NEC

MOS INTEGRATED CIRCUIT

μPD78058F(A)

8-BIT SINGLE-CHIP MICROCONTROLLER

DESCRIPTION

The μPD78058F(A) is an 8-bit single-chip microcontroller belonging to the μPD78058F Subseries of the 78K/0 Series. A stricter quality assurance program is applied to this device, which is classified as special grade, compared to the μPD78058F, which is classified as standard grade.

The Electro Magnetic Interference (EMI) noise generated inside the μPD78058F(A) is reduced compared to the μPD78058 Subseries.

This microcontroller includes a rich assortment of peripheral hardware, such as 8-bit resolution A/D converter, 8-bit resolution D/A converter, timer, serial interface, real-time output port, and interrupt functions.

The μPD78P058F, a one-time PROM version which can be operated in the same supply voltage range as the mask ROM version, and various development tools are also available.

Details of the function descriptions are described in the following user's manuals. Be sure to read them before designing.

μPD78058F, 78058FY Subseries User's Manual: U12068E
78K/0 Series User's Manual – Instructions : U12326E

FEATURES

- EMI noise reduced version (the overall peak level is reduced by 5 to 10 dB.)
- High-capacity on-chip ROM & RAM
  ROM : 60 Kbytes
  High-speed RAM: 1024 bytes
  Buffer RAM : 32 bytes
  Expanded RAM : 1024 bytes
- Package: 80-pin plastic QFP (14 × 14 mm)
- External memory expansion space: 64 Kbytes
- Minimum instruction execution time can be varied from high-speed (0.4 μs) to ultra-low-speed (122 μs)
- I/O ports: 69 (N-ch open-drain: 4)
- 8-bit resolution A/D converter: 8 channels
- 8-bit resolution D/A converter: 2 channels
- Serial interface: 3 channels
- Timer: 5 channels
- Supply voltage: V_{DD} = 2.7 to 6.0 V

APPLICATIONS

Automobile equipment control units, gas detector/cutoff units, safety devices, etc.

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

Document No U12325EJ2V0DS00 (2nd edition)
Date Published October 1997 N
Printed in Japan

The mark ★ shows major revised points.

ORDERING INFORMATION

Part Number	Package	Quality Grade
μPD78058FGC(A)-×××-3B9	80-pin plastic QFP (14 × 14 mm)	Special (for high-reliability electronic equipment)

Remark ××× denotes the ROM code suffix.

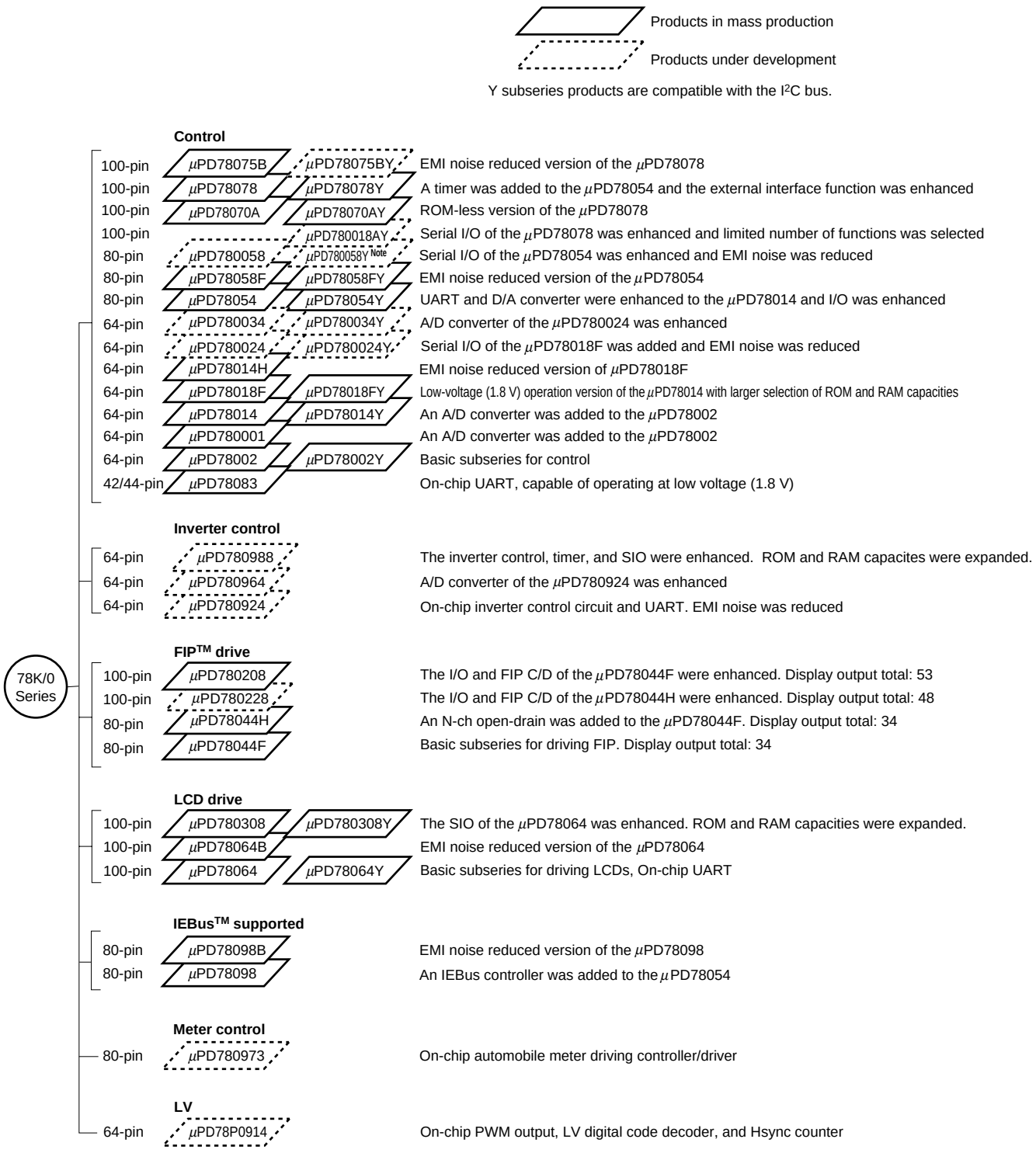
Please refer to "Quality grade on NEC Semiconductor Devices" (Document number C11531E) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

Differences between the μPD78058F(A) and μPD78058F

Item \ Product name	μPD78058F(A)	μPD78058F
Quality grade	Special	Standard
Package	80-pin plastic QFP (14 × 14 mm, resin thickness 2.7 mm)	• 80-pin plastic QFP (14 × 14 mm, resin thickness 2.7 mm) • 80-pin plastic QFP (14 × 14 mm, resin thickness 1.4 mm) • 80-pin plastic TQFP (fine pitch) (12 × 12 mm)

78K/0 SERIES PRODUCT DEVELOPMENT

These products are a further development in the 78K/0 Series. The designations appearing inside the boxes are subseries names.



Note Under planning

The major functional differences among the subseries are shown below.

Subseries Name \ Function		ROM Capacity	Timer				8-bit A/D	10-bit A/D	8-bit D/A	Serial Interface	I/O	V_{DD} MIN. Value	External Expansion
			8-bit	16-bit	Watch	WDT							
Control	μPD78075B	32 K to 40 K	4 ch	1 ch	1 ch	1 ch	8 ch	—	2 ch	3 ch (UART: 1 ch)	88	1.8 V	√
	μPD78078	48 K to 60 K											
	μPD78070A	—									61	2.7 V	
	μPD780058	24 K to 60 K	2 ch							3 ch (Time division UART: 1 ch)	68	1.8 V	
	μPD78058F	48 K to 60 K								3 ch (UART: 1 ch)	69	2.7 V	
	μPD78054	16 K to 60 K										2.0 V	
	μPD780034	8 K to 32 K					—	8 ch	—	3 ch (UART: 1 ch, Time division 3-wire: 1 ch)	51	1.8 V	
	μPD780024						8 ch	—					
	μPD78014H									2 ch	53		
	μPD78018F	8 K to 60 K											
	μPD78014	8 K to 32 K										2.7 V	
	μPD780001	8 K		—	—					1 ch	39		—
	μPD78002	8 K to 16 K			1ch		—				53		√
	μPD78083				—		8 ch			1 ch (UART: 1 ch)	33	1.8 V	—
Inverter control	μPD780988	32 K to 60 K	3 ch	**Note 1**	—	1 ch	—	8 ch	—	3 ch (UART: 2 ch)	47	4.0 V	√
	μPD780964	8 K to 32 K		**Note 2**						2 ch (UART: 2 ch)		2.7 V	
	μPD780924						8 ch	—					
FIP driving	μPD780208	32 K to 60 K	2 ch	1 ch	1 ch	1 ch	8 ch	—	—	2 ch	74	2.7 V	—
	μPD780228	48 K to 60 K	3 ch	—	—					1 ch	72	4.5 V	
	μPD78044H	32 K to 48 K	2 ch	1 ch	1 ch						68	2.7 V	
	μPD78044F	16 K to 40 K								2 ch			
LCD driving	μPD780308	48 K to 60 K	2 ch	1 ch	1 ch	1 ch	8 ch	—	—	3 ch (Time division UART: 1 ch)	57	2.0 V	—
	μPD78064B	32 K								2 ch (UART: 1 ch)			
	μPD78064	16 K to 32 K											
IEBus supported	μPD78098B	40 K to 60 K	2 ch	1 ch	1 ch	1 ch	8 ch	—	2 ch	3 ch (UART: 1 ch)	69	2.7 V	√
	μPD78098	32 K to 60 K											
Meter control	μPD780973	24 K to 32 K	3 ch	1 ch	1 ch	1 ch	5 ch	—	—	2 ch (UART: 1 ch)	56	4.5 V	—
LV	μPD78P0914	32 K	6 ch	—	—	1 ch	8 ch	—	—	2 ch	54	4.5 V	√

Notes 1. 16-bit timer: 2 channels
10-bit timer: 1 channel

2. 10-bit timer: 1 channel

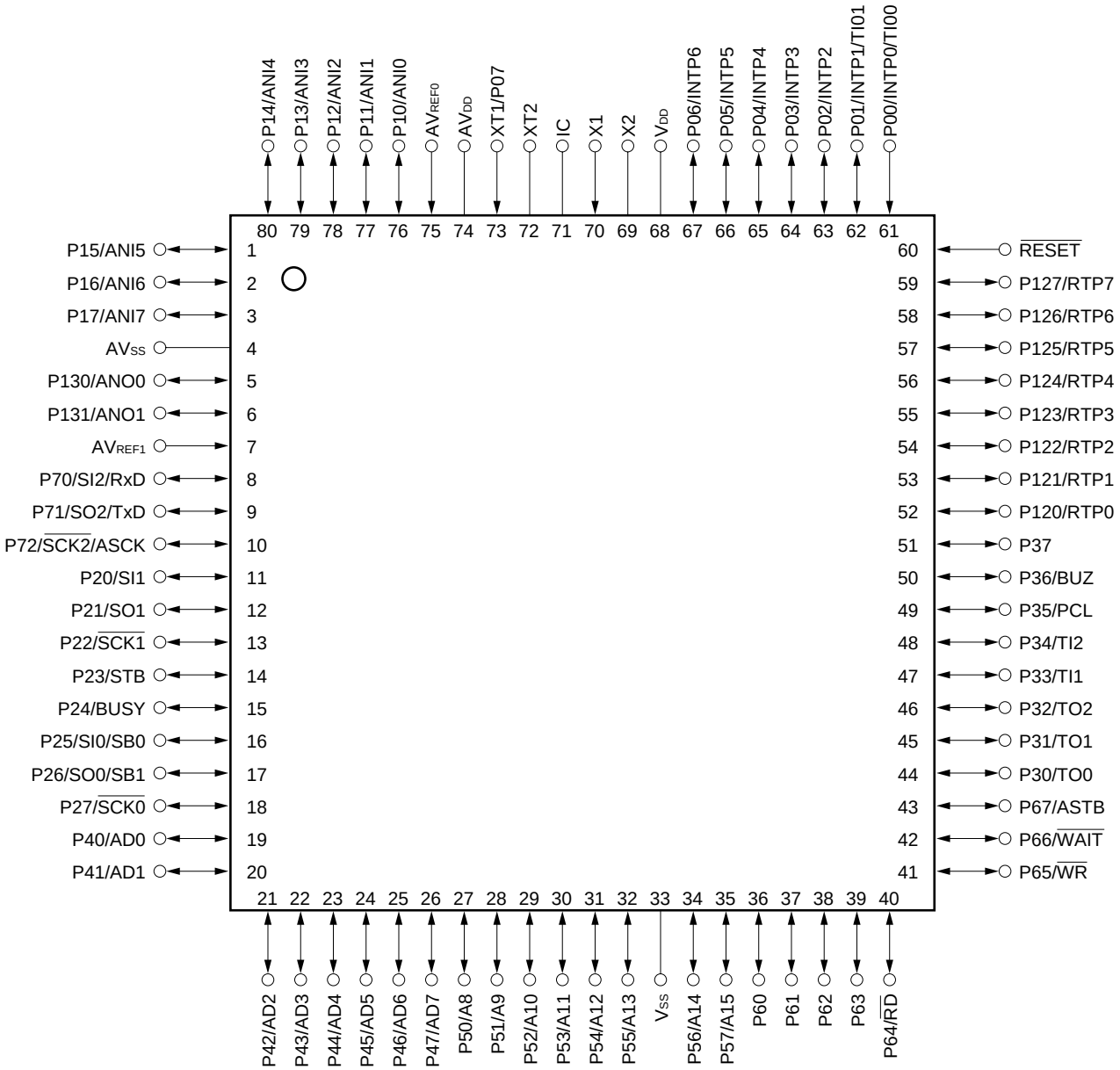
FUNCTIONAL OUTLINE

Item		Function
Internal memory	ROM	60 Kbytes
	High-speed RAM	1024 bytes
	Buffer RAM	32 bytes
	Expanded RAM	1024 Kbytes
Memory space		64 Kbytes
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		• 16-bit operation • Multiply/divide (8 bits × 8 bits,16 bits ÷ 8 bits) • Bit manipulate (set, reset, test, Boolean operation) • BCD adjust, etc.
I/O ports		Total : 69 • CMOS input : 2 • CMOS I/O : 63 • N-ch open-drain I/O : 4
A/D converter		• 8-bit resolution × 8 channels
D/A converter		• 8-bit resolution × 2 channels
Serial interface		• 3-wire serial I/O, SBI, or 2-wire serial I/O mode selectable: 1 channel • 3-wire serial I/O mode (on-chip max. 32 bytes automatic data transmit/receive function): 1 channel • 3-wire serial I/O or UART mode selectable: 1 channel
Timer		• 16-bit timer/event counter : 1 channel • 8-bit timer/event counter : 2 channels • Watch timer : 1 channel • Watchdog timer : 1 channel
Timer output		3 (14-bit PWM output enable × 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 (during 5.0-MHz operation with main system clock) 32.768 kHz (during 32.768-kHz operation with subsystem clock)
Buzzer output		1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (during 5.0-MHz operation with main system clock)
Vectored interrupt source	Maskable	Internal interrupts: 13, external interrupts: 7
	Non-maskable	Internal interrupt: 1
	Software	1
Test input		Internal: 1, external: 1
Supply voltage		V_{DD} = 2.7 to 6.0 V
Operating ambient temperature		T_A = –40 to + 85°C
Package		80-pin plastic QFP (14 × 14 mm)

CONTENTS

1. PIN CONFIGURATION (TOP VIEW)

- **80-pin plastic QFP (14 × 14 mm)**
  μPD78058FGC(A)-×××-3B9



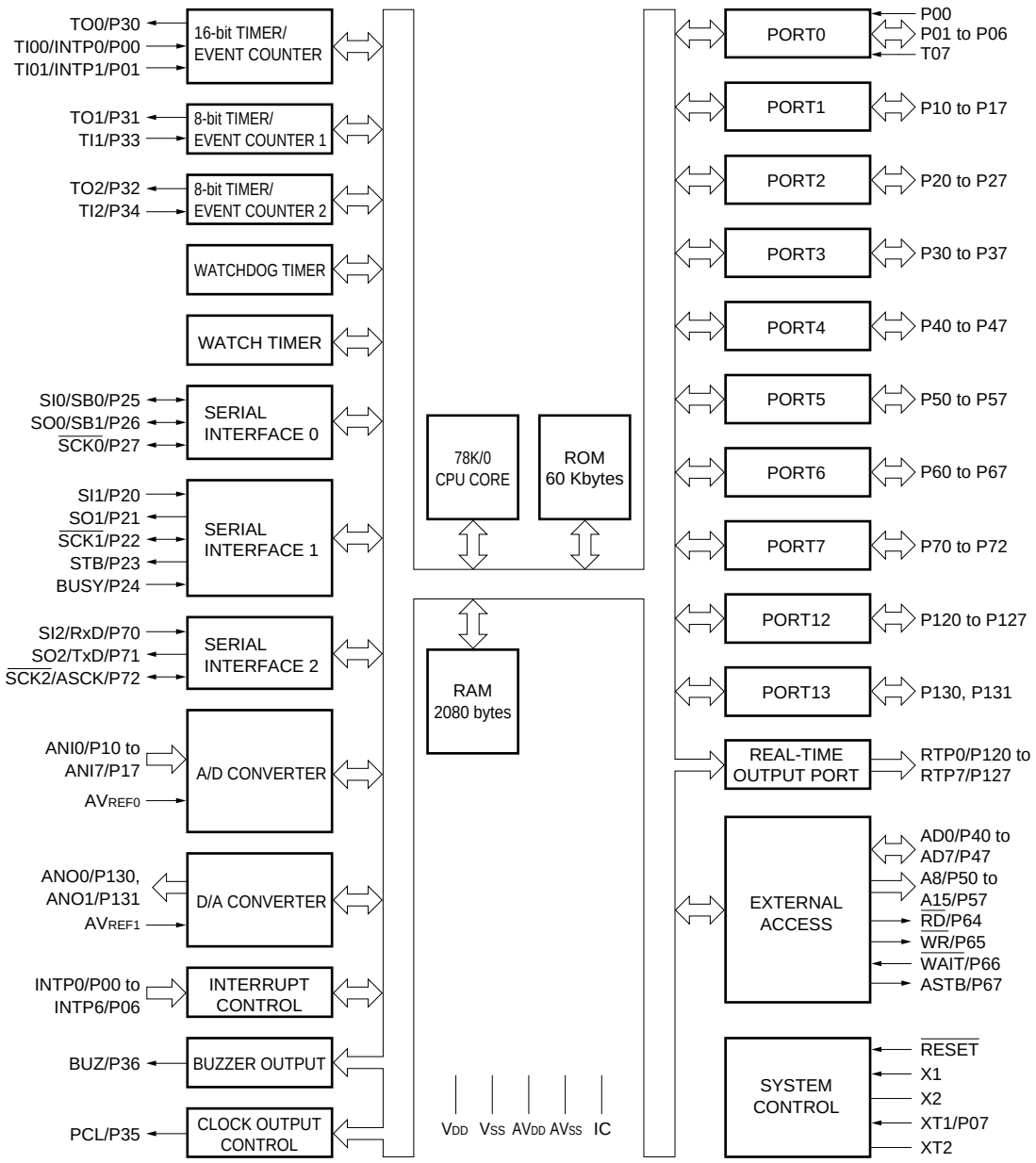
Cautions 1. Connect directly the Internally Connected (IC) pin to V_{SS}.

2. The AV_{DD} pin functions as both an A/D converter power supply and a port power supply. When the μPD78058F(A) is used in applications where the noise generated inside the microcontroller need to be reduced, connect the AV_{DD} pin to another power supply that has the same potential as V_{DD}.

