FUJITSU SEMICONDUCTOR
DATA SHEET

DS07-12528-3E

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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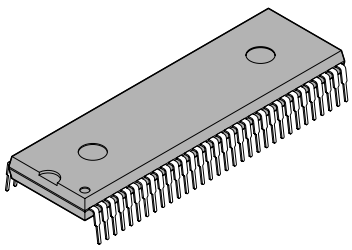
■ PACKAGE

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

Parameter \ Part number	MB89143A	MB89144A	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	32 K × 8 bits Internal PROM	32 K × 8 bits External ROM (Piggyback)
RAM size	256 × 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 capable		10-bit resolution × 12 channels A/D conversion mode (with conversion time of 16.5 µs/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 capable	
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	MB89P147	MB89PV140
Watchdog reset	Internal reset in 524 ms to 1049 ms (at 8 MHz oscillation) when the program runway 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			MDP-64C-P02
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	○	○	×
MDP-64C-P02	×	×	○

○ : Available × : Not available

Note: For more information about each package, see section “■ PACKAGE DIMENSION”.

■ 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. are 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

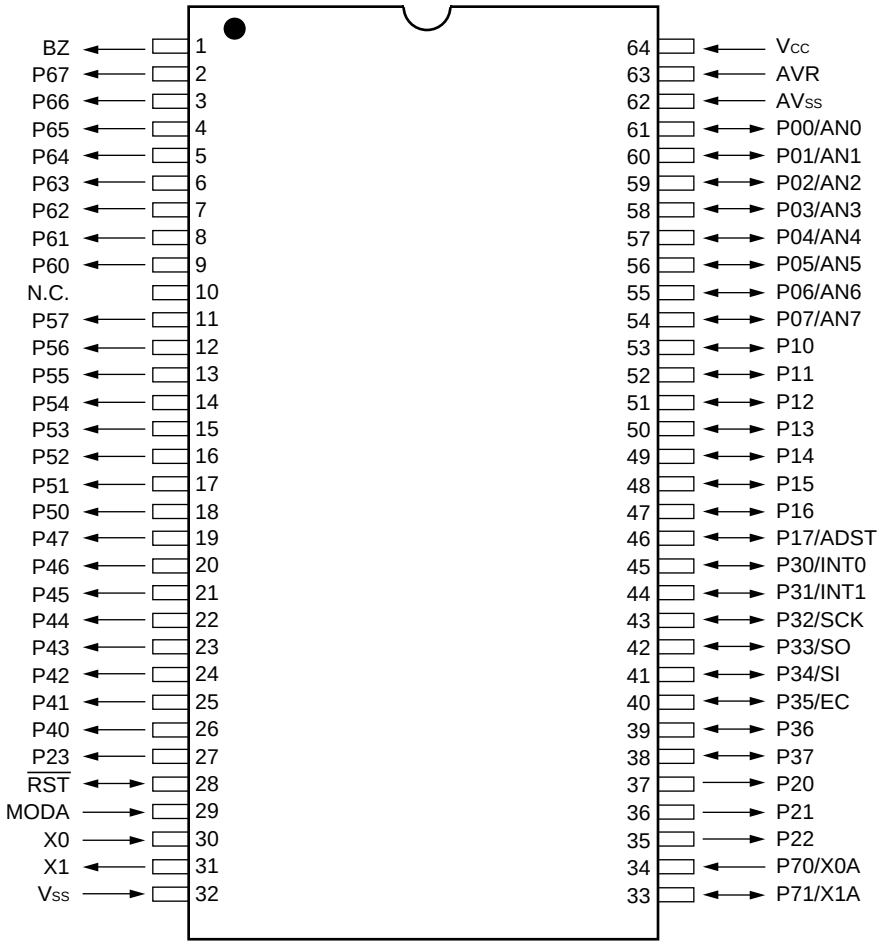
Functions that can be selected as options and how to designate these options vary by the product. Before using options check section “■ MASK OPTIONS”.

Take particular care on the following point:

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

■ PIN ASSIGNMENT (MB89143A/4A only)

(Top view)



Note: When used as general-purpose ports, the P70/X0A and P71/X1A function as input-only ports.

(DIP-64P-M01)

■ PIN DESCRIPTION (MB89143A/4A only)

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	$\overline{RST}$	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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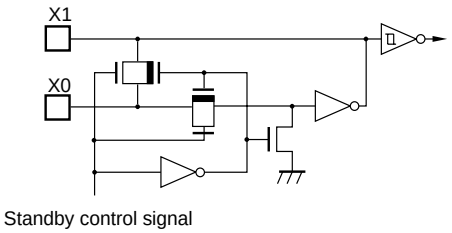
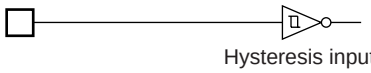
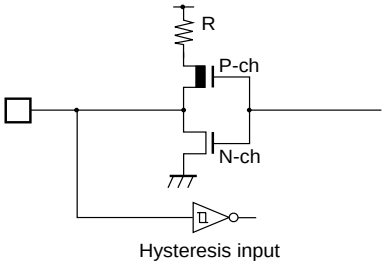
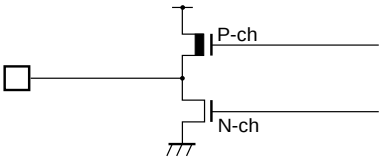
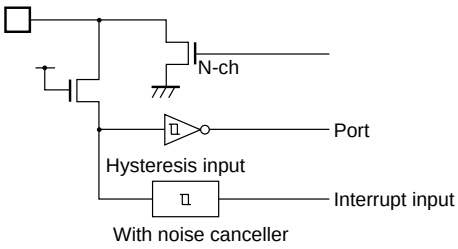
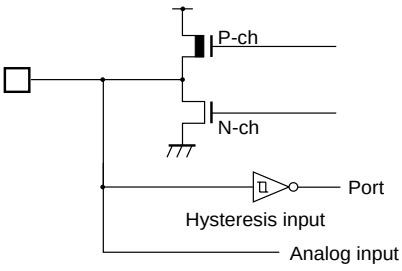
Pin no. SDIP*	Pin name	Circuit type	Function
44	P31/INT1	E	General-purpose I/O port This port is an N-ch open-drain output and hysteresis input type. Also serves as an external interrupt. The interrupt input is a hysteresis input type and with a built-in noise canceller.
45	P30/INT0	I	General-purpose 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		• At an oscillation feedback resistor of approximately 1 MΩ/5.0 V
B		• CMOS input
C		• At an output pull-up resistor (P-ch) of approximately 50 kΩ/5.0 V • CMOS hysteresis input
D		• CMOS output
E		• N-ch open-drain output • CMOS hysteresis input • The interrupt input is with a noise canceller.
F		• CMOS output • CMOS hysteresis input

