

8-bit Proprietary Microcontroller

CMOS

F²MC-8L MB89960 Series

MB89965/P965A/F969A/ MB89PV960

■ DESCRIPTION

The MB89960 series is a single-chip microcontroller that utilizes the F²MC-8L core for low voltage and high speed performance. The microcontroller contains a range of peripheral functions including timers, a serial interface, I²C interface, A/D converter, and external interrupts. The internal I²C interface complies with the SM bus standard and supports an SM bus battery controller.

■ FEATURES

- **Range of package options**
 - QFP and MQFP packages (0.8 mm pitch)
 - LQFP package (0.5 mm and 0.65 mm pitch)
- **High speed operation at low voltage**
Minimum instruction execution time = 0.4 μs (for a 10 MHz oscillation)
- **F²MC-8L CPU core**
Instruction set optimized for controller applications
 - Multiplication and division instructions
 - 16-bit arithmetic operations
 - Bit test branch instructions
 - Bit manipulation instructions, etc.
- **Dual-clock control system**
 - Main clock : 10 MHz max.
(Four speed settings available, oscillation halts in sub-clock mode)
 - Sub-clock : 32.768 kHz (Operation clock for sub-clock mode)
- **Four channels**
 - 8/16-bit timer/counter (8-bit × 2 channels or 16-bit × 1 channel)
 - 21-bit timebase timer
 - Clock prescaler (15-bit)
- **Serial I/O**
Selectable transfer format (MSB-first or LSB-first) supports communications with a wide range of devices.
- **A/D converter**
10-bit × 4 channels

MB89960 Series

- **External interrupts**

- External interrupt 1 (3 channels)

Three independent interrupt inputs can be used to recover from low-power consumption modes (with edge-detection function)

- External interrupt 2 (1 channel with 8 inputs)

Eight inputs can be used to recover from low-power consumption modes (with "L" level detection function)

- **Low-power consumption modes (standby modes)**

- Stop mode (As all oscillations halt in sub-clock mode, current consumption falls to almost zero.)

- Sleep mode (The CPU stops to reduce the current consumption to approximately 1/3 of normal.)

- Clock mode (All operation halts other than the clock prescaler resulting in very low power consumption.)

- **I²C interface***

- Supports Intel SM bus and Philips I²C bus standards.

- Uses a two-wire data transfer protocol.

- **Max. 35 I/O ports**

- Output-only ports (N-ch open drain) : 6

- General-purpose I/O ports (CMOS) : 21

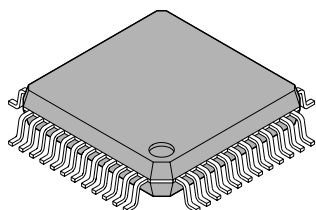
- Output-only ports (CMOS) : 8

* : I²C license

The customer is licensed to use the Philips I²C patent when using this product in an I²C system that complies with the Philips I²C standard specifications.

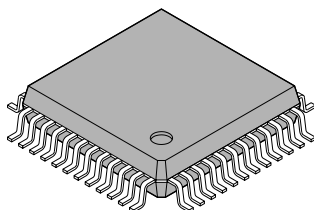
■ PACKAGE

Plastic LQFP, 48-pin



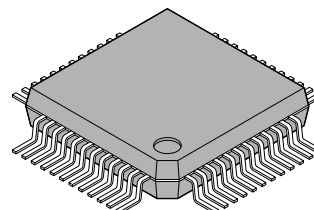
(FPT-48P-M05)

Plastic QFP, 48-pin



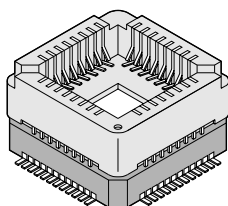
(FPT-48P-M13)

Plastic QFP, 48-pin



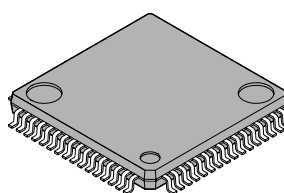
(FPT-48P-M16)

Ceramic MQFP, 48-pin



(MQP-48C-P01)

Plastic LQFP, 64-pin



(FPT-64P-M09)

MB89960 Series

■ PRODUCT LINEUP

Part No.		MB89965	MB89P965A	MB89F969A	MB89PV960
Parameter					
Classification		Mass-produced products (mask ROM products)	One-time product	Flash product	Piggyback/evaluation product for testing and development
ROM size		16 K × 8-bit (Internal mask ROM)		60 K × 8-bit	32 K × 8-bit (External ROM) *
RAM size		512 × 8-bit			1024 × 8-bit
CPU functions		Number of instructions : 136 Instruction bit length : 8-bit Instruction length : 1 to 3 bytes Data bit length : 1-, 8-, 16bits Minimum execution time : 0.4 μs (at 10 MHz) Interrupt processing time : 3.6 μs (at 10 MHz)			
Peripheral functions	Ports	Output-only ports (N-ch open drain) : 6 (4 pins are shared with analog inputs) (2 pins are shared with resource I/O) Output-only ports (CMOS) : 8 General-purpose I/O ports (CMOS) : 21 (shared with resource I/O) Total : 35 (max.)			
	Timebase timer	21-bit Four interrupt intervals selectable 0.82 ms, 3.3 ms, 26.2 ms, or 419.4 ms (approx.) (for main clock)			
	Watchdog timer	Reset trigger period : 419.4 ms (10 MHz main clock) 500 ms (32.768 MHz sub-clock)			
	I ² C interface	One channel. Supports Intel SM bus (version 1.0) and Philips I ² C bus standards. Uses a 2-wire protocol for communications with other devices.			
		Included/Not included (Specified when ordering. See "Ordering Information" for details.)	Included		
	8/16-bit timer/counter Timer	2 channel 8-bit timer/counter operation (independent operation clocks for timer 1 and timer 2) or 16-bit timer/counter operation (operation clock period : 0.8 μs to 204.8 μs) can execute an event counter operation and output a square wave using an external Clock. 1 or 16-bit timer/counter operation mode			
	Serial I/O	8 bits LSB-first or MSB-first selectable Transfer clocks : External or three internal clocks (0.8 μs, 3.2 μs, 12.8 μs)			
	External interrupt 1 (edge)	Selectable edge detection (rising, falling, or either edge) 3 independent channels These can also be used to recover from standby modes (edge detection is still available in stop mode) .			
External interrupt 2 (level)	1 channel with 8 inputs ("L" level interrupts, independent input enable) This can also be used to recover from standby modes (level detection is still available in stop mode) .				

(Continued)

MB89960 Series

(Continued)

Part No.		MB89965	MB89P965A	MB89F969A	MB89PV960
Parameter					
Peripheral functions	A/D converter	4 channel × 10-bit resolution A/D conversion time : 15.2 μs (MB89965, MB89P965A, MB89F969A) 13.2 μs (MB89PV960) Continuous activation is available using the output from the 8/16-bit timer/counter or timebase timer. Reference voltage input (AVR)			
	Clock prescaler	15-bit Interrupt interval : 31.25 ms, 0.25 s, 0.50 s, 1.00 s (for a 32.768 kHz sub-clock)			
Low power consumption (standby modes)		Sleep mode, stop mode, and clock mode			
Process		CMOS			
Operating voltage		3.5 V to 5.5 V			

* : Use the MBM27C256A-20TVM as the external ROM (Operating voltage : 4.5 V to 5.5 V)

Note : Unless otherwise stated, clock periods and conversion times are for 10 MHz operation with the main clock operating at maximum speed.

■ PACKAGES AND CORRESPONDING PRODUCTS

Package	Part No.	MB89965	MB89P965A	MB89F969A	MB89PV960
FPT-48P-M05		○	○	×	×
FPT-48P-M13		○	○	×	×
FPT-48P-M16		○	○	×	×
FPT-64P-M09		×	×	○	×
MQP-48C-P01		×	×	×	○

○ : Available

× : Not available

■ DIFFERENCES AMONG PRODUCTS

1. Memory Space

Please take note of the differences among products before testing and developing software for the MB89960 series.

- The RAM and ROM configurations differ among products.
- If the bottom stack address is set at the top RAM address, this will need to be relocated if changing to a different product.

2. Current Consumption

- In the case of the MB89PV960, add the current consumed by the EPROM which is connected to the top socket.
- When operated at low speed, one-time PROM and EPROM products will consume more current than mask ROM products. However, the current consumption in sleep/stop modes is the same.

3. Functional Differences Between MB89960 Series

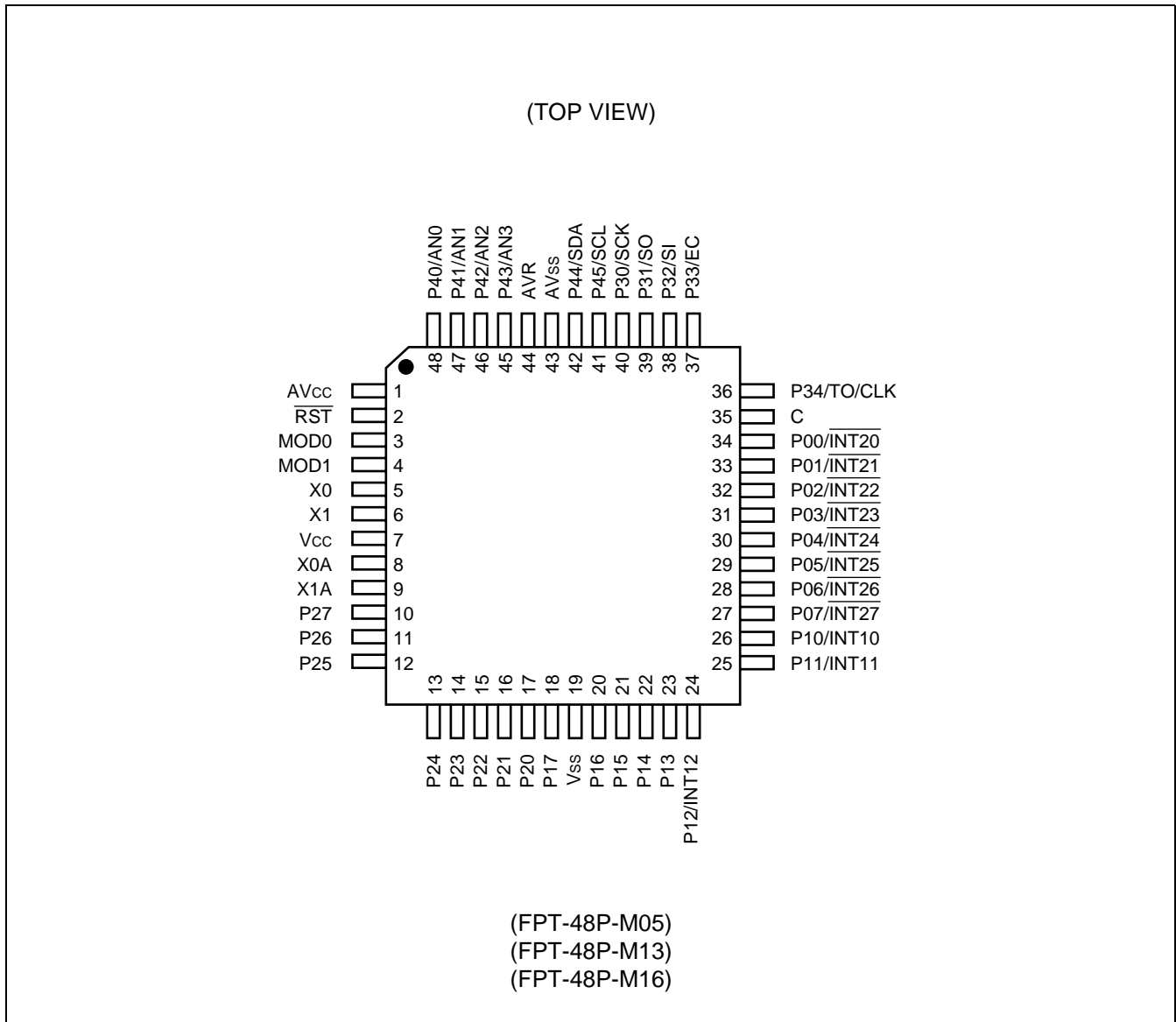
	MB89965/P965A/F969A	MB89PV960
Power-on reset delay time	Regulator stabilization delay time, regulator recovery time, oscillation stabilization delay time	Oscillation stabilization delay time
External reset delay time in stop/sub-clock mode or external interrupt delay time in main stop mode	Regulator recovery time, oscillation stabilization delay time	Oscillation stabilization delay time
Port pin pull-up resistors	Software-selectable	Not available
A/D conversion time	38 instruction cycles	33 instruction cycles
I ² C noise elimination circuit	Always present regardless of ICCR : DMPB bit setting	Disabled if ICCR : DMPB bit = "1"

4. Mask Options

Functions that can be selected as options and the methods used to specify these options vary by the product. Before using mask options, check section " ■ Mask Options".

