

**8-BIT SINGLE-CHIP MICROCONTROLLER**

**DESCRIPTION**

The  $\mu$ PD780053,780054,780055,780056 and 780058 are members of the  $\mu$ PD780058 subseries in the 78K/0 series. These microcontrollers suppress the EMI (Electro Magnetic Interference) noise internally generated to the lower level than the existing  $\mu$ PD78054 subseries. In addition, they have many peripheral hardware units such as an 8-bit resolution A/D converter, 8-bit resolution D/A converter, timers, serial interface, real-time output ports, and interrupt functions.

A flash memory model that can operate on the same voltage as the mask ROM models,  $\mu$ PD78F0058, and various development tools are now under development.

**The functions are explained in detail in the following User's Manuals. Be sure to read these manuals when designing your system.**

**$\mu$ PD780058, 780058Y Subseries User's Manual : U12013E**  
**78K/0 Series User's Manual - Instruction : U12326E**

**FEATURES**

- Internal high-capacity ROM & RAM

Part Number	Item	Program Memory (ROM)	Data Memory		
			Internal high-speed RAM	Internal buffer RAM	Internal expanded RAM
$\mu$ PD780053		24K bytes	1024 bytes	32 bytes	None
$\mu$ PD780054		32K bytes			
$\mu$ PD780055		40K bytes			
$\mu$ PD780056		48K bytes			
$\mu$ PD780058		60K bytes			1024 bytes

- External memory expansion space: 64K bytes
- Minimum instruction execution time changeable from high speed (0.4  $\mu$ s) to ultra low-speed (122  $\mu$ s)
- I/O ports: 68 pins (N-ch open-drain : 4 pins)
- 8-bit resolution A/D converter : 8 channels ( $V_{DD} = 2.7$  to 5.5 V)
- 8-bit resolution D/A converter : 2 channels ( $V_{DD} = 2.7$  to 5.5 V)
- Serial interface : 3 channels
- Timer : 5 channels
- Operating voltage range :  $V_{DD} = 1.8$  to 5.5 V

**APPLICATION FIELDS**

Car audio systems, cellular phones, pagers, printers, AV systems, cameras, PPCs, and vending machines

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

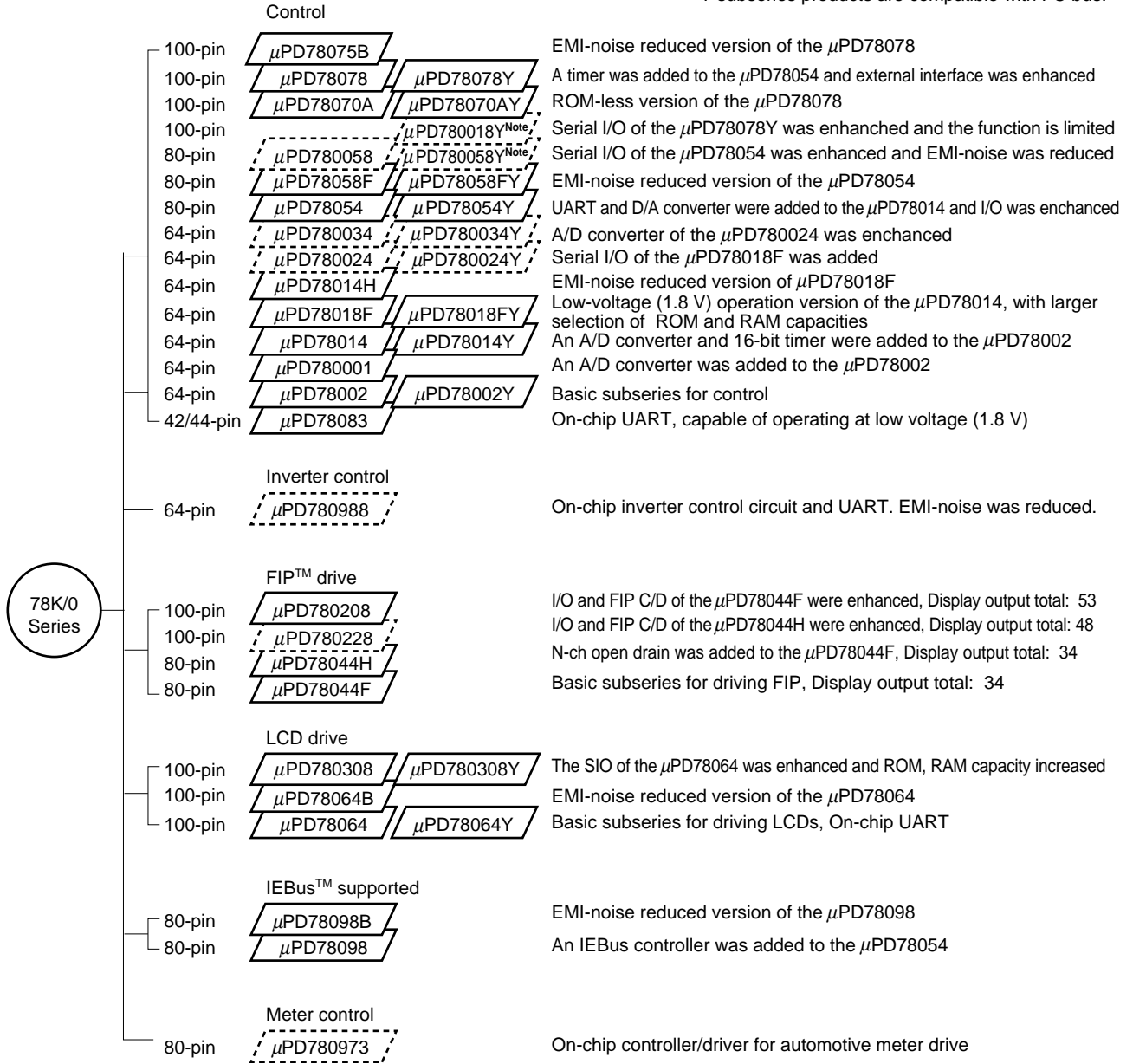
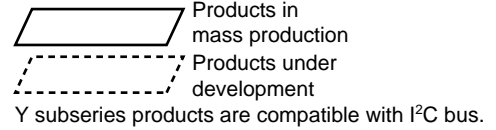
## ★ ORDERING INFORMATION

Part Number	Package
$\mu$ PD780053GC-xxx-8BT	80-pin plastic QFP (14 × 14 mm)
$\mu$ PD780053GK-xxx-BE9	80-pin plastic TQFP (fine pitch) (12 × 12 mm)
$\mu$ PD780054GC-xxx-8BT	80-pin plastic QFP (14 × 14 mm)
$\mu$ PD780054GK-xxx-BE9	80-pin plastic TQFP (fine pitch) (12 × 12 mm)
$\mu$ PD780055GC-xxx-8BT	80-pin plastic QFP (14 × 14 mm)
$\mu$ PD780055GK-xxx-BE9	80-pin plastic TQFP (fine pitch) (12 × 12 mm)
$\mu$ PD780056GC-xxx-8BT	80-pin plastic QFP (14 × 14 mm)
$\mu$ PD780056GK-xxx-BE9	80-pin plastic TQFP (fine pitch) (12 × 12 mm)
$\mu$ PD780058GC-xxx-8BT	80-pin plastic QFP (14 × 14 mm)
$\mu$ PD780058GK-xxx-BE9	80-pin plastic TQFP (fine pitch) (12 × 12 mm)

**Remark** xxx indicates ROM code suffix.

★ 78K/0 SERIES PRODUCT DEVELOPMENT

The following shows the 78K/0 Series products development. Subseries name are shown inside frames.



**Note** Under planning

The following lists the main functional differences between subseries products.

Subseries Name	Function	ROM Capacity	Timer				8-bit A/D	10-bit A/D	8-bit D/A	Serial Interface	I/O	V <sub>DD</sub> MIN. Value	External Expansion				
			8-bit	16-bit	Watch	WDT											
Control	μPD78075B	32 K - 40K	4ch	1ch	1ch	1ch	8ch	-	2ch	3ch (UART : 1ch)	88	1.8 V	○				
	μPD78078	48 K - 60K									61	2.7 V					
	μPD78070A	-															
	μPD780058	24 K - 60 K	2ch							3ch (time division UART: 1ch)	68	1.8 V					
	μPD78058F	48 K - 60 K								3ch (UART: 1ch)	69	2.7 V					
	μPD78054	16 K - 60 K									2.0 V						
	μPD780034	8 K - 32 K								-	8ch	-		3ch (UART: 1ch, time division 3-wire: 1ch)	51	1.8 V	
	μPD780024									8ch	-						
	μPD78014H													2ch	53		
	μPD78018F	8 K - 60 K															
	μPD78014	8 K - 32 K														2.7 V	
	μPD780001	8 K								-	-			1ch	39		-
	μPD78002	8 K - 16 K									1ch			-	53		○
μPD78083			-		8ch		1ch (UART: 1ch)	33	1.8 V	-							
★ Inverter control	μPD780988	32 K - 60 K	3ch	<b>Note</b>	-	1ch	-	8ch	-	3ch (UART: 2ch)	47	4.0 V	○				
FIP drive	μPD780208	32 K - 60 K	2ch	1ch	1ch	1ch	8ch	-	-	2ch	74	2.7 V	-				
	μPD780228	48 K - 60 K								3ch	-	-		1ch	72	4.5 V	
	μPD78044H	32 K - 48 K	2ch	1ch	1ch		68	2.7 V									
	μPD78044F	16 K - 40 K				2ch											
LCD drive	μPD780308	48 K - 60 K	2ch	1ch	1ch	1ch	8ch	-	-	3ch (time division UART: 1ch)	57	2.0 V	-				
	μPD78064B	32 K								2ch (UART : 1 ch)							
	μPD78064	16 K - 32 K															
IEBus supported	μPD78098B	40 K - 60 K	2ch	1ch	1ch	1ch	8ch	-	2ch	3ch (UART : 1 ch)	69	2.7 V	○				
	μPD78098	32 K - 60 K															
LV	μPD78P0914	32 K	6ch	-	-	1ch	8ch	-	-	2ch	54	4.5 V	○				

**Note** 16-bit timer : 2 channels  
 10-bit timer : 1 channel

OVERVIEW OF FUNCTION

Item		Product Name												
		μPD780053	μPD780054	μPD780055	μPD780056	μPD780058								
Internal memory	ROM	24K bytes	32K bytes	40K bytes	48K bytes	60K bytes								
	High-speed RAM	1024 bytes												
	Buffer RAM	32 bytes												
	Expanded RAM	None				1024 bytes								
Memory space		64 K bytes												
General registers		8 bits × 32 registers (8 bits × 8 registers × 4 banks)												
Minimum instruction execution time	On-chip minimum instruction execution time cycle modification function													
	When main system clock selected	0.4 μs/0.8 μs/1.6 μs/3.2 μs/6.4 μs/12.8 μs (at 5.0 MHz operation)												
	When subsystem clock selected	122 μs (at 32.768 kHz operation)												
Instruction set		<ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, boolean operation)</li> <li>• BCD correction, etc.</li> </ul>												
I/O ports		<table border="0"> <tr> <td>Total</td> <td>: 68</td> </tr> <tr> <td>• CMOS input</td> <td>: 2</td> </tr> <tr> <td>• CMOS I/O</td> <td>: 62</td> </tr> <tr> <td>• N-ch open-drain I/O</td> <td>: 4</td> </tr> </table>					Total	: 68	• CMOS input	: 2	• CMOS I/O	: 62	• N-ch open-drain I/O	: 4
Total	: 68													
• CMOS input	: 2													
• CMOS I/O	: 62													
• N-ch open-drain I/O	: 4													
A/D converter		• 8-bit resolution × 8 channels (V <sub>DD</sub> = 2.7 to 5.5 V)												
D/A converter		• 8-bit resolution × 2 channels (V <sub>DD</sub> = 2.7 to 5.5 V)												
Serial interface		<ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable: 1 channel</li> <li>• 3-wire serial I/O mode (on-chip max. 32 bytes automatic data transmit/receive function): 1 channel</li> <li>• 3-wire/serial I/O/UART mode (on-chip time division transfer function) selectable: 1 channel</li> </ul>												
Timer		<ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>												
Timer output		3 (14-bit PWM output × 1)												
Clock output		19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (at main system clock: 5.0 MHz operation) 32.768 kHz (at subsystem clock: 32.768 kHz operation)												
Buzzer output		1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (at main system clock: 5.0 MHz operation)												
★ Vectored interrupt sources	Maskable	Internal interrupt : 13, external interrupt : 6												
	Non-maskable	Internal interrupt : 1												
	Software	1												
Test input		Internal : 1, external : 1												
Supply voltage		V <sub>DD</sub> = 1.8 to 5.5 V												
Operating ambient temperature		T <sub>A</sub> = -40 to +85°C												
★ Package		<ul style="list-style-type: none"> <li>• 80-pin plastic QFP (14 × 14 mm)</li> <li>• 80-pin plastic TQFP (fine pitch) (12 × 12 mm)</li> </ul>												

## CONTENTS

1. PIN CONFIGURATION (TOP VIEW) .....	7
2. BLOCK DIAGRAM .....	9
3. PIN FUNCTIONS .....	10
3.1 PORT PINS .....	10
3.2 OTHER PINS .....	12
3.3 PIN I/O CIRCUITS AND RECOMMENDED CONNECTION OF UNUSED PINS .....	14
4. MEMORY SPACE .....	18
5. PERIPHERAL HARDWARE FUNCTION FEATURES .....	19
5.1 PORTS .....	19
5.2 CLOCK GENERATOR .....	20
5.3 TIMER/EVENT COUNTER .....	20
5.4 CLOCK OUTPUT CONTROL CIRCUIT .....	23
5.5 BUZZER OUTPUT CONTROL CIRCUIT .....	23
5.6 A/D CONVERTER .....	24
5.7 D/A CONVERTER .....	25
5.8 SERIAL INTERFACES .....	25
5.9 REAL-TIME OUTPUT PORT FUNCTIONS .....	27
6. INTERRUPT FUNCTIONS .....	28
6.1 INTERRUPT FUNCTIONS .....	28
6.2 TEST FUNCTIONS .....	32
7. EXTERNAL DEVICE EXPANSION FUNCTIONS .....	33
8. STANDBY FUNCTION .....	33
9. RESET FUNCTION .....	33
10. INSTRUCTION SET .....	34
★ 11. ELECTRICAL SPECIFICATIONS .....	36
12. PACKAGE DRAWINGS .....	63
★ APPENDIX A. DEVELOPMENT TOOLS .....	65
★ APPENDIX B. RELATED DOCUMENTS .....	68

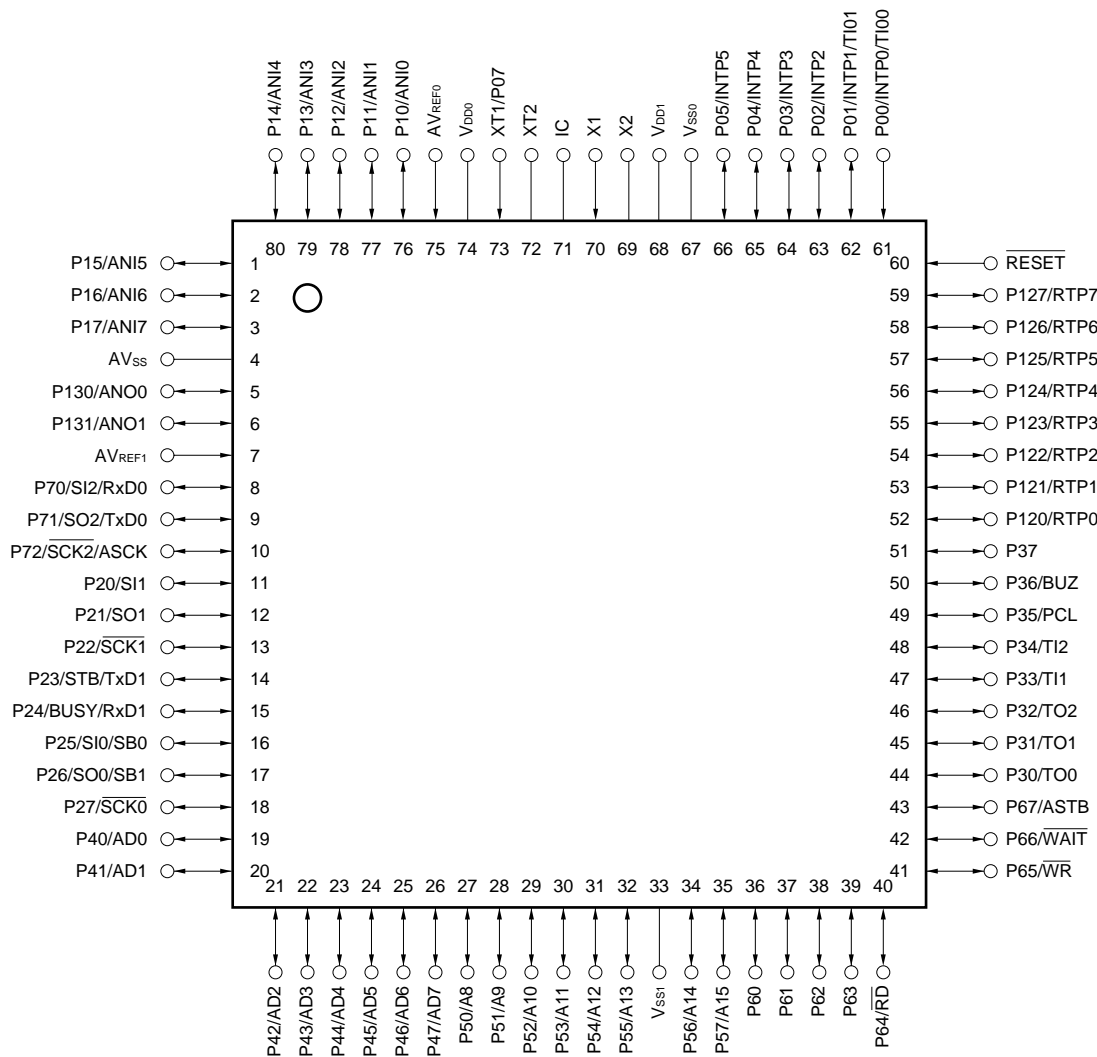
1. PIN CONFIGURATION (TOP VIEW)

- 80-pin plastic QFP (14 × 14 mm)

μPD780053GC-xxx-8BT, 780054GC-xxx-8BT, 780055GC-xxx-8BT, 780056GC-xxx-8BT, 780058GC-xxx-8BT

- 80-pin plastic TQFP (fine pitch) (12 × 12 mm)

μPD780053GK-xxx-BE9, 780054GK-xxx-BE9, 780055GK-xxx-BE9, 780056GK-xxx-BE9, 780058GK-xxx-BE9



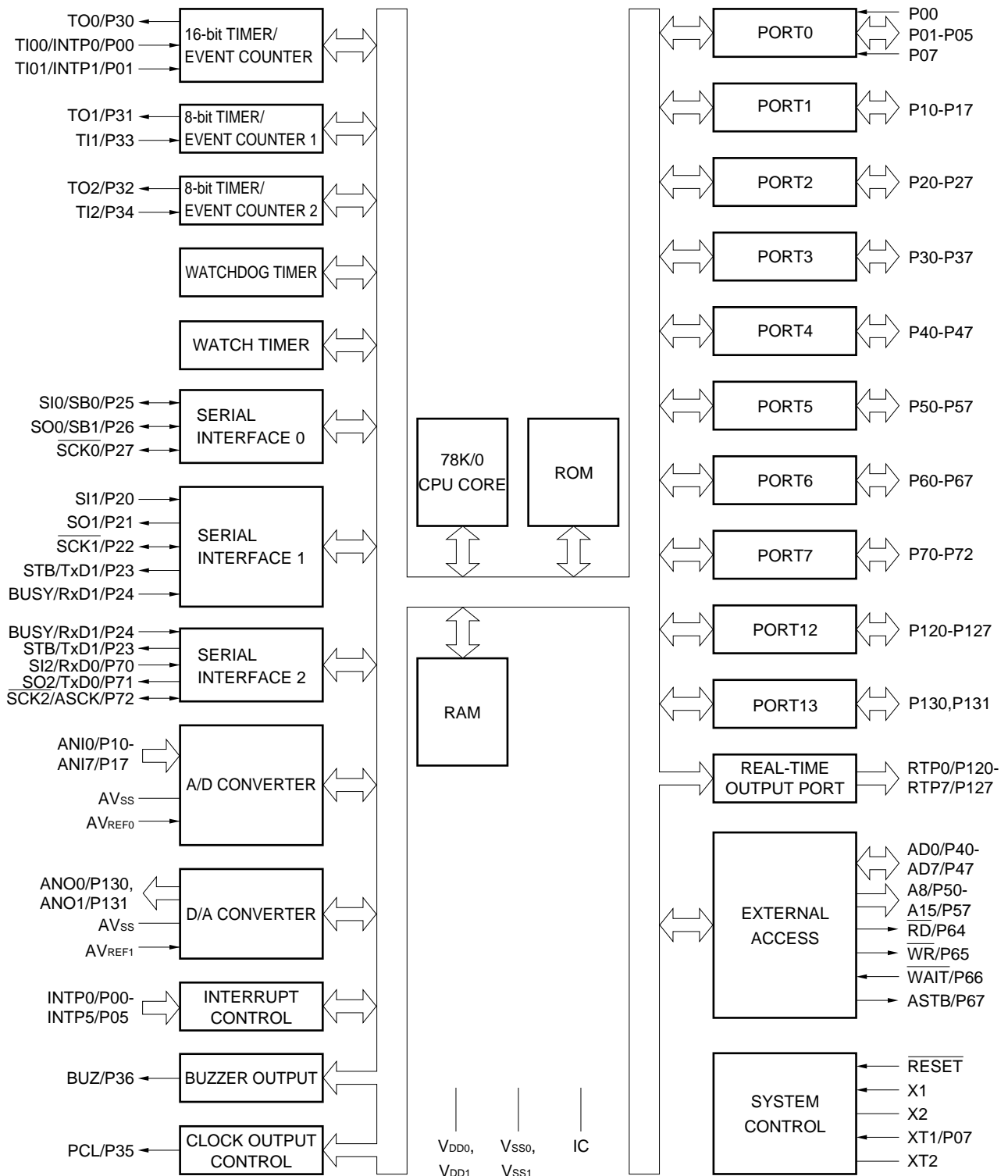
- Cautions**
1. Directly connect the IC (Internally Connected) pins to V<sub>SS0</sub> or V<sub>SS1</sub>.
  2. Connect the AV<sub>SS</sub> pin to V<sub>SS0</sub>.

- Remarks**
1. xxx indicates ROM code suffix.
  2. If the microcontroller is used in an application where the noise generated from the microcontroller must be suppressed, it is recommended that power be supplied to V<sub>DD0</sub> and V<sub>DD1</sub> from separate sources, and that V<sub>SS0</sub> and V<sub>SS1</sub> be connected to separate group lines, to improve noise immunity.

