NEC

MOS INTEGRATED CIRCUIT

μPD75516

4-BIT SINGLE-CHIP MICROCOMPUTER

DESCRIPTION

The μPD75516 is a product in the 75X series(of 4-bit single-chip microcomputers). The 75X series has an architecture which is comparable to that of 8-bit microcomputers.

The μPD75516 possesses high class processing capacities as a 4-bit single-chip microcomputer with built-in A/D converter and serial interface, including the capability to process data in lengths of 1, 4 and 8 bits in addition to its high speed operation.

Details of functions are described in the User's Manual shown below. Be sure to read in design.
μPD75516 User's Manual: IEM–5049

FEATURES

- A large number of I/O Lines: 64 lines (Internal pull-up/pull- down resistor specifiable: 47)
- Built-in 8-bit serial interface: 2 channels
  Built-in NEC standard serial bus interface (SBI)
- Built-in 8-bit AD converter: 8 channels
- High speed operation and a instruction execution time variation function which is effective for saving power.
  - 0.95 μs/1.91 μs/15.3 μs (at 4.19 MHz operation), 122 μs (at 32.768 kHz operation)
- Program memory (ROM) capacity: 16256 × 8 bits
- Data memory (RAM) capacity: 512 × 4 bits
- Powerful timer function: 4 channels
  - 8-bit timer/event counter
  - Watch timer
  - 8-bit basic interval timer
  - Timer/pulse generator: 14-bit PWM with variable output
- Ultra low power consumption clock operation is possible (5 μA TYP.: During operation at 3 V)
- Devices with built-in PROM are available (μPD75P516)

USES

VCRs and CD players, telephones, cameras, etc.

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

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The mark ★ shows major revised points.

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ORDERING INFORMATION

Ordering Code	Package	Quality Grade
μPD75516GF-×××-3B9	80-pin plastic QFP (14 × 20 mm)	Standard

Remarks "×××" means the specified ROM code.

Please refer to "Quality grade on NEC Semiconductor Devices" (Document number IEI-1209) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

LIST OF μPD75516 FUNCTIONS

Item		Function
On-chip memory	ROM	16256 × 8 bits
	RAM	512 × 4bits
General registers		(4 bits × 8 or 8 bits × 4) × 4 banks
Instruction cycle		• 0.95 μs/1.91 μs/15.3 μs (Main system clock: 4.19 MHz operation) • 122 μs (Subsystem clock: 32.768 kHz operation)
Input/output ports	Total	64
	CMOS input	16 (dual function and analog input as INT, SIO, PPO, software pull-up capability: 7)
	CMOS input/output	28 (LED drive: 4) • Software pull-up capability : 16 • Mask option pull-down capability: 4
	N-ch open-drain input/output	20 (LED drive: 8; 10 V withstand voltage, mask option pull-up capability: 20)
A/D converter		8-bit resolution × 8 channels (successive approximation type) • Operating voltage: V_{DD} = 3.5 to 6.0 V
Timer/counters		4 channels { •Timer/event counter • Basic interval timer • Timer/pulse generator (14-bit PWM output capability) • Watch timer
Serial Interface		2 channels { • NEC standard serial bus interface (SBI)/3-wire SIO: 1 channel • Normal clocked serial interface (3-wire SIO): 1 channel
Vectored interrupt		External: 3, internal: 4
Test input		External: 1, internal: 1
Instruction set		• Bit data set/reset/test/Boolean operations • 4-bit data transfer, operation, increment/ decrement, compare • 8-bit data transfer, operation, increment/ decrement, compare
System clock oscillator		• Ceramic/crystal oscillator for main system clock oscillation: 4.19 MHz • Crystal oscillator for subsystem clock oscillation: 32.768 kHz
Operating voltage		V_{DD} = 2.7 to 6.0 V
Package		80-pin plastic QFP (14 × 20 mm)

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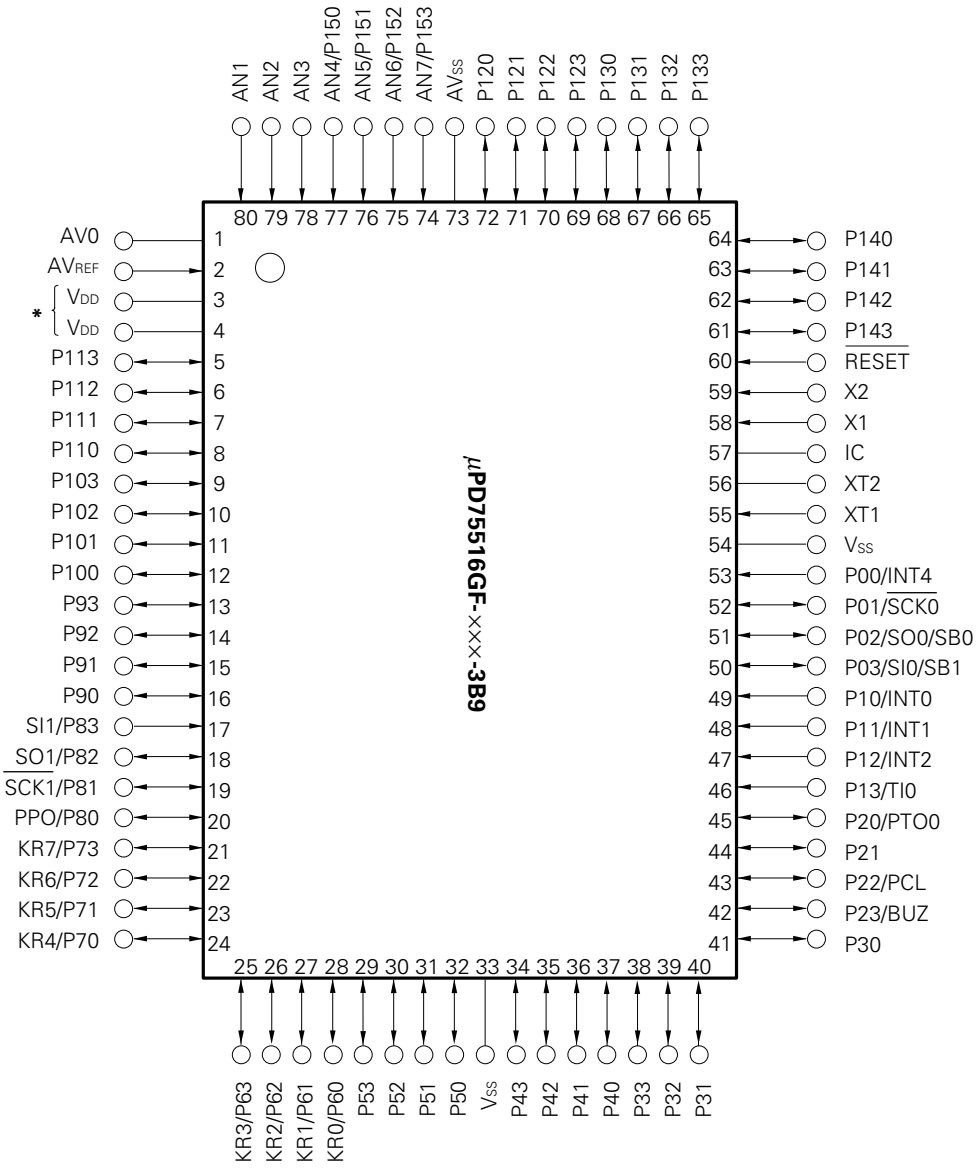
1. PIN CONFIGURATION



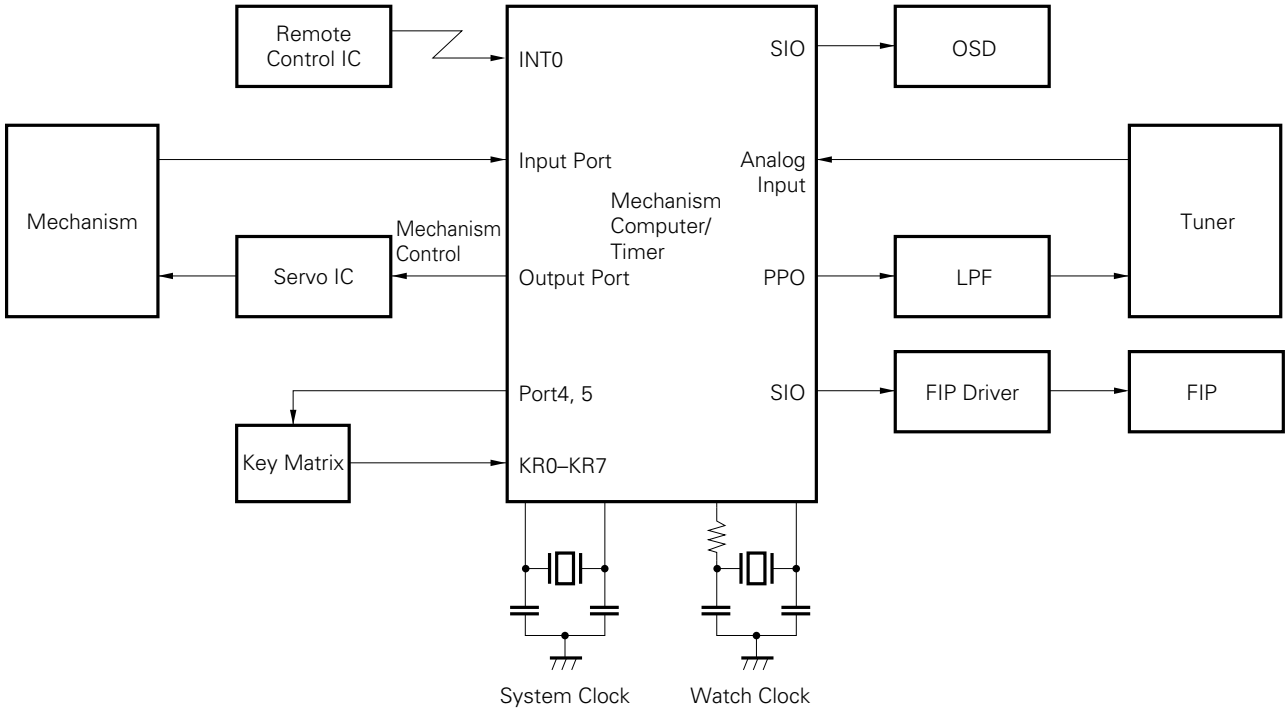
IC: Internally Connected (Connect to V_{SS} directly.)

* Be sure to supply power to both V_{DD} pins.

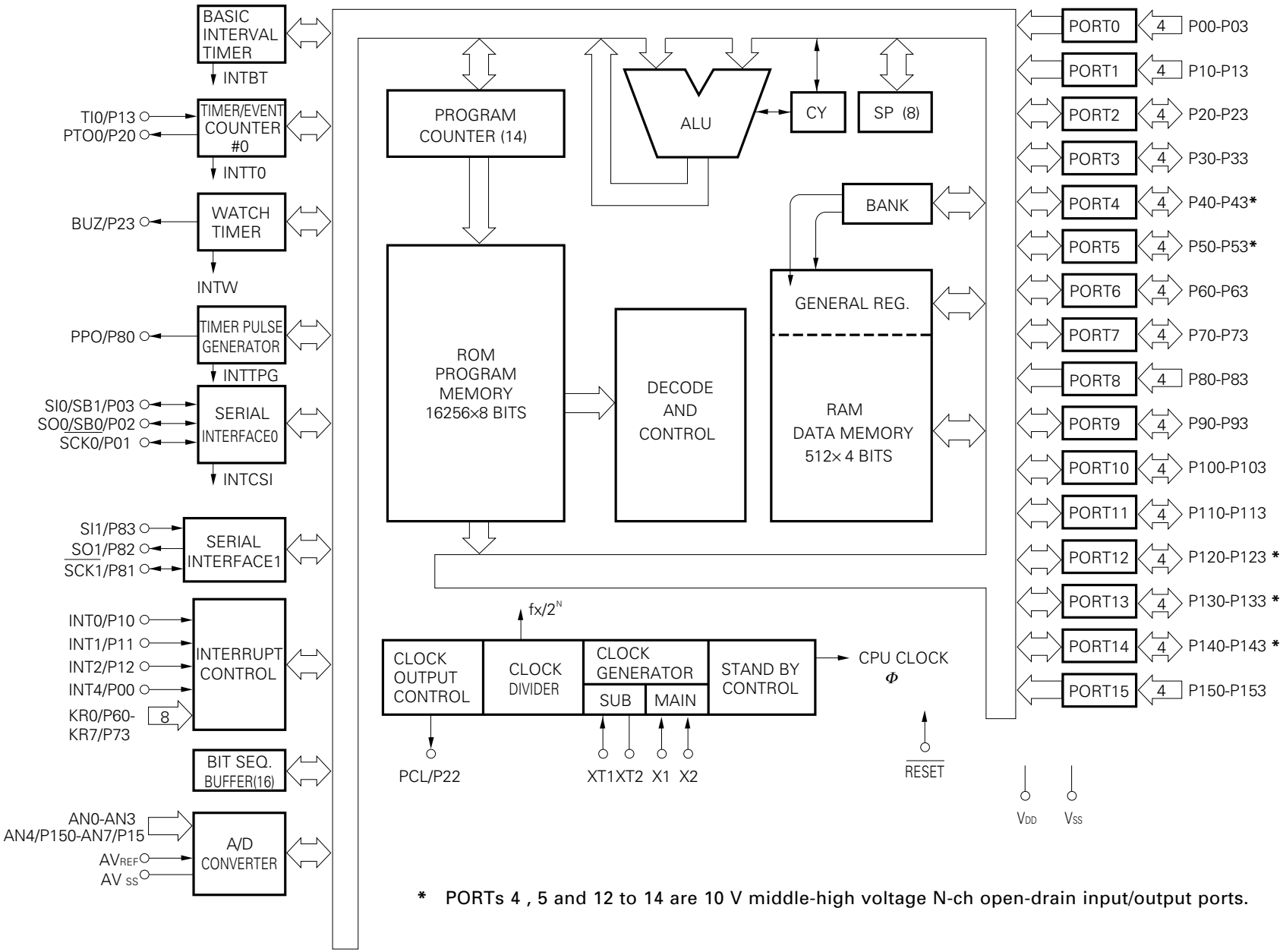
2. EXAMPLE OF SYSTEM CONFIGURATION

VTR (Voltage Synthesizer Tuner)

μPD75516



3. INTERNAL BLOCK DIAGRAM



* PORTs 4 , 5 and 12 to 14 are 10 V middle-high voltage N-ch open-drain input/output ports.

4. PIN FUNCTIONS

4.1 PORT PINS (1/2)

Pin Name	I/O	Dual-Function Pin	Function	8-Bit I/O	After Reset	Input / Output Circuit Type *1
P00	Input	INT4	4-bit input port (PORT0). Internal pull-up resistor can be specified in 3-bit units by software for P01 to P03.	×	Input	Ⓑ
P01		$\overline{SCK0}$				Ⓕ – A
P02		SO0/SB0				Ⓕ – B
P03		SI0/SB1				Ⓜ – C
P10	Input	INT0	4-bit input port (PORT1). Noise removing function available. Internal pull-up resistor can be specified in 4-bit units by software.	×	Input	Ⓑ – C
P11		INT1				
P12		INT2				
P13		TI0				
P20	Input/ output	PTO0	4-bit input/ output port (PORT2). Internal pull-up resistor can be specified in 4-bit units by software.	×	Input	E – B
P21		—				
P22		PCL				
P23		BUZ				
P30 *2	Input/ output	—	Programmable 4-bit input/ output port (PORT3). Input/ output specifiable in 1-bit units. Internal pull-up resistor can be specified in 4-bit units by software.	×	Input	E – C
P31 *2		—				
P32 *2		—				
P33 *2		—				
P40 to P43 *2	Input/ output	—	N-ch open-drain 4-bit input/output port (PORT4). Pull-up resistor can be incorporated in 1-bit units (mask option). 10 V withstand voltage with open-drain.	○	High level (when a pull-up resistor is incorporated) or high impedance	M
P50 to P53 *2	Input/ output	—	N-ch open-drain 4-bit input/ output port (PORT5). Pull-up resistor can be incorporated in 1-bit units (mask option). 10 V withstand voltage with open-drain.		High level (when a pull-up resistor is incorporated) or high impedance	M
P60	Input/ output	KR0	Programmable 4-bit input/output port (PORT6). Input/output specifiable in 1-bit units. Internal pull-up resistor can be specified in 4-bit units by software.	○	Input	Ⓕ– C
P61		KR1				
P62		KR2				
P63		KR3				
P70	Input/ output	KR4	4-bit input/output port (PORT7). Internal pull-up resistor can be specified in 4-bit units by software.		Input	Ⓕ – A
P71		KR5				
P72		KR6				
P73		KR7				

* **1.** Schmitt trigger inputs are circled.
2. Can drive LED directly.

4.1 PORT PINS (2/2)

Pin Name	I/O	Dual-Function Pin	Function	8-Bit I/O	After Reset	Input / Output Circuit Type *
P80	Input	PPO	4-bit input port (PORT8).	×	Input	E
P81		$\overline{\text{SCK1}}$				Ⓕ
P82		SO1				E
P83		SI1				Ⓑ
P90 to P93	Input/ output	——	4-bit input/output port (PORT9) Pull-up resistor can be incorporated in 1-bit units (mask option).	×	Low level (when a pull down resistor is incorporated) or high impedance	V
P100 to P103	Input/ output	——	4-bit input/output port (PORT10).	×	Input	E
P110 to P113	Input/ output	——	4-bit input/output port (PORT11).		Input	E
P120 to P123	Input/ output	——	N-ch open-drain 4-bit input/ output port (PORT12). Pull-up resistor can be incorporated in 1-bit units (mask option). 10 V withstand voltage with open-drain.	×	High level (when a pull-up resistor is incorporated) or high impedance	M
P130 to P133	Input/ output	——	N-ch open-drain 4-bit input/ output port (PORT13). Pull-up resistor can be incorporated in 1-bit units (mask option). 10 V withstand voltage with open-drain.	×	High level (when a pull-up resistor is incorporated) or high impedance	M
P140 to P143	Input/ output	——	N-ch open-drain 4-bit input/ output port (PORT14). Pull-up resistor can be incorporated in 1-bit units (mask option). 10 V withstand voltage with open-drain.	×	High level (when a pull-up resistor is incorporated) or high impedance	M
P150 to P153	Input	AN4 to AN7	4-bit input/output port (PORT15).	×	Input	Y-A

* Schmitt trigger inputs are circled.

4.2 NON-PORT PINS

Pin Name	I/O	Dual-Function Pin	Function		After Reset	Input / Output Circuit Type *
TI0	Input	P13	External event pulse input pin to the timer/event counter.		—	Ⓑ – C
PTO0	Output	P20	Timer/event counter output pin.		Input	E – B
PCL	Output	P22	Clock output pin.		Input	E – B
BUZ	Output	P23	Fixed frequency output pin (for buzzer or system clock trimming).		Input	E – B
$\overline{SCK0}$	Input/ output	P01	Serial clock input/output pin.		Input	Ⓕ – A
SO0/SB0	Input/ output	P02	Serial data output pin. Serial bus input/output pin.		Input	Ⓕ – B
SI0/SB1	Input/ output	P03	Serial data input pin. Serial bus input/output pin.		Input	Ⓜ – C
INT4	Input	P00	Edge-detected vectored interrupt input pin (valid for detection of rising and falling edges).		—	Ⓑ
INT0	Input	P10	Edge-detected vectored interrupt input pin (detected edge selection possible).	Clocked	—	Ⓑ– C
INT1		P11		Asynchronous		
INT2	Input	P12	Edge-detected testable input pin (rising edge detection).	Asynchronous	—	Ⓑ – C
KR0 to KR3	Input	P60 to P63	Serial falling edge detection testable input pin.		Input	Ⓕ – C
KR4 to KR7	Input	P70 to P73	Serial falling edge detection testable input pin.		Input	Ⓕ – A
$\overline{SCK1}$	Input/ output	P81	Serial clock input/output pin.		Input	Ⓕ
SO1	Output	P82	Serial data output pin.		Input	E
SI1	Input	P83	Serial data input pin.		Input	Ⓑ
AN0 to AN3	Input	—	A/D converter analog input pin.		—	Y
AN4 to AN7		P150 to P153				Y-A
AV_{REF}	Input	—	A/D converter reference voltage input pin.		—	Z
AV_{SS}	—	—	A/D converter reference GND potential pin.		—	—
X1, X2	Input	—	Main system clock oscillation crystal/ceramic connection pin. An external clock is input to X1 and an antiphase clock is input to X2.		—	—
XT1	Input	—	Subsystem clock oscillation crystal connection pin. An external clock is input to XT1 and XT2 is leave open.		—	—
XT2	—					
$\overline{RESET}$	Input	—	System reset input pin.		—	Ⓑ
PPO	Output	P80	Timer/pulse generator pulse output pin.		Input	E
IC	—	—	Internally Connected. Connect to V_{SS} directly.		—	—
V_{DD}	—	—	Positive power supply pin.		—	—
V_{SS}	—	—	GND potential pin.		—	—

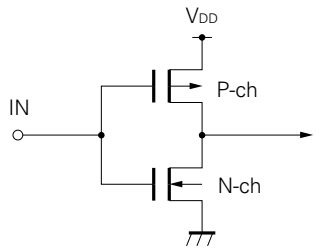
* Schmitt trigger inputs are circled.

4.3 PIN INPUT/OUTPUT CIRCUIT LIST

Use of simplified forms of the input/output circuit for each pin of the μPD75516 are shown as follows.

