

8-bit Proprietary Microcontroller

CMOS

F²MC-8L MB89143A/144A Series

MB89143A/144A

■ DESCRIPTION

The MB89143A/144A has been developed as a general-purpose version of the F²MC-8L* family consisting of proprietary 8-bit, single-chip microcontrollers.

In addition to a compact instruction set, the microcontrollers contain peripheral functions such as dual-clock control system, five operating speed control stages, timers, a serial interface, an A/D converter, buzzer output, high voltage driver, watch prescaler, and an external interrupt. The MB89143A/144A is applicable to a wide range of applications from welfare products to industrial equipment.

* F²MC stands for FUJITSU Flexible Microcontroller.

■ FEATURES

- Minimum execution time: 0.50 μs/8.0-MHz oscillation
- Interrupt servicing time: 4.50 μs/8.0-MHz oscillation
- F²MC-8L family CPU core

Instruction set optimized for controllers

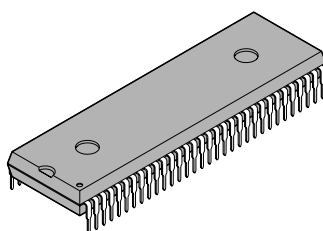
- Multiplication and division instructions
- 16-bit arithmetic operations
- Test and branch instructions
- Bit manipulation instructions, etc.

- Dual-clock control system
- High-voltage ports: 24 channel

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■ PACKAGE

64-pin Plastic SH-DIP



(DIP-64P-M01)

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- Two types of timers
 - 8/16-bit timer/counter (also usable as two 8-bit timers)
 - 21-bit time-base timer
- One 8-bit serial interface
 - Switchable transfer direction allows communication with various equipment.
- 8-bit A/D converter: 8 channels
 - Successive approximation type
- External interrupt: 2 channels
 - Two channels are independent and capable of wake-up from low-power consumption modes. (Rising edge/falling edge/both edges selectability)
 - 0.3 V to +7.0 V can be applied to INT1 (N-ch open-drain)
- Low-power consumption modes
 - Subclock mode (The main clock stops, and the device operates at the subclock.)
 - Watch mode (Only the watch prescaler is operating.)
 - Stop mode (Oscillation stops to minimize the current consumption.)
 - Sleep mode (The CPU stops to reduce the current consumption to approx. 1/3 of normal.)
- Watch prescaler
- Buzzer output
- Watchdog reset, reset output, and power-on reset functions

■ PRODUCT LINEUP

Part number Parameter	MB89143A	MB89144A	MB89144/5/6	MB89P147	MB89PV140
Classification	Mass production products (mask ROM products)			One-time PROM product	Piggyback/evaluation product (for evaluation and development)
ROM size	8 K × 8 bits	12 K × 12 bits	12/16/24 K × 8 bits	32 K × 8 bits Internal PROM	32 K × 8 bits External ROM (Piggyback)
RAM size	256 × 8 bits		256/512/768 × 8 bits	1 K × 8 bits Internal	
CPU functions	Number of instructions:		136		
	Instruction bit length:		8 bits		
	Instruction length:		1 to 3 bytes		
	Data bit length:		1, 8, 16 bits		
	Minimum execution time:		0.5 μs/8 MHz to 8.0 μs/8 MHz, 61 μs/32.768 kHz		
	Interrupt processing time:		4.5 μs/8 MHz to 72.0 μs/8 MHz, 562.5 μs/32.768 kHz		
	Note:		The above times change according to the gear function.		
Ports	High-voltage output ports (P-ch open-drain):		24 (P40 to P47, P50 to P57, and P60 to P67)		
	Buzzer output (P-ch open-drain, high-voltage):		1		
	Output ports (CMOS):		4 (P20 to P23)		
	Input ports (CMOS):		2 (P70 and P71, function as X0A and X1A pins when dual-clock system is used.)		
	I/O ports (CMOS):		23 (P00 to P07, P10 to P17, P30, and P32 to P37)		
	I/O port (N-channel open-drain):		1 (P31)		
	Total:		55		
Time-base timer	Capable of generating four different intervals (at 8.0-MHz oscillation): 0.26 ms, 0.51 ms, 1.02 ms, and 0.524 s				
8/16-bit timer counter	8/16-bit timer operation (Operating clock, internal clock, external trigger) 8/16-bit event counter operation (Rising edge/falling edge/both edges selectability)				
8-bit Serial I/O	8 bits LSB first/MSB first selectability One clock selectable from four transfer clocks (one external shift clock, three internal shift clocks: 4, 8, 16 system clock cycles)				
A/D converter	8-bit resolution × 8 channels A/D conversion mode (with conversion time of 22 μs/8 MHz, and highest gear speed) Continuous activation by external activation cable		10-bit resolution × 12 channels A/D conversion mode (with conversion time of 16.5 ms/ 8 MHz, and highest gear speed) Sense mode (with conversion time of 9.0 μs/8 MHz, and highest gear speed) Continuous activation enabled by external activation cable		
External interrupt	2 independent channels (edge selection, interrupt vector, source flag) Rising edge/falling edge/both edges selectability Built-in analog noise canceller Used also for wake-up from stop/sleep mode. (Edge detection is also permitted in stop mode.)				
Buzzer output	1.95 or 3.91 kHz selectable (at 8-MHz oscillation) Output to a high-voltage pin				

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Part number Parameter	MB89143A	MB89144A	MB89144/5/6	MB89P147	MB89PV140
Watchdog reset	Internal reset in 524 to 1049 ms (at 8 MHz oscillation) when the program runaway occurs				
8-bit PWM timer	None		8-bit timer operation/8-bit resolution PWM operation		
12-bit MPG timer	None		12-bit resolution PWM operation/reload timer operation/ PPG operation		
Standby mode	Sleep mode, stop mode, and watch mode				
Process	CMOS				
Package	DIP-64P-M01		DIP-64P-M01 FPT-64P-M06		MDP-64C-P02 MQP-64C-P01
EPROM for use					MBM27C256A-20
Operating voltage*	4.0 V to 6.0 V		2.7 V to 6.0 V		

* : Varies with conditions such as the operating frequency. (See section “■ Electrical Characteristics.”)

■ PACKAGE AND CORRESPONDING PRODUCTS

Package	MB89143A MB89144A	MB89P147	MB89PV140
DIP-64P-M01	○	○	×
FPT-64P-M06	×	○	×
MDP-64C-P02	×	×	○
MQP-64C-P01	×	×	○

○ : Available × : Not available

* : Under examination for development

Note: For more information about each package, see section “■ Package Dimensions.”

■ DIFFERENCES AMONG PRODUCTS

1. Memory Size

Before evaluating using the piggyback product, verify its differences from the product that will actually be used. Take particular care on the following points:

- On the MB89143A/144A, the upper half of the register bank cannot be used.
- The stack area, etc., is set at the upper limit of the RAM.

2. Functions

Before evaluating using the piggyback product, verify its differences from the product that will actually be used. Take particular care on the following point:

- The A/D converter in the MB89143A/144A is an 8-bit resolution type. The MB89143A/144A contains neither the 8-bit PWM timer nor the 12-bit MPG timer.

3. Current Consumption

- In the case of the MB89PV140, add the current consumed by the EPROM which is connected to the top socket.
- When operated at low speed, the product with an OTPROM (one-time PROM) or an EPROM will consume more current than the product with a mask ROM.

However, the current consumption in sleep/stop modes is the same. (For more information, see section “■ Electrical Characteristics”.)

4. Mask Options

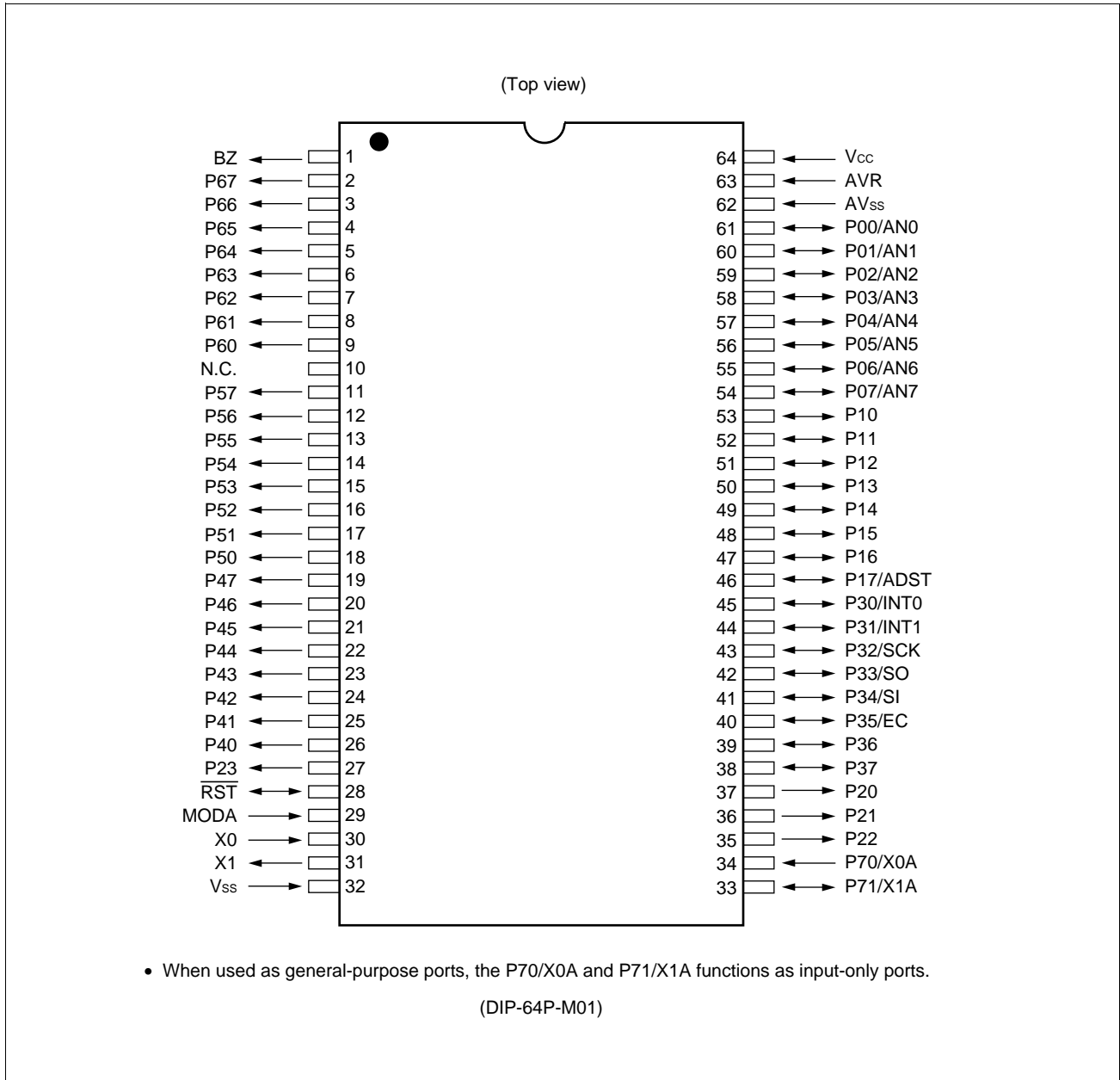
Functions that can be selected as options and how to designate these options vary by the product. Before using options check section “■ Mask Options.”

Take particular care on the following point:

- A pull-up resistor option is not provided for the MB89PV140.

MB89143A/144A

■ PIN ASSIGNMENT



■ PIN DESCRIPTION

Pin no. SDIP*	Pin name	Circuit type	Function
30	X0	A	Main clock oscillator pins Use a crystal oscillator.
31	X1		
29	MODA	B	Operating mode selection pin Connect directly to V _{SS} in normal operation.
28	$\overline{\text{RST}}$	C	Reset I/O pin This pin is an N-ch open-drain output type with a pull-up resistor, and a hysteresis input type. "L" is output from this pin by an internal reset source. The internal circuit is initialized by the input of "L". This pin is with a noise canceller.
54 to 61	P07/AN7 to P00/AN0	F	General-purpose I/O ports These ports are a hysteresis input type. Also serve as an analog input.
46	P17/ADST	H	General-purpose I/O port This port is a hysteresis input type. Also serves as an A/D converter external activation.
47 to 53	P16 to P10	H	General-purpose I/O ports These ports are a hysteresis input type.
34, 33	P70/X0A, P71/X1A	J	Selectable either general-purpose input ports or the subclock oscillator pins by the mask option. These ports are a hysteresis input type when used as general-purpose input ports.
27, 35 to 37	P23 to P20	D	General-purpose output ports
38, 39	P37, P36	H	General-purpose I/O ports These ports are a hysteresis input type.
40	P35/EC		General-purpose I/O port This port is a hysteresis input type. Also serves as the external clock input for the 8/16-bit timer/counter.
41	P34/SI		General-purpose I/O port This port is a hysteresis input type. Also serves as the serial data input for the 8-bit serial interface.
42	P33/SO		General-purpose I/O port This port is a hysteresis input type. Also serves as the serial data output for the 8-bit serial interface.
43	P32/SCK		General-purpose I/O port This port is a hysteresis input type. Also serves as the serial transfer clock for the 8-bit serial interface.

