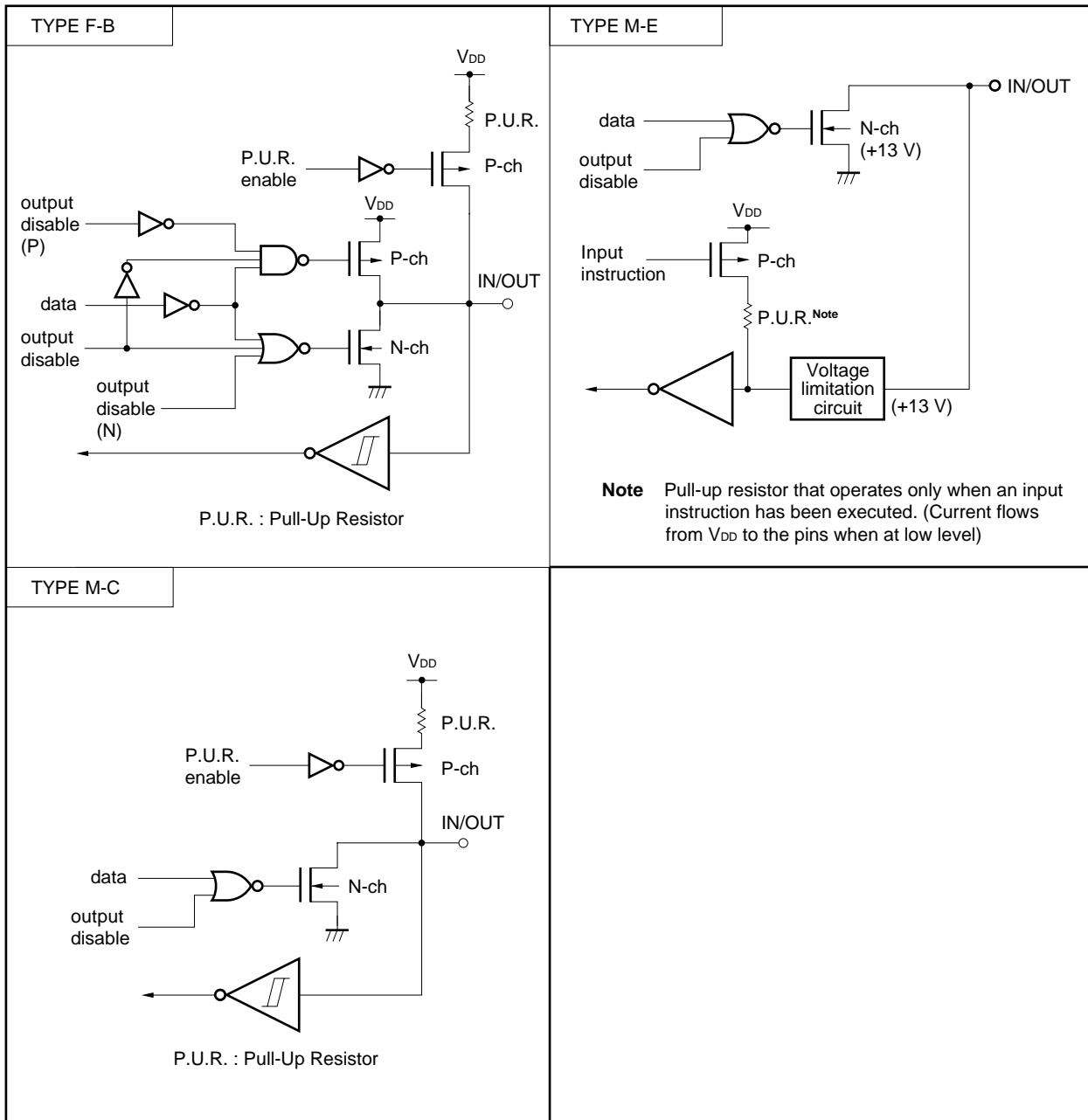


3.3 I/O Circuits for Pins

The I/O circuits for the μPD75P0016's pin are shown in schematic diagrams below.



(Continued)



3.4 Handling of Unused Pins

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Table 3-1. Handling of Unused Pins

Pin	Recommended connection
P00/INT4	Connect to V <sub>SS</sub> or V <sub>DD</sub>
P01/SCK	Individually connect to V <sub>SS</sub> or V <sub>DD</sub> via resistor
P02/SO/SB0	
P03/SI/SB1	Connect to V <sub>SS</sub>
P10/INT0-P12/INT2	Connect to V <sub>SS</sub> or V <sub>DD</sub>
P13/TI0	
P20/PTO0	Input mode : individually connect to V <sub>SS</sub> or V <sub>DD</sub> via resistor Output mode : open
P21/PTO1	
P22/PCL	
P23/BUZ	
P30/MD0-P33/MD3	
P40/D0-P43/D3	Connect to V <sub>SS</sub>
P50/D4-P53/D7	
P60/KR0-P63/KR3	Input mode : individually connect to V <sub>SS</sub> or V <sub>DD</sub> via resistor Output mode : open
P70/KR4-P73/KR7	
P80, P81	
XT1 <sup>Note</sup>	Connect to V <sub>SS</sub>
XT2 <sup>Note</sup>	Open
V <sub>PP</sub>	Make sure to connect directly to V <sub>DD</sub>

**Note** When the subsystem clock is not used, set SOS. 0 to 1 (not to use the internal feedback resistor).

#### 4. SWITCHING BETWEEN MK I AND MK II MODES

Setting a stack bank selection (SBS) register for the μPD75P0016 enables the program memory to be switched between the Mk I mode and the Mk II mode. This capability enables the evaluation of the μPD750004, 750006, or 750008 using the μPD75P0016.

When the SBS bit 3 is set to 1: sets Mk I mode (corresponds to Mk I mode of μPD750004, 750006, and 750008)

When the SBS bit 3 is set to 0: sets Mk II mode (corresponds to Mk II mode of μPD750004, 750006, and 750008)

##### 4.1 Differences between Mk I Mode and Mk II Mode

Table 4-1 lists the differences between the Mk I mode and the Mk II mode of the μPD75P0016.

**Table 4-1. Differences between Mk I Mode and Mk II Mode**

Item		Mk I mode	Mk II mode
Program counter		PC <sub>13-0</sub>	
Program memory (bytes)		16384	
Data memory (bits)		512 × 4	
Stack	Stack bank	Selectable from memory banks 0 and 1	
	Stack bytes	2 bytes	3 bytes
Instruction	BRA !addr1 CALLA !addr1	None	Provided
Instruction execution time	CALL !addr	3 machine cycles	4 machine cycles
	CALLF !faddr	2 machine cycles	3 machine cycles
Supported mask ROM versions and mode		Mk I mode of μPD750004, 750006, and 750008	Mk II mode of μPD750004, 750006, and 750008

- ★ **Caution** The Mk II mode supports a program area which exceeds 16K bytes in the 75X and 75XL series. This mode enhances the software compatibility with products which have more than 16K bytes. When the Mk II mode is selected, the number of stack bytes used in execution of a subroutine call instruction increases by 1 per stack for the usable area compared to the Mk I mode. Furthermore, when a CALL !addr, or CALLF !faddr instruction is used, each instruction takes another machine cycle. Therefore, when more importance is attached to RAM utilization or throughput than software compatibility, use the Mk I mode.

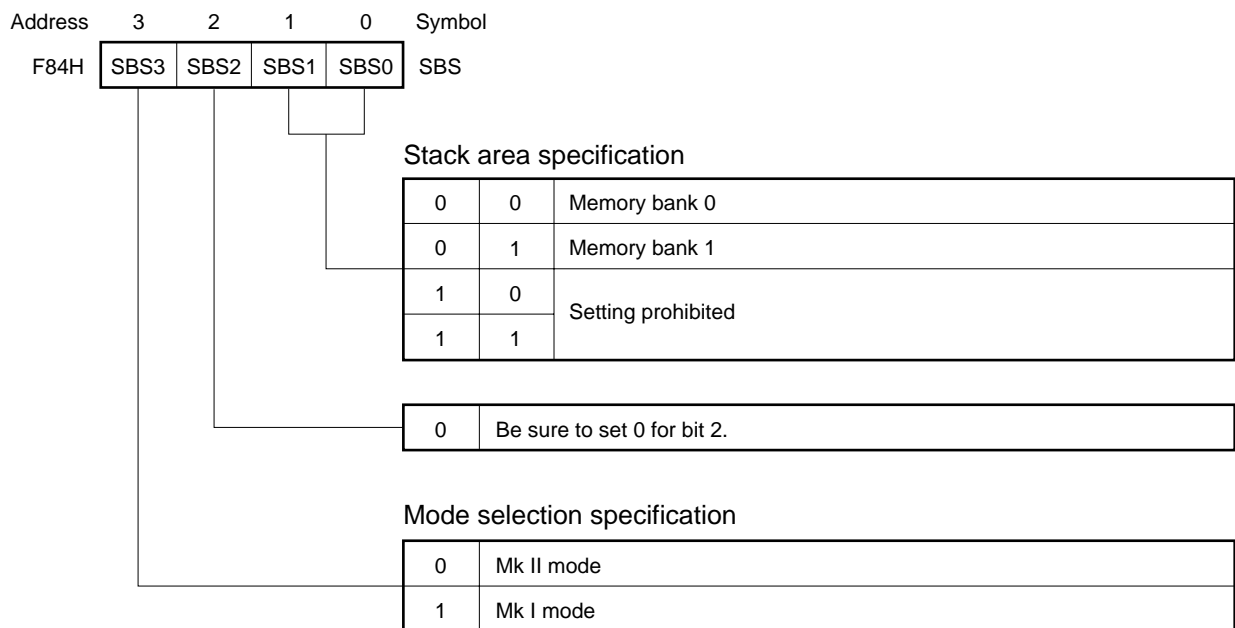
### 4.2 Setting of Stack Bank Selection (SBS) Register

Use the stack bank selection register to switch between the Mk I mode and the Mk II mode. Figure 4-1 shows the format for doing this.

The stack bank selection register is set using a 4-bit memory manipulation instruction. When using the Mk I mode, be sure to initialize the stack bank selection register to 100×B **Note** at the beginning of the program. When using the Mk II mode, be sure to initialize it to 000×B **Note**.

**Note** Set the desired value for ×.

**Figure 4-1. Format of Stack Bank Selection Register**



**Caution** SBS3 is set to “1” after  $\overline{\text{RESET}}$  input, and consequently the CPU operates in the Mk I mode. When using instructions for the Mk II mode, set SBS3 to “0” to enter the Mk II mode before using the instructions.

5. DIFFERENCES BETWEEN μPD75P0016 AND μPD750004, 750006, AND 750008

The μPD75P0016 replaces the internal mask ROM in the μPD750004, 750006, and 750008 with a one-time PROM and features expanded ROM capacity. The μPD75P0016's Mk I mode supports the Mk I mode in the μPD750004, 750006, and 750008 and the μPD75P0016's Mk II mode supports the Mk II mode in the μPD750004, 750006, and 750008.

Table 5-2 lists differences among the μPD75P0016 and the μPD750004, 750006, and 750008. Be sure to check the differences between corresponding versions beforehand, especially when a PROM version is used for debugging or prototype testing of application systems and later the corresponding mask ROM version is used for full-scale production.

Please refer to the μPD750008 User's Manual (U10740E) for details on CPU functions and on-chip hardware.

Table 5-1. Differences between μPD75P0016 and μPD750004, 750006, and 750008

Item		μPD750004	μPD750006	μPD750008	μPD75P0016
Program counter		12-bit	13-bit		14-bit
Program memory (bytes)		Mask ROM 4096	Mask ROM 6144	Mask ROM 8192	One-time PROM 16384
Data memory (× 4 bits)		512			
Mask options	Pull-up resistor for port 4 and port 5	Yes (On-chip/not on-chip can be specified.)			No (On-chip not possible)
	Wait time when RESET	Yes ( $2^{17}/f_x$ or $2^{15}/f_x$ ) <b>Note</b>			No (fixed at $2^{15}/f_x$ ) <b>Note</b>
	Feedback resistor for subsystem clock	Yes (can select usable or unusable.)			No (usable)
Pin connection	Pins 6-9 (CU)	P33-P30			P33/MD3-P30/MD0
	Pins 23-26 (GB)				
	Pin 20 (CU)	IC			V <sub>PP</sub>
	Pin 38 (GB)				
	Pins 34-37 (CU)	P53-P50			P53/D7-P50/D4
	Pins 8-11 (GB)				
	Pins 38-41 (CU)	P43-P40			P43/D3-P40/D0
	Pins 13-16 (GB)				
Other		Noise resistance and noise radiation may differ due to the different circuit complexities and mask layouts.			

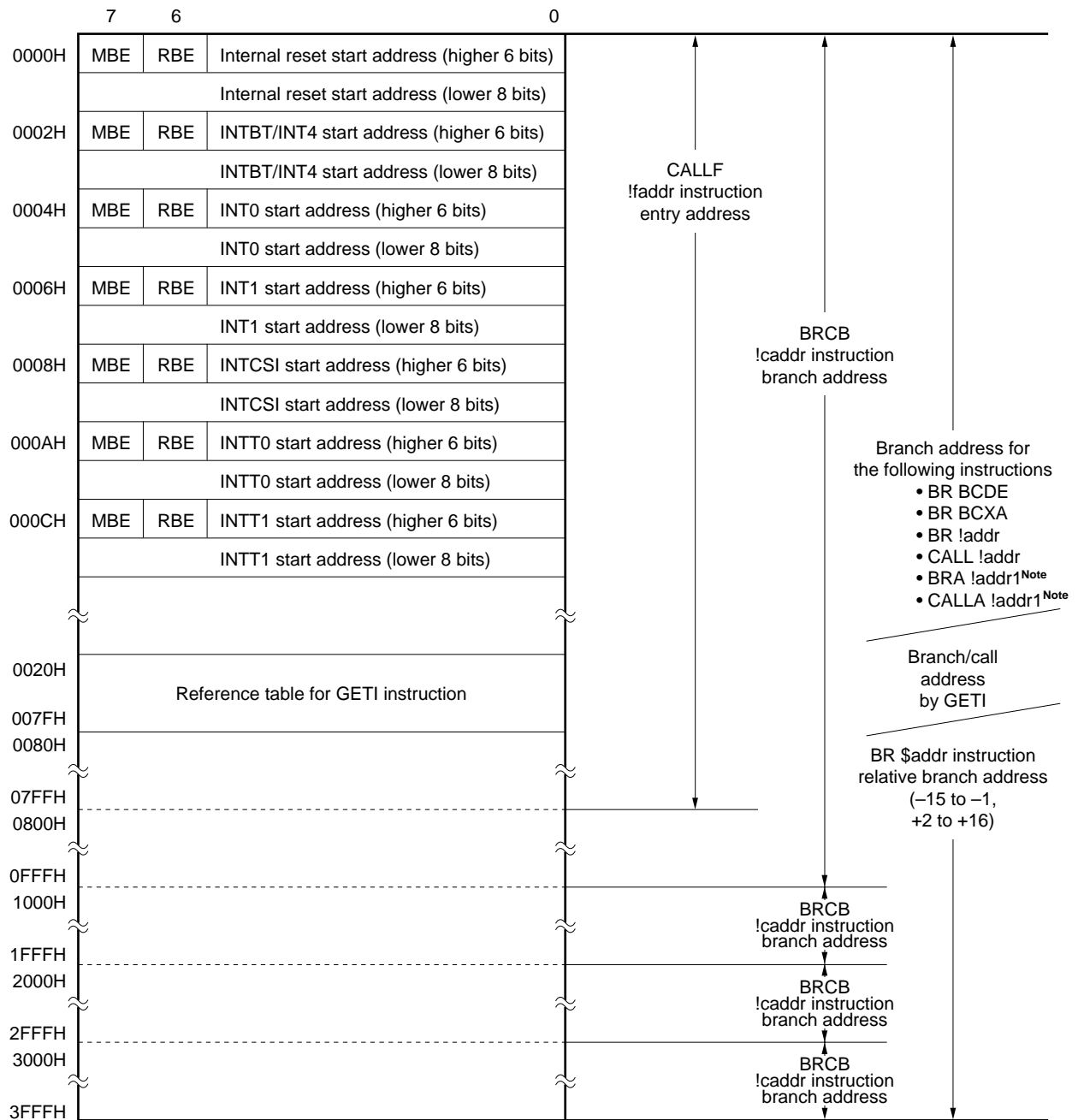
**Note**  $2^{17}/f_x$  : 21.8 ms @ 6.0 MHz, 31.3 ms @ 4.19 MHz

$2^{15}/f_x$  : 5.46 ms @ 6.0 MHz, 7.81 ms @ 4.19 MHz

**Caution** Noise resistance and noise radiation are different in PROM version and mask ROM versions. If using a mask ROM version instead of the PROM version for processes between prototype development and full production, be sure to fully evaluate the CS of the mask ROM version (not ES).