A8-A15	: Address Bus	P130, P131	: Port13
AD0-AD7	: Address/Data Bus	PCL	: Programmable Clock
ANI0-ANI7	: Analog Input	$\overline{RD}$	: Read Strobe
ANO0, ANO1	: Analog Output	$\overline{RESET}$	: Reset
ASCK	: Asynchronous Serial Clock	RTP0-RTP7	: Real-Time Output Port
ASTB	: Address Strobe	RxD0, RxD1	: Receive Data
AVREF0, 1	: Analog Reference Voltage	SB0, SB1	: Serial Bus
AVSS	: Analog Ground	$\overline{SCK0-SCK2}$	: Serial Clock
BUSY	: Busy	SI0-SI2	: Serial Input
BUZ	: Buzzer Clock	SO0-SO2	: Serial Output
IC	: Internally Connected	STB	: Strobe
INTP0-INTP5	: Interrupt from Peripherals	TI00, TI01	: Timer Input
P00-P05, P07	: Port0	TI1, TI2	: Timer Input
P10-P17	: Port1	TO0-TO2	: Timer Output
P20-P27	: Port2	TxD0, TxD1	: Transmit Data
P30-P37	: Port3	V <sub>DD0</sub> , V <sub>DD1</sub>	: Power Supply
P40-P47	: Port4	V <sub>SS0</sub> , V <sub>SS1</sub>	: Ground
P50-P57	: Port5	$\overline{WAIT}$	: Wait
P60-P67	: Port6	$\overline{WR}$	: Write Strobe
P70-P72	: Port7	X1, X2	: Crystal (Main System Clock)
P120-P127	: Port12	XT1, XT2	: Crystal (Subsystem Clock)



2. BLOCK DIAGRAM



**Remark** The internal ROM and RAM capacities differ depending on the product.

### 3. PIN FUNCTIONS

#### 3.1 PORT PINS (1/2)

Pin Name	I/O	Function		After Reset	Dual-Function Pin
P00	Input	Port 0 7-bit input/output port	Input only	Input	INTP0/TI00
P01	Input/ output		Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.	Input	INTP1/TI01
P02					INTP2
P03					INTP3
P04					INTP4
P05					INTP5
P07 <sup>Note 1</sup>	Input		Input only	Input	XT1
P10-P17	Input/ output	Port 1 8-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software <sup>Note 2</sup> .		Input	ANI0-ANI7
P20	Input/ output	Port 2 8-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.	Input	SI1	
P21				SO1	
P22				SCK1	
P23				STB/TxD1	
P24				BUSY/RxD1	
P25				SI0/SB0	
P26				SO0/SB1	
P27				SCK0	
P30	Input/ output	Port 3 8-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.	Input	TO0	
P31				TO1	
P32				TO2	
P33				TI1	
P34				TI2	
P35				PCL	
P36				BUZ	
P37				—	
P40-P47	Input/ output	Port 4 8-bit input/output port. Input/output can be specified in 8-bit unit. When used as an input port, on-chip pull-up resistor can be used by software. Test input flag (KRIF) is set to 1 by falling edge detection.		Input	AD0-AD7

- Notes**
1. When using the P07/XT1 pins as an input port, set 1 in the bit 6 (FRC) of the processor clock control register (PCC). On-chip feedback resistor of the subsystem clock oscillator should not be used.
  2. When using the P10/ANI0 to P17/ANI7 pins as the A/D converter analog input pins, set port 1 to input mode. Use of the on-chip pull-up resistor is cancelled automatically.

3.1 PORT PINS (2/2)

Pin Name	I/O	Function		After Reset	Dual-Function Pin
P50-P57	Input/output	Port 5 8-bit input/output port. LED can be driven directly. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.		Input	A8-A15
P60	Input/output	Port 6 8-bit input/output port. Input/output can be specified bit-wise.	N-ch open-drain input/output port. On-chip pull-up resistor can be used by mask option. LED can be driven directly.	Input	—
P61					
P62					
P63					
P64			When used as an input port, on-chip pull-up resistor can be used by software.		$\overline{RD}$
P65					$\overline{WR}$
P66					$\overline{WAIT}$
P67					ASTB
P70	Input/output	Port 7 3-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.	Input	SI2/RxD0	
P71				SO2/TxD0	
P72				$\overline{SCK2/ASCK}$	
P120-P127	Input/output	Port 12 8-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.		Input	RTP0-RTP7
P130, P131	Input/output	Port 13 2-bit input/output port. Input/output can be specified bit-wise. When used as an input port, on-chip pull-up resistor can be used by software.		Input	ANO0, ANO1

3.2 OTHER PINS (1/2)

Pin Name	I/O	Function	After Reset	Dual-Function Pin
INTP0	Input	External interrupt request input for which the effective edge (rising edge, falling edge, or both rising edge and falling edge) can be specified.	Input	P00/TI00
INTP1				P01/TI01
INTP2				P02
INTP3				P03
INTP4				P04
INTP5				P05
SI0	Input	Serial interface serial data input.	Input	P25/SB0
SI1				P20
SI2				P70/RxD
SO0	Output	Serial interface serial data output.	Input	P26/SB1
SO1				P21
SO2				P71/TxD
SB0	Input/ output	Serial interface serial data input/output.	Input	P25/SI0
SB1				P26/SO0
$\overline{\text{SCK0}}$	Input/ output	Serial interface serial clock input/ output	Input	P27
$\overline{\text{SCK1}}$				P22
$\overline{\text{SCK2}}$				P72/ASCK
STB	Output	Serial interface automatic transmit/receive strobe output.	Input	P23/TxD1
BUSY	Input	Serial interface automatic transmit/receive busy input.	Input	P24/RxD1
RxD0	Input	Asynchronous serial interface serial data input.	Input	P70/SI2
RxD1				P24/BUSY
TxD0	Output	Asynchronous serial interface serial data output.	Input	P71/SO2
TxD1				P23/STB
ASCK	Input	Asynchronous serial interface serial clock input.	Input	P72/ $\overline{\text{SCK2}}$
TI00	Input	External count clock input to the 16-bit timer (TM0)	Input	P00/INTP0
TI01		Capture trigger signal input to the capture register (CR00)		P01/INTP1
TI1		External count clock input to the 8-bit timer (TM1)		P33
TI2		External count clock input to the 8-bit timer (TM2)		P34
TO0	Output	16-bit timer (TM0) output (dual-function as 14-bit PWM output)	Input	P30
TO1		8-bit timer (TM1) output		P31
TO2		8-bit timer (TM2) output		P32
PCL	Output	Clock output (for main system clock, subsystem clock trimming).	Input	P35
BUZ	Output	Buzzer output.	Input	P36
RTP0-RTP7	Output	Real-time output port by which data is output in synchronization with a trigger.	Input	P120-P127
AD0-AD7	Input/ output	Low-order address/data bus at external memory expansion.	Input	P40-P47
A8-A15	Output	High-order address bus at external memory expansion.	Input	P50-P57
$\overline{\text{RD}}$	Output	External memory read operation strobe signal output.	Input	P64
$\overline{\text{WR}}$		External memory write operation strobe signal output.		P65

## 3.2 OTHER PINS (2/2)

Pin Name	I/O	Function	After Reset	Dual-Function Pin
$\overline{\text{WAIT}}$	Input	Wait insertion at external memory access.	Input	P66
ASTB	Output	Strobe output which latches the address information output at port 4 to access external memory.	Input	P67
ANI-ANI7	Input	A/D converter analog input.	Input	P10-P17
ANO0, ANO1	Output	D/A converter analog output.	Input	P130, P131
AVREF0	Input	A/D converter reference voltage input (dual-function as analog power supply).	—	—
AVREF1	Input	D/A converter reference voltage input.	—	—
AVSS	—	A/D converter, D/A converter ground potential. Use at the same potential as V <sub>SS0</sub> .	—	—
$\overline{\text{RESET}}$	Input	System reset input.	—	—
X1	Input	Main system clock oscillation crystal connection.	—	—
X2	—		—	—
XT1	Input	Subsystem clock oscillation crystal connection.	Input	P07
XT2	—		—	—
V <sub>DD0</sub>	—	Port block positive power supply.	—	—
V <sub>SS0</sub>	—	Port block ground potential.	—	—
V <sub>DD1</sub>	—	Positive power supply (except for port and analog blocks).	—	—
V <sub>SS1</sub>	—	Ground potential (except for port and analog blocks).	—	—
IC	—	Internally connected. Connect to V <sub>SS0</sub> or V <sub>SS1</sub> directly.	—	—

### 3.3 PIN I/O CIRCUITS AND RECOMMENDED CONNECTION OF UNUSED PINS

The input/output circuit type of each pin and recommended connection of unused pins are shown in Table 3-1.

For the input/output circuit configuration of each type, see Figure 3-1.

**Table 3-1. Input/Output Circuit Type of Each Pin (1/2)**

Pin Name	Input/Output Circuit Type	I/O	Recommended Connection when Not Used	
P00/INTP0/TI00	2	Input	Connect to $V_{SS0}$ .	
P01/INTP1/TI01	8-C	Input/output	Independently connect to $V_{SS0}$ through resistor.	
P02/INTP2				
P03/INTP3				
P04/INTP4				
P05/INTP5				
P07/XT1	16	Input	Connect to $V_{DD0}$ .	
P10/ANI0-P17/ANI7	11-D	Input/output	Independently connect to $V_{DD0}$ or $V_{SS0}$ through resistor.	
P20/SI1	8-C			
P21/SO1	5-H			
P22/ $\overline{SCK1}$	8-C			
P23/STB/TxD1	5-H			
P24/BUSY/RxD1	8-C			
P25/SI0/SB0	10-B			
P26/SO0/SB1				
P27/ $\overline{SCK0}$				
P30/TO0	5-H			
P31/TO1				
P32/TO2				
P33/TI1	8-C			
P34/TI2				
P35/PCL	5-H			
P36/BUZ				
P37				
P40/AD0-P47/AD7	5-N			Independently connect to $V_{DD0}$ through resistor.
P50/A8-P57/A15	5-H			Independently connect to $V_{DD0}$ or $V_{SS0}$ through resistor.
P60-P63	13-J			Independently connect to $V_{DD0}$ through resistor.
P64/ $\overline{RD}$	5-H	Independently connect to $V_{DD0}$ or $V_{SS0}$ through resistor.		
P65/ $\overline{WR}$				
P66/ $\overline{WAIT}$				
P67/ASTB				

Table 3-1. Input/Output Circuit Type of Each Pin (2/2)

Pin Name	Input/Output Circuit Type	I/O	Recommended Connection when Not Used
P70/SI2/RxD0	8-C	Input/ output	Independently connect to V <sub>DD0</sub> or V <sub>SS0</sub> through resistor.
P71/SO2/TxD0	5-H		
P72/ $\overline{\text{SCK2}}$ /ASCK	8-C		
P120/RTP0- P127/RTP7	5-H		
P130/ANO0 , P131/ANO1	12-C		Independently connect to V <sub>SS0</sub> through resistor.
$\overline{\text{RESET}}$	2	Input	—
XT2	16	—	Leave open.
AV <sub>REF0</sub>	—		Connect to V <sub>SS0</sub> .
AV <sub>REF1</sub>			Connect to V <sub>DD0</sub> .
AV <sub>SS</sub>			Connect to V <sub>SS0</sub> .
IC			Connect to V <sub>SS0</sub> or V <sub>SS1</sub> directly.

Figure 3-1. Pin Input/Output Circuits (1/2)

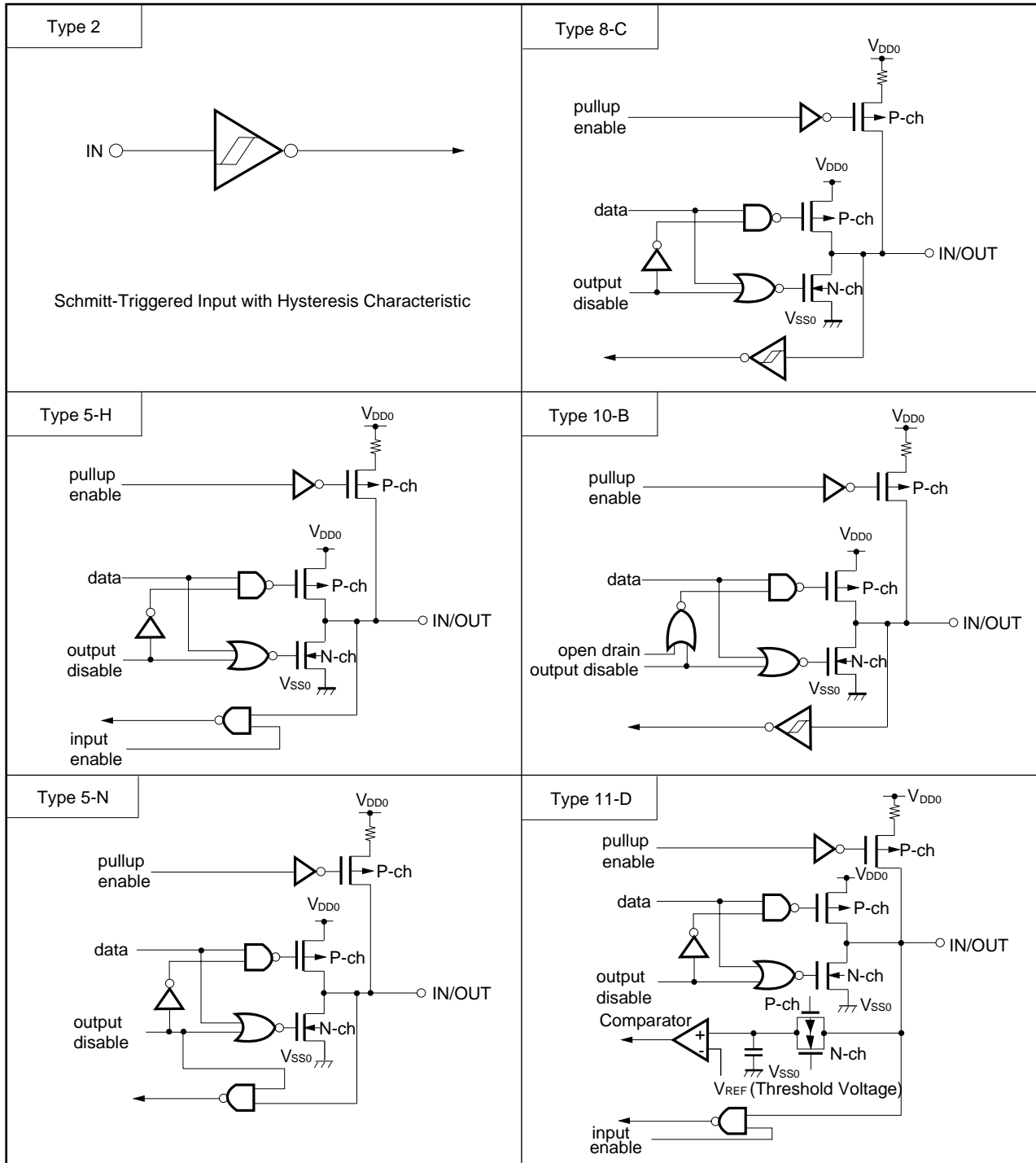
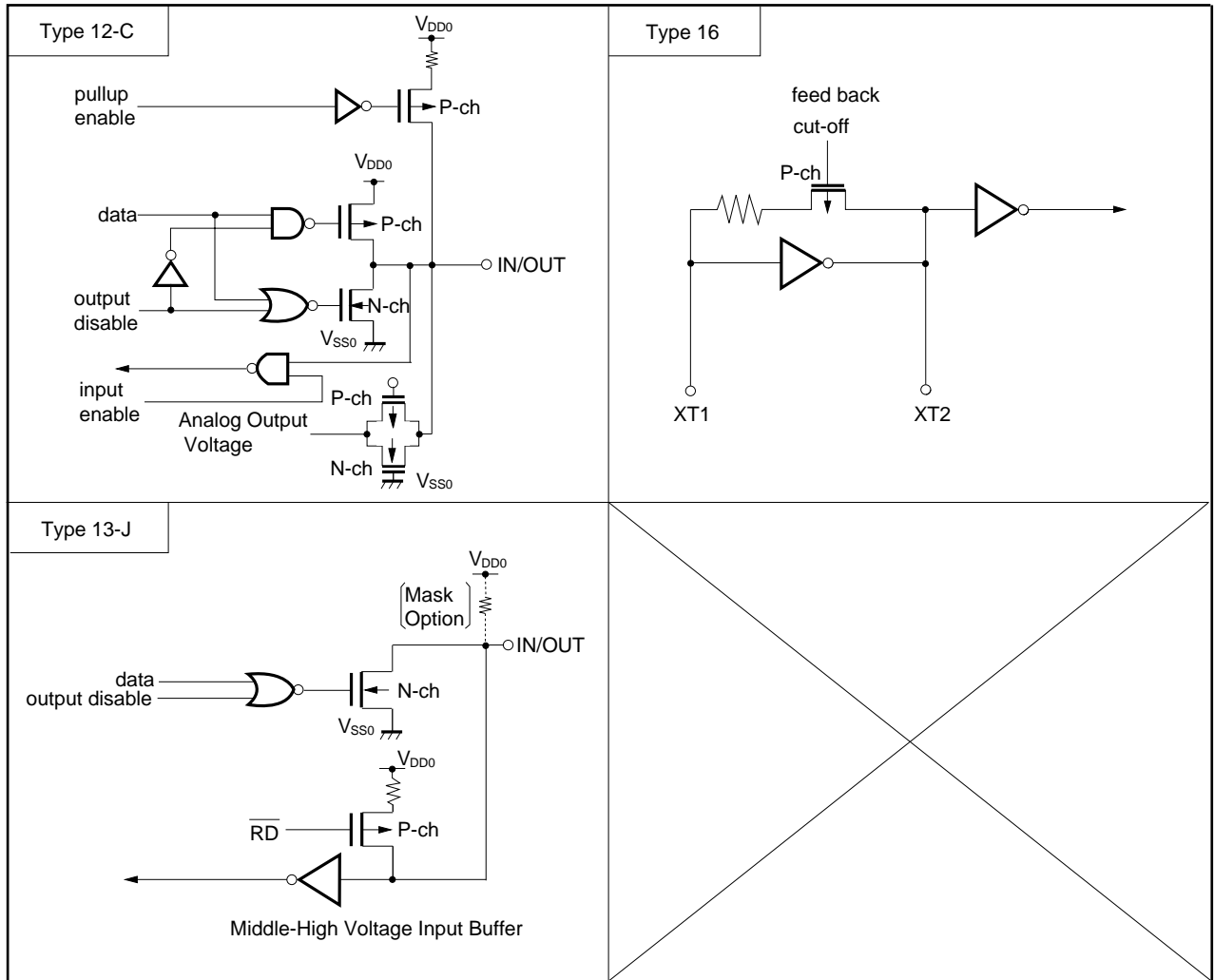




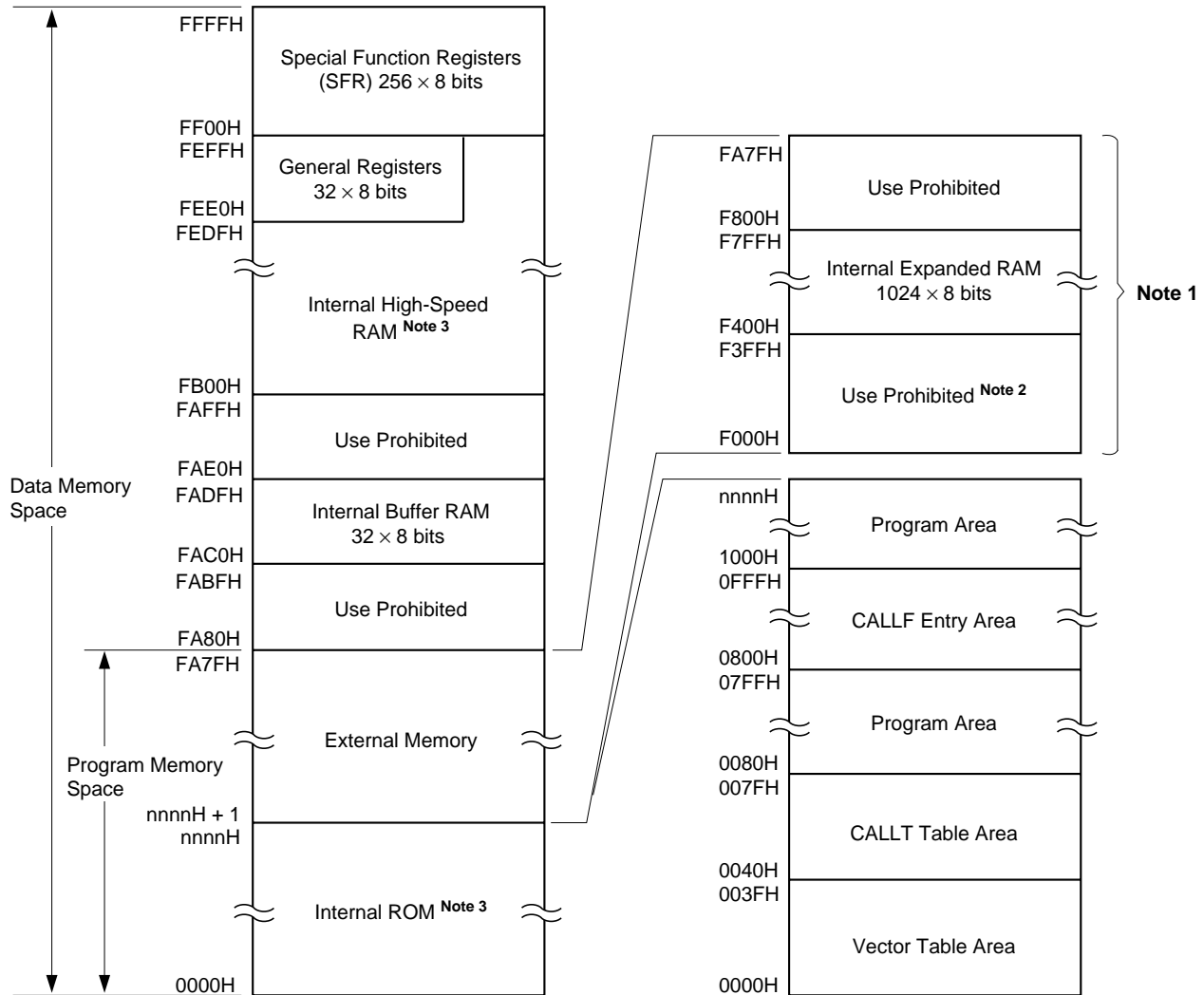
Figure 3-1. Pin Input/Output Circuits (2/2)



4. MEMORY SPACE

Figure 4-1 shows the μPD780053/780054/780055/780056/780058 memory map.

Figure 4-1. Memory Map



- Notes**
1. μPD780058 only
  2. When the external device expansion function is used with the μPD780058, set the internal ROM capacity to 56K bytes or less using the memory size switching register (IMS).
  3. The internal ROM capacity depends on the products (see the next table).

Relevant Product Name	Internal ROM Last Address nnnnH
μPD780053	5FFFH
μPD780054	7FFFH
μPD780055	9FFFH
μPD780056	BFFFH
μPD780058	EFFFH

5. PERIPHERAL HARDWARE FUNCTION FEATURES

5.1 PORTS

The following three types of I/O ports are available.

- CMOS input (P00, P07) : 2
  - CMOS input/output (P01-P05, port 1-port 5, P64-P67, port 7, port 12, port 13) : 62
  - N-channel open-drain input/output (P60-P63) : 4
- 
- Total : 68

Table 5-1. Port Functions

Name	Pin Name	Function
Port 0	P00, P07	Dedicated input port pins
	P01-P05	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 1	P10-P17	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 2	P20-P27	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 3	P30-P37	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 4	P40-P47	Input/output port pins. Input/output specifiable in 8-bit units. When used as input port pins, on-chip pull-up resistor can be used by software. Test flag (KRIF) is set to 1 by falling edge detection.
Port 5	P50-P57	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software. LED direct drive capability.
Port 6	P60-P63	N-channel open-drain input/output port pins. Input/output specifiable bit-wise. On-chip pull-up resistor can be used by mask option. LED direct drive capability.
	P64-P67	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 7	P70-P72	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 12	P120-P127	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.
Port 13	P130, P131	Input/output port pins. Input/output specifiable bit-wise. When used as input port pins, on-chip pull-up resistor can be used by software.

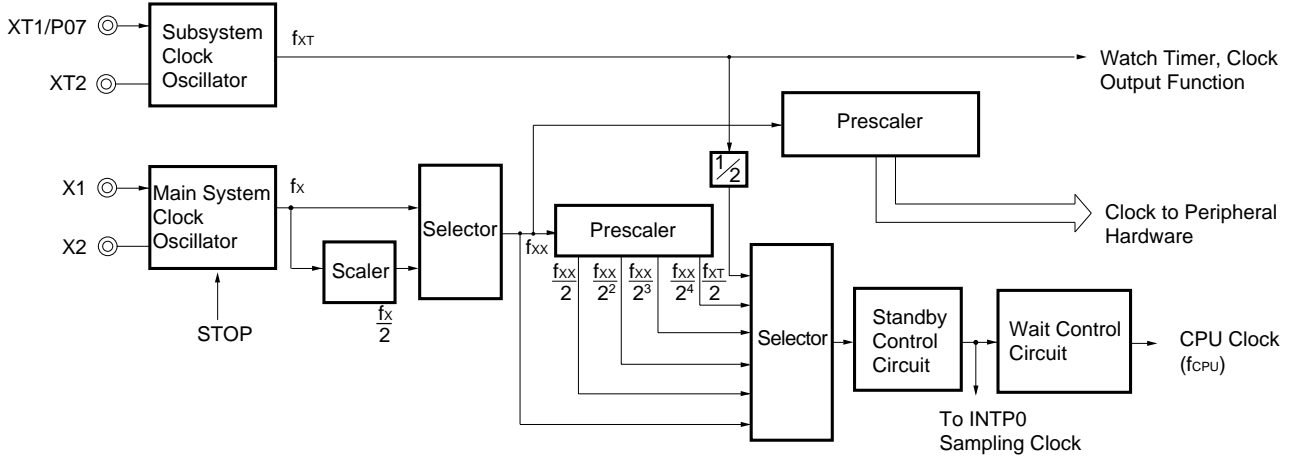
**5.2 CLOCK GENERATOR**

Two types of generators, a main system clock generator and a subsystem clock generator, are available.

