

**8-BIT SINGLE-CHIP MICROCONTROLLER****DESCRIPTION**

The  $\mu$ PD178023, 178024 are 8-bit single-chip CMOS microcontrollers containing hardware for digital tuning systems.

These microcontrollers employ a 78K/0 series architecture CPU and allow easy access to internal memories at high speed and easy control of peripheral hardware units. The high-speed 78K/0 series instructions are ideal for system control.

As peripheral hardware, a prescaler, PLL frequency synthesizer, and frequency counter for digital tuning systems are provided, as well as many I/O ports, timers, A/D converter, serial interface, and a power-ON clear circuit.

In addition, three serial interfaces, I<sup>2</sup>C bus (IIC0), three-wire (SIO3), and UART are provided.

Moreover, a flash memory model, the  $\mu$ PD178F124, that operates in the same supply voltage range as the mask ROM models, and various development tools are also available.

**For the detailed functional description, refer to the following User's Manuals:**

**$\mu$ PD178024 Subseries User's Manual : U13915E**

**78K/0 Series User's Manual - Instruction : U12326E**

**FEATURES**

- High-capacity ROM and RAM

Part Number	Item	Program Memory (ROM)	Data Memory
			Internal high-speed RAM
$\mu$ PD178023		24K bytes	1024 bytes
$\mu$ PD178024		32K bytes	

- Instruction cycle:  
0.45/0.89/1.78/3.56/7.11  $\mu$ s (with crystal resonator of  $f_x = 4.5$  MHz)
- Many internal hardware units  
General-purpose I/O ports, A/D converter, serial interface (I<sup>2</sup>C bus and UART mode), timers, frequency counter, power-ON clear circuit
- Hardware for PLL frequency synthesizer  
Dual modulus prescaler, programmable divider, phase comparator, charge pump
- Vectored interrupt sources: 17
- Supply voltage  
:V<sub>DD</sub> = 4.5 to 5.5 V (during PLL and CPU operations)  
:V<sub>DD</sub> = 3.5 to 5.5 V (during CPU operation)

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.

Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

**APPLICATION FIELD**

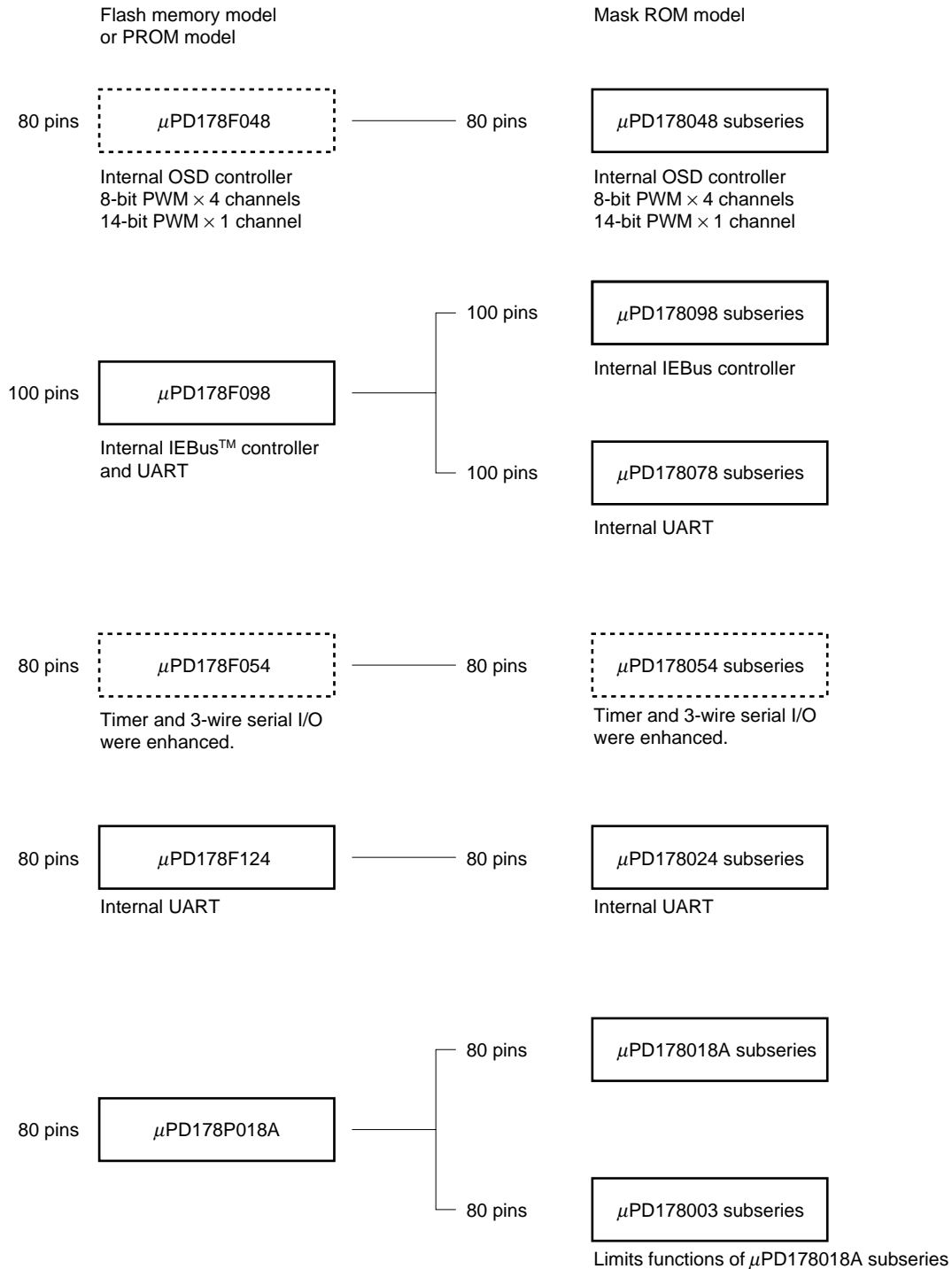
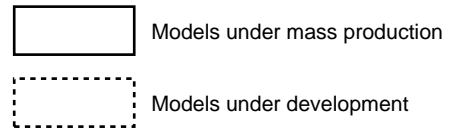
Car stereos

**ORDERING INFORMATION**

Part Number	Package
$\mu$ PD178023GF-xxx-3B9	80-pin plastic QFP (14 × 20)
$\mu$ PD178023GC-xxx-8BT	80-pin plastic QFP (14 × 14)
$\mu$ PD178024GF-xxx-3B9	80-pin plastic QFP (14 × 20)
$\mu$ PD178024GC-xxx-8BT	80-pin plastic QFP (14 × 14)

**Remark** xxx indicates ROM code suffix, which is Exx when the I<sup>2</sup>C bus is used.

★ DEVELOPMENT OF 8-BIT DTS SERIES



FUNCTIONAL OUTLINE

(1/2)

Item		μPD178023	μPD178024
Internal memory	ROM	24 Kbytes (Mask ROM)	32 Kbytes (Mask ROM)
	High-speed RAM	1024 bytes	
General-purpose register		8 bits × 32 registers (8 bits × 8 registers × 4 banks)	
Minimum instruction execution time		0.45 μs/0.89 μs/1.78 μs/3.56 μs/7.11 μs (with crystal resonator of f <sub>x</sub> = 4.5 MHz)	
Instruction set		<ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>	
I/O port		Total : 62 pins <hr/> <ul style="list-style-type: none"> <li>• CMOS I/O : 53 pins</li> <li>• CMOS input : 6 pins</li> <li>• N-ch open-drain output : 3 pins</li> </ul>	
★	A/D converter	8-bit resolution × 6 channels (V <sub>DD</sub> = 3.5 to 5.5 V)	
Serial interface		<ul style="list-style-type: none"> <li>• I<sup>2</sup>C bus mode<sup>Note</sup>: 1 channel</li> <li>• 3-wire mode : 1 channel</li> <li>• UART mode : 1 channel</li> </ul>	
Timer		<ul style="list-style-type: none"> <li>• Basic timer (timer carry FF (10 Hz)) : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watchdog timer : 1 channel</li> </ul>	
Buzzer output		1 channel (1 kHz, 1.5 kHz, 3 kHz, 4 kHz)	
Vectored interrupt source	Maskable	Internal : 11 External: 5	
	Non-maskable	Internal: 1	
	Software	1	
PLL frequency synthesizer	Division mode	2 types <ul style="list-style-type: none"> <li>• Direct division mode (VCOL pin)</li> <li>• Pulse swallow mode (VCOL and VCOH pins)</li> </ul>	
	Reference frequency	Seven types selectable in software (1, 3, 9, 10, 12.5, 25, 50 kHz)	
	Charge pump	Error out output: 2 pins	
	Phase comparator	Unlock detectable in software	

**Note** When the I<sup>2</sup>C bus mode is used (including when the mode is implemented in software without using the peripheral hardware), consult NEC when ordering a mask.

(2/2)

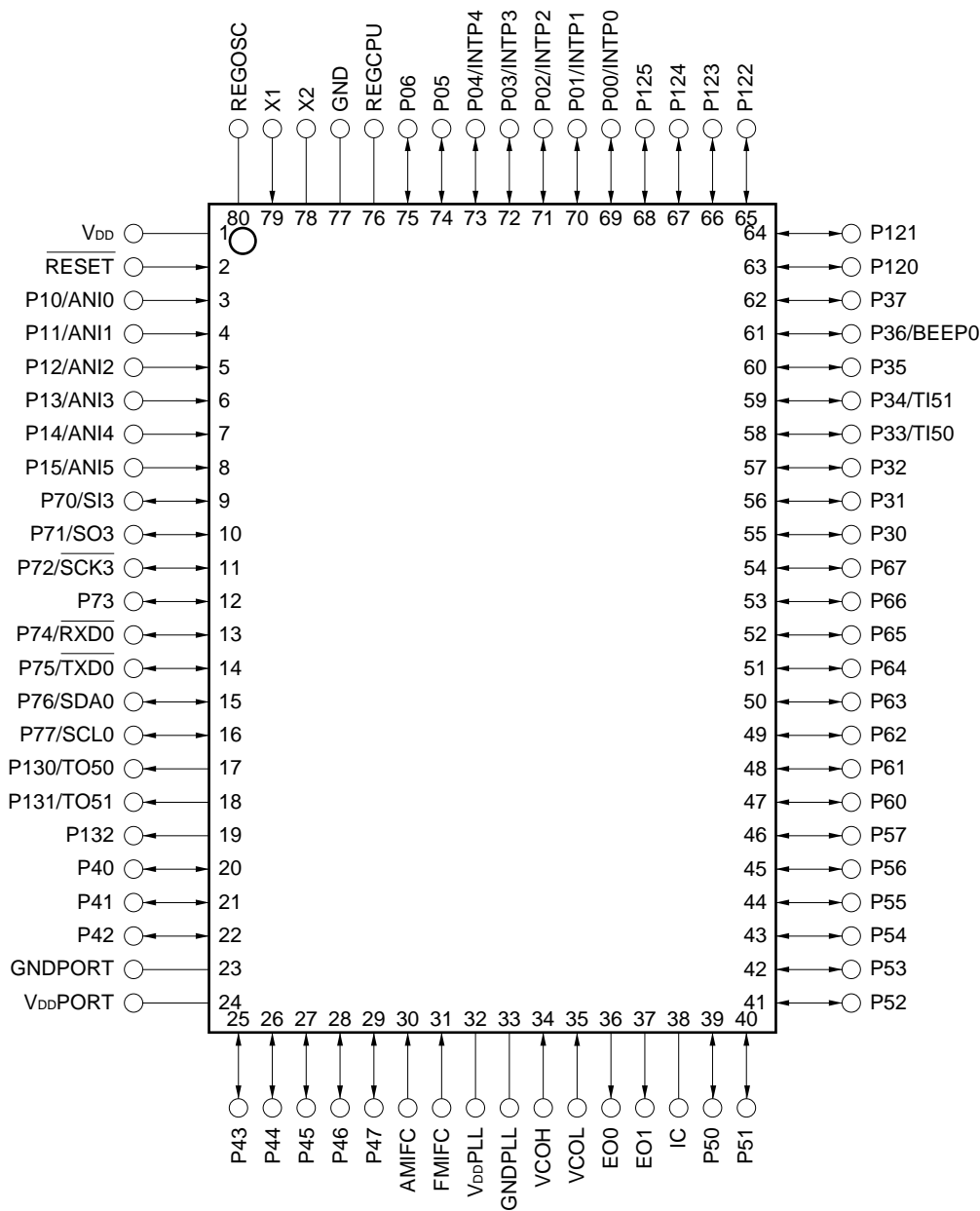
Item	μPD178023	μPD178024
Frequency counter	Frequency measurement <ul style="list-style-type: none"> <li>• AMIFC pin: For 450-kHz counting</li> <li>• FMIFC pin: For 450-kHz/10.7-MHz counting</li> </ul>	
Reset	<ul style="list-style-type: none"> <li>• Reset by <math>\overline{\text{RESET}}</math> pin</li> <li>• Internal reset by watchdog timer</li> <li>• Reset by power-ON clear circuit                             <ul style="list-style-type: none"> <li>• Detection of less than 4.5 V<sup>Note</sup> (Reset does not occur, however.)</li> <li>• Detection of less than 3.5 V<sup>Note</sup> (during CPU operation)</li> <li>• Detection of less than 2.3 V<sup>Note</sup> (in STOP mode)</li> </ul> </li> </ul>	
Supply voltage	<ul style="list-style-type: none"> <li>• V<sub>DD</sub> = 4.5 to 5.5 V (during CPU, PLL operation)</li> <li>• V<sub>DD</sub> = 3.5 to 5.5 V (during CPU operation)</li> </ul>	
Package	<ul style="list-style-type: none"> <li>• 80-pin plastic QFP (14 × 20)</li> <li>• 80-pin plastic QFP (14 × 14)</li> </ul>	

