NEC

MOS INTEGRATED CIRCUIT

μPD78P014

8-BIT SINGLE-CHIP MICROCOMPUTER

DESCRIPTION

The μPD78P014 is a member of the μPD78014 subseries of 78K/0 series products. It uses a one-time-programmable (OTP) ROM or EPROM instead of the mask ROM of the μPD78014.

Because the μPD78P014 can be programmed by users, it is ideally suited for applications involving the evaluation of systems in development stages, small-scale production of many different products, and rapid development and time-to-market of a new product.

Detailed information about product features and specifications can be found in the following document. Please make sure to read this document before starting design.

μPD78014, 78014Y Series User's Manual : IEU-1343

FEATURES

- Pin compatible with mask ROM versions (except V_{PP} pin)
- Internal PROM: 32K bytes[Note]
  - μPD78P014DW : Reprogrammable (ideal for system evaluation)
  - μPD78P014CW, 78P014GC-AB8 : Programmable once only (ideal for small-scale production)
- Internal high-speed RAM: 1024 bytes[Note]
- Buffer RAM: 32 bytes
- Operable over same supply voltage range as mask ROM version (2.7 to 6.0 V)
- Available for the QTOP™ microcomputer

Note The internal PROM and internal high-speed RAM size can be set by means of the memory size switching register.

Remark The QTOP microcomputer is the general term for a single-chip microcomputer with on-chip one-time PROM. NEC supports its program writing, marking, screening, and verification.

Differences from mask ROM versions are as follows:

- The same memory mapping as on a mask ROM version is possible by setting the memory size switching register.
- There is no function for incorporating pull-up resistors by means of a mask option in P60 to P63 pins.

ORDERING INFORMATION

Part No.	Package	Internal ROM
μPD78P014CW	64-pin plastic shrink DIP (750 mil)	One-time PROM
μPD78P014DW	64-pin ceramic shrink DIP (with window) (750 mil)	EPROM
μPD78P014GC-AB8	64-pin plastic QFP (14 × 14 mm)	One-time PROM

In this document, the common parts of the one-time PROM version and EPROM version are represented by PROM.

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

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Date Published January 1995 P
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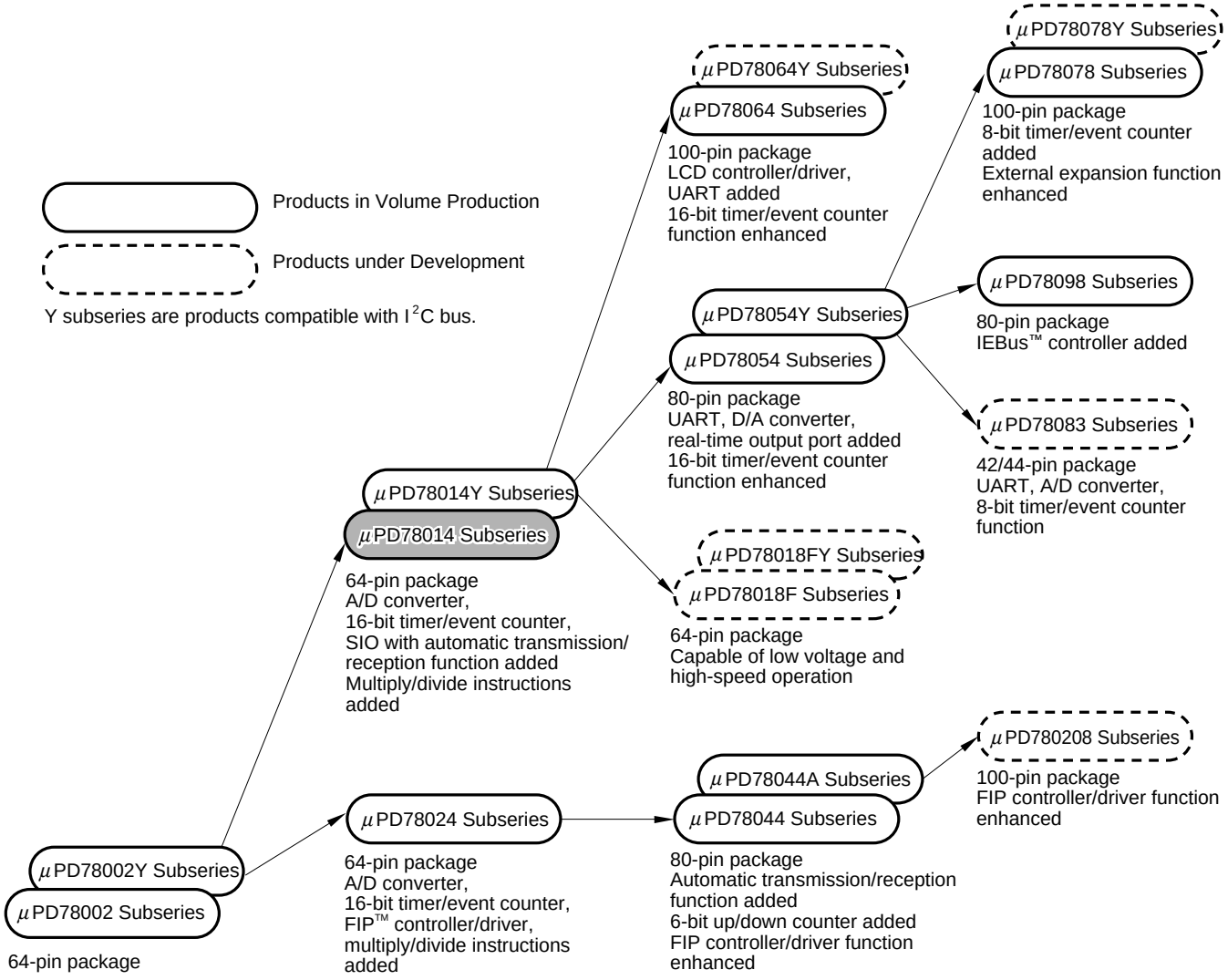
The mark ★ shows revised points.

★ 78K/0 SERIES DEVELOPMENT



OUTLINE OF FUNCTION

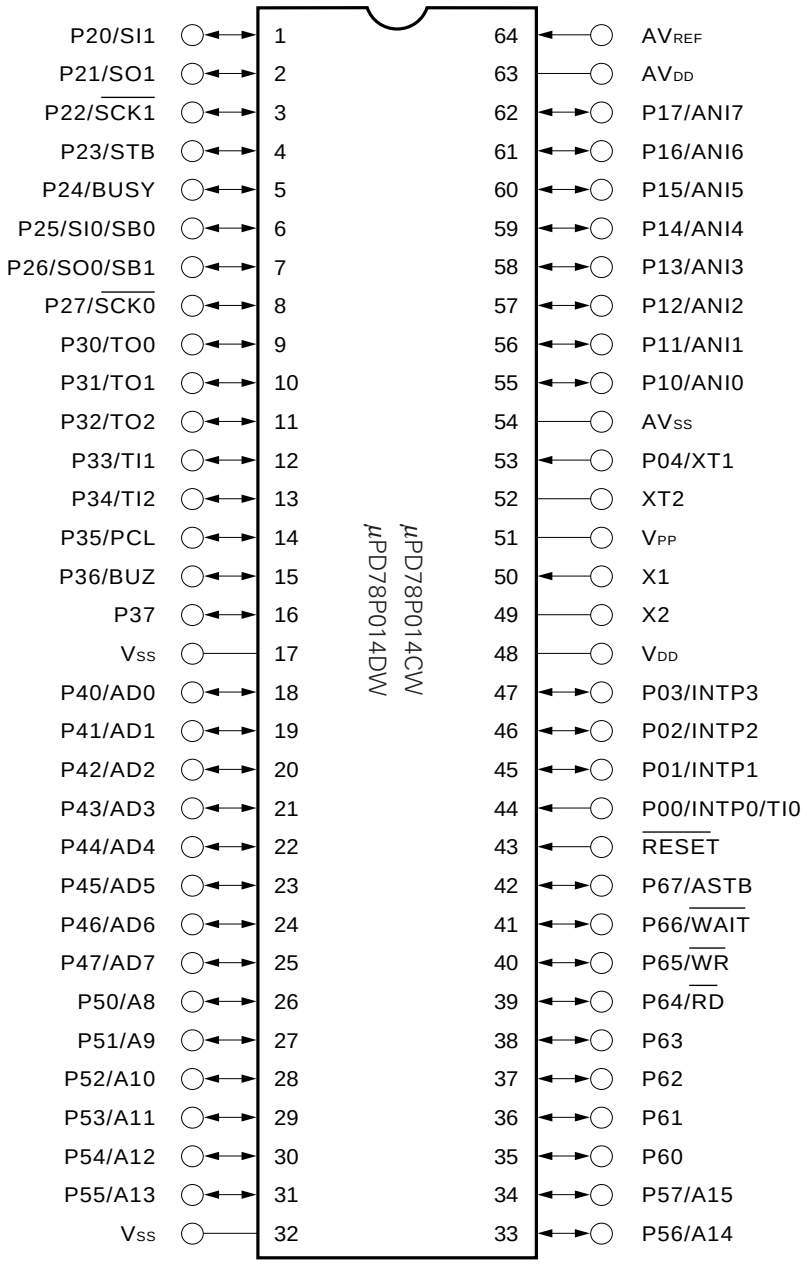
Item		Function
Internal memory		• PROM : 32K bytes[Note] • RAM Internal high-speed RAM : 1024 bytes[Note] Buffer RAM : 32 bytes
Memory space		64K bytes
General registers		8 bits × 32 registers (8 bits × 8 registers × 4 banks)
Instruction cycle		On-chip instruction execution time cycle modification function
	Main system clock selected	0.4 μs/0.8 μs/1.6 μs/3.2 μs/6.4 μs (at 10.0 MHz operation)
	Subsystem clock selected	122 μs (at 32.768 kHz operation)
Instruction set		• 16-bit operation • Multiply/divide (8 bits × 8 bits,16 bits ÷ 8 bits) • Bit manipulate (set, reset, test, Boolean operation) • BCD correction, etc.
I/O ports		Total : 53 • CMOS input : 2 • CMOS I/O : 47 • N-channel open-drain I/O (15 V withstand voltage) : 4
A/D converter		• 8-bit resolution × 8 channels • Operable over a wide power supply voltage range: V_{DD} = 2.7 to 6.0 V
Serial interface		• 3-wire/SBI/2-wire mode selectable : 1 channel • 3-wire mode (on-chip max. 32 bytes automatic data transmit/receive function): 1 channel
Timer		• 16-bit timer/event counter : 1 channel • 8-bit timer/event counter : 2 channels • Clock timer : 1 channel • Watchdog timer : 1 channel
Timer output		3 (14-bit PWM output : 1)
Clock output		39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz (at main system clock 10.0 MHz operation) 32.768 kHz (at subsystem clock 32.768 kHz operation)
Buzzer output		2.4 kHz, 4.9 kHz, 9.8 kHz (at main system clock 10.0 MHz operation)
Vectored interrupts	Maskable interrupts	Internal : 8, External : 4
	Non-maskable interrupt	Internal : 1
	Software interrupt	Internal : 1
Test input		Internal : 1 External : 1
Operating voltage range		V_{DD} = 2.7 to 6.0 V
Operating temperature range		–40 to +85 °C
Package		• 64-pin plastic shrink DIP (750 mil) • 64-pin plastic QFP (14 × 14 mm) • 64-pin ceramic shrink DIP (with window) (750 mil)

Note The capacity of the internal PROM and internal high-speed RAM can be set by means of the memory size switching register.

PIN CONFIGURATION (Top View)

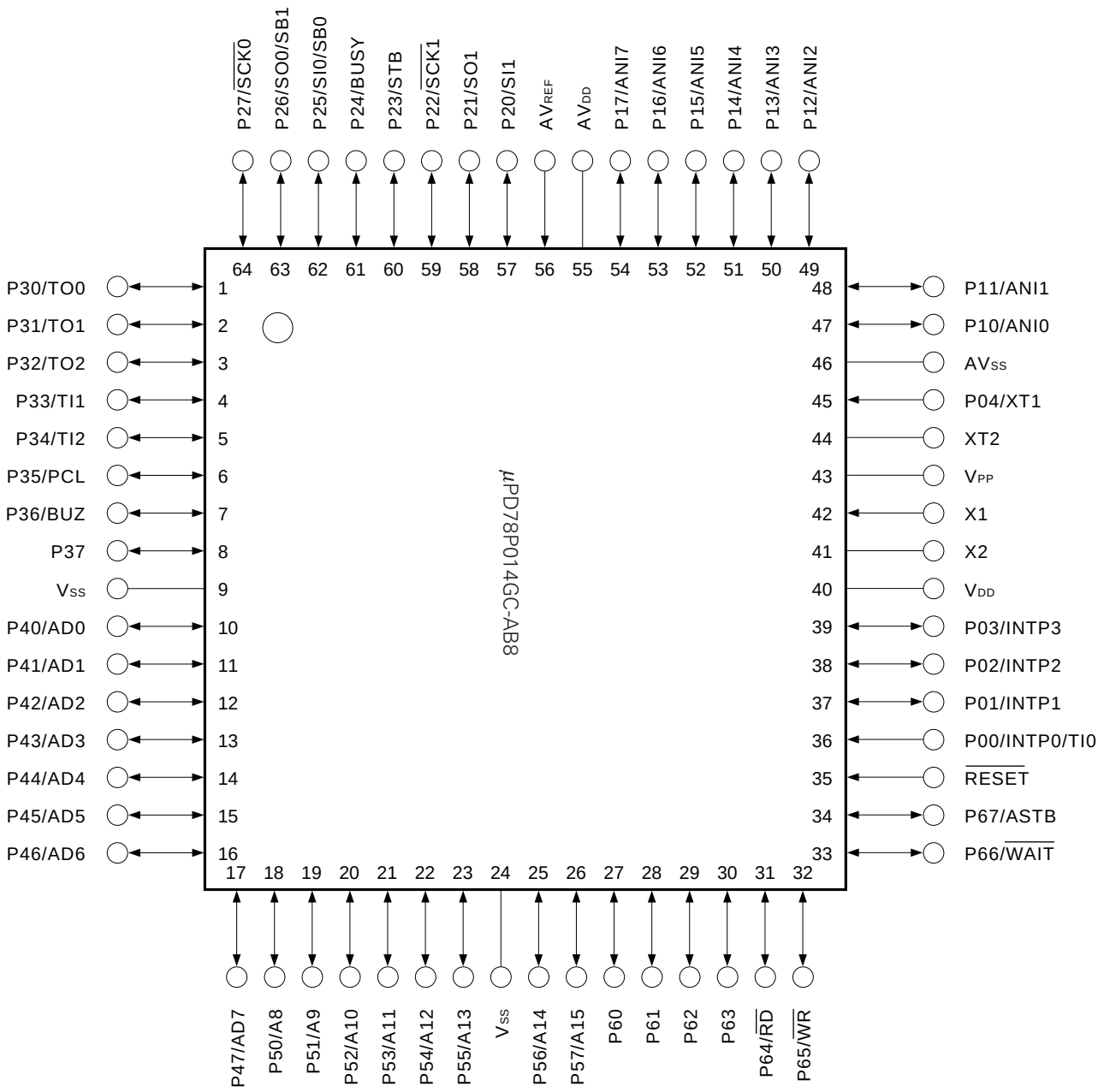
(1) Normal operating mode

64-pin plastic shrink DIP (750 mil)
64-pin ceramic shrink DIP (with window) (750 mil)



Cautions 1. V_{PP} pin should be connected to V_{SS} directly.
2. AV_{DD} pin should be connected to V_{DD}.
3. AV_{SS} pin should be connected to V_{SS}.

64-pin plastic QFP (14 × 14 mm)



Cautions 1. V_{PP} pin should be connected to V_{SS} directly.

2. AV_{DD} pin should be connected to V_{DD}.

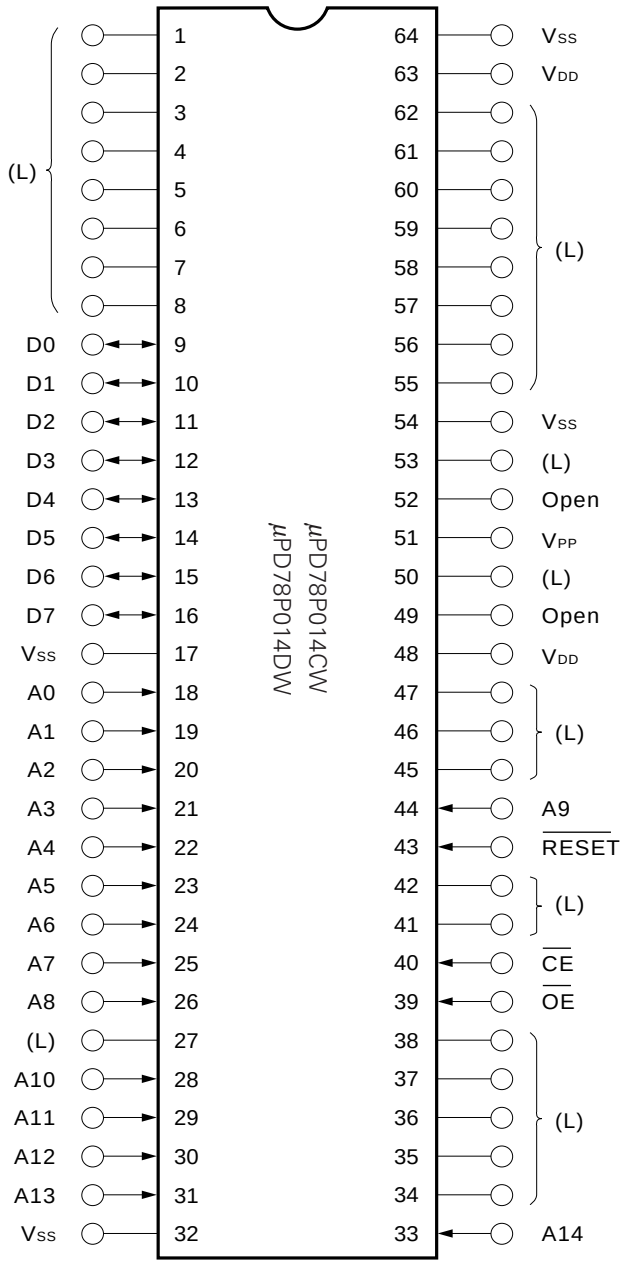
3. AV_{SS} pin should be connected to V_{SS}.

