FUJITSU SEMICONDUCTOR
DATA SHEET

DS07-12560-1E

8-bit Proprietary Microcontroller

CMOS

F²MC-8L MB89490 Series

MB89498/F499/PV490

■ DESCRIPTION

The MB89490 series has been developed as a general-purpose version of the F²MC*-8L family consisting of proprietary 8-bit single-chip microcontrollers.

In addition to a compact instruction set, the general-purpose, single-chip microcontroller contains a variety of peripheral functions such as 21-bit timebase timer, watch prescaler, PWM timer, 8/16-bit timer/counter, remote receiver circuit, LCD controller/driver, external interrupt 0 (edge) , external interrupt 1 (level) , 10-bit A/D converter, UART/SIO, SIO, I²C and watchdog timer reset.

The MB89490 series is designed suitable for compact disc/radio receiver controller as well as in a wide range of applications for consumer product.

* : “F²MC”, an abbreviation for FUJITSU Flexible Microcontroller, is a registered trademark of FUJITSU Ltd.

■ FEATURES

- Package
  QFP, LQFP package for MB89F499, MB89498
  MQFP package for MB89PV490

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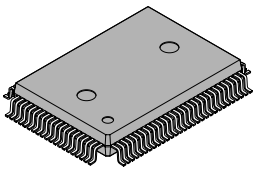
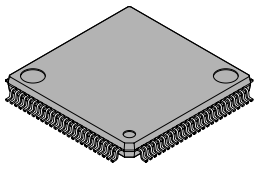
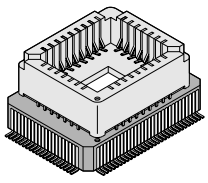
■ PACKAGES

100-pin Plastic QFP	100-pin Plastic LQFP	100-pin Ceramic MQFP
		
(FTP-100P-M06)	(FTP-100P-M05)	(MQP-100C-P01)

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- High speed operating capability at low voltage
- Minimum execution time : 0.32 μs/12.5 MHz
- F²MC-8L family CPU core

  Instruction set optimized for controllers
  - Multiplication and division instructions
  - 16-bit arithmetic operations
  - Branch instructions by test bit
  - Bit manipulation instructions, etc.

- PLL circuit for sub-clock
  - Embedded for PLL clock multiplication circuit for sub-clock
  - Operating clock (PLL for sub-clock) can be selected from no multiplication or 4 times of the sub-clock oscillation frequency.
- 6 timers
  PWM timer × 2
  8/16-bit timer/counter × 2
  21-bit timebase timer
  Watch prescaler
- External interrupt
  Edge detection (selectable edge) : 8 channels
  Low level interrupt (wake-up function) : 8 channels
- 10-bit A/D converter (8 channels)
  10-bit successive approximation type
- UART/SIO
  Synchronous/asynchronous data transfer capability
- SIO
  Switching of synchronous data transfer capability
- LCD controller/driver
  Max 32 segments output × 4 commons
- I²C interface circuit
- Remote receiver circuit
- Low-power consumption mode
  Stop mode (oscillation stops so as to minimize the current consumption.)
  Sleep mode (CPU stops so as to reduce the current consumption to approx. 1/3 of normal.)
  Watch mode (operation except the watch prescaler stops so as to reduce the power comsumption to an extremely low level.)
  Sub-clock mode
- Watchdog timer reset
- I/O ports : Max 66 channels

■ PRODUCT LINEUP

Parameter \ Part number	MB89498	MB89F499	MB89PV490
Classification	Mass production products (mask ROM product)	FLASH	Piggy-back (For evaluation or development)
ROM size	48 K × 8-bit (internal ROM)	60 K × 8-bit (internal FLASH)	60 K × 8-bit (external ROM) *1
RAM size	2 K × 8-bit	2 K × 8-bit	2 K × 8-bit
CPU functions	Number of instructions : 136 Instruction bit length : 8-bit Instruction length : 1 to 3 bytes Data bit length : 1-bit, 8-bit, 16-bit Minimum instruction execution time : 0.32 µs/12.5 MHz Minimum interrupt processing time : 2.88 µs/12.5 MHz		
Ports	General-purpose I/O ports (CMOS) : 56 pins Input ports (CMOS) : 2 pins N-channel open drain I/O ports : 8 pins Total : 66 pins		
21-bit timebase timer	Interrupt generation cycle (0.66 ms, 2.6 ms, 21.0 ms, 335.5 ms) at 12.5 MHz		
Watchdog timer	Reset generation cycle (167.8 ms to 335.5 ms) at 12.5 MHz		
PWM timer 0, 1	8-bit reload timer operation (supports square wave output and operating clock period : 1 t_{inst}, 8 t_{inst}, 16 t_{inst}, 64 t_{inst}) 8-bit accuracy PWM operation		
8/16-bit timer/counter 00, 01	Can be operated either as a 2-channel 8-bit timer/counter (timer 00 and timer 01, each with its own independent operating clock) , or as one 16-bit timer/counter. In timer 00 or 16-bit timer/counter operation, event counter operation by external clock input and square wave output capability		
8/16-bit timer/counter 10, 11	Can be operated either as a 2-channel 8-bit timer/counter (timer 10 and timer 11, each with its own independent operating clock) , or as one 16-bit timer/counter. In timer 10-bit or 16-bit timer/counter operation, event counter operation by external clock input and square wave output capability		
External interrupt 0 (edge)	8 independent channels (selectable edge, interrupt vector, request flag)		
External interrupt 1 (level)	8 channels (low level interrupt)		
A/D converter	10-bit accuracy × 8 channels A/D conversion function (conversion time : 30 t_{inst}) Supports repeated activation by internal clock		
LCD controller/driver	Common output : 4 (Max) Segment output : 32 (Max) LCD driving power (bias) pins : 3 LCD display RAM size : 32 × 4 bits		

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Part number / Parameter	MB89498	MB89F499	MB89PV490
UART/SIO	Synchronous/asynchronous data transfer capability (Max baud rate : 97.656 Kbps at 12.5 MHz) (7-bit and 8-bit with parity bit; 8-bit and 9-bit without parity bit)		
SIO	8-bit serial I/O with LSB first/MSB first selectability 1 clock selectable from 4 operation clock (1 external shift clock and 3 internal shift clock : 0.64 µs, 2.56 µs, 10.24 µs at 12.5 MHz)		
I^2C*2	1 channel (Use a 2-wire protocol to communicate with other device)		
Remote receiver circuit	Selectable maximum noise width removal Reversible input polarity		
Standby mode	Sleep mode, stop mode, watch mode and sub-clock mode		
Process	CMOS		
Operating voltage	2.2 V to 3.6 V	2.7 V to 3.6 V	2.7 V to 3.6 V

*1 : Use MBM27C512 as the external ROM.

*2 : I^2C is complied to Philips I^2C specification.

■ PACKAGE AND CORRESPONDING PRODUCTS

Parameter \ Part number	MB89498	MB89F499	MB89PV490
FPT-100P-M06	O	O	×
FPT-100P-M05	O	O	×
MQP-100C-P01	×	×	O

O : Availabe
× : Not available

■ DIFFERENCES AMONG PRODUCTS

1. Memory Size

Before evaluating using the piggy-back product, verify its differences from the product that will be actually used. Take particular care on the following point : The stack area is set at the upper limit of the RAM.

2. Current Consumption

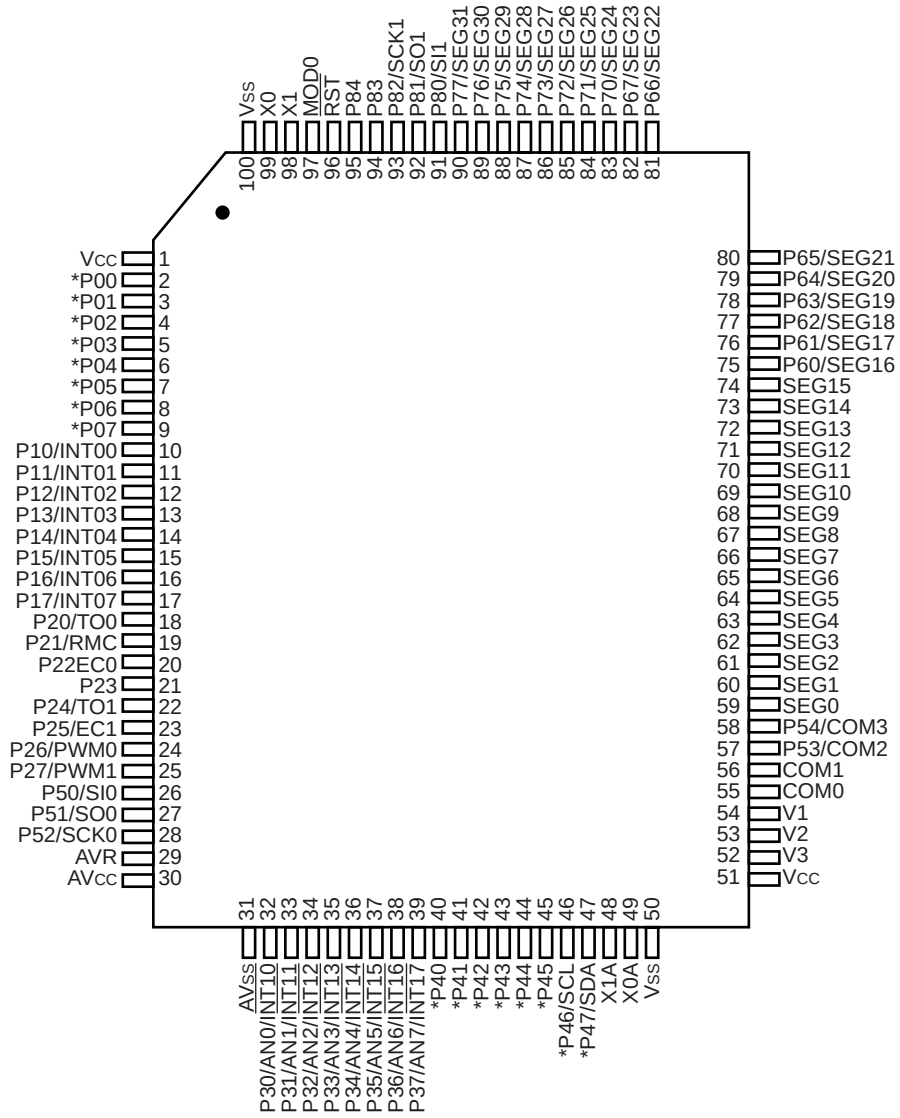
- For the MB89PV490, add the current consumed by the EPROM mounted in the piggy-back socket.
- When operating at low speed, the current consumed by the FLASH product is greater than that for the mask ROM product. However, the current consumption is roughly the same in sleep and stop mode.
- For more information, see “■ ELECTRICAL CHARACTERISTICS.”

3. Oscillation Stabilization Wait Time after Power-on Reset

- For MB89PV490 and MB89F499, the power-on stabilization wait time cannot be selected after power-on reset.
- For MB89498, the power-on stabilization wait time can be selected after power-on reset.
- For more information, please refer to “■ MASK OPTIONS”.

■ PIN ASSIGNMENTS

(TOP VIEW)



(FPT-100P-M06)

* : High current pins

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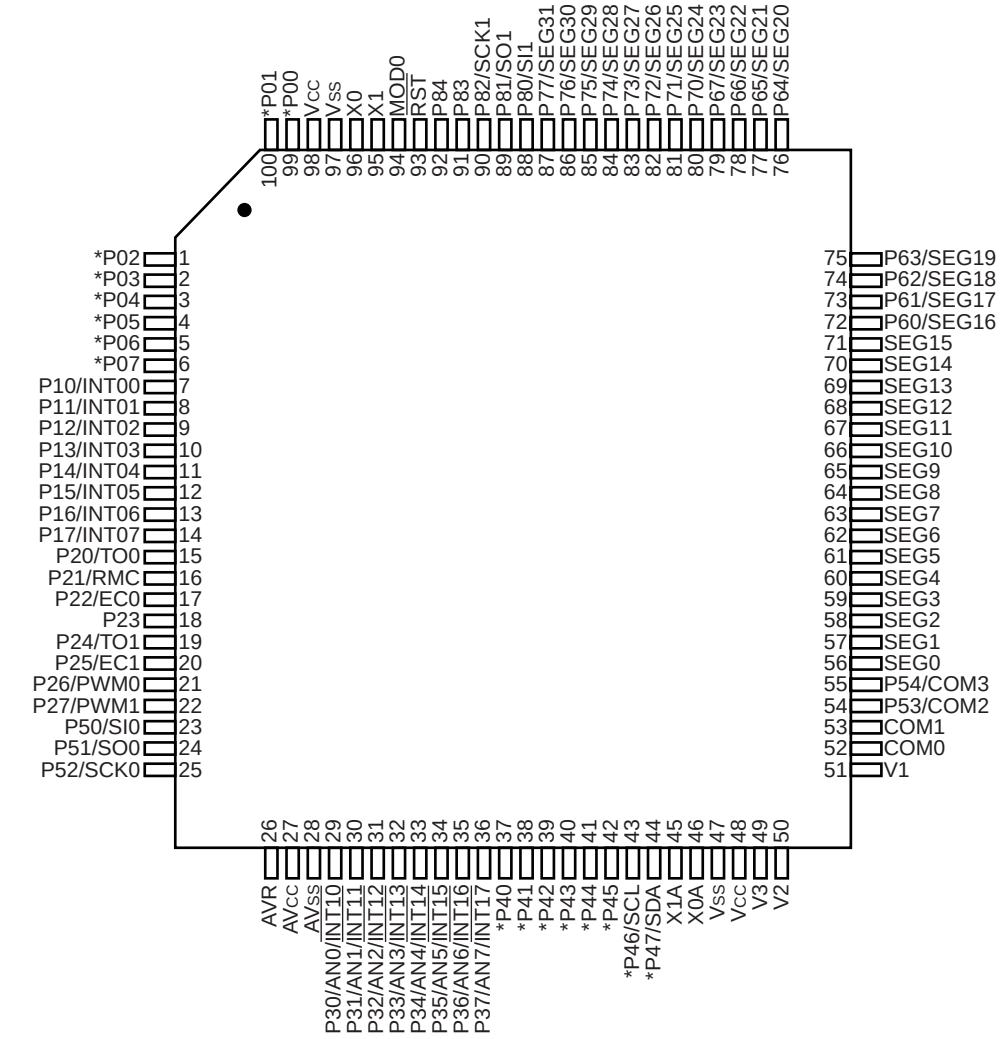
(TOP VIEW)