**Note** These voltages are the maximum values. In practice, the chip may be reset at voltages lower than these.

**PIN CONFIGURATION (Top View)**

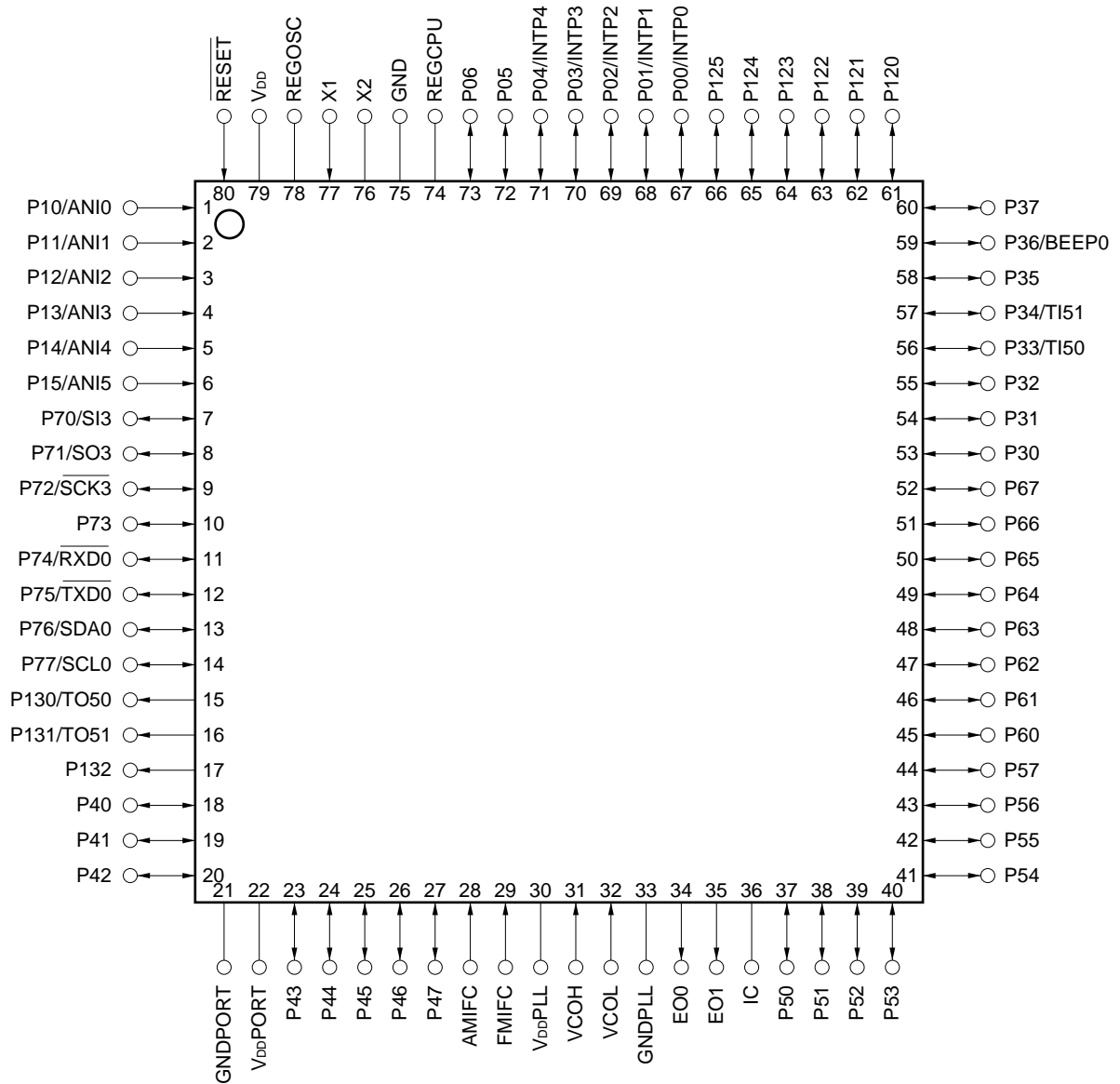
• **80-pin plastic QFP (14 × 20)**

μPD178023GF-xxx-3B9, 178024GF-xxx-3B9



- Cautions**
1. Directly connect the IC (Internally Connected) to GND.
  2. Keep the voltage at V<sub>DD</sub>PORT and V<sub>DD</sub>PLL at the same voltage as V<sub>DD</sub>.
  3. Keep the voltage at GNDPORT and GNDPLL at the same voltage as GND.
  4. Connect each of the REGOSC and REGCPU pins to GND via 0.1-μF capacitor.

- 80-pin plastic QFP (14 × 14)  
μPD178023GC-xxx-8BT, 178024GC-xxx-8BT



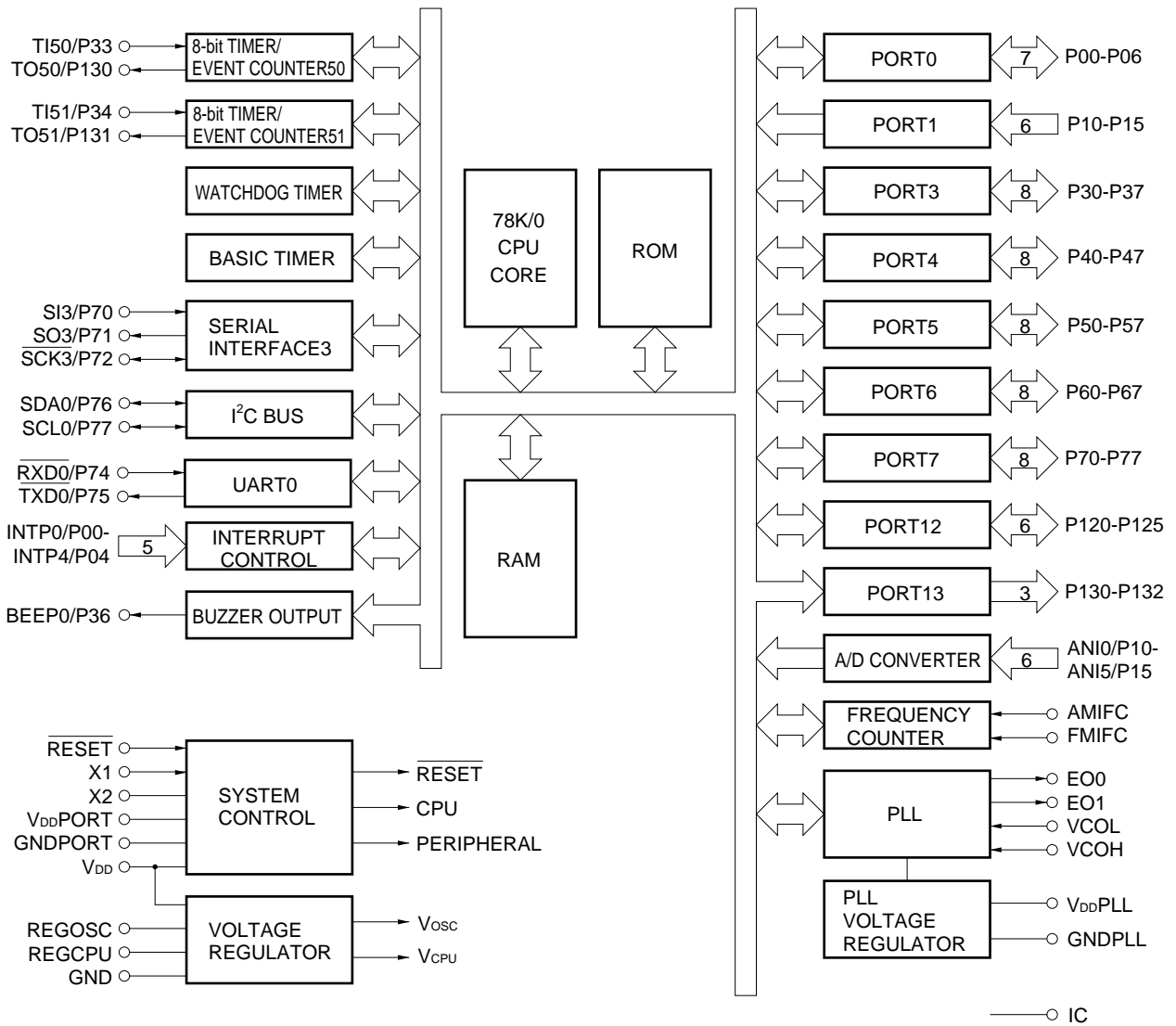
- Cautions**
1. Directly connect the IC (Internally Connected) to GND.
  2. Keep the voltage at V<sub>DD</sub>PORT and V<sub>DD</sub>PLL at the same voltage as V<sub>DD</sub>.
  3. Keep the voltage at GNDPORT and GNDPLL at the same voltage as GND.
  4. Connect each of the REGOSC and REGCPU pins to GND via 0.1-μF capacitor.

**PIN NAME**

AMIFC	: AM intermediate frequency counter input	P130-P132	: Port 13
ANI0-ANI5	: A/D converter input	REGCPU	: Regulator for CPU power supply
BEEP0	: Buzzer output	REGOSC	: Regulator for oscillator
EO0, EO1	: Error out output	$\overline{\text{RESET}}$	: Reset input
FMIFC	: FM intermediate frequency counter input	$\overline{\text{RXD0}}$	: Serial (UART0) data input
GND	: Ground	$\overline{\text{SCK3}}$	: Serial (SIO3) clock input/output
GNDPLL	: PLL ground	$\overline{\text{SCL0}}$	: Serial (IIC0) clock input/output
GNDPORT	: Port ground	$\overline{\text{SDA0}}$	: Serial (IIC0) data input/output
IC	: Internally connected	SI3	: Serial (SIO3) data input
INTP0-INTP4	: Interrupt input	SO3	: Serial (SIO3) data output
P00-P06	: Port 0	TI50, TI51	: 8-bit timer clock input
P10-P15	: Port 1	TO50, TO51	: 8-bit timer output
P30-P37	: Port 3	$\overline{\text{TXD0}}$	: Serial (UART0) data output
P40-P47	: Port 4	VCOL, VCOH	: Local oscillation input
P50-P57	: Port 5	V <sub>DD</sub>	: Power supply
P60-P67	: Port 6	V <sub>DD</sub> PLL	: PLL power supply
P70-P77	: Port 7	V <sub>DD</sub> PORT	: Port power supply
P120-P125	: Port 12	X1, X2	: Crystal resonator



BLOCK DIAGRAM



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

**CONTENTS**

<b>1. PIN FUNCTION LIST .....</b>	<b>11</b>
<b>1.1 Port Pins .....</b>	<b>11</b>
<b>1.2 Pins Other Than Port Pins .....</b>	<b>12</b>
<b>1.3 I/O Circuits of Pins and Recommended Connections of Unused Pins .....</b>	<b>13</b>
<b>2. MEMORY SPACE .....</b>	<b>16</b>
<b>2.1 Memory Size Select Register (IMS) .....</b>	<b>17</b>
<b>2.2 Internal Extension RAM Size Select Register (IXS) .....</b>	<b>18</b>
<b>3. FEATURES OF PERIPHERAL HARDWARE FUNCTIONS .....</b>	<b>19</b>
<b>3.1 Ports .....</b>	<b>19</b>
<b>3.2 Clock Generation Circuit .....</b>	<b>20</b>
<b>3.3 Timers .....</b>	<b>20</b>
<b>3.4 Buzzer Output Control Circuit.....</b>	<b>22</b>
<b>3.5 A/D Converter .....</b>	<b>23</b>
<b>3.6 Serial Interface .....</b>	<b>24</b>
<b>3.7 PLL Frequency Synthesizer .....</b>	<b>26</b>
<b>3.8 Frequency Counter .....</b>	<b>27</b>
<b>4. INTERRUPT FUNCTION .....</b>	<b>28</b>
<b>5. STANDBY FUNCTION .....</b>	<b>31</b>
<b>6. RESET FUNCTION .....</b>	<b>31</b>
<b>7. INSTRUCTION SET .....</b>	<b>32</b>
<b>8. ELECTRICAL SPECIFICATIONS.....</b>	<b>35</b>
<b>9. PACKAGE DRAWING .....</b>	<b>44</b>
<b>10. RECOMMENDED SOLDERING CONDITIONS.....</b>	<b>46</b>
<b>APPENDIX A. DEVELOPMENT TOOLS .....</b>	<b>47</b>
<b>APPENDIX B. RELATED DOCUMENTS .....</b>	<b>49</b>

## 1. PIN FUNCTION LIST

### 1.1 Port Pins

Pin Name	I/O	Function	At Reset	Shared by:
P00-P04	I/O	Port 0. 7-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	INTP0-INTP4
P05, P06				—
P10-P15	Input	Port 1. 6-bit input port.	Input	ANI0-ANI5
P30-P32	I/O	Port 3. 8-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	—
P33				TI50
P34				TI51
P35				—
P36				BEEP0
P37				—
P40-47	I/O	Port 4. 8-bit I/O port. Can be set in input or output mode in 1-bit units. Internal pull-up resistors can be specified in software. Interrupt function by key input is provided.	Input	—
P50-P57	I/O	Port 5. 8-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	—
P60-P67	I/O	Port 6. 8-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	—
P70	I/O	Port 7. 8-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	SI3
P71				SO3
P72				SCK3
P73				—
P74				R̄XD0
P75				T̄XD0
P76				SDA0
P77				SCL0
P120-P125	I/O	Port 12. 6-bit I/O port. Can be set in input or output mode in 1-bit units.	Input	—
P130	Output	Port 13. 3-bit output port. N-ch open-drain output port (12 V withstand)	Low-level output	TO50
P131				TO51
P132				—

1.2 Pins Other Than Port Pins

Pin Name	I/O	Function	At Reset	Shared by:
INTP0-INTP4	Input	External maskable interrupt input whose valid edge (rising edge, falling edge, or both rising and falling edges) can be specified.	Input	P00-P04
SI3	Input	Serial data input to serial interface.	Input	P70
SO3	Output	Serial data output from serial interface.	Input	P71
SDA0	I/O	Serial data input/output to/from serial interface.	Input	P76
		N-ch open drain I/O		
$\overline{\text{SCK3}}$	I/O	Serial clock input/output to/from serial interface.	Input	P72
SCL0		N-ch open drain I/O		P77
$\overline{\text{RXD0}}$	Input	Serial data input to asynchronous serial interface (UART0).	Input	P74
$\overline{\text{TXD0}}$	Output	Serial data output from asynchronous serial interface (UART0).		P75
TI50	Input	External count clock input to 8-bit timer (TM50).	Input	P33
TI51		External count clock input to 8-bit timer (TM51).		P34
TO50	Output	8-bit timer (TM50) output.	Low-level output	P130
TO51		8-bit timer (TM51) output.		P131
BEEP0	Output	Buzzer output.	Input	P36
ANI0-ANI5	Input	Analog input to A/D converter.	Input	P10-P15
EO0, EO1	Output	Error out output from charge pump of PLL frequency synthesizer.	–	–
VCOL	Input	Inputs local oscillation frequency of PLL (in HF and MF modes).	–	–
VCOH		Inputs local oscillation frequency of PLL (in VHF mode).		
AMIFC	Input	Input to AM intermediate frequency counter.	Input	–
FMIFC		Input to FM or AM intermediate frequency counter.		
$\overline{\text{RESET}}$	Input	System reset input.	–	–
X1	Input	Connection of crystal resonator for system clock oscillation.	–	–
X2	–		–	–
REGOSC	–	Regulator for oscillator. Connect this pin to GND via 0.1-μF capacitor.	–	–
REGCPU	–	Regulator for CPU power supply. Connect this pin to GND via 0.1-μF capacitor.	–	–
V <sub>DD</sub>	–	Positive power supply.	–	–
GND	–	Ground.	–	–
V <sub>DD</sub> PORT	–	Port power supply.	–	–
GNDPORT	–	Port ground.	–	–
V <sub>DD</sub> PLL <sup>Note</sup>	–	PLL positive power supply.	–	–
GNDPLL <sup>Note</sup>	–	PLL ground.	–	–
IC	–	Internally connected. Directly connect this pin to GND.	–	–

