NEC

MOS INTEGRATED CIRCUIT

μPD78234(A), 78238(A)

8-BIT SINGLE-CHIP MICROCOMPUTER

Phase-out/Discontinued

DESCRIPTION

The μPD78234(A)/78238(A) are 78K/II series products. The 78K/II is an 8-bit single-chip microcomputer which can access the memory space of 1M bytes with an external expansion.

Functions are described in detail in the following User's Manuals, which should be read when carrying out design work.

μPD78234 Series User's Manual Hardware: IEU-718
78K/II Series User's Manual Instruction : IEU-754

FEATURES

- High reliability compared to μPD78234, 78238
- High-speed instruction execution : 333 ns (at 12 MHz operation)
- I/O pin : 64 pins
- A/D converter (analog 8 inputs)
- D/A converter (analog 2 outputs)
- PWM output (2 outputs)

★

USE

Automotive electrical equipment, combustion control

ORDERING INFORMATION

Ordering Code	Package	Internal ROM	Internal RAM
μPD78234GC(A)-xxx-3B9	80-pin plastic QFP (□ 14 mm)	16K	640
μPD78234GJ(A)-xxx-5BG	94-pin plastic QFP (□ 20 mm)	16K	640
μPD78238GC(A)-xxx-3B9	80-pin plastic QFP (□ 20 mm)	32K	1024

Remarks "xxx" means the ROM code.

QUALITY GRADE

Special

Please refer to "Quality grade on NEC Semiconductor Devices" (Document number IEI-1209) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

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(O. D. No. IC-8416C)
Date Published January 1994 P
Printed in Japan

The mark ★ shows major revised points.

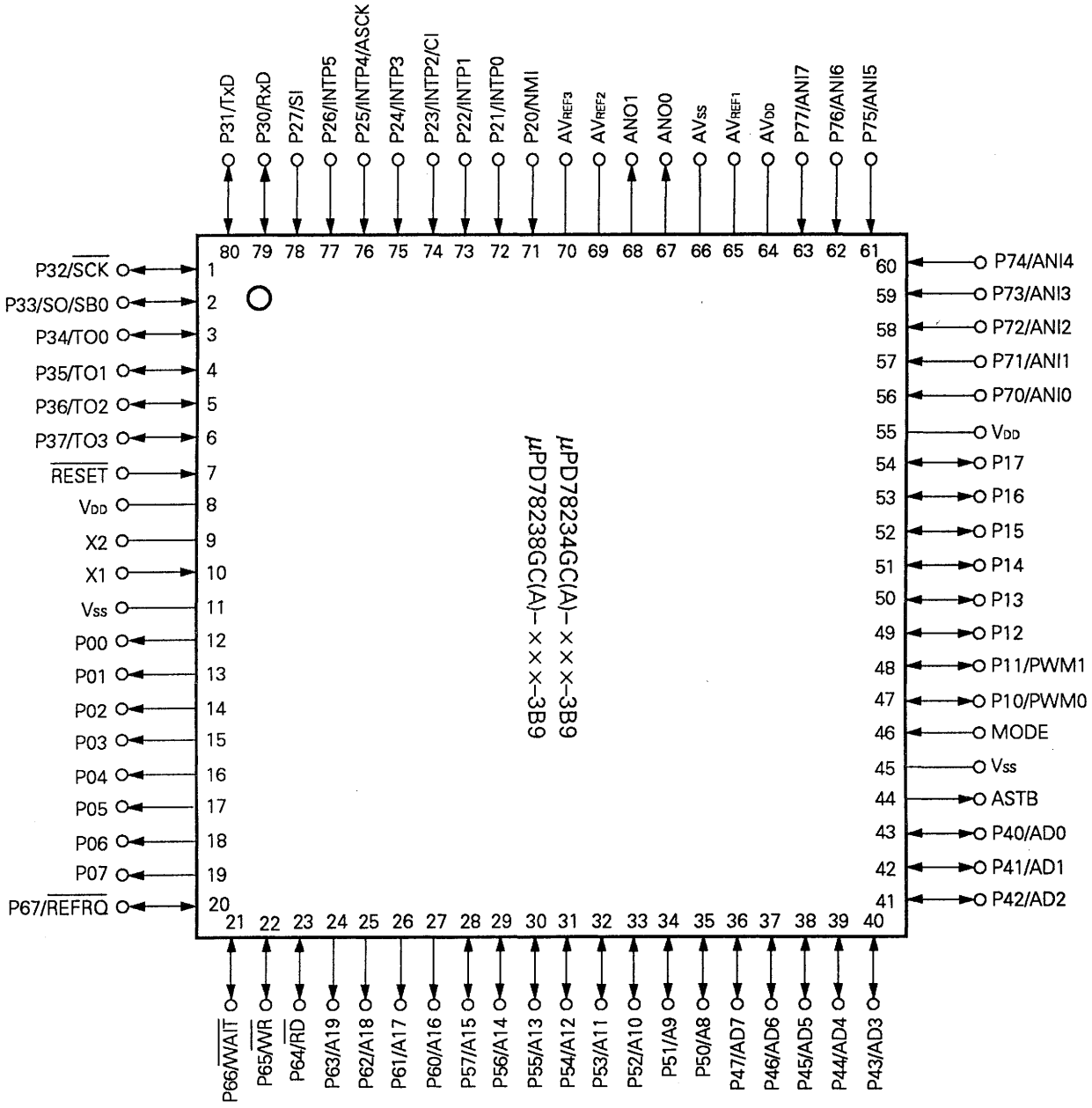
FUNCTION LIST

Item			Function
Number of basic instructions (mnemonics)			65
Minimum instruction execution time (operation at 12 MHz)			333 ns
On-chip memory capacity		ROM	16K bytes: μPD78234(A), 32K bytes: μPD78238(A)
		RAM	640 bytes: μPD78234(A), 1024 bytes: μPD78238(A)
Memory space			Program memory: 64K bytes, data memory: 1M bytes
I/O pins		Input	16
		Output	12
		Input/Output	36
		Total	64
	Pins with additional functions*	Pin with pull-up resistor	42
		LED direct drive output	24
		Transistor direct drive output	8
Rear-time output ports			4 bits × 2 or 8 bits × 1
General registers			8 bits × 8 bits × 4 banks (memory mapping)
Timer/counters			16-bit timer/counter: Timer register × 1, Capture register × 1, Compare register × 2; Pulse output enable (Toggle output, PWM/PPG output, One-shot pulse output)
			8-bit timer/counter 1: Timer register × 1, Capture/compare register × 1, Compare register × 1; Pulse output enable (Real-time output: 4 bits × 2)
			8-bit timer/counter 2: Timer register × 1, Capture register × 1, Compare register × 2; Pulse output enable (Toggle output, PWM/PPG output)
			8-bit timer/counter 3: Timer register × 1, Compare register × 1
PWM output function			12-bit resolution × 2 channels (PWM frequency: 23.4 KHz)
Serial interface			UART : 1 channel (dedicated baud rate generator incorporated) CSI (3-wire serial I/O, SBI) : 1 channel
A/D converter			8-bit resolution × 8 channels
D/A converter			8-bit resolution × 2 channels
Interrupts			19 sources (external 7, internal 12) + BRK instruction Priority order of 2 levels (programmable) 2 types of servicing (vectored interrupt, macro service)
Instruction set			16-bit operation Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits) Bit manipulation BCD adjustment, others
Packages			80-pin plastic QFP (□ 14 mm) 94-pin plastic QFP (□ 20 mm: μPD78234(A) only)

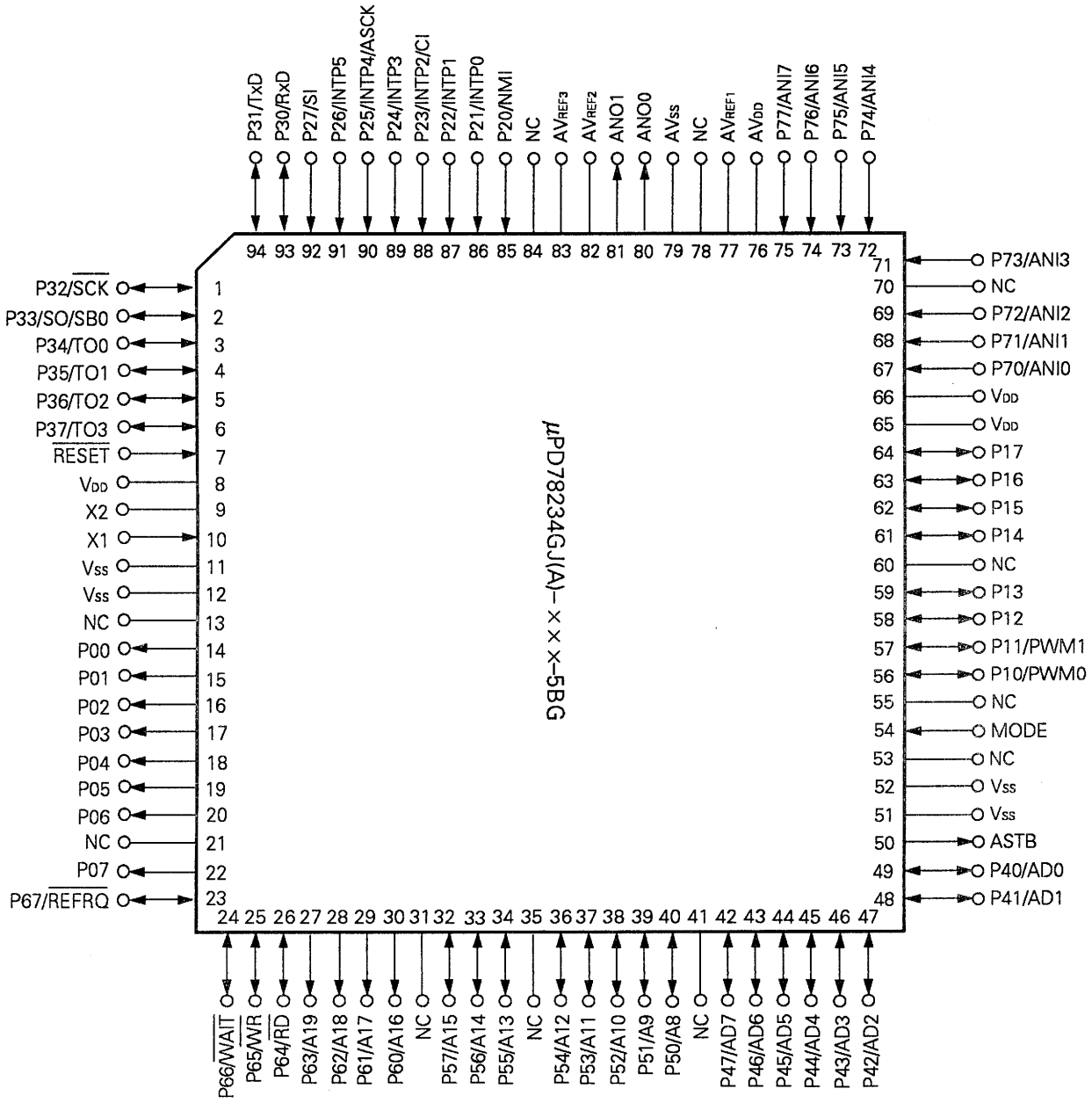
* Pins with additional functions are included in the I/O pins.

PIN CONFIGURATION (TOP VIEW)

80-Pin Plastic QFP (□ 14 mm)

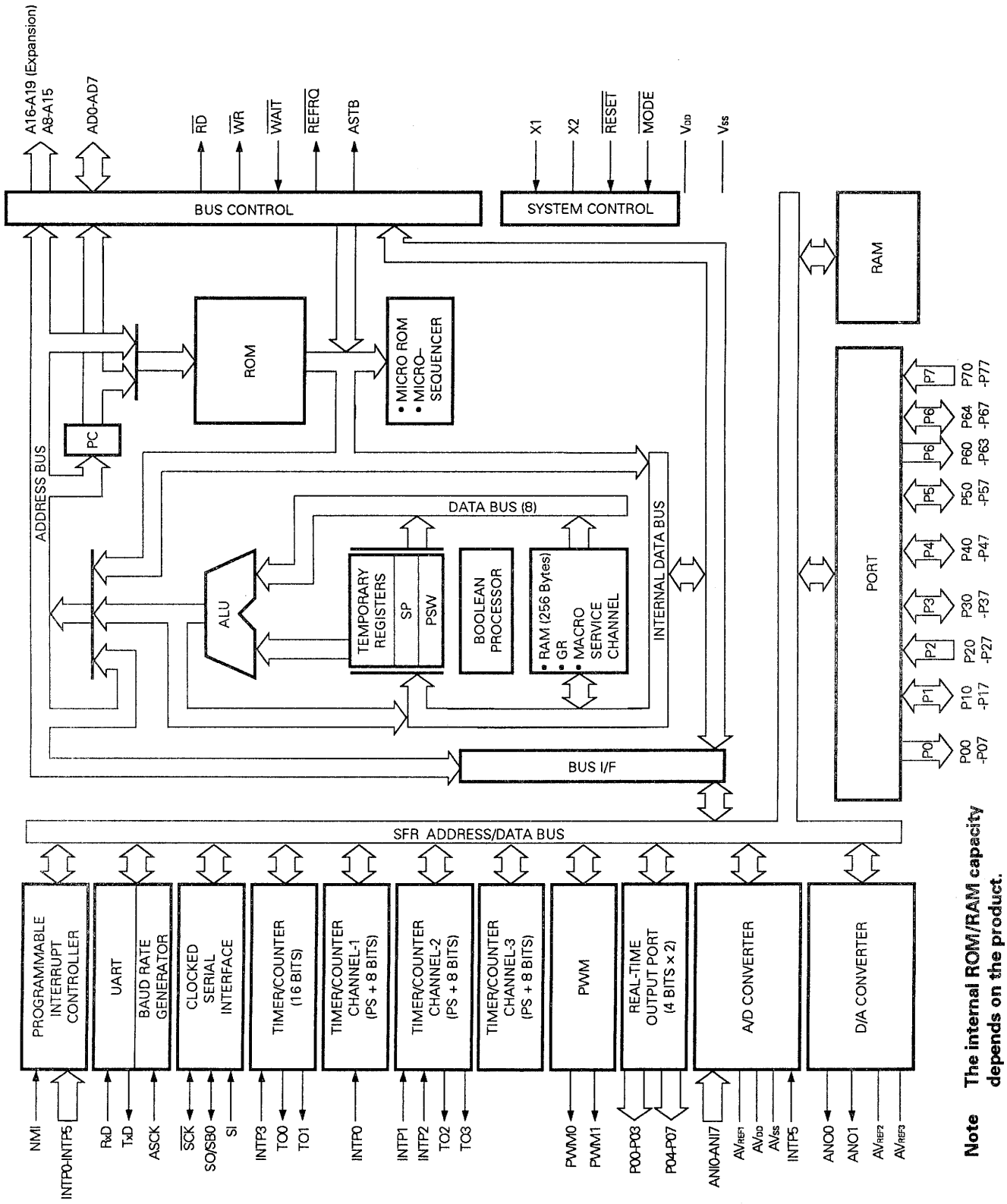


94-Pin Plastic QFP (□ 20 mm)



P00 to P07	:	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
P70 to P77	:	Port 7
TO0 to TO3	:	Timer Output
CI	:	Clock Input
RxD	:	Receive Data
TxD	:	Transmit Data
$\overline{SCK}$	:	Serial Clock
ASCK	:	Asynchronous Serial Clock
SB0	:	Serial Bus
SI	:	Serial Input
SO	:	Serial Output
PWM0, PWM1	:	Pulse Width Modulation Output
NMI	:	Non-maskable Interrupt
INTP0 to INTP5	:	Interrupt From Peripherals
AD0 to AD7	:	Address/Data Bus
A8 to A19	:	Address Bus
$\overline{RD}$	:	Read Strobe
$\overline{WR}$	:	Write Strobe
$\overline{WAIT}$	:	Wait
ASTB	:	Address Strobe
$\overline{REFRQ}$	:	Refresh Request
$\overline{RESET}$	:	Reset
X1, X2	:	Crystal
MODE	:	Mode
ANI0 to ANI7	:	Analog Input
ANO0, ANO1	:	Analog Output
AV_{REF1} to AV_{REF3}	:	Reference Voltage
AV_{DD}	:	Analog Power Supply
AVss	:	Analog Ground
V_{DD}	:	Power Supply
Vss	:	Ground
NC	:	Non-connection

INTERNAL BLOCK DIAGRAM



Note **The internal ROM/RAM capacity depends on the product.**

CONTENTS

1. PIN FUNCTIONS

1.1 PORTS

Pin Name	I/O	Dual-Function Pin	Function	
P00 to P07	Output	———	Port 0 (P0): Usable as real-time output port (4 bits × 2) Transistor drive possible	
P10	Input/output	PWM0	Port 1 (P1): Input/output specifiable bit-wise Internal pull-up resistor connection specifiable as a batch by software for input mode pin LED drive capability	
P11		PWM1		
P12 to P17		———		
P20	Input	NMI	Port 2 (P2): P20 cannot be used as a general-purpose port. (Non-maskable interrupt) However, input level can be checked in interrupt routine. Internal pull-up resistor connection specifiable by software for P22 to P27 as a 6-bit unit.	
P21		INTP0		
P22		INTP1		
P23		INTP2/CI		
P24		INTP3		
P25		INTP4/ASCK		
P26		INTP5		
P27		SI		
P30	Input/output	RxD	Port 3 (P3): Input/output specifiable bit-wise Internal pull-up resistor connection specifiable as a batch by software for input mode pin	
P31		TxD		
P32		$\overline{SCK}$		
P33		SO/SB0		
P34 to P37		TO0 to TO3		
P40 to P47	Input/output	AD0 to AD7	Port 4 (P4): Input/output specifiable as 8-bit unit Internal pull-up resistor connection specifiable by software as an 8-bit unit for input mode pin	LED drive capability
P50 to P57	Input/output	A8 to A15	Port 5 (P5): Input/output specifiable bit-wise Internal pull-up resistor connection specifiable as a batch by software for input mode pin	
P60 to P63	Output	A16 to A19	Port 6 (P6): Input/output specifiable bit-wise for P64 to P67 Internal pull-up resistor connection specifiable as a batch for P64 to P67 by software for input mode pin	
P64	Input/output	$\overline{RD}$		
P65		$\overline{WR}$		
P66		$\overline{WAIT}$		
P67		$\overline{REFRQ}$		
P70 to P77	Input	ANI0 to ANI7	Port 7 (P7)	

1.2 OTHER THAN PORTS

Pin Name	I/O	Function	Dual-Function Pin
TO0 to TO3	Output	Timer output	P34 to P37
CI	Input	Count clock input to 8-bit timer/counter 2	P23 /INTP2
RxD	Input	Serial data input (UART)	P30
TxD	Output	Serial data output (UART)	P31
ASCK	Input	Baud rate clock input (UART)	P25/INTP4
SB0	Input /output	Serial data input/output (SBI)	P33/SO
SI	Input	Serial data input (3-wire serial I/O)	P27
SO	Output	Serial data output (3-wire serial I/O)	P33/SB0
$\overline{SCK}$	Input /output	Serial clock input/output (SBI, 3-wire serial I/O)	P32
NMI	Input	External interrupt request	P20
INTP0			P21
INTP1			P22
INTP2			P23/CI
INTP3			P24
INTP4			P25/ASCK
INTP5			P26
AD0 to AD7	Input /output	Time multiplexing address/data bus (external memory connection)	P40 to P47
A8 to A15	Output	Upper address bus (external memory connection)	P50 to P57
A16 to A19	Output	Upper address when extending address (external memory connection)	P60 to P63
$\overline{RD}$	Output	Read strobe into external memory	P64
$\overline{WR}$	Output	Write strobe into external memory	P65
$\overline{WAIT}$	Input	Wait insertion	P66
ASTB	Output	Time multiplexing address (A0 to A7) latch timing output (at external memory accessed)	—
$\overline{REFRQ}$	Output	Refresh pulse output into external pseudo-static memory	P67
$\overline{RESET}$	Input	Chip reset	—
X1	Input	Crystal connection for system clock oscillation (capability of clock input to X1)	—
X2	—		
MODE	Input	ROM-less operation indication (external access to same space as internal ROM) Normally used at low level	—
ANI0 to ANI7	Input	Analog voltage input for A/D converter	P70 to P77
ANO0, ANO1	Output	Analog voltage output for D/A converter	—
AV_{REF1}	—	Reference voltage apply for A/D converter	—
AV_{REF2}, AV_{REF3}		Reference voltage apply for D/A converter	
AV_{DD}		Positive power supply for A/D converter	
AV_{SS}		GND for A/D converter	
V_{DD}		Positive power supply	
V_{SS}		GND	
NC		Not connected internally	

1.3 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 1-1. For the input/output circuit configuration of each type, see Fig. 1-1.

