8-bit Proprietary Microcontroller

CMOS

F²MC-8L MB89140 Series

MB89145/146 and MB89P147/PV140

■ DESCRIPTION

The MB89140 series is a line of single-chip microcontrollers that use the F²MC*-8L CPU core which can operate at low voltage but at high speed. The MB89140 series contains a variety of peripheral functions, such as timers, a serial interface, an A/D converter, and an external interrupt. The MB89140 series is applicable to a wide range of applications from welfare products to industrial equipment, including portable devices.

*: F²MC is the abbreviation of FUJITSU Flexible Microcontroller.

■ FEATURES

- Minimum execution time: 0.5 µs/8-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.

For the information for microcontroller supports, see the following web site.

http://edevice.fujitsu.com/micom/en-support/

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(Continued)

- Low-voltage operation (when an A/D converter is not used)
- Low current consumption (compatible with dual-clock system)
- High-voltage ports on chip
- Five types of timers
  8-bit PWM timer (also usable as a reload timer)
  12-bit MPG timer (also usable as a PPG output, PWM output, and reload timer)
  8/16-bit timer (also usable as two 8-bit timers)
  21-bit time-base timer
- One serial interface
  Swichable transfer direction allows communication with various equipment.
- 10-bit A/D converter: 12 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
  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.)
  Subclock mode
  Watch mode
- Reset output and power-on reset selectability

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■ PRODUCT LINEUP

Part number Parameter	MB89145	MB89146	MB89P147	MB89PV140
Classification	Mass production products (mask ROM products)		One-time PROM/ EPROM product	Piggyback/ evaluation product (for evaluation and development)
ROM size	16 K × 8 bits (internal mask ROM)	24 K × 8 bits (internal mask ROM)	32 K × 8 bits (internal PROM)	32 K × 8 bits (external ROM)
RAM size	512 × 8 bits	768 × 8 bits	1 K × 8 bits	
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 port (P-ch open-drain): 8 (P60 to P67, for heavy current) 16 (P40 to P47, P50 to P57 for low current) Buzzer output (P-ch open-drain, high-voltage): 1 (heavy current) Output ports (CMOS): 4 (P20 to P23) Input ports (CMOS): 2 (P70 and P71, function as X0A and XIA 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 ports (N-ch open-drain): 1 (P31) Total: 55			
Watch timer	21 bits × 1 (in main clock mode), 15 bits × 1 (at 32.768 kHz)			
8-bit PWM timer (timer 1)	8-bit timer operation (toggled output capable, operating clock: 1, 2, 8, 16 system clock cycles) 8-bit resolution PWM operation (conversion cycle: 128 μs to 2.0 ms at 8.0-MHz oscillation, and highest gear speed)			
12-bit MPG (timer 4)	12-bit resolution PWM operation (maximum conversion cycle of 2048.4 μs to 16.4 ms at 8.0 MHz-oscillation, and highest gear speed) 12-bit resolution reload timer operation (toggled output capable) 12-bit resolution PPG operation (minimum resolution of 0.5 μs at 8.0-MHz oscillation, and highest gear speed)			
8/16-bit timer counter (timer 2, 3)	8/16-bit timer operation (operating clock, internal clock, external trigger) 8/16-bit event counter operation (Rising edge/falling edge/both edges selectability)			

(Continued)

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Part number Parameter	MB89145	MB89146	MB89P147	MB89PV140
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)			
10-bit A/D converter	10-bit resolution × 12 channels A/D conversion mode (conversion time of 16.5 μs/8 MHz, and highest gear speed) Sense mode (conversion time of 9.0 μs/8 MHz, and highest gear speed) 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.)			
Standby mode	Sleep mode, stop mode, watch mode, and subclock mode			
Process	CMOS			
Operating voltage*	2.7 V to 6.0 V			
EPROM for use				MBM27C256A-20TV MBM27C256A-20CZ

* : Varies with conditions such as the operating frequency. (See section "■ ELECTRICAL CHARACTERISTICS".)

■ PACKAGE AND CORRESPONDING PRODUCTS

Package	MB89145 MB89146 MB89P147	MB89PV140
DIP-64P-M01	○	×
FPT-64P-M06	○	×
MDP-64C-P02	×	○
MQP-64C-P01	×	○

○ : Available   × : Not available

Note: For more information about each package, see section "■ PACKAGE DIMENSIONS".

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■ 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 MB89P147, the program area starts from address 8007_H but on the MB89PV140 starts from 8000_H.

  (On the MB89P147, addresses 8000_H to 8006_H comprise the option setting area, option settings can be read by reading these addresses. On the MB89PV140, addresses 8000_H to 8006_H could also be used as a program ROM. However, do not use these addresses in order to maintain compatibility of the MB89P147.)

- The stack area, etc., is set at the upper limit of the RAM.

2. 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".)

3. 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".

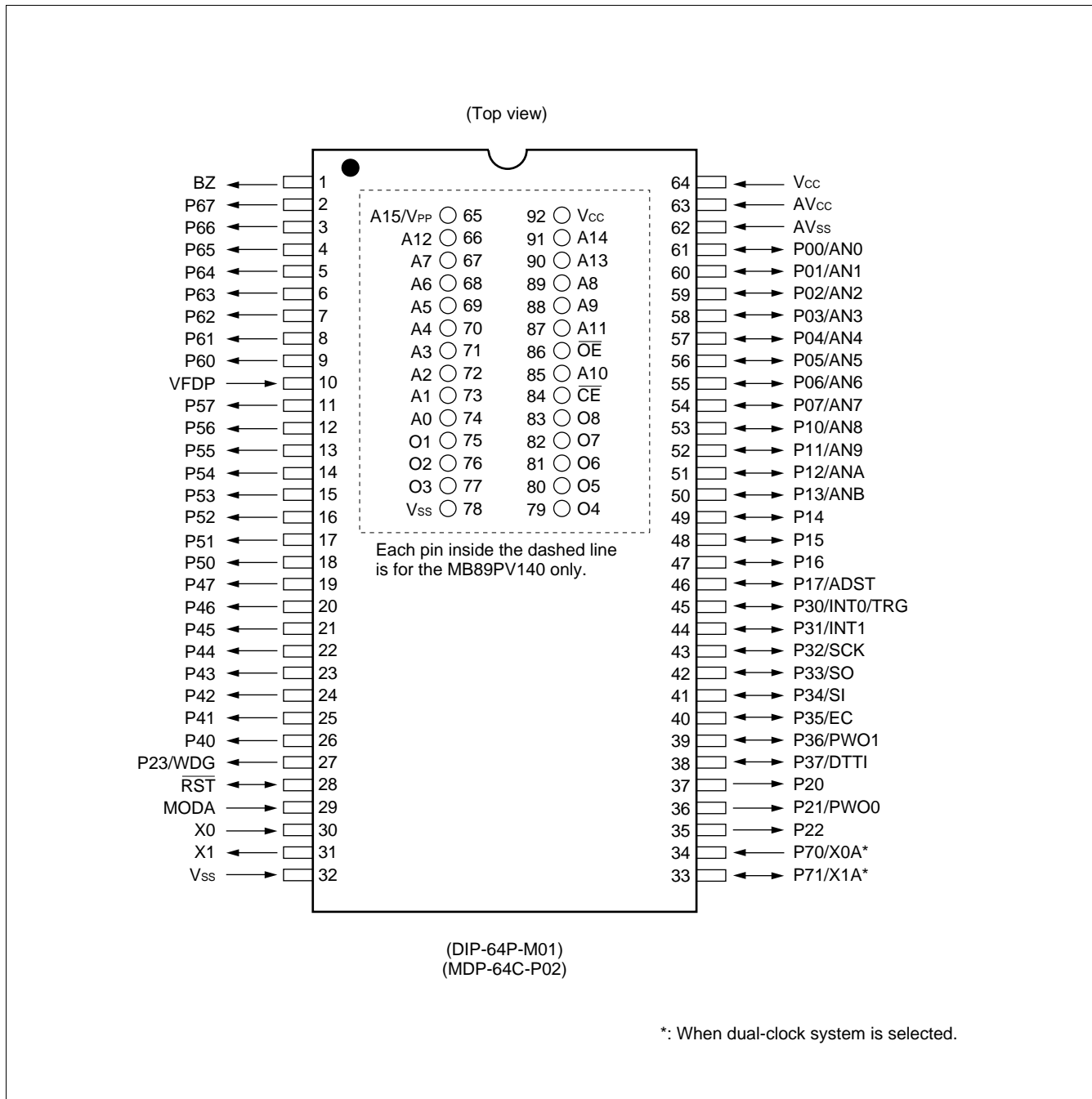Take particular care on the following points:

- Options are fixed on the MB89PV140.

- On the MB89P147, MB89145, and MB89146, the pull-down resistor option can either be selected for all affected pins, or for no pin; it is not possible to specify the pull-down resistor option for individual pins.
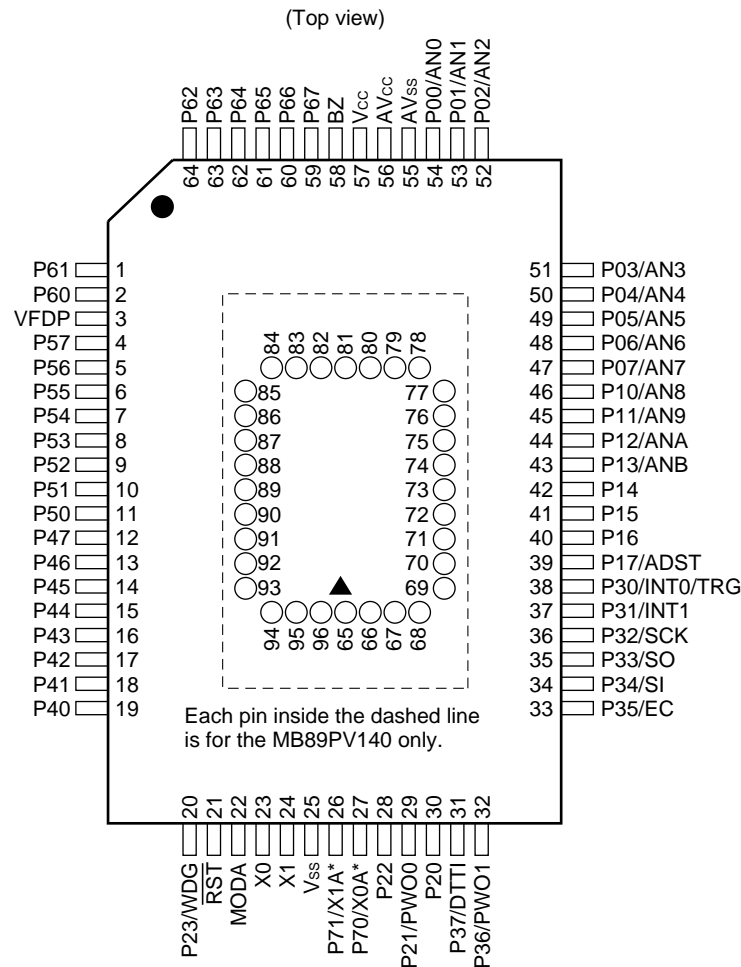
4. Subclock Oscillation Feedback Resistor

A built-in oscillation feedback resistor is provided for the subclock oscillator pin on the MB89PV140, but it is not provided for the MB89145, MB89146, MB89P147. Therefor these products should be connected to an external oscillation feedback resistor.

■ PIN ASSIGNMENT

(Top view)

Pin	Signal		Pin	Signal
1	BZ		64	VCC
2	P67		63	AVCC
3	P66		62	AVSS
4	P65		61	P00/AN0
5	P64		60	P01/AN1
6	P63		59	P02/AN2
7	P62		58	P03/AN3
8	P61		57	P04/AN4
9	P60		56	P05/AN5
10	VFDP		55	P06/AN6
11	P57		54	P07/AN7
12	P56		53	P10/AN8
13	P55		52	P11/AN9
14	P54		51	P12/ANA
15	P53		50	P13/ANB
16	P52		49	P14
17	P51		48	P15
18	P50		47	P16
19	P47		46	P17/ADST
20	P46		45	P30/INT0/TRG
21	P45		44	P31/INT1
22	P44		43	P32/SCK
23	P43		42	P33/SO
24	P42		41	P34/SI
25	P41		40	P35/EC
26	P40		39	P36/PWO1
27	P23/WDG		38	P37/DTTI
28	$\overline{RST}$		37	P20
29	MODA		36	P21/PWO0
30	X0		35	P22
31	X1		34	P70/X0A*
32	VSS		33	P71/X1A*

Inside dashed line (MB89PV140 only):

Pin	Signal		Pin	Signal
65	A15/VPP		92	VCC
66	A12		91	A14
67	A7		90	A13
68	A6		89	A8
69	A5		88	A9
70	A4		87	A11
71	A3		86	$\overline{OE}$
72	A2		85	A10
73	A1		84	$\overline{CE}$
74	A0		83	O8
75	O1		82	O7
76	O2		81	O6
77	O3		80	O5
78	VSS		79	O4

Each pin inside the dashed line is for the MB89PV140 only.

(DIP-64P-M01)
(MDP-64C-P02)

*: When dual-clock system is selected.

(Top view)

(FPT-64P-M06)
(MQP-64C-P01)

*: When dual-clock system is selected.

Each pin inside the dashed line is for the MB89PV140 only.

• **Pin assignment on package top (MB89PV140 only)**

Pin no.	Pin name	Pin no.	Pin name	Pin no.	Pin name	Pin no.	Pin name
65	N.C.	73	A2	81	N.C.	89	$\overline{OE}$
66	A15/V_{PP}	74	A1	82	O4	90	N.C.
67	A12	75	A0	83	O5	91	A11
68	A7	76	N.C.	84	O6	92	A9
69	A6	77	O1	85	O7	93	A8
70	A5	78	O2	86	O8	94	A13
71	A4	79	O3	87	$\overline{CE}$	95	A14
72	A3	80	V_{SS}	88	A10	96	V_{CC}

N.C.: Internally connected. Do not use.