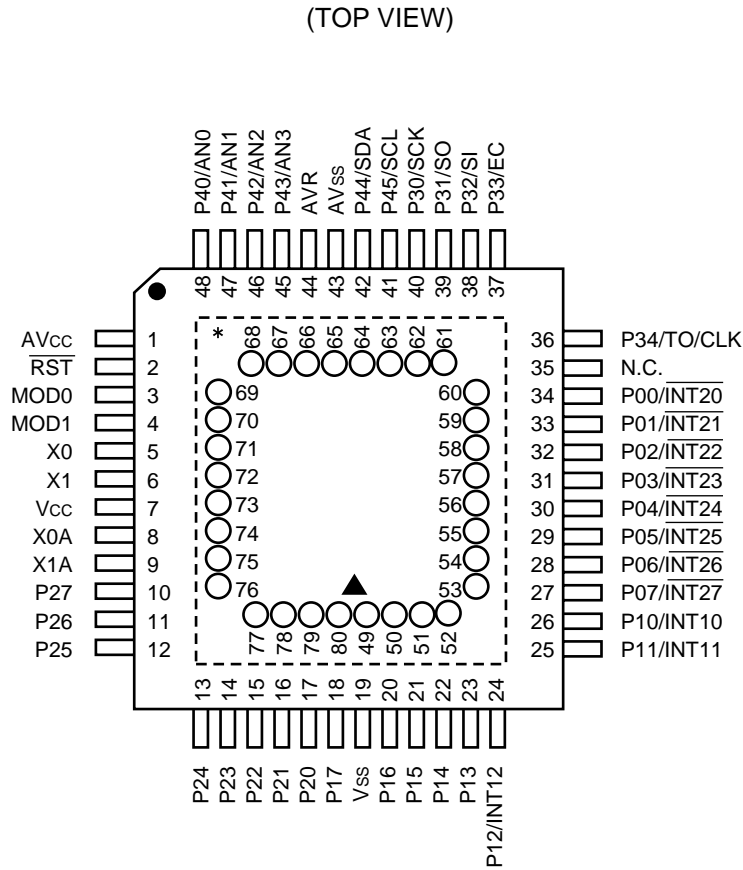
MB89960 Series

■ PIN ASSIGNMENT



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(MQP-48C-P01)

* : Pin assignment on package top (MB89PV960)

Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name
49	V _{PP}	57	N.C.	65	O4	73	\overline{OE}
50	A12	58	A2	66	O5	74	N.C.
51	A7	59	A1	67	O6	75	A11
52	A6	60	A0	68	O7	76	A9
53	A5	61	O1	69	O8	77	A8
54	A4	62	O2	70	\overline{CE}	78	A13
55	A3	63	O3	71	A10	79	A14
56	N.C.	64	V _{SS}	72	N.C.	80	V _{CC}

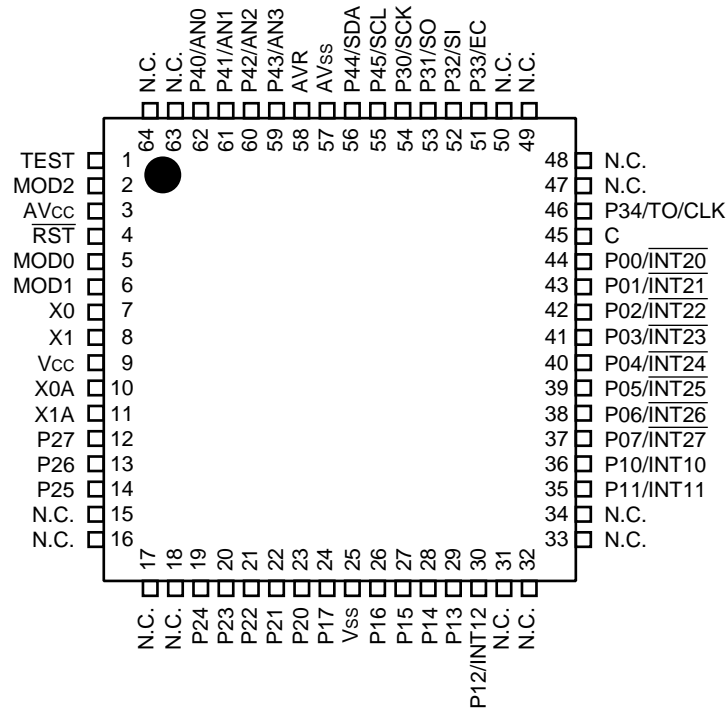
N.C. : Internally connected. Do not use.

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MB89960 Series

(Continued)

(TOP VIEW)



(FPT-64P-M09)

■ PIN DESCRIPTIONS

Pin No.			Pin Name	Circuit Type	Function
MQFP-48*3	LQFP-48*1 QFP-48*2	LQFP-64*4			
5	5	7	X0	A	Oscillator connection pins for the main clock oscillator (crystal oscillator or similar) . When using an external clock, input the clock signal to X0 and leave X1 open.
6	6	8	X1		
8	8	10	X0A	B	Oscillator connection pins for the sub-clock oscillator (crystal oscillator or similar) . When using an external clock (low speed : 32.768 kHz) , input the clock signal to X0A and leave X1A open.
9	9	11	X1A		
3	3	5	MOD0	C	Input pins for setting the memory access mode. Connect directly to V _{ss} .
4	4	6	MOD1		
2	2	4	$\overline{\text{RST}}$	D	Reset I/O pin This is an N-ch open-drain output type with pull-up resistor and a hysteresis input type. The pin outputs "L" when an internal reset is present. Similarly, inputting "L" initializes the internal circuits.
27 to 34	27 to 34	37 to 44	P00/ $\overline{\text{INT20}}$ to P07/ $\overline{\text{INT27}}$	E	General-purpose I/O ports Also serves as the external interrupt 2 inputs (wakeup inputs) . The external interrupt 2 inputs are hysteresis inputs.
24 to 26	24 to 26	30, 35, 36	P10/ $\overline{\text{INT10}}$ to P12/ $\overline{\text{INT12}}$	E	General-purpose I/O ports Also serves as the external interrupt 1 inputs (wakeup inputs) . The external interrupt 1 inputs are hysteresis inputs.
18, 20 to 23	18, 20 to 23	24, 26 to 29	P13 to P17	E	General-purpose I/O ports
10 to 17	10 to 17	12 to 14 19 to 23	P20 to P27	G	General-purpose output-only ports
40	40	54	P30/SCK	F	General-purpose I/O port Also serves as the serial clock I/O. A hysteresis input.
39	39	53	P31/SO	F	General-purpose I/O port Also serves as the serial I/O data output. A hysteresis input.

*1 : FPT-48P-M05

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*2 : FPT-48P-M16, FPT-48P-M13

*3 : MQP-48C-P01

*4 : FPT-64P-M09

MB89960 Series

(Continued)

Pin No.			Pin Name	Circuit Type	Function
MQFP-48*3	LQFP-48*1 QFP-48*2	LQFP-64*4			
38	38	52	P32/SI	F	General-purpose I/O port Also serves as the serial I/O data input. A hysteresis input.
37	37	51	P33/EC	F	General-purpose I/O port Also serves as the external clock input for the 8/ 16-bit timer/counter. A hysteresis input.
36	36	46	P34/TO/ CLK	F	General-purpose I/O port Also serves as the overflow output for the 8/16- bit timer/counter and the CLK clock output. A hysteresis input.
—	35	45	C	—	Connect a 0.1 μ F capacitor on the MB89965, MB89P965A, and MB89F969A.
45 to 48	45 to 48	59 to 62	P40/AN0 to P43/AN3	H	General-purpose Nch open-drain outputs. Also serves as the A/D converter analog inputs.
42	42	56	P44/SDA	I	General-purpose Nch open-drain output. Also serves as the I ² C interface data output.
41	41	55	P45/SCL	I	General-purpose Nch open-drain output. Also serves as the I ² C interface clock I/O.
7	7	9	V _{CC}	—	Power supply pin
19	19	25	V _{SS}	—	Power supply (GND) pin
1	1	3	AV _{CC}	—	A/D converter power supply pin Use this pin at the same voltage as V _{CC} .
44	44	58	AVR	—	A/D converter reference voltage input pin
43	43	57	AV _{SS}	—	A/D converter power supply pin Use this pin at the same voltage as V _{SS} .
35	—	15 to 18 31 to 34 47 to 50 63, 64	N.C.	—	These pins are not connected. Do not connect these on the MB89PV960.
—	—	1	TEST	C	TEST pin. Connect directly to V _{SS} . Only used on the MB89F969A. Treat as an N.C. pin on the MB89965.
—	—	2	MOD2	C	Memory access mode setting pin. Connect di- rectly to V _{SS} . Only used on the MB89F969A. Treat as an N.C. pin on the MB89965.

*1 : FPT-48P-M05

*2 : FPT-48P-M16, FPT-48P-M13

*3 : MQP-48C-P01

*4 : FPT-64P-M09

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• Pin Descriptions for External EPROM (MB89PV960 only)

Pin No.	Pin Name	I/O	Function
49	V _{pp}	O	"H" level output pin
50 51 52 53 54 55	A12 A7 A6 A5 A4 A3	O	Address output pins
58 59 60	A2 A1 A0	O	Address output pins
61 62 63	O1 O2 O3	I	Data input pins
64	V _{ss}	—	Power supply (GND) pin
65 66 67 68 69	O4 O5 O6 O7 O8	I	Data input pins
70	\overline{CE}	O	ROM chip enable pin Outputs "H" during standby mode.
71	A10	O	Address output pin
73	\overline{OE}	O	ROM output enable pin Always outputs "L".
75 76 77 78 79	A11 A9 A8 A13 A14	O	Address output pins
80	V _{cc}	—	EPROM power supply pin
56 57 72 74	N.C.	—	Internally connected pins Always leave open circuit.

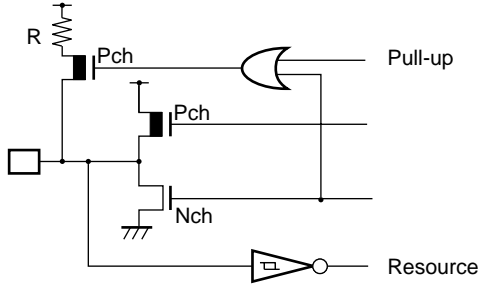
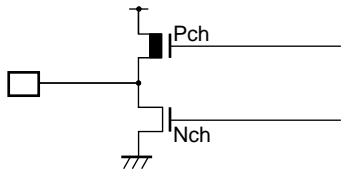
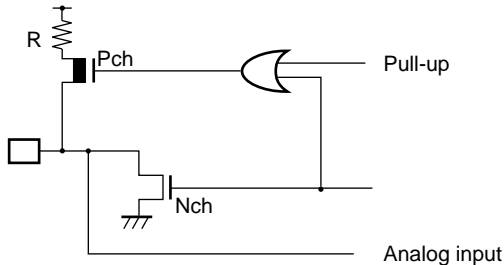
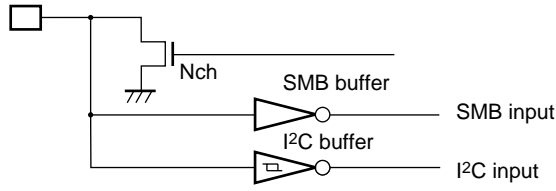
MB89960 Series

I/O CIRCUIT TYPE

Type	Circuit	Remarks
A	<p>Main clock control signal</p>	<p>High speed clock (main clock oscillation)</p> <ul style="list-style-type: none"> Oscillation feedback resistor
B	<p>Sub-clock control signal</p>	<p>Low speed clock (sub-clock oscillation)</p> <ul style="list-style-type: none"> Oscillation feedback resistor
C		<ul style="list-style-type: none"> CMOS input
D		<ul style="list-style-type: none"> Output pull-up resistor (Pch) approx. 50 kΩ (at 5 V) Hysteresis input
E	<p>Pull-up</p> <p>Port</p> <p>Resource</p>	<ul style="list-style-type: none"> CMOS output CMOS input Selectable pull-up resistor approx. 50 kΩ (at 5 V)

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Type	Circuit	Remarks
F		<ul style="list-style-type: none"> • CMOS output • Hysteresis input • Selectable pull-up resistor approx. 50 kΩ (at 5 V)
G		<ul style="list-style-type: none"> • CMOS output
H		<ul style="list-style-type: none"> • Nch-open drain output • Analog input (A/D converter) • Selectable pull-up resistor • (The pull-up resistor cannot be used when used as an analog input.) approx. 50 kΩ (at 5 V)
I		<ul style="list-style-type: none"> • Nch open drain output • Selectable SMB or I²C input buffer

■ HANDLING DEVICES

1. Do not exceed maximum rated voltage (to prevent latch-up)

Latch-up may occur on CMOS ICs if voltage higher than V_{CC} or lower than V_{SS} is applied to input or output pins other than medium- and high voltage pins or if the voltage applied between V_{CC} and V_{SS} higher the rating. If latch-up occurs, the power supply current increases rapidly resulting in thermal damage to circuit elements. Therefore, ensure that maximum ratings are not exceeded in circuit operation. Similarly, when turning the analog power supply on or off, ensure the analog power supply voltages (AV_{CC} and AVR) and analog input voltages do not exceed the digital power supply (V_{CC}).

2. Power supply voltage fluctuations

Rapid fluctuation of the voltage may cause the device to misoperate, even if the voltage remains within the allowed operating range.

The standard for power supply voltage stability is a peak-to-peak V_{CC} ripple voltage at the mains supply frequency (50 to 60 Hz) of 10% or less of V_{CC} and a transient voltage change rate of 0.1 V/ms or less such as when turning the power supply on or off.

3. Treatment of unused input pins

Leaving unused input pins unconnected can cause misoperation or permanent damage to the device due to latchup. Always pull-up or pull-down unused input pins using a 2 k Ω or larger resistor.

If some I/O pins are unused, either set as outputs and leave open circuit or set as inputs and treat in the same way as input pins.

4. Treatment of N.C. pins

Always leave N.C. (internally connected) pins open.

5. Treatment of power supply pins on microcontrollers with an A/D converter

Even if not using the A/D converter, connect to be $AV_{CC} = V_{CC}$ and $AV_{SS} = AVR = V_{SS}$.

6. Precautions on using an external clock

An oscillation stabilization delay occurs after a power-on reset or when recovering from sub-clock or stop mode, even if an external clock is used.

PROGRAMMING SPECIFICATIONS FOR ONE-TIME PROM PRODUCTS

The MB89P965A has a "PROM mode" that enables the microcontroller to be programmed using a general-purpose ROM programmer via a special adaptor. Note, however, that electronic signature mode is not available.

