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April 1st, 2010
Renesas Electronics Corporation

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μPD789101, 789102, 789104, 789111, 789112, 789114

8-BIT SINGLE-CHIP MICROCONTROLLERS

Phase-out/Discontinued

The μPD789101, 789102, and 789104 are μPD789104 Subseries products of the 78K/0S Series.

★ The μPD789111, 789112, and 789114 are μPD789114 Subseries products of the 78K/0S Series.

Besides an 8-bit CPU, these microcontrollers incorporate a variety of hardware such as I/O ports, timers, a serial interface, A/D converters, and interrupt control.

In addition, a flash memory version (μPD78F9116) that can operate within the same power supply voltage range as the mask ROM version, and a range of development tools are also being developed.

Detailed function descriptions are provided in the following user's manuals. Be sure to read them before designing.

μPD789104, 789114, 789124, 789134 Subseries User's Manual: U13045E

78K/0S Series User's Manual Instruction: U11047E

FEATURES

- On-chip multiplier: 8 bits × 8 bits = 16 bits
- ROM and RAM sizes

Part Number \ Item	Program Memory (ROM)	Data Memory (Internal High-Speed RAM)	Package
★ μPD789101, 789111	2 Kbytes	256 bytes	30-pin plastic shrink SOP (300 mils) (GS type, MC-5A4 type)
μPD789102, 789112	4 Kbytes		
μPD789104, 789114	8 Kbytes		

- Minimum instruction execution time can be changed from high-speed (0.4 μs) to low-speed (1.6 μs) (@ 5.0-MHz operation with system clock)
- I/O ports: 20
- Serial interface: 1 channel: Switchable between 3-wire serial I/O and UART modes
- 8-bit resolution A/D converter: 4 channels (μPD789101, 789102, 789104)
- ★ 10-bit resolution A/D converter: 4 channels (μPD789111, 789112, 789114)
- Timers: 3 channels
  - 16-bit timer: 1 channel
  - 8-bit timer/event counter: 1 channel
  - Watchdog timer: 1 channel
- ★ Power supply voltage: V_{DD} = 2.7 to 5.5 V

APPLICATIONS

Cleaners, washing machines, and refrigerators

Document No. U12815EJ2V1DS00 (2nd edition)
Date Published November 1999 N CP(K)
Printed in Japan

The mark ★ shows major revised points.

Phase-out/Discontinued

★ ORDERING INFORMATION

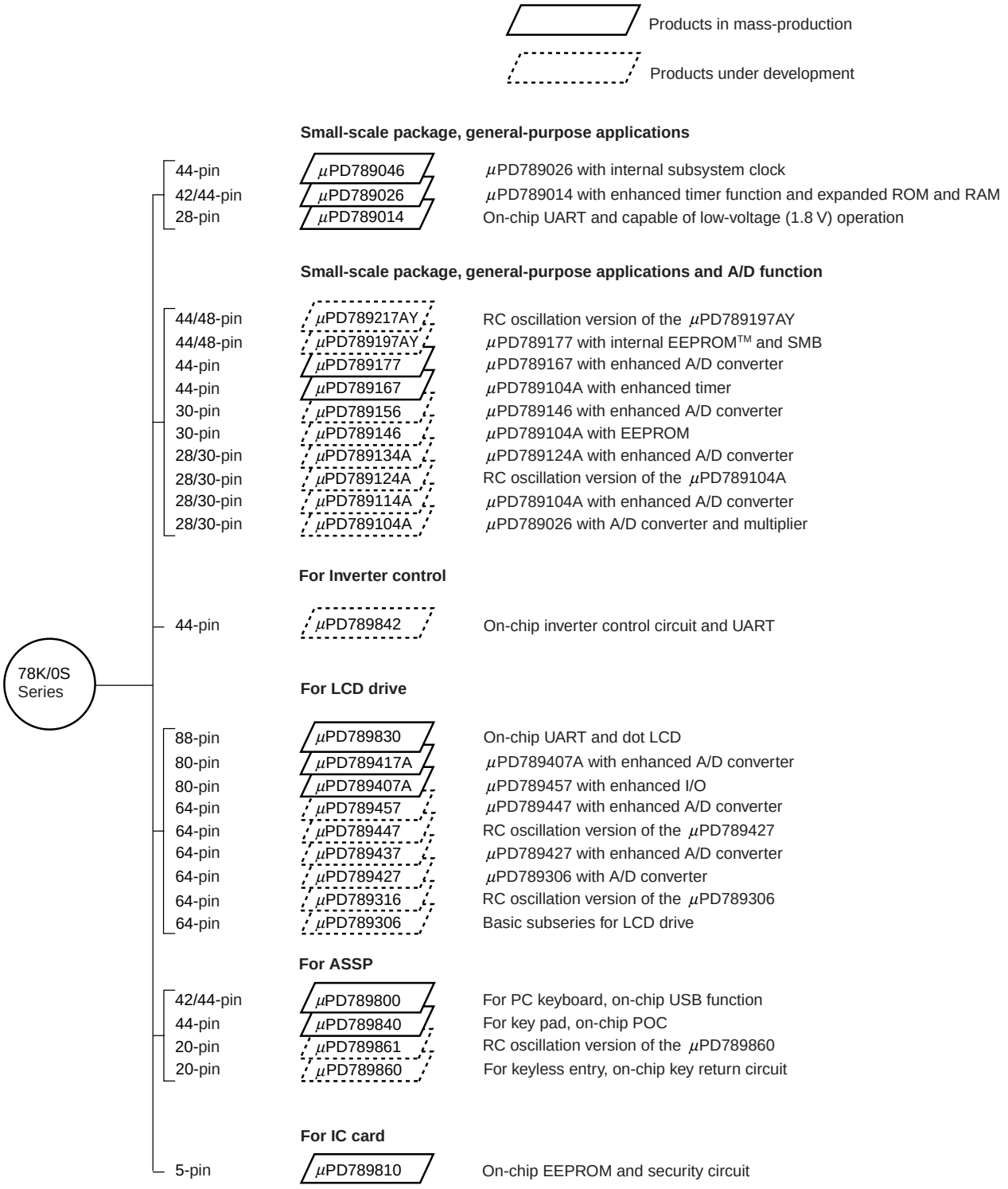
Part Number	Package
μPD789101GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789101MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789102GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789102MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789104GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789104MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789111GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789111MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789112GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789112MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789114GS-×××	30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789114MC-×××-5A4	30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)

Remark ××× indicates ROM code suffix.

Phase-out/Discontinued

★ 78K/0S SERIES LINEUP

The products in the 78K/0S Series are listed below. The names enclosed in boxes are subseries names.



Phase-out/Discontinued

The major functional differences among the subseries are listed below.

★

Subseries Name \ Function		ROM Capacity	Timer				8-bit A/D	10-bit A/D	Serial Interface	I/O	V_{DD} MIN. Value	Remark
			8-bit	16-bit	Watch	WDT						
Small-scale package, general-purpose applications	μPD789046	16 K	1ch	1ch	1ch	1ch	–	–	1ch (UART: 1ch)	34	1.8 V	–
	μPD789026	4 K to 16 K			–							
	μPD789014	2 K to 4 K	2 ch	–						22		
Small-scale package, general-purpose applications + A/D converter	μPD789217AY	16 K to 24 K	3 ch	1 ch	1 ch	1 ch	–	8 ch	2ch (UART: 1ch, SMB: 1ch)	31	1.8 V	RC oscillation version, on-chip EEPROM
	μPD789197AY											On-chip EEPROM
	μPD789177								1 ch (UART: 1 ch)			–
	μPD789167						8 ch	–				
	μPD789156	8 K to 16 K	1 ch		–		–	4 ch		20		On-chip EEPROM
	μPD789146						4 ch	–				
	μPD789134A	2 K to 8 K					–	4 ch				RC oscillation version
	μPD789124A						4 ch	–				
	μPD789114A						–	4 ch				–
	μPD789104A						4 ch	–				
Inverter control	μPD789842	8 K to 16 K	3 ch	**Note**	1 ch	1 ch	8 ch	–	1 ch (UART: 1 ch)	30	4.0 V	–
LCD drive	μPD789830	24 K	1 ch	1 ch	1 ch	1 ch	–	–	1 ch (UART: 1 ch)	30	2.7 V	–
	μPD789417A	12 K to 24 K	3 ch					7 ch		43	1.8 V	
	μPD789407A						7 ch	–		25		
	μPD789457	16 K to 24 K	2 ch				–	4 ch	2 ch (UART: 1 ch)			RC oscillation version
	μPD789447						4 ch	–				
	μPD789437						–	4 ch				–
	μPD789427						4 ch	–				
	μPD789316	8 K to 16 K					–			23		RC oscillation version
	μPD789306											–
ASSP	μPD789800	8 K	2 ch	1 ch	–	1 ch	–	–	2 ch (USB: 1 ch)	31	4.0 V	–
	μPD789840						4 ch		1 ch	29	2.8 V	
	μPD789861	4 K		–			–		–	14	1.8 V	RC oscillation version
	μPD789860											–
IC card	μPD789810	6 K	–	–	–	1 ch	–	–	–	1	2.7 V	On-chip EEPROM

Note 10-bit timer: 1 channel

OVERVIEW OF FUNCTIONS

Item		μPD789101 μPD789111	μPD789102 μPD789112	μPD789104 μPD789114
Internal memory	ROM	2 Kbytes	4 Kbytes	8 Kbytes
	High-speed RAM	256 bytes		
Minimum instruction execution time		0.4/1.6 μs (@ 5.0-MHz operation with system clock)		
General-purpose registers		8 bits × 8 registers		
Instruction set		• 16-bit operations • Bit manipulations (set, reset, and test)		
Multiplier		8 bits × 8 bits = 16 bits		
I/O ports		Total: 20 • CMOS input: 4 • CMOS I/O: 12 • N-ch open-drain (12-V withstand voltage): 4		
★ A/D converters		• 8-bit resolution × 4 channels (μPD789104 Subseries) • 10-bit resolution × 4 channels (μPD789114 Subseries)		
Serial interface		• Switchable between 3-wire serial I/O and UART modes		
Timer		• 16-bit timer: 1 channel • 8-bit timer/event counter: 1 channel • Watchdog timer: 1 channel		
Timer output		1 output (16-bit/8-bit timer alternate function)		
Vectored interrupt sources	Maskable	Internal: 6, External: 3		
	Non-maskable	Internal: 1		
★ Power supply voltage		V_{DD} = 2.7 to 5.5 V		
Operating ambient temperature		T_A = –40 to +85°C		
★ Package		• 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm) • 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)		

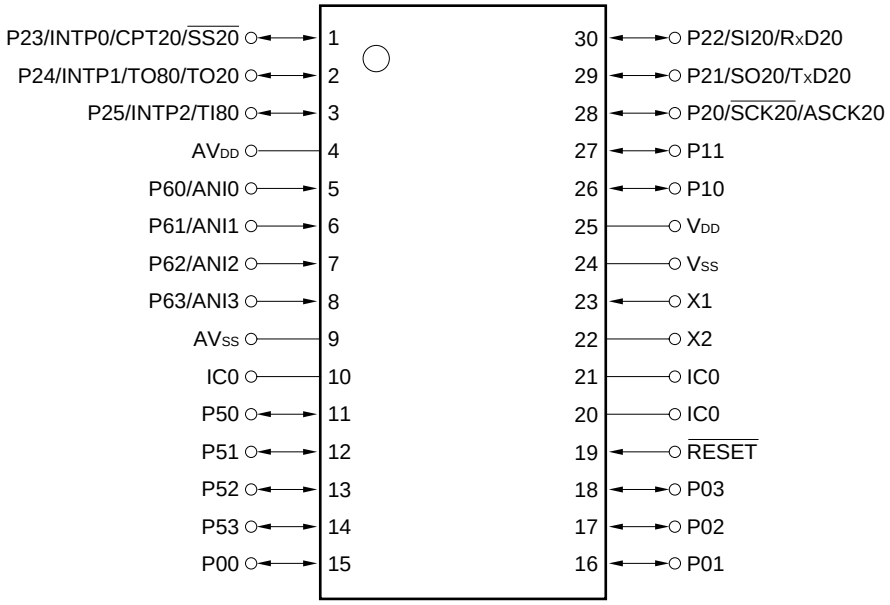
Phase-out/Discontinued

CONTENTS

★ 1. PIN CONFIGURATION (TOP VIEW)

- 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
  μPD789101GS-××× μPD789102GS-××× μPD789104GS-×××
  μPD789111GS-××× μPD789112GS-××× μPD789114GS-×××

- 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
  μPD789101MC-×××-5A4 μPD789102MC-×××-5A4 μPD789104MC-×××-5A4
  μPD789111MC-×××-5A4 μPD789112MC-×××-5A4 μPD789114MC-×××-5A4



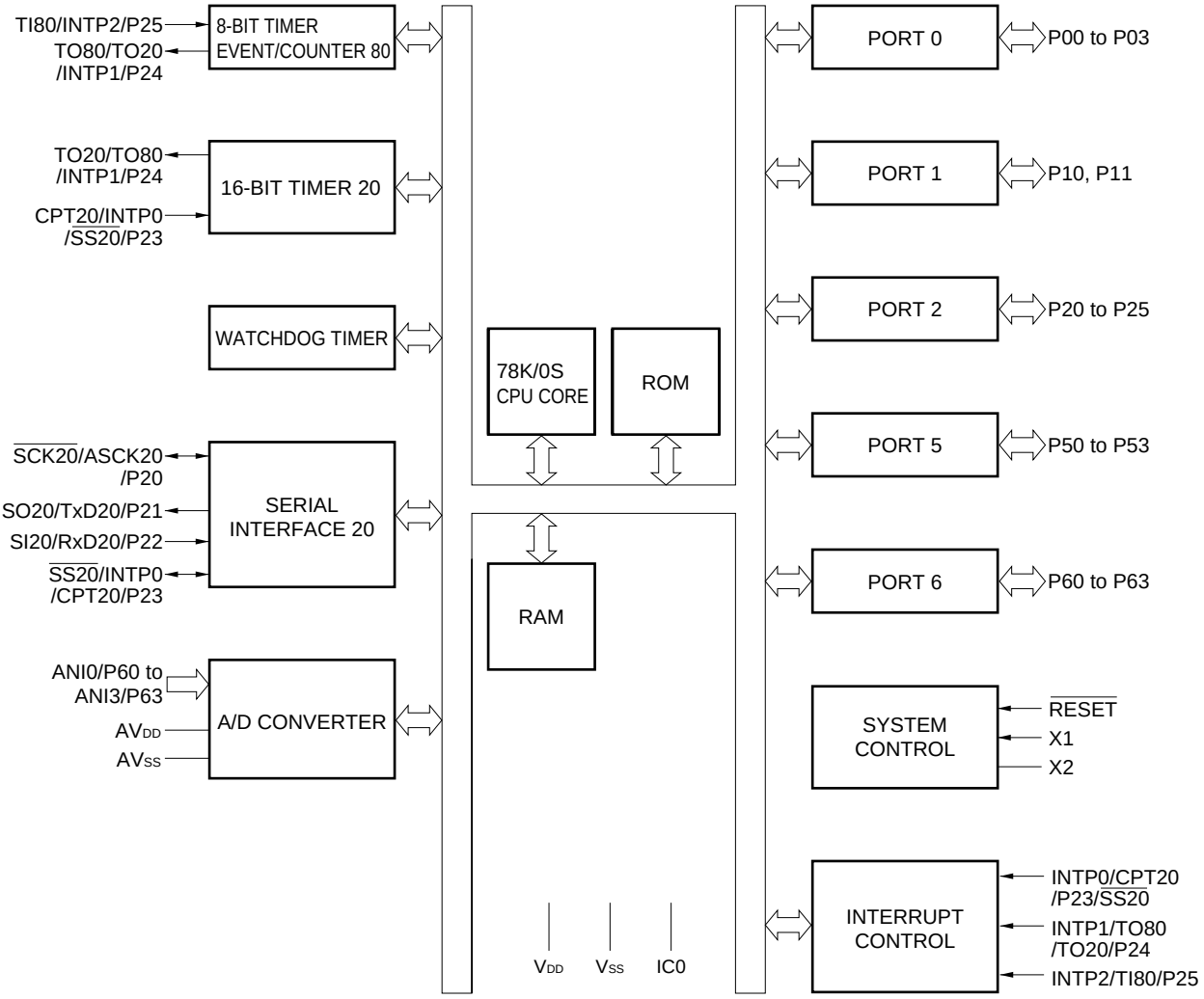
Cautions 1. Connect the IC0 (Internally Connected) pin directly to V_{SS}.