■ PIN DESCRIPTION

Pin no.		Pin name	Circuit type	Function
SDIP*1 MDIP*2	QFP*3 MQFP*4			
30	23	X0	A	Main clock crystal oscillator pins
31	24	X1		
29	22	MODA	C	Operating mode selection pin Connect directly to V$_{SS}$ in normal operation. This pin functions as the V$_{PP}$ pin in EPROM products.
28	21	$\overline{\text{RST}}$	D	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 when the option is set. The internal circuit is initialized by the input of "L". This pin is with a noise canceller.
54 to 61	47 to 54	P07/AN7 to P00/AN0	G	General-purpose I/O ports The input is a hysteresis input type and with a built-in noise canceller. Although these ports also serve as an analog input, analog input does not pass through the hysteresis input noise canceller.
46	39	P17/ADST	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as an A/D converter external activation.
47 to 49	40 to 42	P16 to P14	J	General-purpose I/O ports The input is a hysteresis input type and with a built-in noise canceller.
50 to 53	43 to 46	P13/ANB to P10/AN8	G	General-purpose I/O ports The input is a hysteresis input type and with a built-in noise canceller. Although these ports also serves as an analog input, analog input does not pass through the hysteresis input noise canceller.
34, 33	27, 26	P70/X0A, P71/X1A	B/K	General-purpose I/O ports with a built-in noise canceller (single-clock operation) Function as subclock crystal oscillator pins. (dual-clock operation)
35	28	P22	E	General-purpose output port
27	20	P23/WDG	E	General-purpose output port Also serves as a watchdog output.
36	29	P21/PWO0	E	General-purpose output port Also serves as the PWM output for the 8-bit PWM timer.
37	30	P20	E	General-purpose output port

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*1: DIP-64P-M01
*2: MDP-64C-P02
*3: FPT-64P-M06
*4: MQP-64C-P01

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Pin no.		Pin name	Circuit type	Function
SDIP[*1] MDIP[*2]	QFP[*3] MQFP[*4]			
38	31	P37/DTTI	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. When overcurrent is detected, the 12-bit MPG output can be inactivated by the external edge input.
39	32	P36/PWO1	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as a 12-bit MPG output.
40	33	P35/EC	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as the external clock input for the 8/16-bit timer/counter.
41	34	P34/SI	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as the serial data input for the 8-bit serial interface.
42	35	P33/SO	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as the serial data output for the 8-bit serial interface.
43	36	P32/SCK	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serves as the serial transfer clock for the 8-bit serial interface.
44	37	P31/INT1	F	General-purpose I/O port The output is an N-ch open-drain type. The input is a hysteresis input type and with a built-in noise canceller. Also serves as an external interrupt. The interrupt input is also a hysteresis input type and with a built-in noise canceller.
45	38	P30/INT0/TRG	J	General-purpose I/O port The input is a hysteresis input type and with a built-in noise canceller. Also serve as an external interrupt or as an MPG trigger input. The interrupt input is also a hysteresis input type and with a built-in noise canceller.
1	58	BZ	I	Buzzer output-only pin P-ch high-voltage open-drain output port
19 to 26, 11 to 18	12 to 19, 4 to 11	P47 to P40, P57 to P50	H	Low-current P-ch high-voltage open-drain output ports Products with and without a built-in pull-down resistor between these pins and the VFDP pin are provided.

(Continued)

*1: DIP-64P-M01
*2: MDP-64C-P02
*3: FPT-64P-M06
*4: MQP-64C-P01

(Continued)

Pin no.		Pin name	Circuit type	Function
SDIP[*1] MDIP[*2]	QFP[*3] MQFP[*4]			
2 to 9	59 to 64, 1, 2	P67 to P60	H	Heavy-current P-ch high-voltage open-drain output port Products with and without a built-in pull-down resistor between these pins and the VFDP pin are provided.
10	3	VFDP	—	Voltage supply pin for connection to a pull-down resistor for ports 4, 5, and 6. In products without a built-in pull-down resistor and in the MB89PV140, this pin should be left open.
64	57	V_{CC}	—	Power supply pin
32	25	V_{SS}	—	Power supply (GND) pin
63	56	AV_{CC}	—	A/D converter power supply pin Use this pin at the same voltage as V_{CC}.
62	55	AV_{SS}	—	A/D converter power supply (GND) pin Use this pin at the same voltage as V_{SS}.

*1: DIP-64P-M01
*2: MDP-64C-P02
*3: FPT-64P-M06
*4: MQP-64C-P01

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- **External EPROM pins (MB89PV140 only)**

Pin no.		Pin name	I/O	Function
SDIP*3 MDIP*4	QFP*1 MQFP*2			
65	66	A15/V$_{PP}$	O	"H" level output pin
66 67 68 69 70 71 72 73 74	67 68 69 70 71 72 73 74 75	A12 A7 A6 A5 A4 A3 A2 A1 A0	O	Address output pins
75 76 77	77 78 79	O1 O2 O3	I	Data input pins
78	80	V$_{SS}$	O	Power supply (GND) pin
79 80 81 82 83	82 83 84 85 86	O4 O5 O6 O7 O8	I	Data input pins
84	87	$\overline{CE}$	O	ROM chip enable pin Outputs "H" during standby.
85	88	A10	O	Address output pin
86	89	$\overline{OE}$	O	ROM output enable pin Outputs "L" at all times.
87 88 89	91 92 93	A11 A9 A8	O	Address output pins
90	94	A13		
91	95	A14		
92	96	V$_{CC}$	O	EPROM power supply pin
—	65 76 81 90	N.C.	—	Internally connected pins Be sure to leave them open.

*1: DIP-64P-M01
*2: MDP-64C-P02
*3: FPT-64P-M06
*4: MQP-64C-P01
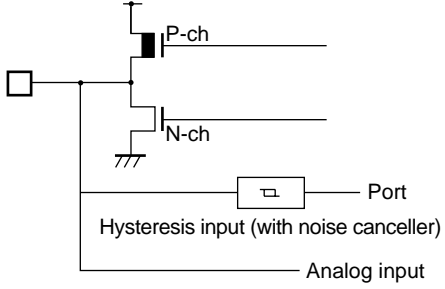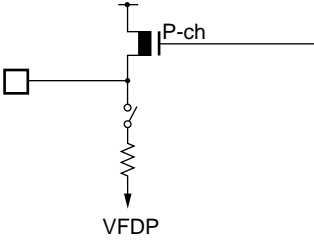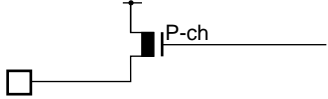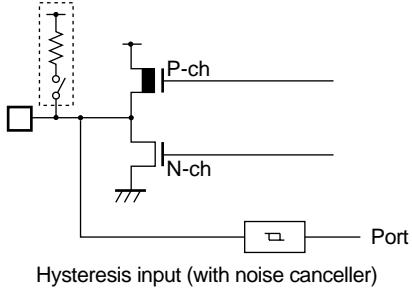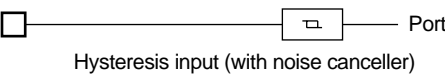
■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A	X1 X0 Standby control signal	• Crystal or ceramic oscillation type (main clock) • At an oscillation feedback resistor of approximately 1 MΩ/5.0 V
B	X1A X0A Standby control signal	• Crystal or ceramic oscillation type (subclock) • At an oscillation feedback resistor of approximately 4.5 MΩ/5.0 V (The built-in feedback resistor is not provided except on the MB89PV140-102.)
C		
D	R P-ch N-ch Hysteresis input (with noise canceller)	• At an output pull-up resistor (P-ch) of approximately 50 kΩ/5.0 V • CMOS hysteresis input (with noise canceller)
E	P-ch N-ch	• CMOS output
F	N-ch Hysteresis input (with noise canceller)	• N-ch open-drain output • CMOS hysteresis input (with noise canceller)

(Continued)

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Type	Circuit	Remarks
G		• CMOS output • CMOS hysteresis input (with noise canceller, except analog input)
H		• P-ch high-voltage open-drain output • Products with and without a built-in pull-down resistor are provided (except the MB89PV140).
I		• P-ch high-voltage open-drain output
J		• CMOS output • CMOS hysteresis input (with noise canceller) • Pull-up resistor optional
K		• CMOS hysteresis input (with noise canceller)

■ 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/INT 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.

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 N.C. Pins

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

4. 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 Hz 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.

5. Precautions when Using an External Clock

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

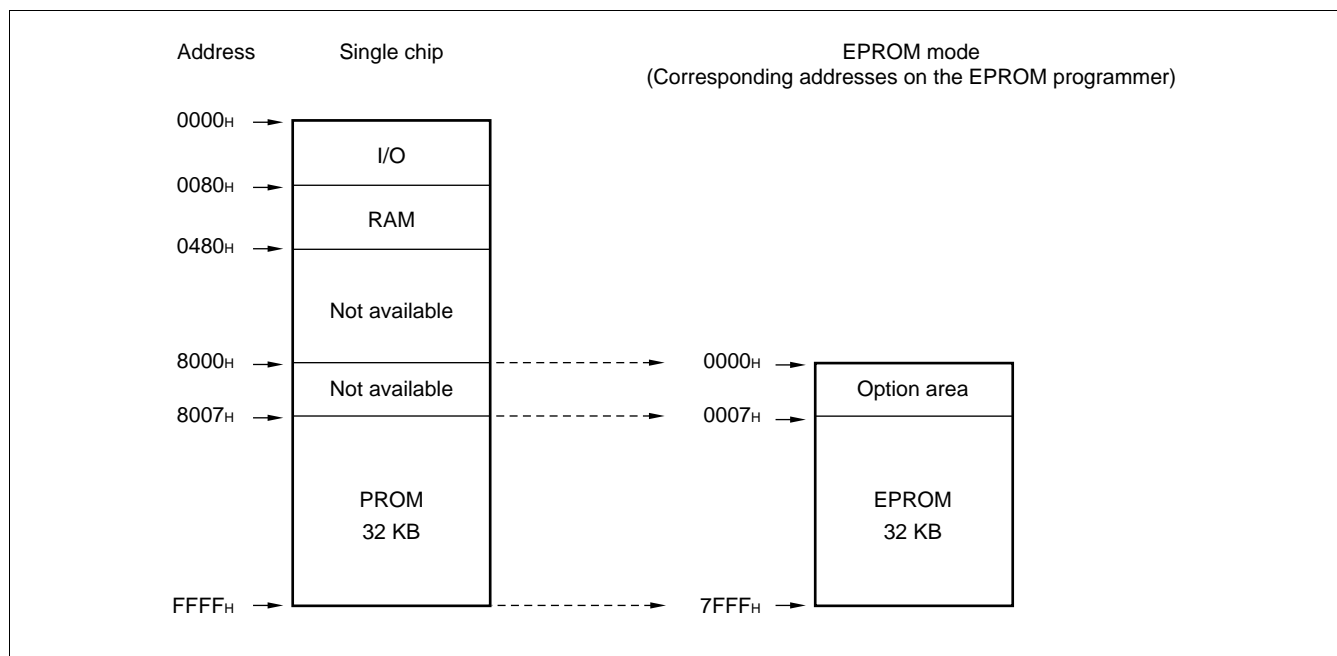## ■ PROGRAMMING TO THE EPROM ON THE MB89P147

The MB89P147 is an OTPROM version of the MB89140 series.

1. Features

- • 32-Kbyte PROM on chip
- • Options can be set using the EPROM programmer.
- • Equivalency to the MBM27C256A in EPROM mode (when programmed with the EPROM programmer)

2. Memory Space

Memory space in each mode such as 32-Kbyte PROM, option area is diagrammed below.

Address	Single chip	EPROM mode (Corresponding addresses on the EPROM programmer)		
0000$_H$	I/O			
0080$_H$	RAM			
0480$_H$				
	Not available			
8000$_H$	Not available		0000$_H$	Option area
8007$_H$			0007$_H$	
	PROM 32 KB			EPROM 32 KB
FFFF$_H$			7FFF$_H$	

3. Programming to the EPROM

In EPROM mode, the MB89P147 functions equivalent to the MBM27C256A. This allows the PROM to be programmed with a general-purpose EPROM programmer (the electronic signature mode cannot be used) by using the dedicated socket adapter.

When the operating ROM area for a single chip is 32 Kbytes (8007$_H$ to FFFF$_H$) the PROM can be programmed as follows:

- • **Programming procedure**

(1) Set the EPROM programmer to the MBM27C256A.

(2) Load program data into the EPROM programmer at 0007$_H$ to 7FFF$_H$ (note that addresses 8007$_H$ to FFFF$_H$ while operating as a single chip assign to 0007$_H$ to 7FFF$_H$ in EPROM mode).
Load option data into addresses 0000$_H$ to 0006$_H$ of the EPROM programmer. (For information about each corresponding option, see "5. Setting OTPROM Options". in section "■ PROGRAMMING TO THE EPROM WITH PIGGYBACK/EVALUATION DEVICE")

(3) Program to 0000$_H$ to 7FFF$_H$ with the EPROM programmer.