6. MEMORY CONFIGURATION

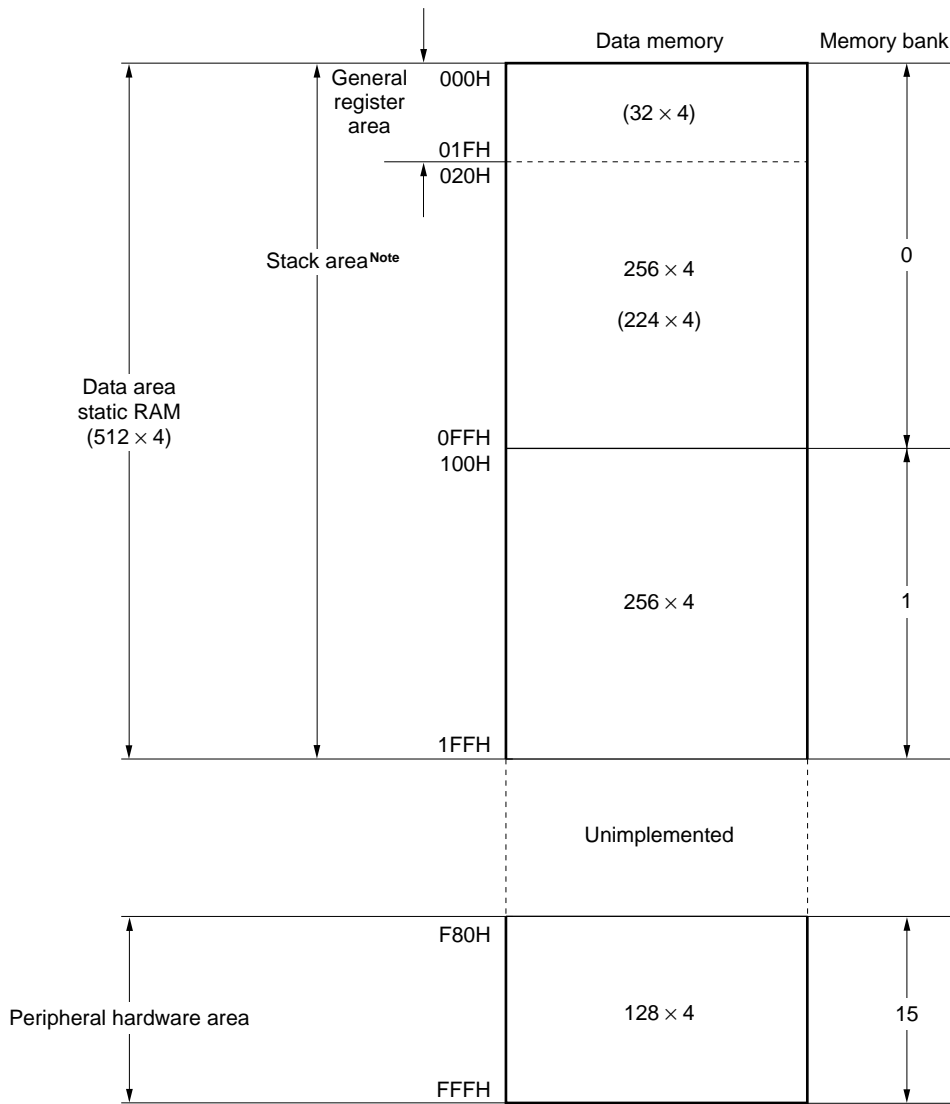
Figure 6-1. Program Memory Map



**Note** Can be used only at Mk II mode.

**Remark** For instructions other than those noted above, the “BR PCDE” and “BR PCXA” instructions can be used to branch to addresses with changes in the PC’s lower 8 bits only.

Figure 6-2. Data Memory Map



**Note** For the stack area, one memory bank can be selected from memory bank 0 or 1.



## 7. INSTRUCTION SET

### (1) Representation and coding formats for operands

In the instruction's operand area, use the following coding format to describe operands corresponding to the instruction's operand representations (for further description, refer to the **RA75X Assembler Package User's Manual [EEU-1363]**). When there are several codes, select and use just one. Upper-case letters, and + and – symbols are key words that should be entered as they are.

For immediate data, enter an appropriate numerical value or label.

Instead of mem, fmem, pmem, bit, etc, a register flag symbol can be described as a label descriptor. (For further description, refer to the **μPD750008 User's Manual [U10740E]**) Labels that can be entered for fmem and pmem are restricted.

Representation	Coding format
reg	X, A, B, C, D, E, H, L
reg1	X, B, C, D, E, H, L
rp	XA, BC, DE, HL
rp1	BC, DE, HL
rp2	BC, DE
rp'	XA, BC, DE, HL, XA', BC', DE', HL'
rp'1	BC, DE, HL, XA', BC', DE', HL'
rpa	HL, HL+, HL–, DE, DL
rpa1	DE, DL
n4	4-bit immediate data or label
n8	8-bit immediate data or label
mem	8-bit immediate data or label <b>Note</b>
bit	2-bit immediate data or label
fmem	FB0H-FBFH, FF0H-FFFH immediate data or label
pmem	FC0H-FFFH immediate data or label
addr	0000H-3FFFH immediate data or label
addr1	0000H-3FFFH immediate data or label (in Mk II mode only)
caddr	12-bit immediate data or label
faddr	11-bit immediate data or label
taddr	20H-7FH immediate data (however, bit0 = 0) or label
PORTn	PORT0-PORT8
IEXXX	IEBT, IECSI, IET0, IET1, IE0-IE2, IE4, IEW
RBn	RB0-RB3
MBn	MB0, MB1, MB15

**Note** When processing 8-bit data, only even addresses can be specified.

**(2) Operation legend**

A	: A register; 4-bit accumulator
B	: B register
C	: C register
D	: D register
E	: E register
H	: H register
L	: L register
X	: X register
XA	: Register pair (XA); 8-bit accumulator
BC	: Register pair (BC)
DE	: Register pair (DE)
HL	: Register pair (HL)
XA'	: Expansion register pair (XA')
BC'	: Expansion register pair (BC')
DE'	: Expansion register pair (DE')
HL'	: Expansion register pair (HL')
PC	: Program counter
SP	: Stack pointer
CY	: Carry flag; bit accumulator
PSW	: Program status word
MBE	: Memory bank enable flag
RBE	: Register bank enable flag
PORT <sub>n</sub>	: Port n (n = 0 to 8)
IME	: Interrupt master enable flag
IPS	: Interrupt priority select register
IE <sub>xxx</sub>	: Interrupt enable flag
RBS	: Register bank select register
MBS	: Memory bank select register
PCC	: Processor clock control register
.	: Delimiter for address and bit
(xx)	: Contents of address xx
xxH	: Hexadecimal data

(3) Description of symbols used in addressing area

*1	MB = MBE • MBS MBS = 0, 1, 15	Data memory addressing
*2	MB = 0	
*3	MBE = 0 : MB = 0 (000H-07FH) MB = 15 (F80H-FFFH) MBE = 1 : MB = MBS MBS = 0, 1, 15	
*4	MB = 15, fmem = FB0H-FBFH, FF0H-FFFH	
*5	MB = 15, pmem = FC0H-FFFH	
*6	addr = 0000H-3FFFH	
*7	addr, addr1 = (Current PC) -15 to (Current PC) -1 (Current PC) +2 to (Current PC) +16	Program memory addressing
*8	caddr = 0000H-0FFFH (PC <sub>13</sub> , 12 = 00B) or 1000H-1FFFH (PC <sub>13</sub> , 12 = 01B) or 2000H-2FFFH (PC <sub>13</sub> , 12 = 10B) or 3000H-3FFFH (PC <sub>13</sub> , 12 = 11B)	
*9	faddr = 0000H-07FFH	
*10	taddr = 0020H-007FH	
*11	addr1 = 0000H-3FFFH (Mk II mode only)	

- Remarks**
1. MB indicates access-enabled memory banks.
  2. In area \*2, MB = 0 for both MBE and MBS.
  3. In areas \*4 and \*5, MB = 15 for both MBE and MBS.
  4. Areas \*6 to \*11 indicate corresponding address-enabled areas.

**(4) Description of machine cycles**

S indicates the number of machine cycles required for skipping of skip-specified instructions. The value of S varies as shown below.

- No skip ..... S = 0
- Skipped instruction is 1-byte or 2-byte instruction ..... S = 1
- Skipped instruction is 3-byte instruction **Note** ..... S = 2

**Note** 3-byte instructions: BR !addr, BRA !addr1, CALL !addr, CALLA !addr1

**Caution** The GETI instruction is skipped for one machine cycle.

One machine cycle equals one cycle (=  $t_{CY}$ ) of the CPU clock  $\Phi$ . Use the PCC setting to select among four cycle times.

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Transfer	MOV	A, # n4	1	1	$A \leftarrow n4$		String-effect A
		reg1, # n4	2	2	$reg1 \leftarrow n4$		
		XA, # n8	2	2	$XA \leftarrow n8$		String-effect A
		HL, # n8	2	2	$HL \leftarrow n8$		String-effect B
		rp2, # n8	2	2	$rp2 \leftarrow n8$		
		A, @HL	1	1	$A \leftarrow (HL)$	*1	
		A, @HL+	1	2 + S	$A \leftarrow (HL)$ , then $L \leftarrow L + 1$	*1	L = 0
		A, @HL-	1	2 + S	$A \leftarrow (HL)$ , then $L \leftarrow L - 1$	*1	L = FH
		A, @rpa1	1	1	$A \leftarrow (rpa1)$	*2	
		XA, @HL	2	2	$XA \leftarrow (HL)$	*1	
		@HL, A	1	1	$(HL) \leftarrow A$	*1	
		@HL, XA	2	2	$(HL) \leftarrow XA$	*1	
		A, mem	2	2	$A \leftarrow (mem)$	*3	
		XA, mem	2	2	$XA \leftarrow (mem)$	*3	
		mem, A	2	2	$(mem) \leftarrow A$	*3	
		mem, XA	2	2	$(mem) \leftarrow XA$	*3	
		A, reg	2	2	$A \leftarrow reg$		
		XA, rp'	2	2	$XA \leftarrow rp'$		
		reg1, A	2	2	$reg1 \leftarrow A$		
		rp'1, XA	2	2	$rp'1 \leftarrow XA$		
	XCH	A, @HL	1	1	$A \leftrightarrow (HL)$	*1	
		A, @HL+	1	2 + S	$A \leftrightarrow (HL)$ , then $L \leftarrow L + 1$	*1	L = 0
		A, @HL-	1	2 + S	$A \leftrightarrow (HL)$ , then $L \leftarrow L - 1$	*1	L = FH
		A, @rpa1	1	1	$A \leftrightarrow (rpa1)$	*2	
		XA, @HL	2	2	$XA \leftrightarrow (HL)$	*1	
		A, mem	2	2	$A \leftrightarrow (mem)$	*3	
		XA, mem	2	2	$XA \leftrightarrow (mem)$	*3	
		A, reg1	1	1	$A \leftrightarrow reg1$		
XA, rp'	2	2	$XA \leftrightarrow rp'$				
Table reference	MOV <sub>T</sub>	XA, @PCDE	1	3	$XA \leftarrow (PC_{13-8} + DE)_{ROM}$		
		XA, @PCXA	1	3	$XA \leftarrow (PC_{13-8} + XA)_{ROM}$		
		XA, @BCDE	1	3	$XA \leftarrow (BCDE)_{ROM}$ <b>Note</b>	*6	
		XA, @BCXA	1	3	$XA \leftarrow (BCXA)_{ROM}$ <b>Note</b>	*6	

**Note** As for the B register, only the lower 2 bits are valid.

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Bit transfer	MOV1	CY, fmem.bit	2	2	$CY \leftarrow (fmem.bit)$	*4	
		CY, pmem.@L	2	2	$CY \leftarrow (pmem7-2 + L3-2.bit(L1-0))$	*5	
		CY, @H + mem.bit	2	2	$CY \leftarrow (H + mem3-0.bit)$	*1	
		fmem.bit, CY	2	2	$(fmem.bit) \leftarrow CY$	*4	
		pmem.@L, CY	2	2	$(pmem7-2 + L3-2.bit(L1-0)) \leftarrow CY$	*5	
		@H + mem.bit, CY	2	2	$(H + mem3-0.bit) \leftarrow CY$	*1	
Operation	ADDS	A, #n4	1	1 + S	$A \leftarrow A + n4$		carry
		XA, #n8	2	2 + S	$XA \leftarrow XA + n8$		carry
		A, @HL	1	1 + S	$A \leftarrow A + (HL)$	*1	carry
		XA, rp'	2	2 + S	$XA \leftarrow XA + rp'$		carry
		rp'1, XA	2	2 + S	$rp'1 \leftarrow rp'1 + XA$		carry
	ADDC	A, @HL	1	1	$A, CY \leftarrow A + (HL) + CY$	*1	
		XA, rp'	2	2	$XA, CY \leftarrow XA + rp' + CY$		
		rp'1, XA	2	2	$rp'1, CY \leftarrow rp'1 + XA + CY$		
	SUBS	A, @HL	1	1 + S	$A \leftarrow A - (HL)$	*1	borrow
		XA, rp'	2	2 + S	$XA \leftarrow XA - rp'$		borrow
		rp'1, XA	2	2 + S	$rp'1 \leftarrow rp'1 - XA$		borrow
	SUBC	A, @HL	1	1	$A, CY \leftarrow A - (HL) - CY$	*1	
		XA, rp'	2	2	$XA, CY \leftarrow XA - rp' - CY$		
		rp'1, XA	2	2	$rp'1, CY \leftarrow rp'1 - XA - CY$		
	AND	A, #n4	2	2	$A \leftarrow A \wedge n4$		
		A, @HL	1	1	$A \leftarrow A \wedge (HL)$	*1	
		XA, rp'	2	2	$XA \leftarrow XA \wedge rp'$		
		rp'1, XA	2	2	$rp'1 \leftarrow rp'1 \wedge XA$		
	OR	A, #n4	2	2	$A \leftarrow A \vee n4$		
		A, @HL	1	1	$A \leftarrow A \vee (HL)$	*1	
		XA, rp'	2	2	$XA \leftarrow XA \vee rp'$		
		rp'1, XA	2	2	$rp'1 \leftarrow rp'1 \vee XA$		
	XOR	A, #n4	2	2	$A \leftarrow A \vee n4$		
		A, @HL	1	1	$A \leftarrow A \vee (HL)$	*1	
XA, rp'		2	2	$XA \leftarrow XA \vee rp'$			
rp'1, XA		2	2	$rp'1 \leftarrow rp'1 \vee XA$			

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Accumulator manipulate	RORC	A	1	1	$CY \leftarrow A_0, A_3 \leftarrow CY, A_{n-1} \leftarrow A_n$		
	NOT	A	2	2	$A \leftarrow \overline{A}$		
Increment/decrement	INCS	reg	1	1 + S	$reg \leftarrow reg + 1$		reg = 0
		rp1	1	1 + S	$rp1 \leftarrow rp1 + 1$		rp1 = 00H
		@HL	2	2 + S	$(HL) \leftarrow (HL) + 1$	*1	(HL) = 0
		mem	2	2 + S	$(mem) \leftarrow (mem) + 1$	*3	(mem) = 0
	DECS	reg	1	1 + S	$reg \leftarrow reg - 1$		reg = FH
		rp'	2	2 + S	$rp' \leftarrow rp' - 1$		rp' = FFH
Compare	SKE	reg, #n4	2	2 + S	Skip if reg = n4		reg = n4
		@HL, #n4	2	2 + S	Skip if (HL) = n4	*1	(HL) = n4
		A, @HL	1	1 + S	Skip if A = (HL)	*1	A = (HL)
		XA, @HL	2	2 + S	Skip if XA = (HL)	*1	XA = (HL)
		A, reg	2	2 + S	Skip if A = reg		A = reg
		XA, rp'	2	2 + S	Skip if XA = rp'		XA = rp'
Carry flag manipulate	SET1	CY	1	1	$CY \leftarrow 1$		
	CLR1	CY	1	1	$CY \leftarrow 0$		
	SKT	CY	1	1 + S	Skip if CY = 1		CY = 1
	NOT1	CY	1	1	$CY \leftarrow \overline{CY}$		