The minimum instruction execution time can also be changed.

- 0.4 μs/0.8 μs/1.6 μs/3.2 μs/6.4 μs/12.8 μs (main system clock: at 5.0 MHz operation)
- 122 μs (subsystem clock: at 32.768 kHz operation)

**Figure 5-1. Clock Generator Block Diagram**



**5.3 TIMER/EVENT COUNTER**

The following five channels of the timer/event counter are available.

- 16-bit timer/event counter : 1 channel
- 8-bit timer/event counter : 2 channels
- Watch timer : 1 channel
- Watchdog timer : 1 channel

**Table 5-2. Operations of Timer/Event Counter**

		16-Bit Timer/Event Counter	8-Bit Timer/Event Counter	Watch Timer	Watchdog Timer
Operation mode	Interval timer	1 channel	2 channels	1 channel	1 channel
	External event counter	1 channel	2 channels	—	—
Function	Timer output	1 output	2 outputs	—	—
	PWM output	1 output	—	—	—
	Pulse width measurement	1 input	—	—	—
	Square wave output	1 output	2 outputs	—	—
	Ono-shot pulse output	1 output	—	—	—
	Interrupt request	2	2	2	1

Figure 5-2. 16-Bit Timer/Event Counter Block Diagram

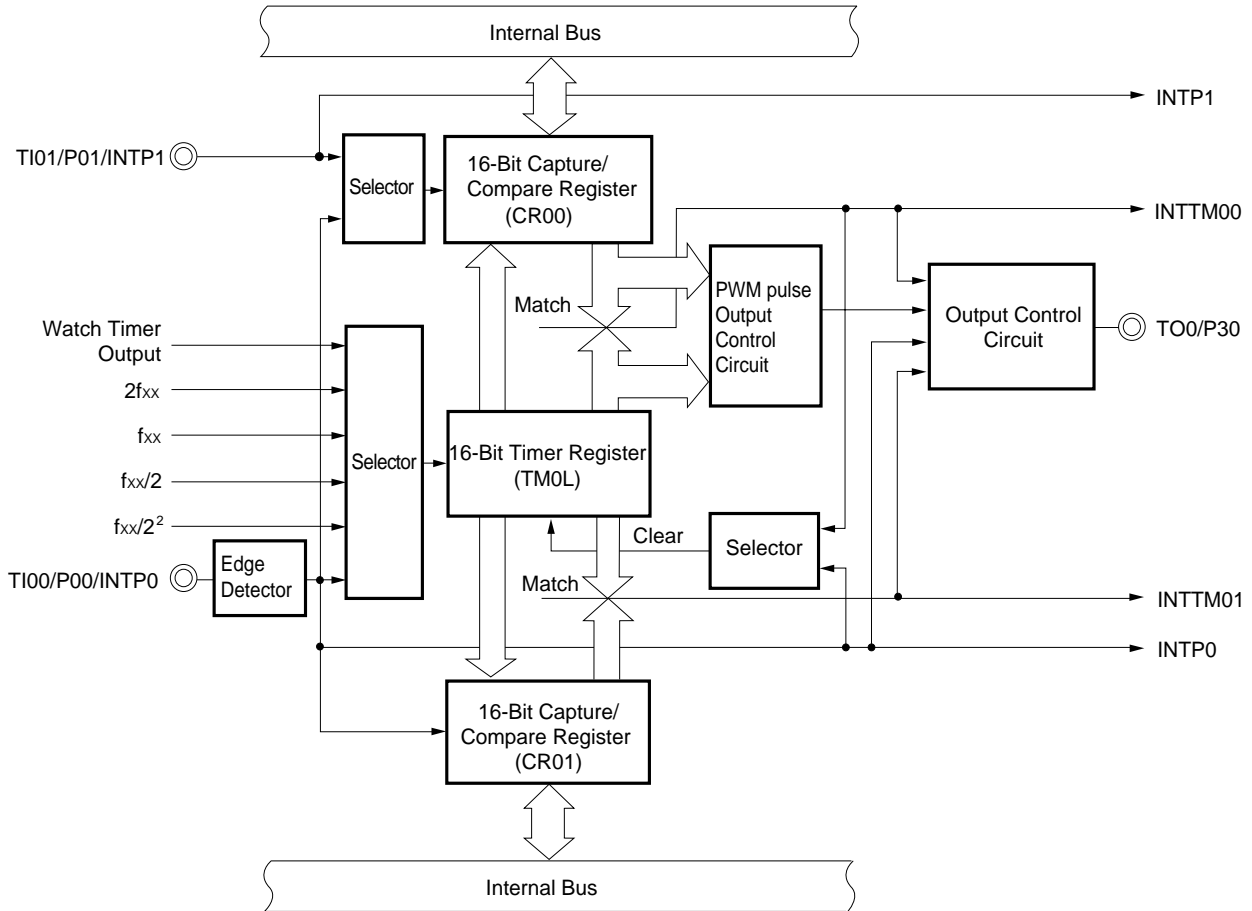


Figure 5-3. 8-Bit Timer/Event Counter Block Diagram

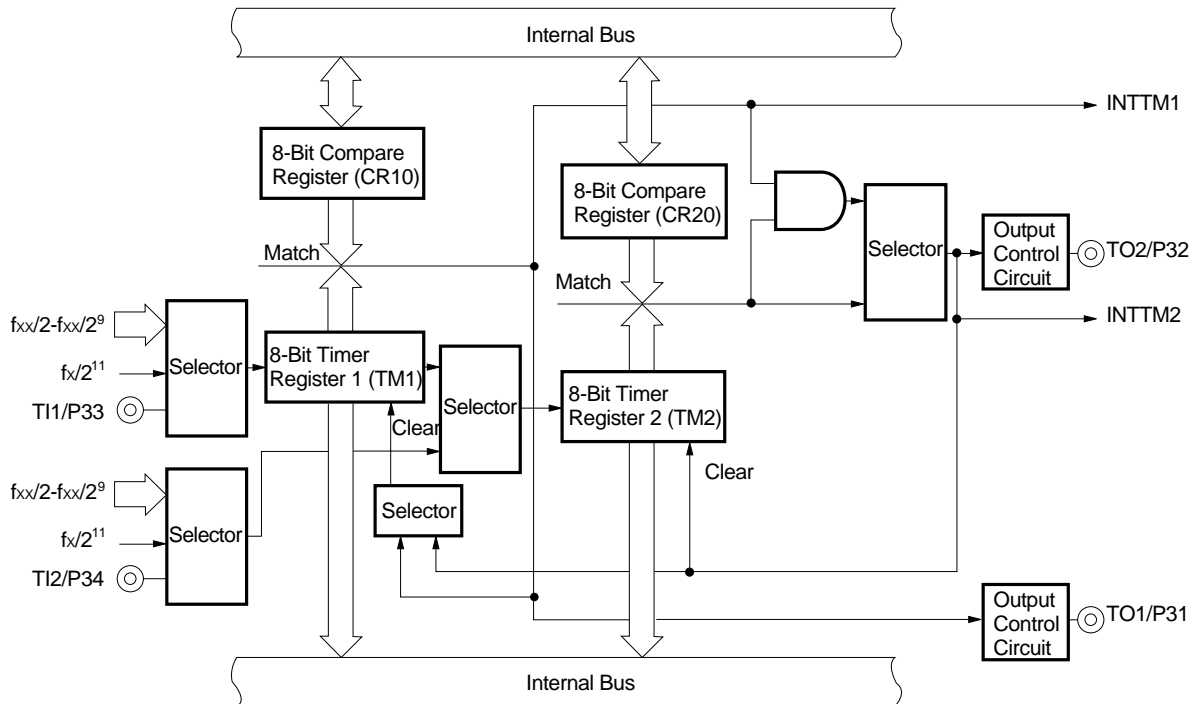


Figure 5-4. Watch Timer Block Diagram

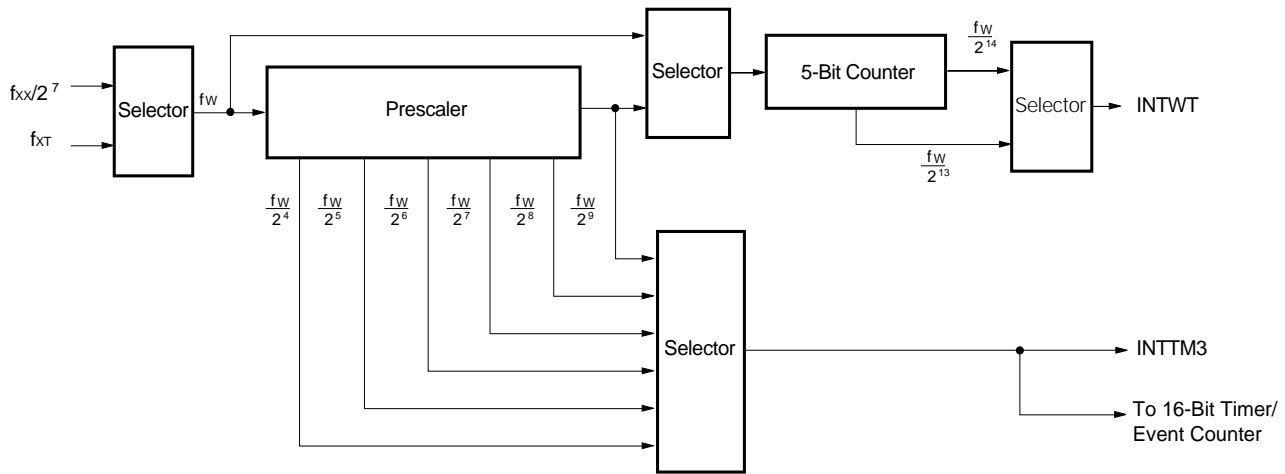
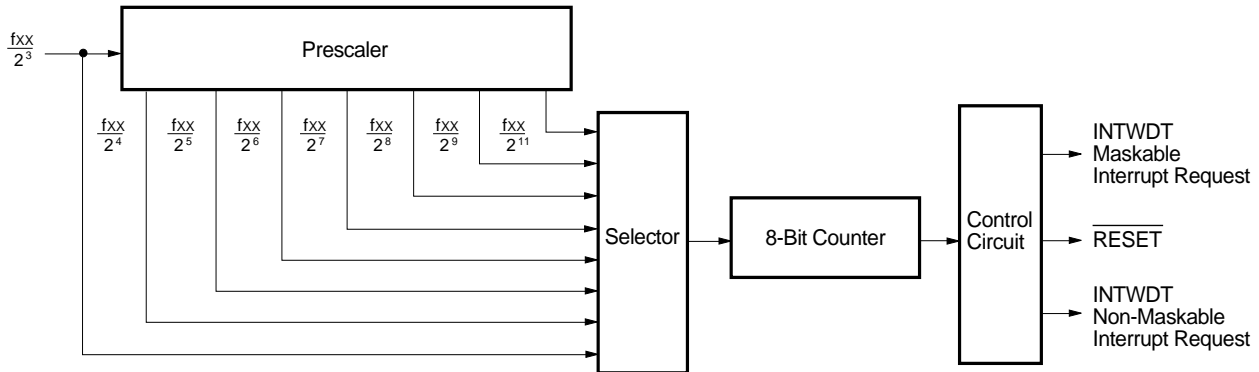


Figure 5-5. Watchdog Timer Block Diagram

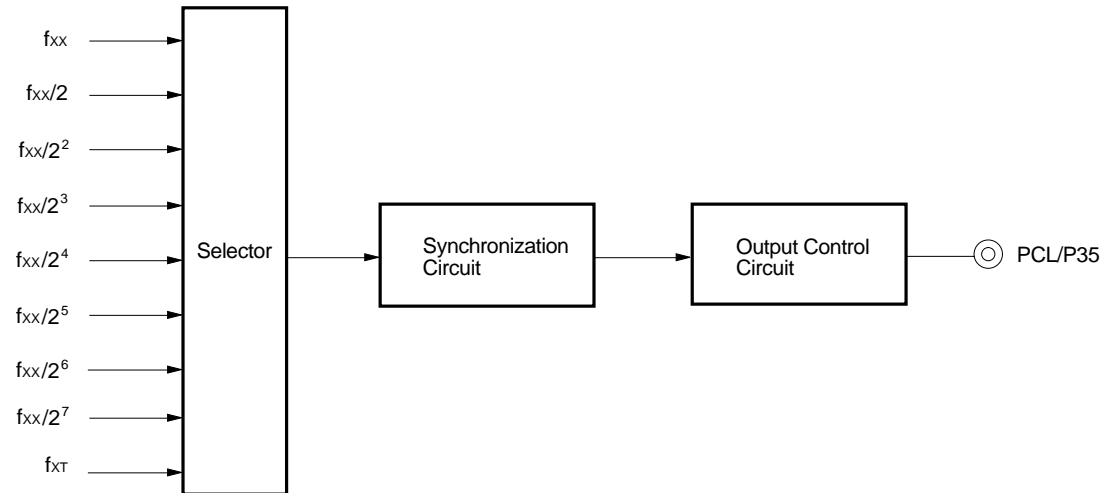


**5.4 CLOCK OUTPUT CONTROL CIRCUIT**

The clock with the following frequency can be output as a clock output.

- 19.5 kHz/39.1 kHz/78.1 kHz/156 kHz/313 kHz/625 kHz/1.25 MHz/2.5 MHz/5.0 MHz (main system clock: at 5.0 MHz operation)
- 32.768 kHz (subsystem clock: at 32.768 kHz operation)

**Figure 5-6. Clock Output Control Circuit Configuration**

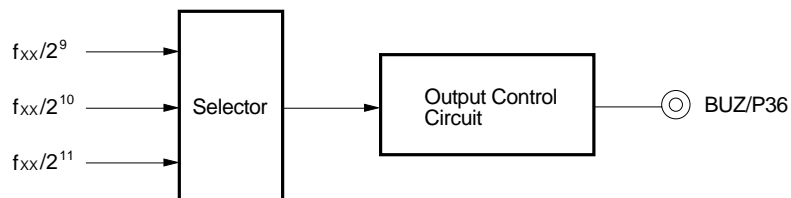


**5.5 BUZZER OUTPUT CONTROL CIRCUIT**

The clock with the following frequency can be output as a buzzer output.

- 1.2 kHz/2.4 kHz/4.9 kHz/9.8 kHz (main system clock: at 5.0 MHz operation)

**Figure 5-7. Buzzer Output Control Circuit Block Diagram**



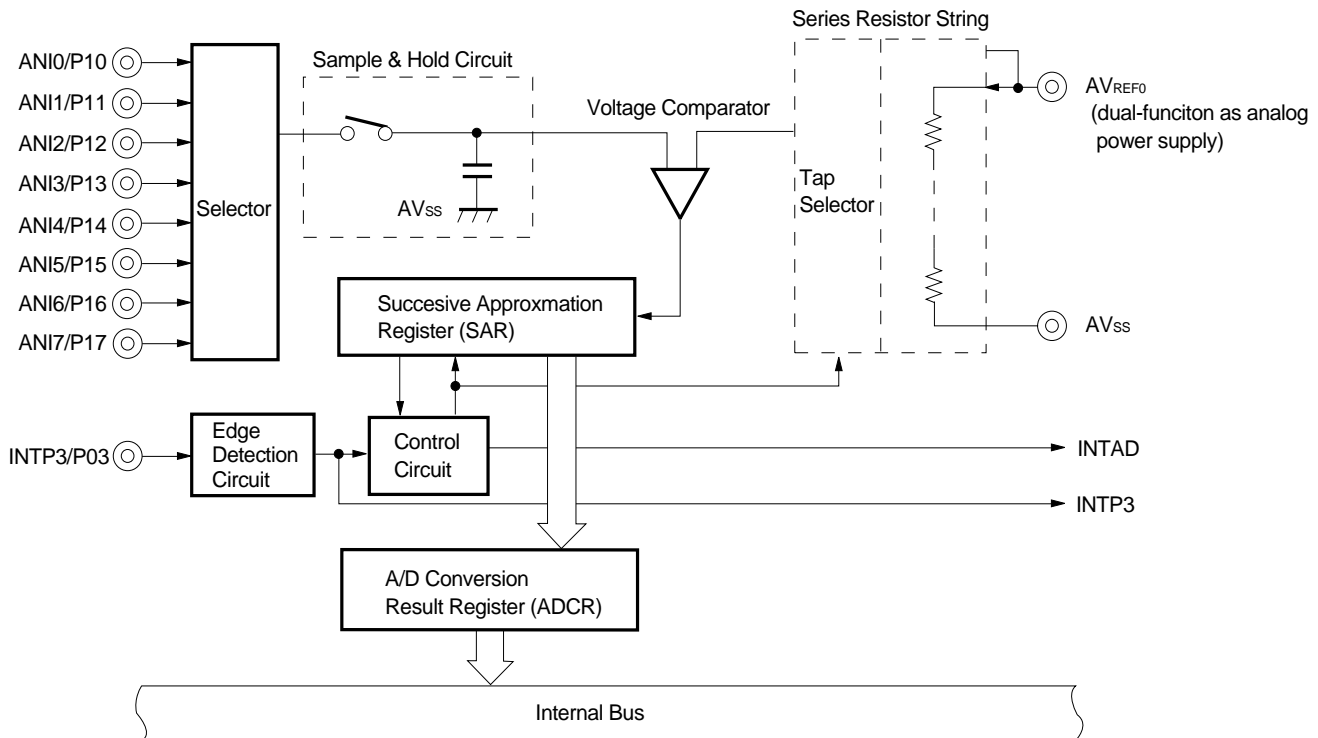
### 5.6 A/D CONVERTER

An A/D converter of 8-bit resolution × 8 channels is incorporated.

The following two types of the A/D conversion operation start-up methods are available.

- Hardware start
- Software start

Figure 5-8. A/D Converter Block Diagram



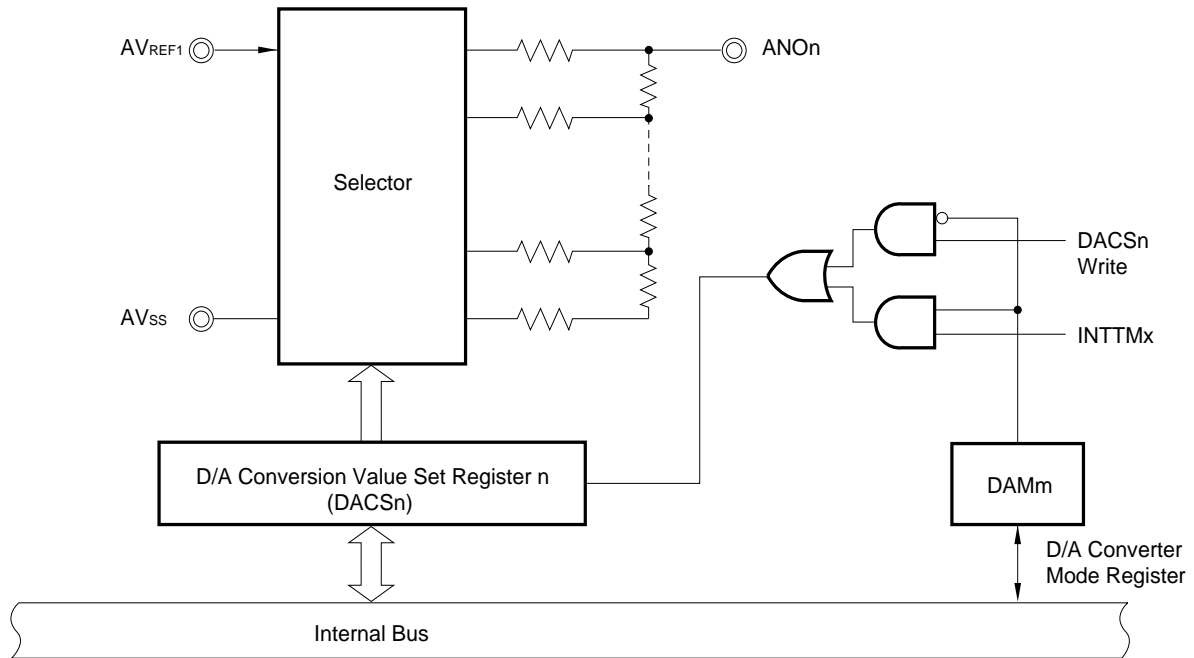


### 5.7 D/A CONVERTER

A D/A converter of 8-bit resolution × 2 channels is available.

Conversion method is R-2R resistor ladder method.

Figure 5-9. D/A Converter Block Diagram



n = 0, 1  
 m = 4, 5  
 x = 1, 2

### 5.8 SERIAL INTERFACES

Three channels of the clocked serial interface are incorporated.