(FPT-100P-M05)

* : High current pins

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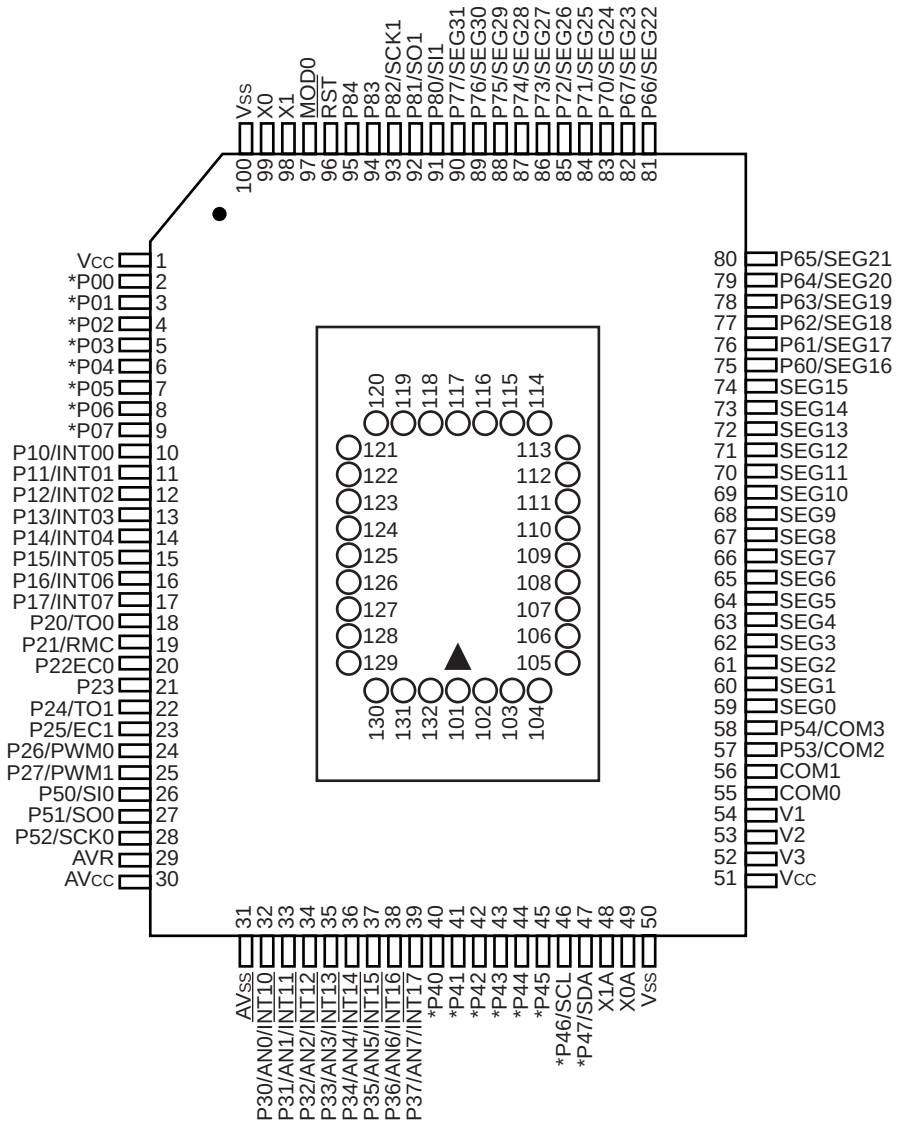
(TOP VIEW)



* : High current pins

(MQP-100C-P01)

Pin assignment on package top (MB89PV490 only)

Pin no.	Pin name	Pin no.	Pin name	Pin no.	Pin name	Pin no.	Pin name	Pin no.	Pin name
101	N.C.	108	A3	115	O3	122	O8	129	A8
102	A15	109	A2	116	V_{SS}	123	$\overline{CE}$	130	A13
103	A12	110	A1	117	N.C.	124	A10	131	A14
104	A7	111	A0	118	O4	125	$\overline{OE}$	132	V_{CC}
105	A6	112	N.C.	119	O5	126	N.C.		
106	A5	113	O1	120	O6	127	A11		
107	A4	114	O2	121	O7	128	A9		

N.C. : As connected internally, do not use.

■ PIN DESCRIPTION

Pin number		Pin name	I/O circuit type	Function
MQFP*1/ QFP*2	LQFP*3			
99	96	X0	A	Connection pins for a crystal or other oscillator circuit. An external clock can be connected to X0. In this case, leave X1 open.
98	95	X1		
49	46	X0A	A	Connection pins for a crystal or other oscillator circuit. An external clock can be connected to X0A. In this case, leave X1A open.
48	45	X1A		
97	94	MOD0	B	Input pin for setting the memory access mode. Connect directly to V_{SS}.
95, 94	92, 91	P84, P83	J	General-purpose CMOS input port.
96	93	$\overline{RST}$	C	Reset I/O pin. The pin is an N-ch open-drain type with pull-up resistor and hysteresis input. The pin outputs an “L” level when an internal reset request is present. Inputting an “L” level initializes internal circuits.
2 to 9	99 to 6	P00 to P07	D	General-purpose CMOS I/O port.
10 to 17	7 to 14	P10/INT00 to P17/INT07	E	General-purpose CMOS I/O port. The pin is shared with external interrupt 0 input.
18	15	P20/TO0	F	General-purpose CMOS I/O port. The pin is shared with 8/16-bit timer/counter 00 and 01 output.
19	16	P21/RMC	E	General-purpose CMOS I/O port. The pin is shared with remote receiver input.
20	17	P22/EC0	E	General-purpose CMOS I/O port. The pin is shared with 8/16-bit timer/counter 00 and 01 input.
21	18	P23	F	General-purpose CMOS I/O port.
22	19	P24/TO1	F	General-purpose CMOS I/O port. The pin is shared with 8/16-bit timer/counter 10 and 11 output.
23	20	P25/EC1	E	General-purpose CMOS I/O port. The pin is shared with 8/16-bit timer/counter 10 and 11 input.
24	21	P26/PWM0	F	General-purpose CMOS I/O port. The pin is shared with PWM0 output.
25	22	P27/PWM1	F	General-purpose CMOS I/O port. The pin is shared with PWM1 output.
32 to 39	29 to 36	P30/AN0/$\overline{INT10}$ to P37/AN7/$\overline{INT17}$	G	General-purpose CMOS I/O port. The pin is shared with external interrupt 1 input and A/D converter input.
40 to 45	37 to 42	P40 to P45	H	General-purpose N-ch open-drain I/O port.
46	43	P46/SCL	H	General-purpose N-ch open-drain I/O port. The pin is shared with I^2C clock I/O.

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Pin number		Pin name	I/O circuit type	Function
MQFP*1/ QFP*2	LQFP*3			
47	44	P47/SDA	H	General-purpose N-ch open-drain I/O port. The pin is shared with I^2C data I/O.
26	23	P50/SI0	E	General-purpose CMOS I/O port. The pin is shared with SIO data input.
27	24	P51/SO0	F	General-purpose CMOS I/O port. The pin is shared with SIO data output.
28	25	P52/SCK0	E	General-purpose CMOS I/O port. The pin is shared with SIO clock I/O.
57	54	P53/COM2	F/I	General-purpose CMOS I/O port. The pin is shared with the LCD common output.
58	55	P54/COM3	F/I	General-purpose CMOS I/O port. The pin is shared with the LCD common output.
75 to 82	72 to 79	P60/SEG16 to P67/SEG23	F/I	General-purpose CMOS I/O port. The pin is shared with LCD segment output.
83 to 90	80 to 87	P70/SEG24 to P77/SEG31	F/I	General-purpose CMOS I/O port. The pin is shared with LCD segment output.
91	88	P80/SI1	E	General-purpose CMOS I/O port. The pin is shared with UART/SIO data input.
92	89	P81/SO1	F	General-purpose CMOS I/O port. The pin is shared with UART/SIO data output.
93	90	P82/SCK1	E	General-purpose CMOS I/O port. The pin is shared with UART/SIO clock I/O.
59 to 74	56 to 71	SEG0 to SEG15	I	LCD segment output-only pin.
55, 56	52, 53	COM0, COM1	I	LCD common output-only pin.
54, 53, 52	51, 50, 49	V1 to V3	—	LCD driving power supply pin.
1, 51	98, 48	V_{CC}	—	Power supply pin.
50, 100	47, 97	V_{SS}	—	Power supply pin (GND) .
30	27	AV_{CC}	—	A/D converter power supply pin.
29	26	AVR	—	A/D converter reference voltage input pin.
31	28	AV_{SS}	—	A/D converter power supply pin. Use at the same voltage level as V_{SS}.

*1 : MQP-100C-P01

*2 : FPT-100P-M06

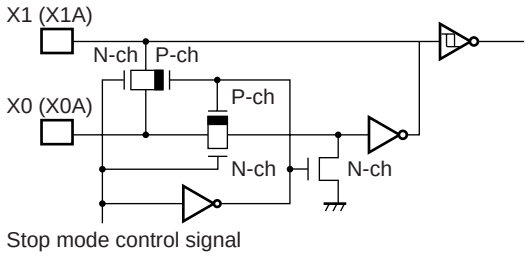
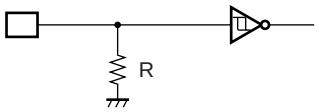
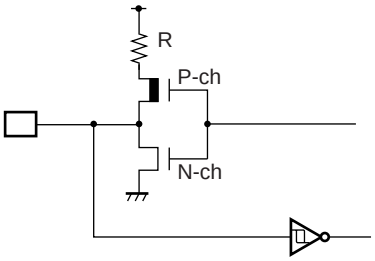
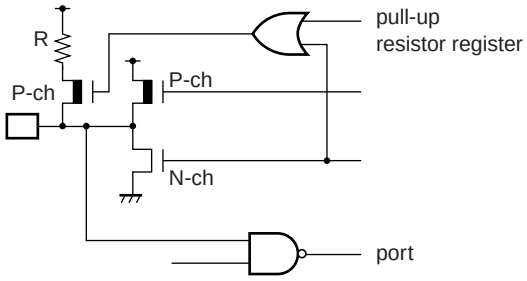
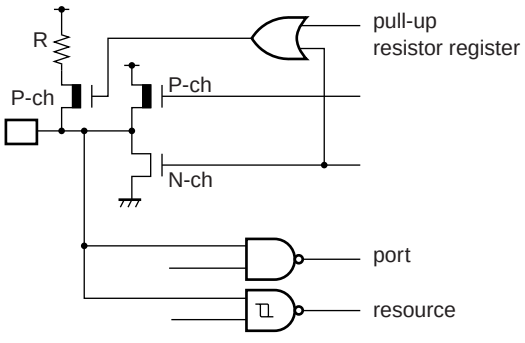
*3 : FPT-100P-M05

- **External EPROM Socket (MB89PV490 only)**

Pin number MQFP*	Pin name	I/O	Function
102 131 130 103 127 124 128 129 104 105 106 107 108 109 110 111	A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0	O	Address output pins.
122 121 120 119 118 115 114 113	O8 O7 O6 O5 O4 O3 O2 O1	I	Data input pins.
101 112 117 126	N.C.	—	Internally connected pins. Always leave open.
116	V_{SS}	O	Power supply pin (GND) .
123	$\overline{CE}$	O	Chip enable pin for the EPROM. Outputs “H” in standby mode.
125	$\overline{OE}$	O	Output enable pin for the EPROM. Always outputs “L”.
132	V_{CC}	O	Power supply pin for the EPROM.