2. Connect the AV_{DD} pin to V_{DD}.

3. Connect the AV_{SS} pin to V_{SS}.

ANI0 to ANI3:	Analog Input	$\overline{RESET}$:	Reset
ASCK20:	Asynchronous Serial Input	RxD20:	Receive Data
AV_{DD}:	Analog Power Supply	$\overline{SCK20}$:	Serial Clock Input/Output
AV_{SS}:	Analog Ground	SI20:	Serial Data Input
CPT20:	Capture Trigger Input	SO20:	Serial Data Output
IC0:	Internally Connected	$\overline{SS20}$:	Chip Select Input
INTP0 to INTP2:	Interrupt from Peripherals	TI80:	Timer Input
P00 to P03:	Port0	TO20, TO80:	Timer Output
P10, P11:	Port1	TxD20:	Transmit Data
P20 to P25:	Port2	V_{DD}:	Power Supply
P50 to P53:	Port5	V_{SS}:	Ground
P60 to P63:	Port6	X1, X2:	Crystal 1, 2

2. BLOCK DIAGRAM



Remark The internal ROM capacity varies depending on the product.

3. PIN FUNCTIONS

3.1 Port Pins

Pin Name	I/O	Function	After Reset	Alternate Function
P00 to P03	I/O	Port 0 4-bit input/output port Input/output can be specified in 1-bit units When used as an input port, an on-chip pull-up resistor can be specified by means of software.	Input	–
P10, P11	I/O	Port 1 2-bit input/output port Input/output can be specified in 1-bit units When used as an input port, an on-chip pull-up resistor can be specified by means of software.	Input	–
P20	I/O	Port 2 6-bit input/output port Input/output can be specified in 1-bit units When used as an input port, an on-chip pull-up resistor can be specified by means of software.	Input	$\overline{\text{SCK20}}$/ASCK20
P21				SO20/TxD20
P22				SI20/RxD20
P23				INTP0/CPT20 /$\overline{\text{SS20}}$
P24				INTP1/TO80/TO20
P25				INTP2/TI80
P50 to P53	I/O	Port 5 4-bit N-ch open-drain input/output port Input/output can be specified in 1-bit units An on-chip pull-up resistor can be specified by the mask option.	Input	–
P60 to P63	Input	Port 6 4-bit input-only port	Input	ANI0 to ANI3

3.2 Non-Port Pins

Pin Name	I/O	Function	After Reset	Alternate Function
INTP0	Input	External interrupt request input for which the valid edge (rising edge, falling edge, or both rising and falling edges) can be specified	Input	P23/CPT20/$\overline{SS20}$
INTP1				P24/TO80/TO20
INTP2				P25/TI80
SI20	Input	Serial interface serial data input	Input	P22/RxD20
SO20	Output	Serial interface serial data output	Input	P21/TxD20
$\overline{SCK20}$	I/O	Serial interface serial clock input/output	Input	P20/ASCK20
ASCK20	Input	Serial clock input for asynchronous serial interface	Input	P20/$\overline{SCK20}$
$\overline{SS20}$	Input	Chip select input for serial interface	Input	P23/CPT20/INTP0
RxD20	Input	Serial data input for asynchronous serial interface	Input	P22/SI20
TxD20	Output	Serial data output for asynchronous serial interface	Input	P21/SO20
TI80	Input	External count clock input to 8-bit timer (TM80)	Input	P25/INTP2
TO80	Output	8-bit timer (TM80) output	Input	P24/INTP1/TO20
TO20	Output	16-bit timer (TM20) output	Input	P24/INTP1/TO80
CPT20	Input	Capture edge input	Input	P23/INTP0/$\overline{SS20}$
ANI0 to ANI3	Input	A/D converter analog input	Input	P60 to P63
AV_{DD}	-	A/D converter analog power supply	–	–
AV_{SS}	-	A/D converter ground potential	–	–
X1	Input	Connecting crystal resonator for main system clock oscillation	–	–
X2	-		–	–
$\overline{RESET}$	Input	System reset input	Input	–
V_{DD}	-	Positive power supply	–	–
V_{SS}	-	Ground potential	–	–
IC0	-	Internally connected. Connect directly to V_{SS}.	–	–

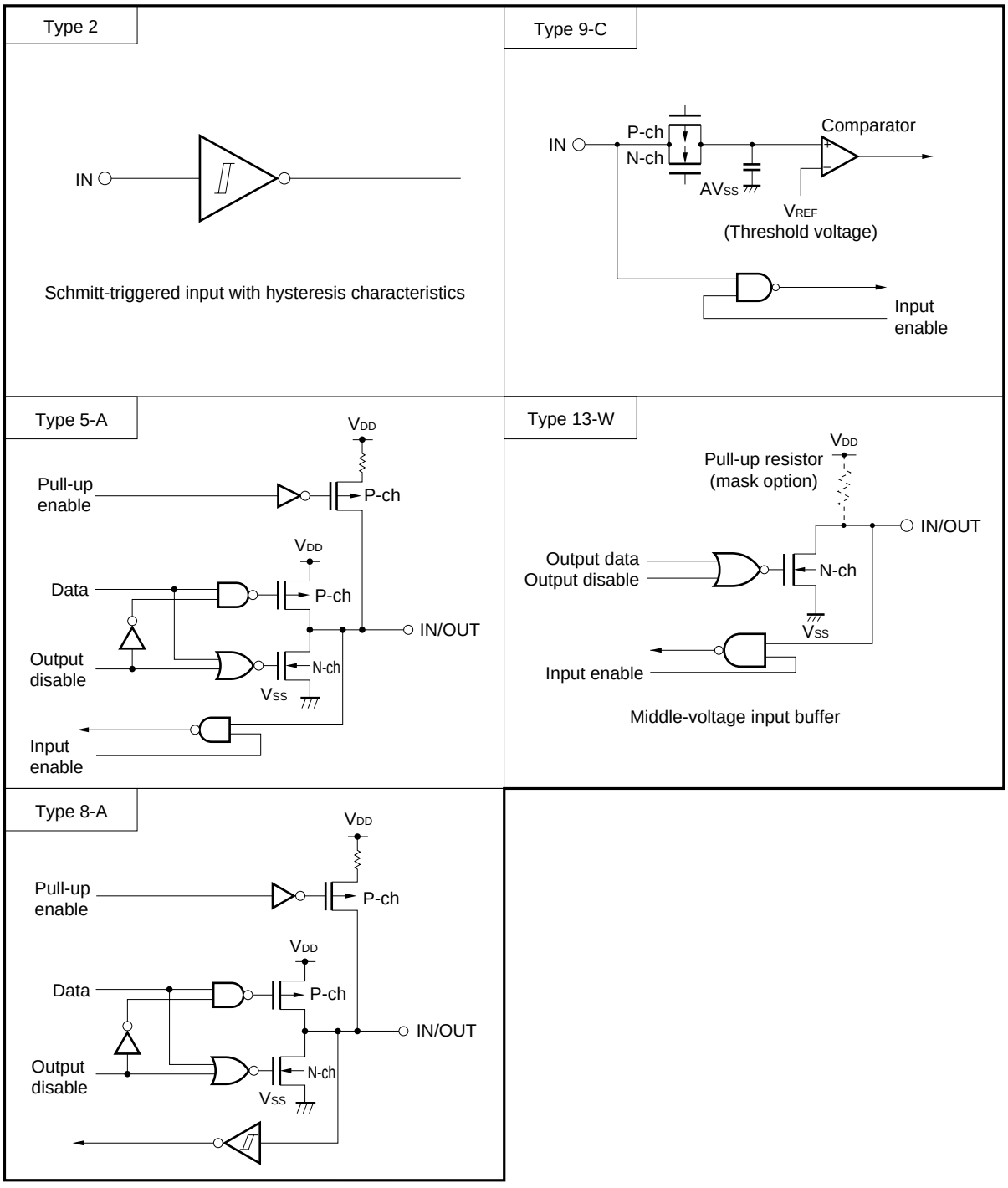
3.3 Pin I/O Circuits and Recommended Connection of Unused Pins

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, refer to Figure 3-1.

★ **Table 3-1. Types of Pin Input/Output Circuits**

Pin Name	Input/Output Circuit Type	I/O	Recommended Connection of Unused Pins
P00 to P03	5-A	I/O	Input: Independently connect to V_{DD} or V_{SS} via a resistor. Output: Leave open
P10, P11			
P20/$\overline{SCK20}$/ASCK20	8-A		
P21/SO20/T_XD20			
P22/SI20/R_XD20			
P23/INTP0/CPT20/$\overline{SS20}$			
P24/INTP1/TO80/TO20			
P25/INTP2/TI80			
P50 to P53	13-W		Input: Independently connect to V_{DD} via a resistor. Output: Leave open
P60/ANI0 to P63/ANI3	9-C	Input	Connect directly to V_{DD} or V_{SS}.
AV_{DD}	–	–	Connect to V_{DD}.
AV_{SS}			Connect to V_{SS}.
$\overline{RESET}$	2	Input	–
IC0	–	–	Connect directly to V_{SS}.

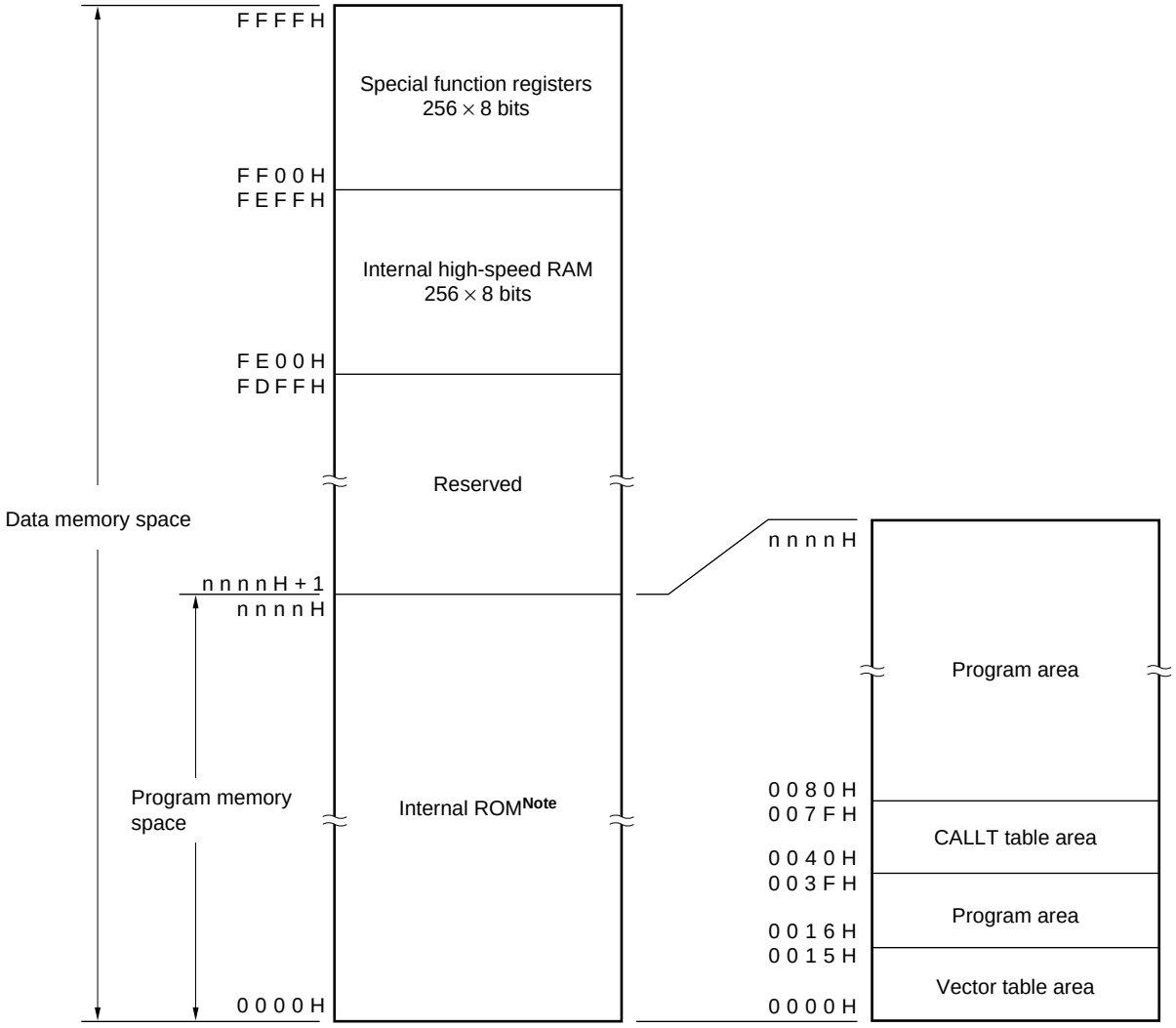
Figure 3-1. Pin Input/Output Circuits



4. MEMORY SPACE

Figure 4-1 shows the memory map of the μPD789101, 789102, 789104, 789111, 789112, and 789114.

Figure 4-1. Memory Map



Note The internal ROM capacity depends on the product. (See the following table).

Part Number	Last Address of Internal ROM nnnnH
μPD789101, 789111	07FFH
μPD789102, 789112	0FFFH
μPD789104, 789114	1FFFH

5. PERIPHERAL HARDWARE FUNCTIONS

5.1 Ports

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

- CMOS Input (port 6): 4
- CMOS input/output (ports 0 to 2): 12
- N-ch open-drain input/output (port 5): 4

Total: 20

Table 5-1. Port Functions

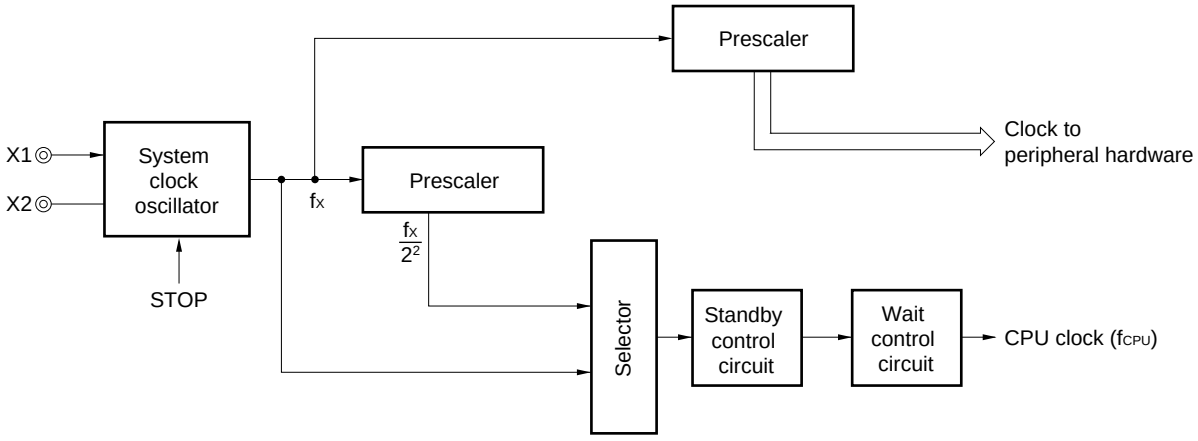
Port Name	Pin Name	Function
Port 0	P00 to P03	Input/output port. Input/output can be specified in 1-bit units. When used as an input port, an on-chip pull-up resistor can be specified by means of software.
Port 1	P10, P11	Input/output port. Input/output can be specified in 1-bit units. When used as an input port, an on-chip pull-up resistor can be specified by means of software.
Port 2	P20 to P25	Input/output port. Input/output can be specified in 1-bit units. An on-chip pull-up resistor can be specified by means of software.
Port 5	P50 to P53	N-channel open-drain input/output port. Input/output can be specified in 1-bit units. An on-chip pull-up resistor can be specified by the mask option.
Port 6	P60 to P63	Input-only port

5.2 Clock Generator

An on-chip system clock generator is provided.
The minimum instruction execution time can be changed.