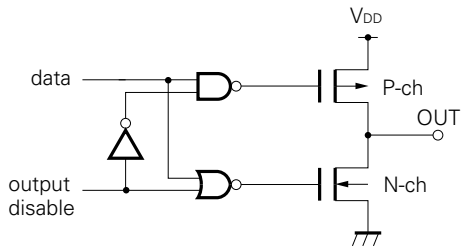
Fig. 4–1 Pin Input/Output Circuit List (1/3)

TYPE A



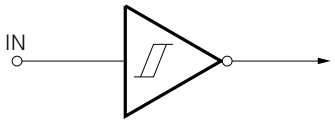
CMOS Specified Input Buffer

TYPE D



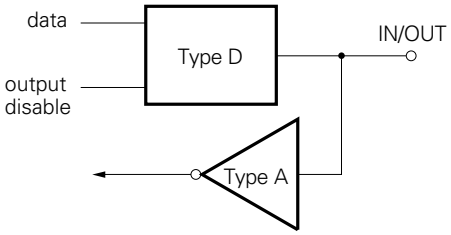
Push-Pull Output which can be Set to Output High Impedance (with Both P-ch and N-ch Set to OFF)

TYPE B



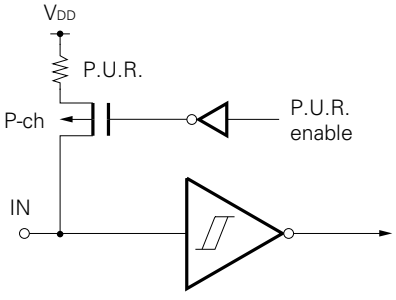
Schmitt Trigger Input Having Hysteresis Characteristics

TYPE E



Input/Output Circuit Consisting of Type D Push-Pull Output and Type A Input Buffer

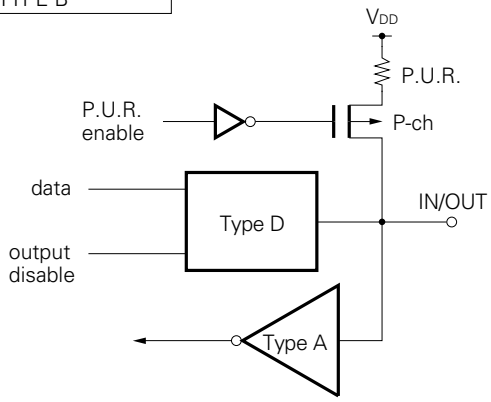
TYPE B-C



P.U.R. : Pull-Up Resistor

Schmitt Trigger Input Having Hysteresis Characteristics

TYPE B



P.U.R. : Pull-Up Resistor

Fig. 4–1 Pin Input/Output Circuit List (2/3)

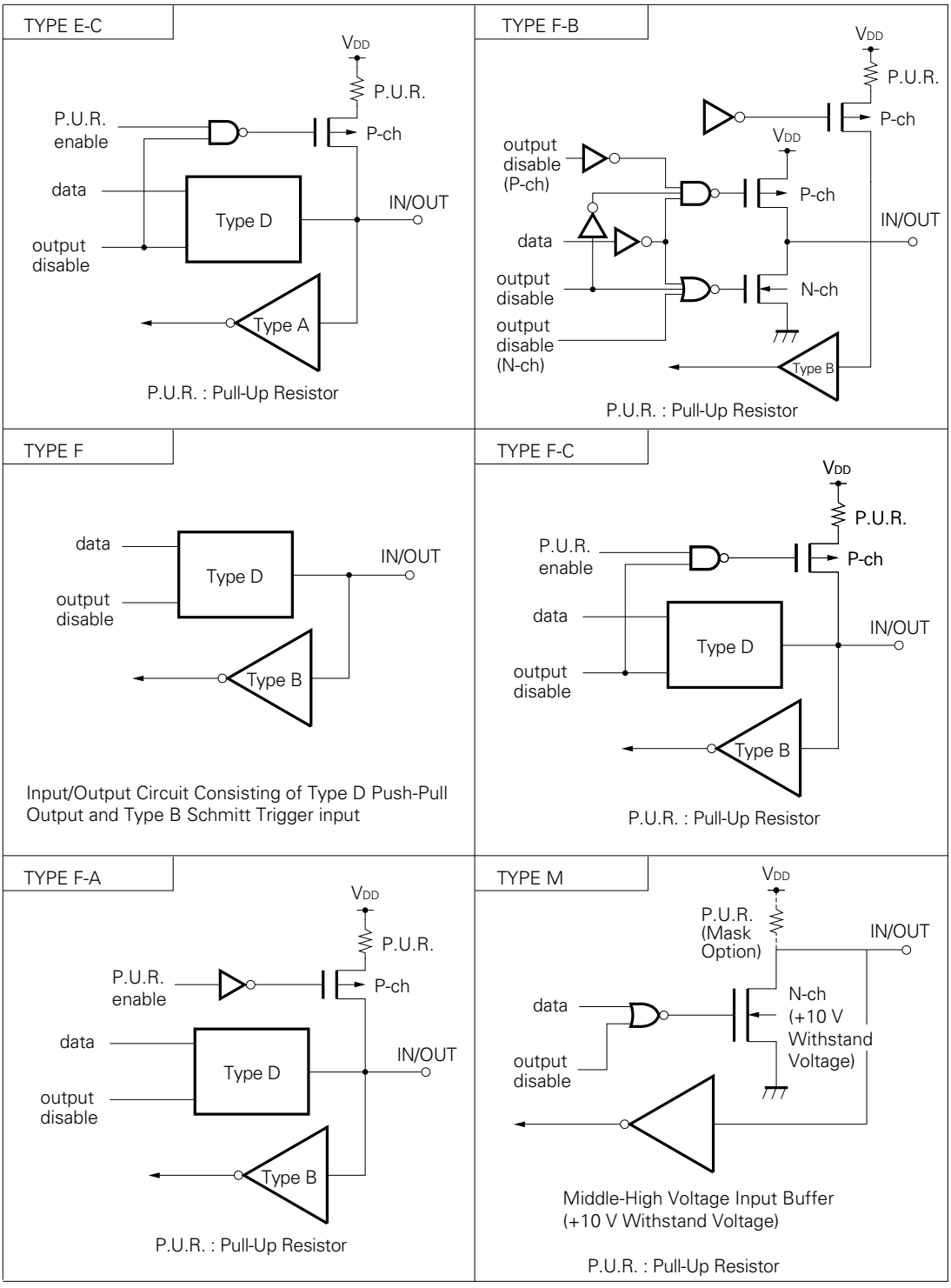
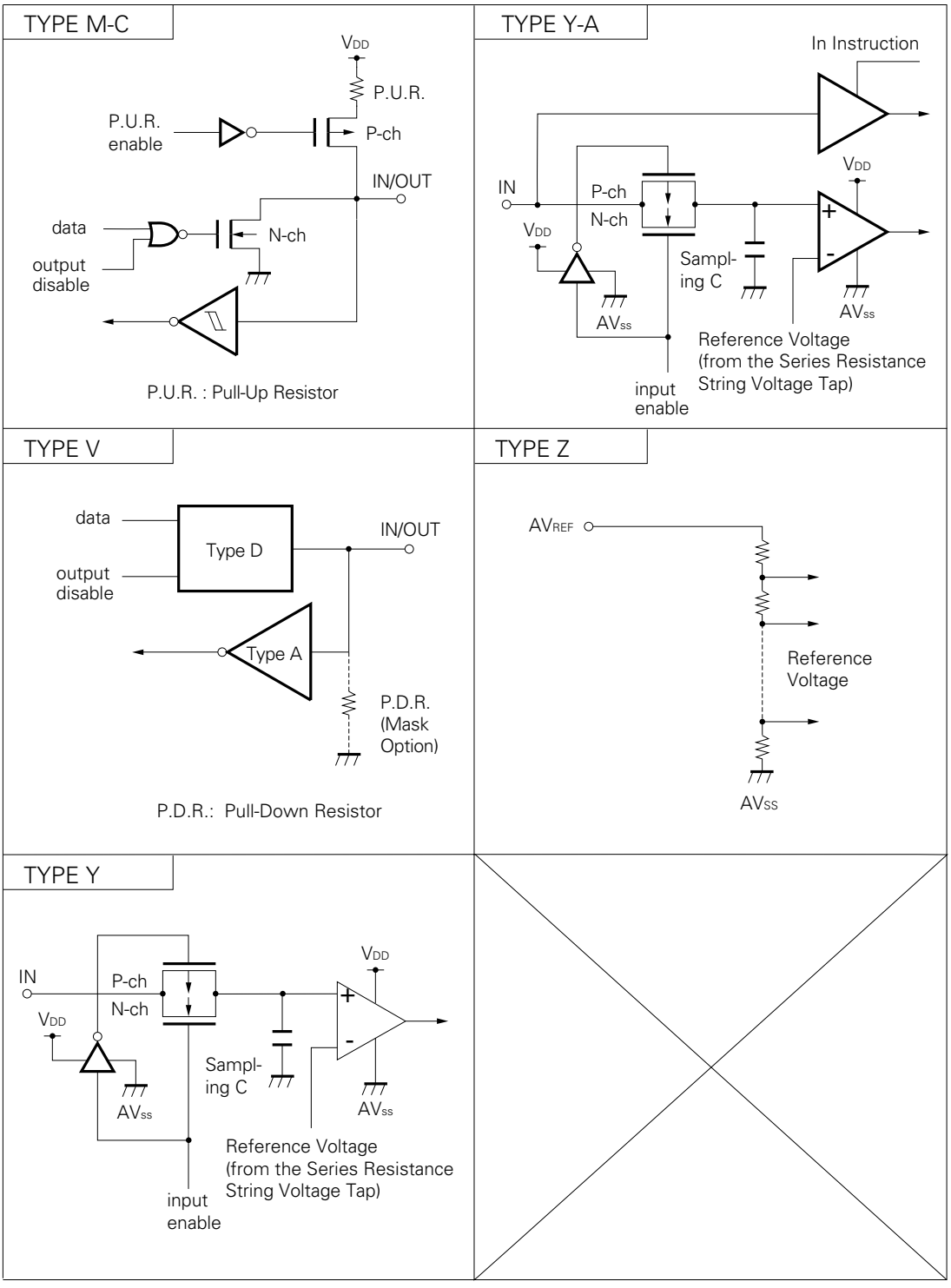


Fig. 4–1 Pin Input/Output Circuit List (3/3)



4.4 RECOMMENDED CONNECTIONS OF UNUSED PINS

Table 4-1 Recommended Connection of Unused Pins

Pin	Recommended Connection
P00/INT4	Connect to V_{SS}
P01/$\overline{SCK0}$	Connect to V_{SS} or V_{DD}
P02/SO0/SB0	
P03/SI1/SB1	
P10/INT0 to P12/INT2	Connect to V_{SS}
P13/TI0	
P20/PTO0	Input state : Connect to V_{SS} or V_{DD} Ouput state : Leave open
P21	
P22/PCL	
P23/BUZ	
P30 to P33	
P40 to P43	
P50 to P53	
P60/KR0 to P63/KR3	
P70/KR4 to P73/KR7	
P80/PPO	Connect to V_{SS} or V_{DD}
P81/$\overline{SCK1}$	
P82/SO1	
P83/SI1	
P90 to P93	Input state : Connect to V_{SS} or V_{DD} Ouput state : Leave open
P100 to P103	
P110 to P113	
P120 to P123	
P130 to P133	
P140 to P143	
P150/AN4 to P153/AN7	Connect to V_{SS}
AN0 to AN3	
XT1	Connect to V_{SS} or V_{DD}
XT2	Leave open
AV_{REF}	Connect to V_{SS}
AV_{SS}	
IC	

4.5 MASK OPTION SELECTION

The following mask options are available for the pins.

(1) Specification of internal pull-up/pull-down resistor

Table 4-2 Pull-Up/Pull-Down Resistor Selection

Pins	Mask Option	
P40 to P43, P50 to P53, P120 to P123, P130 to P133, P140 to P143	① With pull-up resistor (specifiable bit-wise)	② Without pull-up resistor (specifiable bit-wise)
P90 to P93	① With pull-down resistor (specifiable bit-wise)	② Without pull-down resistor (specifiable bit-wise)

(2) Specification of internal feedback resistor for subsystem clock oscillation

Table 4-3 Feedback Resistor Selection

Pins	Mask Option	
XT1, XT2	① With feedback resistor (subsystem clock used)	② Without feedback resistor (subsystem clock not used)

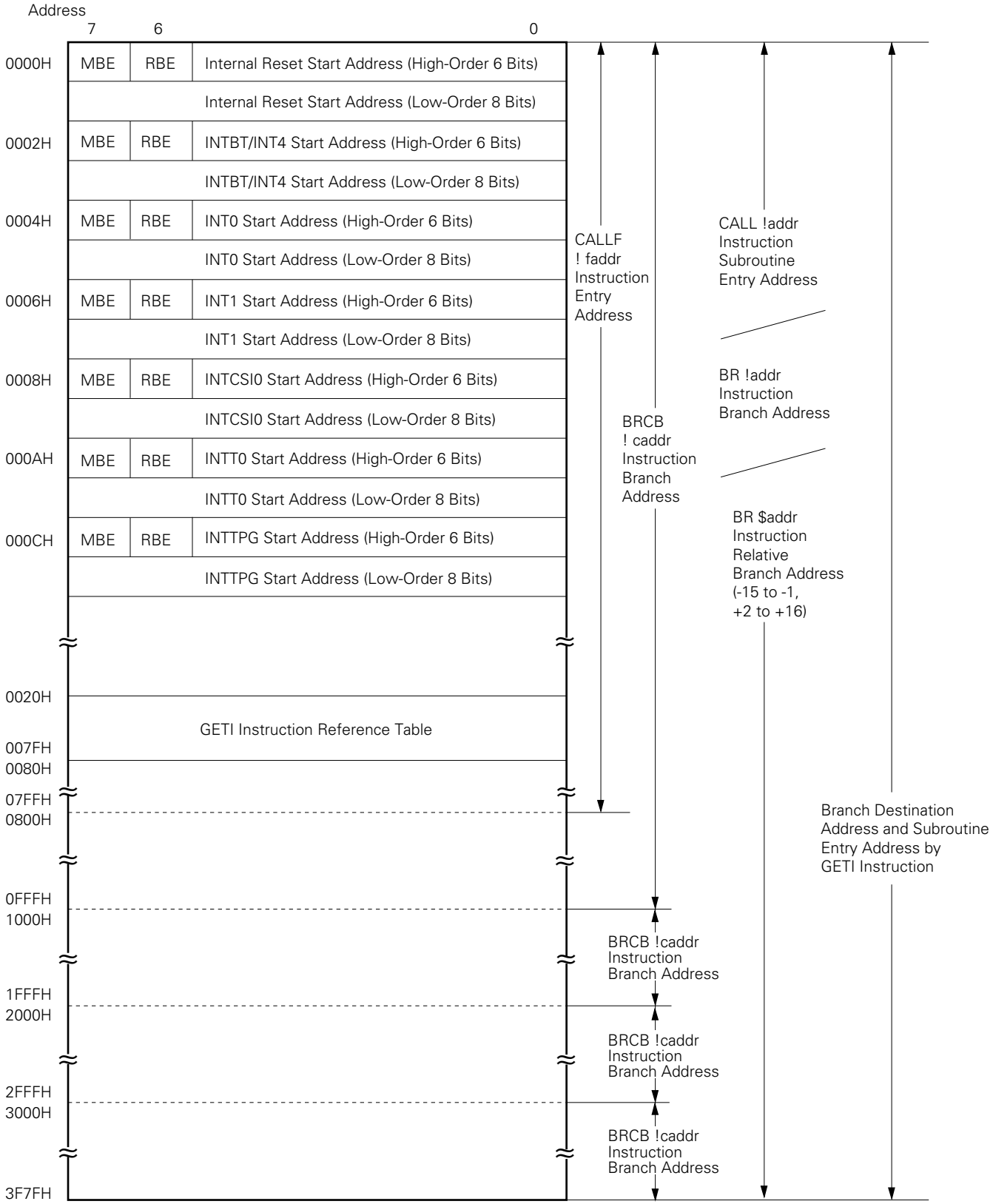
Note When the subsystem clock is not used, operation is not affected if a feedback resistor is incorporated, but the supply current I_{DD} is increased.

5. MEMORY CONFIGURATION

- Program memory (ROM) ..... 12160 × 8 bits (0000H to 2F7FH)
  - 0000H, 0001H : Vector table in which the program start addresses by reset are written.
  - 0002H to 000DH : Vector table in which the program start addresses by interrupt are written.
  - 0020H to 007FH : Table area referred by the GETI instruction.

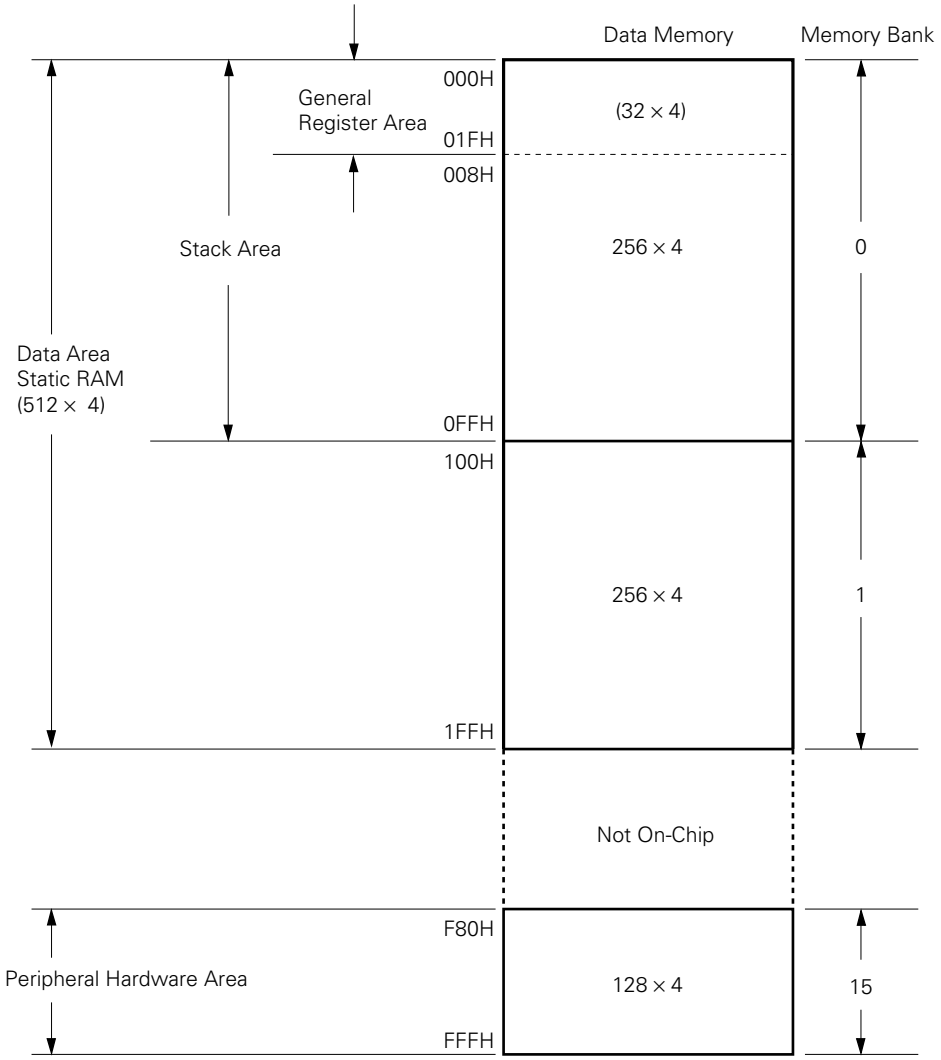
- Data memory
  - Data area ... 512 × 4 bits (000H to 1FFH)
  - Peripheral hardware area ... 128 × 4 bits (F80H to FFFH)

Fig. 5–1 Program Memory Map



Remarks In cases other than above, the program can branch to an address for which only the lower 8–bit of the PC have been changed, by a BR PCDE or BR PCXA instruction.

Fig. 5–2 Data Memory Map



6. PERIPHERAL HARDWARE FUNCTIONS

6.1 PORTS

There are the following 3 types of I/O ports.

- CMOS input (PORT0, 1, 8, 15) : 16
- CMOS input/output (PORT2, 3, 6, 7, 9, 10, 11) : 28
- N-ch open-drain input/output (PORT4, 5, 12, 13, 14) : 20

Total 64

Table 6–1 Port Functions

Port (Pin name)	Function	Operation/Features		Remarks
PORT 0	4-bit input	Can always be read or tested regardless of the operating mode of the dual function pin.		Shares the use of the pin with INT4, $\overline{SCK0}$, SO0/SB0, SI0/SB1.
PORT 1				Shares the use of the pin with INT0 to INT2 and TI0.
PORT 2	4-bit input/output	Can be set in the input or output mode as a 4-bit unit.		Shares the use of the pin with PTO0, PCL, BUZ
PORT 3 *		Can be set in the input or the output mode in 1/4-bit units		———
PORT 4 *	4-bit input/output (N-ch open-drain 10 V withstand voltage)	Can be set in input or output mode in 4-bit units	With ports 4 and 5 as a pair, data can be input and output in 8-bit units.	With a mask option, the internal pull-up resistance can be specified in 1-bit units.
PORT 5 *				
PORT 6	4-bit input/output	Can be set in input or output mode in 1/4-bit units	With ports 6 and 7 as a pair, data can be input and output in 8-bit units.	Shares the use of the pin with KR0 to KR3.
PORT 7		Can be set in input or output mode in 4-bit units		Shares the use of the pin with KR4 to KR7.
PORT 8	4-bit input	Can always be read or tested regardless of the operating mode of the dual function pin.		Shares the use of the pin with PPO, $\overline{SCK1}$, SO1 and SI1.
PORT 9	4-bit input/output	Can be set in input or output mode in 4-bit units.		With a mask option, the internal pull-up resistance can be specified in 1-bit units.
PORT 10	4-bit input/output	Can be set in input or output mode in 4-bit units.		———
PORT 11				
PORT 12	4-bit input/output (N-ch open-drain 10 V withstand voltage)	Can be set in input or output mode in 4-bit units.		With a mask option, the internal pull-up resistance can be specified in 1-bit units.
PORT 13				
PORT 14				
PORT 15	4-bit input	Can always be read or tested regardless of the operating mode of the dual function pin.		Shares the use of the pin with AN4 to AN7.