* : DIP-64P-M01

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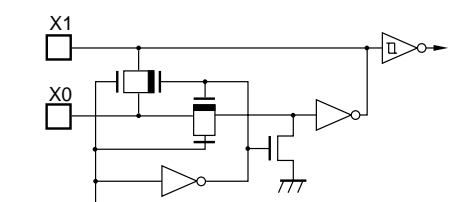
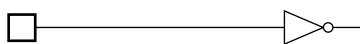
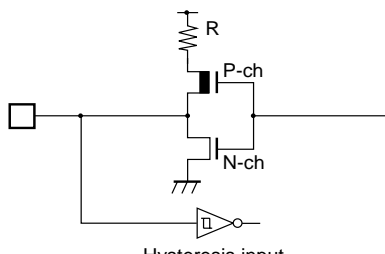
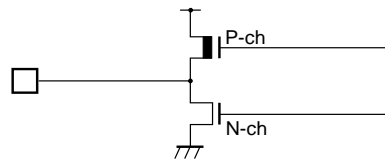
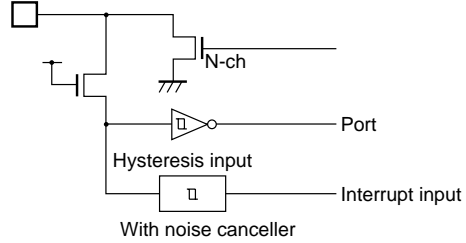
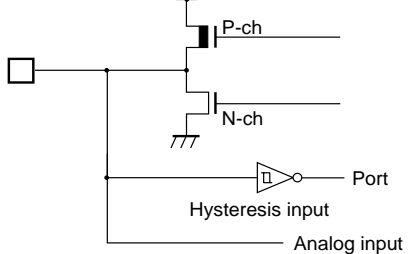
MB89143A/144A

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Pin no.	Pin name	Circuit type	Function
SDIP*			
44	P31/INT1	E	General-purpose I/O port This port is an N-ch open-drain output and hysteresis input type. Also serves as an external interrupt. The interrupt input is a hysteresis input type and with a built-in noise canceller.
45	P30/INT0	I	General-purpose I/O port This port is a hysteresis input type. Also serves as an external interrupt. The interrupt input is a hysteresis input type and with a built-in noise canceller.
1	BZ	G	Buzzer output-only pin P-ch high-voltage open-drain output port
19 to 26, 11 to 18, 2 to 9	P47 to P40, P57 to P50, P67 to P60	G	P-ch high-voltage open-drain output port
10	N.C.	—	Be sure to leave them open.
64	V _{CC}	—	Power supply pin Also serves as an A/D converter power supply.
32	V _{SS}	—	Power supply (GND) pin
63	AVR	—	A/D converter reference voltage input pin
62	AV _{SS}	—	A/D converter power supply pin Use this pin at the same voltage as V _{SS} .

* : DIP-64P-M01

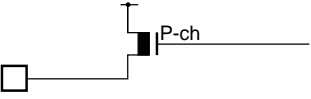
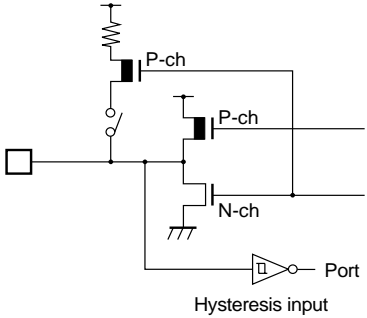
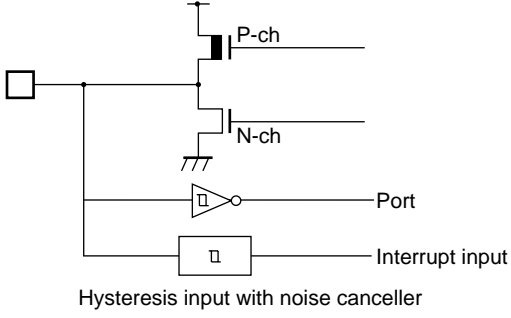
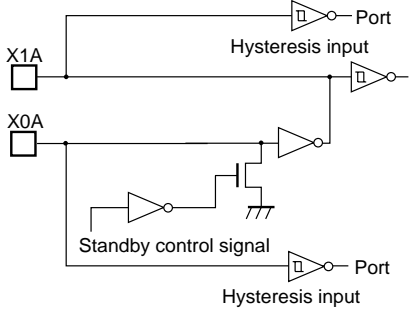
■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A	 <p>Standby control signal</p>	<ul style="list-style-type: none"> At an oscillation feedback resistor of approximately 1 MΩ/5.0 V
B		
C	 <p>Hysteresis input</p>	<ul style="list-style-type: none"> At an output pull-up resistor (P-ch) of approximately 50 kΩ/5.0 V CMOS hysteresis input
D		<ul style="list-style-type: none"> CMOS output
E	 <p>With noise canceller</p>	<ul style="list-style-type: none"> N-ch open-drain output CMOS hysteresis input The interrupt input is with a noise canceller.
F		<ul style="list-style-type: none"> CMOS output CMOS hysteresis input

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Type	Circuit	Remarks
G		<ul style="list-style-type: none"> • P-ch high-voltage open-drain output
H		<ul style="list-style-type: none"> • CMOS output • CMOS hysteresis input • Pull-up resistor optional (Only for P14 to P17 and P32 to P37)
I		<ul style="list-style-type: none"> • CMOS output • CMOS hysteresis input • The interrupt input is with a noise canceller.
J		<ul style="list-style-type: none"> • The oscillation feedback resistor is not provided. • CMOS hysteresis input when subclock is not used

■ HANDLING DEVICES

1. Preventing Latchup

Latchup may occur on CMOS ICs if voltage higher than V_{CC} or lower than V_{SS} is applied to input and output pins other than medium- to high-voltage pins or if higher than the voltage which shows on “1. Absolute Maximum Ratings” in section “■ Electrical Characteristics” is applied between V_{CC} and V_{SS} . (However, up to 7.0 V can be applied to P31/INT1 pin, regardless of V_{CC} .)

When latchup occurs, power supply current increases rapidly and might thermally damage elements. When using, take great care not to exceed the absolute maximum ratings.

Also, take care to prevent the analog power supply (AVR) and analog input from exceeding the digital power supply (V_{CC}) when the analog system power supply is turned on and off.

2. Treatment of Unused Input Pins

Leaving unused input pins open could cause malfunctions. They should be connected to a pull-up or pull-down resistor.

3. Treatment of Power Supply Pins on Microcontrollers with A/D and D/A Converters

Connect to be $AV_{SS} = AVR = V_{SS}$ even if the A/D and D/A converters are not in use.

4. Treatment of N.C. Pins

Be sure to leave (internally connected) N.C. pins open.

5. Power Supply Voltage Fluctuations

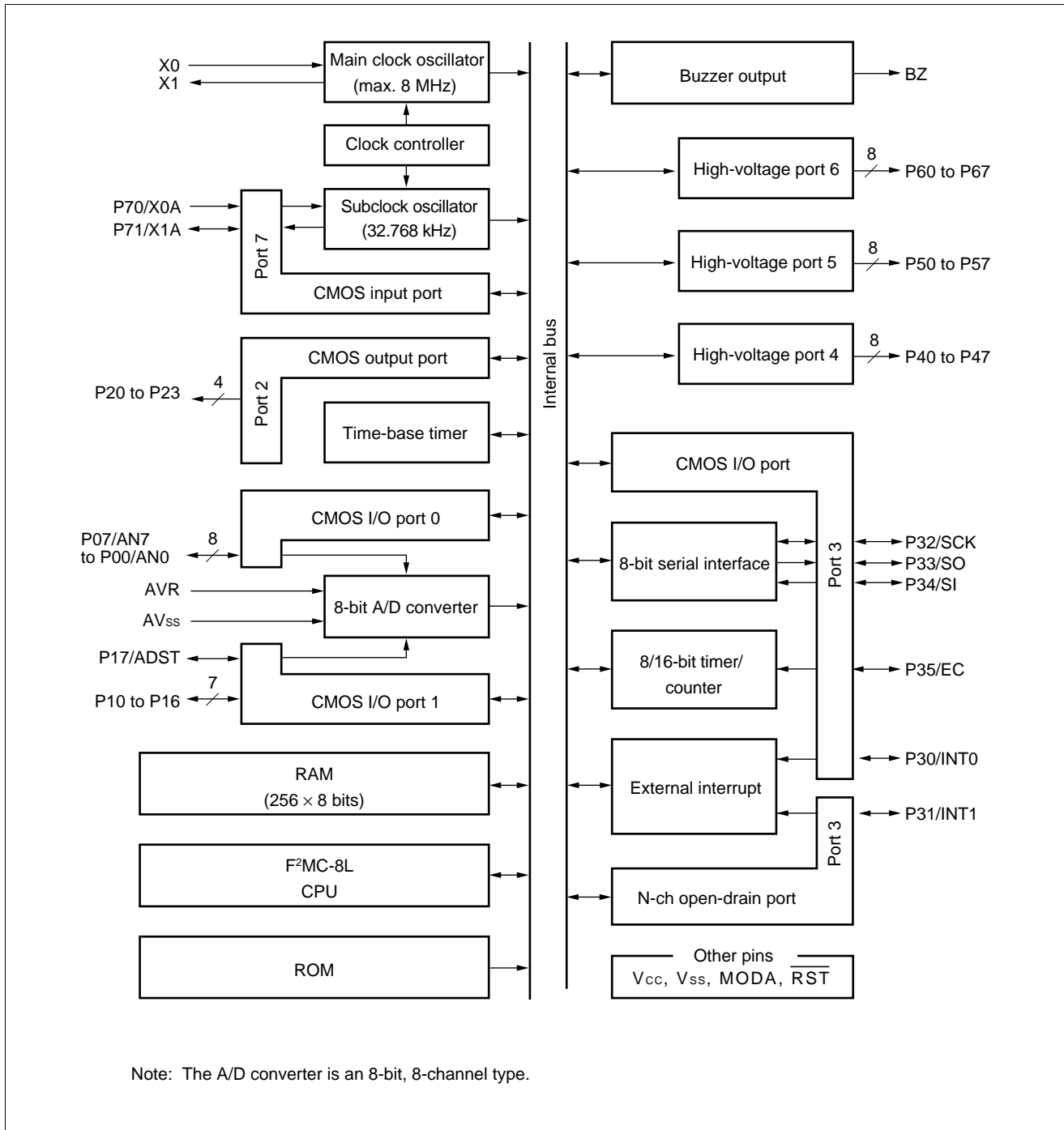
Although V_{CC} power supply voltage is assured to operate within the rated range, a rapid fluctuation of the voltage could cause malfunctions, even if it occurs within the rated range. Stabilizing voltage supplied to the IC is therefore important. As stabilization guidelines, it is recommended to control power so that V_{CC} ripple fluctuations (P-P value) will be less than 10% of the standard V_{CC} value at the commercial frequency (50 to 60 Hz) and the transient fluctuation rate will be less than 0.1 V/ms at the time of a momentary fluctuation such as when power is switched.

6. Precautions when Using an External Clock

Even when an external clock is used, oscillation stabilization time is required for power-on reset and wake-up from stop mode.