- 0.4 μs/1.6 μs (@ 5.0-MHz operation with system clock)

Figure 5-1. Clock Generator Block Diagram



5.3 Timer

Three on-chip timers are provided.

- 16-bit timer 20: 1 channel
- 8-bit timer/event counter 80: 1 channel
- Watchdog timer: 1 channel

Table 5-2. Timer Operation

		16-Bit Timer 20	8-Bit Timer/Event Counter 80	Watchdog Timer
Operation mode	Interval timer	–	1 channel	1 channel
	External event counter	–	1 channel	–
Function	Timer output	1 output	1 output	–
	PWM output	–	1 output	–
★	Square wave output	–	1 output	–
	Capture	1 input	–	–
	Interrupt request	1	1	1

Figure 5-2. Block Diagram of 16-Bit Timer 20 (TM20)

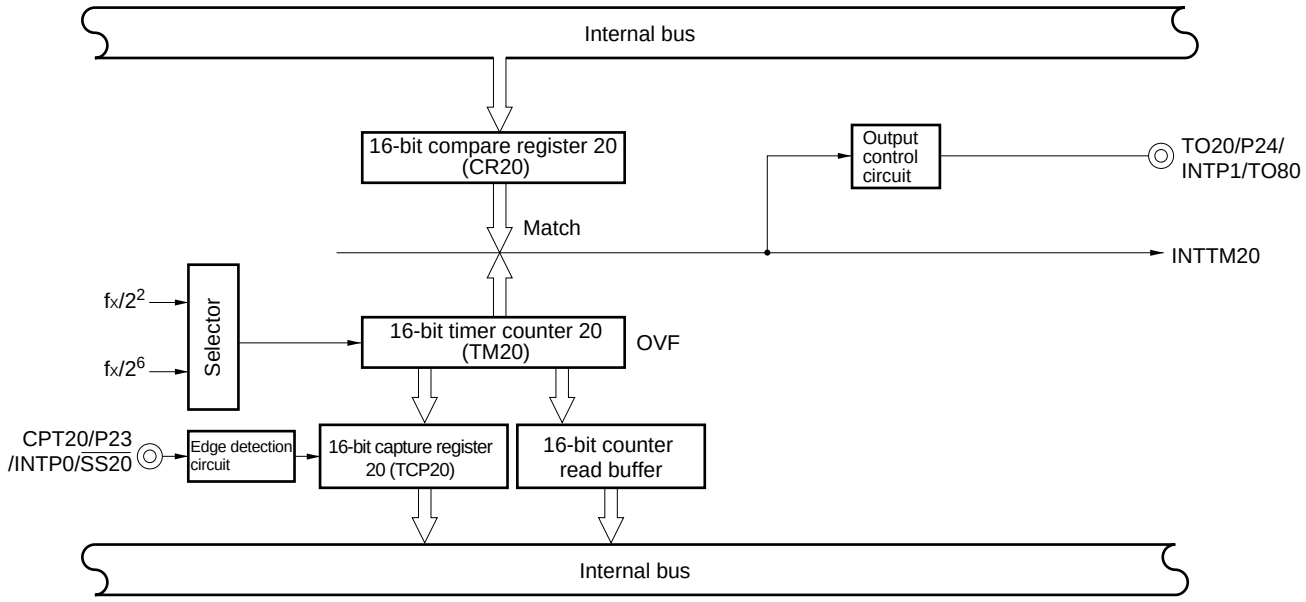


Figure 5-3. Block Diagram of 8-Bit Timer/Event Counter 80 (TM80)

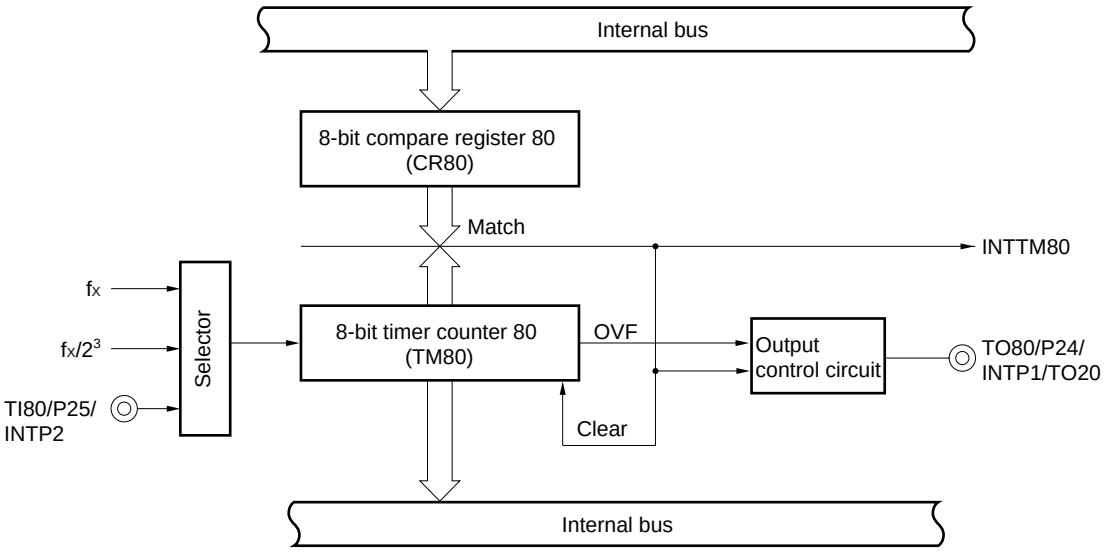
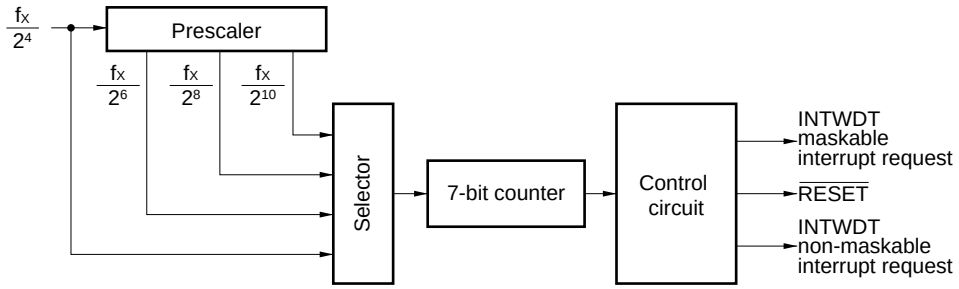


Figure 5-4. Watchdog Timer Block Diagram



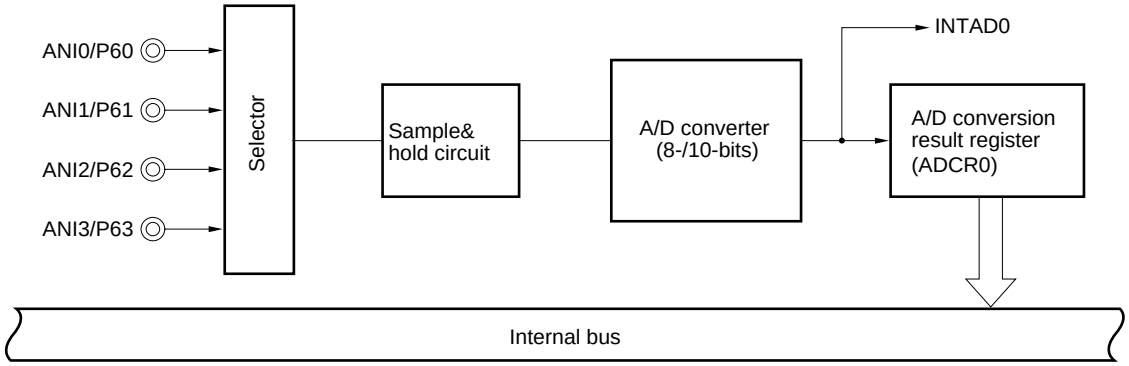
★ 5.4 A/D Converter

The conversion resolution of the A/D converter differs depending on the product as shown below.

- 8-bit A/D converter × 4 channels ⋯ μPD789101, 789102, 789104
- 10-bit A/D converter × 4 channels ⋯ μPD789111, 789112, 789114

A/D conversion can be only started by software.

Figure 5-5. A/D Converter Block Diagram



5.5 Serial Interface 20

A one-channel serial interface is incorporated.

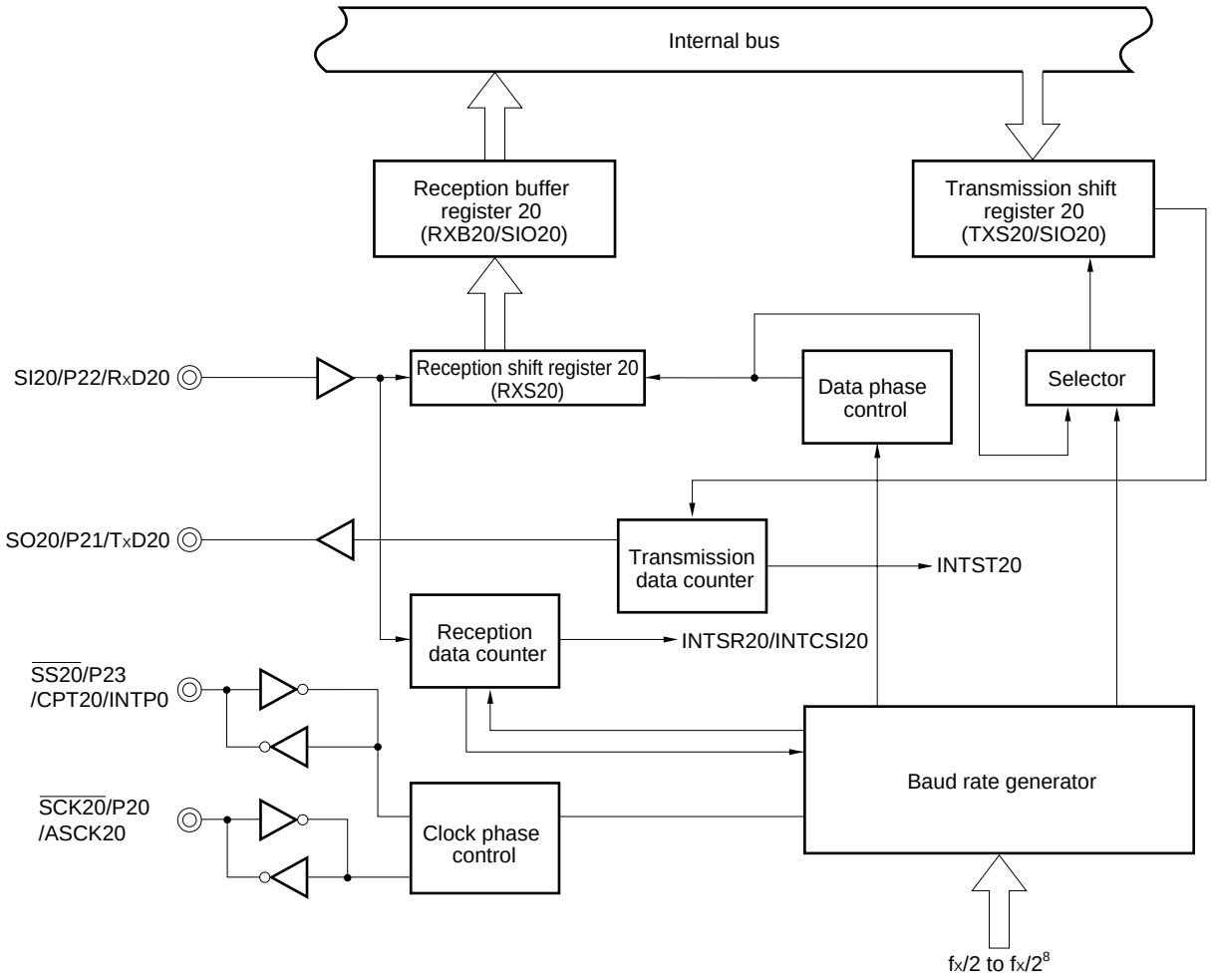
Serial interface 20 has following three modes:

★ • Operation stop mode: Power consumption can be reduced.

• Asynchronous serial interface (UART) mode: A dedicated baud rate generator is incorporated.

• 3-wire serial I/O mode: A function to select the clock phase or data phase is incorporated.

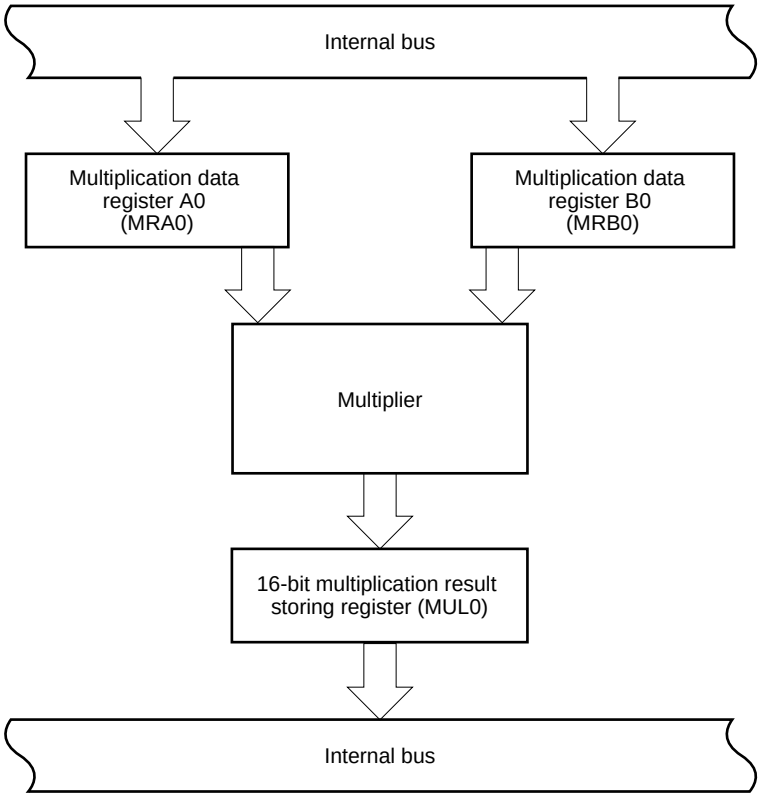
Figure 5-6. Block Diagram of Serial Interface 20



5.6 Multiplier

The calculation of 8 bits × 8 bits = 16 bits can be performed.