- Serifal interface channel 0
- Serifal interface channel 1
- Serifal interface channel 2

Table 5-3. Types and Functions of Serial Interface

Function	Serial Interface Channel 0	Serial Interface Channel 1	Serial Interface Channel 2
3-wire serial I/O mode	○ (MSB/LSB first switchable)	○ (MSB/LSB first switchable)	○ (MSB/LSB first switchable)
3-wire serial I/O mode with automatic transmit/receive function	—	○ (MSB/LSB first switchable)	—
SBI (serial bus interface) mode	○ (MSB first)	—	—
2-wire serial I/O mode	○ (MSB first)	—	—
Asynchronous serial interface (UART) mode (on-chip time division transfer function)	—	—	○ (Dedicated baud rate generator incorporated)

Figure 5-10. Serial Interface Channel 0 Block Diagram

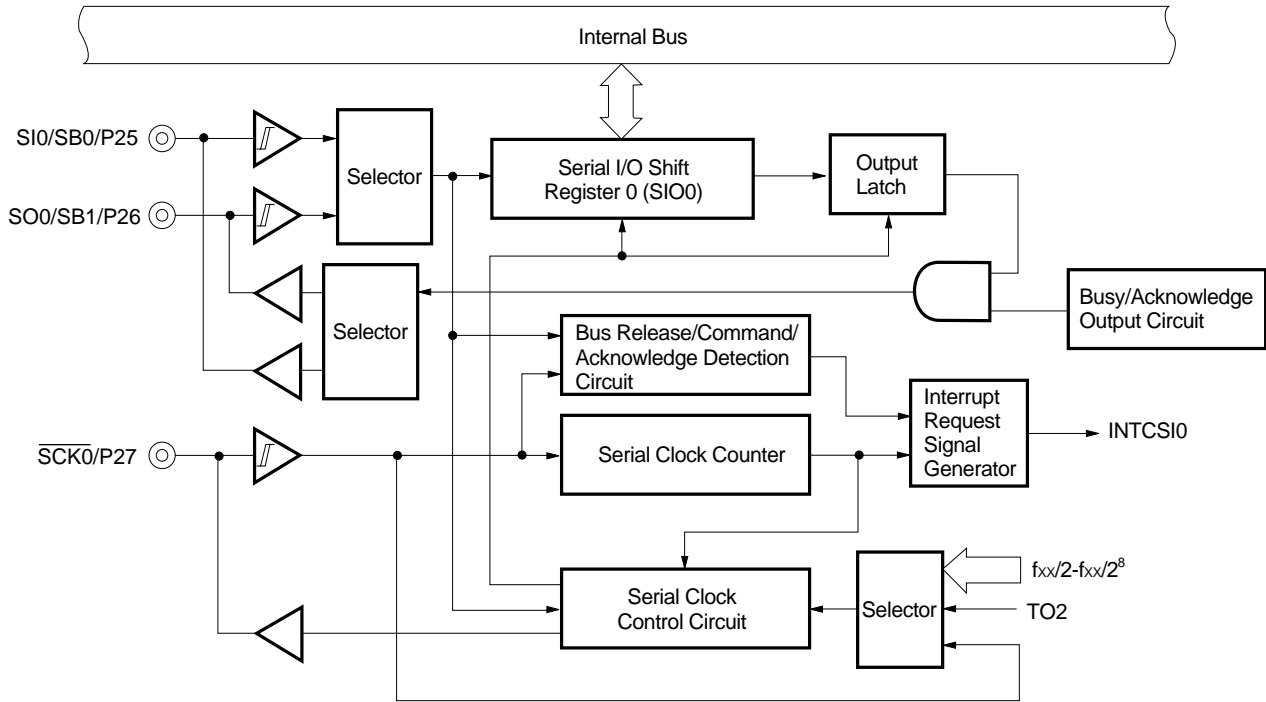


Figure 5-11. Serial Interface Channel 1 Block Diagram

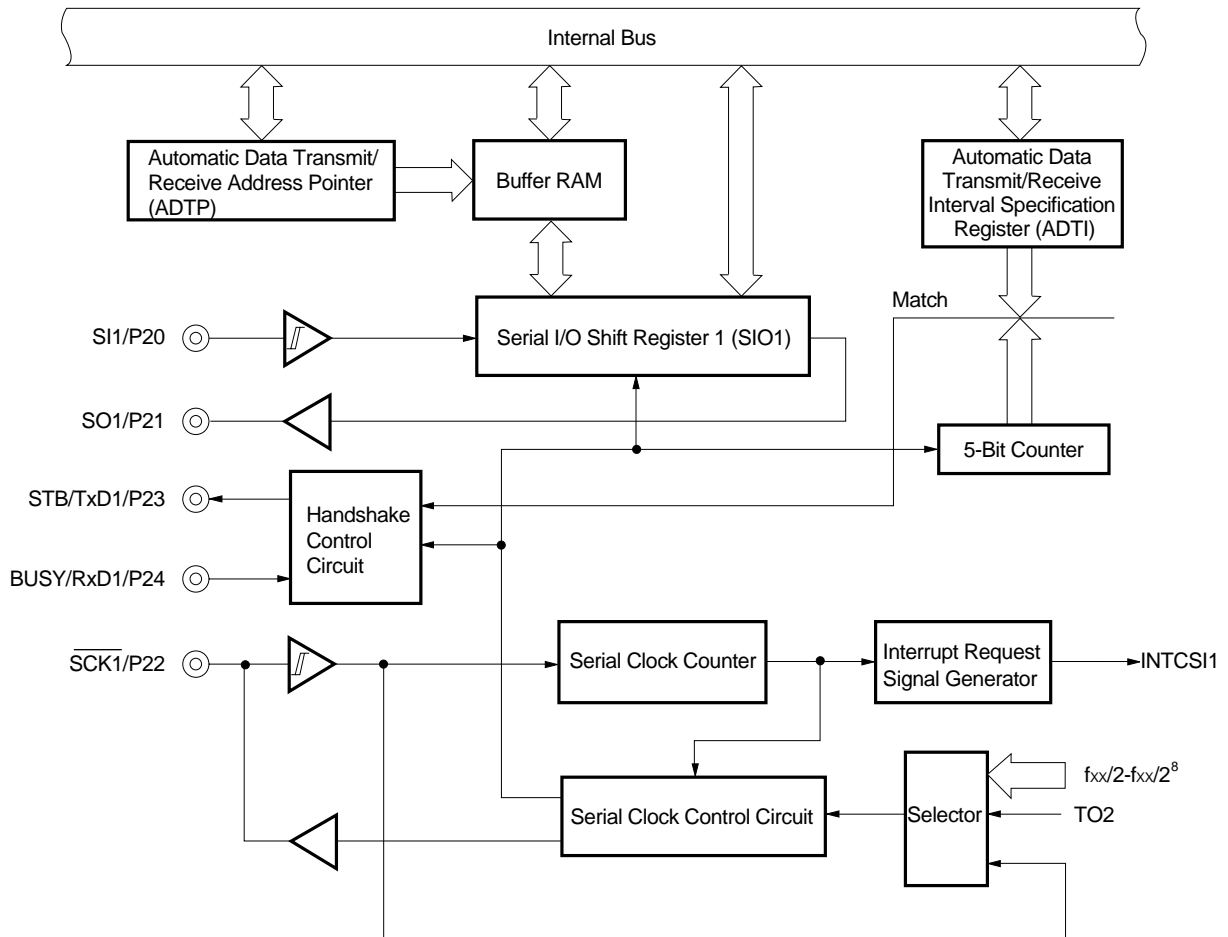
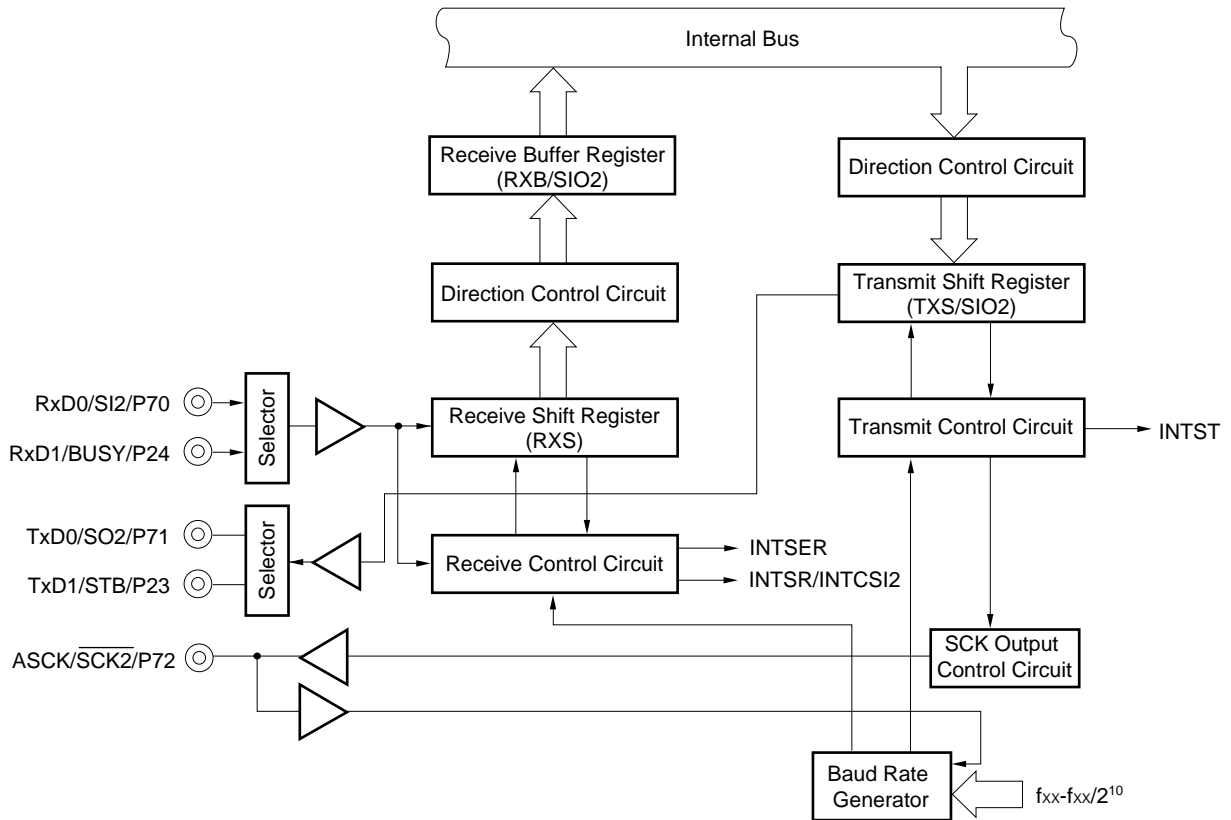


Figure 5-12. Serial Interface Channel 2 Block Diagram

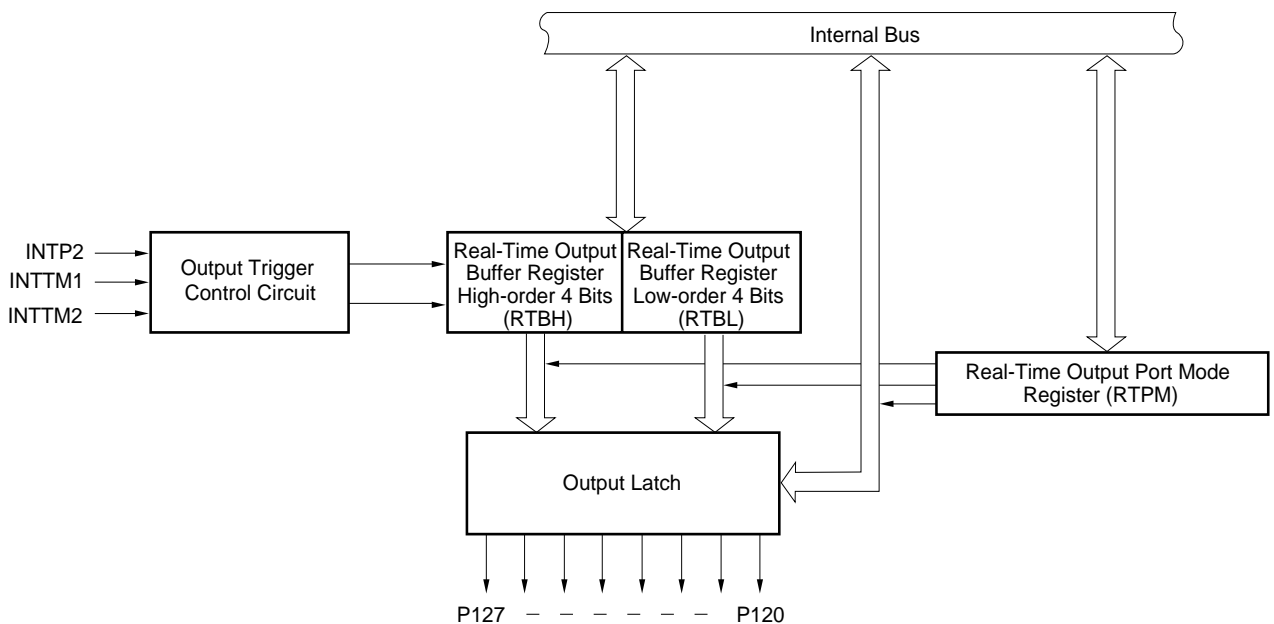


5.9 REAL-TIME OUTPUT PORT FUNCTIONS

Data set previously in the real-time output buffer register is transferred to the output latch by hardware concurrently with timer interrupt request and external interrupt request generation in order to output to off-chip. This is real-time output function. And pins to output to off-chip are called real-time output ports.

By using a real-time output port, a signal which has no jitter can be output. This is most applicable to control of stepping motor, etc.

Figure 5-13. Real-Time Output Port Block Diagram



6. INTERRUPT FUNCTIONS AND TEST FUNCTIONS

6.1 INTERRUPT FUNCTIONS

There are interrupt functions, 21 sources of three different kinds, as shown below.

- Non-maskable : 1
- Maskable : 19
- Software : 1

Table 6-1. Interrupt Source List (1/2)

Interrupt Type	Note 1 Default Priority	Interrupt Source		Internal/ External	Vector Table Address	Basic Configuration Type <sup>Note 2</sup>		
		Name	Trigger					
Non-maskable	—	INTWDT	Watchdog timer overflow (watchdog timer mode 1 selected)	Internal	0004H	(A)		
Maskable	0	INTWDT	Watchdog timer overflow (interval timer mode selected)			External	0006H 0008H 000AH 000CH 000EH 0010H	(B)
	1	INTP0	Pin input edge detection	(C)				
	2	INTP1						
	3	INTP2						
	4	INTP3						
	5	INTP4						
	6	INTP5						
	7	INTCSI0			End of serial interface channel 0 transfer			Internal
	8	INTCSI1	End of serial interface channel 1 transfer					
	9	INTSER	Generation of serial interface channel 2 UART receive error					
	10	INTSR	End of serial interface channel 2 UART reception					
		INTCSI2	End of serial interface channel 2 3- wire transfer					
	11	INTS	End of serial interface channel 2 UART transmission					

**Notes 1.** The default priority is a priority order when two or more maskable interrupt requests are generated simultaneously. 0 is the highest order and 17, the lowest.

**2.** Basic configuration types (A) to (E) correspond to (A) to (E) in Figure 6-1, respectively.

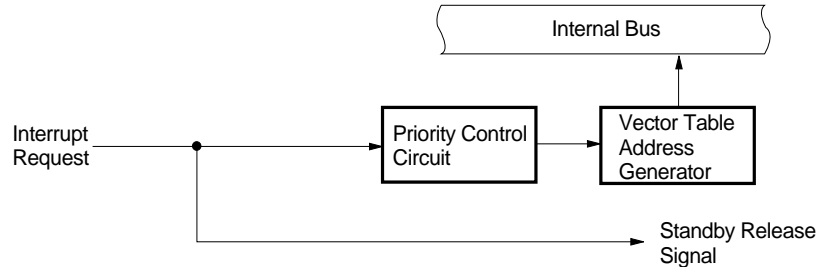
Table 6-1. Interrupt Source List (2/2)

Interrupt Type	Note 1 Default Priority	Interrupt Source		Internal/ External	Vector Table Address	Basic Configuration Type <sup>Note 2</sup>
		Name	Trigger			
	12	INTTM3	Reference time interval signal from watch timer	Internal	001EH	(B)
	13	INTTM00	Generation of match signal of 16-bit timer register and capture/compare register (CR00)		0020H	
	14	INTTM01	Generation of match signal of 16-bit timer register and capture/compare register (CR01)		0022H	
	15	INTTM1	Generation of match signal of 8-bit timer/event counter 1		0024H	
	16	INTTM2	Generation of match signal of 8-bit timer/event counter 2		0026H	
	17	INTAD	End of conversion by A/D converter		0028H	
Software	—	BRK	BRK instruction execution	—	003EH	(E)

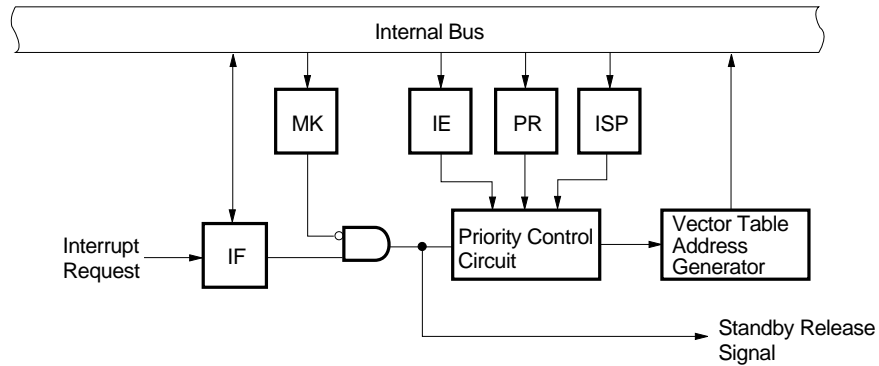
- Notes**
1. The default priority is a priority order when two or more maskable interrupt requests are generated simultaneously. 0 is the highest order and 17, the lowest.
  2. Basic configuration types (A) to (E) correspond to (A) to (E) in Figure 6-1, respectively.

Figure 6-1. Interrupt Function Basic Configuration(1/2)

(A) Internal non-maskable interrupt



(B) Internal maskable interrupt



(C) External maskable interrupt (INTP0)

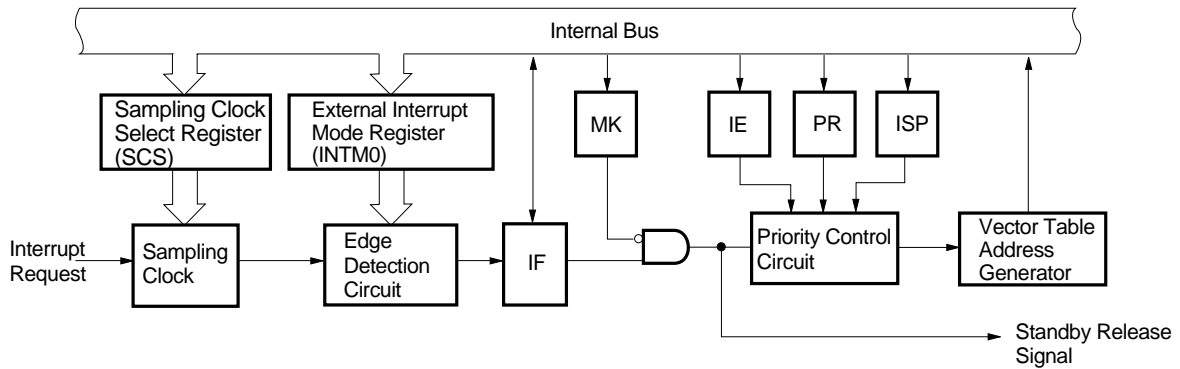
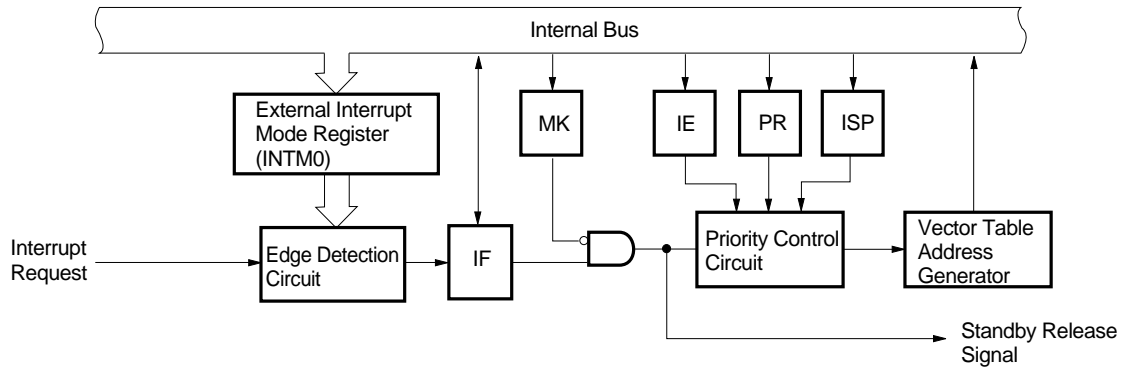
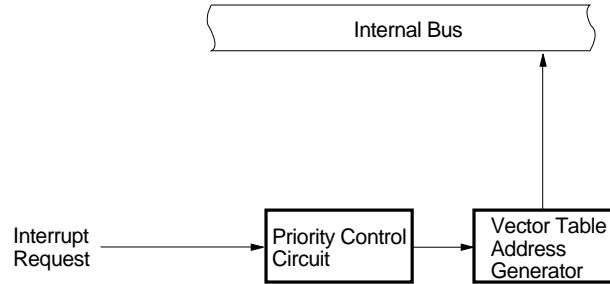


Figure 6-1. Interrupt Function Basic Configuration(2/2)

(D) External maskable interrupt (except INTP0)



(E) Software interrupt



- IF : Interrupt request flag
- IE : Interrupt enable flag
- ISP : In-service priority flag
- MK : Interrupt mask flag
- PR : Priority specification flag

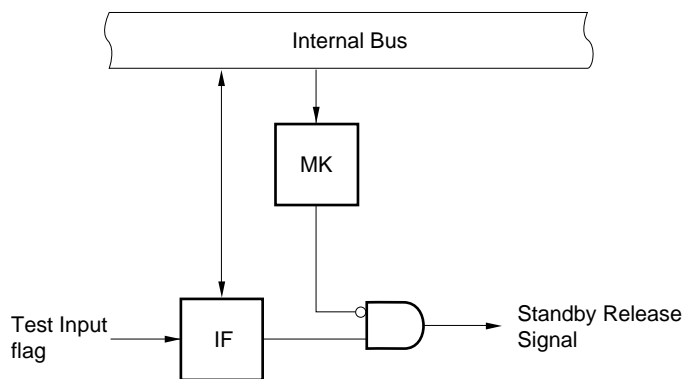
6.2 TEST FUNCTIONS

There are two sources of test functions as shown in Table 6-2.

Table 6-2. Test Input Source List

Test Input Source		Internal/External
Name	Trigger	
INTWT	Watch timer overflow	Internal
INTPT4	Port 4 falling edge detection	External

Figure 6-2. Test Function Basic Configuration



IF : Test input flag  
 MK : Test mask flag



## 7. EXTERNAL DEVICE EXPANSION FUNCTIONS

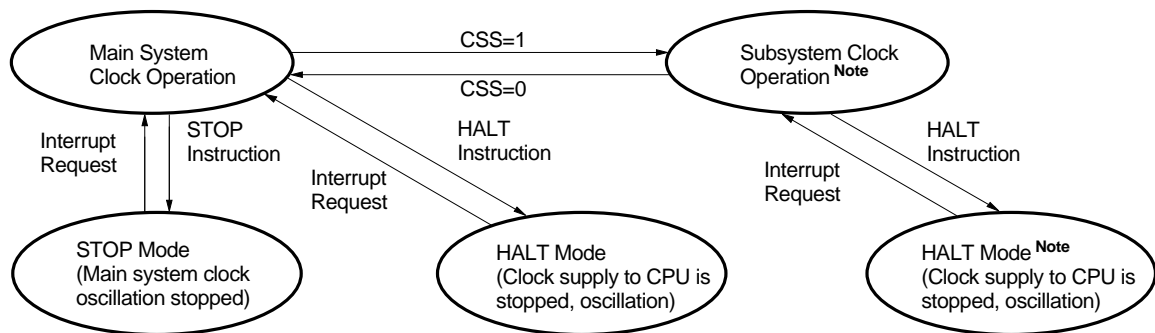
The external device expansion functions connect external devices to areas other than the internal ROM, RAM and SFR. Ports 4 to 6 are used for external device connection.

## 8. STANDBY FUNCTION

There are the following two standby functions to reduce the system power consumption.

- **HALT mode** : The CPU operating clock is stopped.  
The average current consumption can be reduced by intermittent operation in combination with the normal operating mode.
- **STOP mode** : The main system clock oscillation is stopped. The whole operation by the main system clock is stopped, so that the system operates with ultra-low power consumption using only the subsystem clock.

Figure 8-1. Standby Function



**Note** The power consumption can be reduced by stopping the main system clock. When the CPU is operating on the subsystem clock, set the MCC (bit 7 of the processor clock control register (PCC)) to stop the main system clock. The STOP instruction cannot be used.

**Caution** When the main system clock is stopped and the system is operated by the subsystem clock, the subsystem clock should be switched again to the main system clock after the oscillation stabilization time is secured by the program.

**Remark** CSS: Bit 4 of processor clock control register (PCC).

## 9. RESET FUNCTION

There are the following two reset methods.