Table 1-1 Input/Output Circuit Type of Each Pin and Recommended Connection of Unused Pins

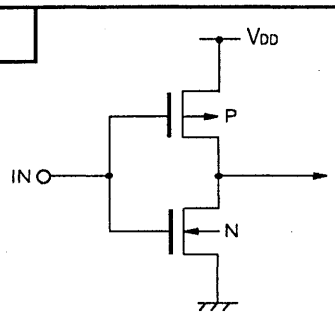
Pin Name	Input/Output Circuit Type	I/O	Recommended Connection when not Used
P00 to P07	4	Output	Leave open.
P10 to P17	5-A	Input/output	Input : Connected to V_{DD}. Output : Leave open.
P20/NMI	2	Input	Connected to V_{DD} or V_{SS}.
P21/INTP0			
P22/INTP1	2-A		Connected to V_{DD}.
P23/INTP2/CI			
P24/INTP3			
P25/INTP4/ASCK			
P26/INTP5			
P27/SI			
P30/RxD	5-A	Input/output	Input : Connected to V_{DD}. Output : Leave open.
P31/TxD			
P32/$\overline{SCK}$	8-A		
P33/SB0/SO	10-A		
P34/TO0 to P37/TO3	5-A		
P40/AD0 to P47/AD7			
P50/A8 to P57/A15			
P60/A16 to P63/A19	4	Output	Leave open.
P64/$\overline{RD}$	5-A	Input/output	Input : Connected to V_{DD}. Output : Leave open.
P65/$\overline{WR}$			
P66/$\overline{WAIT}$			
P67/$\overline{REFRQ}$			
P70/ANI0 to P77/ANI7	9	Input	Connected to V_{SS}.
ANO0, ANO1	12	Output	Leave open.
ASTB	4		
$\overline{RESET}$	2	Input	———
MODE	1		
AV_{REF1} to AV_{REF3}	———		Connected to V_{SS}.
AV_{SS}			
AV_{DD}			Connected to V_{DD}.

Remarks The type numbers are standardized by 78K series, therefore they are not always consecutive numbers in each product. (Some circuits are not incorporated.)

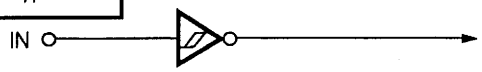
★ **Note With input/output dual-function pins, if input/output mode is indeterminate the pin should be connected to V_{DD} via a resistor of tens of kΩ (in particular, when the reset input pin exceeds the low level input voltage in a power-on reset, and when input/output is switched by software).**

Fig. 1-1 Pin Input/Output Circuits

Type 1

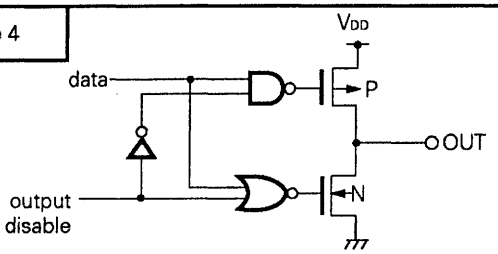


Type 2



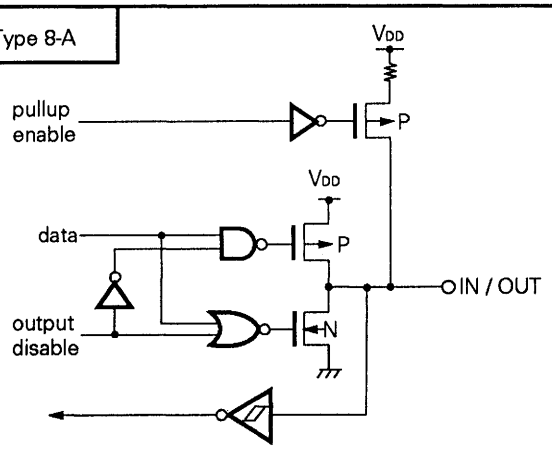
Schmitt-Triggered Input with Hysteresis Characteristic

Type 4

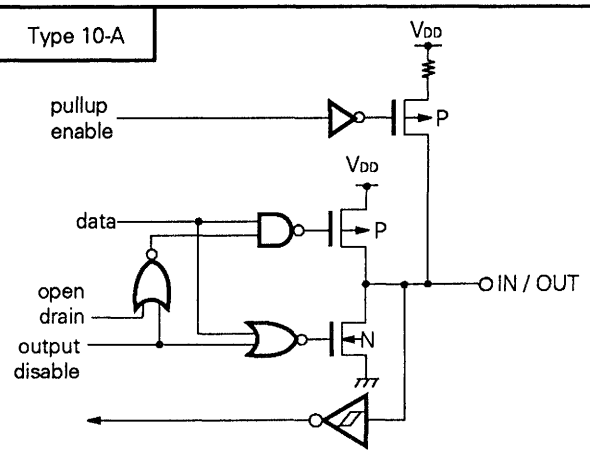


Push-pull output which enables output to be high-impedance (both P-ch and N-ch off).

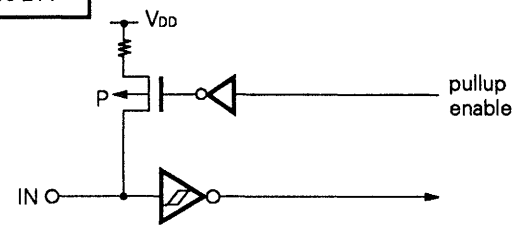
Type 8-A



Type 10-A

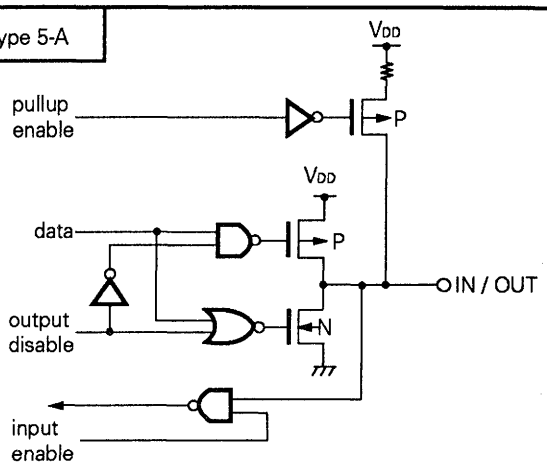


Type 2-A

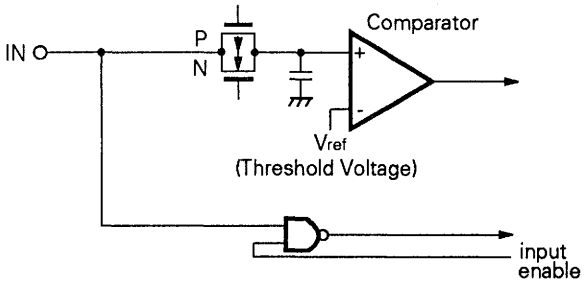


Schmitt-Triggered Input with Hysteresis Characteristic

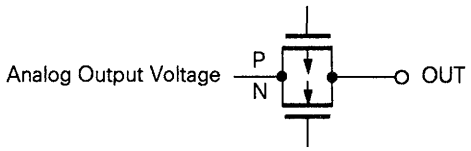
Type 5-A



Type 9



Type 12



2. INTERNAL BLOCK FUNCTIONS

2.1 MEMORY SPACE

A 1M-byte memory space can be accessed. Figs. 2-1 and 2-2 show that memory space. The program memory mapping depends on the MODE pin status.

(1) μPD78234(A)

• MODE = L

The program memory is mapped in internal ROM (16K bytes: 00000H to 03FFFH) and external memory (48256 bytes: 04000H to 0FC7FH). The external memory can be accessed in the external memory expansion mode. The area mapped in external memory can be shared with the data memory.

The data memory is mapped in internal RAM (640 bytes: 0FC80H to 0FEFFH). In the 1M-byte expansion mode, external memory (960K bytes: 10000H to FFFFFH) is mapped as an expansion data memory.

• MODE = H (ROM-less mode)

The program memory is mapped in external memory (64640 bytes: 00000H to 0FC7FH). This area can be shared with the data memory.

The data memory is mapped in internal RAM (640 bytes: 0FC80H to 0FEFFH). In the 1M-byte expansion mode, external memory (960K bytes: 10000H to FFFFFH) is mapped as an expansion data memory.

(2) μPD78238(A)

• MODE = L

The program memory is mapped in internal ROM (32K bytes: 00000H to 07FFFH) and external memory (31488 bytes: 08000H to 0FAFFH). The external memory can be accessed in the external memory extension mode. The area mapped in external memory can be shared with the data memory.

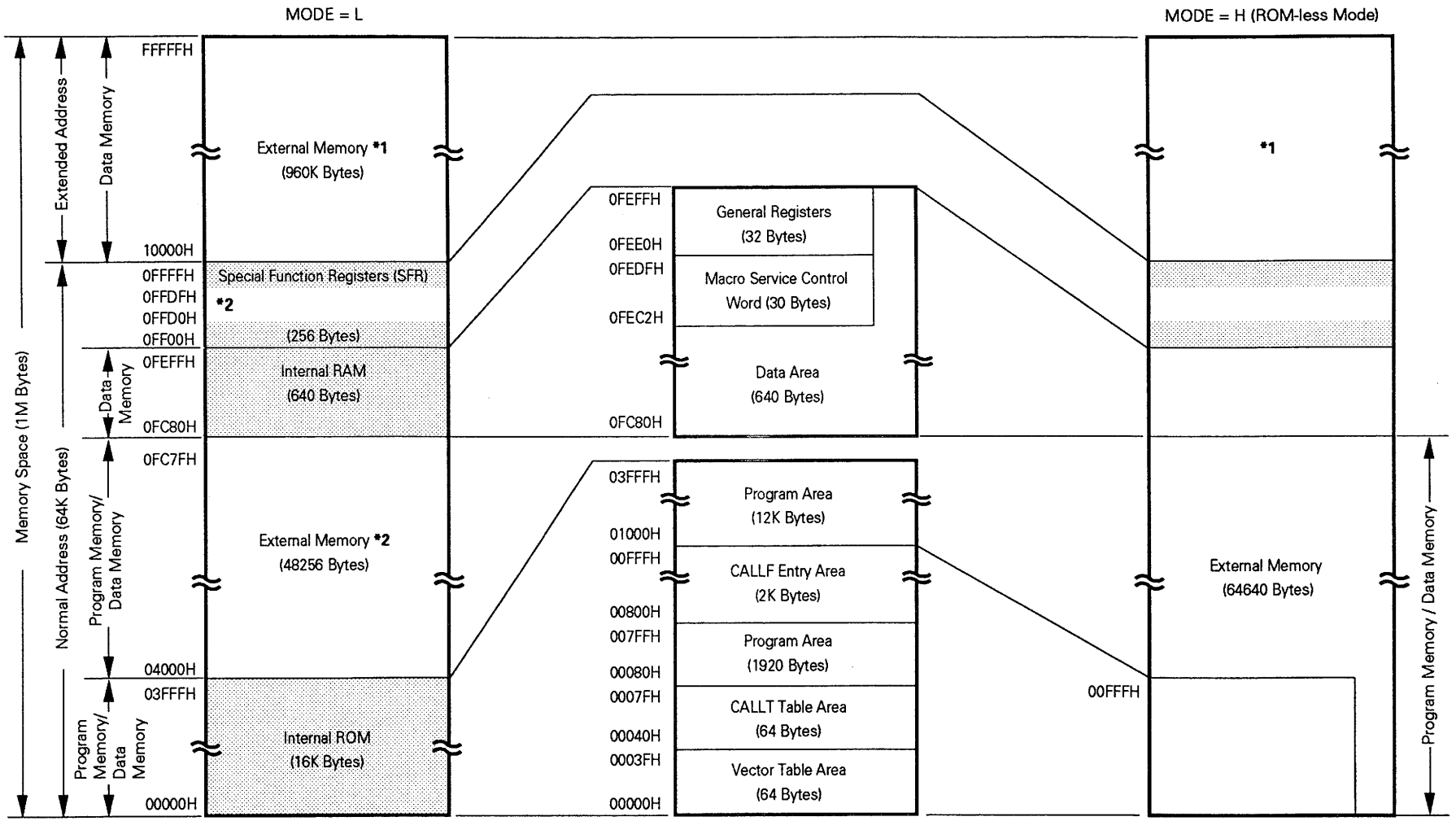
The data memory is mapped in internal RAM (1024 bytes: 0FB00H to 0FEFFH). In the 1M-byte expansion mode, external memory (960K bytes: 10000H to FFFFFH) is mapped as an expansion data memory.

• MODE = H (ROM-less mode)

The program memory is mapped in external memory (64256 bytes: 00000H to 0FAFFH). The area can be shared with the data memory.

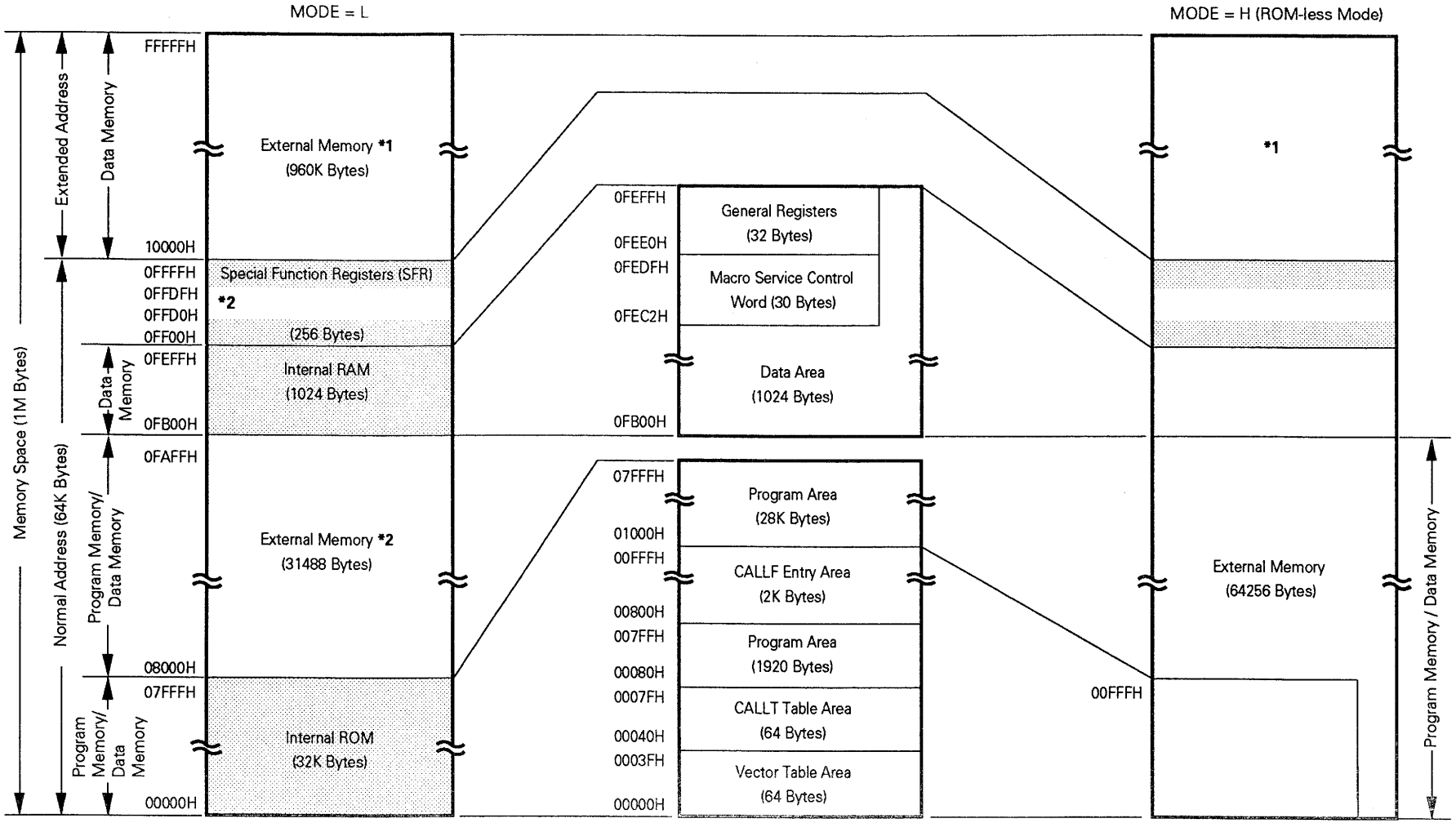
The data memory is mapped in internal RAM (1024 bytes: 0FB00H to 0FEFFH). In the 1M-byte expansion mode, external memory (960K bytes: 10000H to FFFFFH) is mapped as an expansion data memory.

Fig. 2-1 μPD78234(A) Memory Map



* 1. Accessed by 1M-byte expansion mode. Shaded area denotes internal memory.
2. Accessed by external memory expansion mode.

Fig. 2-2 μPD78238(A) Memory Map



* 1. Accessed by 1M-byte expansion mode. Shaded area denotes internal memory.
2. Accessed by external memory expansion mode.

2.2 PORT

Ports shown as Fig. 2-3 are equipped, allowing variety of controls. The function of each port describes Table 2-1. The port 1 to port 6 can be specified to use the internal pull-up resistor by software at input.