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Memory bit manipulate	SET1	mem.bit	2	2	(mem.bit) ← 1	*3	
		fmem.bit	2	2	(fmem.bit) ← 1	*4	
		pmem.@L	2	2	(pmem7-2 + L3-2.bit(L1-0)) ← 1	*5	
		@H + mem.bit	2	2	(H + mem3-0.bit) ← 1	*1	
	CLR1	mem.bit	2	2	(mem.bit) ← 0	*3	
		fmem.bit	2	2	(fmem.bit) ← 0	*4	
		pmem.@L	2	2	(pmem7-2 + L3-2.bit(L1-0)) ← 0	*5	
		@H + mem.bit	2	2	(H + mem3-0.bit) ← 0	*1	
	SKT	mem.bit	2	2 + S	Skip if(mem.bit) = 1	*3	(mem.bit) = 1
		fmem.bit	2	2 + S	Skip if(fmem.bit) = 1	*4	(fmem.bit) = 1
		pmem.@L	2	2 + S	Skip if(pmем7-2 + L3-2.bit(L1-0)) = 1	*5	(pmem.@L) = 1
		@H + mem.bit	2	2 + S	Skip if(H + mem3-0.bit) = 1	*1	(@H + mem.bit) = 1
	SKF	mem.bit	2	2 + S	Skip if(mem.bit) = 0	*3	(mem.bit) = 0
		fmem.bit	2	2 + S	Skip if(fmem.bit) = 0	*4	(fmem.bit) = 0
		pmem.@L	2	2 + S	Skip if(pmем7-2 + L3-2.bit(L1-0)) = 0	*5	(pmem.@L) = 0
		@H + mem.bit	2	2 + S	Skip if(H + mem3-0.bit) = 0	*1	(@H + mem.bit) = 0
	SKTCLR	fmem.bit	2	2 + S	Skip if(fmem.bit) = 1 and clear	*4	(fmem.bit) = 1
		pmem.@L	2	2 + S	Skip if(pmем7-2 + L3-2.bit(L1-0)) = 1 and clear	*5	(pmem.@L) = 1
		@H + mem.bit	2	2 + S	Skip if(H + mem3-0.bit) = 1 and clear	*1	(@H + mem.bit) = 1
	AND1	CY, fmem.bit	2	2	CY ← CY ∧ (fmem.bit)	*4	
		CY, pmem.@L	2	2	CY ← CY ∧ (pmем7-2 + L3-2.bit(L1-0))	*5	
		CY, @H + mem.bit	2	2	CY ← CY ∧ (H + mem3-0.bit)	*1	
	OR1	CY, fmem.bit	2	2	CY ← CY ∨ (fmem.bit)	*4	
		CY, pmem.@L	2	2	CY ← CY ∨ (pmем7-2 + L3-2.bit(L1-0))	*5	
CY, @H + mem.bit		2	2	CY ← CY ∨ (H + mem3-0.bit)	*1		
XOR1	CY, fmem.bit	2	2	CY ← CY ⊕ (fmem.bit)	*4		
	CY, pmem.@L	2	2	CY ← CY ⊕ (pmем7-2 + L3-2.bit(L1-0))	*5		
	CY, @H + mem.bit	2	2	CY ← CY ⊕ (H + mem3-0.bit)	*1		



Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Branch	BR <b>Note 1</b>	addr	—	—	PC <sub>13-0</sub> ← addr ( Assembler selects the most appropriate instruction among the following: • BR !addr • BRCB !caddr • BR \$addr )	*6	
		addr1	—	—	PC <sub>13-0</sub> ← addr1 ( Assembler selects the most appropriate instruction among the following: • BRA !addr1 • BR !addr • BRCB !caddr • BR \$addr1 )	*11	
		!addr	3	3	PC <sub>13-0</sub> ← addr	*6	
		\$addr	1	2	PC <sub>13-0</sub> ← addr	*7	
		\$addr1	1	2	PC <sub>13-0</sub> ← addr1		
		PCDE	2	3	PC <sub>13-0</sub> ← PC <sub>13-8</sub> + DE		
		PCXA	2	3	PC <sub>13-0</sub> ← PC <sub>13-8</sub> + XA		
		BCDE	2	3	PC <sub>13-0</sub> ← BCDE <b>Note 2</b>	*6	
	BCXA	2	3	PC <sub>13-0</sub> ← BCXA <b>Note 2</b>	*6		
	BRA <b>Note 1</b>	!addr1	3	3	PC <sub>13-0</sub> ← addr1	*11	
	BRCB	!caddr	2	2	PC <sub>13-0</sub> ← PC <sub>13, 12</sub> + caddr <sub>11-0</sub>	*8	

- Notes** 1. Shaded areas indicate support for the Mk II mode only. Other areas indicate support for the Mk I mode only.  
 2. As for the B register, only the lower 2 bits are valid.

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Subroutine stack control	CALLA <b>Note</b>	!addr1	3	3	(SP - 5) ← 0, 0, PC <sub>13,12</sub> (SP - 6)(SP - 3)(SP - 4) ← PC <sub>11-0</sub> (SP - 2) ← X, X, MBE, RBE PC <sub>13-0</sub> ← addr1, SP ← SP - 6	*11	
	CALL <b>Note</b>	!addr	3	3	(SP - 4)(SP - 1)(SP - 2) ← PC <sub>11-0</sub> (SP - 3) ← (MBE, RBE, PC <sub>13, 12</sub> ) PC <sub>13-0</sub> ← addr, SP ← SP - 4	*6	
				4	(SP - 5) ← 0, 0, PC <sub>13,12</sub> (SP - 6)(SP - 3)(SP - 4) ← PC <sub>11-0</sub> (SP - 2) ← X, X, MBE, RBE PC <sub>13-0</sub> ← addr, SP ← SP - 6		
	CALLF <b>Note</b>	!faddr	2	2	(SP - 4)(SP - 1)(SP - 2) ← PC <sub>11-0</sub> (SP - 3) ← (MBE, RBE, PC <sub>13, 12</sub> ) PC <sub>13-0</sub> ← 000 + faddr, SP ← SP - 4	*9	
				3	(SP - 5) ← 0, 0, PC <sub>13,12</sub> (SP - 6)(SP - 3)(SP - 4) ← PC <sub>11-0</sub> (SP - 2) ← X, X, MBE, RBE PC <sub>13-0</sub> ← 000 + faddr, SP ← SP - 6		
	RET <b>Note</b>		1	3	(MBE, RBE, PC <sub>13, 12</sub> ) ← (SP + 1) PC <sub>11-0</sub> → (SP)(SP + 3)(SP + 2) SP ← SP + 4		
X, X, MBE, RBE ← (SP + 4) 0, 0, PC <sub>13-12</sub> ← (SP + 1) PC <sub>11-0</sub> ← (SP)(SP + 3)(SP + 2) SP ← SP + 6							
RETS <b>Note</b>		1	3 + S	(MBE, RBE, PC <sub>13, 12</sub> ) ← (SP + 1) PC <sub>11-0</sub> ← (SP)(SP + 3)(SP + 2) SP ← SP + 4 then skip unconditionally		Unconditional	
				X, X, MBE, RBE ← (SP + 4) 0, 0, PC <sub>13-12</sub> ← (SP + 1) PC <sub>11-0</sub> ← (SP)(SP + 3)(SP + 2) SP ← SP + 6 then skip unconditionally			
RETI <b>Note</b>		1	3	MBE, RBE, PC <sub>13, 12</sub> ← (SP + 1) PC <sub>11-0</sub> ← (SP)(SP + 3)(SP + 2) PSW ← (SP + 4)(SP + 5), SP ← SP + 6			
				0, 0, PC <sub>13, 12</sub> ← (SP + 1) PC <sub>11-0</sub> ← (SP)(SP + 3)(SP + 2) PSW ← (SP + 4)(SP + 5), SP ← SP + 6			

**Note** Shaded areas indicate support for the Mk II mode only. Other areas indicate support for the Mk I mode only.

Group	Mnemonic	Operand	No. of bytes	Machine cycle	Operation	Addressing area	Skip condition
Subroutine stack control	PUSH	rp	1	1	$(SP - 1)(SP - 2) \leftarrow rp, SP \leftarrow SP - 2$		
		BS	2	2	$(SP - 1) \leftarrow MBS, (SP - 2) \leftarrow RBS, SP \leftarrow SP - 2$		
	POP	rp	1	1	$rp \leftarrow (SP + 1)(SP), SP \leftarrow SP + 2$		
		BS	2	2	$MBS \leftarrow (SP + 1), RBS \leftarrow (SP), SP \leftarrow SP + 2$		
Interrupt control	EI		2	2	$IME(IPS.3) \leftarrow 1$		
		IE <sub>xxx</sub>	2	2	$IE_{xxx} \leftarrow 1$		
	DI		2	2	$IME(IPS.3) \leftarrow 0$		
		IE <sub>xxx</sub>	2	2	$IE_{xxx} \leftarrow 0$		
I/O	IN <sup>Note 1</sup>	A, PORT <sub>n</sub>	2	2	$A \leftarrow PORT_n \quad (n = 0 - 8)$		
		XA, PORT <sub>n</sub>	2	2	$XA \leftarrow PORT_{n+1}, PORT_n \quad (n = 4, 6)$		
	OUT <sup>Note 1</sup>	PORT <sub>n</sub> , A	2	2	$PORT_n \leftarrow A \quad (n = 2 - 8)$		
		PORT <sub>n</sub> , XA	2	2	$PORT_{n+1}, PORT_n \leftarrow XA \quad (n = 4, 6)$		
CPU control	HALT		2	2	Set HALT Mode( $PCC.2 \leftarrow 1$ )		
	STOP		2	2	Set STOP Mode( $PCC.3 \leftarrow 1$ )		
	NOP		1	1	No Operation		
Special	SEL	RB <sub>n</sub>	2	2	$RBS \leftarrow n \quad (n = 0 - 3)$		
		MB <sub>n</sub>	2	2	$MBS \leftarrow n \quad (n = 0, 1, 15)$		
	GETI <sup>Notes 2, 3</sup>	taddr	1	3	<ul style="list-style-type: none"> <li>When using TBR instruction</li> </ul> $PC_{13-0} \leftarrow (taddr)_{5-0} + (taddr + 1)$	*10	
				4	<ul style="list-style-type: none"> <li>When using TCALL instruction</li> </ul> $(SP - 4)(SP - 1)(SP - 2) \leftarrow PC_{11-0}$ $(SP - 3) \leftarrow MBE, RBE, PC_{13, 12}$ $PC_{13-0} \leftarrow (taddr)_{5-0} + (taddr + 1)$ $SP \leftarrow SP - 4$		
				3	<ul style="list-style-type: none"> <li>When using instruction other than TBR or TCALL</li> </ul> Execute (taddr)(taddr + 1) instructions		
			1	3	<ul style="list-style-type: none"> <li>When using TBR instruction</li> </ul> $PC_{13-0} \leftarrow (taddr)_{5-0} + (taddr + 1)$	*10	
4	<ul style="list-style-type: none"> <li>When using TCALL instruction</li> </ul> $(SP - 5) \leftarrow 0, 0, PC_{13, 12}$ $(SP - 6)(SP - 3)(SP - 4) \leftarrow PC_{11-0}$ $(SP - 2) \leftarrow \times, \times, MBE, RBE$ $PC_{13-0} \leftarrow (taddr)_{5-0} + (taddr + 1)$ $SP \leftarrow SP - 6$						
3	<ul style="list-style-type: none"> <li>When using instruction other than TBR or TCALL</li> </ul> Execute (taddr)(taddr + 1) instructions	Determined by referenced instruction					

- Notes**
- Before executing the IN or OUT instruction, set MBE to 0 or 1 and set MBS to 15.
  - TBR and TCALL are assembler directives for the GETI instruction's table definitions.
  - Shaded areas indicate support for the Mk II mode only. Other areas indicate support for the Mk I mode only.

### 8. ONE-TIME PROM (PROGRAM MEMORY) WRITE AND VERIFY

The program memory in the μPD75P0016 is a 16384 × 8-bit electronic write-enabled one-time PROM. The pins listed in the table below are used for this PROM's write/verify operations. Clock input from the X1 pins is used instead of address input as a method for updating addresses.

Pin name	Function
V <sub>PP</sub>	Pin (usually V <sub>DD</sub> ) where programming voltage is applied during program memory write/verify
X1, X2	Clock input pin for address updating during program memory write/verify. Input the X1 pin's inverted signal to the X2 pin.
MD0/P30-MD3/P33	Operation mode selection pin for program memory write/verify
D0/P40-D3/P43 (lower 4) D4/P50-D7/P53 (higher 4)	8-bit data I/O pin for program memory write/verify
V <sub>DD</sub>	Pin where power supply voltage is applied. Power voltage range for normal operation is 2.2 to 5.5 V. Apply 6.0 V for program memory write/verify.

★

**Caution** Pins not used for program memory write/verify should be processed as follows.

- All unused pins except XT2 ..... Connect to V<sub>SS</sub> via a pull-down resistor
- XT2 pin ..... Leave open

#### 8.1 Operation Modes for Program Memory Write/Verify

When +6 V is applied to the μPD75P0016's V<sub>DD</sub> pin and +12.5 V is applied to its V<sub>PP</sub> pin, program write/verify modes are in effect. Furthermore, the following detailed operation modes can be specified by setting pins MD0 to MD3 as shown below.

Operation mode specification						Operation mode
V <sub>PP</sub>	V <sub>DD</sub>	MD0	MD1	MD2	MD3	
+12.5 V	+6 V	H	L	H	L	Zero-clear program memory address
		L	H	H	H	Write mode
		L	L	H	H	Verify mode
		H	×	H	H	Program inhibit mode

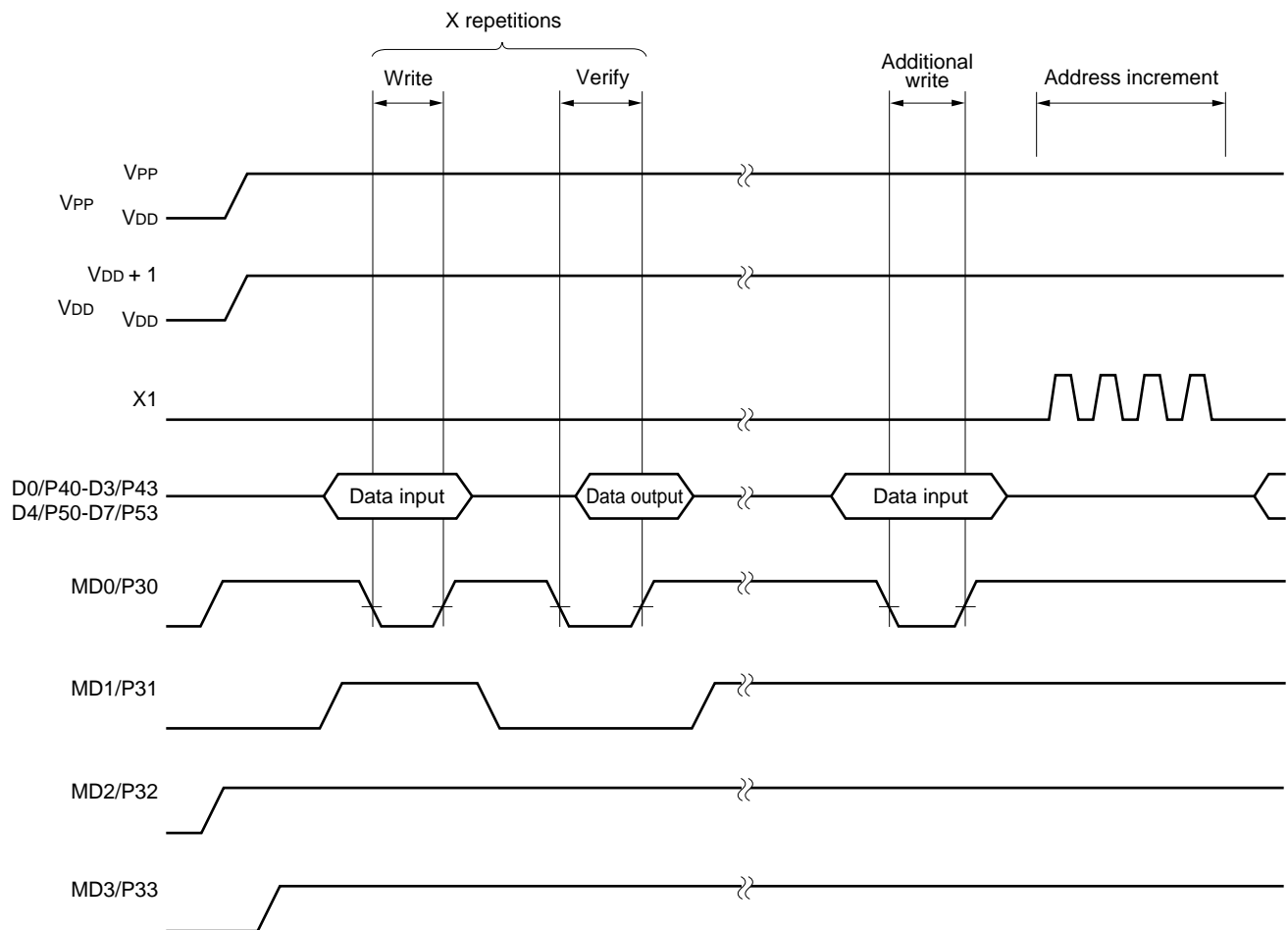
**Remark** ×: L or H

★ 8.2 Steps in Program Memory Write Operation

High-speed program memory write can be executed via the following steps.