- External reset input by  $\overline{\text{RESET}}$  pin
- Internal reset by watchdog time runaway time detection

10. INSTRUCTION SET

(1) 8-bit instruction

MOV, XCH, ADD, ADDC, SUB, SUBC, AND, OR, XOR, CMP, MULU, DIVUW, INC, DEC, ROR, ROL, RORC, ROLC, ROR4, ROL4, PUSH, POP, DBNZ

Second Operand First Operand	#byte	A	r <sup>Note</sup>	sfr	saddr	!addr16	PSW	[DE]	[HL]	[HL + Byte] [HL + B] [HL + C]	\$addr16	1	None
A	ADD ADDC SUB SUBC AND OR XOR CMP		MOV XCH ADD ADDC SUB SUBC AND OR XOR CMP	MOV XCH	MOV XCH ADD ADDC SUB SUBC AND OR XOR CMP	MOV XCH ADD ADDC SUB SUBC AND OR XOR CMP	MOV	MOV XCH	MOV XCH ADD ADDC SUB SUBC AND OR XOR CMP	MOV XCH ADD ADDC SUB SUBC AND OR XOR CMP		ROR ROL RORC ROLC	
r	MOV	MOV ADD ADDC SUB SUBC AND OR XOR CMP											INC DEC
B, C											DBNZ		
sfr	MOV	MOV											
saddr	MOV ADD ADDC SUB SUBC AND OR XOR CMP	MOV									DBNZ		INC DEC
!addr16		MOV											
PSW	MOV	MOV											PUSH POP
[DE]													
[HL]		MOV											ROR4 ROL4
[HL + Byte] [HL + B] [HL + C]		MOV											
X													MULU
C													DIVUW

Note Except r = A

**(2) 16-bit instruction**

MOV, XCHW, ADDW, SUBW, CMPW, PUSH, POP, INCW, DECW

Second Operand First Operand	#word	AX	rp <sup>Note</sup>	sfrp	saddrp	!addr16	SP	None
AX	ADDW SUBW CMPW		MOVW XCHW	MOVW	MOVW	MOVW	MOVW	
rp	MOVW	MOVW <sup>Note</sup>						INCW, DECW PUSH, POP
sfrp	MOVW	MOVW						
saddrp	MOVW	MOVW						
!addr16		MOVW						
SP	MOVW	MOVW						

**Note** Only when rp = BC, DE or HL

**(3) Bit manipulation instruction**

MOV1, AND1, OR1, XOR1, SET1, CLR1, NOT1, BT, BF, BTCLR

Second Operand First Operand	A.bit	sfr.bit	saddr.bit	PSW.bit	[HL].bit	CY	\$addr16	None
A.bit						MOV1	BT BF BTCLR	SET1 CLR1
sfr.bit						MOV1	BT BF BTCLR	SET1 CLR1
saddr.bit						MOV1	BT BF BTCLR	SET1 CLR1
PSW.bit						MOV1	BT BF BTCLR	SET1 CLR1
[HL].bit						MOV1	BT BF BTCLR	SET1 CLR1
CY	MOV1 AND1 OR1 XOR1	MOV1 AND1 OR1 XOR1	MOV1 AND1 OR1 XOR1	MOV1 AND1 OR1 XOR1	MOV1 AND1 OR1 XOR1			SET1 CLR1 NOT1

**(4) Call instruction/branch instruction**

CALL, CALLF, CALLT, BR, BC, BNC, BZ, BNZ, BT, BF, BTCLR, DBNZ

Second Operand First Operand	AX	!addr16	!addr11	[addr5]	\$addr16
Basic instruction	BR	CALL BR	CALLF	CALLT	BR, BC, BNC BZ, BNZ
Compound instruction					BT, BF BTCLR DBNZ

**(5) Other instructions**

ADJBA, ADJBS, BRK, RET, RETI, RETB, SEL, NOP, EI, DI, HALT, STOP

★ 11. ELECTRICAL SPECIFICATIONS

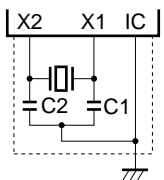
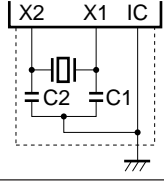
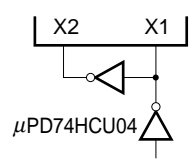
Absolute Maximum Ratings (T<sub>A</sub> = 25 °C)

Parameter	Symbol	Test Conditions		Rating	Unit
Supply voltage	V <sub>DD</sub>			-0.3 to +7.0	V
	AV <sub>DD</sub>			-0.3 to V <sub>DD</sub> + 0.3	V
	AV <sub>REF0</sub>			-0.3 to V <sub>DD</sub> + 0.3	V
	AV <sub>REF1</sub>			-0.3 to V <sub>DD</sub> + 0.3	V
	AV <sub>SS</sub>			-0.3 to +0.3	V
Input voltage	V <sub>I1</sub>	P00-P05, P07, P10-P17, P20-P27, P30-P37, P40-P47, P50-P57, P64-P67, P70-P72, P120-P127, P130, P131, X1, X2, XT2, RESET		-0.3 to V <sub>DD</sub> + 0.3	V
	V <sub>I2</sub>	P60-P63	N-ch Open-drain	-0.3 to +16	V
Output voltage	V <sub>O</sub>			-0.3 to V <sub>DD</sub> + 0.3	V
Analog input voltage	V <sub>AN</sub>	P10-P17	Analog input pin	AV <sub>SS</sub> - 0.3 to AV <sub>REF0</sub> + 0.3	V
Output current, high	I <sub>OH</sub>	1 pin		-10	mA
		P01-P05, P30-P37, P56, P57, P60-P67, P120-P127 total		-15	mA
		P10-P17, P20-P27, P40-P47, P50-P55, P70-P72, P130, P131 total		-15	mA
Output current, low	I <sub>OL</sub> <sup>Note</sup>	1 pin	Peak value	30	mA
			rms value	15	mA
		P50-P55 total	Peak value	100	mA
			rms value	70	mA
		P56, P57, P60-P63 total	Peak value	100	mA
			rms value	70	mA
		P10-P17, P20-P27, P40-P47, P70-P72, P130, P131 total	Peak value	50	mA
			rms value	20	mA
		P01-P05, P30-P37, P64-P67, P120-P127 total	Peak value	50	mA
			rms value	20	mA
Operating ambient temperature	T <sub>A</sub>			-40 to +85	°C
Storage temperature	T <sub>stg</sub>			-65 to +150	°C

**Note** rms value should be calculated as follows: [rms value] = [Peak value] × √duty

**Caution** Product quality may suffer if the absolute maximum rating is exceeded for even a single parameter or even momentarily. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions which ensure that the absolute maximum ratings are not exceeded.

Main System Clock Oscillation Circuit Characteristics (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillator frequency (f <sub>x</sub> ) <sup>Note 1</sup>	V <sub>DD</sub> = Oscillator voltage range	1.0		5.0	MHz
		Oscillation stabilization time <sup>Note 2</sup>	After V <sub>DD</sub> reaches oscillator voltage range MIN.			4	ms
Crystal resonator		Oscillator frequency (f <sub>x</sub> ) <sup>Note 1</sup>		1.0		5.0	MHz
		Oscillation stabilization time <sup>Note 2</sup>	V <sub>DD</sub> = 4.5 to 5.5 V			10	ms
						30	
External clock		X1 input frequency (f <sub>x</sub> ) <sup>Note 1</sup>		1.0		5.0	MHz
		X1 input high/low level width (t <sub>xH</sub> , t <sub>xL</sub> )		85		500	ns

- Notes**
1. Indicates only oscillation circuit characteristics. Refer to **AC Characteristics** for instruction execution time.
  2. Time required to stabilize oscillation after reset or STOP mode release.

**Cautions** 1. When using the main system clock oscillator, wiring in the area enclosed with the broken line should be carried out as follows to avoid an adverse effect from wiring capacitance.

- Wiring should be as short as possible.
- Wiring should not cross other signal lines.
- Wiring should not be placed close to a varying high current.
- The potential of the oscillator capacitor ground should be the same as V<sub>SS1</sub>.
- Do not ground wiring to a ground pattern in which a high current flows.
- Do not fetch a signal from the oscillator.

2. When the main system clock is stopped and the system is operated by the subsystem clock, the subsystem clock should be switched again to the main system clock after the oscillation stabilization time is secured in software.

Subsystem Clock Oscillation Circuit Characteristics (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Crystal resonator		Oscillator frequency (f <sub>XT</sub> ) <b>Note 1</b>		32	32.768	35	kHz
		Oscillation stabilization time <b>Note 2</b>	V <sub>DD</sub> = 4.5 to 5.5 V		1.2	2	s
External clock		XT1 input frequency (f <sub>XT</sub> ) <b>Note 1</b>		32		100	kHz
		XT1 input high/low level width (t <sub>XTH</sub> , t <sub>XTL</sub> )		5		15	μs

- Notes**
1. Indicates only oscillation circuit characteristics. Refer to **AC Characteristics** for instruction execution time.
  2. Time required to stabilize oscillation after V<sub>DD</sub> reaches oscillator voltage MIN.

**Cautions**

1. When using the subsystem clock oscillator, wiring in the area enclosed with the broken line should be carried out as follows to avoid an adverse effect from wiring capacitance.

- Wiring should be as short as possible.
- Wiring should not cross other signal lines.
- Wiring should not be placed close to a varying high current.
- The potential of the oscillator capacitor ground should be the same as V<sub>SS1</sub>.
- Do not ground wiring to a ground pattern in which a high current flows.
- Do not fetch a signal from the oscillator.

2. The subsystem clock oscillation circuit is a circuit with a low amplification level, more prone to misoperation due to noise than the main system clock. Therefore, when using the subsystem clock, take care with the wiring.

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

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit	
Input capacitance	C <sub>IN</sub>	f = 1 MHz Measured pins returned to 0 V.			15	pF	
Input/output capacitance	C <sub>IO</sub>	f = 1 MHz Measured pins returned to 0 V.	P01-P05, P10-P17, P20-P27, P30-P37, P40-P47, P50-P57, P64-P67, P70-P72, P120-P127, P130, P131			15	pF
			P60-P63			20	pF

**Remark** The characteristics of the dual-function pins are the same as those of the port pins unless otherwise specified.

DC Characteristics (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit	
Input voltage, high	V <sub>IH1</sub>	P10-P17, P21, P23, P30-P32, P35-P37, P40-P47, P50-P57, P64-P67, P71, P120-P127, P130, P131	V <sub>DD</sub> = 2.7 to 5.5 V	0.7 V <sub>DD</sub>		V <sub>DD</sub>	V
				0.8 V <sub>DD</sub>		V <sub>DD</sub>	V
	V <sub>IH2</sub>	P00-P05, P20, P22, P24-P27, P33, P34, P70, P72, $\overline{\text{RESET}}$	V <sub>DD</sub> = 2.7 to 5.5 V	0.8 V <sub>DD</sub>		V <sub>DD</sub>	V
				0.85 V <sub>DD</sub>		V <sub>DD</sub>	V
	V <sub>IH3</sub>	P60-P63 (N-ch open-drain)	V <sub>DD</sub> = 2.7 to 5.5 V	0.7 V <sub>DD</sub>		15	V
				0.8 V <sub>DD</sub>		15	V
	V <sub>IH4</sub>	X1, X2	V <sub>DD</sub> = 2.7 to 5.5 V	V <sub>DD</sub> -0.5		V <sub>DD</sub>	V
				V <sub>DD</sub> -0.2		V <sub>DD</sub>	V
	V <sub>IH5</sub>	XT1/P07, XT2	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.8 V <sub>DD</sub>		V <sub>DD</sub>	V
			2.7 V ≤ V <sub>DD</sub> < 4.5 V	0.9 V <sub>DD</sub>		V <sub>DD</sub>	V
<b>Note</b>			0.9 V <sub>DD</sub>		V <sub>DD</sub>	V	
Input voltage, low	V <sub>IL1</sub>	P10-P17, P21, P23, P30-P32, P35-P37, P40-P47, P50-P57, P64-P67, P71, P120-P127, P130, P131	V <sub>DD</sub> = 2.7 to 5.5 V	0		0.3 V <sub>DD</sub>	V
				0		0.2 V <sub>DD</sub>	V
	V <sub>IL2</sub>	P00-P05, P20, P22, P24-P27, P33, P34, P70, P72, $\overline{\text{RESET}}$	V <sub>DD</sub> = 2.7 to 5.5 V	0		0.2 V <sub>DD</sub>	V
				0		0.15 V <sub>DD</sub>	V
	V <sub>IL3</sub>	P60-P63	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0		0.3 V <sub>DD</sub>	V
			2.7 V ≤ V <sub>DD</sub> < 4.5 V	0		0.2 V <sub>DD</sub>	V
				0		0.1 V <sub>DD</sub>	V
	V <sub>IL4</sub>	X1, X2	V <sub>DD</sub> = 2.7 to 5.5 V	0		0.4	V
				0		0.2	V
	V <sub>IL5</sub>	XT1/P07, XT2	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0		0.2 V <sub>DD</sub>	V
2.7 V ≤ V <sub>DD</sub> < 4.5 V			0		0.1 V <sub>DD</sub>	V	
<b>Note</b>			0		0.1 V <sub>DD</sub>	V	
Output voltage, high	V <sub>OH</sub>	V <sub>DD</sub> = 4.5 to 5.5 V, I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -1.0			V	
		I <sub>OH</sub> = -100 μA	V <sub>DD</sub> -0.5			V	
Output voltage, low	V <sub>OL1</sub>	P50-P57, P60-P63	V <sub>DD</sub> = 4.5 to 5.5 V, I <sub>OL</sub> = 15 mA		0.4	2.0	V
		P01-P05, P10-P17, P20-P27, P30-P37, P40-P47, P64-P67, P70-P72, P120-P127, P130, P131	V <sub>DD</sub> = 4.5 to 5.5 V, I <sub>OL</sub> = 1.6 mA			0.4	V
	V <sub>OL2</sub>	SB0, SB1, $\overline{\text{SCK0}}$	V <sub>DD</sub> = 4.5 to 5.5 V, open-drain, pulled-up (R = 1 kΩ)			0.2 V <sub>DD</sub>	V
	V <sub>OL3</sub>	I <sub>OL</sub> = 400 μA				0.5	V

**Note** For use as P07, use an inverter to input the reverse phase of P07 to the XT2 pin.

**Remark** The characteristics of a dual-function pin and a port pin are the same unless specified otherwise.

DC Characteristics ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 1.8$  to  $5.5$  V)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input leakage current, high	$I_{LH1}$	$V_{IN} = V_{DD}$	P00-P05, P10-P17, P20-P27, P30-P37, P40-P47, P50-P57, P60-P67, P70-P72, P120-P127, P130, P131, RESET			3	$\mu$ A
	$I_{LH2}$		X1, X2, XT1/P07, XT2			20	$\mu$ A
	$I_{LH3}$	$V_{IN} = 15$ V	P60-P63			80	$\mu$ A
Input leakage current, low	$I_{LIL1}$	$V_{IN} = 0$ V	P00-P05, P10-P17, P20-P27, P30-P37, P40-P47, P50-P57, P64-P67, P70-P72, P120-P127, P130, P131, $\overline{\text{RESET}}$			-3	$\mu$ A
	$I_{LIL2}$		X1, X2, XT1/P07, XT2			-20	$\mu$ A
	$I_{LIL3}$		P60-P63			-3 <sup>Note</sup>	$\mu$ A
Output leakage current, high	$I_{LOH}$	$V_{OUT} = V_{DD}$				3	$\mu$ A
Output leakage current, low	$I_{LOL}$	$V_{OUT} = 0$ V				-3	$\mu$ A
Mask option pull-up resistor	$R_1$	$V_{IN} = 0$ V, P60-P63		20	40	120	k $\Omega$
Software pull-up resistor	$R_2$	$V_{IN} = 0$ V, P01-P05, P10-P17, P20-P27, P30-P37, P40-P47, P50-P57, P64-P67, P70-P72, P120-P127, P130, P131		15	30	90	k $\Omega$

**Note** For P60 to P63 without on-chip pull-up resistor (specifiable by mask option), a low-level input leakage current of  $-200$   $\mu$ A (MAX.) flows only during the 1.5 clocks (no wait) after an instruction has been executed to read out port 6 (P6) or port mode register 6 (PM6). Outside the period of 1.5 clocks following executing a read-out instruction, the current is  $-3$   $\mu$ A (MAX.).

**Remark** The characteristics of a dual-function pin and a port pin are the same unless specified otherwise.



DC Characteristics (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit	
Power supply current <b>Note 5</b>	I <sub>DD1</sub>	5.0 MHz Crystal oscillation operating mode (f <sub>xx</sub> = 2.5 MHz) <b>Note 3</b>	V <sub>DD</sub> = 5.0 V ±10 % <b>Note 1</b>		4	12	mA
			V <sub>DD</sub> = 3.0 V ±10 % <b>Note 2</b>		0.6	1.8	mA
			V <sub>DD</sub> = 2.0 V ±10 % <b>Note 2</b>		0.35	1.05	mA
		5.0 MHz Crystal oscillation operating mode (f <sub>xx</sub> = 5.0 MHz) <b>Note 4</b>	V <sub>DD</sub> = 5.0 V ±10 % <b>Note 1</b>		6.5	19.5	mA
			V <sub>DD</sub> = 3.0 V ±10 % <b>Note 2</b>		0.8	2.4	mA
	I <sub>DD2</sub>	5.0 MHz Crystal oscillation HALT mode (f <sub>xx</sub> = 2.5 MHz) <b>Note 3</b>	V <sub>DD</sub> = 5.0 V ±10 %		1.4	4.2	mA
			V <sub>DD</sub> = 3.0 V ±10 %		0.5	1.5	mA
			V <sub>DD</sub> = 2.0 V ±10 %		280	840	μA
		5.0 MHz Crystal oscillation HALT mode (f <sub>xx</sub> = 5.0 MHz) <b>Note 4</b>	V <sub>DD</sub> = 5.0 V ±10 %		1.6	4.8	mA
			V <sub>DD</sub> = 3.0 V ±10 %		0.65	1.95	mA
	I <sub>DD3</sub>	32.768 kHz Crystal oscillation operating mode <b>Note 6</b>	V <sub>DD</sub> = 5.0 V ±10 %		60	120	μA
			V <sub>DD</sub> = 3.0 V ±10 %		32	64	μA
			V <sub>DD</sub> = 2.0 V ±10 %		24	48	μA
	I <sub>DD4</sub>	32.768 kHz Crystal oscillation HALT mode <b>Note 6</b>	V <sub>DD</sub> = 5.0 V ±10 %		25	55	μA
			V <sub>DD</sub> = 3.0 V ±10 %		5	15	μA
			V <sub>DD</sub> = 2.0 V ±10 %		2.5	12.5	μA
I <sub>DD5</sub>	XT1 = V <sub>DD</sub> STOP mode When feedback resistor is used	V <sub>DD</sub> = 5.0 V ±10 %		1	30	μA	
		V <sub>DD</sub> = 3.0 V ±10 %		0.5	10	μA	
		V <sub>DD</sub> = 2.0 V ±10 %		0.3	10	μA	
I <sub>DD6</sub>	XT1 = V <sub>DD</sub> STOP mode When feedback resistor is unused	V <sub>DD</sub> = 5.0 V ±10 %		0.1	30	μA	
		V <sub>DD</sub> = 3.0 V ±10 %		0.05	10	μA	
		V <sub>DD</sub> = 2.0 V ±10 %		0.05	10	μA	

- Notes**
1. Operating in high-speed mode (when set the processor clock control register (PCC) to 00H).
  2. Operating in low-speed mode (when set the PCC to 04H).
  3. Operation with f<sub>xx</sub> = f<sub>x</sub>/2 (when oscillation mode selection register (OSMS) is set to 00H)
  4. Operation with f<sub>xx</sub> = f<sub>x</sub> (when OSMS is set to 01H)
  5. This current flows in the V<sub>DD</sub> and AV<sub>DD</sub> pins. However, a current flowing in the A/D converter, D/A converter, and on-chip pull-up resistor are not included.
  6. When the main system clock is halted

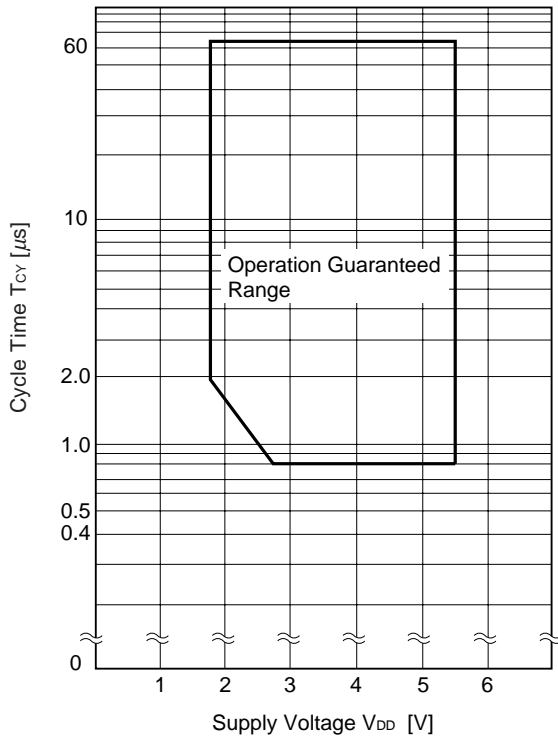
AC Characteristics

(1) Basic operation (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

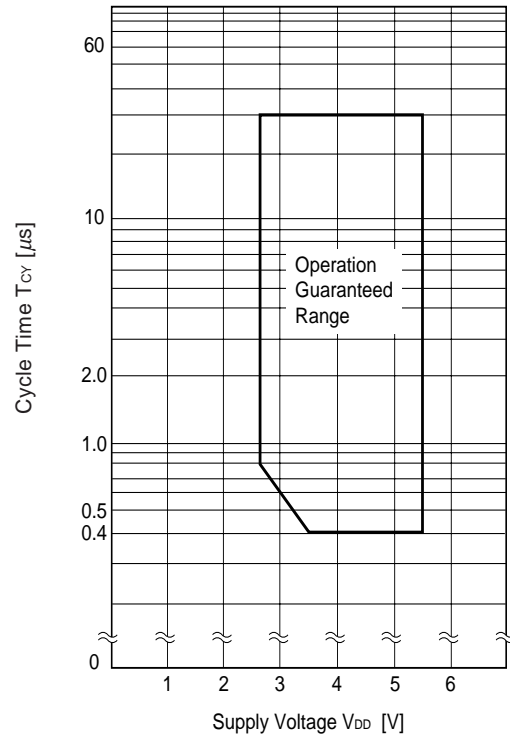
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit	
Cycle time (Min. instruction execution time)	T <sub>cy</sub>	Operating on main system clock (f <sub>xx</sub> = 2.5 MHz) <sup>Note 1</sup>	V <sub>DD</sub> = 2.7 to 5.5 V	0.8		64	μs
				2.0		64	μs
		Operating on main system clock (f <sub>xx</sub> = 5.0 MHz) <sup>Note 2</sup>	V <sub>DD</sub> = 3.5 to 5.5 V	0.4		32	μs
			V <sub>DD</sub> = 2.7 to 3.5 V	0.8		32	μs
		Operating on subsystem clock	40 <sup>Note 3</sup>	122	125	μs	
TI00 input high/ low-level width	t <sub>TIH00</sub> t <sub>TIL00</sub>	3.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	2/f <sub>sam</sub> +0.1 <sup>Note 4</sup>			μs	
		2.7 V ≤ V <sub>DD</sub> < 3.5 V	2/f <sub>sam</sub> +0.2 <sup>Note 4</sup>			μs	
			2/f <sub>sam</sub> +0.5 <sup>Note 4</sup>			μs	
TI01 input high/ low-level width	t <sub>TIH01</sub> t <sub>TIL01</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	10			μs	
			20			μs	
TI1, TI2, TI5, TI6 input frequency	f <sub>TI1</sub>	V <sub>DD</sub> = 4.5 to 5.5 V	0		4	MHz	
			0		275	kHz	
TI1, TI2, TI5, TI6 input high/ low-level width	t <sub>TIH1</sub> t <sub>TIL1</sub>	V <sub>DD</sub> = 4.5 to 5.5 V	100			ns	
			1.8			μs	
Interrupt request input high/ low-level width	t <sub>INTH</sub> t <sub>INTL</sub>	INTP0	3.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	2/f <sub>sam</sub> +0.1 <sup>Note 4</sup>		μs	
			2.7 V ≤ V <sub>DD</sub> < 3.5 V	2/f <sub>sam</sub> +0.2 <sup>Note 4</sup>		μs	
				2/f <sub>sam</sub> +0.5 <sup>Note 4</sup>		μs	
		INTP1-INTP5, P40-P47	V <sub>DD</sub> = 2.7 to 5.5 V	10		μs	
			20		μs		
RESET low level width	t <sub>RSL</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	10			μs	
			20			μs	

- Notes**
1. Operation with f<sub>xx</sub> = f<sub>x</sub>/2 (when oscillation mode selection register (OSMS) is set to 00H)
  2. Operation with f<sub>xx</sub> = f<sub>x</sub> (when OSMS is set to 01H)
  3. Value when external clock is used. When a crystal resonator is used, it is 114 μs (MIN.)
  4. In combination with bits 0 (SCS0) and 1 (SCS1) of sampling clock select register (SCS), selection of f<sub>sam</sub> is possible between f<sub>xx</sub>/2<sup>N</sup>, f<sub>xx</sub>/32, f<sub>xx</sub>/64 and f<sub>xx</sub>/128 (when N= 0 to 4).