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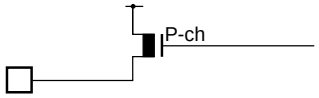
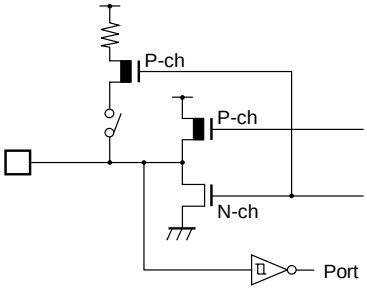
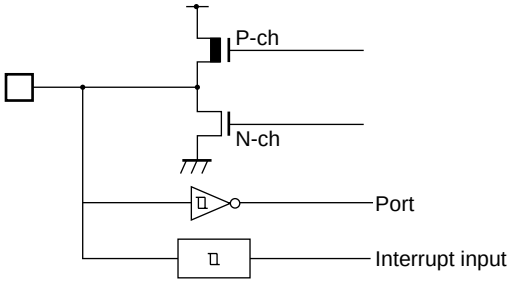
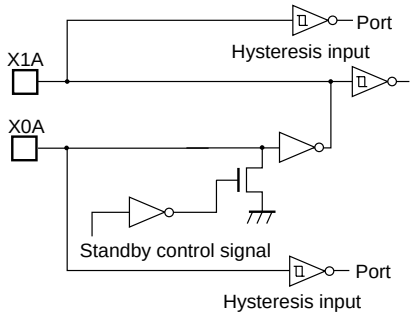
Type	Circuit	Remarks
G		• P-ch high-voltage open-drain output
H		• CMOS output • CMOS hysteresis input • Pull-up resistor optional (Only for P14 to P17 and P32 to P37)
I		• CMOS output • CMOS hysteresis input • The interrupt input is with a noise canceller.
J		• The oscillation feedback resistor is not 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.

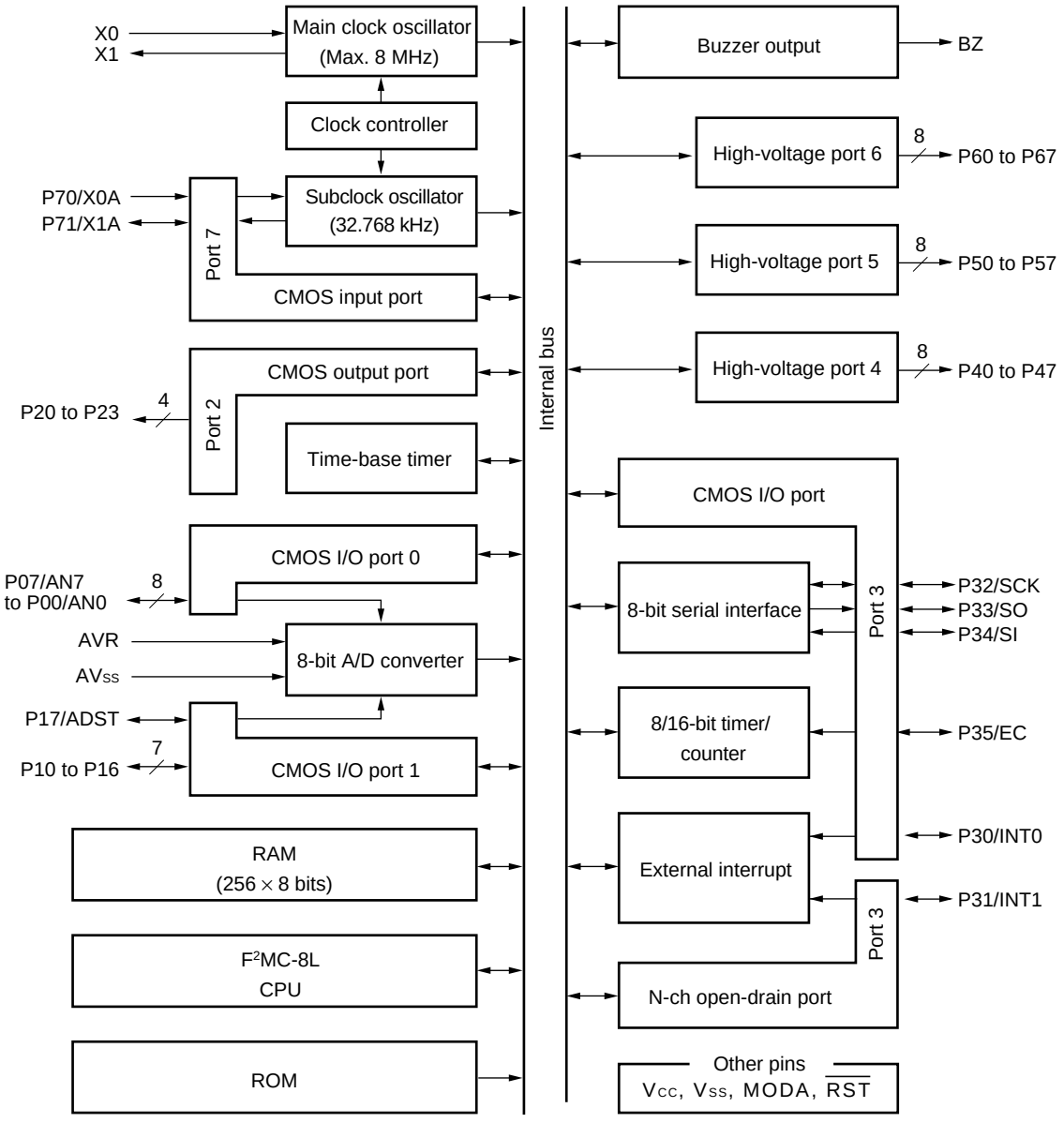
5. Power Supply Voltage Fluctuations

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.