3. The AV_{SS} pin functions as both a ground for A/D and D/A converters and a ground for a port. When the μPD78058F(A) is used in applications where the noise generated inside the microcontroller needs to be reduced, connect the AV_{SS} pin to a ground line other than V_{SS}.

A8 to A15 : Address Bus
AD0 to AD7 : Address/Data Bus
ANI0 to ANI7 : Analog Input
ANO0, ANO1 : Analog Output
ASCK : Asynchronous Serial Clock
ASTB : Address Strobe
AV_{DD} : Analog Power Supply
AV_{REF0}, AV_{REF1} : Analog Reference Voltage
AV_{SS} : Analog Ground
BUSY : Busy
BUZ : Buzzer Clock
IC : Internally Connected
INTP0 to INTP6 : Interrupt from Peripherals
P00 to P07 : Port0
P10 to P17 : Port1
P20 to P27 : Port2
P30 to P37 : Port3
P40 to P47 : Port4
P50 to P57 : Port5
P60 to P67 : Port6
P70 to P72 : Port7
P120 to P127 : Port12
P130, P131 : Port13
PCL : Programmable Clock
$\overline{RD}$: Read Strobe
$\overline{RESET}$: Reset
RTP0 to RTP7 : Real-Time Output Port
RxD : Receive Data
SB0, SB1 : Serial Bus
$\overline{SCK0}$ to $\overline{SCK2}$: Serial Clock
SI0 to SI2 : Serial Input
SO0 to SO2 : Serial Output
STB : Strobe
TI00, TI01 : Timer Input
TI1, TI2, : Timer Input
TO0 to TO2 : Timer Output
TxD : Transmit Data
V_{DD} : Power Supply
V_{SS} : Ground
$\overline{WAIT}$: Wait
$\overline{WR}$: Write Strobe
X1, X2 : Crystal (Main System Clock)
XT1, XT2 : Crystal (Subsystem Clock)

2. BLOCK DIAGRAM



3. PIN FUNCTIONS

3.1 Port Pins (1/2)

Pin Name	I/O	Function		After Reset	Alternate Function
P00	Input	Port 0 8-bit I/O 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
P06					INTP6
P07[Note 1]	Input		Input only	Input	XT1
P10 to 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.[Note 2]		Input	ANI0 to 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					$\overline{SCK1}$
P23					STB
P24					BUSY
P25					SI0/SB0
P26					SO0/SB1
P27					$\overline{SCK0}$

Notes 1. When using the P07/XT1 pins as an input port, set 1 in bit 6 (FRC) of the processor clock control register (PCC). The 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. The on-chip pull-up resistor is cancelled automatically.

Caution For pins that also function as port pins, do not perform the following operations during A/D conversion. If these operations are performed, the total error ratings cannot be kept.

(1) Rewrite the output latch of the output for pins used as a port pin.

(2) Change the output level of pins used as an output pin, even if they are not used as a port pin.

3.1 Port Pins (2/2)

Pin Name	I/O	Function		After Reset	Alternate Function
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 to P47	Input/ output	Port 4 8-bit input/output port. Input/output can be specified in 8-bit units. 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 to AD7
P50 to 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 to A15
P60	Input/ output	Port 6 8-bit input/outport port. Input/output can be specified bit-wise.	N-ch open-drain input/output port. On-chip pull-up resistor can be specified 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.	Input	$\overline{RD}$
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/RxD
P71					SO2/TxD
P72					$\overline{SCK2}$/ASCK
P120 to 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 to 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

Caution For pins that also function as port pins, do not perform the following operations during A/D conversion. If these operations are performed, the total error ratings cannot be kept.

(1) Rewrite the output latch of the output for pins used as a port pin.

(2) Change the output level of pins used as an output pin, even if they are not used as a port pin.

3.2 Non-port Pins (1/2)

Pin Name	I/O	Function	After Reset	Alternate Function
INTP0	Input	External interrupt request input by which the effective edge (rising edge, falling edge, or both rising edge and falling edges) can be specified.	Input	P00/TI00
INTP1				P01/TI01
INTP2				P02
INTP3				P03
INTP4				P04
INTP5				P05
INTP6				P06
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
$\overline{SCK0}$	Input/ output	Serial interface serial clock input/output.	Input	P27
$\overline{SCK1}$				P22
$\overline{SCK2}$				P72/ASCK
STB	Output	Serial interface automatic transmit/receive strobe output.	Input	P23
BUSY	Input	Serial interface automatic transmit/receive busy input.	Input	P24
RxD	Input	Asynchronous serial interface serial data input.	Input	P70/SI2
TxD	Output	Asynchronous serial interface serial data output.	Input	P71/SO2
ASCK	Input	Asynchronous serial interface serial clock input.	Input	P72/$\overline{SCK2}$
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)		P32
PCL	Output	Clock output (for main system clock, subsystem clock trimming).	Input	P35
BUZ	Output	Buzzer output.	Input	P36
RTP0 to RTP7	Output	Real-time output port by which data is output in synchronization with a trigger.	Input	P120 to P127
AD0 to AD7	Input/ output	Low-order address/data bus at external memory expansion.	Input	P40 to P47
A8 to A15	Output	High-order address bus at external memory expansion.	Input	P50 to P57
$\overline{RD}$	Output	External memory read operation strobe signal output.	Input	P64
$\overline{WR}$		External memory write operation strobe signal output.		P65

3.2 Non-port Pins (2/2)

Pin Name	I/O	Function	After Reset	Alternate Function
$\overline{\text{WAIT}}$	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
ANI0 to ANI7	Input	A/D converter analog input.	Input	P10 to P17
ANO0, ANO1	Output	D/A converter analog output.	Input	P130, P131
AV_{REF0}	Input	A/D converter reference voltage input.	—	—
AV_{REF1}	Input	D/A converter reference voltage input.	—	—
AV_{DD}	—	A/D converter analog power supply (shared with the port power supply)	—	—
AV_{SS}	—	A/D and D/A converter ground potential (shared with the port ground potential)	—	—
$\overline{\text{RESET}}$	Input	System reset input.	—	—
X1	Input	Main system clock oscillation crystal connection.	—	—
X2	—		—	—
XT1	Input	Subsystem clock oscillation crystal connection.	Input	P07
XT2	—		—	—
V_{DD}	—	Positive power supply (except for port).	—	—
V_{SS}	—	Ground potential (except for port).	—	—
IC	—	Internally connected. Connect to V_{SS} directly.	—	—

Cautions 1. The AV_{DD} pin functions as both an A/D converter power supply and a port power supply. When the μPD78058F(A) is used in applications where the noise generated inside the microcontroller needs to be reduced, connect the AV_{DD} pin to another power supply that has the same potential as V_{DD}.

2. The AV_{SS} pin functions as both a ground potential of A/D and D/A converters and a ground potential of a port section. When the μPD78058F(A) is used in applications where the noise generated inside the microcontroller needs to be reduced, connect the AV_{SS} pin to a ground line other than V_{SS}.

3.3 Pin I/O Circuits and Recommended Connection of Unused Pins

The input/output circuit type of each pin and the 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_{SS}.
P01/INTP1/TI01	8-D	Input/output	Independently connect to V_{SS} via a resistor.
P02/INTP2			
P03/INTP3			
P04/INTP4			
P05/INTP5			
P06/INTP6			
P07/XT1	16	Input	Connect to V_{DD}.
P10/ANI0 to P17/ANI7	11-C	Input/output	Independently connect to V_{DD} or V_{SS} via a resistor.
P20/SI1	8-D		
P21/SO1	5-J		
P22/$\overline{SCK1}$	8-D		
P23/STB	5-J		
P24/BUSY	8-D		
P25/SI0/SB0	10-C		
P26/SO0/SB1			
P27/$\overline{SCK0}$			
P30/TO0	5-J		
P31/TO1			
P32/TO2			
P33/TI1	8-D		
P34/TI2			
P35/PCL	5-J		
P36/BUZ			
P37			
P40/AD0 to P47/AD7	5-O		Independently connect to V_{DD} via a resistor.
P50/A8 to P57/A15	5-J		Independently connect to V_{DD} or V_{SS} via a resistor.
P60 to P63	13-I		Independently connect to V_{DD} via a resistor.
P64/$\overline{RD}$	5-J		Independently connect to V_{DD} or V_{SS} via a 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/RxD	8-D	Input/output	Independently connect to V_{DD} or V_{SS} via a resistor.
P71/SO2/TxD	5-J		
P72/$\overline{\text{SCK2}}$/ASCK	8-D		
P120/RTP0 to P127/RTP7	5-J		
P130/ANO0, P131/ANO1	12-B	Input/output	Independently connect to V_{SS} via a resistor.
$\overline{\text{RESET}}$	2	Input	—
XT2	16	—	Leave open.
AV_{REF0}	—		Connect to V_{SS} .
AV_{REF1}			Connect to V_{DD} .
AV_{DD}			Connect to another power supply that has the same potential as V_{DD}.
AV_{SS}			Connect to another ground line that has the same potential as V_{SS}.
IC			Connect to V_{SS} directly.

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

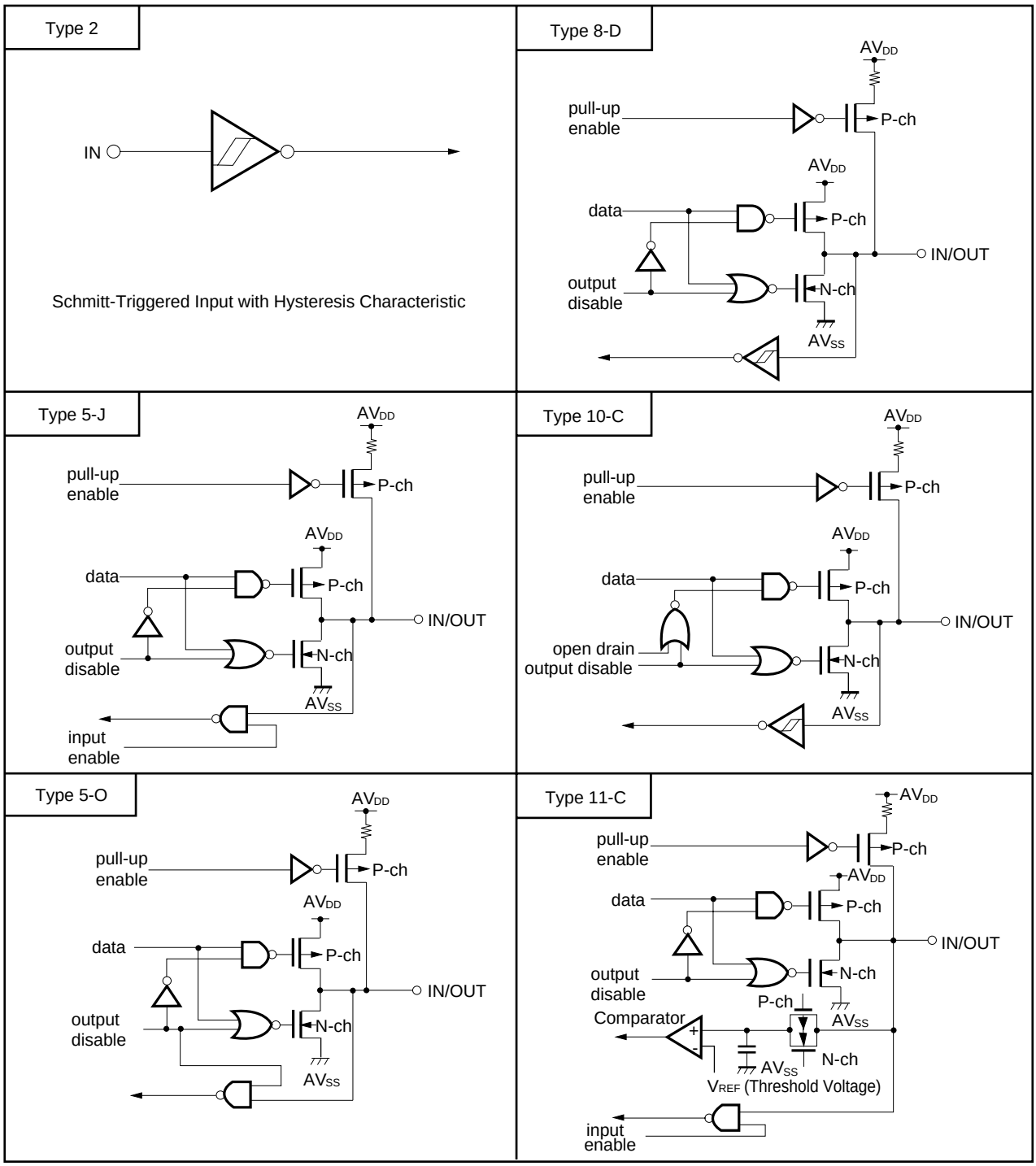
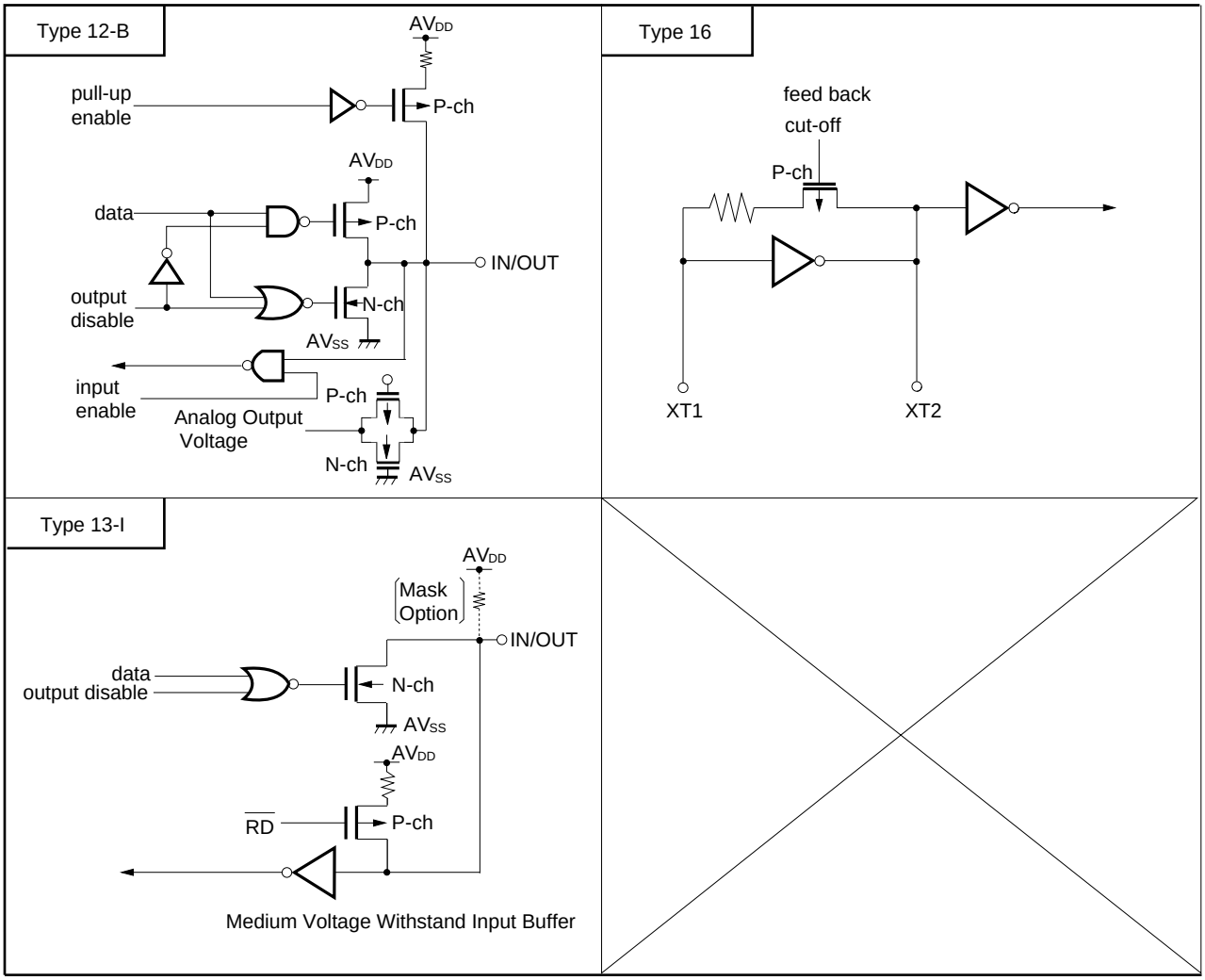


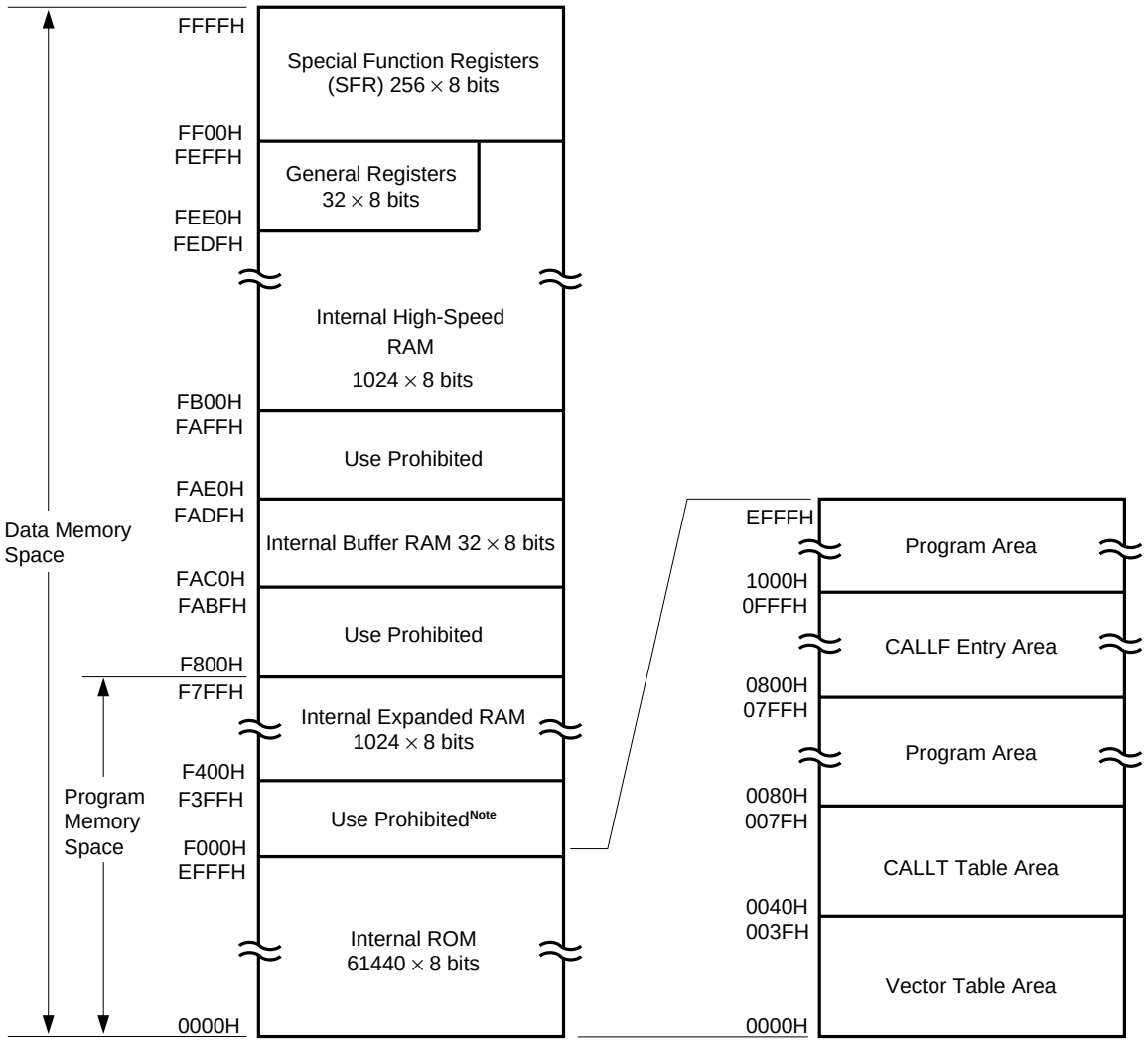
Figure 3-1. Pin Input/Output Circuits (2/2)



4. MEMORY SPACE

Figure 4-1 shows the memory map of the μPD78058F(A).