Figure 5-7. Multiplier Block Diagram



6. INTERRUPT FUNCTION

★ A total of 10 interrupt sources are provided, divided into the following two types.

- Non-maskable interrupts: 1 source
- Maskable interrupts: 9 sources

Table 6-1. Interrupt Source List

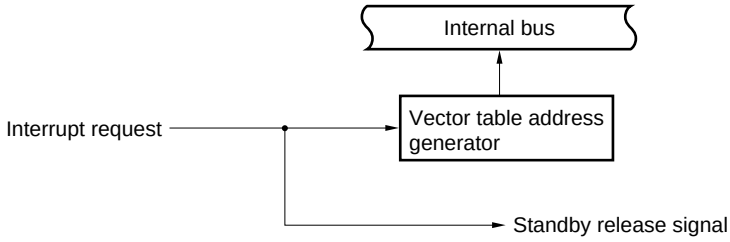
Interrupt Type	Priority[Note 1]	Interrupt Source		Internal/External	Vector Table Address	Basic Configuration Type[Note 2]
		Name	Trigger			
Non-maskable	–	INTWDT	Watchdog timer overflow (with watchdog timer mode 1 selected)	Internal	0004H	(A)
Maskable	0	INTWDT	Watchdog timer overflow (with the interval timer mode selected)			(B)
	1	INTP0	Pin input edge detection	External	0006H	(C)
	2	INTP1			0008H	
	3	INTP2			000AH	
	4	INTSR20	End of serial interface 20 UART reception	Internal	000CH	(B)
		INTCSI20	End of serial interface 20 3-wire SIO transfer reception			
	5	INTST20	End of serial interface 20 UART transmission		000EH	
	6	INTTM80	Generation of matching signal of 8-bit timer/event counter 80		0010H	
	7	INTTM20	Generation of matching signal of 16-bit timer 20		0012H	
	8	INTAD0	A/D conversion completion signal		0014H	

Notes 1. Priority is the priority order when several maskable interrupt requests are generated at the same time. 0 is the highest order and 8 is the lowest order.

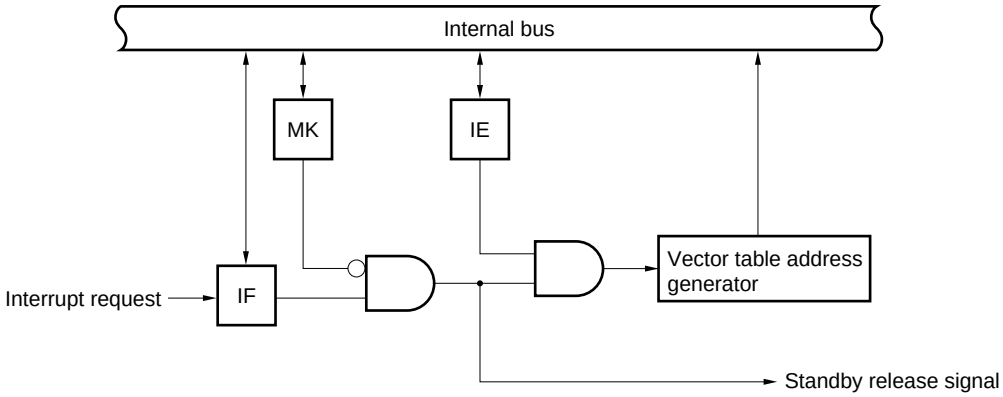
2. Basic configuration types (A), (B), and (C) correspond to (A), (B), and (C) in Figure 6-1.

Figure 6-1. Basic Configuration of Interrupt Function

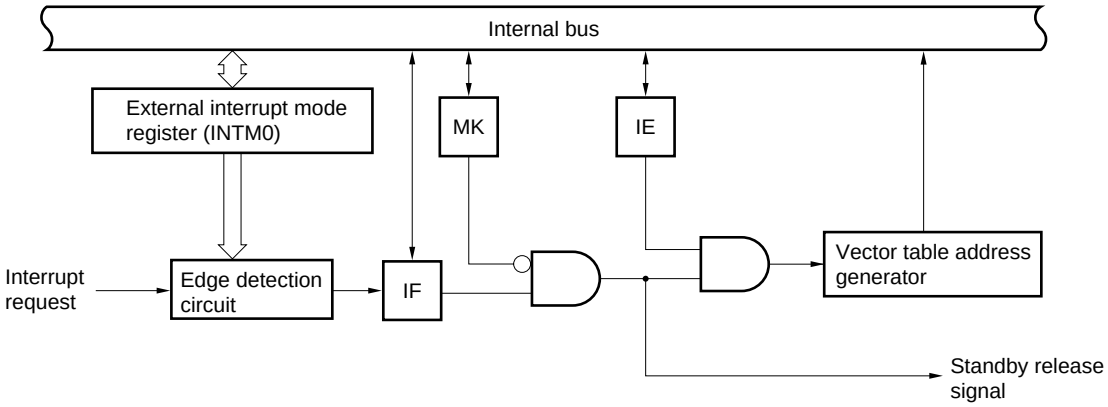
(A) Internal non-maskable interrupt



(B) Internal maskable interrupt



(C) External maskable interrupt



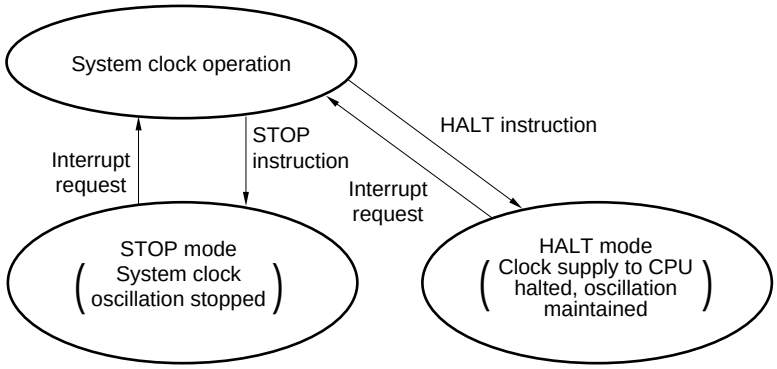
IF: Interrupt request flag
IE: Interrupt enable flag
MK: Interrupt mask flag

7. STANDBY FUNCTION

The following two standby functions are available for further reduction of system current consumption.

- HALT mode: In this mode, the CPU operation clock is stopped. The average current consumption can be reduced by intermittent operation by combining this mode with the normal operation mode.
- STOP mode: In this mode, oscillation of the system clock is stopped. All the operations performed on the system clock are suspended, resulting in extremely small power consumption.

Figure 7-1. Standby Function



8. RESET FUNCTION

The following two reset methods are available.

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

★ 9. INSTRUCTION SET OVERVIEW

The instruction set for the μPD789101, 789102, 789104, 789111, 789112, 789114 is listed later.

9.1 Conventions

9.1.1 Operand identifiers and description methods

Operands are described in the “Operand” column of each instruction in accordance with the description method of the instruction operand identifier (refer to the assembler specifications for detail). When there are two or more description methods, select one of them. Alphabetic letters in capitals and the symbols, #, !, $, and [ ], are keywords and must be described as they are. Each symbol has the following meaning.

- #: Immediate data specification
- !: Absolute address specification
- $: Relative address specification
- [ ]: Indirect address specification

In the case of immediate data, describe an appropriate numeric value or a label. When using a label, be sure to describe the #,!, $, or [ ] symbols.

For operand register identifiers, r and rp, either function names (X, A, C, etc.) or absolute names (names in parentheses in the table below, R0, R1, R2, etc.) can be used for description.

Table 9-1. Operand Identifiers and Description Methods

Identifier	Description Method
r rp sfr	X (R0), A (R1), C (R2), B (R3), E (R4), D (R5), L (R6), H (R7), AX (RP0), BC (RP1), DE (RP2), HL (RP3) Special function register symbol
saddr saddrp	FE20H to FF1FH immediate data or label FE20H to FF1FH immediate data or label (even address only)
addr16 addr5	0000H to FFFFH immediate data or label (Only even addresses for 16-bit data transfer instructions) 0040H to 007FH immediate data or label (even address only)
word byte bit	16-bit immediate data or label 8-bit immediate data or label 3-bit immediate data or label

9.1.2 Descriptions of the operation field

A:	A register; 8-bit accumulator
X:	X register
B:	B register
C:	C register
D:	D register
E:	E register
H:	H register
L:	L register
AX:	AX register pair; 16-bit accumulator
BC:	BC register pair
DE:	DE register pair
HL:	HL register pair
PC:	Program counter
SP:	Stack pointer
PSW:	Program status word
CY:	Carry flag
AC:	Auxiliary carry flag
Z:	Zero flag
IE:	Interrupt request enable flag
NMIS:	Non-maskable interrupt servicing flag
( ):	Memory contents indicated by address or register contents in parentheses
X_H, X_L:	Higher 8 bits and lower 8 bits of 16-bit register
∧:	Logical product (AND)
∨:	Logical sum (OR)
∨:	Exclusive OR
$\overline{\quad}$:	Inverted data
addr16:	16-bit immediate data or label
jdisp8:	Signed 8-bit data (displacement value)

9.1.3 Description of the flag operation field

(Blank):	Not affected
0:	Cleared to 0
1:	Set to 1
×:	Set/cleared according to the result
R:	Previously saved value is restored

9.2 Operations

Mnemonic	Operand	Byte	Clock	Operation	Flag
					Z AC CY
MOV	r, #byte	3	6	r ← byte	
	saddr , #byte	3	6	(addr) ← byte	
	sfr, #byte	3	6	sfr ← byte	
	A, r Note 1	2	4	A ← r	
	r, A Note 1	2	4	r ← A	
	A, saddr	2	4	A ← (saddr)	
	saddr, A	2	4	(saddr) ← A	
	A, sfr	2	4	A ← sfr	
	sfr, A	2	4	sfr ← A	
	A, !addr16	3	8	A ← (addr16)	
	!addr16, A	3	8	(addr16) ← A	
	PSW, #byte	3	6	PSW ← byte	× × ×
	A, PSW	2	4	A ← PSW	
	PSW, A	2	4	PSW ← A	× × ×
	A, [DE]	1	6	A ← (DE)	
	[DE], A	1	6	(DE) ← A	
	A, [HL]	1	6	A ← (HL)	
	[HL], A	1	6	(HL) ← A	
	A, [HL + byte]	2	6	A ← (HL + byte)	
	[HL + byte], A	2	6	(HL + byte) ← A	
XCH	A, X	1	4	A ↔ X	
	A, r Note 2	2	6	A ↔ r	
	A, saddr	2	6	A ↔ (saddr)	
	A, sfr	2	6	A ↔ (sfr)	
	A, [DE]	1	8	A ↔ (DE)	
	A, [HL]	1	8	A ↔ (HL)	
	A, [HL + byte]	2	8	A ↔ (HL + byte)	
MOVW	rp, #word	3	6	rp ← word	
	AX, saddrp	2	6	AX ← (saddrp)	
	saddrp, AX	2	8	(saddrp) ← AX	
	AX, rp Note 3	1	4	AX ← rp	
	rp, AX Note 3	1	4	rp ← AX	
XCHW	AX, rp Note 3	1	8	AX ↔ rp	

Notes 1. Except r = A

2. Except r = A or X

3. Only when rp = BC, DE, HL

Remark One instruction clock cycle is one cycle of the CPU clock (f_{CPU}), selected by the processor clock control register (PCC).

Mnemonic	Operand	Byte	Clock	Operation	Flag
					Z AC CY
ADD	A, #byte	2	4	A, CY ← A + byte	× × ×
	saddr, #byte	3	6	(saddr), CY ← (saddr) + byte	× × ×
	A, r	2	4	A ,CY ← A + r	× × ×
	A, saddr	2	4	A, CY ← A + (saddr)	× × ×
	A, !addr16	3	8	A, CY ← A + (addr16)	× × ×
	A, [HL]	1	6	A, CY ← A + (HL)	× × ×
	A, [HL + byte]	2	6	A, CY ← A + (HL + byte)	× × ×
ADDC	A, #byte	2	4	A, CY ← A + byte + CY	× × ×
	saddr, #byte	3	6	(saddr), CY ← (saddr) + byte + CY	× × ×
	A, r	2	4	A, CY ← A + r + CY	× × ×
	A, saddr	2	4	A, CY ← A + (saddr) + CY	× × ×
	A, !addr16	3	8	A, CY ← A + (addr16) + CY	× × ×
	A, [HL]	1	6	A, CY ← A + (HL) + CY	× × ×
	A, [HL + byte]	2	6	A, CY ← A + (HL + byte) + CY	× × ×
SUB	A, #byte	2	4	A, CY ← A – byte	× × ×
	saddr, #byte	3	6	(saddr), CY ← (saddr) – byte	× × ×
	A, r	2	4	A, CY ← A – r	× × ×
	A, saddr	2	4	A, CY ← A – (saddr)	× × ×
	A, !addr16	3	8	A, CY ← A – (addr16)	× × ×
	A, [HL]	1	6	A, CY ← A – (HL)	× × ×
	A, [HL + byte]	2	6	A, CY ← A – (HL + byte)	× × ×
SUBC	A, #byte	2	4	A, CY ← A – byte – CY	× × ×
	saddr, #byte	3	6	(saddr), CY ← (saddr) – byte – CY	× × ×
	A, r	2	4	A, CY ← A – r – CY	× × ×
	A, saddr	2	4	A, CY ← A – (saddr) – CY	× × ×
	A, !addr16	3	8	A, CY ← A – (addr16) – CY	× × ×
	A, [HL]	1	6	A, CY ← A – (HL) – CY	× × ×
	A, [HL + byte]	2	6	A, CY ← A – (HL + byte) – CY	× × ×
AND	A, #byte	2	4	A ← A ∧ byte	×
	saddr, #byte	3	6	(saddr) ← (saddr) ∧ byte	×
	A, r	2	4	A ← A ∧ r	×
	A, saddr	2	4	A ← A ∧ (saddr)	×
	A, !addr16	3	8	A ← A ∧ (addr16)	×
	A, [HL]	1	6	A ← A ∧ (HL)	×
	A, [HL + byte]	2	6	A ← A ∧ (HL + byte)	×

Remark One instruction clock cycle is one cycle of the CPU clock (f_{CPU}), selected by the processor clock control register (PCC).