■ BLOCK DIAGRAM (MB89143A/4A only)

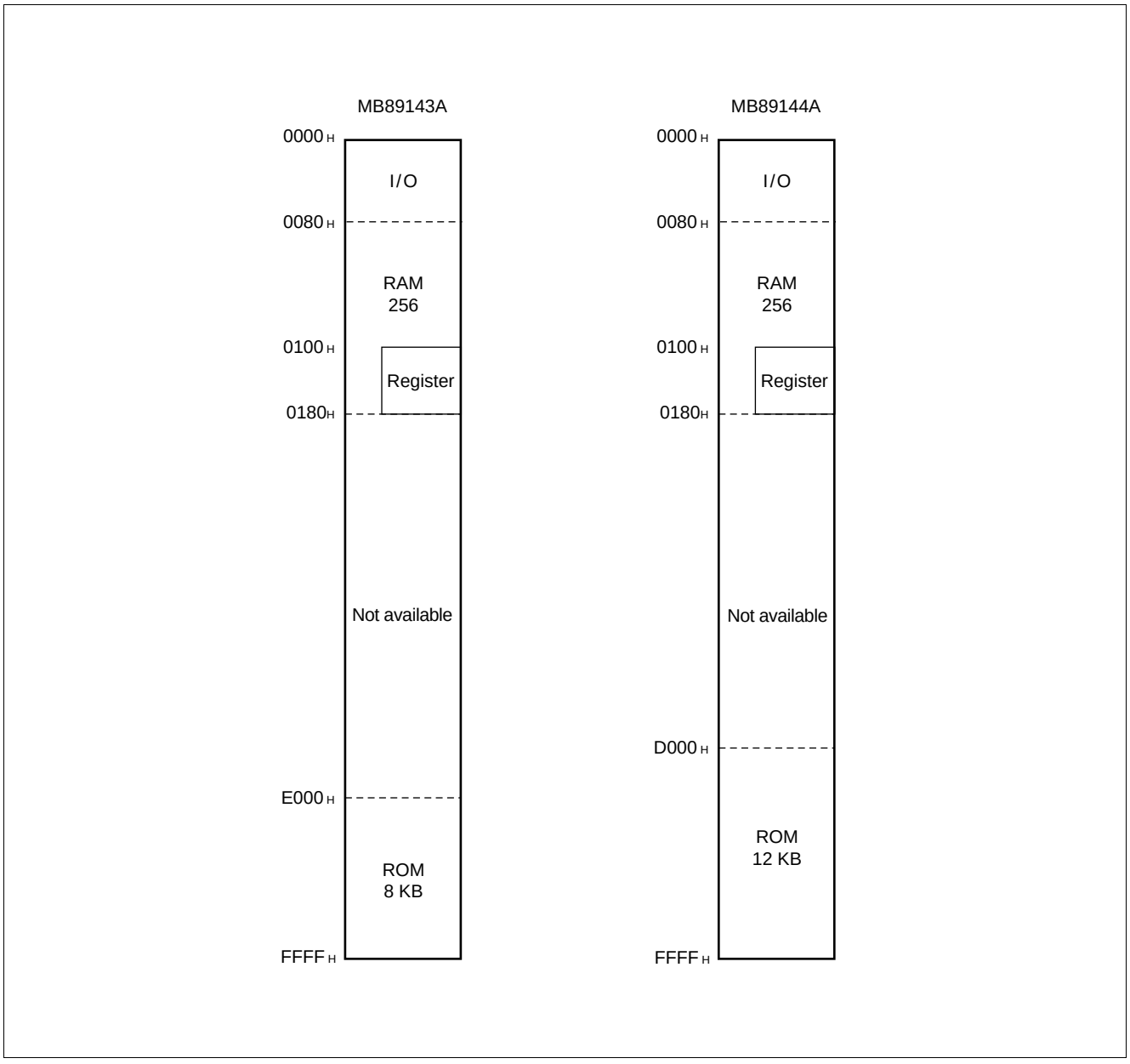


Note: The A/D converter is an 8-bit, 8-channel type.

■ CPU CORE

1. Memory Space

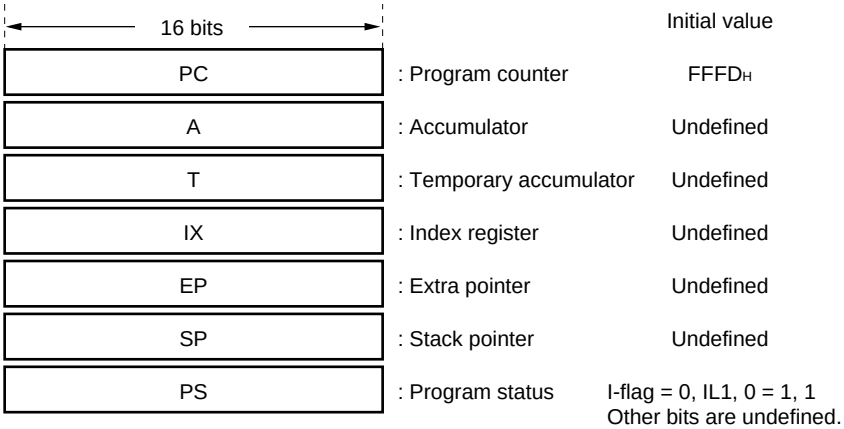
The microcontrollers of the MB89143A/144A series offer a memory space of 64 Kbytes for storing all of I/O, data, and program areas. The I/O area is located at the lowest address. The data area is provided immediately above the I/O area. The data area can be divided into register, stack, and direct areas 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.