1. ROM Programmer Adaptor and Recommended ROM Writers

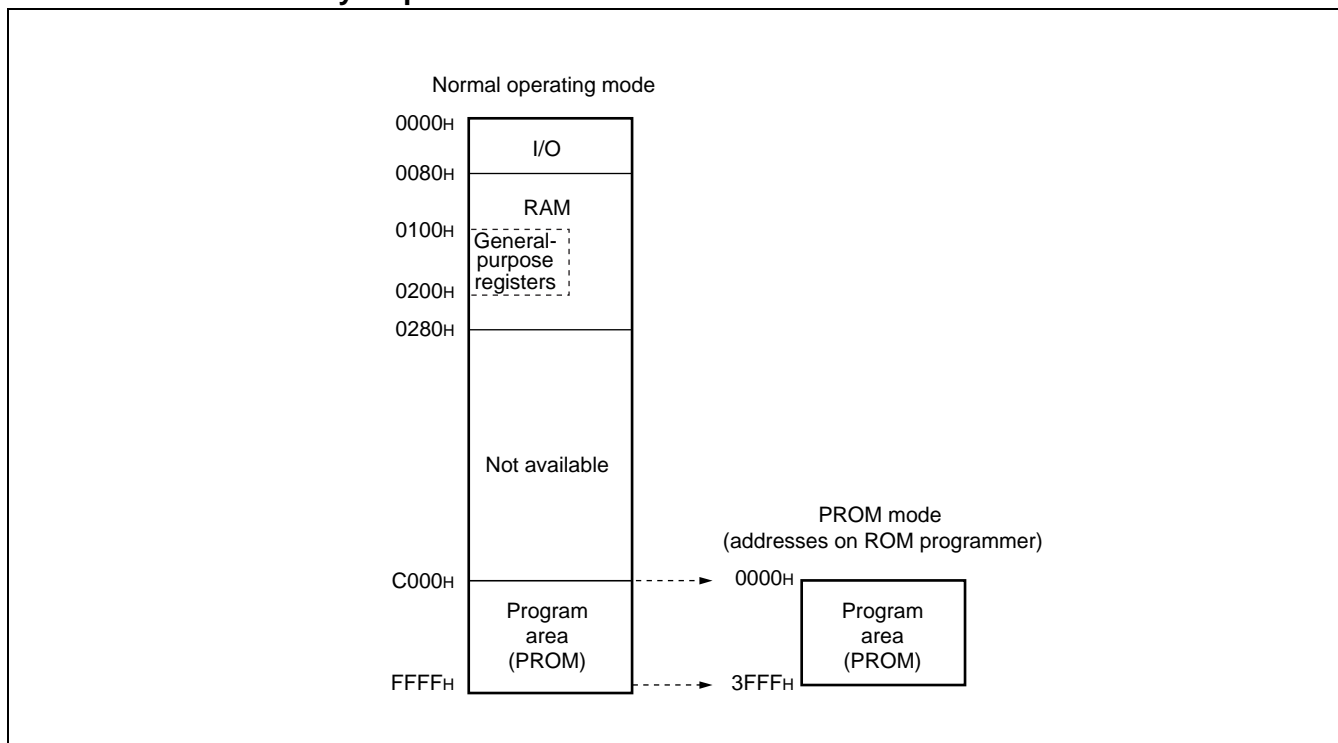
Package Name	Adaptor Part No.	Recommended Programmer Manufacturer and Model
	Sun Hayato Co. Ltd.	
FPT-48P-M05	ROM2-48LQF-32DP-8LA	AF9708 (ver 1.44 or later) AF9709 (ver 1.44 or later)
FPT-48P-M13	ROM2-48QF2-32DP-8LA	
FPT-48P-M16	ROM2-48QF-32DP-8LA	

- Enquiries

Sun Hayato Co. Ltd. : TEL 03-3986-0403

Ando Denki Co. Ltd. : TEL 044-549-7300

2. PROM Mode Memory Map



3. PROM Programming Procedure (When using an Ando EPROM programmer)

- 1) Set the EPROM programmer type code to 17209.
- 2) Load the program data into addresses 0000H to 3FFFH in the EPROM programmer.
- 3) Use the EPROM programmer to program to addresses C000H to FFFFH.

4. Programming Yield

Due to the nature of OTPROM memory, a program test to all bits on a blank OTPROM microcontroller cannot be performed at Fujitsu. For this reason, a programming yield of 100% cannot be assured at all times.

MB89960 Series

■ PROGRAMMING AND ERASING FLASH MEMORY ON THE MB89F969A

1. Flash Memory

The flash memory is located between 1000_H and FFFF_H in the CPU memory map and incorporates a flash memory interface circuit that allows read access and program access from the CPU to be performed in the same way as mask ROM. Programming and erasing flash memory is also performed via the flash memory interface circuit by executing instructions in the CPU. This enables the flash memory to be updated in place under the control of the CPU, providing an efficient method of updating program and data.

2. Flash Memory Features

- 60 K byte × 8-bit configuration (16 K + 8 K + 8 K + 28 K sectors)
- Automatic programming algorithm (Embedded algorithm* : Equivalent to MBM29LV200)
- Includes an erase pause and restart function
- Data polling and toggle bit for detection of program/erase completion
- Detection of program/erase completion via CPU interrupt
- Compatible with JEDEC-standard commands
- Sector Protection (sectors can be combined in any combination)
- No. of program/erase cycles : 10,000 (min.)

Embedded Algorithm is a trademark of Advanced Micro Devices.

3. Procedure for Programming and Erasing Flash Memory

Programming and reading flash memory cannot be performed at the same time. Accordingly, to program or erase flash memory, the program must first be copied from flash memory to RAM so that programming can be performed without program access from flash memory.

4. Flash Memory Register

- Control status register (FMCS)

Address	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Initial value
002EH	INTE	RDYINT	WE	RDY	Reserved	Reserved	—	Reserved	000X00-0B
	R/W	R/W	R/W	R	R/W	R/W	—	R/W	

5. Sector Configuration

The table below shows the sector configuration of flash memory and lists the addresses of each sector for both during CPU access a flash memory programming.

- Sector configuration of flash memory

Flash Memory	CPU Address	Programmer Address
16 K bytes	FFFF _H to C000 _H	1FFFF _H to 1C000 _H
8 K bytes	BFFF _H to A000 _H	1BFFF _H to 1A000 _H
8 K bytes	9FFF _H to 8000 _H	19FFF _H to 18000 _H
28 K bytes	7FFF _H to 1000 _H	17FFF _H to 11000 _H

* : Programmer address

The programmer address is the address to be used instead of the CPU address when programming data from a parallel flash memory programmer. Use the programmer address on programming or erasing using a general-purpose parallel programmer.

6. ROM Programmer Adaptor and Recommended ROM Programmers

Package Name	Adaptor Part No.	Recommended Programmer Manufacturer and Model
	Sun Hayato Co. Ltd.	Ando Denki Co. Ltd.
FPT-64P-M09	FLASH-64QF2-32DP-8LF	AF9708 (ver 1.60 or later) AF9709 (ver 1.60 or later)

- Enquiries

Sun Hayato Co. Ltd. : TEL 03-3986-0403

Ando Denki Co. Ltd. : TEL 044-549-7300

MB89960 Series

PROGRAMMING A PIGGYBACK/EVALUATION EPROM

1. EPROM Type

MBM27C256A-20TVM

2. Programming Adaptor

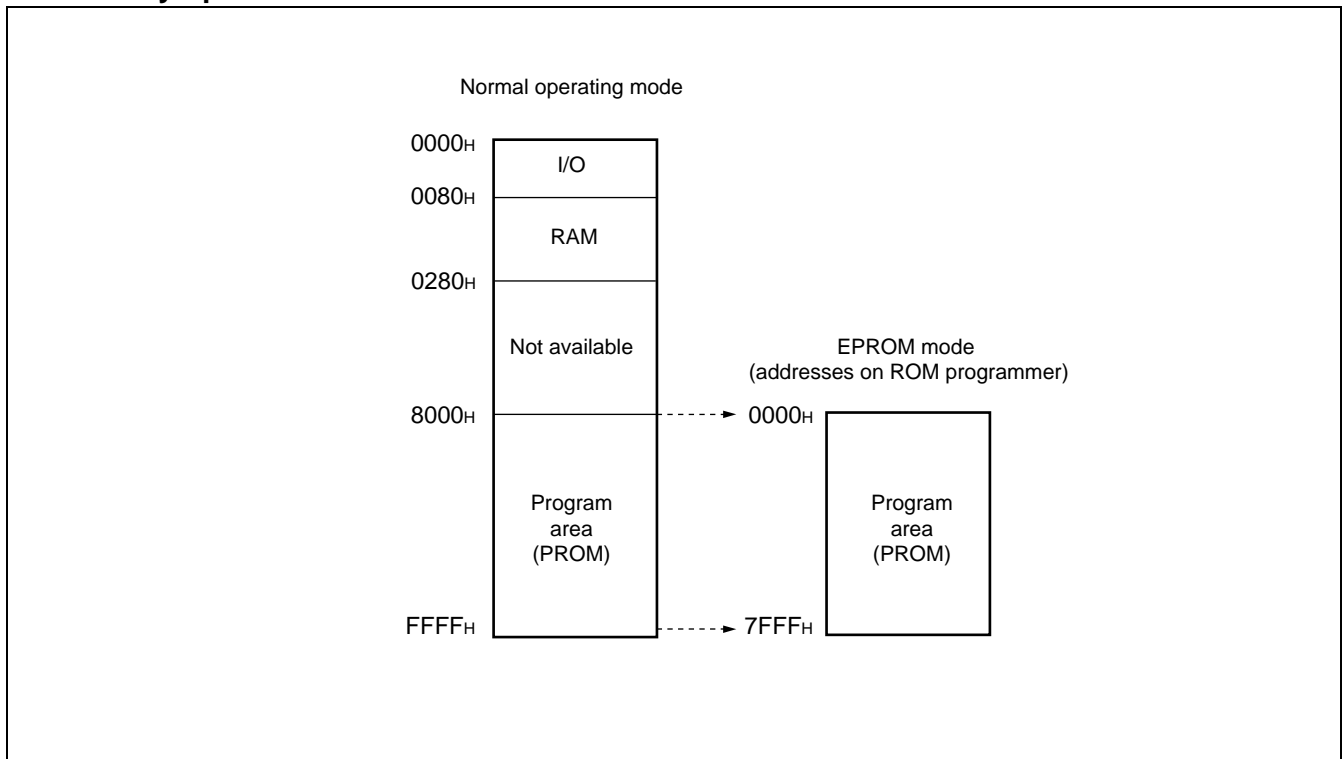
Use the following programming adaptor (made by Sun Hayato Co. Ltd.) to program the EPROM using a ROM programmer.

- Programming adaptor

Package	Adaptor Socket Part No.
LCC-32 (Square)	ROM-32LC-28DP-S

Enquiries Sun Hayato Co. Ltd. : TEL03-3986-0403

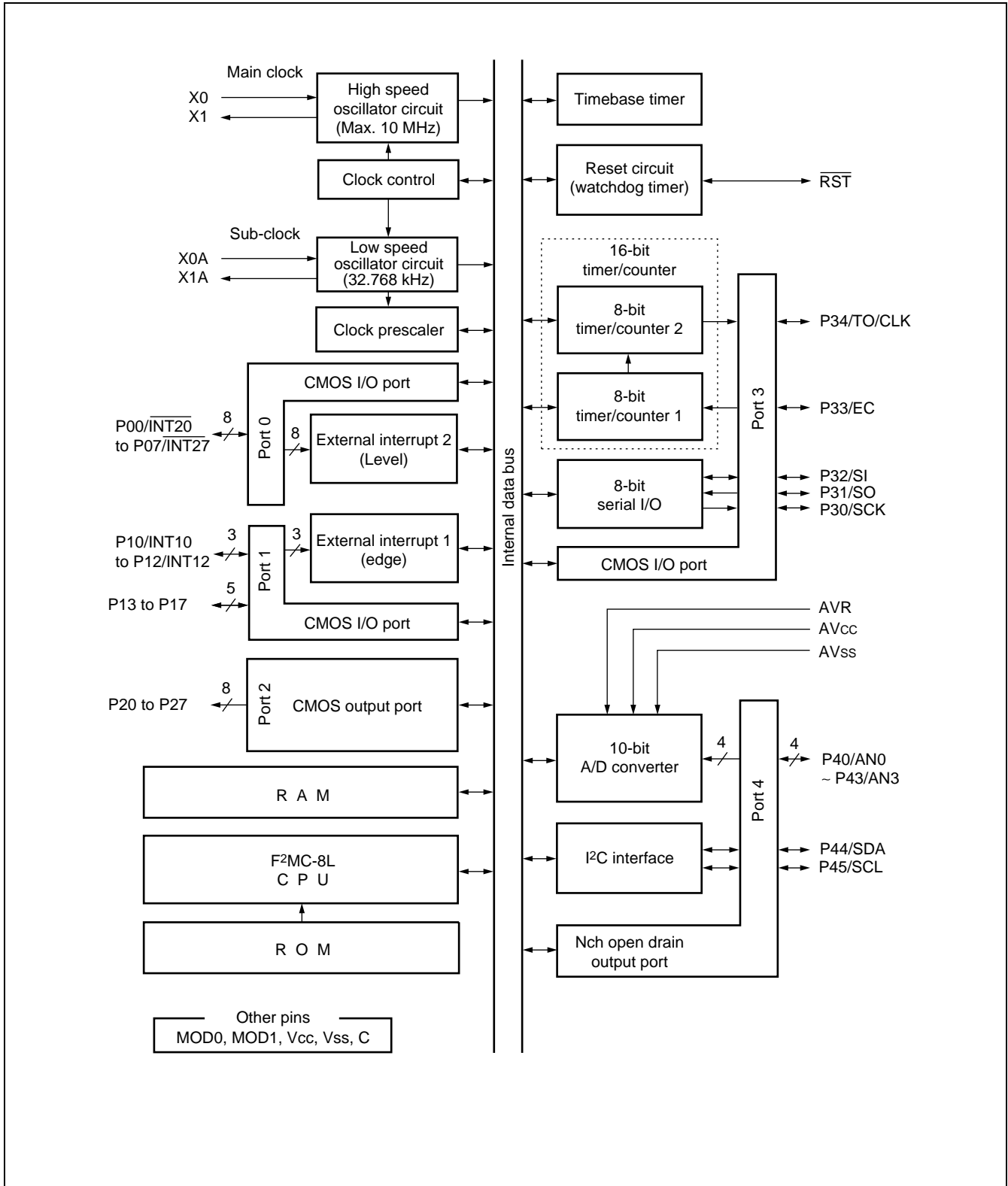
3. Memory Space



4. EPROM Programming Procedure

- (1) Setup the EPROM programmer to the MBM27C256A.
- (2) Load the program data into addresses 0000H to 7FFFH in the EPROM programmer.
- (3) Use the ROM programmer to program to addresses 0000H to 7FFFH.