Figure 4-1. Memory Map



Note When the external device expansion function is used, set the internal ROM capacity to 56 Kbytes or less using the memory size switching register (IMS).

5. PERIPHERAL HARDWARE FUNCTION FEATURES

5.1 Ports

The following 3 types of I/O ports are available.

- CMOS input (P00, P07) : 2
- CMOS input/output (P01 to P06, ports 1 to 5, P64 to P67, port 7, port 12, port 13) : 63
- N-channel open-drain input/output (P60 to P63) : 4

Total : 69

Table 5-1. Port Functions

Name	Pin Name	Function
Port 0	P00, P07	Dedicated input port pins
	P01 to P06	Input/output port pins. Input/output specifiable bit-wise. When used as input/output port pins, on-chip pull-up resistor can be used by software.
Port 1	P10 to 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 to 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 to 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 to 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 input flag (KRIF) is set to 1 by falling edge detection.
Port 5	P50 to 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 to 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 to P67	Input/output port pins. Input/output specifiable bit-wise. When used as input/output port pins, on-chip pull-up resistor can be used by software.
Port 7	P70 to P72	Input/output port pins. Input/output specifiable bit-wise. When used as input/output port pins, on-chip pull-up resistor can be used by software.
Port 12	P120 to P127	Input/output port pins. Input/output specifiable bit-wise. When used as input/output 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/output port pins, on-chip pull-up resistor can be used by software.

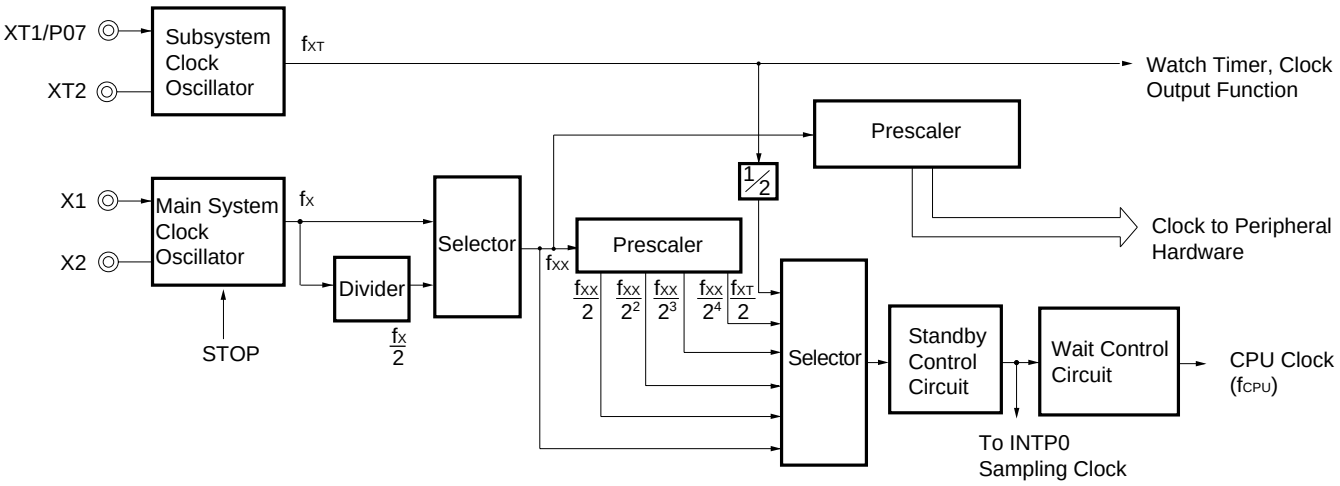
5.2 Clock Generator

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

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 μPD78058F(A) incorporates 5 channels of the timer/event counter.

- 16-bit timer/event counter : 1 channel
- 8-bit timer/event counter : 2 channel
- 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	1 output	2 outputs	—	—
PWM output	1 output	—	—	—
Pulse width measurement	2 inputs	—	—	—
Square wave output	1 output	2 outputs	—	—
One-shot pulse output	1 output	—	—	—
Interrupt request	2	2	1	1
Test input	—	—	1 input	—

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

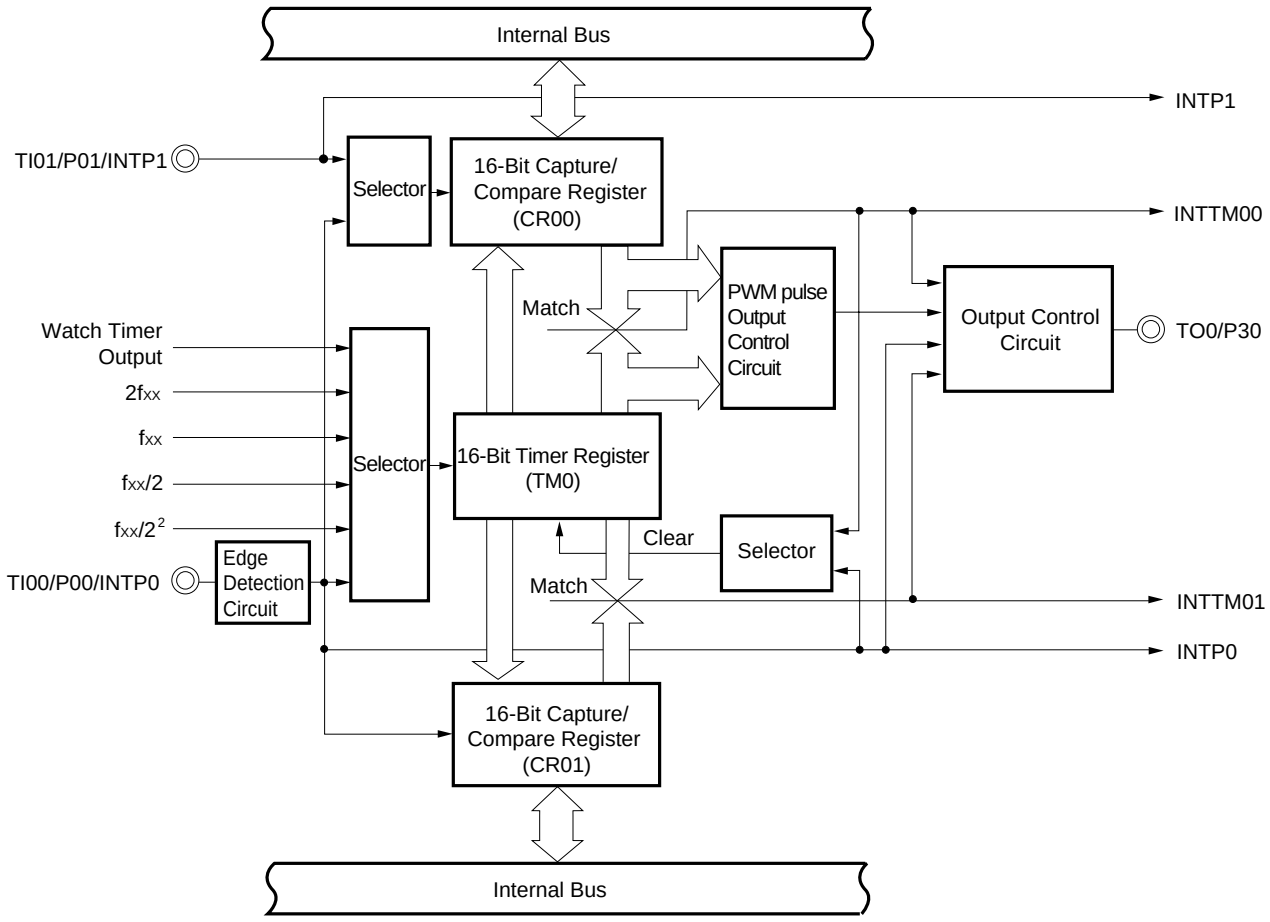


Figure 5-3. 8-Bit Timer/Event Counter Block Diagram

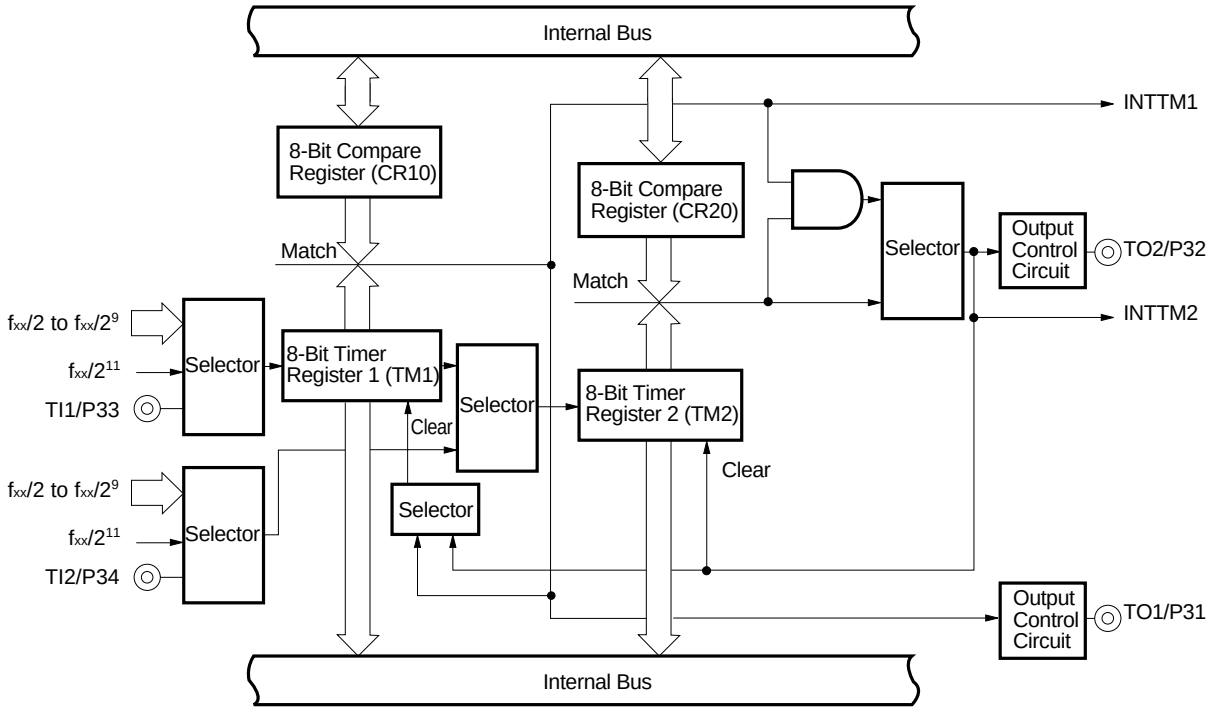


Figure 5-4. Watch Timer Block Diagram

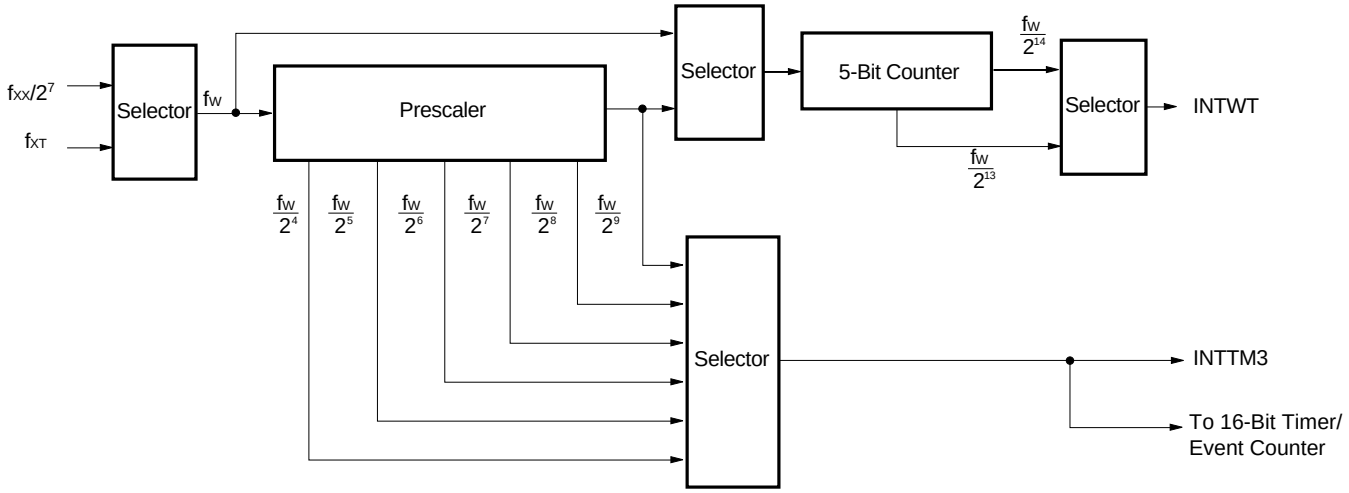
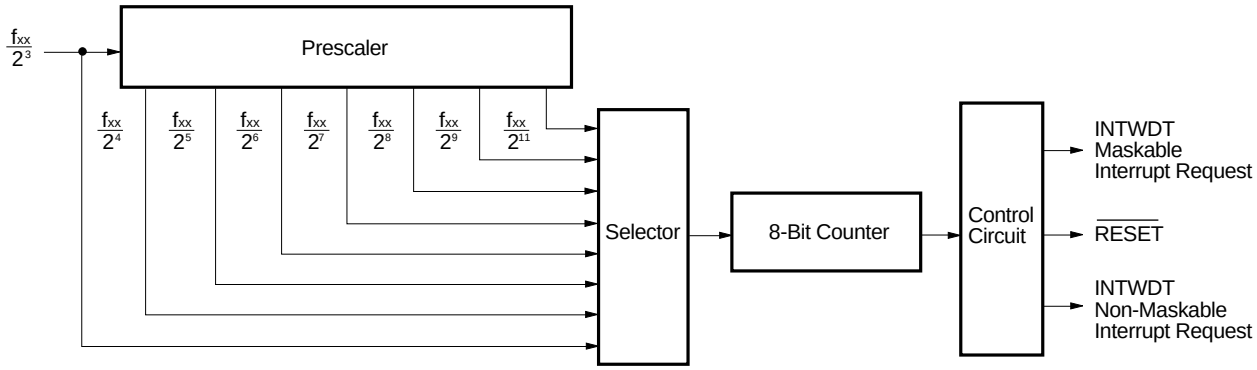


Figure 5-5. Watchdog Timer Block Diagram

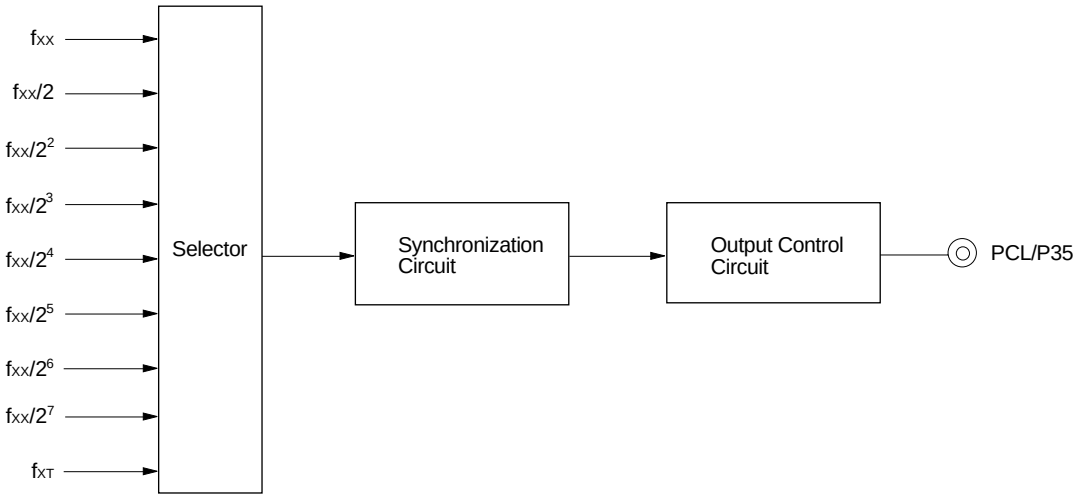


5.4 Clock Output Control Circuit

Clocks with the following frequencies can be output as the 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

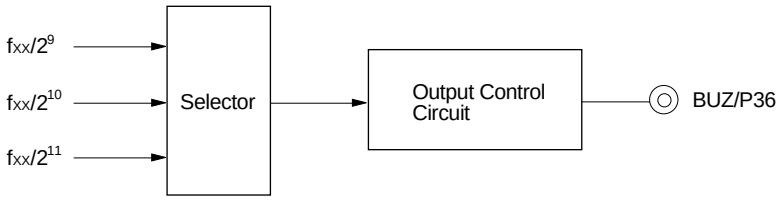


5.5 Buzzer Output Control Circuit

Clocks with the following frequencies can be output as the 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