Fig. 2-3 Port Configuration

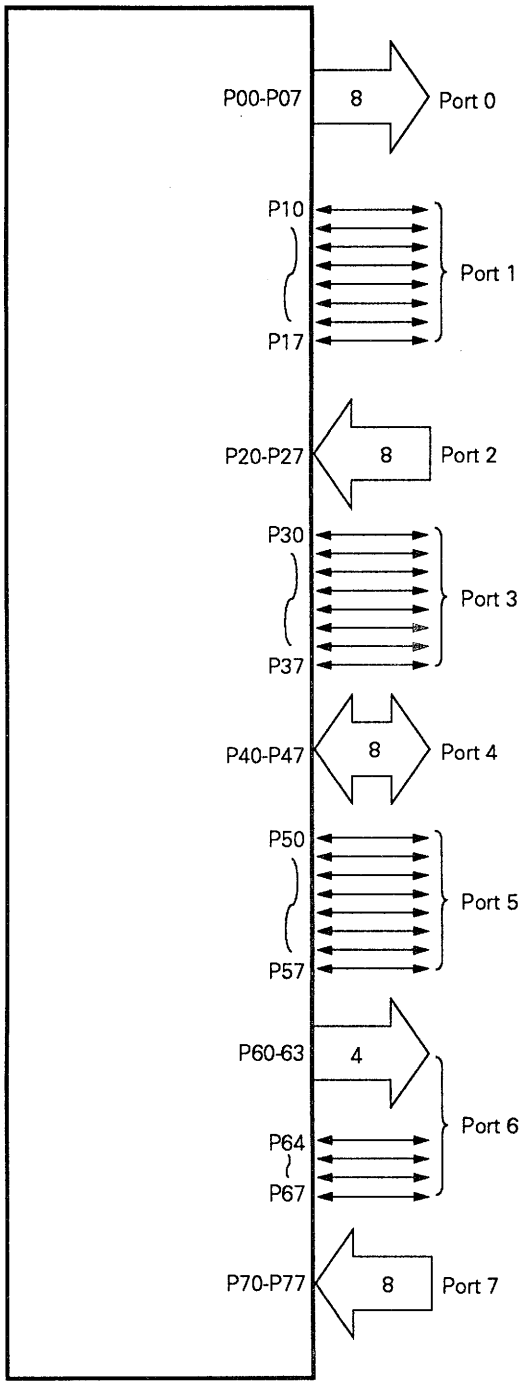


Table 2-1 Port Function

Name	Pin Name	Function	Software Pull-Up Specification
Port 0	P00 to P07	Specifiable as output or high impedance as an 8-bit unit. Operable as 4-bit real-time outputs (P00 to P03, P04 to P07). Transistor drive possible	———
Port 1	P10 to P17	Input or output specifiable bit-wise. LED drive possible.	Specify as a batch for input mode pin
Port 2	P20 to P27	Input port	As a 6-bit unit (P22 to P27)
Port 3	P30 to P37	Input or output specifiable bit-wise	Specify as a batch for input mode pin
Port 4	P40 to P47	Input or output specifiable as an 8-bit unit, LED drive possible	As an 8-bit unit
Port 5	P50 to P57	Input or output specifiable bit-wise. LED drive possible	Specify as a batch for input mode pin
Port 6	P60 to P63	Output port	———
	P64 to P67	Input or output specifiable bit-wise	Specify as a batch for input mode pin
Port 7	P70 to P77	Input port	———

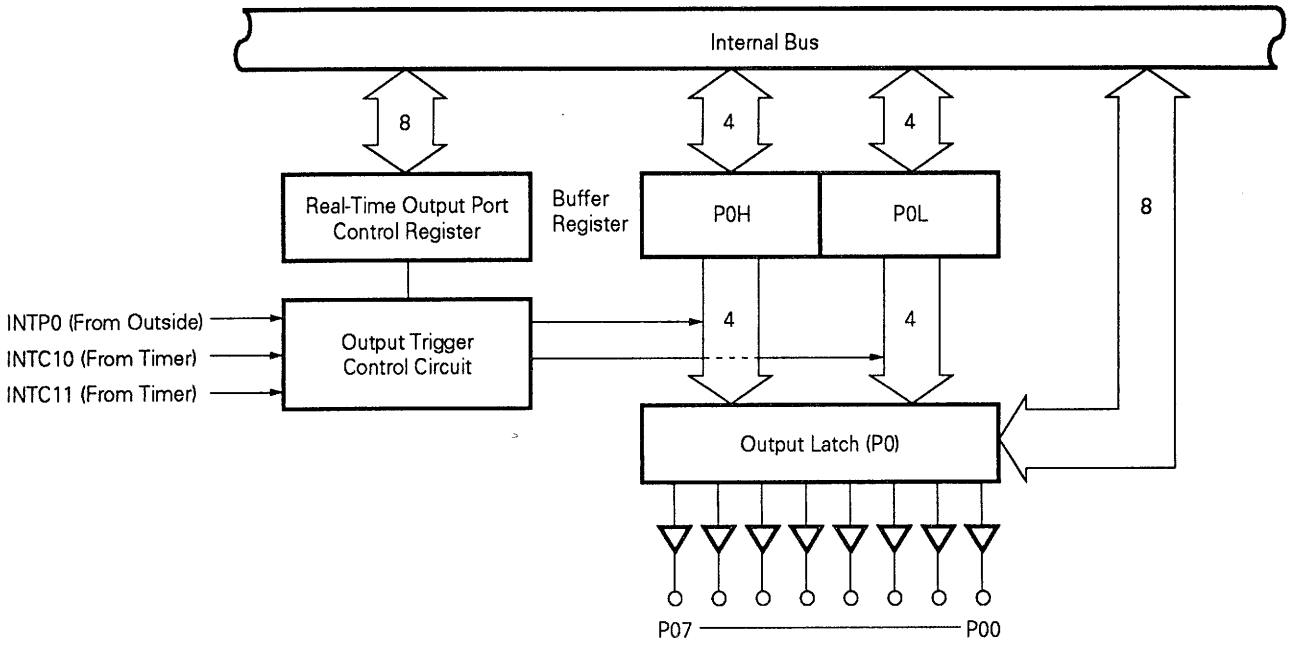
2.3 REAL-TIME OUTPUT PORT

The real-time output port outputs the data stored in the buffer in synchronization with a timer match interrupt or external interrupt. Therefore, a pulse output without jitter can be acquired.

Accordingly, this is suitable for the application (open loop control of a stepping motor, etc.) which outputs any pattern at any interval.

As shown in Fig. 2-4, the port 0 and buffer register are the core of the configuration.

Fig. 2-4 Real-Time Output Port Block Diagram



2.4 TIMER/COUNTER UNIT

One channel of a 16-bit timer/counter unit and 3 channels of an 8-bit timer/counter unit are incorporated.

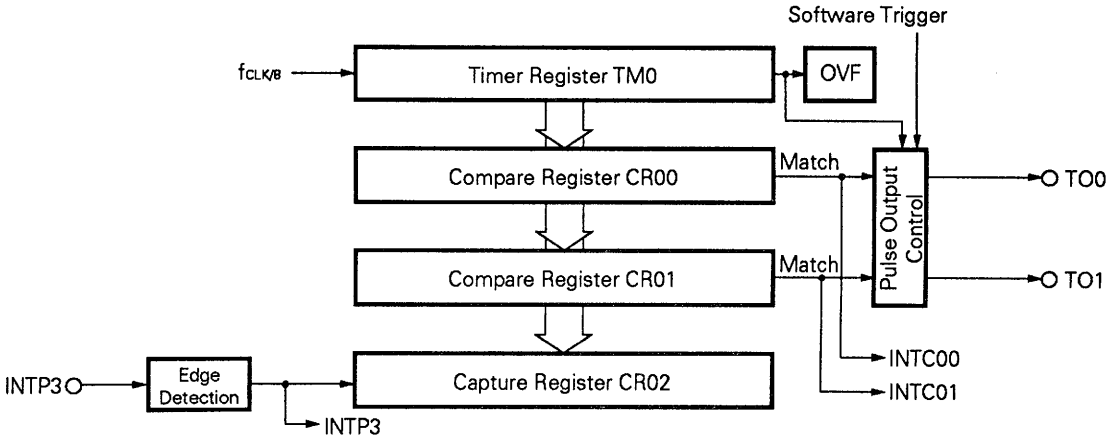
Table 2-2 Types and Functions for Timer/Counter

Type & Function \ Unit		16-Bit Timer/ Counter	8-Bit Timer/ Counter 1	8-Bit Timer/ Counter 2	8-Bit Timer/ Counter 3
Type	Interval timer	2ch	2ch	2ch	1ch
	External event counter	—	—	○	—
	One-shot timer	—	—	○	—
Function	Timer output	2ch	—	2ch	—
	Toggle output	○	—	○	—
	PWM/PPG output	○	—	○	—
	One-shot pulse output	○	—	—	—
	Real-time output	—	○	—	—
	Pulse amplitude measurement	○	○	○	—
	Number of interrupt requests	2	2	2	1
	Clock source of serial interface	—	—	—	○

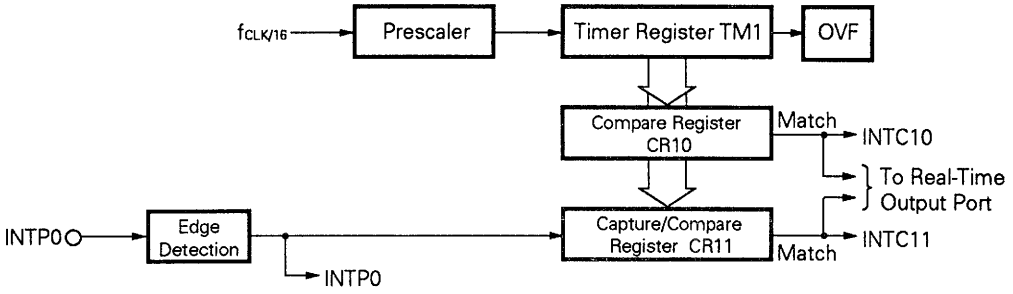
As 7 interrupt requests are supported in total, this functions as the timer of the 7 channels.

Fig. 2-5 Timer/Counter Unit Block Diagram

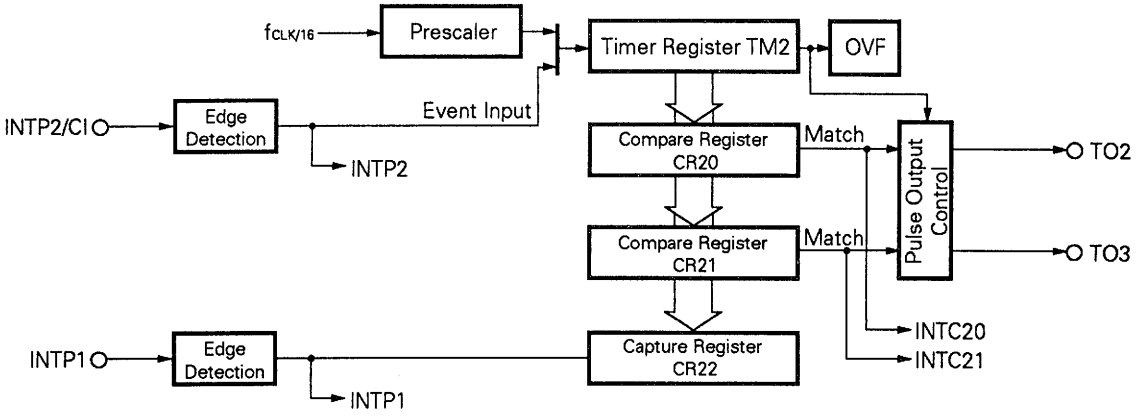
16-bit timer/counter unit



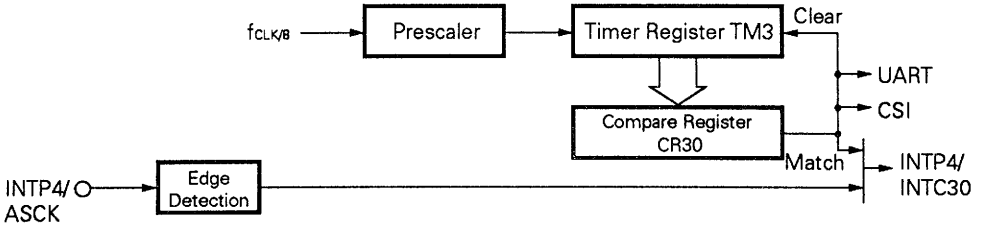
8-bit timer/counter unit 1



8-bit timer/counter unit 2



8-bit timer/counter unit 3

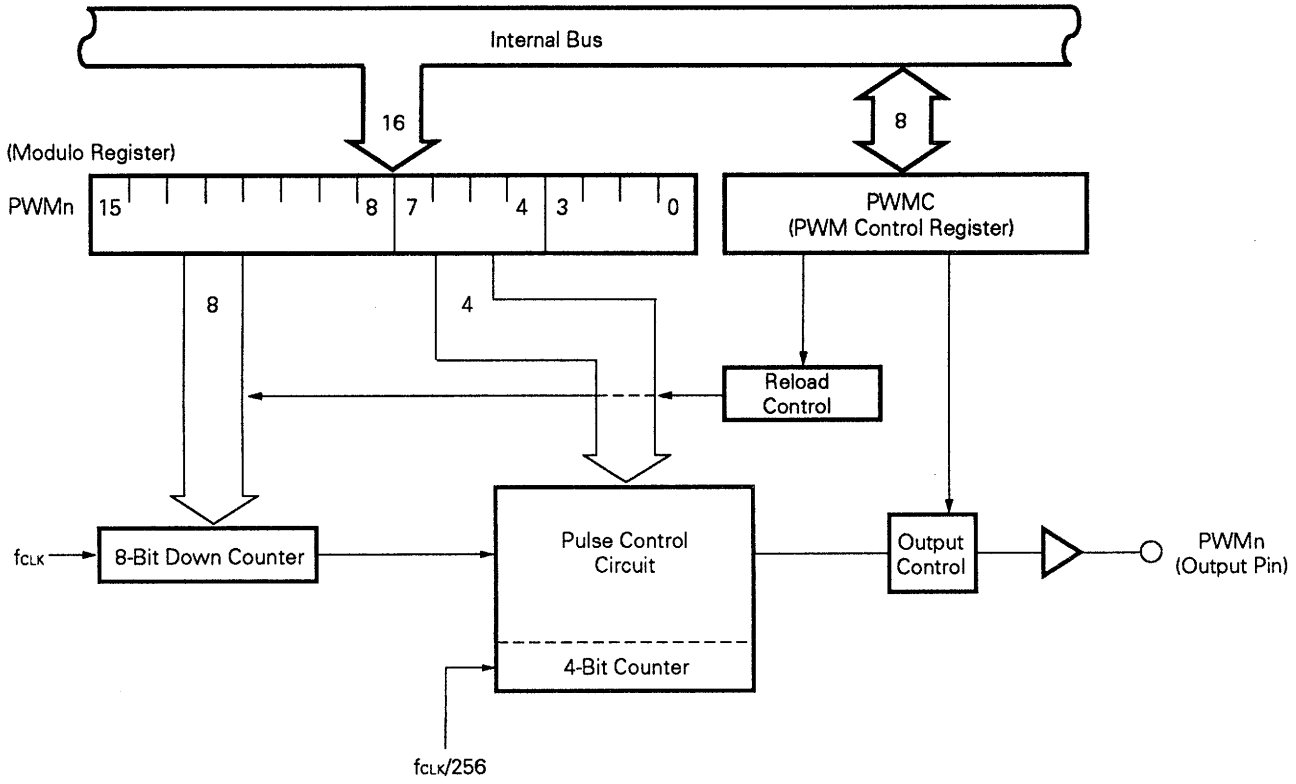


OVF : Overflow Flag

2.5 PWM OUTPUT (PWM0, PWM1)

Two channels of on-chip 12-bit resolution PWM (Pulse Width Modulation) with 23.4 kHz repeat frequency (f_{CLK} = 6 MHz) output circuits are incorporated. The active level of these channels can be selected independently as high or low level. This output is perfect for DC motor speed control.

Fig. 2-6 PWM Output Unit Block Diagram (n = 0, 1)



2.6 A/D CONVERTER

An analog/digital (A/D) converter with 8 multiplexed analog inputs (ANI0 to ANI7) is incorporated.

The conversion is a successive approximation and the conversion result is stored in the 8-bit A/D conversion result register (ADCR). Therefore, the conversion can be executed at high speed and accuracy (converting time 20 μs approximately: In 12 MHz operation).

This prepares the following modes to start the A/D converting operation.

- Hardware start: Starts the conversion with a trigger input (INTP5).
- Software start: Starts the conversion by setting a bit of A/D converter mode register (ADM).

Also, the following modes are prepared for the operation after started.

- Scan mode : Selects analog inputs one after another and acquires the converted data from all pins.
- Select mode : Fixes analog inputs to one pin and acquires the continuous conversion value.

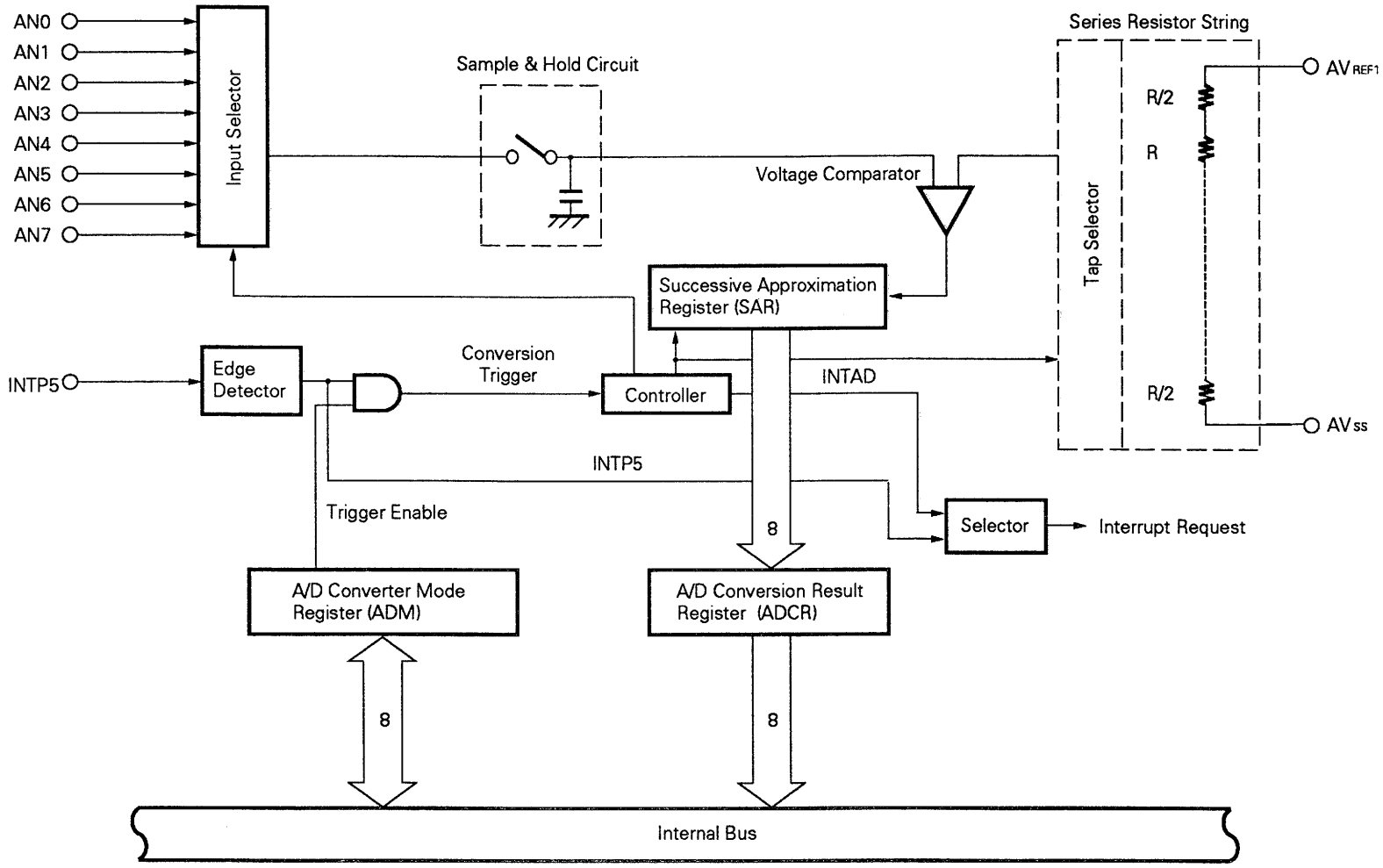
When stopping the above modes and the converting operation, all of them are specified by ADM.

The interrupt request (INTAD) occurs when the converted result is sent to ADCR (except for software start select mode). Therefore, by a macro service, the converted values can be sent into the memory continuously.

Table 2-3 INTAD Generation Mode

	Scan Mode	Select Mode
Hardware start	○	○
Software start	○	—

Fig. 2-7 A/D Converter Block Diagram



2.7 D/A CONVERTER

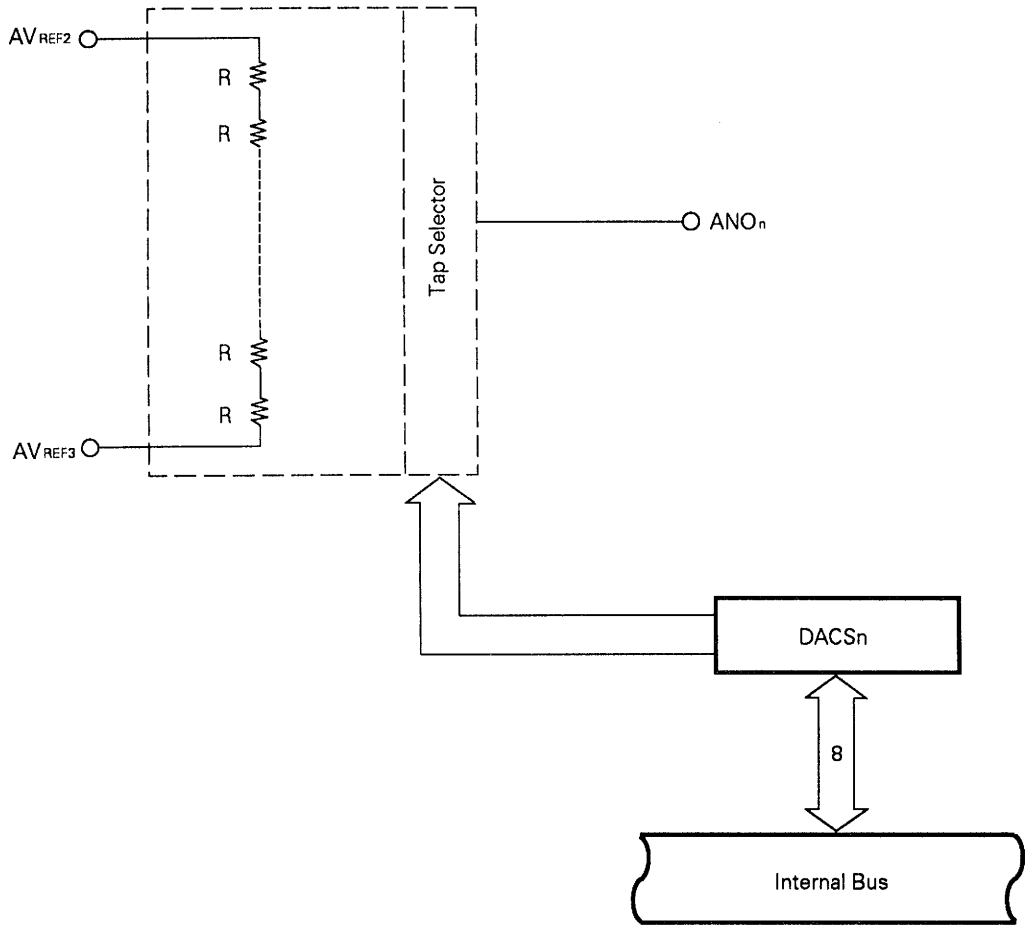
Two 8-bit resolution voltage output type digital/analog (D/A) converters are incorporated.