* : MQP-100C-P01

■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A		• Main/Sub-clock circuit
B		• Hysteresis input (CMOS input in MB89F499) • The pull-down resistor (not available in MB89F499) Approx. 50 kΩ
C		• The pull-up resistor (P-channel) Approx. 50 kΩ • Hysteresis input
D		• CMOS output • I_{OH} = − 4 mA, I_{OL} = 12 mA • CMOS input • Selectable pull-up resistor Approx. 50 kΩ
E		• CMOS output • I_{OH} = − 2 mA, I_{OL} = 4 mA • CMOS port input • Hysteresis resource input • Selectable pull-up resistor Approx. 50 kΩ

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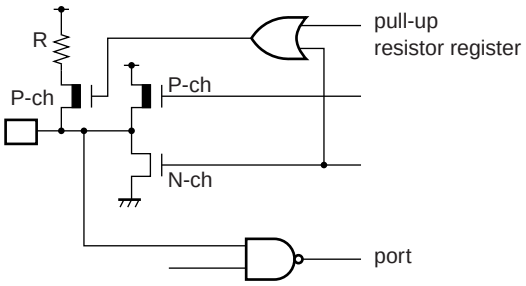
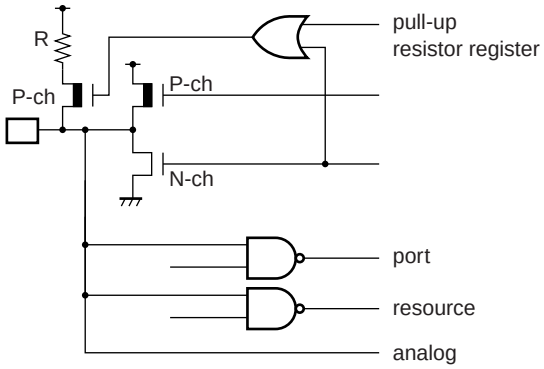
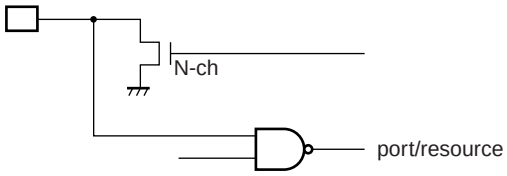
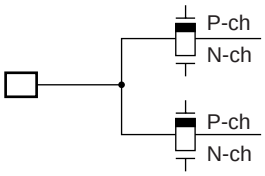
Type	Circuit	Remarks
F		• CMOS output • I_{OH} = − 2 mA, I_{OL} = 4 mA • CMOS input • Selectable pull-up resistor Approx. 50 kΩ
G		• CMOS output • I_{OH} = − 2 mA, I_{OL} = 4 mA • CMOS port input • V_{IH} = 0.85 V_{CC}, V_{IL} = 0.5 V_{CC} resource input • Analog input • Selectable pull-up resistor Approx. 50 kΩ
H		• N-ch open-drain output • I_{OL} = 15 mA • CMOS port input • CMOS resource input • 5 V tolerance
I		• LCD segment output
J		• CMOS input

■ HANDLING DEVICES

1. Preventing Latch-up

Latch-up may occur on CMOS IC 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 “■ ELECTRICAL CHARACTERISTICS” is applied between V_{CC} and V_{SS}.

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

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

2. Treatment of Unused Input Pins

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

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

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

4. Treatment of N.C. Pins

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

5. Power Supply Voltage Stabilization

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. As stabilization guidelines, it is recommended to control voltage fluctuation 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.

6. Precautions when Using an External Clock

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

7. Treatment of Unused dedicated LCD pins

When dedicated LCD pins are not in use, keep them open.

■ PROGRAMMING AND ERASING FLASH MEMORY ON THE MB89F499

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 internal CPU, providing an efficient method of updating program and data.

2. Flash Memory Features

- 60K bytes × 8-bit configuration (16 K + 8 K + 8 K + 28 K sectors)
- Automatic algorithm (Embedded algorithm* : Equivalent to MBM29LV200)
- Includes an erase pause and erase 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 data to the 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

- Flash memory control status register (FMCS)

Address $007A_H$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INTE	RDYINT	WE	RDY	Reserved	Reserved	—	Reserved
R/W	R/W	R/W	R	R/W	R/W	—	R/W

Initial value $000X00\text{-}0_B$

5. Sector Configuration

The table below shows the sector configuration of flash memory and lists the addresses of each sector during CPU access and 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$_H$

* : 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 programmer.

6. ROM Programmer Adaptor and Recommended ROM Programmers

Package	Applicable adapter model	Recommended writer
	Sunhayato Corp.	Ando Electric Co. Ltd.
FPT-100P-M06	FLASH-100QF-32DP-8LF2	AF9708 (ver 1.60 or later) * AF9709 (ver 1.60 or later) *
FPT-100P-M05	FLASH-100SQF-32DP-8LF	

* : For the programmer and the version of the programmer,contact the Flash Support Group, Inc.

Inquirues : Sunhayato Corp. : TEL : 81-(3)-3984-7791
FAX : 81-(3)-3971-0535
E-mail : adapter@sunhayato.co.jp
Flash Support Group, Inc. : FAX : 81-(53)-428-8377
E-mail : support@j-fsg.co.jp

■ PROGRAMMING TO THE EPROM WITH PIGGY-BACK/EVALUATION DEVICE

1. EPROM for Use

MBM27C512-20TV

2. Programming Socket Adapter

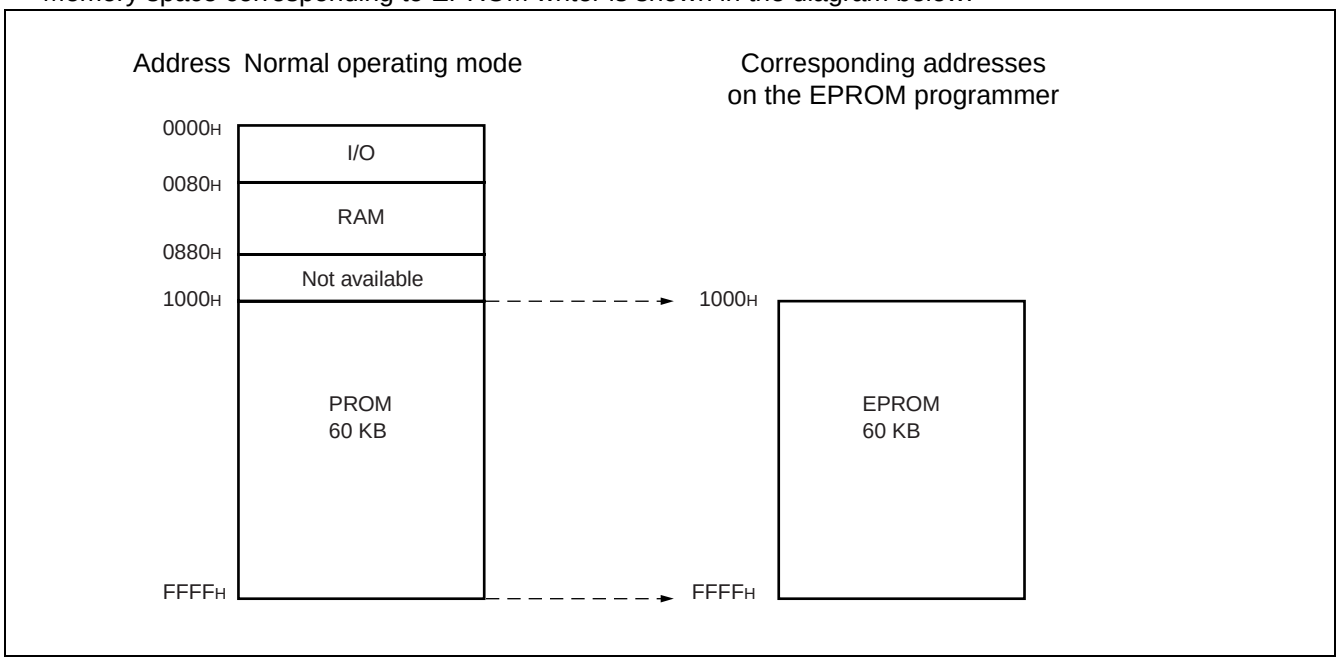
To program to the PROM using an EPROM programmer, use the socket adapter (manufacturer : Sunhayato Corp.) .

Package	Adapter socket part number
LCC-32 (Rectangle)	ROM-32LC-28DP-YG

Inquiry : Sunhayato Corp. : TEL : 81-3-3984-7791
FAX : 81-3-3971-0535
E-mail : adapter@sunhayato.co.jp

3. Memory Space

Memory space corresponding to EPROM writer is shown in the diagram below.



4. Programming to the EPROM

(1) Set the EPROM programmer to the MBM27C512.

(2) Load program data into the EPROM programmer at 1000_H to $FFFF_H$.

(3) Program to 1000_H to $FFFF_H$ with the EPROM programmer.

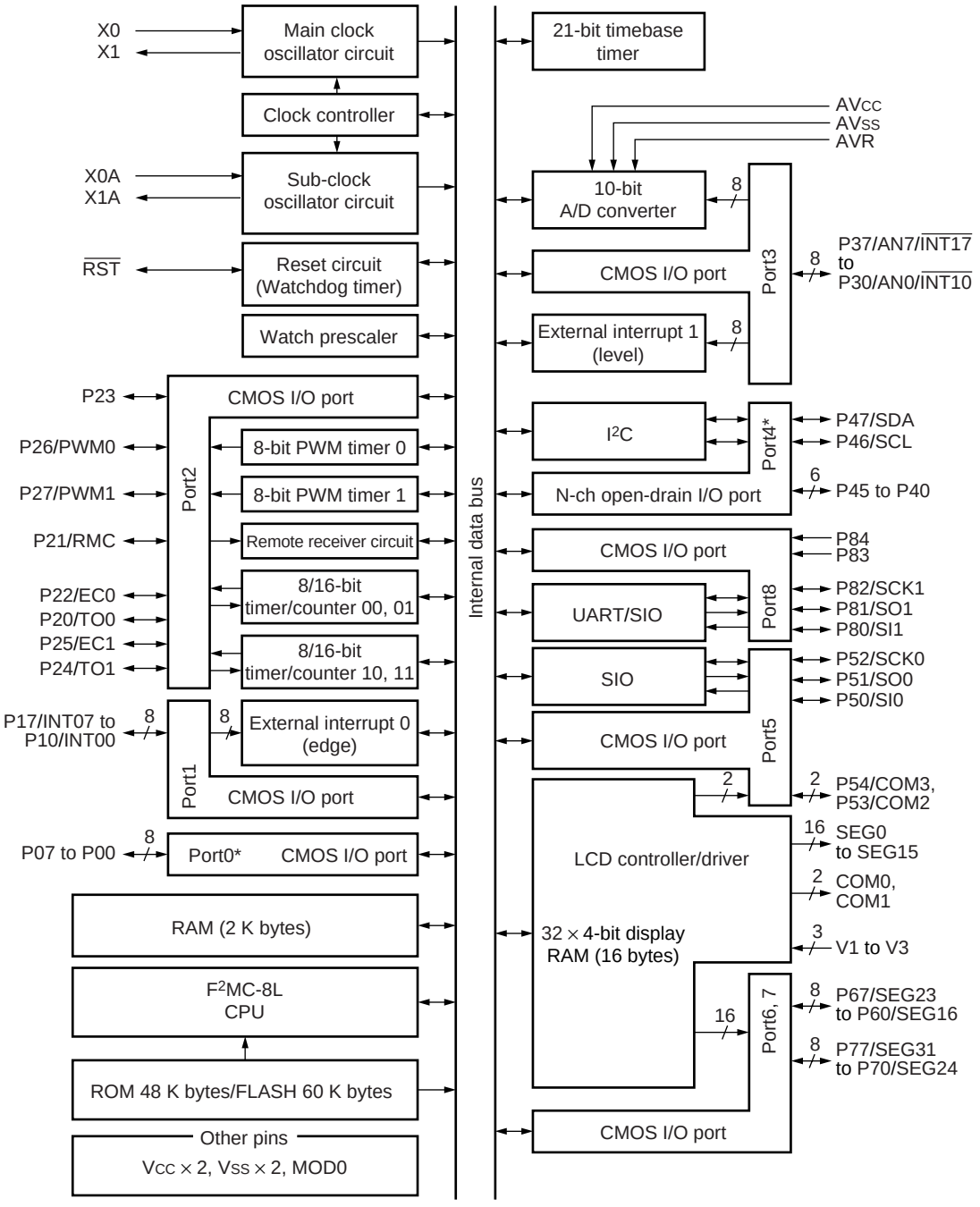
■ ICE PROBE POD ADAPTOR OF PIGGY-BACK/EVA CHIP

The following conversion adapter is required to achieve the same pin layout as the FPT-100P-M05.