2. Registers

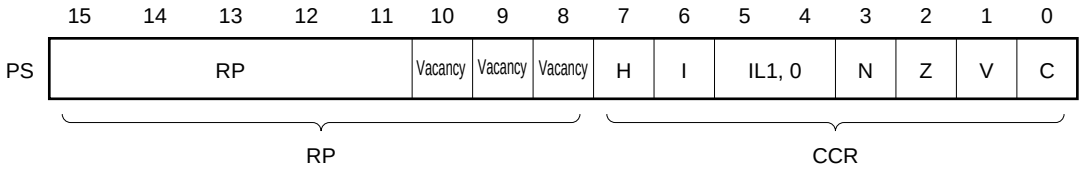
The F²MC-8L family has two types of registers; dedicated registers in the CPU and general-purpose registers in the memory. The following dedicated registers are provided:

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



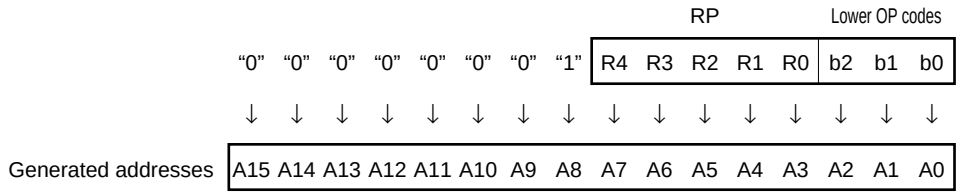
The PS can further be divided into higher 8 bits for use as a register bank pointer (RP) and the lower 8 bits for use as a condition code register (CCR). (See the diagram below.)

Structure of the Program Status Register



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	IL0	Interrupt level	High-low
0	0	1	High
0	1		
1	0	2	
1	1	3	Low = no interrupt

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 to 1 when an arithmetic operation results in 0. Cleared otherwise.

V-flag: Set to 1 if the complement on 2 overflows as a result of an arithmetic operation. Reset if the overflow does not occur.

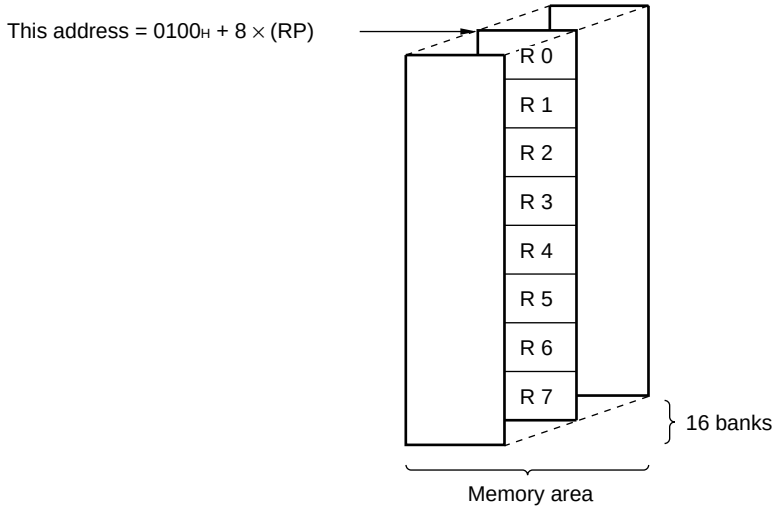
C-flag: Set to 1 when a carry or a borrow from bit 7 occurs as a result of an arithmetic operation.
Cleared otherwise.
Set to the shift-out value in the case of a shift instruction.

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 Configuration



■ 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, 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 to 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
20H	(R/W)	ADDH	A/D data register (H)
21H	(R/W)	ADDL	A/D data register (L)
22H	(W)	PCR0	Port input control register 0
23H	(W)	PCR1	Port input control register 1
24H to 7BH	Vacancy		
7CH	(W)	ILR1	Interrupt level setting register 1
7DH	(W)	ILR2	Interrupt level setting register 2
7EH	(W)	ILR3	Interrupt level setting register 3
7FH	Vacancy		

Note: Do not use vacancies.

■ ELECTRICAL CHARACTERISTICS (MB89143A/4A only)

1. Absolute Maximum Ratings

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

Parameter	Symbol	Rating		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
“H” level average output current	I_{OHAV}	—	–6		Average value (operating current × operation rate)
“H” level maximum output current	I_{OH}	—	–20	mA	P40 to P47, P50 to P57, P60 to P67, BZ
“H” level average output current	I_{OHAV}	—	–10		Average value (operating current × operation rate)
“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	SH-DIP64: DIP-64P-M01
Operating temperature	T_A	–40	+85	°C	
Storage temperature	Tstg	–55	+150	°C	

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

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

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

2. Recommended Operating Conditions

(AV_{SS} = V_{SS} = 0.0 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.”