P00 to P04	:	Port 0
P10 to P17	:	Port 1
P20 to P27	:	Port 2
P30 to P37	:	Port 3
P40 to P47	:	Port 4
P50 to P57	:	Port 5
P60 to P67	:	Port 6
INTP0 to INTP3	:	Interrupt From Peripherals
TI0 to TI2	:	Timer Input
TO0 to TO2	:	Timer Output
SB0, SB1	:	Serial Bus
SI0, SI1	:	Serial Input
SO0, SO1	:	Serial Output
$\overline{SCK0}$, $\overline{SCK1}$	:	Serial Clock
PCL	:	Programmable Clock
BUZ	:	Buzzer Clock
STB	:	Strobe
BUSY	:	Busy

AD0 to AD7	:	Address/Data Bus
A8 to A15	:	Address Bus
$\overline{RD}$	:	Read Strobe
$\overline{WR}$	:	Write Strobe
$\overline{WAIT}$	:	Wait
ASTB	:	Address Strobe
X1, X2	:	Crystal (Main System Clock)
XT1, XT2	:	Crystal (Subsystem Clock)
$\overline{RESET}$	:	Reset
ANI0 to ANI7	:	Analog Input
AV_{DD}	:	Analog Power Supply
AV_{SS}	:	Analog Ground
AV_{REF}	:	Analog Reference Voltage
V_{DD}	:	Power Supply
V_{PP}	:	Programming Power Supply
V_{SS}	:	Ground

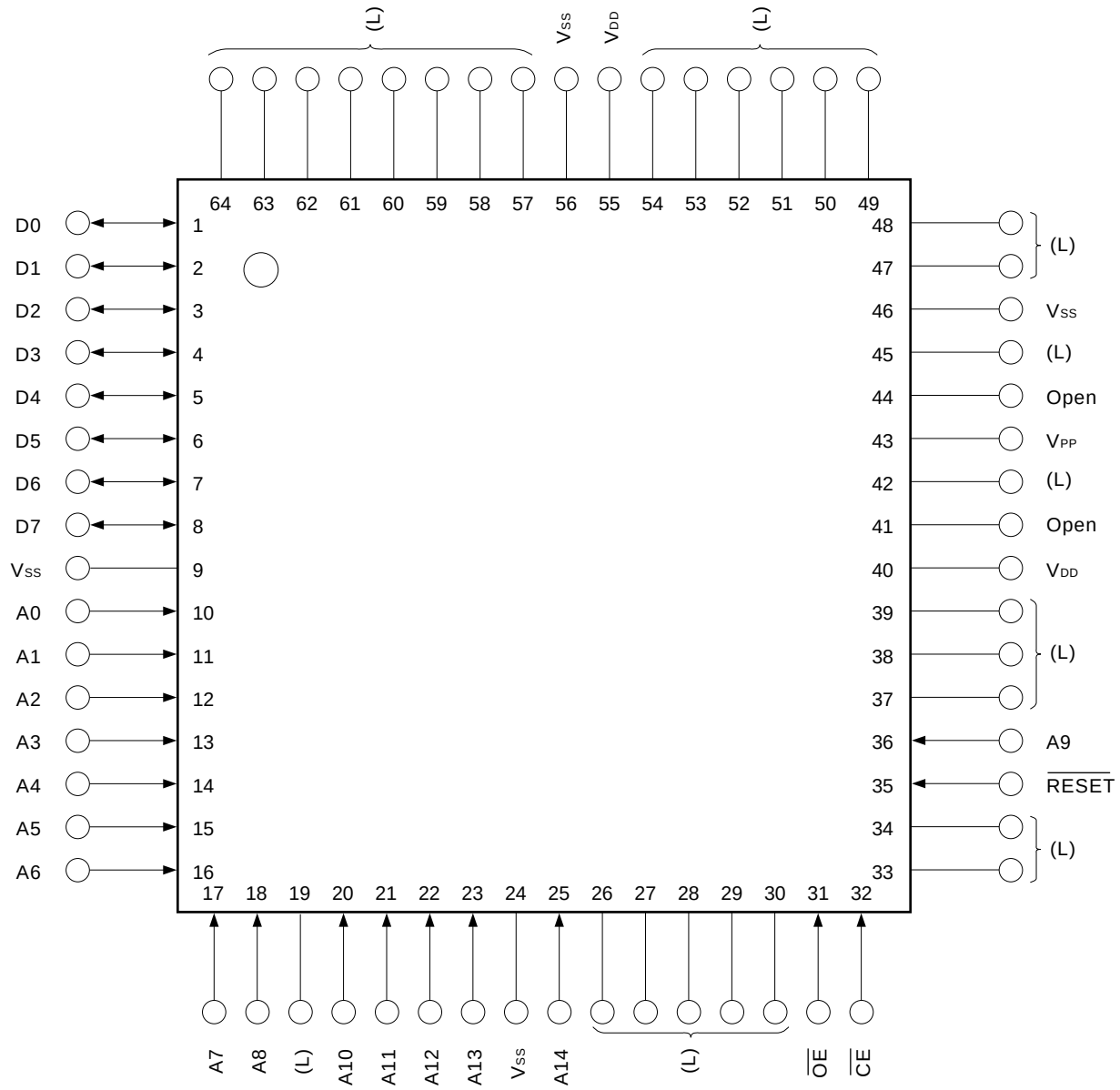
(2) PROM programming mode

64-pin plastic shrink DIP (750 mil)
64-pin ceramic shrink DIP (with window) (750 mil)



Cautions 1. (L) : Connect to VSS individually via a pull-down resistor.
2. VSS : Connect to ground.
3. RESET : Set to low level.
4. Open : Do not make any connection.

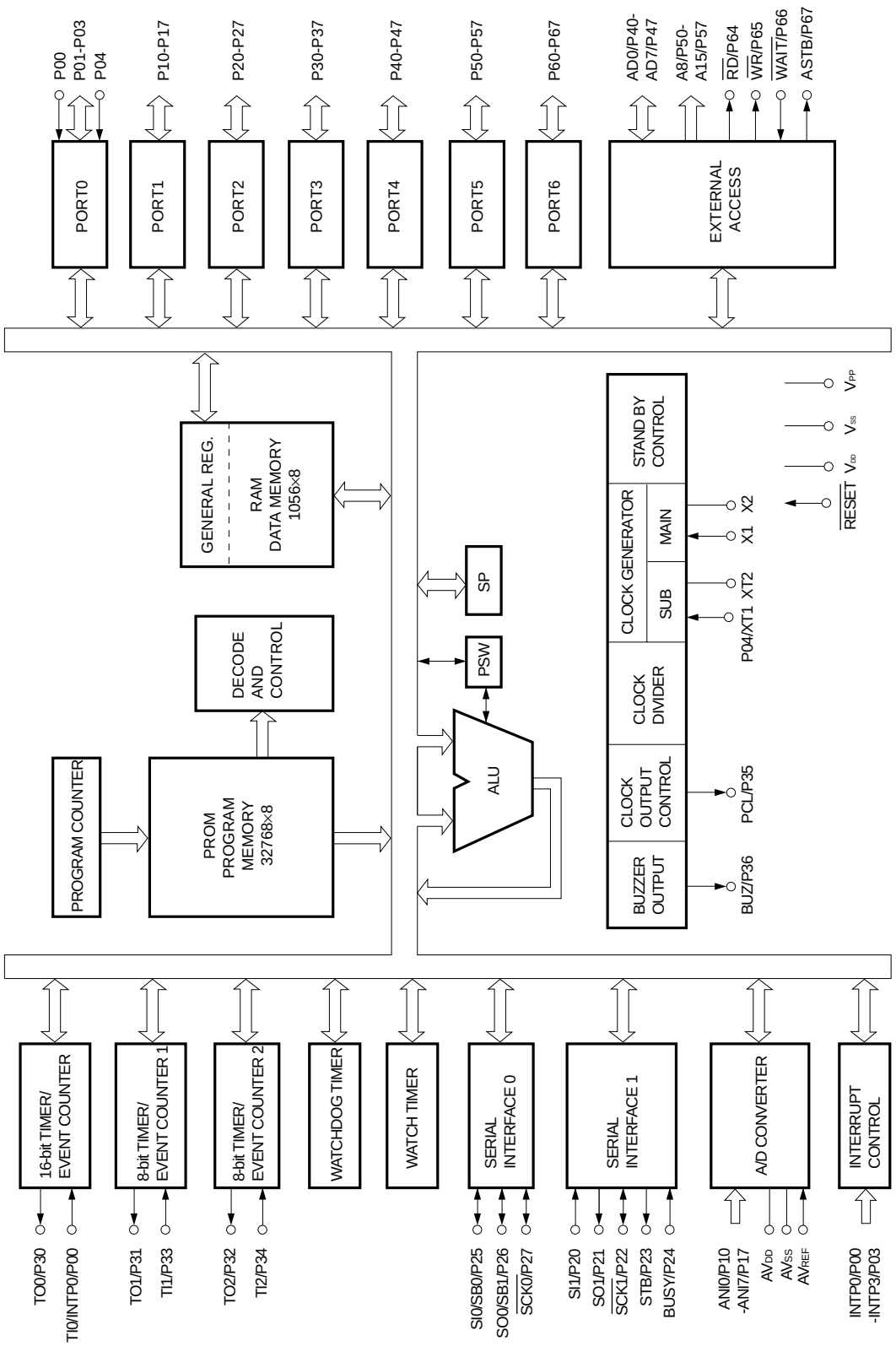
64-pin plastic QFP (14 × 14 mm)



Cautions 1. (L) : Connect to VSS individually with a pull-down resistor.
2. VSS : Connect to ground.
3. RESET : Set to low level.
4. Open : Do not make any connection.

A0 to A14	: Address Bus	RESET	: Reset
D0 to D7	: Data Bus	VDD	: Power Supply
CE	: Chip Enable	VPP	: Programming Power Supply
OE	: Output Enable	VSS	: Ground

BLOCK DIAGRAM



CONTENTS

1. DIFFERENCES BETWEEN μPD78P014 AND MASK ROM VERSION

The μPD78P014 incorporates one-time PROM which can be written to once only, or EPROM to which programs can be written, erased and rewritten.

By setting the internal memory size switching register, it is possible to make the functions of this device, except for the PROM specification and mask option for pins P60 to P63, identical to those of a mask ROM version.

The differences between μPD78P014 and mask ROM versions are shown in Table 1-1.

Table 1-1. Differences Between μPD78P014 and Mask ROM Version

Item	μPD78P014	Mask ROM Version
IC pin	No	Yes
V_{PP} pin	Yes	No
Mask option for pins P60 to P63	No mask option for incorporation of pull-up resistor	Pull-up resistor incorporation possible by means of mask option

Caution In the μPD78P014, the capacity of the internal PROM and internal high-speed RAM can be changed by using the internal memory size switching register.
$\overline{\text{RESET}}$ input sets internal PROM to 32K bytes and internal high-speed RAM to 1K bytes.

2. PIN FUNCTIONS

2.1 Normal Operating Mode Pins

(1) Port pins (1/2)

Pin Name	I/O	Function		After Reset	Alternate Function
P00	Input	Port 0 5-bit I/O port	Input only	Input	INTP0/TI0
P01	Input/ output		Input/output can be specified in 1-bit unit. When used as an input port, pull-up resistor can be used by software.	Input	INTP1
P02					INTP2
P03					INTP3
P04[Note 1]	Input		Input only	Input	XT1
P10 to P17	Input/ output	Port 1 8-bit input/output port. Input/output can be specified in 1-bit unit. When used as an input port, pull-up resistor can be used by software.[Note 2]		Input	ANI0 to ANI7
P20	Input/ output	Port 2 8-bit input/output port. Input/output can be specified in 1-bit unit. When used as an input port, pull-up resistor can be used by software.		Input	SI1
P21					SO1
P22					$\overline{SCK1}$
P23					STB
P24					BUSY
P25					SI0/SB0
P26					SO0/SB1
P27					$\overline{SCK0}$
P30	Input/ output	Port 3 8-bit input/output port. Input/output can be specified in 1-bit unit. When used as an input port, pull-up resistor can be used by software.		Input	TO0
P31					TO1
P32					TO2
P33					TI1
P34					TI2
P35					PCL
P36					BUZ
P37					–
P40 to P47	Input/ output	Port 4 8-bit input/output port. Input/output can be specified in 8-bit unit. When used as an input port, pull-up resistor can be used by software. (Test input flag (KRIF) is set to 1 by falling edge detection.)		Input	AD0 to AD7

Notes 1. When P04/XT1 pins are used as the input ports, set processor clock control register bit 6 (FRC) to 1. (Do not use the on-chip feedback resistor of the subsystem clock oscillation circuit.)

2. When P10/ANI0 to P17/ANI7 pins are used as the analog inputs for A/D converter, the pull-up resistor is automatically disabled.

(1) Port pins (2/2)

Pin Name	I/O	Function		After Reset	Alternate Function
P50 to P57	Input/ output	Port 5 8-bit input/output port. LED can be driven directly. Input/output can be specified in 1-bit unit. When used as an input port, pull-up resistor can be used by software.		Input	A8 to A15
P60	Input/ output	Port 6 8-bit input/output port. Input/output can be specified in 1-bit unit.	N-ch open-drain input/ output port. LED can be driven directly.	Input	—
P61					
P62					
P63					
P64			When used as an input port, pull-up resistor can be used by software.		$\overline{RD}$
P65					$\overline{WR}$
P66					$\overline{WAIT}$
P67					ASTB

(2) Non port pins (1/2)

Pin Name	I/O	Function	After Reset	Altrnate Function
INTP0	Input	External interrupt input with specifiable valid edge (rising edge, falling edge, or both rising and falling edges).	Input	P00/TI0
INTP1				P01
INTP2				P02
INTP3		Falling edge detection external interrupt input.		P03
SI0	Input	Serial interface serial data input.	Input	P25/SB0
SI1				P20
SO0	Output	Serial interface serial data output.	Input	P26/SB1
SO1				P21
SB0	Input/ output	Serial interface serial data input/output.	Input	P25/SI0
SB1				P26/SO0
$\overline{SCK0}$	Input/ output	Serial interface serial clock input/output.	Input	P27
$\overline{SCK1}$				P22
STB	Output	Serial interface automatic transmission/reception strobe output.	Input	P23
BUSY	Input	Serial interface automatic transmission/reception busy input.	Input	P24
TI0	Input	Input of external count clock to 16-bit timer (TM0).	Input	P00/INTP0
TI1		Input of external count clock to 8-bit timer (TM1).		P33
TI2		Input of external count clock to 8-bit timer (TM2).		P34
TO0	Output	16-bit timer (TM0) output (alternate function with 14-bit PWM output).	Input	P30
TO1		8-bit timer (TM1) output.		P31
TO2		8-bit timer (TM2) output.		P32
PCL	Output	Clock output (for trimming main system clock or subsystem clock).	Input	P35
BUZ	Output	Buzzer output.	Input	P36
AD0 to AD7	Input/ output	Low address/data bus when memory is expanded externally.	Input	P40 to P47
A8 to A15	Output	High address bus when memory is expanded externally.	Input	P50 to P57
$\overline{RD}$	Output	External memory read operation strobe signal output.	Input	P64
$\overline{WR}$		External memory write operation strobe signal output.		P65
$\overline{WAIT}$	Input	Wait insertion at external memory access.	Input	P66
ASTB	Output	Output of strobe which externally latches address information to be output to ports 4 and 5 when accessing external memory.	Input	P67

(2) Non port pins (2/2)

Pin Name	I/O	Function	After Reset	Alternate Function
ANI0 to ANI7	Input	A/D converter analog input.	Input	P10 to P17
AV_{REF}	Input	A/D converter reference voltage input.	—	—
AV_{DD}	—	A/D converter analog power supply. Connect to V_{DD}.	—	—
AV_{SS}	—	A/D converter ground potential. Connect to V_{SS}.	—	—
$\overline{RESET}$	Input	System reset input.	—	—
X1	Input	Main system clock oscillation crystal connection.	—	—
X2	—		—	—
XT1	Input	Subsystem clock oscillation crystal connection.	Input	P04
XT2	—		—	—
V_{DD}	—	Positive power supply.	—	—
V_{PP}	—	(High voltage application for program write/verify. Directly connected to V_{SS} in normal operating mode.)	—	—
V_{SS}	—	Ground potential	—	—

2.2 PROM Programming Mode Pins

Pin Name	I/O	Function
$\overline{RESET}$	Input	PROM programming mode setting. When +5 V or +12.5 V is applied to the V_{PP} pin and a low-level signal to the $\overline{RESET}$ pin, the PROM programming mode is set.
V_{PP}	Input	PROM programming mode setting and high voltage application for program write/verify.
A0 to A14	Input	Address bus.
D0 to D7	Input/ output	Data bus.
$\overline{CE}$	Input	PROM enable input/program pulse input.
$\overline{OE}$	Input	PROM read strobe input.
V_{DD}	—	Positive power supply.
V_{SS}	—	Ground potential.

2.3 Pin Input/Output Circuits and Connection of Unused Pins

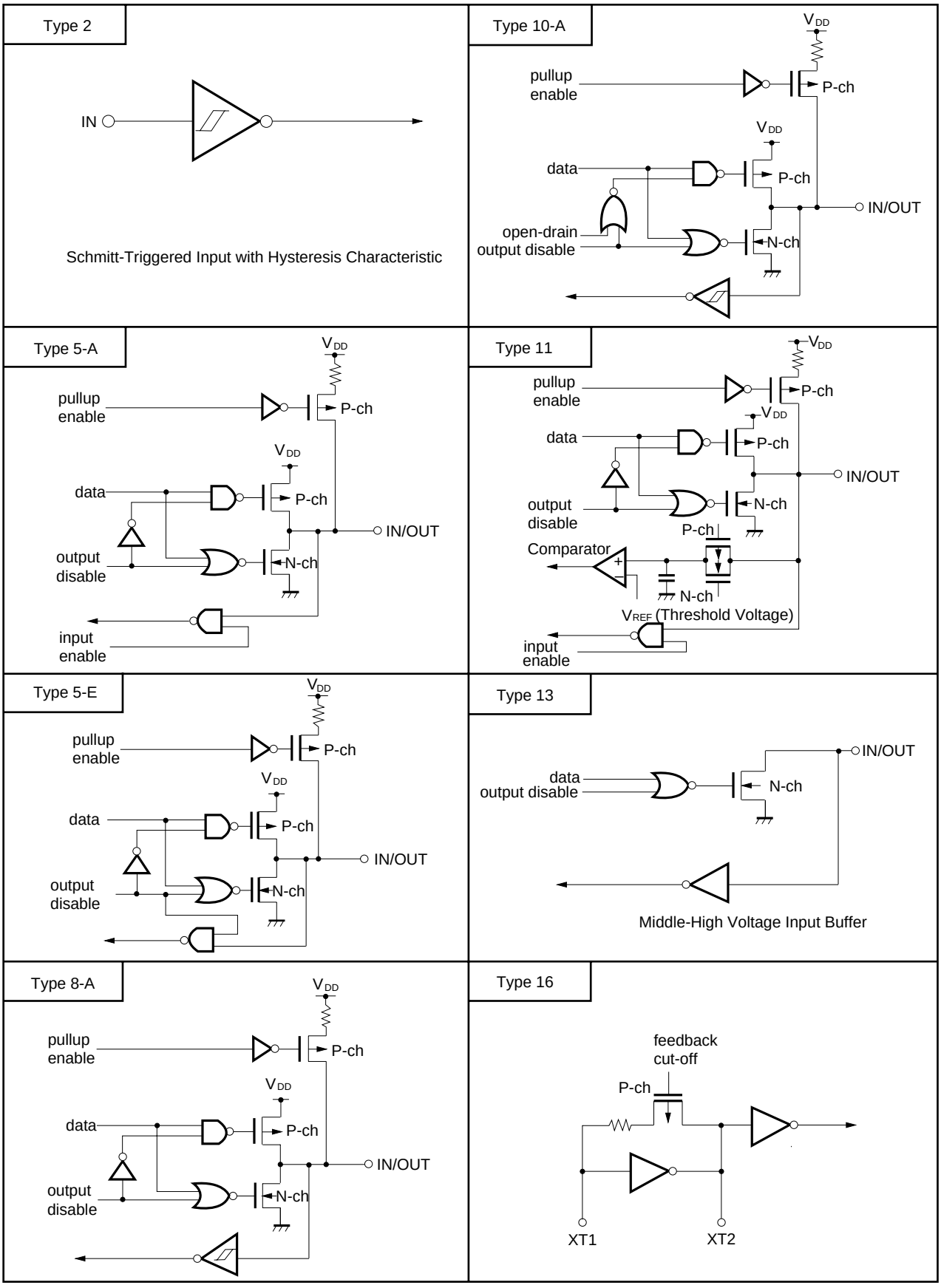
The input/output circuit type of each pin and the recommended connection of unused pins are shown in Table 2-1.