* Can drive a LED directly.

6.2 CLOCK GENERATOR

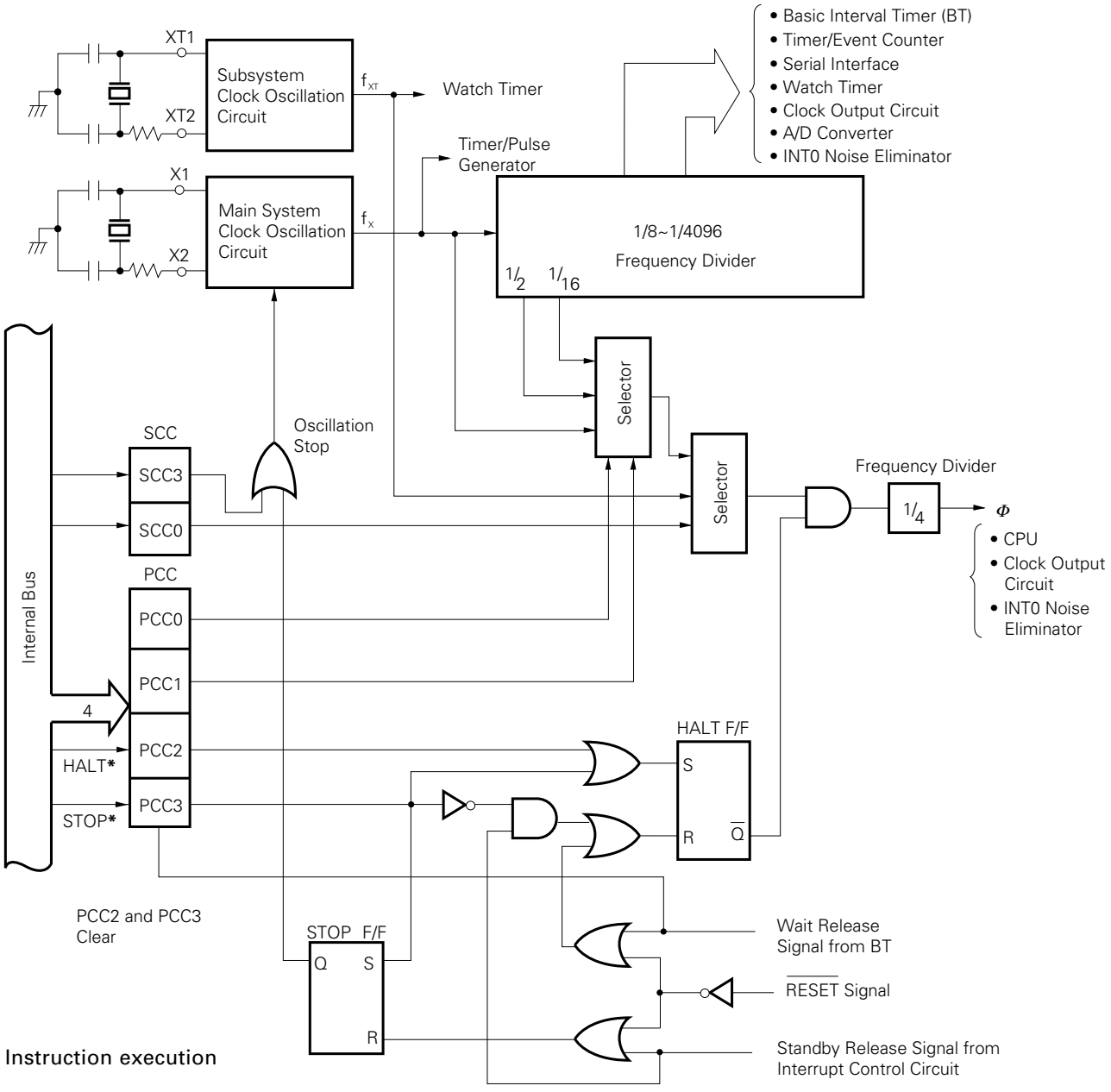
The clock generator operation is determined by the processor clock control register (PCC) and the system clock control register (SCC).

2 kinds of clocks such as a main system clock and a subsystem clock are available.

In addition, the instruction execution time can be changed.

- 0.95 μs, 1.91 μs, 15.3 μs (Main system clock: 4.19 MHz operation)
- 122 μs (Subsystem clock: 32.768 kHz operation)

Fig. 6–1 Clock Generator Block Diagram



* Instruction execution

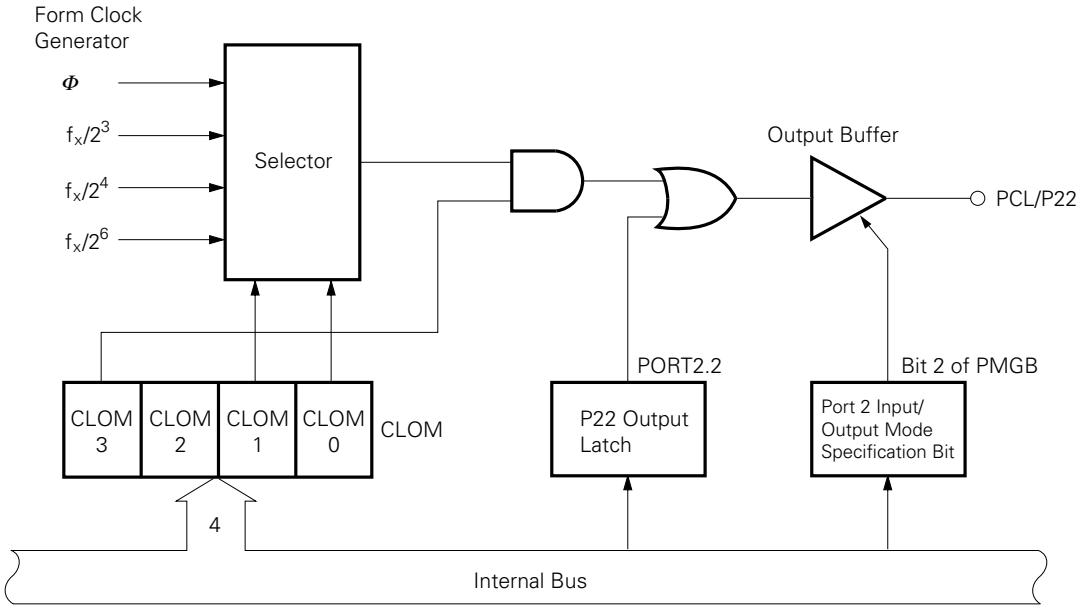
Remarks
1. f_X = Main system clock frequency
2. f_{XT} = Subsystem clock frequency
3. Φ = CPU clock
4. PCC: Processor clock control register
5. SCC: System clock control register
6. One clock cycle (t_{CY}) of Φ is 1 machine cycle of the instruction. With t_{CY}, refer to **"AC CHARACTERISTICS"** in **11. "Electrical Specifications"**. ★

6.3 CLOCK OUTPUT CIRCUIT

The clock output circuit is a circuit which outputs a clock pulse from P22/PCL pin and is used to supply clock pulses to remote control outputs or peripheral LSI's.

- Clock output (PCL) : Φ, 524, 262, 65.5 kHz (4.19 MHz operation)
- Buzzer output (BUZ) : 2 kHz (4.19 MHz, or 32.768 kHz operation)

Fig. 6–2 Clock Output Circuit Configuration



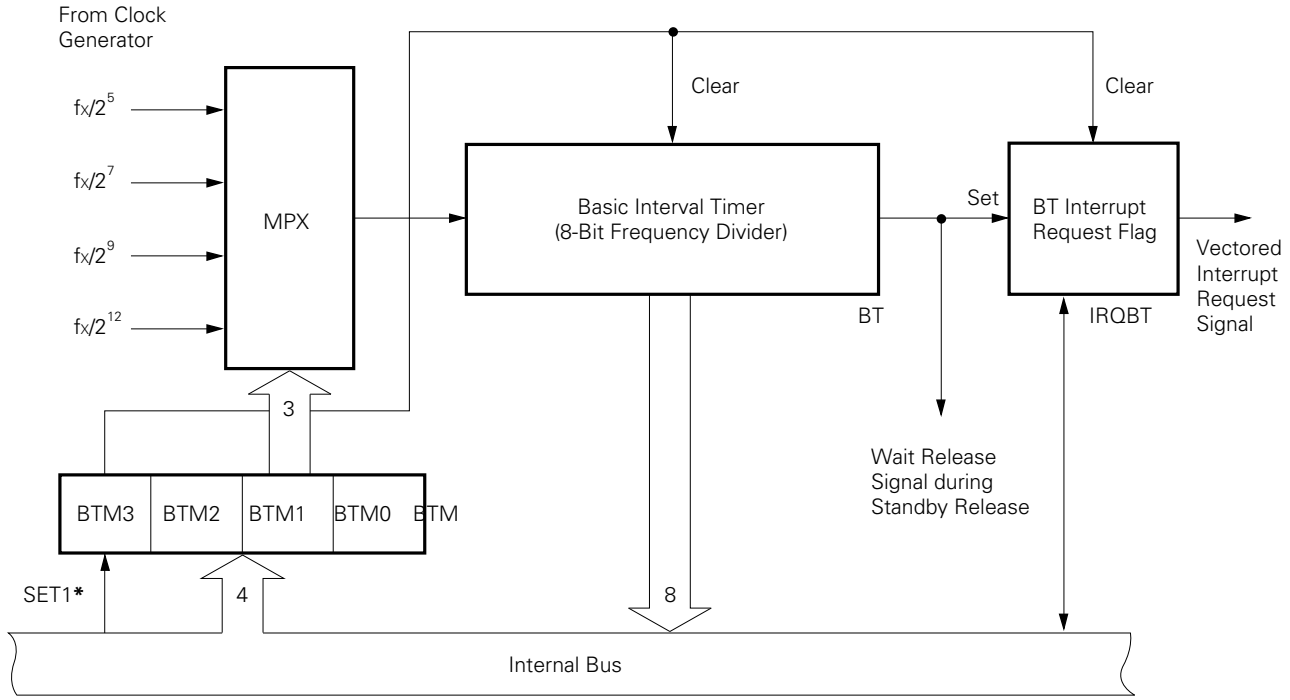
Remarks Consideration is given so that a low amplitude pulse is not output when switching between clock output enable and disable.

6.4 BASIC INTERVAL TIMER

The basic interval timer includes the following functions.

- It operates as an interval timer which generates reference time interrupts.
- It can be applied as a watchdog timer which detects when a program is out of control.
- Selects and counts wait times when the standby mode is released.
- It reads count contents.

Fig. 6–3 Basic Interval Timer Configuration



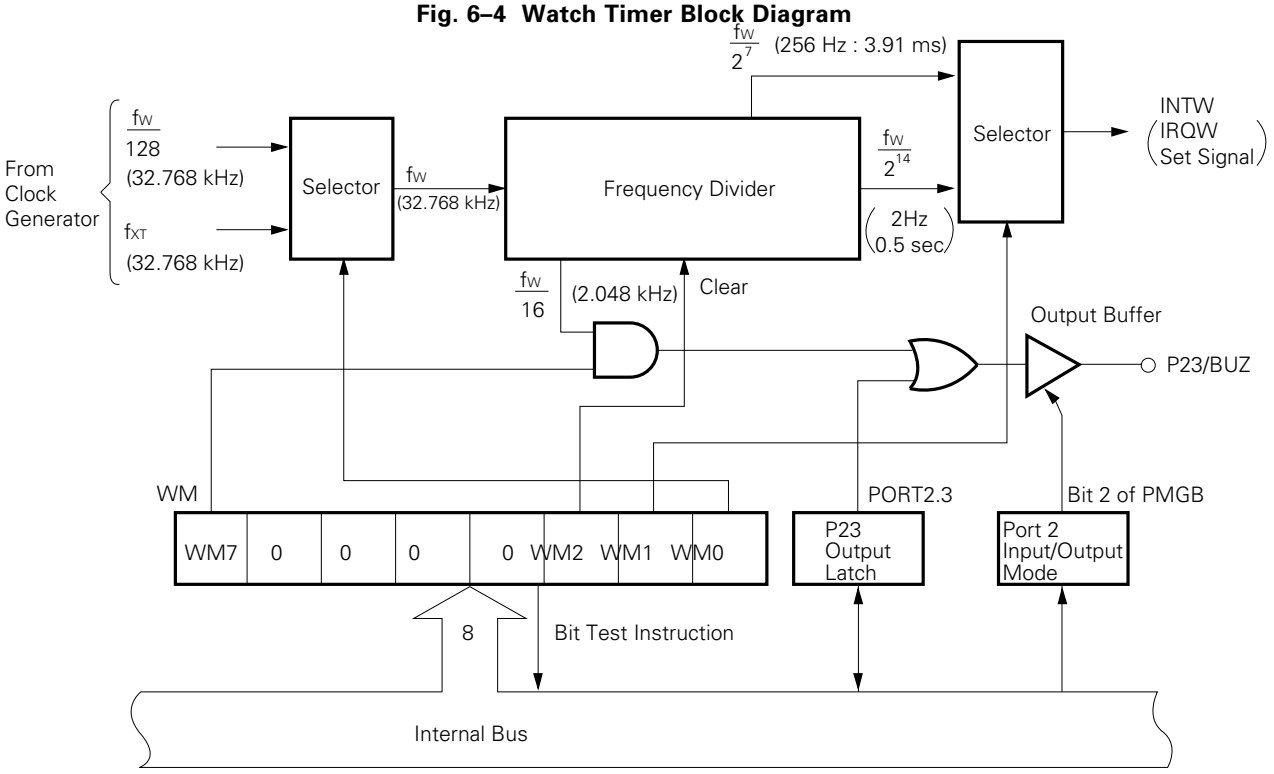
* Instruction execution.

6.5 WATCH TIMER

The μPD75516 incorporates one channel of watch timer which has the following functions.

- Sets test flags (IRQW) at 0.5-second intervals.
  The standby mode can be released with IRQW.
- 0.5-second time intervals can be created in either the main system clock or the subsystem clock.
- In the rapid feed mode, time intervals which are 128 times normal (3.91 ms) can be set, making this function convenient for program debugging and testing.
- A fixed frequency (2.048 kHz) can be output to the P23/BUZ pin for use in generating buzzer sounds and trimming system clock oscillator frequencies.
- The frequency divider can be cleared, so this watch can be started at 0 second.

Fig. 6–4 Watch Timer Block Diagram



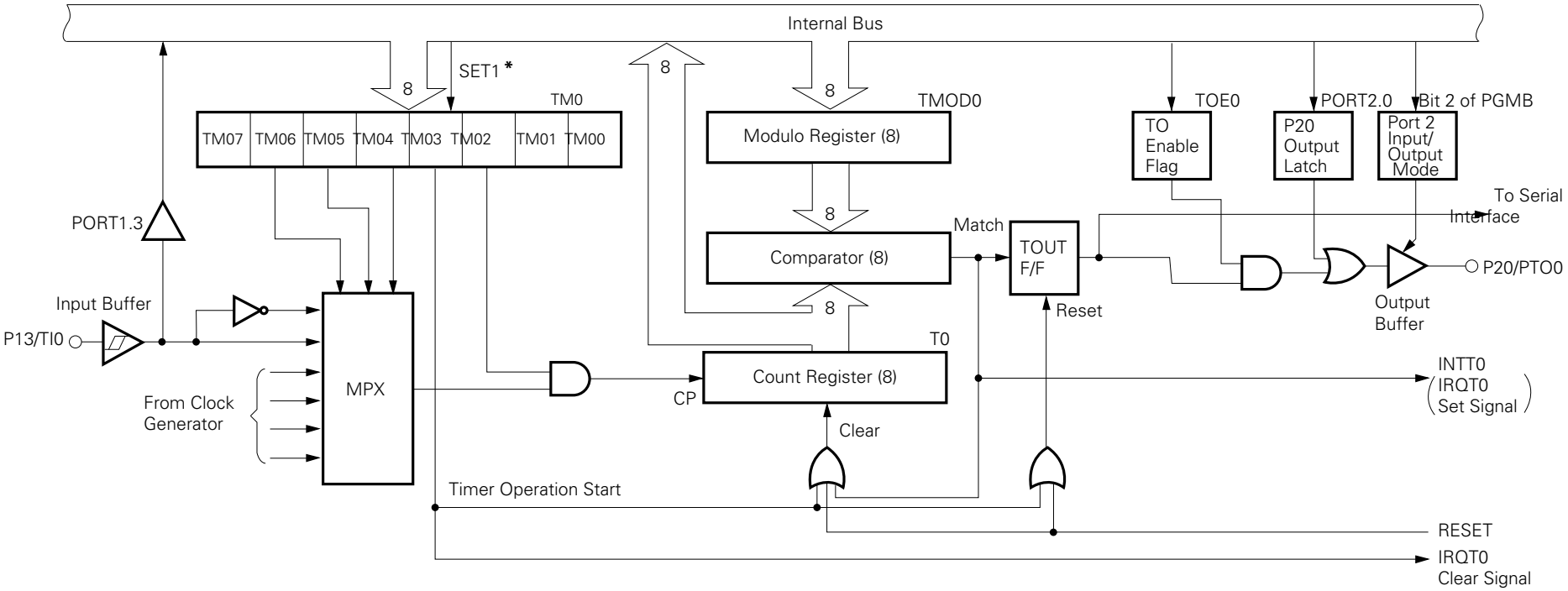
Remarks Values in parentheses are when fX = 4.194304 MHz and fXT = 32.768 kHz.

6.6 TIMER/EVNET COUNTER

The μPD75516 incorporates one channel of timer/event counter which has the following functions.

- Operates as a programmable interval timer.
- Outputs square waves in the desired frequency to the PTO0 pin.
- Operates as an event counter.
- Divides the TI0 pin input into N divisions and outputs it to the PTO0 pin (frequency divider operation).
- Supplies a serial shift clock to the serial interface circuit.
- Count status read function.

Fig. 6–5 Timer/Event Counter Block Diagram



* Instruction execution

6.7 TIMER/PULSE GENERATOR

The μPD75516 incorporates one channel of timer/pulse generator which can be used as a timer or a pulse generator. The timer/pulse generator has the following functions.

(a) Functions available in the timer mode

- 8-bit interval timer operation (IRQTPG generation) enabling the clock source to be varied at 5 levels
- Square wave output to PPO pin

(b) Functions available in the PWM pulse generate mode

- 14-bit accuracy PWM pulse output to the PPO pin (Used as a digital-to analog converter and applicable to tuning)
- Interrupt generation of fixed time interval

If pulse output is not necessary, the PPO pin can be used as a 1-bit output port.

Note If the STOP mode is set while the timer/pulse generator is in operation, miss-operation may result. To prevent that from occurring, preset the timer/pulse generator to the stop state using its mode register.