■ BLOCK DIAGRAM



MB89960 Series

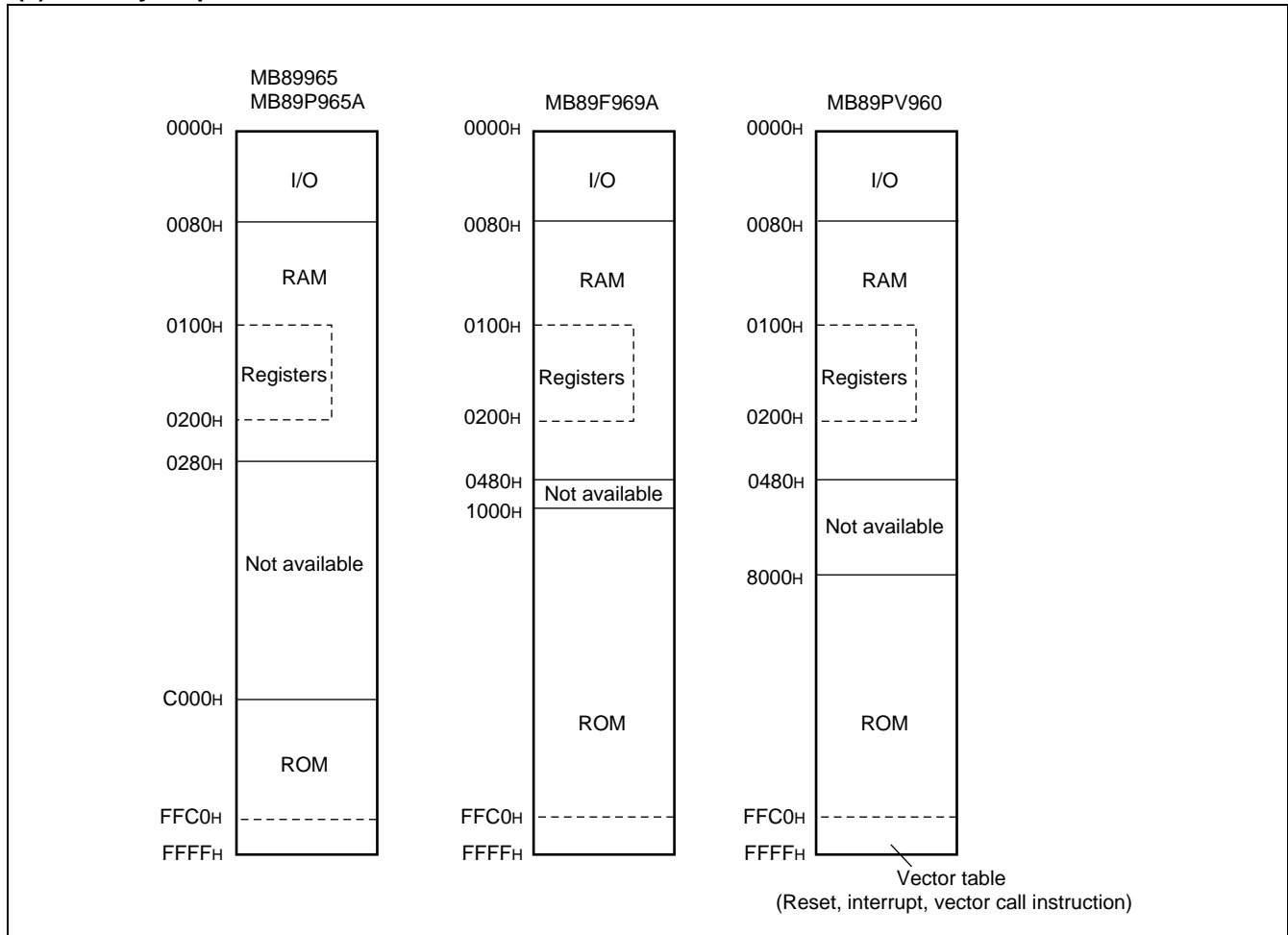
■ CPU CORE

1. Memory Space

(1) Structure of memory space

- **I/O area (address : 0000H to 007FH)**
 - Assign the control registers, data registers, and similar of the internal peripheral functions.
 - As the I/O area is allocated as part of the memory space, it can be accessed in the same way as memory. Direct addressing also provides high speed access.
- **RAM area**
 - Static RAM is provided as an internal data area.
 - The size of internal RAM differs between products.
 - Addresses 80H to FFH provide high speed access using direct addressing.
 - Addresses 100H to 1FFH are used as the general-purpose register area.
 - The initial value of RAM after a reset is undefined.
- **ROM area**
 - ROM memory is provided as the internal program area.
 - The size of internal ROM differs between products.
 - Addresses FFC0H to FFFFH are used for the vector table and similar.

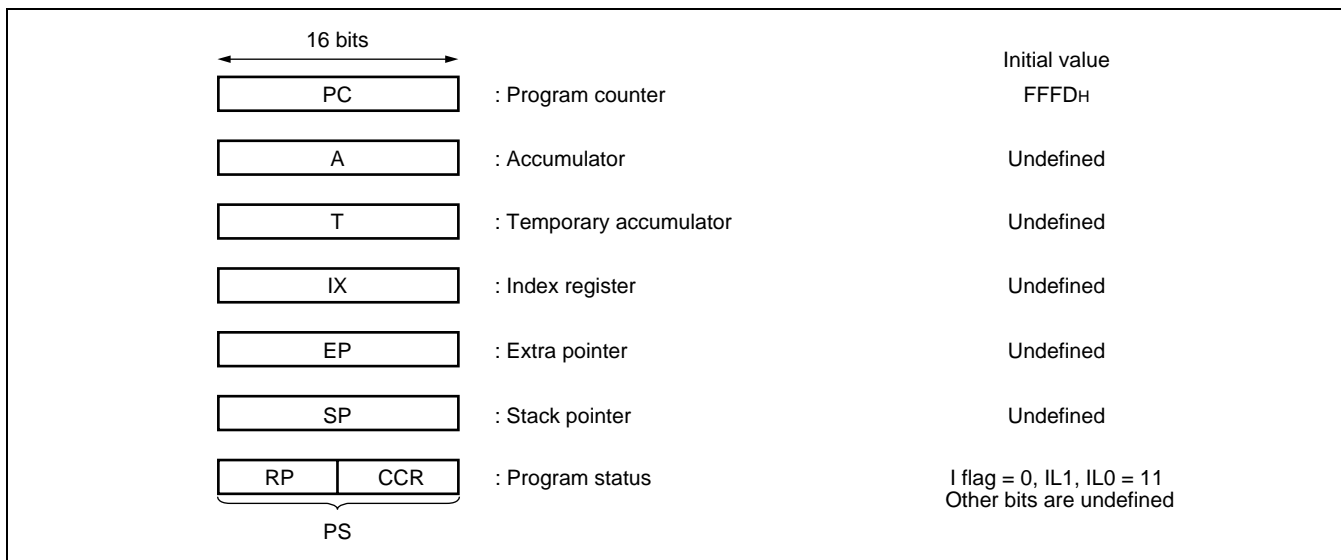
(2) Memory map



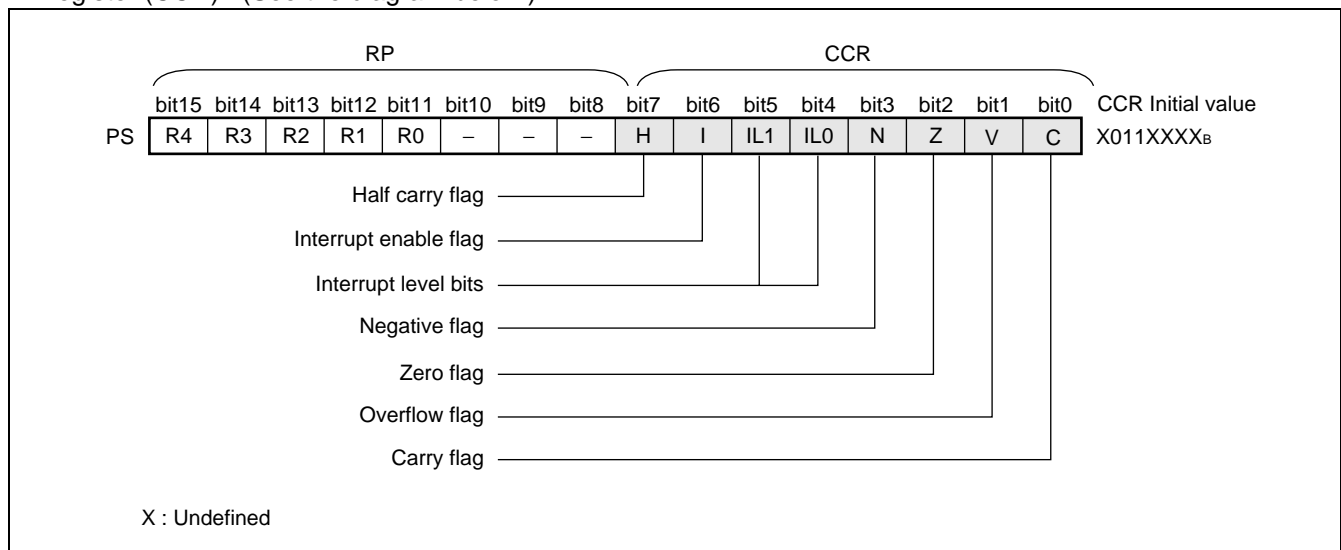
2. Registers

The MB89960 series provides two types of registers: dedicated registers in the CPU and general-purpose registers. The dedicated registers are as follows.

- Program counter (PC) : A 16-bit register for indicating the instruction storage positions.
- Accumulator (A) : A 16-bit register that provides temporary storage for arithmetic operations and similar. Instructions that operate on 8-bit data use the lower byte.
- Temporary accumulator (T) : A 16-bit register used for arithmetic operations with the accumulator. Instructions that operate on 8-bit data use the lower byte.
- Index register (IX) : A 16-bit register used for index modification.
- Extra pointer (EP) : A 16-bit pointer used for indicating a memory address .
- Stack pointer (SP) : A 16-bit register used for indicating a stack area.
- Program status (PS) : A 16-bit register used to store a register pointer and condition code.

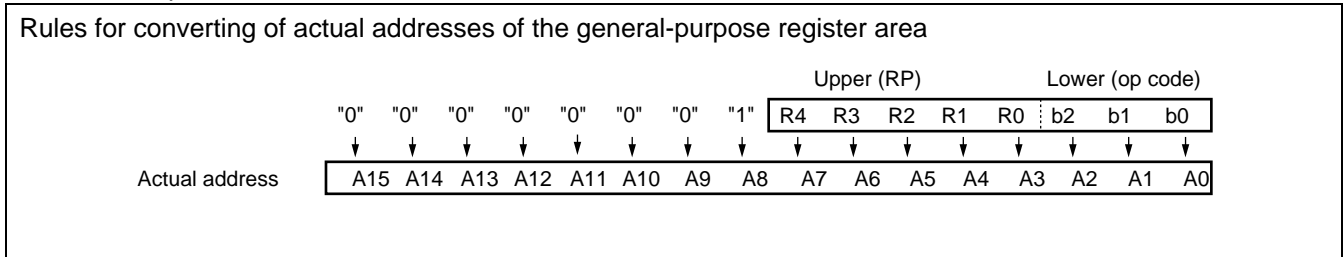


The upper 8 bits of the PS contain the register bank pointer (RP) and the lower 8 bits contain the condition code register (CCR) . (See the diagram below.)



MB89960 Series

The RP contains the address of the currently used register bank. The conversion diagram below shows the relationship between the RP value and actual address.



CCR contains bits that indicate the result of an arithmetic operation or information about transfer data and bits used to control CPU operation when an interrupt occurs.

- H-flag : Set to "1" when a carry from bit 3 to bit 4 or a borrow from bit 4 to bit 3 occurs as a result of an arithmetic operation. Cleared to "0" otherwise. This flag is for decimal adjustment instructions and should be ignored for operations other than addition and subtraction.
- I-flag : Interrupts are enabled when this flag is set to "1" and disabled when the flag is set to "0". Cleared to "0" by a reset.
- IL1, 0 : Indicates the level of interrupts currently allowed. The CPU only processes interrupts with a request level higher than the value indicated by these bits.

IL1	IL0	Interrupt Level	Priority
0	0	1	High
0	1		
1	0	2	Low = No interrupt
1	1	3	

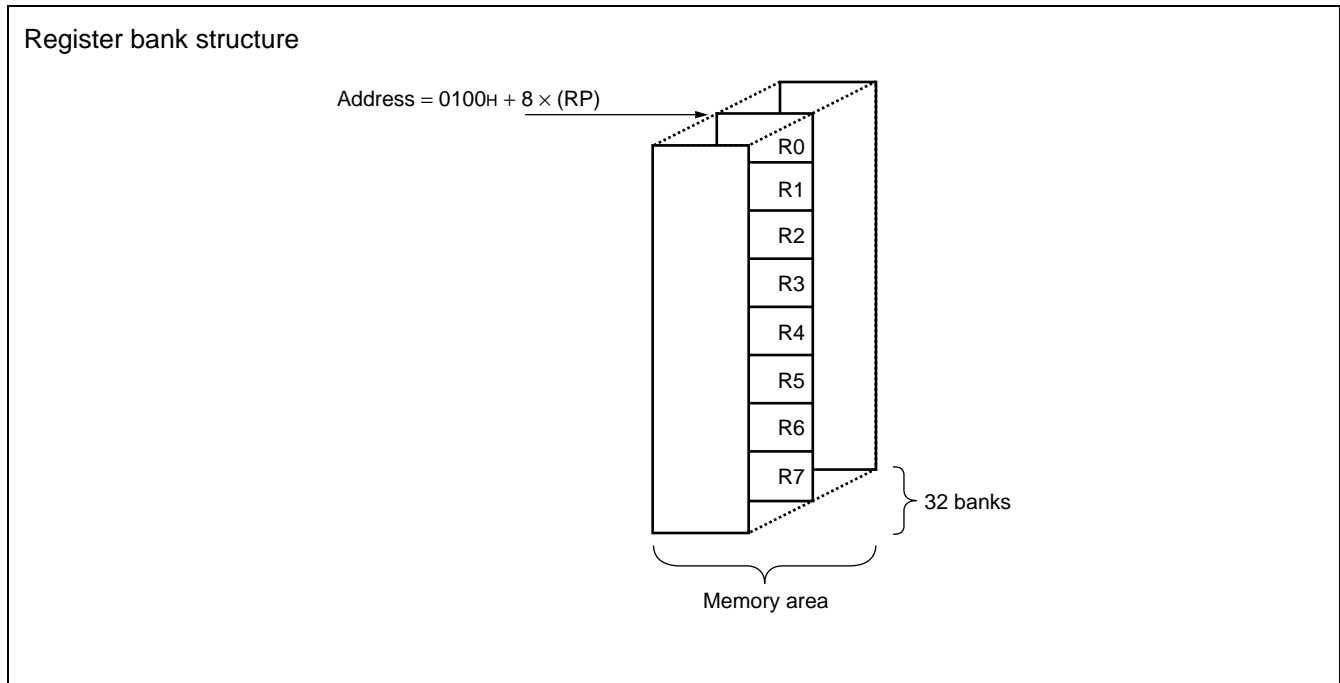
- N-flag : Set to "1" when the MSB of the result of an arithmetic operation is "1" and cleared to "0" when the MSB is "0".
- Z-flag : Set to "1" when the result of an arithmetic operation is zero. Cleared to "0" otherwise
- V-flag : Set to "1" when a 2's complement overflow occurs as the result of an arithmetic operation. Cleared to "0" if no 2's complement overflow occurs.
- C-flag : Set to "1" when a carry from bit 7 or a borrow to bit 7 occurs as the result of an arithmetic operation. Cleared to "0" otherwise. Set to the shift-out value in the case of a shift instruction.

The following general-purpose registers are provided :

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

The general-purpose registers are 8-bit registers and are allocated in the register banks of the memory. Each bank contains 8 registers and all 32 banks can be used on MB89960 series microcontrollers.

The register bank pointer (RP) specifies the bank that is currently in use.