The conversion method is resistance string. The value to be output is written in 8-bit D/A conversion value setting register DACSn and the analog value is output to the ANOn pin. The voltage applied to the AV_{REF2} pin and AV_{REF3} pin determines the output voltage range.

Since the output impedance is high, a current cannot be taken from the output. When the load impedance is low, use by inserting a buffer amp between the output and the load.

The ANOn pin becomes high impedance during the period the $\overline{RESET}$ signal is low level. After reset is cleared, the DACSn register becomes 0.

Fig. 2-8 D/A Converter Block Diagram (n = 0, 1)



2.8 SERIAL INTERFACE

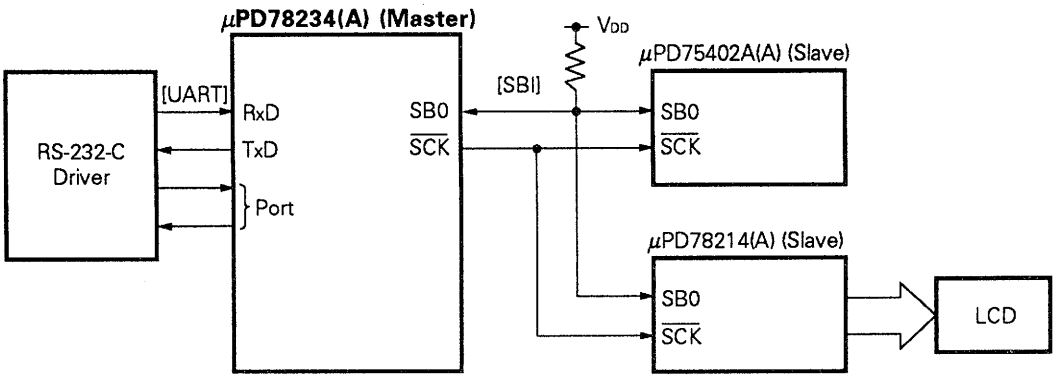
2 independent channels are equipped for serial interfaces.

- ○ Asynchronous serial interface (UART)
- ○ Clocked serial interface
  - • 3-wire serial I/O
  - • Serial bus interface (SBI)

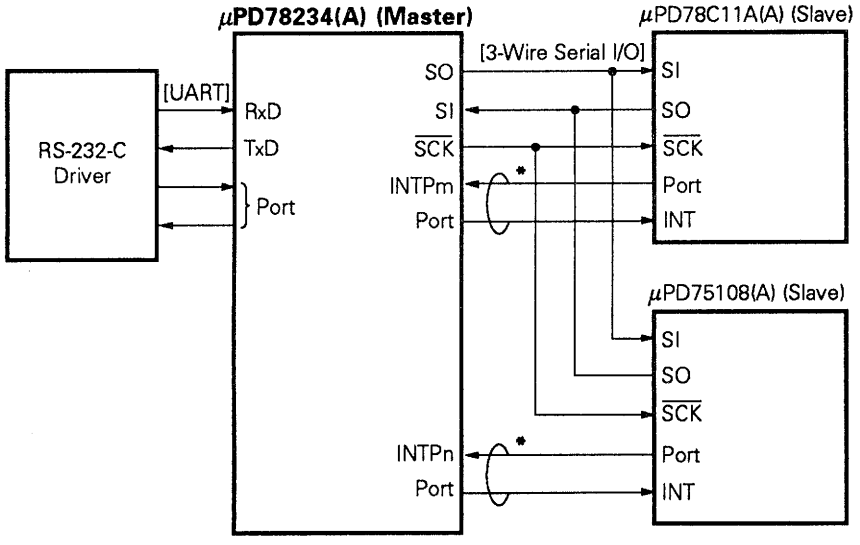
This enables both a communication with the external system and a local communication in the system simultaneously (see **Fig. 2-9**).

Fig. 2-9 Example of Serial Interface

(a) UART + SBI



(b) UART + 3-wire serial I/O



* Handshake line

2.8.1 Asynchronous Serial Interface

A UART (Universal Asynchronous Receiver Transmitter) is incorporated as an asynchronous serial interface. This is the method to transmit the one byte data following the start bit.

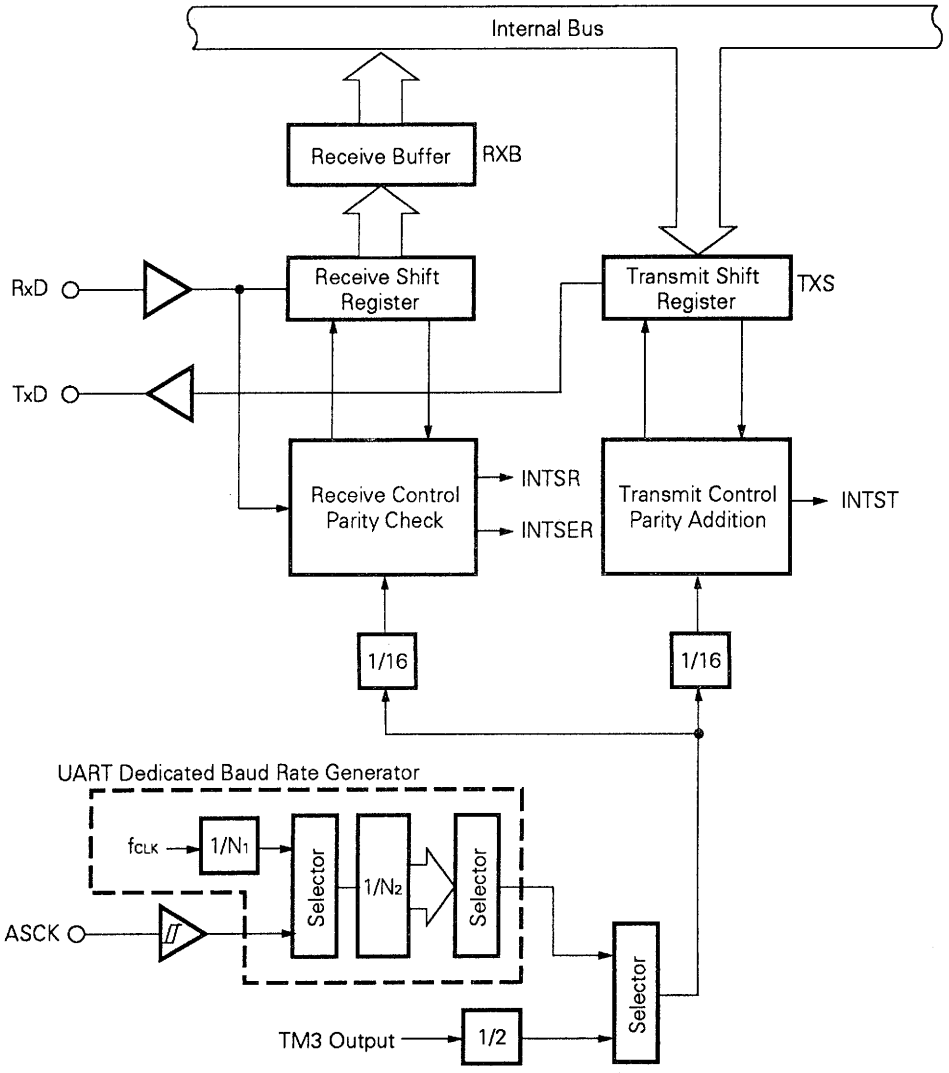
As UART dedicated baud rate generator is incorporated, communications are possible with a wide range of any baud rate.

Also, the baud rate can be defined by dividing the input clock for the ASCK pin.

Moreover, a baud rate can be generated with 8-bit timer/counter 3.

If the UART dedicated baud rate generator is used, the baud rate (31.25 kbps) of the MIDI specification can be acquired.

Fig. 2-10 Asynchronous Serial Interface Block Diagram

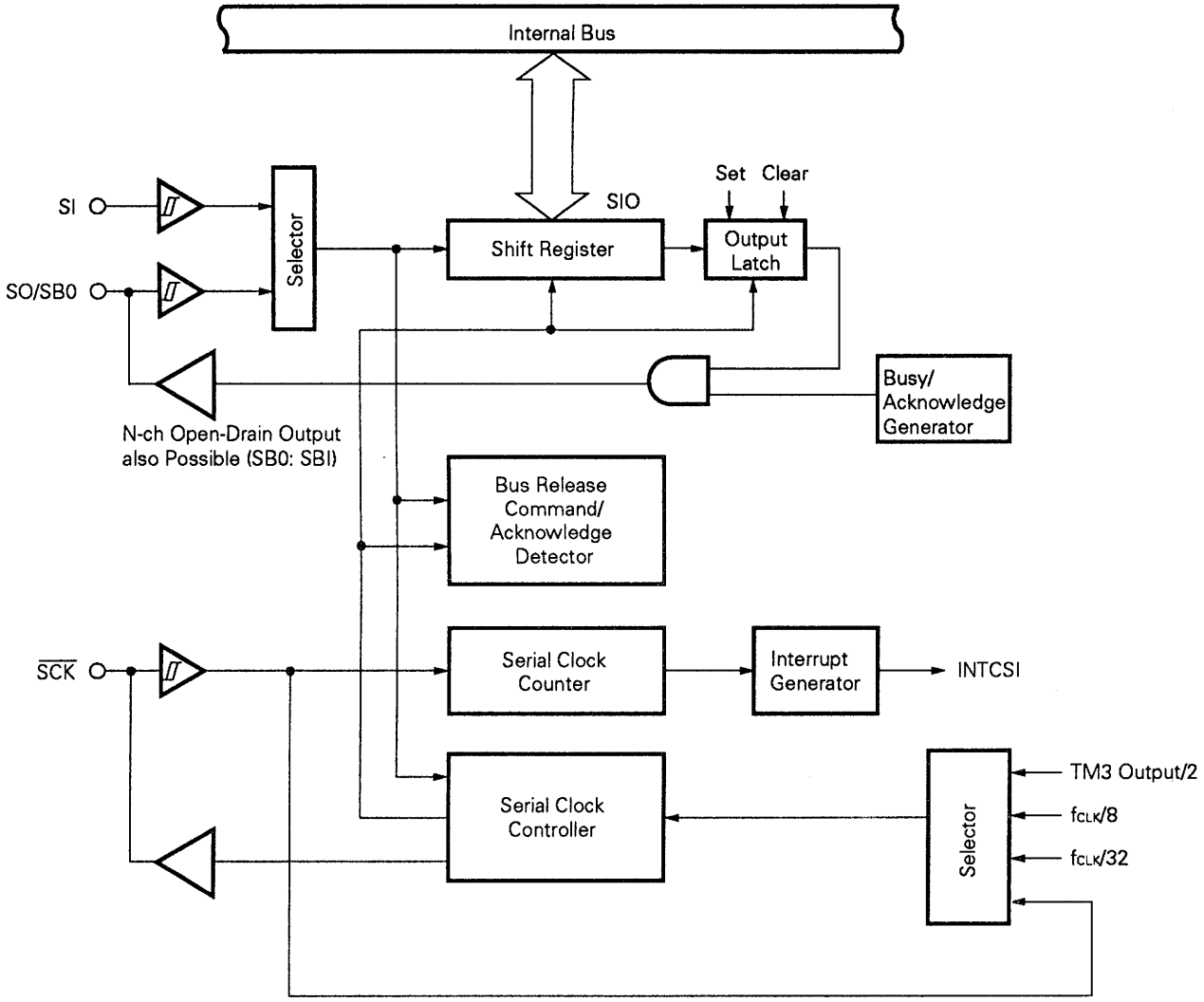


f_{CLK} : Internal system clock frequency (system clock frequency / 2)

2.8.2 Clocked Serial Interface

This is a method to communicate one byte data in synchronization with the serial clock which is activated by master device and starts to transmit.

Fig. 2-11 Clocked Serial Interface Block Diagram



f_{CLK} : Internal system clock frequency (system clock frequency / 2)

(1) 3-wire serial I/O

This is a interface to communicate with a device which incorporates a conventional clocked serial interface.

Basically, the communication is made through 3 wires of serial clock ($\overline{SCK}$) and serial data (SI, SO). In case of connecting with multiple device, the handshake line is required.

(2) SBI

This can communicate with a multiple device through 2 wires of serial clock ($\overline{SCK}$) and serial bus (SB0) and this is a NEC standard serial interface.

The master device outputs "address" from the SB0 pin and selects the communicated slave device. Then, "command" and "data" are transmitted and received between the master and slave.

3. INTERNAL/EXTERNAL CONTROL FUNCTIONS

3.1 INTERRUPT

The interrupt request servicing can be selected from 2 mode in the following table.

Table 3-1 Interrupt Request Servicing

Servicing Mode	Servicing Means	Servicing	PC, PSW Contents
Vectored interrupt	Software	Branch to and execution of service routine (any service contents)	Saved/restored
Macro service	Firmware	Execution of memory-I/O data transfer, etc. (fixed service contents)	Retained

3.1.1 Interrupt Source

The interrupt source includes the 19 types and a BRK instruction execution as shown in Table 3-2.

The priority of the interrupt servicing can be set to 2 levels (high and low priority levels). Therefore, it can separate the levels of the nest control which the interrupt is in progress and the interrupt request which occurs simultaneously (see **Fig. 3-1, Fig. 3-2**). But the nesting advances certainly in the macro service (not held).

The default priority is the priority level (fixed) to service the interrupt requests which occur at the same level simultaneously (see **Fig. 3-2**).

Table 3-2 Interrupt Source

Type	Default Priority	Source		Internal/ External	Macro Service
		Name	Trigger		
Software	—	BRK	Instruction execution	—	—
Non-maskable		NMI	Pin input edge detection	External	
Maskable	0 (highest)	INTP0	Pin input edge detection (TM1 capture trigger)		○
	1	INTP1	Pin input edge detection (TM2 capture trigger)		
	2	INTP2	Pin input edge detection (TM2 event counter input)		
	3	INTP3	Pin input edge detection (TM0 capture trigger)		
	4	INTC00	TM0 to CR00 match signal generation	Internal	
	5	INTC01	TM0 to CR01 match signal generation		
	6	INTC10	TM1 to CR10 match signal generation		
	7	INTC11	TM1 to CR11 match signal generation		
	8	INTC21	TM2 to CR21 match signal generation		
	9	INTP4	Pin input edge detection	External	
		INTC30	TM3 to CR30 match signal generation	Internal	
	10	INTP5	Pin input edge detection	External	
		INTAD	A/D converter conversion termination (transfer to ADCR)	Internal	
	11	INTC20	TM2 to CR20 match signal generation		
	12	INTSER	ASI receive error generation		—
	13	INTSR	ASI receive termination		○
	14	INTST	ASI transmit termination		
	15 (lowest)	INTCSI	CSI transfer termination		

TM0 : 16-bit timer
TM1 to TM3 : 8-bit timer
ASI : Asynchronous serial interface
CSI : Clocked serial interface

Fig. 3-1 Servicing Example for Another Interrupt Request Occurrence while an Interrupt Servicing

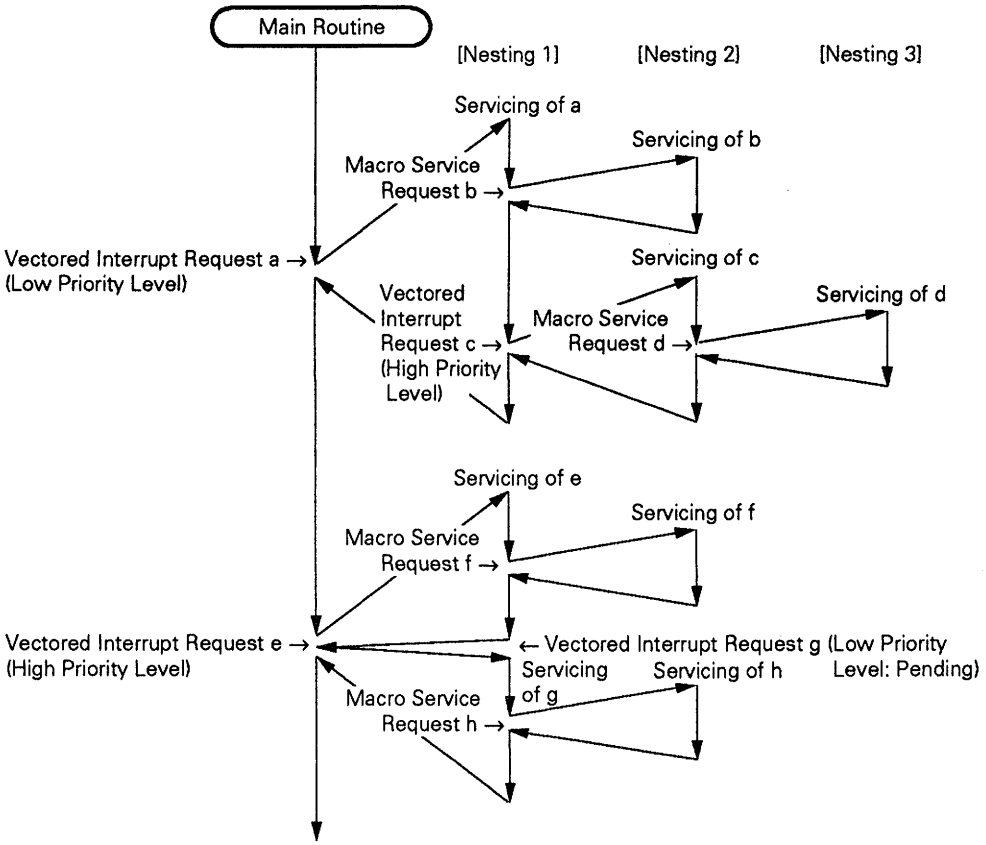
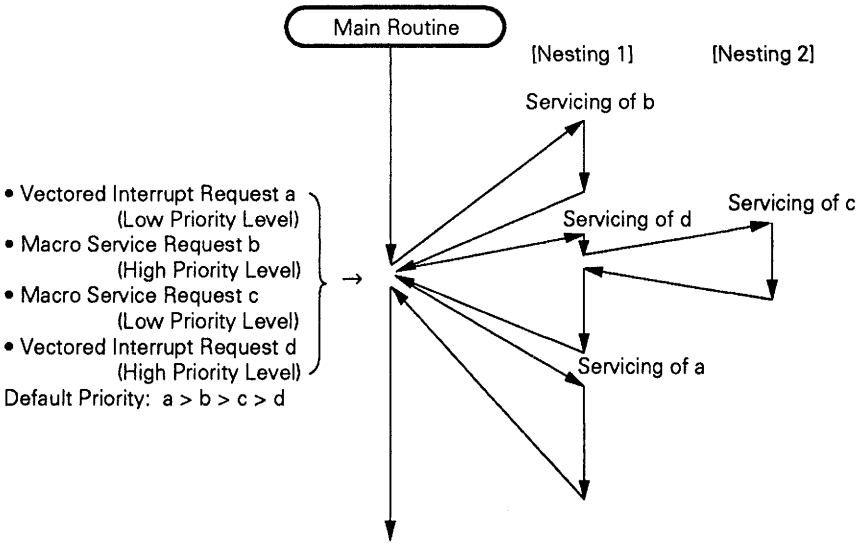


Fig. 3-2 Servicing Example for Simultaneous Occurred Interrupt Request



3.1.2 Vectored Interrupt

The memory contents of the vector table address, which corresponds to the interrupt source, is branched into the service routine as a destination address.