Fig. 6–6 Block Diagram of Timer/Pulse Generator (Timer Mode)

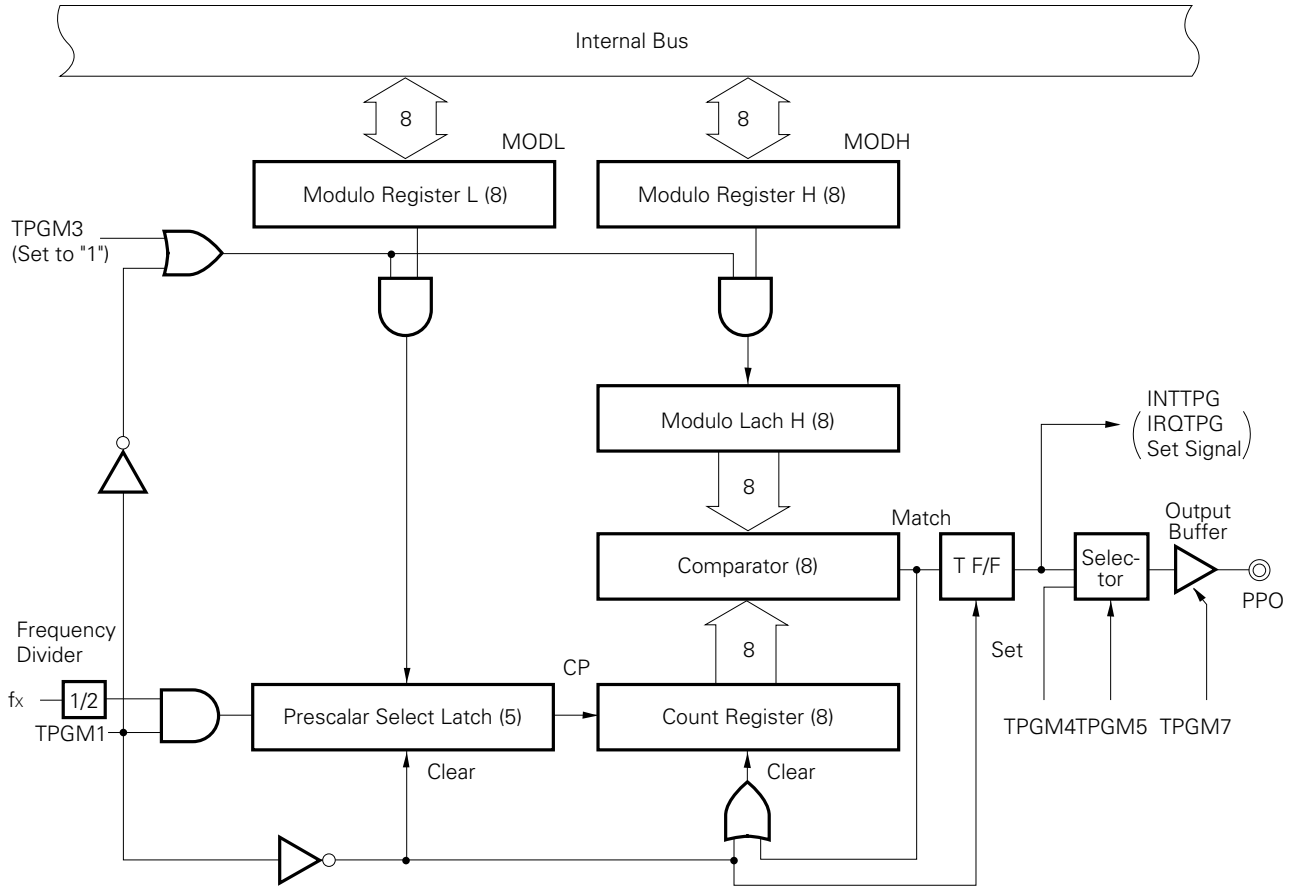
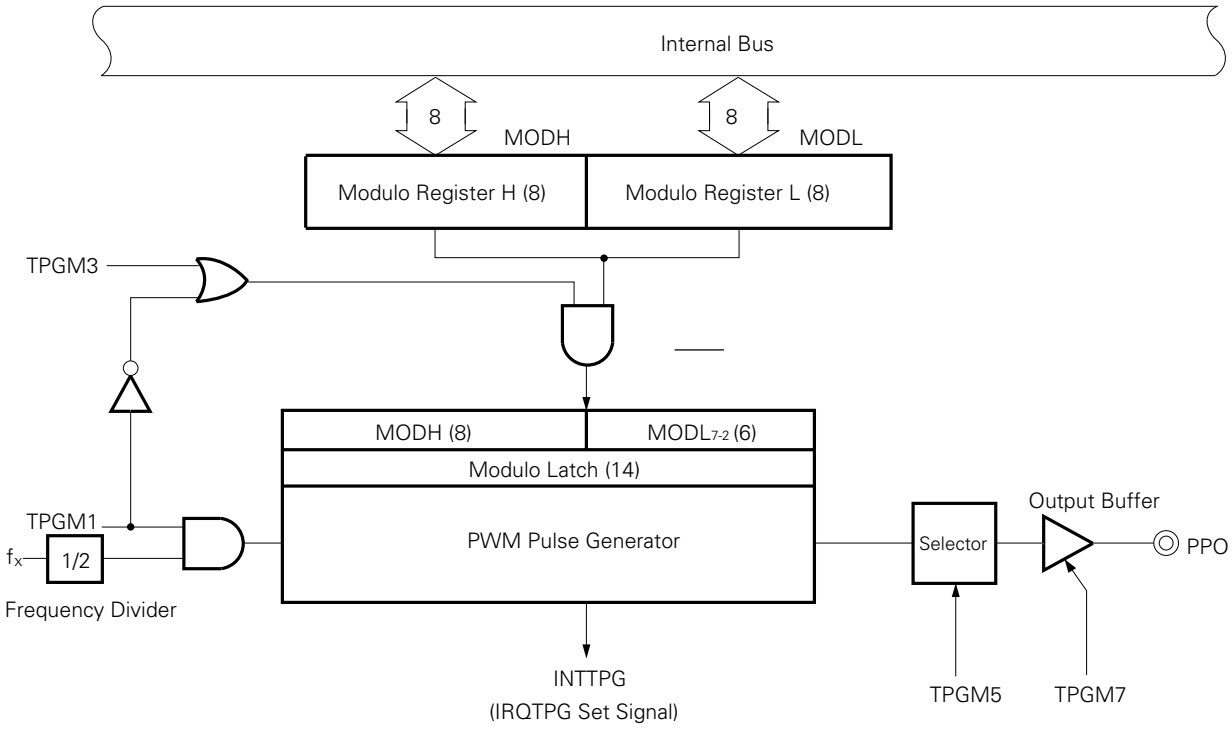


Fig. 6–7 Timer/Pulse Generator Block Diagram (PWM Pulse Generator Mode)



($\frac{2^{15}}{fx}$ = 7.81 ms : fX = 4.19 MHz operation)

6.8 SERIAL INTERFACE

The μPD75516 has two serial interface channels on chip. The differences between channel 0 and channel 1 are shown in Table 6–2.

Table 6–2 Differences between Channels 0 and 1

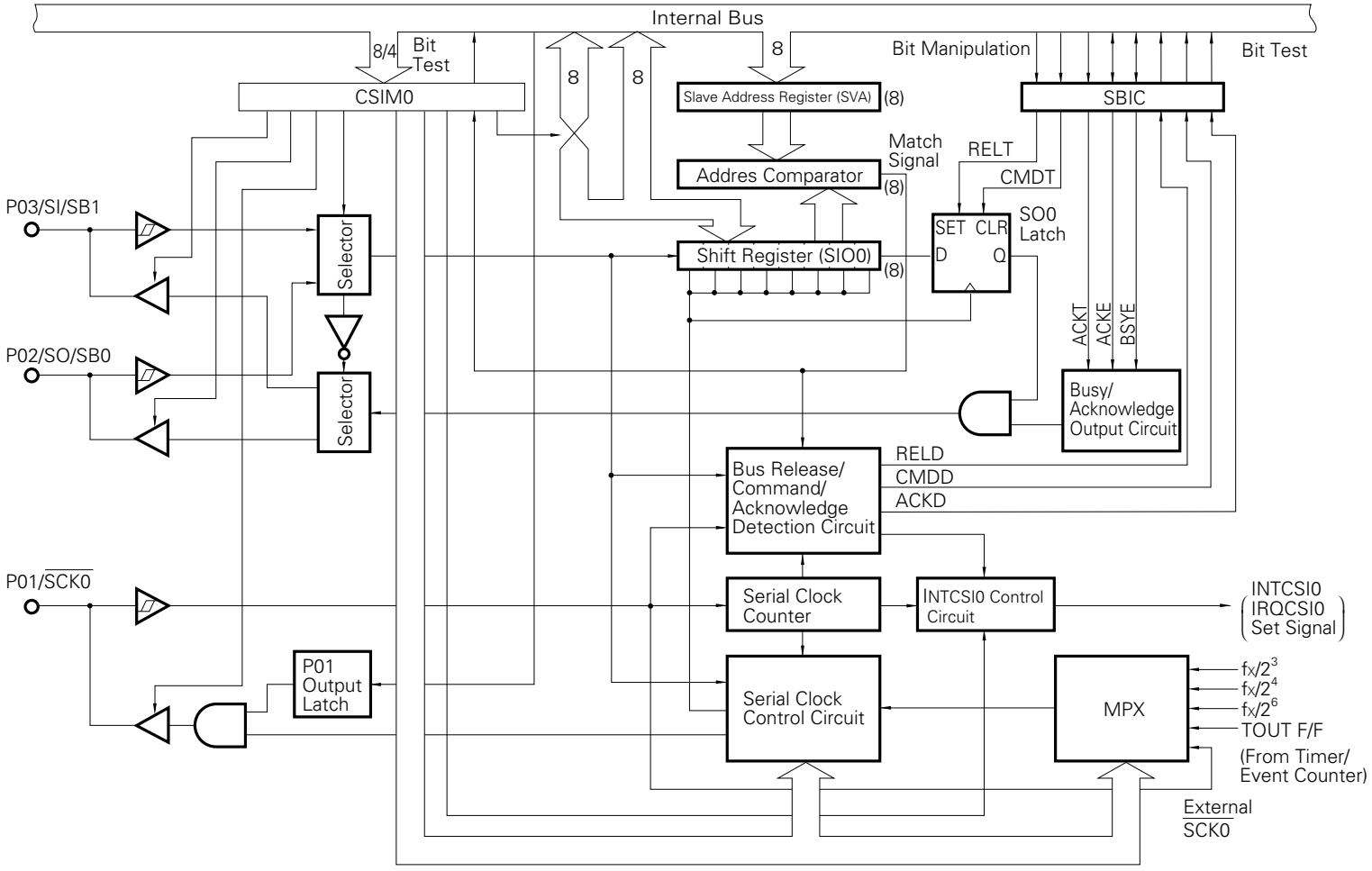
Serial Transfer Mode and Function		Channel 0	Channel 1
3-wire serial I/O	Clock selection	$f_X/2^4$, $f_X/2^3$, TOUT F/F, external clock	$f_X/2^4$, $f_X/2^3$, external clock
	Transfer mode	MSB first/LSB first switchable	MSB first
	Transfer end flag	Serial transfer end interrupt request flag (IRQCSI0)	Serial transfer end flag (EOT)
2-wire serial I/O		Use enabled	None
Serial bus interface (SBI)			

(1) Serial interface (channel 0) functions

The following 4 modes are available to the μPD75516 serial interface (channel 0).

- Operation stop mode
- 3-wire serial I/O mode
- 2-wire serial I/O mode
- SBI mode (serial bus interface mode)

Fig. 6–8 Serial Interface (Channel 0) Block Diagram

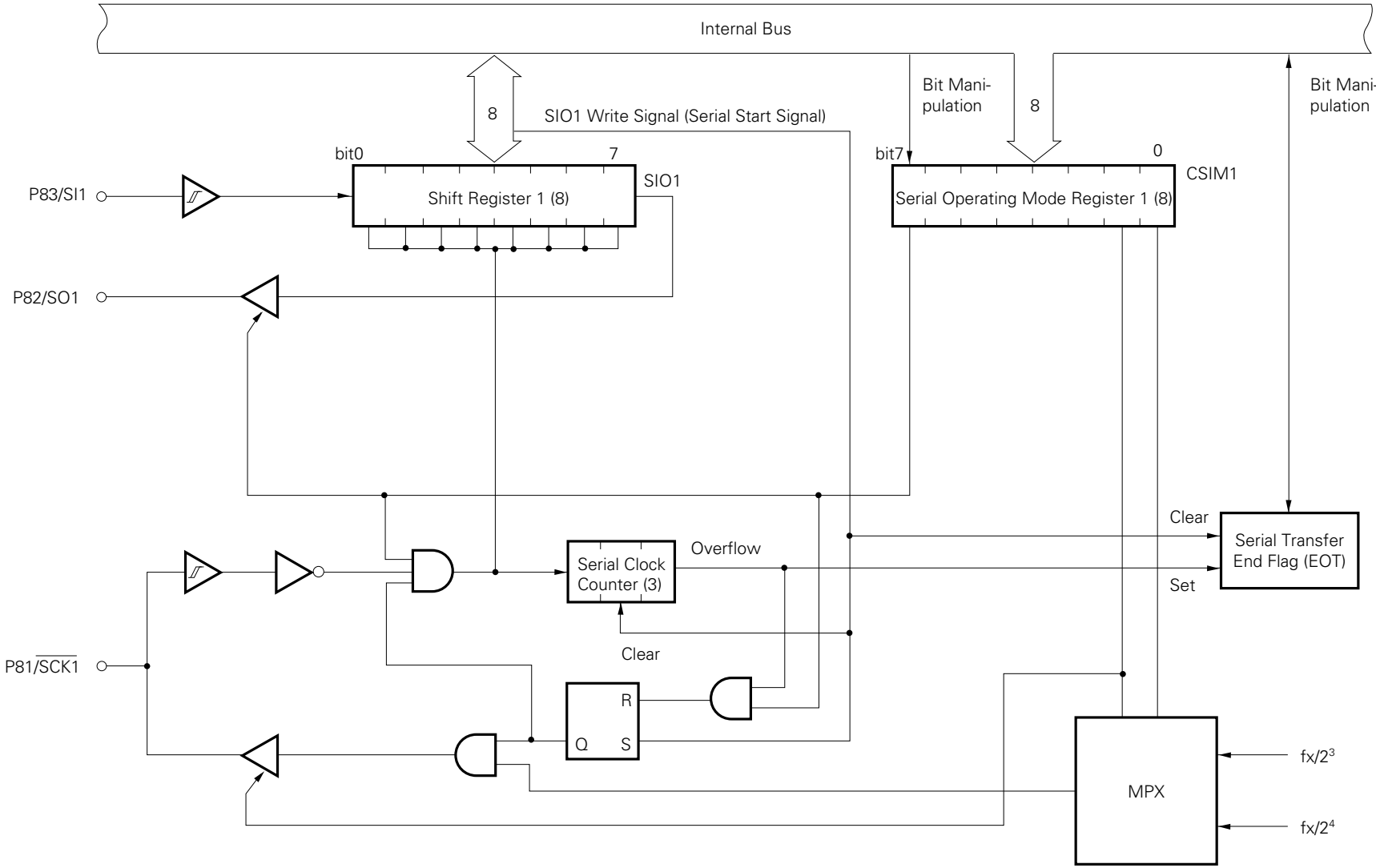


(2) Serial interface (channel 1) functions

The following 2 modes are available to the μPD75516 serial interface (channel 1).

- Operation stop mode
- 3-wire serial I/O mode

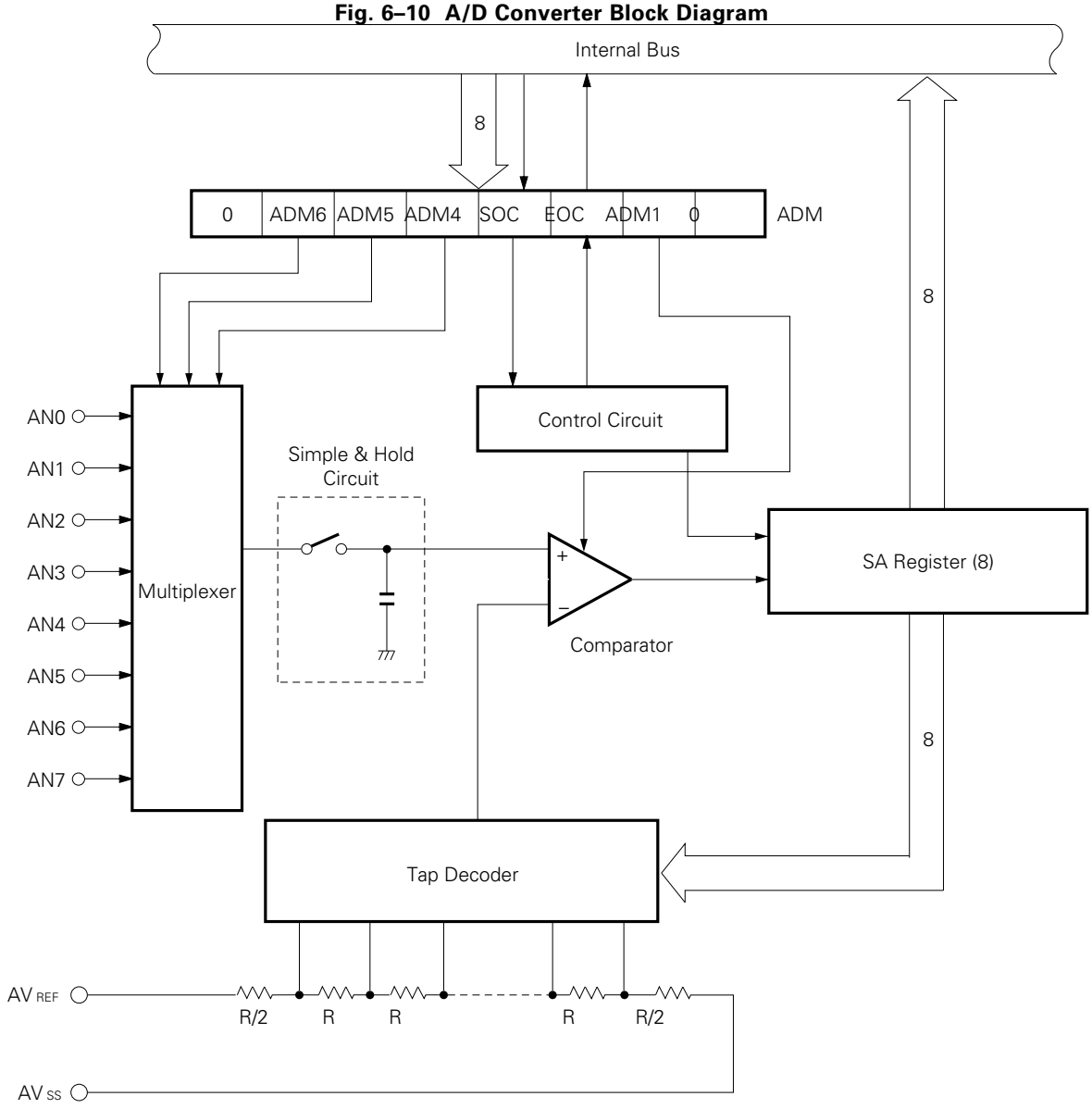
Fig. 6–9 Serial Interface (Channel 1) Block Diagram



6.9 A/D CONVERTER

The μPD75516 incorporates an 8–bit resolution A/D converter with 8–channel analog inputs (AN0 to AN7). The A/D converter employs successive approximation.

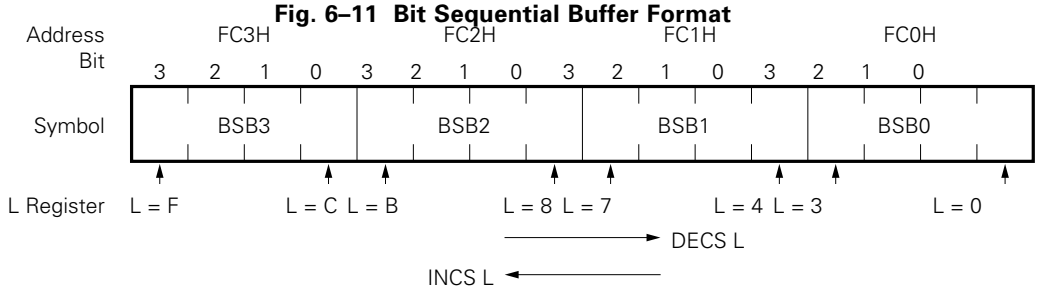
Fig. 6–10 A/D Converter Block Diagram



6.10 BIT SEQUENTIAL BUFFER: 16 BITS

The bit sequential buffer is a special data memory for bit manipulation. In particular it facilitates bit manipulation switch the address and bit specifications sequentially modified, and is thus useful for bit–wise processing of data comprising many bits.

Fig. 6–11 Bit Sequential Buffer Format



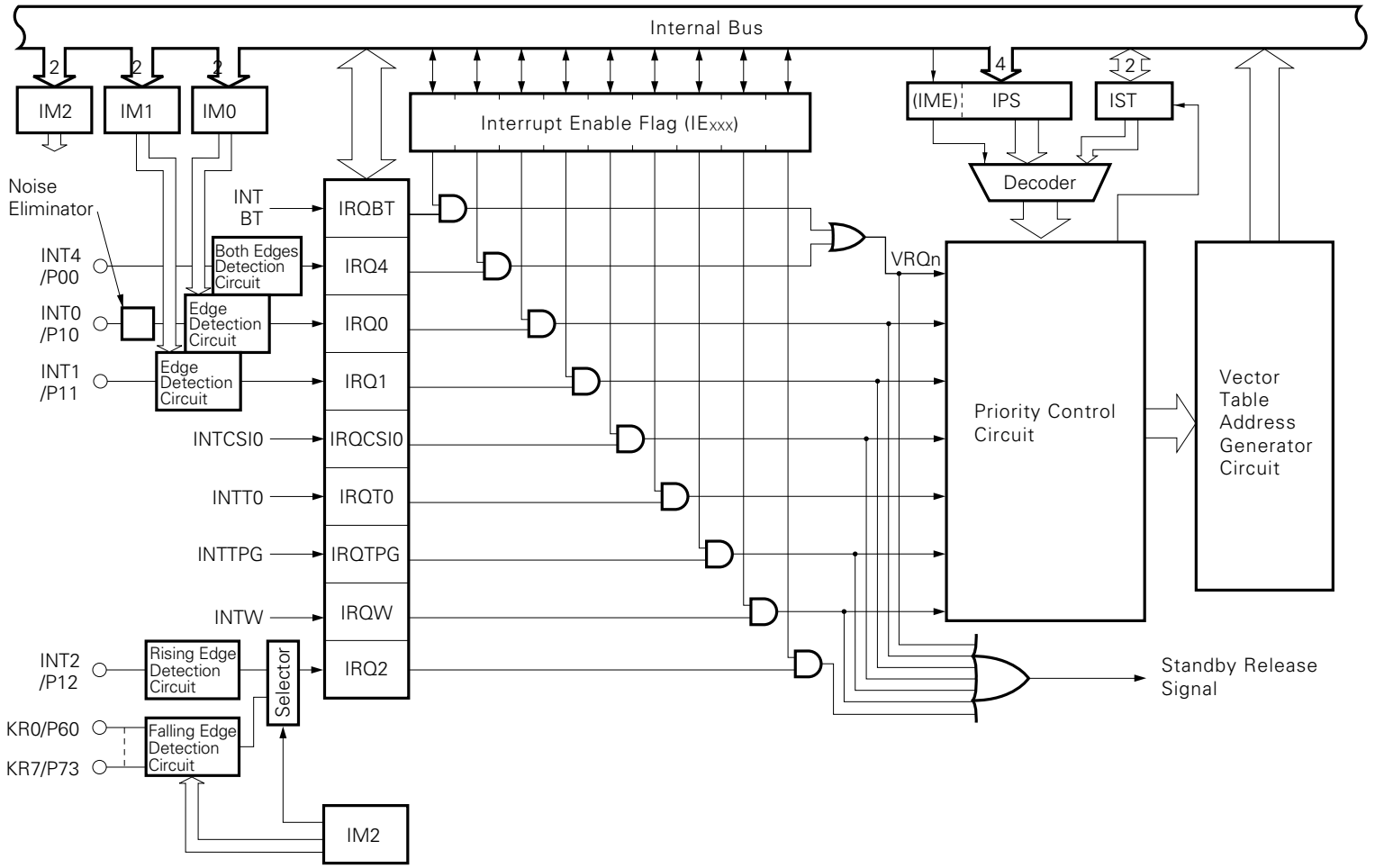
Remarks In pmem.@L addressing, the specified bit shifts in accordance with the L register.