**Note** Connect a capacitor of about 1000 pF between the V<sub>DD</sub>PLL and GNDPLL pins.

### 1.3 I/O Circuits of Pins and Recommended Connections of Unused Pins

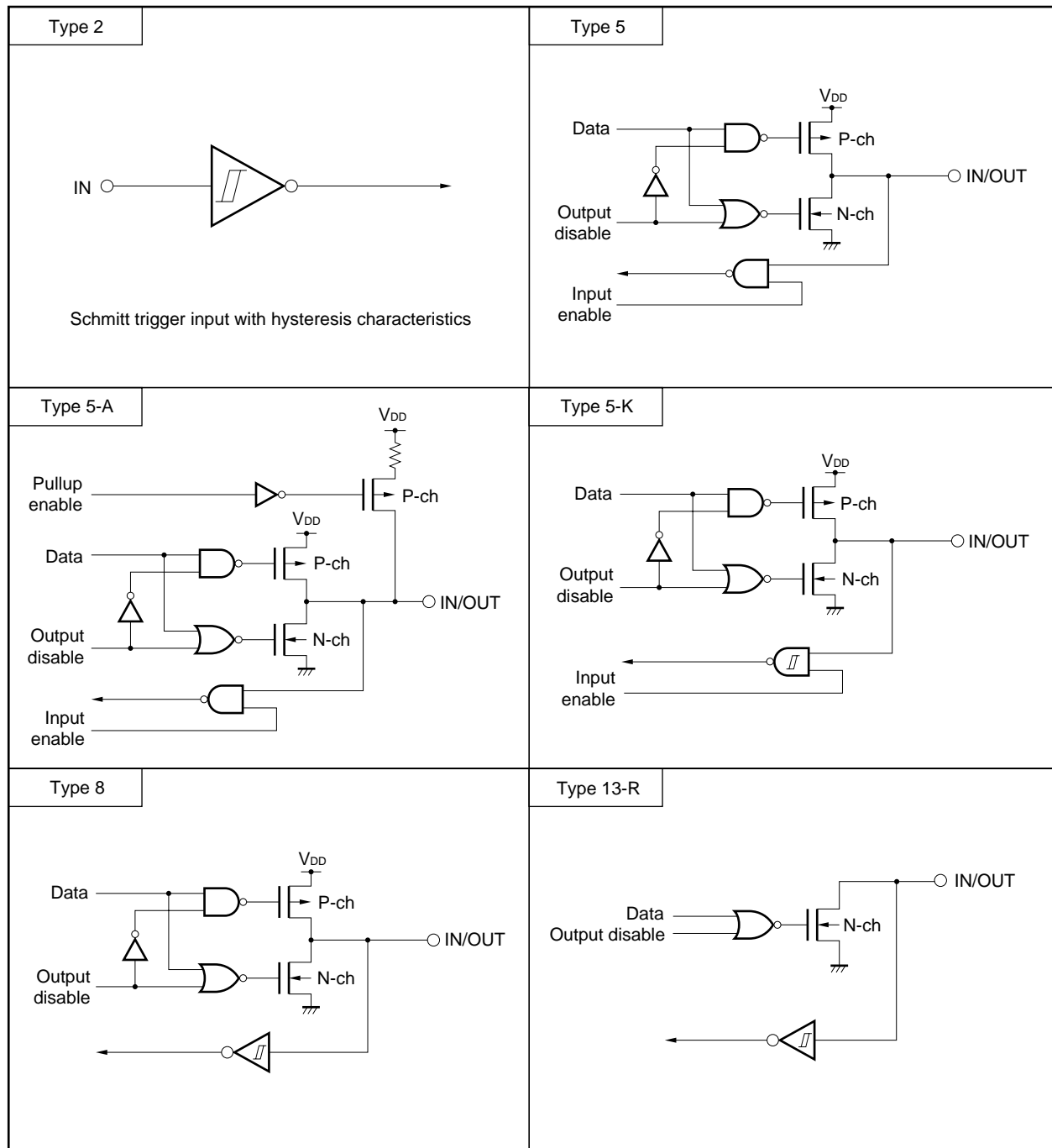
Table 1-1 shows the types of the I/O circuits of the respective pins and the recommended connections of the pins when they are not used. For the configuration of the I/O circuit of each pin, refer to Figure 1-1.

**Table 1-1. I/O Circuit Type of Each Pin**

Pin Name	I/O Circuit Type	I/O	Recommended Connection of Unused Pin	
P00/INTP0-P04/INTP4	8	I/O	Set these pins in general-purpose input mode in software, and connect each of them to V <sub>DD</sub> , V <sub>DD</sub> PORT, GND, or GNDPORT via resistor.	
P05, P06				
P10/ANI0-P15/ANI5	25	Input	Connect each of them to V <sub>DD</sub> , V <sub>DD</sub> PORT, GND, or GNDPORT via resistor.	
P30-P32	5	I/O	Set these pins in general-purpose input mode in software, and output low-level signal. Leave unconnected.	
P33/TI50	5-K			
P34/TI51	5			
P35				
P36/BEEP0				
P37				
P40-P47	5-A			Set these pins in general-purpose input mode in software, and connect each of them to GND or GNDPORT via resistor.
P50-P57	5			Set these pins in general-purpose input mode in software, and connect each of them to V <sub>DD</sub> , V <sub>DD</sub> PORT, GND, or GNDPORT via resistor.
P60-P67	5			Set these pins in general-purpose input mode in software, and output low-level signal. Leave unconnected.
P70/SI3	5-K			Set these pins in general-purpose input mode in software, and connect each of them to V <sub>DD</sub> , V <sub>DD</sub> PORT, GND, or GNDPORT via resistor.
P71/SO3	5			
P72/SCK3	5-K			
P73	5			
P74/RXD0	5-K			
P75/TXD0	5			
P76/SDA0	13-R			
P77/SCL0				
P120-P125	5			
P130/TO50	19	Output	Set these pins to low-level output in software and leave unconnected.	
P131/TO51				
P132				
EO0, EO1	DTS-EO1	Output	Leave unconnected.	
VCOL, VCOH	DTS-AMP	Input	Disable PLL in software and select pull-down.	
AMIFC, FMIFC			Set these pins in general-purpose input port mode in software and connect each of them to V <sub>DD</sub> , V <sub>DD</sub> PORT, GND, or GNDPORT via resistor.	
REGOSC, REGCPU	–	–	Connect these pins to GND via 0.1-μF capacitor.	
RESET	2	Input	–	
V <sub>DD</sub> PLL	–	–	Connect this pin to V <sub>DD</sub> .	
GNDPLL			Directly connect these pins to GND or GNDPORT.	
IC				

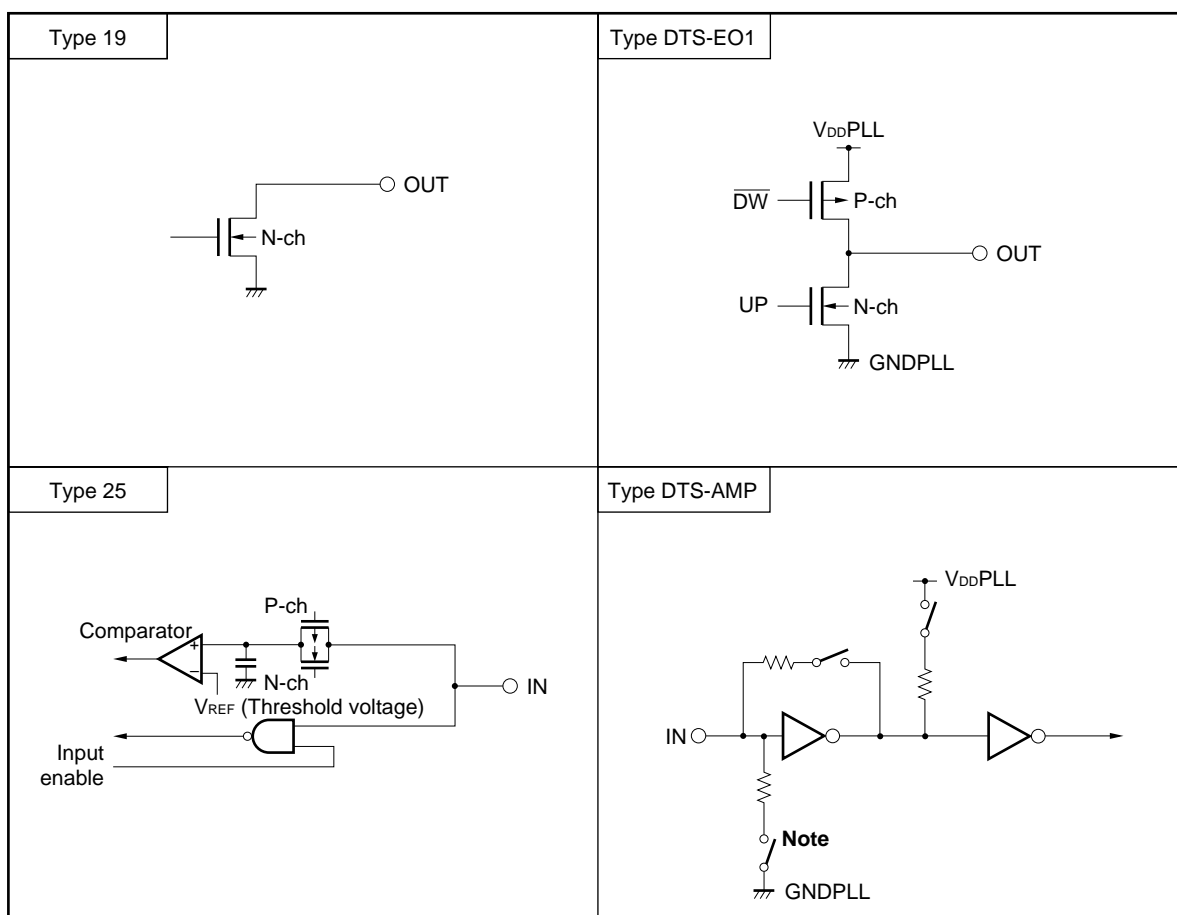
★

Figure 1-1. I/O Circuits of Respective Pins (1/2)



**Remark**  $V_{DD}$  and GND are the positive power supply and ground pins for all port pins. Take  $V_{DD}$  and GND as  $V_{DDPORT}$  and  $GNDPORT$ .

Figure 1-1. I/O Circuits of Respective Pins (2/2)



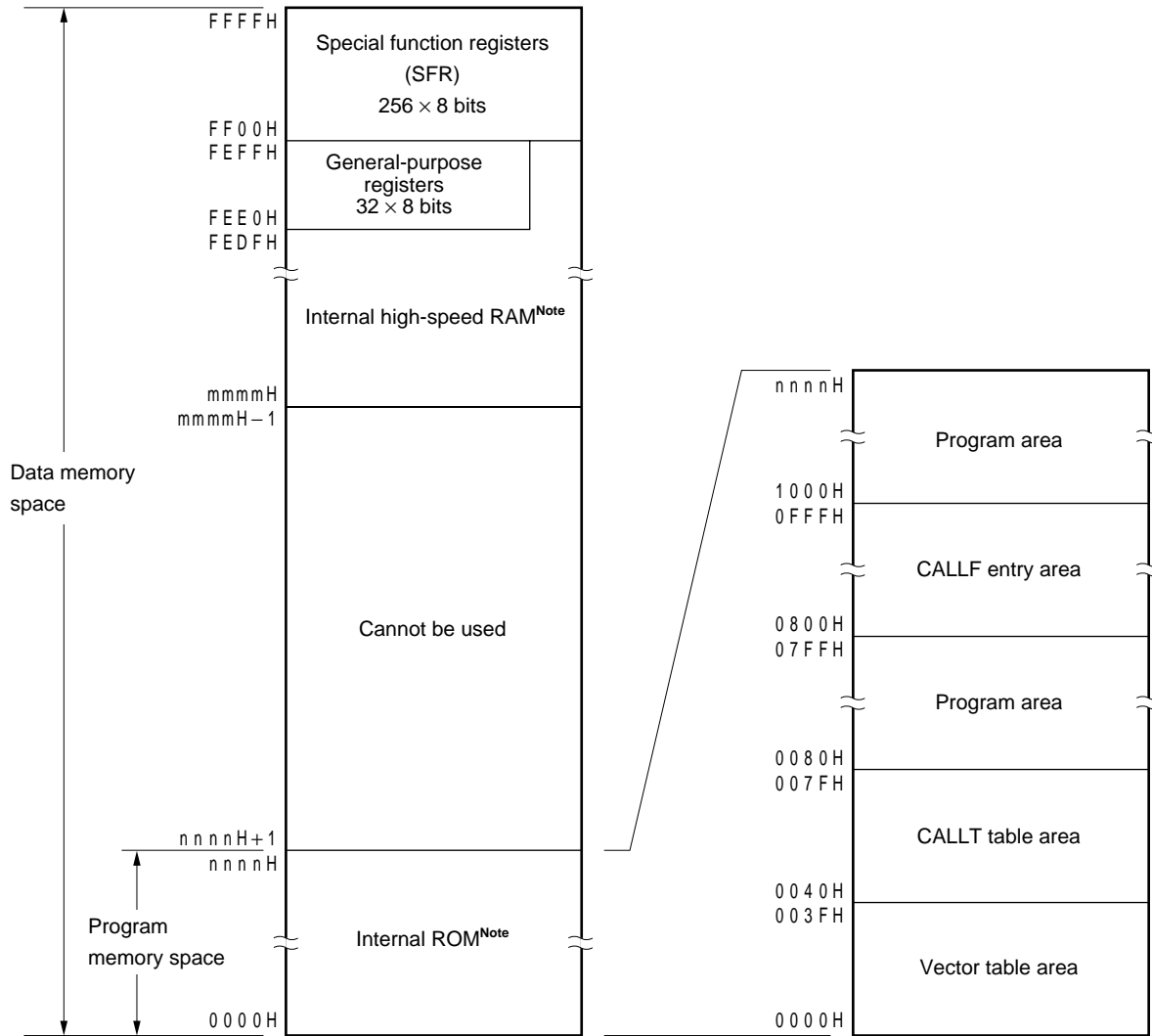
**Note** This switch is selectable in software only for the VCOL and VCOH pins.

**Remark**  $V_{DD}$  and GND are the positive power supply and ground pins for all port pins. Take  $V_{DD}$  and GND as  $V_{DDPORT}$  and  $GNDPORT$ .

2. MEMORY SPACE

Figure 2-1 shows the memory map of the μPD178023, 178024.

Figure 2-1. Memory Map



**Note** The internal ROM and internal high-speed RAM capacities differ depending on the model (refer to the table below).

Target Model Name	Internal ROM End Address nnnH	Internal High-Speed RAM First Address mmmH
μPD178023	5FFFH	FB00H
μPD178024	7FFFH	FB00H



**2.1 Memory Size Select Register (IMS)**

The memory size select register (IMS) sets the internal memory capacity.

Set the μPD178023, μPD178024 to C6H, C8H respectively.

Use an 8-bit memory manipulation instruction to set the IMS.

This register is set to CFH at reset.

**Caution** Be sure to set the IMS to C6H or C8H as the program initial setting. The IMS set value changes to CFH when reset. Therefore, set C6H or C8H again after reset.

**Figure 2-2. Format of Memory Size Select Register (IMS)**

Symbol	7	6	5	4	3	2	1	0	Address	At reset	R/W
IMS	RAM2	RAM1	RAM0	0	ROM3	ROM2	ROM1	ROM0	FFF0H	CFH	R/W

RAM2	RAM1	RAM0	Selects Internal High-speed RAM Capacity			
1	1	0	1024 bytes			
Others			Setting prohibited			

RAM3	RAM2	RAM1	RAM0	Selects Internal ROM Capacity			
0	1	1	0	24K bytes			
1	0	0	0	32K bytes			
Others				Setting prohibited			

Table 2-1 indicates the setting of IMS.

**Table 2-1. Set Value of Memory Size Select Register (IMS)**

Targeted Model	Set Value of IMS
μPD178023	C6H
μPD178024	C8H

## 2.2 Internal Extension RAM Size Select Register (IXS)

The internal extension RAM size select register (IXS) sets the internal extension RAM capacity.

Use the μPD178023, μPD178024 with the initial value (0CH).

Use an 8-bit memory manipulation instruction to set the IXS.

This register is set to 0CH at reset.

**Caution** Do not assign a value other than that the initial value.

**Figure 2-3. Format of Internal Extension RAM Size Select Register (IXS)**

Symbol	7	6	5	4	3	2	1	0	Address	At reset	R/W
IXS	0	0	0	IXRAM4	IXRAM3	IXRAM2	IXRAM1	IXRAM0	FFF4H	0CH	R/W

IXRAM4	IXRAM3	IXRAM2	IXRAM1	IXRAM0	Selects Internal Extension RAM Capacity
0	1	1	0	0	0 byte
Others					Setting prohibited

Table 2-2 indicates the setting of IXS.