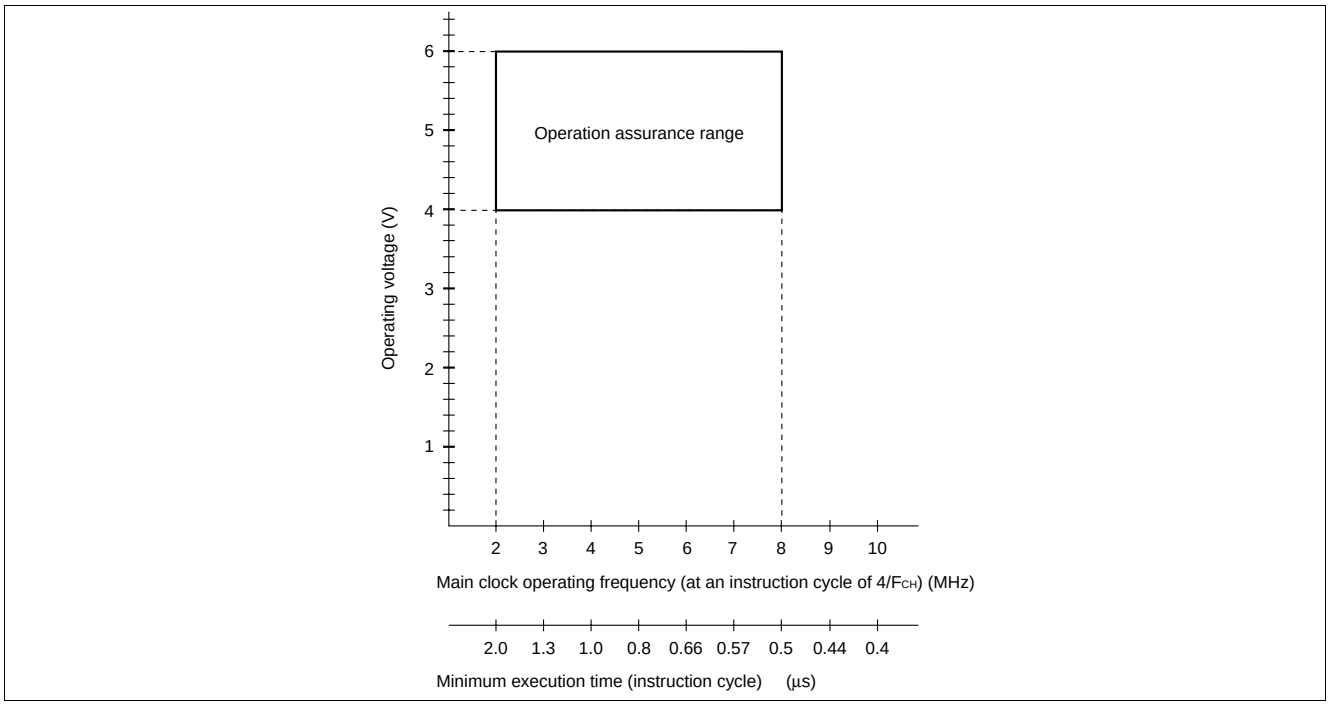


Figure 1 Operating Voltage vs. Main Clock Operating Frequency

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.

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device’s electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

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	

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

(Continued)

(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}		Sleep mode: 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.

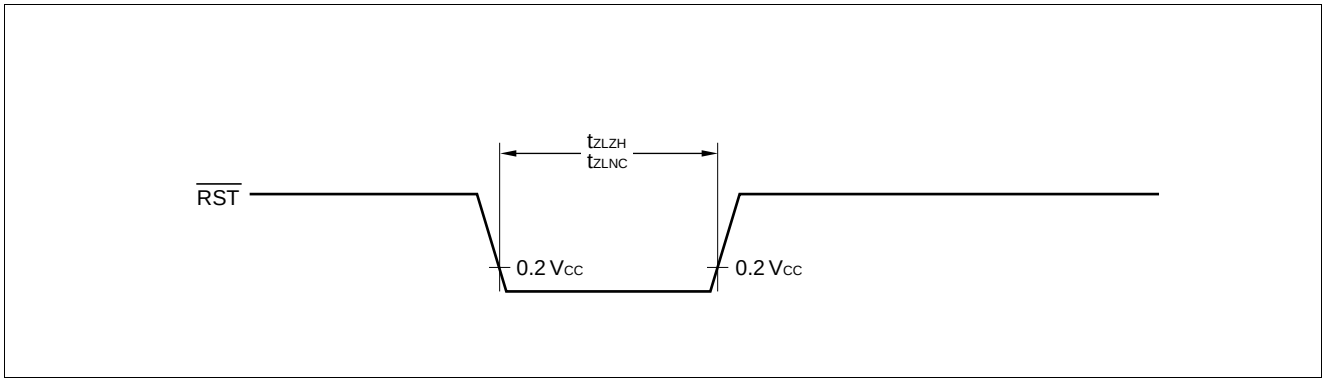
4. AC Characteristics

(1) Reset Timing

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

Parameter	Symbol	Condition	Value			Unit	Remarks
			Min.	Typ.	Max.		
$\overline{RST}$ "L" pulse width	t_{ZLZH}	—	48 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.

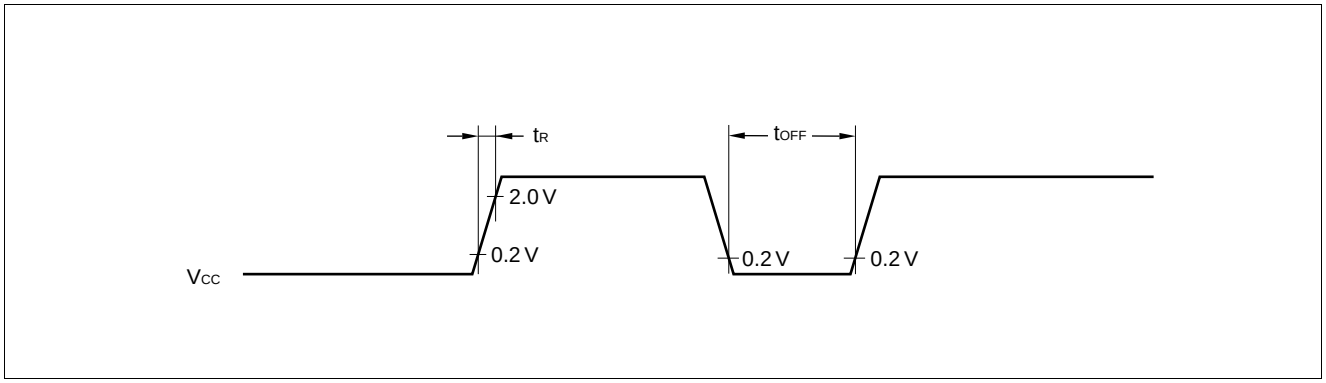


(2) Power-on Reset

(AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°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.