Mnemonic	Operand	Byte	Clock	Operation	Flag
					Z AC CY
OR	A, #byte	2	4	A ← A ∨ byte	×
	saddr, #byte	3	6	(saddr) ← (saddr) ∨ byte	×
	A, r	2	4	A ← A ∨ r	×
	A, saddr	2	4	A ← A ∨ (saddr)	×
	A, !addr16	3	8	A ← A ∨ (addr16)	×
	A, [HL]	1	6	A ← A ∨ (HL)	×
	A, [HL + byte]	2	6	A ← A ∨ (HL + byte)	×
XOR	A, #byte	2	4	A ← A ▽ byte	×
	saddr, #byte	3	6	(saddr) ← (saddr) ▽ byte	×
	A, r	2	4	A ← A ▽ r	×
	A, saddr	2	4	A ← A ▽ (saddr)	×
	A, !addr16	3	8	A ← A ▽ (addr16)	×
	A, [HL]	1	6	A ← A ▽ (HL)	×
	A, [HL + byte]	2	6	A ← A ▽ (HL + byte)	×
CMP	A, #byte	2	4	A – byte	× × ×
	saddr, #byte	3	6	(saddr) – byte	× × ×
	A, r	2	4	A – r	× × ×
	A, saddr	2	4	A – (saddr)	× × ×
	A, !addr16	3	8	A – (addr16)	× × ×
	A, [HL]	1	6	A – (HL)	× × ×
	A, [HL + byte]	2	6	A – (HL + byte)	× × ×
ADDW	AX, #word	3	6	AX, CY ← AX + word	× × ×
SUBW	AX, #word	3	6	AX, CY ← AX – word	× × ×
CMPW	AX, #word	3	6	AX – word	× × ×
INC	r	2	4	r ← r + 1	× ×
	saddr	2	4	(saddr) ← (saddr) + 1	× ×
DEC	r	2	4	r ← r – 1	× ×
	saddr	2	4	(saddr) ← (saddr) – 1	× ×
INCW	rp	1	4	rp ← rp + 1	
DECW	rp	1	4	rp ← rp – 1	
ROR	A, 1	1	2	(CY, $A_7 \leftarrow A_0$, $A_{m-1} \leftarrow A_m$) × 1	×
ROL	A, 1	1	2	(CY, $A_0 \leftarrow A_7$, $A_{m+1} \leftarrow A_m$) × 1	×
RORC	A, 1	1	2	(CY ← A_0, $A_7 \leftarrow$ CY, $A_{m-1} \leftarrow A_m$) × 1	×
ROLC	A, 1	1	2	(CY ← A_7, $A_0 \leftarrow$ CY, $A_{m+1} \leftarrow A_m$) × 1	×

Remark One instruction clock cycle is one cycle of the CPU clock (f_{CPU}), selected by the processor clock control register (PCC).

Mnemonic	Operand	Byte	Clock	Operation	Flag
					Z AC CY
SET1	saddr. bit	3	6	(saddr. bit) ← 1	
	sfr. bit	3	6	sfr. bit ← 1	
	A. bit	2	4	A. bit ← 1	
	PSW. bit	3	6	PSW. bit ← 1	× × ×
	[HL]. bit	2	10	(HL) . bit ← 1	
CLR1	saddr. bit	3	6	(saddr. bit) ← 0	
	sfr. bit	3	6	sfr. bit ← 0	
	A. bit	2	4	A. bit ← 0	
	PSW. bit	3	6	PSW. bit ← 0	× × ×
	[HL]. bit	2	10	(HL) . bit ← 0	
SET1	CY	1	2	CY ← 1	1
CLR1	CY	1	2	CY ← 0	0
NOT1	CY	1	2	CY ← $\overline{CY}$	×
CALL	!addr16	3	6	$(SP-1) \leftarrow (PC+3)_H$, $(SP-2) \leftarrow (PC+3)_L$, PC ← addr16, SP ← SP – 2	
CALLT	[addr5]	1	8	$(SP-1) \leftarrow (PC+1)_H$, $(SP-2) \leftarrow (PC+1)_L$, $PC_H \leftarrow$ (00000000, addr5 + 1), $PC_L \leftarrow$ (00000000, addr5), SP ← SP – 2	
RET		1	6	$PC_H \leftarrow (SP+1)$, $PC_L \leftarrow (SP)$, SP ← SP + 2	
RETI		1	8	$PC_H \leftarrow (SP+1)$, $PC_L \leftarrow (SP)$, PSW ← (SP + 2), SP ← SP + 3, NMIS ← 0	R R R
PUSH	PSW	1	2	(SP – 1) ← PSW, SP ← SP – 1	
	rp	1	4	$(SP-1) \leftarrow rp_H$, $(SP-2) \leftarrow rp_L$, SP ← SP – 2	
POP	PSW	1	4	PSW ← (SP), SP ← SP + 1	R R R
	rp	1	6	$rp_H \leftarrow (SP+1)$, $rp_L \leftarrow (SP)$, SP ← SP + 2	
MOVW	SP, AX	2	8	SP ← AX	
	AX, SP	2	6	AX ← SP	
BR	!addr16	3	6	PC ← addr16	
	$addr16	2	6	PC ← PC + 2 + jdisp8	
	AX	1	6	$PC_H \leftarrow A$, $PC_L \leftarrow X$	

Remark One instruction clock cycle is one cycle of the CPU clock (f_{CPU}), selected by the processor clock control register (PCC).

Mnemonic	Operand	Byte	Clock	Operation	Flag
					Z AC CY
BC	$addr16	2	6	PC ← PC + 2 + jdisp8 if CY = 1	
BNC	$addr16	2	6	PC ← PC + 2 + jdisp8 if CY = 0	
BZ	$addr16	2	6	PC ← PC + 2 + jdisp8 if Z = 1	
BNZ	$addr16	2	6	PC ← PC + 2 + jdisp8 if Z = 0	
BT	saddr. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if (saddr. bit) = 1	
	sfr. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if sfr. bit = 1	
	A. bit , $addr16	3	8	PC ← PC + 3 + jdisp8 if A. bit = 1	
	PSW. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if PSW. bit = 1	
BF	saddr. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if (saddr. bit) = 0	
	sfr. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if sfr. bit = 0	
	A. bit, $addr16	3	8	PC ← PC + 3 + jdisp8 if A. bit = 0	
	PSW. bit, $addr16	4	10	PC ← PC + 4 + jdisp8 if PSW. bit = 0	
DBNZ	B, $addr16	2	6	B ← B – 1, then PC ← PC + 2 + jdisp8 if B ≠ 0	
	C, $addr16	2	6	C ← C – 1, then PC ← PC + 2 + jdisp8 if C ≠ 0	
	saddr, $addr16	3	8	(saddr) ← (saddr) – 1, then PC ← PC + 3 + jdisp8 if(saddr) ≠ 0	
NOP		1	2	No Operation	
EI		3	6	IE ← 1(Enable Interrupt)	
DI		3	6	IE ← 0(Disable Interrupt)	
HALT		1	2	Set HALT Mode	
STOP		1	2	Set STOP Mode	

Remark One instruction clock cycle is one cycle of the CPU clock (f_{CPU}), selected by the processor clock control register (PCC).

10. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = 25°C)

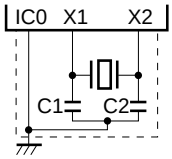
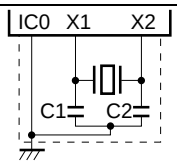
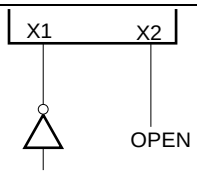
	Parameter	Symbol	Conditions		Ratings	Unit
★	Supply voltage	V_{DD}, AV_{DD}	$V_{DD} = AV_{DD}$		–0.3 to +6.5	V
	Input voltage	V_{I1}	Pins other than P50 to P53		–0.3 to V_{DD} + 0.3	V
		V_{I2}	P50 to P53	With N-ch open drain	–0.3 to +13	V
				With an on-chip pull-up resistor	–0.3 to V_{DD} + 0.3	V
	Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
	Output current, high	I_{OH}	Per pin		–10	mA
			Total for all pins		–30	mA
	Output current, low	I_{OL}	Per pin		30	mA
			Total for all pins		160	mA
	Operating ambient temperature	T_A			–40 to +85	°C
	Storage temperature	T_{stg}			–65 to +150	°C

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. 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, the characteristics of alternate-function pins are the same as those of port pins.

★ **System Clock Oscillator Characteristics**

(T_A = –40 to +85°C, V_{DD} = 2.7 to 5.5 V)

Resonator	Recommended Circuit	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillation frequency (f_X)[Note 1]	V_{DD} = oscillation voltage range	1.0		5.0	MHz
		Oscillation stabilization time[Note 2]	After V_{DD} reaches oscillation voltage range MIN.			4	ms
Crystal resonator		Oscillation frequency (f_X)[Note 1]		1.0		5.0	MHz
		Oscillation stabilization time[Note 2]	V_{DD} = 4.5 to 5.5 V			10	ms
			V_{DD} = 2.7 to 5.5 V			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 oscillator characteristics. Refer to **AC characteristics** for instruction execution time.

2. Time required to stabilize oscillation after a reset or STOP mode release. Use the resonator that stabilizes oscillation during the oscillation wait time.

Caution When using the system clock oscillator, wire as follows in the area enclosed by the broken lines in the above figures to avoid an adverse effect from wiring capacitance.

- **Keep the wiring length as short as possible.**
- **Do not cross the wiring with the other signal lines.**
- **Do not route the wiring near a signal line through which a high fluctuating current flows.**
- **Always make the ground point of the oscillator capacitor the same potential as V_{SS}.**
- **Do not ground the capacitor to a ground pattern through which a high current flows.**
- **Do not fetch signals from the oscillator.**

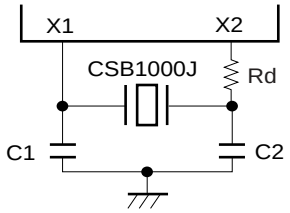
Phase-out/Discontinued

★ **Recommended Oscillator Constant**

Ceramic resonator (T_A = –40 to +85°C) (1/4)

Manufacturer	Part Number	Frequency (MHz)	Recommended Circuit Constant (pF)		Oscillation Voltage Range (V_{DD})		Remarks
			C1	C2	MIN.	MAX.	
Murata Mfg. Co., Ltd. (Lead pin type)	CSB1000J[Note]	1.00	100	100	2.7	5.5	Rd = 2.2 kΩ
	CSA2.00MG	2.00	30	30			
	CST2.00MG		–	–			On-chip capacitor
	CSA4.00MG	4.00	30	30			
	CST4.00MGW		–	–			On-chip capacitor
	CSA4.00MGU		30	30			
	CST4.00MGWU		–	–			On-chip capacitor
	CSA4.19MG	4.19	30	30			
	CST4.19MG		–	–			On-chip capacitor
	CSA4.19MGU		30	30			
	CST4.19MGU		–	–			On-chip capacitor
	CSA4.91MG	4.91	30	30			
	CST4.91MGW		–	–			On-chip capacitor
	CSA4.91MGU		30	30			
	CST4.91MGWU		–	–			On-chip capacitor
	CSA5.00MG	5.00	30	30			
	CST5.00MGW		–	–			On-chip capacitor
	CSA5.00MGU		30	30			
	CST5.00MGWU		–	–			On-chip capacitor

Note When using the CSB1000J (1.0 MHz) of Murata Mfg. Co., Ltd. as a ceramic resonator, a limited resistor (Rd = 2.2 kΩ) is required (see the figure below). The resistor is not required when a recommended resonator other than the CSB1000J is used.

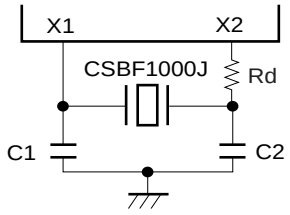


Caution The oscillator constant and oscillation voltage range indicate conditions of stable oscillation. Oscillation frequency precision is not guaranteed. For applications requiring oscillation frequency precision, the oscillation frequency must be adjusted on the implementation circuit. For details, please contact directly the manufacturer of the resonator you will use.

Ceramic resonator (T_A = –40 to +85°C) (2/4)

Manufacturer	Part Number	Frequency (MHz)	Recommended Circuit Constant (pF)		Oscillation Voltage Range (V_{DD})		Remarks
			C1	C2	MIN.	MAX.	
Murata Mfg. Co., Ltd. (SMD type)	CSBF1000J[Note]	1.00	100	100	2.7	5.5	Rd = 2.2 kΩ
	CSAC2.00MGC	2.00	30	30			
	CSTC2.00MG		–	–			On-chip capacitor
	CSAC4.00MGC	4.00	30	30			
	CSAC4.00MGCU						
	CSTCC4.00MG		–	–			On-chip capacitor
	CSTCC4.00MGU						
	CSAC4.19MGC	4.19	30	30			
	CSAC4.19MGCU						
	CSTCC4.19MG		–	–			On-chip capacitor
	CSTCC4.19MGU						
	CSAC4.91MGC	4.91	30	30			
	CSAC4.91MGCU						
	CSTCC4.91MG		–	–			On-chip capacitor
	CSTCC4.91MGU						
	CSAC5.00MGC	5.00	30	30			
	CSAC5.00MGCU						
	CSTCC5.00MG		–	–			On-chip capacitor
	CSTCC5.00MGU						

Note When using the CSBF1000J (1.0 MHz) of Murata Mfg. Co., Ltd. as a ceramic resonator, a limited resistor (Rd = 2.2 kΩ) is required (see the figure below). The resistor is not required when a recommended resonator other than the CSBF1000J is used.



Caution The oscillator constant and oscillation voltage range indicate conditions of stable oscillation. Oscillation frequency precision is not guaranteed. For applications requiring oscillation frequency precision, the oscillation frequency must be adjusted on the implementation circuit. For details, please contact directly the manufacturer of the resonator you will use.

Ceramic resonator (T_A = –40 to +85°C) (3/4)

Manufacturer	Part Number	Frequency (MHz)	Recommended Circuit Constant (pF)		Oscillation Voltage Range (V_{DD})		Remarks
			C1	C2	MIN.	MAX.	
Kyocera Corporation (Lead pin type)	KBR-1000F	1.00	100	100	2.7	5.5	
	KBR-2.0MS	2.00	68	68			
	KBR-4.0MKC	4.00	–	–			On-chip capacitor
	KBR-4.0MKD						
	KBR-4.0MKS						
	KBR-4.0MSA		33	33			
	KBR-4.0MSB						
	KBR-4.19MKC	4.19	–	–			On-chip capacitor
	KBR-4.19MKD						
	KBR-4.19MKS						
	KBR-4.19MSA		33	33			
	KBR-4.19MSB						
	KBR-4.91MKC	4.91	–	–			On-chip capacitor
	KBR-4.91MKD						
	KBR-4.91MKS						
	KBR-4.91MSA		33	33			
	KBR-4.91MSB						
	KBR-5.0MKC	5.00	–	–			On-chip capacitor
	KBR-5.0MKD						
	KBR-5.0MKS						
	KBR-5.0MSA		33	33			
	KBR-5.0MSB						
Kyocera Corporation (SMD type)	KBR-1000Y	1.00	100	100	2.7	5.5	
	PBRC4.00A	4.00	33	33			
	PBRC4.00B		–	–			On-chip capacitor
	PBRC4.19A	4.19	33	33			
	PBRC4.19B		–	–			On-chip capacitor
	PBRC4.91A	4.91	33	33			
	PBRC4.91B		–	–			On-chip capacitor
	PBRC5.00A	5.00	33	33			
	PBRC5.00B		–	–			On-chip capacitor

Caution The oscillator constant and oscillation voltage range indicate conditions of stable oscillation. Oscillation frequency precision is not guaranteed. For applications requiring oscillation frequency precision, the oscillation frequency must be adjusted on the implementation circuit. For details, please contact directly the manufacturer of the resonator you will use.

Ceramic resonator (T_A = –40 to +85°C) (4/4)

Manufacturer	Part Number	Frequency (MHz)	Recommended Circuit Constant (pF)		Oscillation Voltage Range (V_{DD})		Remarks
			C1	C2	MIN.	MAX.	
TDK	CCR4.0MC3	4.00	–	–	2.7	5.5	On-chip capacitor
	FCR4.0M5		33	33			
	FCR4.0MC5		–	–			On-chip capacitor
	CCR4.19MC3	4.19					
	FCR4.19M5		33	33			
	FCR4.19MC5		–	–			On-chip capacitor
	CCR4.91MC3	4.91					
	CCR5.0MC3	5.00					
	FCR5.0MC5						

Caution The oscillator constant and oscillation voltage range indicate conditions of stable oscillation. Oscillation frequency precision is not guaranteed. For applications requiring oscillation frequency precision, the oscillation frequency must be adjusted on the implementation circuit. For details, please contact directly the manufacturer of the resonator you will use.