**Table 2-2. Set Value of Internal Extension RAM Size Select Register**

Targeted Model	Set Value of IXS
μPD178023, 178024	0CH

### 3. FEATURES OF PERIPHERAL HARDWARE FUNCTIONS

#### 3.1 Ports

The following three types of ports are available:

- CMOS input (port 1) : 6 pins
  - CMOS I/O (ports 0, 3 - 7, and 12) : 53 pins
  - N-ch open-drain output (port 13) : 3 pins
- 
- Total : 62 pins

**Table 3-1. Port Functions**

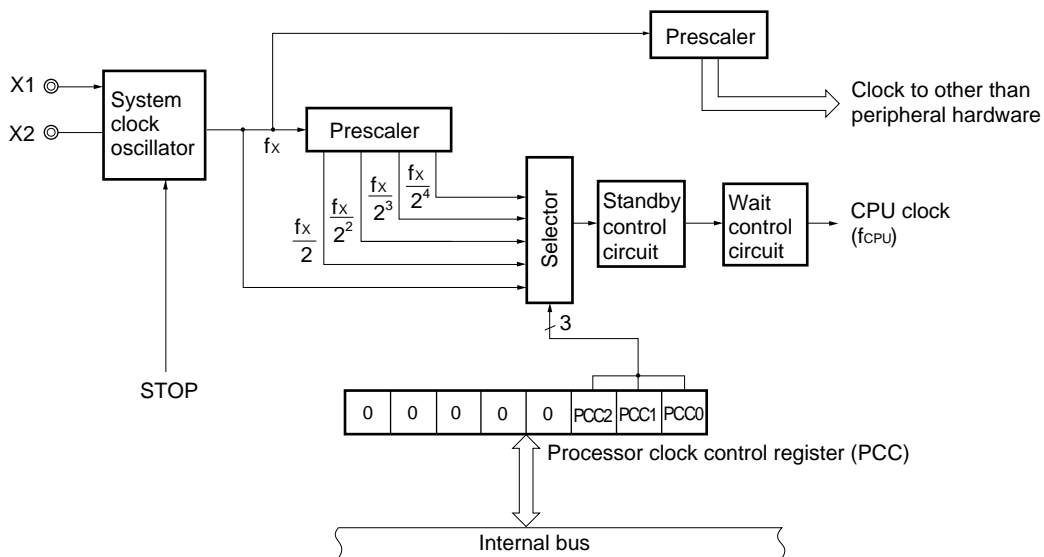
Name	Pin Name	Function
Port 0	P00-P06	I/O port. Can be set in input or output mode in 1-bit units.
Port 1	P10-P15	Input-only port
Port 3	P30-P37	I/O port. Can be set in input or output mode in 1-bit units.
Port 4	P40-P47	I/O port. Can be set in input or output mode in 1-bit units.
Port 5	P50-P57	I/O port. Can be set in input or output mode in 1-bit units.
Port 6	P60-P67	I/O port. Can be set in input or output mode in 1-bit units.
Port 7	P70-P77	I/O port. Can be set in input or output mode in 1-bit units.
Port 12	P120-P125	I/O port. Can be set in input or output mode in 1-bit units.
Port 13	P130-P132	N-ch open-drain output port

### 3.2 Clock Generation Circuit

The instruction execution time can be changed as follows:

- 0.45 μs/0.89 μs/1.78 μs/3.56 μs/7.11 μs (system clock: 4.5-MHz crystal resonator)

Figure 3-1. Block Diagram of Clock Generation Circuit



### 3.3 Timers

Four timer channels are provided.

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

Figure 3-2. Block Diagram of Basic Timer

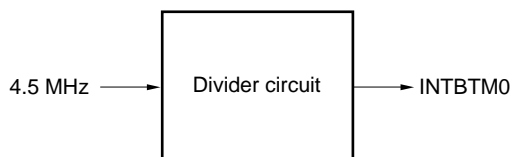


Figure 3-3. Block Diagram of 8-Bit Timer/Event Counter 50

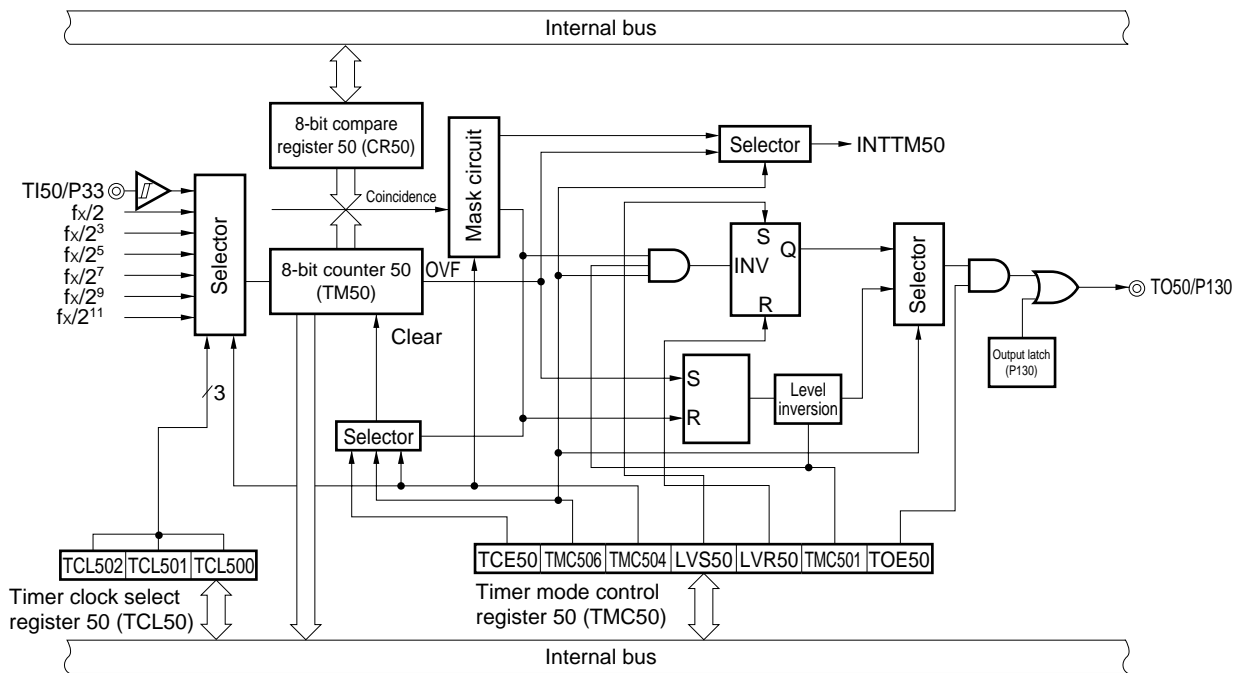


Figure 3-4. Block Diagram of 8-Bit Timer/Event Counter 51

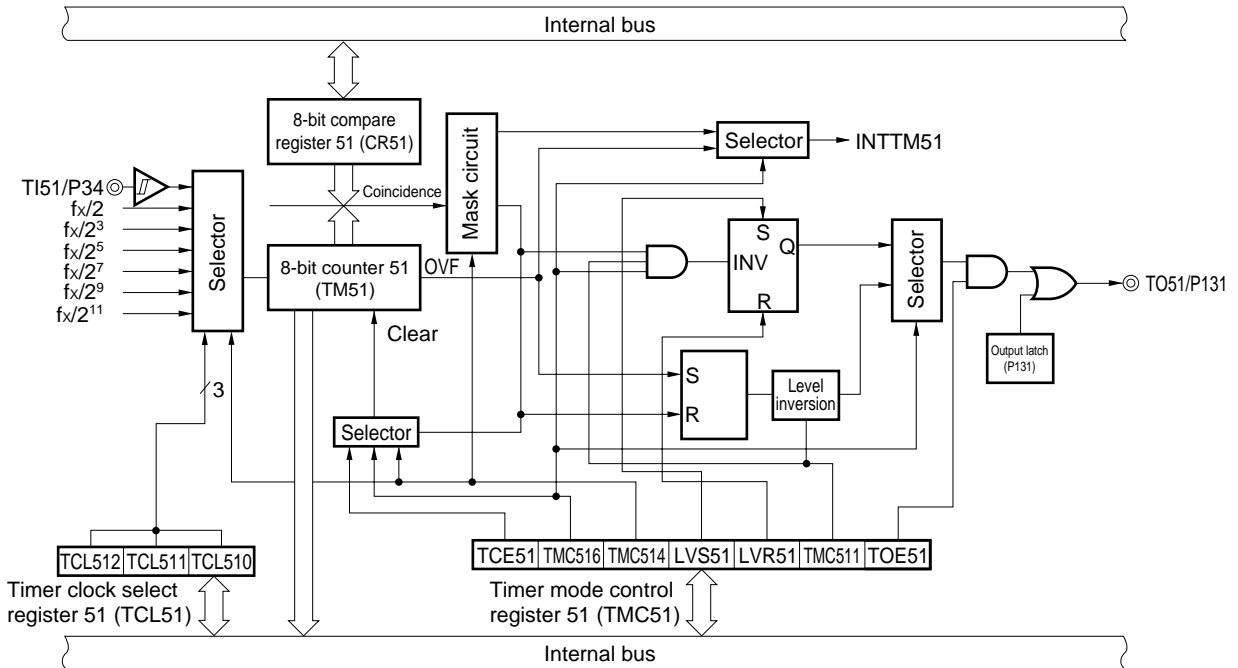
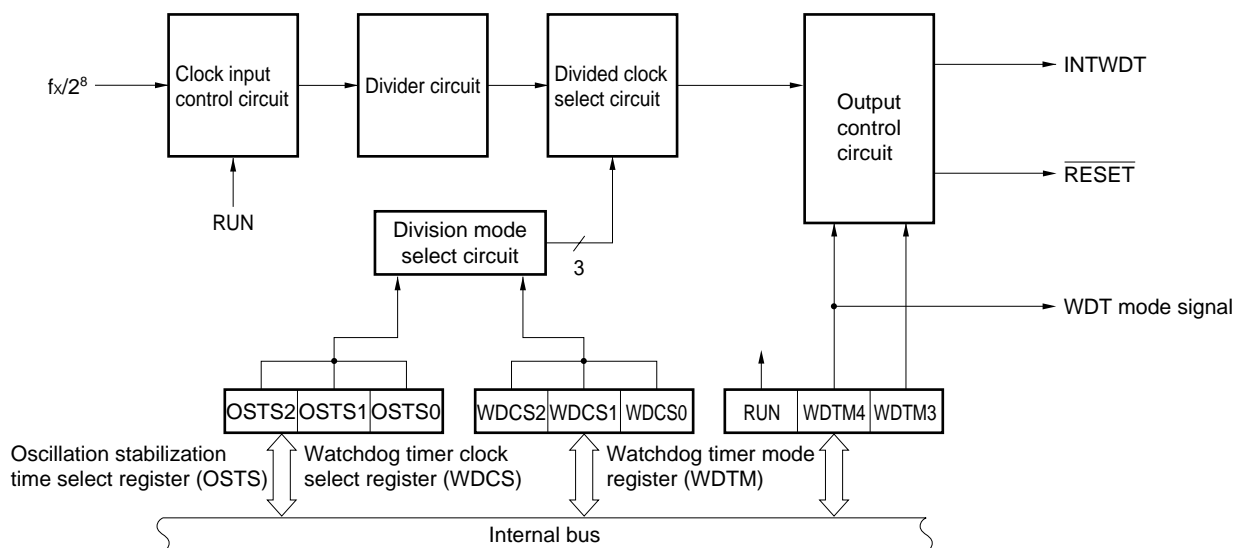


Figure 3-5. Block Diagram of Watchdog Timer

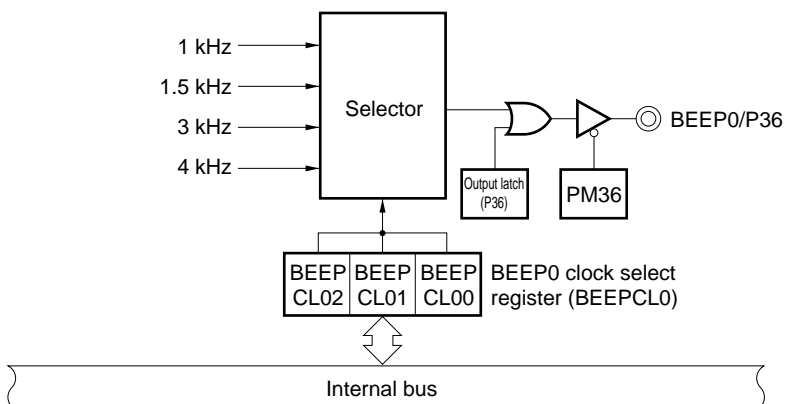


### 3.4 Buzzer Output Control Circuit

The buzzer output frequency is selected as follows.

- BEEP0 ... 1 kHz/1.5 kHz/3 kHz/4 kHz

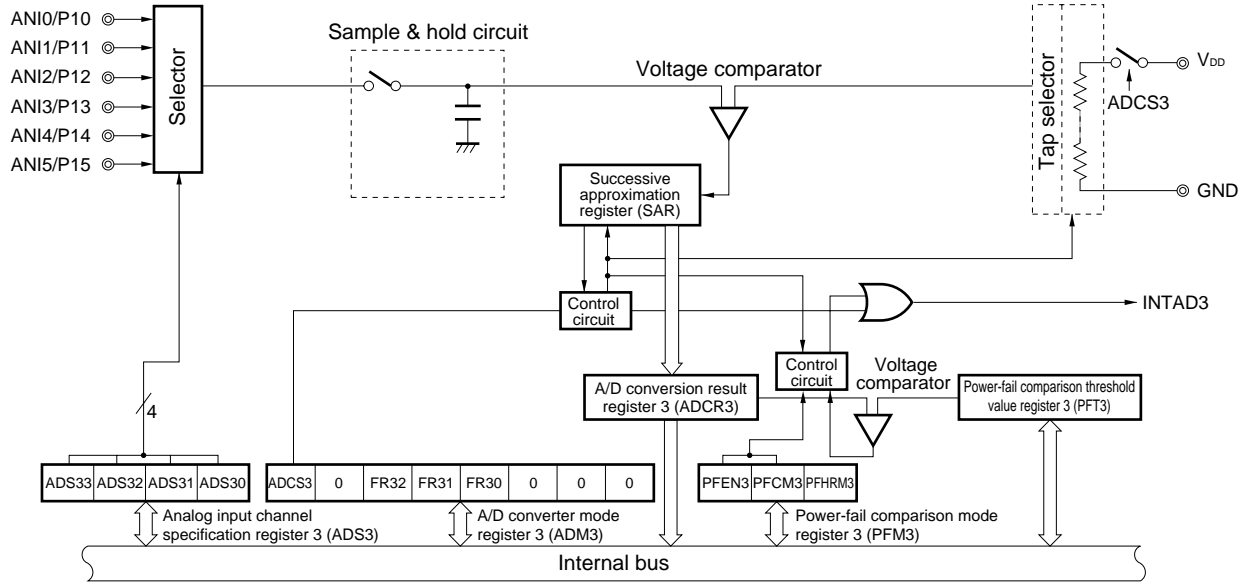
Figure 3-6. Block Diagram of Buzzer Output Control Circuit (BEEP0)



### 3.5 A/D Converter

An A/D converter with a resolution of 8 bits × 6 channels is provided.