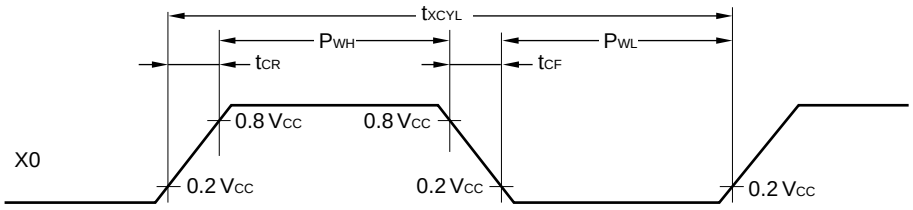


(3) Clock Timing

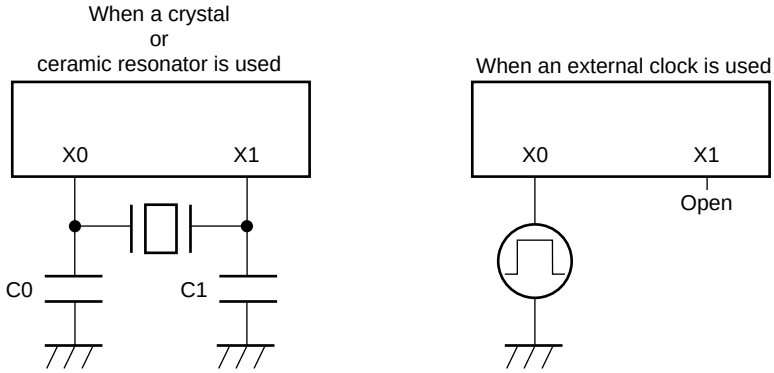
(AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

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

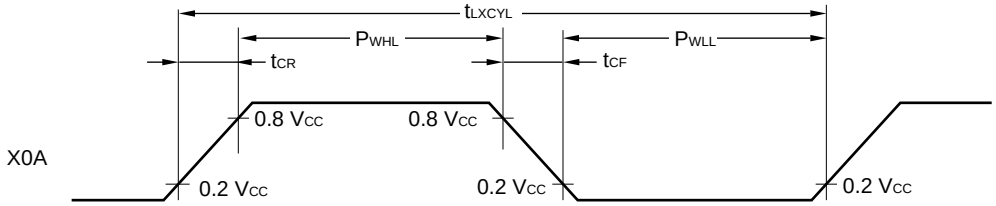
X0 and X1 Timings and Conditions



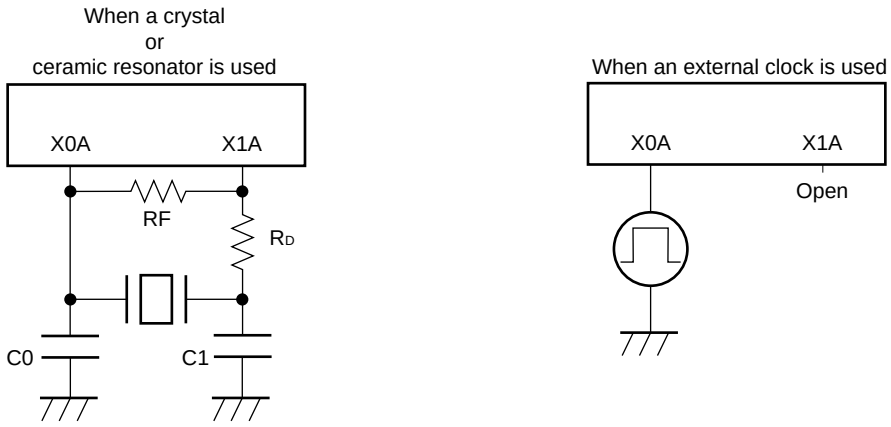
Main Clock Conditions



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.

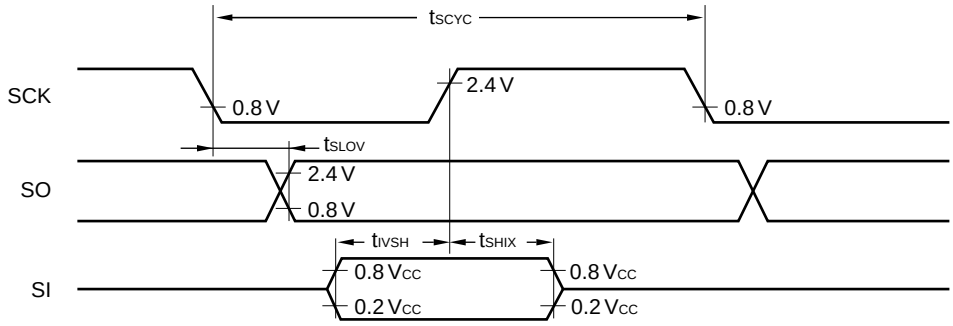
(5) Serial I/O timing

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

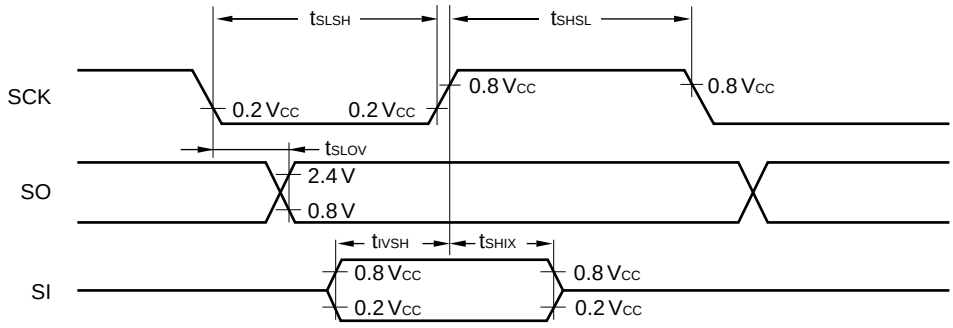
Parameter	Symbol	Pin	Condition	Value		Unit	Remarks
				Min.	Max.		
Serial clock cycle time	t_{SCYC}	SCK	Internal shift clock mode	2 t_{inst}*	—	µs	
SCK ↓ → SO time	t_{SLOV}	SCK, SO		–200	200	ns	
Valid SI → SCK ↑	t_{IVSH}	SI, SCK		1/2 t_{inst}*	—	µs	
SCK ↑ → valid SI hold time	t_{SHIX}	SCK, SI		1/2 t_{inst}*	—	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