- (1) Pull down unused pins to V<sub>SS</sub> via resistors. Set the X1 pin to low.
- (2) Apply +5 V to the V<sub>DD</sub> and V<sub>PP</sub> pins.
- (3) Wait 10 μs.
- (4) Zero-clear mode for program memory addresses.
- (5) Apply +6 V to V<sub>DD</sub> and +12.5 V power to V<sub>PP</sub>.
- (6) Write data using 1-ms write mode.
- (7) Verify mode. If write is verified, go to step (8) and if write is not verified, go back to steps (6) and (7).
- (8) X [= number of write operations from steps (6) and (7)] × 1 ms additional write
- (9) 4 pulse inputs to the X1 pin updates (increments +1) the program memory address.
- (10) Repeat steps (6) to (9) until the last address is completed.
- (11) Zero-clear mode for program memory addresses.
- (12) Apply +5 V to the V<sub>DD</sub> and V<sub>PP</sub> pins.
- (13) Power supply OFF

The following diagram illustrates steps (2) to (9).

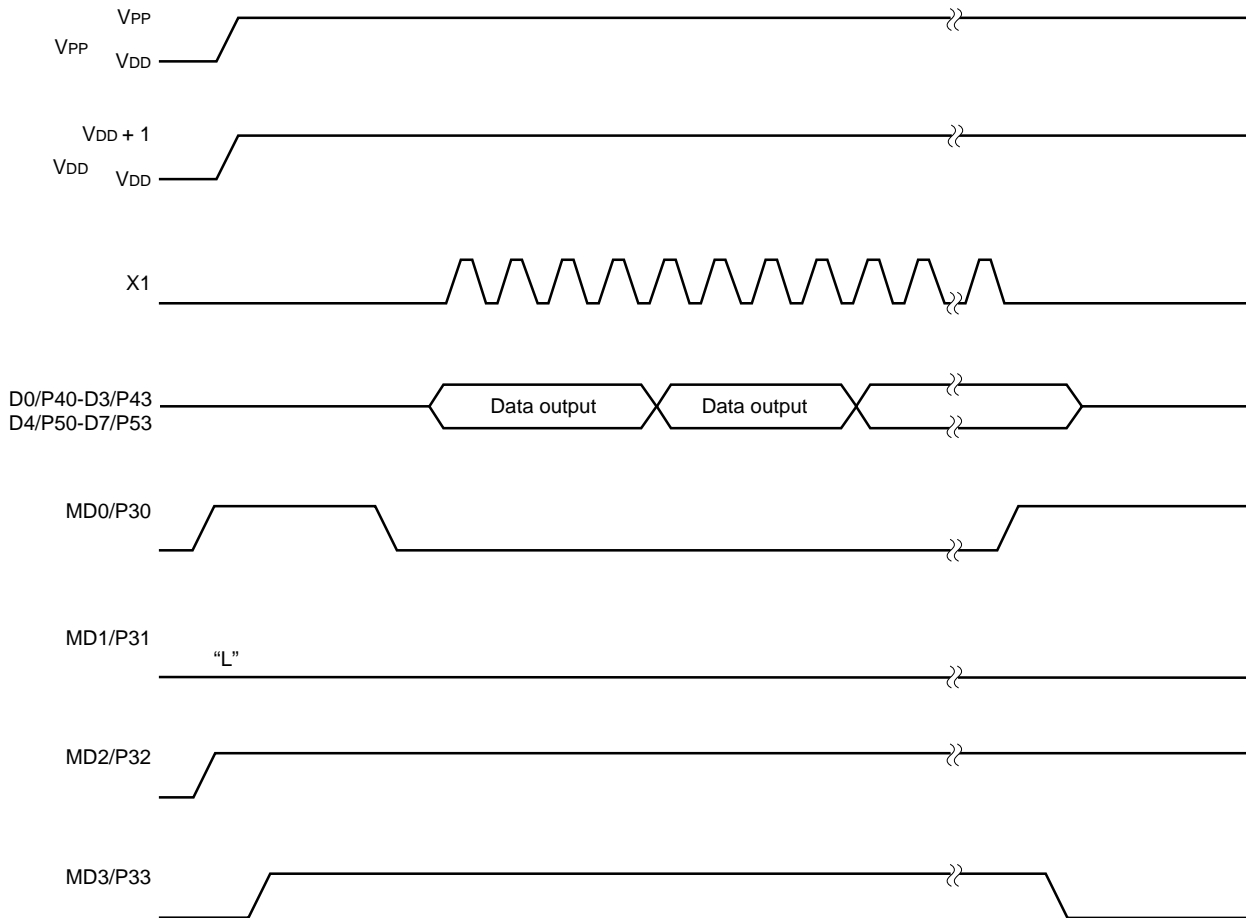


★ 8.3 Steps in Program Memory Read Operation

The μPD75P0016 can read out the program memory contents via the following steps.

- (1) Pull down unused pins to V<sub>SS</sub> via resistors. Set the X1 pin to low.
- (2) Apply +5 V to the V<sub>DD</sub> and V<sub>PP</sub> pins.
- (3) Wait 10 μs.
- (4) Zero-clear mode for program memory addresses.
- (5) Apply +6 V power to V<sub>DD</sub> and +12.5 V to V<sub>PP</sub>.
- (6) Verify mode. When a clock pulse is input to the X1 pin, data is output sequentially to one address at a time based on a cycle of four pulse inputs.
- (7) Zero-clear mode for program memory addresses.
- (8) Apply +5 V power to the V<sub>DD</sub> and V<sub>PP</sub> pins.
- (9) Power supply OFF

The following diagram illustrates steps (2) to (7).



#### 8.4 One-Time PROM Screening

Due to its structure, the one-time PROM cannot be fully tested before shipment by NEC. Therefore, NEC recommends the screening process, that is, after the required data is written to the PROM and the PROM is stored under the high-temperature conditions shown below, the PROM should be verified.

Storage temperature	Storage time
125°C	24 hours

- ★ At present, a fee is charged by NEC for one-time PROM after-programming imprinting, screening, and verify service for the QTOP Microcontroller. For details, contact your sales representative.

9. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V <sub>DD</sub>		-0.3 to +7.0	V
PROM supply voltage	V <sub>PP</sub>		-0.3 to + 13.5	V
Input voltage	V <sub>I1</sub>	Other than port 4, 5	-0.3 to V <sub>DD</sub> + 0.3	V
	V <sub>I2</sub>	Port 4, 5 (N-ch open drain)	-0.3 to + 14	V
Output voltage	V <sub>O</sub>		-0.3 to V <sub>DD</sub> + 0.3	V
High-level output current	I <sub>OH</sub>	Per pin	-10	mA
		Total of all pins	-30	mA
Low-level output current	I <sub>OL</sub>	Per pin	30	mA
		Total of all pins	220	mA
Operating ambient temperature	T <sub>A</sub>		-40 to +85	°C
Storage temperature	T <sub>stg</sub>		-65 to +150	°C

**Caution** If the absolute maximum rating of even one of the parameters is exceeded even momentarily, the quality of the product may be degraded. The absolute maximum ratings are therefore values which, when exceeded, can cause the product to be damaged. Be sure that these values are never exceeded when using the product.

Capacitance (T<sub>A</sub> = 25°C, V<sub>DD</sub> = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input capacitance	C <sub>IN</sub>	f = 1 MHz			15	pF
Output capacitance	C <sub>OUT</sub>	Pins other than tested pins: 0 V			15	pF
I/O capacitance	C <sub>IO</sub>				15	pF



Main System Clock Oscillation Circuit Characteristics (T<sub>A</sub> = - 40 to +85°C)

Resonator	Recommended constants	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillation frequency (f <sub>x</sub> ) <b>Note 1</b>	V <sub>DD</sub> = 2.2 to 5.5 V	1.0		6.0 <b>Note 2</b>	MHz
		Oscillation stabilization time <b>Note 3</b>	After V <sub>DD</sub> has reached MIN. value of oscillation voltage range			4	ms
Crystal resonator		Oscillation frequency (f <sub>x</sub> ) <b>Note 1</b>	V <sub>DD</sub> = 2.2 to 5.5 V	1.0		6.0 <b>Note 2</b>	MHz
		Oscillation stabilization time <b>Note 3</b>	V <sub>DD</sub> = 4.5 to 5.5 V			10	ms
			V <sub>DD</sub> = 2.2 to 5.5 V			30	ms
★ External clock		X1 input frequency (f <sub>x</sub> ) <b>Note 1</b>	V <sub>DD</sub> = 1.8 to 5.5 V	1.0		6.0 <b>Note 4</b>	MHz
★		X1 input high-, low-level widths (t <sub>xH</sub> , t <sub>xL</sub> )	V <sub>DD</sub> = 1.8 to 5.5 V	83.3		500	ns

**Notes 1.** The oscillation frequency and X1 input frequency shown above indicate characteristics of the oscillation circuit only. For the instruction execution time, refer to AC Characteristics.

- ★ **2.** If the oscillation frequency is 4.7 MHz < f<sub>x</sub> ≤ 6.0 MHz at 2.2 V ≤ V<sub>DD</sub> < 2.7 V of the supply voltage, please do not set processor clock control register (PCC) = 0011. If PCC = 0011, one machine cycle is less than 0.85 μs, falling short of the rated value of 0.85 μs.
- 3.** The oscillation stabilization time is the time required for oscillation to be stabilized after V<sub>DD</sub> has been applied or STOP mode has been released.
- ★ **4.** If the X1 input frequency is 4.19 MHz < f<sub>x</sub> ≤ 6.0 MHz at 1.8 V ≤ V<sub>DD</sub> < 2.7 V of the supply voltage, please do not set PCC = 0011. If PCC = 0011, one machine cycle time is less than 0.95 μs, falling short of the rated value of 0.95 μs.

**Caution** When using the main system clock oscillation circuit, wire the portion enclosed in the dotted line in the above figure as follows to prevent adverse influences due to wiring capacitance:

- Keep the wiring length as short as possible.
- Do not cross the wiring with other signal lines.
- Do not route the wiring in the vicinity of a line through which a high alternating current flows.
- Always keep the ground point of the capacitor of the oscillation circuit at the same potential as V<sub>DD</sub>.  
Do not ground to a power supply pattern through which a high current flows.
- Do not extract signals from the oscillation circuit.

**Subsystem Clock Oscillation Circuit Characteristics (T<sub>A</sub> = -40 to +85°C)**

Resonator	Recommended constants	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Crystal resonator		Oscillation frequency (f <sub>XT</sub> ) <sup>Note 1</sup>	V <sub>DD</sub> = 2.2 to 5.5 V	32	32.768	35	kHz
		Oscillation stabilization time <sup>Note 2</sup>	V <sub>DD</sub> = 4.5 to 5.5 V		1.0	2	s
			V <sub>DD</sub> = 2.2 to 5.5 V				10
External clock		XT1 input frequency (f <sub>XT</sub> ) <sup>Note 1</sup>	V <sub>DD</sub> = 1.8 to 5.5 V	32		100	kHz
		XT1 input high-, low-level widths (t <sub>XTH</sub> , t <sub>XTL</sub> )	V <sub>DD</sub> = 1.8 to 5.5 V	5		15	μs

- Notes 1.** The oscillation frequency shown above indicate characteristics of the oscillation circuit only. For the instruction execution time, refer to AC Characteristics.
- 2.** The oscillation stabilization time is the time required for oscillation to be stabilized after V<sub>DD</sub> has been applied.

**Caution** When using the subsystem clock oscillation circuit, wire the portion enclosed in the dotted line in the above figure as follows to prevent adverse influences due to wiring capacitance:

- Keep the wiring length as short as possible.
  - Do not cross the wiring with other signal lines.
  - Do not route the wiring in the vicinity of a line through which a high alternating current flows.
  - Always keep the ground point of the capacitor of the oscillation circuit at the same potential as V<sub>DD</sub>.
- Do not ground to a power supply pattern through which a high current flows.
- Do not extract signals from the oscillation circuit.

The subsystem clock oscillation circuit has a low amplification factor to reduce current dissipation and is more susceptible to noise than the main system clock oscillation circuit. Therefore, exercise utmost care in wiring the subsystem clock oscillation circuit.

★ **RECOMMENDED OSCILLATION CIRCUIT CONSTANT**

**Main System Clock: Ceramic Resonator (T<sub>A</sub> = -40 to +85°C)**

Manufacturer	Part Number	Frequency (MHz)	Oscillation Circuit Constant (pF)		Oscillation Voltage Range (V <sub>DD</sub> )		Remark
			C1	C2	MIN. (V)	MAX. (V)	
TDK Corp.	CCR4.0MC32	4.0	10	10	2.3	5.5	—

**Caution** The oscillation circuit constants and oscillation voltage range indicate conditions for stable oscillation but do not guarantee accuracy of the oscillation frequency. If the application circuit requires accuracy of the oscillation frequency, it is necessary to set the oscillation frequency of the resonator in the application circuit. For this, it is necessary to directly contact the manufacturer of the resonator being used.

DC Characteristics (T<sub>A</sub> = -40 to + 85°C, V<sub>DD</sub> = 2.2 to 5.5 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit	
Low-level output current	I <sub>OL</sub>	Per pin				15	mA	
		Total of all pins				150	mA	
High-level input voltage	V <sub>IH1</sub>	Ports 2, 3, 8	2.7 ≤ V <sub>DD</sub> ≤ 5.5 V	0.7 V <sub>DD</sub>		V <sub>DD</sub>	V	
			2.2 ≤ V <sub>DD</sub> ≤ 2.7 V	0.9 V <sub>DD</sub>		V <sub>DD</sub>	V	
	V <sub>IH2</sub>	Ports 0, 1, 6, 7, $\overline{\text{RESET}}$	2.7 ≤ V <sub>DD</sub> ≤ 5.5 V	0.8 V <sub>DD</sub>		V <sub>DD</sub>	V	
			2.2 ≤ V <sub>DD</sub> ≤ 2.7 V	0.9 V <sub>DD</sub>		V <sub>DD</sub>	V	
	V <sub>IH3</sub>	Ports 4, 5 (N-ch open drain)	2.7 ≤ V <sub>DD</sub> ≤ 5.5 V	0.7 V <sub>DD</sub>		13	V	
			2.2 ≤ V <sub>DD</sub> ≤ 2.7 V	0.9 V <sub>DD</sub>		13	V	
V <sub>IH4</sub>	X1, XT1		V <sub>DD</sub> -0.1		V <sub>DD</sub>	V		
Low-level input voltage	V <sub>IL1</sub>	Ports 2-5, 8	2.7 ≤ V <sub>DD</sub> ≤ 5.5 V	0		0.3 V <sub>DD</sub>	V	
			2.2 ≤ V <sub>DD</sub> ≤ 2.7 V	0		0.1 V <sub>DD</sub>	V	
	V <sub>IL2</sub>	Ports 0, 1, 6, 7, $\overline{\text{RESET}}$	2.7 ≤ V <sub>DD</sub> ≤ 5.5 V	0		0.2 V <sub>DD</sub>	V	
			2.2 ≤ V <sub>DD</sub> ≤ 2.7 V	0		0.1 V <sub>DD</sub>	V	
	V <sub>IL3</sub>	X1, XT1		0		0.1	V	
High-level output voltage	V <sub>OH</sub>	$\overline{\text{SCK}}$ , SO, ports 2, 3, 6-8 I <sub>OH</sub> = -1.0 mA		V <sub>DD</sub> -0.5			V	
Low-level output voltage	V <sub>OL1</sub>	$\overline{\text{SCK}}$ , SO, ports 2-8	I <sub>OL</sub> = 15 mA, V <sub>DD</sub> = 4.5 to 5.5 V		0.2	2.0	V	
			I <sub>OL</sub> = 1.6 mA			0.4	V	
V <sub>OL2</sub>	SB0, SB1	N-ch open drain Pull-up resistor ≥ 1 kΩ				0.2 V <sub>DD</sub>	V	
High-level input leakage current	I <sub>LIH1</sub>	V <sub>IN</sub> = V <sub>DD</sub>	Pins other than X1 and XT1			3	μA	
	I <sub>LIH2</sub>		X1, XT1			20	μA	
	I <sub>LIH3</sub>	V <sub>IN</sub> = 13 V	Ports 4, 5 (N-ch open drain)			20	μA	
Low-level input leakage current	I <sub>LIL1</sub>	V <sub>IN</sub> = 0 V	Pins other than ports 4, 5, X1 and XT1			-3	μA	
	I <sub>LIL2</sub>		X1, XT1			-20	μA	
	I <sub>LIL3</sub>		Ports 4, 5 (N-ch open drain) When input instruction is not executed				-3	μA
			Ports 4, 5 (N-ch open drain) When input instruction is executed	V <sub>DD</sub> = 5.0 V		-10	-27	μA
				V <sub>DD</sub> = 3.0 V		-3	-8	μA
High-level output leakage current	I <sub>LOH1</sub>	V <sub>OUT</sub> = V <sub>DD</sub>	$\overline{\text{SCK}}$ , SO/SB0, SB1, Ports 2, 3, 6-8			3	μA	
	I <sub>LOH2</sub>	V <sub>OUT</sub> = 13 V	Ports 4, 5 (N-ch open drain)			20	μA	
Low-level output leakage current	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V				-3	μA	
Internal pull-up resistor	R <sub>L</sub>	V <sub>IN</sub> = 0 V	Ports 0-3, 6-8 (except P00 pin)		50	100	200	kΩ