MB89960 Series

■ I/O MAP

Address	Abbreviation	Register Name	Read/Write	Initial Value
00 _H	PDR0	Port 0 data register	R/W	XXXXXXXX _B
01 _H	DDR0	Port 0 direction register	W	0000000 _B
02 _H	PDR1	Port 1 data register	R/W	XXXXXXXX _B
03 _H	DDR1	Port 1 direction register	W	0000000 _B
04 _H	PDR2	Port 2 data register	R/W	0000000 _B
05 _H	(Unused area)			
06 _H				
07 _H	SYCC	System clock control register	R/W	X--MM100 _B
08 _H	STBC	Standby control register	R/W	00010-- _B
09 _H	WDTC	Watchdog control register	R/W	0---XXXX _B
0A _H	TBTC	Timebase timer control register	R/W	00---000 _B
0B _H	WPCR	Clock prescaler control register	R/W	00---000 _B
0C _H	PDR3	Port 3 data register	R/W	--XXXX _B
0D _H	DDR3	Port 3 direction register	R/W	--000000 _B
0E _H	PDR4	Port 4 data register	R/W	--111111 _B
0F _H	(Unused area)			
10 _H	IBSR	I ² C bus status register	R	0000000 _B
11 _H	IBCR	I ² C bus control register	R/W	00011000 _B
12 _H	ICCR	I ² C clock control register	R/W	000XXXX _B
13 _H	IADR	I ² C address register	R/W	-XXXXXXX _B
14 _H	IDAR	I ² C data register	R/W	XXXXXXXX _B
15 _H	(Unused area)			
16 _H				
17 _H				
18 _H	T2CR	Timer 2 control register	R/W	X0--XXX0 _B
19 _H	T1CR	Timer 1 control register	R/W	X000XXX0 _B
1A _H	T2DR	Timer 2 data register	R/W	XXXXXXXX _B
1B _H	T1DR	Timer 1 data register	R/W	XXXXXXXX _B
1C _H	SMR	Serial mode register	R/W	0000000 _B
1D _H	SDR	Serial data register	R/W	XXXXXXXX _B
1E _H	(Unused area)			
1F _H				
20 _H	ADC1	A/D control register 1	R/W	000000-0 _B
21 _H	ADC2	A/D control register 2	R/W	-0000001 _B
22 _H	ADDH	A/D data register H	R/W	-----XX _B

(Continued)

(Continued)

Address	Abbreviation	Register Name	Read/Write	Initial Value
23 _H	ADDL	A/D data register L	R/W	XXXXXXXX _B
24 _H	EIC1	External interrupt 1 control register 1	R/W	00000000 _B
25 _H	EIC2	External interrupt 1 control register 2	R/W	----0000 _B
26 _H to 27 _H	(Unused area)			
28 _H	PURR1	Pull-up resistor register 1 (MB89965, P965A, and F969A only)	R/W	11111111 _B
29 _H	PURR2	Pull-up resistor register 2 (MB89965, P965A, and F969A only)	R/W	11111111 _B
2A _H	PURR3	Pull-up resistor register 3 (MB89965, P965A, nd F969A only)	R/W	XXX11111 _B
2B _H	PURR4	Pull-up resistor register 4 (MB89965, P965A, and F969A only)	R/W	XXXX1111 _B
2C _H to 31 _H	(Unused area)			
32 _H	EIE2	External interrupt 2 control register	R/W	00000000 _B
33 _H	EIF2	External interrupt 2 flag register	R/W	-----0 _B
34 _H to 7B _H	(Unused area)			
7C _H	ILR1	Interrupt level setting register 1	W	11111111 _B
7D _H	ILR2	Interrupt level setting register 2	W	11111111 _B
7E _H	ILR3	Interrupt level setting register 3	W	11111111 _B
7F _H	ITR	Interrupt test register	Not available	XXXXXX00 _B

- Read/write notation

R/W : Reading and writing available

R : Read-only

W : Write-only

- Initial value notation

0 : Initial value of bit is "0".

1 : Initial value of bit is "1".

X : Initial value of bit is undefined.

M : Initial value of bit is specified by mask option.

- : Bit is not used.

Note : Do not use the "unused areas".

MB89960 Series

■ 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} AV_{CC}	$V_{SS} - 0.3$	$V_{SS} + 6.0$	V	*
	AVR	$V_{SS} - 0.3$	$V_{SS} + 6.0$		
Input voltage	V_I	$V_{SS} - 0.3$	$V_{CC} + 0.3$	V	Pins other than P44 and P55
		$V_{SS} - 0.3$	$V_{SS} + 6.0$		Pins P44 and P45
Output voltage	V_O	$V_{SS} - 0.3$	$V_{CC} + 0.3$	V	Pins other than P44 and P55
		$V_{SS} - 0.3$	$V_{SS} + 6.0$		Pins P44 and P45
"L" level maximum output current	I_{OL}	—	15	mA	
"L" level average output current	I_{OLAV}	—	4	mA	Average value (operating current × operating ratio)
"L" level total maximum output current	ΣI_{OL}	—	100	mA	
"L" level total average output current	ΣI_{OLAV}	—	40	mA	Average value (operating current × operating ratio)
"H" level maximum output current	I_{OH}	—	-15	mA	
"H" level average output current	I_{OHAV}	—	-4	mA	Average value (operating current × operating ratio)
"H" level total maximum output current	ΣI_{OH}	—	-50	mA	
"H" level total average output current	ΣI_{OHAV}	—	-20	mA	Average value (operating current × operating ratio)
Power consumption	P_D	—	300	mW	MB89F969A only
		—	450		
Operating temperature	T_A	-40	+85	°C	
Storage temperature	T_{stg}	-55	+150	°C	

* : Set AV_{CC} to the same potential as V_{CC} .
Also ensure that AV_{CC} does not exceed V_{CC} at power on.

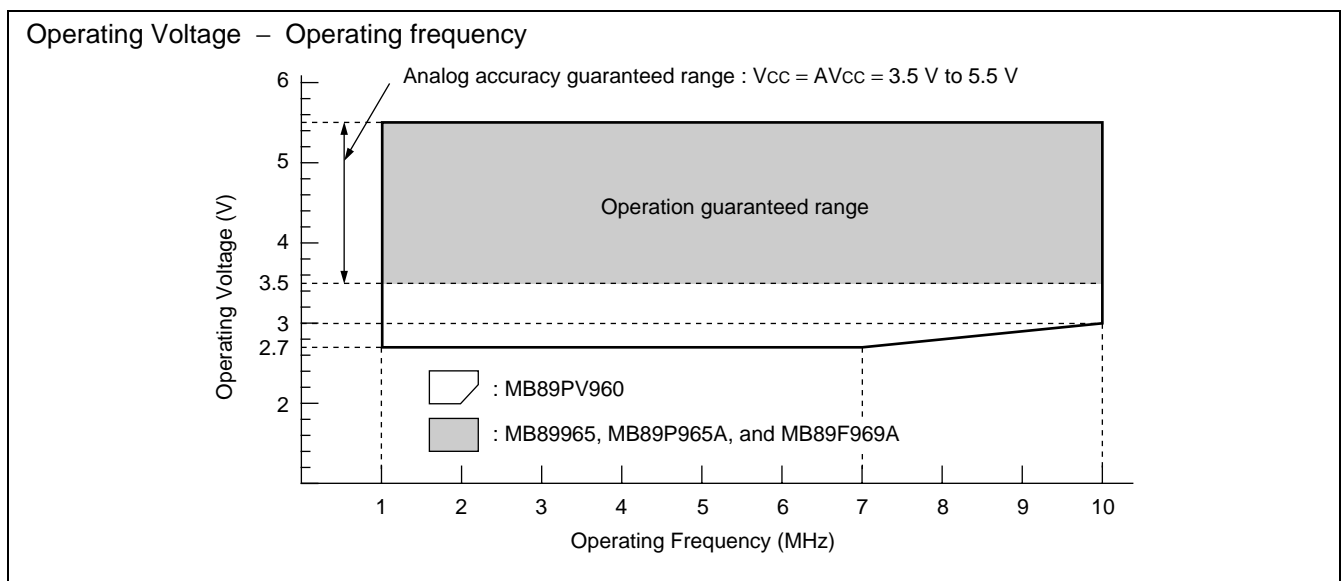
WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

2. Recommended Operating Conditions

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

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC} AV_{CC}	3.5*	5.5*	V	Normal operation guaranteed range (MB89965/P965A/F969A)
		3.0	5.5	V	To maintain RAM state in stop mode (MB89965/P965A/F969A)
		2.7*	5.5*	V	Normal operation guaranteed range (MB89PV960)
		1.5	5.5	V	To maintain RAM state in stop mode (MB89PV960)
	AVR	3.5	AV_{CC}	V	
Operating temperature	T_A	-40	+85	°C	

* : Differs depending on the operating frequency and analog guaranteed range. See the figure below and "5. Electrical Characteristics for the A/D Converter".



The figure above shows the frequency of the external oscillator when the instruction cycle setting is $4/F_C$. As the operating voltage depends on the instruction cycle, change to the new instruction cycle value if using the gear function to change the operating speed.

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.

MB89960 Series

3. DC Characteristics

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

Parameter	Symbol	Pin Name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
"H" level input voltage	V_{IH}	P00 to P07, P10 to P17, P30 to P34	—	$0.7 V_{CC}$	—	$V_{CC} + 0.3$	V	
	V_{IHS}	\overline{RST} , INT20 to INT27, INT10 to INT12, SI, SCK, EC, TEST	—	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V	
	V_{IHM}	MOD0/1/2	—	$V_{CC} - 0.3$	—	$V_{CC} + 0.3$	V	MOD pin input
	V_{IHSMB}	SCL, SDA	—	$V_{SS} + 1.4$	—	$V_{SS} + 5.5$	V	When SMB selected
	V_{IH2C}			$0.7 V_{CC}$	—	$V_{SS} + 5.5$	V	When I ² C selected
"L" level input voltage	V_{IL}	P00 to P07, P10 to P17, P30 to P34	—	$V_{SS} - 0.3$	—	$0.3 V_{CC}$	V	
	V_{ILS}	\overline{RST} , INT20 to INT27, INT10 to INT12, SI, SCK, EC, TEST	—	$V_{SS} - 0.3$	—	$0.2 V_{CC}$	V	
	V_{ILM}	MOD0/1/2	—	$V_{SS} - 0.3$	—	$V_{SS} + 0.3$	V	MOD pin input
	V_{ILSMB}	SCL, SDA	—	$V_{SS} - 0.3$	—	$V_{SS} + 0.6$	V	When SMB selected
	V_{IL2C}			$V_{SS} - 0.3$	—	$0.3 V_{CC}$	V	When I ² C selected
Voltage applied to open drain output pins	V_D	P40 to P45	—	$V_{SS} - 0.3$	—	$V_{CC} + 0.3$	V	
"H" level output voltage	V_{OH}	P00 to P07, P10 to P17, P20 to P27, P30 to P34	$I_{OH} = -2.0\text{ mA}$	4.0	—	—	V	
"L" level output voltage	V_{OL}	P00 to P07, P10 to P17, P20 to P27, P30 to P34, P40 to P45, \overline{RST}	$I_{OL} = 4.0\text{ mA}$	—	—	0.4	V	

(Continued)

MB89960 Series

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

Parameter	Sym- bol	Pin Name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Input leak current	I _{LI}	P00 to P07, P10 to P17, P20 to P27, P30 to P34, P40 to P45	$0\text{ V} < V_I < V_{CC}$	-5	—	+5	μA	Without pull-up resistor option
		MOD0/1/2, TEST		-10	—	+10		
Open-drain output leak current	I _{LIOD}	P40 to P45	$0\text{ V} < V_I < V_{SS} + 5.5\text{ V}$	—	—	+5	μA	
Pull-up resistance	R _{PULL}	P00 to P07, P10 to P17, P20 to P27, P30 to P34, P40 to P45, RST	$V_I = 0.0\text{ V}$	25	50	100	Ω	With pull-up resistor option
Power supply current*1	I _{CC1}	V_{CC} (when using an external clock)	$F_{CH} = 10.0\text{ MHz}$ $t_{INST}^{*2} = 0.4\text{ }\mu\text{s}$ main run mode	—	10	20	mA	MB89PV960
				—	4	7		MB89965 MB89P965A
				—	5	8		MB89F969A
	I _{CC2}		$F_{CH} = 10.0\text{ MHz}$ $t_{INST}^{*2} = 6.4\text{ }\mu\text{s}$ main run mode	—	3	8	mA	MB89PV960
				—	1	3		MB89965 MB89P965A MB89F969A
	I _{CCS1}		$F_{CH} = 10.0\text{ MHz}$ $t_{INST}^{*2} = 0.4\text{ }\mu\text{s}$ main sleep mode	—	3	8	mA	MB89PV960
—		2		4	MB89965 MB89P965A MB89F969A			

(Continued)

MB89960 Series

(Continued)

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

Parameter	Sym- bol	Pin Name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Power supply current*1	I _{CCS2}	V _{CC} (when using an external clock)	F _{CH} = 10.0 MHz t _{INST} *2 = 6.4 μs main sleep mode	—	1	3	mA	
	I _{CCL}		F _{CH} = 32.768 kHz sub run mode	—	70	150	μA	MB89PV960
				—	20	100		MB89965
				—	0.3	1	mA	MB89P965A MB89F969A
	I _{CCLS}		F _{CH} = 32.768 kHz sub sleep mode	—	10	50	μA	
	I _{CCF}		F _{CH} = 32.768 kHz • clock mode, main stop mode	—	5	15	μA	
I _{CCH}	T _A = +25 °C • sub stop mode	—	1	10	μA	MB89PV960		
		—	5	10		MB89965 MB89P965A MB89F969A		
Input capacitance	C _{IN}	Except AV _{CC} , AV _{SS} , V _{CC} , and AV _{SS}	f = 1 MHz	—	10	—	pF	

*1 : The power supply current values are for an external clock.

*2 : See “(4) Instruction Cycle” in “4. AC Characteristics”.