As the CPU executes the interrupt servicing, the following operations occur.

- O When branch: Saving the CPU status (PC, PSW contents) to the stack.
- O When return: Restoring the CPU status (PC, PSW contents) from the stack.

The RETI instruction executes returning to the main routine from the service routine.

Table 3-3 Vector Table Address

Interrupt Source	Vector Table Address
BRK	003EH
NMI	0002H
INTP0	0006H
INTP1	0008H
INTP2	000AH
INTP3	000CH
INTC00	0014H
INTC01	0016H
INTC10	0018H
INTC11	001AH

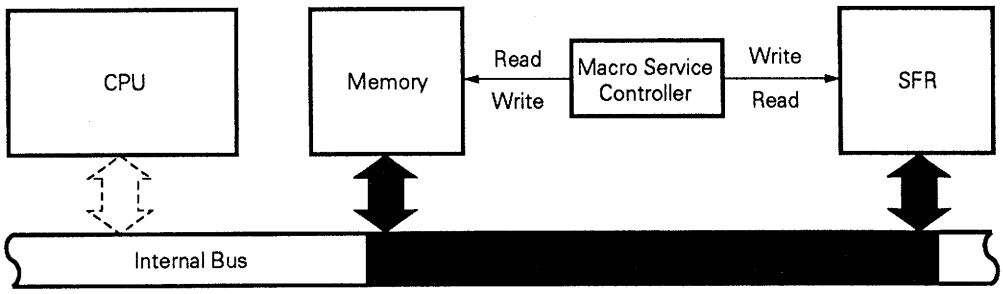
Interrupt Source	Vector Table Address
INTC21	001CH
INTP4	000EH
INTC30	
INTP5	0010H
INTAD	
INTC20	0012H
INTSER	0020H
INTSR	0022H
INTST	0024H
INTCSI	0026H

3.1.3 Macro Service

This is a function to transfer the data between the memory special functional registers (SFR) not through the CPU. The macro service controller accesses the memory and SFR during the same transfer cycle, and transfers directly without fetching data.

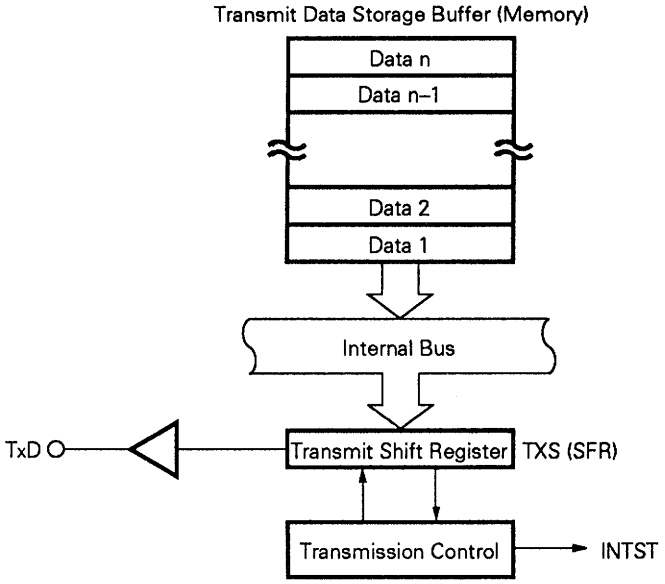
The high-speed data transfer is enabled because the CPU status is not saved/restored and no data is fetched.

Fig. 3-3 Macro Service



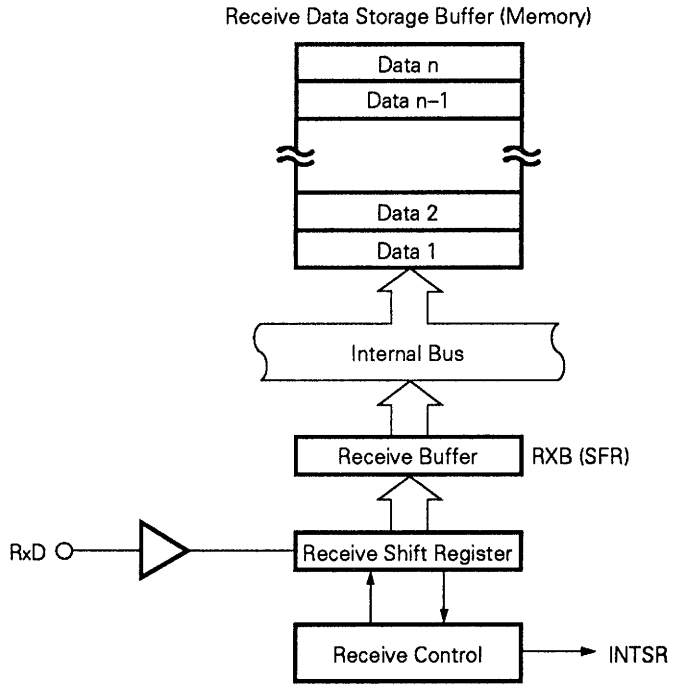
3.1.4 Macro Service Application Example

(1) Transmit operation of serial interface



Whenever the macro service request INTST is generated, the next send data is transferred to TXS from the memory. When the data n (last byte) is transferred to TXS (The send data storage buffer becomes empty.), a vectored interrupt request INTST is generated.

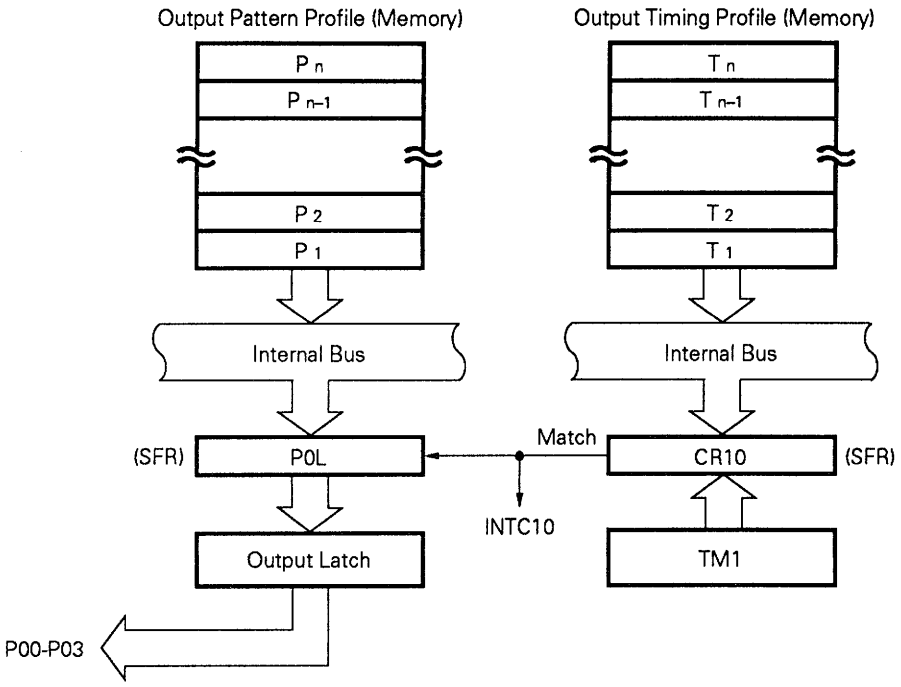
(2) Receive operation of serial interface



Whenever the macro service request INTSR is generated, the receive data is transferred to the memory from RXB. When the data n (last byte) is transferred to the memory (There is not enough space in the receive data storage buffer.), the vectored interrupt request INTSR is generated.

(3) Real-time output port

The INTC10 and INTC11 become output triggers of the real-time output port. In the macro service to them, the next output pattern and interval can be set simultaneously. Therefore, the INTC10 and INTC11 can control 2-system stepping motor independently. Also, it can be applied to control a PWM or DC motor, etc.



Whenever the macro service request INTC10 is generated, the pattern and timing are transferred to P0L and CR10 respectively. When the contents of the TM1 match with the contents of the CR10, the next INTC10 is generated and the contents of the P0L is sent to the output latch. If Tn (last byte) is sent to CR10, a vectored interrupt request INTC10 is generated.

The same operation is available for INTC11 (different point: CR10 → CR11, P0L → P0H, P00 to P03 → P04 to P07).

3.2 LOCAL BUS INTERFACE

A memory and an I/O (memory mapped I/O) can be connected to support the 1M-byte memory space (see **Figs. 2-1, 2-2**).

3.2.1 Memory Expansion

The following modes have been prepared as a memory expansion function.

- External memory expansion mode:
  Program memory and data memory can be expanded externally by 48256 bytes (μPD78234(A)) and 31488 bytes (μPD78238(A)). However, this area can be used unconditionally in the ROM-less mode (MODE=H).
- 1M-byte expansion mode:
  Expands the data memory by 960K bytes and becomes a 1M-byte memory space.

3.2.2 Programmable Wait

A wait can be independently inserted to the memory mapped on both a normal address (μPD78234(A): 00000H to 0FC7FH, μPD78238(A): 00000H to 0FAFFH) and an extended address (10000H to FFFFFH). Therefore, the efficiency of the entire system is not decreased even if the memory with different access time is connected.

3.2.3 Pseudo-Static RAM Refresh Function

The refresh operations are as follows.

- Pulse refresh:
  Outputs the refresh pulse to $\overline{\text{REFRQ}}$ pin in synchronization with a bus cycle.
- Power-down self refresh:
  Outputs a low-level to the $\overline{\text{REFRQ}}$ pin in the standby mode and holds the contents of the pseudo-static RAM.

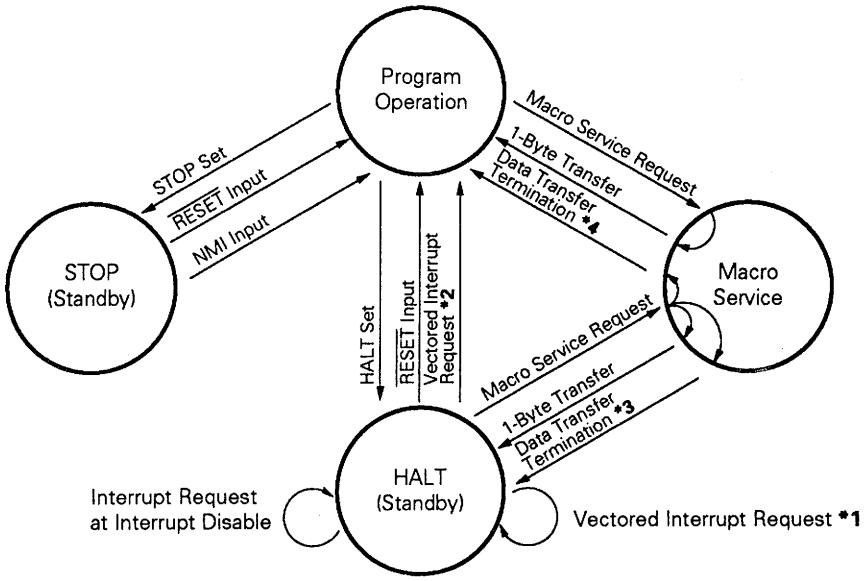
3.3 STANDBY

This is a function to reduce the power consumption of the chip. The following modes have been prepared.

- HALT mode: Stops the operation clock of the CPU. The average power consumption can be reduced by the normal operation and the intermittent operation during normal operations.
- STOP mode: Stops the oscillator. This stops all operation in the chip and makes the minute power consumption status only with leakage current.

These modes are programmable.
Also, the macro service can be started from the HALT mode.

Fig. 3-4 Standby Status Transitions



* 1. In the case of a low-priority vectored interrupt request (when low-priority interrupts are disabled when a HALT setting is made).
2. In the case of a high-priority vectored interrupt request, or when low-priority interrupts are enabled when a HALT setting is made.
3. In the case of a low-priority macro service (when low-priority interrupts are disabled when a HALT setting is made).
4. In the case of a high-priority macro service, or when low-priority interrupts are enabled when a HALT setting is made).

3.4 RESET

When a low level is input to the $\overline{\text{RESET}}$ pin, the internal hardware is initialized (reset state).

When the $\overline{\text{RESET}}$ input becomes from a low level to a high level, the following data is set in the program counter (PC).

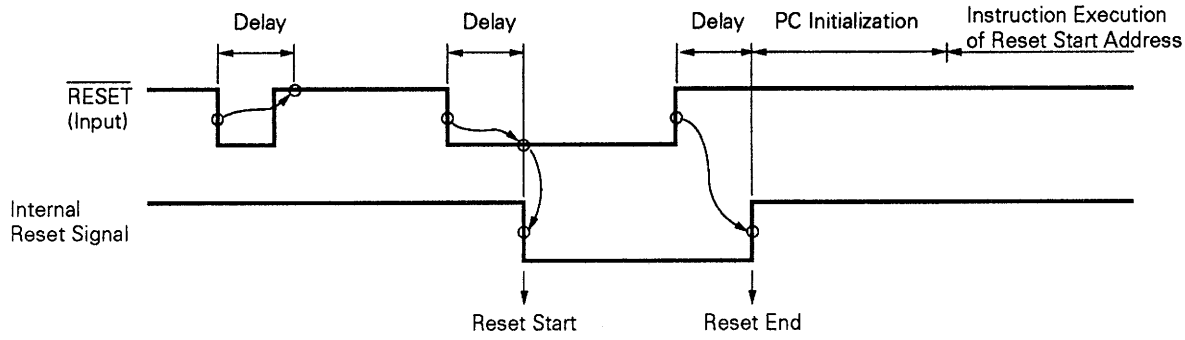
- O Lower 8 bits of PC: Contents of 0000H address
- O Upper 8 bits of PC: Contents of 0001H address

The contents of the PC set the destination address and the program starts to be executed from the address. Therefore, it can start from any address by reset start.

Please set the program for the contents of each register as required.

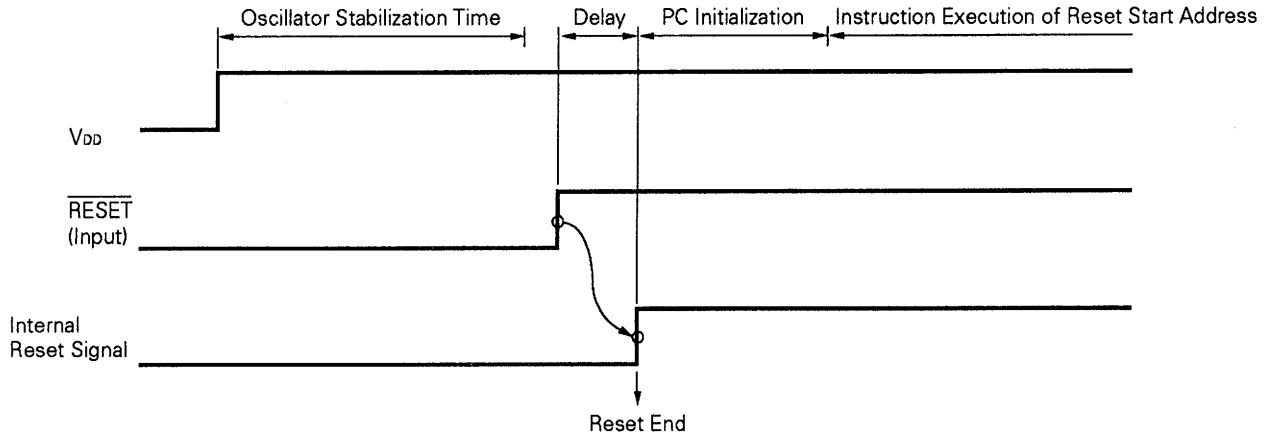
A noise eliminator is incorporated in the $\overline{\text{RESET}}$ input circuit to prevent any error from noise. This noise eliminator is a sampling circuit based on analog delay.

Fig. 3-5 Reset Acknowledge



Set the $\overline{\text{RESET}}$ signal active in the reset operation at power-on until oscillator stabilization time (approx. 40 ms) elapses.

Fig. 3-6 Reset Operation at Power-On



4. INSTRUCTION SET ★

(1) 8-bit instructions

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

Table 4-1 8-Bit Instruction Classified by Addressing

1st Operand \ 2nd Operand	#byte	A	r r'	saddr saddr'	sfr	mem	&mem	!addr16	&!addr16	PSW	n	None*2
A	ADD*1		MOV XCH	MOV XCH ADD*1	MOV XCH ADD*1	MOV XCH ADD*1	MOV XCH ADD*1	MOV	MOV	MOV		
r	MOV		MOV XCH ADD*1								ROR RORC ROL ROLC SHR SHL	MULU DIVUW DEC INC
r1												DBNZ
saddr	MOV ADD*1	MOV		MOV XCH ADD*1								DEC INC DBNZ
sfr	MOV ADD*1	MOV										POP PUSH
mem &mem		MOV										
mem1 &mem1												ROR4 ROL4
!addr16 &!addr16		MOV										
PSW	MOV	MOV										POP PUSH
STBC	MOV											

* 1 ADDC, SUB, SUBC, AND, OR, XOR and CMP are the same as ADD.

2 There is no second operand, or the second operand is not an operand address.

(2) 16-bit instructions

MOVW, ADDW, SUBW, CMPW, INCW, DECW, SHRW, SHLW, PUSH, POP

Table 4-2 16-Bit Instruction Classified by Addressing

1st Operand \ 2nd Operand	#word	AX	rp rp'	saddrp	sfrp	mem1	&mem1	SP	n	None
AX	ADDW SUBW CMPW		ADDW SUBW CMPW	MOVW ADDW SUBW CMPW	MOVW ADDW SUBW CMPW	MOVW	MOVW	MOVW		
rp	MOVW		MOVW						SHLW SHRW	DECW INCW PUSH POP
saddrp	MOVW	MOVW								
sfrp	MOVW	MOVW								
mem1 &mem1		MOVW								
SP	MOVW	MOVW								DECW INCW

(3) Bit manipulation instructions

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

Table 4-3 Bit Manipulation Instructions Classified by Addressing

1st Operand \ 2nd Operand	CY	A.bit	/A.bit	X.bit	/X.bit	saddr. bit	/saddr. bit	sfr.bit	/sfr.bit	PSW.bit	/PSW. bit	None*
CY		MOV1 AND1 OR1 XOR1	AND1 OR1	MOV1 AND1 OR1 XOR1	AND1 OR1	MOV1 AND1 OR1 XOR1	AND1 OR1	MOV1 AND1 OR1 XOR1	AND1 OR1	MOV1 AND1 OR1 XOR1	AND1 OR1	CLR1 NOT1 SET1
A.bit	MOV1											CLR1 NOT1 SET1 BF BT BTCLR
X.bit	MOV1											CLR1 NOT1 SET1 BF BT BTCLR
saddr.bit	MOV1											CLR1 NOT1 SET1 BF BT BTCLR
sfr.bit	MOV1											CLR1 NOT1 SET1 BF BT BTCLR
PSW.bit	MOV1											CLR1 NOT1 SET1 BF BT BTCLR

* There is no second operand, or the second operand is not an operand address.

(4) Call/branch instructions

CALL, CALLF, CALLT, BR, BC, BT, BF, BTCLR, DBNZ, BL, BNC, BNL, BZ, BE, BNZ, BNE

Table 4-4 Call/Branch Instructions Classified by Addressing

Instruction Addressing Operand	$addr16	!addr16	rp	!addr11	[addr5]
Basic instruction	BR BC*	CALL BR	CALL BR	CALLF	CALLT
Compound instruction	BT BF BTCLR DBNZ				

* BL, BNC, BNL, BZ, BF, BNZ and BNE are the same as BC.