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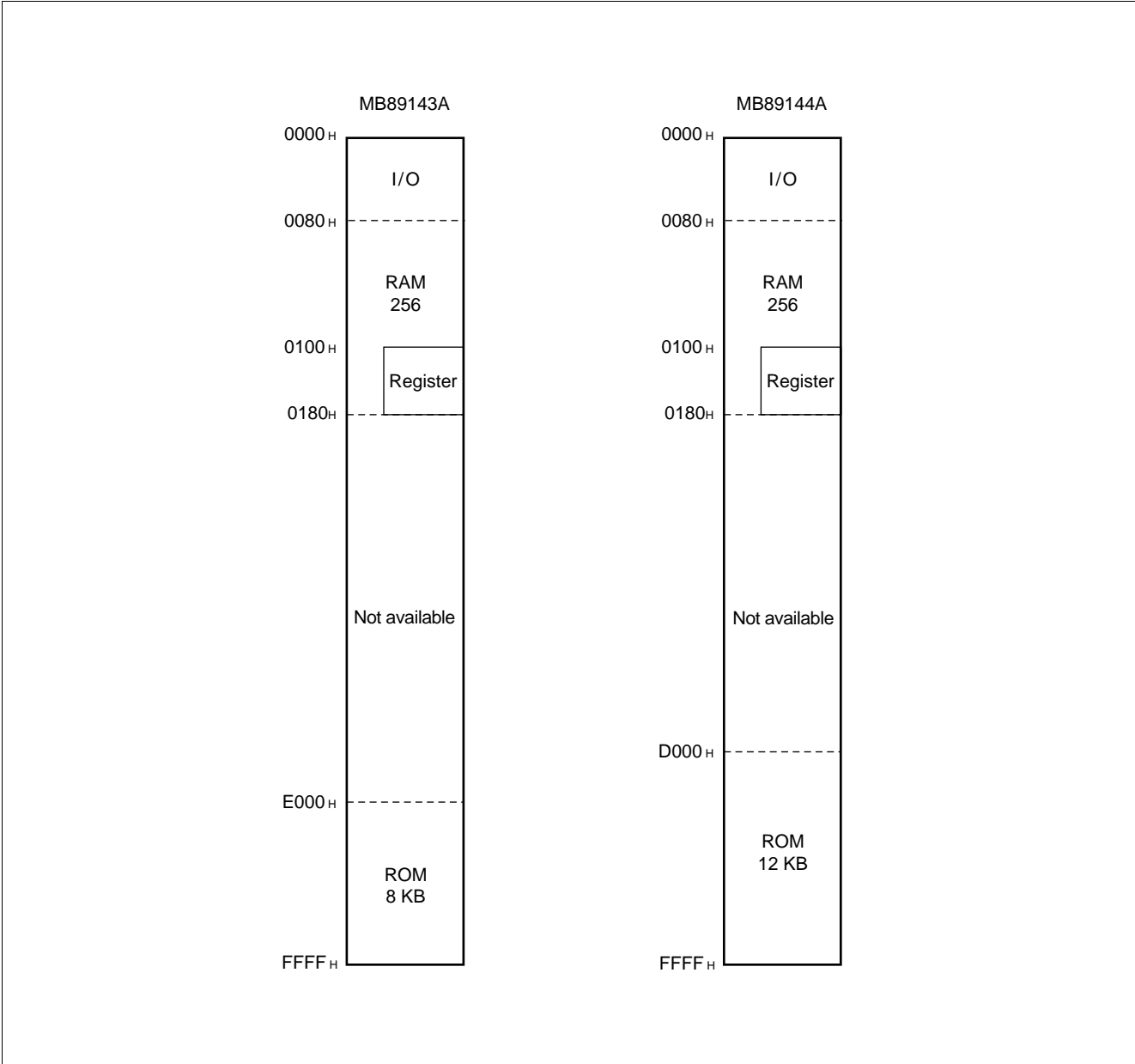
■ BLOCK DIAGRAM



■ CPU CORE

1. Memory Space

The microcontrollers of the MB89143A/144A series offer a memory space of 64 Kbytes for storing all of I/O, data, and program areas. The I/O area is located at the lowest address. The data area is provided immediately above the I/O area. The data area can be divided into register, stack, and direct areas according to the application. The program area is located at exactly the opposite end, that is, near the highest address. Provide the tables of interrupt reset vectors and vector call instructions toward the highest address within the program area. The memory space of the MB89143A/144A series is structured as illustrated below.

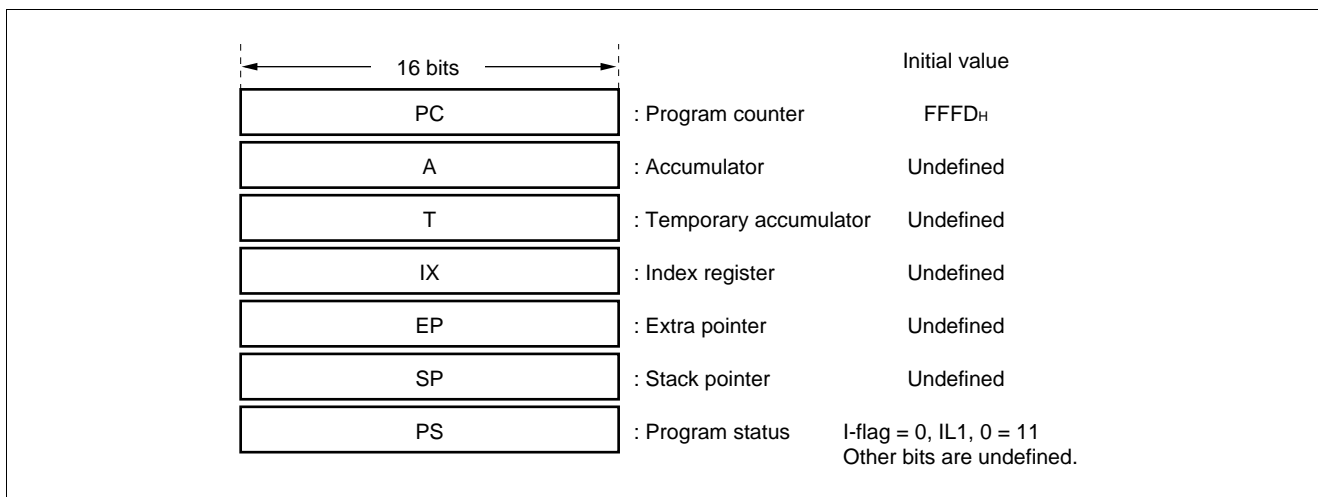


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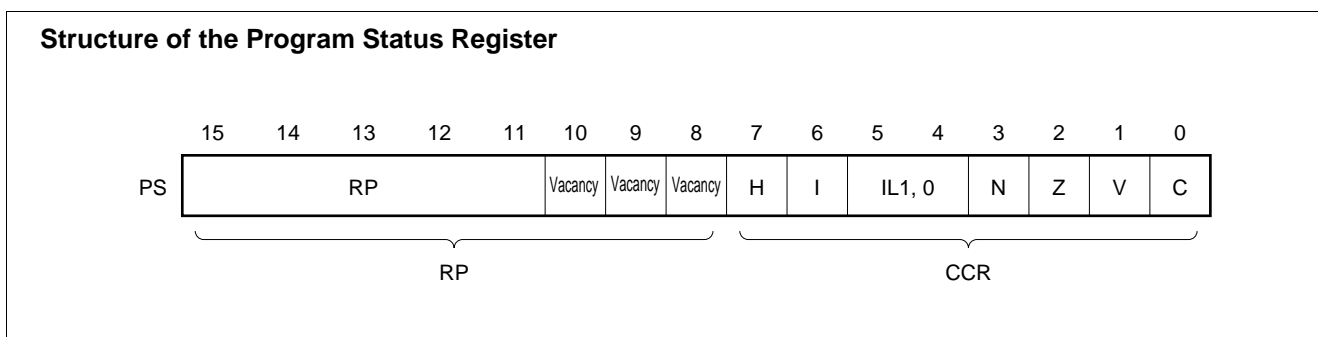
2. Registers

The F²MC-8L family has two types of registers; dedicated registers in the CPU and general-purpose registers in the memory. The following dedicated registers are provided:

- Program counter (PC): A 16-bit register for indicating instruction storage positions
- Accumulator (A): A 16-bit temporary register for storing arithmetic operations, etc. When the instruction is an 8-bit data processing instruction, the lower byte is used.
- Temporary accumulator (T): A 16-bit register which performs arithmetic operations with the accumulator. When the instruction is an 8-bit data processing instruction, the lower byte is used.
- Index register (IX): A 16-bit register for index modification
- Extra pointer (EP): A 16-bit pointer for indicating a memory address
- Stack pointer (SP): A 16-bit register for indicating a stack area
- Program status (PS): A 16-bit register for storing a register pointer, a condition code



The PS can further be divided into higher 8 bits for use as a register bank pointer (RP) and the lower 8 bits for use as a condition code register (CCR). (See the diagram below.)



The RP indicates the address of the register bank currently in use. The relationship between the pointer contents and the actual address is based on the conversion rule illustrated below.

Rule for Conversion of Actual Addresses of the General-purpose Register Area



The CCR consists of bits indicating the results of arithmetic operations and the contents of transfer data and bits for control of CPU operations at the time of an interrupt.

H-flag: Set when a carry or a borrow from bit 3 to bit 4 occurs as a result of an arithmetic operation. Cleared otherwise. This flag is for decimal adjustment instructions.

I-flag: Interrupt is allowed when this flag is set to 1. Interrupt is prohibited when the flag is set to 0. Set to 0 when reset.

IL1, 0: Indicates the level of the interrupt currently allowed. Processes an interrupt only if its request level is higher than the value indicated by this bit.

IL1	ILO	Interrupt level	High-low
0	0	1	High
0	1		↑
1	0	2	↓ Low = no interrupt
1	1	3	

N-flag: Set if the MSB is set to 1 as the result of an arithmetic operation. Cleared when the bit is set to 0.

Z-flag: Set when an arithmetic operation results in 0. Cleared otherwise.

V-flag: Set if the complement on 2 overflows as a result of an arithmetic operation. Reset if the overflow does not occur.

C-flag: Set when a carry or a borrow from bit 7 occurs as a result of an arithmetic operation. Cleared otherwise. Set to the shift-out value in the case of a shift instruction.

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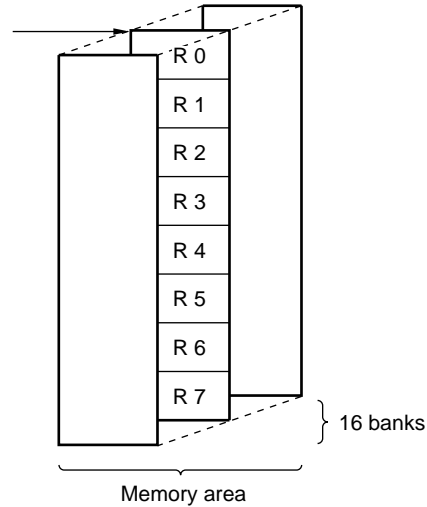
The following general-purpose registers are provided:

General-purpose registers: An 8-bit register for storing data

The general-purpose registers are 8 bits and located in the register banks of the memory. One bank contains eight registers and up to a total of 16 banks can be used on the MB89143A/144A. The bank currently in use is indicated by the register bank pointer (RP).

Register Bank Configuraiton

This address = $0100H + 8 \times (RP)$



■ I/O MAP

Address	Read/write	Register name	Register description
00H	(R/W)	PDR0	Port 0 data register
01H	(W)	DDR0	Port 0 data direction register
02H	(R/W)	PDR1	Port 1 data register
03H	(W)	DDR1	Port 1 data direction register
04H	(R/W)	PDR2	Port 2 data register
05H			Vacancy
06H			Vacancy
07H	(R/W)	SYCC	System clock control register
08H	(R/W)	STBC	Standby control register
09H	(R/W)	WDTE	Watchdog timer control register
0AH	(R/W)	TBCR	Time-base timer control register
0BH	(R/W)	WPCR	Watch prescaler control register
0CH	(R/W)	PDR3	Port 3 data register
0DH	(W)	DDR3	Port 3 data direction register
0EH	(R/W)	BUZR	Buzzer register
0FH	(R/W)	EIC	External interrupt control register
10H	(R/W)	PDR4	Port 4 data register
11H	(R/W)	PDR5	Port 5 data register
12H	(R/W)	PDR6	Port 6 data register
13H	(R)	PDR7	Port 7 data register
14H			Vacancy
15H			Vacancy
16H			Vacancy
17H			Vacancy
18H	(R/W)	T3CR	Timer 3 control register
19H	(R/W)	T2CR	Timer 2 control register
1AH	(R/W)	T3DR	Timer 3 data register
1BH	(R/W)	T2DR	Timer 2 data register
1CH	(R/W)	SMR	Serial mode register
1DH	(R/W)	SDR	Serial data register
1EH	(R/W)	ADC1	A/D converter control register 1
1FH	(R/W)	ADC2	A/D converter control register 2

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Address	Read/write	Register name	Register description
20 _H	(R/W)	ADDH	A/D data register (H)
21 _H	(R/W)	ADDL	A/D data register (L)
22 _H	(W)	PCR0	Port input control register 0
23 _H	(W)	PCR1	Port input control register 1
24 _H to 7B _H			Vacancy
7C _H	(W)	ILR1	Interrupt level setting register 1
7D _H	(W)	ILR2	Interrupt level setting register 2
7E _H	(W)	ILR3	Interrupt level setting register 3
7F _H			Vacancy

Note: Do not use vacancies.