★

DC Characteristics (T<sub>A</sub> = -40 to + 85 °C, V<sub>DD</sub> = 2.2 to 5.5 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit		
Supply current <sup>Note 1</sup>	I <sub>DD1</sub>	6.0 MHz <sup>Note 2</sup> crystal oscillation C1 = C2 = 22 pF	V <sub>DD</sub> = 5.0 V ± 10 % <sup>Note 3</sup>			3.7	11.0	mA	
			V <sub>DD</sub> = 3.0 V ± 10 % <sup>Note 4</sup>			0.73	2.2	mA	
	I <sub>DD2</sub>		HALT mode	V <sub>DD</sub> = 5.0 V ± 10 %		0.92	2.6	mA	
				V <sub>DD</sub> = 3.0 V ± 10 %		0.3	0.9	mA	
	I <sub>DD1</sub>	4.19 MHz <sup>Note 2</sup> crystal oscillation C1 = C2 = 22 pF	V <sub>DD</sub> = 5.0 V ± 10 % <sup>Note 3</sup>			2.7	8.0	mA	
			V <sub>DD</sub> = 3.0 V ± 10 % <sup>Note 4</sup>			0.57	1.7	mA	
	I <sub>DD2</sub>		HALT mode	V <sub>DD</sub> = 5.0 V ± 10 %		0.9	2.5	mA	
				V <sub>DD</sub> = 3.0 V ± 10 %		0.28	0.8	mA	
	I <sub>DD3</sub>	32.768 kHz <sup>Note 5</sup> crystal oscillation	Low-voltage mode <sup>Note 6</sup>	V <sub>DD</sub> = 3.0 V ± 10 %		42	126	μA	
				V <sub>DD</sub> = 2.5 V ± 10 %		23	69	μA	
				V <sub>DD</sub> = 3.0 V, T <sub>A</sub> = 25 °C		42	84	μA	
			Low current dissipation mode <sup>Note 7</sup>	V <sub>DD</sub> = 3.0 V ± 10 %		39	117	μA	
				V <sub>DD</sub> = 3.0 V, T <sub>A</sub> = 25 °C		39	78	μA	
	I <sub>DD4</sub>		HALT mode	Low-voltage mode <sup>Note 6</sup>	V <sub>DD</sub> = 3.0 V ± 10 %		8.5	25	μA
					V <sub>DD</sub> = 2.5 V ± 10 %		5.0	15	μA
V <sub>DD</sub> = 3.0 V, T <sub>A</sub> = 25 °C						8.5	17	μA	
Low current consumption mode <sup>Note 7</sup>			V <sub>DD</sub> = 3.0 V ± 10 %		3.5	12	μA		
	V <sub>DD</sub> = 3.0 V, T <sub>A</sub> = 25 °C		3.5	7	μA				
I <sub>DD5</sub>	XT1 = 0V <sup>Note 8</sup> STOP mode	V <sub>DD</sub> = 5.0 V ± 10 %			0.05	10	μA		
		V <sub>DD</sub> = 3.0 V ± 10 %		0.02	5	μA			
			T <sub>A</sub> = 25 °C		0.02	3	μA		

- Notes**
- The current flowing through the internal pull-up resistor is not included.
  - Including the case when the subsystem clock oscillates.
  - When the device operates in high-speed mode with the processor clock control register (PCC) set to 0011.
  - When the device operates in low-speed mode with PCC set to 0000.
  - When the device operates on the subsystem clock, with the system clock control register (SCC) set to 1001 and oscillation of the main system clock stopped.
  - When the suboscillation circuit control register (SOS) is set to 0000.
  - When SOS is set to 0010.
  - When SOS is set to 00×1, and the suboscillation circuit feedback resistor is not used (×: don't care).

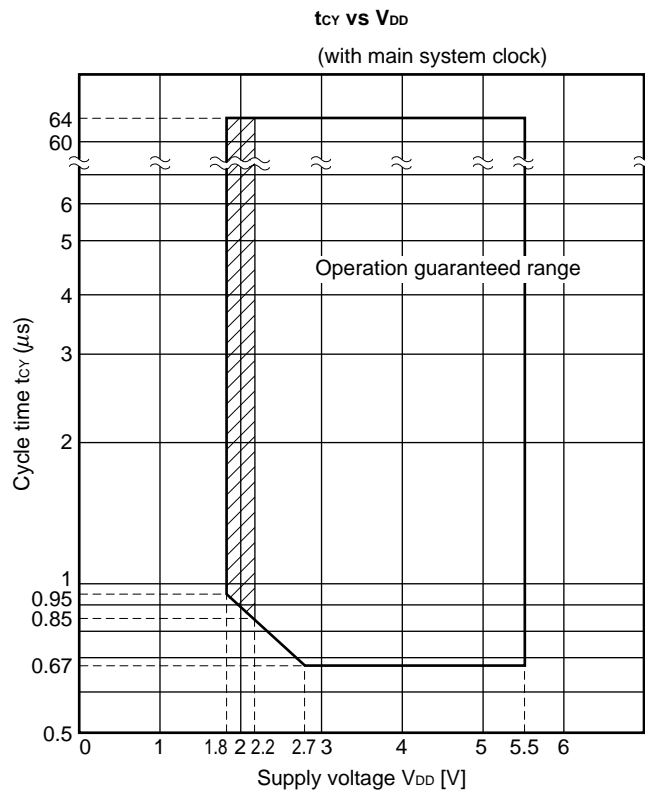
★

AC Characteristics (T<sub>A</sub> = -40 to + 85°C, V<sub>DD</sub> = 2.2 to 5.5 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit	
★ CPU clock cycle time <sup>Note 1</sup> (minimum instruction execution time = 1 machine cycle)	t <sub>cy</sub>	Operates with main system clock	with ceramic oscillator or crystal resonator	V <sub>DD</sub> = 2.7 to 5.5 V	0.67	64	μs	
					0.85	64	μs	
			with external clock	V <sub>DD</sub> = 2.7 to 5.5 V	0.67	64	μs	
				V <sub>DD</sub> = 1.8 to 5.5 V	0.95	64	μs	
		Operates with subsystem clock		114	122	125	μs	
TI0 input frequency	f <sub>TI</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		0		1.0	MHz	
				0		275	kHz	
TI0 high-, low-level widths	t <sub>TIH</sub> , t <sub>TIL</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		0.48			μs	
				1.8			μs	
★ Interrupt input high-, low-level widths	t <sub>INTH</sub> , t <sub>INTL</sub>	INT0	IM02 = 0	<b>Note 2</b>			μs	
			IM02 = 1	10			μs	
		INT1, 2, 4			10			μs
		KR0-KR7			10			μs
RESET low-level width	t <sub>RSL</sub>			10			μs	

**Notes 1.** The cycle time of the CPU clock (Φ) is determined by the oscillation frequency of the connected resonator (and external clock), the system clock control register (SCC), and processor clock control register (PCC). The figure on the right shows the supply voltage V<sub>DD</sub> vs. cycle time t<sub>cy</sub> characteristics when the device operates with the main system clock.

**2.** 2t<sub>cy</sub> or 128/f<sub>x</sub> depending on the setting of the interrupt mode register (IM0).



**Remark** Shaded area indicates operation when external clock is used.

**Serial Transfer Operation**

**2-wire and 3-wire serial I/O modes ( $\overline{\text{SCK}}$  ... internal clock output): ( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 2.2$  to  $5.5$  V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK}}$ cycle time	$t_{\text{KCY1}}$	$V_{DD} = 2.7$ to $5.5$ V	1300			ns
			3800			ns
$\overline{\text{SCK}}$ high-, low-level widths	$t_{\text{KL1}}$ , $t_{\text{KH1}}$	$V_{DD} = 2.7$ to $5.5$ V	$t_{\text{KCY1}}/2-50$			ns
			$t_{\text{KCY1}}/2-150$			ns
SI <sup>Note 1</sup> setup time (vs. $\overline{\text{SCK}}$ ↑)	$t_{\text{SIK1}}$	$V_{DD} = 2.7$ to $5.5$ V	150			ns
			500			ns
SI <sup>Note 1</sup> hold time (vs. $\overline{\text{SCK}}$ ↑)	$t_{\text{KSI1}}$	$V_{DD} = 2.7$ to $5.5$ V	400			ns
			600			ns
$\overline{\text{SCK}}$ ↓ → SO <sup>Note 1</sup> output delay time	$t_{\text{KSO1}}$	$R_L = 1$ kΩ <sup>Note 2</sup> $C_L = 100$ pF	$V_{DD} = 2.7$ to $5.5$ V		250	ns
				0		1000

- Notes 1.** Read as SB0 or SB1 when using the 2-wire serial I/O mode.  
**2.**  $R_L$  and  $C_L$  respectively indicate the load resistance and load capacitance of the SO output line.

**2-wire and 3-wire serial I/O modes ( $\overline{\text{SCK}}$  ... external clock input): ( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 2.2$  to  $5.5$  V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK}}$ cycle time	$t_{\text{KCY2}}$	$V_{DD} = 2.7$ to $5.5$ V	800			ns
			3200			ns
$\overline{\text{SCK}}$ high-, low-level widths	$t_{\text{KL2}}$ , $t_{\text{KH2}}$	$V_{DD} = 2.7$ to $5.5$ V	400			ns
			1600			ns
SI <sup>Note 1</sup> setup time (vs. $\overline{\text{SCK}}$ ↑)	$t_{\text{SIK2}}$	$V_{DD} = 2.7$ to $5.5$ V	100			ns
			150			ns
SI <sup>Note 1</sup> hold time (vs. $\overline{\text{SCK}}$ ↑)	$t_{\text{KSI2}}$	$V_{DD} = 2.7$ to $5.5$ V	400			ns
			600			ns
$\overline{\text{SCK}}$ ↓ → SO <sup>Note 1</sup> output delay time	$t_{\text{KSO2}}$	$R_L = 1$ kΩ <sup>Note 2</sup> $C_L = 100$ pF	$V_{DD} = 2.7$ to $5.5$ V		300	ns
				0		1000

- Notes 1.** Read as SB0 or SB1 when using the 2-wire serial I/O mode.  
**2.**  $R_L$  and  $C_L$  respectively indicate the load resistance and load capacitance of the SO output line.

**SBI mode ( $\overline{\text{SCK}}$  ... internal clock output (master)): ( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 2.2$  to  $5.5$  V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK}}$ cycle time	$t_{\text{KCY3}}$	$V_{DD} = 2.7$ to $5.5$ V	1300			ns
			3800			ns
$\overline{\text{SCK}}$ high-, low-level widths	$t_{\text{KL3}}$	$V_{DD} = 2.7$ to $5.5$ V	$t_{\text{KCY3}}/2-50$			ns
	$t_{\text{KH3}}$		$t_{\text{KCY3}}/2-150$			ns
SB0, 1 setup time (vs. $\overline{\text{SCK}}$ $\uparrow$ )	$t_{\text{SIK3}}$	$V_{DD} = 2.7$ to $5.5$ V	150			ns
			500			ns
SB0, 1 hold time (vs. $\overline{\text{SCK}}$ $\uparrow$ )	$t_{\text{KSI3}}$		$t_{\text{KCY3}}/2$			ns
$\overline{\text{SCK}}$ $\downarrow \rightarrow$ SB0, 1 output delay time	$t_{\text{KSO3}}$	$R_L = 1$ k $\Omega$ Note $C_L = 100$ pF	$V_{DD} = 2.7$ to $5.5$ V	0	250	ns
				0	1000	ns
$\overline{\text{SCK}}$ $\uparrow \rightarrow$ SB0, 1 $\downarrow$	$t_{\text{KSB}}$		$t_{\text{KCY3}}$			ns
SB0, 1 $\downarrow \rightarrow \overline{\text{SCK}}$ $\downarrow$	$t_{\text{SBK}}$		$t_{\text{KCY3}}$			ns
SB0, 1 low-level width	$t_{\text{SBL}}$		$t_{\text{KCY3}}$			ns
SB0, 1 high-level width	$t_{\text{SBH}}$		$t_{\text{KCY3}}$			ns

**Note**  $R_L$  and  $C_L$  respectively indicate the load resistance and load capacitance of the SB0 and 1 output lines.

**SBI mode ( $\overline{\text{SCK}}$  ... external clock input (slave)): ( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 2.2$  to  $5.5$  V)**

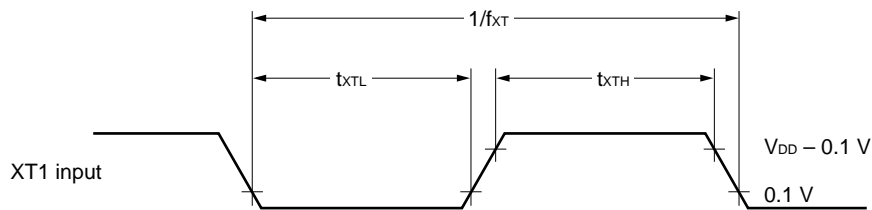
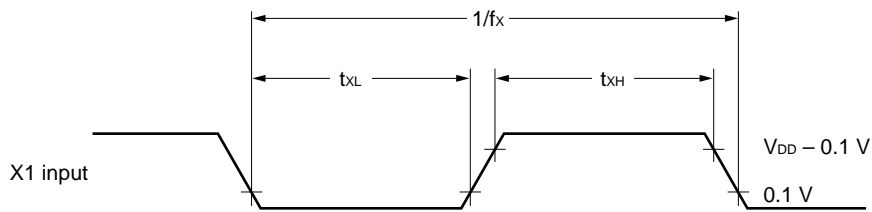
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK}}$ cycle time	$t_{\text{KCY4}}$	$V_{DD} = 2.7$ to $5.5$ V	800			ns
			3200			ns
$\overline{\text{SCK}}$ high-, low-level widths	$t_{\text{KL4}}$	$V_{DD} = 2.7$ to $5.5$ V	400			ns
	$t_{\text{KH4}}$		1600			ns
SB0, 1 setup time (vs. $\overline{\text{SCK}}$ $\uparrow$ )	$t_{\text{SIK4}}$	$V_{DD} = 2.7$ to $5.5$ V	100			ns
			150			ns
SB0, 1 hold time (vs. $\overline{\text{SCK}}$ $\uparrow$ )	$t_{\text{KSI4}}$		$t_{\text{KCY4}}/2$			ns
$\overline{\text{SCK}}$ $\downarrow \rightarrow$ SB0, 1 output delay time	$t_{\text{KSO4}}$	$R_L = 1$ k $\Omega$ Note $C_L = 100$ pF	$V_{DD} = 2.7$ to $5.5$ V	0	300	ns
				0	1000	ns
$\overline{\text{SCK}}$ $\uparrow \rightarrow$ SB0, 1 $\downarrow$	$t_{\text{KSB}}$		$t_{\text{KCY4}}$			ns
SB0, 1 $\downarrow \rightarrow \overline{\text{SCK}}$ $\downarrow$	$t_{\text{SBK}}$		$t_{\text{KCY4}}$			ns
SB0, 1 low-level width	$t_{\text{SBL}}$		$t_{\text{KCY4}}$			ns
SB0, 1 high-level width	$t_{\text{SBH}}$		$t_{\text{KCY4}}$			ns

**Note**  $R_L$  and  $C_L$  respectively indicate the load resistance and load capacitance of the SB0 and 1 output lines.