7. INTERRUPT FUNCTIONS

The μPD75516 has nine types of interrupt sources and can generate multiple interrupts with priority order. 2 kind of test sources are also available. INT2 of these test sources is an edge detection testable input. The μPD75516 interrupt control circuit has the following functions:

- Hardware-controller vectored interrupt function which can control interrupt acknowledge with the interrupt enable flag (IE×××) and the interrupt master enable flag (IME).
- Function of setting any interrupt start address.
- Multiple interrupt function which can specify priority order with the interrupt priority select register (IPS).
- Interrupt request flag (IRQ×××) test function (Interrupt generation can be checked by software).
- Standby mode release function (Interrupt to be released by interrupt enable flag can be selected).

Fig. 7-1 Interrupt Control Circuit Block Diagram



8. STANDBY FUNCTIONS

Two standby modes (STOP mode and HALT mode) are available for the μPD75516 to decrease power consumption in the program standby mode.

Table 8-1 Operation Status in Standby Mode

		STOP Mode	HALT Mode
Set instruction		STOP instruction	HALT instruction
System clock when set		Setting enabled only with main system clock.	Setting enabled with either main system clock or subsystem clock.
Operating state	Clock generator	Oscillator stops only with main system clock.	Stops only with CPU clock Φ (Oscillation continued).
	Basic interval timer	Operation stopped.	Operation (IRQBT set at reference time intervals).
	Serial interface (channel 0)	Operation enabled only when external $\overline{SCK0}$ input is selected for serial clock.	Operation enabled when the main system clock oscillates or with external $\overline{SCK0}$.
	Serial interface (channel 1)	Operation enabled only when external $\overline{SCK1}$ input is selected for serial clock.	Operation enabled only when the main system clock oscillates.
	Timer/event counter	Operation enabled only when TI0 pin input is specified for count clock.	Operation enabled only when the main system clock oscillates.
	Watch timer	Operation enabled only fXT is selected for count clock.	Operation enabled.
	A/D converter	Operation stopped.	Operation enabled only when the main system clock oscillates.
	Timer/pulse generator	Operation stopped.	Operation enabled only when the main system clock oscillates.
	External interrupt	INT1, 2, and 4 operation enabled. INT0 operation disabled.	
	CPU	Operation stopped.	
Release signal		Interrupt request signal or $\overline{RESET}$ input from operational hardware enabled by interrupt enable flag.	

9. RESET FUNCTION

The μPD75516 is reset and the hardware is initialized as shown in Table 9-1 by $\overline{\text{RESET}}$ input. The reset operation timing is shown in Fig. 9-1.

Fig. 9-1 Reset Operation by $\overline{\text{RESET}}$ Input

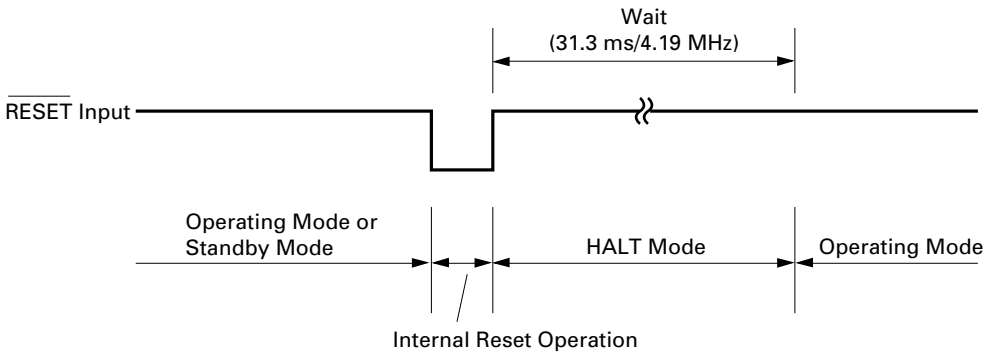


Table 9-1 Status of Each Hardware after Resetting (1/2)

Hardware		$\overline{\text{RESET}}$ Input in Standby Mode	$\overline{\text{RESET}}$ Input during Operation
Program counter (PC)		Low-order 6 bits of program memory address 0000H are set in PC13 to 8 and the contents of address 0001H are set in PC7 to 0.	Same as the left
PSW	Carry flag (CY)	Held	Undefined
	Skip flag (SK0 to 2)	0	0
	Interrupt status flag (IST0, 1)	0	0
	Bank enable flag (MBE, RBE)	Bit 6 of program memory address 0000H is set in RBE, and bit 7 is set in MBE.	Same as the left
Stack pointer (SP)		Undefined	Undefined
Data memory (RAM)		Held*	Undefined
General register (X, A, H, L, D, E, B, C)		Held	Undefined
Bank selection register (MBS, RBS)		0, 0	0, 0
Basic interval timer	Counter (BT)	Undefined	Undefined
	Mode register (BTM)	0	0
Timer/event counter	Counter (T0)	0	0
	Modulo register (TMOD0)	FFH	FFH
	Mode register (TM0)	0	0
	TOE0, TOUT F/F	0, 0	0, 0
Timer/pulse generator	Modulo register	Held	Held
	Mode register	0	0
Watch timer	Mode register (WM)	0	0

* Data of data memory addresses 0F8H to 0FDH becomes undefined by $\overline{\text{RESET}}$ input.

Table 9-1 Hardware Statuses after Reset (2/2)

Hardware		$\overline{\text{RESET}}$ Input in Standby Mode	$\overline{\text{RESET}}$ Input during Operation
Serial interface (channel 0)	Shift register (SIO0)	Held	Undefined
	Operating mode register 0 (CSIM0)	0	0
	SBI control register (SBIC)	0	0
	Slave address register (SVA)	Held	Undefined
	P01/$\overline{\text{SCK0}}$ output latch	1	1
A/D converter	Mode register (ADM), EOC	04H (EOC = 1)	04H (EOC = 1)
	SA register	7FH	7FH
Clock generator and clock output circuit	Processor clock control register (PCC)	0	0
	System clock control register (SCC)	0	0
	Clock output mode register (CLOM)	0	0
Serial interface (channel 1)	Shift register (SIO1)	Held	Undefined
	Operating mode register 1 (CSIM1)	0	0
	Serial transfer end flag (EOT)	0	0
Interrupt function	Interrupt request flag (IRQ×××)	Reset (0)	Reset (0)
	Interrupt enable flag (IE×××)	0	0
	Interrupt master enable flag (IME)	0	0
	INT0, 1, and 2 mode registers (IM0, 1, 2)	0, 0, 0	0, 0, 0
Digital port	Output buffer	Off	Off
	Output latch	Clear (0)	Clear (0)
	Input/output mode register (PMGA, B, C)	0	0
	Pull-up resistor specify register (POGA)	0	0
Bit sequential buffer (BSB0 to BSB3)		Held	Undefined

10. INSTRUCTION SET

(1) Operand identifier and description

Enter an operand in the operand column of each instruction using the description method relating to the operand identifier of the instruction (For details, refer to **"RA75X Assembler Package User's Manual – Language Volume" (EEU–730)**). If more than one description method is available, select one. Capital alphabetic letters, plus and minus signs are keywords. Describe them as they are.

In the case of immediate data, describe appropriate numerical values or labels.

Identifier	Description Method
reg reg1	X, A, B, C, D, E, H, L X, B, C, D, E, H, L
rp rp1 rp2 rp' rp'1	XA, BC, DE, HL BC, DE, HL BC, DE XA, BC, DE, HL, XA', BC', DE', HL' BC, DE, HL, XA', BC', DE', HL'
rpa rpa1	HL, HL+, HL-, DE, DL DE, DL
n4 n8	4-bit immediate data or label 8-bit immediate data or label
mem bit	8-bit immediate data or label* 2-bit immediate data or label
fmem pmem	FB0H to FBFH and FF0H to FFFH immediate data or labels FC0H to FFFH immediate data or labels
addr caddr faddr	0000H to 3F7FH immediate data or labels 12-bit immediate data or label 11-bit immediate data or label
taddr	20H to 7FH immediate data (bit0 = 0) or label
PORTn IE××× RBn MBn	PORT0 to PORT15 IEBT, IECSI0, IET0, IE0, IE1, IE2, IE4, IEW, IETPG RB0 to RB3 MB0, MB1, MB2, MB15

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

(2) Legend for operation description

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′	: Expanded register pair (XA′)
BC′	: Expanded register pair (BC′)
DE′	: Expanded register pair (DE′)
HL′	: Expanded 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
PORTn	: Port n (n = 0 to 15)
IME	: Interrupt master enable flag
IPS	: Interrupt priority select register
IE×××	: Interrupt enable flag
RBS	: Register bank select register
MBS	: Memory bank select register
PCC	: Processor clock control register
.	: Address and bit delimiter
(××)	: Contents addressed by ××
××H	: Hexadecimal data

(3) Description of symbols in the addressing area column

*1	MB = MBE • MBS (MBS = 0, 1, 15)	Data Memory Addressing
*2	MB = 0	
*3	MBE = 0 : MB = 0 (00H to 7FH) MB = 15 (80H to FFH) MBE = 1 : MB = MBS (MBS = 0, 1, 15)	
*4	MB = 15, fmem = FB0H to FBFH, FF0H to FFFH	
*5	MB = 15, pmem = FC0H to FFFH	
*6	addr = 0000H to 3F7FH	Program Memory Addressing
*7	addr = (Current PC) – 15 to (Current PC) – 1, (Current PC) + 2 to (Current PC) + 16	
*8	caddr = 0000H to 0FFFH ($PC_{13, 12}$ = 00B) or 1000H to 1FFFH ($PC_{13, 12}$ = 01B) or 2000H to 2FFFH ($PC_{13, 12}$ = 10B) or 3000H to 3F7FH ($PC_{13, 12}$ = 11B)	
*9	faddr = 0000H to 07FFH	
*10	taddr = 0020H to 007FH	

Remarks 1. MB indicates accessible memory bank.

2. In *2, MB = 0 irrespective of MBE and MBS.

3. In *4 and *5, MB = 15 irrespective of MBE and MBS.

4. *6 to *10 indicate addressable areas.

(4) Description of the machine cycle column

S indicates the number of machine cycles required for skip operation by an instruction having skip function. The S value varies as follows:

- When not skipped ..... S = 0
- When 1-byte or 2-byte instructions are skipped ..... S = 1
- When 3-byte instructions are skipped (BR !adder, CALL !adder instruction) ... S = 2

Note GETI instruction is skipped in one machine cycle.

One machine cycle is equal to one cycle (= t_{CY}) of CPU clock Φ and three time periods are available according to PCC setting.

Note 1	Mnemonic	Operands	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Transfer	MOV	A, #n4	1	1	A←n4		Stack A
		reg1, #n4	2	2	reg1←n4		
		XA, #n8	2	2	XA←n8		Stack A
		HL, #n8	2	2	HL←n8		Stack B
		rp2, #n8	2	2	rp2←n8		
		A, @HL	1	1	A←(HL)	*1	
		A, @HL+	1	2 + S	A←(HL), then L←L+1	*1	L = 0
		A, @HL–	1	2 + S	A←(HL), then L←L–1	*1	L = FH
		A, @rpa1	1	1	A←(rpa1)	*2	
		XA, @HL	2	2	XA←(HL)	*1	
		@HL, A	1	1	(HL)←A	*1	
		@HL, XA	2	2	(HL)←XA	*1	
		A, mem	2	2	A←(mem)	*3	
		XA, mem	2	2	XA←(mem)	*3	
		mem, A	2	2	(mem)←A	*3	
		mem, XA	2	2	(mem)←XA	*3	
		A, reg	2	2	A←reg		
		XA, rp'	2	2	XA←rp'		
		reg1, A	2	2	reg1←A		
		rp'1, XA	2	2	rp'1←XA		
	XCH	A, @HL	1	1	A↔(HL)	*1	
		A, @HL+	1	2 + S	A↔(HL), then L←L+1	*1	L = 0
		A, @HL–	1	2 + S	A↔(HL), then L←L–1	*1	L = FH
		A, @rpa1	1	1	A↔(rpa1)	*2	
		XA, @HL	2	2	XA↔(HL)	*1	
		A, mem	2	2	A↔(mem)	*3	
		XA, mem	2	2	XA↔(mem)	*3	
		A, reg1	1	1	A↔reg1		
		XA, rp'	2	2	XA↔rp'		
Note 2	MOVT	XA, @PCDE	1	3	XA←$(PC_{13-8}+DE)_{ROM}$		
		XA, @PCXA	1	3	XA←$(PC_{13-8}+XA)_{ROM}$		

Note **1.** Instruction Group
2. Table reference

Note	Mnemonic	Operand	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Bit transfer	MOV1	CY, fmem.bit	2	2	CY←(fmem.bit)	*4	
		CY, pmem.@L	2	2	CY←(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))	*5	
		CY, @H+mem.bit	2	2	CY←(H+mem$_{3-0}$.bit)	*1	
		fmem.bit, CY	2	2	(fmem.bit)←CY	*4	
		pmem.@L, CY	2	2	(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))←CY	*5	
		@H+mem.bit, CY	2	2	(H+mem$_{3-0}$.bit)←CY	*1	
Operation	ADDS	A, #n4	1	1 + S	A←A+n4		carry
		XA, #n8	2	2 + S	XA←XA+n8		carry
		A, @HL	1	1 + S	A←A+(HL)	*1	carry
		XA, rp'	2	2 + S	XA←XA+rp'		carry
		rp'1, XA	2	2 + S	rp'1←rp'1+XA		carry
	ADDC	A, @HL	1	1	A, CY←A+(HL)+CY	*1	
		XA, rp'	2	2	XA, CY←XA+rp'+CY		
		rp'1, XA	2	2	rp'1, CY←rp'1+XA+CY		
	SUBS	A, @HL	1	1 + S	A←A–(HL)	*1	borrow
		XA, rp'	2	2 + S	XA←XA–rp'		borrow
		rp'1, XA	2	2 + S	rp'1←rp'1–XA		borrow
	SUBC	A, @HL	1	1	A, CY←A–(HL)–CY	*1	
		XA, rp'	2	2	XA, CY←XA–rp'–CY		
		rp'1, XA	2	2	rp'1, CY←rp'1–XA–CY		
	AND	A, #n4	2	2	A←A∧n4		
		A, @HL	1	1	A←A∧(HL)	*1	
		XA, rp'	2	2	XA←XA∧rp'		
		rp'1, XA	2	2	rp'1←rp'1∧XA		
	OR	A, #n4	2	2	A←A∨n4		
		A, @HL	1	1	A←A∨(HL)	*1	
		XA, rp'	2	2	XA←XA∨rp'		
		rp'1, XA	2	2	rp'1←rp'1∨XA		
	XOR	A, #n4	2	2	A←A⊻n4		
		A, @HL	1	1	A←A⊻(HL)	*1	
		XA, rp'	2	2	XA←XA⊻rp'		
		rp'1, XA	2	2	rp'1←rp'1⊻XA		

Note Instruction Group

Note 1	Mnemonic	Operands	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Note 2	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←reg+1		reg = 0
		rp1	1	1 + S	rp1←rp1+1		rp1 = 00H
		@HL	2	2 + S	(HL)←(HL)+1	*1	(HL) = 0
		mem	2	2 + S	(mem)←(mem)+1	*3	(mem) = 0
	DECS	reg	1	1 + S	reg←reg–1		reg = FH
		rp'	2	2 + S	rp'←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 manipulation	SET1	CY	1	1	CY←1		
	CLR1	CY	1	1	CY←0		
	SKT	CY	1	1 + S	Skip if CY = 1		CY = 1
	NOT1	CY	1	1	$CY \leftarrow \overline{CY}$		

Note **1.** Instruction Group
2. Accumulator manipulation

Note	Mnemonic	Operands	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Memory bit manipulation	SET1	mem.bit	2	2	(mem.bit)←1	*3	
		fmem.bit	2	2	(fmem.bit)←1	*4	
		pmem.@L	2	2	(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))←1	*5	
		@H + mem.bit	2	2	(H+mem$_{3-0}$.bit)←1	*1	
	CLR1	mem.bit	2	2	(mem.bit)←0	*3	
		fmem.bit	2	2	(fmem.bit)←0	*4	
		pmem.@L	2	2	(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))←0	*5	
		@H+mem.bit	2	2	(H+mem$_{3-0}$.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 (pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$)) = 1	*5	(pmem.@L) = 1
		@H+mem.bit	2	2 + S	Skip if (H+mem$_{3-0}$.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 (pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$)) = 0	*5	(pmem.@L) = 0
		@H+mem.bit	2	2 + S	Skip if (H+mem$_{3-0}$.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 (pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))=1 and clear	*5	(pmem.@L) = 1
		@H+mem.bit	2	2 + S	Skip if (H+mem$_{3-0}$.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∧(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))	*5	
		CY, @H+mem.bit	2	2	CY←CY∧(H+mem$_{3-0}$.bit)	*1	
	OR1	CY, fmem.bit	2	2	CY←CY∨(fmem.bit)	*4	
		CY, pmem.@L	2	2	CY←CY∨(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))	*5	
		CY, @H+mem.bit	2	2	CY←CY∨(H+mem$_{3-0}$.bit)	*1	
	XOR1	CY, fmem.bit	2	2	CY←CY⊻(fmem.bit)	*4	
		CY, pmem.@L	2	2	CY←CY⊻(pmem$_{7-2}$+L$_{3-2}$.bit(L$_{1-0}$))	*5	
		CY, @H+mem.bit	2	2	CY←CY⊻(H+mem$_{3-0}$.bit)	*1	
Branch	BR	addr	—	—	PC$_{13-0}$←addr (Optimum instruction is selected from among BR !addr, BRCB !caddr and BR $addr by an assembler.)	*6	
		!addr	3	3	PC$_{13-0}$←addr	*6	
		$addr	1	2	PC$_{13-0}$←addr	*7	
	BRCB	!caddr	2	2	PC$_{13-0}$←PC$_{13,12}$+caddr$_{11-0}$	*8	
	BR	PCDE	2	3	PC$_{13-0}$←PC$_{13-8}$+DE		
		PCXA	2	3	PC$_{13-0}$←PC$_{13-8}$+XA		

Note Instruction Group

Note	Mnemonic	Operands	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Subroutine stack control	CALL	!addr	3	3	(SP–4) (SP–1) (SP–2)←PC_{11-0} (SP–3)← MBE, RBE, $PC_{13, 12}$ PC_{13-0}←addr, SP←SP–4	*6	
	CALLF	!faddr	2	2	(SP–4) (SP–1) (SP–2)←PC_{11-0} (SP–3)← MBE, RBE, $PC_{13, 12}$ PC_{13-0}←00, faddr, SP←SP–4	*9	
	RET		1	3	MBE, RBE, $PC_{13, 12}$←(SP+1) PC_{11-0}←(SP) (SP+3) (SP+2) SP←SP+4		
	RETS		1	3 + S	MBE, RBE, $PC_{13, 12}$←(SP+1) PC_{11-0}←(SP) (SP+3) (SP+2) SP←SP+4 then skip unconditionally		Unconditional
	RETI		1	3	$PC_{13, 12}$←(SP+1) PC_{11-0}←(SP) (SP+3) (SP+2) PSW←(SP+4) (SP+5), SP←SP+6		
	PUSH	rp	1	1	(SP–1) (SP–2)←rp, SP←SP–2		
		BS	2	2	(SP–1)←MBS, (SP–2)←RBS, SP←SP–2		
	POP	rp	1	1	rp←(SP+1) (SP), SP←SP+2		
		BS	2	2	MBS←(SP+1), RBS←(SP), SP←SP+2		
Interrupt control	EI		2	2	IME(IPS.3)←1		
		IE×××	2	2	IE×××←1		
	DI		2	2	IME(IPS.3)←0		
		IE×××	2	2	IE×××←0		
Input/output	IN *	A, PORTn	2	2	A←PORTn (n = 0 to 15)		
		XA, PORTn	2	2	XA←PORTn+1, PORTn (n = 4, 6)		
	OUT *	PORTn, A	2	2	PORTn←A (n = 2 to 7, 9 to 14)		
		PORTn, XA	2	2	PORTn+1, PORTn←XA (n = 4, 6)		
CPU control	HALT		2	2	Set HALT Mode (PCC.2←1)		
	STOP		2	2	Set STOP Mode (PCC.3←1)		
	NOP		1	1	No Operation		
Special	SEL	RBn	2	2	RBS←n (n = 0 to 3)		
		MBn	2	2	MBS←n (n = 0, 1, 15)		

* MBE = 0 or MBE = 1 and MBE = 15 must be set for execution of IN/OUT instruction

Note Instruction Group

Note	Mnemonic	Operands	No. of Bytes	Machine Cycle	Operation	Addressing Area	Skip Condition
Special	GETI *	taddr	1	3	• TBR instruction $PC_{13-0} \leftarrow (taddr)_{4-0} + (taddr+1)$	*10	
					• TCALL instruction $(SP-4)(SP-1) \leftarrow PC_{11-0}$ $(SP-3) \leftarrow$ MBE, RBE, $PC_{13, 12}$ $PC_{13-0} \leftarrow (taddr)_{5-0} + (taddr+1)$ $SP \leftarrow SP-4$		
					• (taddr) (taddr+1) instruction executed in the case of instruction except TBR and TCALL instructions		Depends on instructions referred to.