Adaptor part number: 100QF-100SQF-8L

Inquiry : Sunhayato Corp. : TEL : 81-3-3984-7791
FAX : 81-3-3971-0535
E-mail : adapter@sunhayato.co.jp

■ BLOCK DIAGRAM



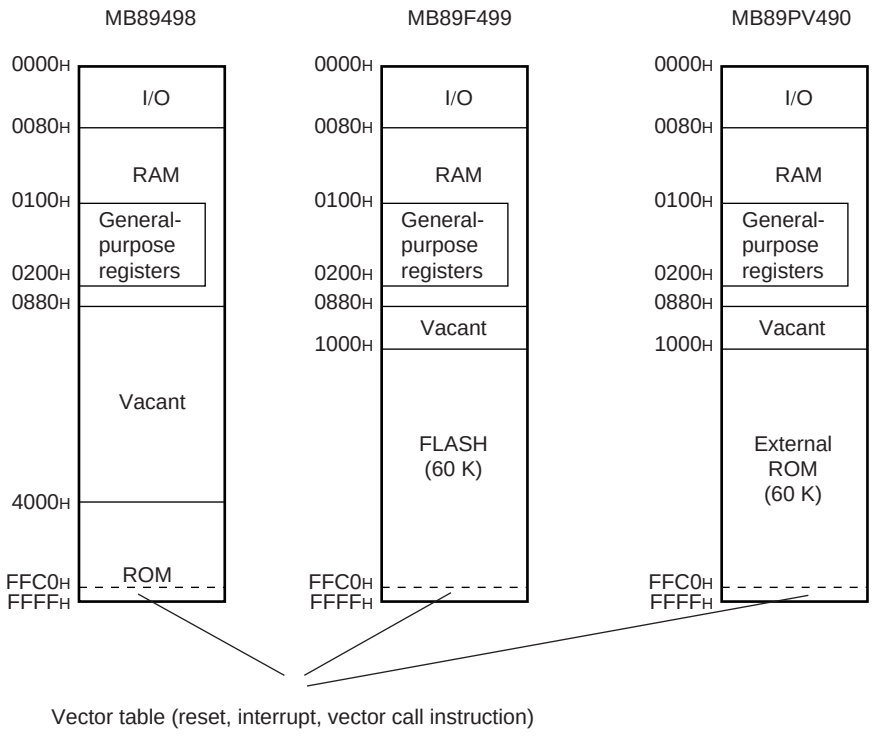
* : High current I/O port.

■ CPU CORE

1. Memory Space

The microcontrollers of the MB89490 series offer a memory space of 64K bytes for storing all of I/O, data, and program areas. The I/O area is located 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 MB89490 series is structured as illustrated below.

Memory Space



2. Registers

The F²MC-8L family has 2 types of registers; dedicated registers in the CPU and general-purpose registers in the memory. The following 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.

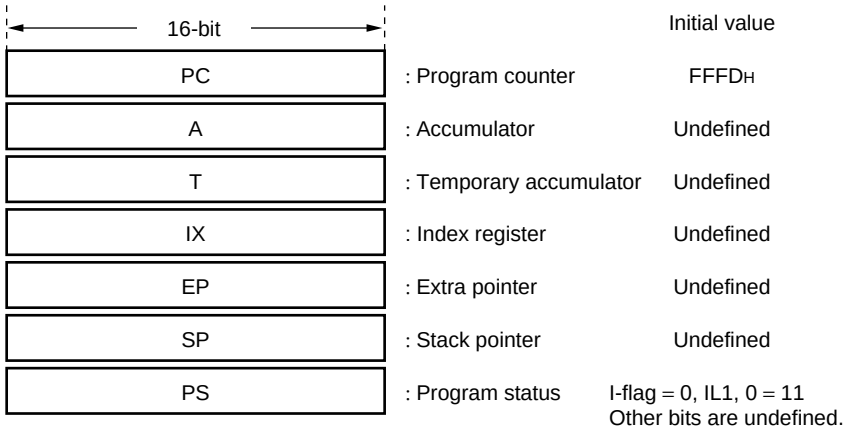
Temporary accumulator (T) : A 16-bit register for performing arithmetic operations with the accumulator. When the instruction is an 8-bit data processing instruction, the lower byte is used.

Index register (IX) : A 16-bit register for index modification.

Extra pointer (EP) : A 16-bit pointer for indicating a memory address.

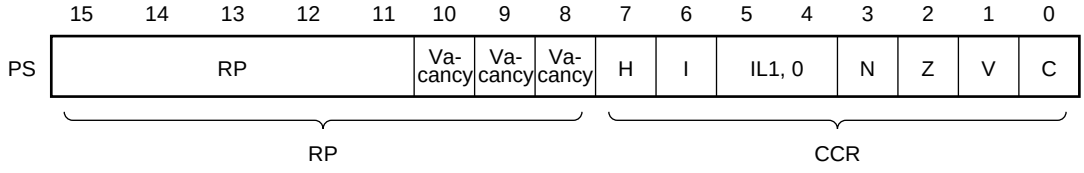
Stack pointer (SP) : A 16-bit register for indicating a stack area.

Program status (PS) : A 16-bit register for storing a register pointer and condition code.



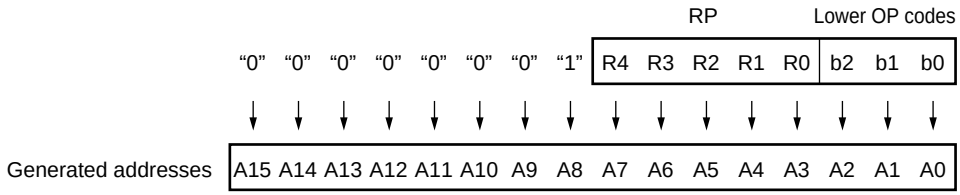
The PS can further be divided into higher 8-bit for use as a register bank pointer (RP) and the lower 8-bit for use as a condition code register (CCR) . (See the diagram below.)

Structure of the Program Status Register



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

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



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

H-flag : Set to "1" when a carry or a borrow from bit 3 to bit 4 occurs as a result of an arithmetic operation. Clear to "0" 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". Clear to "0" at reset.

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

IL1	IL0	Interrupt level	High-low
0	0	1	High ↕ Low
0	1		
1	0	2	
1	1	3	

N-flag : Set to "1" if the MSB is set to "1" as the result of an arithmetic operation. Clear to "0" otherwise.

Z-flag : Set to "1" when an arithmetic operation results in "0". Clear to "0" otherwise.

V-flag : Set to "1" if the complement on 2 overflows as a result of an arithmetic operation. Clear to "0" if the overflow does not occur.

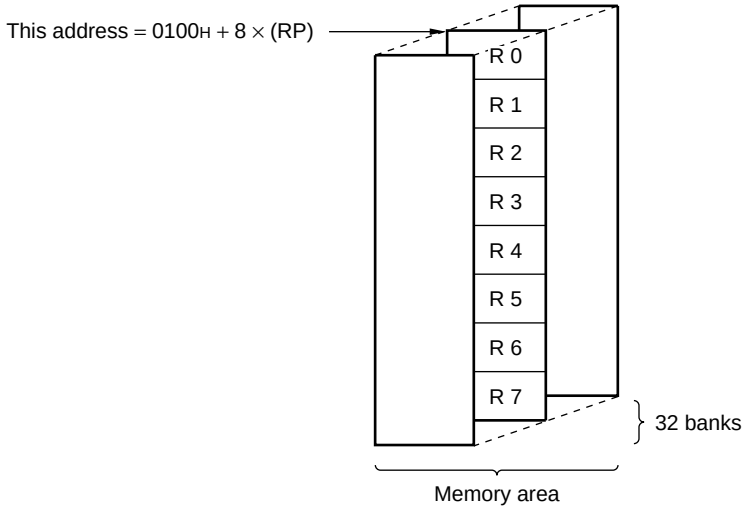
C-flag : Set to "1" when a carry or a borrow from bit 7 occurs as a result of an arithmetic operation. Clear to "0" otherwise. Set to the shift-out value in the case of a shift instruction.

The following general-purpose registers are provided :

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

The general-purpose registers are 8-bit and located in the register banks of the memory.
1 bank contains 8 registers. Up to a total of 32 banks can be used on the MB89490 series. The bank currently in use is indicated by the register bank pointer (RP) .

Register Bank Configuration



■ I/O MAP

Address	Register name	Register description	Read/Write	Initial value
00_H	PDR0	Port 0 data register	R/W	$XXXXXXXX_B$
01_H	DDR0	Port 0 direction register	W*	00000000_B
02_H	PDR1	Port 1 data register	R/W	$XXXXXXXX_B$
03_H	DDR1	Port 1 direction register	W*	00000000_B
04_H	PDR2	Port 2 data register	R/W	00000000_B
05_H	(Reserved)			
06_H	DDR2	Port 2 direction register	R/W	00000000_B
07_H	SYCC	System clock control register	R/W	$X\text{-}1MM100_B$
08_H	STBC	Standby control register	R/W	$00010XXX_B$
09_H	WDTC	Watchdog timer control register	W*	$0\text{---}XXXX_B$
$0A_H$	TBTC	Timebase timer control register	R/W	$00\text{---}000_B$
$0B_H$	WPCR	Watch prescaler control register	R/W	$00\text{--}0000_B$
$0C_H$	PDR3	Port 3 data register	R/W	$XXXXXXXX_B$
$0D_H$	DDR3	Port 3 direction register	R/W	11111111_B
$0E_H$	RSFR	Reset flag register	R	$XXXX\text{----}_B$
$0F_H$	PDR4	Port 4 data register	R/W	11111111_B
10_H	PDR5	Port 5 data register	R/W	$\text{---}XXXXX_B$
11_H	DDR5	Port 5 direction register	R/W	$\text{---}00000_B$
12_H	PDR6	Port 6 data register	R/W	$XXXXXXXX_B$
13_H	DDR6	Port 6 direction register	R/W	00000000_B
14_H	PDR7	Port 7 data register	R/W	$XXXXXXXX_B$
15_H	DDR7	Port 7 direction register	R/W	00000000_B
16_H	PDR8	Port 8 data register	R/W	$\text{---}XXXXX_B$
17_H	DDR8	Port 8 direction register	R/W	$\text{---}00000_B$
18_H	EIC0	External interrupt 0 control register 0	R/W	00000000_B
19_H	EIC1	External interrupt 0 control register 1	R/W	00000000_B
$1A_H$	EIC2	External interrupt 0 control register 2	R/W	00000000_B
$1B_H$	EIC3	External interrupt 0 control register 3	R/W	00000000_B
$1C_H$	EIE1	External interrupt 1 enable register	R/W	00000000_B
$1D_H$	EIF1	External interrupt 1 flag register	R/W	$\text{-------}0_B$
$1E_H$	SMR	Serial mode register	R/W	00000000_B
$1F_H$	SDR	Serial data register	R/W	$XXXXXXXX_B$
20_H	T01CR	Timer 01 control register	R/W	$000000X0_B$
21_H	T00CR	Timer 00 control register	R/W	$000000X0_B$
22_H	T01DR	Timer 01 data register	R/W	$XXXXXXXX_B$

(Continued)

Address	Register name	Register description	Read/Write	Initial value
23_H	T00DR	Timer 00 data register	R/W	$XXXXXXXX_B$
24_H	T11CR	Timer 11 control register	R/W	$000000X0_B$
25_H	T10CR	Timer 10 control register	R/W	$000000X0_B$
26_H	T11DR	Timer 11 data register	R/W	$XXXXXXXX_B$
27_H	T10DR	Timer 10 data register	R/W	$XXXXXXXX_B$
28_H	ADER	A/D input enable register	R/W	11111111_B
29_H	ADC0	A/D control register 0	R/W	$-00000X0_B$
$2A_H$	ADC1	A/D control register 1	R/W	-0000001_B
$2B_H$	ADDH	A/D data register (Upper byte)	R	$------XX_B$
$2C_H$	ADDL	A/D data register (Lower byte)	R	$XXXXXXXX_B$
$2D_H$	CNTR0	PWM 0 timer control register	R/W	$0-000000_B$
$2E_H$	COMR0	PWM 0 timer compare register	W*	$XXXXXXXX_B$
$2F_H$	SMC0	UART/SIO serial mode control register	R/W	00000000_B
30_H	SMC1	UART/SIO serial mode control register	R/W	00000000_B
31_H	SSD	UART/SIO serial status/data register	R/W	$00001---_B$
32_H	SIDR/SODR	UART/SIO serial data register	R/W	$XXXXXXXX_B$
33_H	SRC	UART/SIO serial rate control register	R/W	$XXXXXXXX_B$
34_H	CNTR1	PWM 1 timer control register	R/W	$0-000000_B$
35_H	COMR1	PWM 1 timer compare register	W*	$XXXXXXXX_B$
36_H	IBSR	I^2C bus status register	R	00000000_B
37_H	IBCR	I^2C bus control register	R/W	00000000_B
38_H	ICCR	I^2C clock control register	R/W	$000XXXXX_B$
39_H	IADR	I^2C address register	R/W	$-XXXXXXX_B$
$3A_H$	IDAR	I^2C data register	R/W	$XXXXXXXX_B$
$3B_H$	PLLCR	Sub PLL control register	R/W	$----0000_B$
$3C_H$ to $3F_H$	(Reserved)			
40_H	RMN	Remote control counter register	R	$XXXXXXXX_B$
41_H	RMC	Remote control control register	R/W	00000000_B
42_H	RMS	Remote control status register	R/W	$0X000001_B$
43_H	RMD	Remote control FIFO data register	R	$X----XXX_B$
44_H	RMCD0	Remote control compare register 0	R/W	11111111_B
45_H	RMCD1	Remote control compare register 1	R/W	11111111_B
46_H	RMCD2	Remote control compare register 2	R/W	11111111_B
47_H	RMCD3	Remote control compare register 3	R/W	11111111_B
48_H	RMCD4	Remote control compare register 4	R/W	11111111_B