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

(AV_{SS} = V_{SS} = 0.0 V)

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V _{CC} AVR	V _{SS} - 0.3	V _{SS} + 7.0	V	AVR ≤ V _{CC} + 0.3*1
Input voltage	V _{I1}	V _{SS} - 0.3	V _{CC} + 0.3	V	P00 to P07, P10 to P17, P30, P32 to P37, P70, P71
	V _{I2}	V _{SS} - 0.3	7	V	P31
	V _{I3}	V _{CC} - 40	V _{CC} + 0.3	V	P40 to P47, P50 to P57, P60 to P67, BZ*2
Output voltage	V _{O1}	V _{SS} - 0.3	V _{CC} + 0.3	V	P00 to P07, P10 to P17, P20 to P23, P30 to P37
	V _{O2}	—	V _{CC} + 0.3	V	P40 to P47, P50 to P57, P60 to P67, BZ*2
"H" level total maximum output current	ΣI _{OH}	—	-100	mA	
"H" level total average output current	ΣI _{OHAV}	—	-75	mA	Average value (operating current × operation rate)
"H" level maximum output current	I _{OH}	—	-12	mA	P00 to P07, P30, P32 to P37, P10 to P17, P20 to P23 Average value (operating current × operation rate)
"H" level average output current	I _{OHAV}	—	-6		
"H" level maximum output current	I _{OH}	—	-20	mA	P40 to P47, P50 to P57, P60 to P67, BZ Average value (operating current × operation rate)
"H" level average output current	I _{OHAV}	—	-10		
"L" level total maximum output current	ΣI _{OL}	—	50	mA	
"L" level total average output current	ΣI _{OLAV}	—	30	mA	Average value (operating current × operation rate)
"L" level maximum output current	I _{OL}	—	12	mA	P00 to P07, P10 to P17, P20 to P23, P30 to P37
"L" level average output current	I _{OLAV}	—	6		
Power consumption	P _D	—	470	mW	SDIP64 : DIP-64P-M01
Operating temperature	T _A	-40	+85	°C	
Storage temperature	T _{stg}	-55	+150	°C	

*1: Take care so that AVR does not exceed V_{CC} + 0.3 V and V_{CC}, such as when power is turned on.

*2: V_I and V_O must not exceed V_{CC} + 0.3 V.

Precautions: Permanent device damage may occur if the above "Absolute Maximum Ratings" are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

MB89143A/144A

2. Recommended Operating Conditions

($AV_{SS} = V_{SS} = 0.0\text{ V}$)

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC}	4.0*	6.0*	V	Normal operation assurance range* at highest gear speed
		3.5*	6.0*	V	Normal operation assurance range* at highest gear speed
		2.5	6.0	V	When in watch mode or subclock operation mode
		1.5	6.0	V	Retains the RAM state in stop mode
A/D converter reference input voltage	AVR	0.0	V_{CC}	V	
Operating temperature	T_A	-40	+85	°C	

* : These values vary with the operating frequency, instruction cycle, and analog assurance range. See Figure 1 and "5. A/D Converter Electrical Characteristics."

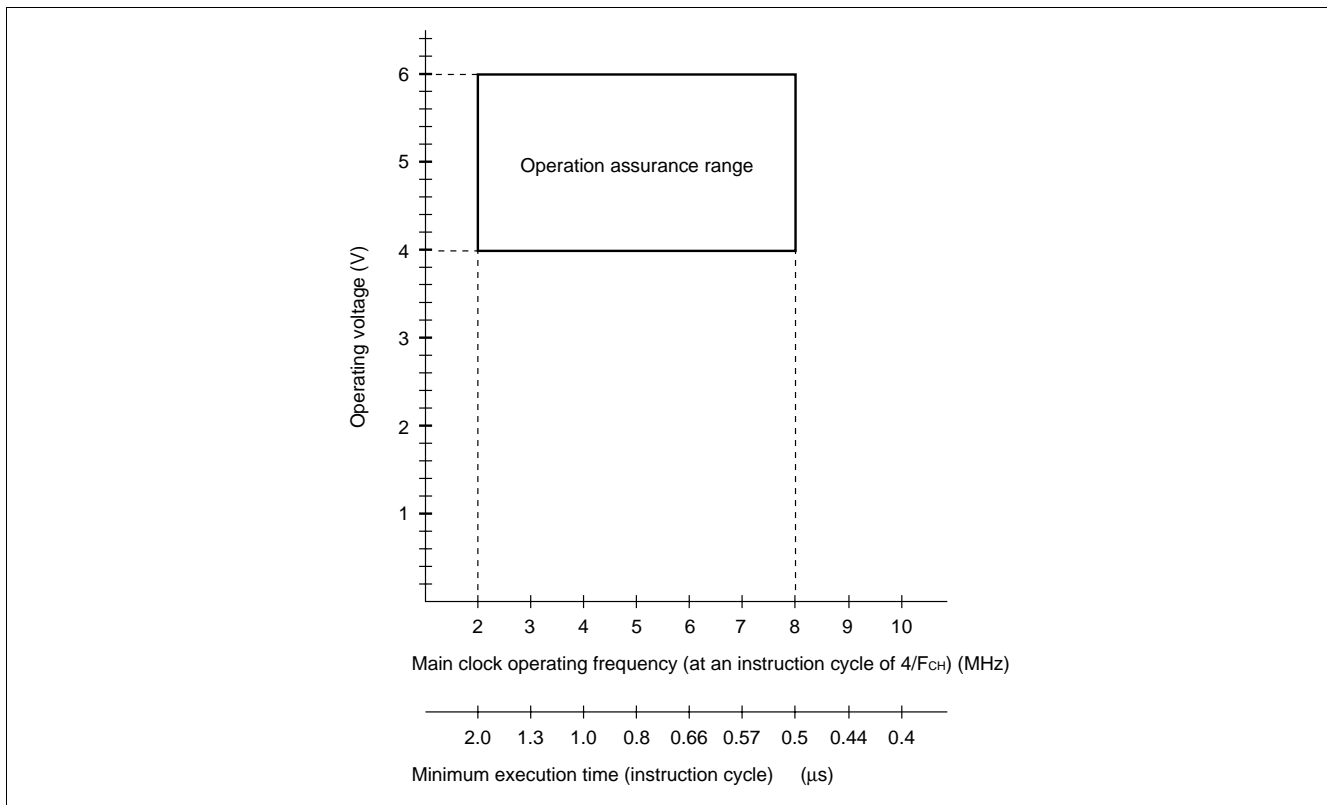


Figure 1 Operating Voltage vs. Main Clock Operating Frequency

Figure 1 indicates the operating frequency of the external oscillator at an instruction cycle of $4/F_{CH}$.

Since the operating voltage range is dependent on the instruction cycle, see minimum execution time if the operating speed is switched using a gear.

3. DC Characteristics

(AVR = V_{CC} = 5.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = -40°C to +85°C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
"H" level input voltage	V _{IHS}	P00 to P07, P10 to P17, P30 to P37, P70, P71, X0, \overline{RST} , X1, MODA	—	0.8 V _{CC}	—	V _{CC} + 0.3	V	
"L" level input voltage	V _{ILS}	P00 to P07, P10 to P17, P30 to P37, P70, P71, X0, \overline{RST} , X1, MODA	—	V _{SS} - 0.3	—	0.2 V _{CC}	V	
Open-drain output pin application voltage	V _{D1}	P31	—	V _{SS} - 0.3	—	7.0	V	
"H" level output voltage	V _{OH1}	P00 to P07, P10 to P17, P20 to P23, P30 to P37	I _{OH} = -2.0 mA	2.4	—	—	V	Except P31
	V _{OH2}	P40 to P47, P50 to P57, P60 to P67	I _{OH} = -10 mA	3.0	—	—	V	
"L" level output voltage	V _{OL1}	P00 to P07, P10 to P17, P20 to P23, P30 to P37	I _{OL} = 1.8 mA	—	—	0.4	V	
	V _{OL2}	\overline{RST}	I _{OL} = 4.0 mA	—	—	0.6	V	
Input leakage current	I _{LI1}	P00 to P07, P10 to P17, P30 to P37, P70, P71	0 V < V _I < V _{CC}	—	—	±5	μA	Except pins with pull-up resistor
	I _{LI2}	P14 to P17, P32 to P37	V _I = 0.0 V	-200	-100	-50	μA	Only for pins with pull-up resistor
Output leakage current	I _{LO1}	P40 to P47, P50 to P57, P60 to P67	V _I = V _{CC} - 35 V	—	—	-10	μA	
Pull-up resistance	R _{PULL}	\overline{RST} , P14 to P17, P32 to P37	V _I = 0.0 V	25	50	100	kΩ	
Power supply current	I _{CC1}	V _{CC}	F _{CH} = 8 MHz, V _{CC} = 5.0 V, t _{inst} = 0.5 μs, when A/D conversion is stopped	—	9	15	mA	

(Continued)

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(Continued)

(AVR = V_{CC} = 5.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = -40°C to +85°C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks	
				Min.	Typ.	Max.			
Power supply current	I _{CC2}	V _{CC}	F _{CH} = 8 MHz, V _{CC} = 3.5 V, t _{inst} = 8.0 μs, when A/D conversion is stopped	—	1.5	2	mA		
	I _{CCS1}		Sleep mode	F _{CH} = 8 MHz V _{CC} = 5.0 V t _{inst} = 0.5 μs	—	3	7	mA	
	I _{CCS2}			F _{CH} = 8 MHz V _{CC} = 3.5 V t _{inst} = 8.0 μs	—	1	1.5	mA	
	I _{CCL}		F _{CL} = 32.768 kHz V _{CC} = 3.0 V Subclock mode	—	50	150	μA		
	I _{CCLS}		F _{CL} = 32.768 kHz V _{CC} = 3.0 V Subclock mode	—	25	50	μA		
	I _{CCT}		F _{CL} = 32.768 kHz V _{CC} = 3.0 V • Watch mode • Main clock stop mode at dual-clock system	—	3	15	μA		
	I _{CCH}		F _{CL} = 32.768 kHz T _A = +25°C • Subclock stop mode • Main clock stop mode at single-clock system	—	—	10	μA		
	I _{CCA}		F _{CH} = 8 MHz, V _{CC} = 5.0 V, T _A = +25°C, t _{inst} = 0.5 μs, when A/D conversion is activated	—	11.5	19.5	mA	When the gear function is used, the power supply current varies with the measurement point.	
	I _R		AVR	F _{CH} = 8 MHz, T _A = +25°C, when A/D conversion is activated	—	200	—	μA	
I _{RH}	F _{CH} = 8 MHz, T _A = +25°C, when A/D conversion is stopped	—		—	10	μA			
Input capacitance	C _{IN}	Other than AV _{SS} , AVR, V _{CC} , and V _{SS}	f = 1 MHz	—	10	—	pF		

Note: The power supply current is measured at the external clock.

