NEC

MOS INTEGRATED CIRCUITS

μPD78F9116B, 78F9116B(A)

8-BIT SINGLE-CHIP MICROCONTROLLERS

DESCRIPTION

The μPD78F9116B is a μPD789114A Subseries product of the 78K/0S Series.

The μPD78F9116B replaces the internal ROM of the μPD789111A,789112A and 789114A with flash memory, which enables the writing/erasing of a program while the device is mounted on the board.

A stricter quality assurance program (called special grade in NEC's grade classification) is applied to the μPD78F9116B(A), compared to the μPD78F9116B, which are classified as standard grade.

Because flash memory allows the program to be written and erased electrically with the device mounted on the board, this product is ideal for the evaluation stages of system development, small-scale production, and rapid development of new products.

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

μPD789104A, 789114A, 789124A, 789134A Subseries User's Manual: U14643E
78K/0S Series User's Manual Instruction: U11047E

FEATURES

- Pin-compatible with mask ROM version (excluding V_{PP} pin)
- Flash memory: 16 KB
- Internal high-speed RAM: 256 bytes
- On-chip multiplier: 8 bits × 8 bits = 16 bits
- Minimum instruction execution time can be changed from high-speed (0.2 μs) to low-speed (0.8 μs) (@ 10.0 MHz operation with system clock, V_{DD} = 4.5 to 5.5 V)
- I/O ports: 20
- Serial interface: 1 channel: Switchable between 3-wire serial I/O and UART modes
- 10-bit resolution A/D converter: 4 channels
- Timers: 3 channels
  - 16-bit timer: 1 channel
  - 8-bit timer/event counter: 1 channel
  - Watchdog timer: 1 channel
- Power supply voltage: V_{DD} = 1.8 to 5.5 V

APPLICATIONS

Cleaners, washing machines, refrigerators and battery-charger

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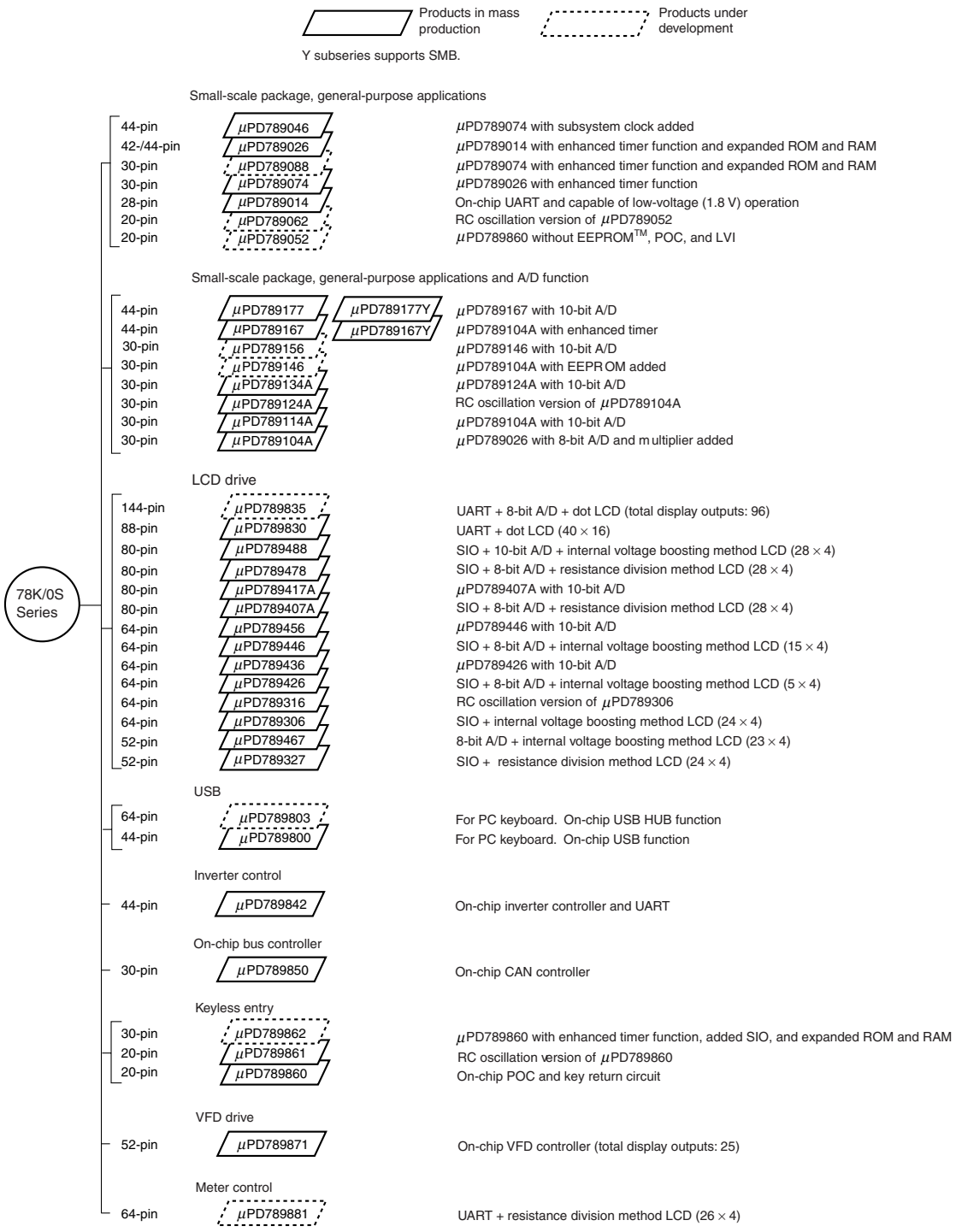
ORDERING INFORMATION

Part number	Package	Quality grade
μPD78F9116BMC-5A4	30-pin plastic SSOP (7.62 mm (300))	Standard
μPD78F9116BMC(A)-5A4	30-pin plastic SSOP (7.62 mm (300))	Special

Please refer to "Quality Grades on NEC Semiconductor Devices" (Document No. C11531E) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

78K/0S SERIES LINEUP

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



Remark VFD (Vacuum Fluorescent Display) is referred to as FIP™ (Fluorescent Indicator Panel) in some documents, but the functions of the two are the same.

The major functional differences among the subseries are listed below.

Series for General-Purpose and LCD Drive

Subseries Name \ Function		ROM Capacity (Bytes)	Timer				8-Bit A/D	10-Bit A/D	Serial Interface	I/O	V_{DD} MIN.Value	Remarks
			8-Bit	16-Bit	Watch	WDT						
Small-scale package, general-purpose applications	μPD789046	16 K	1 ch	1 ch	1 ch	1 ch	–	–	1 ch (UART: 1ch)	34	1.8 V	–
	μPD789026	4 K to 16 K			–							
	μPD789088	16 K to 32 K	3 ch							24		
	μPD789074	2 K to 8 K	1 ch									
	μPD789014	2 K to 4 K	2 ch	–						22		
	μPD789062	4 K							–	14		RC-oscillation version
	μPD789052											–
Small-scale package, general-purpose applications + A/D converter	μPD789177	16 K to 24 K	3 ch	1 ch	1 ch	1ch	–	8 ch	1 ch (UART: 1ch)	31	1.8 V	–
	μPD789167						8 ch	–				
	μPD789156	8 K to 16 K	1 ch		–		–	4 ch		20		On-chip EEPROM
	μPD789146						4 ch	–				
	μPD789134A	2 K to 8 K					–	4 ch				RC-oscillation version
	μPD789124A						4 ch	–				
	μPD789114A						–	4 ch				–
	μPD789104A						4 ch	–				
LCD drive	μPD789835	24 K to 60 K	6 ch	–	1 ch	1 ch	3 ch	–	1 ch (UART: 1ch)	37	1.8 V[Note]	Dot LCD supported
	μPD789830	24 K	1 ch	1 ch			–			30	2.7 V	
	μPD789488	32 K	3 ch					8 ch	2 ch (UART: 1ch)	45	1.8 V	–
	μPD789478	24 K to 32 K					8 ch	–				
	μPD789417A	12 K to 24 K					–	7 ch	1 ch (UART: 1ch)	43		
	μPD789407A						7 ch	–				
	μPD789456	12 K to 16 K	2 ch				–	6 ch		30		
	μPD789446						6 ch	–				
	μPD789436						–	6 ch		40		
	μPD789426						6 ch	–				
	μPD789316	8 K to 16 K					–		2 ch (UART: 1ch)	23		RC-oscillation version
	μPD789306											–
	μPD789467	4 K to 24 K		–			1 ch		–	18		
	μPD789327						–		1 ch	21		

Note Flash memory version: 3.0 V

Series for ASSP

Subseries Name \ Function		ROM Capacity (Bytes)	Timer				8-Bit A/D	10-Bit A/D	Serial Interface	I/O	V_{DD} MIN.Value	Remarks
			8-Bit	16-Bit	Watch	WDT						
USB	μPD789803	8 K to 16 K	2 ch	–	–	1 ch	–	–	2 ch (USB: 1 ch)	41	3.6 V	–
	μPD789800	8 K								31	4.0 V	
Inverter control	μPD789842	8 K to 16 K	3 ch	**Note 1**	1 ch	1 ch	8 ch	–	1 ch (UART: 1 ch)	30	4.0 V	–
On-chip bus controller	μPD789850	16 K	1 ch	1 ch	–	1 ch	4 ch	–	2 ch (UART: 1 ch)	18	4.0 V	–
Keyless entry	μPD789861	4 K	2 ch	–	–	1 ch	–	–	–	14	1.8 V	RC-oscillation version, on-chip EEPROM
	μPD789860											On-chip EEPROM
	μPD789862	16 K	1 ch	2 ch					1 ch (UART: 1 ch)	22		
VFD drive	μPD789871	4 K to 8 K	3 ch	–	1 ch	1 ch	–	–	1 ch	33	2.7 V	–
Meter control	μPD789881	16 K	2 ch	1 ch	–	1 ch	–	–	1 ch (UART: 1 ch)	28	2.7 V[Note 2]	–

Notes 1. 10-bit timer: 1 channel

2. Flash memory version: 3.0 V

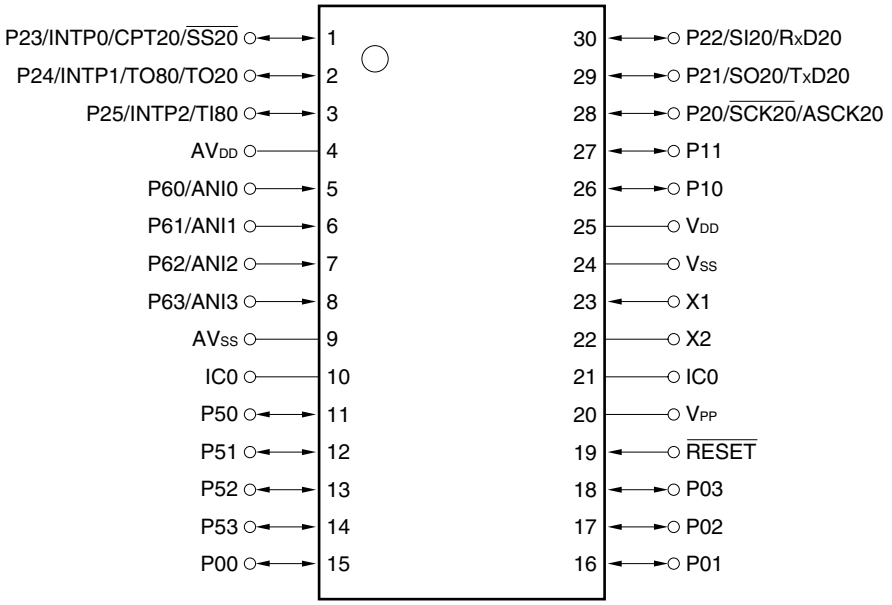
OVERVIEW OF FUNCTIONS

Item		function
Internal memory	Flash memory	16 KB
	High-speed RAM	256 bytes
Minimum instruction execution time		0.2/0.8 μs (@ 10.0 MHz operation with system clock, V_{DD} = 4.5 to 5.5 V)
General-purpose registers		8 bits × 8 registers
Instruction set		• 16-bit operations • Bit manipulations (set, reset, and test)
Multiplier		8 bits × 8 bits = 16 bits
I/O ports		Total: 20 • CMOS input: 4 • CMOS I/O: 12 • N-ch open-drain (12 V withstand voltage): 4
A/D converters		10-bit resolution × 4 channels
Serial interface		Switchable between 3-wire serial I/O and UART modes
Timer		• 16-bit timer: 1 channel • 8-bit timer/event counter: 1 channel • Watchdog timer: 1 channel
Timer output		1 output (16-bit/8-bit timer alternate function)
Vectored interrupt sources	Maskable	Internal: 6, External: 3
	Non-maskable	Internal: 1
Power supply voltage		V_{DD} = 1.8 to 5.5 V
Operating ambient temperature		T_A = –40 to +85°C
Package		30-pin plastic SSOP (7.62 mm (300))