(Continued)

(Continued)

Address	Register name	Register description	Read/Write	Initial value
49H	RMCD5	Remote control compare register 5	R/W	11111111B
4AH	RMCI	Remote interrupt register	R/W	0000-000B
4BH to 5DH	(Reserved)			
5EH	LOCR	LCD controller output control register	R/W	-0000000B
5FH	LCR	LCD controller control register	R/W	00010000B
60H to 6FH	VRAM	LCD data RAM	R/W	XXXXXXXXB
70H	PUCR0	Port 0 pull up resistor control register	R/W	11111111B
71H	PUCR1	Port 1 pull up resistor control register	R/W	11111111B
72H	PUCR2	Port 2 pull up resistor control register	R/W	11111111B
73H	PUCR3	Port 3 pull up resistor control register	R/W	11111111B
74H	PUCR5	Port 5 pull up resistor control register	R/W	---11111B
75H	PUCR6	Port 6 pull up resistor control register	R/W	11111111B
76H	PUCR7	Port 7 pull up resistor control register	R/W	11111111B
77H	PUCR8	Port 8 pull up resistor control register	R/W	-----111B
78H to 79H	(Reserved)			
7AH	FMCS	Flash memory control status registger	R/W	000X00-0B
7BH	ILR1	Interrupt level setting register 1	W*	11111111B
7CH	ILR2	Interrupt level setting register 2	W*	11111111B
7DH	ILR3	Interrupt level setting register 3	W*	11111111B
7EH	ILR4	Interrupt level setting register 4	W*	11111111B
7FH	(Reserved)			

* : Bit manipulation instruction cannot be used.

- **Read/write access symbols**
  R/W : Readable and writable
  R : Read-only
  W : Write-only

- **Initial value symbols**
  0 : The initial value of this bit is “0”.
  1 : The initial value of this bit is “1”.
  X : The initial value of this bit is undefined.
  - : Unused bit.
  M : The initial value of this bit is determined by mask option.

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

Parameter	Symbol	Rating		Unit	Remarks
		Min	Max		
Power supply voltage*1	V_{CC} AV_{CC}	V_{SS} – 0.3	V_{SS} + 4.0	V	AV_{CC} must be equal to V_{CC}
	AVR	V_{SS} – 0.3	V_{SS} + 4.0	V	
LCD power supply voltage	V1 to V3	V_{SS} – 0.3	V_{CC}	V	
Input voltage *1	V_I	V_{SS} – 0.3	V_{CC} + 0.3	V	Except P40 to P47
		V_{SS} – 0.3	V_{SS} + 6.0	V	P40 to P47 in MB89PV490 and MB89498
		V_{SS} – 0.3	V_{SS} + 5.5	V	P40 to P47 in MB89F499
Output voltage*1	V_O	V_{SS} – 0.3	V_{CC} + 0.3	V	
Maximum clamp current	I_{CLAMP}	– 2.0	+ 2.0	mA	*2
Total maximum clamp current	$\Sigma\|I_{CLAMP}\|$	—	20	mA	*2
“L” level maximum output current	I_{OL}	—	15	mA	
“L” level average output current	I_{OLAV}	—	4	mA	Average value (operating current × operating rate)
“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 rate)
“H” level maximum output current	I_{OH}	—	– 15	mA	
“H” level average output current	I_{OHAV}	—	– 4	mA	Average value (operating current × operating rate)
“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 rate)
Power consumption	P_D	—	300	mW	
Operating temperature	T_A	– 40	+ 85	°C	
Storage temperature	Tstg	– 55	+ 150	°C	

*1 : The parameter is based on $AV_{SS} = V_{SS} = 0.0$ V.

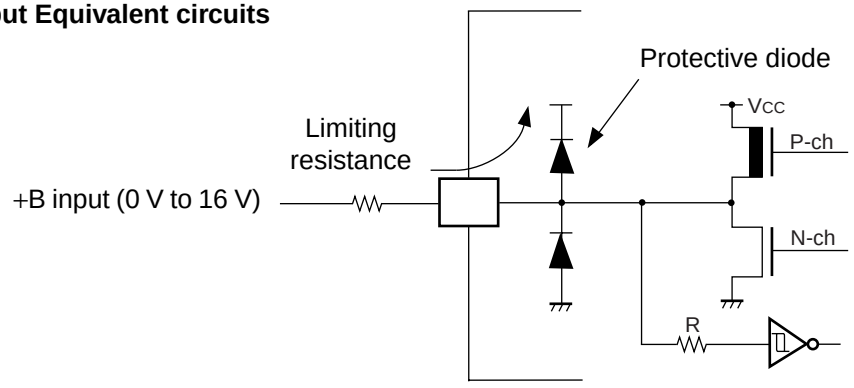
*2 :
- Applicable to pins : P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P52, P80 to P82
- Use within recommended operating conditions.
- Use at DC voltage (current) .
- The +B signal should always be applied with a limiting resistance placed between the +B signal and the microcontroller.
- The value of the limiting resistance should be set so that when the +B signal is applied the input current to the microcontroller pin does not exceed rated values, either instantaneously or for prolonged periods.

(Continued)

(Continued)

- Note that when the microcontroller drive current is low, such as in the power saving modes, the +B input potential may pass through the protective diode and increase the potential at the V_{CC} pin, and this may affect other devices.
- Note that if a +B signal is input when the microcontroller current is off (not fixed at 0 V) , the power supply is provided from the pins, so that incomplete operation may result.
- Note that if the +B input is applied during power-on, the power supply is provided from the pins and the resulting supply voltage may not be sufficient to operate the power-on result.
- Care must be taken not to leave the +B input pin open.
- Note that analog system input/output pins other than the A/D input pins (LCD drive pins, comparator input pins, etc.) cannot accept +B signal input.
- Sample recommended circuits :

- **Input/Output Equivalent circuits**



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*	3.6	V	Normal operation assurance range	MB89PV490 and MB89F499
		2.2*	3.6	V	Normal operation assurance range	MB89498
		1.5	3.6	V	Retains the RAM state in stop mode	
	AVR	2.7	3.6	V		
LCD power supply voltage	V1 to V3	Vss	Vcc	V		
Operating temperature	T_A	–40	+85	°C		

* : These values depend on the operating conditions and the analog assurance range. See Figure 1, 2 and "5. A/D Converter Electrical Characteristics."

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.

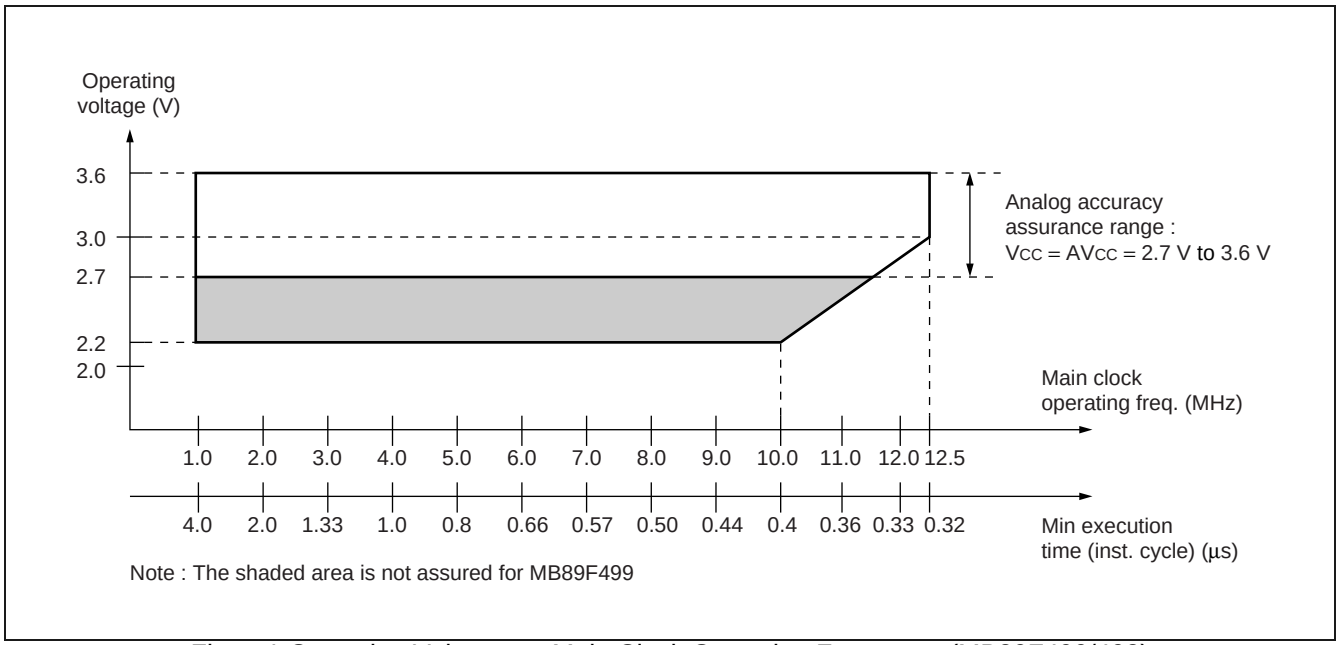


Figure1 Operating Voltage vs. Main Clock Operating Frequency (MB89F499/498)

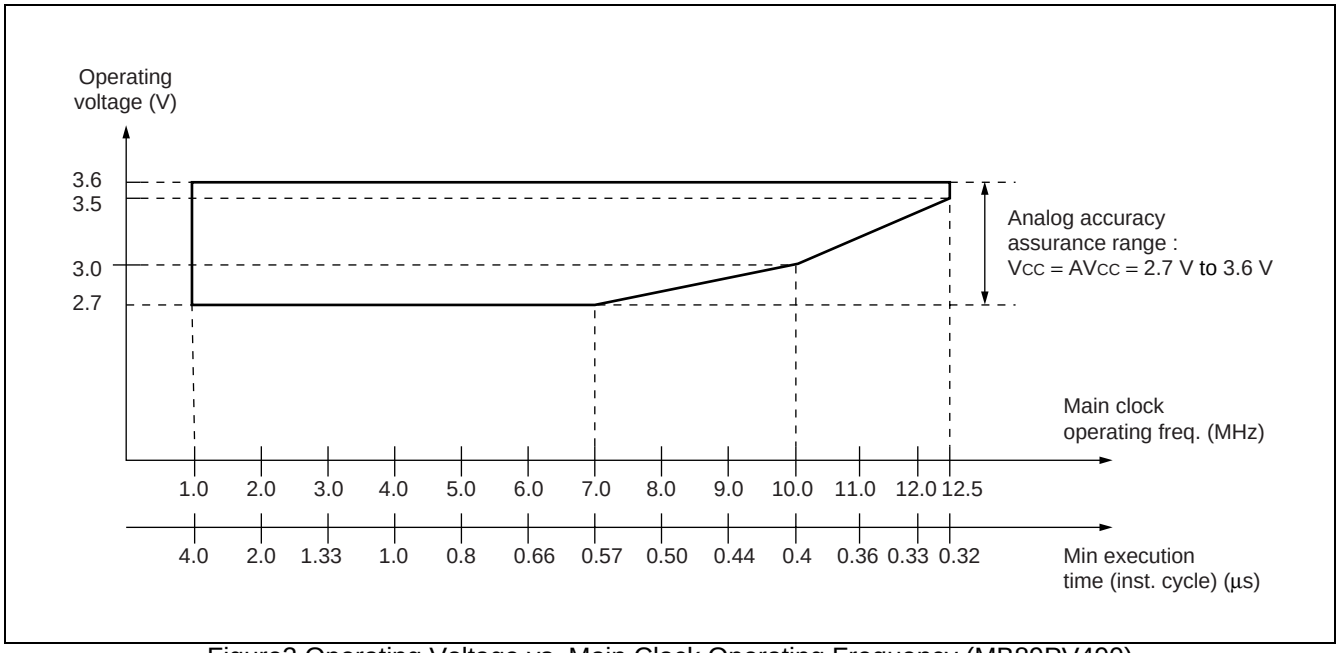


Figure2 Operating Voltage vs. Main Clock Operating Frequency (MB89PV490)

Figure 1 and 2 indicate 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 figure 1 and 2 if the operating speed is switched using a gear.