★ **DC Characteristics (T_A = –40 to +85°C, V_{DD} = 2.7 to 5.5 V) (1/2)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output current, high	I_{OH}	Per pin				–1	mA
		Total for all pins				–15	mA
Output current, low	I_{OL}	Per pin				10	mA
		Total for all pins				80	mA
Input voltage, high	V_{IH1}	Pins other than described below		0.7V_{DD}		V_{DD}	V
	V_{IH2}	P50 to P53, V_{DD} = 3.5 to 5.5 V	With N-ch open drain	0.7V_{DD}		12	V
			With on-chip pull-up resistor	0.7V_{DD}		V_{DD}	V
	V_{IH3}	$\overline{\text{RESET}}$, P20 to P25, P40 to P45		0.8V_{DD}		V_{DD}	V
	V_{IH4}	X1, X2	V_{DD} = 2.7 to 5.5 V	V_{DD} – 0.1		V_{DD}	V
			V_{DD} = 4.5 to 5.5 V	V_{DD} – 0.5		V_{DD}	V
Input voltage, low	V_{IL1}	Pins other than described below		0		0.3V_{DD}	V
	V_{IL2}	P50 to P53, V_{DD} = 3.5 to 5.5 V		0		0.3V_{DD}	V
	V_{IL3}	$\overline{\text{RESET}}$, P20 to P25, P40 to P45		0		0.2V_{DD}	V
	V_{IL4}	X1, X2	V_{DD} = 2.7 to 5.5 V	0		0.1	V
			V_{DD} = 4.5 to 5.5 V	0		0.4	V
Output voltage, high	V_{OH1}	V_{DD} = 4.5 to 5.5 V, I_{OH} = –1 mA		V_{DD} – 1.0			V
	V_{OH2}	V_{DD} = 2.7 to 5.5 V, I_{OH} = –100 μA		V_{DD} – 0.5			V
Output voltage, low	V_{OL1}	Pins other than P50 to P53	V_{DD} = 4.5 to 5.5 V, I_{OL} = 10 mA			1.0	V
			V_{DD} = 2.7 to 5.5 V I_{OL} = 400 μA			0.5	V
	V_{OL2}	P50 to P53	V_{DD} = 4.5 to 5.5 V, I_{OL} = 10 mA			1.0	V
			V_{DD} = 2.7 to 5.5 V I_{OL} = 1.6 mA			0.4	V
Input leakage current, high	I_{LIH1}	Pins other than X1, X2, or P50 to P53	V_{IN} = V_{DD}			3	μA
	I_{LIH2}	X1, X2				20	μA
	I_{LIH3}	P50 to P53 (N-ch open drain)	V_{IN} = 12 V			20	μA
Input leakage current, low	I_{LIL1}	Pins other than X1, X2, or P50 to P53	V_{IN} = 0 V			–3	μA
	I_{LIL2}	X1, X2				–20	μA
	I_{LIL3}	P50 to P53 (N-ch open drain)				–3[Note]	μA

Note When pull-up resistors are not connected to P50 to P53 (specified by the mask option) and when port 5 is in input mode, a low-level input leakage current of –30 μA (MAX.) flows only for 1 cycle time after a read instruction has been executed to port 5.

Remark Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

★ **DC Characteristics (T_A = –40 to +85°C, V_{DD} = 2.7 to 5.5 V) (2/2)**

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Output leakage current, high	I_{LOH}	$V_{OUT} = V_{DD}$				3	μA
Output leakage current, low	I_{LOL}	V_{OUT} = 0 V				–3	μA
Software pull-up resistor	R_1	V_{IN} = 0 V, for pins other than P50 to P53		50	100	200	kΩ
Mask option pull-up resistor	R_2	V_{IN} = 0 V, P50 to P53		10	30	60	kΩ
Power supply current[Note 1]	I_{DD1}[Note 1]	5.0-MHz crystal oscillation operating mode (C1 = C2 = 22pF)	V_{DD} = 5.0 V±10%[Note 3]		1.8	3.2	mA
			V_{DD} = 3.0 V±10%[Note 4]		0.45	0.9	mA
	I_{DD2}[Note 1]	5.0-MHz crystal oscillation HALT mode (C1 = C2 = 22pF)	V_{DD} = 5.0 V±10%[Note 3]		0.8	1.6	mA
			V_{DD} = 3.0 V±10%[Note 4]		0.3	0.6	mA
	I_{DD3}[Note 1]	STOP mode	V_{DD} = 5.0 V±10%		0.1	10	μA
			V_{DD} = 3.0 V±10%		0.05	5.0	μA
	I_{DD4}[Note 2]	5.0-MHz crystal oscillation A/D operating mode (C1 = C2 = 22pF)	V_{DD} = 5.0 V±10%		3.0	5.5	mA
			V_{DD} = 3.0 V±10%		1.65	3.2	mA

Notes 1. The current flowing to the ports (including the current flowing through an on-chip pull-up resistor) and AV_{DD} current are not included.

2. The current flowing to the ports (including the current flowing through an on-chip pull-up resistor) is not included.

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

4. Low-speed mode operation (when PCC is set to 02H).

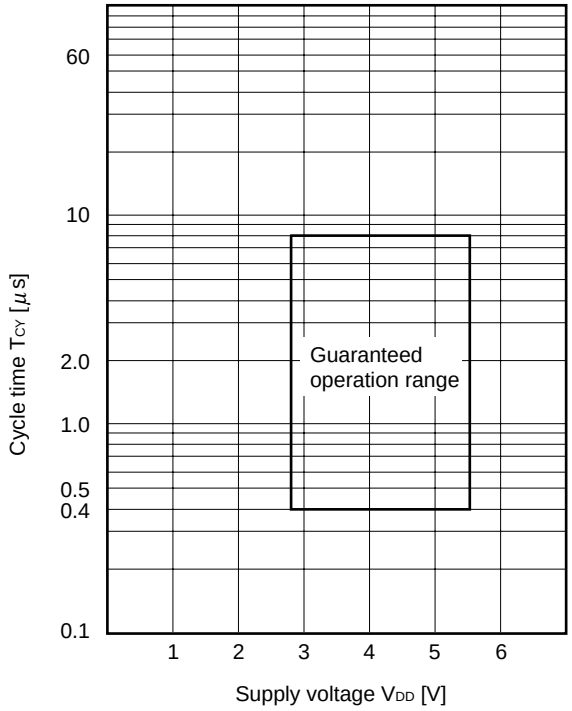
Remark Unless specified otherwise, the characteristics of alternate-function pins are the same as those of port pins.

AC Characteristics

(1) Basic operation (T_A = –40 to +85°C, V_{DD} = 2.7 to 5.5 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Cycle time (minimum instruction execution time)	T_{CY}		0.4		8	μs
TI80 input high-/low-level width	t_{TIH}, t_{TIL}		0.1			μs
TI80 input frequency	f_{TI}		0		4	MHz
Interrupt input high-/low-level width	t_{INTH}, t_{INTL}	INTP0 to INTP2	10			μs
$\overline{\text{RESET}}$ low-level width	t_{RSL}		10			μs

★ **T_{CY} vs V_{DD} (at 5.0 MHz operation with system clock)**



(2) Serial interface (T_A = –40 to +85°C, V_{DD} = 2.7 to 5.5 V)

(i) 3-wire serial I/O mode ($\overline{SCK20}$...Internal clock output)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
$\overline{SCK20}$ cycle time	t_{KCY1}		800			ns
$\overline{SCK20}$ high-/low-level width	t_{KH1}, t_{KL1}		$t_{KCY1}/2 - 50$			ns
SI20 setup time (to $\overline{SCK20}\uparrow$)	t_{SIK1}		150			ns
SI20 hold time (from $\overline{SCK20}\uparrow$)	t_{KSI1}		400			ns
SO20 output delay time from $\overline{SCK20}\downarrow$	t_{KSO1}	R = 1 kΩ, C = 100 pF[Note]	0		250	ns

Note R and C are the load resistance and load capacitance of the SO output line.

(ii) 3-wire serial I/O mode ($\overline{SCK20}$...External clock input)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
★ $\overline{SCK20}$ cycle time	t_{KCY2}		900			ns
$\overline{SCK20}$ high-/low-level width	t_{KH2}, t_{KL2}		400			ns
SI20 setup time (to $\overline{SCK20}\uparrow$)	t_{SIK2}		100			ns
SI20 hold time (from $\overline{SCK20}\uparrow$)	t_{KSI2}		400			ns
SO20 output delay time from $\overline{SCK20}\downarrow$	t_{KSO2}	R = 1 kΩ, C = 100 pF[Note]	0		300	ns
★ SO20 setup time (for $\overline{SS20}\downarrow$ when $\overline{SS20}$ is used)	t_{KAS2}				120	ns
★ SO20 disable time (for $\overline{SS20}\uparrow$ when $\overline{SS20}$ is used)	t_{KDS2}				240	ns

Note R and C are the load resistance and load capacitance of the SO output line.

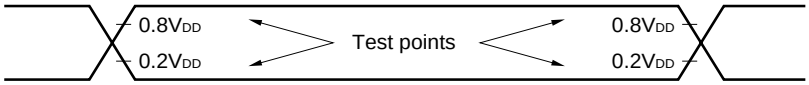
(iii) UART mode (Dedicated baud rate generator output)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate					78125	bps

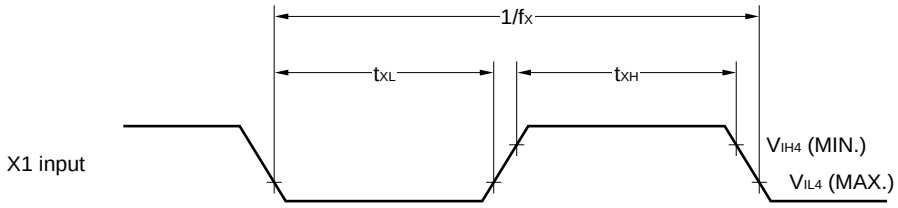
(iv) UART mode (external clock input)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
★ ASCK20 cycle time	t_{KCY3}		900			ns
ASCK20 high-/low-level width	t_{KH3}, t_{KL3}		400			ns
Transfer rate					39063	bps
ASCK20 rise/fall time	t_R, t_F				1	μs

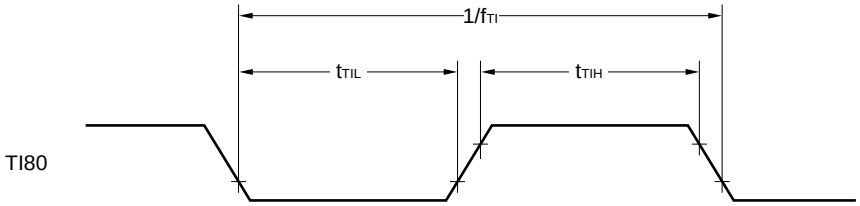
AC Timing Test Points (excluding X1 input)



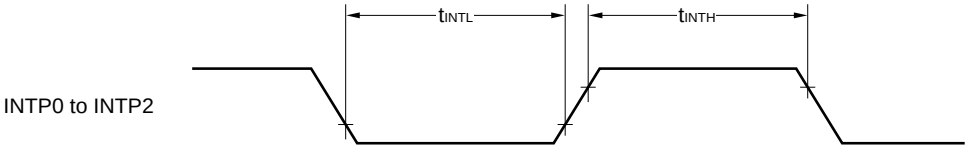
Clock Timing



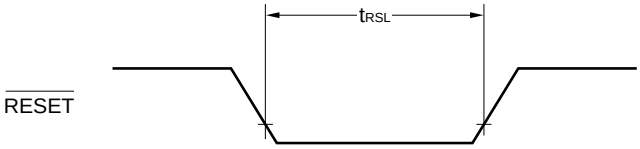
TI Timing



Interrupt Input Timing

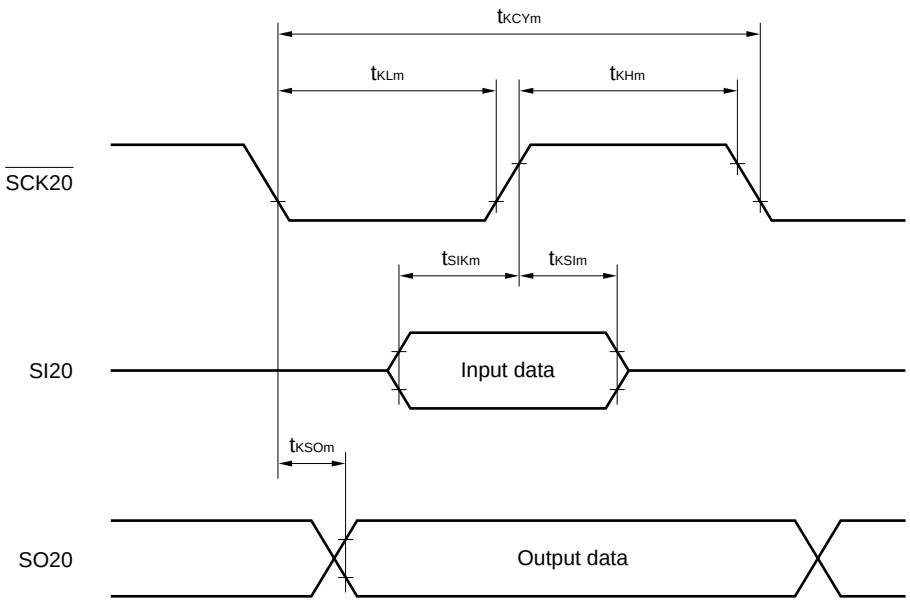


$\overline{\text{RESET}}$ Input Timing



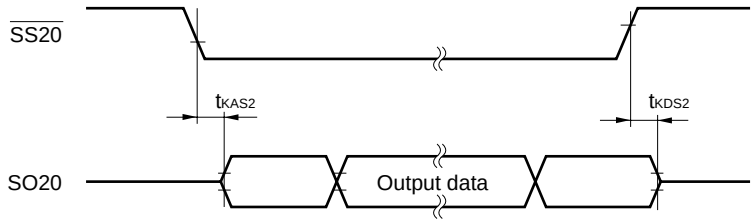
Serial Transfer Timing

3-wire serial I/O mode:

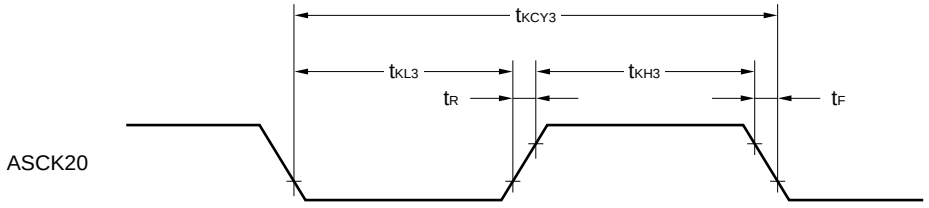


m = 1, 2

★ **3-wire serial I/O mode (when $\overline{SS20}$ is used):**



UART mode (external clock input):



★ **8-Bit A/D Converter Characteristics (μPD789101, 789102, 789104)**

(T_A = –40 to +85°C, AV_{DD} = V_{DD} = 2.7 to 5.5 V, AV_{SS} = V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution			8	8	8	bit
Overall error[Note]				±0.4	±0.6	%FSR
Conversion time	t_{CONV}		14		100	μs
Analog input voltage	V_{IAN}		0		AV_{DD}	V

Note Excludes quantization error (±0.2%).