CONTENTS

1. PIN CONFIGURATION (TOP VIEW)

- 30-pin plastic SSOP (7.62 mm (300))
  μPD78F9116BMC-5A4
  μPD78F9116BMC(A)-5A4



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

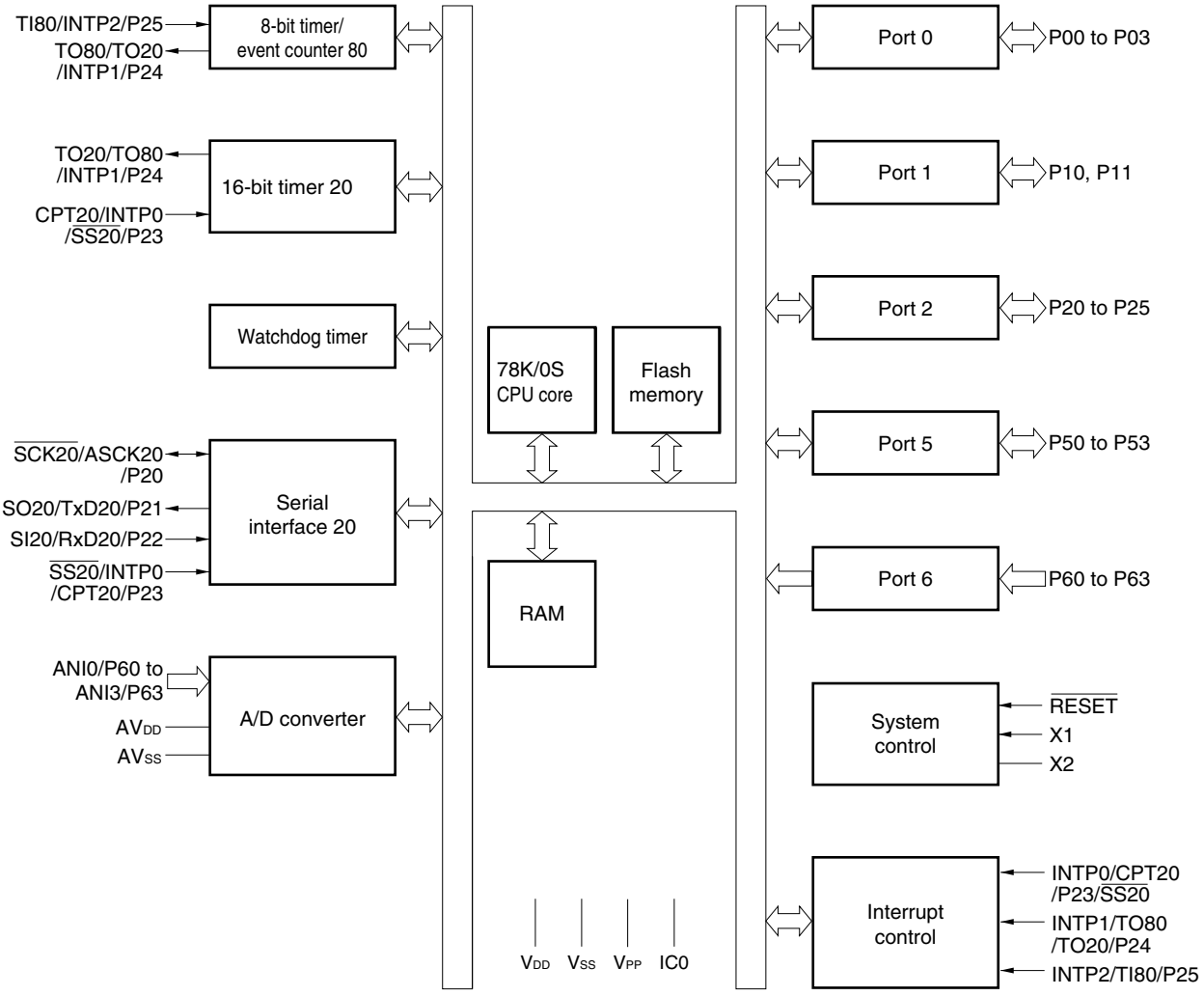
2. Connect the V_{PP} pin directly to V_{SS} in normal operation mode.

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

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

ANI0 to ANI3:	Analog input	$\overline{\text{RESET}}$:	Reset
ASCK20:	Asynchronous serial input	RxD20:	Receive data
AV_{DD}:	Analog power supply	$\overline{\text{SCK20}}$:	Serial clock input/output
AV_{SS}:	Analog ground	SI20:	Serial data input
CPT20:	Capture trigger input	SO20:	Serial data output
IC0:	Internally connected	$\overline{\text{SS20}}$:	Chip select input
INTP0 to INTP2:	Interrupt from peripherals	TI80:	Timer input
P00 to P03:	Port0	TO20, TO80:	Timer output
P10, P11:	Port1	TxD20:	Transmit data
P20 to P25:	Port2	V_{DD}:	Power supply
P50 to P53:	Port5	V_{PP}:	Programming power supply
P60 to P63:	Port6	V_{SS}:	Ground
		X1, X2:	Crystal 1, 2

2. BLOCK DIAGRAM



3. DIFFERENCES BETWEEN μPD78F9116B, 78F9116B(A), AND MASK ROM VERSIONS

The μPD78F9116B and 78F9116B(A) are products in which flash memory is substituted for the internal ROM of the mask ROM version. The differences between the μPD78F9116B, 78F9116B(A), and the mask ROM versions are shown in Table 3-1.

Table 3-1. Differences Between μPD78F9116B, 78F9116B(A), and Mask ROM Versions

Item		Flash Memory Version	Mask ROM Version		
		μPD78F9116B μPD78F9116B(A)	μPD789111A μPD789111A(A)	μPD789112A μPD789112A(A)	μPD789114A μPD789114A(A)
Internal memory	ROM	16 KB (Flash memory)	2 KB	4 KB	8 KB
	High-speed RAM	256 bytes			
Pull-up resistor		12 (software control only)	16 (software control: 12, mask option specification: 4)		
V_{PP} pin		Provided	Not provided		
Electric characteristics		See the relevant data sheet			

Caution There are differences in noise immunity and noise radiation between the flash memory and mask ROM versions. When pre-producing an application set with the flash memory version and then mass-producing it with the mask ROM version, be sure to conduct sufficient evaluations for the commercial samples (not engineering samples) of the mask ROM version.

4. PIN FUNCTIONS

4.1 Port Pins

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

4.2 Non-Port Pins

Pin Name	I/O	Function	After Reset	Alternate Function
INTP0	Input	External interrupt request input for which the valid edge (rising edge, falling edge, or both rising and falling edges) can be specified	Input	P23/CPT20/$\overline{SS20}$
INTP1				P24/TO80/TO20
INTP2				P25/TI80
SI20	Input	Serial interface serial data input	Input	P22/RxD20
SO20	Output	Serial interface serial data output	Input	P21/TxD20
$\overline{SCK20}$	I/O	Serial interface serial clock input/output	Input	P20/ASCK20
ASCK20	Input	Serial clock input for asynchronous serial interface	Input	P20/$\overline{SCK20}$
$\overline{SS20}$	Input	Chip select input for serial interface	Input	P23/CPT20/INTP0
RxD20	Input	Serial data input for asynchronous serial interface	Input	P22/SI20
TxD20	Output	Serial data output for asynchronous serial interface	Input	P21/SO20
TI80	Input	External count clock input to 8-bit timer/event counter 80	Input	P25/INTP2
TO80	Output	8-bit timer/event counter 80 output	Input	P24/INTP1/TO20
TO20	Output	16-bit timer 20 output	Input	P24/INTP1/TO80
CPT20	Input	Capture edge input	Input	P23/INTP0/$\overline{SS20}$
ANI0 to ANI3	Input	A/D converter analog input	Input	P60 to P63
AV_{DD}	-	A/D converter analog power supply	–	–
AV_{SS}	-	A/D converter ground potential	–	–
X1	Input	Connecting crystal resonator for main system clock oscillation	–	–
X2	-		–	–
$\overline{RESET}$	Input	System reset input	Input	–
V_{DD}	-	Positive power supply	–	–
V_{SS}	-	Ground potential	–	–
V_{PP}	-	Sets flash memory programming mode. Applies high voltage when a program is written or verified.	–	–
IC0	-	Internally connected. Connect directly to V_{SS}.	–	–

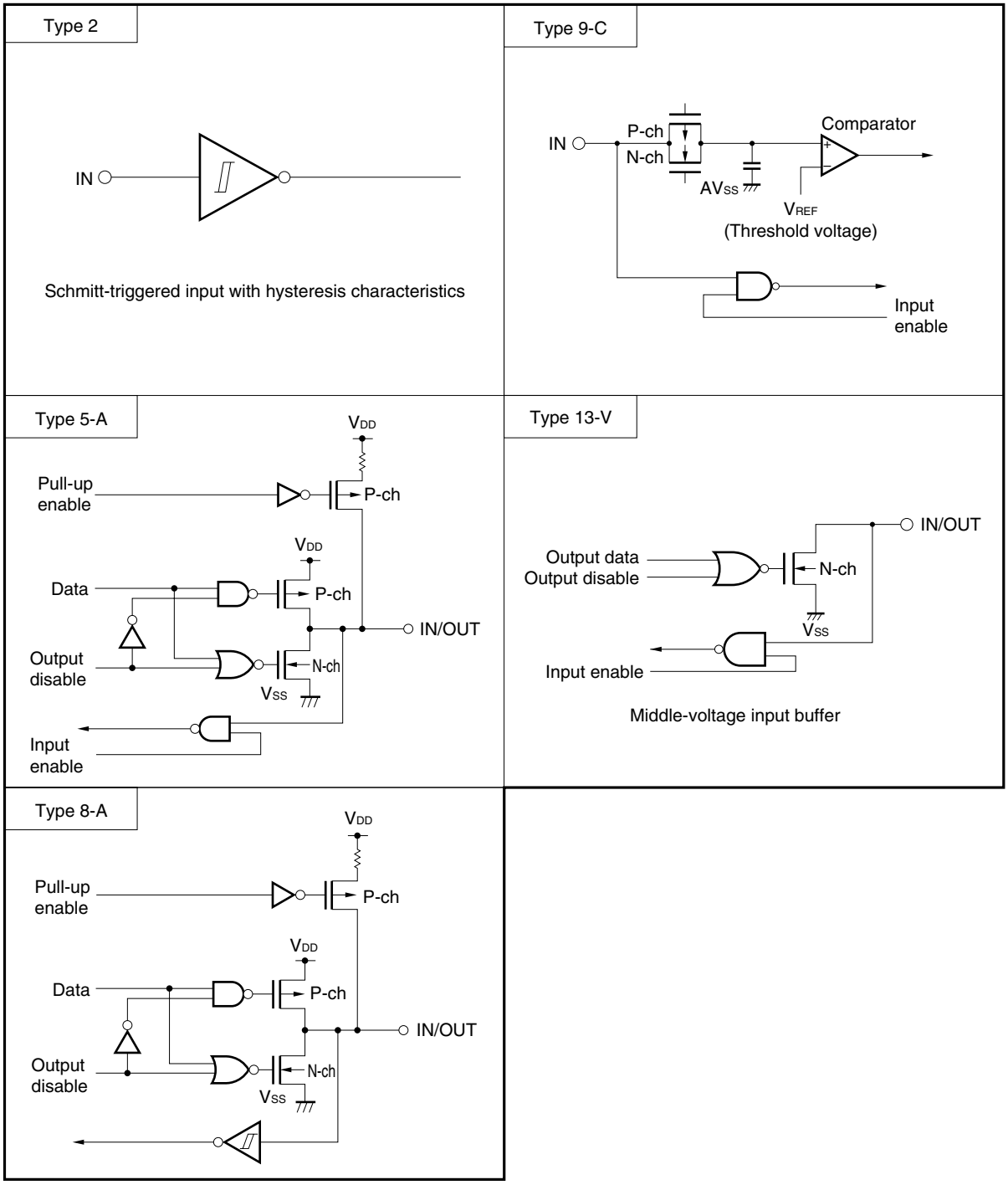
4.3 Pin I/O Circuits and Recommended Connection of Unused Pins

The input/output circuit type of each pin and recommended connection of unused pins are shown in Table 4-1. For the input/output circuit configuration of each type, refer to Figure 4-1.