(5) Other instructions

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

5. ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS (Ta = 25 °C)

PARAMETER	SYMBOL	TEST CONDITIONS	RATING	UNIT
Supply voltage	V_{DD}		−0.5 to +7.0	V
	AV_{DD}		AVss to V_{DD} +0.5	V
	AVss		−0.5 to +0.5	V
Input voltage	V_I		−0.5 to V_{DD} +0.5	V
Output voltage	V_O		−0.5 to V_{DD} +0.5	V
Output current low	I_{OL}	1 pin	15	mA
		All output pins total	100	mA
Output current high	I_{OH}	1 pin	−10	mA
		All output pins total	−50	mA
A/D converter reference input voltage	AV_{REF1}		−0.5 to V_{DD} +0.3	V
D/A converter reference input voltage	AV_{REF2}		−0.5 to V_{DD} +0.3	V
	AV_{REF3}		−0.5 to V_{DD} +0.3	V
Operating temperature	T_{opt}		−40 to +85	°C
Storage temperature	T_{stg}		−65 to +150	°C

Note **Product quality may suffer if the absolute maximum rating is exceeded for even a single parameter, or even momentarily. In other words, the absolute maximum ratings are rated values at whch 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.** ★

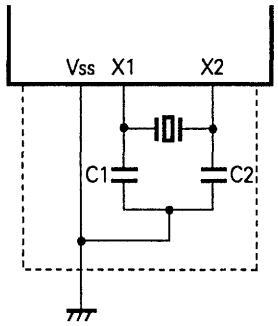
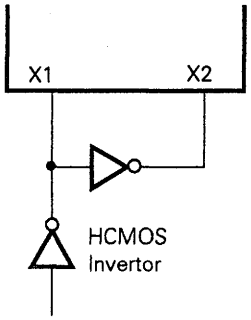
OPERATING CONDITIONS

CLOCK FREQUENCY	OPERATING TEMPERATURE (T_{opt})	SUPPLY VOLTAGE (V_{DD})
4 MHz ≤ fxx ≤ 12 MHz	−40 to +85 °C	+5.0 V ±10 %

CAPACITANCE (Ta = 25 °C, V_{DD} = Vss = 0 V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Input capacitance	C_I	f = 1 MHz Unmeasured pins returned to 0 V.			20	pF
Output capacitance	C_O				20	pF
I/O capacitance	C_{IO}				20	pF

OSCILLATOR CHARACTERISTICS (Ta = –40 to +85 °C, V_{DD} = +5 V ±10 %, V_{SS} = 0 V)

RESONATOR	RECOMMENDED CIRCUIT	PARAMETER	MIN.	MAX.	UNIT
Ceramic resonator or crystal resonator		Oscillator frequency (f_{XX})	4	12	MHz
External clock		X1 input frequency (f_X)	4	12	MHz
		X1 input rising/falling time (t_{XR}, t_{XF})	0	30	ns
		X1 input high/low level width (t_{WXH}, t_{WXL})	30	130	ns

Note When the subsystem clock oscillator is used, the followings 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.**

DC CHARACTERISTICS (Ta = –40 to +85 °C, V_{DD} = AV_{DD} = +5 V ±10 %, V_{SS} = AV_{SS} = 0 V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Input voltage low	V_{IL}		0		0.8	V
Input voltage high	V_{IH1}	Pins except for *1	2.2		V_{DD}	V
	V_{IH2}	Pin of *1	0.8 V_{DD}		V_{DD}	V
Output voltage low	V_{OL1}	I_{OL} = 2.0 mA			0.45	V
	V_{OL2}	I_{OL} = 8.0 mA *2			1.0	V
Output voltage high	V_{OH1}	I_{OH} = –1.0 mA	V_{DD}–1.0			V
	V_{OH2}	I_{OH} = –100 μA	V_{DD}–0.5			V
	V_{OH3}	I_{OH} = –5.0 mA *3	2.0			V
X1 input current low	I_{IL}	0 V ≤ V_I ≤ V_{IL}			–100	μA
X1 input current high	I_{IH}	V_{IH2} ≤ V_I ≤ V_{DD}			100	μA
Input leakage current	I_{LI}	0 V ≤ V_I ≤ V_{DD}			±10	μA
Output leakage current	I_{LO}	0 V ≤ V_O ≤ V_{DD}			±10	μA
V_{DD} supply current	I_{DD1}	Operating mode fxx = 12 MHz		20	40	mA
	I_{DD2}	HALT mode fxx = 12 MHz		7	20	mA
Data retention voltage	V_{DDDR}	STOP mode	2.5		5.5	V
Data retention current	I_{DDDR}	STOP mode V_{DDDR} = 2.5 V			10	μA
		STOP mode V_{DDDR} = 5 V ±10 %			20	μA
Pull-up resistor	R_L	V_I = 0 V	15	40	80	kΩ

* 1. X1, X2, $\overline{\text{RESET}}$, P20/NMI, P21/INTP0, P22/INTP1, P23/INTP2/CI, P24/INTP3, P25/INTP4/ASCK, P26/INTP5, P27/SI, P32/$\overline{\text{SCK}}$, P33/SO/SB0, MODE pins

2. P10 to P17, P40/AD0 to P47/AD7, P50/A8 to P57/A15 pins

3. P00 to P07 pins

AC CHARACTERISTICS (Ta = –40 to +85 °C, V_{DD} = +5 V ±10 %, V_{SS} = 0 V)
READ/WRITE OPERATION (1/2)

	PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	MAX.	UNIT
	X1 input clock cycle time	t_{CYX}		82	250	ns
	Address setup time (to ASTB↓)	t_{SAST} •		52		ns
	Address hold time (from ASTB↓) *	t_{HSTA}		25		ns
	Address hold time (from $\overline{RD}$↑)	t_{HRA}		30		ns
	Address hold time (from $\overline{WR}$↑)	t_{HWA}		30		ns
	$\overline{RD}$↓ delay time from address	t_{DAR} •		129		ns
	Address float time (from $\overline{RD}$↓)	t_{FAR} •		11		ns
	Data input time from address	t_{DAID} •	No. of waits = 0		228	ns
	Data input time from ASTB↓	t_{DSTID} •	No. of waits = 0		181	ns
	Data input time from $\overline{RD}$↓	t_{DRID} •	No. of waits = 0		100	ns
	$\overline{RD}$↓ delay time from ASTB↓	t_{DSTR} •		52		ns
	Data hold time (from $\overline{RD}$↑)	t_{HRID}		0		ns
	Address active time from $\overline{RD}$↑	t_{DRA} •		124		ns
	ASTB↑ delay time from $\overline{RD}$↑	t_{DRST} •		124		ns
	$\overline{RD}$ low-level width	t_{WRL} •	No. of waits = 0	124		ns
	ASTB high-level width	t_{WSTH} •		52		ns
	$\overline{WR}$↓ delay time from address	t_{DAW} •		129		ns
	Data output time from ASTB↓	t_{DSTOD} •			142	ns
	Data output time from $\overline{WR}$↓	t_{DWOD} •			60	ns
★	$\overline{WR}$↓ delay time from ASTB↓	t_{DSTW1} •	Refresh disabled	52		ns
		t_{DSTW2} •	Refresh enabled	129		ns
	Data setup time (to $\overline{WR}$↑)	t_{SODWR} •	No. of waits = 0	146		ns
	Data setup time (to $\overline{WR}$↓)	t_{SODWF} •	Refresh enabled	22		ns
	Data hold time (from $\overline{WR}$↑) *	t_{HWOD}		20		ns
	ASTB↑ delay time from $\overline{WR}$↑	t_{DWST} •		42		ns
★	$\overline{WR}$ low-level width	t_{WWL1} •	Refresh disabled No. of waits = 0	196		ns
		t_{WWL2} •	Refresh enabled No. of waits = 0	114		ns
	$\overline{WAIT}$↓ input time from address	t_{DAWT} •			146	ns
	$\overline{WAIT}$↓ input time from ASTB↓	t_{DSTWT} •			84	ns

* The hold time includes the time to hold the V_{OH} and V_{OL} under the load conditions of C_L = 100 pF and R_L = 2 kΩ.

Remarks 1. The values in the above table are based on "fxx = 12 MHz and C_L = 100 pF".
2. For a parameter with a dot (•) in the SYMBOL column, refer to **DEFINITION OF t_{CYX} DEPENDENT BUS TIMINGS** as well.

READ/WRITE OPERATION (2/2)

PARAMETER		SYMBOL	TEST CONDITIONS	MIN.	MAX.	UNIT
$\overline{WAIT}$ hold time from ASTB↓		t_{HSTWT} •	No. of external waits = 1	174		ns
$\overline{WAIT}$↑ delay time from ASTB↓		t_{DSTWTH} •	No. of external waits = 1		273	ns
$\overline{WAIT}$↓ input time from $\overline{RD}$↓		t_{DRWTL} •			22	ns
$\overline{WAIT}$ hold time from $\overline{RD}$↓		t_{HRWT} •	No. of external waits = 1	87		ns
$\overline{WAIT}$↑ delay time from $\overline{RD}$↓		t_{DRWTH} •	No. of external waits = 1		186	ns
Data input time from $\overline{WAIT}$↑		t_{DWTID} •			62	ns
$\overline{WR}$↑ delay time from $\overline{WAIT}$↑		t_{DWTW} •		154		ns
$\overline{RD}$↑ delay time from $\overline{WAIT}$↑		t_{DWTR} •		72		ns
$\overline{WAIT}$ input time from $\overline{WR}$↓ (At refresh disabled)		t_{DWWTL} •			22	ns
$\overline{WAIT}$ hold time from $\overline{WR}$↓	Refresh disabled	t_{HWWT1} •	No. of external waits = 1	87		ns
	Refresh enabled	t_{HWWT2} •	No. of external waits = 1	5		ns
$\overline{WAIT}$↑ delay time from $\overline{WR}$↓	Refresh disabled	t_{DWWTH1} •	No. of external waits = 1		186	ns
	Refresh enabled	t_{DWWTH2} •	No. of external waits = 1		104	ns
$\overline{REFRQ}$↓ delay time from $\overline{RD}$↑		t_{DRRFQ} •		154		ns
$\overline{REFRQ}$↓ delay time from $\overline{WR}$↑		t_{DWRFQ} •		72		ns
$\overline{REFRQ}$ low-level width		t_{WRFQL} •		120		ns
ASTB↑ delay time from $\overline{REFRQ}$↑		t_{DRFQST} •		280		ns

Remarks 1. The values in the above table are based on "fxx = 12 MHz and C_L = 100 pF".

2. For a parameter with a dot (•) in the SYMBOL column, refer to **DEFINITION OF t_{CYX} DEPENDENT BUS TIMINGS** as well.

SERIAL OPERATION

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	MAX.	UNIT
Serial clock cycle time	t_{CYSK}	Input	External clock	1.0		μs
		Output	Internal divided by 16	1.3		μs
			Internal divided by 64	5.3		μs
Serial clock low-level width	t_{WSKL}	Input	External clock	420		ns
		Output	Internal divided by 16	556		ns
			Internal divided by 64	2.5		μs
Serial clock high-level width	t_{WSKH}	Input	External clock	420		ns
		Output	Internal divided by 16	556		ns
			Internal divided by 64	2.5		μs
SI, SB0 setup time (to $\overline{SCK}$↑)	t_{SSK}			150		ns
SI, SB0 hold time (from $\overline{SCK}$↑)	t_{HSK}			400		ns
SO/SB0 output delay time (from $\overline{SCK}$↓)	t_{DSBSK1}	CMOS push-pull output (3-wire serial I/O mode)		0	300	ns
	t_{DSBSK2}	Open-drain output (SBI mode), R_L = 1 kΩ		0	800	ns
SB0 high hold time (from $\overline{SCK}$↑)	t_{HSBSK}	SBI mode		4		t_{CYX}
SB0 low setup time (to $\overline{SCK}$↓)	t_{SSBSK}			4		t_{CYX}
SB0 low-level width	t_{WSBL}			4		t_{CYX}
SB0 high-level width	t_{WSBH}			4		t_{CYX}

Remarks The values in the above table are based on "fxx = 12 MHz and C_L = 100 pF".

OTHER OPERATIONS

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	MAX.	UNIT
NMI low-level width	t_{WNIL}		10		μs
NMI high-level width	t_{WNIH}		10		μs
INTP0 to INTP5 low-level width	t_{WITL}		24		t_{CYX}
INTP0 to INTP5 high-level width	t_{WITH}		24		t_{CYX}
$\overline{\text{RESET}}$ low-level width	t_{WRSL}		10		μs
$\overline{\text{RESET}}$ high-level width	t_{WRSH}		10		μs

EXTERNAL CLOCK TIMING

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	MAX.	UNIT
X1 input low-level width	t_{WXL}		30	130	ns
X1 input high-level width	t_{WXH}		30	130	ns
X1 input rise time	t_{XR}		0	30	ns
X1 input fall time	t_{XF}		0	30	ns
X1 input clock cycle time	t_{CYX}		82	250	ns

A/D CONVERTER CHARACTERISTICS (T_a = –40 to +85 °C, V_{DD} = AV_{DD} = +5 V ±10 %, V_{SS} = AV_{SS} = 0 V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Resolution			8			bit
Overall error *1		4.0 V ≤ AV_{REF1} ≤ AV_{DD} Ta = –10 to +70 °C			0.4	%
		3.4 V ≤ AV_{REF1} ≤ AV_{DD}			0.8	%
		4.0 V ≤ AV_{REF1} ≤ AV_{DD}			0.6	%
Quantization error					±1/2	LSB
Conversion time	t_{CONV}	The FR bit of ADM is to be "0"	360			t_{CYX}
		The FR bit of ADM is to be "1"	240			t_{CYX}
Sampling time	t_{SAMP}	The FR bit of ADM is to be "0"	72			t_{CYX}
		The FR bit of ADM is to be "1"	48			t_{CYX}
Analog input voltage	V_{IAN}		–0.3		AV_{REF1} +0.3	V
Analog input impedance	R_{AN}			1000		MΩ
Reference voltage	AV_{REF1}		3.4		AV_{DD}	V
AV_{REF} current	AI_{REF1}	fxx = 12 MHz		1.5	3.0	mA
		*2		0.7	1.5	mA
AV_{DD} supply current	AI_{DD1}	fxx = 12 MHz		1.4	3.0	mA
	AI_{DD2}	*3		10	20	μA

* 1. Quantization error is not included. Represented by the ratio to full-scale value.
2. When ADM register CS bit is 0
3. When ADM register CS bit is 0 and STOP mode is set

D/A CONVERTER CHARACTERISTICS (Ta = –40 to +85 °C, AV_{REF2} = V_{DD} + 5 V ±10 %, AV_{REF3} = V_{SS} = 0 V)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Resolution					8	BIT
Overall error		Load conditions: 4 MΩ, 30 pF			0.4	%
		Load conditions: 2 MΩ, 30 pF			0.6	%
		AV_{REF2} = 0.75 V_{DD} AV_{REF3} = 0.25 V_{DD} Load conditions: 4 MΩ, 30 pF			0.6	%
		AV_{REF2} = 0.75 V_{DD} AV_{REF3} = 0.25 V_{DD} Load conditions: 2 MΩ, 30 pF			0.8	%
Settling time		Load conditions: 2 MΩ, 30 pF			10	μs
Output resistor	R_O	*		20		kΩ
Analog reference voltage	AV_{REF2}		0.75 V_{DD}		V_{DD}	V
Analog reference voltage	AV_{REF3}		0		0.25 V_{DD}	V
Reference power input current	AI_{REF2}		0		5	mA
Reference power input current	AI_{REF3}		–5		0	mA

* When DACS0, 1 = 7FH

DEFINITION OF t_{CYX} DEPENDENT BUS TIMINGS (1/2)

PARAMETER	SYMBOL	CALCULATION FOMULA	MIN./MAX.	12 MHz	UNIT
X1 input clock cycle time	t_{CYX}		MIN.	82	ns
Address setup time (to ASTB↓)	t_{SAST}	t_{CYX} – 30	MIN.	52	ns
$\overline{RD}$↓ delay time from address	t_{DAR}	2t_{CYX} – 35	MIN.	129	ns
Address float time (from $\overline{RD}$↓)	t_{FAR}	t_{CYX}/2 – 30	MIN.	11	ns
Data input time from address	t_{DAID}	(4 + 2n) t_{CYX} – 100	MAX.	228 *	ns
Data input time from ASTB↓	t_{DSTID}	(3 + 2n) t_{CYX} – 65	MAX.	181 *	ns
Data input time from $\overline{RD}$↓	t_{DRID}	(2 + 2n) t_{CYX} – 64	MAX.	100 *	ns
$\overline{RD}$↓ delay time from ASTB↓	t_{DSTR}	t_{CYX} – 30	MIN.	52	ns
Address active time from $\overline{RD}$↑	t_{DRA}	2t_{CYX} – 40	MIN.	124	ns
ASTB↑ delay time from $\overline{RD}$↑	t_{DRST}	2t_{CYX} – 40	MIN.	124	ns
$\overline{RD}$ low-level width	t_{WRL}	(2 + 2n) t_{CYX} – 40	MIN.	124 *	ns
ASTB high-level width	t_{WSTH}	t_{CYX} – 30	MIN.	52	ns
$\overline{WR}$↓ delay time from address	t_{DAW}	2t_{CYX} – 35	MIN.	129	ns
Data output time from ASTB↓	t_{DSTOD}	t_{CYX} + 60	MAX.	142	ns
$\overline{WR}$↓ delay time from ASTB↓	t_{DSTW1}	t_{CYX} – 30 (Refresh disabled)	MIN.	52	ns ★
	t_{DSTW2}	2t_{CYX} – 35 (Refresh enabled)	MIN.	129	ns
Data setup time (to $\overline{WR}$↑)	t_{SODWR}	(3 + 2n) t_{CYX} – 100	MIN.	146 *	ns
Data setup time (to $\overline{WR}$↓)	t_{SODWF}	t_{CYX} – 60 (Refresh enabled)	MIN.	22	ns
ASTB↑ delay time from $\overline{WR}$↑	t_{DWST}	t_{CYX} – 40	MIN.	42	ns
$\overline{WR}$ low-level width	t_{WWL1}	(3 + 2n) t_{CYX} – 50 (Refresh disabled)	MIN.	196 *	ns ★
	t_{WWL2}	(2 + 2n) t_{CYX} – 50 (Refresh enabled)	MIN.	114 *	ns
$\overline{WAIT}$↓ input time from address	t_{DAWT}	3t_{CYX} – 100	MAX.	146	ns
$\overline{WAIT}$↓ input time from ASTB↓	t_{DSTWT}	2t_{CYX} – 80	MAX.	84	ns

Remarks "n" indicates the number of waits.

* When n = 0

DEFINITION OF t_{CYX} DEPENDENT BUS TIMINGS (2/2)

PARAMETER		SYMBOL	CALCULATION FOMULA	MIN./MAX.	12 MHz	UNIT
$\overline{WAIT}$ hold time from ASTB↓		t_{HSTWT}	2Xt_{CYX} + 10	MIN.	174 *	ns
$\overline{WAIT}$↑ delay time from ASTB↓		t_{DSTWTH}	2(1 + X)t_{CYX} – 55	MAX.	273 *	ns
$\overline{WAIT}$↓ input time from $\overline{RD}$↓		t_{DRWTL}	t_{CYX} – 60	MAX.	22	ns
$\overline{WAIT}$ hold time from $\overline{RD}$↓		t_{HRWT}	(2X – 1)t_{CYX} + 5	MIN.	87 *	ns
$\overline{WAIT}$↑ delay time from $\overline{RD}$↓		t_{DRWTH}	(2X + 1)t_{CYX} – 60	MAX.	186 *	ns
Data input time from $\overline{WAIT}$↑		t_{DWTID}	t_{CYX} – 20	MAX.	62	ns
$\overline{WR}$↑ delay time from $\overline{WAIT}$↑		t_{DWTW}	2t_{CYX} – 10	MIN.	154	ns
$\overline{RD}$↑ delay time from $\overline{WAIT}$↑		t_{DWTR}	t_{CYX} – 10	MIN.	72	ns
$\overline{WAIT}$ input time from $\overline{WR}$↓ (At refresh disabled)		t_{DWWTL}	t_{CYX} – 60	MAX.	22	ns
$\overline{WAIT}$ hold time from $\overline{WR}$↓	Refresh disabled	t_{HWWT1}	(2X – 1)t_{CYX} + 5	MIN.	87 *	ns
	Refresh mode	t_{HWWT2}	(2X – 1)t_{CYX} + 5	MIN.	5 *	ns
$\overline{WAIT}$↑ delay time from $\overline{WR}$↓	Refresh disabled	t_{DWWTH1}	(2X + 1)t_{CYX} – 60	MAX.	186 *	ns
	Refresh mode	t_{DWWTH2}	2Xt_{CYX} – 60	MAX.	104 *	ns
$\overline{REFRQ}$↓ delay time from $\overline{RD}$↑		t_{DRRFQ}	2t_{CYX} – 10	MIN.	154	ns
$\overline{REFRQ}$↓ delay time from $\overline{WR}$↑		t_{DWRFQ}	t_{CYX} – 10	MIN.	72	ns
$\overline{REFRQ}$ low-level width		t_{WRFQL}	2t_{CYX} – 44	MIN.	120	ns
ASTB↑ delay time from $\overline{REFRQ}$↑		t_{DRFQST}	4t_{CYX} – 48	MIN.	280	ns

Remarks 1. X: The number of the external wait. (1, 2, ...)