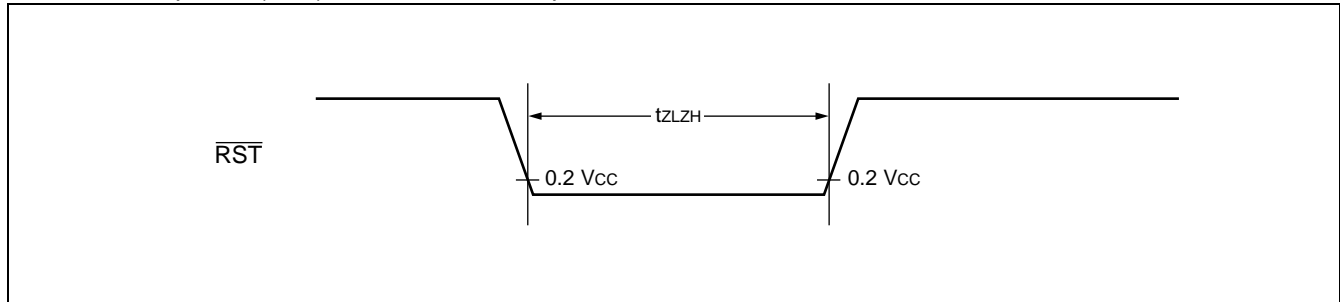
4. AC Characteristics

(1) Reset Timing

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

Parameter	Symbol	Condition	Value		Unit	Remarks
			Min.	Max.		
$\overline{\text{RST}}$ "L" pulse width	t_{LZH}	—	48 t_{HCYL}^*	—	ns	

* : t_{HCYL} is the period ($1/F_c$) of the oscillation input to X0.



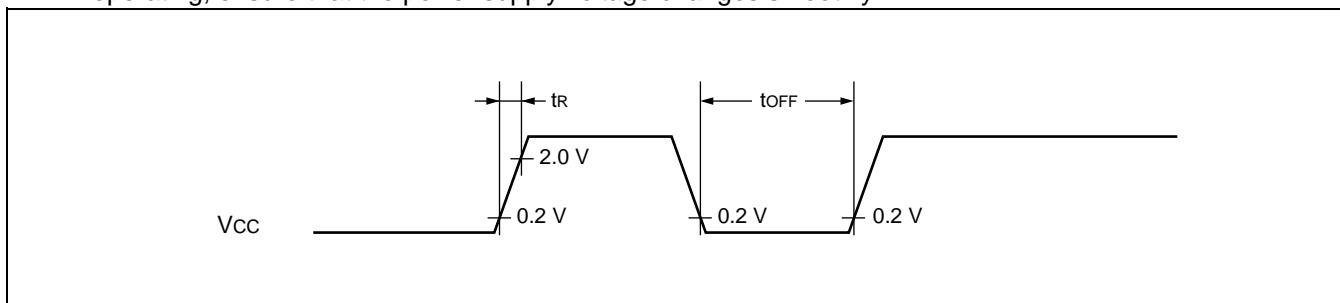
(2) Power-On Reset

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

Parameter	Symbol	Condition	Value		Unit	Remarks
			Min.	Max.		
Power supply rising time	t_{R}	—	0.5	50	ms	
Power supply cutoff time	t_{OFF}	—	1	—	ns	For repeated operation

Note : Ensure that the power supply rising time is less than the selected oscillation stabilization delay time.

For example, if the main clock frequency $F_c = 10\text{ MHz}$ and $2^{14}/F_c$ is selected as the oscillation stabilization delay time, the resulting oscillation stabilization delay time is 1.6 ms. As rapid changes in the power supply voltage may cause a power-on reset, if you need to change the power supply voltage while the device is operating, ensure that the power supply voltage changes smoothly.



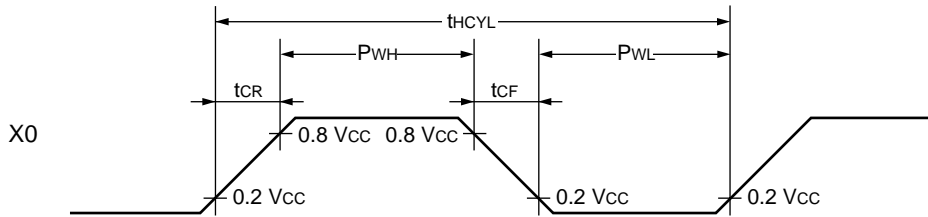
MB89960 Series

(3) Clock Timings

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

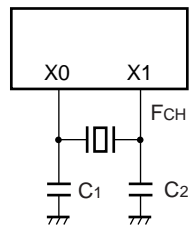
Parameter	Symbol	Pin Name	Value			Unit	Remarks
			Min.	Typ.	Max.		
Clock frequency	F_{CH}	X0, X1	1	—	10	MHz	Main clock
	F_{CL}	X0A, X1A	—	32.768	—	kHz	Sub clock
Clock cycle time	t_{HCYL}	X0, X1	100	—	1000	ns	Main clock
	t_{LCYL}	X0A, X1A	—	30.5	—	μs	Sub clock
Input clock pulse width	P_{WH} P_{WL}	X0	20	—	—	ns	External clock
	P_{WHL} P_{WLL}	X0A	—	15.2	—	μs	External clock
Input clock rising/falling time	t_{CR} t_{CF}	X0	—	—	10	ns	External clock

• X0 and X1 clock timing and input conditions

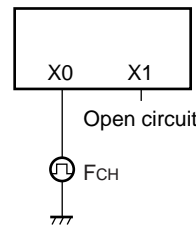


• Clock configurations

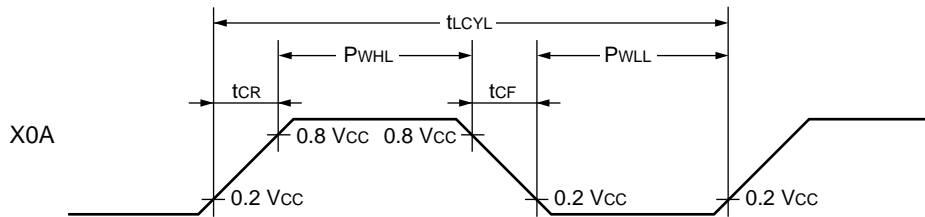
When using a crystal oscillator or ceramic oscillator



When using an external clock

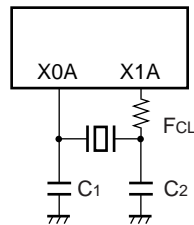


• X0A and X1A clock timing conditions

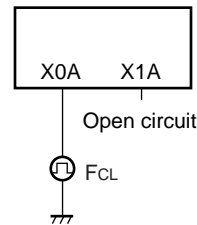


• Sub clock configuration

When using a crystal oscillator or ceramic oscillator



When using an external clock



(4) Instruction Cycle

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

Parameter	Symbol	Value	Unit	Remarks
Instruction cycle (Minimum instruction execution time)	t _{INST}	4/F _{CH} , 8/F _{CH} , 16/F _{CH} , 64/F _{CH}	μs	F _{CH} = 10 MHz (4/F _{CH}) operation time t _{INST} = 0.4 μs
		2/F _{CL}		F _{CL} = 32.768 kHz operation time t _{INST} = 61.036 μs

MB89960 Series

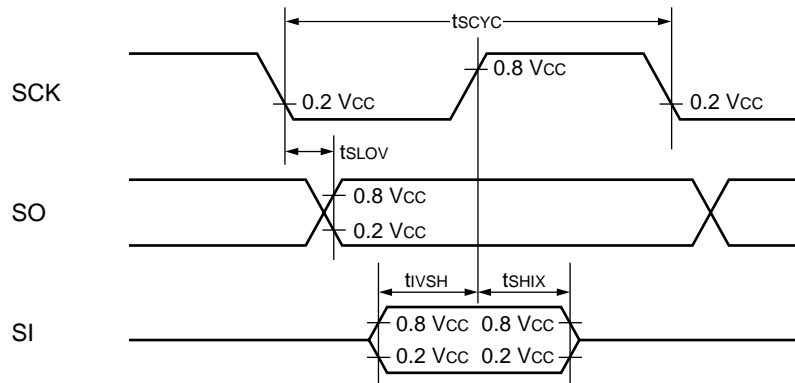
(5) Serial I/O Timings

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

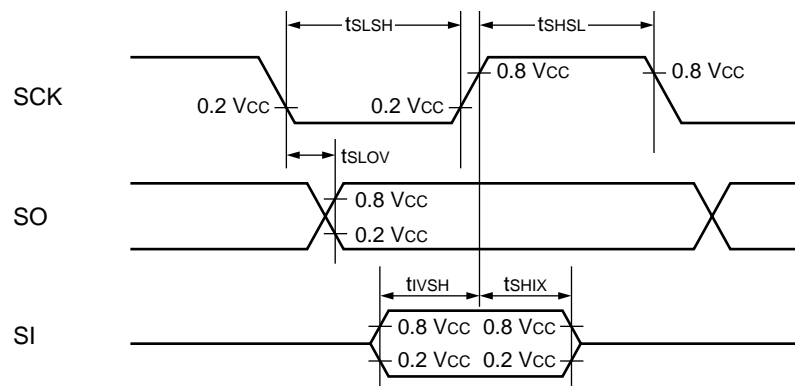
Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min.	Max.		
Serial clock cycle time	t_{SCYC}	SCK	Internal clock operation	$2 t_{INST}^*$	—	μs	
SCK $\downarrow \rightarrow$ SO delay time	t_{SLOV}	SCK, SO		-200	200	ns	
Valid SI \rightarrow SCK \uparrow	t_{IVSH}	SCK, SI		200	—	ns	
SCK $\uparrow \rightarrow$ valid SI hold time	t_{SHIX}	SCK, SI		200	—	ns	
Serial clock "H" pulse width	t_{SHSL}	SCK	External clock operation	t_{INST}^*	—	μs	
Serial clock "L" pulse width	t_{SLSH}	SCK		t_{INST}^*	—	μs	
SCK $\downarrow \rightarrow$ SO delay time	t_{SLOV}	SCK, SO		0	200	ns	
Valid SI \rightarrow SCK	t_{IVSH}	SCK, SI		200	—	μs	
SCK $\uparrow \rightarrow$ valid SI hold time	t_{SHIX}	SCK, SI		200	—	μs	

* : See "(4) Instruction cycle" for a definition of t_{INST} .

• Internal shift clock mode



• External shift clock mode

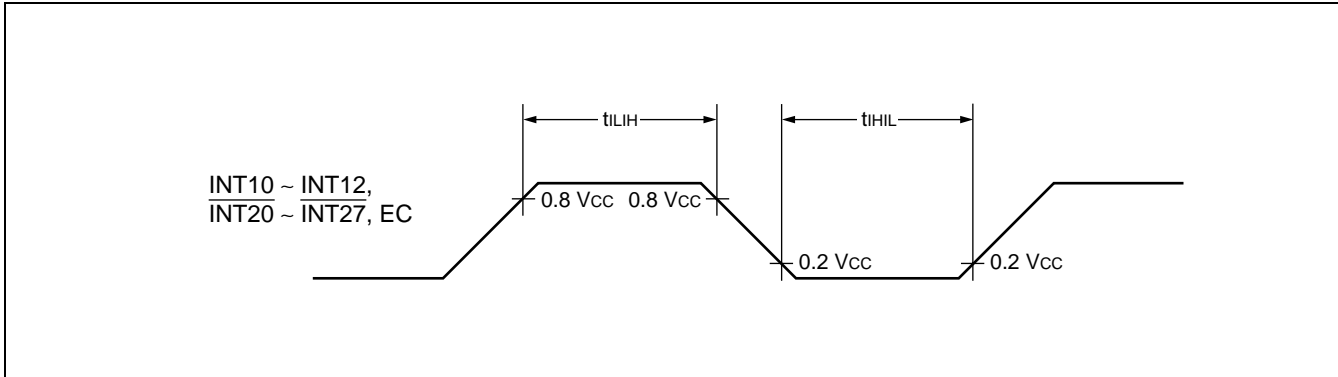


(6) Peripheral Input Timings

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

Parameter	Symbol	Pin Name	Value		Unit	Remarks
			Min.	Max.		
Peripheral input "H" pulse width	t_{LIH}	INT10 to INT12, INT20 to INT27, EC	$2 t_{INST}^*$	—	μs	
Peripheral input "L" pulse width	t_{HIL}		$2 t_{INST}^*$	—	μs	

* : See "(4) Instruction cycle" for a definition of t_{INST} .



MB89960 Series

(7) I²C Timings

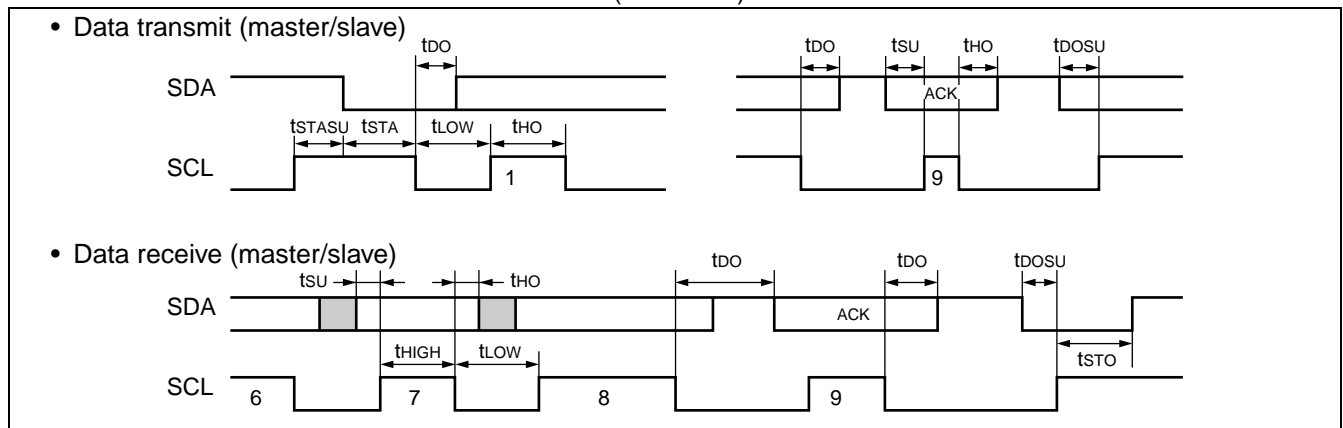
(V_{CC} = 5.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = -40 °C to +85 °C)

Parameter	Sym bol	Pin	Value		Unit	Remarks
			Min.	Max.		
Start condition output	t _{STA}	SCL SDA	$1/4t_{INST}^{*1} \times m^{*2} \times n^{*3} - 20$	$1/4t_{INST}^{*1} \times m^{*2} \times n^{*3} + 20$	ns	Master mode
Stop condition output	t _{STO}	SCL SDA	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) - 20$	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) + 20$	ns	Master mode
Start condition detect	t _{STA}	SCL SDA	$1/4t_{INST}^{*1} \times 6 + 40$	—	ns	
Stop condition detect	t _{STO}	SCL SDA	$1/4t_{INST}^{*1} \times 6 + 40$	—	ns	
Restart condition output	t _{STASU}	SCL SDA	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) - 20$	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) + 20$	ns	Master mode
Restart condition detect	t _{STASU}	SCL SDA	$1/4t_{INST}^{*1} \times 4 + 40$	—	ns	
SCL output "L" width	t _{LOW}	SCL	$1/4t_{INST}^{*1} \times m^{*2} \times n^{*3} - 20$	$1/4t_{INST}^{*1} \times m^{*2} \times n^{*3} + 20$	ns	Master mode
SCL output "H" width	t _{HIGH}	SCL	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) - 20$	$1/4t_{INST}^{*1} \times (m^{*2} \times n^{*3} + 8) + 20$	ns	Master mode
SDA output delay	t _{DO}	SDA	$1/4t_{INST}^{*1} \times 4 - 20$	$1/4t_{INST}^{*1} \times 4 + 20$	ns	
SDA output setup time after interrupt	t _{DOSU}	SDA	$1/4t_{INST}^{*1} \times 4 - 20$	—	ns	
SCL input "L" pulse width	t _{LOW}	SCL	$1/4t_{INST}^{*1} \times 6 + 40$	—	ns	
SCL input "H" pulse width	t _{HIGH}	SCL	$1/4t_{INST}^{*1} \times 2 + 40$	—	ns	
SDA input setup time	t _{SU}	SDA	40	—	ns	
SDA hold time	t _{HO}	SDA	0	—	ns	

*1: See "(4) Instruction cycle" for a definition of t_{INST}.