* TBR and TCALL instructions are assembled pseudo-instructions to define the GETI instruction table.

Note Instruction Group

11. ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS (Ta = 25 °C)

PARAMETER	SYMBOL	TEST CONDITIONS		RATING	UNIT
Power supply voltage	V_{DD}			–0.3 to +7.0	V
Input voltage	V_{I1}	Except ports 4, 5 and 12 to 14		–0.3 to V_{DD} +0.3	V
	V_{I2}	Ports 4, 5 and 12 to 14	Internal pull-up resistor	–0.3 to V_{DD} +0.3	V
			Open-drain	–0.3 to +11	V
Output voltage	V_O			–0.3 to V_{DD} +0.3	V
Output current high	I_{OH}	1 pin		–15	mA
		All pins		–30	mA
Output current low	V_{OL}*	1 pin	Peak value	30	mA
			Effective value	15	mA
		Total of ports 0, 2, 3 and 4	Peak value	100	mA
			Effective value	60	mA
		Total of ports 5 to 11	Peak value	100	mA
			Effective value	60	mA
		Total of ports 12 to 14	Peak value	40	mA
			Effective value	25	mA
Operating temperature	T_{opt}			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

* Calculate the effective value with the formula [Effective value] = [Peak value] × $\sqrt{\text{duty}}$.

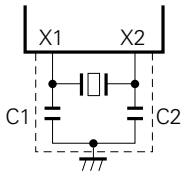
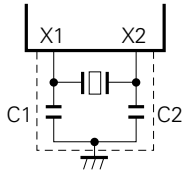
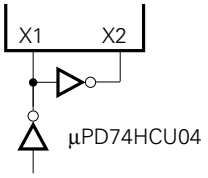
OPERATING VOLTAGE

PARAMETER		SYMBOL	TEST CONDITIONS	MIN.	MAX.	UNIT
A/D converter	Power supply voltage	V_{DD}		3.5	6.0	V
	Ambient temperature	Ta		–10	+70	°C
Timer/pulse generator	Power supply voltage	V_{DD}		4.5	6.0	V
	Ambient temperature	Ta		–40	+85	°C
Other circuits	Power supply voltage	V_{DD}		2.7	6.0	V
	Ambient temperature	Ta		–40	+85	°C

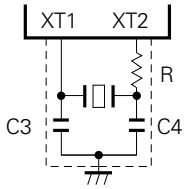
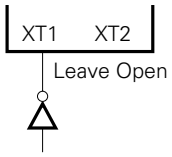
CAPACITANCE (Ta = 25 °C, V_{DD} = 0 V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Input capacitance	C_I	f = 1 MHz Unmeasured pin returned to 0 V			15	pF
Output capacitance	C_O				15	pF
Input /output capacitance	C_{IO}				15	pF

MAIN SYSTEM CLOCK OSCILLATOR CHARACTERISTICS (Ta = –40 to +85 °C, V_{DD} = 2.7 to 6.0 V)

RESONATOR	RECOMMENDED CIRCUIT	PARAMETER	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Ceramic resonator		Oscillator frequency (f_X) ***1***	V_{DD} = Oscillation voltage range	1.0		5.0***3***	MHz
		Oscillation stabilization time ***2***	After V_{DD} reaches the minimum value in the oscillation voltage range			4	ms
Crystal resonator		Oscillator frequency (f_X) ***1***		1.0	4.19	5.0***3***	MHz
		Oscillation stabilization time ***2***	V_{DD} = 4.5 to 6.0 V			10	ms
						30	ms
External clock		X1 input frequency (f_X) ***1***		1.0		5.0***3***	MHz
		X1 high and low level widths (t_{XH}, t_{XL})		100		500	ns

SUBSYSTEM CLOCK OSCILLATOR CHARACTERISTICS (Ta = –40 to +85 °C, V_{DD} = 2.7 to 6.0 V)

RESONATOR	RECOMMENDED CIRCUIT	PARAMETER	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Crystal resonator		Oscillator frequency (f_{XT}) ***1***		32	32.768	35	kHz
		Oscillation stabilization time ***2***	V_{DD} = 4.5 to 6.0 V		1.0	2	s
						10	s
External clock		XT1 input frequency (f_{XT}) ***1***		32		100	kHz
		XT1 high and low level widths (t_{XTH}, t_{XTL})		5		15	μs

*** 1.** Oscillator characteristics only. Refer to the description of AC characteristics for details of instruction execution time.

2. Time required for oscillation to become stabilized after V_{DD} reaches MIN. of the oscillation voltage range or after STOP mode release.

3. When the oscillator frequency is 4.19 MHz < fX ≤ 5.0 MHz, PPC = 0011 should not be selected as the instruction execution time. If PCC = 0011 is selected, one machine cycle is less than 0.95 μs, and the specification MIN. value of 0.95 μs will not be achieved.

Note When the system clock oscillator is used, the following points should be noted concerning wiring in the section enclosed by dots, in order to prevent the effects of wiring capacitance, etc. ★

- **Keep the wiring as short as possible.**
- **Do not cross any other signal lines, and keep clear of lines in which a high fluctuating current flows.**
- **Ensure that oscillator capacitor connection points are always at the same potential as VDD. Do not connect in a power supply pattern in which a high current flows.**
- **Do not take a signal from the oscillator.**

The subsystem clock oscillator is designed to be a circuit with the low amplification factor to achieve low consumption current, with the result that it is more prone to misoperation due to noise than the main system clock oscillator. Therefore, when using the subsystem clock, special care is required for the wiring method.

RECOMMENDED OSCILLATOR CONSTANTS

MAIN SYSTEM CLOCK : CERAMIC RESONATOR (Ta = –40 to +85 °C)

MANUFACTURER	PRODUCT NAME	EXTERNAL CAPACITANCE (pF)		OSCILLATION VOLTAGE RANGE (V)		REMARKS
		C1	C2	MIN.	MAX.	
Kyocera Corp.	KBR–1000H	100	100	2.7	6.0	
	KBR–2.0MS	47	47			
	KBR–4.0MS	33	33			
Murata Mfg. Co., Ltd.	CSA 2.00MG CSA 4.00MGU CSA 4.19MG093 CSA 4.91MGU	30	30	2.7	6.0	
	CSA 4.91MG	30	30	3.0		
	CST 2.00MG CST 4.00MGU CST 4.19MG093 CST 4.91MGU	On-chip	On-chip	2.7		
	CST 4.91MG	On-chip	On-chip	3.0		
Toko, Inc.	CRHF 3.00 CRHF 4.19	27	27	3.0	6.0	

MAIN SYSTEM CLOCK : CRYSTAL RESONATOR (Ta = –20 to +70 °C)

MANUFACTURER	PRODUCT NAME	EXTERNAL CAPACITANCE (pF)		OSCILLATION VOLTAGE RANGE (V)		REMARKS
		C1	C2	MIN.	MAX.	
Kinseki	HC–49/U	27	27	2.7	6.0	

DC CHARACTERISTICS (Ta = –40 to 85 °C, V_{DD} = 2.7 to 6.0 V)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Input voltage high	V_{IH1}	Ports 2, 3, 9 to 11, P80, P82		0.7 V_{DD}		V_{DD}	V
	V_{IH2}	Ports 0, 1, 6, 7, 15, P81, P83, $\overline{RESET}$		0.8 V_{DD}		V_{DD}	V
	V_{IH3}	Port 4, 5, 12 to 14	Internal pull-up resistor	0.7 V_{DD}		V_{DD}	V
			Open-drain	0.7 V_{DD}		10	V
	V_{IH4}	X1, X2, XT1		V_{DD}–0.5		V_{DD}	V
Input Voltage low	V_{IL1}	Ports 2 to 5, 9 to 14, P80, P82		0		0.3 V_{DD}	V
	V_{IL2}	Ports 0, 1, 6, 7, 15, P81, P83, $\overline{RESET}$		0		0.2 V_{DD}	V
	V_{IL3}	X1, X2, XT1		0		0.4	V
Output voltage high	V_{OH}	V_{DD} = 4.5 to 6.0 V, I_{OH} = –1 mA		V_{DD}–1.0			V
		I_{OH} = 100 μA		V_{DD}–0.5			V
Output voltage low	V_{OL}	Ports 3, 4, 5	V_{DD} = 4.5 to 6.0V, I_{OL} = 15 mA		0.4	2.0	V
		V_{DD} = 4.5 to 6.0 V, I_{OL} = 1.6 mA				0.4	V
		I_{OL} = 400 μA				0.5	V
		SB0, 1	Open-drain pull-up resistance ≥ 1k Ω			0.2 V_{DD}	V
Input leakage current high	I_{LIH1}	V_I = V_{DD}	Except below			3	μA
	I_{LIH2}		X1, X2, XT1			20	μA
	I_{LIH3}	V_I = 9 V	Ports 4, 5, 12 to 14 (when open-drain)			20	μA
Input leakage current low	I_{LIL1}	V_I = 0 V	Except below			–3	μA
	I_{LIL2}		X1, X2, XT1			–20	μA
Output leakage current high	I_{LOH1}	V_O = V_{DD}	Except below			3	μA
	I_{LOH2}	V_O = 9 V	Ports 4, 5, 12 to 14 (when open-drain)			20	μA
Output leakage current low	I_{LOL}	V_O = 0 V				–3	μA
Internal pull-up resistor	R_{U1}	Ports 0, 1, 2, 3, 6, 7 (except P00) V_I = 0 V	V_{DD} = 5.0 V ±10%	15	40	80	kΩ
			V_{DD} = 3.0 V ± 10%	30		300	kΩ
	R_{U2}	Ports 4, 5, 12 to 14 V_O = V_{DD} –2.0 V	V_{DD} = 5.0 V ± 10%	15	40	70	kΩ
			V_{DD} = 3.0 V ± 10%	10		60	kΩ
Internal pull-down resistor	R_D	V_O = 2 V	Port 9	20	70	140	kΩ

DC CHARACTERISTICS (Ta = –40 to 85 °C, V_{DD} = 2.7 to 6.0 V)

PARAMETER	SYMBOL	TEST CONDITIONS			MIN.	TYP.	MAX.	UNIT
Supply current ***1**	I_{DD1}	4.19 MHz crystal oscillation C1 = C2 = 22 pF ***2**	Operating mode	V_{DD} = 5 V ± 10% ***3**		3	9	mA
				V_{DD} = 3 V ± 10% ***4**		0.55	1.5	mA
	I_{DD2}		HALT mode	V_{DD} = 5 V ± 10%		600	1800	μA
				V_{DD} = 3 V ± 10%		200	600	μA
	I_{DD3}	32.768 kHz crystal oscillation ***5**	Operating mode	V_{DD} = 3 V ± 10%		40	120	μA
	I_{DD4}		HALT mode	V_{DD} = 3 V ± 10%		5	15	μA
	I_{DD5}	XT1 = 0 V STOP mode	V_{DD} = 5 V ± 10%			0.5	20	μA
			V_{DD} = 3 V ± 10%			0.3	10	μA
				Ta = 25 °C			5	μA

***** **1.** Current flowing to the internal pull-up resistor excluded.

2. Subsystem clock oscillation also included.

3. When operated in the high speed mode with the processor clock control register (PCC) set to 0011.

4. When operated in the low speed mode with PCC = 0000.

5. When operated on the subsystem clock after the main system clock oscillation stop with the system clock control register (SCC) set to 1001.

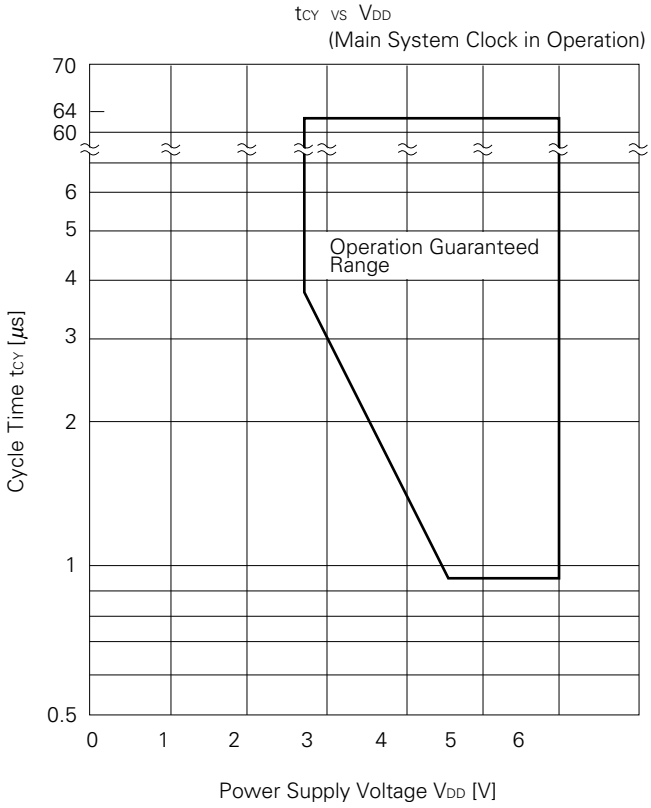
AC CHARACTERISTICS (Ta = –40 to +85 °C , V_{DD} = 2.7 to 6.0 V)

(1) Basic Operation

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
CPU clock cycle time (minimum instruction execution time = 1 machine cycle)***1**	t_{CY}	Operation with main system clock	V_{DD} = 4.5 to 6.0 V	0.95		64	μs
				3.8		64	μs
		Operation with subsystem clock		114	122	125	μs
TI0 input frequency	f_{TI}	V_{DD} = 4.5 to 6.0 V		0		1	MHZ
				0		275	kHz
TI0 input high and low-level widths	t_{TIH}, t_{TIL}	V_{DD} = 4.5 to 6.0 V		0.48			μs
				1.8			μs
Interrupt input high and low-level widths	t_{INTH}, t_{INTL}	INT0		***2**			μs
		INT1, 2, 4		10			μs
		KR0–7		10			μs
$\overline{\text{RESET}}$ low-level width	t_{RSL}			10			μs

*** 1.** The CPU clock (Φ) cycle time is determined by the oscillator frequency of the connected resonator, the system clock control register (SCC) and the processor clock control register (PCC). The cycle time t_{CY} characteristics for power supply voltage V_{DD} when the main system clock is in operation is shown below.

2. $2t_{CY}$ or $128/f_X$ is set by interrupt mode register (IM0) setting.



(2) Serial Transfer Operation

(a) 2-wire and 3-wire serial I/O mode ($\overline{SCK}$...Internal clock output)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
$\overline{SCK}$ cycle time	t_{KCY1}	V_{DD} = 4.5 to 6.0 V		1600			ns
				3800			ns
$\overline{SCK}$ high and low level widths	t_{KL1}	V_{DD} = 4.5 to 6.0 V		$(t_{KCY1}/2)-50$			ns
	t_{KH1}			$(t_{KCY1}/2)-150$			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK1}			150			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI1}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO1}	R_L = 1 kΩ C_L = 100 pF*	V_{DD} = 4.5 to 6.0 V			250	ns
						1000	ns

* R_L and C_L are SO output line load resistance and load capacitance, respectively.

(b) 2-wire and 3-wire serial I/O mode ($\overline{SCK}$...External clock input)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
$\overline{SCK}$ cycle time	t_{KCY2}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high and low level widths	t_{KL2}	V_{DD} = 4.5 to 6.0 V		400			ns
	t_{KH2}			1600			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK2}			100			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI2}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO2}	R_L = 1 kΩ C_L = 100 pF*	V_{DD} = 4.5 to 6.0 V			300	ns
						1000	ns

* R_L and C_L are SO output line load resistance and load capacitance, respectively.

(c) SBI mode ($\overline{SCK}$...Internal clock output (master))

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
$\overline{SCK}$ cycle time	t_{KCY3}	V_{DD} = 4.5 to 6.0 V		1600			ns
				3800			ns
$\overline{SCK}$ high and low level widths	t_{KL3}	V_{DD} = 4.5 to 6.0 V		$t_{KCY3}/2-50$			ns
	t_{KH3}			$t_{KCY3}/2-150$			ns
SB0 and SB1 setup time (to $\overline{SCK}\uparrow$)	t_{SIK3}			150			ns
SB0 and SB1 hold time (from $\overline{SCK}\uparrow$)	t_{KSI3}			$t_{KCY3}/2$			ns
SB0 and SB1 output delay time from $\overline{SCK}\downarrow$	t_{KSO3}	R_L = 1 kΩ C_L = 100 pF*	V_{DD} = 4.5 to 6.0 V	0		250	ns
				0		1000	ns
SB0, SB1↓ from $\overline{SCK}\uparrow$	t_{KSB}			t_{KCY3}			ns
$\overline{SCK}\downarrow$ from SB0, SB1↓	t_{SBK}			t_{KCY3}			ns
SB0 and SB1 low-level widths	t_{SBL}			t_{KCY3}			ns
SB0 and SB1 high-level widths	t_{SBH}			t_{KCY3}			ns

* R_L and C_L are SO output line load resistance and load capacitance, respectively.

(d) SBI mode ($\overline{SCK}$...External clock input (slave))

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
$\overline{SCK}$ cycle time	t_{KCY4}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high and low level widths	t_{KL4}	V_{DD} = 4.5 to 6.0 V		400			ns
	t_{KH4}			1600			ns
SB0 and SB1 setup time (to $\overline{SCK}\uparrow$)	t_{SIK4}			100			ns
SB0 and SB1 hold time (from $\overline{SCK}\uparrow$)	t_{KSI4}			$t_{KCY4}/2$			ns
SB0 and SB1 output delay time from $\overline{SCK}\downarrow$	t_{KSO4}	R_L = 1 kΩ C_L = 100 pF*	V_{DD} = 4.5 to 6.0 V	0		300	ns
				0		1000	ns
SB0, SB1↓ from $\overline{SCK}\uparrow$	t_{KSB}			t_{KCY4}			ns
$\overline{SCK}\downarrow$ from SB0, SB1↓	t_{SBK}			t_{KCY4}			ns
SB0 and SB1 low-level widths	t_{SBL}			t_{KCY4}			ns
SB0 and SB1 high-level widths	t_{SBH}			t_{KCY4}			ns

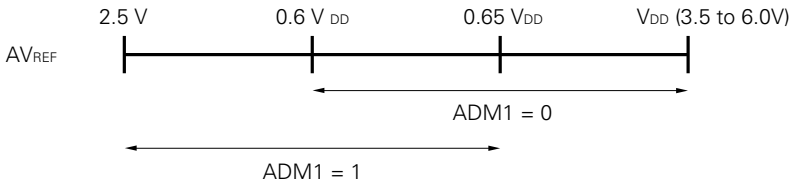
* R_L and C_L are SO output line load resistance and load capacitance, respectively.

(3) A/D Converter (Ta = –10 to +70 °C, V_{DD} = 3.5 to 6.0 V, AV_{SS} = V_{SS} = 0V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Resolution			8	8	8	bit
Absolute accuracy***1**		2.5 V ≤ AV_{REF} ≤ V_{DD}***2**			±1.5	LSB
Conversion time***3**	t_{CONV}				168/f_X	μs
Sampling time***4**	t_{SAMP}				44/f_X	μs
Analog input voltage	V_{IAN}		AV_{SS}		AV_{REF}	V
Analog input impedance	R_{AN}			1000		MΩ
AV_{REF} current	I_{REF}			1.0	2.0	mA

* **1.** Absolute accuracy with the quantization error (±1/2 LSB) excluded.

2. ADM1 is set as shown below with regard to the A/D converter reference voltage (AV_{REF}).



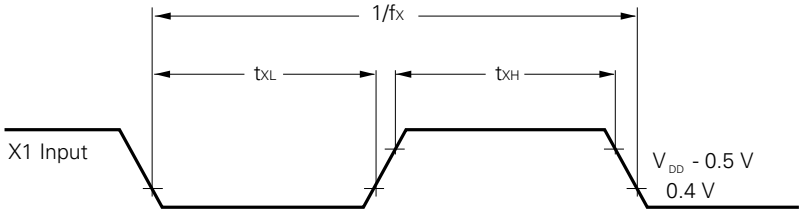
When 0.6 V_{DD} ≤ AV_{REF} ≤ 0.65 V_{DD}, the ADM1 can be set either to 0 or 1.