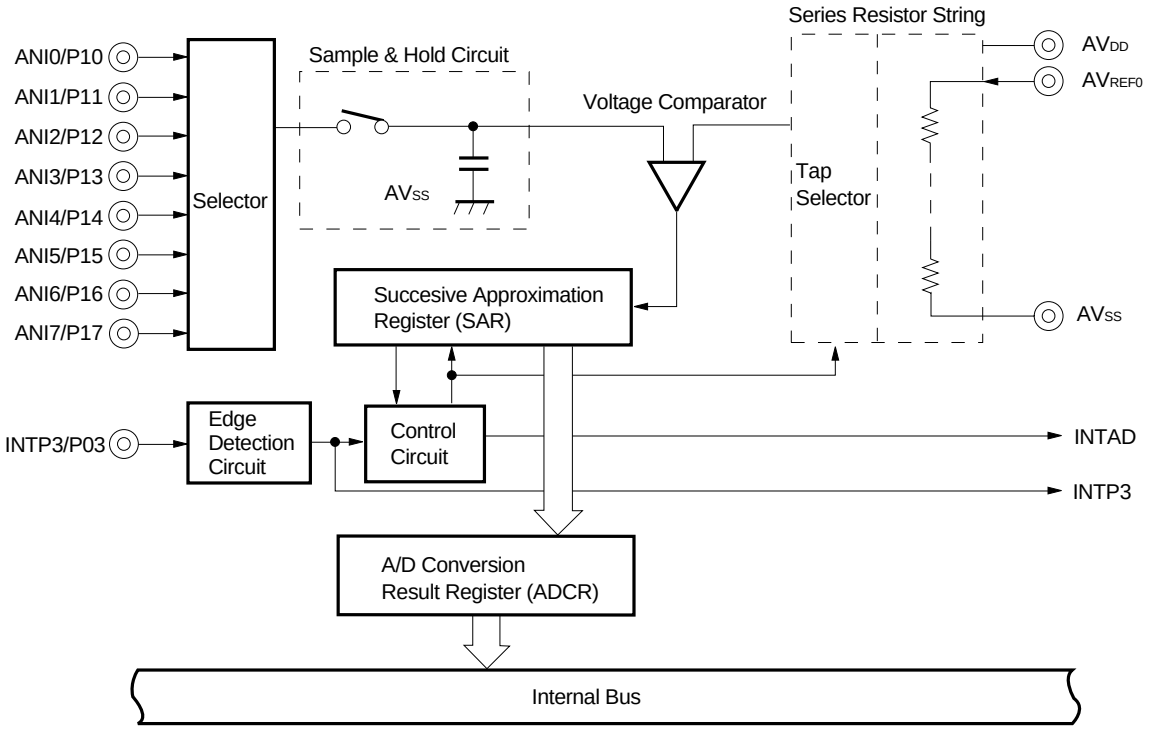
5.6 A/D Converter

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

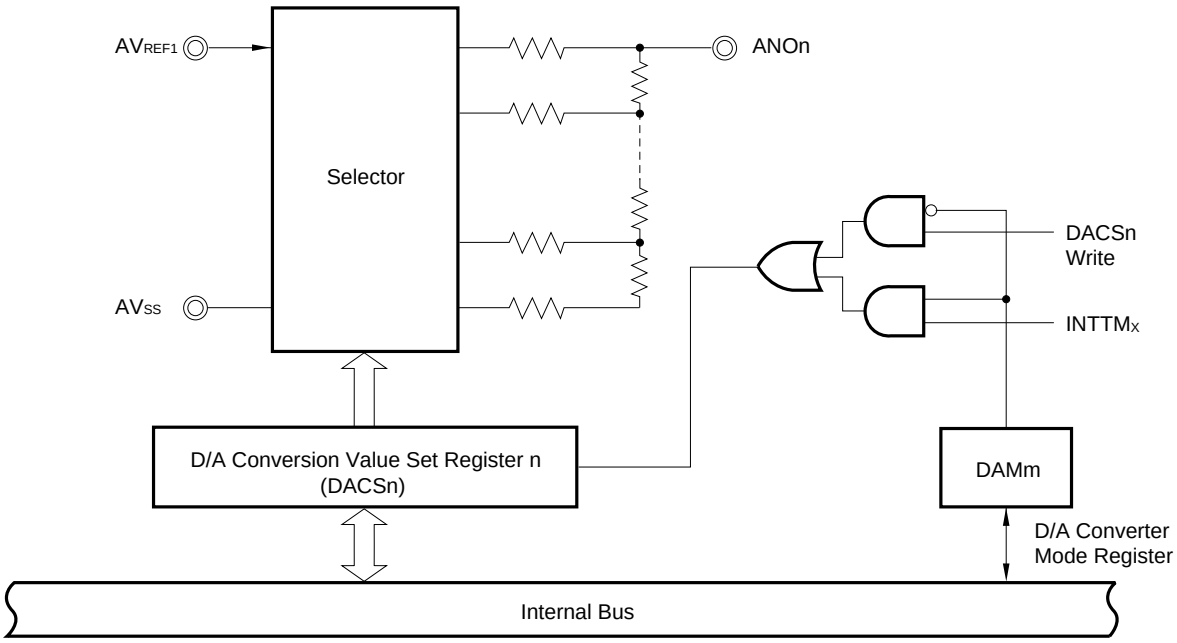


5.7 D/A Converter

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

3 channels of the clocked serial interface are incorporated.

- Serial interface channel 0
- Serial interface channel 1
- Serial 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 transmission/reception 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	—	—	√ (Dedicated baud rate generator incorporated)

Figure 5-10. Serial Interface Channel 0 Block Diagram

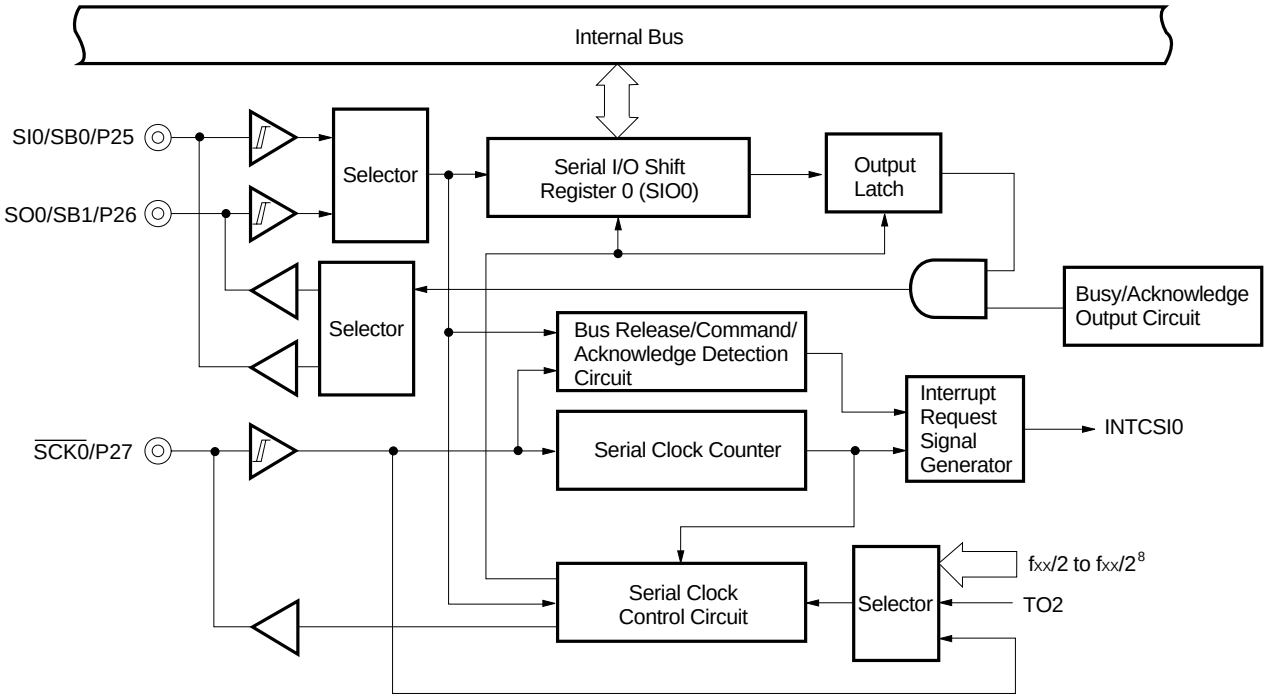


Figure 5-11. Serial Interface Channel 1 Block Diagram

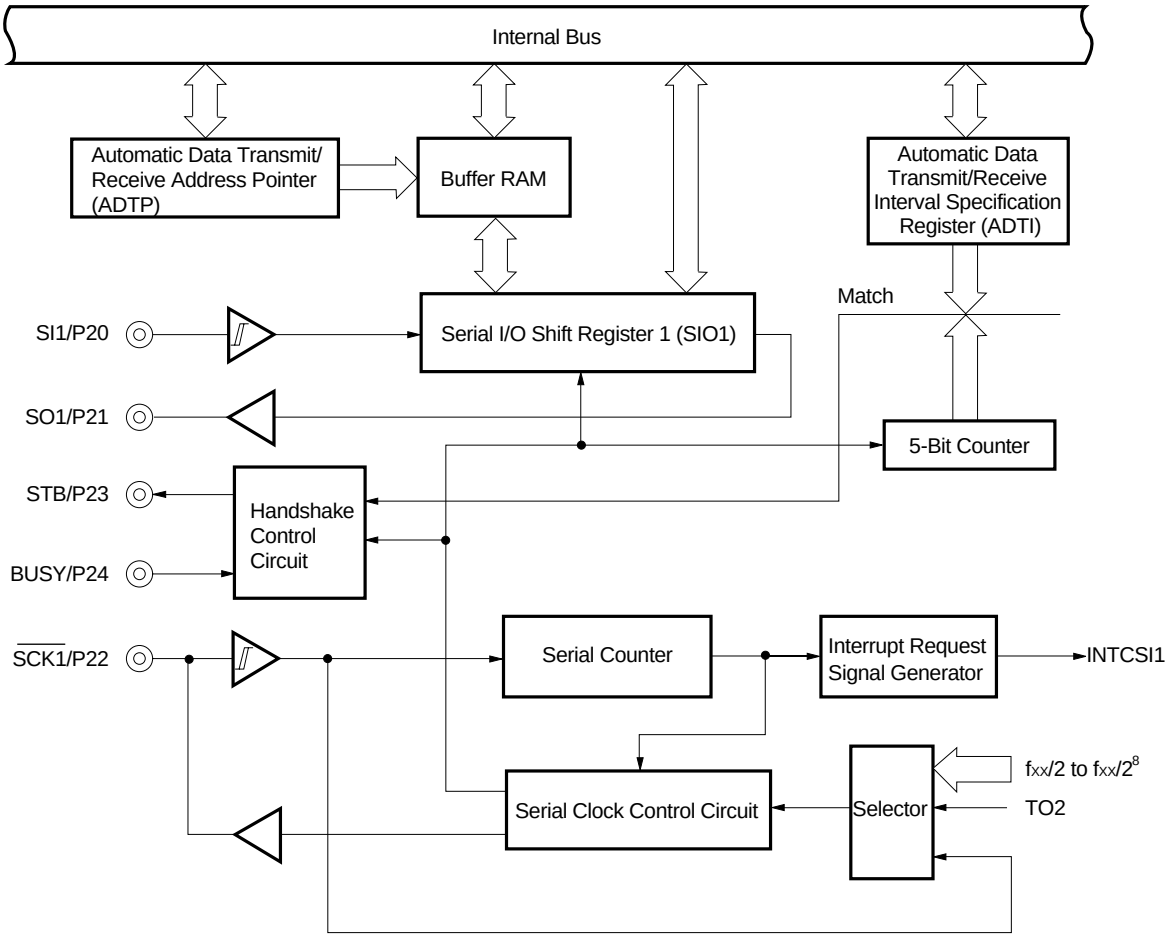
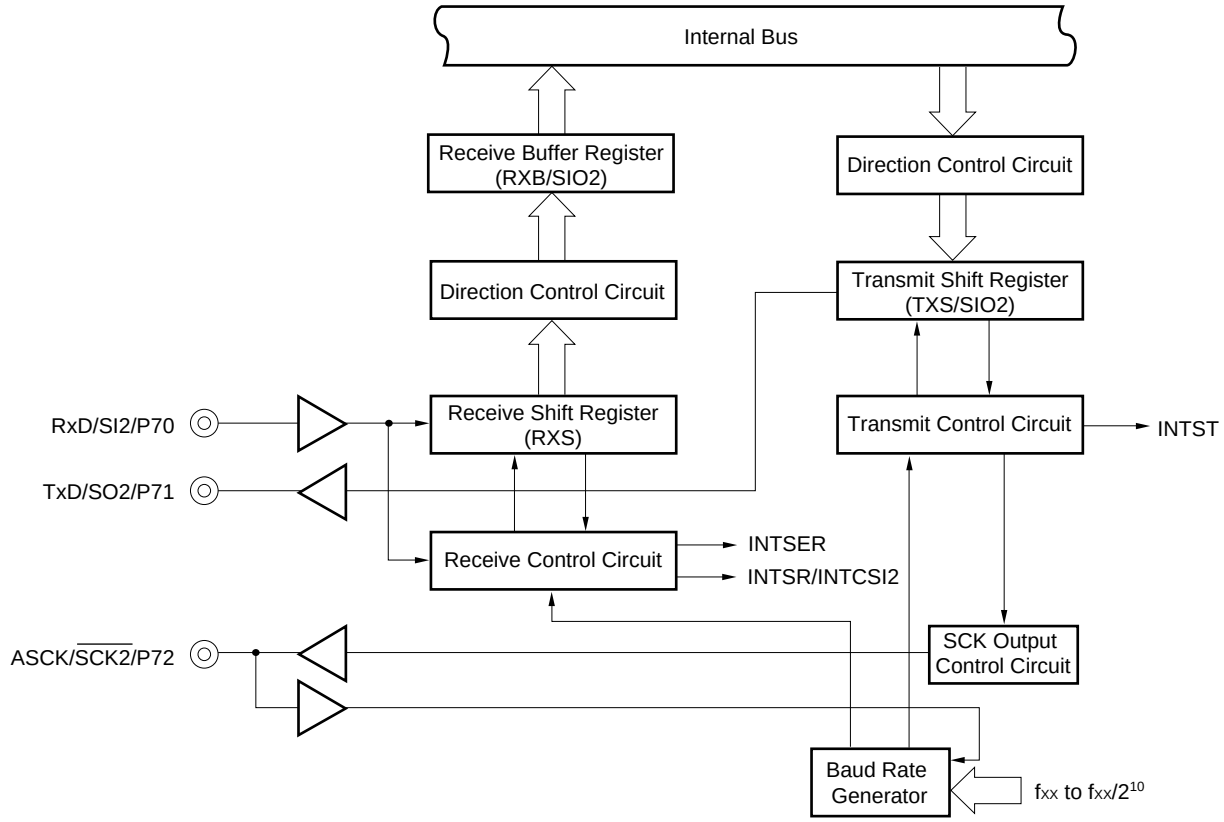


Figure 5-12. Serial Interface Channel 2 Block Diagram

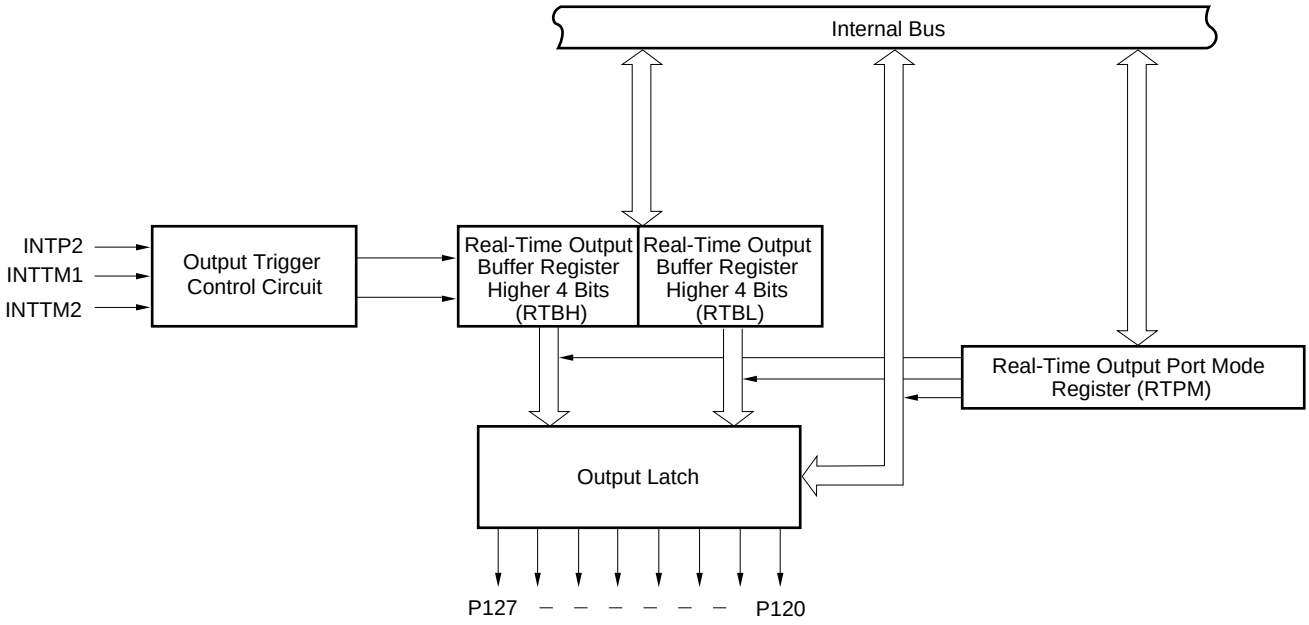


5.9 Real-Time Output Port Functions

The real-time output function consists in transferring data set previously in the real-time output buffer register to the output latch by hardware concurrently with a timer interrupt request or external interrupt request generation in order to output to off-chip. Pins used 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 motors, etc.

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



6. INTERRUPT FUNCTIONS AND TEST FUNCTIONS

6.1 Interrupt Functions

There are 22 interrupt functions of three different types, as shown below.

- Non-maskable : 1
- Maskable : 20
- Software : 1

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

Interrupt Type	Default Priority[Note 1]	Interrupt Source		Internal/ External	Vector Table Address	Basic Configuration Type[Note 2]
		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)			(B)
	1	INTP0	Pin input edge detection	External	0006H	(C)
	2	INTP1			0008H	(D)
	3	INTP2			000AH	
	4	INTP3			000CH	
	5	INTP4			000EH	
	6	INTP5			0010H	
	7	INTP6			0012H	
	8	INTCSI0	End of serial interface channel 0 transfer	Internal	0014H	(B)
	9	INTCSI1	End of serial interface channel 1 transfer		0016H	
	10	INTSER	Generation of serial interface channel 2 UART receive error		0018H	
	11	INTSR	End of serial interface channel 2 UART reception		001AH	
		INTCSI2	End of serial interface channel 2 3-wire transfer			
	12	INTST	End of serial interface channel 2 UART transmission		001CH	

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 18, the lowest.

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

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

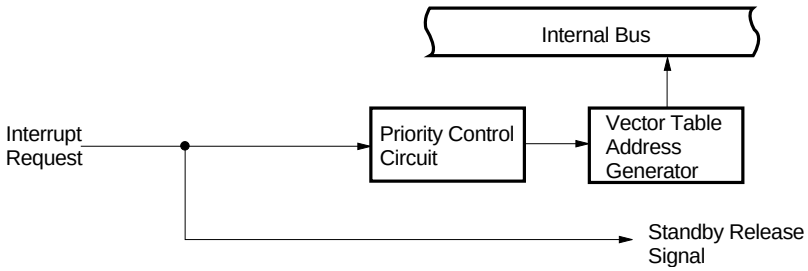
Interrupt Type	Default Priority[Note 1]	Interrupt Source		Internal/ External	Vector Table Address	Basic Configuration Type[Note 2]
		Name	Trigger			
Maskable	13	INTTM3	Reference time interval signal from watch timer	Internal	001EH	(B)
	14	INTTM00	Generation of match signal of 16-bit timer register and capture/compare register (CR00)		0020H	
	15	INTTM01	Generation of match signal of 16-bit timer register and capture/compare register (CR01)		0022H	
	16	INTTM1	Generation of match signal of 8-bit timer/event counter 1		0024H	
	17	INTTM2	Generation of match signal of 8-bit timer/event counter 2		0026H	
	18	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 18, the lowest.

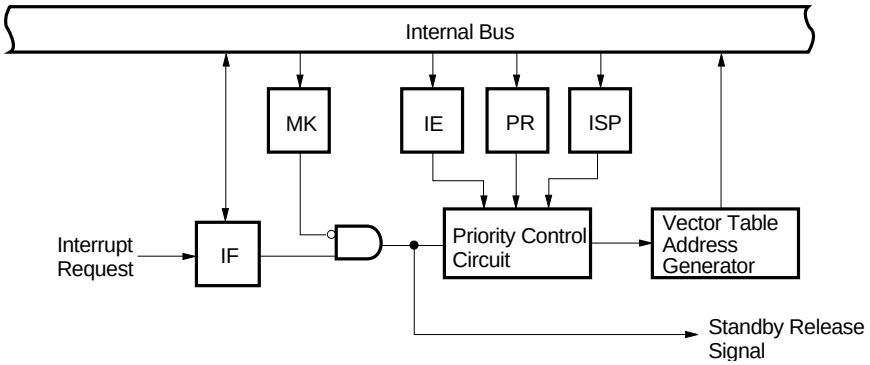
2. Basic configuration types (A) to (E) correspond to (A) to (E) in Figure 6-1, respectively.