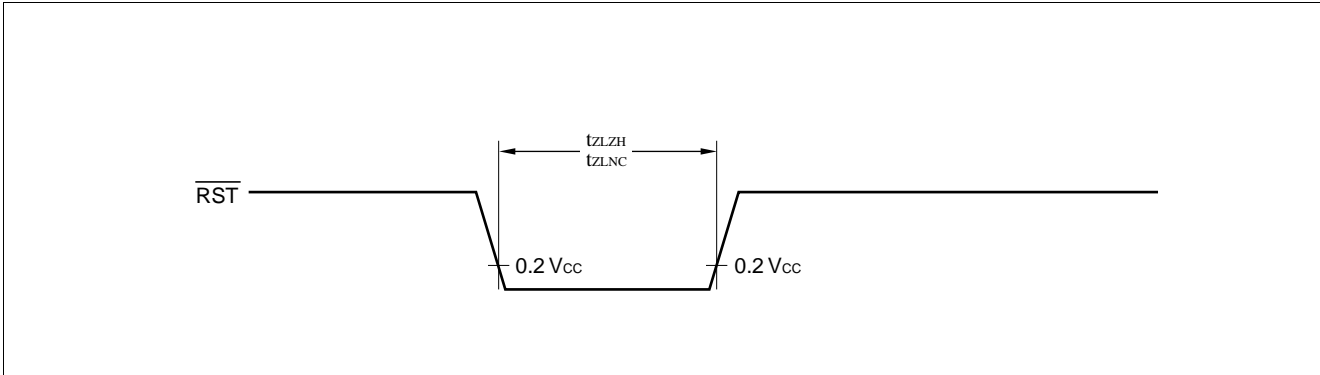
4. AC Characteristics

(1) Reset Timing

($AVR = V_{CC} = 5.0 V \pm 10\%$, $AV_{SS} = V_{SS} = 0.0 V$, $T_A = -40^\circ C$ to $+85^\circ C$)

Parameter	Symbol	Condition	Value			Unit	Remarks
			Min.	Typ.	Max.		
\overline{RST} "L" pulse width	t_{ZLZH}	—	$16 t_{XCYL}$	—	—	ns	
\overline{RST} noise limit width	t_{ZLNC}	—	20	40	60	ns	

Note: t_{XCYL} is the oscillation cycle ($1/F_{CH}$) to input to the X0 pin.

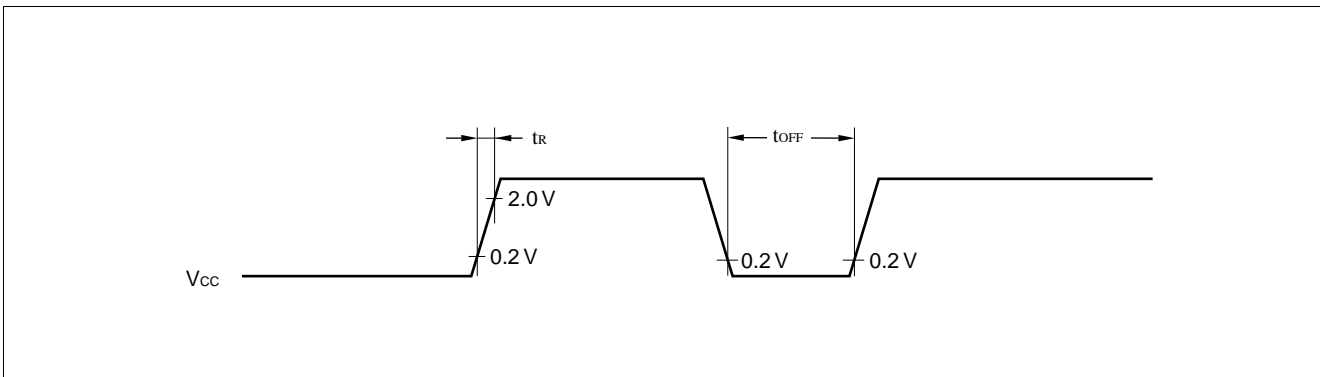


(2) Power-on Reset

($AV_{SS} = V_{SS} = 0.0 V$, $T_A = -40^\circ C$ to $+85^\circ C$)

Parameter	Symbol	Condition	Value		Unit	Remarks
			Min.	Max.		
Power supply rising time	t_R	—	—	50	ms	Power-on reset function only
Power supply cut-off time	t_{OFF}	—	1	—	ms	Due to repeated operations

Note: Make sure that power supply rises within the selected oscillation stabilization time.
If power supply voltage needs to be varied in the course of operation, a smooth voltage rise is recommended.



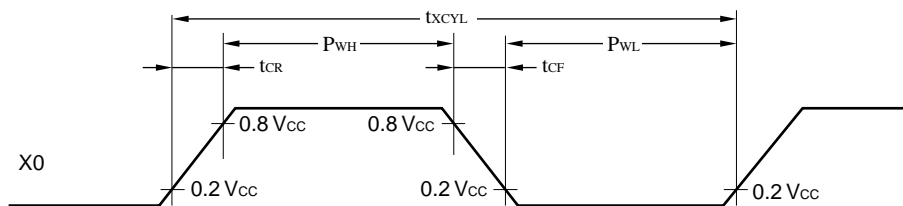
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(3) Clock Timing

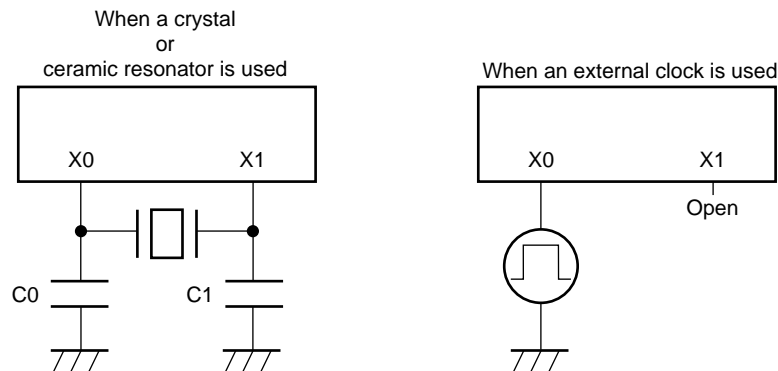
($V_{SS} = V_{SS} = 0.0\text{ V}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Clock frequency	F_{CH}	X0, X1	—	2	—	8	MHz	
	F_{CL}	X0A, X1A	—	—	32.768	—	kHz	
Clock cycle time	t_{XCYL}	X0, X1	—	125	—	500	ns	
	t_{LXCYL}	X0A, X1A	—	—	30.5	—	μs	
Input clock pulse width	P_{WH} P_{WL}	X0	—	30	—	—	ns	External clock
	P_{WHL} P_{WLL}	X0A	—	—	15.2	—	ns	
Input clock rising/ falling time	t_{CR} t_{CF}	X0, X0A	—	—	—	10	ns	External clock

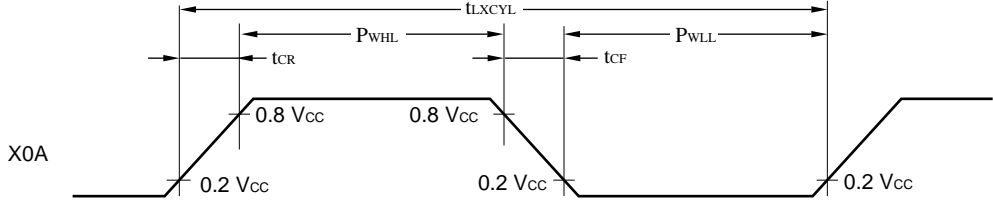
X0 and X1 Timings and Conditions



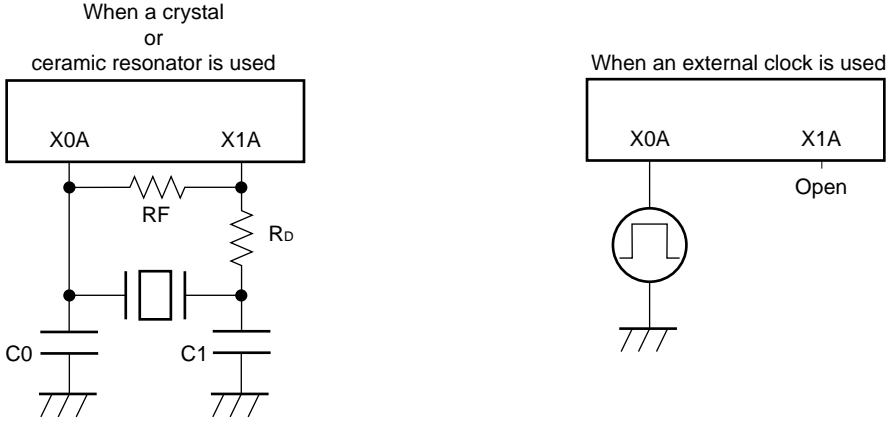
Main Clock Conditions



X0A and X1A Timings and Conditions



Subclock Conditions



Note: The subclock oscillator feedback resistor is connected externally in dual-clock products.

(4) Instruction Cycle

Parameter	Symbol	Value (typical)	Unit	Remarks
Instruction cycle time	t _{inst}	4/F _{CH} , 8/F _{CH} , 16/F _{CH} , 32/F _{CH}	μs	(4/F _{CH}) t _{inst} = 0.5 μs when operating at F _{CH} = 8 MHz
		2/F _{CL}	μs	t _{inst} = 61.036 μs when operating at F _{CL} = 32.768 kHz

Note: When operating at 8 MHz, the cycle varies with the set execution time.

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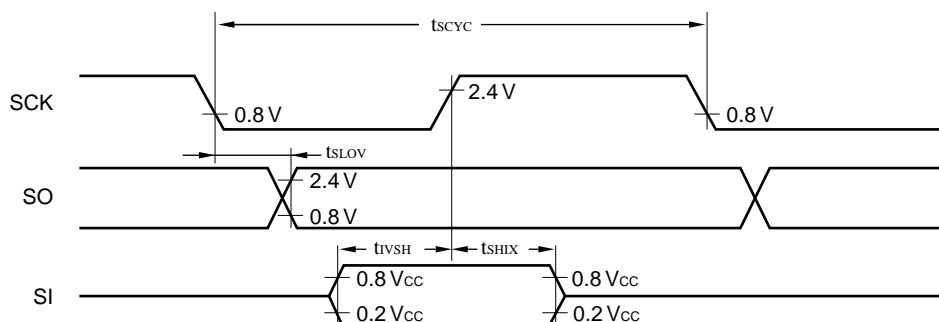
(5) Serial I/O timing

(AVR = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = -40°C to +85°C)

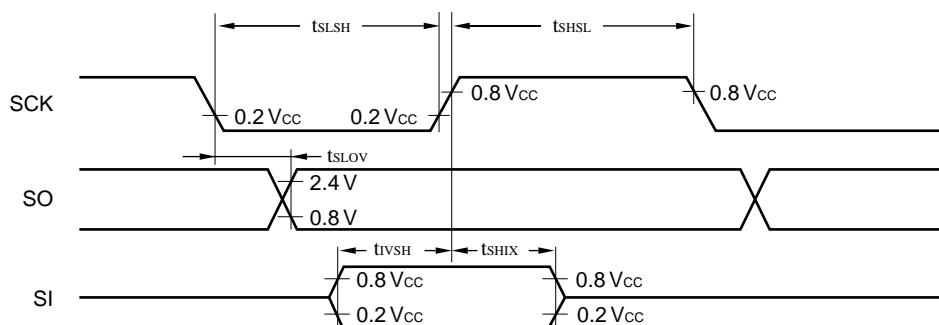
Parameter	Symbol	Pin	Condition	Value		Unit	Remarks
				Min.	Max.		
Serial clock cycle time	t _{SCYC}	SCK	Internal shift clock mode	2 t _{inst} *	—	μs	
SCK ↓ → SO time	t _{SLOV}	SCK, SO		-200	200	ns	
Valid SI → SCK ↑	t _{IVSH}	SI, SCK		1/2 t _{inst} *	—	μs	
SCK ↑ → valid SI hold time	t _{SHIX}	SCK, SI		1/2 t _{inst} *	—	μs	
Serial clock "H" pulse width	t _{SHSL}	SCK	External shift clock mode	1 t _{inst} *	—	μs	
Serial clock "L" pulse width	t _{SLSH}	SCK		1 t _{inst} *	—	μs	
SCK ↓ → SO time	t _{SLOV}	SCK, SO		0	200	ns	
Valid SI → SCK ↑	t _{IVSH}	SI, SCK		1/2 t _{inst} *	—	μs	
SCK ↑ → valid SI hold time	t _{SHIX}	SCK, SI		1/2 t _{inst} *	—	μs	

* : For information on t_{inst}, see "(4) Instruction Cycle."