Remark FSR: Full-scale range

★ **10-Bit A/D Converter Characteristics (μPD789111, 789112, 789114)**

(T_A = –40 to +85°C, AV_{DD} = V_{DD} = 2.7 to 5.5 V, AV_{SS} = V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution			10	10	10	bit
Overall error[Note]		4.5 V ≤ V_{DD} ≤ 5.5 V		±0.2	±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V		±0.4	±0.6	%FSR
Conversion time	t_{CONV}		14		100	μs
Zero-scale error[Note]		4.5 V ≤ V_{DD} ≤ 5.5 V			±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V			±0.6	%FSR
Full-scale error[Note]		4.5 V ≤ V_{DD} ≤ 5.5 V			±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V			±0.6	%FSR
Non-integral linearity error[Note]	INL	4.5 V ≤ V_{DD} ≤ 5.5 V			±2.5	LSB
		2.7 V ≤ V_{DD} < 4.5 V			±4.5	LSB
Non-differential linearity error[Note]	DNL	4.5 V ≤ V_{DD} ≤ 5.5 V			±1.5	LSB
		2.7 V ≤ V_{DD} < 4.5 V			±2.0	LSB
Analog input voltage	V_{IAN}		0		AV_{DD}	V

Note Excludes quantization error (±0.05%).

Remark FSR: Full-scale range

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

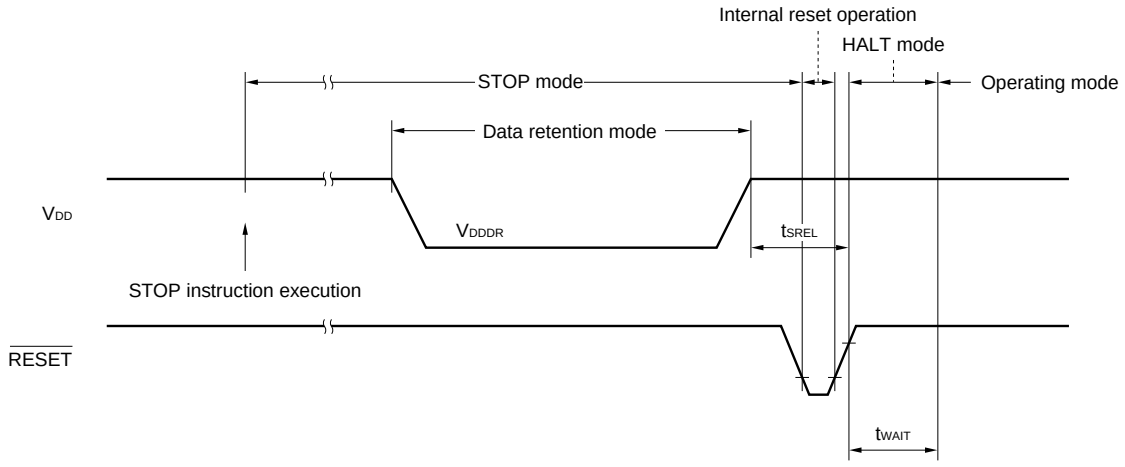
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	V_{DDDR}		1.8		5.5	V
Release signal set time	t_{SREL}		0			μs
Oscillation stabilization wait time[Note 1]	t_{WAIT}	Release by $\overline{\text{RESET}}$		$2^{15}/f_X$		ms
		Release by interrupt request		**Note 2**		ms

Notes 1. The oscillation stabilization wait time is the period during which the CPU operation is stopped to avoid unstable operation at the beginning of oscillation.

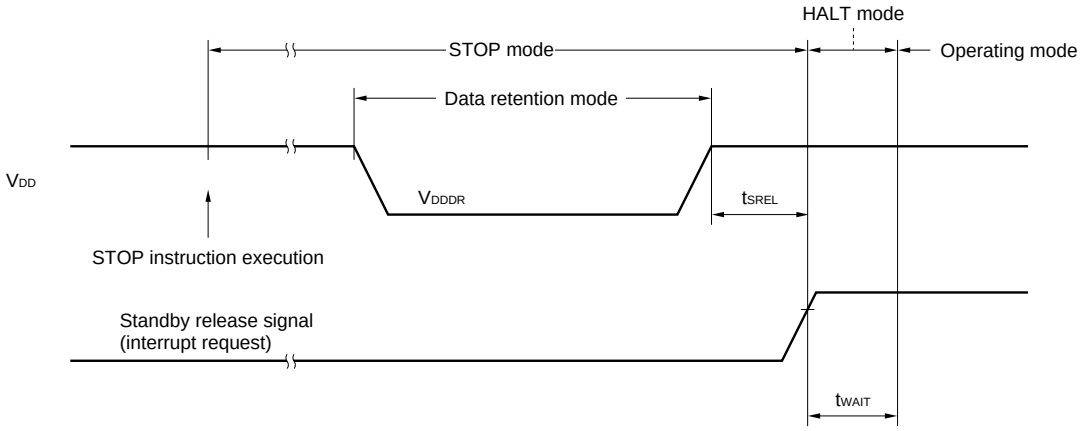
2. Selection of $2^{12}/f_X$, $2^{15}/f_X$, or $2^{17}/f_X$ is possible with bits 0 to 2 (OSTS0 to OSTS2) of the oscillation stabilization time select register.

Remark f_X: System clock oscillation frequency

Data Retention Timing (STOP mode release by $\overline{\text{RESET}}$)

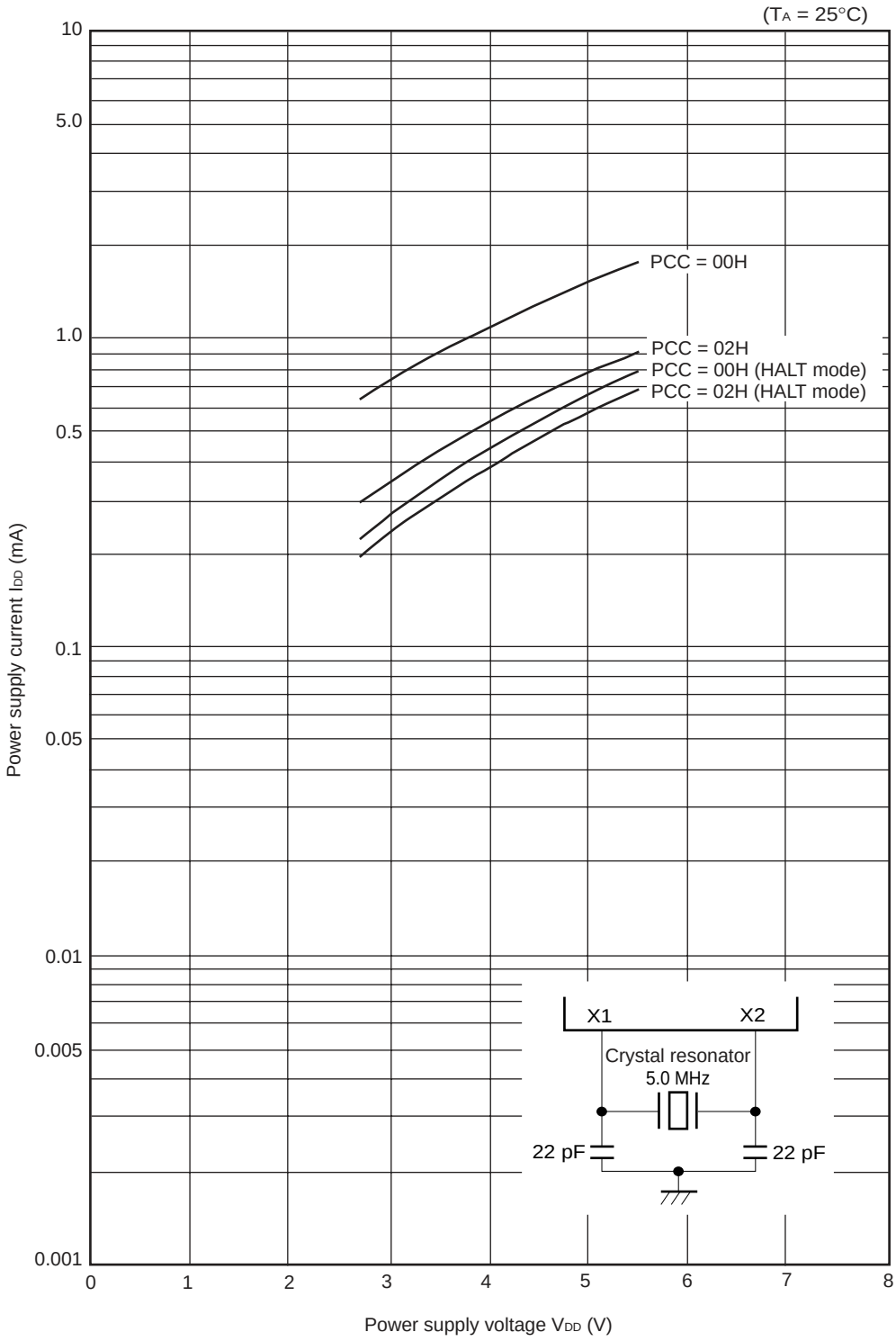


Data Retention Timing (Standby release signal: STOP mode release by interrupt signal)

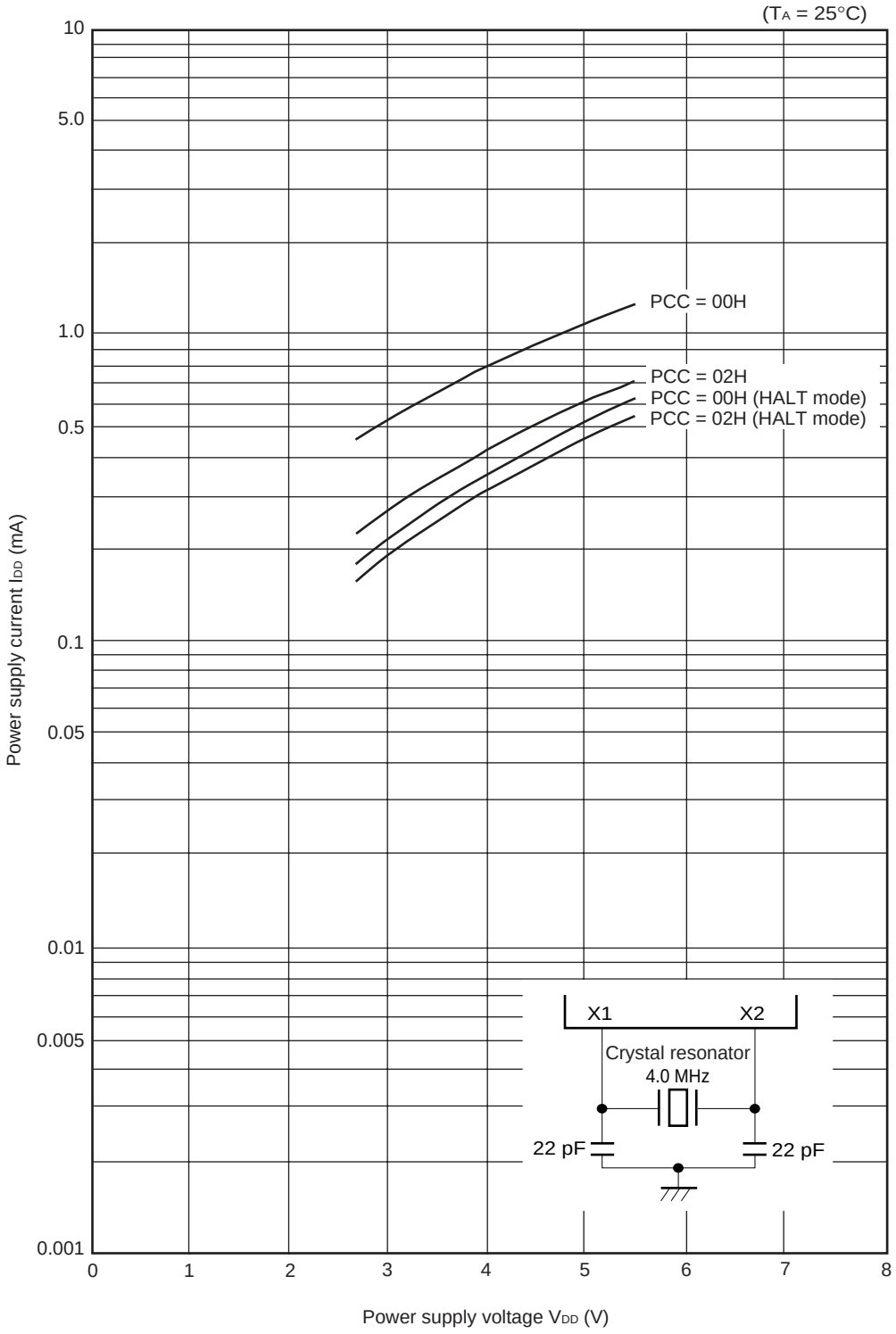


★ 11. CHARACTERISTICS CURVES (REFERENCE VALUES)

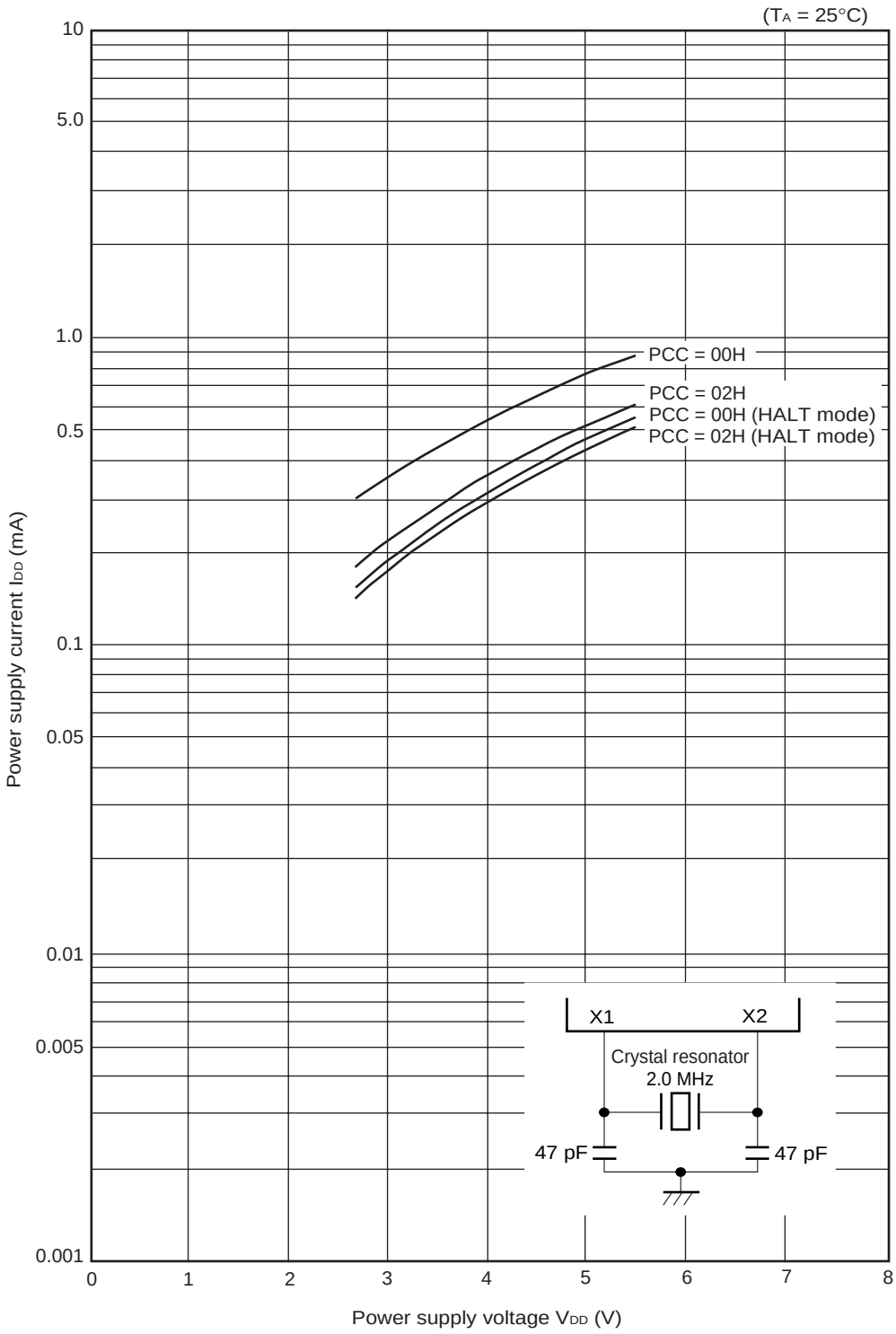
I_{DD} vs V_{DD} (System clock: 5.0-MHz crystal resonator)