*2: m is the value set in the ICCR : CS4 and CS3 bits (bits 4 to 3) .

*3: n is the value set in the ICCR : CS2 to CS0 bits (bits 2 to 0) .



5. Electrical Characteristics for the A/D Converter

(AVCC = 3.5 V to 5.5 V, AVSS = VSS = 0.0 V, TA = -40 °C to +85 °C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Resolution	—	—	—	—	—	10	bit	
Total error			—	-5.0	—	+5.0	LSB	
Non-linearity error			—	-2.5	—	+2.5	LSB	
Differential linearity error			—	-1.9	—	+1.9	LSB	
Zero transition voltage	V _{OT}	—	AVR = AVCC	AVR - 3.5 LSB	AVR + 0.5 LSB	AVR + 4.5 LSB	mV	
Full-scale transition voltage	V _{FST}		V _{CC} - 6.5 LSB	V _{CC} - 1.5 LSB	V _{CC} + 1.5 LSB	mV		
Variation between channels	—		—	—	4	LSB		
A/D mode conversion time*2	—	—	—	—	60 t _{INST} *1	—	μs	MB89965 MB89P965A MB89F969A
				—	38 t _{INST} *1	—	μs	MB89PV960
A/D sampling time				—	16 t _{INST} *1	—	μs	
Analog input current	I _{AIN}	AN0 to AN3	—	—	10	μA		
Analog input voltage range	V _{AIN}	—	AVSS	—	AVR	V		
Power supply current	I _A	AVCC	A/D operation	—	1.5	3	mA	
	I _{AH}		TA = +25 °C A/D stop	—	1	5	μA	
Reference voltage	—	—	—	AVSS + 3.5	—	AVCC	V	
Reference voltage supply current	I _R	AVR	A/D operation	—	400	—	μA	
	I _{RH}		A/D stop	—	—	5	μA	

*1 : See “ (4) Instruction cycle” for a definition of t_{INST}.

*2 : Includes sampling time.

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6. A/D Converter Glossary

- Resolution

The change in analog voltage that can be recognized by the A/D converter.

- Linearity error (unit : LSB)

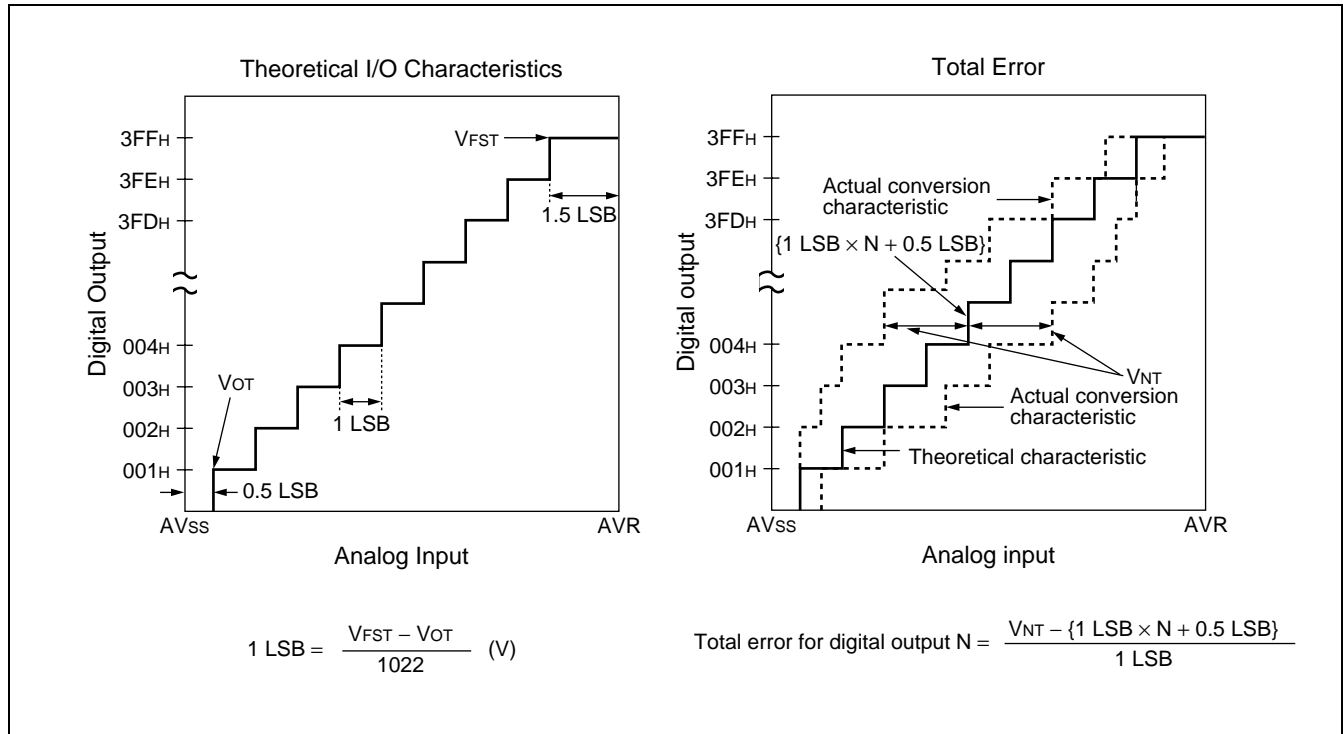
The deviation between the actual conversion characteristics and the line linking the zero transition point (“00 0000 0000_B” ↔ “00 0000 0001_B”) and the full scale transition point (“11 1111 1110_B” ↔ “11 1111 1111_B”).

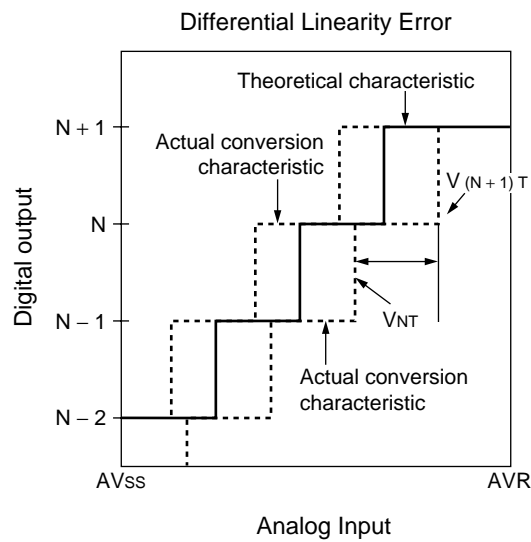
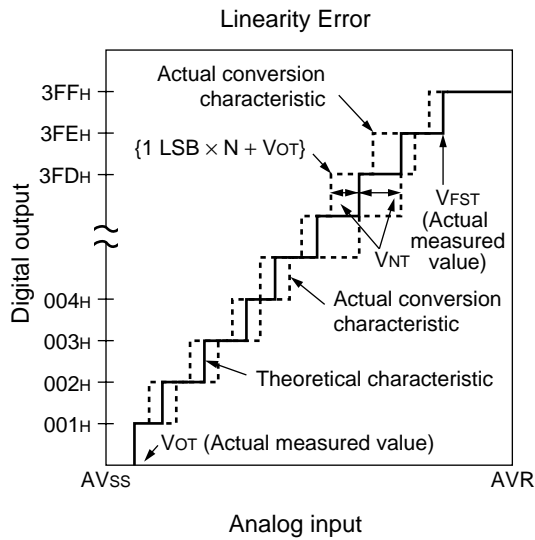
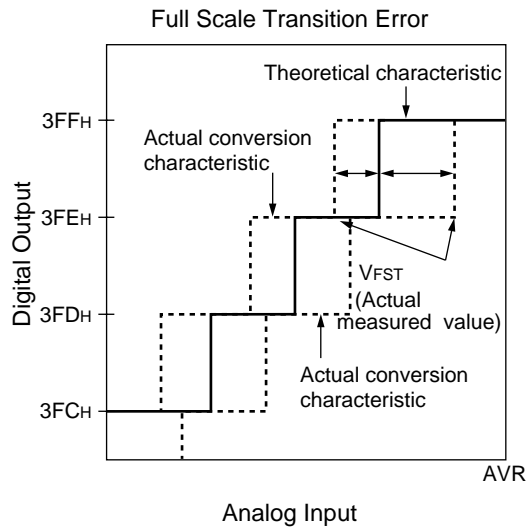
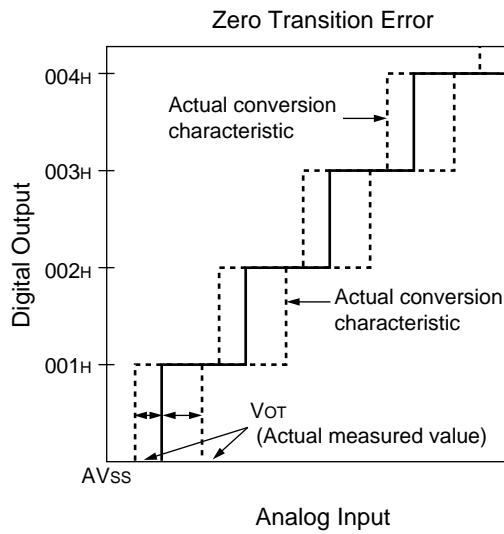
- Differential linearity error (unit : LSB)

The variation from the ideal input voltage required to change the output code by 1 LSB.

- Total error (unit : LSB)

The total error is the difference between the actual value and the theoretical value.





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

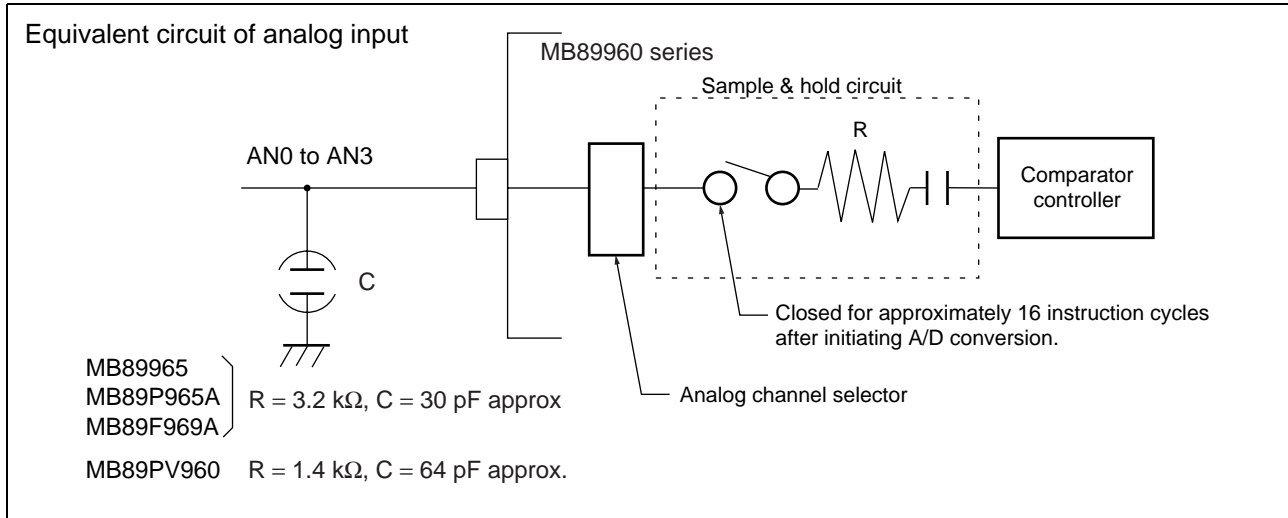
$$\text{Differential linearity error of digital output } N = \frac{V_{(N+1)T} - V_{NT}}{1 \text{ LSB}} - 1$$

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7. Notes for A/D Conversion

- Analog input pins and input impedance

The A/D converter incorporates a sample & hold circuit as shown below. When an A/D conversion starts, the voltage at the analog input pin is captured by the sample & hold capacitor for a period of 16 instruction cycles. Accordingly, if the output impedance of the external circuit connected to the analog input is high, the analog input voltage may not stabilize within the period of the analog input sampling time. Therefore, ensure that the output impedance of the external circuit is sufficiently low (10 kΩ or less). If it is not possible to reduce the output impedance of the external circuit, connecting an external capacitor of approximately 0.1 μF is recommended.



- Error

The relative error increases as $|AVR - AV_{SS}|$ becomes smaller.

8. Electrical Characteristics of Flash Memory

- Programming and erasing characteristics

Parameter			Sym bol	Pin Name	Condition	Value			Unit	Remarks
						Min.	Typ.	Max.		
Power supply current*1			I _{FWE}	V _{CC}	V _{CC} = 5.0 V	—	—	40	mA	
Sector erasing time	Fixed time per sector regardless of size	Successful completion time	—	—	—	—	1	15	s	
		Unsuccess- ful comple- tion time				—	—	*2	—	
Programming time	per byte	Successful completion time	—	—	—	—	8	3600	μs	
		Unsuccess- ful comple- tion time				—	650	3600	μs	

*1 : Automatic algorithm executing

*2 : If a fault occurs during sector erasing, detection via DQ₅ may not be available (DQ₅ = 1 may not occur) .
Accordingly, a fault must be assumed after 15 s, even if DQ₅ does not go to "1".