4. Recommended Screening Conditions

High-temperature aging is recommended as the pre-assembly screening procedure for a product with a blanked OTPROM microcomputer program.

```
            ┌─────────────────────┐
            │   Program, verify   │
            └─────────────────────┘
                      │
                      ▼
            ┌─────────────────────┐
            │        Aging        │
            │   +150 ˚C, 48 h     │
            └─────────────────────┘
                      │
                      ▼
            ┌─────────────────────┐
            │  Data verification  │
            └─────────────────────┘
                      │
                      ▼
            (      Assembly       )
```
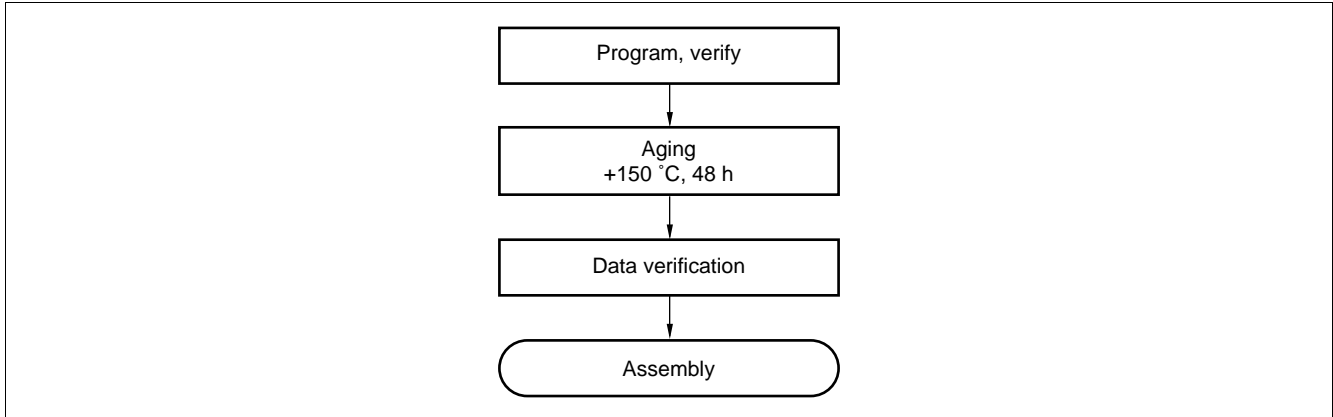
5. Programming Yield

All bits cannot be programmed at Fujitsu Microelectronics shipping test to a blanked OTPROM microcomputer, due to its nature. For this reason, a programming yield of 100% cannot be assured at all times.

■ PROGRAMMING TO THE EPROM WITH PIGGYBACK/EVALUATION DEVICE

1. EPROM for Use

MBM27C256A-20TV, MBM27C256A-20CZ

2. Memory Space

Memory space in each mode, such as 32-Kbyte PROM, option area is diagrammed below.

Address	Single chip		Corresponding addresses on the EPROM programmer
0000$_H$	I/O		
0080$_H$	RAM		
0480$_H$	Not available		
8000$_H$	Not available		0000$_H$ — Option area
8007$_H$			0007$_H$
	PROM 32 KB		EPROM 32 KB
FFFF$_H$			7FFF$_H$
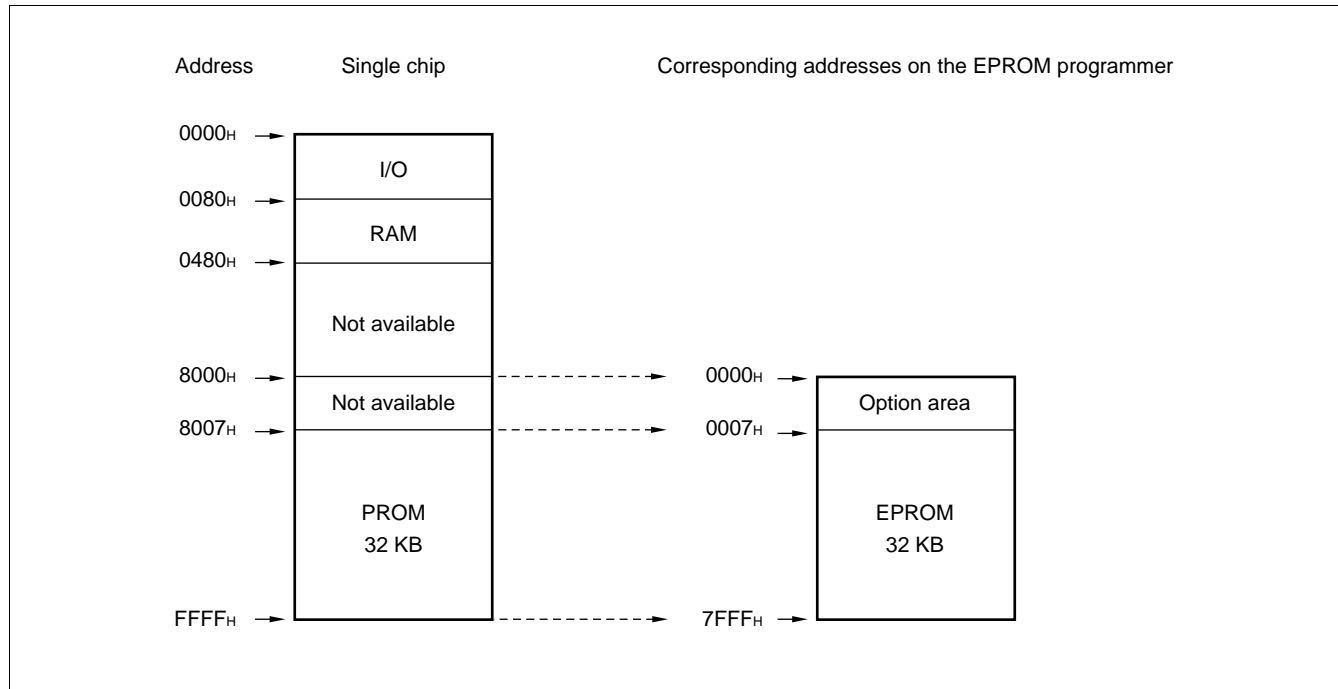
3. Programming to the EPROM

(1) Set the EPROM programmer to the MBM27C256A.

(2) Load program data into the EPROM programmer at 0007$_H$ to 7FFF$_H$.

(3) Program to 0000$_H$ to 7FFF$_H$ with the EPROM programmer.

4. Setting PROM Options

The programming procedure is the same as that for the PROM. Options can be set by programming values at the addresses shown on the memory map. The relationship between bits and options is shown on the following bit map:

• **OTPROM option bit map**

|	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
8000H (0000H)	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Single/dual-clock system 1: Dual clock 0: Single clock	Reset pin output 1: Yes 0: No	Power-on reset 1: Yes 0: No	Reserved (Write 1 bit to this bit.)	Reserved (Write 1 bit to this bit.)
8001H (0001H)	P17 Pull-up 1: No 0: Yes	P16 Pull-up 1: No 0: Yes	P15 Pull-up 1: No 0: Yes	P14 Pull-up 1: No 0: Yes	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable
8002H (0002H)	P37 Pull-up 1: No 0: Yes	P36 Pull-up 1: No 0: Yes	P35 Pull-up 1: No 0: Yes	P34 Pull-up 1: No 0: Yes	P33 Pull-up 1: No 0: Yes	P32 Pull-up 1: No 0: Yes	Vacancy Readable and writable	Vacancy Readable and writable
8003H (0003H)	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable
8004H (0004H)	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable
8005H (0005H)	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable
8006H (0006H)	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable	Vacancy Readable and writable

Notes: • Initial value is 1 for each bit.
• Do not write 0 to the vacant bit.
  The read value of the vacant bit is 1, unless 0 is written to it.
• The parenthesized addresses are the corresponding addresses on the EPROM programmer.
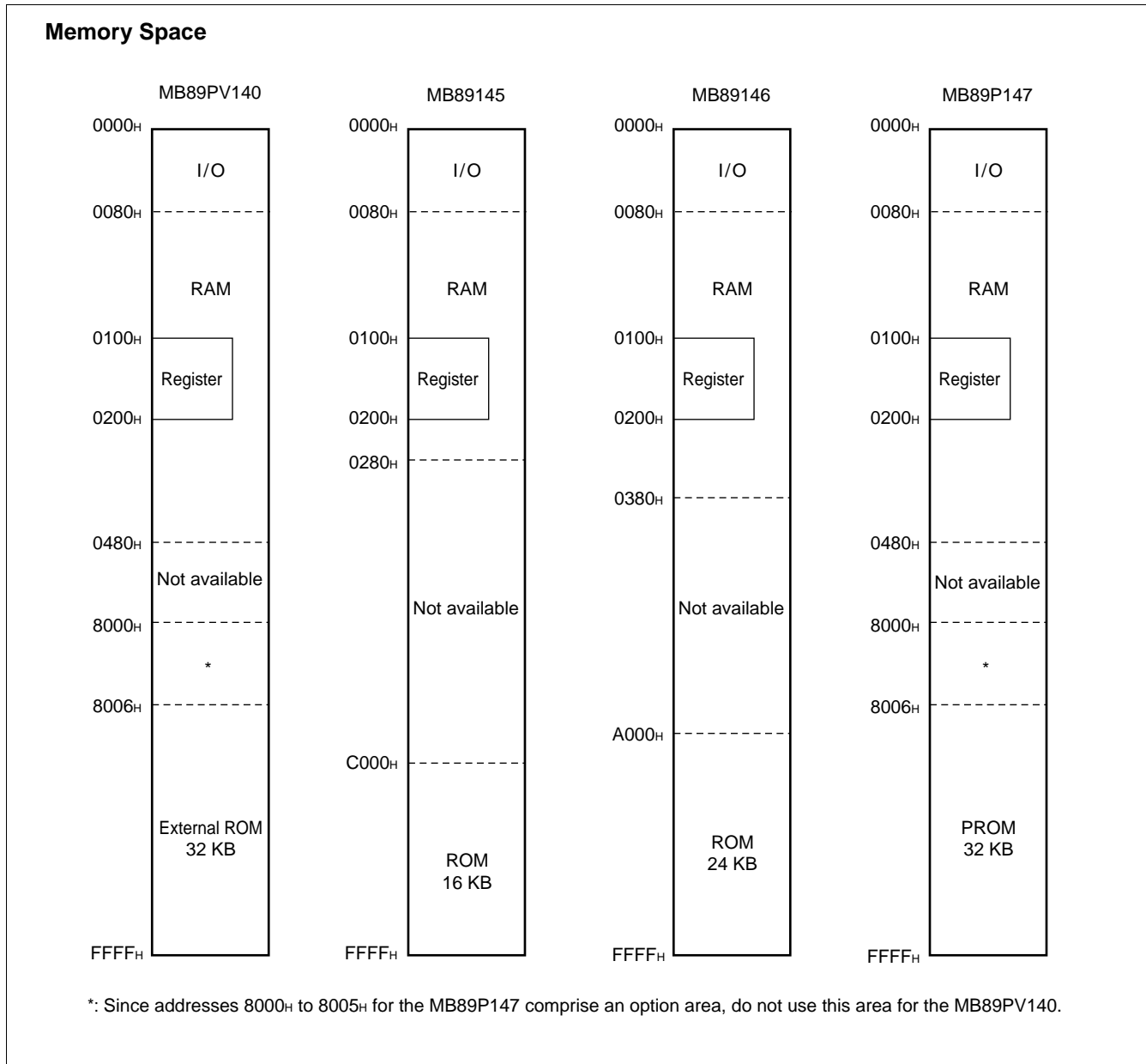
■ BLOCK DIAGRAM
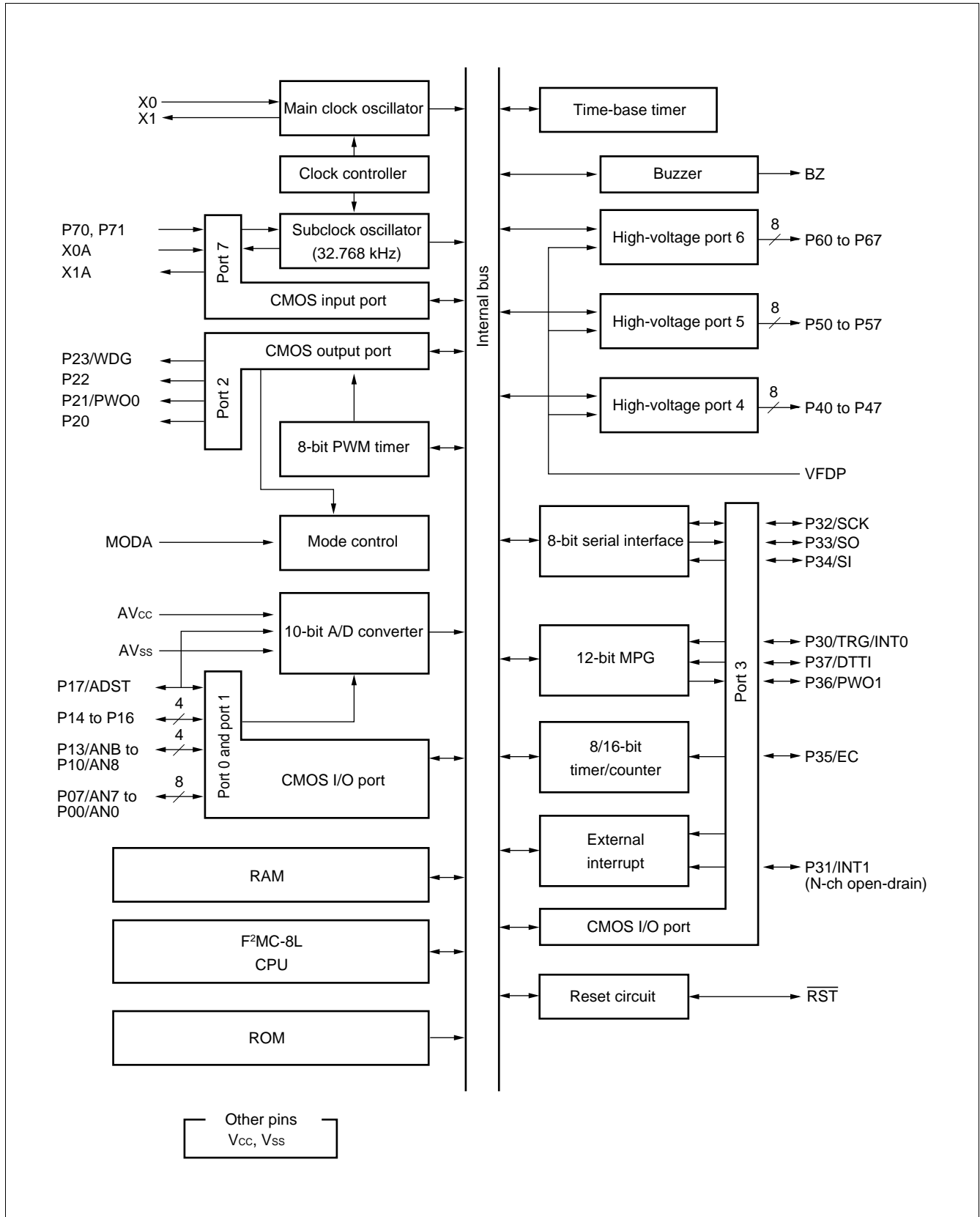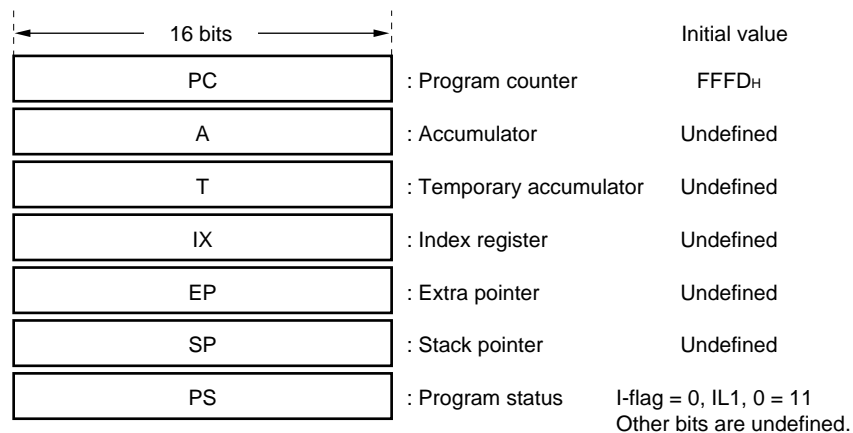
MB89140 Series