Figure 3-7. Block Diagram of A/D Converter



### 3.6 Serial Interface

The μPD178023 and 178024 have three serial interface channels.

- Serial interface IIC0
- Serial interface SIO3
- Serial interface UART0

Figure 3-8. Block Diagram of Serial Interface IIC0

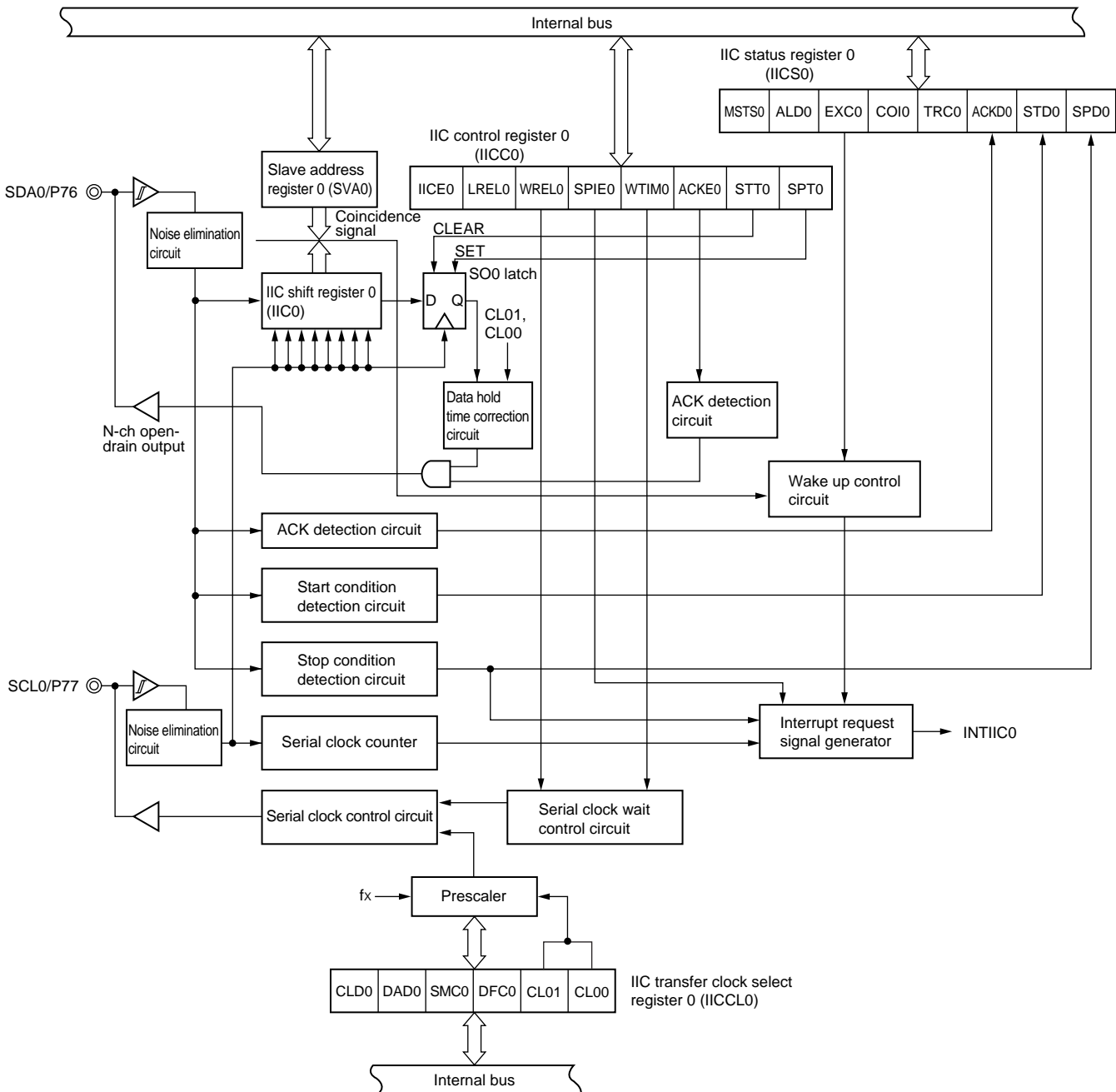




Figure 3-9. Block Diagram of Serial Interface SIO3

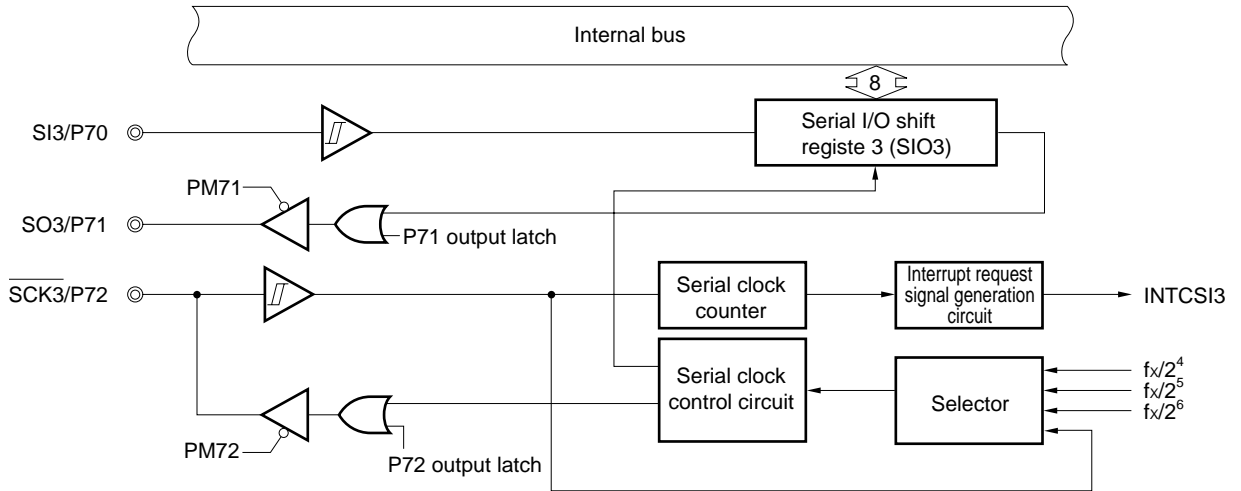
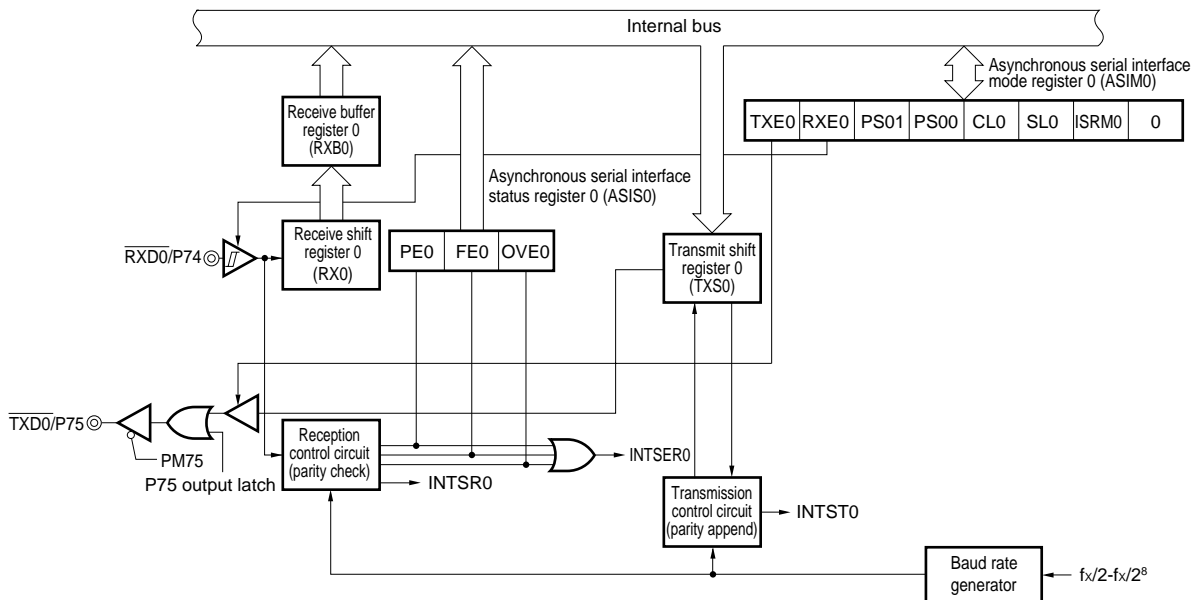
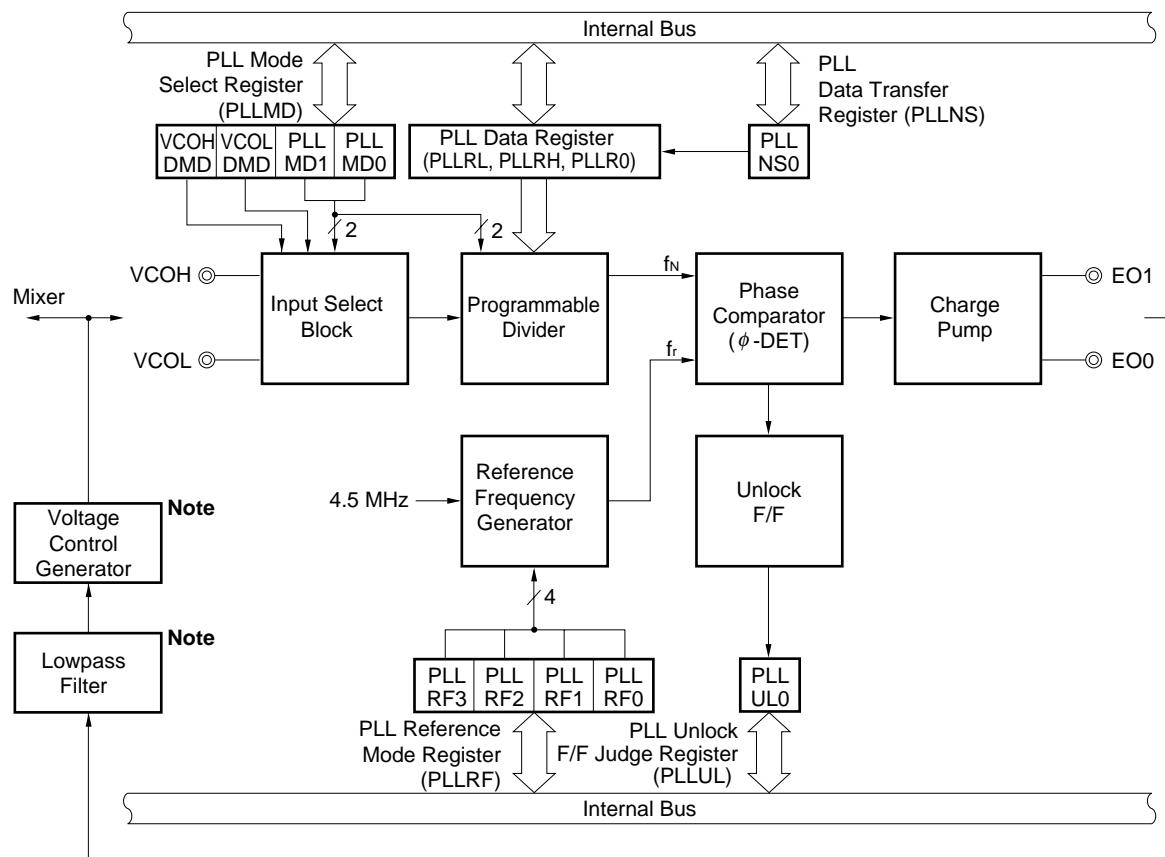


Figure 3-10. Block Diagram of Serial Interface UART0



3.7 PLL Frequency Synthesizer

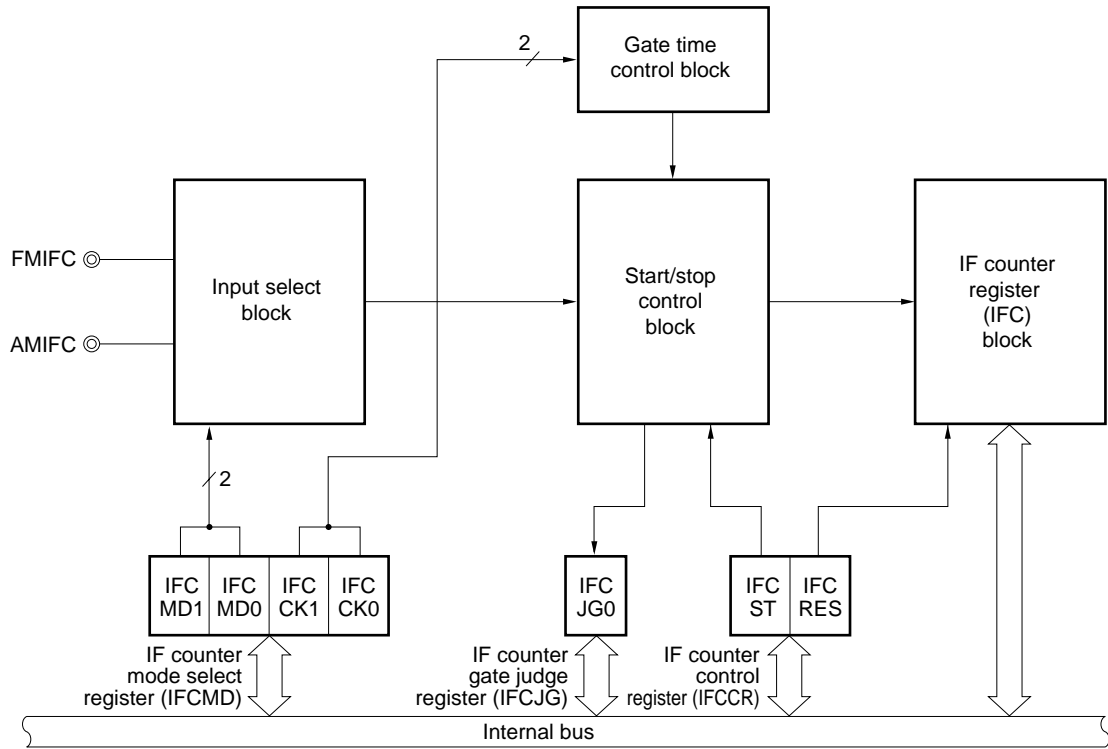
Figure 3-11. Block Diagram of PLL Frequency Synthesizer



**Note** External circuit.

3.8 Frequency Counter

Figure 3-12. Block Diagram of Frequency Counter



#### 4. INTERRUPT FUNCTION

The μPD178023 and 178024 have the following three types and 17 sources of interrupts:

- Non-maskable : 1<sup>Note</sup>
- Maskable : 16<sup>Note</sup>
- Software : 1

**Note** Two types of watchdog interrupt sources (INTWDT), non-maskable and maskable, are available, and either of them can be selected.