The configuration of each type of input/output circuit is shown in Figure 2-1.

Table 2-1. Type of Pin Input/Output Circuits

Pin Name	Input/Output Circuit Type	I/O	Recommended Connection for Used Pins
P00/INTP0/TI0	2	Input	Connect to V_{SS}.
P01/INTP1	8-A	Input/output	Input : Connect to V_{SS}. Output : Leave open.
P02/INTP2			
P03/INTP3			
P04/XT1	16	Input	Connected to V_{SS}.
P10/ANI0 to P17/ANI7	11	Input/output	Input : Connect to V_{DD} or V_{SS}. Output : Leave open.
P20/SI1	8-A	Input/output	Input : Connect to V_{DD} or V_{SS}. Output : Leave open.
P21/SO1	5-A		
P22/$\overline{SCK1}$	8-A		
P23/STB	5-A		
P24/BUSY	8-A		
P25/SI0/SB0	10-A		
P26/SO0/SB1			
P27/$\overline{SCK0}$			
P30/TO0	5-A	Input/output	Input : Connect to V_{DD} or V_{SS}. Output : Leave open.
P31/TO1			
P32/TO2			
P33/TI1	8-A		
P34/TI2			
P35/PCL	5-A		
P36/BUZ			
P37			
P40/AD0 to P47/AD7	5-E	Input/output	Input : Connect to V_{DD} or V_{SS}. Output : Leave open.
P50/A8 to P57/A15	5-A	Input/output	Input : Connect to V_{DD} or V_{SS}. Output : Leave open.
P60 to P63	13		
P64/$\overline{RD}$	5-A		
P65/$\overline{WR}$			
P66/$\overline{WAIT}$			
P67/ASTB			
$\overline{RESET}$	2	Input	—
XT2	16	—	Leave open.
AV_{REF}	—		Connect to V_{SS}.
AV_{DD}			Connect to V_{DD}.
AV_{SS}			Connect to V_{SS}.
V_{PP}			Directly connect to V_{SS}.

Figure 2-1. Pin Input/Output Circuits



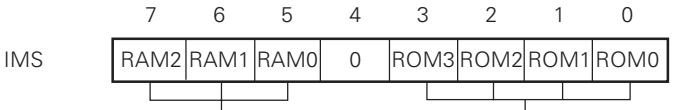
3. INTERNAL MEMORY SIZE SWITCHING REGISTER (IMS)

This register is used to prevent part of the internal memory from being used by software. Setting the internal memory size switching register (IMS) enables memory mapping identical to that of a mask ROM version with different internal memory (ROM and RAM) to be used.

The IMS register is set by an 8-bit memory manipulation instruction.

$\overline{\text{RESET}}$ input sets this register to C8H.

Figure 3-1. Internal Memory Size Switching Register Format



ROM3	ROM2	ROM1	ROM0	Internal ROM Capacity Selection
0	0	0	1	4 K bytes
0	0	1	0	8 K bytes
0	1	0	0	16 K bytes
0	1	1	0	24 K bytes
1	0	0	0	32K bytes
Other than above				Setting prohibited

RAM2	RAM1	RAM0	Internal High-Speed RAM Capacity Selection
0	0	0	768 bytes
0	0	1	640 bytes
0	1	0	512 bytes
0	1	1	384 bytes
1	0	0	256 bytes
1	0	1	Setting prohibited
1	1	0	1024 bytes
1	1	1	896 bytes

The IMS set values to make the memory map identical to various mask ROM versions are shown in Table 3-1.

Table 3-1. Examples of Internal Memory Size Switching Register Settings

Target Mask ROM Version	IMS Set Value	Target Mask ROM Version	IMS Set Value
μPD78001B	82H	μPD78012B	44H
μPD78002B	64H	μPD78013	C6H
μPD78011B	42H	μPD78014	C8H

4. PROM PROGRAMMING

The μPD78P014 incorporates a 32K-byte PROM as program memory. When programming the μPD78P014, the PROM programming mode is set by means of the V_{PP} and $\overline{RESET}$ pins. For the connection of unused pins, see **"PIN CONFIGURATION (2) PROM programming mode"**.

4.1 Operating Modes

When +5 V or +12.5 V is applied to the V_{PP} pin and a low-level signal is applied to the $\overline{RESET}$ pin, the μPD78P014 enters the programming mode. This is one of the operating modes shown in Table 4-1 below according to the setting of the $\overline{CE}$ and $\overline{OE}$ pins.

Also, the PROM contents can be read by setting the read mode.

Table 4-1. PROM Programming Operating Modes

Operating Mode \ Pins	$\overline{RESET}$	V_{PP}	V_{DD}	$\overline{CE}$	$\overline{OE}$	D0 to D7
Program write	L	+12.5 V	+6 V	L	H	Data input
Program verify				H	L	Data output
Program inhibit				H	H	High-impedance
Read		+5 V	+5 V	L	L	Data output
Output disable				L	H	High-impedance
Standby				H	L/H	High-impedance

4.2 PROM Write Procedure

The PROM write procedure is as shown below, allowing high-speed writing.

(1) Fix the $\overline{\text{RESET}}$ pin low. Supply +5 V to the V_{PP} pin. Unused pins are handled as shown in **"PIN CONFIGURATION (2) PROM programming mode"**.
(2) Supply +6 V to the V_{DD} pin and +12.5 V to the V_{PP} pin.
(3) Supply the initial address.
(4) Supply the write data.
(5) Supply a 1 ms program pulse (active low) to the $\overline{\text{CE}}$ pin.
(6) Verify mode. If written, go to (8); if not written, repeat (4) through (6). When the write operation has been repeated 25 times, go to (7).
(7) Halt write operation due to defective device.
(8) Supply write data and supply (times repeated in (4) through (6)) × 3 ms program pulse (additional write).
(9) Increment the address.
(10) Repeat (4) through (9) until the final address.

Timing for steps (2) through (8) above is shown in Figure 4-1.

Figure 4-1. PROM Write/Verify Timing

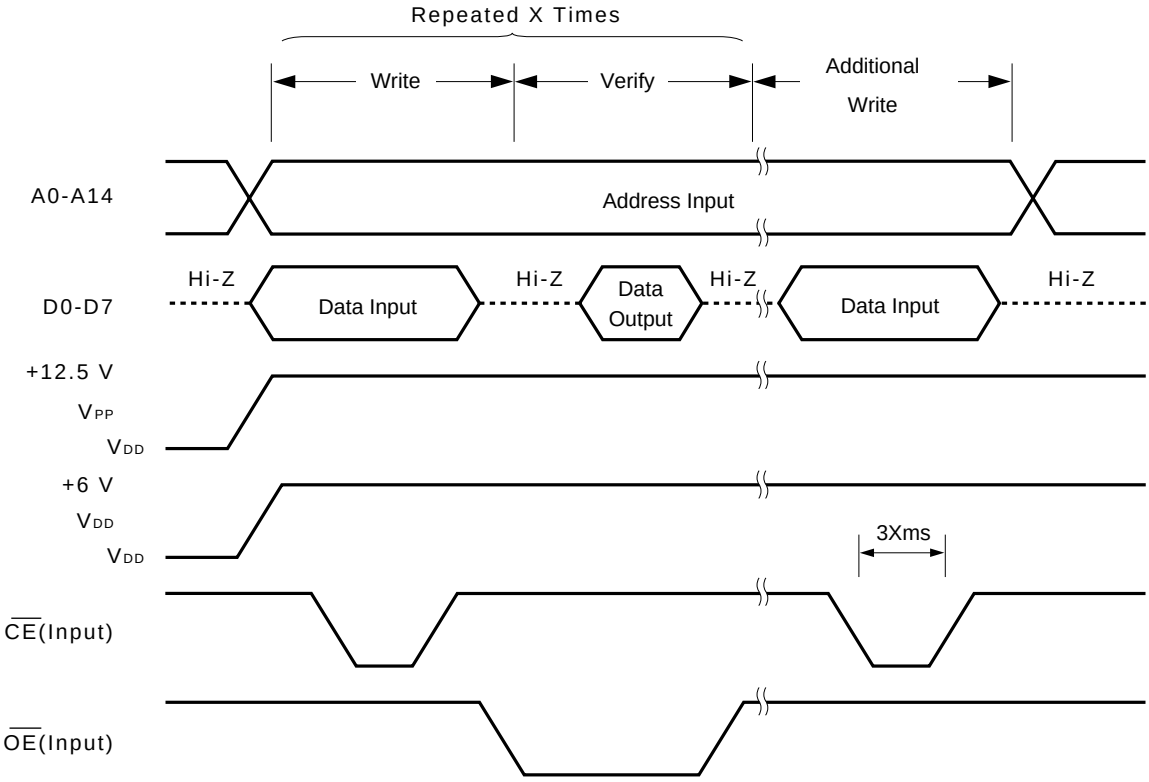
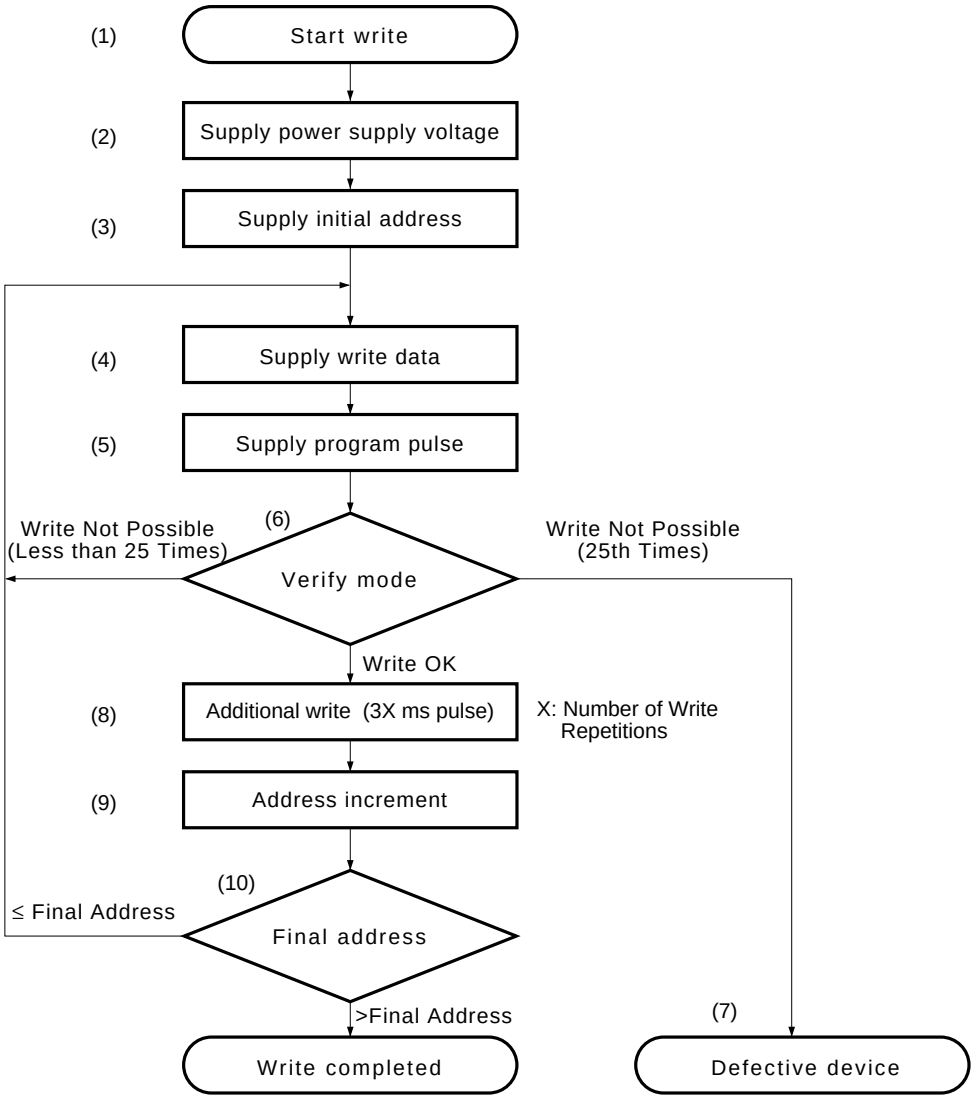


Figure 4-2. Write Procedure Flowchart



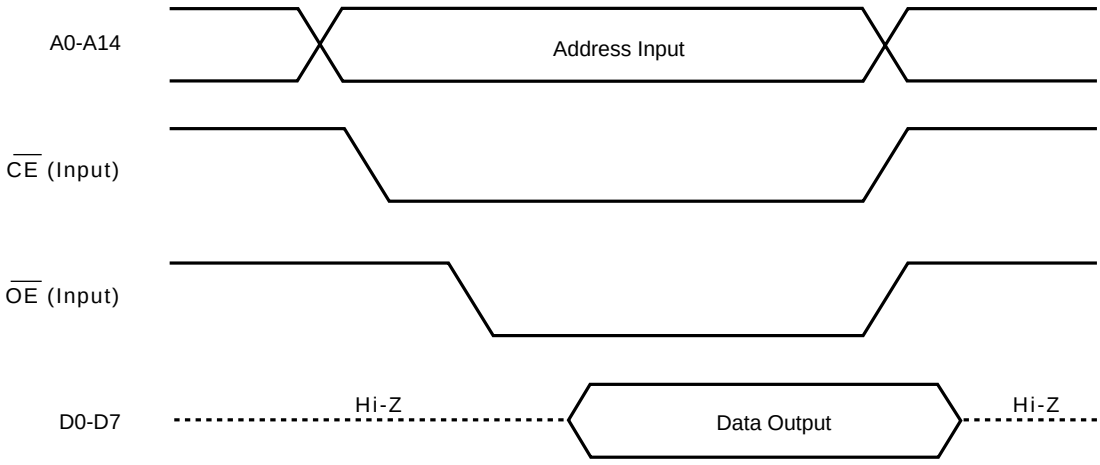
4.3 PROM Read Procedure

PROM contents can be read onto the external data bus (D0 to D7) using the following procedure.

(1) Fix the $\overline{\text{RESET}}$ pin low. Supply +5 V to the V_{PP} pin. Unused pins are handled as shown in **"PIN CONFIGURATION (2) PROM programming mode"**.
(2) Supply +5 V to the V_{DD} and V_{PP} pins.
(3) Input address of data to be read to pins A0 through A14.
(4) Read mode .
(5) Output data to pins D0 through D7.

Timing for steps (2) through (5) above is shown in Figure 4-3.

Figure 4-3. PROM Read Timing



5. ERASURE PROCEDURE (μPD78P014DW ONLY)

With the μPD78P014DW, it is possible to erase (set to FFH) data written to the program memory, and rewrite the memory.

The data can be erased by exposing the window to light with a wavelength of approximately 400 nm or less. Usually, exposure is performed with ultraviolet light with a wavelength of 254 nm. The amount of exposing required for complete erasure is shown below.

- UV intensity x erasure time: 15 W•s/cm^2 or more
- Erasure time: 15 to 20 minutes (using a 12,000 μW/cm^2 ultraviolet lamp. A longer erasure time may be required in case of deterioration of the ultraviolet lamp or dirt on the erasure window).

Erasure should be carried out with the ultraviolet lamp placed at a distance of 2.5 cm or less from the window. If the ultraviolet lamp is fitted with a filter, this should be removed before performing exposure.

6. OPAQUE FILM FOR ERASURE WINDOW (μPD78P014DW ONLY)

An opaque film should be applied to the erasure window except when erasing the EPROM contents, in order to prevent the EPROM contents from being unintentionally erased by light other than from the erasure lamp, and the internal circuits other than EPROM from misoperation due to light.

7. ONE-TIME PROM VERSION SCREENING

One-time PROM versions (μPD78P014CW and μPD78P014GC-AB8) cannot be fully tested and shipped by NEC for reasons related to their structure. It is recommended that after writing the necessary data and storing at high temperature under the following conditions, screening should be conducted to verify the PROM.

Storage Temperature	Storage Time
125 °C	24 hours

NEC provides charged services for one-time PROM writing, marking, screening, and verification, under the name "QTOP Microcomputer". Contact NEC for details. ★

8. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_a = 25 °C)

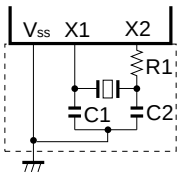
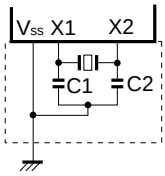
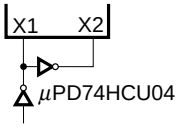
Parameter	Symbol	Test Conditions		Ratings	Unit
Supply voltage	V_{DD}			–0.3 to +7.0	V
				–0.3 to +13.5	V
	V_{PP}			–0.3 to V_{DD} + 0.3	V
	AV_{DD}			–0.3 to V_{DD} + 0.3	V
	AV_{REF}			–0.3 to + 0.3	V
Input voltage	AV_{SS}	P00 to P04, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67, X1, X2, XT2		–0.3 to V_{DD} + 0.3	V
	V_{I1}				
		P60 to P63	Open-drain	–0.3 to +16	V
	V_{I2}	A9	PROM programming mode	–0.3 to +13.5	V
Output voltage	V_{I3}			–0.3 to V_{DD} + 0.3	V
Analog input voltage	V_O	P10 to P17	Analog input pins	AV_{SS} – 0.3 to AV_{REF} + 0.3	V
Output current high	V_{AN}	1 pin		–10	mA
		Total for P10 to P17, P20 to P27, P30 to P37		–15	mA
	I_{OH}	Total for P01 to P03, P40 to P47, P50 to P57, P60 to P67		–15	mA
Output current low	I_{OL} Note	1 pin	Peak value	30	mA
			R.m.s. value	15	mA
		Total for P40 to P47, P50 to P55	Peak value	100	mA
			R.m.s. value	70	mA
		Total for P01 to P03, P56, P57, P60 to P67	Peak value	100	mA
			R.m.s. value	70	mA
		Total for P01 to P03, P64 to P67	Peak value	50	mA
			R.m.s. value	20	mA
		Total for P10 to P17, P20 to P27, P30 to P37	Peak value	50	mA
			R.m.s. value	20	mA
Operating temperature	T_{opt}			–40 to +85	°C
Storage temperature	T_{stg}			–65 to +150	°C

Note The r.m.s. value should be calculated as follows: [R.m.s. value] = [Peak value] x $\sqrt{\text{Duty}}$

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

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

Main System Clock Oscillator Characteristics (T_a = –40 to +85 °C, V_{DD} = 2.7 to 6.0 V)

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillation frequency (f_X)Note 1	V_{DD} = Oscillation voltage range	1		10	MHz
		Oscillation stabilization timeNote 2	After V_{DD} has reached MIN. of oscillation voltage range			4	ms
Crystal resonator		Oscillation frequency (f_X)Note 1		1	8.38	10	MHz
		Oscillation stabilization timeNote 2	V_{DD} = 4.5 to 6.0 V			10	ms
						30	
External clock		X1 input frequency (f_X)Note 1		1.0		10.0	MHz
		X1 input high-/low-level width (t_{XH}/t_{XL})		42.5		500	ns

Notes 1. Only the oscillator characteristics are shown. Refer to AC characteristics for instruction execution times.