Internal Shift Clock Mode



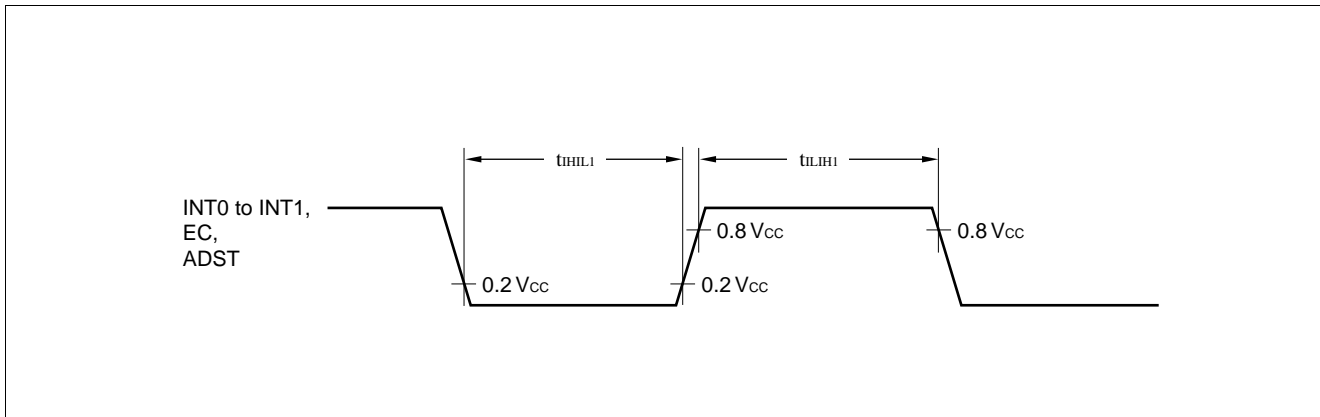
External Shift Clock Mode



(6) Peripheral Input Timing

(AVR = $V_{CC} = 5.0 V \pm 10\%$, $AV_{SS} = V_{SS} = 0.0 V$, $T_A = -40^\circ C$ to $+85^\circ C$)

Parameter	Symbol	Pin	Condition	Value		Unit	Remarks
				Min.	Max.		
Peripheral input "H" pulse width 1	t_{LH1}	EC, ADST, INT0 to INT1	—	$2 t_{inst}$	—	μs	
Peripheral input "L" pulse width 1	t_{HL1}	EC, ADST, INT0 to INT1	—	$2 t_{inst}$	—	μs	

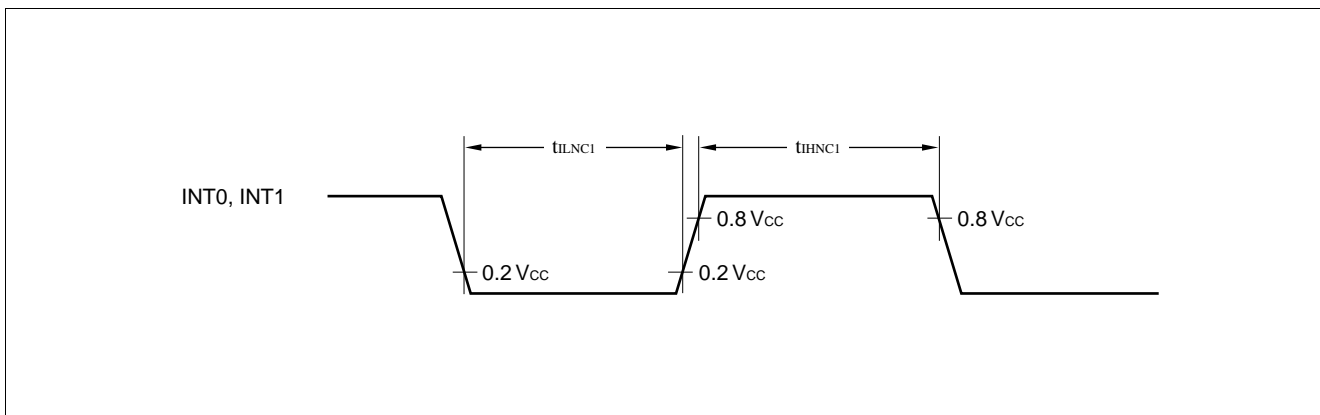


(7) Peripheral Input Noise Limit Width

(AVR = $V_{CC} = 5.0 V \pm 10\%$, $AV_{SS} = V_{SS} = 0.0 V$, $T_A = -40^\circ C$ to $+85^\circ C$)

Parameter	Symbol	Pin	Value			Unit	Remarks
			Min.	Typ.	Max.		
Peripheral input "H" level noise limit width 1	t_{HNC1}	INT1, INT0	50	100	250	ns	
Peripheral input "L" level noise limit width 1	t_{LNC1}	INT1, INT0	50	100	250	ns	

Note: The minimum values is always canceled, while values over the maximum value are not canceled.



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5. A/D Converter Electrical Characteristics

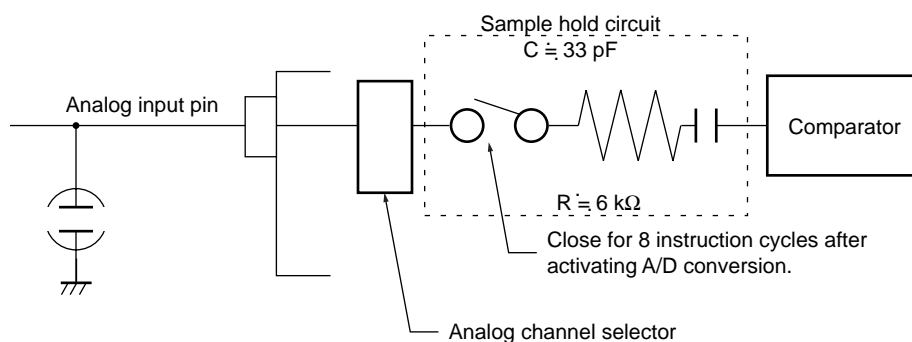
($V_{CC} = 5.0 \text{ V} \pm 10\%$, $AV_{SS} = V_{SS} = 0.0 \text{ V}$, $F_{CH} = 8 \text{ MHz}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Resolution	—	—	—	—	—	8	bit	
Total error	—	—	—	—	—	± 3.0	LSB	
Linearity error	—	—	—	—	—	± 1.0	LSB	
Differential linearity error	—	—	—	—	—	± 0.9	LSB	
Zero transition voltage	V_{OT}	AN0 to AN7	—	$AV_{SS} - 1.5 \text{ LSB}$	$AV_{SS} + 0.5 \text{ LSB}$	$AV_{SS} + 2.5 \text{ LSB}$	mV	
Full-scale transition voltage	V_{FST}	AN0 to AN7	—	$AVR - 3.5 \text{ LSB}$	$AVR - 1.5 \text{ LSB}$	$AVR + 0.5 \text{ LSB}$	mV	
Interchannel disparity	—	—	—	—	—	1.0	LSB	
A/D conversion time	—	—	—	—	$44 t_{inst}$	—	μs	
Sense mode conversion time	—	—	—	—	$12 t_{inst}$	—	μs	
Analog port input current	I_{AIN}	AN0 to AN7	$AVR = V_{CC} = 5.0 \text{ V}$	—	—	10	μA	
Analog input voltage	—	AN0 to AN7	—	0	—	AVR	V	
Reference voltage	—	AVR	—	4.5	—	V_{CC}	V	
Reference-voltage supply current	I_R	AVR	$AVR = 5.0 \text{ V}$	—	200	—	μA	

- Notes:
- The smaller the $|AVR - AV_{SS}|$, the greater the error would become relatively.
 - The output impedance of the external circuit for the analog input must satisfy the following conditions:
Output impedance of the external circuit < Approx. $10 \text{ k}\Omega$
If the output impedance of the external circuit is too high, an analog voltage sampling time might be insufficient (sampling time = $22 \mu\text{s}$ at 8 MHz oscillation).

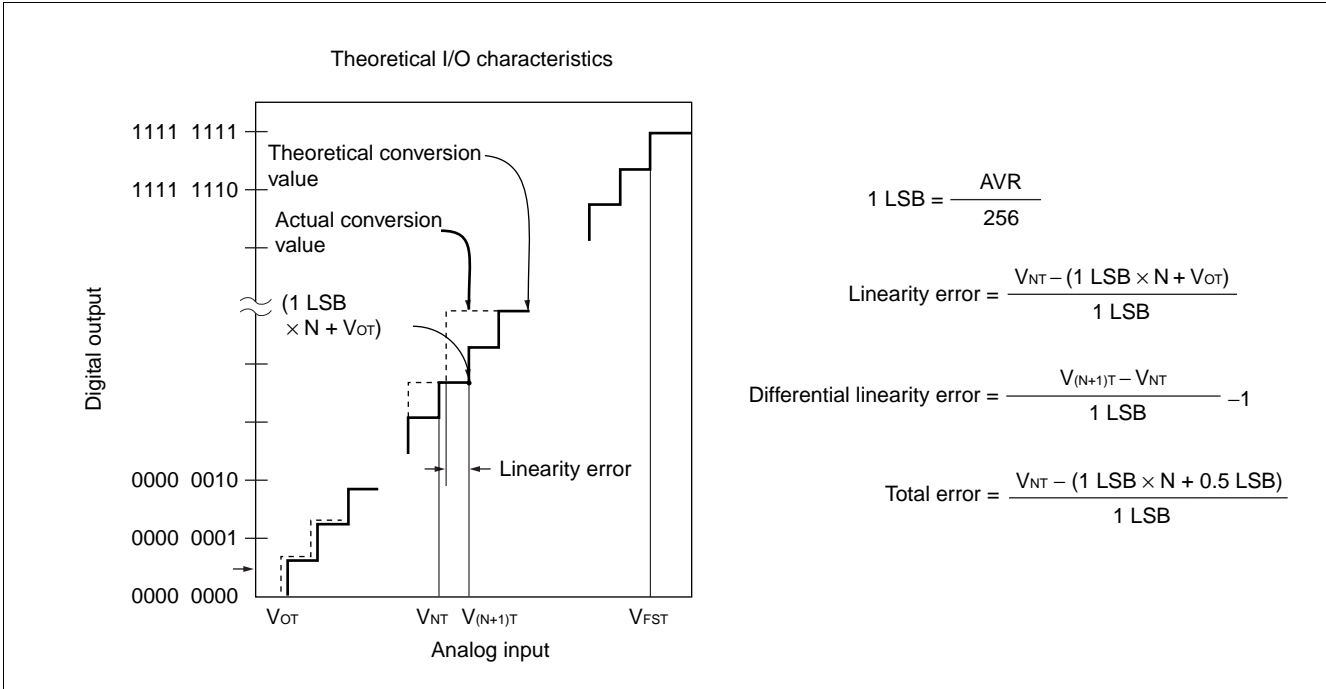
Analog Input Equivalent Circuit

If the analog input impedance is $10 \text{ k}\Omega$ or more, it is recommended to connect an external capacitor of approx. $0.1 \mu\text{F}$.



6. A/D Glossary

- Resolution
Analog changes that are identifiable with the A/D converter
- Linearity error
The deviation of the straight line connecting the zero transition point (“0000 0000” ↔ “0000 0001”) with the full-scale transition point (“1111 1111” ↔ “1111 1110”) from actual conversion characteristics
- Differential linearity error
The deviation of input voltage needed to change the output code by 1 LSB from the theoretical value
- Total error
The difference between actual and theoretical value
This error is caused by the zero transition error, full-scale transition error, linearity error, quantization error, and noise.



■ INSTRUCTIONS

Execution instructions can be divided into the following four groups:

- Transfer
- Arithmetic operation
- Branch
- Others

Table 1 lists symbols used for notation of instructions.