3. DC Characteristics

($AV_{CC} = V_{CC} = 3.0$ V, $AV_{SS} = V_{SS} = 0.0$ V, $T_A = -40$ °C to +85 °C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min	Typ	Max		
"H" level input voltage	V_{IH}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P54, P60 to P67, P70 to P77, P80 to P84, SCL, SDA,	—	0.7 V_{CC}	—	V_{CC} + 0.3	V	
		P40 to P47	—	0.7 V_{CC}	—	V_{SS} + 6.0	V	MB89498
			—	0.7 V_{CC}	—	V_{SS} + 5.5	V	MB89F499
	V_{IHS}	$\overline{RST}$, MOD0, EC0, EC1, SCK0, SI0, SCK1, SI1, RMC, INT00 to INT07	—	0.8 V_{CC}	—	V_{CC} + 0.3	V	
	V_{IHA}	$\overline{INT10}$ to $\overline{INT17}$	—	0.85 V_{CC}	—	V_{CC} + 0.3	V	
"L" level input voltage	V_{IL}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P54, P60 to P67, P70 to P77, P80 to P84, SCL, SDA,	—	V_{SS} − 0.3	—	0.3 V_{CC}	V	
	V_{ILS}	$\overline{RST}$, MOD0, EC0, EC1, SCK0, SI0, SCK1, SI1, RMC, INT00 to INT07	—	V_{SS} − 0.3	—	0.2 V_{CC}	V	
	V_{ILA}	$\overline{INT10}$ to $\overline{INT17}$	—	V_{SS} − 0.3	—	0.5 V_{CC}	V	
Open-drain output pin application voltage	V_D	P40 to P47	—	V_{SS} − 0.3	—	V_{SS} + 6.0	V	MB89498
			—	V_{SS} − 0.3	—	V_{SS} + 5.5	V	MB89F499

(Continued)

($AV_{CC} = V_{CC} = 3.0$ V, $AV_{SS} = V_{SS} = 0.0$ V, $T_A = -40$ °C to +85 °C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min	Typ	Max		
"H" level output voltage	V_{OH}	P10 to P17, P20 to P27, P30 to P37, P50 to P54, P60 to P67, P70 to P77, P80 to P82	$I_{OH} = -2.0$ mA	2.2	—	—	V	
		P00 to P07	$I_{OH} = -4.0$ mA	2.2	—	—	V	
"L" level output voltage	V_{OL}	P10 to P17, P20 to P27, P30 to P37, P50 to P54, P60 to P67, P70 to P77, P80 to P82, $\overline{RST}$	$I_{OL} = 4.0$ mA	—	—	0.4	V	
		P00 to P07	$I_{OL} = 12.0$ mA	—	—	0.4	V	
		P40 to P47	$I_{OL} = 15.0$ mA	—	—	0.4	V	
Input leakage current	I_{LI}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P40 to P47, P50 to P54, P60 to P67, P70 to P77, P80 to P84	$0.45 V < V_I < V_{CC}$	–5	—	+5	µA	Without pull-up resistor
Open-drain output leakage current	I_{LOD}	P40 to P47	$0.0 V < V_I < V_{CC}$	–5	—	+5	µA	
Pull-down resistance	R_{DOWN}	MOD0	$V_I = V_{CC}$	25	50	100	kΩ	Except MB89F499
Pull-up resistance	R_{PULL}	P00 to P07, P10 to P17, P20 to P27, P30 to P37, P50 to P54, P60 to P67, P70 to P77, P80 to P82, $\overline{RST}$	$V_I = 0.0$ V	25	50	100	kΩ	When pull-up resistor is selected (except $\overline{RST}$)
Common output impedance	R_{VCOM}	COM0 to COM3	V1 to V3 = +3.0 V	—	—	2.5	kΩ	

(Continued)

(AV_{CC} = V_{CC} = 3.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min	Typ	Max		
Segment output impedance	R_{VSEG}	SEG0 to SEG31	V1 to V3 = +3.0 V	—	—	15	kΩ	
LCD divided resistance	R_{LCD}	—	Between V_{CC} and V_{SS}	300	500	750	kΩ	
LCD controller/ driver leakage current	I_{LCDL}	V1 to V3, COM0 to COM3, SEG0 to SEG31	—	–1	—	+1	µA	
Power supply current	I_{CC1}	V_{CC}	F_{CH} = 12.5 MHz t_{inst} = 0.33 µs Main clock run mode	—	8.0	12	mA	MB89F499
				—	7.0	12.0	mA	MB89498
	I_{CC2}		F_{CH} = 12.5 MHz t_{inst} = 5.33 µs Main clock run mode	—	1.0	3.0	mA	MB89F499 MB89498
	I_{CCS1}		F_{CH} = 12.5 MHz t_{inst} = 0.33 µs Main clock sleep mode	—	3.0	5.0	mA	MB89F499 MB89498
	I_{CCS2}		F_{CH} = 12.5 MHz t_{inst} = 5.33 µs Main clock sleep mode	—	0.6	2.0	mA	MB89F499 MB89498
	I_{CCL}		F_{CL} = 32.768 kHz Sub-clock mode T_A = +25 °C	—	40.0	60.0	µA	MB89F499 MB89498
	I_{CCLPLL}		F_{CL} = 32.768 kHz Sub-clock mode T_A = +25 °C sub PLL × 4	—	180.0	250.0	µA	MB89F499 MB89498
	I_{CCLS}		F_{CL} = 32.768 kHz Sub-clock sleep mode T_A = +25 °C	—	14.0	30.0	µA	MB89F499 MB89498
	I_{CCT}		F_{CL} = 32.768 kHz Watch mode Main clock stop mode T_A = +25 °C	—	1.5	13.0	µA	MB89F499 MB89498

(Continued)

(Continued)

(AV_{CC} = V_{CC} = 3.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

Parameter	Symbol	Pin	Condition	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current	I_{CCH}	V_{CC}	T_A = +25 °C Sub-clock stop mode	—	0.8	4.0	µA	MB89F499 MB89498
	I_A	AV_{CC}	AV_{CC} = 3.0 V, T_A = +25 °C	—	1.2	4.4	mA	A/D converting
	I_{AH}		T_A = +25 °C	—	0.8	4.0	µA	A/D stop
Input capacitance	C_{IN}	Except V_{CC}, V_{SS}, AV_{CC}, AV_{SS}, AVR	f = 1 MHz	—	10.0	—	pF	

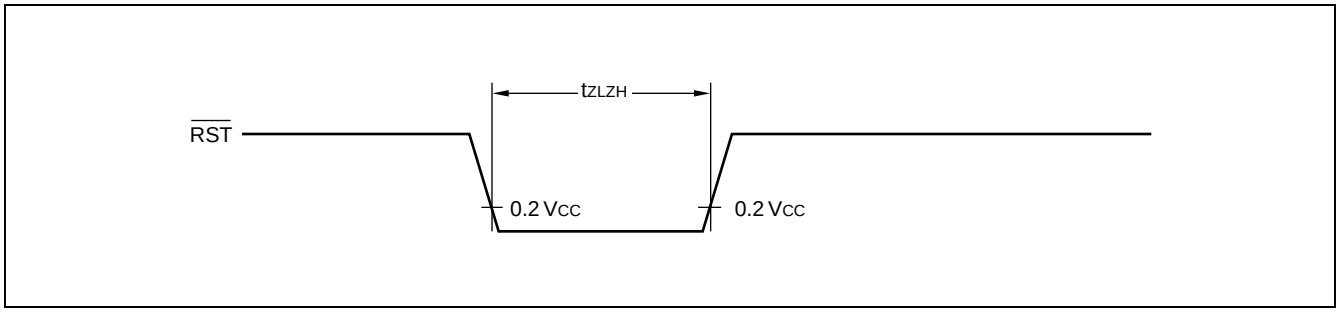
4. AC Characteristics

(1) Reset Timing

(AV_{CC} = V_{CC} = 3.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

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

Note : t_{HCYL} is the oscillation cycle ($1/F_{CH}$) to input to the X0 pin.
The MCU operation is not guaranteed when the "L" pulse width is shorter than t_{ZLZH}.

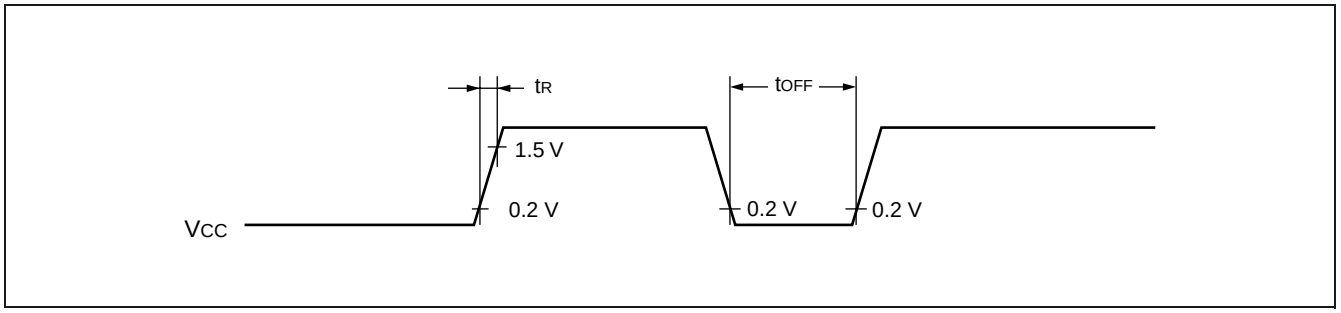


(2) Power-on Reset

(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 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.
Rapid changes in power supply voltage may cause a power-on reset. If power supply voltage needs to be varied in the course of operation, a smooth voltage rise is recommended.

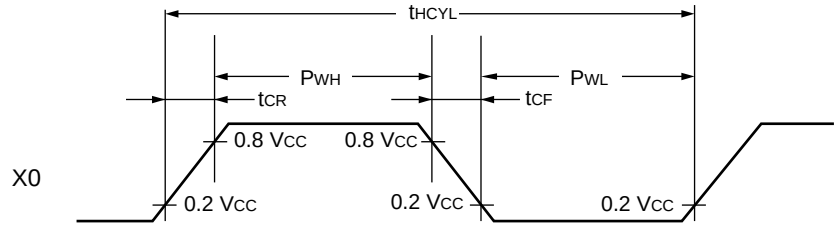


(3) Clock Timing

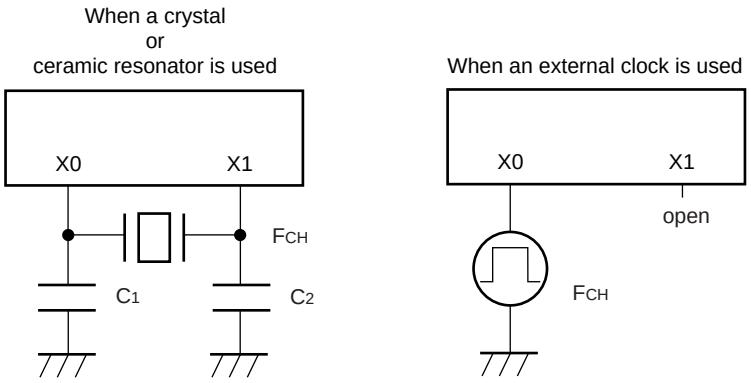
(AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

Parameter	Symbol	Pin	Value			Unit	Remarks
			Min	Typ	Max		
Clock frequency	F_{CH}	X0, X1	1	—	12.5	MHz	
	F_{CL}	X0A, X1A	—	32.768	75	kHz	
Clock cycle time	t_{HCYL}	X0, X1	80	—	1000	ns	
	t_{LCYL}	X0A, X1A	13.3	30.5	—	µs	
Input clock pulse width	P_{WH} P_{WL}	X0	20	—	—	ns	External clock
	P_{WHL} P_{WLL}	X0A	—	15.2	—	µs	
Input clock rising/falling time	t_{CR} t_{CF}	X0, X0A	—	—	10	ns	