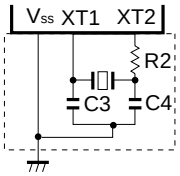
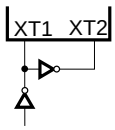
2. This is the time required for oscillation to stabilize after a reset or STOP mode release.

Cautions 1. When the main system clock oscillator is used, the following should be noted concerning wiring in the area in the figure enclosed by a dotted line to prevent the influence of wiring capacitance, etc.

- **The wiring should be kept as short as possible.**
- **No other signal lines should be crossed.**
- **Keep away from lines carrying a high fluctuating current.**
- **The oscillator capacitor grounding point should always be at the same potential as V_{SS}.**
- **Do not connect to a ground pattern carrying a high current.**
- **A signal should not be taken from the oscillator.**

2. When the main system clock is stopped and the device is operating on the subsystem clock, wait until the oscillation stabilization time has been secured by the program before switching back to the main system clock.

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

Resonator	Recommended Circuit	Parameter	Test Conditions	MIN.	TYP.	MAX.	Unit
Crystal resonator		Oscillation frequency (f_{XT})[Note 1]		32	32.768	35	kHz
		Oscillation stabilization time[Note 2]	V_{DD} = 4.5 to 6.0 V		1.2	2	s
						10	
External clock		XT1 input frequency (f_{XT})[Note 1]		32		100	kHz
		XT1 input high-/low-level width (t_{XTH}/t_{XTL})		5		15	μs

Notes 1. Only the oscillator characteristics are shown. Refer to AC characteristics for instruction execution times.

2. Time required to stabilize oscillation after V_{DD} reaches MIN. of oscillation voltage range.

Cautions 1. When the subsystem clock oscillator is used, the following should be noted concerning wiring in the area in the figure enclosed by a dotted line to prevent the influence of wiring capacitance, etc.

- **The wiring should be kept as short as possible.**
- **No other signal lines should be crossed.**
- **Keep away from lines carrying a high fluctuating current.**
- **The oscillator capacitor grounding point should always be at the same potential as V_{SS}.**
- **Do not connect to a ground pattern carrying a high current.**
- **A signal should not be taken from the oscillator.**

2. The subsystem clock oscillator is a circuit with a low amplification level, more prone to misoperation due to noise than the main system clock. When using the subsystem clock, special care is needed regarding the wiring method.

Recommended Oscillation Constants

Main System Clock: Ceramic Resonator (T_a = –40 to +85 °C)

Manufacturer	Product Name	Frequency (MHz)	Recommended Oscillator Constant Range			Oscillation Voltage	
			C1 (pF)	C2 (pF)	R1 (kΩ)	MIN. (V)	MAX. (V)
Murata Mfg.	CSB1000J	1.00	100	100	6.8	2.8	6.0
	CSB××××J	1.01 to 1.25	100	100	4.7	2.8	6.0
	CSA×. ×××MK	1.26 to 1.79	100	100	0	2.8	6.0
	CSA×. ××MG093	1.80 to 2.44	100	100	0	2.7	6.0
	CST×. ××MG093		Incorporated	Incorporated	0	2.7	6.0
	CSA×. ××MG	2.45 to 4.18	30	30	0	2.7	6.0
	CST×. ××MGW		Incorporated	Incorporated	0	2.7	6.0
	CSA×. ××MGU	4.19 to 6.00	30	30	0	2.7	6.0
	CST×. ××MGWU		Incorporated	Incorporated	0	2.7	6.0
	CSA×. ××MT	6.01 to 10.0	30	30	0	3.0	6.0
	CST×. ××MTW		Incorporated	Incorporated	0	3.0	6.0

Remark ×. ××, ×. ××× and ×××× indicate frequency.

Subsystem Clock: Crystal Resonator (T_a = –40 to +60 °C)

Manufacturer	Product Name	Frequency (kHz)	Recommended Oscillator Constant Range			Oscillation Voltage	
			C3 (pF)	C4 (pF)	R2 (kΩ)	MIN. (V)	MAX. (V)
Daishinku Corp.	DT-38 (1TA632E00, load capacitance 6.3 pF)	32.768	10	10	100	2.7	6.0

Capacitance (T_a = 25 °C, V_{DD} = V_{SS} = 0 V)

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input capacitance	C_{IN}	f = 1 MHz Unmeasured pins returned to 0 V				15	pF
Input/output capacitance	C_{IO}	f = 1 MHz Unmeasured pins returned to 0 V	P01 to P03, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67			15	pF
			P60 to P63			20	pF

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Input voltage high	V_{IH1}	P10 to P17, P21, P23, P30 to P32, P35 to P37, P40 to P47, P50 to P57, P64 to P67		0.7 V_{DD}		V_{DD}	V
	V_{IH2}	P00 to P03, P20, P22, P24 to P27, P33, P34, $\overline{\text{RESET}}$		0.8 V_{DD}		V_{DD}	V
	V_{IH3}	P60 to P63	Open-drain	0.7 V_{DD}		15	V
	V_{IH4}	X1, X2		V_{DD} – 0.5		V_{DD}	V
	V_{IH5}	XT1/P04, XT2	V_{DD} = 4.5 to 6.0 V	V_{DD} – 0.5		V_{DD}	V
				V_{DD} – 0.3		V_{DD}	V
Input voltage low	V_{IL1}	P10 to P17, P21, P23, P30 to P32, P35 to P37, P40 to P47, P50 to P57, P64 to P67		0		0.3 V_{DD}	V
	V_{IL2}	P00 to P03, P20, P22, P24 to P27, P33, P34, $\overline{\text{RESET}}$		0		0.2 V_{DD}	V
	V_{IL3}	P60 to P63	V_{DD} = 4.5 to 6.0 V	0		0.3 V_{DD}	V
				0		0.2 V_{DD}	V
	V_{IL4}	X1, X2		0		0.4	V
	V_{IL5}	XT1/P04, XT2	V_{DD} = 4.5 to 6.0 V	0		0.4	V
				0		0.3	V
Output voltage high	V_{OH1}	V_{DD} = 4.5 to 6.0 V, I_{OH} = –1 mA		V_{DD} – 1.0			V
		I_{OH} = –100 μA		V_{DD} – 0.5			V
Output voltage low	V_{OL1}	P50 to P57, P60 to P63	V_{DD} = 4.5 to 6.0 V, I_{OL} = 15 mA		0.4	2.0	V
		P01 to P03, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P64 to P67	V_{DD} = 4.5 to 6.0 V, I_{OL} = 1.6 mA			0.4	V
	V_{OL2}	SB0, SB1, $\overline{\text{SCK0}}$	V_{DD} = 4.5 to 6.0 V, open-drain, pulled high (R = 1 kΩ)			0.2 V_{DD}	V
	V_{OL3}	I_{OL} = 400 μA				0.5	V
Input leakage current high	I_{LIH1}	V_{IN} = V_{DD}	P00 to P03, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P60 to P67, $\overline{\text{RESET}}$			3	μA
	I_{LIH2}		X1, X2, XT1/P04, XT2			20	μA
	I_{LIH3}	V_{IN} = 15 V	P60 to P63			80	μA
Input leakage current low	I_{LIL1}	V_{IN} = 0 V	P00 to P03, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P60 to P67, $\overline{\text{RESET}}$			–3	μA
	I_{LIL2}		X1, X2, XT1/P04, XT2			–20	μA

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Output leakage current high	I_{LOH1}	V_{OUT} = V_{DD}				3	μA
Output leakage current low	I_{LOL}	V_{OUT} = 0 V				–3	μA
Software pull-up resistor	R_2	V_{IN} = 0 V, P01 to P03, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P57, P64 to P67	4.5 V ≤ V_{DD} ≤ 6.0 V	15	40	90	kΩ
			2.7 V ≤ V_{DD} < 4.5 V	20		500	kΩ
Supply current[Note 3]	I_{DD1}	8.38 MHz crystal oscillation operating mode	V_{DD} = 5.0 V ± 10%[Note 1]		9	27	mA
			V_{DD} = 3.0 V ± 10%[Note 2]		1	3	mA
	I_{DD2}	8.38 MHz crystal oscillation HALT mode	V_{DD} = 5.0 V ± 10%		1.4	4.2	mA
			V_{DD} = 3.0 V ± 10%		550	1650	μA
	I_{DD3}	32.768 kHz crystal oscillation operating mode	V_{DD} = 5.0 V ± 10%		90	180	μA
			V_{DD} = 3.0 V ± 10%		50	100	μA
	I_{DD4}	32.768 kHz crystal oscillation HALT mode	V_{DD} = 5.0 V ± 10%		25	50	μA
			V_{DD} = 3.0 V ± 10%		5	10	μA
	I_{DD5}	XT1 = 0 V STOP mode Feedback resistor used	V_{DD} = 5.0 V ± 10%		1	30	μA
			V_{DD} = 3.0 V ± 10%		0.5	10	μA
	I_{DD6}	XT1 = 0 V STOP mode Feedback resistor not used	V_{DD} = 5.0 V ± 10%		0.1	30	μA
			V_{DD} = 3.0 V ± 10%		0.05	10	μA

Notes 1. High-speed mode operation (when processor clock control register is set to 00H).

2. Low-speed mode operation (when processor clock control register is set to 04H).

3. Not including AV_{REF} currents or port currents

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

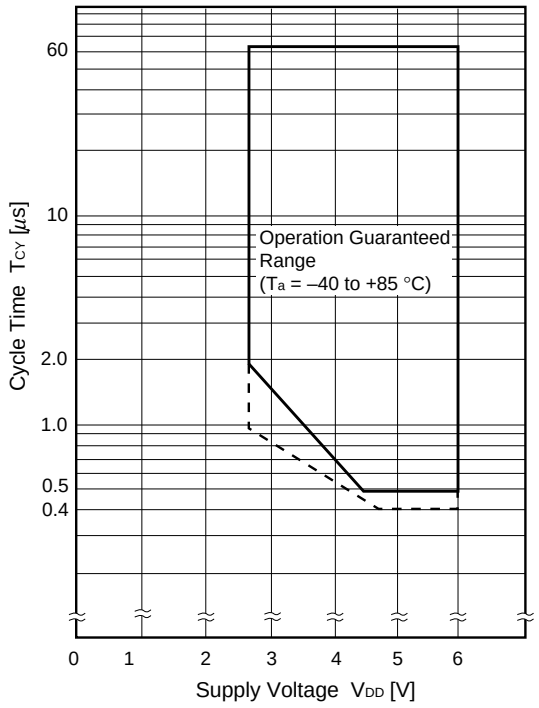
AC Characteristics

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
Cycle time (Min. instruction execution time)	T_{CY}	Operating with main system clock	V_{DD} = 4.5 to 6.0 V	0.48		64	μs
				1.91		64	μs
			T_a = –40 to +40 °C V_{DD} = 4.75 to 6.0 V	0.4		64	μs
			T_a = –40 to +40 °C	0.96		64	μs
		Operating with subsystem clock		40	122	125	μs
TI input frequency	f_{TI}	V_{DD} = 4.5 to 6.0 V		0		4	MHz
				0		275	kHz
TI input high-/low-level width	t_{TIH}	V_{DD} = 4.5 to 6.0 V		100			ns
	t_{TIL}			1.8			μs
Interrupt input high-/low-level width	t_{INTH}	INTP0		$8/f_{sam}$ Note			μs
	t_{INTL}	INTP1 to INTP3		10			μs
		KR0 to KR7		10			μs
$\overline{RESET}$ low-level width	t_{RSL}			10			μs

Note In combination with bits 0 (SCS0) and 1 (SCS1) of sampling clock select register, selection of f_{sam} is possible between $f_X/2^{N+1}$, $f_X/64$, and $f_X/128$ (N = 0 to 4).

T_{CY} vs V_{DD} (At main system clock operation)



Caution When T_a = –40 to +40 °C, the operation guaranteed range is extended to the dotted line.

(2) Read/write operation (T_a = –40 to +85 °C, V_{DD} = 2.7 to 6.0 V)

Parameter	Symbol	Test Conditions	MIN.	MAX.	Unit
ASTB high-level width	t_{ASTH}		$0.5t_{CY}$		ns
Address setup time	t_{ADS}		$0.5t_{CY}$ – 30		ns
Address hold time	t_{ADH}	Load resistance ≥ 5 kΩ	10		ns
Data input time from address	t_{ADD1}			$(2 + 2n)t_{CY}$ – 50	ns
	t_{ADD2}		5	$(3 + 2n)t_{CY}$ – 100	ns
Data input time from $\overline{RD}\downarrow$	t_{RDD1}			$(1 + 2n)t_{CY}$ – 25	ns
	t_{RDD2}			$(2.5 + 2n)t_{CY}$ – 100	ns
Read data hold time	t_{RDH}		0		ns
$\overline{RD}$ low-level width	t_{RDL1}		$(1.5 + 2n)t_{CY}$ – 20		ns
	t_{RDL2}		$(2.5 + 2n)t_{CY}$ – 20		ns
$\overline{WAIT}\downarrow$ input time from $\overline{RD}\downarrow$	t_{RDWT1}			$0.5t_{CY}$	ns
	t_{RDWT2}			$1.5t_{CY}$	ns
$\overline{WAIT}\downarrow$ input time from $\overline{WR}\downarrow$	t_{WRWT}			$0.5t_{CY}$	ns
$\overline{WAIT}$ low-level width	t_{WTL}		$(0.5 + 2n)t_{CY}$ + 10	$(2 + 2n)t_{CY}$	ns
Write data setup time	t_{WDS}		100		ns
Write data hold time	t_{WDH}		5		ns
$\overline{WR}$ low-level width	t_{WRL1}		$(2.5 + 2n)t_{CY}$ – 20		ns
$\overline{RD}\downarrow$ delay time from ASTB↓	t_{ASTRD}		$0.5t_{CY}$ – 30		ns
$\overline{WR}\downarrow$ delay time from ASTB↓	t_{ASTWR}		$1.5t_{CY}$ – 30		ns
ASTB↑ delay time from $\overline{RD}\uparrow$ in external fetch	t_{RDAST}		t_{CY} – 10	t_{CY} + 40	ns
Address hold time from $\overline{RD}\uparrow$ in external fetch	t_{RDADH}		t_{CY}	t_{CY} + 50	ns
Write data output time from $\overline{RD}\uparrow$	t_{RDWD}		10		ns
$\overline{WR}\downarrow$ delay time from write data	t_{WDWR}	V_{DD} = 4.5 to 6.0 V	$0.5t_{CY}$ – 120	$0.5t_{CY}$	ns
			$0.5t_{CY}$ – 170	$0.5t_{CY}$	ns
Address hold time from $\overline{WR}\uparrow$	t_{WRADH}	V_{DD} =4.5 to 6.0 V	t_{CY}	t_{CY} + 60	ns
			t_{CY}	t_{CY} + 100	ns
$\overline{RD}\uparrow$ delay time from $\overline{WAIT}\uparrow$	t_{WTRD}		$0.5t_{CY}$	$2.5t_{CY}$ + 80	ns
$\overline{WR}\uparrow$ delay time from $\overline{WAIT}\uparrow$	t_{WTWR}		$0.5t_{CY}$	$2.5t_{CY}$ + 80	ns

Remarks 1. $t_{CY} = T_{CY}/4$

2. n indicates number of waits.

3. C_L = 100 pF (C_L indicates the load capacitance of pins P40/AD0 to P47/AD7, P50/A8 to P57/A15, P64/$\overline{RD}$, P65/$\overline{WR}$, P66/$\overline{WAIT}$, P67/ASTB.)

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK}$ cycle time	t_{KCY1}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high-/low-level width	t_{KH1}	V_{DD} = 4.5 to 6.0 V		$t_{KCY1}/2 - 50$			ns
	t_{KL1}			$t_{KCY1}/2 - 150$			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK1}			100			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI1}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO1}	C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V			300	ns
						1000	ns

Note C is the load capacitance of SO output line.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK}$ cycle time	t_{KCY2}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high-/low-level width	t_{KH2}	V_{DD} = 4.5 to 6.0 V		400			ns
	t_{KL2}			1600			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK2}			100			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI2}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO2}	C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V			300	ns
						1000	ns
★ $\overline{SCK}$ rise and fall times (For serial interface channel 0)	t_{R2} t_{F2}	When using the external device expansion function				160	ns
★		When not using the external device expansion function	When using the 16-bit timer output function			700	ns
★			When not using the 16-bit timer output function			1000	ns
★ $\overline{SCK}$ rise and fall times (For serial interface channel 1)	t_{R2} t_{F2}	When using the external device expansion function				160	ns
★		When not using the external device expansion function				1000	ns

Note C is the load capacitance of SO output line.