2. $t_{CYX} \cong 82$ ns (f_{XX} = 12 MHz)

3. "n" indicates the number of waits.

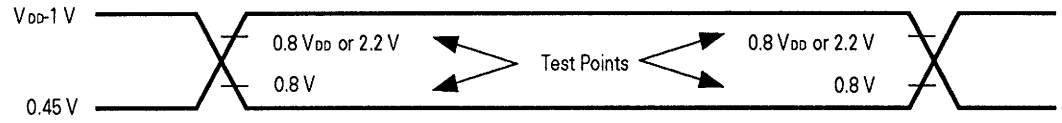
* When X = 1

DATA RETENTION CHARACTERISTICS (Ta = –40 to +85 °C)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Data retention voltage	V_{DDDR}	STOP mode	2.5		5.5	V
Data retention current	I_{DDDR}	V_{DDDR} = 2.5 V			10	μA
		V_{DDDR} = 5 V ±10 %			20	μA
V_{DD} rise time	t_{RVD}		200			μs
V_{DD} fall time	t_{FVD}		200			μs
V_{DD} hold time (from STOP mode setting)	t_{HVD}		0			ms
STOP release signal input time	t_{DREL}		0			ms
Oscillation stabilization wait time	t_{WAIT}	Crystal resonator	30			ms
		Ceramic resonator	5			ms
Input voltage low	V_{IL}	Specified pin*	0		0.1 V_{DDDR}	V
Input voltage high	V_{IH}		0.9 V_{DDDR}		V_{DDDR}	V

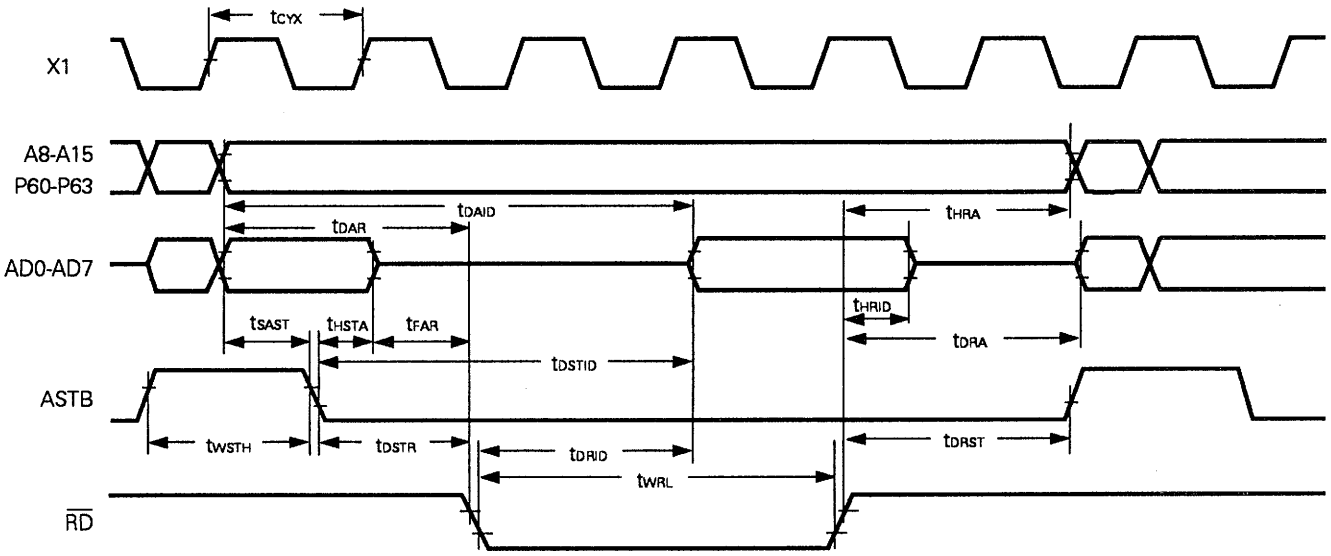
* $\overline{\text{RESET}}$, MODE, P20/NMI, P21/INTP0, P22/INTP1, P23/INTP2/CI, P24/INTP3, P25/INTP4/ASCK, P26/INTP5, P27/SI, P32/$\overline{\text{SCK}}$, P33/SO/SB0 pins