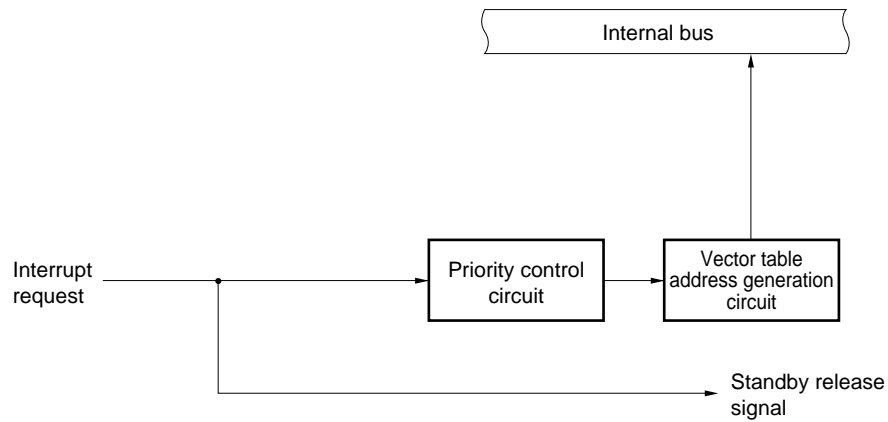
**Table 4-1. Interrupt Sources**

Interrupt Type	Default Priority <sup>Note 1</sup>	Interrupt Source		Internal/ External	Vector Table Address	Basic Configuration Type <sup>Note 2</sup>
		Name	Trigger			
Non-maskable	–	INTWDT	Overflow of watchdog timer (when watchdog timer mode 1 is selected)	Internal	0004H	(A)
Maskable	0	INTWDT	Overflow of watchdog timer (when interval timer mode is selected)			
	1	INTP0	Pin input edge detection	External	0006H	(C)
	2	INTP1			0008H	
	3	INTP2			000AH	
	4	INTP3			000CH	
	5	INTP4			000EH	
	6	INTKY			Detection of key input of port 4	
	7	INTIIC0	End of transfer by serial interface IIC0	0012H		
	8	INTBTM0	Generation of basic timer match signal	0014H		
	9	INTAD3	End of conversion by A/D converter	0016H		
	10	–	–	–	0018H <sup>Note 3</sup>	–
	11	INTCSI3	End of transfer by serial interface SIO3	Internal	001AH	(B)
	12	INTTM50	Generation of coincidence signal of 8-bit timer/event counter 50		001CH	
	13	INTTM51	Generation of coincidence signal of 8-bit timer/event counter 51		001EH	
	14	INTSER0	Reception error of serial interface UART0		0020H	
	15	INTSR0	End of reception by serial interface UART0		0022H	
	16	INTST0	End of transmission by serial interface UART0		0024H	
Software	–	BRK	Execution of BRK instruction		–	

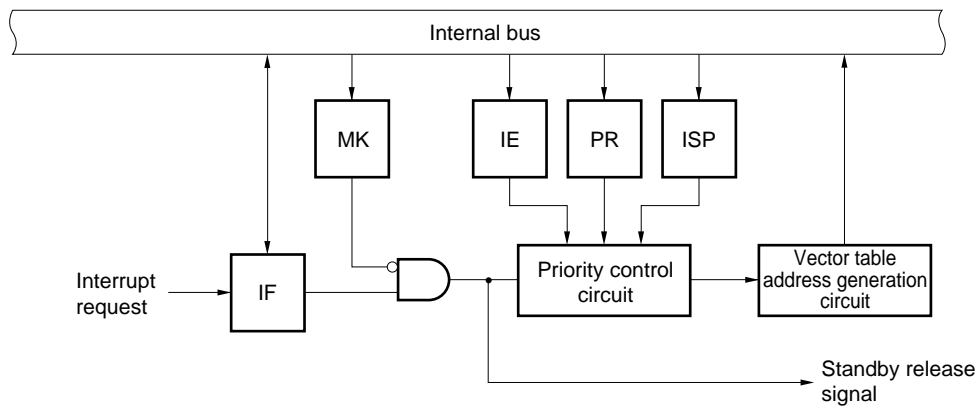
- Notes**
1. If two or more maskable interrupts occur at the same time, they are acknowledged or kept pending according to their default priorities. The default priority 0 is the highest, while 16 is the lowest.
  2. (A) to (D) under the heading Basic Configuration Type corresponds to (A) to (D) in Figure 4-1.
  3. There are no interrupt sources corresponding to vector addresses 0018H.

Figure 4-1. Basic Configuration of Interrupt Function (1/2)

(A) Internal non-maskable interrupt



(B) Internal maskable interrupt



(C) External maskable interrupt

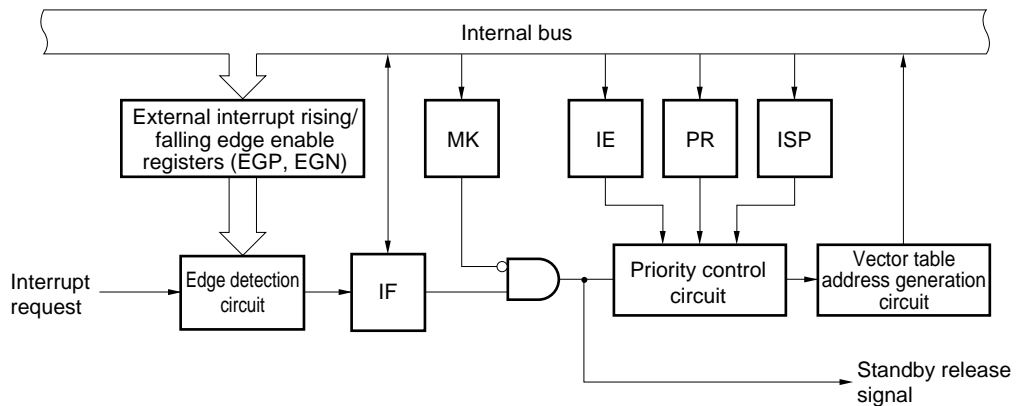
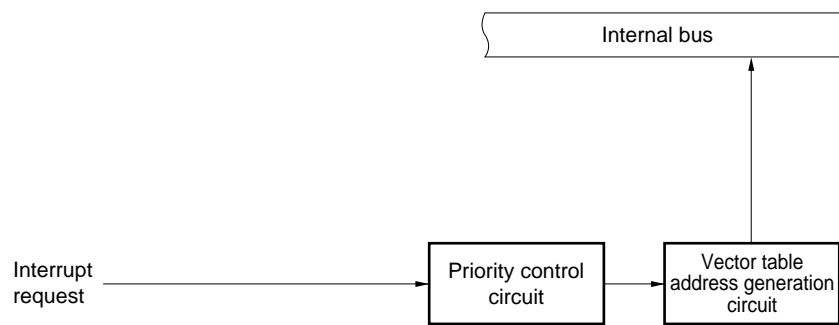


Figure 4-1. Basic Configuration of Interrupt Function (2/2)

## (D) Software interrupt



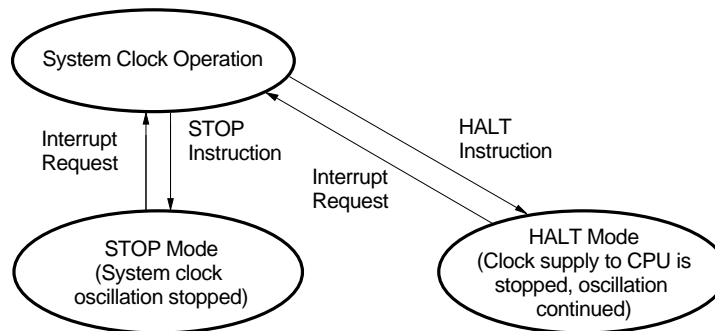
- Remark**
- IF : Interrupt request flag
  - IE : Interrupt enable flag
  - ISP : In-service priority flag
  - MK : Interrupt mask flag
  - PR : Priority specification flag

## 5. 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 system clock oscillation is stopped. All operations by the system clock are stopped and current consumption can be considerably reduced.

Figure 5-1. Standby Function



## 6. RESET FUNCTION

There are the following three reset methods.

- External reset input by  $\overline{\text{RESET}}$  pin
- Internal reset by watchdog timer runaway time detection
- Internal reset by Power-On Clear (POC).

7. 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

Second Operand First 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]													
[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

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

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

**(3) Bit manipulation instructions**

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

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

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

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

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

**(5) Other instructions**

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

8. ELECTRICAL SPECIFICATIONS

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

Parameter	Symbol	Conditions		Rating	Unit
Supply voltage	V <sub>DD</sub>			-0.3 to +6.0	V
	V <sub>DDPORT</sub>			-0.3 to V <sub>DD</sub> + 0.3 <sup>Note 1</sup>	V
	V <sub>DDPLL</sub>			-0.3 to V <sub>DD</sub> + 0.3 <sup>Note 1</sup>	V
Input voltage	V <sub>I</sub>			-0.3 to V <sub>DD</sub> + 0.3	V
Output voltage	V <sub>O</sub>	Excluding P130 to P132		-0.3 to V <sub>DD</sub> + 0.3	V
Output breakdown voltage	V <sub>BDS</sub>	P130-P132	N-ch open drain	16	V
Analog input voltage	V <sub>AN</sub>	P10-P15	Analog input pin	-0.3 to V <sub>DD</sub> + 0.3	V
High-level output current	I <sub>OH</sub>	1 pin		-8	mA
		Total of P00-P06, P30-P37, P54-P57, P60-P67, and P120-P125		-15	mA
		Total of P40-P47, P50-P53, and P70-P77		-15	mA
Low-level output current	I <sub>OL</sub> <sup>Note 2</sup>	1 pin	Peak value	16	mA
			r.m.s	8	mA
		Total of P00-P06, P30-P37, P40-P47, P50-P57, P60-P67, P70-P77, P120-P125, and P130-P132	Peak value	30	mA
			r.m.s	15	mA
Operating temperature	T <sub>A</sub>			-40 to +85	°C
Storage temperature	T <sub>stg</sub>			-55 to +125	°C

★

★

- Notes** 1. Keep the voltage at V<sub>DDPORT</sub> and V<sub>DDPLL</sub> same as that at the V<sub>DD</sub> pin.  
 2. Calculate the r.m.s as follows: [r.m.s] = [Peak value] × √Duty

**Caution** If the rated value of even one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. The absolute maximum ratings, therefore, are the values exceeding which the product may be physically damaged. Be sure to use the product with these ratings never being exceeded.

**Remark** Unless otherwise specified, the characteristics of a multiplexed pin are the same as those of the corresponding port pin.

Recommended Supply Voltage Ranges (T<sub>A</sub> = -40 to +85°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Supply voltage	V <sub>DD1</sub>	When CPU and PLL are operating	4.5	5.0	5.5	V
	V <sub>DD2</sub>	When CPU is operating and PLL is stopped	3.5	5.0	5.5	V
Data retention voltage	V <sub>DDR</sub>	When crystal oscillation stops	2.3		5.5	V
Output breakdown voltage	V <sub>BDS</sub>	P130-P132 (N-ch open drain)			15	V

DC Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 3.5 to 5.5 V) (1/2)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
High-level input voltage	V <sub>IH1</sub>	P10-P15, P30-P32, P35-P37, P40-P47, P50-P57, P60-P67, P71, P73, P120-P125	0.7 V <sub>DD</sub>		V <sub>DD</sub>	V
	V <sub>IH2</sub>	P00-P06, P33, P34, P70, P72, P74-P75, RESET	0.8 V <sub>DD</sub>		V <sub>DD</sub>	V
	V <sub>IH3</sub>	P76, P77 (N-ch open-drain I/O)	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0.7 V <sub>DD</sub>	V <sub>DD</sub>	V
Low-level input voltage	V <sub>IL1</sub>	P10-P15, P30-P32, P35-P37, P40-P47, P50-P57, P60-P67, P71, P73, P120-P125	0		0.3 V <sub>DD</sub>	V
	V <sub>IL2</sub>	P00-P06, P33, P34, P70, P72, P74-P75, RESET	0		0.2 V <sub>DD</sub>	V
	V <sub>IL3</sub>	P76, P77 (N-ch open-drain I/O)	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V	0	0.3 V <sub>DD</sub>	V
High-level output voltage	V <sub>OH1</sub>	P00-P06, P30-P37, P40-P47, P50-P57, P60-P67, P70-P77, P120-P125	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V, I <sub>OH</sub> = -1 mA	V <sub>DD</sub> - 1.0		V
			3.5 V ≤ V <sub>DD</sub> < 4.5 V, I <sub>OH</sub> = -100 μA	V <sub>DD</sub> - 0.5		V
	V <sub>OH2</sub>	EO0, EO1	V <sub>DD</sub> = 4.5 to 5.5 V, I <sub>OH</sub> = -3 mA	V <sub>DD</sub> - 1.0		V
Low-level output voltage	V <sub>OL1</sub>	P00-P06, P30-P37, P40-P47, P50-P57, P60-P67, P70-P75, P120-P125	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V, I <sub>OL</sub> = 1 mA		1.0	V
			3.5 V ≤ V <sub>DD</sub> < 4.5 V, I <sub>OL</sub> = 100 μA		0.5	V
	V <sub>OL2</sub>	EO0, EO1	V <sub>DD</sub> = 4.5 to 5.5 V, I <sub>OL</sub> = 3 mA		1.0	V
	V <sub>OL3</sub>	P76, P77 (N-ch open-drain I/O)	4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V I <sub>OL</sub> = 3 mA		0.4	V
			4.5 V ≤ V <sub>DD</sub> ≤ 5.5 V I <sub>OL</sub> = 6 mA		0.6	V
High-level input leakage current	I <sub>LH</sub>	P00-P06, P10-P15, P30-P37, P40-P47, P50-P57, P60-P67, P70-P77, P120-P125, RESET	V <sub>IN</sub> = V <sub>DD</sub>		3	μA

**Remark** Unless otherwise specified, the characteristics of a multiplexed pin are the same as those of the corresponding port pin.

DC Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 3.5 to 5.5 V) (2/2)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Low-level input leakage current	I <sub>LIL</sub>	P00-P06, P10-P15, P30-P37, P40-P47, P50-P57, P60-P67, P70-P77, P120-P125, $\overline{\text{RESET}}$	V <sub>IN</sub> = 0 V			-3	μA
Output off leakage current	I <sub>LOH1</sub>	P130-P132	V <sub>OUT</sub> = 15 V			-3	μA
	I <sub>LOL1</sub>	P130-P132	V <sub>OUT</sub> = 0 V			3	μA
	I <sub>LOH2</sub>	P76, P77 (at N-ch open drain I/O)	V <sub>OUT</sub> = V <sub>DD</sub>			-3	μA
	I <sub>LOL2</sub>	P76, P77 (at N-ch open drain I/O)	V <sub>OUT</sub> = 0 V			3	μA
	I <sub>LOH3</sub>	EO0, EO1	V <sub>OUT</sub> = V <sub>DD</sub>			-3	μA
	I <sub>LOL3</sub>	EO0, EO1	V <sub>OUT</sub> = 0 V			3	μA
★ Supply current <sup>Note</sup>	I <sub>DD1</sub>	When CPU is operating and PLL is stopped. Sine wave input to X1 pin At f <sub>x</sub> = 4.5 MHz V <sub>IN</sub> = V <sub>DD</sub>			2.5	15	mA
	I <sub>DD2</sub>	In HALT mode with PLL stopped. Sine wave input to X1 pin At f <sub>x</sub> = 4.5 MHz V <sub>IN</sub> = V <sub>DD</sub>			0.2	0.8	mA
Data retention voltage	V <sub>DDR1</sub>	When crystal resonator is oscillating		3.5		5.5	V
	V <sub>DDR2</sub>	When crystal oscillation is stopped	Power-failure detection function	2.2			V
	V <sub>DDR3</sub>		Data memory retained	2.0			V
Data retention current	I <sub>DDR1</sub>	When crystal oscillation is stopped	T <sub>A</sub> = 25°C, V <sub>DD</sub> = 5 V		2.0	4.0	μA
	I <sub>DDR2</sub>				2.0	20	μA

**Note** Excluding AV<sub>DD</sub> current and V<sub>DD</sub>PLL current.

**Remarks 1.** f<sub>x</sub>: System clock oscillation frequency

**2.** Unless otherwise specified, the characteristics of a multiplexed pin are the same as those of the corresponding port pin.