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

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

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

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

	Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
	$\overline{SCK}$ cycle time	t_{KCY4}	V_{DD} = 4.5 to 6.0 V		800			ns
					3200			ns
	$\overline{SCK}$ high-/low-level width	t_{KH4}	V_{DD} = 4.5 to 6.0 V		400			ns
		t_{KL4}			1600			ns
	SB0, SB1 setup time (to $\overline{SCK}\uparrow$)	t_{SIK4}	V_{DD} = 4.5 to 6.0 V		100			ns
					300			ns
	SB0, SB1 hold time (from $\overline{SCK}\uparrow$)	t_{KSI4}			$t_{KCY4}/2$			ns
	SB0, SB1 output delay time from $\overline{SCK}\downarrow$	t_{KSO4}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		300	ns
					0		1000	ns
	SB0, SB1$\downarrow$ from $\overline{SCK}\uparrow$	t_{KSB}			t_{KCY4}			ns
	$\overline{SCK}\downarrow$ from SB0, SB1$\downarrow$	t_{SBK}			t_{KCY4}			ns
	SB0, SB1 high-level width	t_{SBH}			t_{KCY4}			ns
	SB0, SB1 low-level width	t_{SBL}			t_{KCY4}			ns
★	$\overline{SCK}$ rise and fall times	t_{R4} t_{F4}	When using the external device expansion function				160	ns
★			When not using the external device expansion function	When using the 16-bit timer output function			700	ns
★				When not using the 16-bit timer output function			1000	ns

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK}$ cycle time	t_{KCY5}	V_{DD} = 4.5 to 6.0 V		1600			ns
				3800			ns
$\overline{SCK}$ high-level width	t_{KH5}	R = 1 kΩ, C = 100 pF[Note]		$t_{KCY5}/2 - 50$			ns
$\overline{SCK}$ low-level width	t_{KL5}			$t_{KCY5}/2 - 50$			ns
SB0, SB1 setup time (to $\overline{SCK}\uparrow$)	t_{SIK5}			300			ns
SB0, SB1 hold time (from $\overline{SCK}\uparrow$)	t_{KSI5}			600			ns
SB0, SB1 output delay time from $\overline{SCK}\downarrow$	t_{KSO5}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		250	ns
				0		1000	ns

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit	
$\overline{SCK}$ cycle time	t_{KCY6}	V_{DD} = 4.5 to 6.0 V		1600			ns	
				3800			ns	
$\overline{SCK}$ high-level width	t_{KH6}			650			ns	
$\overline{SCK}$ low-level width	t_{KL6}			800			ns	
SB0, SB1 setup time (to $\overline{SCK}\uparrow$)	t_{SIK6}			100			ns	
SB0, SB1 hold time (from $\overline{SCK}\uparrow$)	t_{KSI6}			$t_{KCY6}/2$			ns	
SB0, SB1 output delay time from $\overline{SCK}\downarrow$	t_{KSO6}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V	0		300	ns	
				0		1000	ns	
$\overline{SCK}$ rise and fall times	t_{R6} t_{F6}	When using the external device expansion function				160	ns	★
		When not using the external device expansion function	When using the 16-bit timer output function			700	ns	★
			When not using the 16-bit timer output function			1000	ns	★

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

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK}$ cycle time	t_{KCY7}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high/low-level width	t_{KH7}	V_{DD} = 4.5 to 6.0 V		$t_{KCY7}/2 - 50$			ns
	t_{KL7}			$t_{KCY7}/2 - 150$			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK7}			100			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI7}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO7}	C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V			300	ns
						1000	ns
STB$\uparrow$ from $\overline{SCK}\uparrow$	t_{SBD}			400		t_{KCY7}	ns
Strobe signal high-level width	t_{SBW}			$t_{KCY7} - 30$		$t_{KCY7} + 30$	ns
Busy signal setup time (to busy signal detection timing)	t_{BYS}			100			ns
Busy signal hold time (from busy signal detection timing)	t_{BYH}			100			ns
$\overline{SCK}\downarrow$ from busy inactive	t_{SPS}					$2t_{KCY7}$	ns

Note C is the load capacitance of the SO output line.

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

Parameter	Symbol	Test Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK}$ cycle time	t_{KCY8}	V_{DD} = 4.5 to 6.0 V		800			ns
				3200			ns
$\overline{SCK}$ high/low-level width	t_{KH8}	V_{DD} = 4.5 to 6.0 V		400			ns
	t_{KL8}			1600			ns
SI setup time (to $\overline{SCK}\uparrow$)	t_{SIK8}			100			ns
SI hold time (from $\overline{SCK}\uparrow$)	t_{KSI8}			400			ns
SO output delay time from $\overline{SCK}\downarrow$	t_{KSO8}	C = 100 pF[Note]	V_{DD} = 4.5 to 6.0 V			300	ns
						1000	ns
★ $\overline{SCK}$ rise and fall times	t_{R8}, t_{F8}	When using the external device expansion function				160	ns
★		When not using the external device expansion function				1000	ns

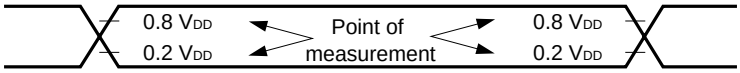
Note C is the load capacitance of the SO output line.

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

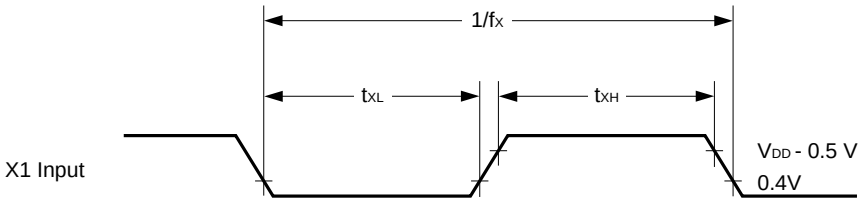
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Resolution			8	8	8	bit
Overall error[Note]					0.6	%
Conversion time	t_{CONV}		19.1		200	μs
Sampling time	t_{SAMP}		24/f_x			μs
Analog input voltage	V_{IAN}		AV_{SS}		AV_{REF}	V
Reference voltage	AV_{REF}		2.7		AV_{DD}	V
AV_{REF} current	I_{REF}			0.5	1.5	mA

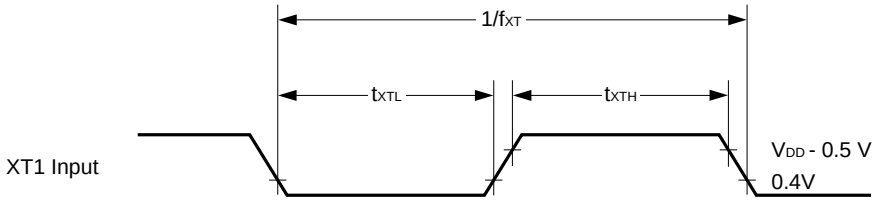
Note Excluding quantization error (±1/2LSB). Shown as a percentage of the full scale value.

AC Timing Test Point (Excluding X1 and XT1 Input)

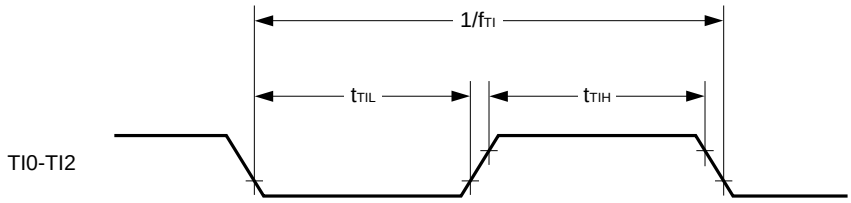


Clock Timing



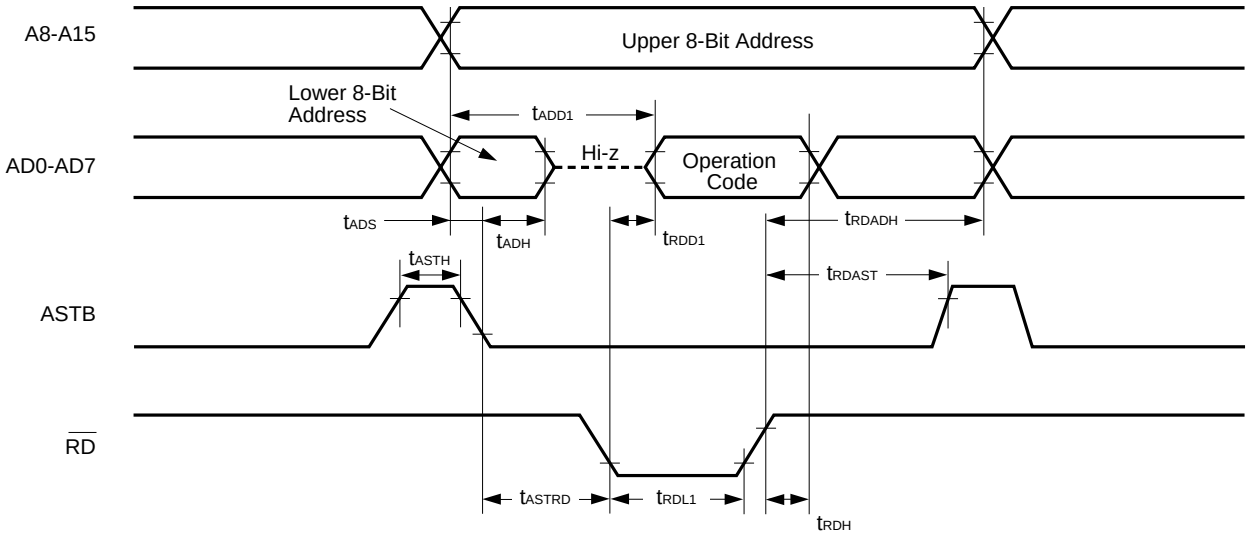


TI Timing

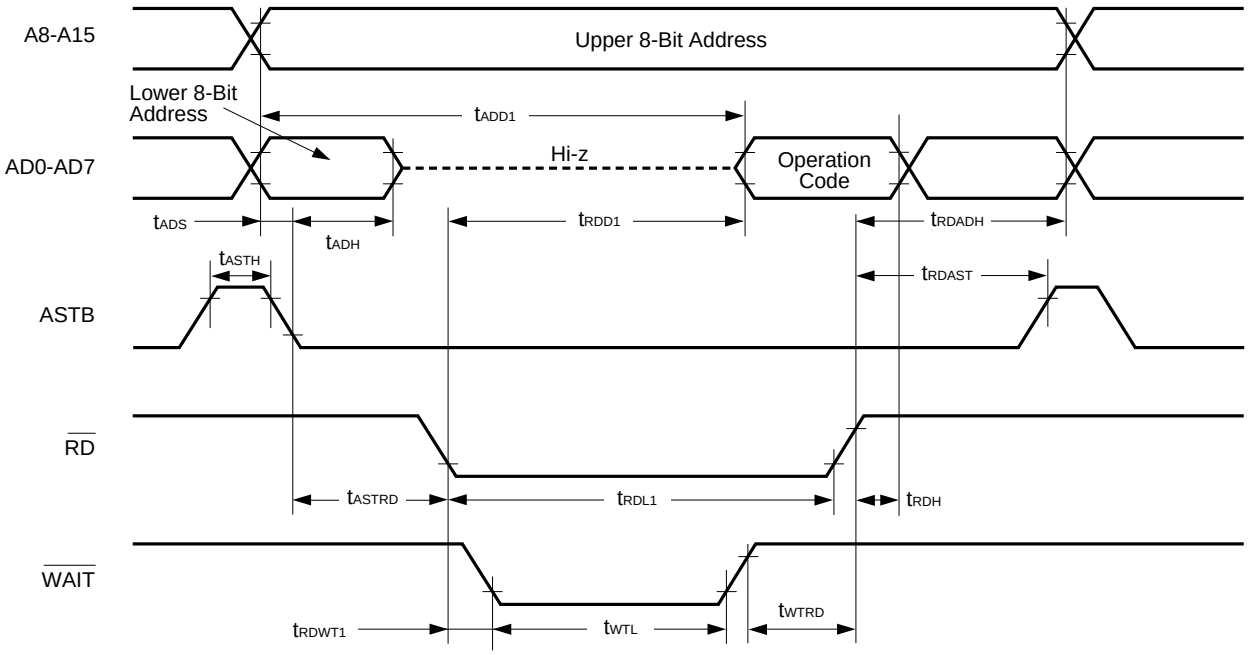


Read/Write Operation

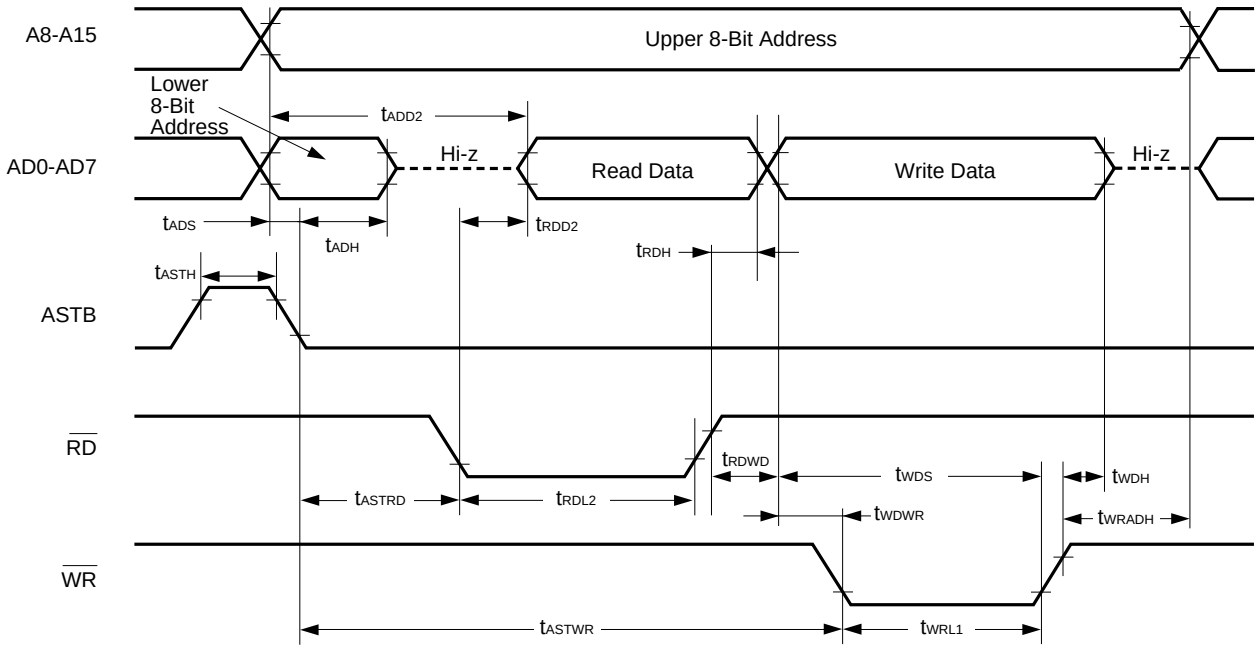
External fetch (no wait):



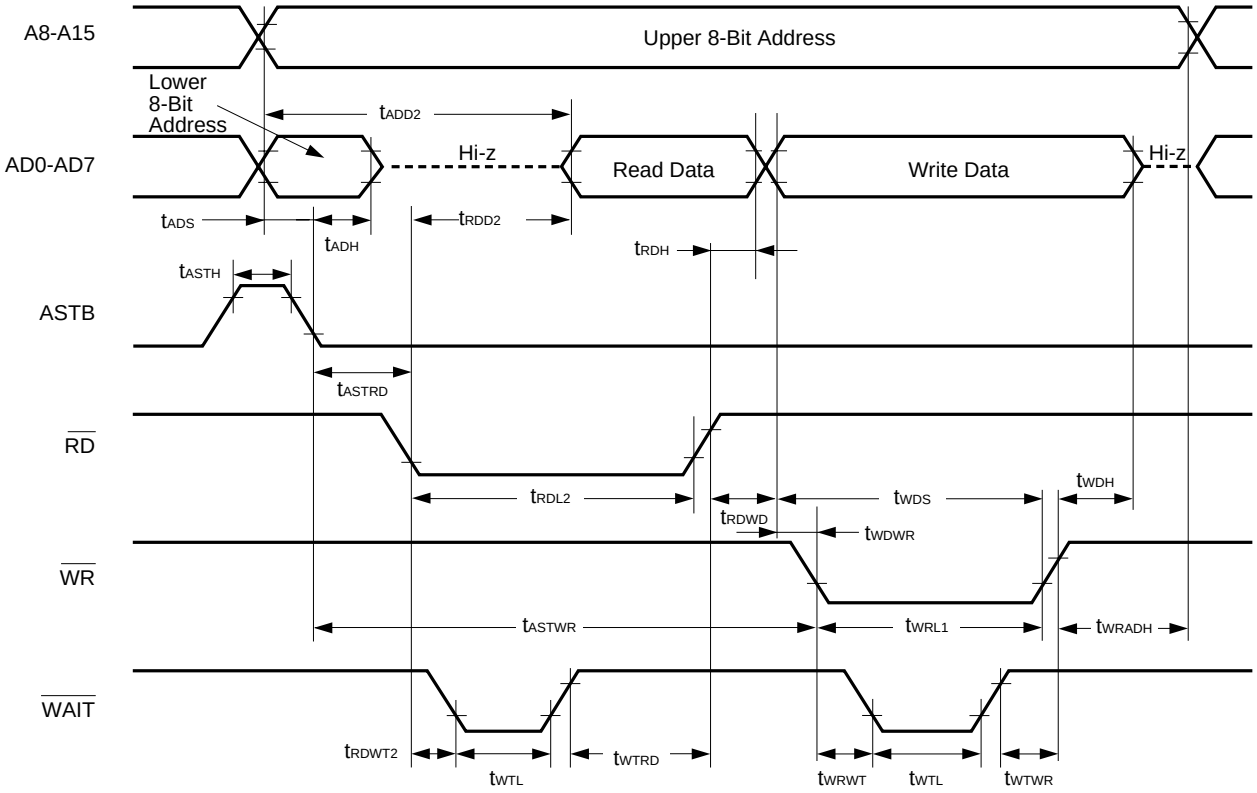
External fetch (wait insertion):



External data access (no wait):

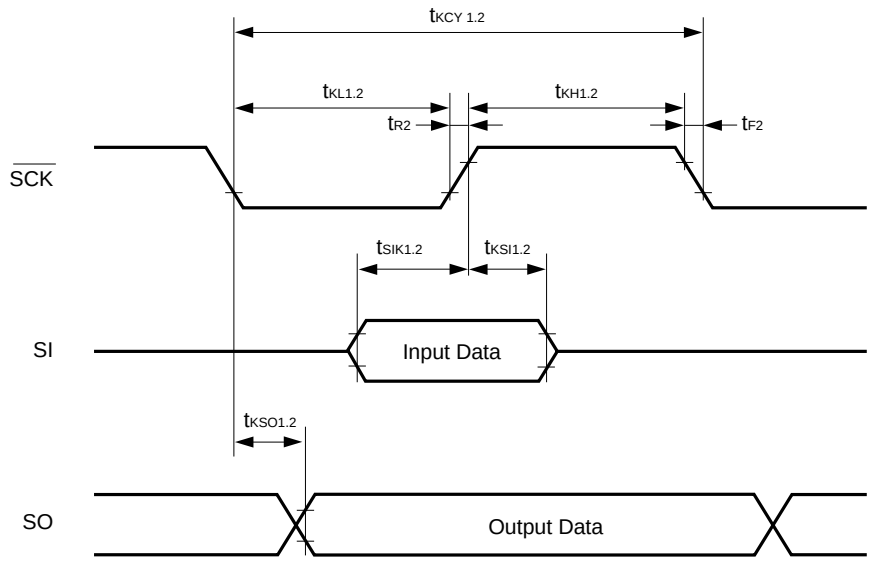


External data access (wait insertion):