★  $T_{CY}$  vs  $V_{DD}$  (At  $f_{XX} = f_X/2$  main system clock operation)



$T_{CY}$  vs  $V_{DD}$  (At  $f_{XX} = f_X$  main system clock operation)



(2) Read/write operation

(a) When MCS = 1, PCC2 to PCC0 = 000B (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 4.5 to 5.5 V)

Parameter	Symbol	Test Conditions	MIN.	MAX.	Unit
ASTB high-level width	t <sub>ASTH</sub>		0.85t <sub>cy</sub> - 50		ns
Address setup time	t <sub>ADS</sub>		0.85t <sub>cy</sub> - 50		ns
Address hold time	t <sub>ADH</sub>		50		ns
Data input time from address	t <sub>ADD1</sub>			(2.85 + 2n)t <sub>cy</sub> - 80	ns
	t <sub>ADD2</sub>			(4 + 2n)t <sub>cy</sub> - 100	ns
Data input time from $\overline{RD}\downarrow$	t <sub>RDD1</sub>			(2 + 2n)t <sub>cy</sub> - 100	ns
	t <sub>RDD2</sub>			(2.85 + 2n)t <sub>cy</sub> - 100	ns
Read data hold time	t <sub>RDH</sub>		0		ns
$\overline{RD}$ low-level width	t <sub>RDL1</sub>		(2 + 2n)t <sub>cy</sub> - 60		ns
	t <sub>RDL2</sub>		(2.85 + 2n)t <sub>cy</sub> - 60		ns
$\overline{WAIT}\downarrow$ input time from $\overline{RD}\downarrow$	t <sub>RDWT1</sub>			0.85t <sub>cy</sub> - 50	ns
	t <sub>RDWT2</sub>			2t <sub>cy</sub> - 60	ns
$\overline{WAIT}\downarrow$ input time from $\overline{WR}\downarrow$	t <sub>WRWT</sub>			2t <sub>cy</sub> - 60	ns
$\overline{WAIT}$ low-level width	t <sub>WTL</sub>		(1.15 + 2n)t <sub>cy</sub>	(2 + 2n)t <sub>cy</sub>	ns
Write data setup time	t <sub>WDS</sub>		(2.85 + 2n)t <sub>cy</sub> - 100		ns
Write data hold time	t <sub>WDH</sub>		20		ns
$\overline{WR}$ low-level width	t <sub>WRL</sub>		(2.85 + 2n)t <sub>cy</sub> - 60		ns
$\overline{RD}\downarrow$ delay time from ASTB $\downarrow$	t <sub>ASTRD</sub>		25		ns
$\overline{WR}\downarrow$ delay time from ASTB $\downarrow$	t <sub>ASTWR</sub>		0.85t <sub>cy</sub> + 20		ns
ASTB $\uparrow$ delay time from $\overline{RD}\uparrow$ in external fetch	t <sub>RDAST</sub>		0.85t <sub>cy</sub> - 10	1.15t <sub>cy</sub> + 20	ns
Address hold time from $\overline{RD}\uparrow$ in external fetch	t <sub>RDADH</sub>		0.85t <sub>cy</sub> - 50	1.15t <sub>cy</sub> + 50	ns
Write data output time from $\overline{RD}\uparrow$	t <sub>RDWD</sub>		40		ns
Write data output time from $\overline{WR}\downarrow$	t <sub>WRWD</sub>		0	50	ns
Address hold time from $\overline{WR}\uparrow$	t <sub>WRADH</sub>		0.85t <sub>cy</sub>	1.15t <sub>cy</sub> + 40	ns
$\overline{RD}\uparrow$ delay time from $\overline{WAIT}\uparrow$	t <sub>WTRD</sub>		1.15t <sub>cy</sub> + 40	3.15t <sub>cy</sub> + 40	ns
$\overline{WR}\uparrow$ delay time from $\overline{WAIT}\uparrow$	t <sub>WTWR</sub>		1.15t <sub>cy</sub> + 30	3.15t <sub>cy</sub> + 30	ns

- Remarks**
1. MCS: Oscillation mode selection register (OSMS) bit 0
  2. PCC2 to PCC0: Processor clock control register (PCC) bit 2 to bit 0
  3. t<sub>cy</sub> = T<sub>cy</sub>/4
  4. n indicates number of waits.

(b) When except MCS = 1, PCC2 to PCC0 = 000B (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 2.0 to 5.5 V)

Parameter	Symbol	Test Conditions	MIN.	MAX.	Unit
ASTB high-level width	t <sub>ASTH</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	t <sub>CY</sub> - 80		ns
			t <sub>CY</sub> - 150		ns
Address setup time	t <sub>ADS</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	t <sub>CY</sub> - 80		ns
			t <sub>CY</sub> - 150		ns
Address hold time	t <sub>ADH</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0.4t <sub>CY</sub> - 10		ns
			0.37t <sub>CY</sub> - 40		ns
Data input time from address	t <sub>ADD1</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		(3 + 2n)t <sub>CY</sub> - 160	ns
				(3 + 2n)t <sub>CY</sub> - 320	ns
	t <sub>ADD2</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		(4 + 2n)t <sub>CY</sub> - 200	ns
				(4 + 2n)t <sub>CY</sub> - 300	ns
Data input time from $\overline{RD}\downarrow$	t <sub>RDD1</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		(1.4 + 2n)t <sub>CY</sub> - 70	ns
				(1.37 + 2n)t <sub>CY</sub> - 120	ns
	t <sub>RDD2</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		(2.4 + 2n)t <sub>CY</sub> - 70	ns
				(2.37 + 2n)t <sub>CY</sub> - 120	ns
Read data hold time	t <sub>RDH</sub>		0		ns
$\overline{RD}$ low-level width	t <sub>RDL1</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	(1.4 + 2n)t <sub>CY</sub> - 20		ns
			(1.37 + 2n)t <sub>CY</sub> - 20		ns
	t <sub>RDL2</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	(2.4 + 2n)t <sub>CY</sub> - 20		ns
			(2.37 + 2n)t <sub>CY</sub> - 20		ns
$\overline{WAIT}\downarrow$ input time from $\overline{RD}\downarrow$	t <sub>RDWT1</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		t <sub>CY</sub> - 100	ns
				t <sub>CY</sub> - 200	ns
	t <sub>RDWT2</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		2t <sub>CY</sub> - 100	ns
				2t <sub>CY</sub> - 200	ns
$\overline{WAIT}\downarrow$ input time from $\overline{WR}\downarrow$	t <sub>WRWT</sub>	V <sub>DD</sub> = 2.7 to 5.5 V		2t <sub>CY</sub> - 100	ns
				2t <sub>CY</sub> - 200	ns
$\overline{WAIT}$ low-level width	t <sub>WTL</sub>		(1 + 2n)t <sub>CY</sub>	(2 + 2n)t <sub>CY</sub>	ns
Write data setup time	t <sub>WDS</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	(2.4 + 2n)t <sub>CY</sub> - 60		ns
			(2.37 + 2n)t <sub>CY</sub> - 100		ns
Write data hold time	t <sub>WDH</sub>		20		ns
$\overline{WR}$ low-level width	t <sub>WRL</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	(2.4 + 2n)t <sub>CY</sub> - 20		ns
			(2.37 + 2n)t <sub>CY</sub> - 20		ns
$\overline{RD}\downarrow$ delay time from ASTB $\downarrow$	t <sub>ASTRD</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0.4t <sub>CY</sub> - 30		ns
			0.37t <sub>CY</sub> - 50		ns
$\overline{WR}\downarrow$ delay time from ASTB $\downarrow$	t <sub>ASTWR</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	1.4t <sub>CY</sub> - 30		ns
			1.37t <sub>CY</sub> - 50		ns

- Remarks**
1. MCS: Oscillation mode selection register (OSMS) bit 0
  2. PCC2 to PCC0: Processor clock control register (PCC) bit 2 to bit 0
  3. t<sub>CY</sub> = T<sub>CY</sub>/4
  4. n indicates number of waits.

(b) When except MCS = 1, PCC2 to PCC0 = 000B (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 2.0 to 5.5 V)

Parameter	Symbol	Test Conditions	MIN.	MAX.	Unit
ASTB↑ delay time from RD↑ in external fetch	t <sub>RDAST</sub>		t <sub>cy</sub> - 10	t <sub>cy</sub> + 20	ns
Address hold time from RD↑ in external fetch	t <sub>RDADH</sub>		t <sub>cy</sub> - 50	t <sub>cy</sub> + 50	ns
Write data output time from RD↑	t <sub>RDWD</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0.4t <sub>cy</sub> - 20		ns
			0.37t <sub>cy</sub> - 40		ns
Write data output time from WR↓	t <sub>WRWD</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0	60	ns
			0	120	ns
Address hold time from WR↑	t <sub>WRADH</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	t <sub>cy</sub>	t <sub>cy</sub> + 60	ns
			t <sub>cy</sub>	t <sub>cy</sub> + 120	ns
RD↑ delay time from WAIT↑	t <sub>WTRD</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0.6t <sub>cy</sub> + 180	2.6t <sub>cy</sub> + 180	ns
			0.63t <sub>cy</sub> + 350	2.63t <sub>cy</sub> + 350	ns
WR↑ delay time from WAIT↑	t <sub>WTWR</sub>	V <sub>DD</sub> = 2.7 to 5.5 V	0.6t <sub>cy</sub> + 120	2.6t <sub>cy</sub> + 120	ns
			0.63t <sub>cy</sub> + 240	2.63t <sub>cy</sub> + 240	ns

- Remarks**
1. MCS: Oscillation mode selection register (OSMS) bit 0
  2. PCC2 to PCC0: Processor clock control register (PCC) bit 2 to bit 0
  3. t<sub>cy</sub> = T<sub>cy</sub>/4
  4. n indicates number of waits.

(3) Serial interface (T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 1.8 to 5.5 V)

(a) Serial interface channel 0

(i) 3-wire serial I/O mode ( $\overline{\text{SCK0}}$ ... Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK0}}$ cycle time	t <sub>KCY1</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	800			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	1600			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	3200			ns
			4800			ns
$\overline{\text{SCK0}}$ high/low-level width	t <sub>KH1</sub> , t <sub>KL1</sub>	V <sub>DD</sub> = 4.5 to 5.5 V	t <sub>KCY1</sub> /2 - 50			ns
			t <sub>KCY1</sub> /2 - 100			ns
SIO setup time (to $\overline{\text{SCK0}}$ ↑)	t <sub>SIK1</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	100			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	150			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	300			ns
			400			ns
SIO hold time (from $\overline{\text{SCK0}}$ ↑)	t <sub>KSI1</sub>		400			ns
SO0 output delay time from $\overline{\text{SCK0}}$ ↓	t <sub>KSO1</sub>	C = 100 pF <b>Note</b>			300	ns

**Note** C is the load capacitance of SO0 output line.

(ii) 3-wire serial I/O mode ( $\overline{\text{SCK0}}$ ... External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK0}}$ cycle time	t <sub>KCY2</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	800			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	1600			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	3200			ns
			4800			ns
$\overline{\text{SCK0}}$ high/low-level width	t <sub>KH2</sub> , t <sub>KL2</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	400			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	800			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	1600			ns
			2400			ns
SIO setup time (to $\overline{\text{SCK0}}$ ↑)	t <sub>SIK2</sub>	2.0 V ≤ V <sub>DD</sub> ≤ 5.5 V	100			ns
			150			ns
SIO hold time (from $\overline{\text{SCK0}}$ ↑)	t <sub>KSI2</sub>		400			ns
SO0 output delay time from $\overline{\text{SCK0}}$ ↓	t <sub>KSO2</sub>	C = 100 pF <b>Note</b> V <sub>DD</sub> = 2.0 to 5.5V			300	ns
					500	ns
$\overline{\text{SCK0}}$ rise, fall time	t <sub>R2</sub> , t <sub>F2</sub>	When using external device expansion function			160	ns
		When not using external device expansion function			1000	ns

**Note** C is the load capacitance of SO0 output line.

(iii) SBI mode ( $\overline{\text{SCK0}}$ ... Internal clock output)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK0}}$ cycle time	$t_{\text{KCY3}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		800			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		3200			ns
				4800			ns
$\overline{\text{SCK0}}$ high/low-level width	$t_{\text{KH3}}, t_{\text{KL3}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		$t_{\text{KCY3}}/2 - 50$			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		$t_{\text{KCY3}}/2 - 150$			ns
SB0, SB1 setup time (to $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SIK3}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		100			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		300			ns
				400			ns
SB0, SB1 hold time (from $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{KSI3}}$			$t_{\text{KCY3}}/2$			ns
SB0, SB1 output delay time from $\overline{\text{SCK0}}\downarrow$	$t_{\text{KSO3}}$	R = 1 kΩ , C = 100 pF <small>Note</small>	V <sub>DD</sub> = 4.5 to 5.5 V	0		250	ns
				0		1000	ns
SB0, SB1↓ from $\overline{\text{SCK0}}\uparrow$	$t_{\text{KSB}}$			$t_{\text{KCY3}}$			ns
$\overline{\text{SCK0}}\downarrow$ from SB0, SB1↓	$t_{\text{SBK}}$			$t_{\text{KCY3}}$			ns
SB0, SB1 high-level width	$t_{\text{SBH}}$			$t_{\text{KCY3}}$			ns
SB0, SB1 low-level width	$t_{\text{SBL}}$			$t_{\text{KCY3}}$			ns

**Note** R and C are the load resistors and load capacitance of the  $\overline{\text{SCK0}}$ , SB0 and SB1 output line.

(iv) SBI mode ( $\overline{\text{SCK0}}$ ... External clock input)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK0}}$ cycle time	$t_{\text{KCY4}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		800			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		3200			ns
				4800			ns
$\overline{\text{SCK0}}$ high/low-level width	$t_{\text{KH4}}, t_{\text{KL4}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		400			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		1600			ns
				2400			ns
SB0, SB1 setup time (to $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SIK4}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V		100			ns
		2.0 V ≤ V <sub>DD</sub> < 4.5 V		300			ns
				400			ns
SB0, SB1 hold time (from $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{KSI4}}$			$t_{\text{KCY4}}/2$			ns
SB0, SB1 output delay time from $\overline{\text{SCK0}}\downarrow$	$t_{\text{KSO4}}$	R = 1 kΩ , C = 100 pF <small>Note</small>	V <sub>DD</sub> = 4.5 to 5.5 V	0		300	ns
				0		1000	ns
SB0, SB1↓ from $\overline{\text{SCK0}}\uparrow$	$t_{\text{KSB}}$			$t_{\text{KCY4}}$			ns
$\overline{\text{SCK0}}\downarrow$ from SB0, SB1↓	$t_{\text{SBK}}$			$t_{\text{KCY4}}$			ns
SB0, SB1 high-level width	$t_{\text{SBH}}$			$t_{\text{KCY4}}$			ns
SB0, SB1 low-level width	$t_{\text{SBL}}$			$t_{\text{KCY4}}$			ns
$\overline{\text{SCK0}}$ rise, fall time	$t_{\text{R4}}, t_{\text{F4}}$	When using external device expansion function				160	ns
		When not using external device expansion function				1000	ns

**Note** R and C are the load resistors and load capacitance of the SB0 and SB1 output line.



(v) 2-wire serial I/O mode ( $\overline{\text{SCK0}}$ ... Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit	
$\overline{\text{SCK0}}$ cycle time	$t_{\text{KCY5}}$	R = 1 kΩ, C = 100 pF <b>Note</b>	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	1600			ns
				3200			ns
				4800			ns
$\overline{\text{SCK0}}$ high-level width	$t_{\text{KH5}}$	V <sub>DD</sub> = 2.7 to 5.5 V	$t_{\text{KCY5}}/2 - 160$			ns	
			$t_{\text{KCY5}}/2 - 190$			ns	
$\overline{\text{SCK0}}$ low-level width	$t_{\text{KL5}}$	V <sub>DD</sub> = 4.5 to 5.5 V	$t_{\text{KCY5}}/2 - 50$			ns	
			$t_{\text{KCY5}}/2 - 100$			ns	
SB0, SB1 setup time (to $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SIK5}}$	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	300			ns	
			2.7 V ≤ V <sub>DD</sub> < 4.5 V	350		ns	
			2.0 V ≤ V <sub>DD</sub> < 2.7 V	400		ns	
				500		ns	
SB0, SB1 hold time (from $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SI5}}$		600			ns	
						ns	
SB0, SB1 output delay time from $\overline{\text{SCK0}}\downarrow$	$t_{\text{KS05}}$		0		300	ns	

**Note** R and C are the load resistors and load capacitance of the  $\overline{\text{SCK0}}$ , SB0 and SB1 output line.

(vi) 2-wire serial I/O mode ( $\overline{\text{SCK0}}$ ... Internal clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK0}}$ cycle time	$t_{\text{KCY6}}$	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	1600			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	3200			ns
			4800			ns
$\overline{\text{SCK0}}$ high-level width	$t_{\text{KH6}}$	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	650			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	1300			ns
			2100			ns
$\overline{\text{SCK0}}$ low-level width	$t_{\text{KL6}}$	2.7 V ≤ V <sub>DD</sub> ≤ 5.5 V	800			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	1600			ns
			2400			ns
SB0, SB1 setup time (to $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SIK6}}$	V <sub>DD</sub> = 2.0 to 5.5 V	100			ns
			150			ns
SB0, SB1 hold time (from $\overline{\text{SCK0}}\uparrow$ )	$t_{\text{SI6}}$		$t_{\text{KCY6}}/2$			ns
SB0, SB1 output delay time from $\overline{\text{SCK0}}\downarrow$	$t_{\text{KS06}}$	R = 1 kΩ, C = 100 pF <b>Note</b>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0	300	ns
			2.0 V ≤ V <sub>DD</sub> < 4.5 V	0	500	ns
				0	800	ns
$\overline{\text{SCK0}}$ rise, fall time	$t_{\text{R6}}, t_{\text{F6}}$	When using external device expansion function			160	ns
		When not using external device expansion function			1000	ns

**Note** R and C are the load resistors and load capacitance of the SB0 and SB1 output line.

(b) Serial interface channel 1

(i) 3-wire serial I/O mode (SCK1...Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
SCK1 cycle time	t <sub>KCY7</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	800			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	1600			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	3200			ns
			4800			ns
SCK1 high/low-level width	t <sub>KH7</sub> , t <sub>KL7</sub>	V <sub>DD</sub> = 4.5 to 5.5 V	t <sub>KCY7</sub> /2-50			ns
			t <sub>KCY7</sub> /2-100			ns
SI1 setup time (to SCK1↑)	t <sub>SIK7</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	100			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	150			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	300			ns
			400			ns
SI1 hold time (from SCK1↑)	t <sub>KSI7</sub>		400			ns
SO1 output delay time from SCK1↓	t <sub>KSO7</sub>	C = 100 pF <b>Note</b>			300	ns

**Note** C is the load capacitance of the SO1 output line.

(ii) 3-wire serial I/O mode (SCK1...External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
SCK1 cycle time	t <sub>KCY8</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	800			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	1600			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	3200			ns
			4800			ns
SCK1 high/low-level width	t <sub>KH8</sub> , t <sub>KL8</sub>	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	400			ns
		2.7 V ≤ V <sub>DD</sub> < 4.5 V	800			ns
		2.0 V ≤ V <sub>DD</sub> < 2.7 V	1600			ns
			2400			ns
SI1 setup time (to SCK1↑)	t <sub>SIK8</sub>	V <sub>DD</sub> = 2.0 to 5.5 V	100			ns
			150			ns
SI1 hold time (from SCK1↑)	t <sub>KIS8</sub>		400			ns
SO1 output delay time from SCK1↓	t <sub>KSO8</sub>	C = 100 pF <b>Note</b> V <sub>DD</sub> = 2.0 to 5.5 V			300	ns
					500	ns
SCK1 rise, fall time	t <sub>r8</sub> , t <sub>f8</sub>	When using external device expansion function			160	ns
		When not using external device expansion function			1000	ns

**Note** C is the load capacitance of the SO1 output line.

(iii) 3-wire serial I/O mode with automatic transmit/receive function ( $\overline{\text{SCK1}}$ ...Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK1}}$ cycle time	$t_{\text{KCY9}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	800			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	1600			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	3200			ns
			4800			ns
$\overline{\text{SCK1}}$ high/low-level width	$t_{\text{KH9}}, t_{\text{KL9}}$	$V_{\text{DD}} = 4.5 \text{ to } 5.5 \text{ V}$	$t_{\text{KCY9}}/2-50$			ns
			$t_{\text{KCY9}}/2-100$			ns
SI1 setup time (to $\overline{\text{SCK1}}\uparrow$ )	$t_{\text{SIK9}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	100			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	150			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	300			ns
			400			ns
SI1 hold time (from $\overline{\text{SCK1}}\uparrow$ )	$t_{\text{KSI9}}$		400			ns
SO1 output delay time from $\overline{\text{SCK1}}\downarrow$	$t_{\text{KSO9}}$	$C = 100 \text{ pF}$ <b>Note</b>			300	ns
STB $\uparrow$ from $\overline{\text{SCK1}}\uparrow$	$t_{\text{SBD}}$		$t_{\text{KCY9}}/2-100$		$t_{\text{KCY9}}/2+100$	ns
Strobe signal high-level width	$t_{\text{SBW}}$	$2.7 \text{ V} \leq V_{\text{DD}} < 5.5 \text{ V}$	$t_{\text{KCY9}}-30$		$t_{\text{KCY9}}+30$	ns
		$2.0 \text{ V} < V_{\text{DD}} < 2.7 \text{ V}$	$t_{\text{KCY9}}-60$		$t_{\text{KCY9}}+60$	ns
			$t_{\text{KCY9}}-90$		$t_{\text{KCY9}}+90$	ns
Busy signal setup time (to busy signal detection timing)	$t_{\text{BYS}}$		100			ns
Busy signal hold time (from busy signal detection timing)	$t_{\text{BYH}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	100			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	150			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	200			ns
			300			ns
$\overline{\text{SCK1}}\downarrow$ from busy inactive	$t_{\text{SPS}}$				$2t_{\text{KCY9}}$	ns

**Note** C is the load capacitance of the SO1 output line.

(iv) 3-wire serial I/O mode with automatic transmit/receive function ( $\overline{\text{SCK1}}$ ...External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK1}}$ cycle time	$t_{\text{KCY10}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	800			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	1600			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	3200			ns
			4800			ns
$\overline{\text{SCK1}}$ high/low-level width	$t_{\text{KH10}}, t_{\text{KL10}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	400			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	800			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	1600			ns
			2400			ns
SI1 setup time (to $\overline{\text{SCK1}}\uparrow$ )	$t_{\text{SIK10}}$	$V_{\text{DD}} = 2.0 \text{ to } 5.5 \text{ V}$	100			ns
			150			ns
SI1 hold time (from $\overline{\text{SCK1}}\uparrow$ )	$t_{\text{KSI10}}$		400			ns
SO1 output delay time from $\overline{\text{SCK1}}\downarrow$	$t_{\text{KSO10}}$	C = 100 pF <b>Note</b>	$V_{\text{DD}} = 2.0 \text{ to } 5.5 \text{ V}$		300	ns
					500	ns
$\overline{\text{SCK1}}$ rise, fall time	$t_{\text{R10}}, t_{\text{F10}}$	When using external device expansion function			160	ns
		When not using external device expansion function			1000	ns

**Note** C is the load capacitance of the SO1 output line.

(c) Serial interface channel 2

(i) 3-wire serial I/O mode ( $\overline{\text{SCK2}}$ ...Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK2}}$ cycle time	$t_{\text{KCY11}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	800			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	1600			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	3200			ns
			4800			ns
$\overline{\text{SCK2}}$ high/low-level width	$t_{\text{KH11}}, t_{\text{KL11}}$	$V_{\text{DD}} = 4.5 \text{ to } 5.5 \text{ V}$	$t_{\text{KCY11}}/2-50$			ns
			$t_{\text{KCY11}}/2-100$			ns
SI2 setup time (to $\overline{\text{SCK2}}\uparrow$ )	$t_{\text{SIK11}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	100			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	150			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	300			ns
			400			ns
SI2 hold time (from $\overline{\text{SCK2}}\uparrow$ )	$t_{\text{KSI11}}$		400			ns
SO2 output delay time from $\overline{\text{SCK2}}\downarrow$	$t_{\text{KSO11}}$	$C = 100 \text{ pF}$ <b>Note</b>			300	ns