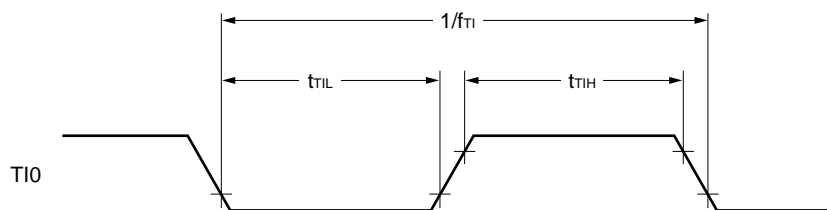
★ AC Timing Test Points (except X1 and XT1 inputs)



★ Clock timing



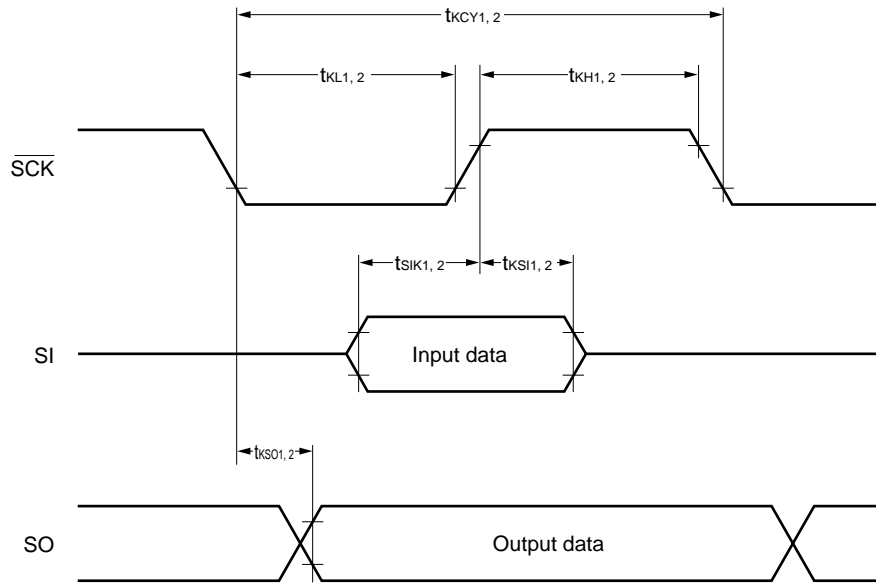
T10 timing



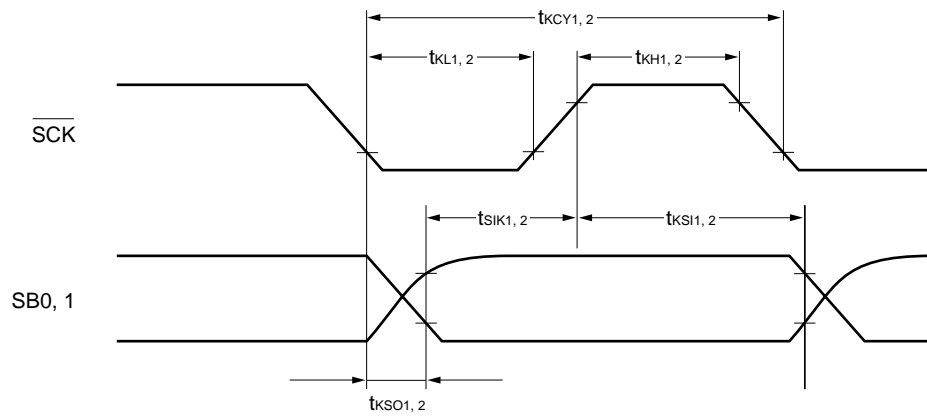


Serial Transfer Timing

3-wire serial I/O mode

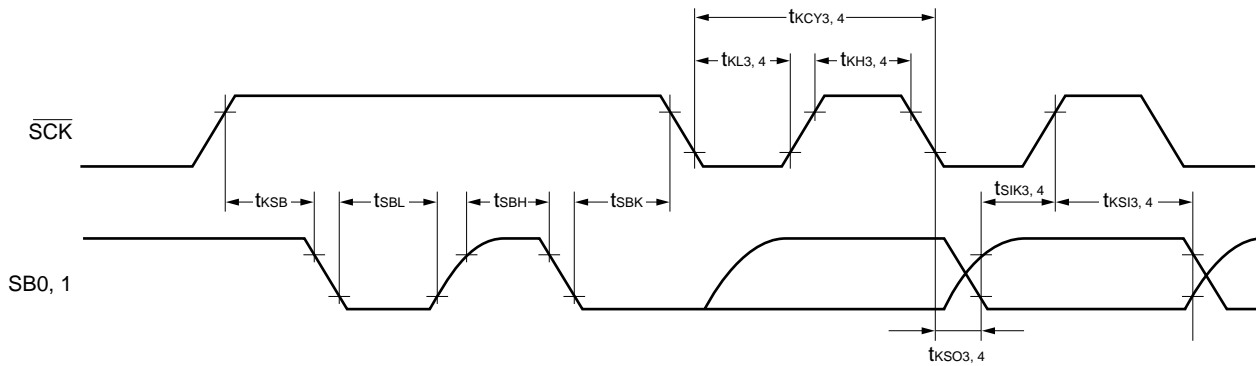


2-wire serial I/O mode

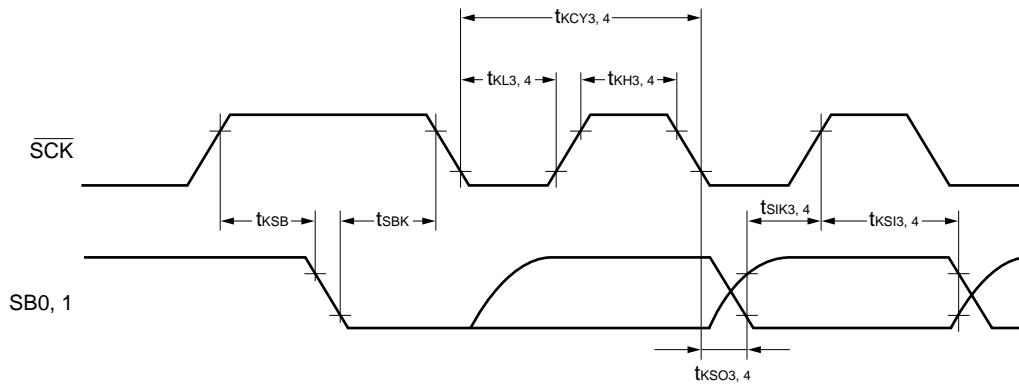


Serial Transfer Timing

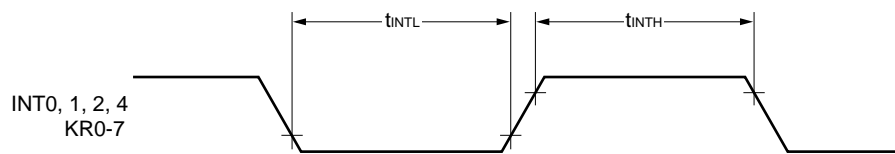
Bus release signal transfer



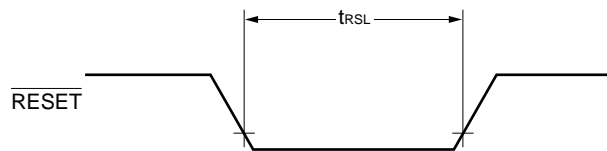
Command signal transfer



Interrupt input timing



RESET input timing



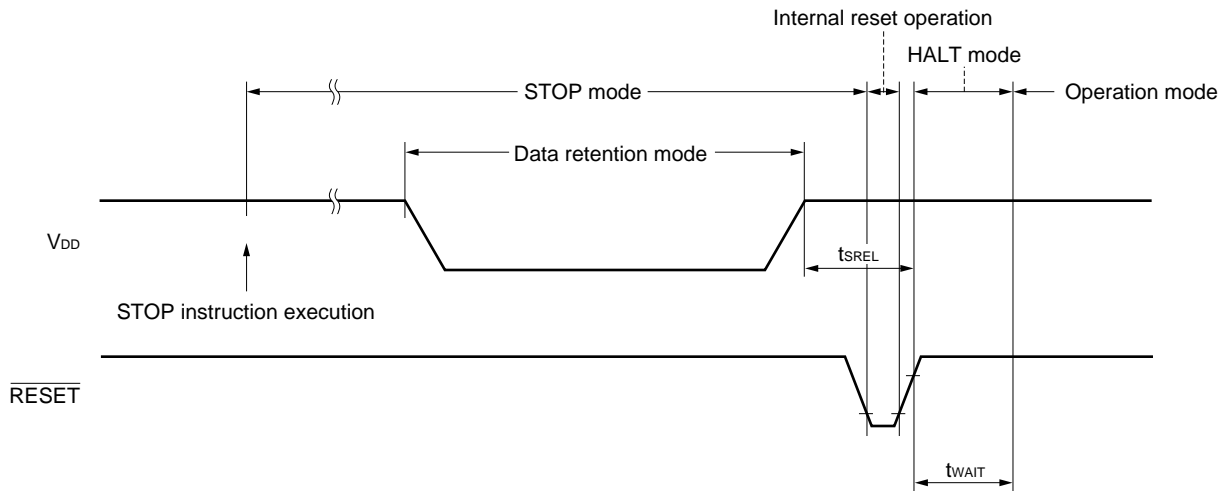
**Data Retention Characteristics of Data Memory in STOP Mode and at Low Supply Voltage**  
 (T<sub>A</sub> = -40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Release signal setup time	t <sub>SREL</sub>		0			μs
Oscillation stabilization wait time <b>Note 1</b>	t <sub>WAIT</sub>	Released by $\overline{\text{RESET}}$		2 <sup>15</sup> /f <sub>x</sub>		ms
		Released by interrupt request		<b>Note 2</b>		ms

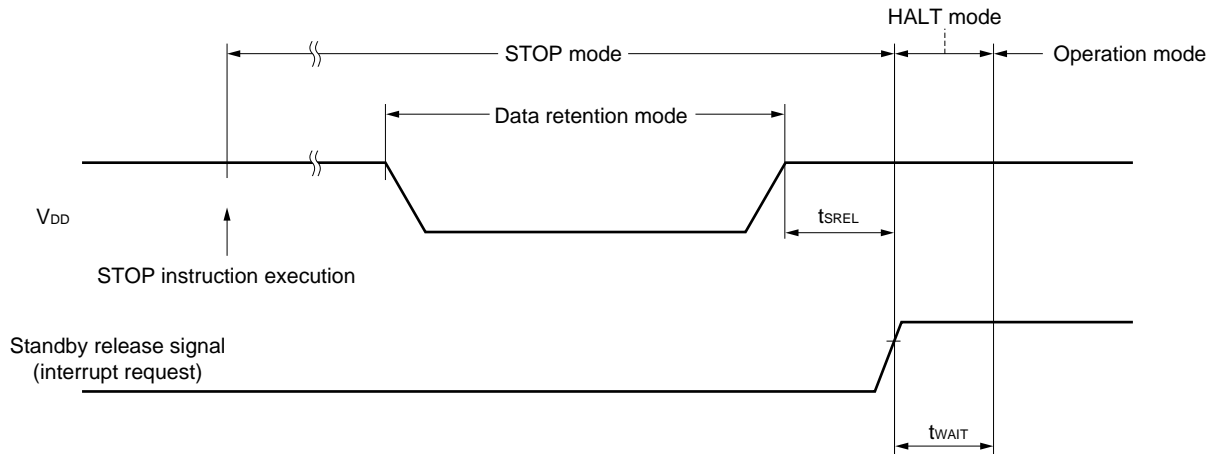
- Notes 1.** The oscillation stabilization wait time is the time during which the CPU stops operating to prevent unstable operation when oscillation is started.
- 2.** Set by the basic interval timer mode register (BTM). (Refer to the **table** below.)

BTM3	BTM2	BTM1	BTM0	Wait Time	
				f <sub>x</sub> = 4.19 MHz	f <sub>x</sub> = 6.0 MHz
-	0	0	0	2 <sup>20</sup> /f <sub>x</sub> (approx. 250 ms)	2 <sup>20</sup> /f <sub>x</sub> (approx. 175 ms)
-	0	1	1	2 <sup>17</sup> /f <sub>x</sub> (approx. 31.3 ms)	2 <sup>17</sup> /f <sub>x</sub> (approx. 21.8 ms)
-	1	0	1	2 <sup>15</sup> /f <sub>x</sub> (approx. 7.81 ms)	2 <sup>15</sup> /f <sub>x</sub> (approx. 5.46 ms)
-	1	1	1	2 <sup>13</sup> /f <sub>x</sub> (approx. 1.95 ms)	2 <sup>13</sup> /f <sub>x</sub> (approx. 1.37 ms)

**Data retention timing (when STOP mode released by  $\overline{\text{RESET}}$ )**



**Data retention timing (standby release signal: when STOP mode released by interrupt signal)**



**DC Programming Characteristics (T<sub>A</sub> = 25 ± 5°C, V<sub>DD</sub> = 6.0 ± 0.25 V, V<sub>PP</sub> = 12.5 ± 0.3 V, V<sub>SS</sub> = 0V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input voltage, high	V <sub>IH1</sub>	Other than X1, X2 pins	0.7 V <sub>DD</sub>		V <sub>DD</sub>	V
	V <sub>IH2</sub>	X1, X2	V <sub>DD</sub> - 0.5		V <sub>DD</sub>	V
Input voltage, low	V <sub>IL1</sub>	Other than X1, X2 pins	0		0.3 V <sub>DD</sub>	V
	V <sub>IL2</sub>	X1, X2	0		0.4	V
Input leakage current	I <sub>LI</sub>	V <sub>IN</sub> = V <sub>IL</sub> or V <sub>IH</sub>			10	μA
Output voltage, high	V <sub>OH</sub>	I <sub>OH</sub> = - 1 mA	V <sub>DD</sub> - 1.0			V
Output voltage, low	V <sub>OL</sub>	I <sub>OL</sub> = 1.6 mA			0.4	V
V <sub>DD</sub> supply current	I <sub>DD</sub>				30	mA
V <sub>PP</sub> supply current	I <sub>PP</sub>	MD0 = V <sub>IL</sub> , MD1 = V <sub>IH</sub>			30	mA

- Cautions**
1. Keep V<sub>PP</sub> to within +13.5 V, including overshoot.
  2. Apply V<sub>DD</sub> before V<sub>PP</sub> and turn it off after V<sub>PP</sub>.

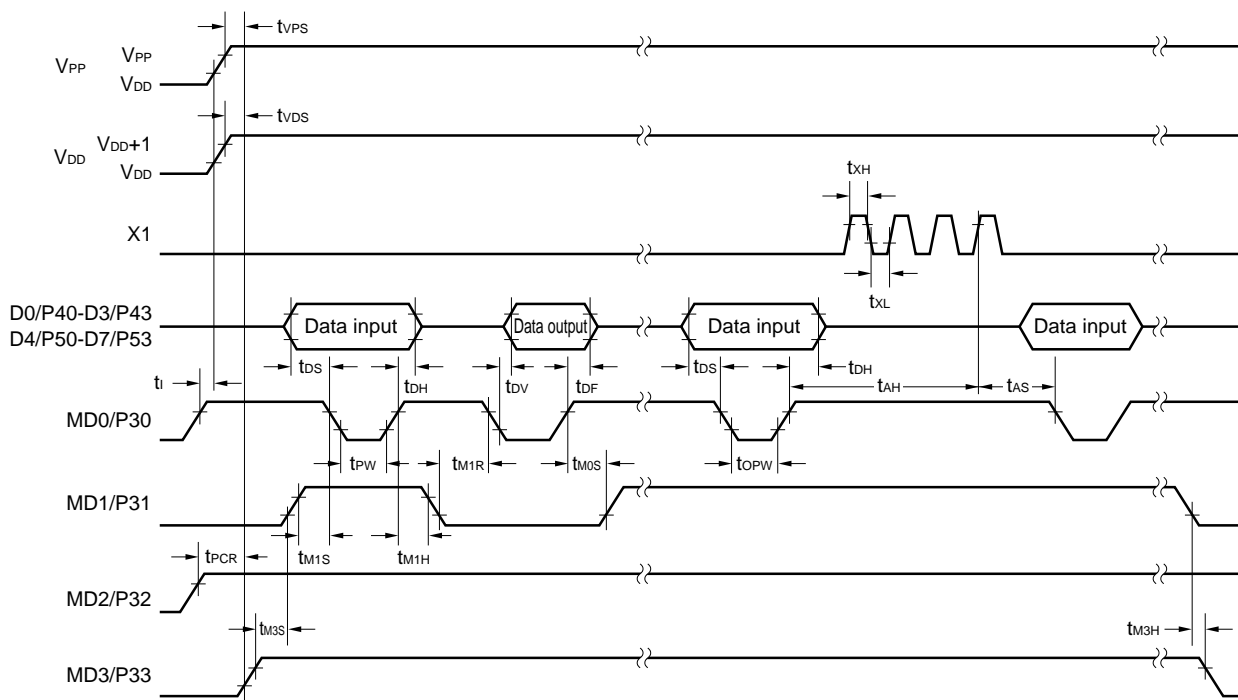
**AC Programming Characteristics (T<sub>A</sub> = 25 ± 5°C, V<sub>DD</sub> = 6.0 ± 0.25 V, V<sub>PP</sub> = 12.5 ± 0.3 V, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Note 1	Conditions	MIN.	TYP.	MAX.	Unit
Address setup time <b>Note 2</b> (vs. MD0 ↓)	t <sub>AS</sub>	t <sub>AS</sub>		2			μs
MD1 setup time (vs. MD0 ↓)	t <sub>M1S</sub>	t <sub>OES</sub>		2			μs
Data setup time (vs. MD0 ↓)	t <sub>DS</sub>	t <sub>DS</sub>		2			μs
Address hold time <b>Note 2</b> (vs. MD0 ↑)	t <sub>AH</sub>	t <sub>AH</sub>		2			μs
Data hold time (vs. MD0 ↑)	t <sub>DH</sub>	t <sub>DH</sub>		2			μs
MD0 ↑ → data output float delay time	t <sub>DF</sub>	t <sub>DF</sub>		0		130	ns
V <sub>PP</sub> setup time (vs. MD3 ↑)	t <sub>VPS</sub>	t <sub>VPS</sub>		2			μs
V <sub>DD</sub> setup time (vs. MD3 ↑)	t <sub>VDS</sub>	t <sub>VCS</sub>		2			μs
Initial program pulse width	t <sub>PW</sub>	t <sub>PW</sub>		0.95	1.0	1.05	ms
Additional program pulse width	t <sub>OPW</sub>	t <sub>OPW</sub>		0.95		21.0	ms
MD0 setup time (vs. MD1 ↑)	t <sub>MOS</sub>	t <sub>CES</sub>		2			μs
MD0 ↓ → data output delay time	t <sub>DV</sub>	t <sub>DV</sub>	MD0 = MD1 = V <sub>IL</sub>			1	μs
MD1 hold time (vs. MD0 ↑)	t <sub>M1H</sub>	t <sub>OEH</sub>	t <sub>M1H</sub> + t <sub>M1R</sub> ≥ 50 μs	2			μs
MD1 recovery time (vs. MD0 ↓)	t <sub>M1R</sub>	t <sub>OR</sub>		2			μs
Program counter reset time	t <sub>PCR</sub>	—		10			μs
X1 input high-, low-level width	t <sub>XH</sub> , t <sub>XL</sub>	—		0.125			μs
X1 input frequency	f <sub>X</sub>	—				4.19	MHz
Initial mode set time	t <sub>1</sub>	—		2			μs
MD3 setup time (vs. MD1 ↑)	t <sub>M3S</sub>	—		2			μs
MD3 hold time (vs. MD1 ↓)	t <sub>M3H</sub>	—		2			μs
MD3 setup time (vs. MD0 ↓)	t <sub>M3SR</sub>	—	When program memory is read	2			μs
Address <b>Note 2</b> → data output delay time	t <sub>DAD</sub>	t <sub>ACC</sub>	When program memory is read			2	μs
★ Address <b>Note 2</b> → data output hold time	t <sub>HAD</sub>	t <sub>OH</sub>	When program memory is read	0		130	ns
MD3 hold time (vs. MD0 ↑)	t <sub>M3HR</sub>	—	When program memory is read	2			μs
MD3 ↓ → data output float delay time	t <sub>DFR</sub>	—	When program memory is read			2	μs