Table 4-1. Types of Pin Input/Output Circuits

Pin Name	Input/Output Circuit Type	I/O	Recommended Connection of Unused Pins
P00 to P03	5-A	I/O	Input: Independently connect to V_{DD} or V_{SS} via a resistor. Output: Leave open
P10, P11			
P20/$\overline{SCK20}$/ASCK20	8-A		
P21/SO20/TxD20			
P22/SI20/RxD20			
P23/INTP0/CPT20/$\overline{SS20}$			Input: Independently connect to V_{SS} via a resistor. Output: Leave open
P24/INTP1/TO80/TO20			
P25/INTP2/TI80			
P50 to P53	13-V		Input: Independently connect to V_{DD} via a resistor. Output: Leave open
P60/ANI0 to P63/ANI3	9-C	Input	Connect directly to V_{DD} or V_{SS}.
AV_{DD}	–	–	Connect directly to V_{DD}.
AV_{SS}			Connect directly to V_{SS}.
$\overline{RESET}$	2	Input	–
IC0	–	–	Connect directly to V_{SS}.
V_{PP}			Connect a 10 kΩ pull-down resistor or connect directly to V_{SS}.

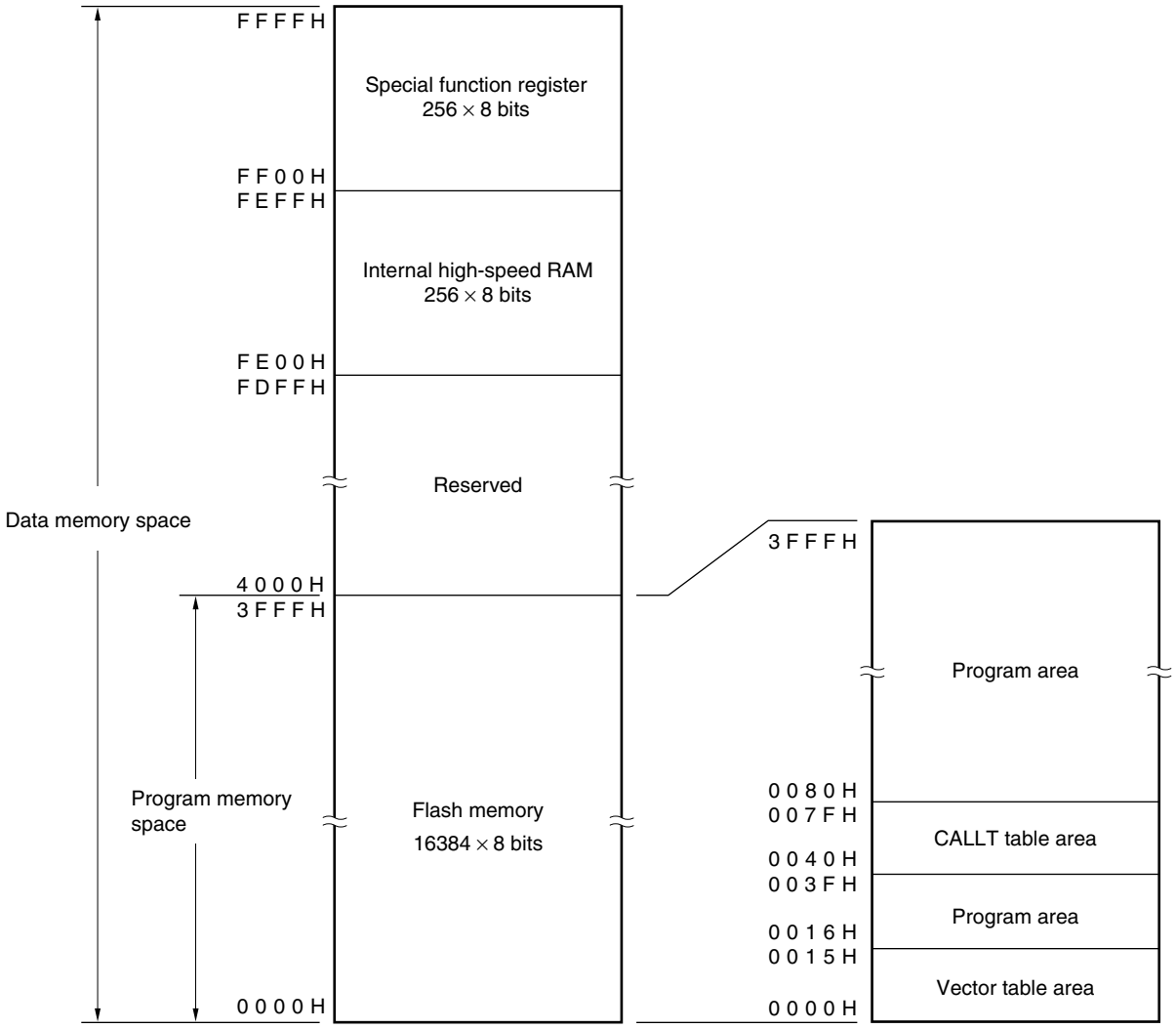
Figure 4-1. Pin I/O Circuits



5. MEMORY SPACE

Figure 5-1 shows the memory map of the μPD78F9116B and 78F9116B(A).

Figure 5-1. Memory Map



6. FLASH MEMORY CHARACTERISTICS

Flash memory programming is performed by connecting a dedicated flash programmer (Flashpro III (part no. FL-PR3, PG-FP3)/Flashpro IV[Note] (part no. FL-PR4, PG-FP4)) to the target system with the flash memory mounted on the target system (on-board). A flash memory writing adapter (program adapter), which is a target board used exclusively for programming, is also provided.

Note Under development

Remark FL-PR3, FL-PR4, and the program adapter are the products made by Naito Densei Machida Mfg. Co., Ltd. (TEL +81-45-475-4191).

Programming using flash memory has the following advantages.

- Software can be modified after the microcontroller is solder-mounted on the target system.
- Distinguishing software facilities low-quantity, varied model production
- Easy data adjustment when starting mass production

6.1 Programming Environment

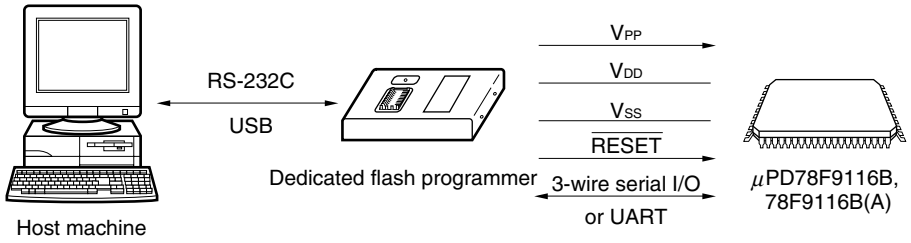
The following shows the environment required for μPD78F9116B and 78F9116B(A) flash memory programming.

When Flashpro III (part no. FL-PR3, PG-FP3) or Flashpro IV (Part no. FL-PR4, PG-FP4) is used as a dedicated flash programmer, a host machine is required to control the dedicated flash programmer. Communication between the host machine and flash programmer is performed via RS-232C/USB (Rev. 1.1).

For details, refer the manuals for Flashpro III/Flashpro IV.

Remark USB is supported by Flashpro IV only.

Figure 6-1. Environment for Writing Program to Flash Memory



6.2 Communication Mode

Use the communication mode shown in Table 6-1 to perform communication between the dedicated flash programmer and the μPD78F9116B or 78F9116B(A).

Table 6-1. Communication Mode List

Communication Mode	TYPE Setting[Note 1]					Pins used	Number of V_{PP} pulses
	COMM PORT	SIO clock	CPU clock	Flash clock	Multiple rate		
3-wire serial I/O (SIO3)	SIO ch-0 (3-wire, sync.)	100 Hz to 1.25 MHz[Note 2]	Optional	1 to 10 MHz[Note 2]	1.0	$\overline{SCK20}$/ASCK20/P20 SO20/TxD20/P21 SI20/RxD20/P22	0
	SIO ch-1 (3-wire, sync.)					P00 P01 P02	1
UART (UART0)	UART ch-0	4800 to 76800 bps[Note 2, 3]	Optional	1 to 10 MHz[Note 2]		TxD20/SO20/P21 RxD20/SI20/P22	8

Notes 1. Selection items for TYPE settings on the dedicated flash programmer (Flashpro III (part no. FL-PR3, PG-FP3)/Flashpro IV (Part no. FL-PR4, PG-FP4)).

2. The possible setting range differs depending on the voltage. For details, refer to **8. ELECTRICAL SPECIFICATIONS**.

Caution Be sure to select a communication mode depending on the number of V_{PP} pulses shown in Table 6-1.

Figure 6-2. Communication Mode Selection Format

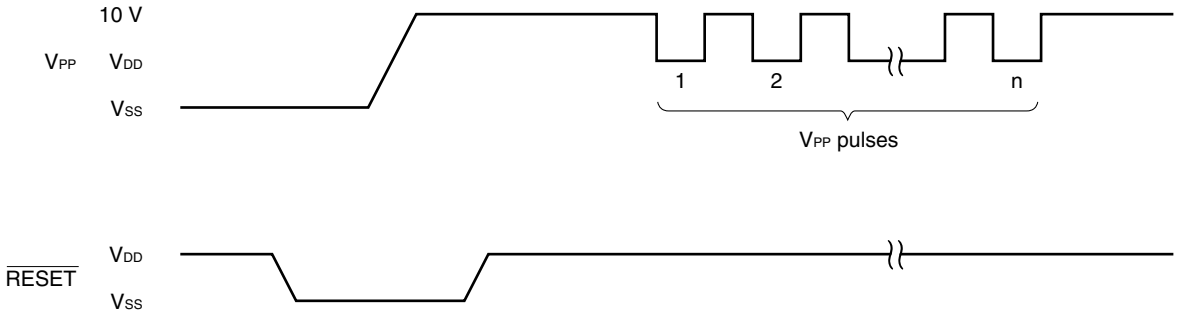
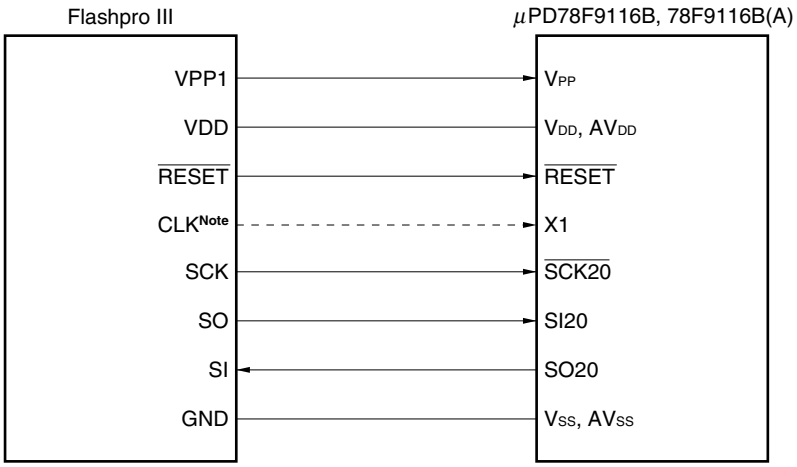
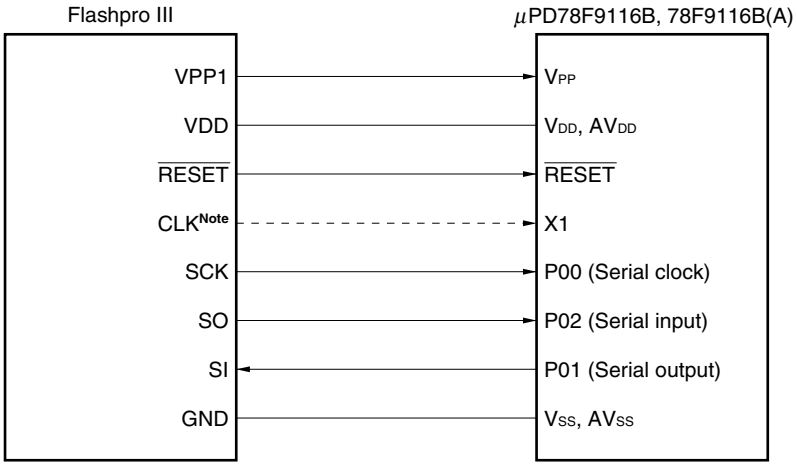


Figure 6-3. Example of Connection with Dedicated Flash Programmer

(a) 3-Wired Serial I/O Mode (SIO ch-0)



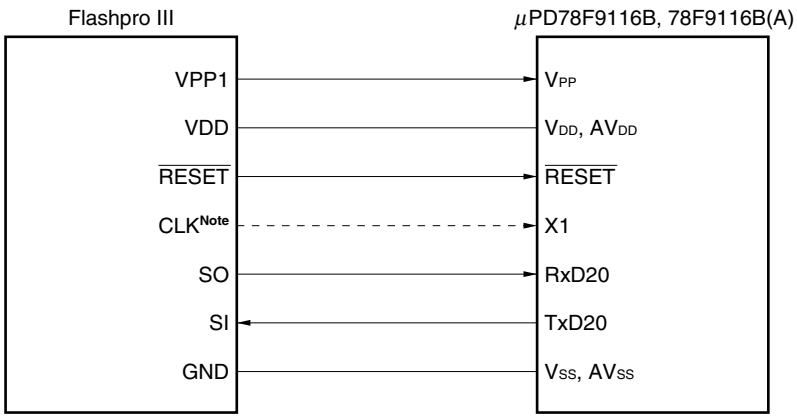
(b) 3-Wired Serial I/O Mode (SIO ch-1)



Note Connect this pin when the system clock is supplied by Flashpro III. When a resonator has already been connected to the X1 pin, the CLK pin does not need to be connected.