■ CPU CORE

1. Memory Space

The microcontrollers of the MB89140 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 MB89140 series is structured as illustrated below.

Memory Space

*: Since addresses 8000H to 8005H for the MB89P147 comprise an option area, do not use this area for the MB89PV140.

2. Registers

The F^{2}MC-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

	Initial value
PC : Program counter	FFFD$_H$
A : Accumulator	Undefined
T : Temporary accumulator	Undefined
IX : Index register	Undefined
EP : Extra pointer	Undefined
SP : Stack pointer	Undefined
PS : Program status	I-flag = 0, IL1, 0 = 11 Other bits are undefined.

(16 bits)

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

15 14 13 12 11	10	9	8	7	6	5 4 3	2	1	0
PS RP	Vacancy	Vacancy	Vacancy	H	I	IL1, 0	N	Z	V C

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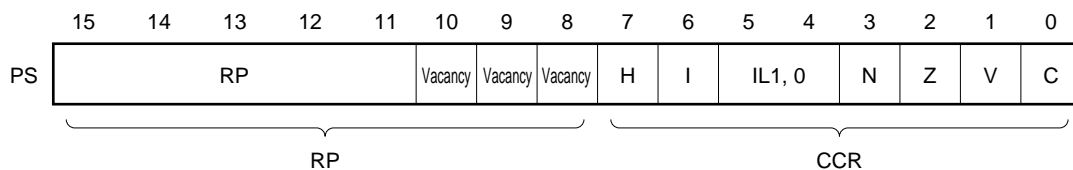
The RP indicates the address of the register bank currently in use. The relationship between the pointer contents and the actual address is based on the conversion rule illustrated below.

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

							RP					Lower OP codes		
"0"	"0"	"0"	"0"	"0"	"0"	"0"	"1"	R4	R3	R2	R1	R0	b2	b1	b0

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

Generated addresses   A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
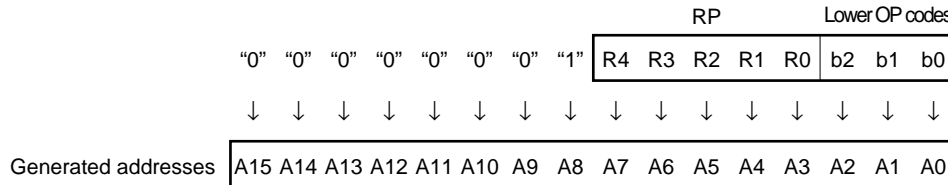
The CCR consists of bits indicating the results of arithmetic operations and the contents of transfer data and bits for control of CPU operations at the time of an interrupt.

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 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.

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 32 banks can be used in the MB89140 series. The bank currently in use is indicated by the register bank pointer (RP).

Register Bank Configuration

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

| R 0 |
| R 1 |
| R 2 |
| R 3 |
| R 4 |
| R 5 |
| R 6 |
| R 7 |

32 banks

Memory area
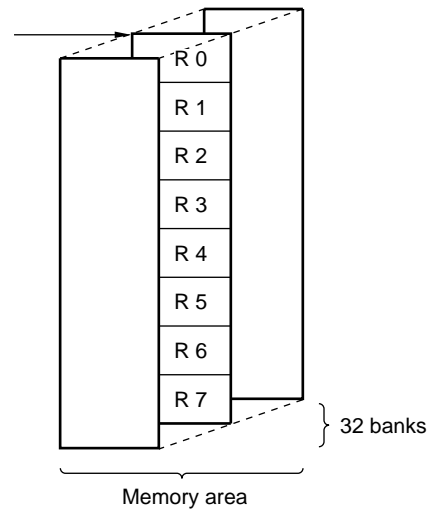
■ I/O MAP

Address	Read/write	Register name	Register description
00$_H$	(R/W)	PDR0	Port 0 data register
01$_H$	(W)	DDR0	Port 0 data direction register
02$_H$	(R/W)	PDR1	Port 1 data register
03$_H$	(W)	DDR1	Port 1 data direction register
04$_H$	(R/W)	PDR2	Port 2 data register
05$_H$			Vacancy
06$_H$			Vacancy
07$_H$	(R/W)	SYCC	System clock control register
08$_H$	(R/W)	STBC	Standby control register
09$_H$	(R/W)	WDTC	Watchdog timer control register
0A$_H$	(R/W)	TBCR	Time-base timer control register
0B$_H$	(R/W)	WPCR	Watch prescaler control register
0C$_H$	(R/W)	PDR3	Port 3 data register
0D$_H$	(W)	DDR3	Port 3 data direction register
0E$_H$	(R/W)	BUZR	Buzzer register
0F$_H$	(R/W)	EIC	External interrupt control register
10$_H$	(R/W)	PDR4	Port 4 data register
11$_H$	(R/W)	PDR5	Port 5 data register
12$_H$	(R/W)	PDR6	Port 6 data register
13$_H$	(R)	PDR7	Port 7 data register
14$_H$			Vacancy
15$_H$			Vacancy
16$_H$	(W)	COMR	8-bit PWM timer compare register
17$_H$	(R/W)	CNTR	8-bit PWM timer control register
18$_H$	(R/W)	T3CR	Timer 3 control register
19$_H$	(R/W)	T2CR	Timer 2 control register
1A$_H$	(R/W)	T3DR	Timer 3 data register
1B$_H$	(R/W)	T2DR	Timer 2 data register
1C$_H$	(R/W)	SMR	Serial mode register
1D$_H$	(R/W)	SDR	Serial data register
1E$_H$	(R/W)	ADC1	A/D converter control register 1
1F$_H$	(R/W)	ADC2	A/D converter control register 2

(Continued)

(Continued)

Address	Read/write	Register name	Register description
20$_H$	(R/W)	ADDH	A/D converter data register (H)
21$_H$	(R/W)	ADDL	A/D converter data register (L)
22$_H$	(W)	PCR0	Port input control register 0
23$_H$	(W)	PCR1	Port input control register 1
24$_H$	(R/W)	MCNT	MPG control register
25$_H$	(R/W)	INTSTR	MPG interrupt status register
26$_H$	(W)	CMCLBR (H)	MPG compare clear buffer register H
27$_H$	(W)	CMCLBR (L)	MPG compare clear buffer register L
28$_H$	(W)	OUTCBR (H)	MPG output buffer register H
29$_H$	(W)	OUTCBR (L)	MPG output buffer register L
2A$_H$			Vacancy
2B$_H$			Vacancy
2C$_H$			Vacancy
2D$_H$			Vacancy
2E$_H$			Vacancy
2F$_H$			Vacancy
30$_H$ to 77$_H$			Vacancy
78$_H$			Vacancy
79$_H$			Vacancy
7A$_H$			Vacancy
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

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

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC}	$V_{SS} - 0.3$	$V_{SS} + 7.0$	V	
	AV_{CC}	$V_{SS} - 0.3$	$V_{SS} + 7.0$	V	*2
I/O voltage	V_{IO1}	$V_{SS} - 0.3$	$V_{CC} + 0.3$	V	Except P31
	V_{IO2}	$V_{SS} - 0.3$	7	V	P31
"H" level total average output current	ΣI_{OH}	—	−120	mA	Average value (operating current × operating rate)
"H" level maximum output current	I_{OH}	—	−12	mA	P00 to P07, P10 to P17, P20 to P23, P30, P32 to P37
		—	−20	mA	P40 to P47, P50 to P57
		—	−36	mA	P60 to P67, BZ
"H" level average output current	I_{OHAV}	—	−6	mA	P00 to P07, P10 to P17, P20 to P23, P30, P32 to P37 Average value (operating current × operating rate)[*1]
		—	−10	mA	P40 to P47, P50 to P57 Average value (operating current × operating rate)[*1]
		—	−18	mA	P60 to P67, BZ Average value (operating current × operating rate)[*1]
"L" level total average output current	ΣI_{OLAV}	—	150	mA	Average value (operating current × operating rate)[*1]
"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	mA	P00 to P07, P10 to P17, P20 to P23, P30 to P37 Average value (operating current × operating rate)[*1]
Power consumption	P_D	—	500	mW	
Operating temperature	T_A	−40	+85	°C	
Storage temperature	T_{stg}	−55	+150	°C	

*1: The total average output current is defined as the average current that flows through all of the relevant pins in a 100 ms period. The output peak current is defined as the peak value of any one of the relevant pins. The average output current is defined as the average current that flows through any one of the relevant pins in a 100 ms period.

*2: Use AV_{CC} and V_{CC} set at the same voltage.
Take care so that AV_{CC} does not exceed V_{CC}, such as when power is turned on.

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$_{CC}$ AV$_{CC}$	2.7*	6.0*	V	Normal operation assurance range*
		2.2	6.0	V	In watch mode or subclock operation (Only for the MB89P147, the minimum value is 2.7 V.)
		1.5	6.0	V	Retains the RAM state in stop mode
	VFDP	V$_{CC}$ – 40	V$_{CC}$ + 0.3	V	
Operating temperature	T$_A$	–40	+85	°C	

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

Figure 1   Operating Voltage vs. Main Clock Operating Frequency
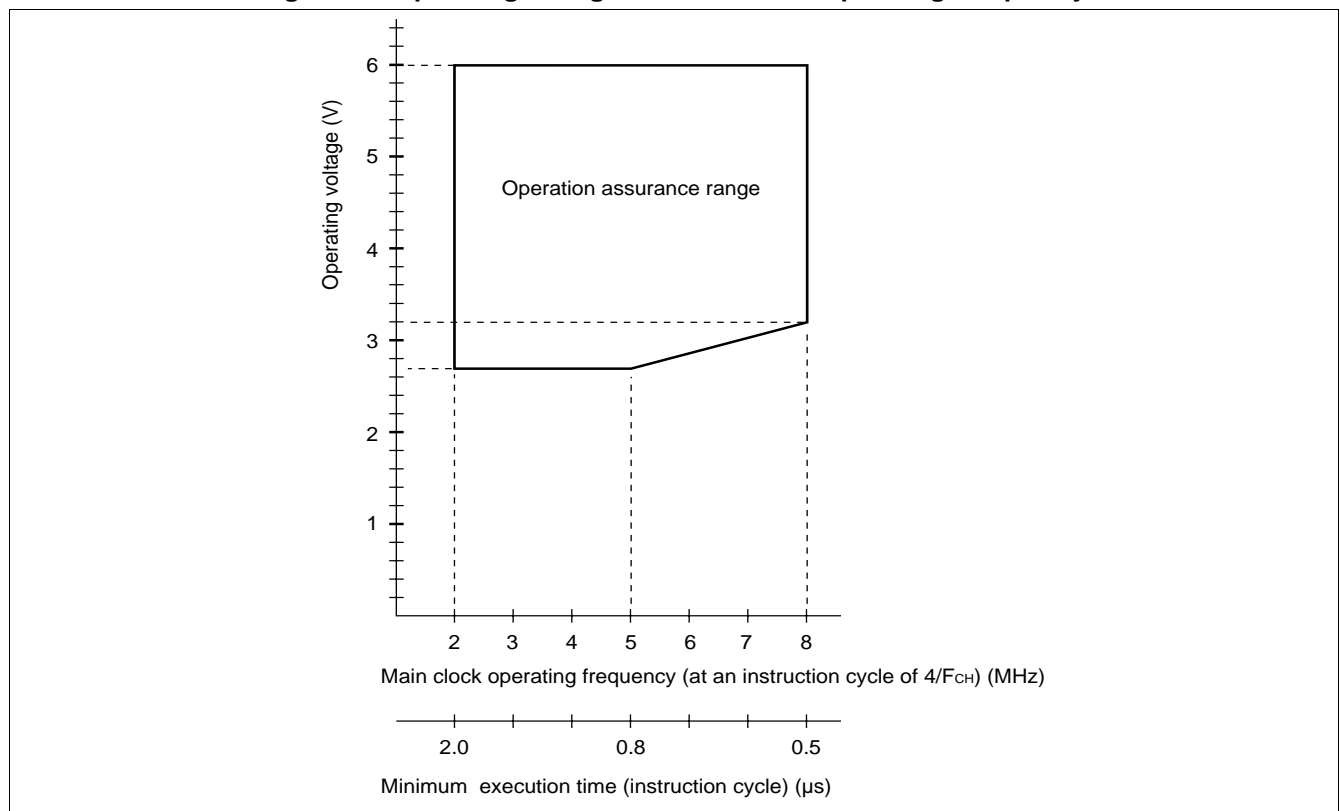
Figure 1 indicates the operating frequency of the external oscillator at an instruction cycle of 4/F$_{CH}$.