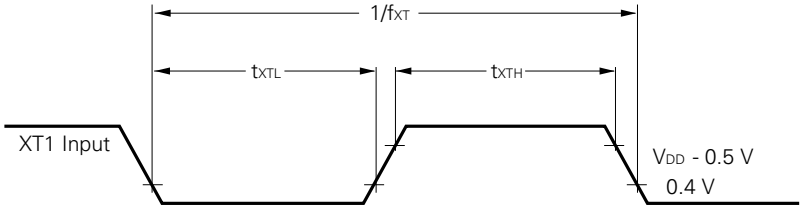
3. This is the time form the execution of the conversion start instruction to the conversion end (EOC = 1) (operating at 40.1 μs : f_X = 4.19 MHz).

4. This is the time from the execution of the conversion start instruction to the sampling end (operating at 10.5 μs : f_X = 4.19 MHz).

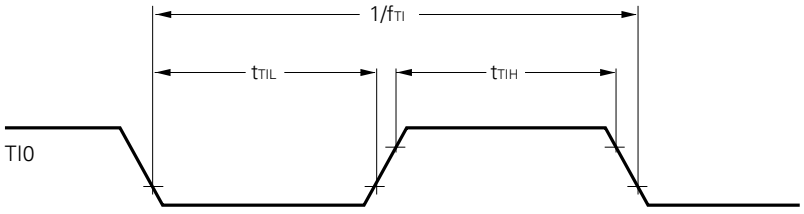
AC Timing Test Points (Except X1 and XT1 Inputs)

Clock Timing



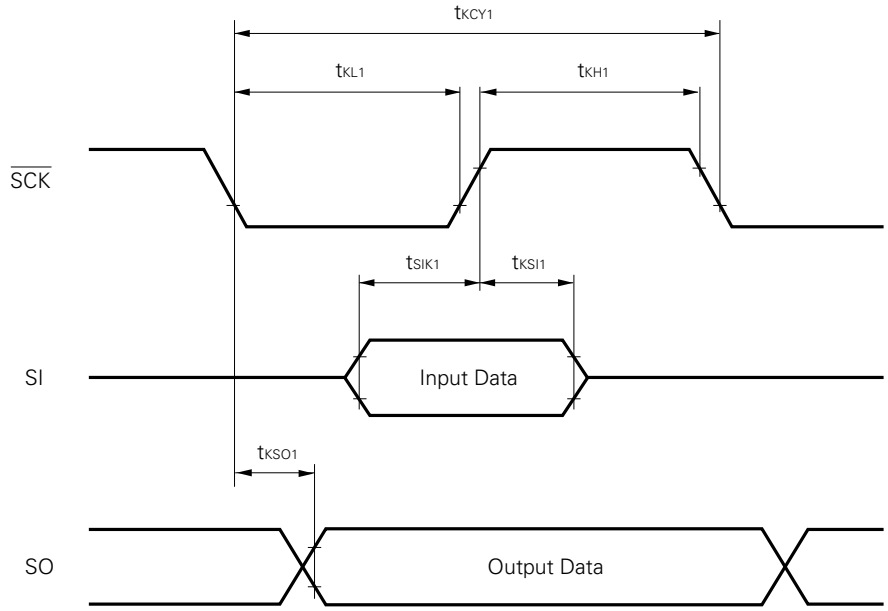


TI0 Timing

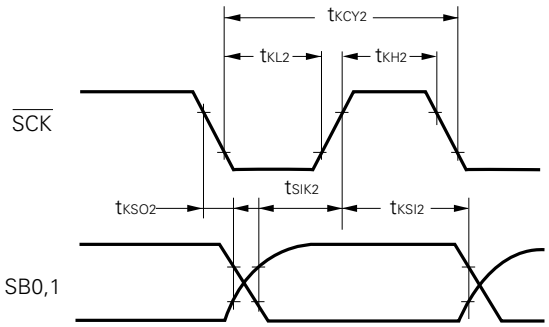


Serial Transfer Timing

3-wire serial I/O mode:

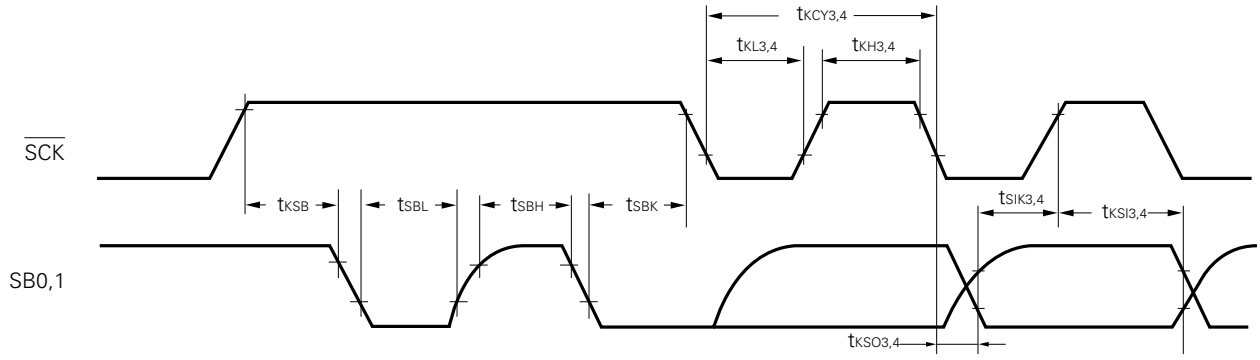


2-wire serial I/O mode:

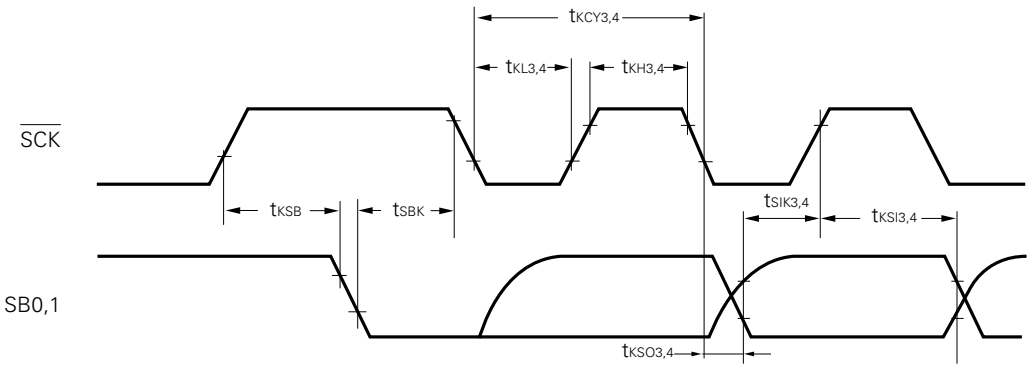


Serial Transfer Timing

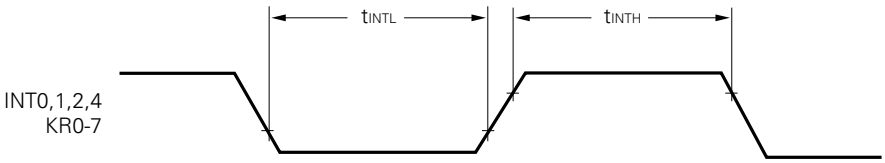
Bus release signal transfer:



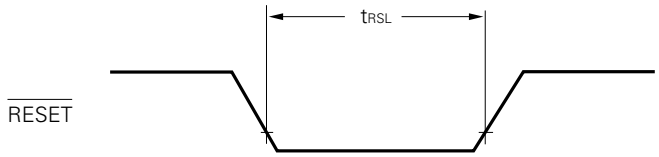
Command signal transfer:



Interrupt Input Timing



$\overline{\text{RESET}}$ Input Timing



DATA MEMORY STOP MODE LOW POWER SUPPLY VOLTAGE DATA RETENTION CHARACTERISTICS (Ta = –40 to +85 °C)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Data retention power supply voltage	V_{DDDR}		2.0		6.0	V
Data retention power supply current *1	I_{DDDR}	V_{DDDR} = 2.0 V		0.1	10	μA
Release signal set time	t_{SREL}		0			μs
Oscillation stabilization wait time *2	t_{WAIT}	Release by $\overline{RESET}$		$2^{17}/f_X$		ms
		Release by interrupt request		*3		ms

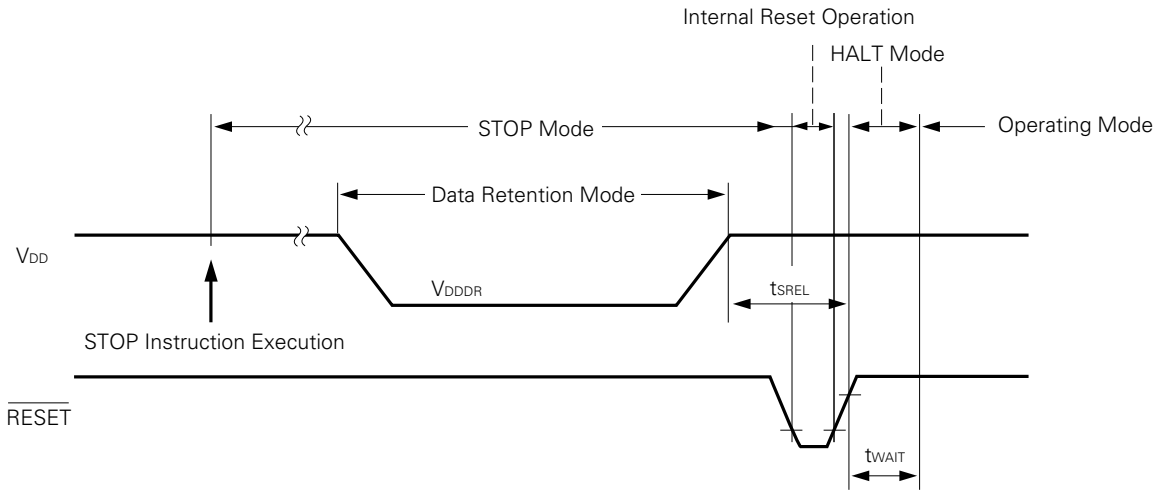
* **1.** Current to the internal pull-up resistor is not included.

2. Oscillation stabilization wait time is time to stop CPU operation to prevent unstable operation upon oscillation start.

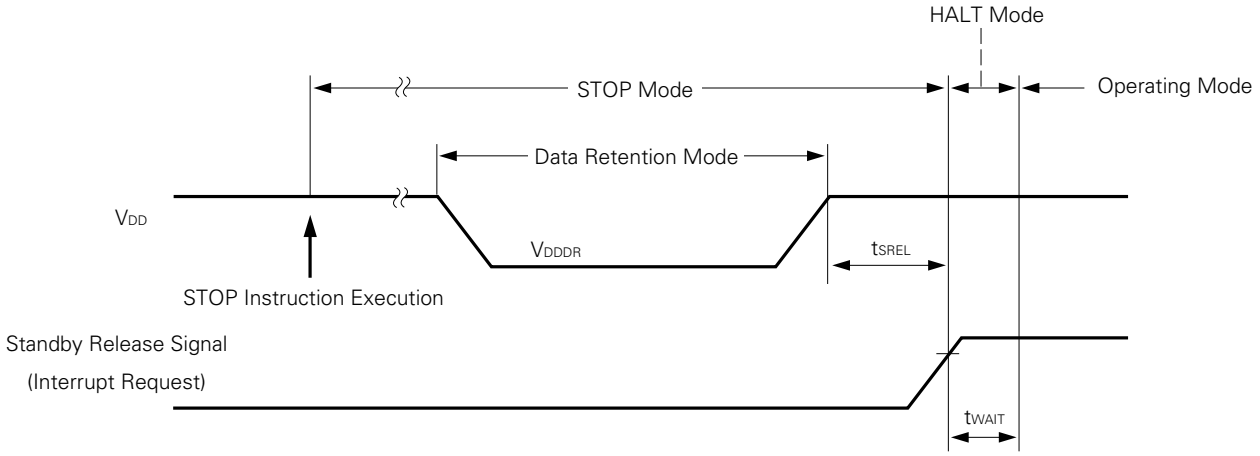
3. According to the setting of the basic interval timer mode register (BTM) (see below).

BTM3	BTM2	BTM1	BTM0	Wait Time (Values at f_X = 4.19 MHz in parentheses)
—	0	0	0	$2^{20}/f_X$ (approx. 250 ms)
—	0	1	1	$2^{17}/f_X$ (approx. 31.3 ms)
—	1	0	1	$2^{15}/f_X$ (approx. 7.82 ms)
—	1	1	1	$2^{13}/f_X$ (approx. 1.95 ms)

Data Retention Timing (STOP Mode Release by $\overline{RESET}$)

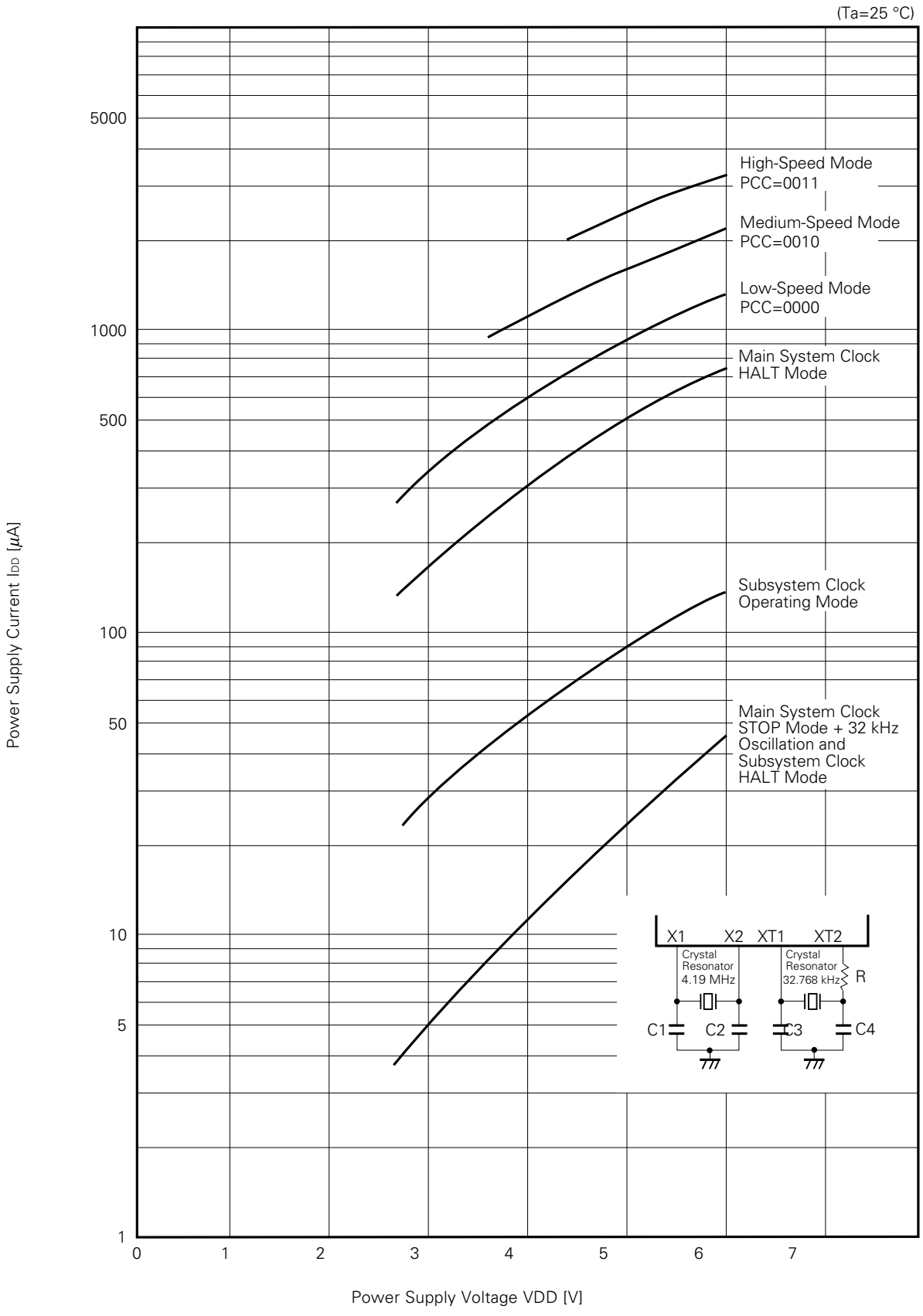


Data Retention Timing (Standby Release Signal: STOP Mode Release by Interrupt Signal)

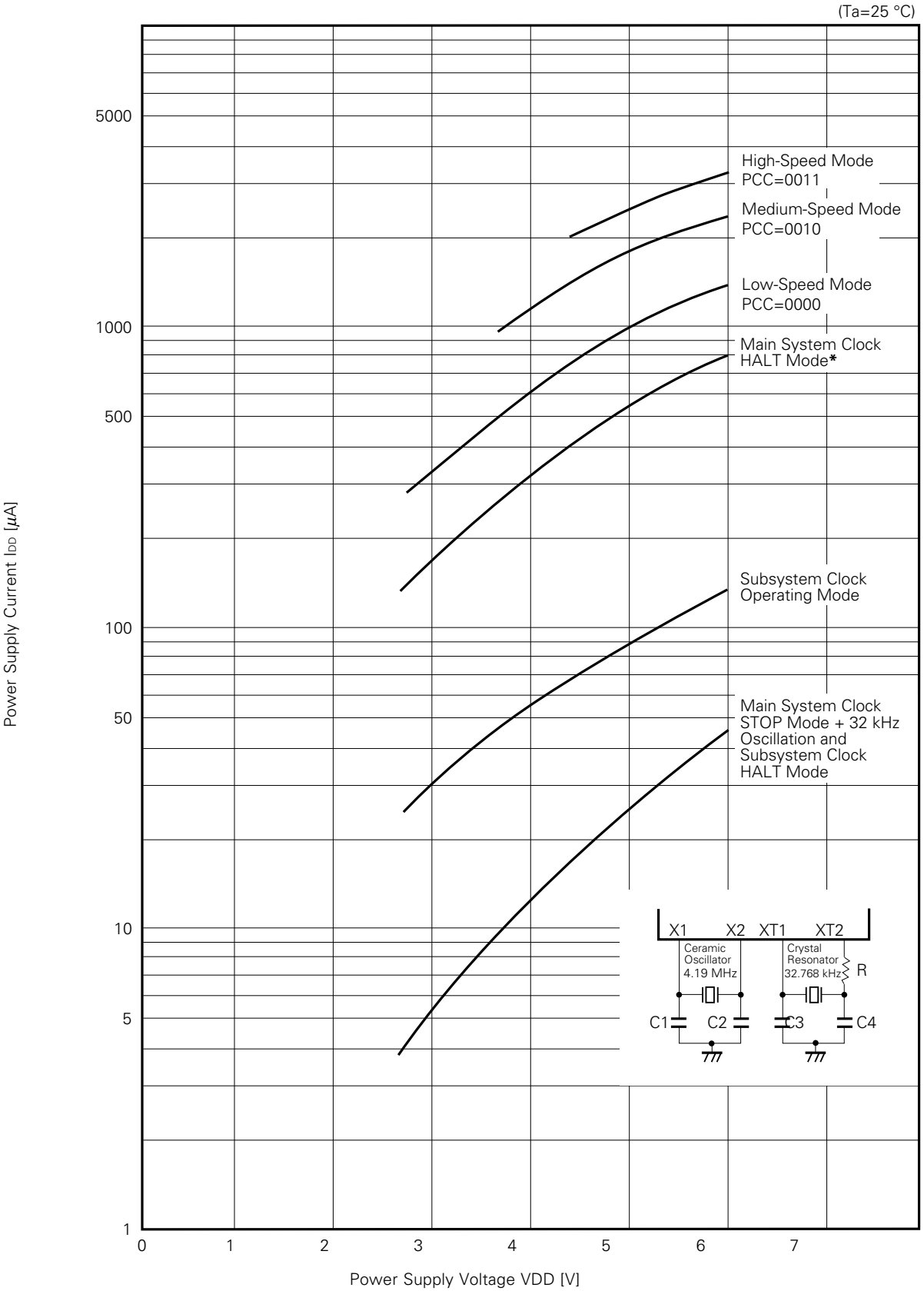


12. CHARACTERISTIC CURVES

I_{DD} vs V_{DD} (Main System Clock : Crystal Oscillation)