**Reference Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 4.5 to 5.5 V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
★ Supply current	I <sub>DD3</sub>	When CPU and PLL are operating. Sine wave input to VCOH pin At f <sub>IN</sub> = 160 MHz V <sub>IN</sub> = 0.15 V <sub>P-P</sub>		5		mA

**AC Characteristics**

**(1) Basic operation (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 3.5 to 5.5 V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Cycle time (minimum instruction execution time)	T <sub>CY</sub>	f <sub>x</sub> = 4.5 MHz	0.44		7.11	μs
TI50, TI51 input frequency	f <sub>TI5</sub>				2	MHz
TI50, TI51 input high-/low-level widths	t <sub>TIH5</sub> t <sub>TIL5</sub>		200			ns
Interrupt input high-/low-level widths	t <sub>INTH</sub> t <sub>INTL</sub>	INTP0-INTP4	1			μs
RESET pin low-level width	t <sub>RSL</sub>		10			μs

(2) Serial interface (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 3.5 to 5.5 V)

(a) Serial interface (IIC0)

I<sup>2</sup>C bus mode

Parameter		Symbol	Standard Mode		High-speed Mode		Unit
			MIN.	MAX.	MIN.	MAX.	
SCL0 clock frequency		f <sub>CLK</sub>	0	100	0	400	kHz
Bus free time (between stop and start conditions)		t <sub>BUF</sub>	4.7	–	1.3	–	μs
Hold time <sup>Note 1</sup>		t <sub>HD : STA</sub>	4.0	–	0.6	–	μs
SCL0 clock low-level width		t <sub>LOW</sub>	4.7	–	1.3	–	μs
SCL0 clock high-level width		t <sub>HIGH</sub>	4.0	–	0.6	–	μs
Start/restart condition setup time		t <sub>SU : STA</sub>	4.7	–	0.6	–	μs
Data hold time	CBUS compatible master	t <sub>HD : DAT</sub>	5.0	–	–	–	μs
	I <sup>2</sup> C bus		0 <sup>Note 2</sup>	–	0 <sup>Note 2</sup>	0.9 <sup>Note 3</sup>	μs
Data setup time		t <sub>SU : DAT</sub>	250	–	100 <sup>Note 4</sup>	–	ns
SDA0 and SCL0 signal rise time		t <sub>R</sub>	–	1000	20+0.1Cb <sup>Note 5</sup>	300	ns
SDA0 and SCL0 signal fall time		t <sub>F</sub>	–	300	20+0.1Cb <sup>Note 5</sup>	300	ns
Stop condition setup time		t <sub>SU : STO</sub>	4.0	–	0.6	–	μs
Pulse width of spike restrained by input filter		t <sub>SP</sub>	–	–	0	50	ns
Each bus line capacitive load		C <sub>b</sub>	–	400	–	400	pF

- Notes**
- The first clock pulse is generated at the start condition after this period.
  - The device needs to internally supply a hold time of at least 300 ns for the SDA0 signal to fill the undefined area at the falling edge of the SCL0 (V<sub>IHmin.</sub> of the SCL0 signal).
  - Unless the device extends the low hold time (t<sub>LOW</sub>) of the SCL0 signal, it is necessary to fill only the maximum data hold time (t<sub>HD : DAT</sub>).
  - The high-speed mode I<sup>2</sup>C bus can be used in the standard mode I<sup>2</sup>C bus system. In this case, satisfy the following conditions:
    - When the device does not extend the low hold time of the SCL0 signal  
t<sub>SU : DAT</sub> ≥ 250 ns
    - When the device extends the low hold time of the SCL0 signal  
Send the next data bit to the SDA line before releasing the SCL0 line (t<sub>Rmax.</sub> + t<sub>SU:DAT</sub> = 1000 + 250 = 1250 ns : in the standard mode I<sup>2</sup>C bus specification)
  - C<sub>b</sub>: Total capacitance of one bus line (unit: pF)

(b) Serial interface (SIO3)

(i) 3-wire serial I/O mode ( $\overline{\text{SCK3}}$  ... internal clock output)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK3}}$ cycle time	$t_{\text{KCY1}}$		800			ns
$\overline{\text{SCK3}}$ high/low-level width	$t_{\text{KH1}},$ $t_{\text{KL1}}$		$t_{\text{KCY1}}/2 - 50$			ns
SI3 setup time (to $\overline{\text{SCK3}}\uparrow$ )	$t_{\text{SIK1}}$		100			ns
SI3 hold time (from $\overline{\text{SCK3}}\uparrow$ )	$t_{\text{KSI1}}$		400			ns
$\overline{\text{SCK3}}\downarrow \rightarrow \text{SO3}$ output delay time	$t_{\text{KSO1}}$	C = 100 pF <b>Note</b>			300	ns

**Note** C is the load capacitance of  $\overline{\text{SCK3}}$  and SO3 output line.

(ii) 3-wire serial I/O mode ( $\overline{\text{SCK3}}$  ... external clock input)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
$\overline{\text{SCK3}}$ cycle time	$t_{\text{KCY2}}$		800			ns
$\overline{\text{SCK3}}$ high/low-level width	$t_{\text{KH2}},$ $t_{\text{KL2}}$		400			ns
SI3 setup time (to $\overline{\text{SCK3}}\uparrow$ )	$t_{\text{SIK2}}$		100			ns
SI3 hold time (from $\overline{\text{SCK3}}\uparrow$ )	$t_{\text{KSI2}}$		400			ns
$\overline{\text{SCK3}}\downarrow \rightarrow \text{SO3}$ output delay time	$t_{\text{KSO2}}$	C = 100 pF <b>Note</b>			300	ns
$\overline{\text{SCK3}}$ at rising or falling edge time	$t_{\text{R2}}, t_{\text{F2}}$				1000	ns

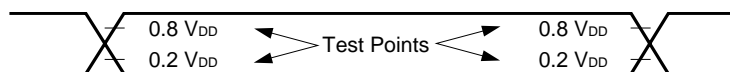
**Note** C is the load capacitance of SO3 output line.

(d) Serial interface (UART0: Dedicated baud rate generator output)

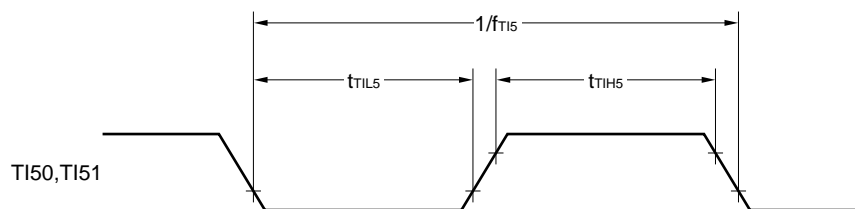
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate					38400	bps



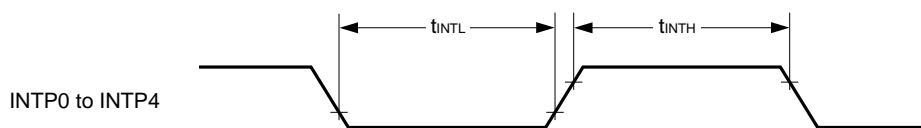
AC Timing Test Point (Excluding X1 Input)



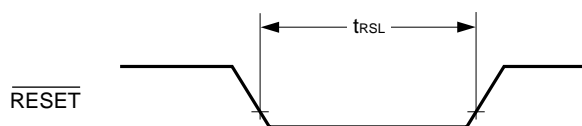
TI Timing



Interrupt Input Timing

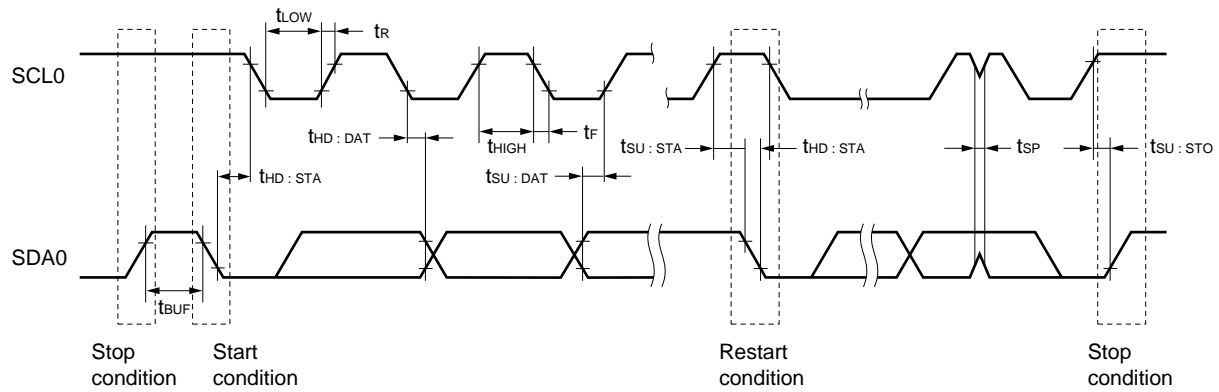


$\overline{\text{RESET}}$  Input Timing

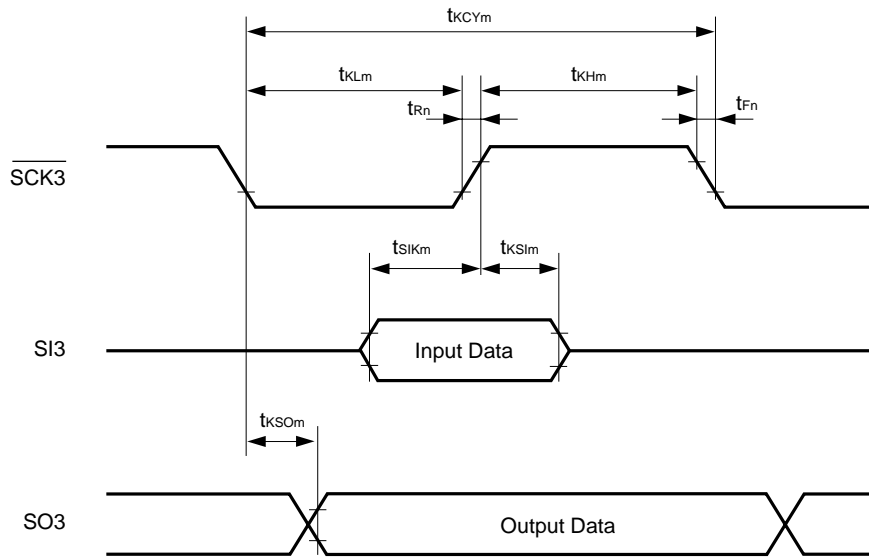


Serial Transfer Timing

I<sup>2</sup>C bus mode:



3-wire serial I/O mode:



Remark  $m = 1, 2$   
 $n = 2$

★ **A/D Converter Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 3.5 to 5.5 V)**

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution			8	8	8	bit
Total conversion error <sup>Note</sup>		V <sub>DD</sub> = 4.5 to 5.5			±1.0	%
					±1.4	%
Conversion time	t <sub>CONV</sub>		21.3		64.0	μs
Analog input voltage	V <sub>IAN</sub>		0		V <sub>DD</sub>	V

**Note** Excluding quantization error (±1/2LSB)

**PLL Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 4.5 to 5.5 V)**

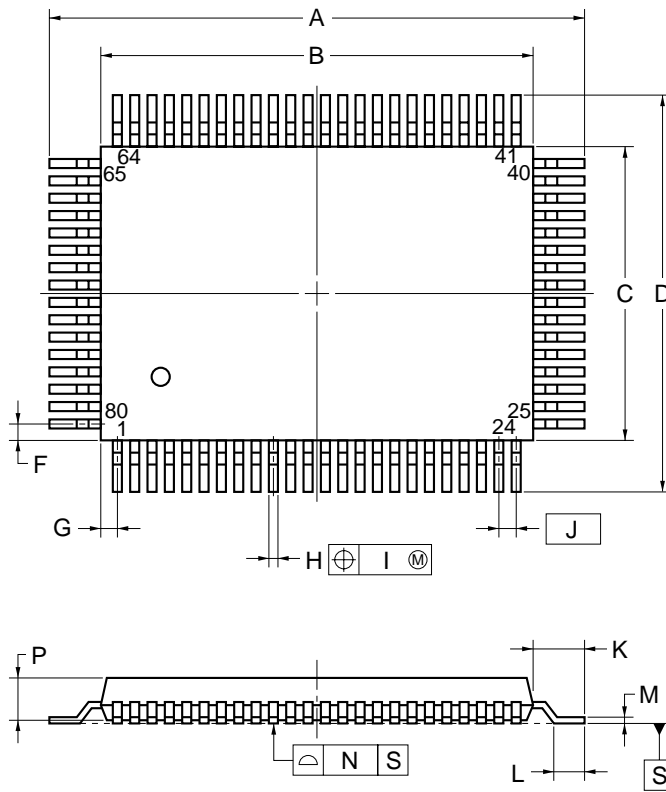
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Operating frequency	f <sub>IN1</sub>	VCOL pin, MF mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	0.5		3.0	MHz
	f <sub>IN2</sub>	VCOL pin, HF mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	10		40	MHz
	f <sub>IN3</sub>	VCOH pin, VHF mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	60		130	MHz
	f <sub>IN4</sub>	VCOH pin, VHF mode, sine wave input, V <sub>IN</sub> = 0.3 V <sub>P-P</sub>	40		160	MHz

**IFC Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>DD</sub> = 4.5 to 5.5 V)**

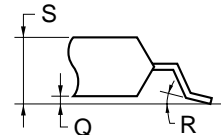
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Operating frequency	f <sub>IN5</sub>	AMIFC pin, AMIF count mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	0.4		0.5	MHz
	f <sub>IN6</sub>	FMIFC pin, FMIF count mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	10		11	MHz
	f <sub>IN7</sub>	FMIFC pin, AMIF count mode, sine wave input, V <sub>IN</sub> = 0.15 V <sub>P-P</sub>	0.4		0.5	MHz

9. PACKAGE DRAWING

80-PIN PLASTIC QFP (14x20)



detail of lead end



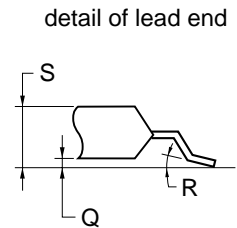
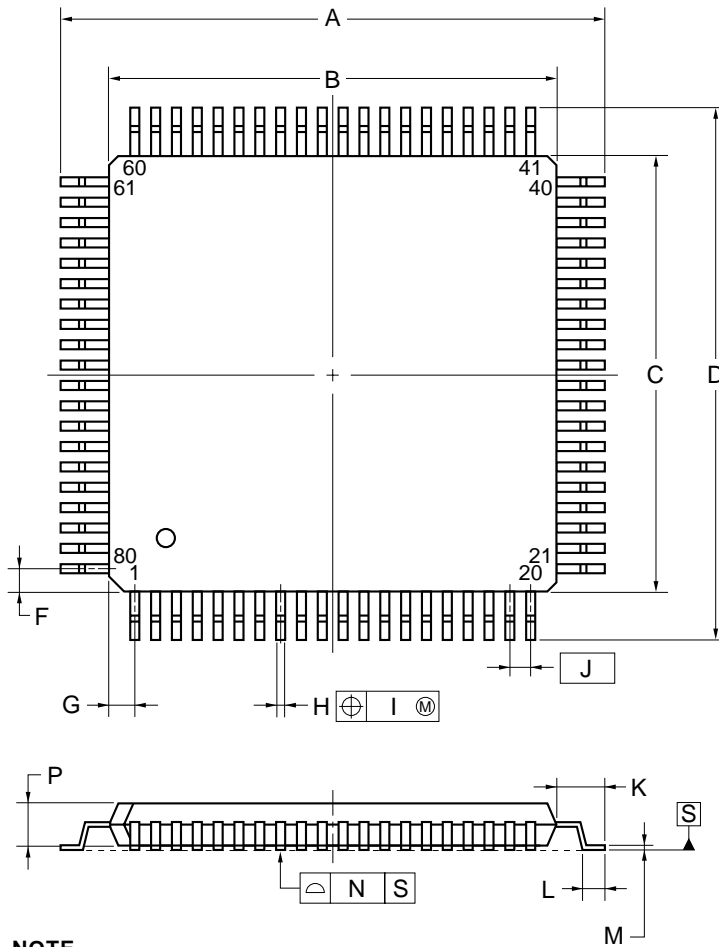
NOTE

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

ITEM	MILLIMETERS
A	23.6±0.4
B	20.0±0.2
C	14.0±0.2
D	17.6±0.4
F	1.0
G	0.8
H	0.37 <sup>+0.08</sup> <sub>-0.07</sub>
I	0.15
J	0.8 (T.P.)
K	1.8±0.2
L	0.8±0.2
M	0.17 <sup>+0.08</sup> <sub>-0.07</sub>
N	0.10
P	2.7±0.1
Q	0.1±0.1
R	5°±5°
S	3.0 MAX.