Table 1 Instruction Symbols

Symbol	Meaning
dir	Direct address (8 bits)
off	Offset (8 bits)
ext	Extended address (16 bits)
#vct	Vector table number (3 bits)
#d8	Immediate data (8 bits)
#d16	Immediate data (16 bits)
dir: b	Bit direct address (8:3 bits)
rel	Branch relative address (8 bits)
@	Register indirect (Example: @A, @IX, @EP)
A	Accumulator A (Whether its length is 8 or 16 bits is determined by the instruction in use.)
AH	Upper 8 bits of accumulator A (8 bits)
AL	Lower 8 bits of accumulator A (8 bits)
T	Temporary accumulator T (Whether its length is 8 or 16 bits is determined by the instruction in use.)
TH	Upper 8 bits of temporary accumulator T (8 bits)
TL	Lower 8 bits of temporary accumulator T (8 bits)
IX	Index register IX (16 bits)

(Continued)

(Continued)

Symbol	Meaning
EP	Extra pointer EP (16 bits)
PC	Program counter PC (16 bits)
SP	Stack pointer SP (16 bits)
PS	Program status PS (16 bits)
dr	Accumulator A or index register IX (16 bits)
CCR	Condition code register CCR (8 bits)
RP	Register bank pointer RP (5 bits)
Ri	General-purpose register Ri (8 bits, i = 0 to 7)
×	Indicates that the very × is the immediate data. (Whether its length is 8 or 16 bits is determined by the instruction in use.)
(×)	Indicates that the contents of × is the target of accessing. (Whether its length is 8 or 16 bits is determined by the instruction in use.)
((×))	The address indicated by the contents of × is the target of accessing. (Whether its length is 8 or 16 bits is determined by the instruction in use.)

Columns indicate the following:

Mnemonic: Assembler notation of an instruction

~: Number of instructions

#: Number of bytes

Operation: Operation of an instruction

TL, TH, AH: A content change when each of the TL, TH, and AH instructions is executed. Symbols in the column indicate the following:

- “–” indicates no change.
- dH is the 8 upper bits of operation description data.
- AL and AH must become the contents of AL and AH immediately before the instruction is executed.
- 00 becomes 00.

N, Z, V, C: An instruction of which the corresponding flag will change. If + is written in this column, the relevant instruction will change its corresponding flag.

OP code: Code of an instruction. If an instruction is more than one code, it is written according to the following rule:

Example: 48 to 4F ← This indicates 48, 49, ... 4F.

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Table 2 Transfer Instructions (48 instructions)

Mnemonic	~	#	Operation	TL	TH	AH	NZVC	OP code
MOV dir,A	3	2	(dir) ← (A)	-	-	-	-----	45
MOV @IX +off,A	4	2	((IX) +off) ← (A)	-	-	-	-----	46
MOV ext,A	4	3	(ext) ← (A)	-	-	-	-----	61
MOV @EP,A	3	1	((EP)) ← (A)	-	-	-	-----	47
MOV Ri,A	3	1	(Ri) ← (A)	-	-	-	-----	48 to 4F
MOV A,#d8	2	2	(A) ← d8	AL	-	-	++--	04
MOV A,dir	3	2	(A) ← (dir)	AL	-	-	++--	05
MOV A,@IX +off	4	2	(A) ← ((IX) +off)	AL	-	-	++--	06
MOV A,ext	4	3	(A) ← (ext)	AL	-	-	++--	60
MOV A,@A	3	1	(A) ← ((A))	AL	-	-	++--	92
MOV A,@EP	3	1	(A) ← ((EP))	AL	-	-	++--	07
MOV A,Ri	3	1	(A) ← (Ri)	AL	-	-	++--	08 to 0F
MOV dir,#d8	4	3	(dir) ← d8	-	-	-	-----	85
MOV @IX +off,#d8	5	3	((IX) +off) ← d8	-	-	-	-----	86
MOV @EP,#d8	4	2	((EP)) ← d8	-	-	-	-----	87
MOV Ri,#d8	4	2	(Ri) ← d8	-	-	-	-----	88 to 8F
MOVW dir,A	4	2	(dir) ← (AH),(dir + 1) ← (AL)	-	-	-	-----	D5
MOVW @IX +off,A	5	2	((IX) +off) ← (AH), ((IX) +off + 1) ← (AL)	-	-	-	-----	D6
MOVW ext,A	5	3	(ext) ← (AH), (ext + 1) ← (AL)	-	-	-	-----	D4
MOVW @EP,A	4	1	((EP)) ← (AH),(EP + 1) ← (AL)	-	-	-	-----	D7
MOVW EP,A	2	1	(EP) ← (A)	-	-	-	-----	E3
MOVW A,#d16	3	3	(A) ← d16	AL	AH	dH	++--	E4
MOVW A,dir	4	2	(AH) ← (dir), (AL) ← (dir + 1)	AL	AH	dH	++--	C5
MOVW A,@IX +off	5	2	(AH) ← ((IX) +off), (AL) ← ((IX) +off + 1)	AL	AH	dH	++--	C6
MOVW A,ext	5	3	(AH) ← (ext), (AL) ← (ext + 1)	AL	AH	dH	++--	C4
MOVW A,@A	4	1	(AH) ← ((A)), (AL) ← ((A) + 1)	AL	AH	dH	++--	93
MOVW A,@EP	4	1	(AH) ← ((EP)), (AL) ← ((EP) + 1)	AL	AH	dH	++--	C7
MOVW A,EP	2	1	(A) ← (EP)	-	-	dH	-----	F3
MOVW EP,#d16	3	3	(EP) ← d16	-	-	-	-----	E7
MOVW IX,A	2	1	(IX) ← (A)	-	-	-	-----	E2
MOVW A,IX	2	1	(A) ← (IX)	-	-	dH	-----	F2
MOVW SP,A	2	1	(SP) ← (A)	-	-	-	-----	E1
MOVW A,SP	2	1	(A) ← (SP)	-	-	dH	-----	F1
MOV @A,T	3	1	((A)) ← (T)	-	-	-	-----	82
MOVW @A,T	4	1	((A)) ← (TH),((A) + 1) ← (TL)	-	-	-	-----	83
MOVW IX,#d16	3	3	(IX) ← d16	-	-	-	-----	E6
MOVW A,PS	2	1	(A) ← (PS)	-	-	dH	-----	70
MOVW PS,A	2	1	(PS) ← (A)	-	-	-	++++	71
MOVW SP,#d16	3	3	(SP) ← d16	-	-	-	-----	E5
SWAP	2	1	(AH) ↔ (AL)	-	-	AL	-----	10
SETB dir: b	4	2	(dir): b ← 1	-	-	-	-----	A8 to AF
CLRB dir: b	4	2	(dir): b ← 0	-	-	-	-----	A0 to A7
XCH A,T	2	1	(AL) ↔ (TL)	AL	-	-	-----	42
XCHW A,T	3	1	(A) ↔ (T)	AL	AH	dH	-----	43
XCHW A,EP	3	1	(A) ↔ (EP)	-	-	dH	-----	F7
XCHW A,IX	3	1	(A) ↔ (IX)	-	-	dH	-----	F6
XCHW A,SP	3	1	(A) ↔ (SP)	-	-	dH	-----	F5
MOVW A,PC	2	1	(A) ← (PC)	-	-	dH	-----	F0

- Notes:
- During byte transfer to A, T ← A is restricted to low bytes.
 - Operands in more than one operand instruction must be stored in the order in which their mnemonics are written. (Reverse arrangement of F²MC-8 family)

Table 3 Arithmetic Operation Instructions (62 instructions)

Mnemonic	~	#	Operation	TL	TH	AH	NZVC	OP code
ADDC A,Ri	3	1	$(A) \leftarrow (A) + (Ri) + C$	-	-	-	++++	28 to 2F
ADDC A,#d8	2	2	$(A) \leftarrow (A) + d8 + C$	-	-	-	++++	24
ADDC A,dir	3	2	$(A) \leftarrow (A) + (dir) + C$	-	-	-	++++	25
ADDC A,@IX +off	4	2	$(A) \leftarrow (A) + ((IX) + off) + C$	-	-	-	++++	26
ADDC A,@EP	3	1	$(A) \leftarrow (A) + ((EP)) + C$	-	-	-	++++	27
ADDCW A	3	1	$(A) \leftarrow (A) + (T) + C$	-	-	dH	++++	23
ADDC A	2	1	$(AL) \leftarrow (AL) + (TL) + C$	-	-	-	++++	22
SUBC A,Ri	3	1	$(A) \leftarrow (A) - (Ri) - C$	-	-	-	++++	38 to 3F
SUBC A,#d8	2	2	$(A) \leftarrow (A) - d8 - C$	-	-	-	++++	34
SUBC A,dir	3	2	$(A) \leftarrow (A) - (dir) - C$	-	-	-	++++	35
SUBC A,@IX +off	4	2	$(A) \leftarrow (A) - ((IX) + off) - C$	-	-	-	++++	36
SUBC A,@EP	3	1	$(A) \leftarrow (A) - ((EP)) - C$	-	-	-	++++	37
SUBCW A	3	1	$(A) \leftarrow (T) - (A) - C$	-	-	dH	++++	33
SUBC A	2	1	$(AL) \leftarrow (TL) - (AL) - C$	-	-	-	++++	32
INC Ri	4	1	$(Ri) \leftarrow (Ri) + 1$	-	-	-	+++-	C8 to CF
INCW EP	3	1	$(EP) \leftarrow (EP) + 1$	-	-	-	----	C3
INCW IX	3	1	$(IX) \leftarrow (IX) + 1$	-	-	-	----	C2
INCW A	3	1	$(A) \leftarrow (A) + 1$	-	-	dH	++--	C0
DEC Ri	4	1	$(Ri) \leftarrow (Ri) - 1$	-	-	-	+++-	D8 to DF
DECW EP	3	1	$(EP) \leftarrow (EP) - 1$	-	-	-	----	D3
DECW IX	3	1	$(IX) \leftarrow (IX) - 1$	-	-	-	----	D2
DECW A	3	1	$(A) \leftarrow (A) - 1$	-	-	dH	++--	D0
MULU A	19	1	$(A) \leftarrow (AL) \times (TL)$	-	-	dH	----	01
DIVU A	21	1	$(A) \leftarrow (T) / (AL), MOD \rightarrow (T)$	dL	00	00	----	11
ANDW A	3	1	$(A) \leftarrow (A) \wedge (T)$	-	-	dH	++R-	63
ORW A	3	1	$(A) \leftarrow (A) \vee (T)$	-	-	dH	++R-	73
XORW A	3	1	$(A) \leftarrow (A) \nabla (T)$	-	-	dH	++R-	53
CMP A	2	1	$(TL) - (AL)$	-	-	-	++++	12
CMPW A	3	1	$(T) - (A)$	-	-	-	++++	13
RORC A	2	1	$\rightarrow C \rightarrow A$	-	-	-	++-+	03
ROLC A	2	1	$\leftarrow C \leftarrow A$	-	-	-	++-+	02
CMP A,#d8	2	2	$(A) - d8$	-	-	-	++++	14
CMP A,dir	3	2	$(A) - (dir)$	-	-	-	++++	15
CMP A,@EP	3	1	$(A) - ((EP))$	-	-	-	++++	17
CMP A,@IX +off	4	2	$(A) - ((IX) + off)$	-	-	-	++++	16
CMP A,Ri	3	1	$(A) - (Ri)$	-	-	-	++++	18 to 1F
DAA	2	1	Decimal adjust for addition	-	-	-	++++	84
DAS	2	1	Decimal adjust for subtraction	-	-	-	++++	94
XOR A	2	1	$(A) \leftarrow (AL) \nabla (TL)$	-	-	-	++R-	52
XOR A,#d8	2	2	$(A) \leftarrow (AL) \nabla d8$	-	-	-	++R-	54
XOR A,dir	3	2	$(A) \leftarrow (AL) \nabla (dir)$	-	-	-	++R-	55
XOR A,@EP	3	1	$(A) \leftarrow (AL) \nabla ((EP))$	-	-	-	++R-	57
XOR A,@IX +off	4	2	$(A) \leftarrow (AL) \nabla ((IX) + off)$	-	-	-	++R-	56
XOR A,Ri	3	1	$(A) \leftarrow (AL) \nabla (Ri)$	-	-	-	++R-	58 to 5F
AND A	2	1	$(A) \leftarrow (AL) \wedge (TL)$	-	-	-	++R-	62
AND A,#d8	2	2	$(A) \leftarrow (AL) \wedge d8$	-	-	-	++R-	64
AND A,dir	3	2	$(A) \leftarrow (AL) \wedge (dir)$	-	-	-	++R-	65

(Continued)

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(Continued)