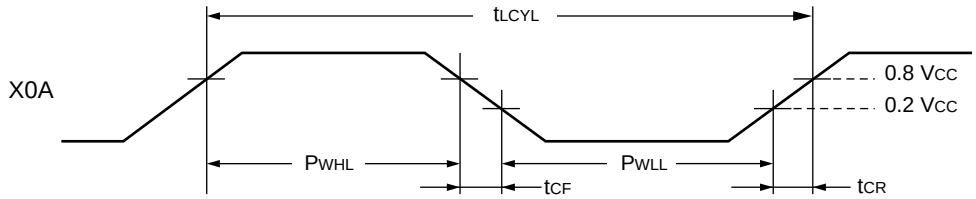
X0 and X1 Timing and Conditions



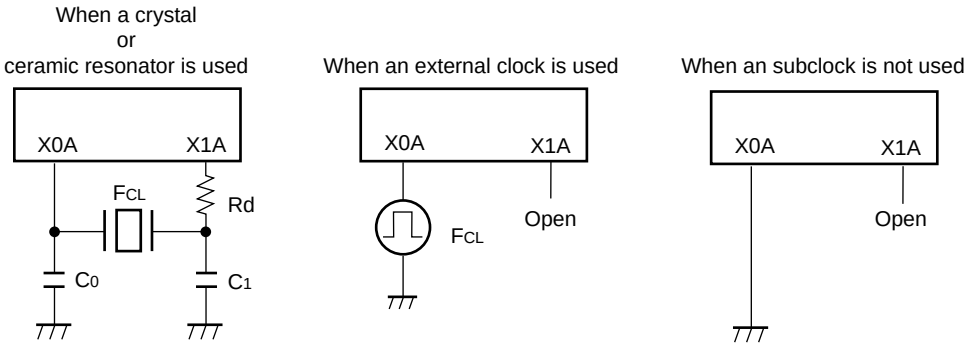
Main Clock Conditions



Sub-clock Timing and Conditions



Sub-clock Conditions

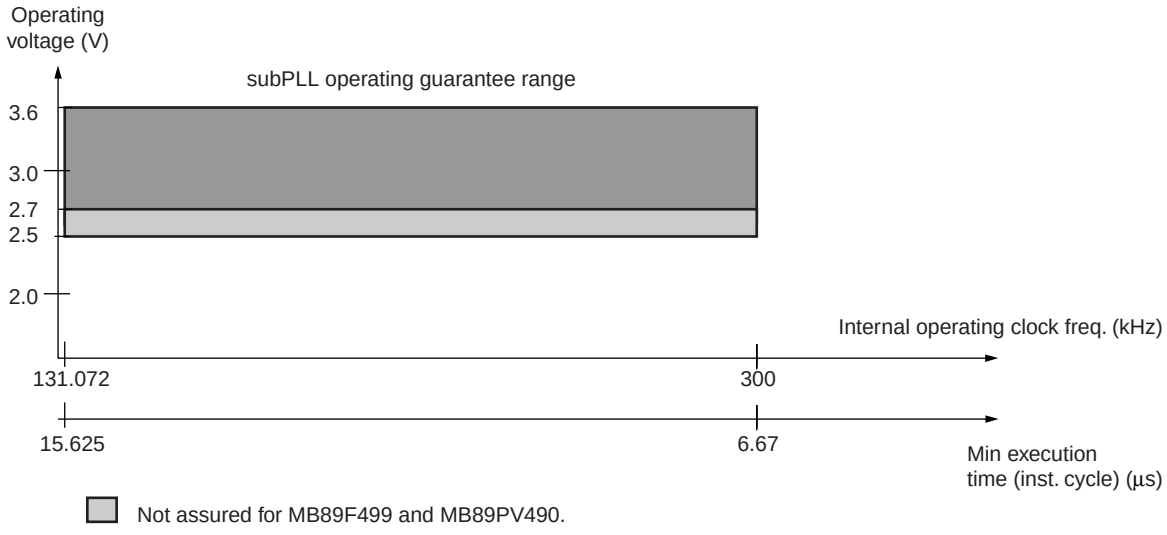


(4) Instruction Cycle

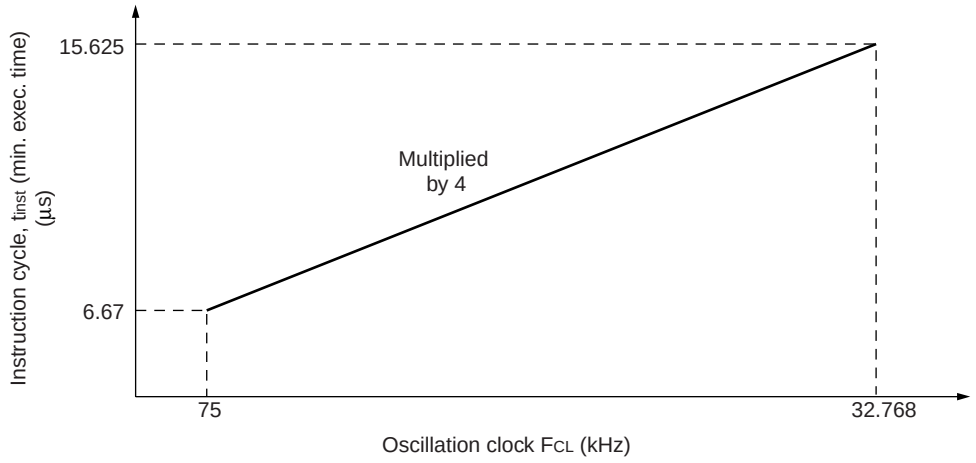
Parameter	Symbol	Value (typical)	Unit	Remarks
Instruction cycle (minimum execution time)	t_{inst}	$4/F_{CH}$, $8/F_{CH}$, $16/F_{CH}$, $64/F_{CH}$	µs	$(4/F_{CH})$ t_{inst} = 0.32 µs when operating at F_{CH} = 12.5 MHz
		$2/F_{CL}$, $1/2F_{CL}$	µs	$(2/F_{CL})$ t_{inst} = 61.036 µs when operating at F_{CL} = 32.768 kHz

- PLL operation guarantee range (sub PLL × 4)

Relationship between internal operating clock frequency and power supply voltage



Relationship between sub-clock oscillating frequency and instruction cycle when sub PLL is enabled



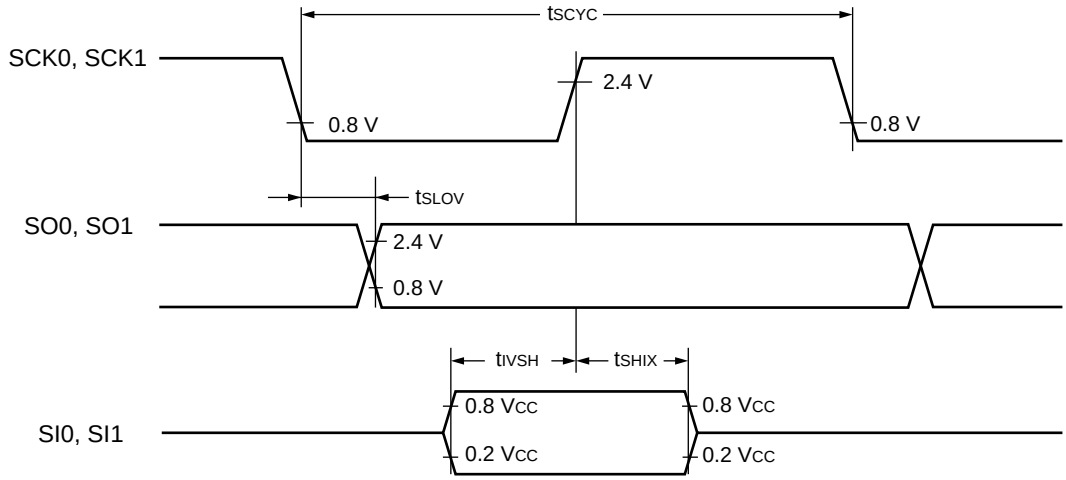
(5) Serial I/O Timing

(AV_{CC} = V_{CC} = 3.0 V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

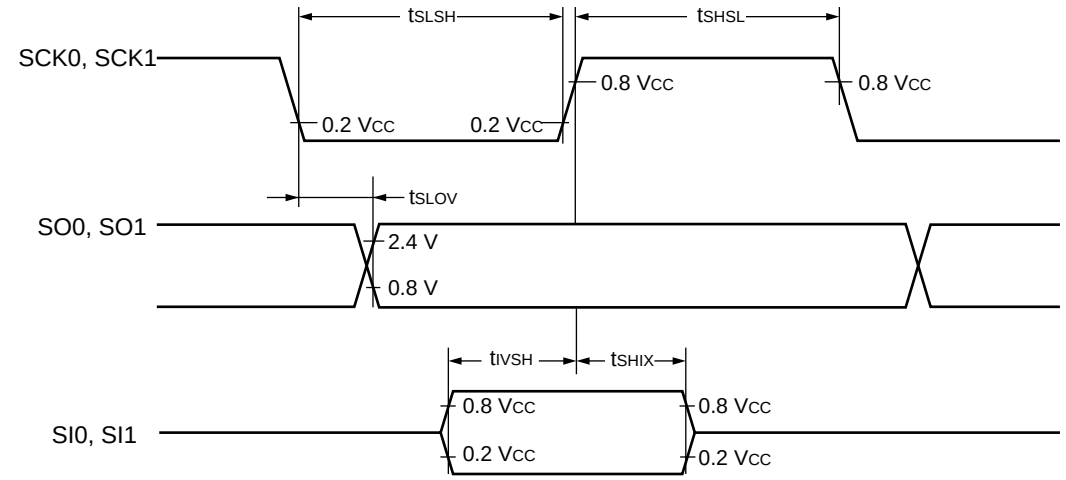
Parameter	Symbol	Pin	Condition	Value		Unit
				Min	Max	
Serial clock cycle time	t_{SCYC}	SCK0, SCK1	Internal shift clock mode	2 t_{inst}*	—	µs
SCK ↓ → SO time	t_{SLOV}	SCK0, SCK1, SO0, SO1		–200	200	ns
Valid SI → SCK ↑	t_{IVSH}	SI0, SI1, SCK0, SCK1		1/2 t_{inst}*	—	µs
SCK ↑ → valid SI hold time	t_{SHIX}	SCK0, SCK1, SI0, SI1		1/2 t_{inst}*	—	µs
Serial clock “H” pulse width	t_{SHSL}	SCK0, SCK1	External shift clock mode	1 t_{inst}*	—	µs
Serial clock “L” pulse width	t_{SLSH}			1 t_{inst}*	—	µs
SCK ↓ → SO time	t_{SLOV}	SCK0, SCK1, SO0, SO1		0	200	ns
Valid SI → SCK ↑	t_{IVSH}	SI0, SI1, SCK0, SCK1		1/2 t_{inst}*	—	µs
SCK ↑ → valid SI hold time	t_{SHIX}	SCK0, SCK1, SI0, SI1		1/2 t_{inst}*	—	µs

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

Internal Clock Operation



External Clock Operation



(6) I²C Timing

(V_{CC} = 3.0V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

Parameter	Symbol	Pin	Value		Unit	Remarks
			Min	Max		
Start condition output	t_{STA}	SCL SDA	1/4 t_{inst}*1 × M × N – 20	1/4 t_{inst} × M × N + 20	ns	At master mode
Stop condition output	t_{STO}	SCL SDA	1/4 t_{inst} × (M × N + 8) – 20	1/4 t_{inst} × (M*2 × N*3 + 8) + 20	ns	At master mode
Start condition detect	t_{STA}	SCL SDA	1/4 t_{inst} × 6 + 40	—	ns	
Stop condition detect	t_{STO}	SCL SDA	1/4 t_{inst} × 6 + 40	—	ns	
Re-start condition output	t_{STASU}	SCL SDA	1/4 t_{inst} × (M × N + 8) – 20	1/4 t_{inst} × (M × N + 8) + 20	ns	At master mode
Re-start condition detect	t_{STASU}	SCL SDA	1/4 t_{inst} × 4 + 40	—	ns	
SCL output LOW width	t_{LOW}	SCL	1/4 t_{inst} × M × N – 20	1/4 t_{inst} × M × N + 20	ns	At master mode
SCL output HIGH width	t_{HIGH}	SCL	1/4 t_{inst} × (M × N + 8) – 20	1/4 t_{inst} × (M × N + 8) + 20	ns	At master mode
SDA output delay	t_{DO}	SDA	1/4 t_{inst} × 4 – 20	1/4 t_{inst} × 4 + 20	ns	
SDA output setup time after interrupt	t_{DOSU}	SDA	1/4 t_{inst} × 4 – 20	—	ns	*4
SCL input LOW pulse width	t_{LOW}	SCL	1/4 t_{inst} × 6 + 40	—	ns	
SCL input HIGH pulse width	t_{HIGH}	SCL	1/4 t_{inst} × 2 + 40	—	ns	
SDA input setup time	t_{SU}	SDA	40	—	ns	
SDA hold time	t_{HO}	SDA	0	—	ns	

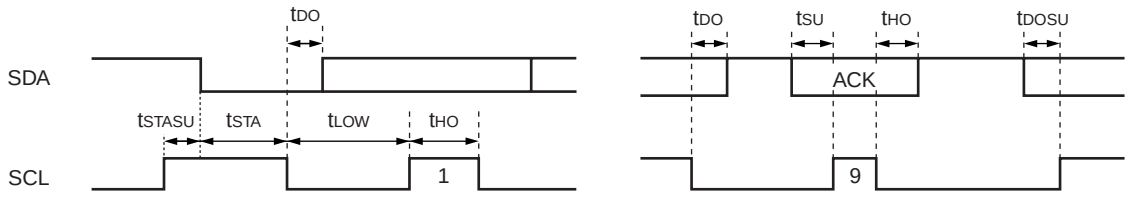
*1 : For information in t_{inst}, see “ (4) Instruction Cycle”.

*2 : M is defined in the I²C clock control register ICCR bit 4 and bit 3 (CS4 and CS3). For details, please refer to the H/W manual register explanation.