Caution The V_{DD} pin, if already connected to the power supply, must be connected to the VDD pin of the dedicated flash programmer. Before using the power supply connected to the V_{DD} pin, supply voltage before starting programming.

(c) UART Mode



Note Connect this pin when the system clock is supplied by Flashpro III. When a resonator has already been connected to the X1 pin, the CLK pin does not need to be connected.

Caution The V_{DD} pin, if already connected to the power supply, must be connected to the VDD pin of the dedicated flash programmer. Before using the power supply connected to the V_{DD} pin, supply voltage before starting programming.

If Flashpro III (part no. FL-PR3, PG-FP3)/Flashpro IV is used as a dedicated flash programmer, the following signals are generated for the μPD78F9116B and 78F9116B(A). For details, refer to the manual of Flashpro III/Flashpro IV.

Table 6-2. Pin Connection List

Signal Name	I/O	Pin Function	Pin Name	3-Wire Serial I/O	UART
VPP1	Output	Write voltage	V_{PP}	◎	◎
VPP2	–	–		×	×
VDD	I/O	V_{DD} voltage generation/voltage monitoring	V_{DD}/AV_{DD}	◎Note	◎Note
GND	–	Ground	V_{SS}/AV_{SS}	◎	◎
CLK	Output	Clock output	X1	○	○
RESET	Output	Reset signal	$\overline{RESET}$	◎	◎
SI	Input	Reception signal	SO20/P01/TxD20	◎	◎
SO	Output	Transmit signal	SI20/P02/RxD20	◎	◎
SCK	Output	Transfer clock	SCK20/P00	◎	×
HS	–	–	–	×	×

Note V_{DD} voltage must be supplied before programming is started.

Remark ◎: Pin must be connected.
○: If the signal is supplied on the target board, pin need not be connected.
×: Pin need not be connected.

6.3 On-Board Pin Processing

When performing programming on the target system, provide a connector on the target system to connect the dedicated flash programmer.

An on-board function that allows switching between normal operation mode and flash memory programming mode may be required in some cases.

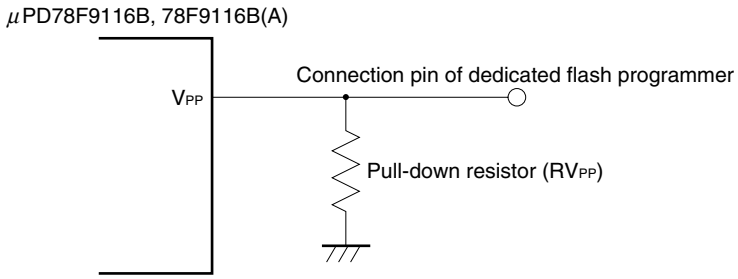
<V_{PP} pin>

In normal operation mode, input 0 V to the V_{PP} pin. In flash memory programming mode, a write voltage of 10.0 V (TYP.) is supplied to the V_{PP} pin, so perform the following.

(1) Connect a pull-down resistor (RV_{PP} = 10 kΩ) to the V_{PP} pin.
(2) Use the jumper on the board to switch the V_{PP} pin input to either the writer or directly to GND.

A V_{PP} pin connection example is shown below.

Figure 6-4. V_{PP} Pin Connection Example



<Serial interface pin>

The following shows the pins used by the serial interface.

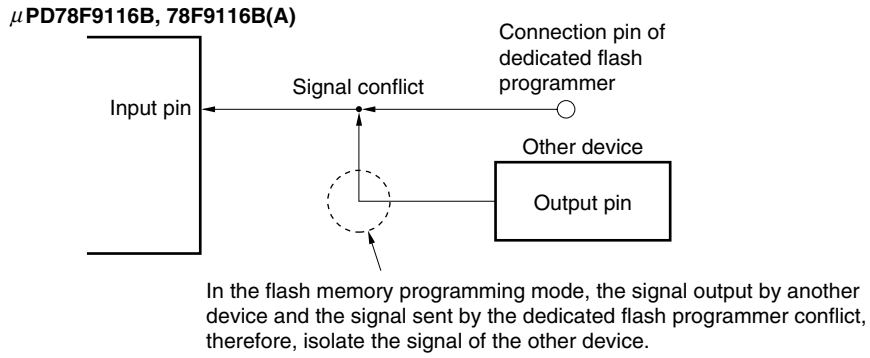
Serial Interface	Pins Used
3-wire serial I/O (SIO3)	$\overline{SCK20}$, SO20, SI20
	P00, P01, P02
UART	TxD20, RxD20

When connecting the dedicated flash programmer a serial interface pin that is connected to another device on-board, signal conflict or abnormal operation of the other devices may occur. Care must therefore be taken with such connections.

(1) Signal conflict

If the dedicated flash programmer (output) is connected to a serial interface pin (input) that is connected to another device (output), a signal conflict occurs. To prevent this, isolate the connection with the other device or set the other device to the output high impedance status.

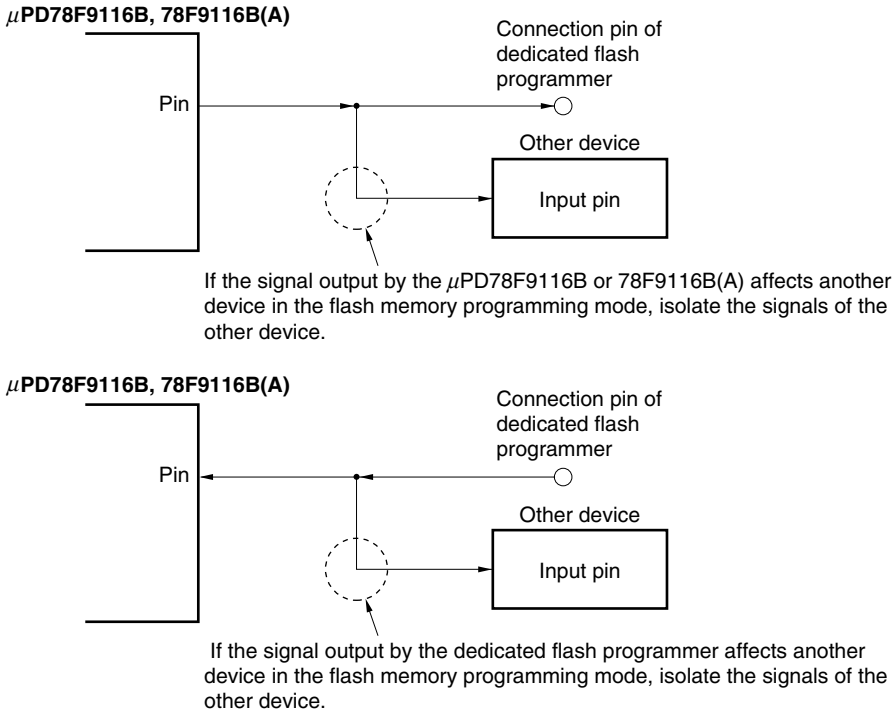
Figure 6-5. Signal Conflict (Input Pin of Serial Interface)



(2) Abnormal operation of other device

If the dedicated flash programmer (output or input) is connected to a serial interface pin (input or output) that is connected to another device (input), a signal is output to the device, and this may cause an abnormal operation. To prevent this abnormal operation, isolate the connection with the other device or set so that the input signals to the other device are ignored.

Figure 6-6. Abnormal Operation of Other Device

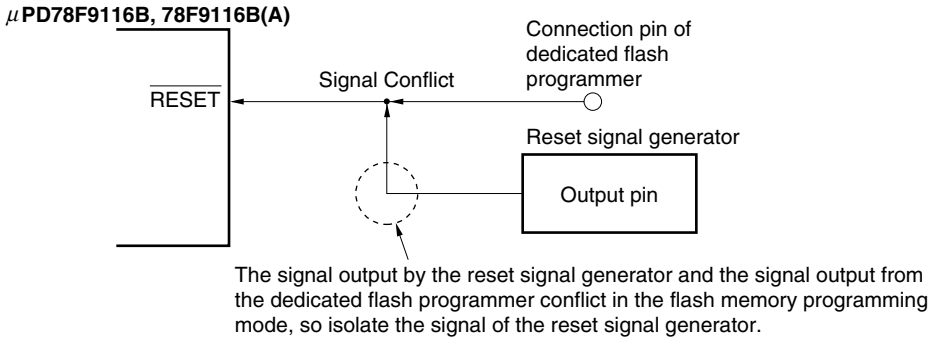


<$\overline{\text{RESET}}$ pin>

If the reset signal of the dedicated flash programmer is connected to the $\overline{\text{RESET}}$ pin connected to the reset signal generator on-board, a signal conflict occurs. To prevent this, isolate the connection with the reset signal generator.

If the reset signal is input from the user system in the flash memory programming mode, a normal programming operation cannot be performed. Therefore, do not input reset signals from other than the dedicated flash programmer.

Figure 6-7. Signal Conflict ($\overline{\text{RESET}}$ Pin)



<Port pins>

When the μPD78F9116B or 78F9116B(A) enters the flash memory programming mode, all the pins other than those that communicate in flash memory programming are in the same status as immediately after reset.

If the external device does not recognize initial statuses such as the output high impedance status, therefore, connect the external device to V_{DD} or V_{SS}.

<Oscillation pins>

When using the on-board clock, connect X1 and X2 as required in the normal operation mode.

When using the clock output of the flash programmer, connect it directly to X1, disconnecting the main resonator on-board, and leave the X2 pin open.

<Power supply>

When using the power supply output of the flash programmer, connect the V_{DD} and V_{SS} pins to VDD and GND of the flash programmer, respectively.

When using the on-board power supply, connect it as required in the normal operation mode. Because the flash programmer monitors the voltage, however, VDD of the flash programmer must be connected.

For the other power pins (AV_{DD} and A_{SS}), supply the same power supply as in the normal operation mode.

6.4 Connection When Using Flash Memory Writing Adapter

The following shows an example of the recommended connection when using the flash memory writing adapter.