**Note** C is the load capacitance of the SO2 output line.

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(ii) 3-wire serial I/O mode ( $\overline{\text{SCK2}}$ ...External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK2}}$ cycle time	$t_{\text{KCY12}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	800			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	1600			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	3200			ns
			4800			ns
$\overline{\text{SCK2}}$ high/low-level width	$t_{\text{KH12}},$ $t_{\text{KL12}}$	$4.5 \text{ V} \leq V_{\text{DD}} \leq 5.5 \text{ V}$	400			ns
		$2.7 \text{ V} \leq V_{\text{DD}} < 4.5 \text{ V}$	800			ns
		$2.0 \text{ V} \leq V_{\text{DD}} < 2.7 \text{ V}$	1600			ns
			2400			ns
SI2 setup time (to $\overline{\text{SCK2}}\uparrow$ )	$t_{\text{SIK12}}$	$V_{\text{DD}} = 2.0 \text{ to } 5.5 \text{ V}$	100			ns
			150			ns
SI2 hold time (from $\overline{\text{SCK2}}\uparrow$ )	$t_{\text{KSI12}}$		400			ns
SO2 output delay time from $\overline{\text{SCK2}}\downarrow$	$t_{\text{KSO12}}$	$C = 100 \text{ pF}$ <b>Note</b>	$V_{\text{DD}} = 2.0 \text{ to } 5.5 \text{ V}$		300	ns
					500	ns
$\overline{\text{SCK2}}$ rise, fall time	$t_{\text{R12}},$ $t_{\text{F12}}$	Other than below			160	ns
		$V_{\text{DD}} = 4.5 \text{ to } 5.5 \text{ V}$ When not using external device expansion function			1	μs

**Note** C is the load capacitance of the SO2 output line.

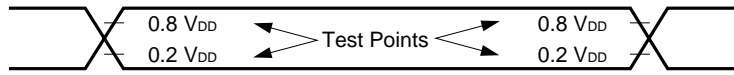
(iii) UART mode (Dedicated baud rate generator output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate		$4.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			78125	bps
		$2.7\text{ V} \leq V_{DD} < 4.5\text{ V}$			39063	bps
		$2.0\text{ V} \leq V_{DD} < 2.7\text{ V}$			19531	bps
					9766	bps

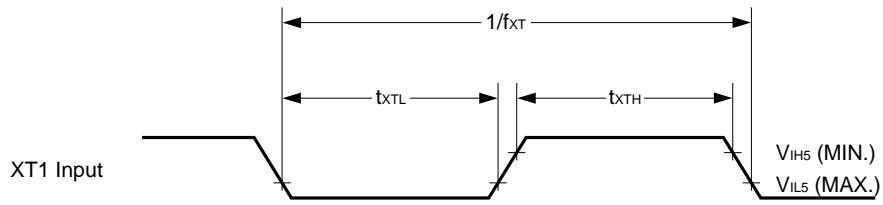
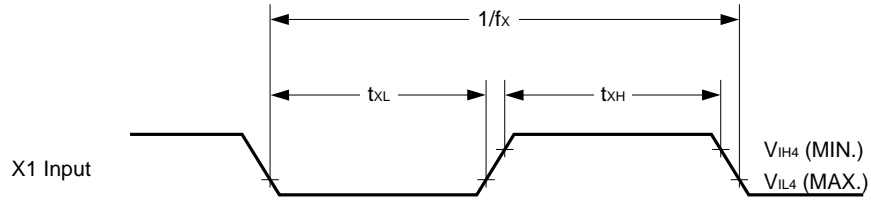
★ (iv) UART mode (External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
ASCK cycle time	$t_{KCY13}$	$4.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	800			ns
		$2.7\text{ V} \leq V_{DD} < 4.5\text{ V}$	1600			ns
		$2.0\text{ V} \leq V_{DD} < 2.7\text{ V}$	3200			ns
			4800			ns
ASCK high-/low-level width	$t_{KH13}, t_{KL13}$	$4.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	400			ns
		$2.7\text{ V} \leq V_{DD} < 4.5\text{ V}$	800			ns
		$2.0\text{ V} \leq V_{DD} < 2.7\text{ V}$	1600			ns
			2400			ns
Transfer rate		$4.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$			39063	bps
		$2.7\text{ V} \leq V_{DD} < 4.5\text{ V}$			19531	bps
		$2.0\text{ V} \leq V_{DD} < 2.7\text{ V}$			9766	bps
					6510	bps
ASCK rise, fall time	$t_{R13}, t_{F13}$	$V_{DD} = 4.5\text{ to }5.5\text{ V}$ , when not using external device expansion function.			1000	ns
					160	ns

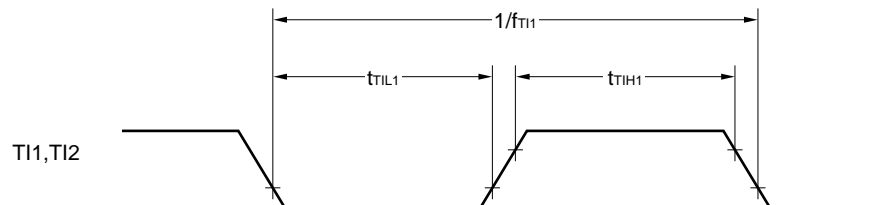
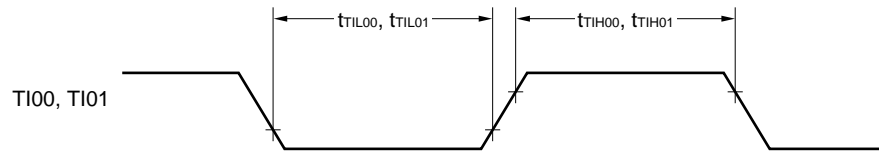
AC Timing Test Point (Excluding X1, XT1 Input)



Clock Timing

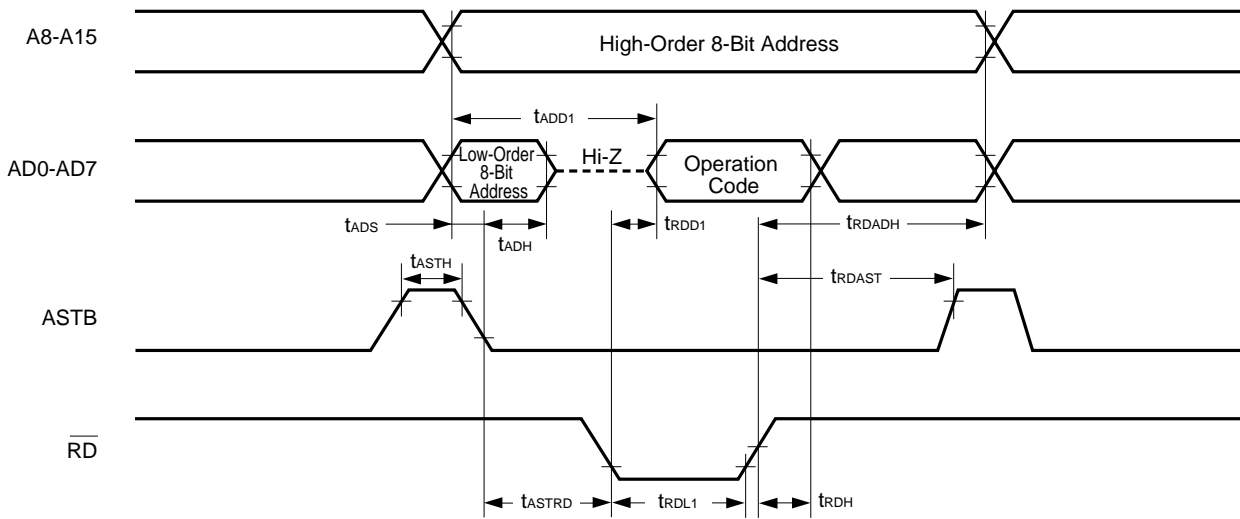


TI Timing

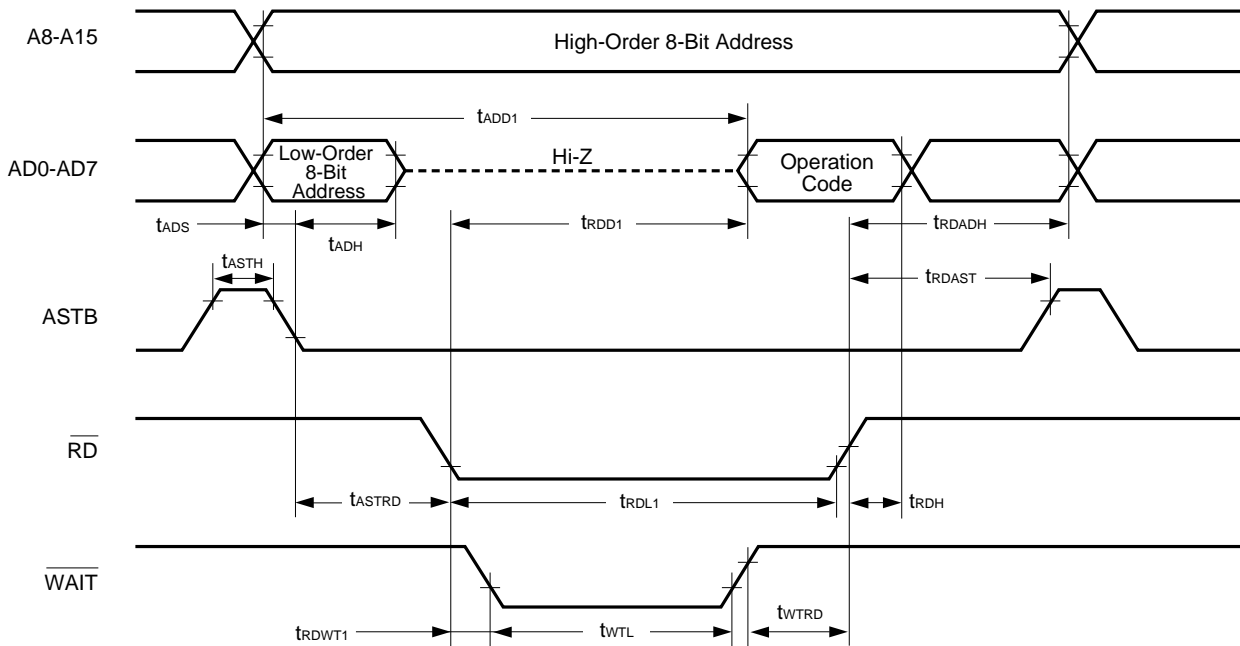


Read/Write Operation

External fetch (no wait) :

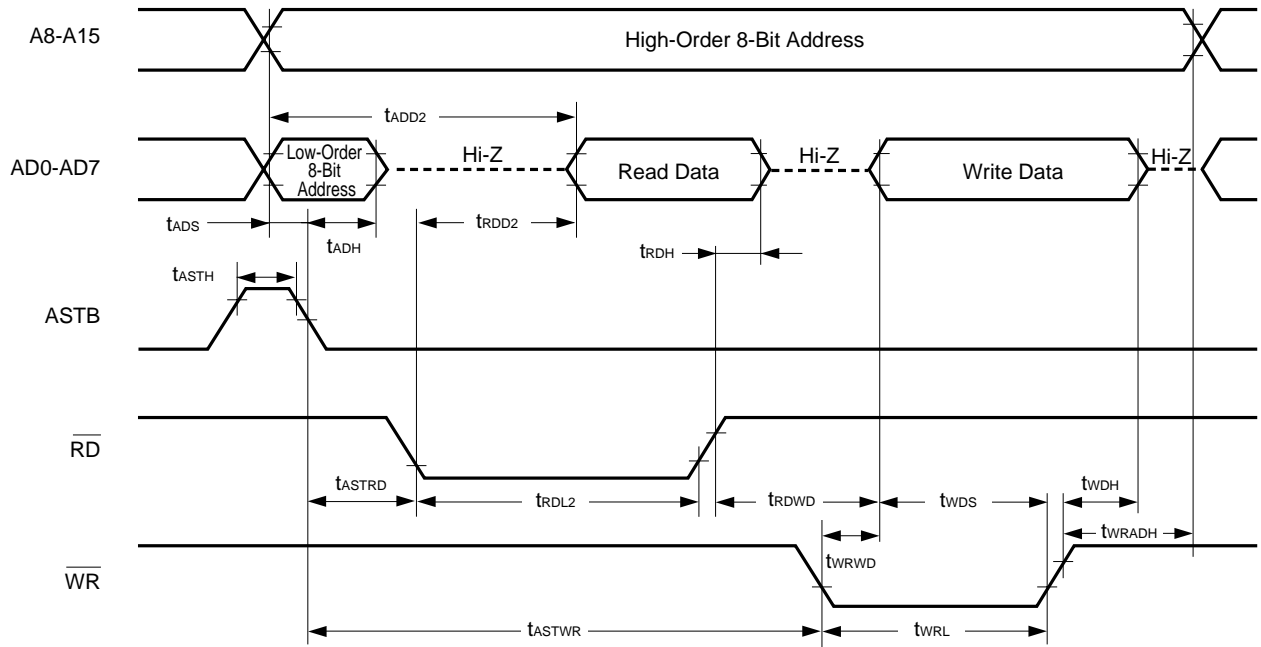


External fetch (wait insertion) :

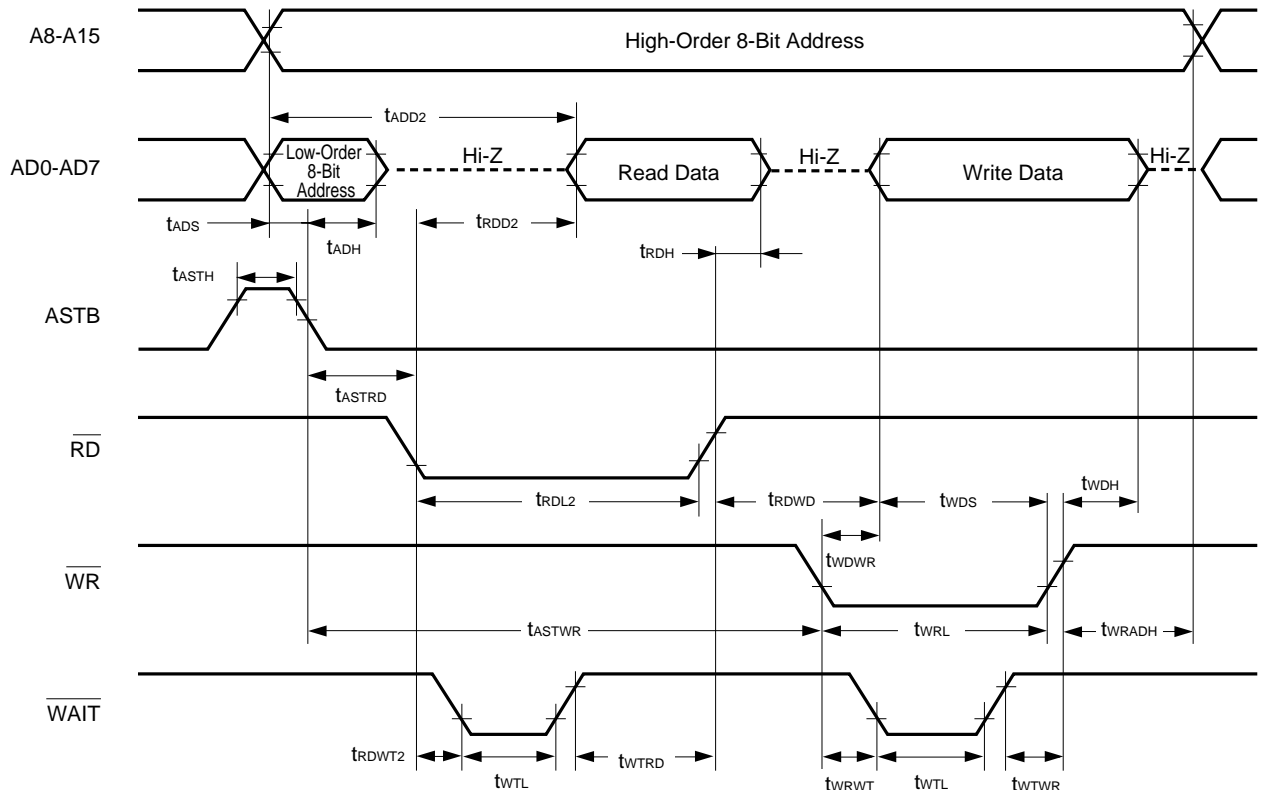




External data access (no wait) :

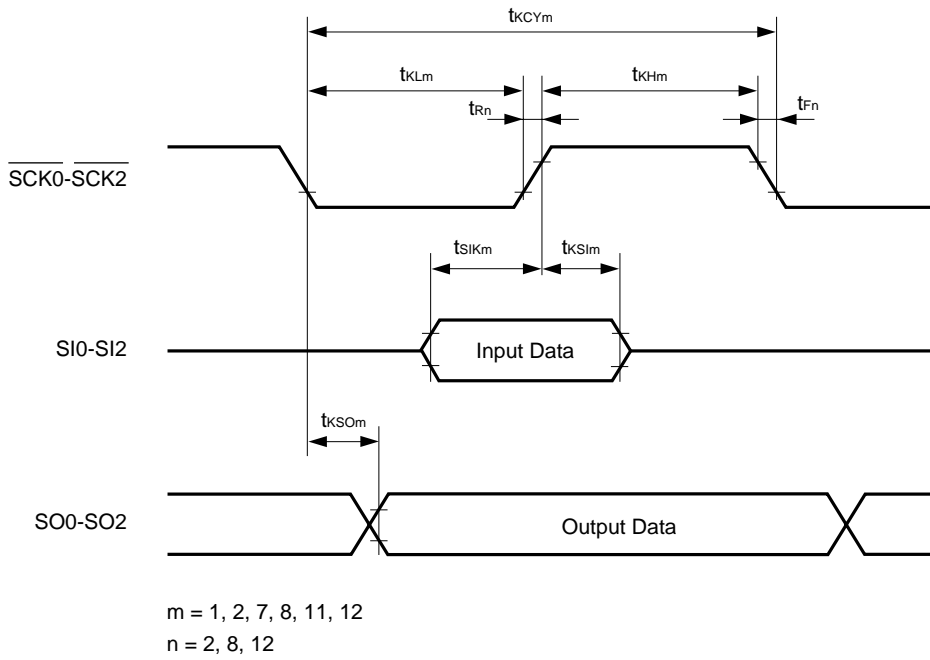


External data access (wait insertion) :

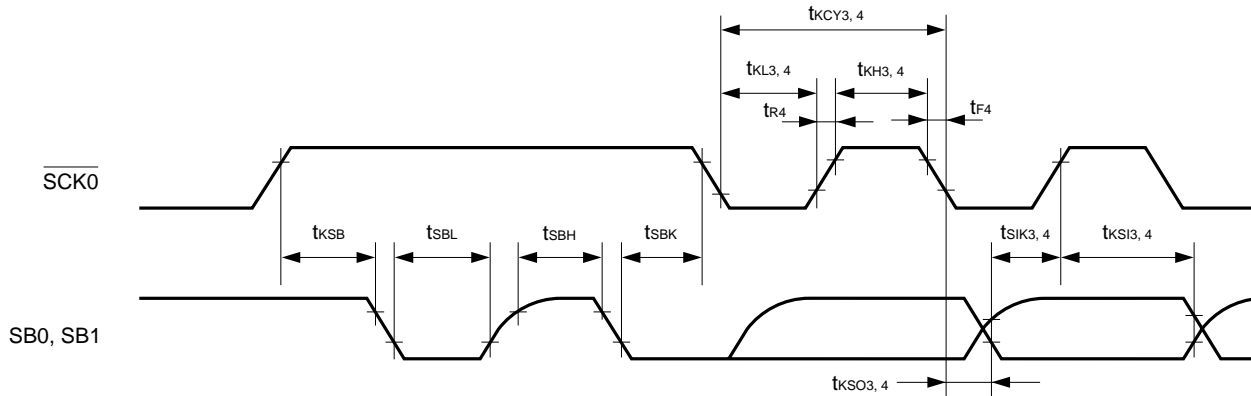


Serial Transfer Timing

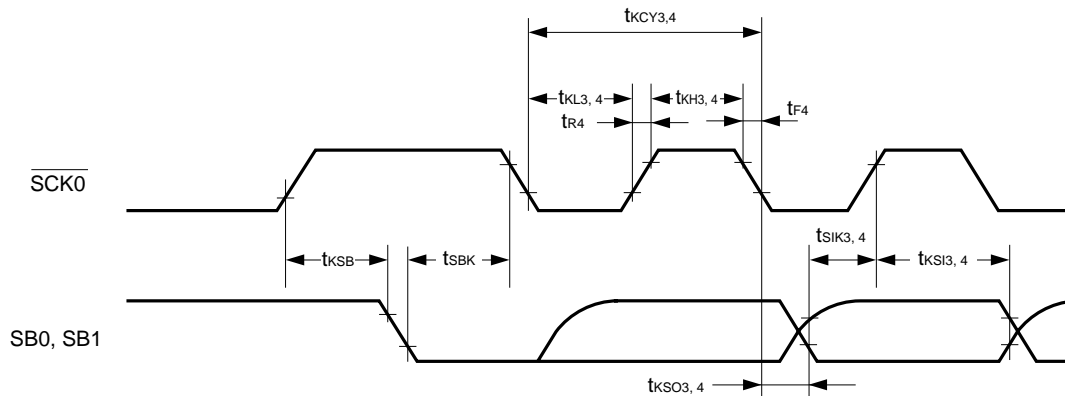
3-wire serial I/O mode :



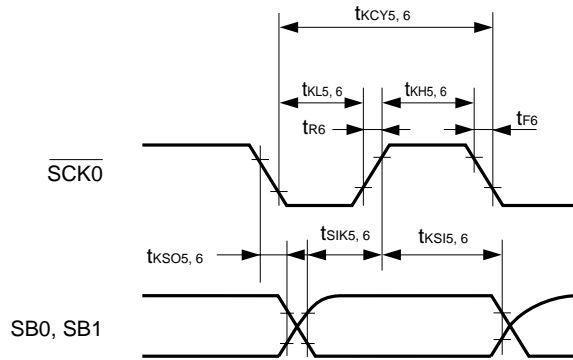
SBI mode (bus release signal transfer) :



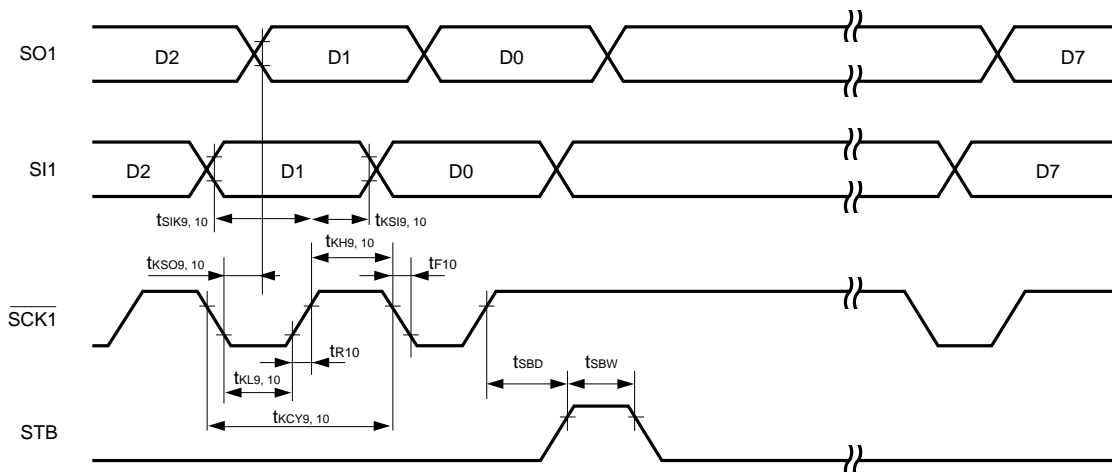
SBI mode (command signal transfer) :



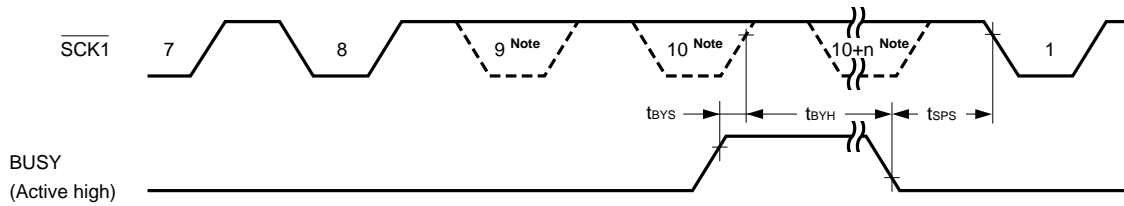
2-wire serial I/O mode :



3-wire serial I/O mode with automatic transmit/receive function :

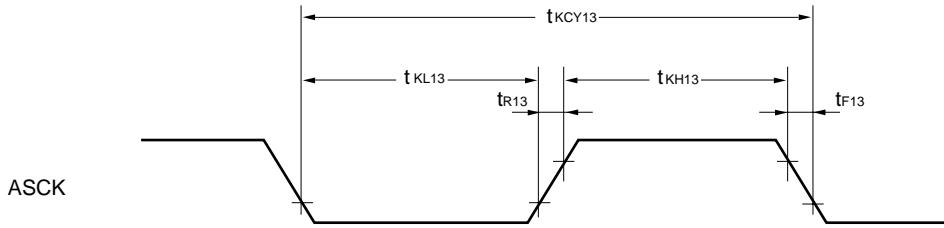


3-wire serial I/O mode with automatic transmit/receive function (busy processing) :



**Note** The signal is not actually driven low here; it is shown as such to indicate the timing.

UART mode (external clock input) :



A/D Converter Characteristics ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 2.7$  to  $5.5$  V,  $AV_{SS} = V_{SS} = 0$  V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Resolution			8	8	8	bit
Overall error <sup>Note</sup>					±1.0	%
Conversion time	$t_{CONV}$		16		100	μs
Sampling time	$t_{SAMP}$		12/ $f_{xx}$			μs
Analog input voltage	$V_{IAN}$		$AV_{SS}$		$AV_{REF0}$	V
Reference voltage	$AV_{REF0}$		2.7		$AV_{DD}$	V
$AV_{REF0}$ current	$I_{REF0}$	When A/D converter is operating <sup>Note 2</sup>		500	1500	μA
		When A/D converter is not operating <sup>Note 3</sup>		0	3	μA
Resistance between $AV_{REF0}$ and $AV_{SS}$	$R_{REF0}$	When A/D conversion is not performed	4	14		kΩ

- Notes**
1. Overall error excluding quantization error ( $\pm 1/2$  LSB). It is indicated as a ratio to the full-scale value.
  2. The current flowing to  $AV_{REF0}$  pin when bit 7 (CS) of the A/D converter mode register (ADM) is 1.
  3. The current flowing to  $AV_{REF0}$  pin when bit 7 (CS) of the A/D converter mode register (ADM) is 0.