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 representatives beforehand.

3. DC Characteristics

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

Parameter	Symbol	Pin	Condition	Value Min.	Value Typ.	Value Max.	Unit	Remarks
"H" level input voltage	V_{IHS}	P00 to P07, P10 to P17, P30 to P37, P70, P71, X0, X1, $\overline{RST}$, MODA	—	$0.7\ V_{CC}$	—	$V_{CC} + 0.3$	V	Hysteresis input
"L" level input voltage	V_{ILS}	P00 to P07, P10 to P17, P30 to P37, P70, P71, X0, X1, $\overline{RST}$, MODA		$V_{SS} - 0.3$	—	$0.2\ V_{CC}$	V	Hysteresis input
"H" level output voltage	V_{OH1}	P00 to P07, P10 to P17, P20 to P23, P30, P32 to P37	$I_{OH} = -2.0$ mA	2.4	—	—	V	
	V_{OH2}	P40 to P47, P50 to P57	$I_{OH} = -10$ mA	3.0	—	—	V	
	V_{OH3}	P60 to P67, BZ	$I_{OH} = -18$ mA	3.0	—	—	V	
"L" level output voltage	V_{OL1}	P00 to P07, P10 to P17, P20 to P23, P30, P32 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, MODA	$0.45 \text{ V} < V_I < V_{CC}$	—	—	±5	µA	Without pull-up resistor for P14 to P17 and P32 to P37
	I_{LI2}	P14 to P17, P32 to P37	$V_I = 0.0$ V	−200	−100	−50	µA	With pull-up resistor
Output leakage current	I_{LO1}	P40 to P47, P50 to P57	$V_I = VFDP = V_{CC} - 40$ V	—	—	−10	µA	
	I_{LO2}	P60 to P67, BZ	$V_I = VFDP = V_{CC} - 40$ V	—	—	−20	µA	
Pull-up resistance	R_{PULU}	$\overline{RST}$ P14 to P17, P32 to P37	$V_I = 0.0$ V	25	50	100	kΩ	With pull-up resistor
Pull-down resistance	R_{PULD}	P40 to P47, P50 to P57, P60 to P67	$V_{OH} = 5.0$ V	50	100	150	kΩ	With pull-down resistor optional

(Continued)

(Continued)

(AV$_{CC}$ = V$_{CC}$ = 5.0 V, AV$_{SS}$ = V$_{SS}$ = 0.0 V, T$_A$ = –40°C to +85°C)

Parameter	Symbol	Pin	Condition	Value Min.	Value Typ.	Value Max.	Unit	Remarks
Power supply current[1]	I$_{CC1}$	V$_{CC}$	F$_{CH}$ = 8 MHz V$_{CC}$ = 5.0 V t$_{inst}$[2] = 0.5 μs Output open	—	9	15	mA	
	I$_{CC2}$		F$_{CH}$ = 8 MHz V$_{CC}$ = 3.2 V t$_{inst}$[2] = 8.0 μs Output open	—	1.5	2	mA	
				—	2.5	5.0	mA	MB89P147
	I$_{CCS1}$		Sleep mode: F$_{CH}$ = 8 MHz V$_{CC}$ = 5.0 V t$_{inst}$[2] = 0.5 μs	—	3	7	mA	
	I$_{CCS2}$		Sleep mode: F$_{CH}$ = 8 MHz V$_{CC}$ = 3.2 V t$_{inst}$[2] = 8.0 μs	—	1	1.5	mA	
	I$_{CCL}$		Subclock mode F$_{CL}$ = 32.768 kHz V$_{CC}$ = 3.0 V	—	50	150	μA	
				—	1	3	mA	MB89P147
	I$_{CCLS}$		Subclock sleep mode F$_{CL}$ = 32.768 kHz V$_{CC}$ = 3.0 V	—	25	50	μA	
	I$_{CCT}$		Watch mode F$_{CL}$ = 32.768 kHz V$_{CC}$ = 3.0 V	—	3	15	μA	
	I$_{CCH}$		Subclock stop mode T$_A$ = +25°C	—	—	10	μA	
	I$_A$	AV$_{CC}$	F$_{CH}$ = 8 MHz	—	1.5	4	mA	when A/D conversion is activated
	I$_{AH}$		T$_A$ = +25°C	—	1	5	μA	when A/D conversion is stopped
Input capacitance	C$_{IN}$	Other than AV$_{CC}$, AV$_{SS}$, V$_{CC}$, and V$_{SS}$	f = 1 MHz	—	10	—	pF	

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

*2: For information on t$_{inst}$, see "(4) Instruction Cycle" in "4. AC Characteristics".

Note: F$_{CH}$ indicates the main clock oscillation frequency. When F$_{CH}$ = 8 MHz, the 4/F$_{CH}$ execution time is 0.5 μs, and the 64/F$_{CH}$ execution time is 8 μs.

4. AC Characteristics

(1) Reset Timing

(AV$_{CC}$ = V$_{CC}$ = 5.0 V, AV$_{SS}$ = V$_{SS}$ = 0.0 V, T$_A$ = –40°C to +85°C)

Parameter	Symbol	Condition	Value			Unit	Remarks
			Min.	Typ.	Max.		
RST "L" pulse width	t$_{ZLZH}$	—	48 t$_{XCYL}$	—	—	ns	
RST noise limit width	t$_{ZLNC}$		30	50	80	ns	

Note: T$_{XCYL}$ is the oscillation cycle (1/F$_{CH}$) to input to the X0 pin.
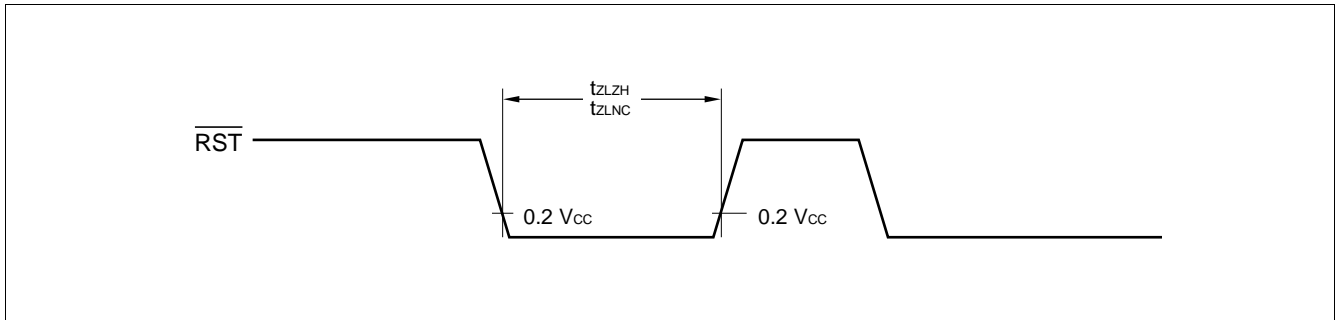
(2) Power-on Reset

(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.
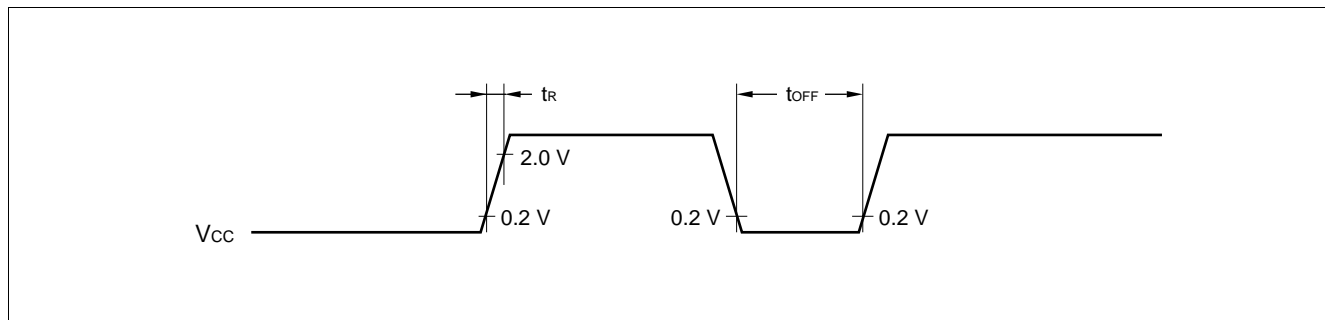
FUJITSU

(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	—	µs	
Input clock rising/falling time	t$_{CR}$ t$_{CF}$	X0, X0A		—	—	10	ns	External clock

X0 and X1 Timing and Conditions
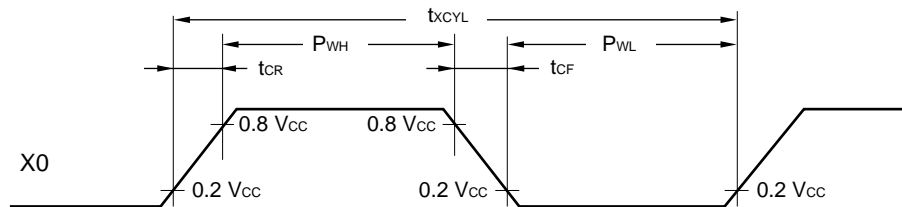
Main Clock Conditions

When a crystal or ceramic resonator is used
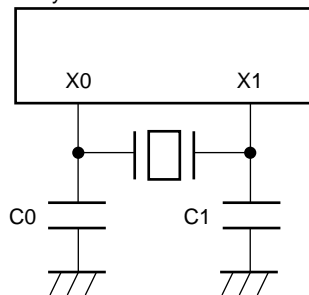
When an external clock is used
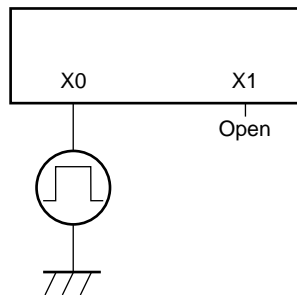
X0A and X1A Timing and Conditions
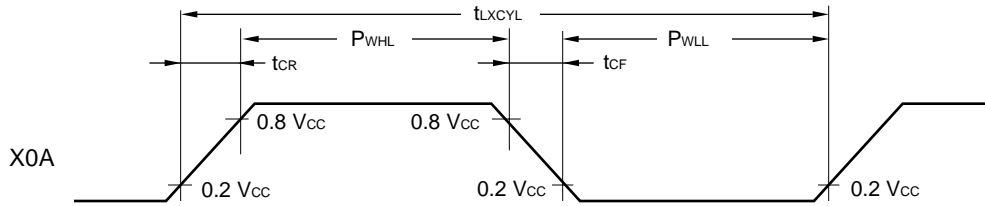
Subclock Conditions

MB89PV140

When a crystal or ceramic resonator is used
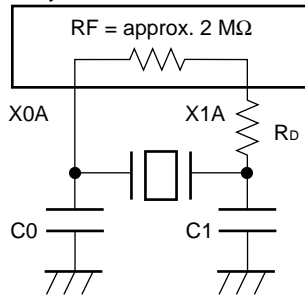
When an external clock is used
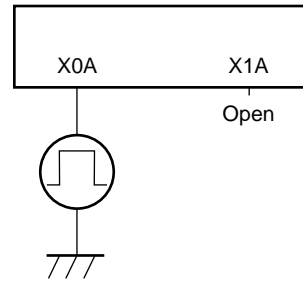
Mask ROM products and MB89P147

When a crystal or ceramic resonator is used
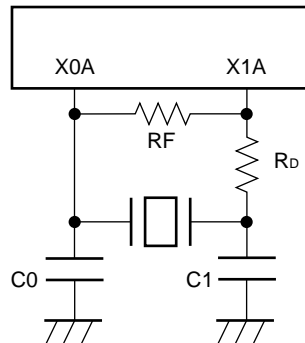
When an external clock is used
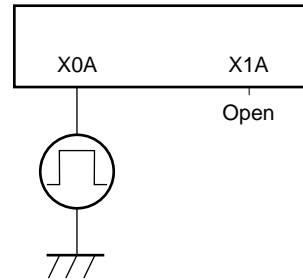
Note: The subclock oscillator feedback resistor is connected externally in dual-clock mask ROM products and in the MB89P147. (The subclock oscillator feedback resistor is connected internally in the MB89PV140-102.)