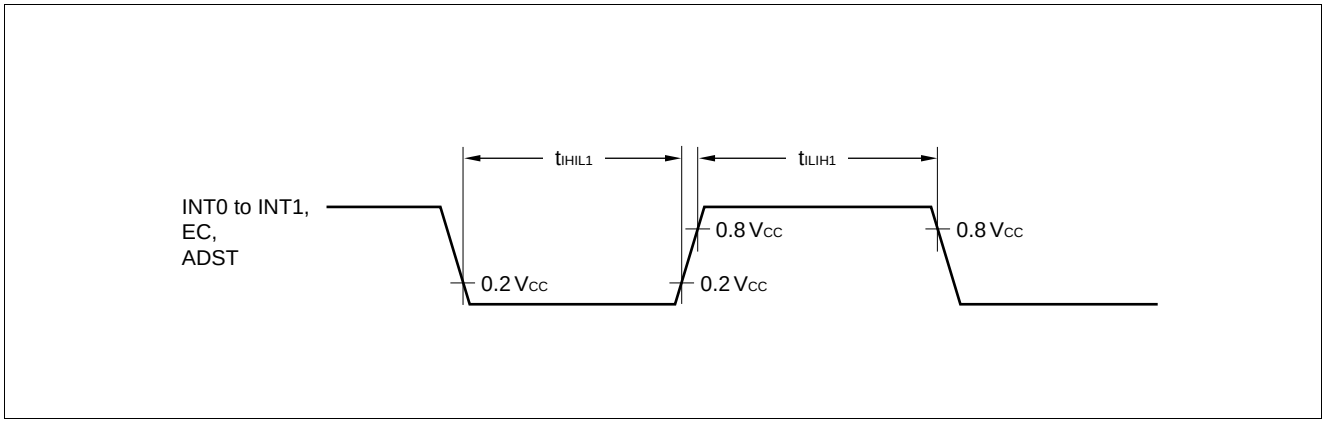
External Shift Clock Mode



(6) Peripheral Input Timing

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

Parameter	Symbol	Pin	Condition	Value		Unit	Remarks
				Min.	Max.		
Peripheral input “H” pulse width 1	t_{ILIH1}	EC, ADST, INT0 to INT1	—	2 t_{inst}	—	µs	
Peripheral input “L” pulse width 1	t_{IHIL1}	EC, ADST, INT0 to INT1	—	2 t_{inst}	—	µs	

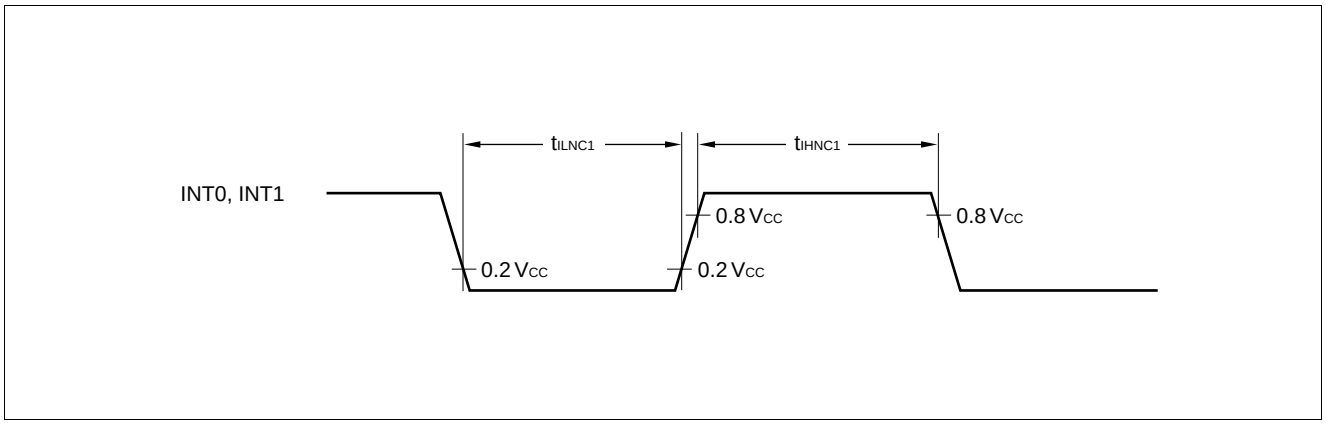


(7) Peripheral Input Noise Limit Width

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

Parameter	Symbol	Pin	Value			Unit	Remarks
			Min.	Typ.	Max.		
Peripheral input “H” level noise limit width 1	t_{IHNC1}	INT1, INT0	50	100	250	ns	
Peripheral input “L” level noise limit width 1	t_{ILNC1}	INT1, INT0	50	100	250	ns	

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



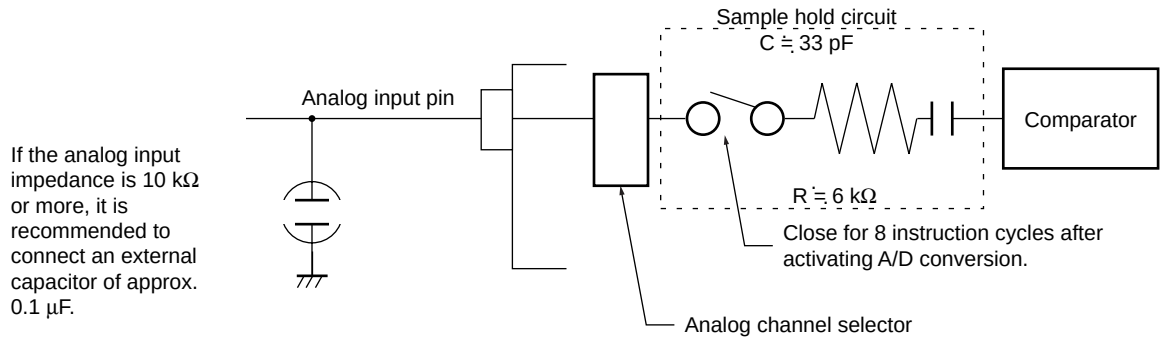
5. A/D Converter Electrical Characteristics