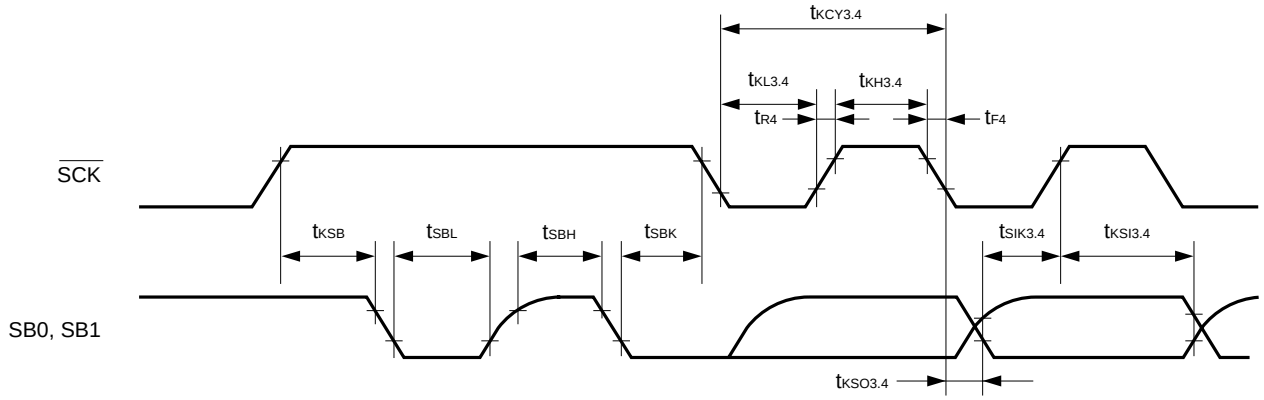


Serial Transfer Timing

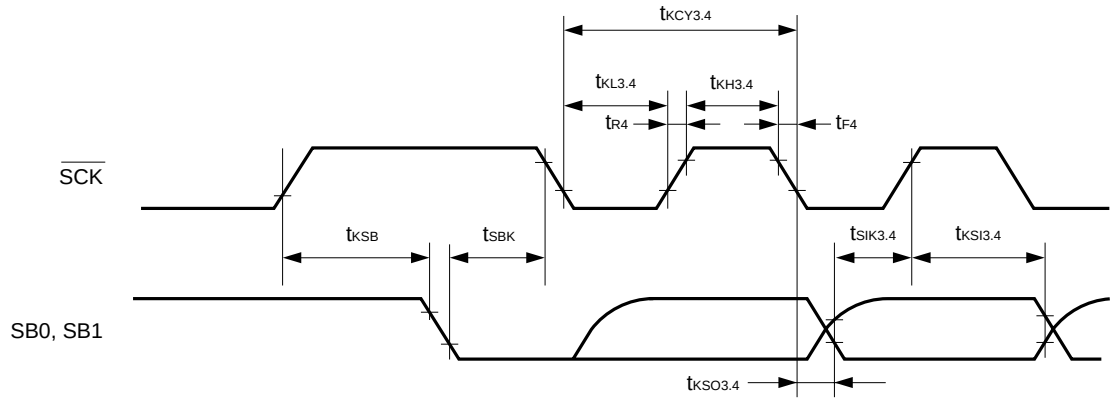
3-wire serial I/O mode:



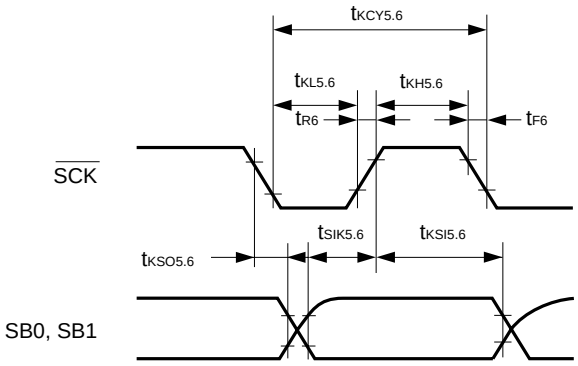
SBI mode (bus release signal transfer):



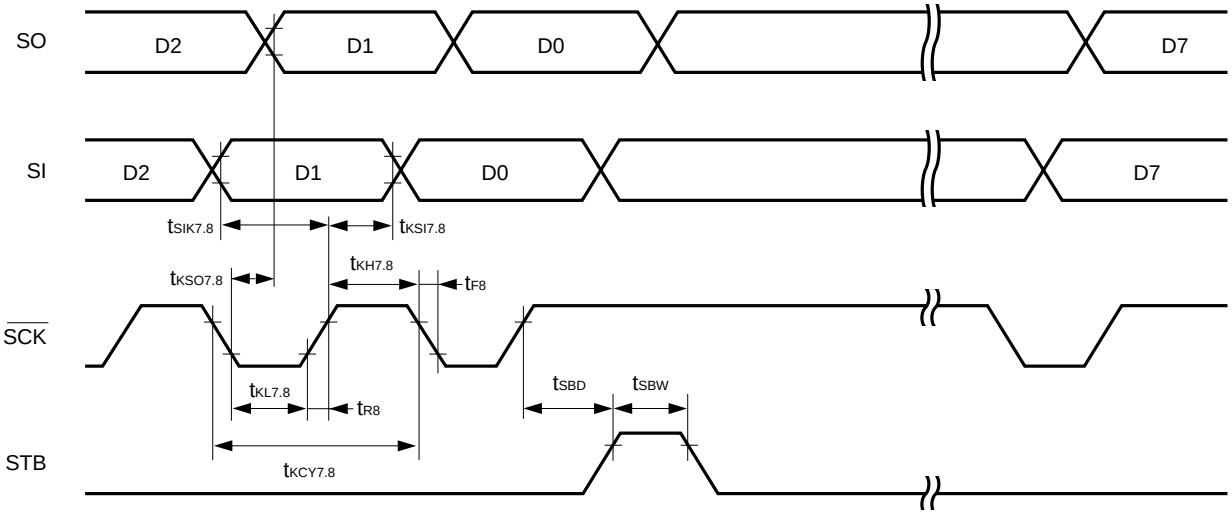
SBI mode (command signal transfer):



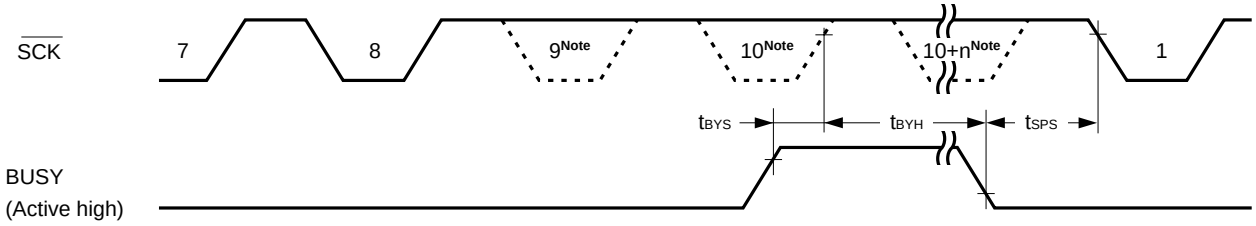
2-wire serial I/O mode:



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



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



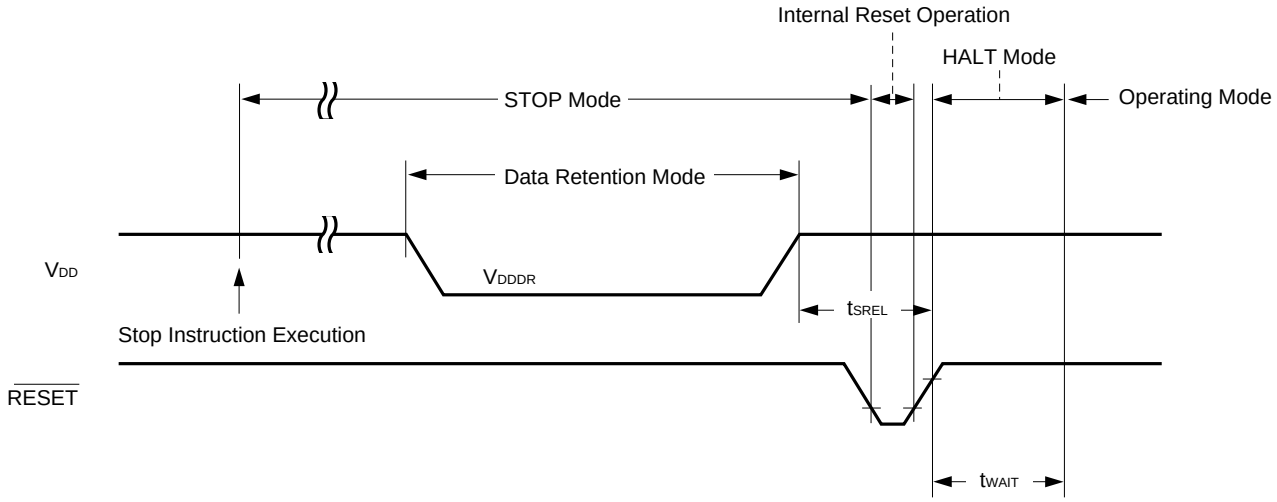
Note The signal is not actually low here, but is represented in this way to show the timing.

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

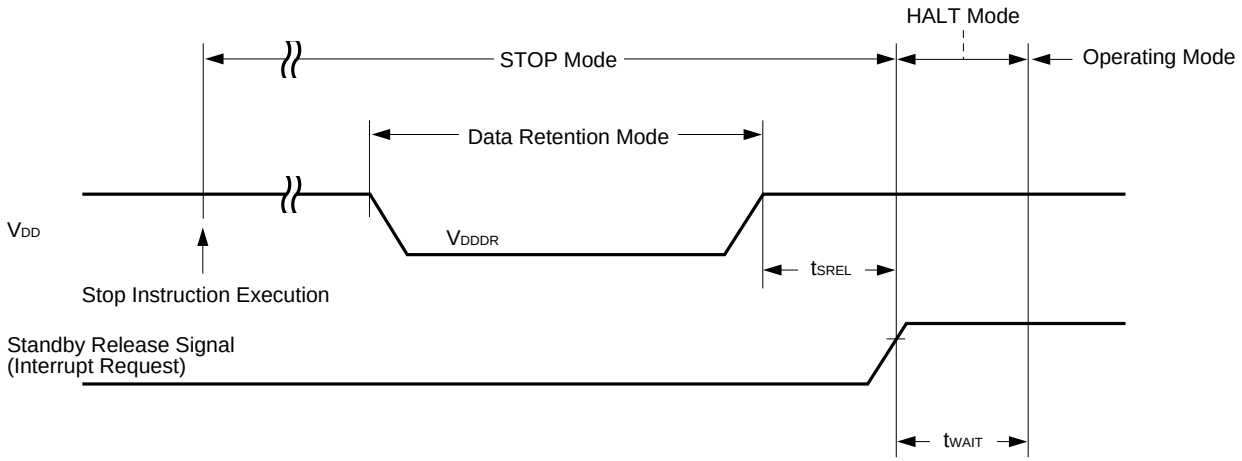
Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Data retention power supply voltage	V_{DDDR}		2.0		6.0	V
Data retention power supply current	I_{DDDR}	V_{DDDR} = 2.0 V Subsystem clock stop and feedback resistor disconnected		0.1	10	μA
Release signal set time	t_{SREL}		0			μs
Oscillation stabilization wait time	t_{WAIT}	Release by $\overline{RESET}$		$2^{18}/f_x$		ms
		Release by interrupt		**Note**		ms

Note In combination with bits 0 to 2 (OSTS0 to OSTS2) of oscillation stabilization time select register, selection of $2^{13}/f_x$ and $2^{15}/f_x$ to $2^{18}/f_x$ is possible.

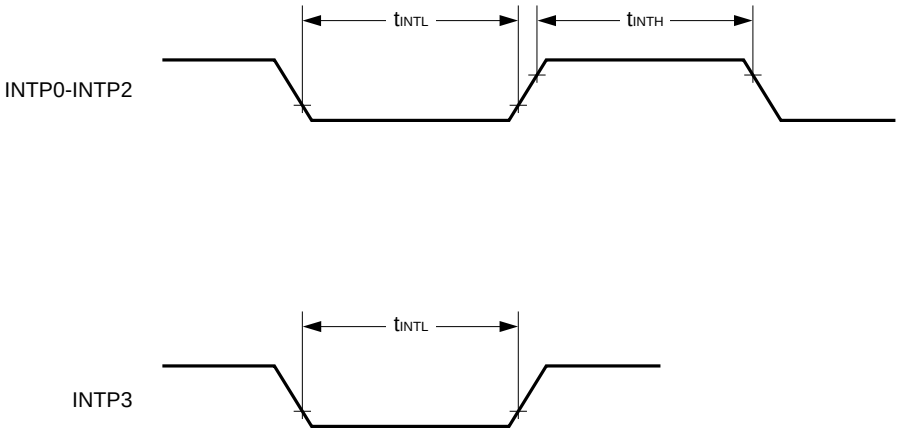
Data Retention Timing (STOP Mode Release by $\overline{RESET}$)



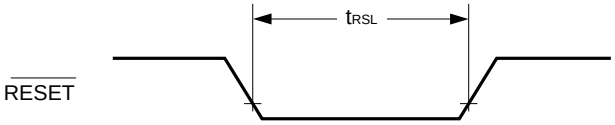
Data Retention Timing (Standby Release Signal: STOP Mode Release by Interrupt Signal)



Interrupt Input Timing



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



DC Programming Characteristics (T_a = 25 ± 5 °C, V_{SS} = 0 V)

Parameter	Symbol	Symbol[Note]	Test Conditions	MIN.	TYP.	MAX.	Unit
Input voltage high	V_{IH}	V_{IH}		0.7 V_{DDP}		V_{DDP}	V
Input voltage low	V_{IL}	V_{IL}		0		0.3 V_{DDP}	V
Input leakage current	I_{LIP}	I_{LI}	0 ≤ V_I ≤ V_{DDP}			10	μA
Output voltage high	V_{OH1}	V_{OH1}	I_{OH} = –400 μA	2.4			V
	V_{OH2}	V_{OH2}	I_{OH} = –100 μA	V_{DD} – 0.7			V
Output voltage low	V_{OL}	V_{OL}	I_{OL} = 2.1 mA			0.45	V
Output leakage current	I_{LO}	—	0 ≤ V_O ≤ V_{DDP}, $\overline{OE}$ = V_{IH}			10	μA
V_{DDP} supply voltage	V_{DDP}	V_{CC}	Program memory write mode	5.75	6.0	6.25	V
			Program memory read mode	4.5	5.0	5.5	V
V_{PP} supply voltage	V_{PP}	V_{PP}	Program memory write mode	12.5	12.5	12.8	V
			Program memory read mode	V_{PP} = V_{DDP}			
V_{DDP} supply current	I_{DD}	I_{CC}	Program memory write mode		5	30	mA
			Program memory read mode $\overline{CE}$ = V_{IL}, V_I = V_{IH}		5	30	mA
V_{PP} supply current	I_{PP}	I_{PP}	Program memory write mode $\overline{CE}$ = V_{IL}, $\overline{OE}$ = V_{IH}		5	30	mA
			Program memory read mode		1	100	μA

Note Corresponding μPD27C256A symbol.

Program Operation

AC Characteristics (T_a = 25 ± 5 °C, V_{DD} = 6.0 ± 0.25 V, V_{PP} = 12.5 ± 0.3 V, V_{SS} = 0 V)

Parameter	Symbol	Symbol[Note]	Test Conditions	MIN.	TYP.	MAX.	Unit
Address setup time (to $\overline{CE}\downarrow$)	t_{SAC}	t_{AS}		2			μs
$\overline{OE}\downarrow$ delay time from data	t_{DDOO}	t_{OES}		2			μs
Input data setup time (to $\overline{CE}\downarrow$)	t_{SIDC}	t_{DS}		2			μs
Address hold time (from $\overline{CE}\uparrow$)	t_{HCA}	t_{AH}		2			μs
Input data hold time (from $\overline{CE}\uparrow$)	t_{HCID}	t_{DH}		2			μs
Output data hold time (from $\overline{OE}\uparrow$)	t_{HOOD}	t_{DF}		0		130	ns
V_{PP} setup time (to $\overline{CE}\downarrow$)	t_{SVPC}	t_{VPS}		1			ms
V_{DDP} setup time (to $\overline{CE}\downarrow$)	t_{SVDC}	t_{VDS}		1			ms
Initial program pulse width	t_{WL1}	t_{PW}		0.95	1.0	1.05	ms
Additional program pulse width	t_{WL2}	t_{OPW}		2.85		78.75	ms
Data output time from $\overline{OE}\downarrow$	t_{DOOD}	t_{OE}				1	μs

Note Corresponding μPD27C256A symbol.

Read Operation

AC Characteristics (T_a = 25 ± 5 °C, V_{DD} = 5.0 ± 0.5 V, V_{PP} = V_{DD}, V_{SS} = 0 V)

Parameter	Symbol	Symbol[Note]	Test Conditions	MIN.	TYP.	MAX.	Unit
Data output time from address	t_{DAOD}	t_{ACC}				200	ns
Data output time from $\overline{CE}\downarrow$	t_{DCOD}	t_{CE}				200	ns
Data output time from $\overline{OE}\downarrow$	t_{DOOD}	t_{OE}				75	ns
Data hold time (from $\overline{OE}\uparrow$)	t_{HCOD}	t_{DF}		0		60	ns
Data hold time (from address)	t_{HAOD}	t_{OH}		0			ns

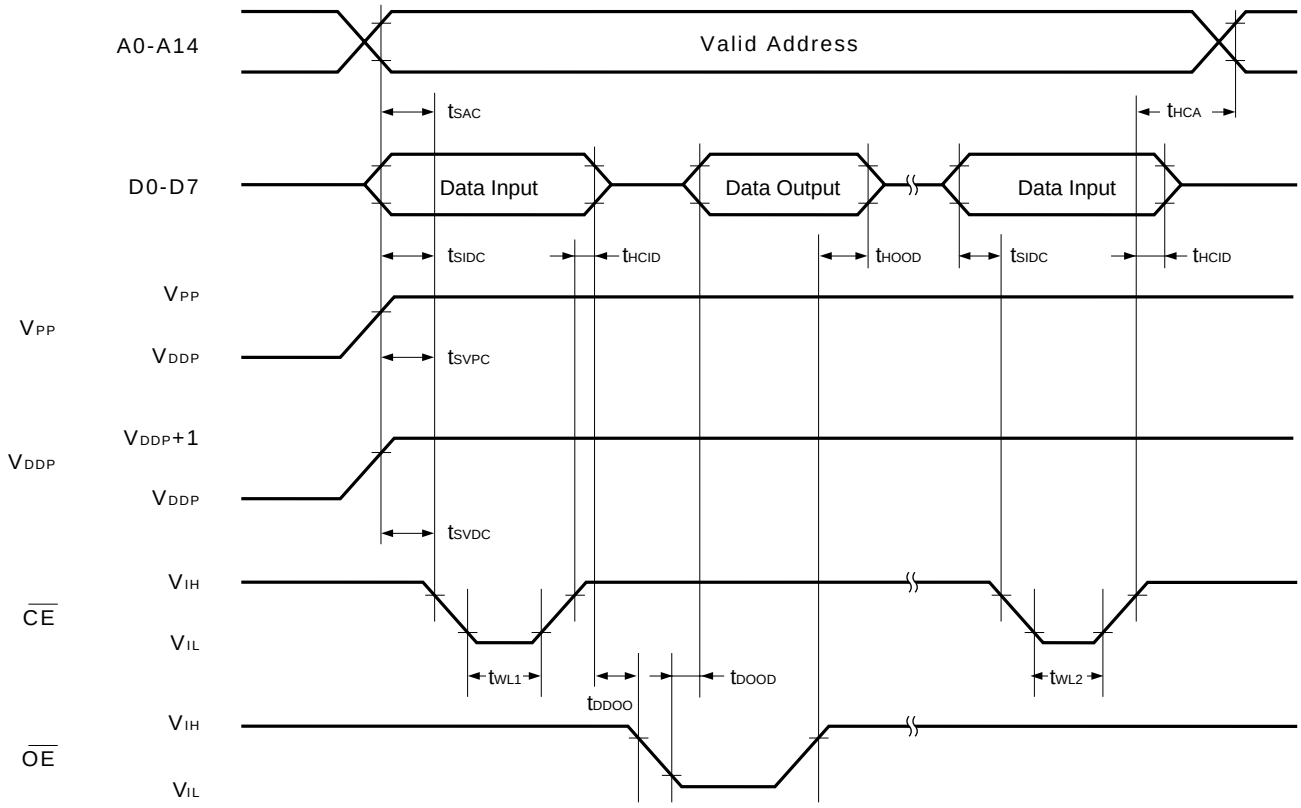
Note Corresponding μPD27C256A symbol.