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

(A) Internal non-maskable interrupt



(B) Internal maskable interrupt



(C) External maskable interrupt (INTP0)

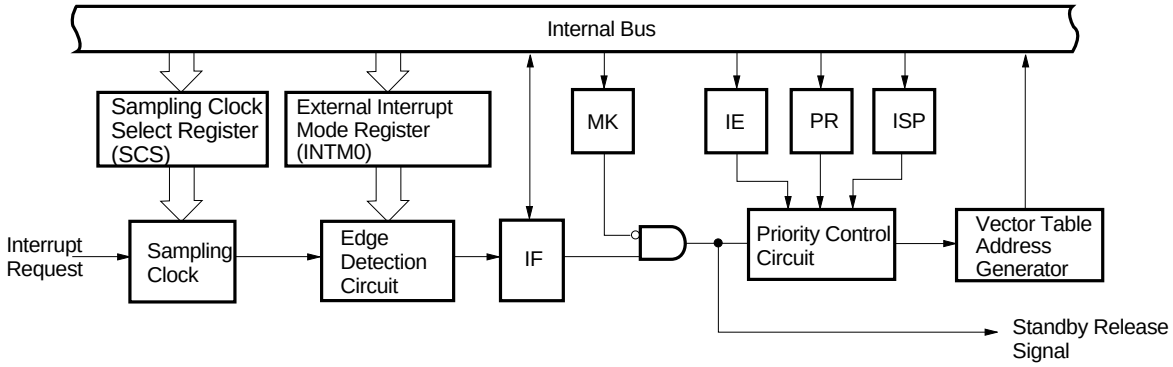
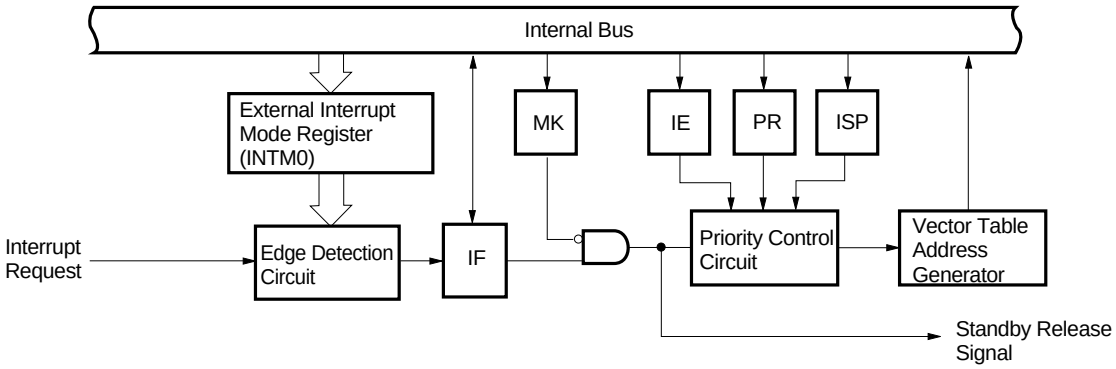
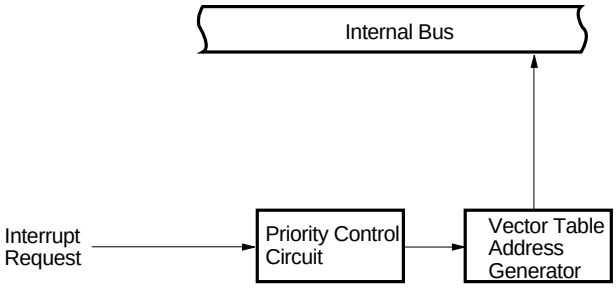


Figure 6-1. Interrupt Function Basic Configuration(2/2)

(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

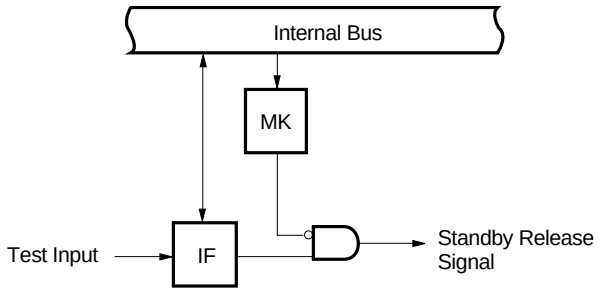
6.2 Test Functions

There are two sources of test function 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

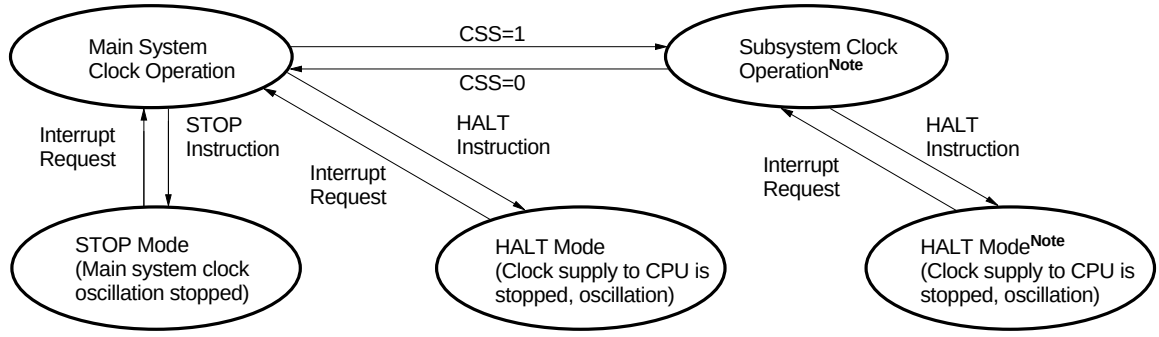
The external device expansion functions connect external devices to areas other than the internal ROM, RAM and SFR. Ports 4 to 6 are used for external device connection.

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 consumption current 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. Stand-by Function



Note The power consumption is reduced by stopping the main system clock. When the CPU is operating on the subsystem clock, set bit 7 (MCC) in 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 in the 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 instructions

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

First Operand \ Second Operand	#byte	A	r[Note]	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]		MOV											
[HL]		MOV											ROR4 ROL4
[HL + byte] [HL + B] [HL + C]		MOV											
X													MULU
C													DIVUW

Note Except r = A

(2) 16-bit instructions

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

First instruction \ Second instruction	#word	AX	rp[Note]	sfrp	saddrp	!addr16	SP	None
AX	ADDW SUBW CMPW		MOVW XCHW	MOVW	MOVW	MOVW	MOVW	
rp	MOVW	MOVW[Note]						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 instructions

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

First instruction \ Second instruction	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 instructions

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

First instruction \ Second instruction	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_A = 25°C)

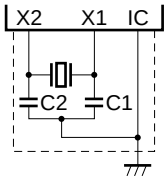
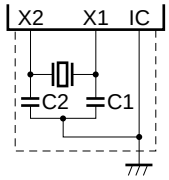
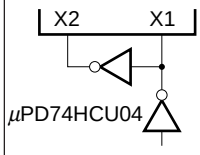
Parameter	Symbol	Test Conditions		Rating	Unit
Supply voltage	V_{DD}			–0.3 to +7.0	V
	AV_{DD}			–0.3 to V_{DD} + 0.3	V
	AV_{REF0}			–0.3 to V_{DD} + 0.3	V
	AV_{REF1}			–0.3 to V_{DD} + 0.3	V
	AV_{SS}			–0.3 to +0.3	V
Input voltage	V_{I1}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67, P70 to P72, P120 to P127, P130, P131, X1, X2, XT2, $\overline{\text{RESET}}$		–0.3 to V_{DD} + 0.3	V
	V_{I2}	P60 to P63	N-ch Open-drain	–0.3 to +16	V
Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
Analog input voltage	V_{AN}	P10 to P17	Analog input pin	AV_{SS} – 0.3 to AV_{REF0} + 0.3	V
High-level output current	I_{OH}	1 pin		–10	mA
		P01 to P06, P30 to P37, P56, P57, P60 to P67, P120 to P127 total		–15	mA
		P10 to P17, P20 to P27, P40 to P47, P50 to P55, P70 to P72, P130, P131 total		–15	mA
Low-level output current	I_{OL}[Note]	1 pin	Peak value	30	mA
			Effective value	15	mA
		P50 to P55 total	Peak value	100	mA
			Effective value	70	mA
		P56, P57, P60 to P63 total	Peak value	100	mA
			Effective value	70	mA
		P10 to P17, P20 to P27, P40 to P47, P70 to P72, P130, P131 total	Peak value	50	mA
			Effective value	20	mA
		P01 to P06, P30 to P37, P64 to P67, P120 to P127 total	Peak value	50	mA
			Effective value	20	mA
Operating ambient temperature	T_A			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

Note Effective value should be calculated as follows: [Effective value] = [Peak value] × $\sqrt{\text{duty}}$

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 that ensure that the absolute maximum ratings are not exceeded.

Remark Unless specified otherwise, alternate pin characteristics are the same as port pin characteristics.

Main System Clock Oscillation Circuit Characteristics (T_A = –40 to 85°C, V_{DD} = 2.7 to 6.0 V)

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillator frequency (f_X)Note 1	V_{DD} = Oscillator voltage range	1.0		5.0	MHz
		Oscillation stabilization timeNote 2	After V_{DD} reaches oscillator voltage range MIN.			4	ms
Crystal resonator		Oscillator frequency (f_X)Note 1		1.0		5.0	MHz
		Oscillation stabilization timeNote 2	V_{DD} = 4.5 to 6.0 V			10	ms
						30	
External clock		X1 input frequency (f_X)Note 1		1.0		5.0	MHz
		X1 input high/low level width (t_{XH}, t_{XL})		85		500	ns

Notes 1. Indicates only oscillation circuit characteristics. Refer to "**AC CHARACTERISTICS**" for instruction execution time.

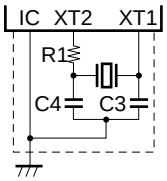
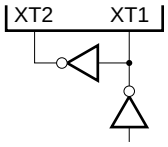
2. Time required to stabilize oscillation after reset or STOP mode release.

Cautions 1. When using the main system clock oscillator, wiring in the area enclosed with the broken line in the above figures 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_{SS}.**
- **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 by the program.

Subsystem Clock Oscillation Circuit Characteristics (T_A = –40 to +85°C, V_{DD} = 2.7 to 6.0 V)

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillator frequency (f_{XT})Note 1		32	32.768	35	kHz
		Oscillation stabilization time Note 2	V_{DD} = 4.5 to 6.0 V		1.2	2	s
						10	
External clock		XT1 input frequency (f_{XT})Note 1		32		100	kHz
		XT1 input high/low level width (t_{XTH}, t_{XTL})		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_{DD} reaches MIN. oscillating voltage frequency.

Cautions 1. When using the subsystem clock oscillator, wiring in the area enclosed with the broken line in the above figures 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_{SS}.**
- **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 oscillator is a low-amplitude circuit in order to achieve a low consumption current, and is more prone to mulfunction due to noise than the main system clock oscillator. Particular care is therefore required with the wiring method when the subsystem clock is used.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input capacitance	C_{IN}	f = 1 MHz Unmeasured pins returned to 0 V.				15	pF
Input/Output	C_{IO}	f = 1 MHz Unmeasured pins returned to 0 V.	P01 to P06, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67, P70 to P72, P120 to P127, P130, P131			15	pF
			P60 to P63			20	pF

Remark Unless otherwise specified, alternate pin characteristics are the same as port pin characteristics.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input voltage, high	V_{IH1}	P10 to P17, P21, P23, P30 to P32, P35 to P37, P40 to P47, P50 to P57, P64 to P67, P71, P120 to P127, P130, P131		0.7 V_{DD}		V_{DD}	V
	V_{IH2}	P00 to P06, P20, P22, P24 to P27, P33, P34, P70, P72, $\overline{\text{RESET}}$		0.8 V_{DD}		V_{DD}	V
	V_{IH3}	P60 to P63 (N-ch Open-drain)		0.7 V_{DD}		15	V
	V_{IH4}	X1, X2		V_{DD} – 0.5		V_{DD}	V
	V_{IH5}	XT1/P07, XT2	V_{DD} = 4.5 to 6.0 V	0.8 V_{DD}		V_{DD}	V
				0.9 V_{DD}		V_{DD}	V
Input voltage, low	V_{IL1}	P10 to P17, P21, P23, P30 to P32, P35 to P37, P40 to P47, P50 to P57, P64 to P67, P71, P120 to P127, P130, P131		0		0.3 V_{DD}	V
	V_{IL2}	P00 to P06, P20, P22, P24 to P27, P33, P34, P70, P72, $\overline{\text{RESET}}$		0		0.2 V_{DD}	V
	V_{IL3}	P60 to P63	V_{DD} = 4.5 to 6.0 V	0		0.3 V_{DD}	V
				0		0.2 V_{DD}	V
	V_{IL4}	X1, X2		0		0.4	V
	V_{IL5}	XT1/P07, XT2	V_{DD} = 4.5 to 6.0 V	0		0.2 V_{DD}	V
				0		0.1 V_{DD}	V
Output voltage, high	V_{OH}	V_{DD} = 4.5 to 6.0 V, I_{OH} = –1 mA		V_{DD} – 1.0			V
		I_{OH} = –100 μA		V_{DD} – 0.5			V
Output voltage, low	V_{OL1}	P50 to P57, P60 to P63	V_{DD} = 4.5 to 6.0 V, I_{OL} = 15 mA		0.4	2.0	V
		P01 to P06, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P64 to P67, P70 to P72, P120 to P127, P130, P131	V_{DD} = 4.5 to 6.0 V, I_{OL} = 1.6 mA			0.4	V
	V_{OL2}	SB0, SB1, $\overline{\text{SCK0}}$	V_{DD} = 4.5 to 6.0 V, N-ch open-drain at pull-up time (R = 1 KΩ)			0.2 V_{DD}	V
	V_{OL3}	I_{OL} = 400 μA				0.5	V
Input leakage current, high	I_{LIH1}	V_{IN} = V_{DD}	P00 to P06, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P60 to P67, P70 to P72, P120 to P127, P130, P131, $\overline{\text{RESET}}$			3	μA
	I_{LIH2}		X1, X2, XT1/P07, XT2			20	μA
	I_{LIH3}	V_{IN} = 15 V	P60 to P63			80	μA

Remark Unless specified otherwise, alternate pin characteristics are the same as port pin characteristics.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input leakage current, low	I_{LIL1}	V_{IN} = 0 V	P00 to P06, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67, P70 to P72, P120 to P127, P130, P131, $\overline{\text{RESET}}$			–3	μA
	I_{LIL2}		X1, X2, XT1/P07, XT2			–20	μA
	I_{LIL3}		P60 to P63			–3[Note]	μA
Output leakage current, high	I_{LOH}	V_{OUT} = V_{DD}				3	μA
Output leakage current, low	I_{LOL}	V_{OUT} = 0 V				–3	μA
Mask option pull-up resistor	R_1	V_{IN} = 0 V, P60 to P63		20	40	90	kΩ
Software pull-up resistor	R_2	V_{IN} = 0 V, P01 to P06, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67, P70 to P72, P120 to P127, P130, P131	V_{DD} = 4.5 V to 6.0 V	15	40	90	kΩ
				20		500	kΩ

Note When the pull-up resistor is not included in P60 to P63 (specified by a mask option), the –200 μA (MAX.) low-level input leakage current is passed only at the 1.5 clock interval (no wait) when the read instruction to port 6 (PM6) and port mode register (PM6) is executed. At other than the 1.5 interval, –3 μA (MAX.) is passed.

Remark Unless specified otherwise, alternate pin characteristics are the same as port pin characteristics.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Power supply current[Note 1]	I_{DD1}	5.0-MHz Crystal oscillation operating mode (f_{XX} = 2.5 MHz)[Note 2]	V_{DD} = 5.0 V ±10 %[Note 5]		4	12	mA
			V_{DD} = 3.0 V ±10 %[Note 6]		0.6	1.8	mA
		5.0-MHz Crystal oscillation operating mode (f_{XX} = 5.0 MHz)[Note 3]	V_{DD} = 5.0 V ±10 %[Note 5]		6.5	19.5	mA
			V_{DD} = 3.0 V ±10 %[Note 6]		0.8	2.4	mA
	I_{DD2}	5.0-MHz Crystal oscillation HALT mode (f_{XX} = 2.5 MHz)[Note 2]	V_{DD} = 5.0 V ±10 %		1.4	4.2	mA
			V_{DD} = 3.0 V ±10 %		0.5	1.5	mA
		5.0-MHz Crystal oscillation HALT mode (f_{XX} = 5.0 MHz)[Note 3]	V_{DD} = 5.0 V ±10 %		1.6	4.8	mA
			V_{DD} = 3.0 V ±10 %		0.65	1.95	mA
	I_{DD3}	32.768-kHz Crystal oscillation operating mode[Note 4]	V_{DD} = 5.0 V ±10 %		60	120	μA
			V_{DD} = 3.0 V ±10 %		32	64	μA
	I_{DD4}	32.768-kHz Crystal oscillation HALT mode[Note 4]	V_{DD} = 5.0 V ±10 %		25	55	μA
			V_{DD} = 3.0 V ±10 %		5	15	μA
	I_{DD5}	XT1 = V_{DD} STOP mode When feedback resistor is used	V_{DD} = 5.0 V ±10 %		1	30	μA
			V_{DD} = 3.0 V ±10 %		0.5	10	μA
	I_{DD6}	XT1 = V_{DD} STOP mode When feedback resistor is not used	V_{DD} = 5.0 V ±10 %		0.1	30	μA
			V_{DD} = 3.0 V ±10 %		0.05	10	μA

Notes 1. Passed through the V_{DD} and AV_{DD} pins. Does not include the current which is passed through the A/D converter, D/A converter, and on-chip pull-up resistor.