(4) Instruction Cycle

Parameter	Symbol	Value (typical)	Unit	Remarks
Instruction cycle (minimum execution time)	t_{inst}	$4/F_{CH}$, $8/F_{CH}$, $16/F_{CH}$, $64/F_{CH}$	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

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(5) Serial I/O Timing

(AV$_{CC}$ = 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 Min.	Value Max.	Unit	Remarks
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
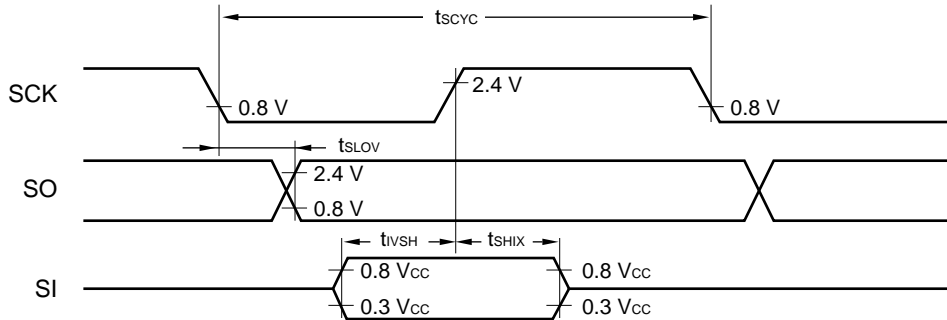
External Shift Clock Mode
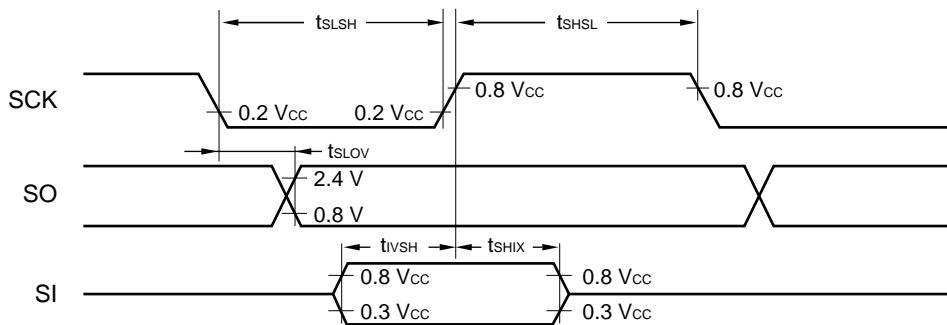
(6) Peripheral Input Timing

(AV$_{CC}$ = 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 Min.	Value Max.	Unit	Remarks
Peripheral input "H" pulse width 1	t$_{ILIH1}$	TRG, DTTI, ADST, EC, INT0, INT1	—	2 t$_{inst}$*	—	µs	
Peripheral input "L" pulse width 1	t$_{IHIL1}$	TRG, DTTI, ADST, EC, INT0, INT1	—	2 t$_{inst}$*	—	µs	

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

(7) Peripheral Input Noise Limit Width

(AV$_{CC}$ = V$_{CC}$ = 5.0 V±10%, AV$_{SS}$ = V$_{SS}$ = 0.0 V, T$_A$ = –40°C to +85°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Remarks
Peripheral input "H" level noise limit width 1	t$_{IHNC1}$	All inputs except INT1 and INT0	7	15	30	ns	MB89P147/PV140
			15	30	60	ns	Except MB89P147/PV140
Peripheral input "L" level noise limit width 1	t$_{ILNC1}$	All inputs except INT1 and INT0	7	15	30	ns	MB89P147/PV140
			15	30	60	ns	Except MB89P147/PV140
Interrupt "H" level noise limit width 2	t$_{IHNC2}$	INT1, INT0	30	50	100	ns	MB89P147/PV140
			50	100	250	ns	Except MB89P147/PV140
Interrupt "L" level noise limit width 2	t$_{ILNC2}$	INT1, INT0	30	50	100	ns	MB89P147/PV140
			50	100	250	ns	Except MB89P147/PV140

TRG DTTI ADST INT0, INT1 EC — t$_{IHIL1}$ 0.2 V$_{CC}$ — 0.8 V$_{CC}$ / 0.2 V$_{CC}$ — t$_{ILIH1}$ 0.8 V$_{CC}$

P00 to P07, P01 to P17 P30 to P37, P70, P71 TRG, SCK, SI, EC, DTTI, ADST INT1, INT0 — t$_{ILNC1}$ t$_{ILNC2}$ 0.2 V$_{CC}$ — 0.8 V$_{CC}$ / 0.2 V$_{CC}$ — t$_{IHNC1}$ t$_{IHNC2}$ 0.8 V$_{CC}$
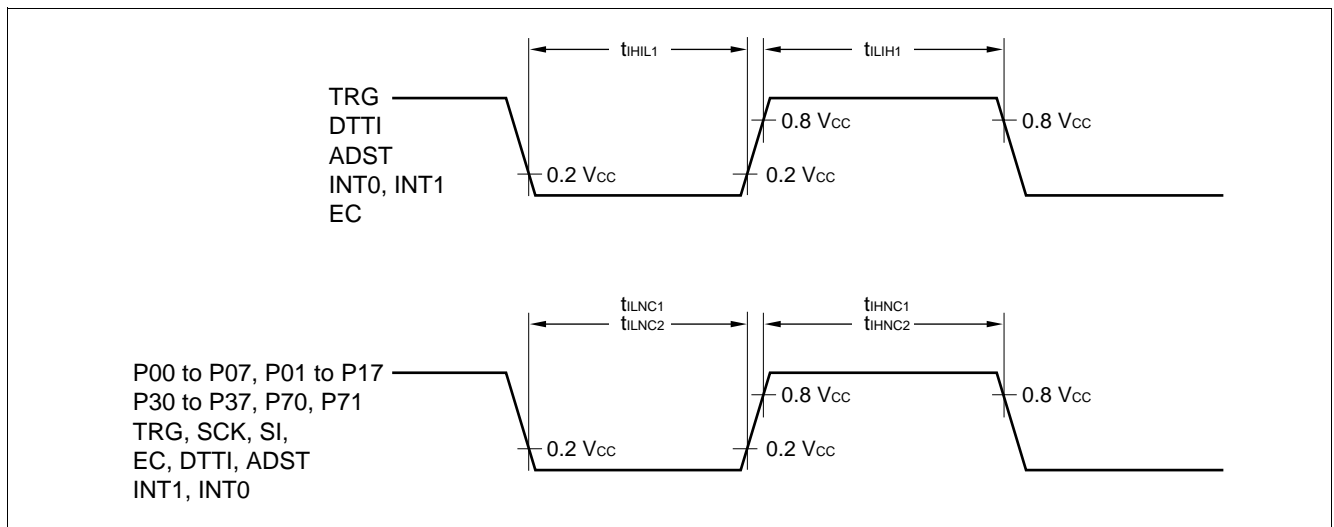
5. A/D Converter Electrical Characteristics

(AV$_{CC}$ = V$_{CC}$ = 5.0 V+10%, F$_{CH}$ = 8 MHz, AV$_{SS}$ = V$_{SS}$ = 0.0 V, T$_A$ = –40°C to +85°C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Resolution	—	—	—	—	—	10	bit	
Total error			AV$_{CC}$ = V$_{CC}$ = 5.0 V	—	—	±3.0	LSB	
Linearity error				—	—	±2.0	LSB	
Differential linearity error				—	—	±1.5	LSB	
Zero transition voltage	V$_{OT}$	AN0 to ANB	—	AV$_{SS}$ – 1.5 LSB	AV$_{SS}$ + 0.5 LSB	AV$_{SS}$ + 2.5 LSB	V	
Full-scale transition voltage	V$_{FST}$	AN0 to ANB	—	AV$_{CC}$ – 3.5 LSB	AV$_{CC}$ – 1.5 LSB	AV$_{CC}$ + 0.5 LSB	V	
Interchannel disparity	—	—	—	—	—	4	LSB	
A/D mode conversion time			At 8-MHz oscillation	33	—	—	t$_{inst*}$	
Analog port input current	I$_{AIN}$	AN0 to ANB	AV$_{CC}$ = V$_{CC}$ = 5.0 V	—	—	10	μA	
Analog input voltage	—	AN0 to ANB	—	0.0	—	AV$_{CC}$	V	

* : For information on t$_{inst}$, see "(4) Instruction Cycle" in "4. AC Characteristics".

Notes: • The smaller |AV$_{CC}$ - AV$_{ss}$|, the greater the error would become relatively.
 • The output impedance of the external circuit connected to an analog input block should be no more than several kΩ. If the output impedance is too high, the analog voltage sampling time might be insufficient.
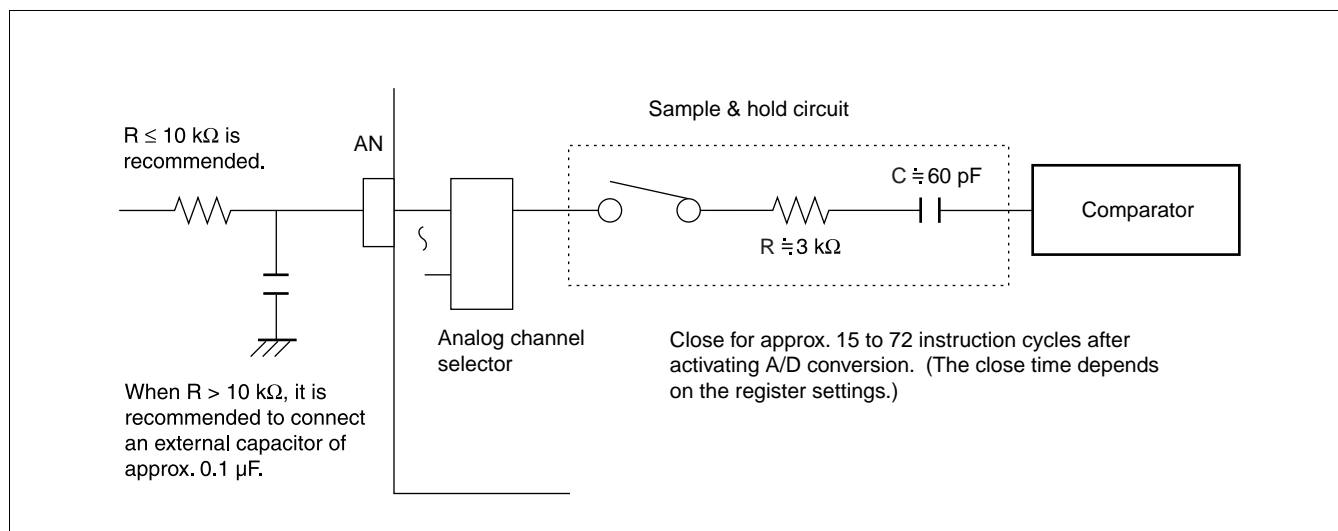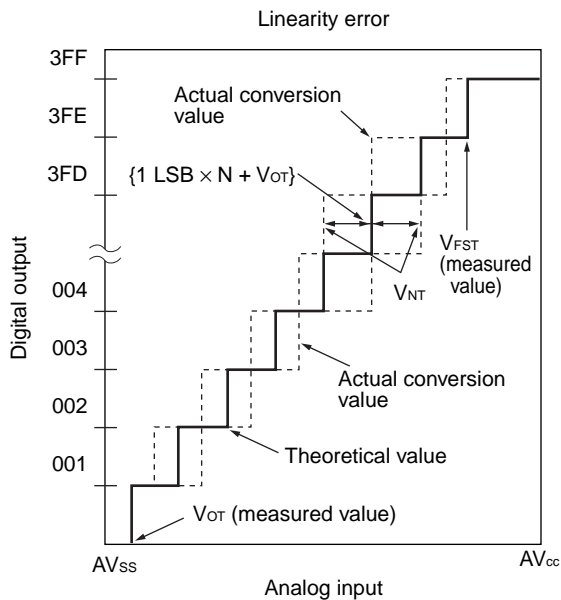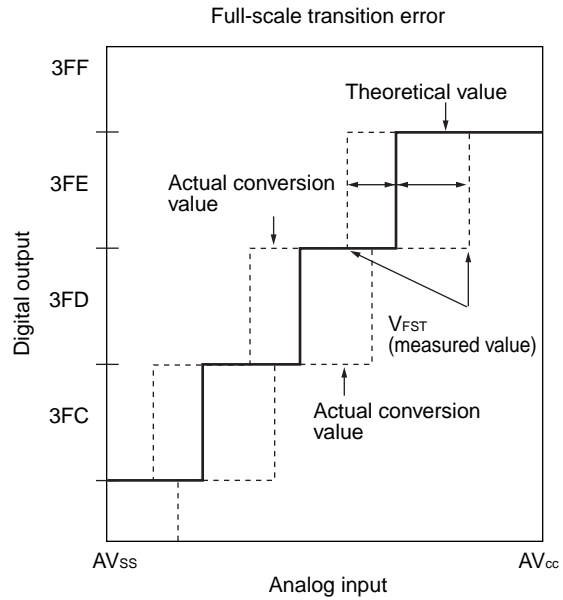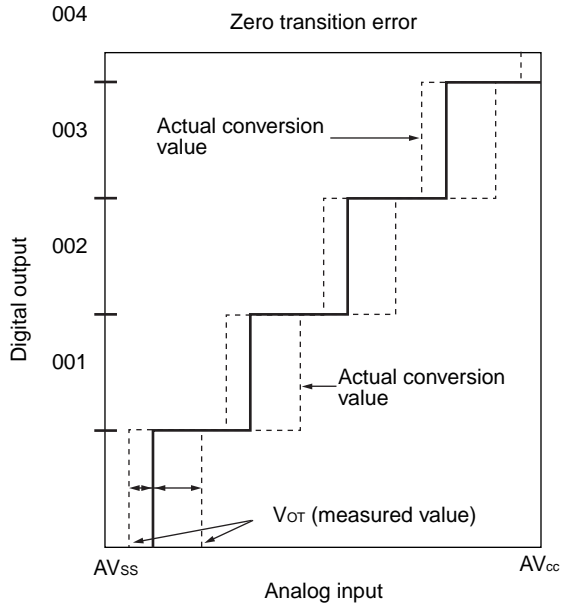
(1) A/D Glossary

- Resolution
  Analog changes that are identifiable with the A/D converter

- Linearity error
  The deviation of the straight line connecting the zero transition point ("00 0000 0000" $\leftrightarrow$ "00 0000 0001") with the full-scale transition point ("11 1111 1110" $\leftrightarrow$ "11 1111 1111") 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 theoretical and actual values
  This error is caused by the zero transition error, full-scale transition error, linearity error, quantization error and noise.