AC Timing Test Point

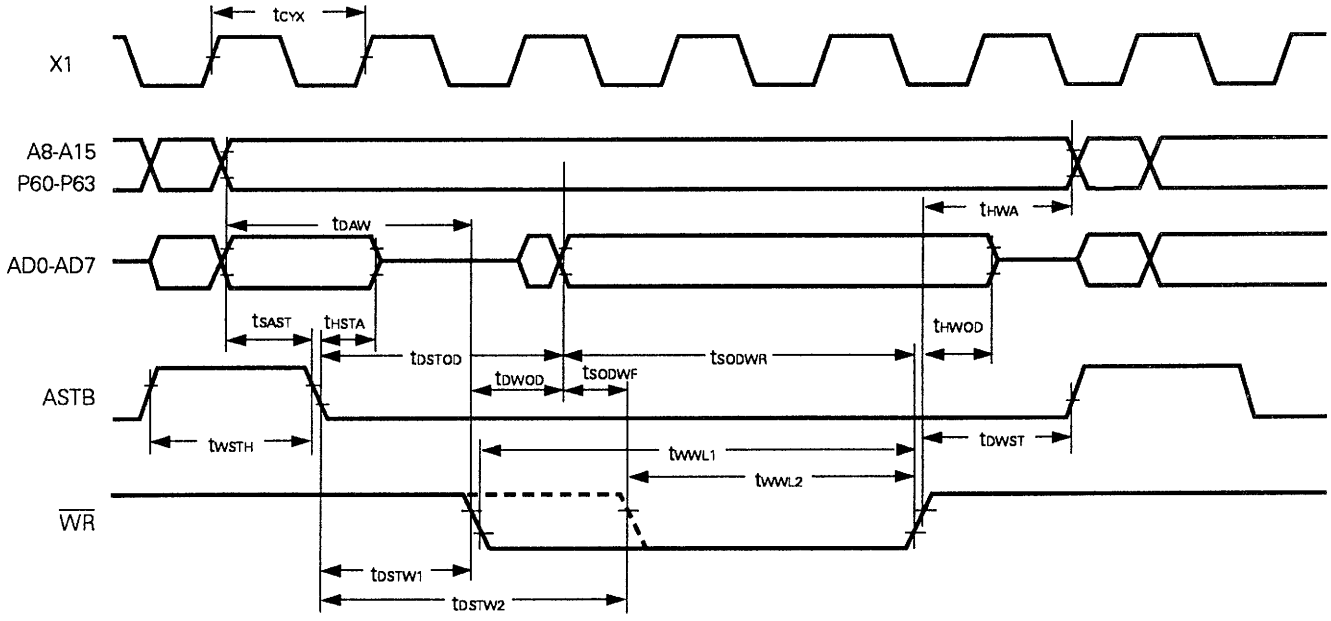


Timing Waveform

Read operation

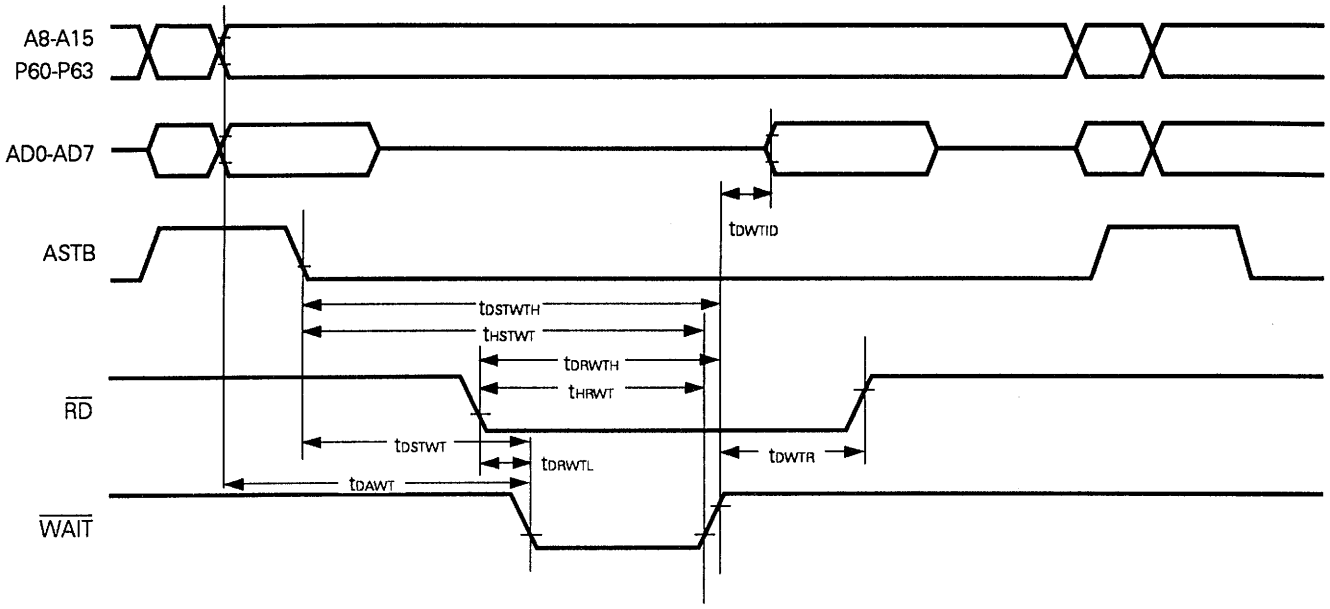


Write operation

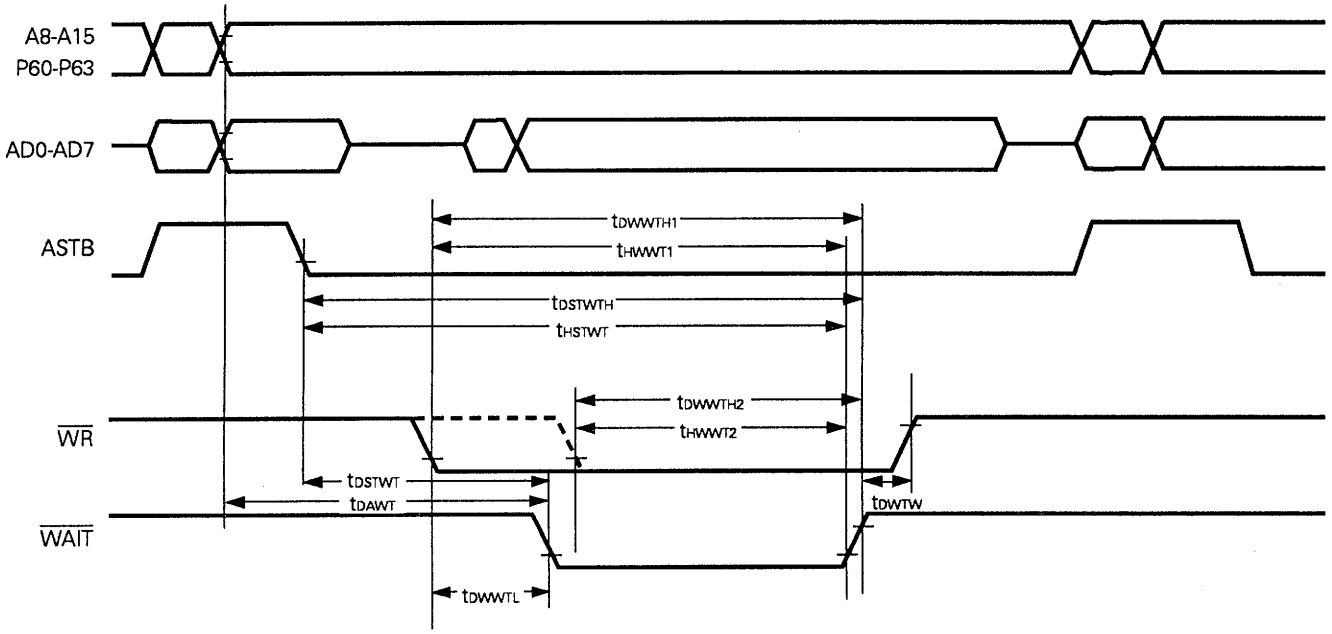


External WAIT Signal Input Timing

Read operation

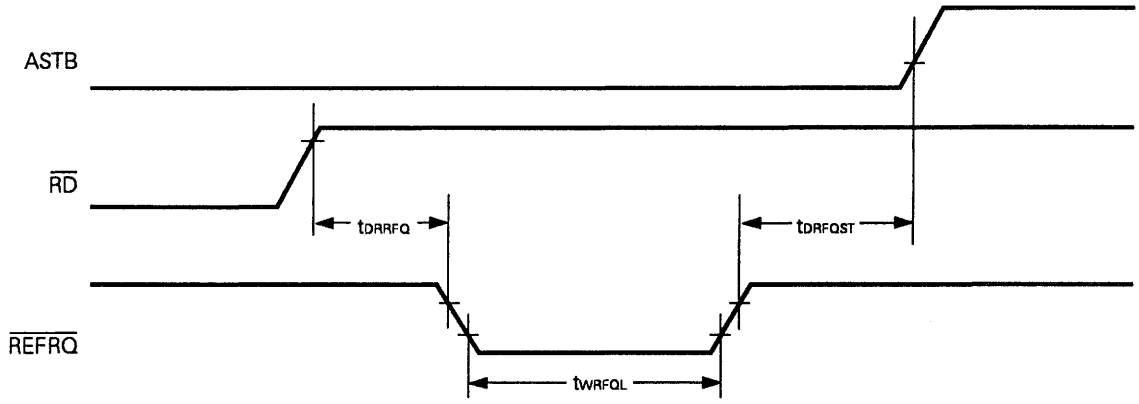


Write operation

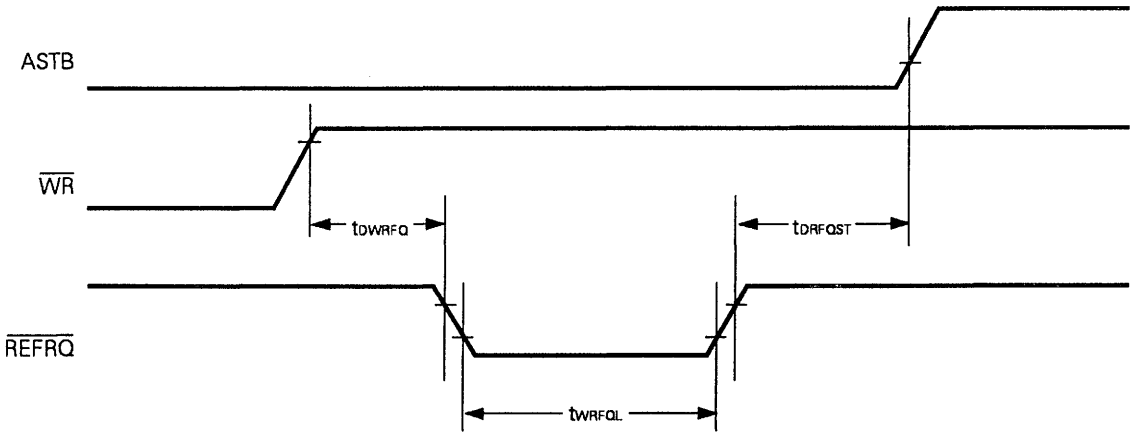


Refresh Timing Waveform

Refresh after read

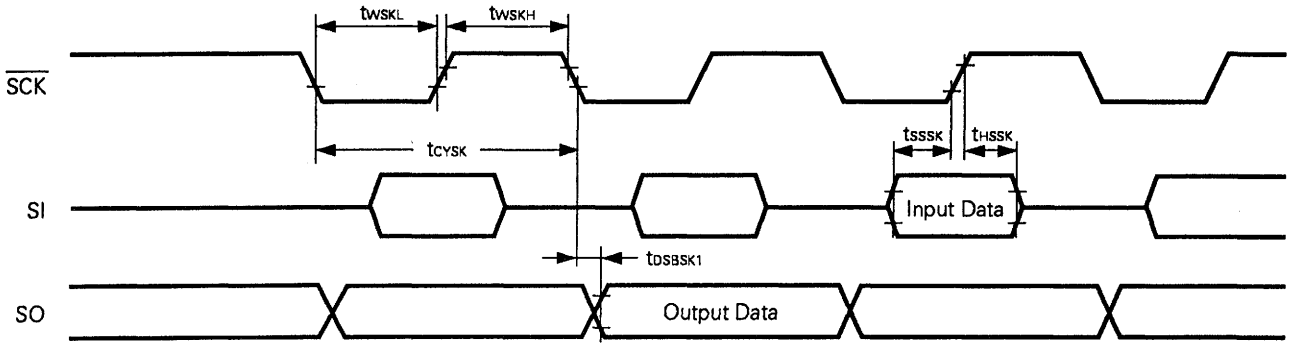


Refresh after write



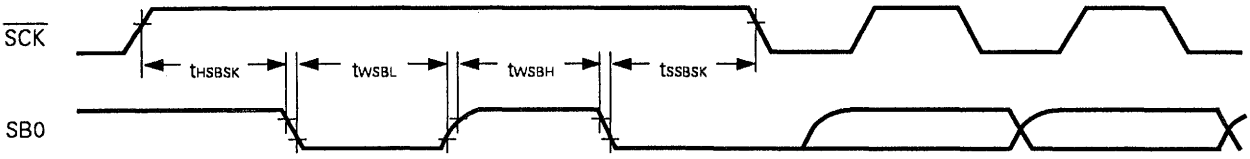
Serial Operation

3-wire serial I/O mode

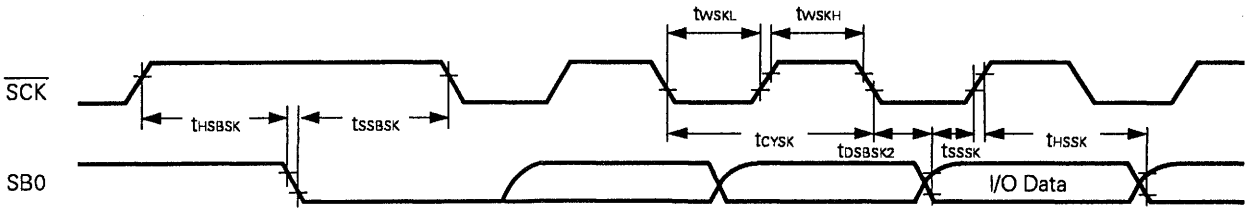


SBI Mode

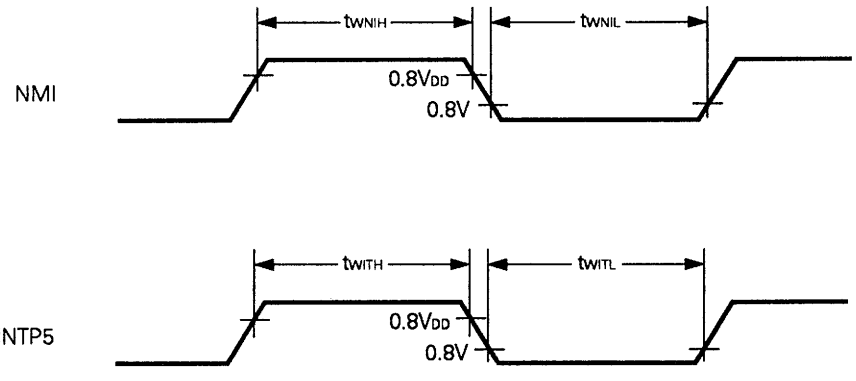
Bus release signal transfer



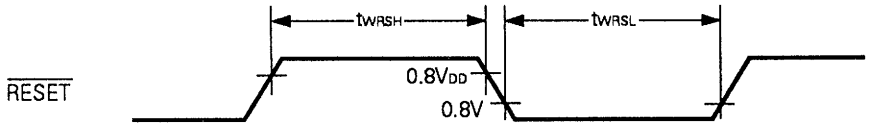
Command signal transfer



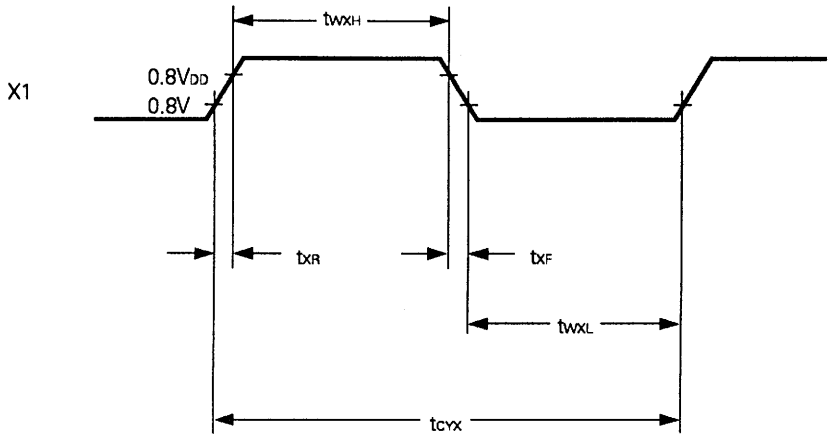
Interrupt Input Timing



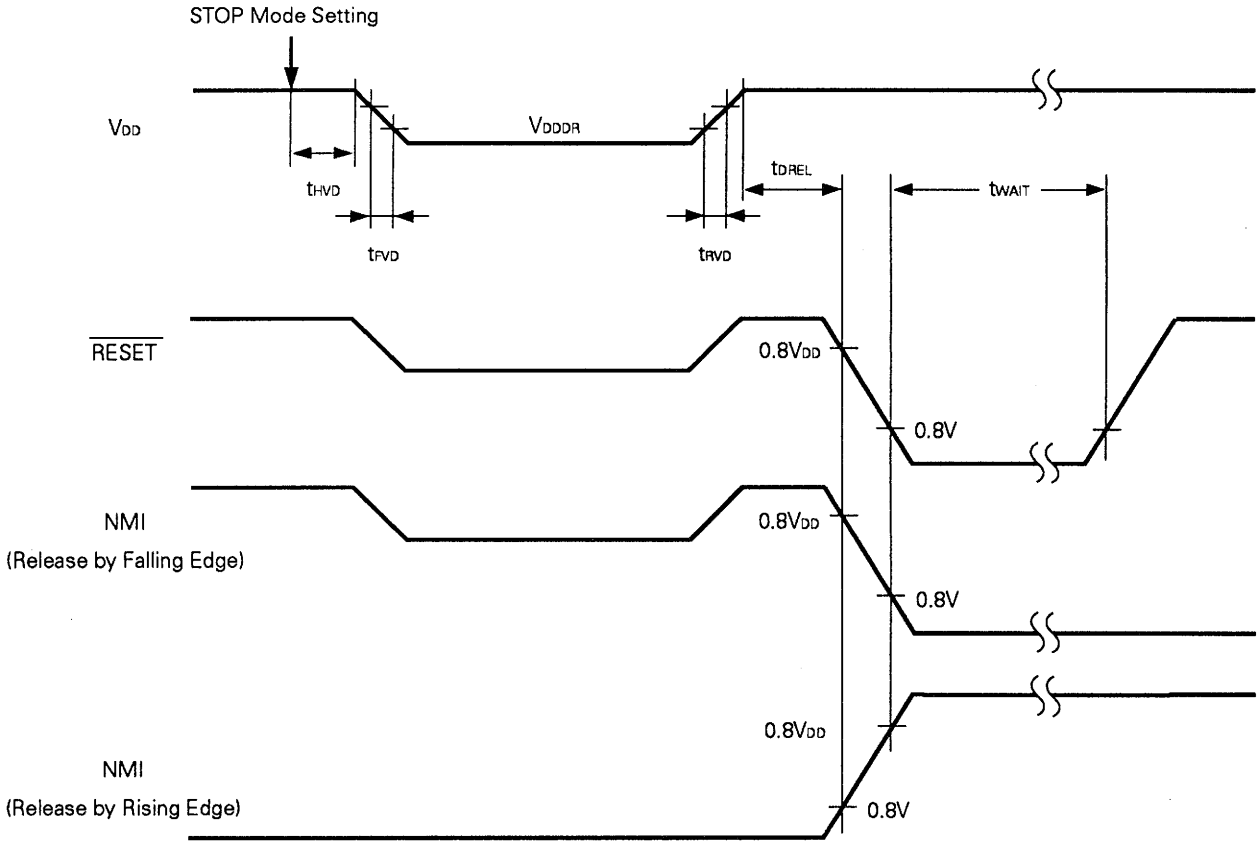
Reset Input Timing



External Clock Timing

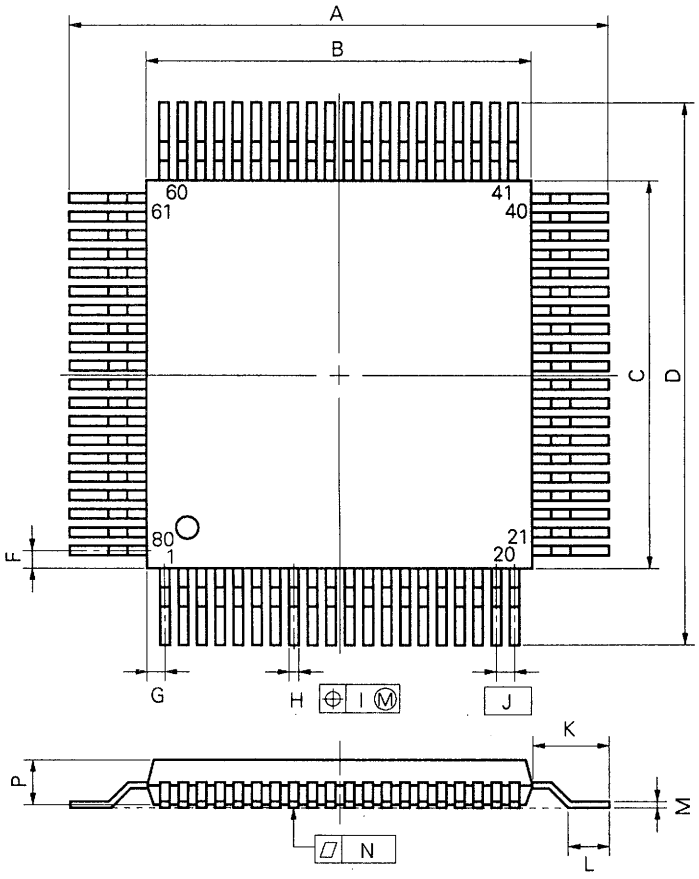


Data Retention Characteristics

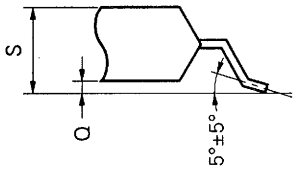


6. PACKAGE INFORMATION

80 PIN PLASTIC QFP (□14)



detail of lead end



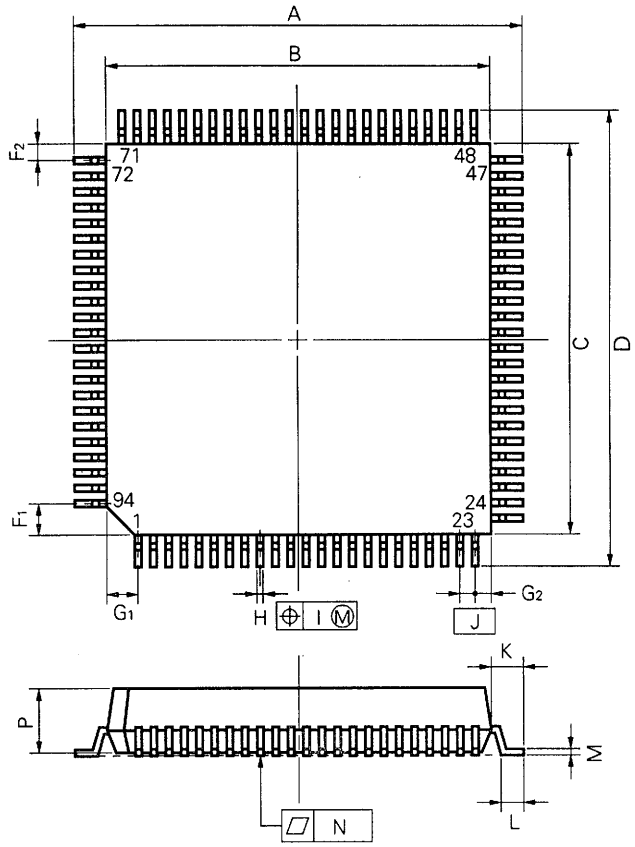
S80GC-65-3B9-3

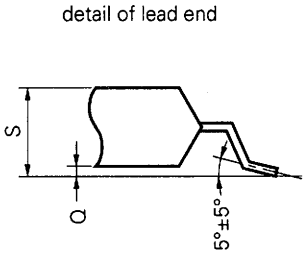
NOTE

Each lead centerline is located within 0.13 mm (0.005 inch) of its true position (T.P.) at maximum material condition.

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

94 PIN PLASTIC QFP (□20)





S94GJ-80-5BG-2

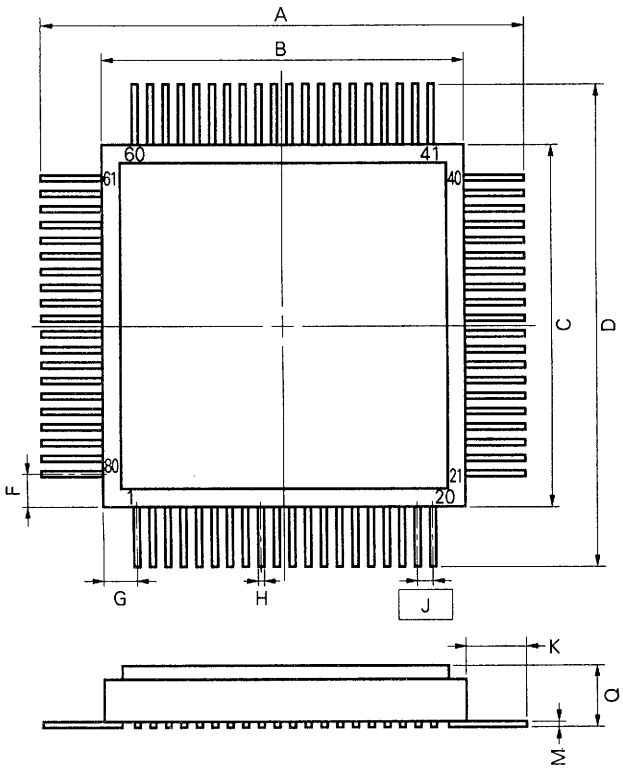
NOTE

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

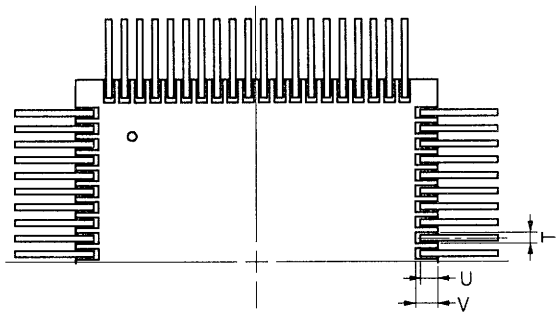
ITEM	MILLIMETERS	INCHES
A	23.2±0.4	$0.913^{+0.017}_{-0.016}$
B	20.0±0.2	$0.787^{+0.009}_{-0.008}$
C	20.0±0.2	$0.787^{+0.009}_{-0.008}$
D	23.2±0.4	$0.913^{+0.017}_{-0.016}$
F_1	1.6	0.063
F_2	0.8	0.031
G_1	1.6	0.063
G_2	0.8	0.031
H	0.35±0.10	$0.014^{+0.004}_{-0.005}$
I	0.15	0.006
J	0.8 (T.P.)	0.031 (T.P.)
K	1.6±0.2	0.063±0.008
L	0.8±0.2	$0.031^{+0.009}_{-0.008}$
M	$0.15^{+0.10}_{-0.05}$	$0.006^{+0.004}_{-0.003}$
N	0.12	0.005
P	3.7	0.146
Q	0.1±0.1	0.004±0.004
S	4.0 MAX.	0.158 MAX.

★ μPD78234GC(A)-xxx-3B9 ONLY

80 PIN CERAMIC QFP (14 × 14) (FOR ES)



(Bottom View)



X80B-65A-1

ITEM	MILLIMETERS	INCHES
A	19.7±0.4	$0.776^{+0.016}_{-0.017}$
B	15.0	0.591
C	15.0	0.591
D	19.7±0.4	$0.776^{+0.016}_{-0.017}$
F	1.3	0.051
G	1.3	0.051
H	0.2	0.008
J	0.65 (T.P.)	0.026 (T.P.)
K	2.35±0.15	$0.093^{+0.006}_{-0.007}$
M	0.15	0.006
Q	3.1 MAX.	0.123 MAX.
T	0.45	0.018
U	0.7	0.028
V	1.0	0.039

7. RECOMMENDED SOLDERING CONDITIONS

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

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

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

Table 7-1 Recommended Soldering Conditions List of Surface Mount Type

(1) μPD78234GC(A)-×××-3B9 : 80-pin plastic QFP (□ 14 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 230 °C, Duration: 30 sec. max. (at 210 °C or above), Number of times: once, Time limit: 2 days* (thereafter 16 hours prebaking at 125 °C required)	IR30-162-1
VPS	Package peak temperature: 215 °C, Duration: 40 sec. max. (at 200 °C or above), Number of times: once, Time limit: 2 days* (thereafter 16 hours prebaking at 125 °C required)	VP15-162-1
Wave soldering	Solder bath temperature: 260 °C or below, Duration: 10 sec. max., Number of times: once, Time limit: 2 days* (thereafter 16 hours prebaking at 125 °C required) Preheating temperature: 120 °C max. (Package surface temperature)	WS60-162-1
Pin part heating	Pin part temperature: 300 °C or below, Duration: 3 sec. max. (per device side)	———

(2) μPD78234GJ(A)-×××-5BG : 94-pin plastic QFP (□ 20 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 230 °C, Duration: 30 sec. max. (at 210 °C or above), Number of times: once, Time limit: 7 days* (thereafter 10 hours prebaking at 125 °C required)	IR30-107-1
VPS	Package peak temperature: 215 °C, Duration: 40 sec. max. (at 200 °C or above), Number of times: once, Time limit: 7 days* (thereafter 10 hours prebaking at 125 °C required)	VP15-107-1
Wave soldering	Solder bath temperature: 260 °C or below, Duration: 10 sec. max., Number of times: once, Time limit: 7 days* (thereafter 10 hours prebaking at 125 °C required) Preheating temperature: 120 °C max. (Package surface temperature)	WS60-107-1
Pin part heating	Pin part temperature: 300 °C or below, Duration: 3 sec. max. (per device side)	———

(3) μPD78238GC(A)-×××-3B9 : 80-pin plastic QFP (□ 14 mm)

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235 °C, Duration: 30 sec. max. (at 210 °C or above), Number of times: once, Time limit: 2 days* (thereafter 20 hours prebaking at 125 °C required)	IR35-202-1
VPS	Package peak temperature: 215 °C, Duration: 40 sec. max. (at 200 °C or above), Number of times: once, Time limit: 2 days* (thereafter 20 hours prebaking at 125 °C required)	VP15-202-1
Wave soldering	Solder bath temperature: 260 °C or below, Duration: 10 sec. max., Number of times: once, Time limit: 2 days* (thereafter 20 hours prebaking at 125 °C required) Preheating temperature: 120 °C max. (Package surface temperature)	WS60-202-1
Pin part heating	Pin part temperature: 300 °C or below, Duration: 3 sec. max. (per device side)	———

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

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

Notice

A version of this product with improved recommended soldering conditions is available. For details (improvements such as infrared reflow peak temperature extension (235 °C), number of times: twice, relaxation of time limit), contact NEC sales personnel.

APPENDIX A. DEVELOPMENT TOOLS

The following development tools are available for system development using μPD78234(A)/78238(A).

Language Software

RA78K/II *1, 2	78K/II series assembler package
CC78K/II *1, 2	78K/II series C compiler package
CC78K/II-L *1, 2	78K/II series C compiler library source file

PROM Write Tools

PG-1500	PROM programmer
PA-78P238GC PA-78P238GJ PA-78P238KF PA-78P238LQ	Programmer adapter connected to PG-1500
PG-1500 controller *1	PG-1500 control program

Debugging Tools

IE-78230-R-A IE-78230-R *3	μPD78234 series in-circuit emulator
IE-78200-R-BK	78K/II series break board
IE-78230-R-EM IE-78200-R-EM *3	μPD78234 series evaluation emulation board
EP-78230GC-R EP-78230GJ-R EP-78230LQ-R	μPD78234 series emulation probe
EV-9200G-94 EV-9200GC-80	Sockets mounted on the user system circuit board for 80-/94-pin plastic QFP
EV-9900	A tool to remove the μPD78P238KF from EV-9200G-94
SD78K/II *1	IE-78230-R-A screen debugger
DF78230 *1	μPD78234 series device file

Real-Time OS

RX78K/II *1, 2	78K/II series real-time OS

Fuzzy Inference Development Supporting System

FE9000 *1	Fuzzy knowledge data creation tool
FT9080 *1	Translator
FI78K/II *1	Fuzzy inference module
FD78K/II *1, 4	Fuzzy inference debugger

* 1. PC-9800 series (MS-DOS™) based, IBM PC/AT™ (PC DOS™) based.
2. HP9000 series 300™ (HP-UX™) based, SPARC station™ (Sun OS™) based, EWS-4800 series™ (EWS-UX/V™) based.
3. No longer manufactured and not available for purchase.
4. Under development.

Remarks. For development tools manufactured by a third party, see **"78K/II Series Development Tools Selection Guide (EF-231)"**.

APPENDIX B. RELATED DOCUMENTS ★

Device Related Documents

Document Name		Document Number
μPD78234 Series User's Manual Hardware Volume		
78K/II Series User's Manual Instruction Volume		
78K/II Series Application Note	Introduction	
	Application volume	
	Floating Point Operation Program Volume	
78K/II Series Selection Guide		
78K/II Series Instruction Application Table		
78K/II Series Instruction Set		
μPD78234 Series Special Function Register Application Table		

Development Tools Related Documents (User's Manual)

Document Name		Document Number
RA78K Series Assembler Package	Operation Volume	
	Language Volume	
RA78K Series Structured Assembler Preprocessor		
CC78K Series C Compiler	Operation Volume	
	Language Volume	
CC78K Series Library Source File		
PG-1500 PROM Programmer		
PG-1500 Controller		
IE-78230-R-A In-Circuit Emulator		
IE-78230-R In-Circuit Emulator	Hardware Volume	
	Software Volume	
SD78K/II Screen Debugger	Introductory	
	Reference Volume	
78K/II Series Development Tools Selection Guide		

Note The contents of the above related documents are subject to change without notice. The latest documents should be used for design, etc.

Built-In Software Related Documents (User's Manual)

Document Name		Document Number
RX78K/II Real-time OS	Basic Volume	
	Installation Volume	
	Debugger Volume	
	Technical Volume	
Fuzzy Knowledge Data Creation Tool		
78K/0, 78K/II, 87AD Series Fuzzy Inference Development Supporting System	Translator	
78K/II Series Fuzzy Inference Development Supporting System	Fuzzy Inference Module	
78K/II Series Fuzzy Inference Debugger		

Other Related Documents

Document Name	Document Number
QTOP Microcomputer Brochure	
Package Manual	
Surface Mount Technology Manual	
Quality Grade on NEC Semiconductor Devices	
NEC Semiconductor Device Reliability & Quality Control	
Electrostatic Discharge (ESD) Test	
Semiconductor Devices Quality Guide Guarantee Guide	
Microcomputer Related Products Guide Other Manufacturers Volume	

Note The contents of the above related documents are subject to change without notice. The latest documents should be used for design, etc.

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