Figure 6-8. Example of Flash Memory Writing Adapter Connection When Using 3-Wire Serial I/O Mode (SIO-ch0)

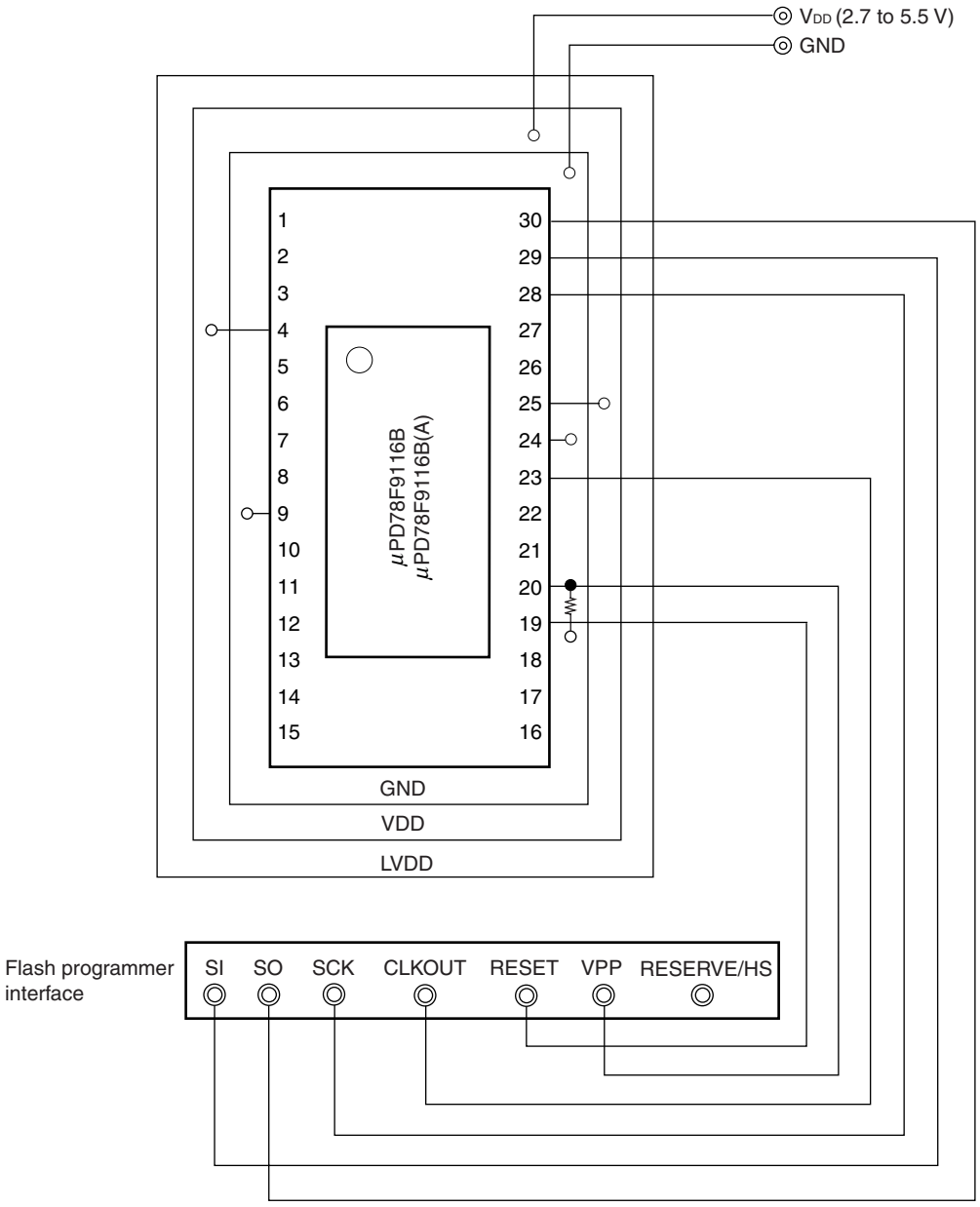


Figure 6-9. Example of Flash Memory Writing Adapter Connection When Using 3-Wire Serial I/O Mode (SIO-ch1)

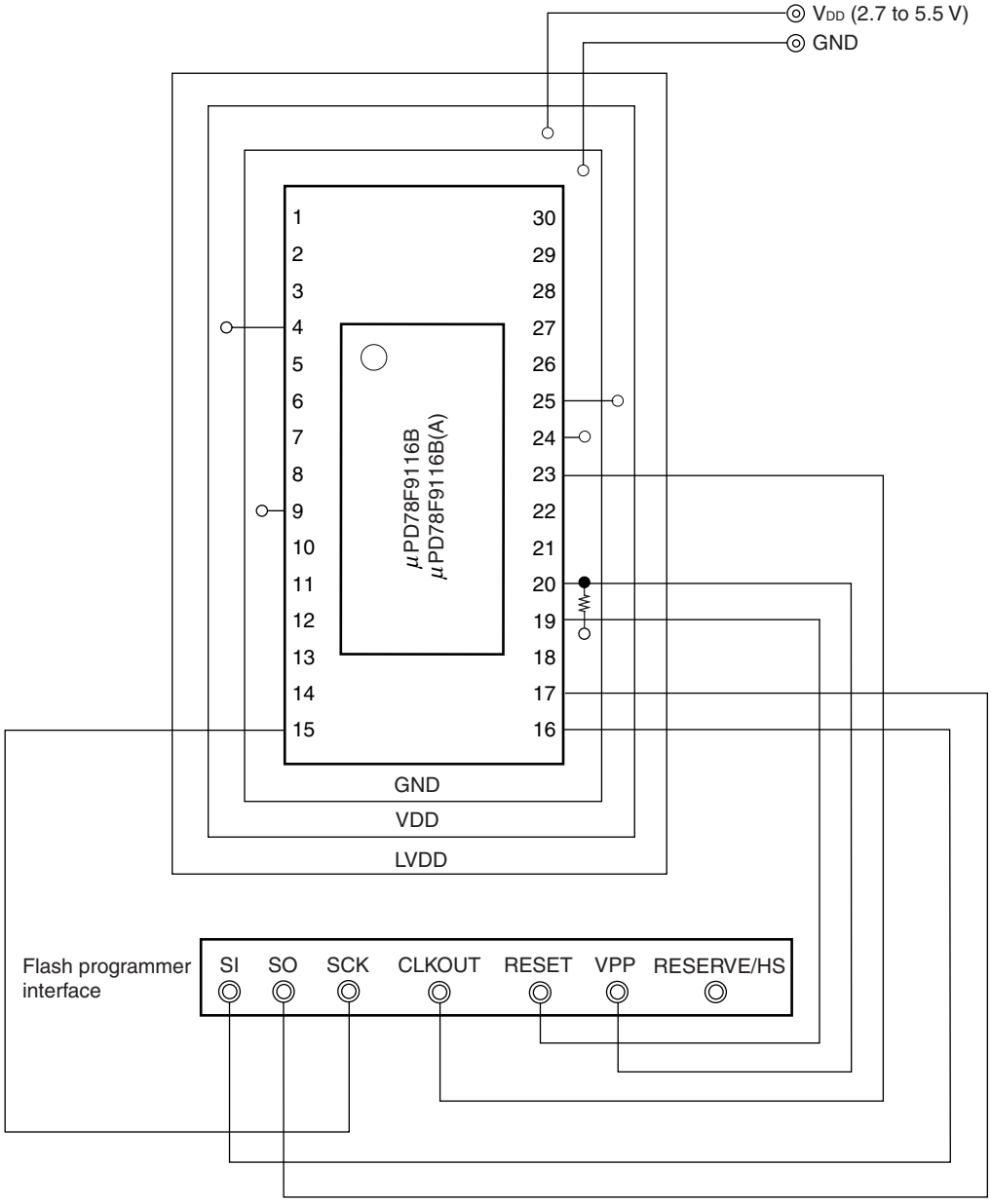
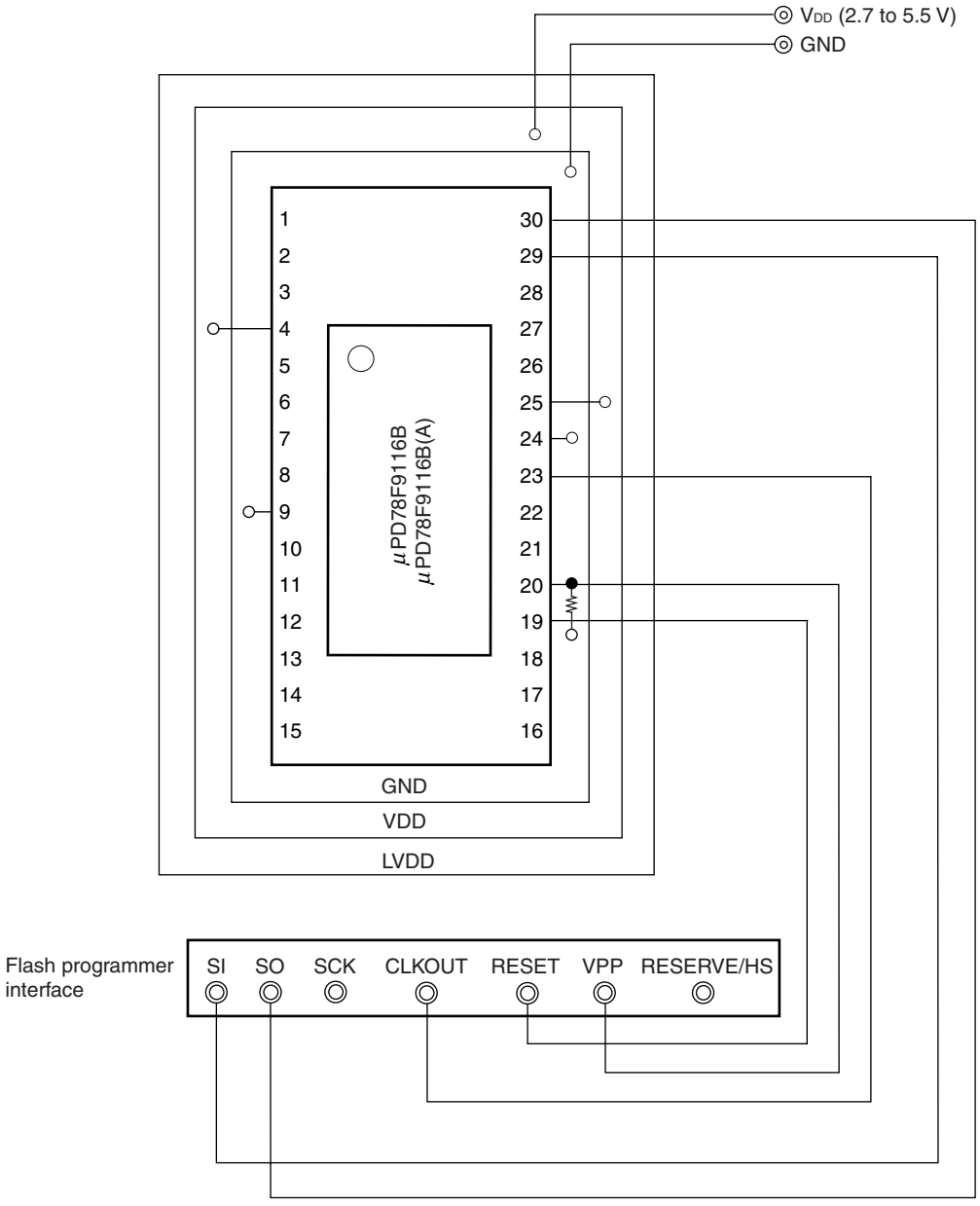


Figure 6-10. Example of Flash Memory Writing Adapter Connection When Using UART Mode



7. INSTRUCTION SET OVERVIEW

This section shows a list of the instruction set for the μPD78F9116B and 78F9116B(A).