Theoretical I/O characteristics

Total error

$$1 \text{ LSB} = \frac{V_{FST} - V_{OT}}{1022} \text{ (V)}$$

$$\text{Total error for digital output N} = \frac{V_{NT} - \{1 \text{ LSB} \times N + 0.5 \text{ LSB}\}}{1 \text{ LSB}}$$

(Continued)

(Continued)

Zero transition error

004
003 — Actual conversion value
002
001
Digital output
Actual conversion value
V_{OT} (measured value)
AV$_{SS}$ — Analog input — AV$_{CC}$

Full-scale transition error

3FF
3FE
3FD
3FC
Digital output
Theoretical value
Actual conversion value
V_{FST} (measured value)
Actual conversion value
AV$_{SS}$ — Analog input — AV$_{CC}$

Linearity error

3FF
3FE
3FD
004
003
002
001
Digital output
Actual conversion value
$\{1\ \text{LSB} \times N + V_{OT}\}$
V_{FST} (measured value)
V_{NT}
Actual conversion value
Theoretical value
V_{OT} (measured value)
AV$_{SS}$ — Analog input — AV$_{CC}$

Differential linearity error

N + 1
N
N – 1
N – 2
Digital output
Theoretical value
Actual conversion value
$V_{(N+1)\,T}$
V_{NT}
Actual conversion value
AV$_{SS}$ — Analog input — AV$_{CC}$

$$\text{Linearity error for digital output } N = \frac{V_{NT} - \{1\ \text{LSB} \times N + V_{OT}\}}{1\ \text{LSB}}$$

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

■ EXAMPLE CHARACTERISTICS

(1) "L" Level Output Voltage

V_{OL} vs. I_{OL}

V_{OL} (V)

$T_A = +25°C$

$V_{CC} = 2.5$ V
$V_{CC} = 3.0$ V
$V_{CC} = 4.0$ V
$V_{CC} = 5.0$ V
$V_{CC} = 6.0$ V

0.5
0.4
0.3
0.2
0.1
0.0

0 1 2 3 4 5 6 7 8 9 10

I_{OL} (mA)

(2) "H" Level Output Voltage

$V_{CC} - V_{OH}$ vs. I_{OH}

$V_{CC} - V_{OH}$ (V)

$T_A = +25°C$

$V_{CC} = 2.5$ V
$V_{CC} = 3.0$ V
$V_{CC} = 4.0$ V
$V_{CC} = 5.0$ V
$V_{CC} = 6.0$ V

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

0.0 −0.5 −1.0 −1.5 −2.0 −2.5 −3.0

I_{OH} (mA)
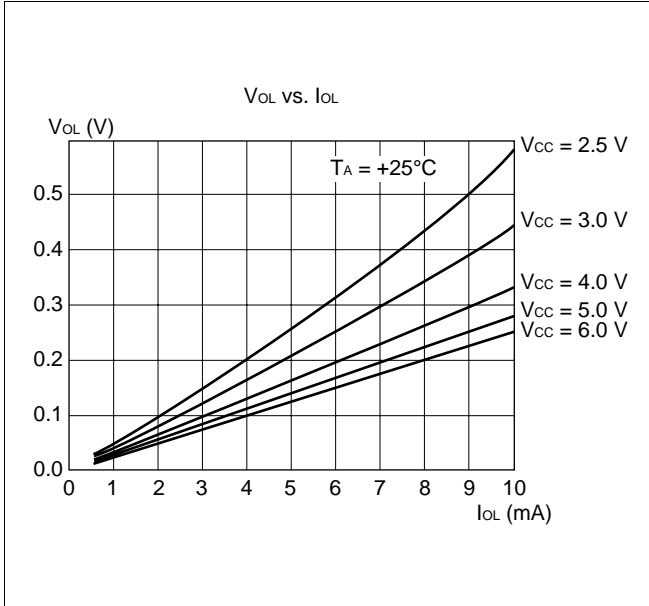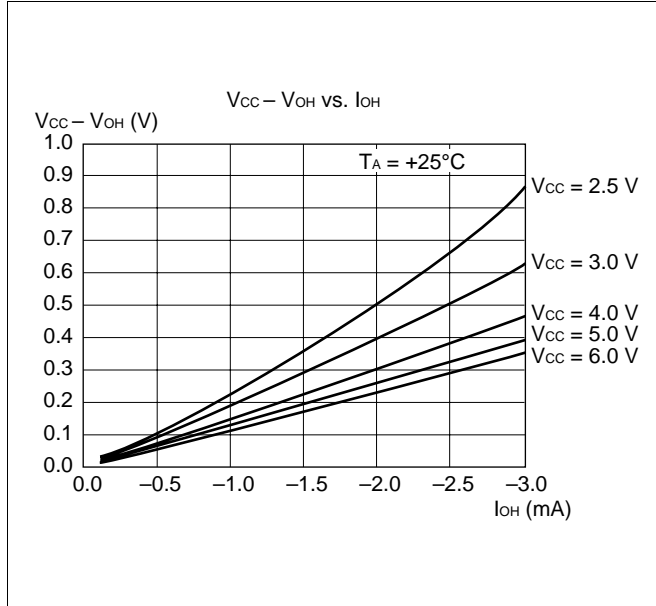
(3) "H" Level Input Voltage/"L" Level Input Voltage (Hysteresis Input)

CMOS hysteresis input

V_{IN} (V)

$T_A = +25°C$

V_{IHS}
V_{ILS}

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

0 1 2 3 4 5 6 7

V_{CC} (V)

V_{IHS}: Threshold when input voltage in hysteresis characteristics is set to "H" level

V_{ILS}: Threshold when input voltage in hysteresis characteristics is set to "L" level
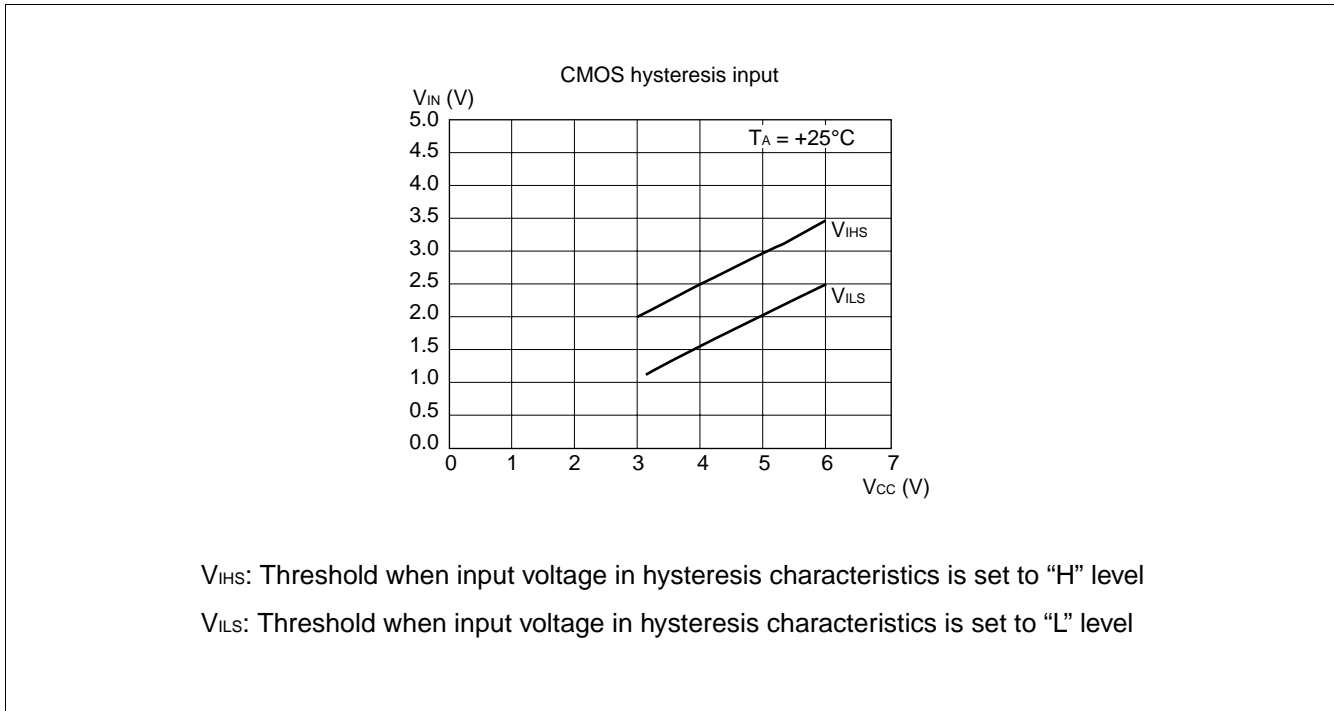
(4)   Power Supply Current (External Clock)

I_{CC1} vs. V_{CC}, I_{CC2} vs. V_{CC}

I_{CC} (mA)

F_{CH} = 8 MHz
T_A = +25°C

Divide by 4 (I_{CC1})

Divide by 64 (I_{CC2})

V_{CC} (V)

I_{CCS1} vs. V_{CC}, I_{CCS2} vs. V_{CC}

I_{CCS} (mA)

F_{CH} = 8 MHz
T_A = +25°C

Divide by 4 (I_{CCS1})

Divide by 64 (I_{CCS2})

V_{CC} (V)

I_{CCL} vs. V_{CC}

I_{CCL} (µA)

T_A = +25°C

V_{CC} (V)

I_{CCLS} vs. V_{CC}

I_{CCLS} (µA)

T_A = +25°C

V_{CC} (V)

(Continued)

(Continued)

I_{CCT} vs. V_{CC}

I_{CCT} (µA)

$T_A = +25°C$

V_{CC} (V)

I_{CCH} vs. V_{CC}

I_{CCH} (µA)

$T_A = +25°C$

V_{CC} (V)

(5) Pull-up Resistance

R_{PULL} vs. V_{CC}

R_{PULL} (kΩ)

$T_A = +85°C$
$T_A = +25°C$
$T_A = −40°C$

V_{CC} (V)