PROM Mode Setting

AC Characteristics (T_a = 25 ± 5 °C, V_{SS} = 0 V)

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
PROM mode setup time	t_{SMA}		10			μs

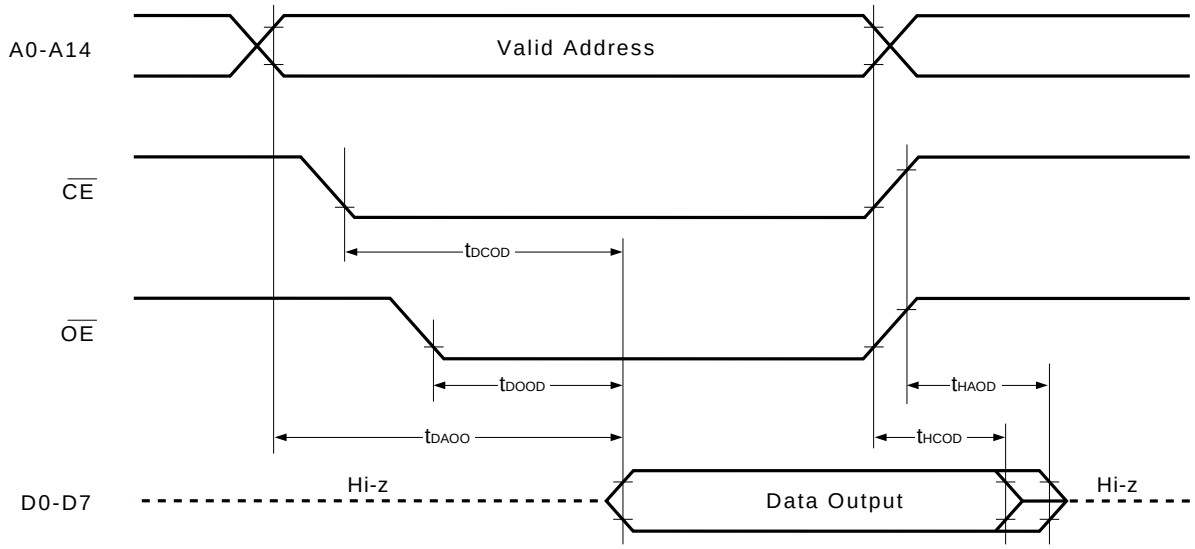
PROM Write Mode Timing



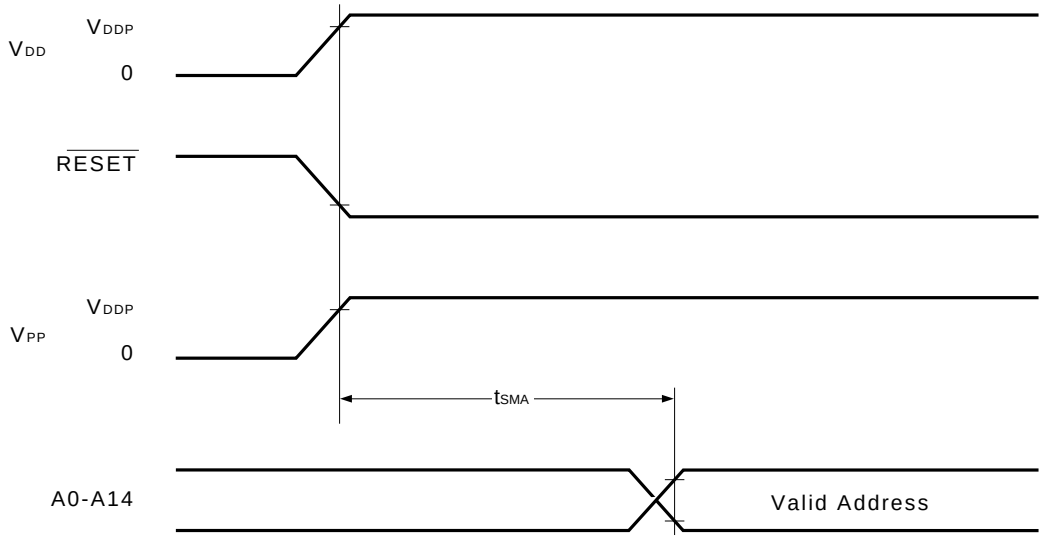
Cautions 1. V_{DDP} should be applied before V_{PP}, and cut after V_{PP}.

2. V_{PP} should not reach +13V or above including overshoot.

PROM Read Mode Timing

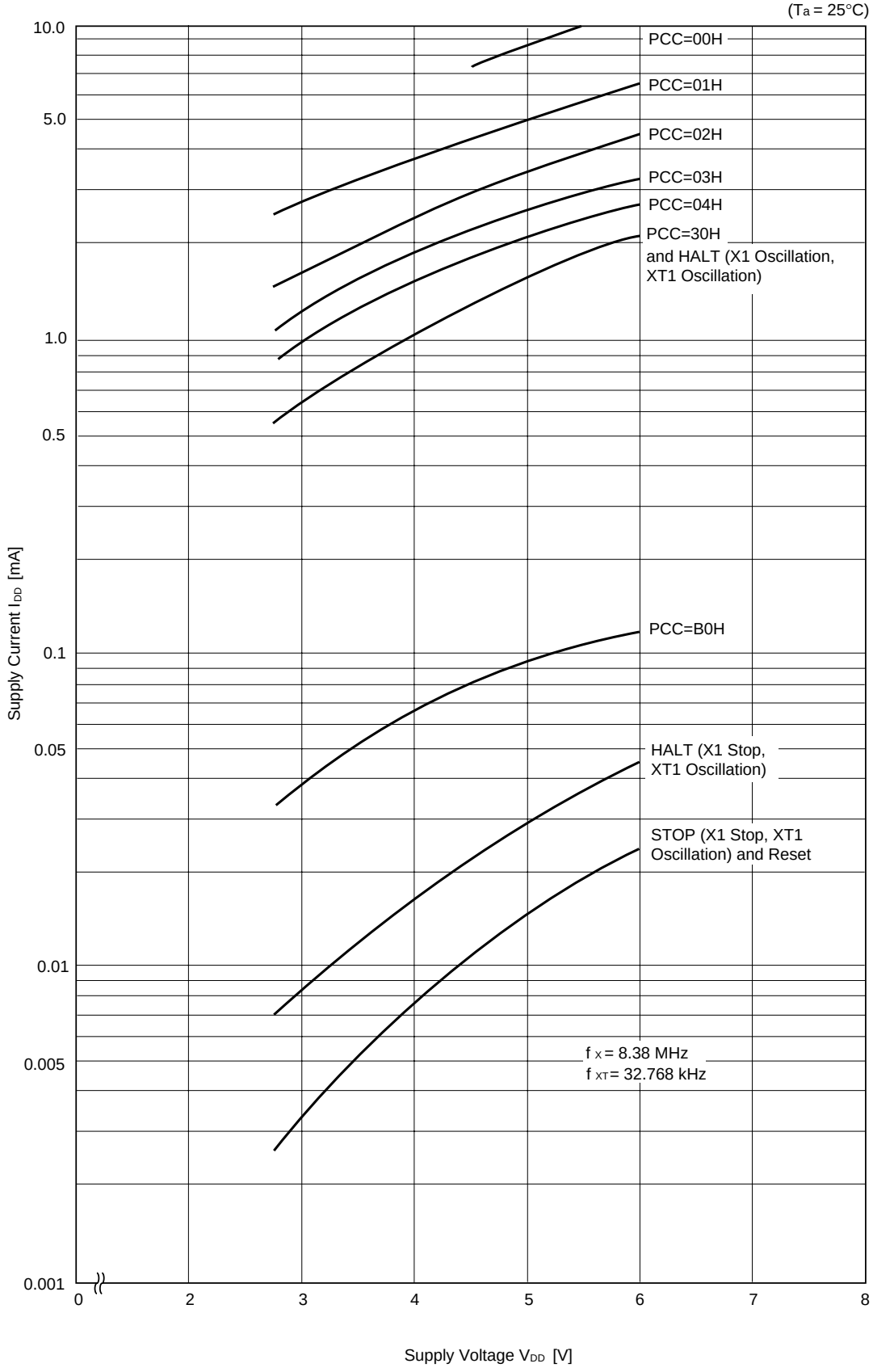


PROM Mode Setting Timing

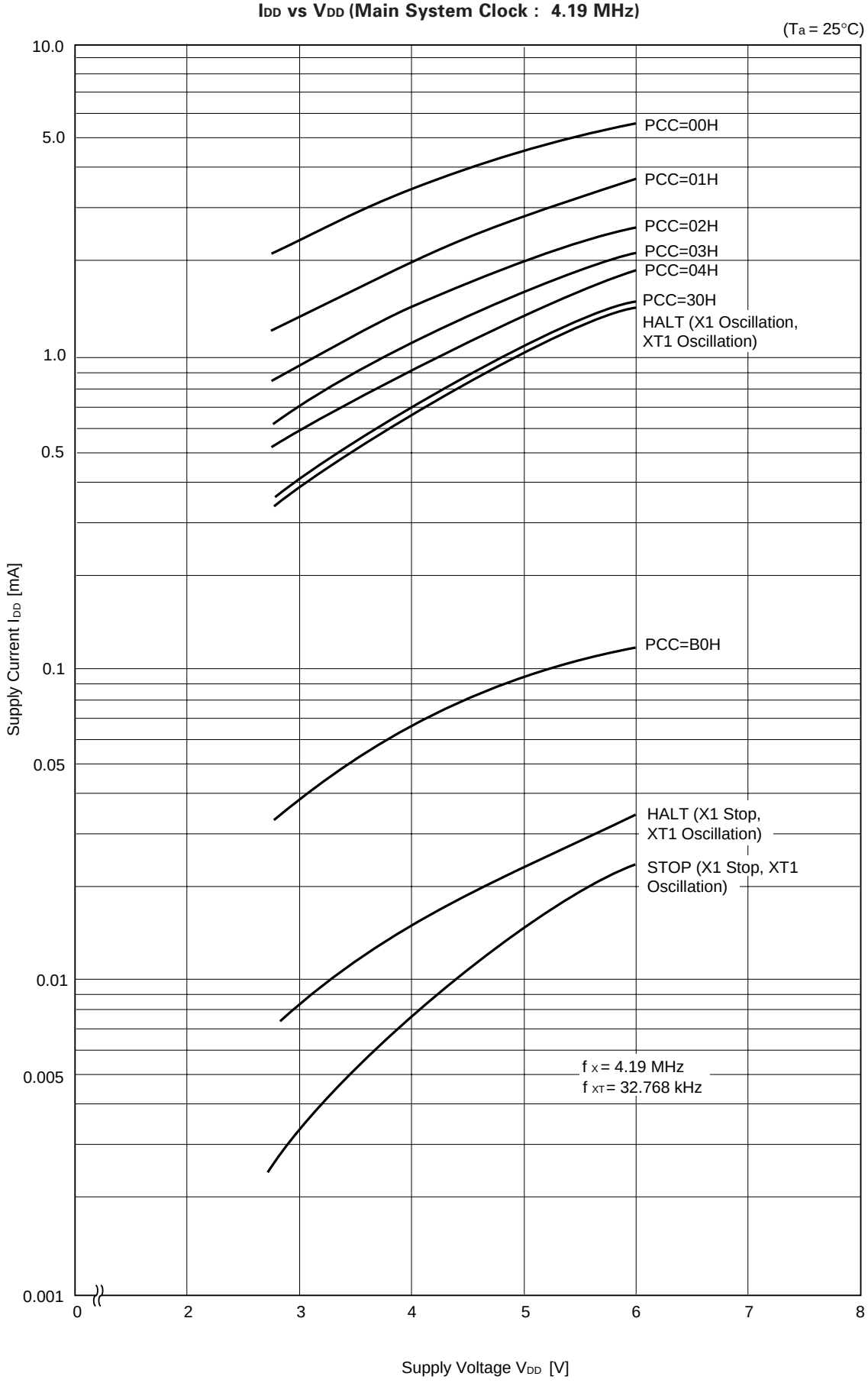


9. CHARACTERISTIC CURVES (FOR REFERENCE ONLY)

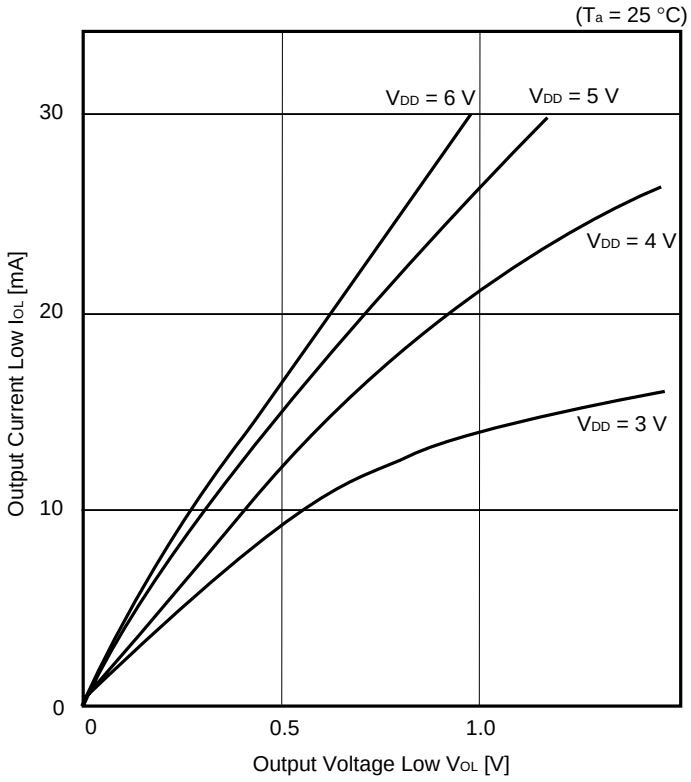
I_{DD} vs V_{DD} (Main System Clock : 8.38 MHz)



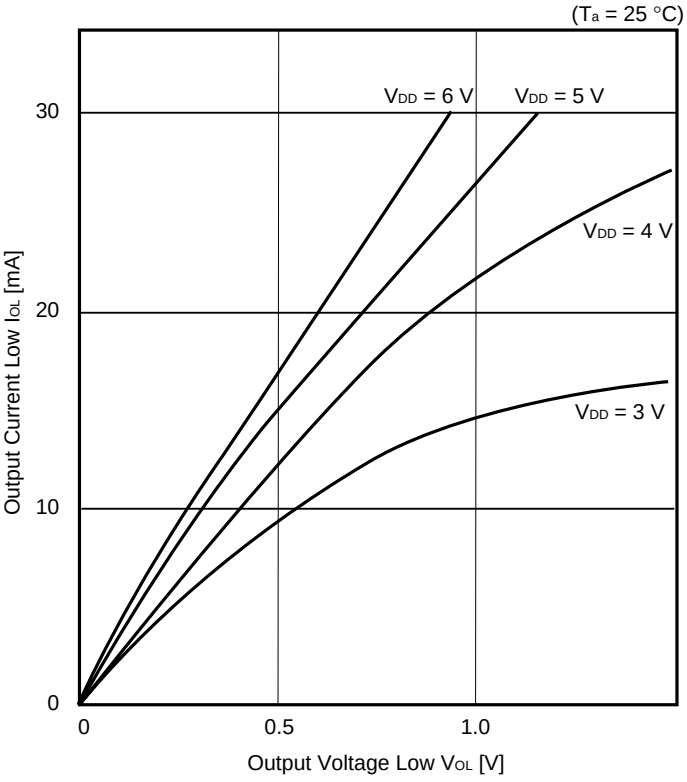
I_{DD} vs V_{DD} (Main System Clock : 4.19 MHz)



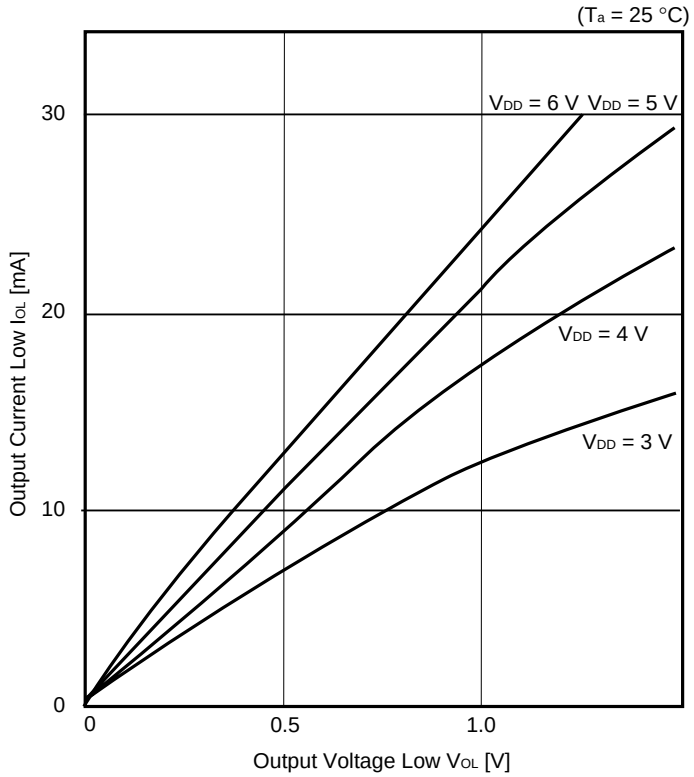
V_{OL} vs I_{OL} (Ports 0 , 2 to 5, P64 to P67)