7.1 Conventions

7.1.1 Operand identifiers and description methods

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

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

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

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

Table 7-1. Operand Identifiers and Description Methods

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

7.1.2 Descriptions of the operation field

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

7.1.3 Description of the flag operation field

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

7.2 Operations

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

Notes 1. Except r = A

2. Except r = A or X

3. Only when rp = BC, DE, HL

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

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

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

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

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

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

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

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

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

8. ELECTRICAL SPECIFICATIONS

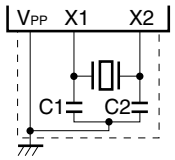
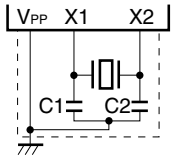
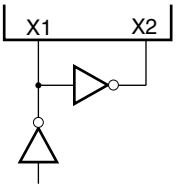
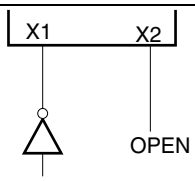
Absolute Maximum Ratings (T_A = 25°C)

Parameter	Symbol	Conditions		Ratings	Unit
Supply voltage	V_{DD}, AV_{DD}	V_{DD} = AV_{DD}		–0.3 to +6.5	V
	V_{PP}			–0.3 to +10.5	V
Input voltage	V_{I1}	Pins other than P50 to P53		–0.3 to V_{DD} + 0.3	V
	V_{I2}	P50 to P53	With N-ch open drain	–0.3 to +13	V
Output voltage	V_O			–0.3 to V_{DD} + 0.3	V
Output current, high	I_{OH}	Per pin	μPD78F9116B	–10	mA
		Total for all pins		–30	mA
		Per pin	μPD78F9116B(A)	10	mA
		Total for all pins		120	mA
Output current, low	I_{OL}	Per pin	μPD78F9116B	30	mA
		Total for all pins		160	mA
		Per pin	μPD78F9116B(A)	–7	mA
		Total for all pins		–22	mA
Operating ambient temperature	T_A	In normal operation mode		–40 to +85	°C
		During flash memory programming		10 to 40	°C
Storage temperature	T_{stg}			–40 to +125	°C

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

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

System Clock Oscillator Characteristics (T_A = –40 to +85°C, V_{DD} = 1.8 to 5.5 V)

Resonator	Recommended Circuit	Parameter	Conditions	MIN.	TYP.	MAX.	Unit
Ceramic resonator		Oscillation frequency (f_X)[Note 1]	V_{DD} = 4.5 to 5.5 V	1.0		10.0	MHz
			V_{DD} = 3.0 to 5.5 V	1.0		6.0	MHz
			V_{DD} = 1.8 to 5.5 V	1.0		5.0	MHz
		Oscillation stabilization time[Note 2]	After V_{DD} reaches oscillation voltage range MIN.			4	ms
Crystal resonator		Oscillation frequency (f_X)[Note 1]	V_{DD} = 4.5 to 5.5 V	1.0		10.0	MHz
			V_{DD} = 3.0 to 5.5 V	1.0		6.0	MHz
			V_{DD} = 1.8 to 5.5 V	1.0		5.0	MHz
		Oscillation stabilization time[Note 2]	V_{DD} = 4.5 to 5.5 V			10	ms
			V_{DD} = 1.8 to 5.5 V			30	
External clock		X1 input frequency (f_X)[Note 1]	V_{DD} = 4.5 to 5.5 V	1.0		10.0	MHz
			V_{DD} = 3.0 to 5.5 V	1.0		6.0	MHz
			V_{DD} = 1.8 to 5.5 V	1.0		5.0	MHz
		X1 input high-/low-level width (t_{XH}, t_{XL})	V_{DD} = 4.5 to 5.5 V	45		500	ns
			V_{DD} = 3.0 to 5.5 V	75		500	ns
			V_{DD} = 1.8 to 5.5 V	85		500	ns
		X1 input frequency (f_X)[Note 1]	V_{DD} = 2.7 to 5.5 V	1.0		5.0	MHz
		X1 input high-/low-level width (t_{XH}, t_{XL})		85		500	ns

Notes 1. Indicates only oscillator characteristics. Refer to **AC characteristics** for instruction execution time.

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

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

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

Remark For the resonator selection and oscillator constant, customers are requested to either evaluate the oscillation themselves or apply to the resonator manufacturer for evaluation.

DC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.8 to 5.5 V) (1/2)

Parameter	Symbol	Conditions			MIN.	TYP.	MAX.	Unit
Output current, high	I_{OH}	Per pin	μPD78F9116B				–1	mA
		Total for all pins					–15	mA
		Per pin	μPD78F9116B(A)				–1	mA
		Total for all pins					–11	mA
Output current, low	I_{OL}	Per pin	μPD78F9116B				10	mA
		Total for all pins					80	mA
		Per pin	μPD78F9116B(A)				3	mA
		Total for all pins					60	mA
Input voltage, high	V_{IH1}	Pins other than described below		V_{DD} = 2.7 to 5.5 V	0.7 V_{DD}		V_{DD}	V
				V_{DD} = 1.8 to 5.5 V	0.9 V_{DD}		V_{DD}	V
	V_{IH2}	P50 to P53	N-ch open drain	V_{DD} = 2.7 to 5.5 V	0.7 V_{DD}		12	V
				V_{DD} = 1.8 to 5.5 V, T_A = 25 to 85 °C	0.9 V_{DD}		12	V
	V_{IH3}	$\overline{\text{RESET}}$, P20 to P25		V_{DD} = 2.7 to 5.5 V	0.8 V_{DD}		V_{DD}	V
				V_{DD} = 1.8 to 5.5 V	0.9 V_{DD}		V_{DD}	V
	V_{IH4}	X1, X2		V_{DD} = 4.5 to 5.5 V	V_{DD} – 0.5		V_{DD}	V
				V_{DD} = 1.8 to 5.5 V	V_{DD} – 0.1		V_{DD}	V
Input voltage, low	V_{IL1}	Pins other than described below		V_{DD} = 2.7 to 5.5 V	0		0.3 V_{DD}	V
				V_{DD} = 1.8 to 5.5 V	0		0.1 V_{DD}	V
	V_{IL2}	P50 to P53	N-ch open drain	V_{DD} = 2.7 to 5.5 V	0		0.3 V_{DD}	V
				V_{DD} = 1.8 to 5.5 V, T_A = 25 to 85 °C	0		0.1 V_{DD}	V
	V_{IL3}	$\overline{\text{RESET}}$, P20 to P25		V_{DD} = 2.7 to 5.5 V	0		0.2 V_{DD}	V
				V_{DD} = 1.8 to 5.5 V	0		0.1 V_{DD}	V
	V_{IL4}	X1, X2		V_{DD} = 4.5 to 5.5 V	0		0.4	V
				V_{DD} = 1.8 to 5.5 V	0		0.1	V
Output voltage, high	V_{OH1}	V_{DD} = 4.5 to 5.5 V, I_{OH} = –1 mA			V_{DD} – 1.0			V
	V_{OH2}	V_{DD} = 1.8 to 5.5 V, I_{OH} = –100 μA			V_{DD} – 0.5			V
Output voltage, low	V_{OL1}	Pins other than P50 to P53	V_{DD} = 4.5 to 5.5 V, I_{OL} = 10 mA (μPD78F9116B)				1.0	V
			V_{DD} = 4.5 to 5.5 V, I_{OL} = 3 mA (μPD78F9116B(A))				1.0	V
			V_{DD} = 1.8 to 5.5 V, I_{OL} = 400 μA				0.5	V
	V_{OL2}	P50 to P53	V_{DD} = 4.5 to 5.5 V, I_{OL} = 10 mA (μPD78F9116B)				1.0	V
			V_{DD} = 4.5 to 5.5 V, I_{OL} = 3 mA (μPD78F9116B(A))				1.0	V
			V_{DD} = 1.8 to 5.5 V, I_{OL} = 1.6 mA				0.4	V

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

DC Characteristics (T_A = –40 to +85°C, V_{DD} = 1.8 to 5.5 V) (2/2)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Input leakage current, high	I_{LIH1}	Pins other than X1, X2, or P50 to P53	$V_{IN} = V_{DD}$			3	μA
	I_{LIH2}	X1, X2				20	μA
	I_{LIH3}	P50 to P53 (N-ch open drain)	V_{IN} = 12 V			20	μA
Input leakage current, low	I_{LIL1}	Pins other than X1, X2, or P50 to P53	V_{IN} = 0 V			–3	μA
	I_{LIL2}	X1, X2				–20	μA
	I_{LIL3}	P50 to P53 (N-ch open drain)				–3 Note 1	μA
Output leakage current, high	I_{LOH}	$V_{OUT} = V_{DD}$				3	μA
Output leakage current, low	I_{LOL}	V_{OUT} = 0 V				–3	μA
Software pull-up resistor	R_1	V_{IN} = 0 V, for pins other than P50 to P53		50	100	200	kΩ
Power supply current	I_{DD1} Note 2	10.0 MHz crystal oscillation operating mode	V_{DD} = 5.0 V±10% Note 4		10.0	20.0	mA
		6.0 MHz crystal oscillation operating mode	V_{DD} = 5.0 V±10% Note 4		6.0	12.0	mA
		5.0 MHz crystal oscillation operating mode (C1 = C2 = 22 pF)	V_{DD} = 5.0 V±10% Note 4		4.0	10.0	mA
			V_{DD} = 3.0 V±10% Note 5		1.0	2.5	mA
			V_{DD} = 2.0 V±10% Note 5		0.8	2.0	mA
	I_{DD2} Note 2	10.0 MHz crystal oscillation HALT mode	V_{DD} = 5.0 V±10% Note 4		1.2	6.0	mA
		6.0 MHz crystal oscillation HALT mode	V_{DD} = 5.0 V±10% Note 4		0.9	2.8	mA
		5.0 MHz crystal oscillation HALT mode (C1 = C2 = 22 pF)	V_{DD} = 5.0 V±10% Note 4		0.6	2.5	mA
			V_{DD} = 3.0 V±10% Note 5		0.3	2.0	mA
			V_{DD} = 2.0 V±10% Note 5		0.2	1.5	mA
	I_{DD3} Note 2	STOP mode	V_{DD} = 5.0 V±10%		0.1	30	μA
			V_{DD} = 3.0 V±10%		0.05	10	μA
			V_{DD} = 2.0 V±10%		0.05	10	μA
	I_{DD4} Note 3	10.0 MHz crystal oscillation A/D operating mode	V_{DD} = 5.0 V±10% Note 4		11.0	22.5	mA
		6.0 MHz crystal oscillation A/D operating mode	V_{DD} = 5.0 V±10% Note 4		7.0	14.5	mA
		5.0 MHz crystal oscillation A/D operating mode (C1 = C2 = 22 pF)	V_{DD} = 5.0 V±10% Note 4		5.0	12.5	mA
			V_{DD} = 3.0 V±10% Note 5		2.0	5.0	mA
			V_{DD} = 2.0 V±10% Note 5		1.8	4.5	mA

Notes 1. When port 5 is in input mode, a low-level input leakage current of –60 μA (MAX.) flows only for 1 cycle time after a read instruction has been executed to port 5.

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

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

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

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

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

Flash Memory Write/Erase Characteristics (T_A = 10 to 40°C, V_{DD} = 1.8 to 5.5 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Operating frequency	f_X	V_{DD} = 4.5 to 5.5 V	1.0		10.0	MHz
		V_{DD} = 3.0 to 5.5 V	1.0		6.0	MHz
		V_{DD} = 2.7 to 5.5 V	1.0		5.0	MHz
		V_{DD} = 1.8 to 5.5 V	1.0		1.25	MHz
Write current (V_{DD} pin) Note	I_{DDW}	When V_{PP} supply voltage = V_{PP1} (5.0 MHz crystal oscillation operating mode)			21	mA
Write current (V_{PP} pin) Note	I_{PPW}	When V_{PP} supply voltage = V_{PP1}			22.5	mA
Erase current (V_{DD} pin) Note	I_{DDE}	When V_{PP} supply voltage = V_{PP1} (5.0 MHz crystal oscillation operating mode)			3	mA
Erase current (V_{PP} pin) Note	I_{PPE}	When V_{PP} supply voltage = V_{PP1}			115	mA
Unit erase time	t_{er}		0.2	0.2	0.2	s
Total erase time	t_{era}				20	s
Write count		Erase/write are regarded as 1 cycle			20	Times
V_{PP} supply voltage	V_{PP0}	In normal operation	0		0.2V_{DD}	V
	V_{PP1}	During flash memory programming	9.7	10.0	10.3	V

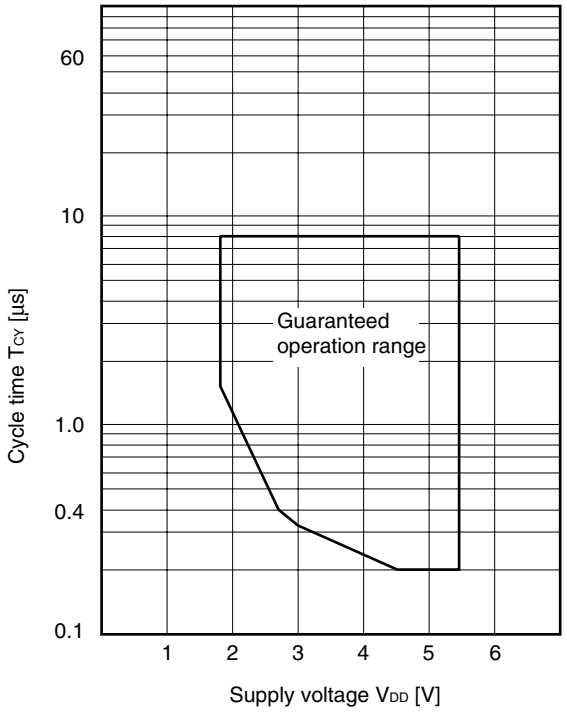
Note The current flowing to the ports (including the current flowing through an on-chip pull-up resistor) and AV_{DD} current are not included.