2. Main system clock $f_{XX} = f_X/2$ operation (when an oscillation mode selection register (OSMS) is set to 00H)

3. Main system clock $f_{XX} = f_X$ operation (when the OSMS is set to 01H)

4. When the operation of the main system clock is stopped

5. High-speed mode operation (when a processor clock control register (PCC) is set to 00H)

6. Low-speed mode operation (when the PCC is set to 04H)

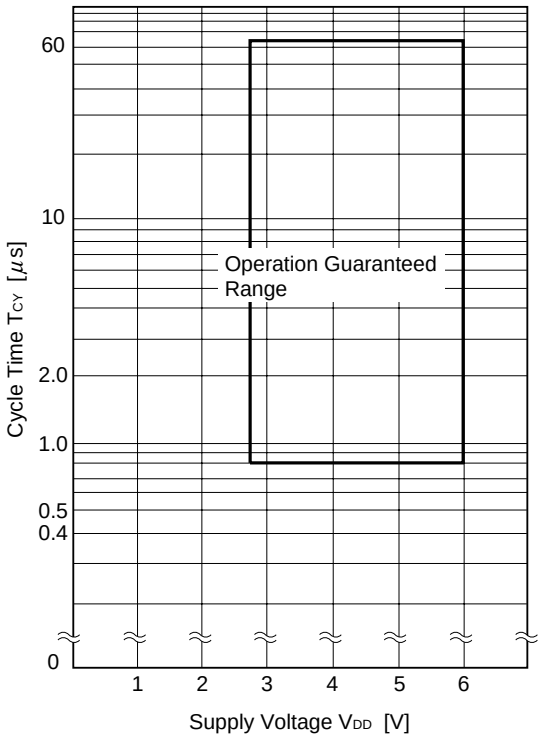
AC CHARACTERISTICS

(1) Basic Operation (T_A = –40 to +85°C, V_{DD} = 2.7 to 6.0 V)

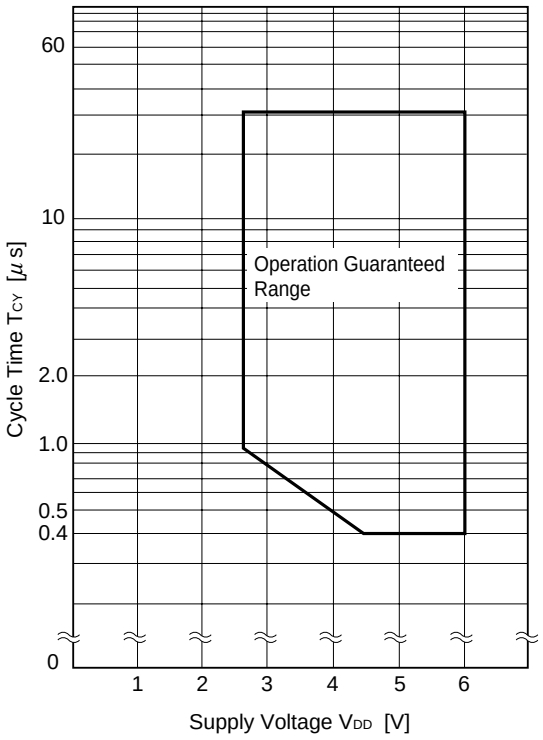
Parameter	Symbol	Test Conditions			MIN.	TYP.	MAX.	Unit
Cycle time (Min. instruction execution time)	T_{CY}	Operating on main system clock	$f_{XX} = f_X/2$ Note 1		0.8		64	μs
			$f_{XX} = f_X$ Note 2	V_{DD} = 4.5 to 6.0 V	0.4		32	μs
					0.8		32	μs
		Operating on subsystem clock			40 Note 3	122	125	μs
TI00 input high/low-level width	t_{TIH00}, t_{TIL00}	V_{DD} = 4.5 to 6.0 V			$2/f_{sam}$ + 0.1 Note 4			μs
					$2/f_{sam}$ + 0.2 Note 4			μs
TI01 input high/low-level width	t_{TIH01}, t_{TIL01}				10			μs
TI1, TI2 input frequency	f_{TI1}	V_{DD} = 4.5 to 6.0 V			0		4	MHz
					0		275	kHz
TI1, TI2 input high/low-level width	t_{TIH1}, t_{TIL1}	V_{DD} = 4.5 to 6.0 V			100			ns
					1.8			μs
Interrupt request input high/low-level width	t_{INTH}, t_{INTL}	INTP0		V_{DD} = 4.5 to 6.0 V	$2/f_{sam}$ + 0.1 Note 4			μs
					$2/f_{sam}$ + 0.2 Note 4			μs
		INTP1 to INTP6, KR0 to KR7			10			μs
$\overline{\text{RESET}}$ low level width	t_{RSL}				10			μs

Notes
1. When the operation of the main system clock $f_{XX} = f_X/2$ (When oscillation mode selection register is set to 00H)
2. When the operation of the main system clock $f_{XX} = f_X$ (When oscillation mode selection register is set to 01H)
3. Value when the external clock is used. 114 μs (MIN.) when a crystal resonator is used.
4. Selection of f_{sam} is possible between $f_{XX}/2^N$, $f_{XX}/32$, $f_{XX}/64$ and $f_{XX}/128$ (when N = 0 to 4) using bits 0 (SCS0) and 1 (SCS1) of sampling clock select register (SCS).

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_A = –40 to +85°C, V_{DD} = 4.5 to 6.0 V)

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

Remarks 1. MCS: Oscillation mode selection register bit 0

2. PCC2 to PCC0: Processor clock control register (PCC) bits 2 to 0

3. $t_{CY} = T_{CY}/4$

4. n indicates the number of waits.

(b) When except MCS = 1, PCC2 to PCC0 = 000B (T_A = –40 to +85°C, V_{DD} = 2.7 to 6.0 V)

Parameter	Symbol	Test Conditions	MIN.	MAX.	Unit
ASTB high-level width	t_{ASTH}		t_{CY} – 80		ns
Address setup time	t_{ADS}		t_{CY} – 80		ns
Address hold time	t_{ADH}		0.4t_{CY} – 10		ns
Data input time from address	t_{ADD1}			(3 + 2n)t_{CY} – 160	ns
	t_{ADD2}			(4 + 2n)t_{CY} – 200	ns
Data input time from $\overline{RD}$↓	t_{RDD1}			(1.4 + 2n)t_{CY} – 70	ns
	t_{RDD2}			(2.4 + 2n)t_{CY} – 70	ns
Read data hold time	t_{RDH}		0		ns
$\overline{RD}$ low-level width	t_{RDL1}		(1.4 + 2n)t_{CY} – 20		ns
	t_{RDL2}		(2.4 + 2n)t_{CY} – 20		ns
$\overline{WAIT}$↓ input time from $\overline{RD}$↓	t_{RDWT1}			t_{CY} – 100	ns
	t_{RDWT2}			2t_{CY} – 100	ns
$\overline{WAIT}$↓ input time from $\overline{WR}$↓	t_{WRWT}			2t_{CY} – 100	ns
$\overline{WAIT}$ low-level width	t_{WTL}		(1 + 2n)t_{CY}	(2 + 2n)t_{CY}	ns
Write data setup time	t_{WDS}		(2.4 + 2n)t_{CY} – 60		ns
Write data hold time	t_{WDH}		20		ns
$\overline{WR}$ low-level width	t_{WRL}		(2.4 + 2n)t_{CY} – 60		ns
$\overline{RD}$↓ delay time from ASTB↓	t_{ASTRD}		0.4t_{CY} – 30		ns
$\overline{WR}$↓ delay time from ASTB↓	t_{ASTWR}		1.4t_{CY} – 30		ns
ASTB↑ delay time from $\overline{RD}$↑ in external fetch	t_{RDAST}		t_{CY} – 10	t_{CY} + 20	ns
Address hold time from $\overline{RD}$↑ in external fetch	t_{RDADH}		t_{CY} – 50	t_{CY} + 50	ns
Write data output time from $\overline{RD}$↑	t_{RDWD}		0.4t_{CY} – 20		ns
Write data output time from $\overline{WR}$↓	t_{RDWD}		0	60	ns
Address hold time from $\overline{WR}$↑	t_{WRADH}		t_{CY}	t_{CY} + 60	ns
$\overline{RD}$↑ delay time from $\overline{WAIT}$↑	t_{WTRD}		0.6t_{CY} + 180	2.6t_{CY} + 180	ns
$\overline{WR}$↑ delay time from $\overline{WAIT}$↑	t_{WTWR}		0.6t_{CY} + 120	2.6t_{CY} + 120	ns

Remarks 1. MCS: Oscillation mode selection register (OSMS) bit 0

2. PCC2 to PCC0: Processor clock control register (PCC) bits 2 to 0

3. $t_{CY} = T_{CY}/4$

4. n indicates the number of waits.

(3) Serial Interface (T_A = –40 to +85°C, V_{DD} = 2.7 to 6.0 V)

(a) Serial interface channel 0

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

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY1}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK0}$ high/low-level width	t_{KH1}, t_{KL1}	V_{DD} = 4.5 to 6.0 V	$t_{KCY1}/2$ – 50			ns
			$t_{KCY1}/2$ – 100			ns
SI0 setup time (to $\overline{SCK0}$↑)	t_{SIK1}	V_{DD} = 4.5 to 6.0 V	100			ns
			150			ns
SI0 hold time (from $\overline{SCK0}$↑)	t_{KSI1}		400			ns
SO0 output delay time from $\overline{SCK0}$↓	t_{KSO1}	C = 100 pF Note			300	ns

Note C is the load capacitance of the $\overline{SCK0}$ and SO0 output lines.

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

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY2}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK0}$ high/low-level width	t_{KH2}, t_{KL2}	V_{DD} = 4.5 to 6.0 V	400			ns
			800			ns
SI0 setup time (to $\overline{SCK0}$↑)	t_{SIK2}		100			ns
SI0 hold time (from $\overline{SCK0}$↑)	t_{KSI2}		400			ns
SO0 output delay time from $\overline{SCK0}$↓	t_{KSO2}	C = 100 pF Note			300	ns
$\overline{SCK0}$ rise, fall time	t_{R2}, t_{F2}	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 SO0 output line.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY3}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK0}$ high/low-level width	t_{KH3}, t_{KL3}	V_{DD} = 4.5 to 6.0 V		$t_{KCY3}/2 - 50$			ns
				$t_{KCY3}/2 - 150$			ns
SB0, SB1 setup time (to $\overline{SCK0}$↑)	t_{SIK3}	V_{DD} = 4.5 to 6.0 V		100			ns
				300			ns
SB0, SB1 hold time (from $\overline{SCK0}$↑)	t_{KSI3}			$t_{KCY3}/2$			ns
SB0, SB1 output delay time from $\overline{SCK0}$↓	t_{KSO3}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		250	ns
				0		1000	ns
SB0, SB1↓ from $\overline{SCK0}$↑	t_{KSB}			t_{KCY3}			ns
$\overline{SCK0}$↓ from SB0, SB1↓	t_{SBK}			t_{KCY3}			ns
SB0, SB1 high-level width	t_{SBH}			t_{KCY3}			ns
SB0, SB1 low-level width	t_{SBL}			t_{KCY3}			ns

Note R and C are the load resistance and load capacitance of the $\overline{SCK0}$, SB0, and SB1 output lines.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY4}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK0}$ high/low-level width	t_{KH4}, t_{KL4}	V_{DD} = 4.5 to 6.0 V		400			ns
				1600			ns
SB0, SB1 setup time (to $\overline{SCK0}$↑)	t_{SIK4}	V_{DD} = 4.5 to 6.0 V		100			ns
				300			ns
SB0, SB1 hold time (from $\overline{SCK0}$↑)	t_{KSI4}			t_{KCY4}/2			ns
SB0, SB1 output delay time from $\overline{SCK0}$↓	t_{KSO4}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		300	ns
				0		1000	ns
SB0, SB1↓ from $\overline{SCK0}$↑	t_{KSB}			t_{KCY4}			ns
$\overline{SCK0}$↓ from SB0, SB1↓	t_{SBK}			t_{KCY4}			ns
SB0, SB1 high-level width	t_{SBH}			t_{KCY4}			ns
SB0, SB1 low-level width	t_{SBL}			t_{KCY4}			ns
$\overline{SCK0}$ rise, fall time	t_{R4}, t_{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 resistance and load capacitance of the SB0 and SB1 output lines.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY5}	R = 1 kΩ, C = 100 pF[Note]		800			ns
$\overline{SCK0}$ high-level width	t_{KH5}			$t_{KCY5}/2 - 160$			ns
$\overline{SCK0}$ low-level width	t_{KL5}		V_{DD} = 4.5 to 6.0 V	$t_{KCY5}/2 - 50$			ns
				$t_{KCY5}/2 - 150$			ns
SB0, SB1 setup time (to $\overline{SCK0}$↑)	t_{SIK5}		V_{DD} = 4.5 to 6.0 V	300			ns
				350			ns
SB0, SB1 hold time (from $\overline{SCK0}$↑)	t_{KSI5}			600			ns
SB0, SB1 output delay time from $\overline{SCK0}$↓	t_{KSO5}			0		300	ns

Note R and C are the load resistance and load capacitance of the $\overline{SCK0}$, SB0, and SB1 output lines.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK0}$ cycle time	t_{KCY6}			1600			ns
$\overline{SCK0}$ high-level width	t_{KH6}			650			ns
$\overline{SCK0}$ low-level width	t_{KL6}			800			ns
SB0, SB1 setup time (to $\overline{SCK0}$↑)	t_{SIK6}			100			ns
SB0, SB1 hold time (from $\overline{SCK0}$↑)	t_{KSI6}			$t_{KCY6}/2$			ns
SB0, SB1 output delay time from $\overline{SCK0}$↓	t_{KSO6}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		300	ns
				0		500	ns
$\overline{SCK0}$ rise, fall time	t_{R6}, t_{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 resistance and load capacitance of the SB0 and SB1 output lines.

(b) Serial interface channel 1

(i) 3-wire serial I/O mode ($\overline{SCK1}$...Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK1}$ cycle time	t_{KCY7}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK1}$ high/low-level width	t_{KH7}, t_{KL7}	V_{DD} = 4.5 to 6.0 V	$t_{KCY7}/2 - 50$			ns
			$t_{KCY7}/2 - 100$			ns
SI1 setup time (to $\overline{SCK1}\uparrow$)	t_{SIK7}	V_{DD} = 4.5 to 6.0 V	100			ns
			150			ns
SI1 hold time (from $\overline{SCK1}\uparrow$)	t_{KSI7}		400			ns
SO1 output delay time from $\overline{SCK1}\downarrow$	t_{KSO7}	C = 100 pF Note			300	ns

Note C is the load capacitance of the $\overline{SCK1}$ and SO1 output line.

(ii) 3-wire serial I/O mode ($\overline{SCK1}$...External clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK1}$ cycle time	t_{KCY8}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK1}$ high/low-level width	t_{KH8}, t_{KL8}	V_{DD} = 4.5 to 6.0 V	400			ns
			800			ns
SI1 setup time (to $\overline{SCK1}\uparrow$)	t_{SIK8}		100			ns
SI1 hold time (from $\overline{SCK1}\uparrow$)	t_{KSI8}		400			ns
SO1 output delay time from $\overline{SCK1}\downarrow$	t_{KSO8}	C = 100 pF Note			300	ns
$\overline{SCK1}$ rise, fall time	t_{R8}, t_{F8}	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 ($\overline{SCK1}$... Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK1}$ cycle time	t_{KCY9}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK1}$ high/low-level width	t_{KH9}, t_{KL9}	V_{DD} = 4.5 to 6.0 V	$t_{KCY9}/2 - 50$			ns
			$t_{KCY9}/2 - 100$			ns
SI1 setup time (to $\overline{SCK1}\uparrow$)	t_{SIK9}	V_{DD} = 4.5 to 6.0 V	100			ns
			150			ns
SI1 hold time (from $\overline{SCK1}\uparrow$)	t_{KSI9}		400			ns
SO1 output delay time from $\overline{SCK1}\downarrow$	t_{KSO9}	C = 100 pF [Note]			300	ns
STB$\downarrow$ from $\overline{SCK1}\uparrow$	t_{SBD}		$t_{KCY9}/2 - 100$		$t_{KCY9}/2 + 100$	ns
Strobe signal high-level width	t_{SBW}		$t_{KCY9}/2 - 30$		$t_{KCY9}/2 + 30$	ns
Busy signal setup time (to busy signal detection timing)	t_{BYS}		100			ns
Busy signal hold time (from busy signal detection timing)	t_{BYH}	V_{DD} = 4.5 to 6.0 V	100			ns
			150			ns
$\overline{SCK1}\downarrow$ from busy inactive	t_{SPS}				$2t_{KCY9}$	ns

Note C is the load capacitance of the $\overline{SCK1}$ and SO1 output lines.

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

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK1}$ cycle time	t_{KCY10}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK1}$ high/low-level width	t_{KH10}, t_{KL10}	V_{DD} = 4.5 to 6.0 V	400			ns
			800			ns
SI1 setup time (to $\overline{SCK1}\uparrow$)	t_{SIK10}		100			ns
SI1 hold time (from $\overline{SCK1}\uparrow$)	t_{KSI10}		400			ns
SO1 output delay time from $\overline{SCK1}\downarrow$	t_{KSO10}	C = 100 pF [Note]			300	ns
$\overline{SCK1}$ rise, fall time	t_{R10}, t_{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 ($\overline{SCK2}$...Internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK2}$ cycle time	t_{KCY11}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
$\overline{SCK2}$ high/low-level width	t_{KH11}, t_{KL11}	V_{DD} = 4.5 to 6.0 V	$t_{KCY11}/2 - 50$			ns
			$t_{KCY11}/2 - 100$			ns
SI2 setup time (to $\overline{SCK2}$↑)	t_{SIK11}	V_{DD} = 4.5 to 6.0 V	100			ns
			150			ns
SI2 hold time (from $\overline{SCK2}$↑)	t_{KSI11}		400			ns
SO2 output delay time from $\overline{SCK1}$↓	t_{KSO11}	C = 100 pF Note			300	ns

Note C is the load capacitance of the $\overline{SCK2}$ and SO2 output lines.

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

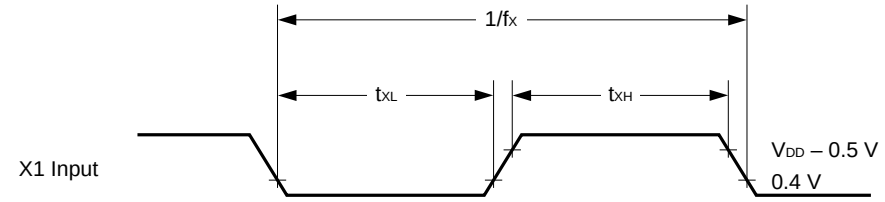
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate		V_{DD} = 4.5 to 6.0 V			78125	bps
					39063	bps

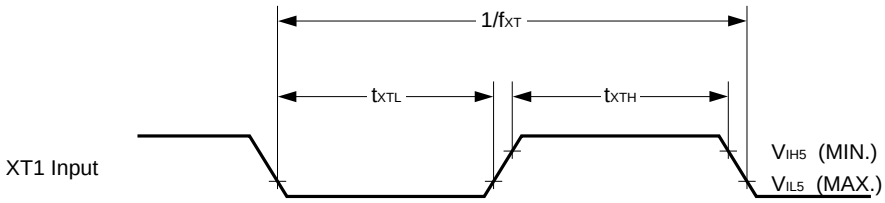
(iii) UART mode (External clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
ASCK cycle time	t_{KCY12}	V_{DD} = 4.5 to 6.0 V	800			ns
			1600			ns
ASCK high-/low-level width	t_{KH12}, t_{KL12}	V_{DD} = 4.5 to 6.0 V	400			ns
			800			ns
Transfer rate		V_{DD} = 4.5 to 6.0 V			39063	bps
					19531	bps
ASCK rise, fall time	t_{R12}, t_{F12}	V_{DD} = 4.5 to 6.0 V When not using external device expansion function			1000	ns
					160	ns

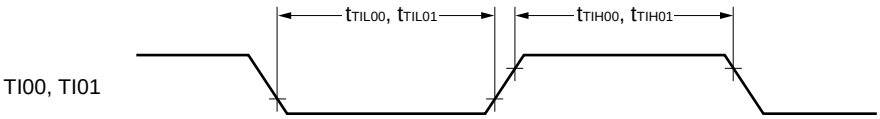
AC Timing Test Point (Excluding X1, XT1 Input)