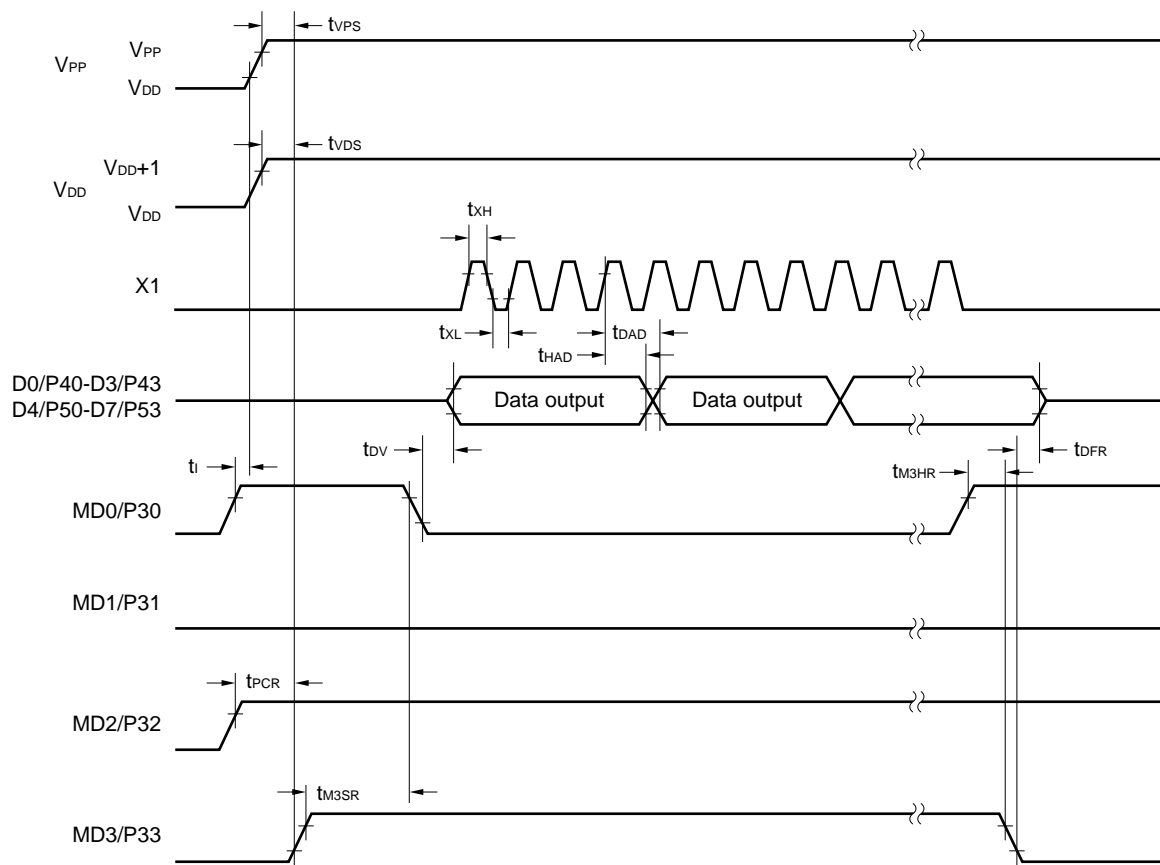
**Notes** 1. Symbol of corresponding μPD27C256A

2. The internal address signal is incremented by one at the rising edge of the fourth X1 input and is not connected to a pin.

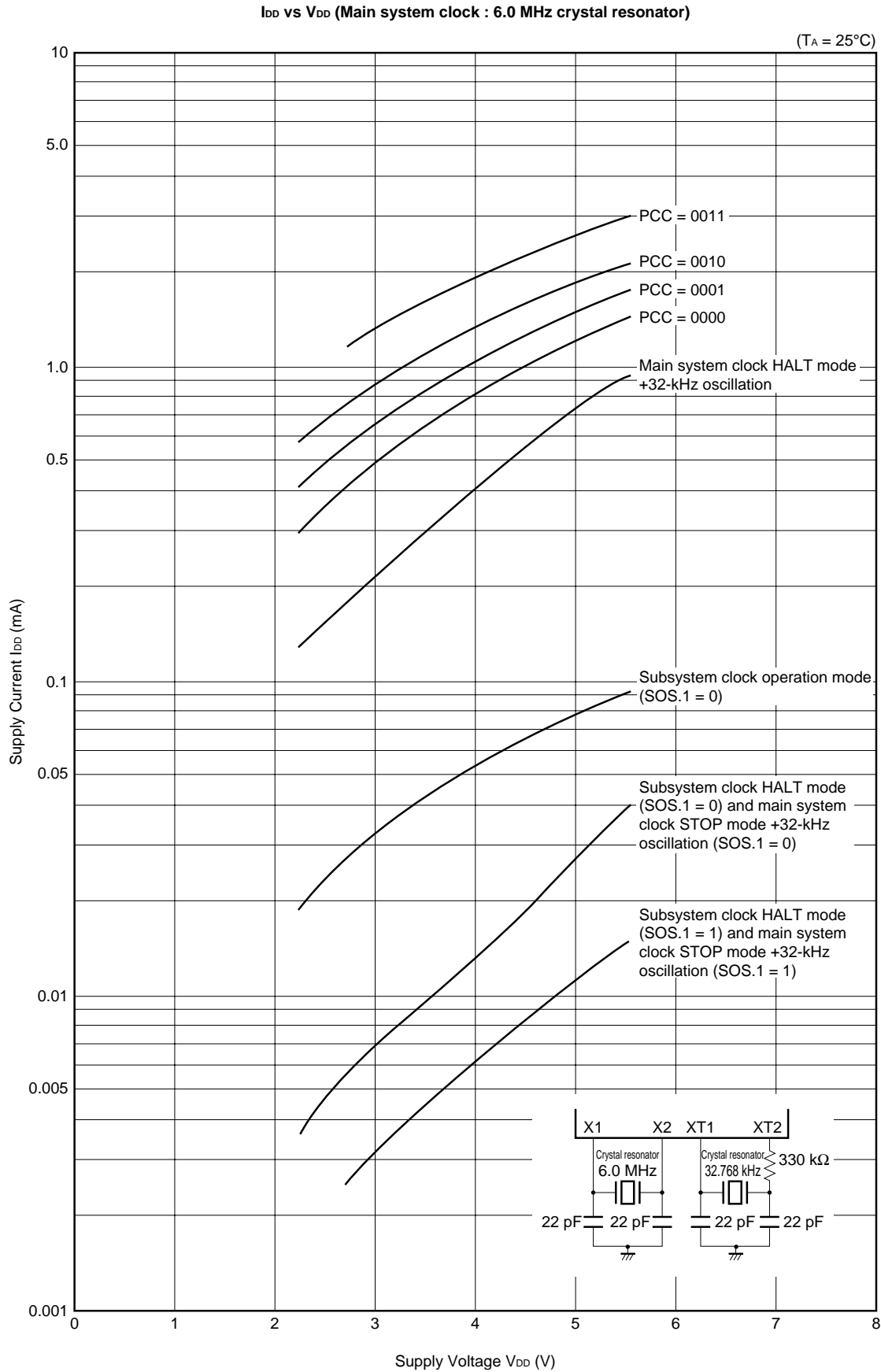
Program Memory Write Timing



Program Memory Read Timing

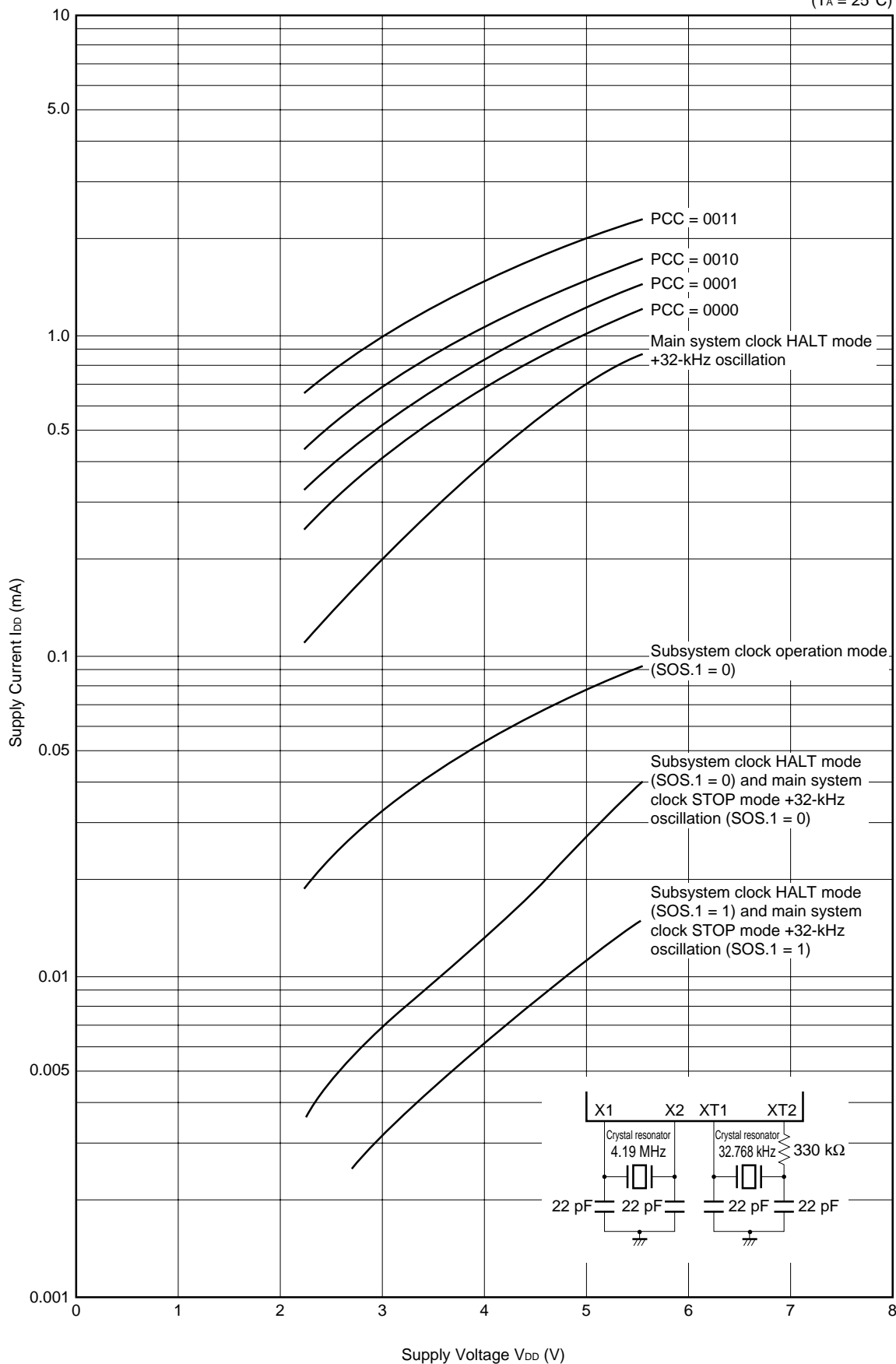


★ 10. CHARACTERISTICS CURVES (REFERENCE VALUE)



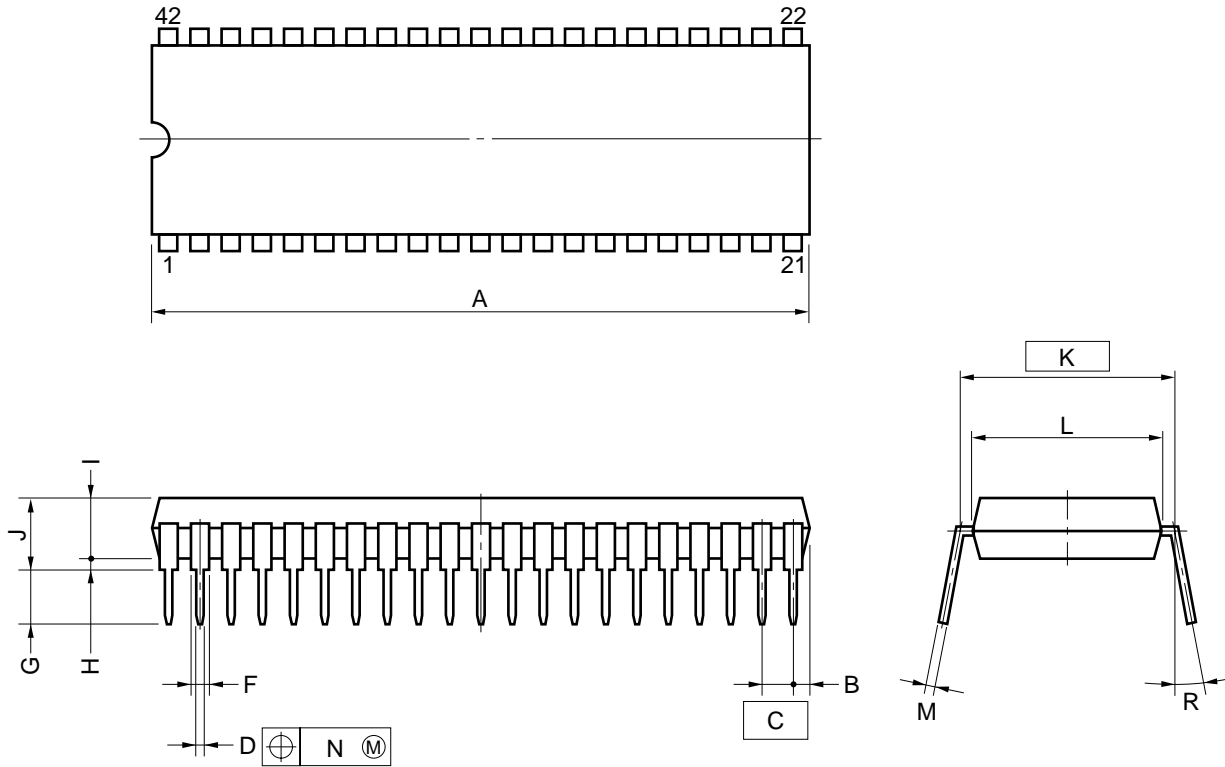
I<sub>DD</sub> vs V<sub>DD</sub> (Main system clock : 4.19 MHz crystal resonator)

(T<sub>A</sub> = 25°C)



11. PACKAGE DRAWINGS

42PIN PLASTIC SHRINK DIP (600 mil)



NOTES

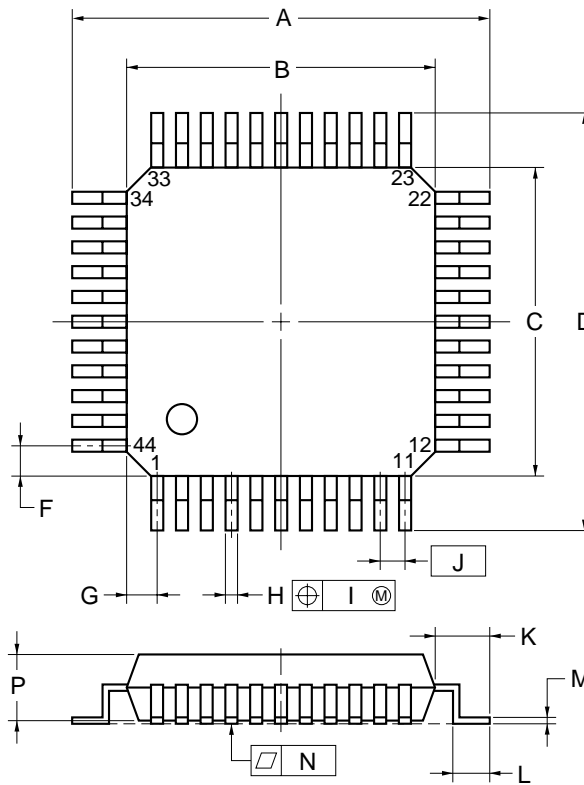
- 1) Each lead centerline is located within 0.17 mm (0.007 inch) of its true position (T.P.) at maximum material condition.
- 2) Item "K" to center of leads when formed parallel.