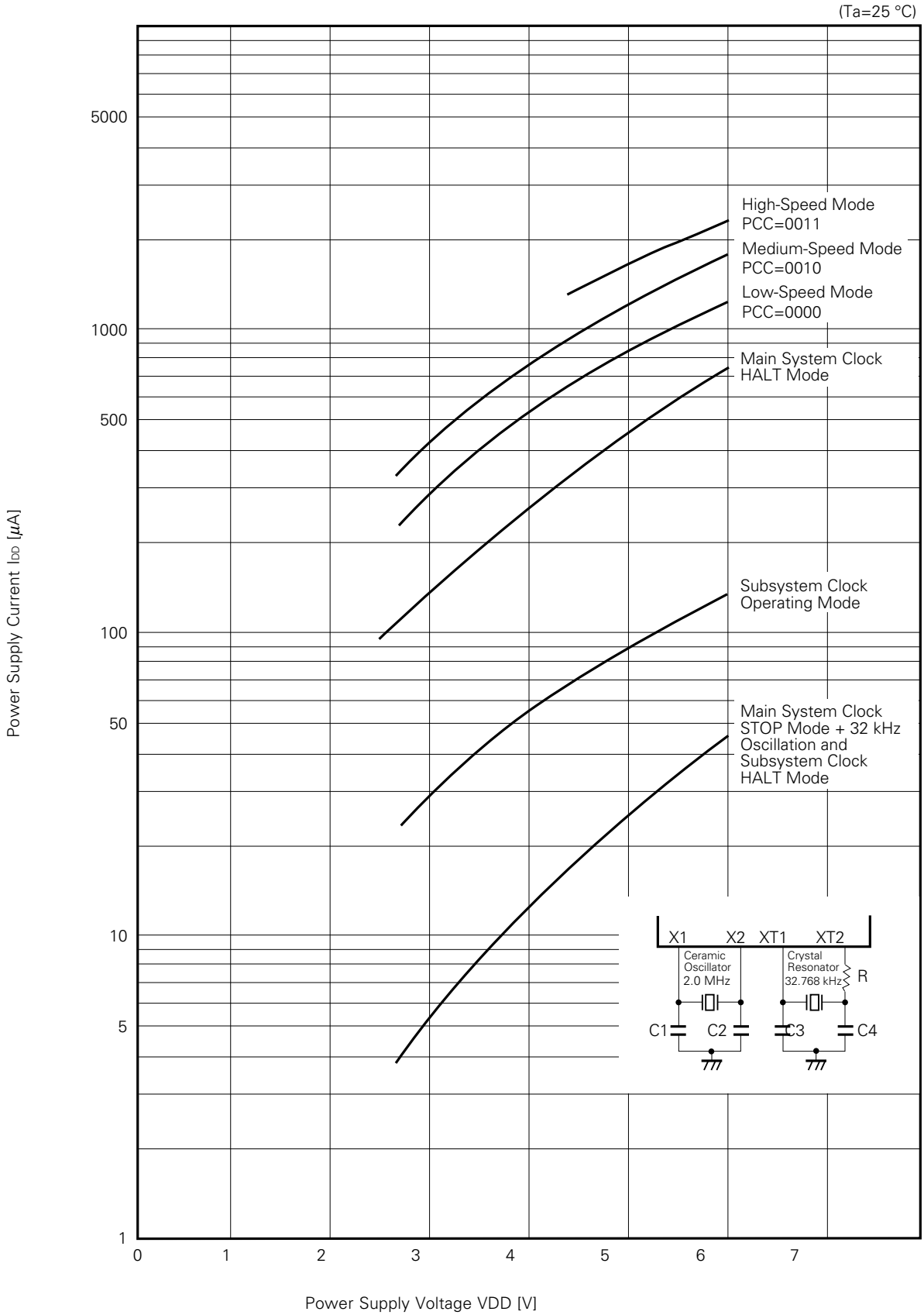


I_{DD} vs V_{DD} (Main System Clock : Crystal Oscillation)

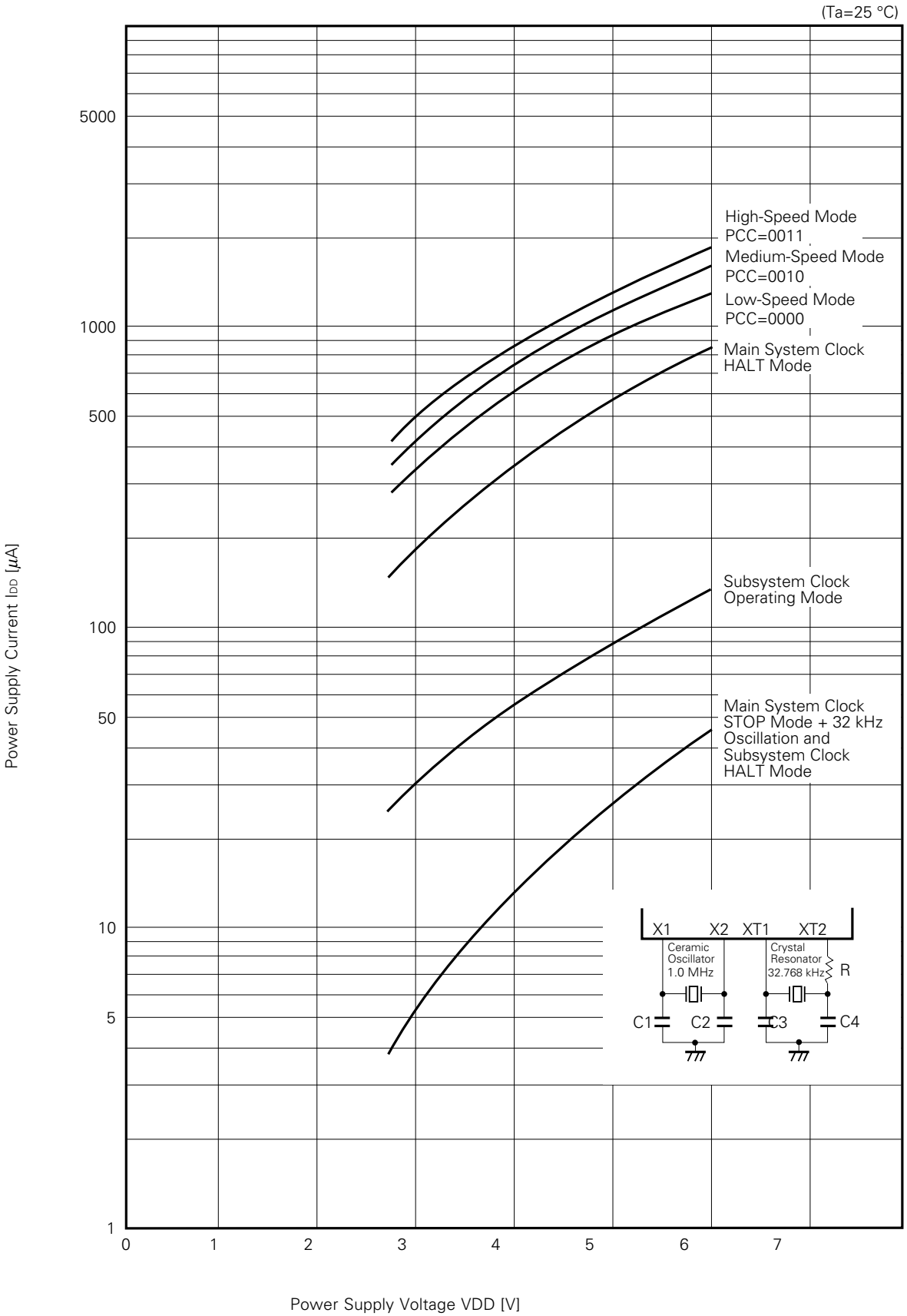


* This is larger than the crystal oscillation by about 10%.

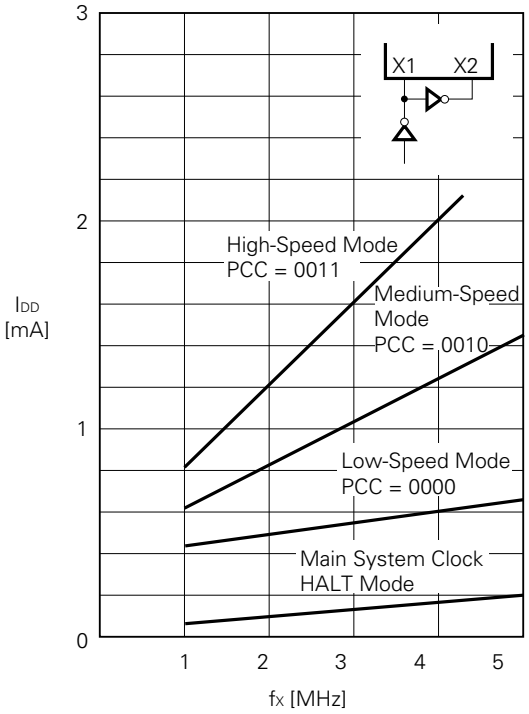
I I_{DD} vs V_{DD} (Main System Clock : Crystal Oscillation)



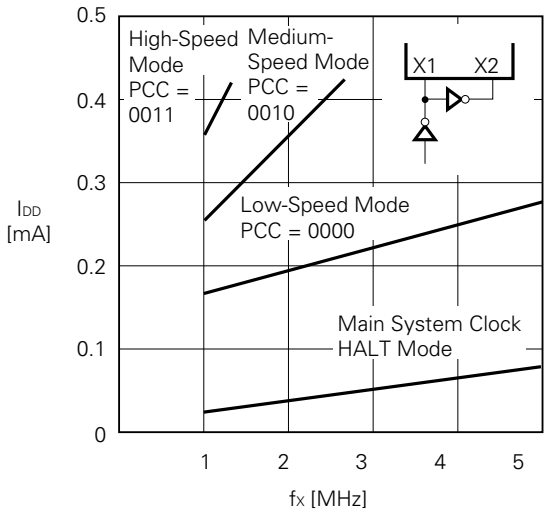
I_{DD} vs V_{DD} (Main System Clock : Crystal Oscillation)



I_{DD} vs f_X (V_{DD} = 5V, Ta = 25°C)

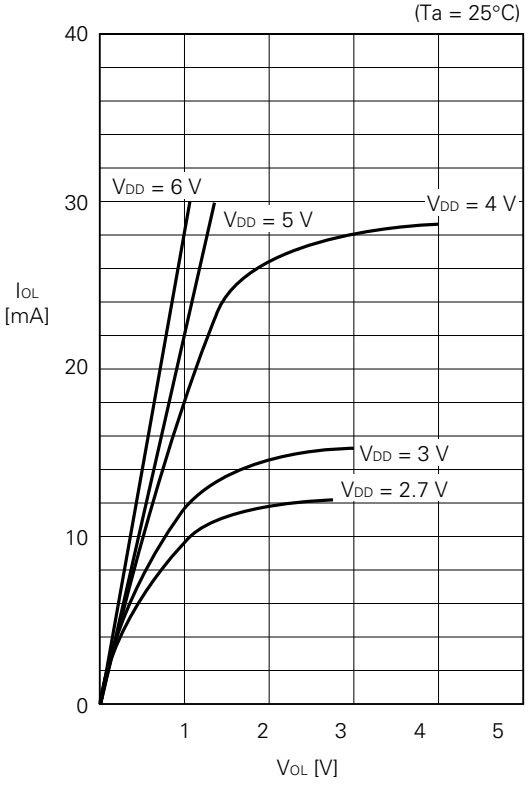


I_{DD} vs f_X (V_{DD} = 3V, Ta = 25°C)



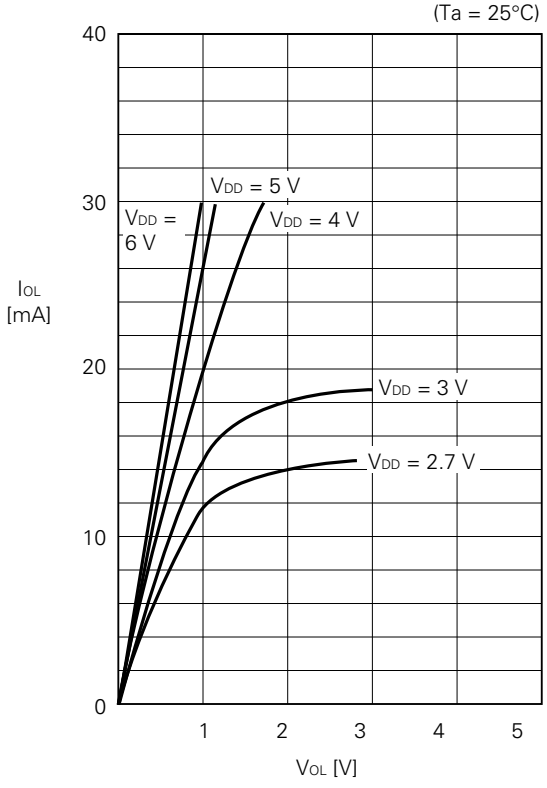
V_{OL} vs I_{OL} (Port 0, 2, 6, 7)

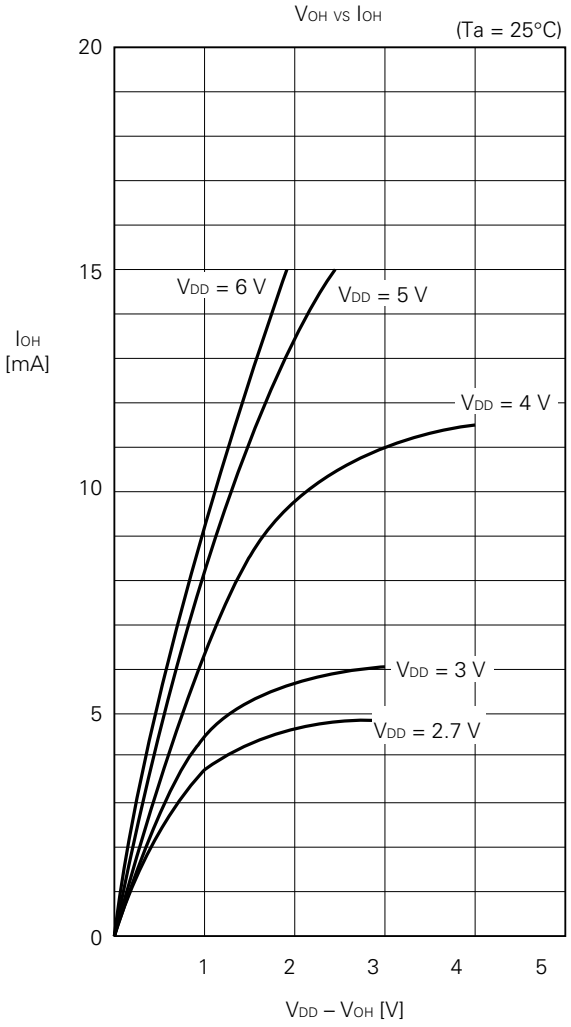
(Ta = 25°C)



V_{OL} vs I_{OL} (Port 3, 4 ,5)

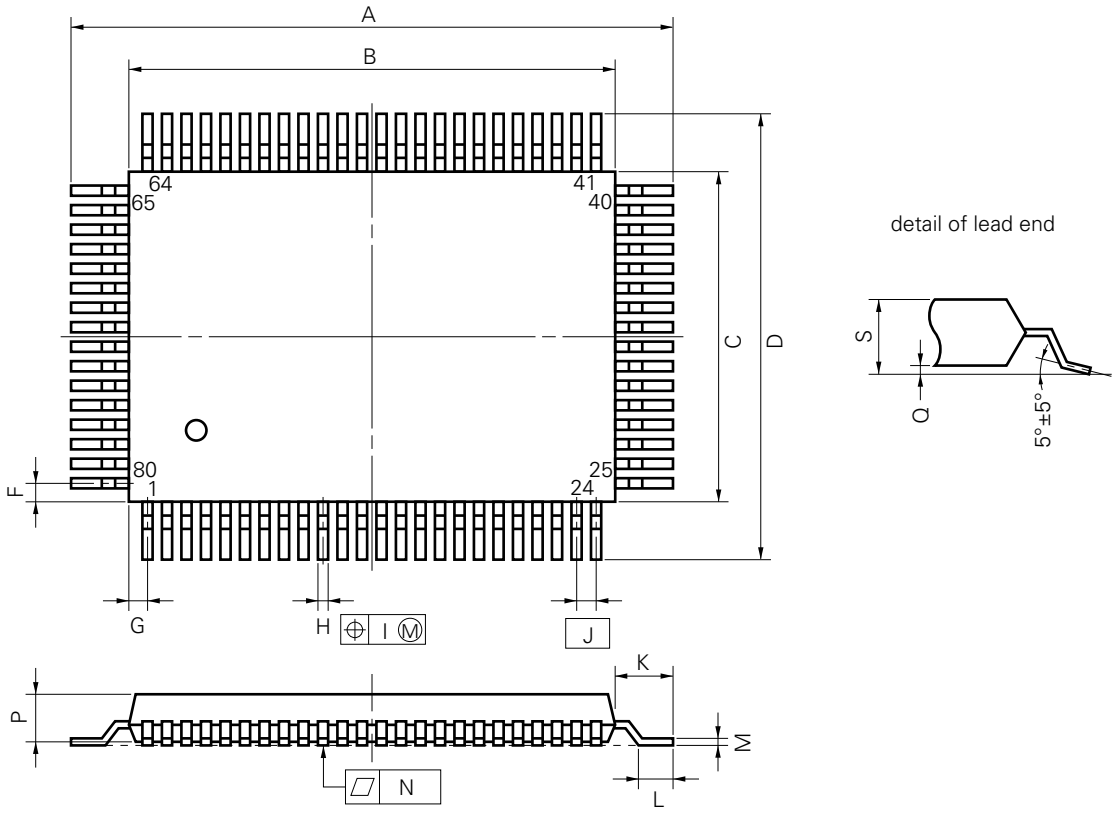
(Ta = 25°C)




VOH vs IOH
(Ta = 25°C)
20
15
10
5
0
IOH
[mA]
VDD = 6 V
VDD = 5 V
VDD = 4 V
VDD = 3 V
VDD = 2.7 V
1
2
3
4
5
VDD – VOH [V]

13. PACKAGE INFORMATION

80 PIN PLASTIC QFP (14×20)



P80GF-80-3B9-2

NOTE

Each lead centerline is located within 0.15 mm (0.006 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	23.6±0.4	0.929±0.016
B	20.0±0.2	$0.795^{+0.009}_{-0.008}$
C	14.0±0.2	$0.551^{+0.009}_{-0.008}$
D	17.6±0.4	0.693±0.016
F	1.0	0.039
G	0.8	0.031
H	0.35±0.10	$0.014^{+0.004}_{-0.005}$
I	0.15	0.006
J	0.8 (T.P.)	0.031 (T.P.)
K	1.8±0.2	$0.071^{+0.008}_{-0.009}$
L	0.8±0.2	$0.031^{+0.009}_{-0.008}$
M	$0.15^{+0.10}_{-0.05}$	$0.006^{+0.004}_{-0.003}$
N	0.15	0.006
P	2.7	0.106
Q	0.1±0.1	0.004±0.004
S	3.0 MAX.	0.119 MAX.

★ 14. RECOMMEDED SOLDERING CONDITIONS

The μPD75516 should be soldered and mounted under the conditions recommended in the table below.

For details of recommended soldering conditions for the surface mounting type, refer to the document **"Semiconductor Device Mount Technology" (IEI-1207)**.

For soldering methods and conditions other than those recommended below, contact our salesman.

Table 4–1 Surface Mount Type Soldering Conditions

μPD75516GF–×××–3B9: 80–pin plastic QFP (14 × 20 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 230 °C Duration: 30 sec. max. (at 210 °C or above) Number of times: Once	IR30-00-1
VPS	Package peak temperature: 215 °C Duration: 40 sec. max. (at 200 °C or above) Number of times: Once	VP15-00-1
Wave Soldering	Solder bath temperature: 260 °C or less Duration: 10 sec. max. Number of times: Once Preheating temperature: 120 °C max. (package surface temperature)	WS60-00-1
Pin part heating	Pin part temperature: 300 °C or less Duration: 3 sec. max. (Per device side)	——

Note Use of more than one soldering method should be avoided (except in the case of pin part heating).

Products to improve the recommended soldering conditions are available. (Improvements: Extension of the infrared reflow peak temperature to 235oC, doubled frequency, increased life, etc.)
For further details, consult our sales personnel.

APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for the development of systems using the μPD75516.

Hardware	IE–75000–R ***1** IE–75001–R		In–circuit emulator for use with the 75X series
	IE–75000–R–EM ***2**		Emulation board for use with the IE–75000–R and the IE–75001–R
	EP–75516GF–R	EV–9200G–80	Emulation probe for use with the μPD75516. 80–pin conversion socket EV–9200G–80 included
	PG–1500		PROM programmer
	PA–75P516GF		Connect to PG–1500 with PROM programmer adapter for use with the μPD75P516GF
Software	IE control program		Host machine PC–9800 series (MS–DOS™ Ver. 3.30 to Ver. 5.00A ***3**) IBM PC/AT™ (PC DOS™ Ver. 3.1)
	PG–1500 controller		
	RA75X relocatable assembler		

***** **1.** Maintenance product
2. Not a built–in component in the IE–75001–R
3. Ver. 5.00/5.00A has a task swapping function, which cannot be used with this software.

Remarks Refer to the **"75X Series Selection Guide"** (IF–151) for third–party development tools.

★ APPENDIX B. RELATED DOCUMENTS

Device Related Documents

Document Name		Document Number
User's Manual		IEM–5049
Instruction Application Table		IEM–5036
Application Note	Basic Volume	IEM–5104
	A/D Converter Volume	IEA–630
75X Series Selection Guide		IF–151

Development Tools Documents

Document Name			Document Number
Hardware	IE–75000–R/IE–75000–R User's Manual		EEU–846
	IE–75000–R–EM User's Manual		EEU–673
	EP–75516GF–R User's Manual		EEU–703
	PG–1500 User's Manual		EEU–651
Software	RA75X Assembler Package User's Manual	Operation Volume	EEU–731
		Language Volume	EEU–730
	PG–1500 Controller User's Manual		EEU–704

Other Documents

Document Name	Document Number
Package Manual	IEI–635
Surface Mount Technology Manual	IEI–1207
Quality Grade on NEC Semiconductor Devices	IEI–1209
NEC Semiconductor Device Reliability & Quality Control	IEM–5068
Electrostatic Discharge (ESD) Test	MEM–539
Semiconductor Device Quality Guide Guarantee Guide	MEI–603
Microcomputer Related Products Guide – Other Manufacturers Volume	MEI–604

Note The information in these related documents is subject to change without notice. For design purpose, etc., be sure to use the latest ones.

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Special : Automotive and Transportation equipment, Traffic control systems, Antidisaster systems, Anticrime systems, etc.

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