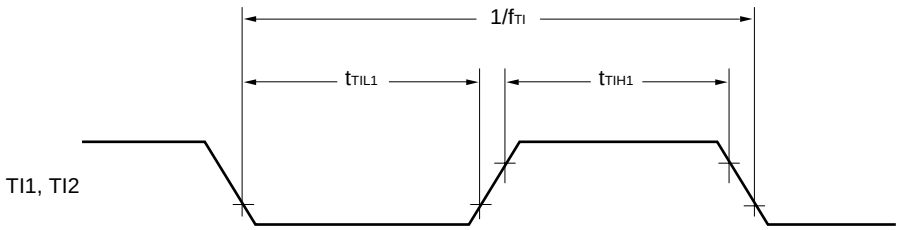
Clock Timing





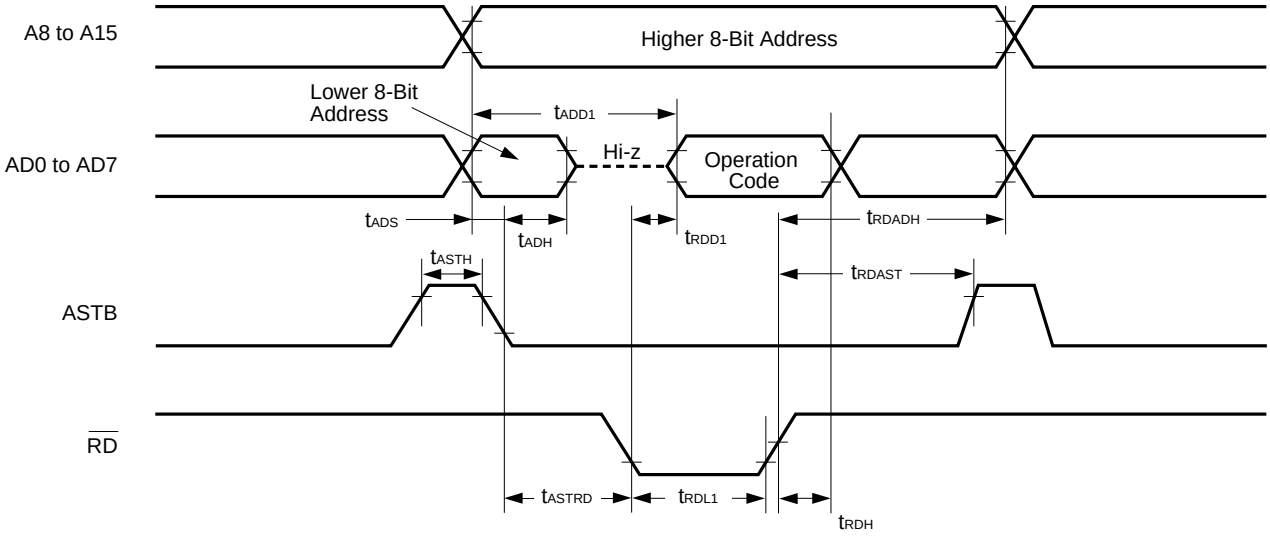
TI Timing



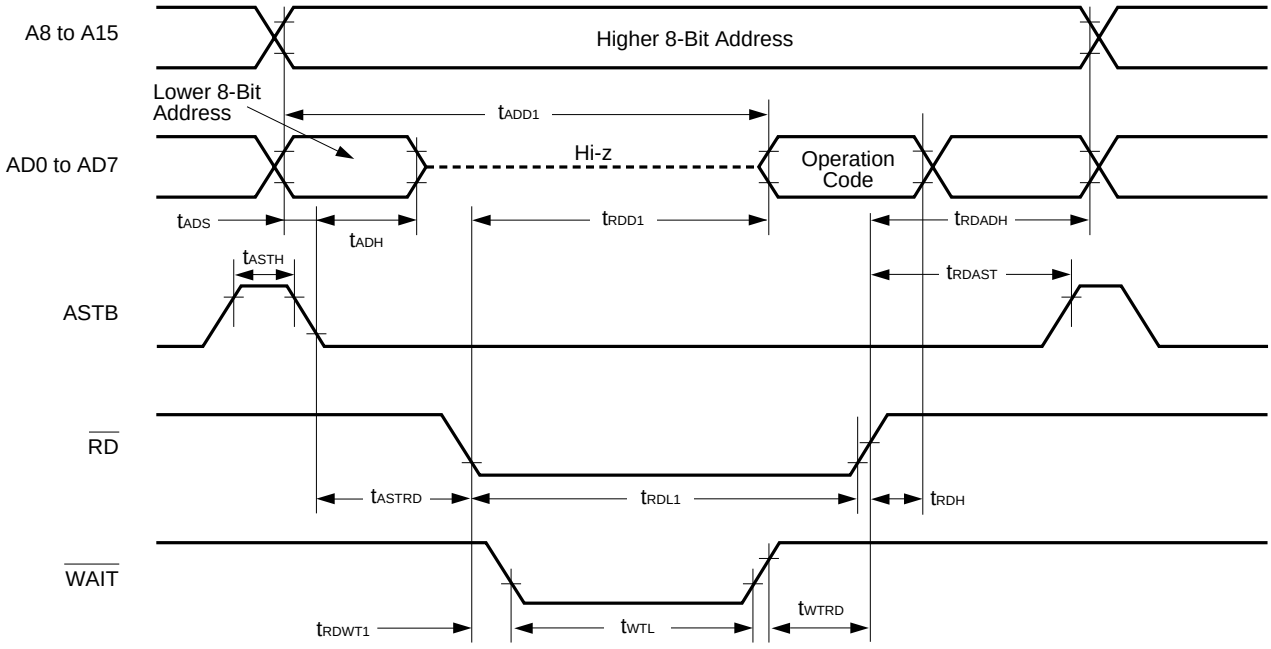


Read/Write Operation

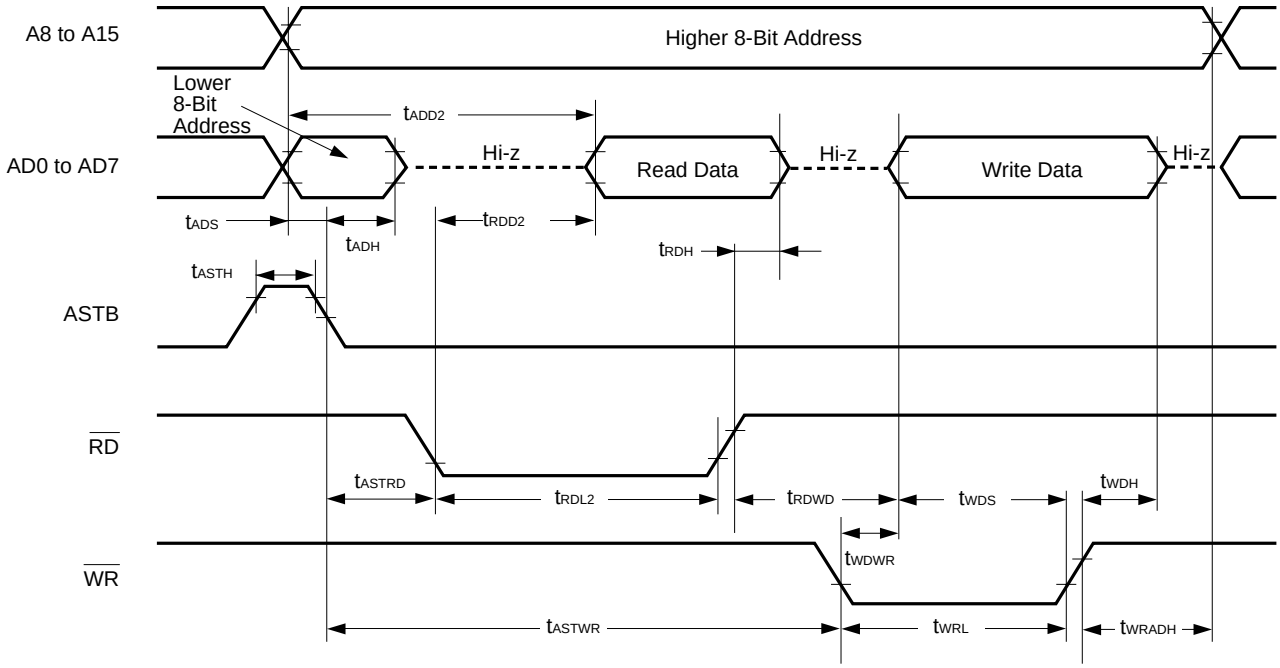
External Fetch (No Wait) :



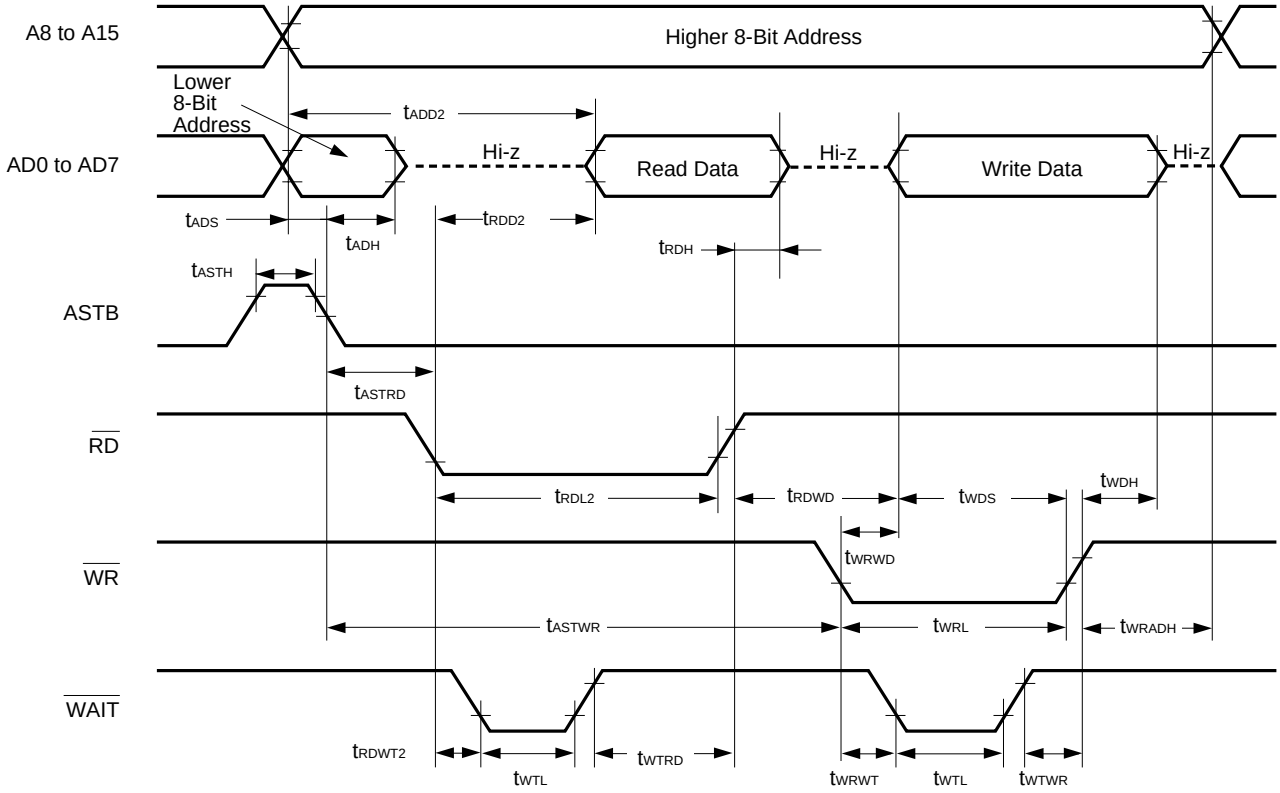
External Fetch (Wait Insertion) :



External Data Access (No Wait) :

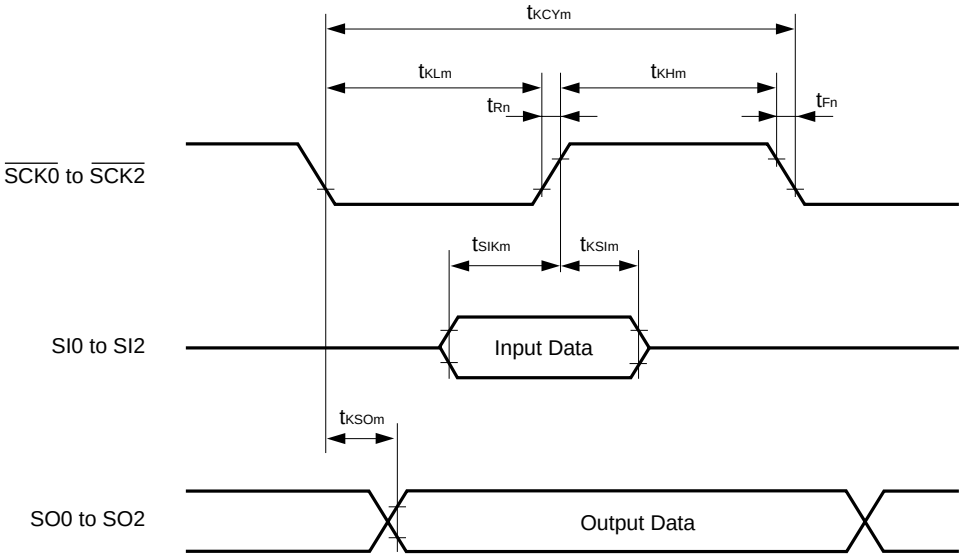


External Data Access (Wait Insertion) :



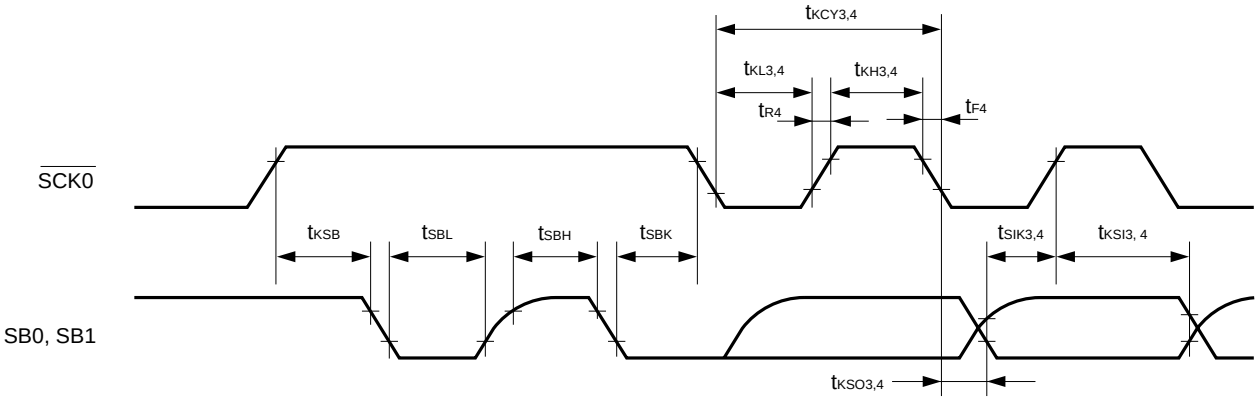
Serial Transfer Timing

3-wire Serial I/O Mode :

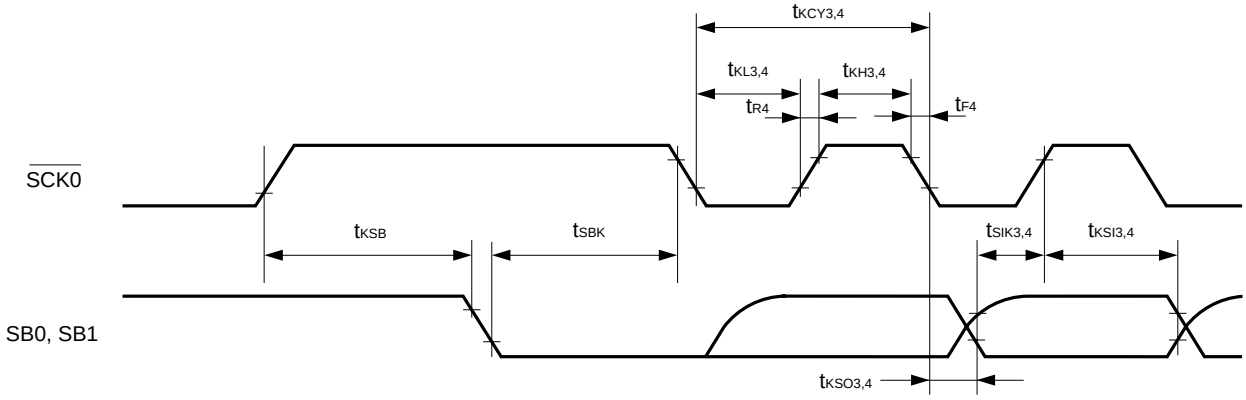


m = 1, 2, 7, 8, 11
n = 2, 8

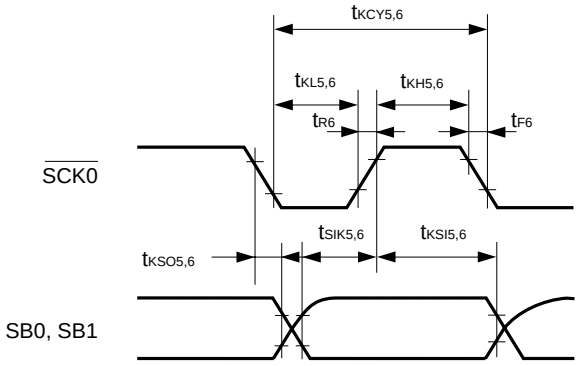
SBI Mode (Bus Release Signal Transfer) :



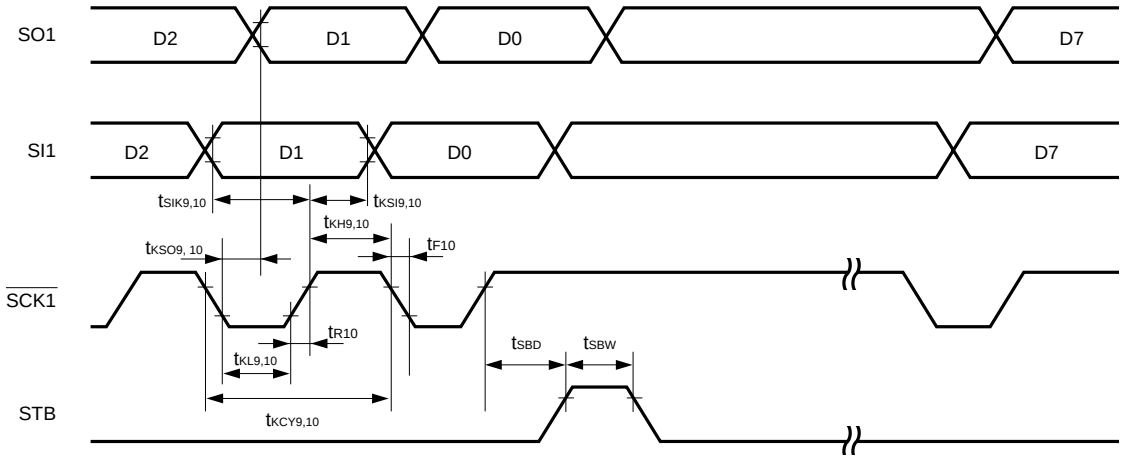
SBI Mode (Command Signal Transfer) :



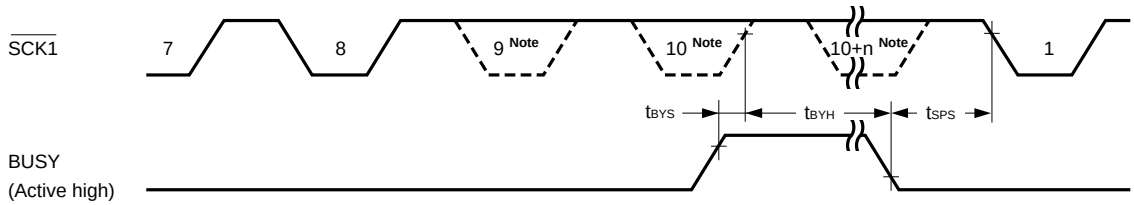
2-wire Serial I/O Mode :



3-wire Serial I/O Mode with Automatic Transmit/Receive Function :

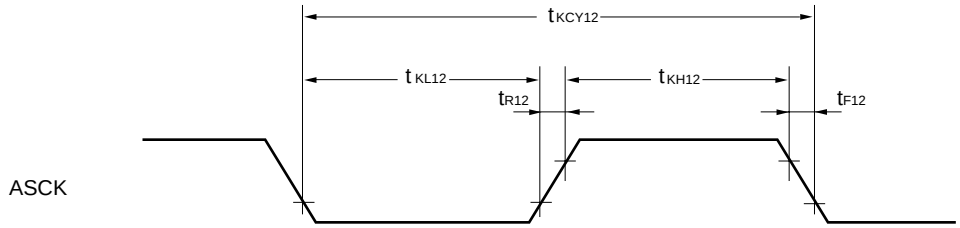


3-wire Serial I/O Mode with Automatic Transmit/Receive Function (Busy processing) :



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, AV_{DD} = V_{DD} = 2.7 to 6.0 V, AV_{SS} = V_{SS} = 0 V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Resolution			8	8	8	bit
Overall error Note		2.7 V ≤ AV_{REF0} ≤ AV_{DD}			±0.6	%
Conversion time	t_{CONV}		19.1		200	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
Resistance between AV_{REF0} and AV_{SS}	R_{AIREF0}		4	14		kΩ

Note Overroll error excluding quantization error (±1/2 LSB). It is indicated as a ratio to the full-scale value.