(V_{CC} = 5.0 V±10%, AV_{SS} = V_{SS} = 0.0 V, F_{CH} = 8 MHz, T_A = –40°C to +85°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 LSB	AV_{SS} + 0.5 LSB	AV_{SS} + 2.5 LSB	mV	
Full-scale transition voltage	V_{FST}	AN0 to AN7	—	AVR – 3.5 LSB	AVR – 1.5 LSB	AVR + 0.5 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 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 V	—	200	—	µA	

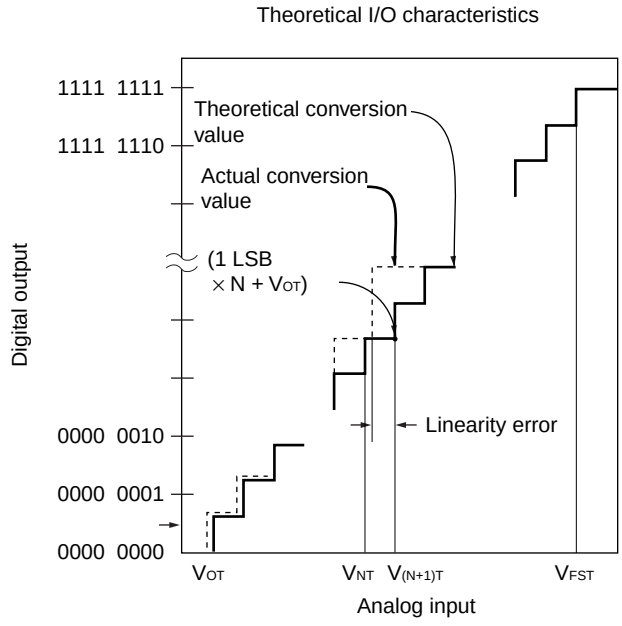
Notes:
- The smaller the | AVR – AV_{SS} |, the greater the error would become relatively.
- The output impedance of the external circuit for the analog input must satisfy the following conditions:
  Output impedance of the external circuit < Approx. 10 kΩ
  If the output impedance of the external circuit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

Analog Input Equivalent Circuit



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.



$$1\ \text{LSB} = \frac{\text{AVR}}{256}$$

$$\text{Linearity error} = \frac{V_{NT} - (1\ \text{LSB} \times N + V_{OT})}{1\ \text{LSB}}$$

$$\text{Differential linearity error} = \frac{V_{(N+1)T} - V_{NT}}{1\ \text{LSB}} - 1$$

$$\text{Total error} = \frac{V_{NT} - (1\ \text{LSB} \times N + 0.5\ \text{LSB})}{1\ \text{LSB}}$$

■ MASK OPTIONS

No.	Part number / Parameter	MB89143A/144A	MB89PV140		MB89P147V1
	Specification method	Specify when ordering masking	101	102	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

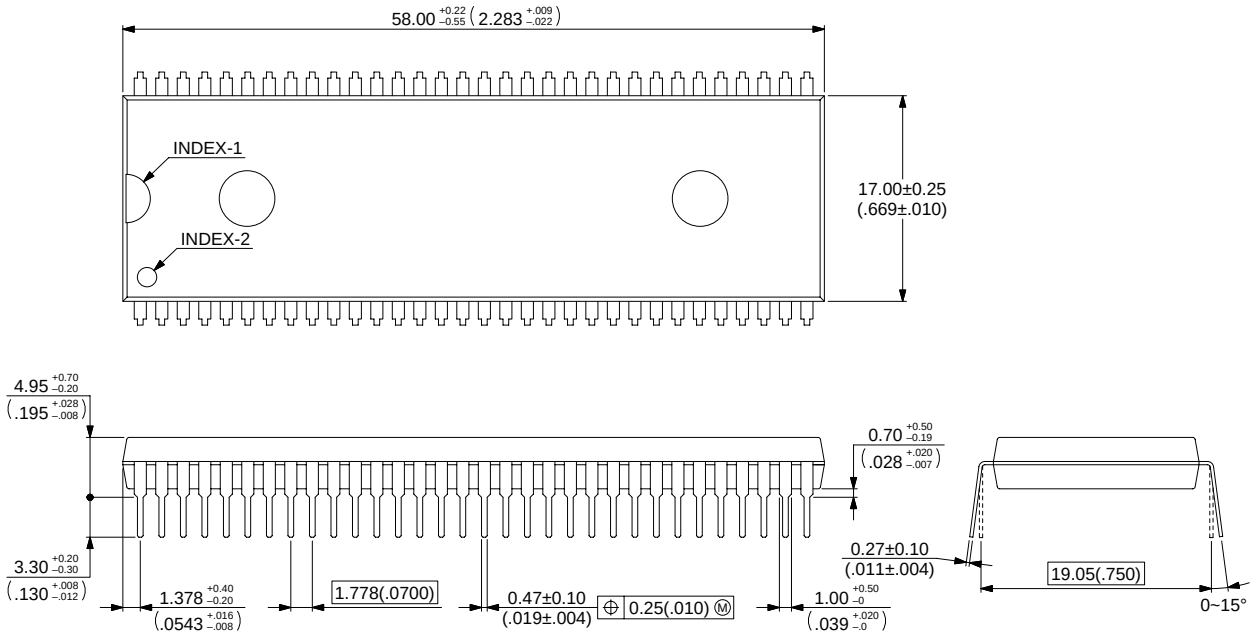
■ ORDERING INFORMATION

Part number	Package	Remarks
MB89143AP-SH MB89144AP-SH MB89P147V1P-SH	64-pin Plastic SH-DIP (DIP-64P-M01)	

■ PACKAGE DIMENSION

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

Note: Pins width and pins thickness include plating thickness.



Dimensions in mm (inches)

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