ITEM	MILLIMETERS	INCHES
A	39.13 MAX.	1.541 MAX.
B	1.78 MAX.	0.070 MAX.
C	1.778 (T.P.)	0.070 (T.P.)
D	0.50±0.10	0.020 <sup>+0.004</sup> <sub>-0.005</sub>
F	0.9 MIN.	0.035 MIN.
G	3.2±0.3	0.126±0.012
H	0.51 MIN.	0.020 MIN.
I	4.31 MAX.	0.170 MAX.
J	5.08 MAX.	0.200 MAX.
K	15.24 (T.P.)	0.600 (T.P.)
L	13.2	0.520
M	0.25 <sup>+0.10</sup> <sub>-0.05</sub>	0.010 <sup>+0.004</sup> <sub>-0.003</sub>
N	0.17	0.007
R	0~15°	0~15°

P42C-70-600A-1



44 PIN PLASTIC QFP (□10)



NOTE

Each lead centerline is located within 0.16 mm (0.007 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	13.2±0.2	0.520 <sup>+0.008</sup> <sub>-0.009</sub>
B	10.0±0.2	0.394 <sup>+0.008</sup> <sub>-0.009</sub>
C	10.0±0.2	0.394 <sup>+0.008</sup> <sub>-0.009</sub>
D	13.2±0.2	0.520 <sup>+0.008</sup> <sub>-0.009</sub>
F	1.0	0.039
G	1.0	0.039
H	0.37 <sup>+0.08</sup> <sub>-0.07</sub>	0.015 <sup>+0.003</sup> <sub>-0.004</sub>
I	0.16	0.007
J	0.8 (T.P.)	0.031 (T.P.)
K	1.6±0.2	0.063±0.008
L	0.8±0.2	0.031 <sup>+0.009</sup> <sub>-0.008</sub>
M	0.17 <sup>+0.06</sup> <sub>-0.05</sub>	0.007 <sup>+0.002</sup> <sub>-0.003</sub>
N	0.10	0.004
P	2.7	0.106
Q	0.125±0.075	0.005±0.003
R	3° <sup>+7°</sup> <sub>-3°</sub>	3° <sup>+7°</sup> <sub>-3°</sub>
S	3.0 MAX.	0.119 MAX.

S44GB-80-3BS

**12. RECOMMENDED SOLDERING CONDITIONS**

Solder the μPD75P0016 under the following recommended conditions.

For the details on the recommended soldering conditions, refer to Information Document **Semiconductor Device Mounting Technology Manual (C10535E)**.

For the soldering methods and conditions other than those recommended, consult NEC.

**Table 12-1. Soldering Conditions of Surface Mount Type**

**μPD75P0016GB-3BS-MTX: 44-pin plastic QFP (10 × 10 mm, 0.8-mm pitch)**

Soldering method	Soldering conditions	Symbol of recommended condition
Infrared reflow	Package peak temperature: 235°C, Time: 30 seconds max. (210°C min.), Number of times: 3 max.	IR35-00-3
VPS	Package peak temperature: 215°C, Time: 40 seconds max. (200°C min.), Number of times: 3 max.	VP15-00-3
Wave soldering	Soldering bath temperature: 260°C max., Time: 10 seconds max., Number of times: 1 Preheating temperature: 120°C max. (package surface temperature)	WS60-00-1
Partial heating	Pin temperature: 300°C max., Time: 3 seconds max. (per side of device)	–

**Caution** Do not use two or more soldering methods in combination (except the partial heating method).

**Table 12-2. Soldering Conditions of Insertion Type**

**μPD75P0016CU: 42-pin plastic Shrink DIP (600 mil, 1.778-mm pitch)**

Soldering method	Soldering conditions
Wave soldering (pin only)	Soldering bath temperature: 260°C max., Time: 10 seconds max.
Partial heating	Pin temperature: 300°C max., Time: 3 seconds max. (per pin)

**Caution** Apply wave soldering to the pins only. Be careful not to allow solder jet to come into direct contact with the body of the chip.

APPENDIX A. FUNCTION LIST OF μPD75008, 750008, 75P0016

(1/2)

Item		μPD75008	μPD750008	μPD75P0016
Program memory		Mask ROM 0000H - 1F7FH (8064 × 8 bits)	Mask ROM 0000H - 1FFFH (8192 × 8 bits)	One-time PROM 0000H - 3FFFH (16384 × 8 bits)
Data memory		000H - 1FFH (512 × 4 bits)		
CPU		75X Standard CPU	75XL CPU	
General register		4 bits × 8 or 8 bits × 4	(4 bits × 8 or 8 bits × 4) × 4 banks	
Instruction execution time	When main system clock is selected	• 0.95, 1.91, 15.3 μs (at 4.19 MHz operation)	• 0.95, 1.91, 3.81, 15.3 μs (at 4.19 MHz operation) • 0.67, 1.33, 2.67, 10.7 μs (at 6.0 MHz operation)	
	When subsystem clock is selected	122 μs (at 32.768 kHz operation)		
Stack	SBS register	None	Yes	SBS.3 = 1: Mk I mode selected SBS.3 = 0: Mk II mode selected
	Stack area	000H - 0FFH	n00H - nFFH (n = 0, 1)	
	Stack operation of subroutine call instruction	2-byte stack	In Mk I mode: 2-byte stack In Mk II mode: 3-byte stack	
Instructions	BRA !addr1 CALLA !addr1	Unusable	In Mk I mode: Unusable In Mk II mode: Usable	
	MOVT XA, @BCDE MOVT XA, @BCXA BR BCDE BR BCXA		Usable	
	CALL !addr	3 machine cycles	Mk I mode: 3 machine cycles Mk II mode: 4 machine cycles	
	CALLF !faddr	2 machine cycles	Mk I mode: 2 machine cycles Mk II mode: 3 machine cycles	
Timer		3 channels • Basic interval timer: 1 channel • 8-bit timer/event counter: 1 channel • Watch timer: 1 channel	4 channels • Basic interval timer/watchdog timer: 1 channel • 8-bit timer/event counter: 1 channel • 8-bit timer counter: 1 channel • Watch timer: 1 channel	
Clock output (PCL)		• Φ, 524, 262, 65.5 kHz (main system clock: at 4.19 MHz operation)	• Φ, 524, 262, 65.5 kHz (main system clock: at 4.19 MHz operation) • Φ, 750, 375, 93.8 kHz (main system clock: at 6.0 MHz operation)	
BUZ output (BUZ)		• 2 kHz	• 2, 4, 32 kHz (main system clock: at 4.19 MHz operation) • 2.93, 5.86, 46.9 kHz (main system clock: at 6.0 MHz operation)	

(2/2)

Item		μPD75008	μPD75008	μPD75P0016
Serial interface		Compatible with 3 kinds of mode <ul style="list-style-type: none"> <li>• 3-wire serial I/O mode ... MSB/LSB-first can be switched</li> <li>• 2-wire serial I/O mode</li> <li>• SBI mode</li> </ul>		
SOS register	Feedback resistor cut flag (SOS.0)	On-chip feedback resistor specifiable by mask option	On chip	
	Sub oscillator current cut flag (SOS.1)	None	On chip	
Register bank selection register (RBS)		None	Yes	
Standby release by INT0		Not possible	Possible	
Vectored interrupt		External: 3 Internal: 3	External: 3 Internal: 4	
Processor clock control register (PCC)		PCC = 0, 2, 3 can be used	PCC = 0 to 3 can be used	
Supply voltage		V <sub>DD</sub> = 2.7 to 6.0 V	V <sub>DD</sub> = 2.2 to 5.5 V	
Operating ambient temperature		T <sub>A</sub> = -40 to +85°C		
Package		<ul style="list-style-type: none"> <li>• 42-pin plastic shrink DIP (600 mil, 1.778-mm pitch)</li> <li>• 44-pin plastic QFP (10 × 10 mm, 0.8-mm pitch)</li> </ul>		

**APPENDIX B. DEVELOPMENT TOOLS**

The following development tools are provided for system development using the μPD75P0016. The 75XL series uses a common relocatable assembler, in combination with a device file matching each machine.

RA75X relocatable assembler	Host machine			Part number (product name)
		OS	Supply medium	
	PC-9800 series	MS-DOS™ ( Ver.3.30 to Ver.6.2 <b>Note</b> )	3.5" 2HD	μS5A13RA75X
	IBM PC/AT™ or compatible	Refer to <b>OS for IBM PCs</b>	3.5" 2HC	μS7B13RA75X

Device file	Host machine			Part number (product name)
		OS	Supply medium	
	PC-9800 series	MS-DOS ( Ver.3.30 to Ver.6.2 <b>Note</b> )	3.5" 2HD	μS5A13DF750008
	IBM PC/AT or compatible	Refer to <b>OS for IBM PCs</b>	3.5" 2HC	μS7B13DF750008

**Note** Ver. 5.00 and the upper versions of Ver. 5.00 are provided with a task swap function, but it does not work with this software.

**Remark** The operation of the assembler and device file is guaranteed only on the above host machines and OSs.

PROM Write Tools

★

Hardware	PG-1500	A stand-alone system can be configured of a single-chip microcomputer with on-chip PROM when connected to an auxiliary board (companion product) and a programmer adapter (separately sold). Alternatively, a PROM programmer can be operated on a host machine for programming. In addition, typical PROMs in capacities ranging from 256 K to 4 M bits can be programmed.			
	PA-75P008CU	This is a PROM programmer adapter for the μPD75P0016CU/GB. It can be used when connected to a PG-1500.			
	PA-75P0016GB	This is a PROM programmer adapter for the μPD75P0016GB-3BS-MTX. It can be used when connected to a PG-1500.			
Software	PG-1500 controller	Establishes serial and parallel connections between the PG-1500 and a host machine for host-machine control of the PG-1500.			
		Host machine		Part number (product name)	
			OS	Supply medium	
		PC-9800 Series	MS-DOS ( Ver.3.30 to Ver.6.2 <b>Note</b> )	3.5" 2HD	μS5A13PG1500
	IBM PC/AT or compatible	Refer to <b>OS for IBM PCs</b>	3.5" 2HD	μS7B13PG1500	

**Note** Ver. 5.00 and the upper versions of Ver. 5.00 are provided with a task swapping function, but it does not work with this software.

**Remark** Operation of the PG-1500 controller is guaranteed only on the above host machine and OSs.

**Debugging Tools**

In-circuit emulators (IE-75000-R and IE-75001-R) are provided as program debugging tools for the μPD75P0016. Various system configurations using these in-circuit emulators are listed below.

Hardware	IE-75000-R <sup>Note 1</sup>	The IE-75000-R is an in-circuit emulator to be used for hardware and software debugging during development of application systems that use 75X or 75XL Series products. For development of the μPD750008 subseries, the IE-75000-R is used with a separately sold emulation board IE-75300-R-EM and emulation probe EP-75008CU-R or EP-75008GB-R. These products can be applied for highly efficient debugging when connected to a host machine and PROM programmer. The IE-75000-R can include a connected emulation board (IE-75000-R-EM).			
	IE-75001-R	The IE-75001-R is an in-circuit emulator to be used for hardware and software debugging during development of application systems that use 75X or 75XL Series products. The IE-75001-R is used with a separately sold emulation board (IE-75300-R-EM) and emulation probe EP-75008CU-R or EP-75008GB-R. These products can be applied for highly efficient debugging when connected to a host machine and PROM programmer.			
	IE-75300-R-EM	This is an emulation board for evaluating application systems that use the μPD750008 subseries. It is used in combination with the IE-75000-R or IE-75001-R in-circuit emulator.			
	EP-75008CU-R	This is an emulation probe for the μPD75P0016CU. When being used, it is connected with the IE-75000-R or IE-75001-R and the IE-75300-R-EM.			
	EP-75008GB-R	This is an emulation probe for the μPD75P0016GB.			
	EV-9200G-44	When being used, it is connected with the IE-75000-R or IE-75001-R and the IE-75300-R-EM. It includes a 44-pin conversion socket (EV-9200G-44) to facilitate connections with various target systems.			
Software	IE control program	This program can control the IE-75000-R or IE-75001-R on a host machine when connected to the IE-75000-R or IE-75001-R via an RS-232-C or Centronics I/F.			
		Host machine	OS	Supply medium	Part number (product name)
		PC-9800 series	MS-DOS ( Ver.3.30 to Ver.6.2 <sup>Note 2</sup> )	3.5" 2HD	μS5A13IE75X
		IBM PC/AT or compatible	Refer to <b>OS for IBM PCs</b>	3.5" 2HC	μS7B13IE75X

- Notes**
1. This is a service part provided for maintenance purpose only.
  2. Ver. 5.00 and the upper versions of Ver. 5.00 are provided with a task swapping function, but it does not work with this software.

- Remarks**
1. Operation of the IE control program is guaranteed only on the above host machine and OSs.
  2. The μPD75000 subseries consists of the μPD750004, 750006, 750008 and 75P00016.

**OS for IBM PCs**

The following operating systems for the IBM PC are supported.

OS	Version
PC DOS™	Ver.3.1 to Ver.6.3 J6.1/V>Note to J6.3/V>Note
MS-DOS	Ver.5.0 to Ver.6.22 5.0/V>Note to J6.2/V>Note
IBM DOS™	J5.02/V>Note

**Note** Supports English version only.

**Caution** Ver 5.0 and above include a task swapping function, but this software is not able to use that function.



★ APPENDIX C. RELATED DOCUMENTS

Some of the following related documents are preliminary. This document, however, is not indicated as preliminary.

Device Related Documents

Document name	Document No.	
	Japanese	English
μPD750004, 750006, 750008, 750004(A), 750006(A), 750008(A) Data Sheet	U10738J	U10738E
μPD75P0016 Data Sheet	U10328J	This document
μPD750008 User's Manual	U10740J	U10740E
μPD750008, 750108 Instruction List	U11456J	–
75XL Series Selection Guide	U10453J	U10453E

Development Tool Related Documents

Document name			Document No.	
			Japanese	English
Hardware	IE-75000 R/IE-75001-R User's Manual		EEU-846	EEU-1416
	IE-75300-R-EM User's Manual		U11354J	U11354E
	EP-750008CU-R User's Manual		EEU-699	EEU-1317
	EP-750008GB-R User's Manual		EEU-698	EEU-1305
	PG-1500 User's Manual		U11940J	U11940E
Software	RA75X Assembler Package User's Manual	Operation	U12622J	U12622E
		Language	U12385J	U12385E
	PG-1500 Controller User's Manual	PC-9800 Series (MS-DOS) Base	EEU-704	EEU-1291
		IBM PC Series (PC DOS) Base	EEU-5008	U10540E

Other Documents

Document name	Document No.	
	Japanese	English
SEMICONDUCTOR SELECTION GUIDE Products & Package (CD-ROM)	X13769X	
Semiconductor Device Mounting Technology Manual	C10535J	C10535E
Quality Grades on NEC Semiconductor Devices	C11531J	C11531E
NEC Semiconductor Device Reliability/Quality Control System	C10983J	C10983E
Guide to Prevent Damage for Semiconductor Devices Electrostatic Discharge (ESD)	C11892J	C11892E
Guide for Products Related to Microcomputer : Other Companies	C11416J	–

**Caution** The above related documents are subject to change without notice. For design purpose, etc., be sure to use the latest documents.

## NOTES FOR CMOS DEVICES

### ① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

**Note:** Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

### ② HANDLING OF UNUSED INPUT PINS FOR CMOS

**Note:** No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS device behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

### ③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

**Note:** Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

## Regional Information

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- Device availability
- Ordering information
- Product release schedule
- Availability of related technical literature
- Development environment specifications (for example, specifications for third-party tools and components, host computers, power plugs, AC supply voltages, and so forth)
- Network requirements

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Tel: 55-11-6462-6810  
Fax: 55-11-6462-6829

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