Caution For pins that also function as port pins (refer to 3.1 Port Pins), do not perform the following operations during A/D conversion. If these operations are performed, the total error ratings cannot be kept (except for LCD segment output alternate-function pin).

(1) Rewrite the output latch while the pin is used as a port pin.

(2) Change the output level of the pin used as an output pin, even if it is not used as a port pin.

Remarks 1. f_{XX}: Main system clock frequency (f_X or f_X/2)

2. f_X: Main system clock oscillation frequency

D/A Converter Characteristics (T_A = –40 to +85°C, V_{DD} = 2.7 to 6.0 V, AV_{SS} = V_{SS} = 0 V)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Resolution						8	bit
Overall error		R = 2 MΩ Note 1				1.2	%
		R = 4 MΩ Note 1				0.8	%
		R = 10 MΩ Note 1				0.6	%
Settling time		C = 30 pF Note 1	4.5 V ≤ AV_{REF1} ≤ 6.0 V			10	μs
			2.7 V ≤ AV_{REF1} < 4.5 V			15	μs
Output resistance	R_O	**Note 2**			10		kΩ
Analog reference voltage	AV_{REF1}			2.0		V_{DD}	V
Resistance between AV_{REF1} and AV_{SS}	R_{AIREF1}	DACS0, DACS1 = 55H Note 2		4	8		kΩ

Notes 1. R and C denote the D/A converter output pin load resistance and load capacitance, respectively.

2. Value for 1 D/A converter channel

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

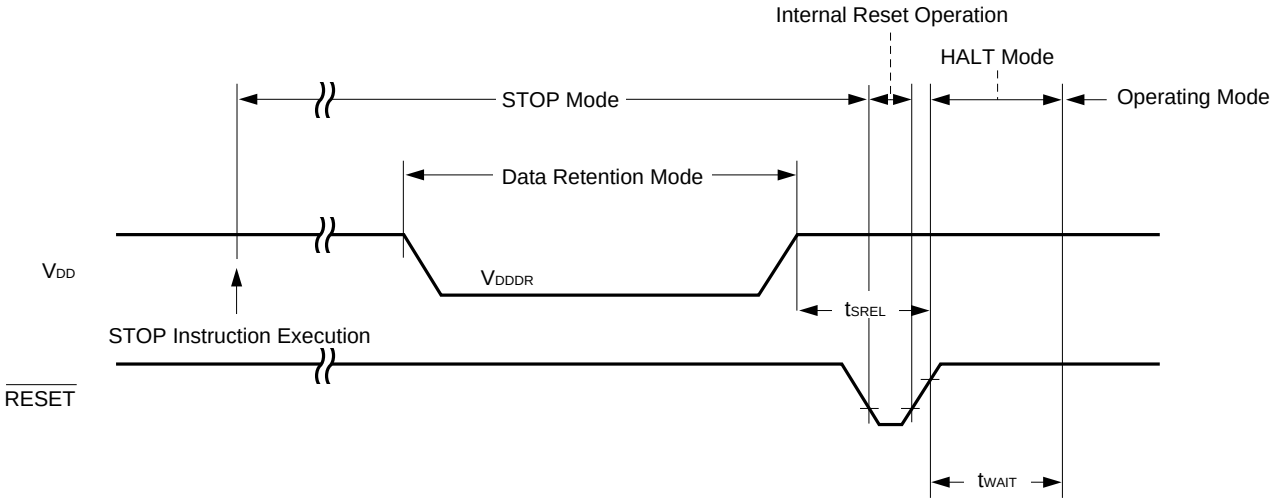
Data Memory STOP Mode Low Supply Voltage Data Retention Characteristics (T_A = –40 to +85°C)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Data retention power supply voltage	V_{DDDR}		1.8		6.0	V
Data retention power supply current	I_{DDDR}	V_{DDDR} = 1.8 V Subsystem clock stop and feed-back resister disconnected		0.1	10	μA
Release signal set time	t_{SREL}		0			μs
Oscillation stabilization wait time	t_{WAIT}	Release by $\overline{RESET}$		$2^{17}/f_X$		ms
		Release by interrupt request		**Note**		ms

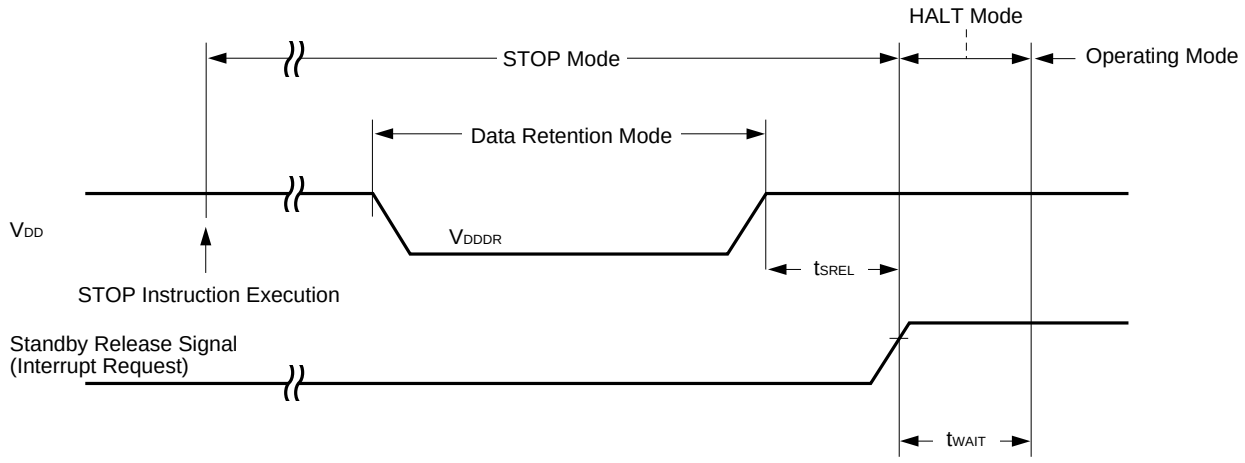
Note In combination with bits 0 to 2 (OSTS0 to OSTS2) of oscillation stabilization time select register, selection of $2^{12}/f_{XX}$ and $2^{14}/f_{XX}$ to $2^{17}/f_{XX}$ is possible.

Remark f_{XX}: Main system clock frequency (f_X or $f_X/2$)
f_X: Main system clock oscillatior frequency

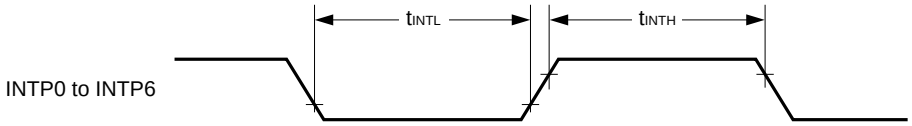
Data Retention Timing (STOP Mode Release by $\overline{RESET}$)



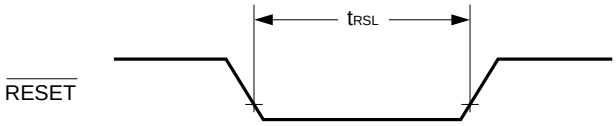
Data Retention Timing (Standby Release Signal: STOP Mode Release by Interrupt Request Signal)



Interrupt Request Input Timing

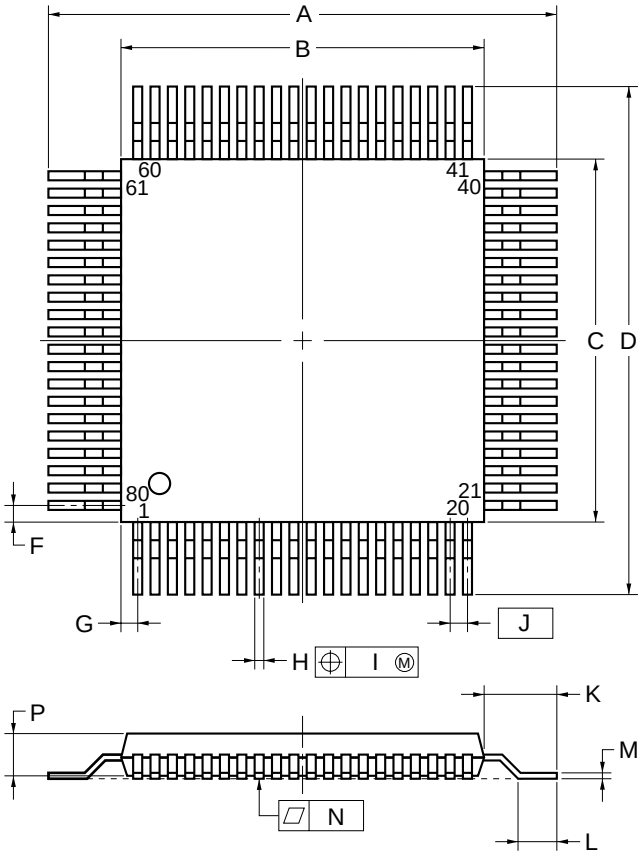


$\overline{\text{RESET}}$ Input Timing

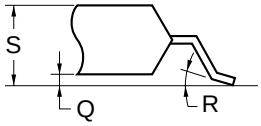


12. PACKAGE DRAWINGS

80 PIN PLASTIC QFP (14x14)



detail of lead end



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	17.2±0.4	0.677±0.016
B	14.0±0.2	$0.551^{+0.009}_{-0.008}$
C	14.0±0.2	$0.551^{+0.009}_{-0.008}$
D	17.2±0.4	0.677±0.016
F	0.825	0.032
G	0.825	0.032
H	0.30±0.10	$0.012^{+0.004}_{-0.005}$
I	0.13	0.005
J	0.65 (T.P.)	0.026 (T.P.)
K	1.6±0.2	0.063±0.008
L	0.8±0.2	$0.031^{+0.009}_{-0.008}$
M	$0.15^{+0.10}_{-0.05}$	$0.006^{+0.004}_{-0.003}$
N	0.10	0.004
P	2.7±0.1	$0.106^{+0.005}_{-0.004}$
Q	0.1±0.1	0.004±0.004
R	5°±5°	5°±5°
S	3.0 MAX.	0.119 MAX.

S80GC-65-3B9-5

Remark Dimensions and materials of ES product are the same as those of mass-production products.

13. RECOMMENDED SOLDERING CONDITIONS

This product should be soldered and mounted under the conditions recommended in the table below.

For detail of recommended soldering conditions, refer to the information document **Semiconductor Device Mounting Technology Manual (C10535E).**

For soldering methods and conditions other than those recommended below, contact an NEC sales representative.

Table 13-1. Surface Mounting Type Soldering Conditions

μPD78058FGC(A)-×××-3B9 : 80-pin Plastic QFP (14 × 14 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235°C, Duration: 30 sec. max. (at 210°C or above), Number of times: Three times max.	IR35-00-3
VPS	Package peak temperature: 215°C, Duration: 40 sec. max. (at 200°C or above), Number of times: Three times max.	VP15-00-3
Wave soldering	Solder bath temperature : 260°C max., Duration : 10 sec. max., Number of times: once, Preheating temperature : 120°C max. (package surface temperature)	WS60-00-1
Partial heating	Pin temperature: 300°C max. Duration: 3 sec. max. (per pin row)	—

Caution Use of more than one soldering method should be avoided (except in the case of partial heating).

APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for system development using the μPD78058F(A).

Language Processing Software

RA78K/0[Notes 1, 2, 3, 4]	Assembler package common to the 78K/0 Series
CC78K/0[Notes 1, 2, 3, 4]	C compiler package common to the 78K/0 Series
DF78054[Notes 1, 2, 3, 4]	Device file common to the μPD78054 Subseries
CC78K/0-L[Notes 1, 2, 3, 4]	C compiler library source file common to the 78K/0 Series

PROM Writing Tools

PG-1500	PROM programmer
PA-78P054GC	Programmer adapters connected to PG-1500
PG-1500 controller[Notes 1, 2]	PG-1500 control program

Notes 1. PC-9800 series based
2. IBM PC/AT™ and compatibles based
3. HP9000 series 700™ based, SPARCstation™ based
4. NEWS™ based

Remark The RA78K/0 and CC78K/0 are used in combination with the DF78054.

★ **Debugging Tools**

(1) In-circuit Emulators (when IE-78K0-NS is used)

IE-78K0-NS[Note 5]	In-circuit emulator common to 78K/0 Series
IE-70000-MC-PS-B	Power supply unit for IE-78K0-NS
IE-70000-98-IF-C[Note 5]	Interface adapter when PC-9800 series (except for notebooks) is used as host machine.
IE-70000-CD-IF[Note 5]	Interface adapter and cable when PC-9800 series notebook is used as host machine.
IE-70000-PC-IF-O[Note 5]	Interface adapter when IBM PC/AT or compatibles is used as host machine.
IE-780308-NS-EM1[Note 5]	Emulation board to emulate μPD780308 Subseries
NP-80GC	Emulation probe for 80-pin plastic QFP (GC-3B9 type)
EV-9200GC-64	Socket for mounting on target system board created for 80-pin plastic QFP (GC-3B9 type)
ID78K0-NS[Notes 2, 3, 5]	Integrated debugger for IE-78K0-NS
SM78K0[Notes 2, 3]	System simulator common to 78K/0 Series
DF78054[Notes 1, 2, 3, 4]	Device file for μPD78054 Subseries

(2) In-circuit Emulators (when IE-78001-R-A is used)

IE-78001-R-A[Note 5]	In-circuit emulator common to 78K/0 Series
IE-70000-98-IF-B IE-70000-98-IF-C[Note 5]	Interface adapter when PC-9800 series (except for notebooks) is used as host machine.
IE-70000-PC-IF-B IE-70000-PC-IF-C[Note 5]	Interface adapter when IBM PC/AT or its compatibles is used as host machine.
IE-78000-R-SV3	Interface adapter and cable when EWS is used as host machine.
IE-780308-NS-EM1[Note 5]	Emulation board common to μPD780308 Subseries
IE-78K0-R-EX1[Note 5]	Emulation probe conversion board that is necessary when using IE-780308-NS-EM1 on IE-78001-R-A
EP-78230GC-R	Emulation probe for 80-pin plastic QFP (GC-3B9 type)
EV-9200GC-80	Socket for mounting on target system board created for 80-pin plastic QFP (GC-3B9 type)
ID78K0[Notes 1, 2, 3, 4]	Integrated debugger for IE-78001-R-A
SM78K0[Notes 2, 3]	System simulator common to 78K/0 Series
DF78054[Notes 1, 2, 3, 4]	Device file for μPD78054 Subseries

Notes 1. HP9000 series 700 based, SPARCstation based
2. PC-9800 series based
3. IBM PC/AT and compatibles based
4. NEWS™ based
5. Under development

Remarks 1. The ID78K0-NS, ID78K0, and SM78K0 are used in combination with the DF78054.
2. The NP-80GC is a product of Naito Densei Machida Seisakusho Co., Ltd. (044-822-3813). Contact an NEC sales representative about purchasing.

Real-Time OS

RX78K/0[Notes 1, 2, 3, 4]	Real-time OS for the 78K/0 Series
MX78K/0[Notes 1, 2, 3, 4]	Real-time OS for the 78K/0 Series

Notes 1. PC-9800 series based
2. IBM PC/AT™ and its compatibles based
3. NEWS based
4. HP9000 series 700™ based, SPARCstation™ based

Remarks 1. For third party development tools, see the **78K/0 Series Selection Guide (U11126E)**.
2. The RX78K/0 is used in combination with the DF78054.

APPENDIX B. RELATED DOCUMENTS

Device Related Documents

Document Name	Document No. (English)	Document No. (Japanese)
μPD78058F, 78058FY Subseries User's Manual	U12068E	U12068J
μPD78058F(A) Data Sheet	This document	U12325J
μPD78P058F Data Sheet	U11796E	U11796J
78K/0 Series User's Manual – Instructions	U12326E	U12326J
78K/0 Series Instruction Set	—	U10904J
78K/0 Series Instruction Table	—	U10903J
★ 78K/0 Series Application Note Basics (III)	U10182E	U10182J

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

Development Tool Related Documents (User's Manual)

Document Name		Document No. (English)	Document No. (Japanese)
RA78K Series Assembler Package	Operation	EEU-1399	EEU-809
	Language	EEU-1404	EEU-815
RA78K Series Structured Assembler Preprocessor		EEU-1402	U12323J
RA78K0 Assembler Package	Operation	U11802E	U11802J
	Assembly language	U11801E	U11801J
	Structured assembly language	U11789E	U11789J
CC78K Series C Compiler	Operation	EEU-1280	EEU-656
	Language	EEU-1284	EEU-655
CC78K/0 C Compiler	Operation	U11517E	U11517J
	Language	U11518E	U11518J
CC78K/0 C Compiler Application Note	Programming know-how	EEA-1208	EEA-618
CC78K Series Library Source File		–	U12322J
PG-1500 PROM Programmer		EEU-1335	U11940J
PG-1500 Controller PC-9800 Series (MS-DOS) based		EEU-1291	EEU-704
PG-1500 Controller IBM PC series (PC DOS) based		U10540E	EEU-5008
★ IE-78K0-NS		To be prepared	To be prepared
★ IE-78001-R-A		To be prepared	To be prepared
★ IE-780308-NS-EM1		To be prepared	To be prepared
EP-78230		EEU-1515	EEU-985
SM78K0 System Simulator, Windows™ based	Reference	U10181E	U10181J
SM78K Series System Simulator	External parts user open interface specification	U10092E	U10092J
★ ID78K0-NS Integrated Debugger		Under preparation	To be prepared
ID78K0 Integrated Debugger, EWS based	Reference	—	U11151J
ID78K0 Integrated Debugger, PC based	Reference	U11539E	U11539J
ID78K0 Integrated Debugger, Windows based	Guide	U11649E	U11649J

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

Embedded Software Documents (User's Manual)

Document Name		Document No. (English)	Document No. (Japanese)
78K/0 Series Real-time OS	Basics	U11537E	U11537J
	Installation	U11536E	U11536J
78K/0 Series OS MX78K0	Basics	U12257E	U12257J

Other Documents

Document Name	Document No. (English)	Document No. (Japanese)
IC Package Manual	C10943X	
Semiconductor Device Mounting Technology Manual	C10535E	C10535J
Quality Grades on NEC Semiconductor Devices	C11531E	C11531J
NEC Semiconductor Device Reliability/Quality Control System	C10983E	C10983J
★ Guide to Prevent Damage for Semiconductor Devices by Electrostatic Discharge (ESD)	C11892E	C11892J
Guide to Quality Assurance for Semiconductor Devices	MEI-1202	C11893J
Microcontroller Related Product Guide — Third Party	—	C11416J

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

[MEMO]

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 devices 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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