**Remark**  $f_{xx}$ : Main system clock frequency ( $f_x$  or  $f_x/2$ )  
 $f_x$ : Main system clock oscillation frequency

D/A Converter Characteristics ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 2.7$  to  $5.5$  V,  $AV_{SS} = V_{SS} = 0$  V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Resolution					8	bit
Overall error		$R = 2$ MΩ <sup>Note 1</sup>			1.2	%
		$R = 4$ MΩ <sup>Note 1</sup>			0.8	%
		$R = 10$ MΩ <sup>Note 1</sup>			0.6	%
Settling time		$C=30$ pF <sup>Note 1</sup>	$AV_{REF1} = 4.5$ to $5.5$ V		10	μs
					15	μs
Output resistance	$R_O$	<b>Note 2</b>		8		kΩ
Analog reference voltage	$AV_{REF1}$		2.7		$V_{DD}$	V
$AV_{REF1}$ current	$I_{REF1}$	<b>Note 2</b>			2.5	mA
Resistance between $AV_{REF1}$ and $AV_{SS}$	$R_{AIREF1}$	DACS0, DACS1 = 55H <sup>Note 2</sup>	4	8		kΩ

- Notes**
1. R and C denote D/A converter output pin load resistance and load capacitance, respectively.
  2. Value for 1 D/A converter channel

**Remark** DACS0 and DACS1: D/A conversion value setting register 0 and 1

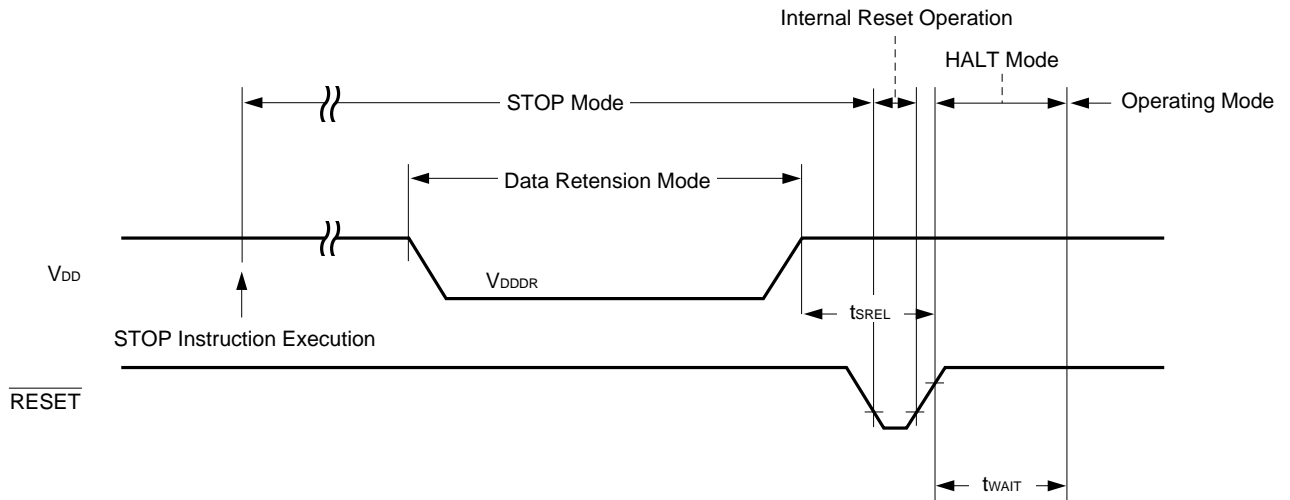
Data Memory STOP Mode Low Supply Voltage Data Retention Characteristics (T<sub>A</sub> = -40 to +85°C)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Data retention power supply voltage	V <sub>DDDR</sub>		1.8		5.5	V
Data retention power supply current	I <sub>DDDR</sub>	V <sub>DDDR</sub> = 1.8 V Subsystem clock stop and feed-back resistor disconnected		0.1	10	μA
Release signal set time	t <sub>SREL</sub>		0			μs
Oscillation stabiliation wait time	t <sub>WAIT</sub>	Release by $\overline{\text{RESET}}$		2 <sup>17</sup> /f <sub>x</sub>		ms
		Release by interrupt		Note		ms

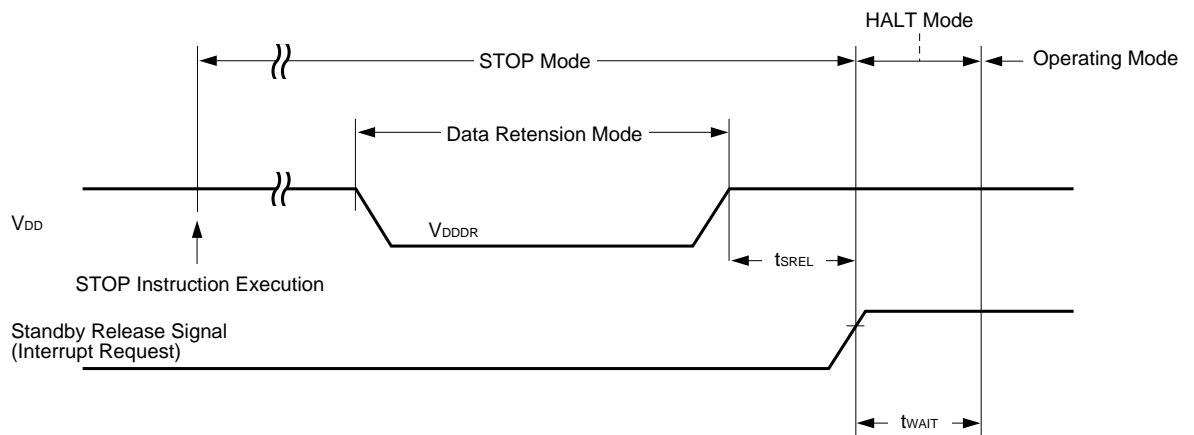
**Note** In combination with bits 0 to 2 (OSTS0 to OSTS2) of oscillation stabilization time select register (OSTS), selection of 2<sup>12</sup>/f<sub>xx</sub> and 2<sup>14</sup>/f<sub>xx</sub> to 2<sup>17</sup>/f<sub>xx</sub> is possible.

**Remark** f<sub>xx</sub>: Main system clock frequency (f<sub>x</sub> or f<sub>x</sub>/2)  
f<sub>x</sub> : Main system clock oscillator frequency

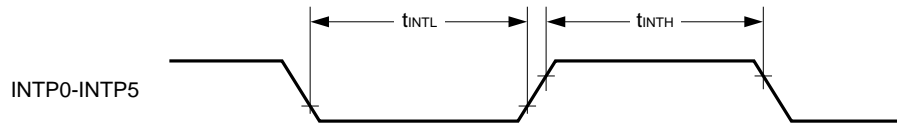
Data Retention Timing (STOP Mode Release by  $\overline{\text{RESET}}$ )



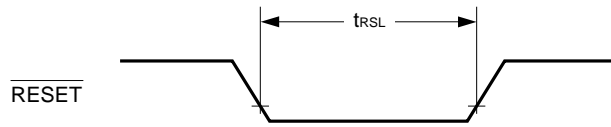
Data Retention Timing (Standby Release Signal: STOP Mode Release by Interrupt Signal)



Interrupt Input Timing

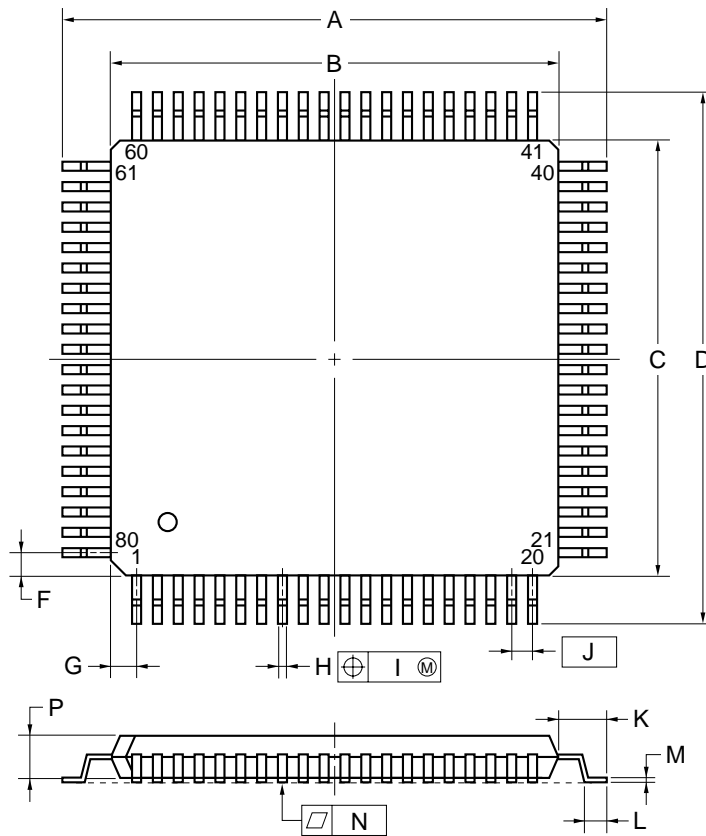


$\overline{\text{RESET}}$  Input Timing



12. PACKAGE DRAWINGS

80 PIN PLASTIC QFP (14×14)



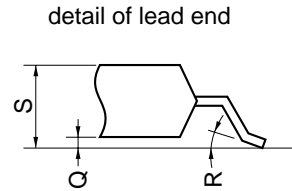
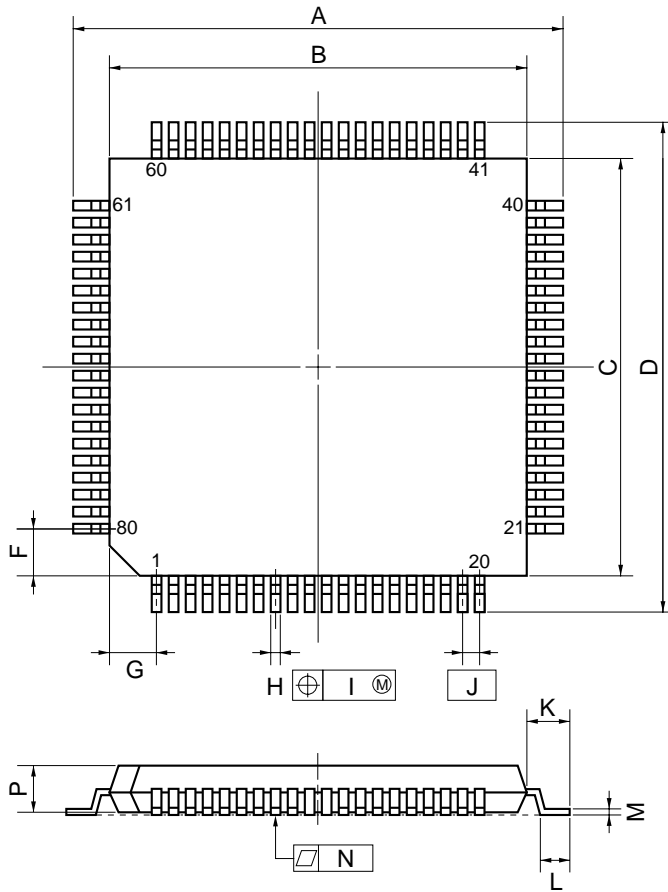
NOTE

Each lead centerline is located within 0.13 mm (0.005 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	17.20±0.20	0.677±0.008
B	14.00±0.20	0.551 <sup>+0.009</sup> <sub>-0.008</sub>
C	14.00±0.20	0.551 <sup>+0.009</sup> <sub>-0.008</sub>
D	17.20±0.20	0.677±0.008
F	0.825	0.032
G	0.825	0.032
H	0.32±0.06	0.013 <sup>+0.002</sup> <sub>-0.003</sub>
I	0.13	0.005
J	0.65 (T.P.)	0.026 (T.P.)
K	1.60±0.20	0.063±0.008
L	0.80±0.20	0.031 <sup>+0.009</sup> <sub>-0.008</sub>
M	0.17 <sup>+0.03</sup> <sub>-0.07</sub>	0.007 <sup>+0.001</sup> <sub>-0.003</sub>
N	0.10	0.004
P	1.40±0.10	0.055±0.004
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	1.70 MAX.	0.067 MAX.

P80GC-65-8BT

80 PIN PLASTIC TQFP (FINE PITCH) (□ 12)



**NOTE**  
Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	14.0±0.2	0.551 <sup>+0.009</sup> <sub>-0.008</sub>
B	12.0±0.2	0.472 <sup>+0.009</sup> <sub>-0.008</sub>
C	12.0±0.2	0.472 <sup>+0.009</sup> <sub>-0.008</sub>
D	14.0±0.2	0.551 <sup>+0.009</sup> <sub>-0.008</sub>
F	1.25	0.049
G	1.25	0.049
H	0.22 <sup>+0.05</sup> <sub>-0.04</sub>	0.009±0.002
I	0.10	0.004
J	0.5 (T.P.)	0.020 (T.P.)
K	1.0±0.2	0.039 <sup>+0.009</sup> <sub>-0.008</sub>
L	0.5±0.2	0.020 <sup>+0.008</sup> <sub>-0.009</sub>
M	0.145 <sup>+0.055</sup> <sub>-0.045</sub>	0.006±0.002
N	0.10	0.004
P	1.05	0.041
Q	0.05±0.05	0.002±0.002
R	5°±5°	5°±5°
S	1.27 MAX.	0.050 MAX.

P80GK-50-BE9-4



★ APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for developing systems using the μPD780058 subseries. Refer to (5) Cautions when the development tools are used.

(1) Language processing software

RA78K/0	78K/0 series common assembler package
CC78K/0	78K/0 series common C compiler package
DF780058	Device file for the μPD780058 subseries
CC78K/0-L	78K/0 series common C compiler library source file

(2) Flash memory writing tools

Flashpro II (Part number: FL-PR2)	Dedicated flash programmer for microcomputers incorporating flash memory
FA-80GC <sup>Note</sup> FA-80GK <sup>Note</sup>	Adapter for flash memory writing

**Note** Under development

(3) Debugging tools

- When using the IE-78K0-NS in-circuit emulator

IE-78K0-NS <sup>Note</sup>	78K/0 series common in-circuit emulator
IE-70000-MC-PS-B	Power supply unit for IE-78K0-NS
IE-70000-98-IF-C <sup>Note</sup>	Interface adapter necessary when a PC-9800 series computer (except notebook-type personal computer) is used as host machine
IE-70000-CD-IF <sup>Note</sup>	PC card and interface cable necessary when a PC-9800 series notebook-type personal computer is used as host machine
IE-70000-PC-IF-C <sup>Note</sup>	Interface adapter necessary when an IBM PC/AT™ or a compatible machine is used as host machine
IE-780308-NS-EM1 <sup>Note</sup>	Emulation board common to the μPD780308 subseries
NP-80GC <sup>Note</sup>	Emulation probe for 80-pin plastic QFP (GC-8BT type)
NP-80GK <sup>Note</sup>	Emulation probe for 80-pin plastic TQFP (GK-BE9 type)
TGK-080SDW	Conversion adapter to connect the board of the target system to be mounted on 80-pin plastic TQFP (GK-BE9 type) and NP-80GK
EV-9200GC-80	Socket to be mounted on the board of the target system for 80-pin plastic QFP (GC-8BT type)
ID78K0-NS <sup>Note</sup>	Integrated debugger for IE-78K0-NS
SM78K0	78K/0 series common system simulator
DF780058	Device file for the μPD780058 subseries

**Note** Under development

- When using the IE-78001-R-A in-circuit emulator

IE-78001-R-A <sup>Note</sup>	78K/0 series common in-circuit emulator
IE-70000-98-IF-B IE-70000-98-IF-C <sup>Note</sup>	Interface adapter necessary when a PC-9800 series computer (except notebook-type personal computer) is used as host machine
IE-70000-PC-IF-B IE-70000-PC-IF-C <sup>Note</sup>	Interface adapter necessary when an IBM PC/AT or a compatible machine is used as host machine
IE-78000-R-SV3	Interface adapter and cable necessary when an EWS is used as host machine
IE-780308-NS-EM1 <sup>Note</sup> IE-780308-R-EM	Emulation board common to the $\mu$ PD780308 subseries
IE-78K0-R-EX1 <sup>Note</sup>	Emulation probe conversion board necessary when the IE-780308-NS-EM1 is used in the IE-78001-R-A.
EP-78230GC-R	Emulation probe for 80-pin plastic QFP (GC-8BT type)
EP-78054GK-R	Emulation probe for 80-pin plastic TQFP (GK-BE9 type)
TGK-080SDW	Conversion adapter to connect the board of the target system to be mounted on 80-pin plastic TQFP (GK-BE9 type) and EP-78054GK-R
EV-9200GC-80	Socket to be mounted on the board of the target system made for the 80-pin plastic QFP (GC-8BT type)
ID78K0	Integrated debugger for IE-78001-R-A
SM78K0	78K/0 series common system simulator
DF780058	Device file for the $\mu$ PD780058 subseries

**Note** Under development

#### (4) Real-time OS

RX78K/0	Real-time OS for 78K/0 series
MX78K0	OS for 78K/0 series

**(5) Cautions when the development tools are used**

- The ID78K0-NS, ID78K0, and SM78K0 are used in combination with the DF780058.
- The CC78K/0 and RX78K/0 are used in combination with the RA78K/0 and DF780058.
- Flashpro II, FA-80GC, FA-80GK, NP-80GC, and NP-80GK are products of Naito Densai Machida Mfg. Co., Ltd. (TEL: (044)822-3813). Contact an NEC distributor when purchasing these products.
- TGK-080SDW is a product of Tokyo Eletech Corp.  
 Inquiry : Daimaru Kogyo, Ltd. Electronics Dept. (TEL: Tokyo (03) 3820-7112)  
 Electronics 2nd Dept. (TEL: Osaka (06) 244-6672)
- Refer to the **78K/0 Series Selection Guide (U11126E)** for information on third party development tools.
- Host machines and OSs compatible with the software are as follows:

Host Machine [OS] Software	PC	EWS
	PC-9800 Series [Windows™] IBM PC/AT and compatible machines [Japanese/English Windows]	HP9000 series 700™ [HP-UX™] SPARCstation™ [SunOS™] NEWS™ (RISC) [NEWS-OS™]
RA78K/0	○ <small>Note</small>	○
CC78K/0	○ <small>Note</small>	○
ID78K0-NS	○	-
ID78K0	○	○
SM78K0	○	-
RX78K/0	○ <small>Note</small>	○
MX78K0	○ <small>Note</small>	○

**Note** DOS based software

## ★ APPENDIX B. RELATED DOCUMENTS

## Documents Related Devices

Document Name	Document No.	
	Japanese	English
μPD780058, 780058Y Subseries User's Manual	U12013J	U12013E
μPD780053, 780054, 780055, 780056, 780058 Data Sheet	U12182J	This document
μPD78F0058 Preliminary Product Information	U12092J	U12092E
78K/0 Series User's Manual - Instruction	U12326J	U12326E
78K/0 Series Instruction Table	U10903J	—
78K/0 Series Instruction Set	U10904J	—

## Development Tool Documents (User's Manual)

Document Name		Document No.	
		Japanese	English
RA78K0 Assembler Package	Operation	U11802J	U11802E
	Assembly Language	U11801J	U11801E
	Structured Assembly Language	U11789J	U11789E
RA78K Series Structured Assembler Preprocessor		U12323J	EEU-1402
CC78K0 C Compiler	Operation	U11517J	U11517E
	Language	U11518J	U11518E
CC78K/0 C Compiler Application Note	Programming Know-How	U13034J	U13034E
CC78K Series Library Source File		U12322J	—
IE-78K0-NS		Planned	Planned
IE-78001-R-EM		Planned	Planned
IE-780308-NS-EM1		Planned	Planned
IE-780308-R-EM		U11362J	U11362E
EP-78230		EEU-985	EEU-1515
EP-78054GK-R		EEU-932	EEU-1468
SM78K0 System Simulator Windows Based	Reference	U10181J	U10181E
SM78K Series System Simulator	External Part User Open Interface Specifications	U10092J	U10092E
ID78K0-NS Integrated Debugger PC Based	Reference	U12900J	Planned
ID78K0 Integrated Debugger EWS Based	Reference	U11151J	—
ID78K0 Integrated Debugger PC Based	Reference	U11539J	U11539E
ID78K0 Integrated Debugger Windows Based	Guide	U11649J	U11649E

**Caution** The documents listed above are subject to change without notice. Be sure to use the latest documents for designing your system.

**Documents Related to Embedded Software (User's Manual)**

Document Name		Document No.	
		Japanese	English
78K/0 Series Real-Time OS	Fundamentals	U11537J	U11537E
	Installation	U11536J	U11536E
78K/0 Series OS MX78K0	Fundamental	U12257J	U12257E

**Other Related Documents**

Document Name	Document No.	
	Japanese	English
IC Package Manual	C10943X	
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 by Electrostatic Discharge (ESD)	C11892J	C11892E
Semiconductor Device Quality/Reliability Handbook	C12769J	—
Microcomputer Product Series Guide	U11416J	—

**Caution** The documents listed above are subject to change without notice. Be sure to use the latest documents for designing your system.

## 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

Some information contained in this document may vary from country to country. Before using any NEC product in your application, please contact the NEC office in your country to obtain a list of authorized representatives and distributors. They will verify:

- 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

In addition, trademarks, registered trademarks, export restrictions, and other legal issues may also vary from country to country.

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Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

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Anti-radioactive design is not implemented in this product.