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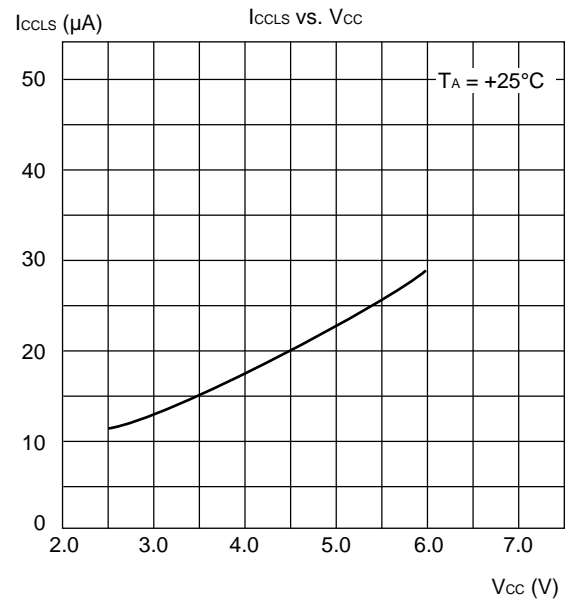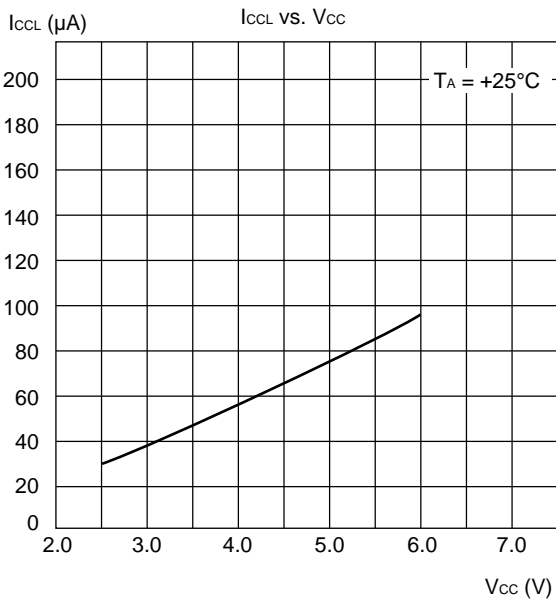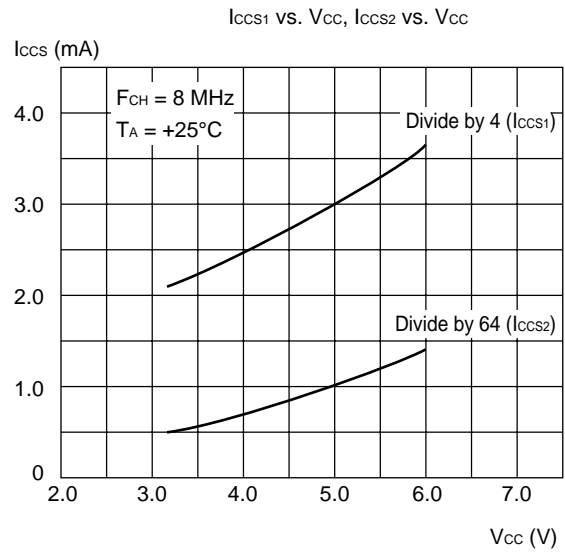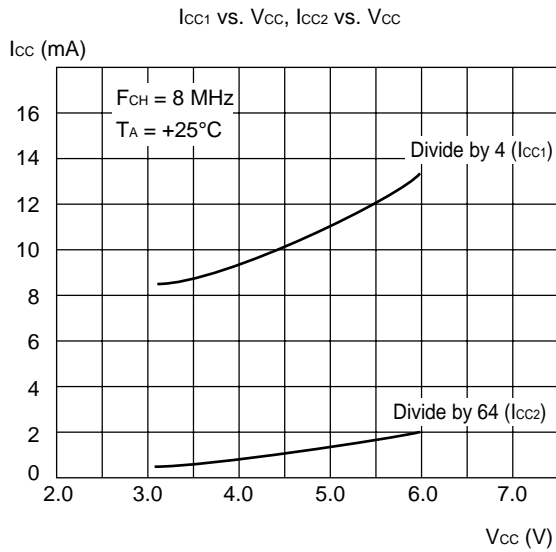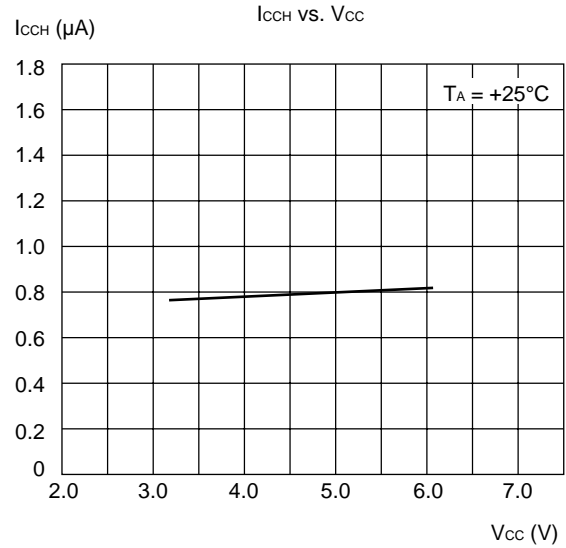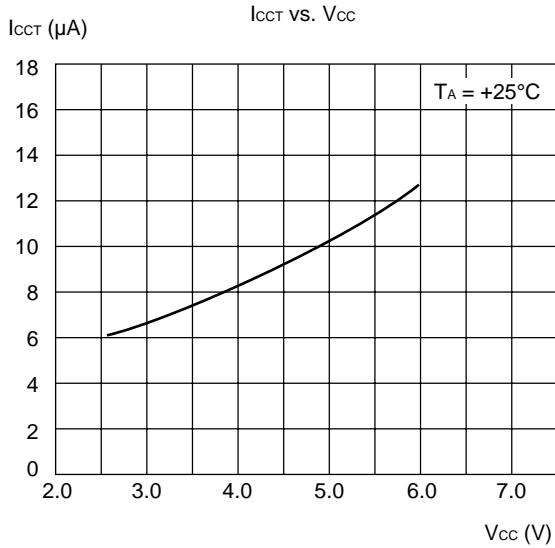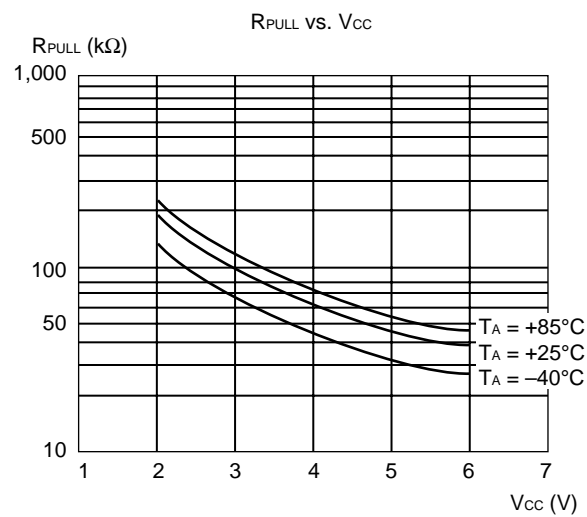
■ MASK OPTIONS
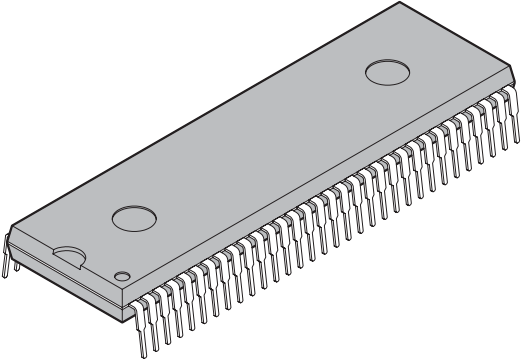
No.		MB89PV140 -101	MB89PV140 -102	MB89145V1 MB89146V1	MB89145V2 MB89146V2	MB89P147V1	MB89P147V2
1	Power-on reset With power-on reset Without power-on reset	Fixed to with power-on reset		Specify when ordering masking		Set with EPROM programmer	
2	Reset pin output With reset output Without reset output	Fixed to with power-on reset		Specify when ordering masking		Set with EPROM programmer	
3	Clock mode selection Single-clock mode Dual-clock mode	Single clock	Dual clock	Specify when ordering masking		Set with EPROM programmer	
4	Pull-up resistors P14 to P17 P32 to P37	Fixed to without pull-up resistor		Specify when ordering masking (specify by pin)		Set with EPROM programmer (specify by pin)	
5	Pull-down resistors P47 to P40 P57 to P50 P67 to P60	Fixed to without pull-up resistor		Without pull-down resistor	All pins with pull-down resistor	Without pull-down resistor	All pins with pull-down resistor

■ ORDERING INFORMATION

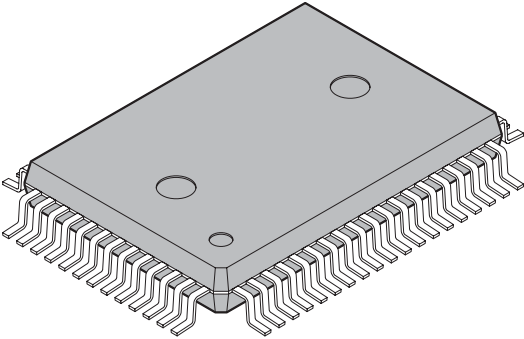| Part number	Package	Remarks
MB89145V1P-SH MB89145V2P-SH MB89146V1P-SH MB89146V2P-SH MB89P147-V1P-SH MB89P147-V2P-SH	64-pin Plastic SH-DIP (DIP-64P-M01)	
MB89145V1PF MB89145V2PF MB89146V1PF MB89146V2PF MB89P147-V1PF MB89P147-V2PF	64-pin Plastic QFP (FPT-64P-M06)	
MB89PV140-101C-ES-SH MB89PV140-102C-ES-SH	64-pin Ceramic MDIP (MDP-64C-P02)	
MB89PV140-101CF-ES MB89PV140-102CF-ES	64-pin Ceramic MQFP (MQP-64C-P01)	

■ PACKAGE DIMENSIONS

64-pin plastic SH-DIP	Lead pitch	1.778mm(70mil)
	Package width × package length	17 × 58 mm
	Sealing method	Plastic mold
	Mounting height	5.65 mm MAX
(DIP-64P-M01)		

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

Note: Pins width and pins thickness include plating thickness.

$58.00 ^{+0.22}_{-0.55} \left(2.283 ^{+.009}_{-.022} \right)$

INDEX-1

INDEX-2

17.00 ± 0.25
$(.669 \pm .010)$

$4.95 ^{+0.70}_{-0.20}$
$\left(.195 ^{+.028}_{-.008} \right)$

$0.70 ^{+0.50}_{-0.19}$
$\left(.028 ^{+.020}_{-.007} \right)$

$3.30 ^{+0.20}_{-0.30}$
$\left(.130 ^{+.008}_{-.012} \right)$

$1.378 ^{+0.40}_{-0.20}$
$\left(.0543 ^{+.016}_{-.008} \right)$

1.778(.0700)

0.47 ± 0.10
$(.019 \pm .004)$

⊕ 0.25(.010) Ⓜ

0.27 ± 0.10
$(.011 \pm .004)$

19.05(.750)

$1.00 ^{+0.50}_{-0}$
$\left(.039 ^{+.020}_{-.0} \right)$

0~15

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Dimensions in mm (inches).
Note: The values in parentheses are reference values.

Please check the latest package dimensions at the following URL.
http://edevice.fujitsu.com/package/en-search/

(Continued)
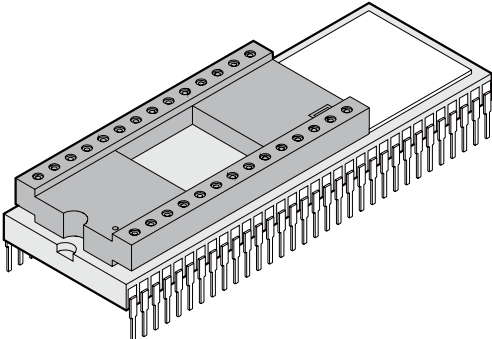
	64-pin plastic QFP	Lead pitch	1.00 mm
		Package width × package length	14 × 20 mm
		Lead shape	Gullwing
		Sealing method	Plastic mold
		Mounting height	3.35 mm MAX
	(FPT-64P-M06)	Code (Reference)	P-QFP64-14×20-1.00

64-pin plastic QFP
(FPT-64P-M06)

Note 1) * : These dimensions do not include resin protrusion.
Note 2) Pins width and pins thickness include plating thickness.
Note 3) Pins width do not include tie bar cutting remainder.

24.70±0.40(.972±.016)
*20.00±0.20(.787±.008)
0.17±0.06 (.007±.002)
18.70±0.40 (.736±.016)
*14.00±0.20 (.551±.008)
INDEX
1.00(.039)
0.42±0.08 (.017±.003)
0.20(.008) Ⓜ
"A"
0.10(.004)

Details of "A" part
$3.00^{+0.35}_{-0.20}$ (Mounting height)
$(.118^{+.014}_{-.008})$
0~8°
$0.25^{+0.15}_{-0.20}$
1.20±0.20 (.047±.008)
$(.010^{+.006}_{-.008})$ (Stand off)

Dimensions in mm (inches).
Note: The values in parentheses are reference values.

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Please check the latest package dimensions at the following URL.
http://edevice.fujitsu.com/package/en-search/

(Continued)

64-pin ceramic MDIP	Lead pitch	1.778mm (70mil)
	Row spacing	19.05mm (750mil)
	Motherboard material	Ceramic
	Mounted packing material	Plastic
(MDP-64C-P02)		
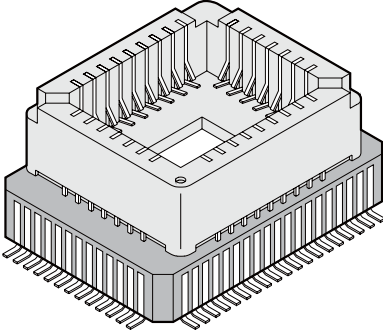
64-pin ceramic MDIP
(MDP-64C-P02)

56.90±0.64
(2.240±.025)

0°~9°

15.24(.600)
TYP

18.75±0.30
(.738±.012)

19.05±0.30
(.750±.012)

INDEX AREA

2.54±0.25
(.100±.010)

33.02(1.300)REF

0.25±0.05
(.010±.002)

10.16(.400)MAX

1.27±0.25
(.050±.010)

1.778±0.25
(.070±.010)

0.46 +0.13 −0.08
(.018 +.005 −.003)

0.90±0.13
(.035±.005)

3.43±0.38
(.135±.015)

55.12(2.170)REF

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Dimensions in mm (inches).
Note: The values in parentheses are reference values.

Please check the latest package dimensions at the following URL.
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(Continued)

64-pin ceramic MQFP	Lead pitch	1.00 mm
	Lead shape	Straight
	Motherboard material	Ceramic
	Mounted package material	Plastic
(MQP-64C-P01)		

64-pin ceramic MQFP
(MQP-64C-P01)

INDEX AREA

18.70(.736)TYP
16.30±0.33 (.642±.013)
15.58±0.20 (.613±.008)

1.27±0.13 (.050±.005)

22.30±0.33 (.878±.013)

24.70(.972) TYP

0.30(.012) TYP

12.02(.473) TYP
10.16(.400) TYP
18.12±0.20 (.713±.008)
14.22(.560) TYP

1.27±0.13 (.050±.005)

0.30(.012)TYP
7.62(.300)TYP
9.48(.373)TYP
11.68(.460)TYP

12.00(.472)TYP
1.00±0.25 (.039±.010)
$1.20 ^{+0.40}_{-0.20}$ $\left(.047 ^{+.016}_{-.008}\right)$

1.00±0.25 (.039±.010)

18.00(.709) TYP

0.40±0.10 (.016±.004)
0.40±0.10 (.016±.004)
$1.20 ^{+0.40}_{-0.20}$ $\left(.047 ^{+.016}_{-.008}\right)$

0.50(.020)TYP
10.82(.426) MAX
0.15±0.05 (.006±.002)

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Dimensions in mm (inches).
Note: The values in parentheses are reference values.

Please check the latest package dimensions at the following URL.
http://edevice.fujitsu.com/package/en-search/

■ MAIN CHANGES IN THIS EDITION

Page	Section	Change Results
3	■ PRODUCT LINEUP	Changed the name of a timer. Clock timer → Watch timer
16	■ PROGRAMMING TO THE EPROM ON THE MB89P147	Deleted the "6. EPROM Programmer Socket Adapter".
17	■ PROGRAMMING TO THE EPROM WITH PIGGYBACK/EVALUATION DEVICE	Deleted the "2. Programming Socket Adapter".
35	■ ELECTRICAL CHARACTERISTICS A/D Converter Electrical Characteristics	Changed the unit of "Zero transition voltage" and "Full-scale transition voltage". mV → V
41	■ ORDERING INFORMATION	Changed the ordering information. MB89P147V1P-SH → MB89P147-V1P-SH MB89P147V2P-SH → MB89P147-V2P-SH MB89P147V1PF → MB89P147-V1PF MB89P147V2PF → MB89P147-V2PF MB89PV140C-101-ES-SH → MB89PV140-101C-ES-SH MB89PV140C-102-ES-SH → MB89PV140-102C-ES-SH MB89PV140CF-101-ES → MB89PV140-101CF-ES MB89PV140CF-102-ES → MB89PV140-102CF-ES

The vertical lines marked in the left side of the page show the changes.

MEMO

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