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■ MASK OPTIONS

NO	Part No.	MB89965	MB89P965A/ MB89F969A	MB89PV960
	Specifying procedure	Specify when ordering mask	Not available	Not available
1	Initial value* selection for main clock oscillation stabilization delay time ($F_{CH} = 10 \text{ MHz}$) <ul style="list-style-type: none"> • 01 : $2^{12}/F_{CH}$ (0.4 ms approx.) • 10 : $2^{16}/F_{CH}$ (6.6 ms approx.) • 11 : $2^{18}/F_{CH}$ (26.2 ms approx.) 	Selectable	$2^{18}/F_{CH}$ (26.2 ms approx.)	$2^{18}/F_{CH}$ (26.2 ms approx.)

F_{CH} : Frequency of main clock oscillation

* : This specifies the initial value after a reset of the oscillation stabilization delay time setting bits in the system clock control register (SYCC : WT1, WT0)

■ ORDERING INFORMATION

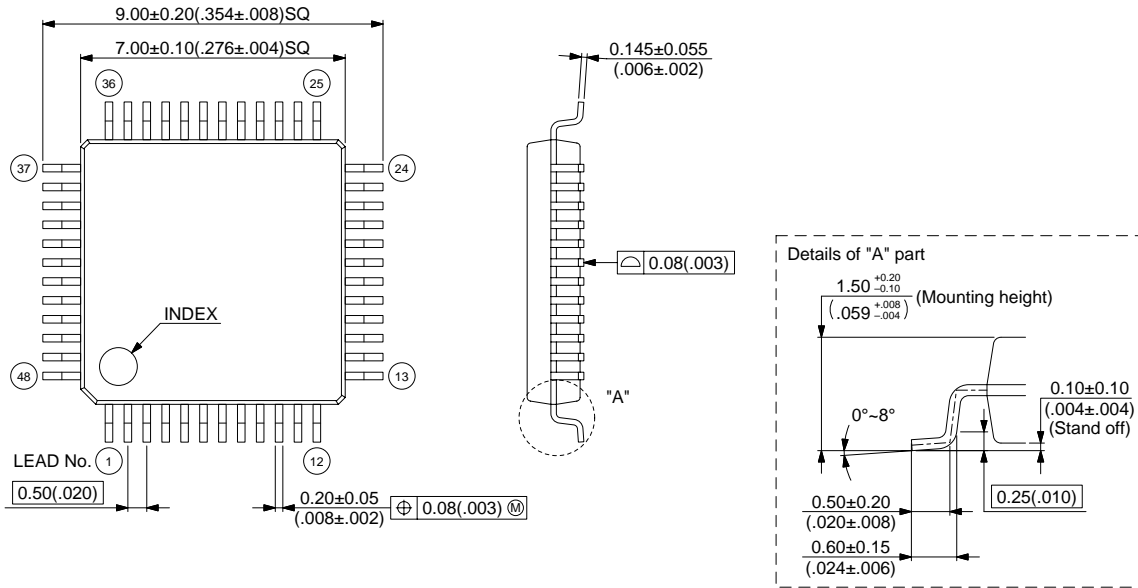
Part Number	Package	Remarks
MB89965PFV1 MB89P965APFV1 MB89965CPFV1	Plastic LQFP, 48-pin (FPT-48P-M05)	The MB89965PFV1 does not have an I ² C function.
MB89965PFM MB89P965APFM MB89965CPFM	Plastic QFP, 48-pin (FPT-48P-M13)	The MB89965PFM does not have an I ² C function.
MB89965PF MB89P965APF MB89965CPF	Plastic QFP, 48-pin (FPT-48P-M16)	The MB89965PF does not have an I ² C function.
MB89F969APFM	Plastic LQFP, 64-pin (FPT-64P-M09)	
MB89PV960CF	Ceramic MQFP, 48-pin (MQP-48C-P01)	

■ PACKAGE DIMENSIONS

(These package dimensions are provisional. Please obtain the actual dimensions of the final product separately.)

Plastic LQFP, 48-pin
(FPT-48P-M05)

Note : The pin width and thickness includes plating.

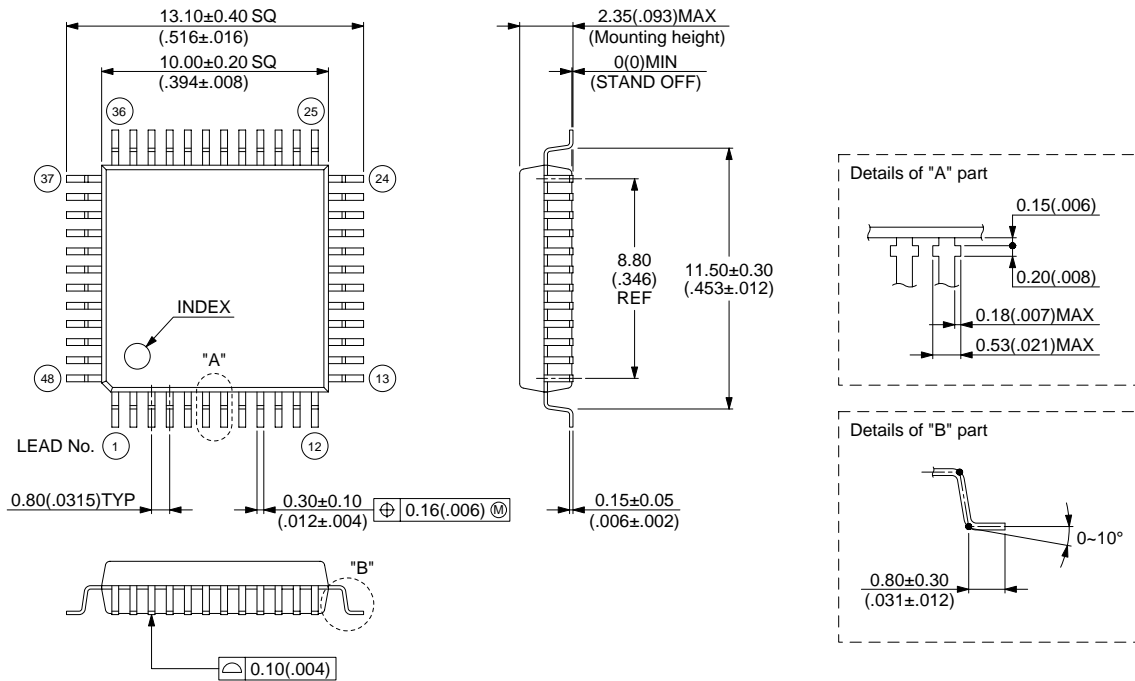


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Dimensions in mm (inches).

MB89960 Series

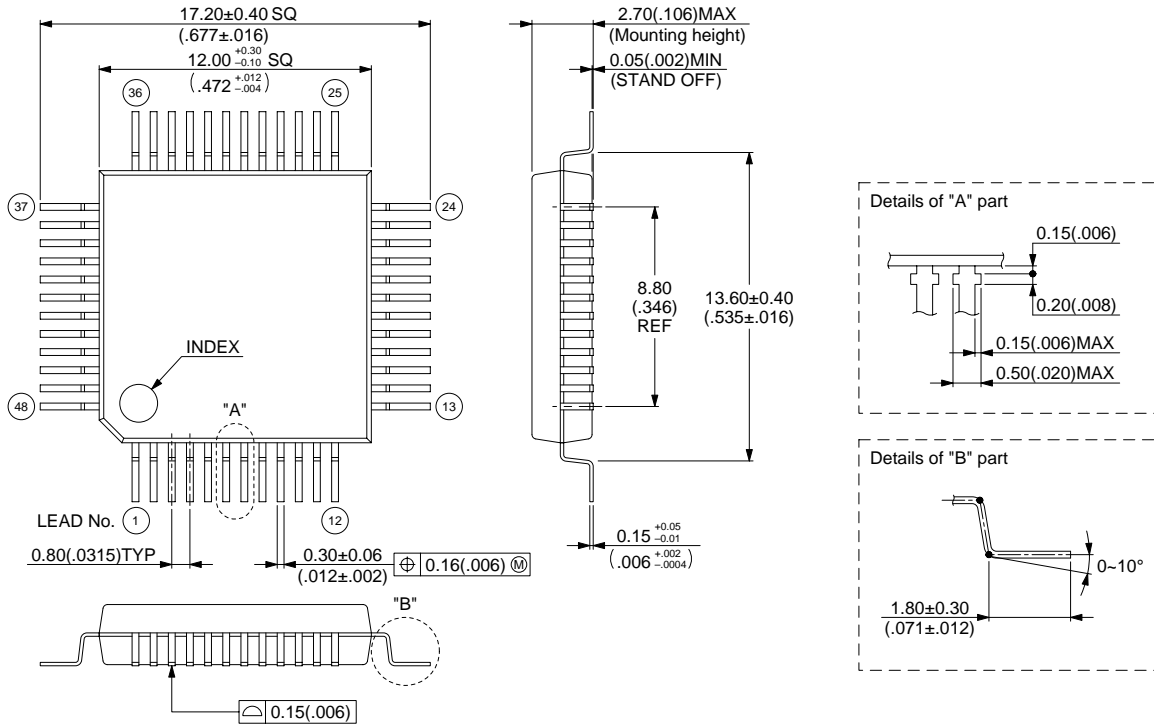
Plastic QFP, 48-pin
(FPT-48P-M13)



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Dimensions in mm (inches).

Plastic QFP, 48-pin
(FPT-48P-M16)

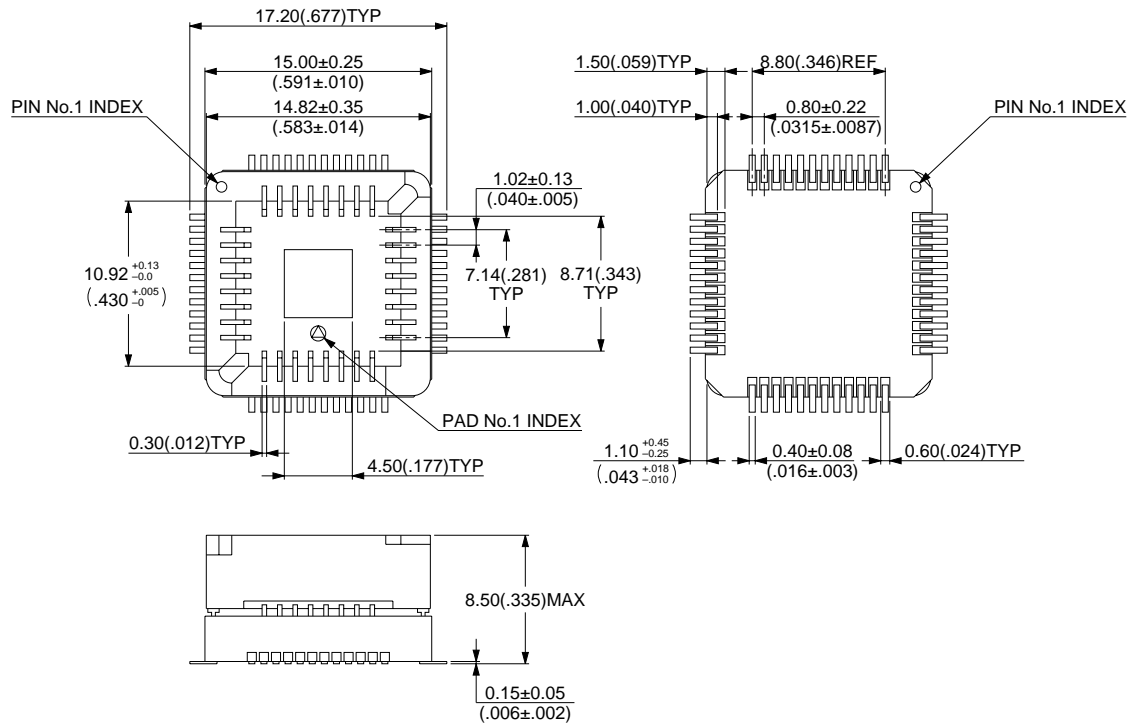


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Dimensions in mm (inches).

MB89960 Series

Ceramic MQFP, 48-pin
(MQP-48C-P01)

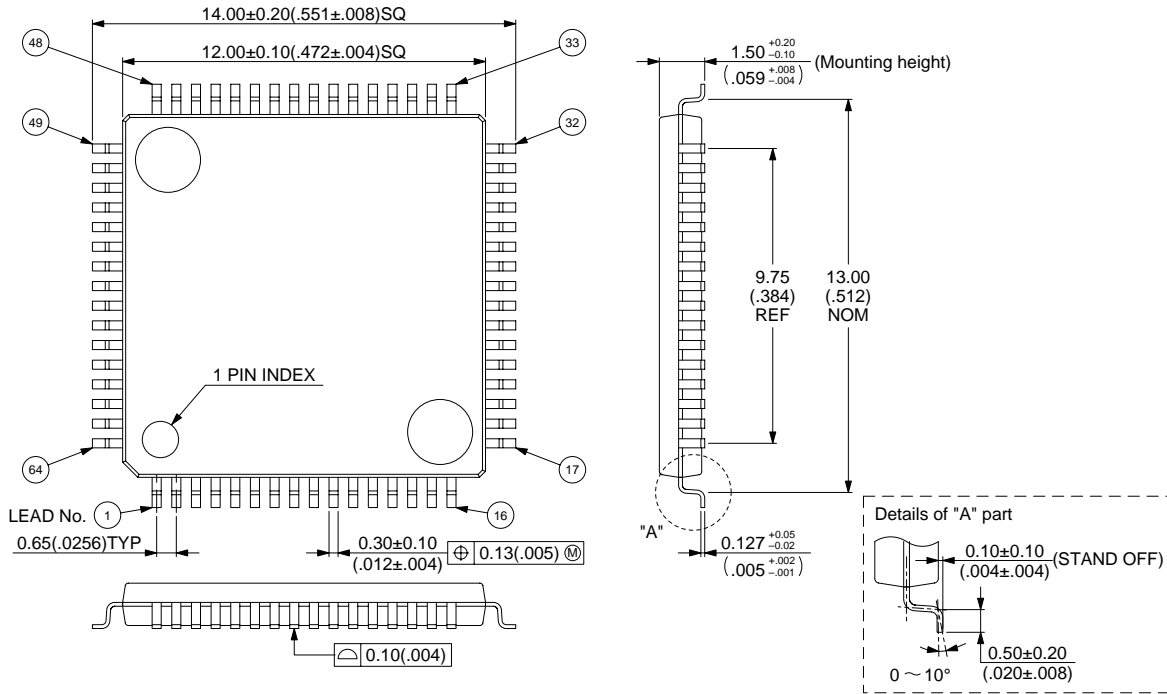


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Dimensions in mm (inches).

MB89960 Series

Plastic LQFP, 64-pin
(FPT-64P-M09)



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Dimensions in mm (inches).

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