I_{DD} vs V_{DD} (System clock: 4.0-MHz crystal resonator)

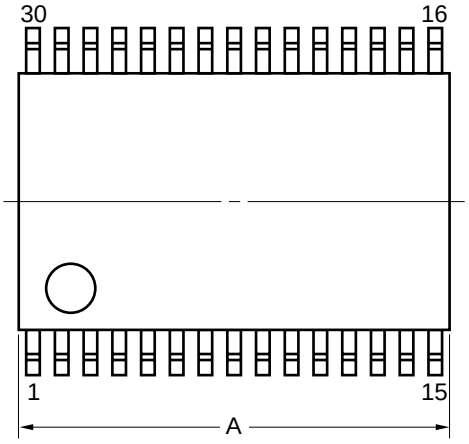


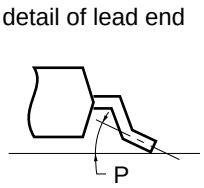
I_{DD} vs V_{DD} (System clock: 2.0-MHz crystal resonator)

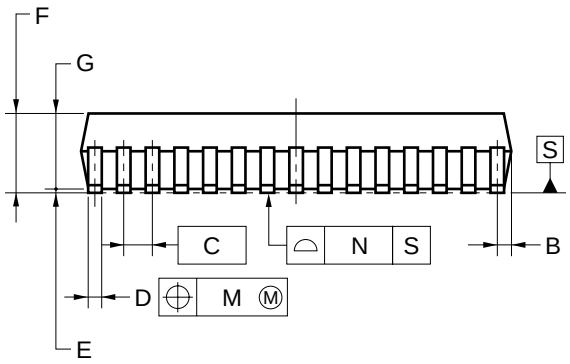


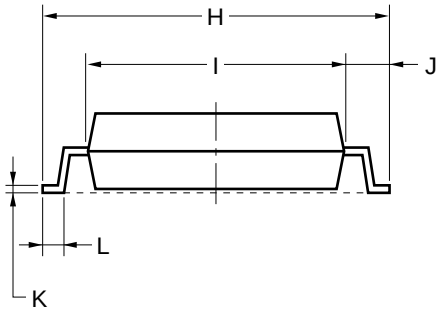
★ **12. PACKAGE DRAWING**

30 PIN PLASTIC SHRINK SOP (300 mil)









NOTES

1. Controlling dimension —— millimeter.

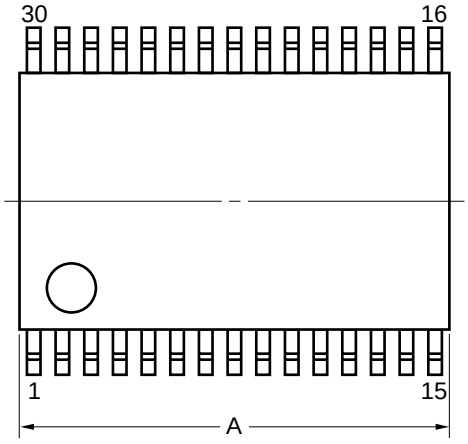
2. Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	9.85±0.26	0.388±0.011
B	0.51 MAX.	0.020 MAX.
C	0.65 (T.P.)	0.026 (T.P.)
D	$0.32^{+0.08}_{-0.07}$	$0.013^{+0.003}_{-0.004}$
E	0.125±0.075	0.005±0.003
F	2.0 MAX.	0.079 MAX.
G	1.7±0.1	0.067±0.004
H	8.1±0.2	0.319±0.008
I	6.1±0.2	0.240±0.008
J	1.0±0.2	$0.039^{+0.009}_{-0.008}$
K	$0.17^{+0.08}_{-0.07}$	$0.007^{+0.003}_{-0.004}$
L	0.5±0.2	$0.020^{+0.008}_{-0.009}$
M	0.10	0.004
N	0.10	0.004
P	$3^{\circ}{}^{+7^{\circ}}_{-3^{\circ}}$	$3^{\circ}{}^{+7^{\circ}}_{-3^{\circ}}$

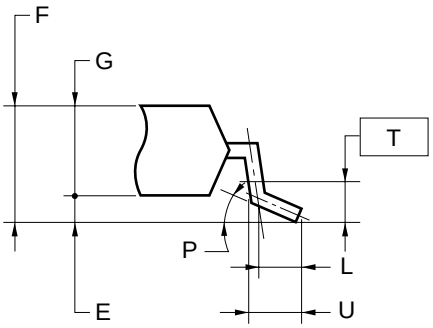
P30GS-65-300B-2

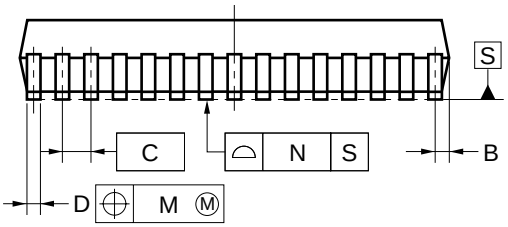
Phase-out/Discontinued

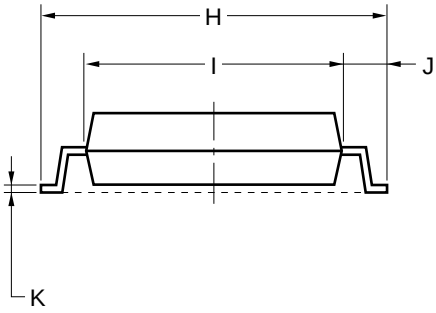
30 PIN PLASTIC SSOP (300 mil)



detail of lead end







NOTE

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

ITEM	MILLIMETERS
A	9.85±0.15
B	0.45 MAX.
C	0.65 (T.P.)
D	$0.24^{+0.08}_{-0.07}$
E	0.1±0.05
F	1.3±0.1
G	1.2
H	8.1±0.2
I	6.1±0.2
J	1.0±0.2
K	0.17±0.03
L	0.5
M	0.13
N	0.10
P	$3^{\circ}{}^{+5^{\circ}}_{-3^{\circ}}$
T	0.25
U	0.6±0.15

S30MC-65-5A4-1

★ 13. RECOMMENDED SOLDERING CONDITIONS

The μPD789101, 789102, 789104, 789111, 789112, and 789114 should be soldered and mounted under the following recommended conditions.

For the details of the recommended soldering conditions, refer to the document **Semiconductor Device Mounting Technology Manual (C10535E)**. For soldering methods and conditions other than those recommended below, contact your NEC sales representative.

Table 13-1. Surface Mounting Type Soldering Conditions (1/2)

μPD789101GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789102GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789104GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789111GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789112GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)
μPD789114GS-xxx: 30-pin plastic shrink SOP (300 mils, resin thickness 1.7 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 30 sec. Max. (at 210°C or higher), Count: twice or less, Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 hours)	IR35-207-2
VPS	Package peak temperature: 215°C, Time: 40 sec. Max. (at 200°C or higher), Count: twice or less, Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 hours)	VP15-207-2
Wave soldering	Solder bath temperature: 260°C Max., Time: 10 sec. Max., Count: once, Preheating temperature: 120°C Max. (package surface temperature), Exposure limit: 7 days[Note] (after that, prebake at 125°C for 20 hours)	WS60-207-1
Partial heating	Pin temperature: 300°C Max., Time: 3 sec. Max. (per pin row)	–

Note After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

Caution Do not use different soldering methods together (except for partial heating).

Table 13-1. Surface Mounting Type Soldering Conditions (2/2)

μPD789101MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789102MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789104MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789111MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789112MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)
μPD789114MC-xxx-5A4: 30-pin plastic shrink SOP (300 mils, resin thickness 1.2 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 30 sec. Max. (at 210°C or higher), Count: three times or less	IR35-00-3
VPS	Package peak temperature: 215°C, Time: 40 sec. Max. (at 200°C or higher), Count: three times or less	VP15-00-3
Wave soldering	Solder bath temperature: 260°C Max., Time: 10 sec. Max., Count: once, Preheating temperature: 120°C Max. (package surface temperature)	WS60-00-1
Partial heating	Pin temperature: 300°C Max., Time: 3 sec. Max. (per pin row)	–

Caution Do not use different soldering methods together (except for partial heating).

Phase-out/Discontinued

★ APPENDIX A DEVELOPMENT TOOLS

The following development tools are available for system development using the μPD789101, μPD789102, μPD789104, μPD789111, μPD789112, and μPD789114.

Language Processing Software

RA78K0S[Notes 1, 2, 3]	Assembler package common to 78K/0S Series
CC78K0S[Notes 1, 2, 3]	C compiler package common to 78K/0S Series
DF789136[Notes 1, 2, 3]	Device file for μPD789104, 789114 Subseries

Flash Memory Writing Tools

Flashpro III (Model number: FL-PR3[Note 4], PG-FP3)	Dedicated flash programmer for on-chip flash memory
FA-30GS[Note 4]	Flash memory writing adapter
FA30MC[Notes 4, 5]	

Debugging Tools (1/2)

IE-78K0S-NS In-circuit emulator	In-circuit emulator serves to debug hardware and software when developing application systems using a 78K/0S Series product. It supports the ID78K0S-NS integrated debugger. Used in combination with an AC adapter, emulation probe, and interface adapter connecting to the host machine.
IE-70000-MC-PS-B AC adapter	Adapter used to supply power from a power outlet of 100 V AC to 240 V AC.
IE-70000-98-IF-C Interface adapter	Adapter when PC-9800 series PC (except notebook type) is used as the IE-78K0S-NS host machine (C bus supported).
IE-70000-CD-IF-A PC card interface	PC card and interface cable when notebook PC is used as the IE-78K0S-NS host machine (PCMCIA socket supported).
IE-70000-PC-IF-C Interface adapter	Adapter when using an IBM PC/AT™ or compatible as the IE-78K0S-NS host machine.
IE-70000-PCI-IF Interface adapter	Adapter when using PC that includes a PCI bus as the IE-78K0S-NS host machine.
IE-789136-NS-EM1 Emulation board	Board for emulation of the peripheral hardware peculiar to a device. Used in combination with an in-circuit emulator.
NP-36GS[Note 4]	Board used to connect the in-circuit emulator to the target system. For a 30-pin plastic shrink SOP (GS, MC-5A4 type), used in combination with NGS-30.
NGS-30[Note 4] Conversion socket	Conversion socket used to connect the NP-36GS to the target system board designed to mount a 30-pin plastic shrink SOP (GS, MC-5A4 type).

Notes 1. PC-9800 series (MS-DOS™ + Windows™) based

2. IBM PC/AT or compatibles (Japanese/English Windows) based

3. HP9000 series 700™ (HP-UX™), SPARCstation™ (SunOS™, Solaris™), or NEWS™ (NEWS-OS™) based.

4. Products made by Naito Densei Machida Mfg. Co., Ltd. (Phone: +81-44-822-3813). Contact an NEC distributor regarding the purchase of these products.

5. Under development

Remark RA78K0S, CC78K0S, and SM78K0S are used in combination with the DF789136.

Debugging Tools (2/2)

SM78K0S[Notes 1, 2]	System simulator common to 78K/0S Series
ID78K0S-NS[Notes 1, 2]	Integrated debugger common to 78K/0S Series
DF789136[Notes 1, 2]	Device file for μPD789104, 789114 Subseries

Real-time OS

MX78K0S[Notes 1, 2]	OS for 78K/0S Series

Notes 1. PC-9800 series (MS-DOS + Windows) based.

2. IBM PC/AT or compatibles (Japanese/English Windows) based.

★ APPENDIX B RELATED DOCUMENTS

Documents Related to Devices

Document Name	Document No.	
	Japanese	English
μPD789101, 789102, 789104, 789111, 789112, 789114 Data Sheet	U12815J	This manual
μPD78F9116 Data Sheet	U13037J	U13037E
μPD789104, 789114, 789124, 789134 Subseries User's Manual	U13045J	U13045E
78K/0S Series User's Manual Instruction	U11047J	U11047E

Documents Related to Development Tools (User's Manuals)

Document Name		Document No.	
		Japanese	English
RA78K0S Assembler Package	Operation	U11622J	U11622E
	Assembly Language	U11599J	U11599E
	Structured Assembly Language	U11623J	U11623E
CC78K0S C Compiler	Operation	U11816J	U11816E
	Language	U11817J	U11817E
SM78K0S System Simulator Windows Based	Reference	U11489J	U11489E
SM78K Series System Simulator	External Parts User Open Interface Specifications	U10092J	U10092E
ID78K0S-NS Integrated Debugger Windows Based	Reference	U12901J	U12901E
IE-78K0S-NS In-circuit Emulator		U13549J	U13549E
IE-789136-NS-EM1 Emulation Board		To be prepared	To be prepared

Documents Related to Embedded Software (User's Manuals)

Document Name		Document No.	
		Japanese	English
78K/0S Series OS MX78K0S	Fundamental	U12938J	U12938E

Caution The related documents listed above are subject to change without notice. Be sure to use the latest version of each document for designing.

Other Related Documents

Document Name	Document No.	
	Japanese	English
SEMICONDUCTORS SELECTION GUIDE Products & Packages (CD-ROM)	X13769X	
Semiconductor Device Mounting Technology Manual	C10535J	C10535E
Quality Grades on NEC Semiconductor Devices	C11531J	C11531E
NEC Semiconductor Device Reliability/Quality Control System	C10983J	C10983E
Guide to Prevent Damage for Semiconductor Devices by Electrostatic Discharge (ESD)	C11892J	C11892E
Guide to Microcomputer-Related Products by Third Party	U11416J	–

Caution The related documents listed above are subject to change without notice. Be sure to use the latest version of each document for designing.

[MEMO]

[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.

Phase-out/Discontinued

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

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Fax: 408-588-6130
800-729-9288

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Duesseldorf, Germany
Tel: 0211-65 03 02
Fax: 0211-65 03 490

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Milton Keynes, UK
Tel: 01908-691-133
Fax: 01908-670-290

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Fax: 02-528-4411

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United Square, Singapore 1130
Tel: 65-253-8311
Fax: 65-250-3583

NEC Electronics Taiwan Ltd.
Taipei, Taiwan
Tel: 02-2719-2377
Fax: 02-2719-5951

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