AC Characteristics

(1) Basic operation (T_A = –40 to +85°C, V_{DD} = 1.8 to 5.5 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Cycle time (minimum instruction execution time)	T_{CY}	V_{DD} = 4.5 to 5.5 V	0.2		8	μs
		V_{DD} = 3.0 to 5.5 V	0.33		8	μs
		V_{DD} = 2.7 to 5.5 V	0.4		8	μs
		V_{DD} = 1.8 to 5.5 V	1.6		8	μs
TI80 input high-/low-level width	t_{TIH}, t_{TIL}	V_{DD} = 2.7 to 5.5 V	0.1			μs
		V_{DD} = 1.8 to 5.5 V	1.8			μs
TI80 input frequency	f_{TI}	V_{DD} = 2.7 to 5.5 V	0		4	MHz
		V_{DD} = 1.8 to 5.5 V	0		275	kHz
Interrupt input high-/low-level width	t_{INTH}, t_{INTL}	INTP0 to INTP2	10			μs
$\overline{\text{RESET}}$ low-level width	t_{RSL}		10			μs
CPT20 input high-/low-level width	t_{CPH}, t_{CPL}		10			μs

T_{CY} vs V_{DD}



(2) Serial interface (T_A = –40 to +85°C, V_{DD} = 1.8 to 5.5 V)

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

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK20}$ cycle time	t_{KCY1}	V_{DD} = 2.7 to 5.5 V		800			ns
		V_{DD} = 1.8 to 5.5 V		3200			ns
$\overline{SCK20}$ high-/low-level width	t_{KH1}, t_{KL1}	V_{DD} = 2.7 to 5.5 V		$t_{KCY1}/2 - 50$			ns
		V_{DD} = 1.8 to 5.5 V		$t_{KCY1}/2 - 150$			ns
SI20 setup time (to $\overline{SCK20}$↑)	t_{SIK1}	V_{DD} = 2.7 to 5.5 V		150			ns
		V_{DD} = 1.8 to 5.5 V		500			ns
SI20 hold time (from $\overline{SCK20}$↑)	t_{KSI1}	V_{DD} = 2.7 to 5.5 V		400			ns
				600			ns
SO20 output delay time from $\overline{SCK20}$↓	t_{KSO1}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 2.7 to 5.5 V	0		250	ns
			V_{DD} = 1.8 to 5.5 V	0		1000	ns

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

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

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
$\overline{SCK20}$ cycle time	t_{KCY2}	V_{DD} = 2.7 to 5.5 V		800			ns
		V_{DD} = 1.8 to 5.5 V		3200			ns
$\overline{SCK20}$ high-/low-level width	t_{KH2}, t_{KL2}	V_{DD} = 2.7 to 5.5 V		400			ns
		V_{DD} = 1.8 to 5.5 V		1600			ns
SI20 setup time (to $\overline{SCK20}$↑)	t_{SIK2}	V_{DD} = 2.7 to 5.5 V		100			ns
		V_{DD} = 1.8 to 5.5 V		150			ns
SI20 hold time (from $\overline{SCK20}$↑)	t_{KSI2}	V_{DD} = 2.7 to 5.5 V		400			ns
		V_{DD} = 1.8 to 5.5 V		600			ns
SO20 output delay time from $\overline{SCK20}$↓	t_{KSO2}	R = 1 kΩ, C = 100 pF[Note]	V_{DD} = 2.7 to 5.5 V	0		300	ns
			V_{DD} = 1.8 to 5.5 V	0		1000	ns
SO20 setup time (for $\overline{SS20}$↓ when $\overline{SS20}$ is used)	t_{KAS2}	V_{DD} = 2.7 to 5.5 V				120	ns
		V_{DD} = 1.8 to 5.5 V				400	ns
SO20 disable time (for $\overline{SS20}$↑ when $\overline{SS20}$ is used)	t_{KDS2}	V_{DD} = 2.7 to 5.5 V				240	ns
		V_{DD} = 1.8 to 5.5 V				800	ns

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

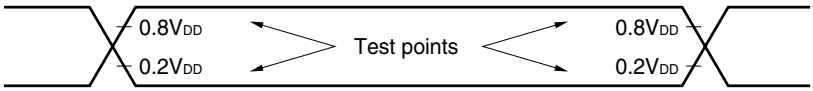
(iii) UART mode (Dedicated baud rate generator output)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Transfer rate		V_{DD} = 2.7 to 5.5 V			78125	bps
		V_{DD} = 1.8 to 5.5 V			19531	bps

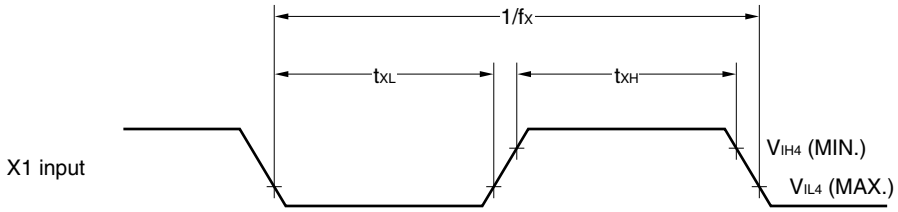
(iv) UART mode (external clock input)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
ASCK20 cycle time	t_{KCY3}	V_{DD} = 2.7 to 5.5 V	800			ns
		V_{DD} = 1.8 to 5.5 V	3200			ns
ASCK20 high-/low-level width	t_{KH3}, t_{KL3}	V_{DD} = 2.7 to 5.5 V	400			ns
		V_{DD} = 1.8 to 5.5 V	1600			ns
Transfer rate		V_{DD} = 2.7 to 5.5 V			39063	bps
		V_{DD} = 1.8 to 5.5 V			9766	bps
ASCK20 rise/fall time	t_R, t_F				1	μs

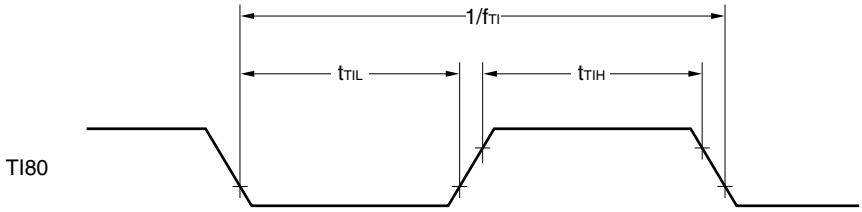
AC Timing Test Points (excluding X1 input)



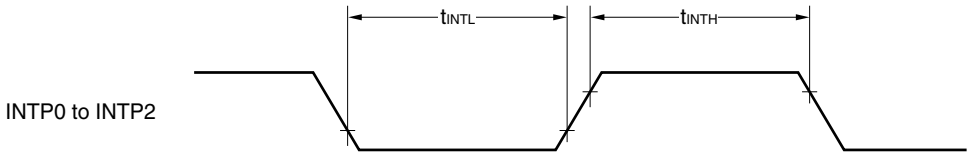
Clock Timing



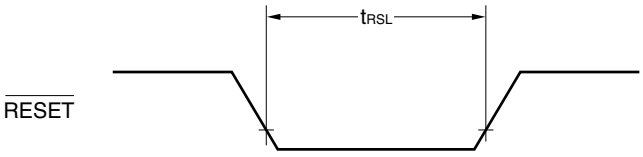
TI Timing



Interrupt Input Timing

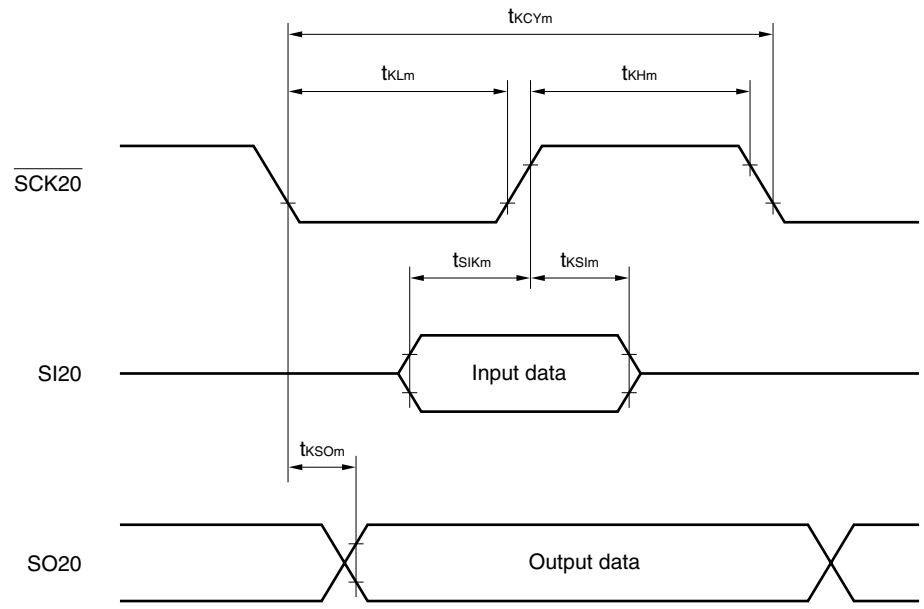


$\overline{\text{RESET}}$ Input Timing



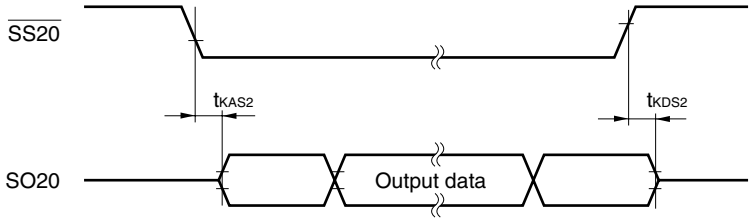
Serial Transfer Timing

3-wire serial I/O mode:

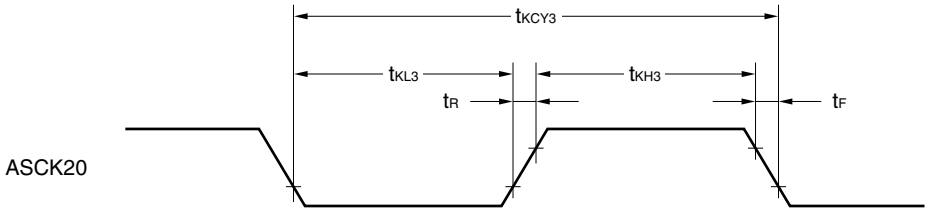


m = 1, 2

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



UART mode (external clock input):



10-Bit A/D Converter Characteristics (T_A = –40 to +85°C, AV_{DD} = V_{DD} = 1.8 to 5.5 V, AV_{SS} = V_{SS} = 0 V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Resolution			10	10	10	bit
Overall error[Note1,2]		4.5 V ≤ V_{DD} ≤ 5.5 V		±0.2	±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V		±0.4	±0.6	%FSR
		1.8 V ≤ V_{DD} < 2.7 V		±0.8	±1.2	%FSR
Conversion time	t_{CONV}	4.5 V ≤ V_{DD} ≤ 5.5 V	12		100	μs
		2.7 V ≤ V_{DD} < 4.5 V	14		100	μs
		1.8 V ≤ V_{DD} < 2.7 V	28		100	μs
Zero-scale error[Note1,2]		4.5 V ≤ V_{DD} ≤ 5.5 V			±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V			±0.6	%FSR
		1.8 V ≤ V_{DD} < 2.7 V			±1.2	%FSR
Full-scale error[Note1,2]		4.5 V ≤ V_{DD} ≤ 5.5 V			±0.4	%FSR
		2.7 V ≤ V_{DD} < 4.5 V			±0.6	%FSR
		1.8 V ≤ V_{DD} < 2.7 V			±1.2	%FSR
Integral linearity error[Note1]	ILE	4.5 V ≤ V_{DD} ≤ 5.5 V			±2.5	LSB
		2.7 V ≤ V_{DD} < 4.5 V			±4.5	LSB
		1.8 V ≤ V_{DD} < 2.7 V			±8.5	LSB
Differential linearity error[Note1]	DLE	4.5 V ≤ V_{DD} ≤ 5.5 V			±1.5	LSB
		2.7 V ≤ V_{DD} < 4.5 V			±2.0	LSB
		1.8 V ≤ V_{DD} < 2.7 V			±3.5	LSB
Analog input voltage	V_{IAN}		0		AV_{DD}	V

Notes 1. Excludes quantization error (±0.05%FSR).