Mnemonic	~	#	Operation	TL	TH	AH	NZVC	OP code
AND A,@EP	3	1	$(A) \leftarrow (AL) \wedge ((EP))$	-	-	-	++R-	67
AND A,@IX +off	4	2	$(A) \leftarrow (AL) \wedge ((IX) +off)$	-	-	-	++R-	66
AND A,Ri	3	1	$(A) \leftarrow (AL) \wedge (Ri)$	-	-	-	++R-	68 to 6F
OR A	2	1	$(A) \leftarrow (AL) \vee (TL)$	-	-	-	++R-	72
OR A,#d8	2	2	$(A) \leftarrow (AL) \vee d8$	-	-	-	++R-	74
OR A,dir	3	2	$(A) \leftarrow (AL) \vee (dir)$	-	-	-	++R-	75
OR A,@EP	3	1	$(A) \leftarrow (AL) \vee ((EP))$	-	-	-	++R-	77
OR A,@IX +off	4	2	$(A) \leftarrow (AL) \vee ((IX) +off)$	-	-	-	++R-	76
OR A,Ri	3	1	$(A) \leftarrow (AL) \vee (Ri)$	-	-	-	++R-	78 to 7F
CMP dir,#d8	5	3	$(dir) - d8$	-	-	-	++++	95
CMP @EP,#d8	4	2	$((EP)) - d8$	-	-	-	++++	97
CMP @IX +off,#d8	5	3	$((IX) +off) - d8$	-	-	-	++++	96
CMP Ri,#d8	4	2	$(Ri) - d8$	-	-	-	++++	98 to 9F
INCW SP	3	1	$(SP) \leftarrow (SP) + 1$	-	-	-	----	C1
DECW SP	3	1	$(SP) \leftarrow (SP) - 1$	-	-	-	----	D1

Table 4 Branch Instructions (17 instructions)

Mnemonic	~	#	Operation	TL	TH	AH	NZVC	OP code
BZ/BEQ rel	3	2	If $Z = 1$ then $PC \leftarrow PC + rel$	-	-	-	----	FD
BNZ/BNE rel	3	2	If $Z = 0$ then $PC \leftarrow PC + rel$	-	-	-	----	FC
BC/BLO rel	3	2	If $C = 1$ then $PC \leftarrow PC + rel$	-	-	-	----	F9
BNC/BHS rel	3	2	If $C = 0$ then $PC \leftarrow PC + rel$	-	-	-	----	F8
BN rel	3	2	If $N = 1$ then $PC \leftarrow PC + rel$	-	-	-	----	FB
BP rel	3	2	If $N = 0$ then $PC \leftarrow PC + rel$	-	-	-	----	FA
BLT rel	3	2	If $V \vee N = 1$ then $PC \leftarrow PC + rel$	-	-	-	----	FF
BGE rel	3	2	If $V \vee N = 0$ then $PC \leftarrow PC + rel$	-	-	-	----	FE
BBC dir: b,rel	5	3	If $(dir: b) = 0$ then $PC \leftarrow PC + rel$	-	-	-	-+--	B0 to B7
BBS dir: b,rel	5	3	If $(dir: b) = 1$ then $PC \leftarrow PC + rel$	-	-	-	-+--	B8 to BF
JMP @A	2	1	$(PC) \leftarrow (A)$	-	-	-	----	E0
JMP ext	3	3	$(PC) \leftarrow ext$	-	-	-	----	21
CALLV #vct	6	1	Vector call	-	-	-	----	E8 to EF
CALL ext	6	3	Subroutine call	-	-	-	----	31
XCHW A,PC	3	1	$(PC) \leftarrow (A), (A) \leftarrow (PC) + 1$	-	-	dH	----	F4
RET	4	1	Return from subroutine	-	-	-	----	20
RETI	6	1	Return from interrupt	-	-	-	Restore	30

Table 5 Other Instructions (9 instructions)

Mnemonic	~	#	Operation	TL	TH	AH	NZVC	OP code
PUSHW A	4	1		-	-	-	----	40
POPW A	4	1		-	-	dH	----	50
PUSHW IX	4	1		-	-	-	----	41
POPW IX	4	1		-	-	-	----	51
NOP	1	1		-	-	-	----	00
CLRC	1	1		-	-	-	----R	81
SETC	1	1		-	-	-	----S	91
CLRI	1	1		-	-	-	----	80
SETI	1	1		-	-	-	----	90

■ INSTRUCTION MAP

L/H	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NOP	SWAP	RET	RETI	PUSHW A	POPW A	MOV A,ext A	MOVW A,PS A	CLRI	SETI	CLRB dir: 0	BBC dir: 0,rel	INCW A	DECW A	JMP @A	MOVW A,PC
1	MULU A	DIVU A	JMP addr16	CALL addr16	PUSHW IX	POPW IX	MOV ext,A	MOVW PSA	CLRC	SETC	CLRB dir: 1	BBC dir: 1,rel	INCW SP	DECW SP	MOVW SPA	MOVW A,SP
2	ROLC A	CMP A	ADDC A	SUBC A	XCH A, T	XOR A	AND A	OR A	MOV @A,T	MOV A,@A	CLRB dir: 2	BBC dir: 2,rel	INCW IX	DECW IX	MOVW IX,A	MOVW A,IX
3	RORC A	CMPW A	ADDCW A	SUBCW A	XCHW A, T	XORW A	ANDW A	ORW A	MOVW @A,T	MOVW A,@A	CLRB dir: 3	BBC dir: 3,rel	INCW EP	DECW EP	MOVW EPA	MOVW A,EP
4	MOV A,#d8	CMP A,#d8	ADDC A,#d8	SUBC A,#d8	XOR A,#d8	XOR A,#d8	AND A,#d8	OR A,#d8	DAA	DAS	CLRB dir: 4	BBC dir: 4,rel	MOVW A,ext	MOVW ext,A	MOVW A,#d16	XCHW A,PC
5	MOV A,dir	CMP A,dir	ADDC A,dir	SUBC A,dir	MOV dir,A	XOR A,dir	AND A,dir	OR A,dir	MOV dir,#d8	CMP dir,#d8	CLRB dir: 5	BBC dir: 5,rel	MOVW A,dir	MOVW dir,A	MOVW SP,#d16	XCHW A,SP
6	MOV A,@IX+d	CMP A,@IX+d	ADDC A,@IX+d	SUBC A,@IX+d	MOV @IX+d,A	XOR A,@IX+d	AND A,@IX+d	OR A,@IX+d	MOV @IX+d,#d8	CMP @IX+d,#d8	CLRB dir: 6	BBC dir: 6,rel	MOVW A,@IX+d	MOVW @IX+d,A	MOVW IX,#d16	XCHW A,IX
7	MOV A,@EP	CMP A,@EP	ADDC A,@EP	SUBC A,@EP	MOV @EPA	XOR A,@EP	AND A,@EP	OR A,@EP	MOV @EP,#d8	CMP @EP,#d8	CLRB dir: 7	BBC dir: 7,rel	MOVW A,@EP	MOVW @EPA	MOVW EP,#d16	XCHW A,EP
8	MOV A,R0	CMP A,R0	ADDC A,R0	SUBC A,R0	MOV R0,A	XOR A,R0	AND A,R0	OR A,R0	MOV R0,#d8	CMP R0,#d8	SETB dir: 0	BBS dir: 0,rel	INC R0	DEC R0	CALLV #0	BNC rel
9	MOV A,R1	CMP A,R1	ADDC A,R1	SUBC A,R1	MOV R1,A	XOR A,R1	AND A,R1	OR A,R1	MOV R1,#d8	CMP R1,#d8	SETB dir: 1	BBS dir: 1,rel	INC R1	DEC R1	CALLV #1	BC rel
A	MOV A,R2	CMP A,R2	ADDC A,R2	SUBC A,R2	MOV R2,A	XOR A,R2	AND A,R2	OR A,R2	MOV R2,#d8	CMP R2,#d8	SETB dir: 2	BBS dir: 2,rel	INC R2	DEC R2	CALLV #2	BP rel
B	MOV A,R3	CMP A,R3	ADDC A,R3	SUBC A,R3	MOV R3,A	XOR A,R3	AND A,R3	OR A,R3	MOV R3,#d8	CMP R3,#d8	SETB dir: 3	BBS dir: 3,rel	INC R3	DEC R3	CALLV #3	BN rel
C	MOV A,R4	CMP A,R4	ADDC A,R4	SUBC A,R4	MOV R4,A	XOR A,R4	AND A,R4	OR A,R4	MOV R4,#d8	CMP R4,#d8	SETB dir: 4	BBS dir: 4,rel	INC R4	DEC R4	CALLV #4	BNZ rel
D	MOV A,R5	CMP A,R5	ADDC A,R5	SUBC A,R5	MOV R5,A	XOR A,R5	AND A,R5	OR A,R5	MOV R5,#d8	CMP R5,#d8	SETB dir: 5	BBS dir: 5,rel	INC R5	DEC R5	CALLV #5	BZ rel
E	MOV A,R6	CMP A,R6	ADDC A,R6	SUBC A,R6	MOV R6,A	XOR A,R6	AND A,R6	OR A,R6	MOV R6,#d8	CMP R6,#d8	SETB dir: 6	BBS dir: 6,rel	INC R6	DEC R6	CALLV #6	BGE rel
F	MOV A,R7	CMP A,R7	ADDC A,R7	SUBC A,R7	MOV R7,A	XOR A,R7	AND A,R7	OR A,R7	MOV R7,#d8	CMP R7,#d8	SETB dir: 7	BBS dir: 7,rel	INC R7	DEC R7	CALLV #7	BLT rel

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■ MASK OPTIONS

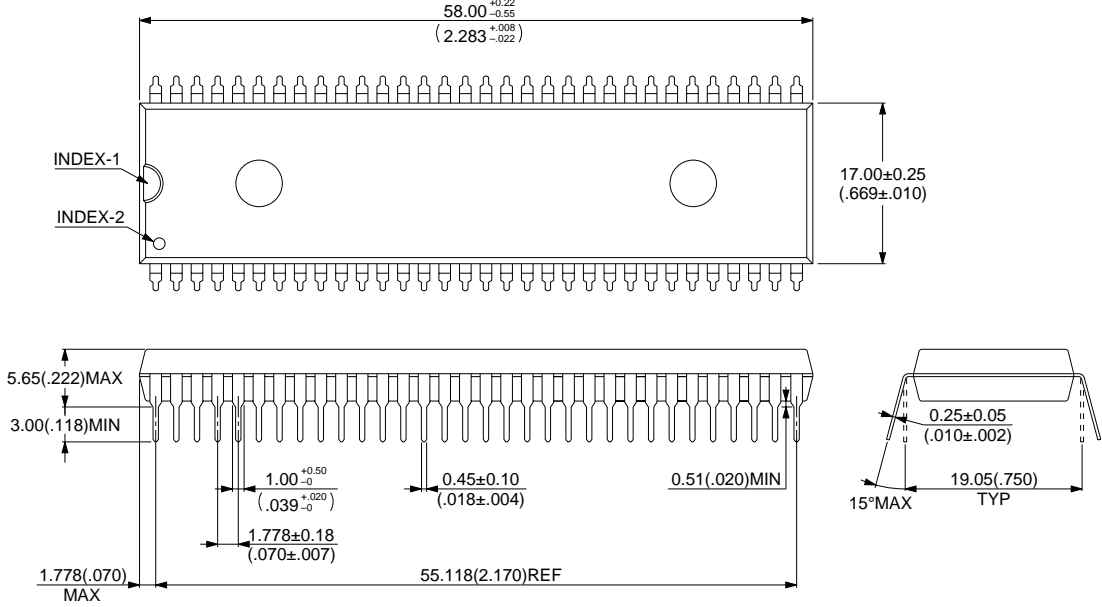
No.	Part number	MB89143A/144A	MB89PV140		MB89P147V1
	Parameter		101	102	
	Specification method	Specify when ordering masking			Set in EPROM
1	Clock mode selection Single-clock mode Dual-clock mode	Can be set	Single clock	Dual clock	Can be set
2	Pull-up resistors P14 to P17, P32 to P37	Specify by pin	Without pull-up resistor	Without pull-up resistor	Can be set per pin
3	Power-on reset With Without	With power-on rest	With power-on reset	With power-on reset	Can be set
4	Reset output With Without	Can be set	With reset output	With reset output	Can be set
5	Pull-down resistors P40 to P47 P50 to P57 P60 to P67	Without pull-down resistor	Without pull-down resistor	Without pull-down resistor	Without pull-down resistor

■ ORDERING INFORMATION

Part number	Package	Remarks
MB89143AP MB89144AP	64-pin Plastic SH-DIP (DIP-64P-M01)	

■ PACKAGE DIMENSIONS

64-pin Plastic SH-DIP
(DIP-64P-M01)



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Dimensions in mm (inches)

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