P80GF-80-3B9-5

80-PIN PLASTIC QFP (14x14)



NOTE

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

ITEM	MILLIMETERS
A	17.20±0.20
B	14.00±0.20
C	14.00±0.20
D	17.20±0.20
F	0.825
G	0.825
H	0.32±0.06
I	0.13
J	0.65 (T.P.)
K	1.60±0.20
L	0.80±0.20
M	0.17 <sup>+0.03</sup> <sub>-0.07</sub>
N	0.10
P	1.40±0.10
Q	0.125±0.075
R	3° <sup>+7°</sup> <sub>-3°</sub>
S	1.70 MAX.

P80GC-65-8BT-1

**10. RECOMMENDED SOLDERING CONDITIONS**

Solder this product under the following recommended conditions.

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

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

**Table 10-1. Soldering Conditions for Surface-Mount Type**

μPD178023GF-XXX-3B9: 80-pin plastic QFP (14 × 20)

μPD178024GF-XXX-3B9: 80-pin plastic QFP (14 × 20)

Soldering Method	Soldering Conditions	Recommended Conditions Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 30 sec max. (210°C min.), Number of times: 3 max.	IR35-00-3
VPS	Package peak temperature: 215°C, Time: 40 sec max. (200°C min.), Number of times: 3 max.	VP15-00-3
Wave soldering	Solder bath temperature: 260°C max., Time: 10 sec max., Number of times: 1, Preheating temperature: 120°C max., (Package surface temperature)	WS60-00-1
Partial heating	Pin temperature: 300°C max., Time: 3 sec max (per device side)	—

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

μPD178023GC-XXX-8BT: 80-pin plastic QFP (14 × 14)

μPD178024GC-XXX-8BT: 80-pin plastic QFP (14 × 14)

Soldering Method	Soldering Conditions	Recommended Conditions Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 30 sec max. (210°C min.), Number of times: 2 max.	IR35-00-2
VPS	Package peak temperature: 215°C, Time: 40 sec max. (200°C min.), Number of times: 2 max.	VP15-00-2
Wave soldering	Solder bath temperature: 260°C max., Time: 10 sec max., Number of times: 1, Preheating temperature: 120°C max., (Package surface temperature)	WS60-00-1
Partial heating	Pin temperature: 300°C max., Time: 3 sec max (per device side)	—

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

## APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for development of systems using the μPD178023, 178024 subseries.

### (1) Language processor software

RA78K0 <sup>Notes 1, 2, 3</sup>	Assembler package common to 78K/0 series
CC78K0 <sup>Notes 1, 2, 3</sup>	C compiler package common to 78K/0 series
DF178124 <sup>Notes 1, 2, 3</sup>	Device file for μPD178024 subseries
CC78K0-L <sup>Notes 1, 2, 3</sup>	C compiler library source file common to 78K/0 series

### (2) Flash memory writing tools

Fashpro III (Part number: FL-PR3 <sup>Note 4</sup> , PG-FP3)	Dedicated flash writer
FA-80GF <sup>Note 4</sup>	Flash memory writing adapter
FA-80GC-8BT <sup>Note 4</sup>	

### (3) Debugging tools

#### • When in-circuit emulator IE-78K0-NS is used

IE-78K0-NS	In-circuit emulator common to 78K/0 series
IE-70000-MC-PS-B	Power supply unit for IE-78K0-NS
IE-78K0-NS-PA	Performance board for enhancing and expanding the IE-78K0-NS function
IE-70000-98-IF-C	Interface adapter necessary when a PC-9800 series (except notebook-type PC) is used as host machine (C bus supported)
IE-70000-CD-IF-A	PC card and interface cable necessary when a notebook-type PC is used as host machine (PCMCIA socket supported)
IE-70000-PC-IF-C	Interface adapter when a IBM PC/AT™ compatible machine is used (ISA bus supported)
IE-70000-PCI-IF	Interface adapter necessary when a PC with a PCI bus is used as host machine
IE-178134-NS-EM1	Emulation board for emulating the μPD178024 subseries
NP-80GF <sup>Note 4</sup>	Emulation probe for 80-pin plastic QFP (GF-3B9 type)
EV-9200G-80	Socket to be mounted on the board of the target system for 80-pin plastic QFP (GF-3B9 type)
NP-80GC <sup>Note 4</sup>	Emulation probe for 80-pin plastic QFP (GC-8BT type)
EV-9200GC-80	Socket to be mounted on the board of the target system for 80-pin plastic QFP (GC-8BT type)
SM78K0 <sup>Notes 1, 2</sup>	System simulator common to 78K/0 series
ID78K0-NS <sup>Notes 1, 2</sup>	Integrated debugger common to 78K/0 series
DF178124 <sup>Notes 1, 2, 3</sup>	Device file for μPD178024 subseries

**Notes** 1. PC-9800 series (Japanese Windows™) based

2. IBM PC/AT compatible machine (Japanese/English Windows) based

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

4. Products of Naito Densetsu Machida Mfg. Co., Ltd. (Tel: 044-822-3813).

**Remark** Use the RA78K0, CC78K0, and SM78K0 in combination with the DF178124.

• When in-circuit emulator IE-78001-R-A is used

IE-78001-R-A	In-circuit emulator common to 78K/0 series
IE-70000-98-IF-C	Interface adapter necessary when a PC-9800 series (except notebook-type PC) is used as host machine (C bus supported)
IE-70000-PC-IF-C	Interface adapter when a IBM PC/AT compatible machine is used (ISA bus supported)
IE-70000-PCI-IF	Interface adapter necessary when a PC with a PCI bus is used as host machine
IE-78000-R-SV3	Interface adapter and cable necessary when an EWS is used as host machine
IE-178134-NS-EM1	Emulation board for emulating the μPD178024 subseries
IE-78K0-R-EX1	Emulation probe conversion board necessary when using IE-178134-NS-EM1 on IE-78001-R-A.
EP-78130GF-R	Emulation probe for 80-pin plastic QFP (GF-3B9 type)
EV-9200G-80	Socket to be mounted on the board of the target system for 80-pin plastic QFP (GF-3B9 type)
EP-78230GC-R	Emulation probe for 80-pin plastic QFP (GC-8BT type)
EV-9200GC-80	Socket to be mounted on the board of the target system for 80-pin plastic QFP (GC-8BT type)
SM78K0 <sup>Notes 1, 2</sup>	System simulator common to 78K/0 series
ID78K0 <sup>Notes 1, 2</sup>	Integrated debugger common to 78K/0 series
DF178124 <sup>Notes 1, 2, 3</sup>	Device file for μPD178024 subseries

Real-time OS

RX78K0 <sup>Notes 1, 2, 3</sup>	Real-time OS for 78K/0 series
MX78K0 <sup>Notes 1, 2, 3</sup>	OS for 78K/0 series

- Notes**
1. PC-9800 series (Japanese Windows) based
  2. IBM PC/AT compatible machine (Japanese/English windows) based
  3. HP9000 series 700 (HP-UX) based, SPARCstation (SunOS, Solaris) based, NEWS (NEW-OS) based

**Remark** Use SM78K0 in combination with the DF178124.



**APPENDIX B. RELATED DOCUMENTS**

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such.

**Device Documents**

Title		Document No.	
		Japanese	English
μPD178023, 178024 Data Sheet		U14126J	This document
★	μPD178F124 Data Sheet	U14933J	U14933E
μPD178024 Subseries User's Manual		U13915J	U13915E
78K/0 Series User's Manual—Instruction		U12326J	U12326E
78K/0 Series Application Note	Basics (I)	U12704J	U12704E

**Development Tool Documents (User's Manual)**

Title		Document No.		
		Japanese	English	
RA78K0 Assembler Package	Operation	U11802J	U11802E	
	Assembly Language	U11801J	U11801E	
	Structured Assembly Language	U11789J	U11789E	
CC78K0 C Compiler	Operation	U11517J	U11517E	
	Language	U11518J	U11518E	
★	IE-78001-R-A In-circuit Emulator		U14142J	To be prepared
★	IE-78K0-NS In-circuit Emulator		U13731J	U13731E
IE-178134-NS-EM1 Emulation Board		To be prepared	To be prepared	
EP-78230 Emulation Probe		EEU-985	EEU-1515	
EP-78130 Emulation Probe		–	EEU-1470	
SM78K0 System Simulator Windows Based	Reference	U10181J	U10181E	
★	SM78K0S, SM78K0 System Simulator Ver. 2.10 or Later Windows Based	Operation	U14910J	To be prepared
SM78K Series System Simulator	External Parts User Open Interface Specifications	U10092J	U10092E	
ID78K0 Integrated Debugger EWS Based	Reference	U11151J	–	
ID78K0 Integrated Debugger PC Based	Reference	U11539J	U11539E	
ID78K0 Integrated Debugger Windows Based	Guide	U11649J	U11649E	
★	ID78K0-NS Integrated Debugger Ver. 2.00 or Later Windows Based	Operation	U14379J	U14379E
★	ID78K0-NS, ID78K0S-NS Integrated Debugger Ver. 2.20 or Later Windows Based	Operation	U14910J	To be prepared

**Caution** The contents of the above documents are subject to change without notice. Please ensure that the latest versions are used in design work, etc.

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

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

**Other Documents**

Title	Document No.	
	Japanese	English
SEMICONDUCTOR SELECTION GUIDE Products & Packages (CD-ROM)	X13769X	
Semiconductor Device Mounting Technology Manual	C10535J	C10535E
Quality Guides on NEC Semiconductor Devices	C11531J	C11531E
NEC Semiconductor Device Reliability and Quality Control	C10983J	C10983E
Guide to Prevent Damage for Semiconductor Devices by Electrostatic Discharge (ESD)	C11892J	C11892E
Semiconductor Device Quality/Reliability Handbook	C12769J	—
Microcomputer Product Series Guide	U11416J	—

**Caution** The contents of the above documents are subject to change without notice. Ensure that the latest versions are used in design work, etc.

[MEMO]

[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.

Purchase of NEC I<sup>2</sup>C components conveys a license under the Philips I<sup>2</sup>C Patent Rights to use these components in an I<sup>2</sup>C system, provided that the system conforms to the I<sup>2</sup>C Standard Specification as defined by Philips.

**IEBus is a trademark of NEC Corporation.**

**Windows is a either registered trademark or a trademark of Microsoft Corporation in the United States and/or other countries.**

**PC/AT is a trademark of IBM Corporation.**

**HP9000 series 700 and HP-UX are trademarks of Hewlett-Packard Company.**

**SPARCstation is a trademark of SPARC International, Inc.**

**Solaris and SunOS are trademarks of Sun Microsystems, Inc.**

**NEWS and NEWS-OS are trademarks of Sony Corporation.**

## 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.

### **NEC Electronics Inc. (U.S.)**

Santa Clara, California  
Tel: 408-588-6000  
800-366-9782  
Fax: 408-588-6130  
800-729-9288

### **NEC Electronics (Germany) GmbH**

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

### **NEC Electronics (UK) Ltd.**

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

### **NEC Electronics Italiana s.r.l.**

Milano, Italy  
Tel: 02-66 75 41  
Fax: 02-66 75 42 99

### **NEC Electronics (Germany) GmbH**

Benelux Office  
Eindhoven, The Netherlands  
Tel: 040-2445845  
Fax: 040-2444580

### **NEC Electronics (France) S.A.**

Velizy-Villacoublay, France  
Tel: 01-30-67 58 00  
Fax: 01-30-67 58 99

### **NEC Electronics (France) S.A.**

Madrid Office  
Madrid, Spain  
Tel: 91-504-2787  
Fax: 91-504-2860

### **NEC Electronics (Germany) GmbH**

Scandinavia Office  
Taebly, Sweden  
Tel: 08-63 80 820  
Fax: 08-63 80 388

### **NEC Electronics Hong Kong Ltd.**

Hong Kong  
Tel: 2886-9318  
Fax: 2886-9022/9044

### **NEC Electronics Hong Kong Ltd.**

Seoul Branch  
Seoul, Korea  
Tel: 02-528-0303  
Fax: 02-528-4411

### **NEC Electronics Singapore Pte. Ltd.**

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

### **NEC Electronics Taiwan Ltd.**

Taipei, Taiwan  
Tel: 02-2719-2377  
Fax: 02-2719-5951

### **NEC do Brasil S.A.**

Electron Devices Division  
Guarulhos-SP Brasil  
Tel: 55-11-6462-6810  
Fax: 55-11-6462-6829

J00.7

The export of this product from Japan is regulated by the Japanese government. To export this product may be prohibited without governmental license, the need for which must be judged by the customer. The export or re-export of this product from a country other than Japan may also be prohibited without a license from that country. Please call an NEC sales representative.

**• The information in this document is current as of August, 2000. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC's data sheets or data books, etc., for the most up-to-date specifications of NEC semiconductor products. Not all products and/or types are available in every country. Please check with an NEC sales representative for availability and additional information.**

- No part of this document may be copied or reproduced in any form or by any means without prior written consent of NEC. NEC assumes no responsibility for any errors that may appear in this document.
- NEC does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC semiconductor products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC or others.
- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of customer's equipment shall be done under the full responsibility of customer. NEC assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.
- While NEC endeavours to enhance the quality, reliability and safety of NEC semiconductor products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC semiconductor products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment, and anti-failure features.
- NEC semiconductor products are classified into the following three quality grades:  
"Standard", "Special" and "Specific". The "Specific" quality grade applies only to semiconductor products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of a semiconductor product depend on its quality grade, as indicated below. Customers must check the quality grade of each semiconductor product before using it in a particular application.

"Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

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

"Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

The quality grade of NEC semiconductor products is "Standard" unless otherwise expressly specified in NEC's data sheets or data books, etc. If customers wish to use NEC semiconductor products in applications not intended by NEC, they must contact an NEC sales representative in advance to determine NEC's willingness to support a given application.

(Note)

- (1) "NEC" as used in this statement means NEC Corporation and also includes its majority-owned subsidiaries.
- (2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).