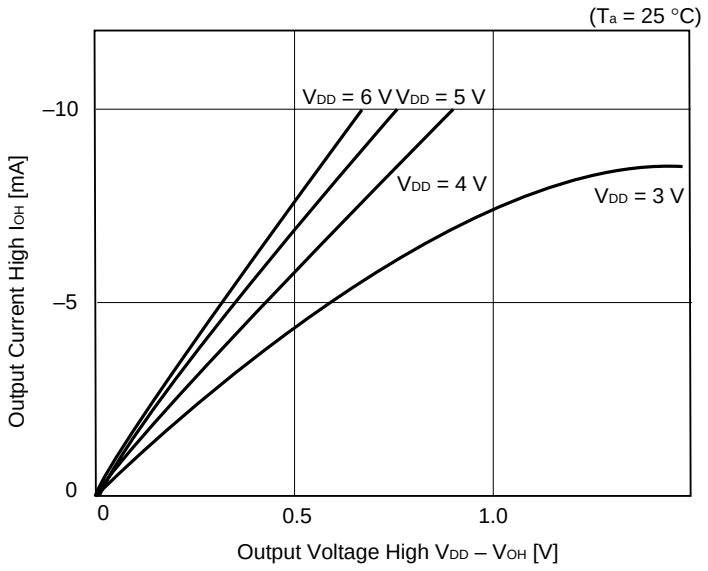
V_{OL} vs I_{OL} (Port 1)



V_{OL} vs I_{OL} (P60 to P63)

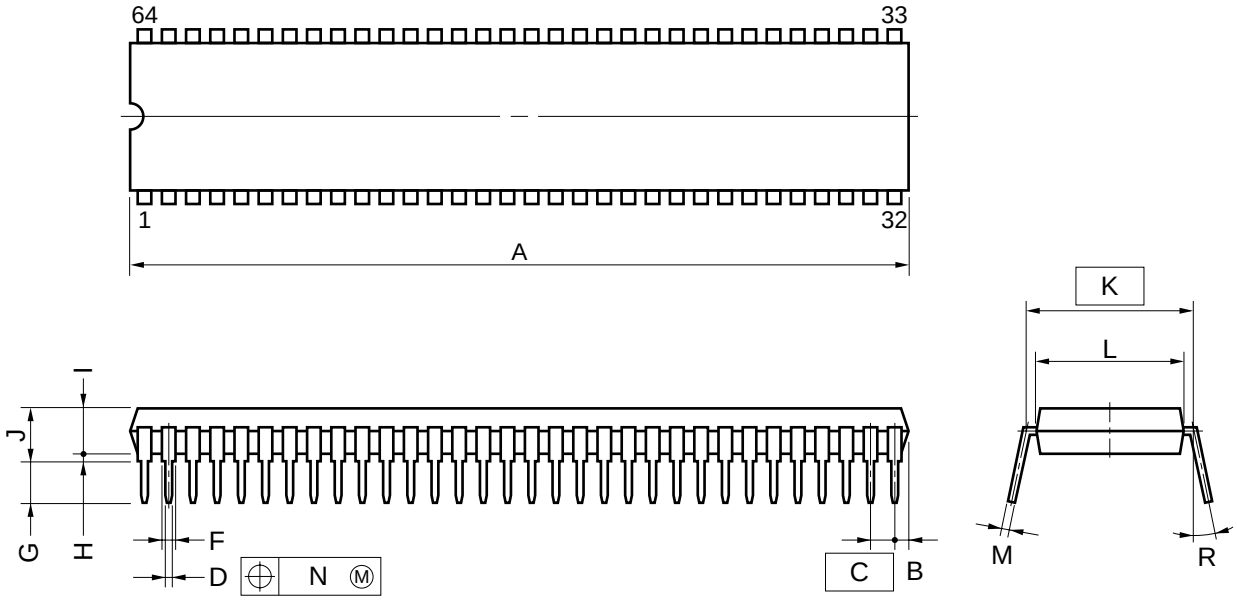


V_{OH} vs I_{OH} (Ports 0 to 5, P64 to P67)



10. PACKAGE DRAWINGS

64 PIN PLASTIC SHRINK DIP (750 mil)



NOTE

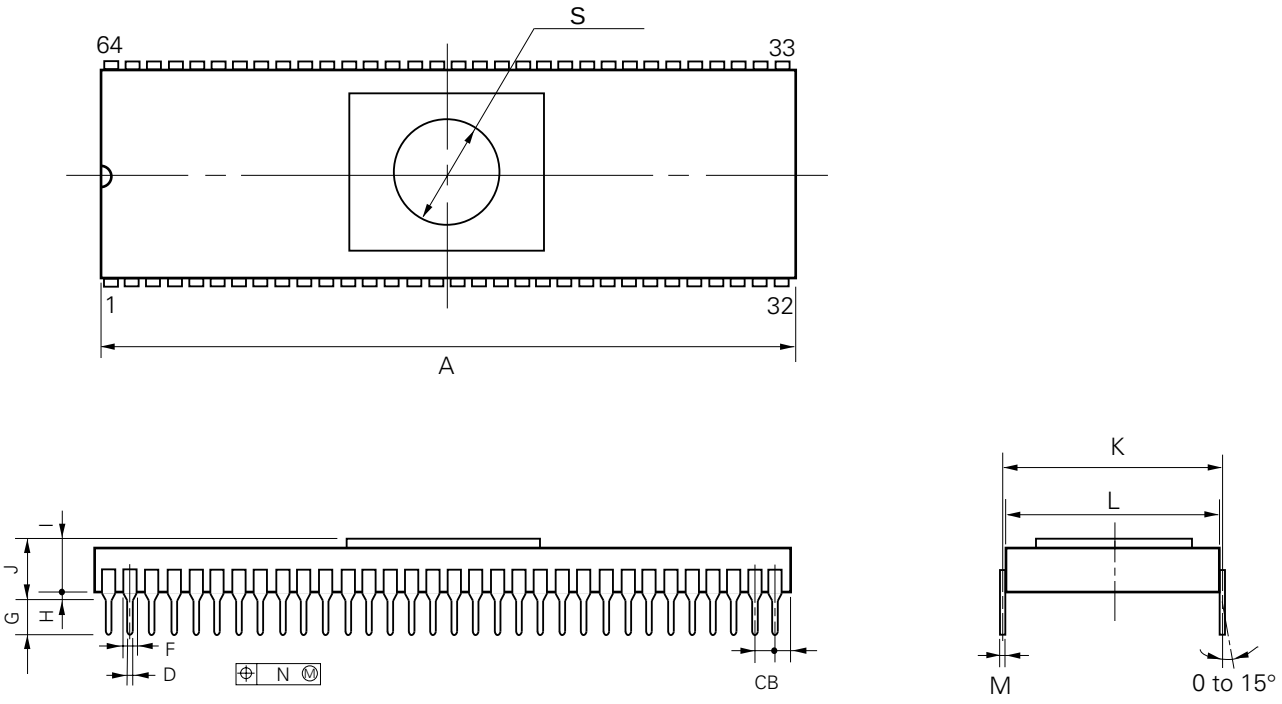
1) Each lead centerline is located within 0.17 mm (0.007 inch) of its true position (T.P.) at maximum material condition.

2) Item "K" to center of leads when formed parallel.

ITEM	MILLIMETERS	INCHES
A	58.68 MAX.	2.311 MAX.
B	1.78 MAX.	0.070 MAX.
C	1.778 (T.P.)	0.070 (T.P.)
D	0.50 ± 0.10	$0.020^{+0.004}_{-0.005}$
F	0.9 MIN.	0.035 MIN.
G	3.2 ± 0.3	0.126 ± 0.012
H	0.51 MIN.	0.020 MIN.
I	4.31 MAX.	0.170 MAX.
J	5.08 MAX.	0.200 MAX.
K	19.05 (T.P.)	0.750 (T.P.)
L	17.0	0.669
M	$0.25^{+0.10}_{-0.05}$	$0.010^{+0.004}_{-0.003}$
N	0.17	0.007
R	0~15°	0~15°

P64C-70-750A,C-1

64 PIN CERAMIC SHRINK DIP (750 mil)



P64DW-70-750A

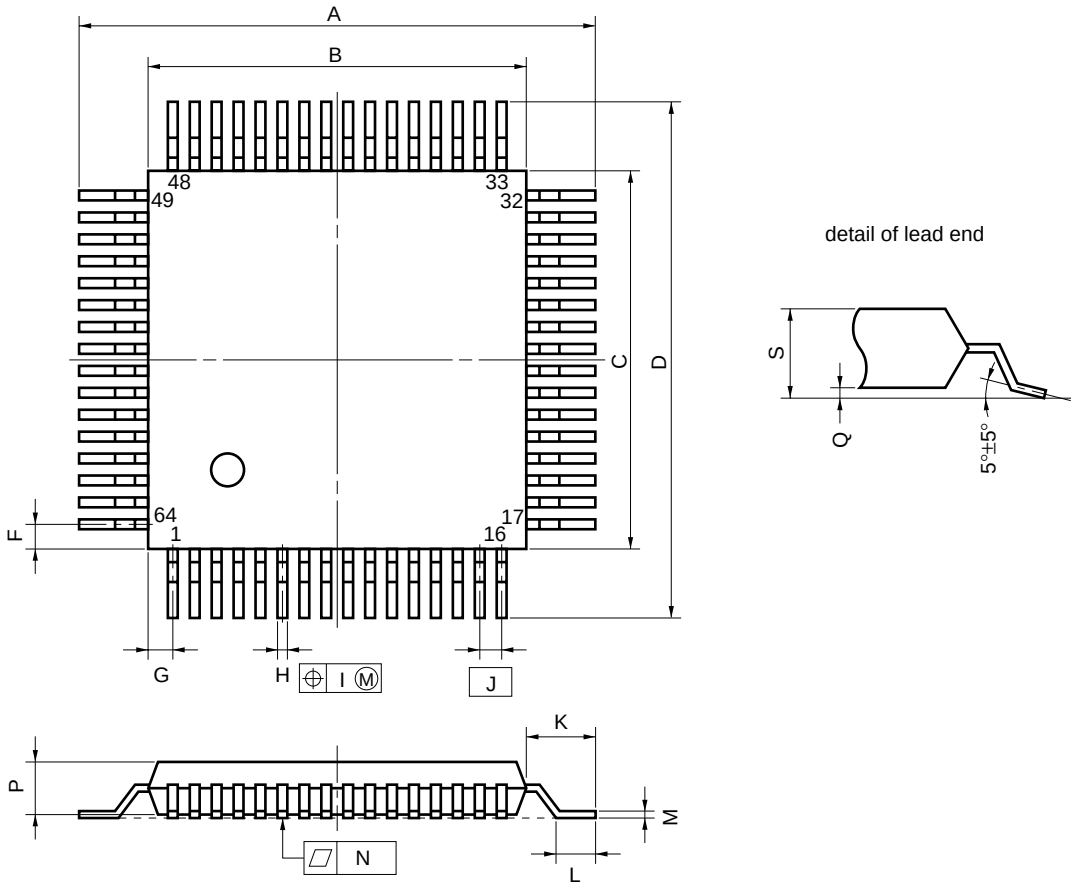
NOTES

1) Each lead centerline is located within 0.25 mm (0.010 inch) of its true position (T.P.) at maxi-mum material condition.

2) Item "K" to center of leads when formed parallel.

ITEM	MILLIMETERS	INCHES
A	58.68 MAX.	2.310 MAX.
B	1.78 MAX.	0.070 MAX.
C	1.778 (T.P.)	0.070 (T.P.)
D	$0.46^{\pm 0.05}$	$0.018^{\pm 0.002}$
F	0.8 MIN.	0.031 MIN.
G	$3.5^{\pm 0.3}$	$0.138^{\pm 0.012}$
H	1.0 MIN.	0.039 MIN.
I	3.0	0.118
J	5.08 MAX.	0.200 MAX.
K	19.05 (T.P.)	0.750 (T.P.)
L	18.8	0.740
M	$0.25^{\pm 0.05}$	$0.010^{+0.002}_{-0.003}$
N	0.25	0.01
S	⌀ 8.89	⌀ 0.350

64 PIN PLASTIC QFP (□14)



P64GC-80-AB8-3

NOTE

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

ITEM	MILLIMETERS	INCHES
A	17.6±0.4	0.693±0.016
B	14.0±0.2	$0.551^{+0.009}_{-0.008}$
C	14.0±0.2	$0.551^{+0.009}_{-0.008}$
D	17.6±0.4	0.693±0.016
F	1.0	0.039
G	1.0	0.039
H	0.35±0.10	$0.014^{+0.004}_{-0.005}$
I	0.15	0.006
J	0.8 (T.P.)	0.031 (T.P.)
K	1.8±0.2	0.071±0.008
L	0.8±0.2	$0.031^{+0.009}_{-0.008}$
M	$0.15^{+0.10}_{-0.05}$	$0.006^{+0.004}_{-0.003}$
N	0.10	0.004
P	2.55	0.100
Q	0.1±0.1	0.004±0.004
S	2.85 MAX.	0.112 MAX.

11. RECOMMENDED SOLDERING CONDITIONS

The μPD78P014 should be soldered and mounted under the conditions recommended in the table below.

For detail of recommended soldering conditions, refer to the information document **"Semiconductor Device Mounting Technology Manual" (IEI-1207)**.

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

Table 11-1. Surface Mounted Type Soldering Conditions

μPD78P014GC-AB8: 64-pin plastic QFP (14 × 14 mm)

Soldering Method	Soldering Conditions	Symbol
Infrared ray reflow	Package peak temperature: 230 °C Duration: 30 sec. max. (at 210 °C or above) Number of times: Once Time limit: 2 days[Note] (thereafter 20 hours prebaking required at 125 °C)	IR30-202-1
VPS	Package peak temperature: 215 °C Duration: 40 sec. max. (at 200 °C or above) Number of times: Once Time limit: 2 days[Note] (thereafter 20 hours prebaking required at 125 °C)	VP15-202-1
Pin partial heating	Pin temperature: 300 °C max. Duration: 3 sec. max. (Per side of the device)	—

Note For the storage period after dry-pack decapsulation, storage conditions are max. 25°C, 65% RH.

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

Table 11-2. Insert Type Soldering Conditions

μPD78P014CW: 64-pin plastic shrink DIP (750 mil)
μPD78P014DW: 64-pin ceramic shrink DIP (with window) (750 mil)

Soldering Method	Soldering Conditions
Wave soldering (Pin only)	Solder bath temperature : 260 °C max. Duration: 10 sec. max.
★ Pin partial heating	Pin temperature: 300 °C max. Duration: 3 sec. max (per 1 pin).

Caution The wave soldering applies to the pin only. Ensure that no solder touches the body directly.

APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for system development using the μPD78P014.

Language Processing Software

RA78K/0 Note 1, 2, 3	78K/0 series common assembler package
CC78K/0 Note 1, 2, 3	78K/0 series common C compiler package
DF78014 Note 1, 2, 3	μPD78014 subseries device file ★
CC78K/0-L Note 1, 2, 3	78K/0 series common C compiler library source file

PROM Writing Tools

PG-1500	PROM programmer
PA-78P014CW PA-78P014GC	Programmer adapter connected to PG-1500
PG-1500 controller Note 1, 2	PG-1500 control program

Debugging Tools

IE-78000-R	78K/0 series common in-circuit emulators
IE-78000-R-BK	78K/0 series common break board
IE-78014-R-EM	μPD78002/78014 subseries evaluation emulation boards
EP-78240CW-R EP-78240GC-R	μPD78244 subseries common emulation probes
EV-9200GC-64	Socket to be mounted on a user system board made for 64-pin plastic QFP
SD78K/0 Note 1, 2	IE-78000-R screen debugger
SM78K/0 Note 3, 4, 5, 6	78K/0 series common system simulator ★
DF78014 Note 1, 2, 3, 4, 5	μPD78014 subseries device file

Real-Time OS

RX78K/0 Note 1, 2, 3	78K/0 series common real-time OS
MX78K/0 Note 1, 2, 3, 6	78K/0 series common OS ★

Fuzzy Inference Development Support System

FE9000 Note 1/FE9200 Note 5	Fuzzy knowledge data creation tool
FT9080 Note 1/FT9085 Note 2	Translator
FI78K0 Note 1, 2	Fuzzy inference module
FD78K0 Note 1, 2	Fuzzy inference debugger

Notes 1. PC-9800 series (MS-DOS™) based
2. IBM PC/AT™ (PC DOS™) based
★ **3.** HP9000 series 300™, HP9000 series 700™ (HP-UX™) based, SPARCstation™ (SunOS™) based, EWS-4800 series (EWS-UX/V) based
4. PC-9800 series (MS-DOS+Windows™) based
5. IBM PC/AT (PC DOS + Windows) based
6. Under development

Remarks 1. For third party development tools, see the **78K/0 Series Selection Guide (IF-1185)**.
★ **2.** RA78K/0, CC78K/0, SD78K/0, and SM78K/0 are used together with the DF78014.

APPENDIX B. RELATED DOCUMENTS

Device Related Documents

Document Name		Document No. (Japanese)	Document No. (English)
μPD78014/78014Y Series User's Manual		IEU-780	IEU-1343
78K/0 Series User's Manual Instructions		IEU-849	IEU-1372
78K/0 Series Application Notes	Basic I	IEA-715	IEA-1288
	Basic II	IEA-740	IEA-1299
	Electronic Notebook	IEA-744	IEA-1301

Development Tool Related Documents (User's Manual)

Document Name		Document No. (Japanese)	Document No. (English)
RA78K Series Assembler Package	Operation	EEU-809	EEU-1399
	Language	EEU-815	EEU-1404
RA78K Series Structured Assembler Preprocessor		EEU-817	EEU-1402
CC78K Series C Compiler	Operation	EEU-656	EEU-1280
	Language	EEU-655	EEU-1284
PG-1500 PROM Programmer		EEU-651	EEU-1335
PG-1500 Controller		EEU-704	EEU-1291
IE-78000-R		EEU-810	EEU-1398
IE-78000-R-BK		EEU-867	EEU-1427
SD78K/0 Screen Debugger	Basic	EEU-852	EEU-1414
	Reference	EEU-816	EEU-1413

Other Related Documents

Document Name	Document No. (Japanese)	Document No. (English)
Package Manual	IEI-635	IEI-1213
Semiconductor Device Mounting Technology Manual	IEI-616	IEI-1207
Quality Grades on Semiconductor Devices	IEI-620	IEI-1209
Semiconductor Devices Quality Guarantee Guide	MEI-603	MEI-1202

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

[MEMO]

NOTES FOR CMOS DEVICES

① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note: Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note: No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note: Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

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