2. It is indicated as a ratio to the full-scale value (%FSR).

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

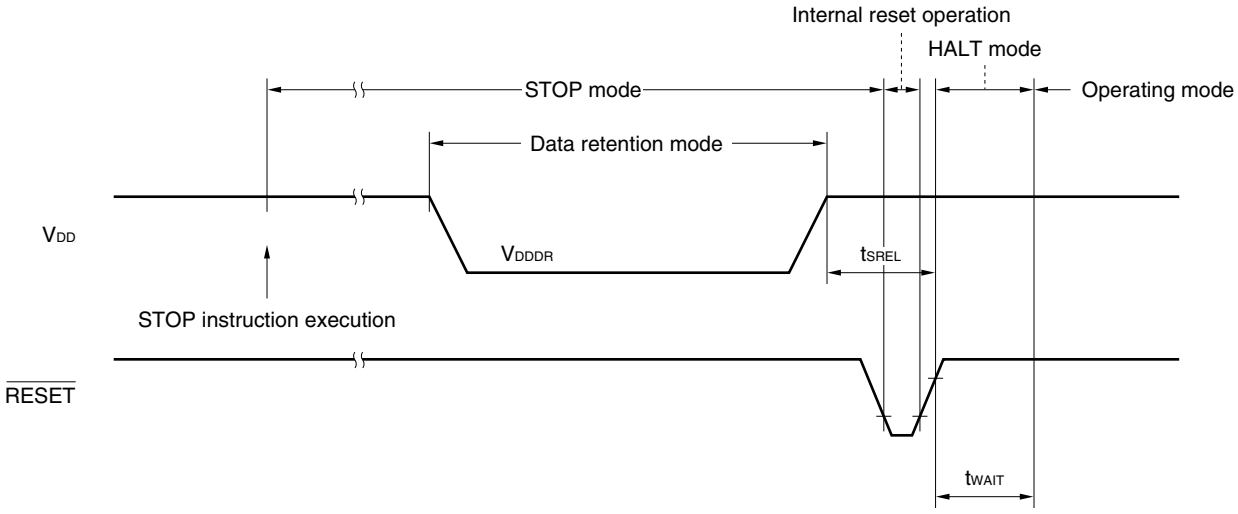
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Data retention supply voltage	V_{DDDR}		1.8		5.5	V
Release signal set time	t_{SREL}		0			μs
Oscillation stabilization wait time[Note 1]	t_{WAIT}	Release by $\overline{RESET}$		$2^{15}/f_X$		ms
		Release by interrupt request		**Note 2**		ms

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

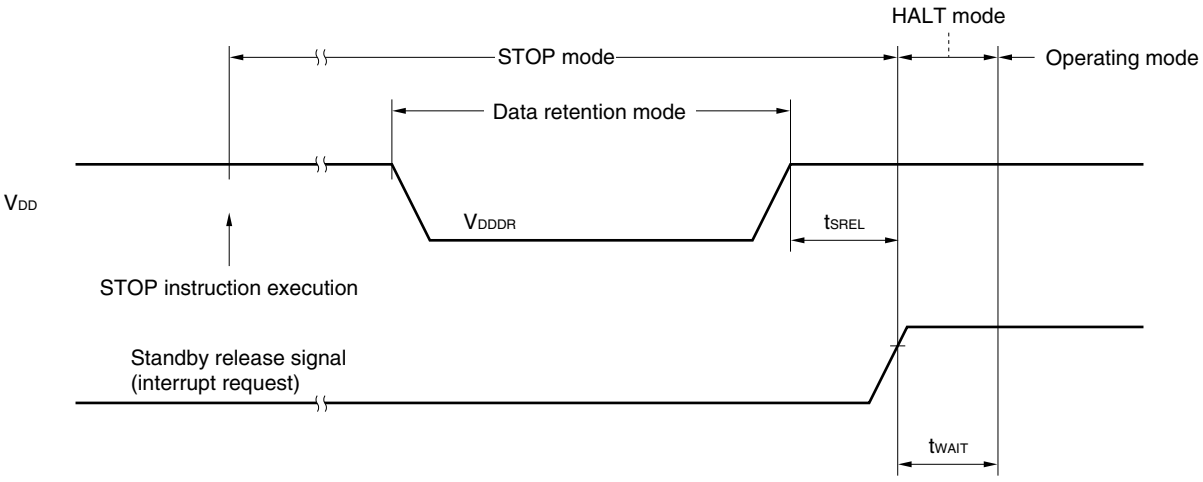
2. Selection of $2^{12}/f_X$, $2^{15}/f_X$, or $2^{17}/f_X$ is possible with bits 0 to 2 (OSTS0 to OSTS2) of the oscillation stabilization time select register.

Remark fx: System clock oscillation frequency

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

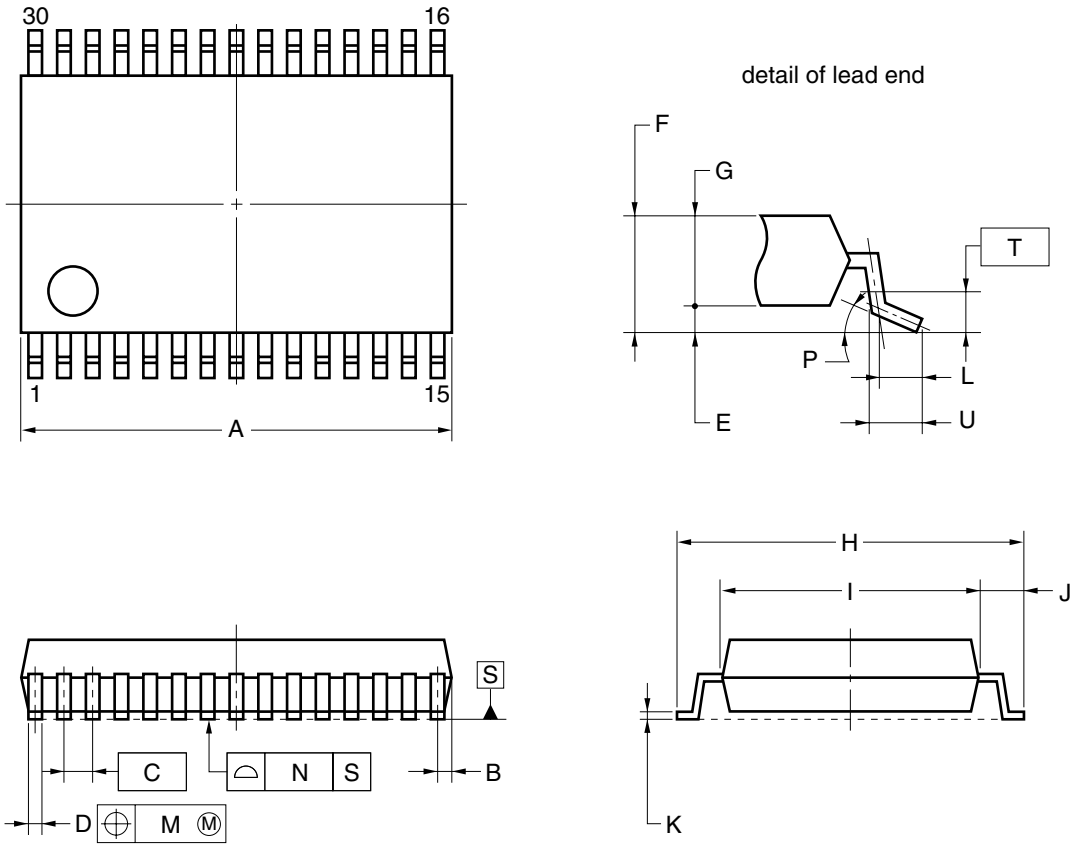


Data Retention Timing (Standby release signal: STOP mode release by interrupt signal)



9. PACKAGE DRAWING

30-PIN PLASTIC SSOP (7.62 mm (300))



NOTE

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

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

S30MC-65-5A4-2

10. RECOMMENDED SOLDERING CONDITIONS

The μPD78F9116B and 78F9116B(A) should be soldered and mounted under the following recommended conditions.

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

Table 10-1. Surface Mounting Type Soldering Conditions

μPD78F9116BMC-5A4: 30-pin plastic SSOP (7.62 mm (300))
μPD78F9116BMC(A)-5A4: 30-pin plastic SSOP (7.62 mm (300))

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 30 seconds max. (at 210°C or higher), Count: Three times or less: 3 max., Exposure limit: 7days[Note] (after that, prebake at 125°C for 10 hours)	IR35-107-3
VPS	Package peak temperature: 215°C, Time: 40 seconds max. (at 200°C or higher), Count: Three time or less, Exposure limit: 7days[Note] (after that, prebake at 125°C for 10 hours)	VP15-107-3
Wave soldering	Solder bath temperature: 260°C max., Time: 10 seconds max., Count: Once Preheating temperature: 120°C or below (package surface temperature), Exposure limit : 7days[Note] (after that, prebake at 125°C for 10 hours)	WS60-107-1
Partial heating	Pin temperature: 300°C max., Time: 3 sec. max. (per pin row)	–

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

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

APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for system development using the μPD78F9116B and 78F9116B(A).

Software package

SP78K0S[Notes 1, 2]	CD-ROM in which the development tools (software) common to the 78K/0S Series are included as a package

Language Processing Software

RA78K0S[Notes 1, 2, 3]	Assembler package common to 78K/0S Series
CC78K0S[Notes 1, 2, 3]	C compiler package common to 78K/0S Series
DF789136[Notes 1, 2, 3]	Device file for μPD78F9116B

Flash Memory Writing Tools

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

Debugging Tools (1/2)

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

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

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

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

4. Products made by Naito Densei Machida Mfg. Co., Ltd. (Phone: +81-45-475-4191)

Remark RA78K0S, CC78K0S, SM78K0S, and ID78K0S-NS are used in combination with the DF789136.

Debugging Tools (2/2)

SM78K0S[Notes 1, 2]	System simulator common to 78K/0S Series
ID78K0S-NS[Notes 1, 2]	Integrated debugger common to 78K/0S Series
DF789136[Notes 1, 2]	Device file for μPD78F9116B

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

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

Remark RA78K0S, CC78K0S, SM78K0S, and ID78K0S-NS are used in combination with the DF789136.

APPENDIX B. RELATED DOCUMENTS

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

Documents Related to Devices

Document Name	Document No.
μPD789101A, 102A, 104A, 111A, 112A, 114A, 101A(A), 102A(A), 104A(A), 111A(A), 112A(A), 114A(A) Data Sheet	U14590E
μPD78F9116B, 78F9116B(A) Data Sheet	This manual
μPD789104A, 789114A, 789124A, 789134A Subseries User's Manual	U14643E
78K/0S Series User's Manual Instructions	U11047E

Documents Related to Development Software Tools (User's Manuals)

Document Name		Document No.
RA78K0S Assembler Package	Operation	U14876E
	Language	U14877E
	Structured Assembly Language	U11623E
CC78K0S C Compiler	Operation	U14871E
	Language	U14872E
SM78K0S, SM78K0 System Simulator Ver. 2.10 or Later	Operation (Windows Based)	U14611E
SM78K Series System Simulator Ver. 2.10 or Later	External Part User Open Interface Specification	U15006E
ID78K0-NS, ID78K0S-NS Integrated Debugger Ver. 2.20 or Later	Operation (Windows Based)	U14910E
Project Manager Ver. 3.12 or Later (Windows Based)		U14610E

Documents Related to Development Hardware Tools (User's Manuals)

Document Name	Document No.
IE-78K0S-NS In-Circuit Emulator	U13549E
IE-78K0S-NS-A In-Circuit Emulator	U15207E
IE-789136-NS-EM1 Emulation Board	U14363E

Documents Related to Flash Memory Writing

Document Name	Document No.
PG-FP3 Flash Memory Programmer User's Manual	U13502E

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

Other Related Documents

Document Name	Document No.
SEMICONDUCTOR SELECTION GUIDE - Products & Packages -	X13769E
Semiconductor Device Mounting Technology Manual	C10535E
Quality Grades on NEC Semiconductor Devices	C11531E
NEC Semiconductor Device Reliability/Quality Control System	C10983E
Guide to Prevent Damage for Semiconductor Devices by Electrostatic Discharge (ESD)	C11892E

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

[MEMO]

[MEMO]

[MEMO]

NOTES FOR CMOS DEVICES

① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note:

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

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

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

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

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

Regional Information

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

- Device availability
- Ordering information
- Product release schedule
- Availability of related technical literature
- Development environment specifications (for example, specifications for third-party tools and components, host computers, power plugs, AC supply voltages, and so forth)
- Network requirements

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

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