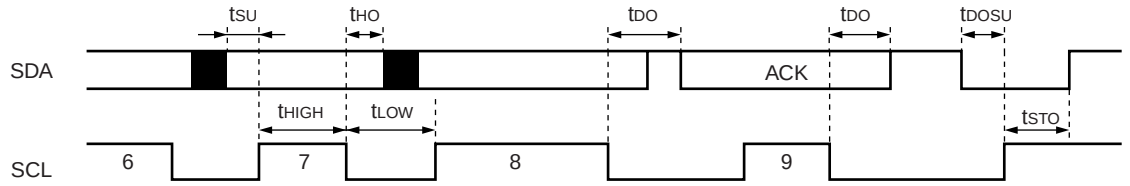
*3 : N is defined in the I²C clock control register ICCR bit 2 to bit 0 (CS2 to CS0).

*4 : When the interrupt period is greater than SCL “L” width, SDA and SCL output (Standard) value is based on hypothesis when rising time is 0 ns.

Data transmit (master/slave)



Data receive (master/slave)

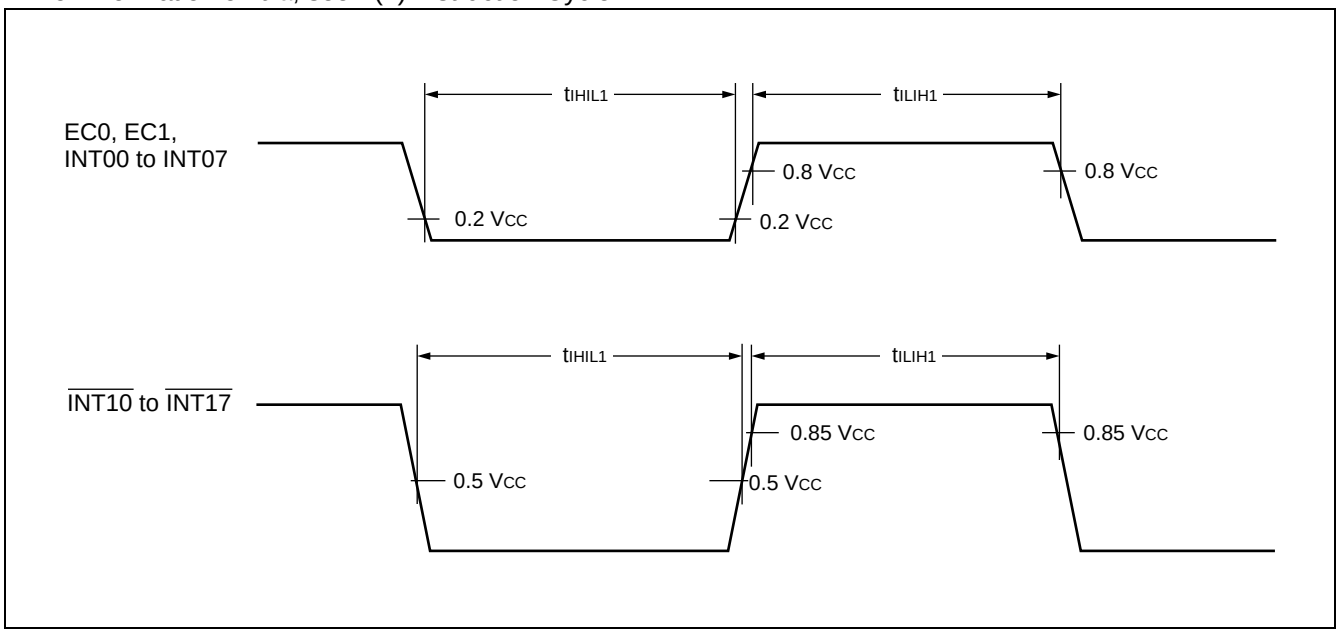


(7) Peripheral Input Timing

($AV_{CC} = V_{CC} = 3.0$ V, $AV_{SS} = V_{SS} = 0.0$ V, $T_A = -40$ °C to +85 °C)

Parameter	Symbol	Pin	Value		Unit	Remarks
			Min	Max		
Peripheral input “H” pulse width 1	t_{ILIH1}	EC0, EC1, INT00 to INT07, $\overline{INT10}$ to $\overline{INT17}$	2 t_{inst}*	—	µs	
Peripheral input “L” pulse width 1	t_{IHIL1}		2 t_{inst}*	—	µs	

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



5. A/D Converter Electrical Characteristics

(1) A/D Converter Electrical Characteristics

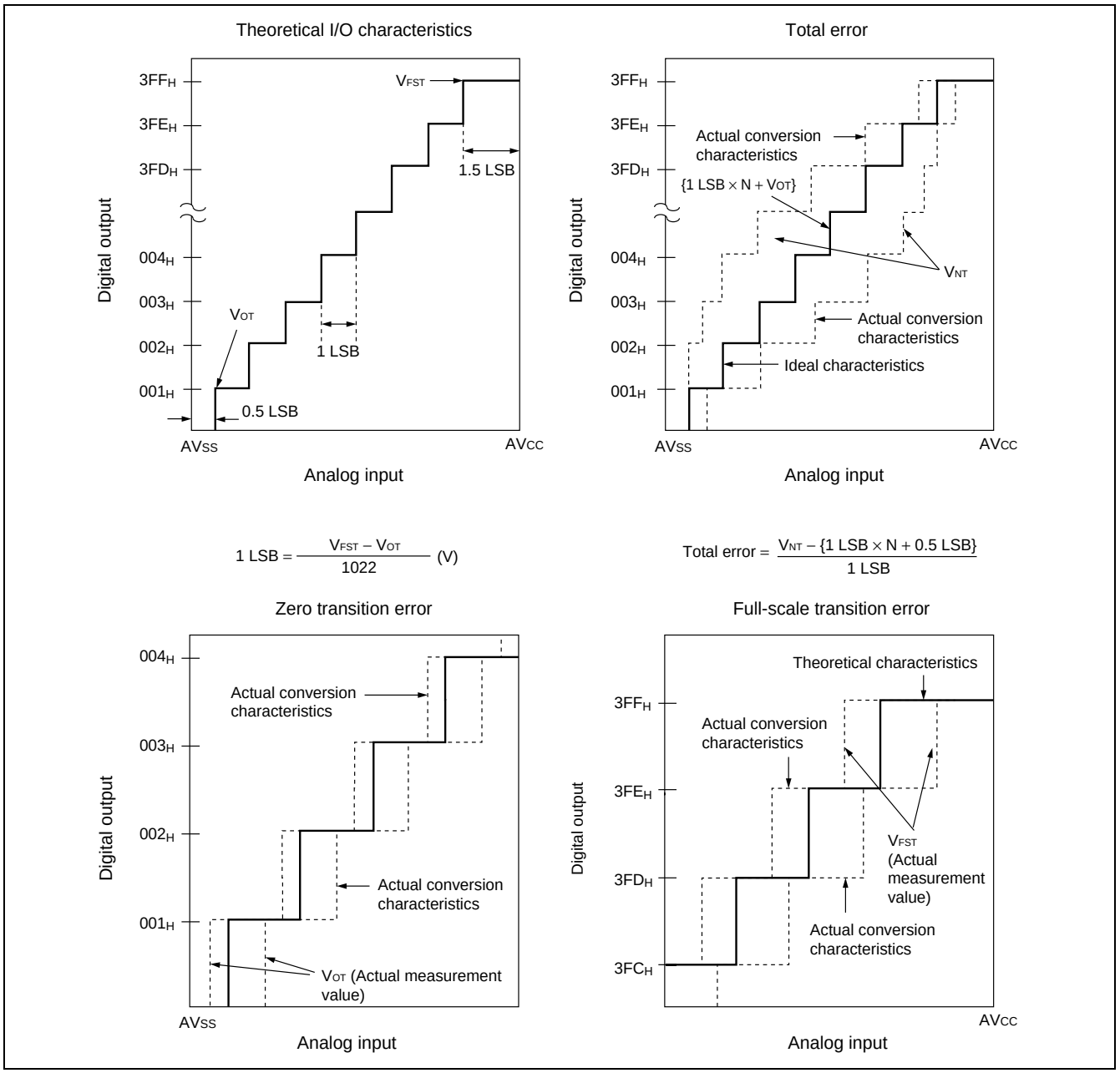
(AV_{CC} = V_{CC} = 2.7 V to 3.6 V, AV_{SS} = V_{SS} = 0.0 V, T_A = –40 °C to +85 °C)

Parameter	Symbol	Pin	Value			Unit	Remarks
			Min	Typ	Max		
Resolution	—	—	—	10	—	bit	
Total error			—	—	±3.0	LSB	
Linearity error			—	—	±2.5	LSB	
Differential linearity error			—	—	±1.9	LSB	
Zero transition voltage	V_{OT}		AV_{SS} – 1.5 LSB	AV_{SS} + 0.5 LSB	AV_{SS} + 2.5 LSB	mV	
Full-scale transition voltage	V_{FST}		AV_{CC} – 3.5 LSB	AV_{CC} – 1.5 LSB	AV_{CC} – 0.5 LSB	mV	
A/D mode conversion time	—		30 t_{inst}*	—	—	µs	
Analog port input current	I_{AIN}	AN0 to AN7	—	—	10	µA	
Analog input voltage	V_{AIN}		AV_{SS}	—	AVR	V	
Reference voltage	—	AVR	AV_{SS} + 2.7	—	AV_{CC}	V	
Reference voltage supply current	I_R		—	95.0	170.0	µA	A/D is activated
	I_{RH}		—	—	4.0	µA	A/D is stopped

* : For information on t_{inst}, see “ (4) Instruction Cycle” in “4. AC Characteristics”.

(2) A/D Converter Glossary

- Resolution
  Analog changes that are identifiable with the A/D converter.
  When the number of bits is 10, analog voltage can be divided into $2^{10} = 1024$.
- Linearity error (unit : LSB)
  The deviation of the straight line connecting the zero transition point (“00 0000 0000” ↔ “00 0000 0001”) with the full-scale transition point (“11 1111 1111” ↔ “11 1111 1110”) from actual conversion characteristics.
- Differential linearity error (unit : LSB)
  The deviation of input voltage needed to change the output code by 1 LSB from the theoretical value.
- Total error (unit : LSB)
  The difference between theoretical and actual conversion values.



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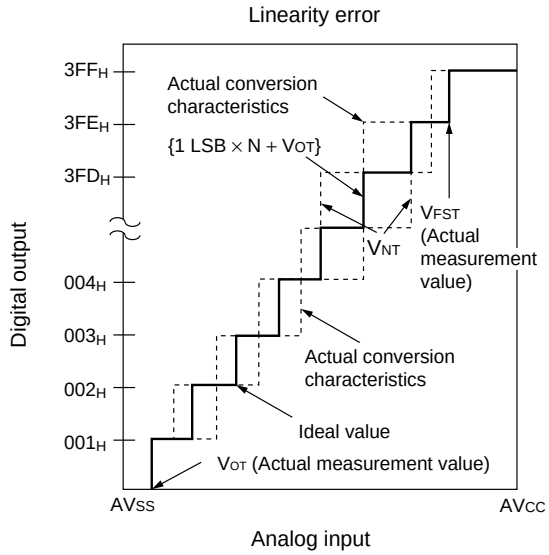
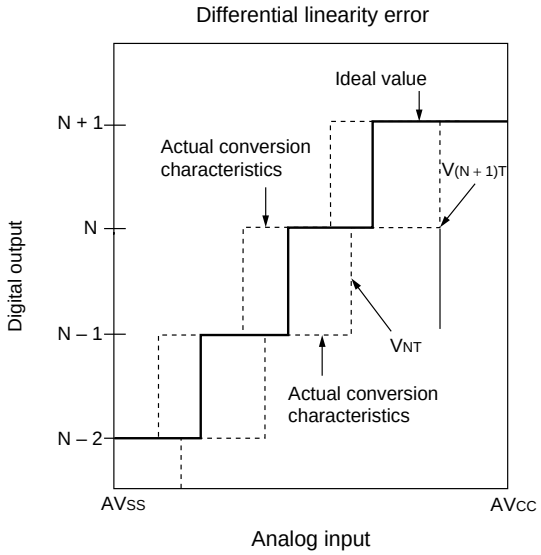




$$\text{Linearity error} = \frac{V_{NT} - \{1\ \text{LSB} \times N + V_{OT}\}}{1\ \text{LSB}}$$

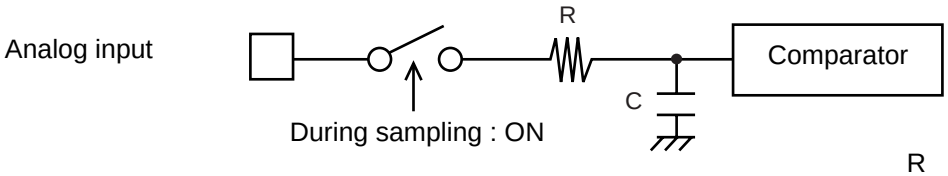
$$\text{Differential linearity error} = \frac{V_{(N+1)T} - V_{NT}}{1\ \text{LSB}} - 1$$

(3) Notes on Using A/D Converter

● About the external impedance of the analog input and its sampling time

- A/D converter with sample and hold circuit. If the external impedance is too high to keep sufficient sampling time, the analog voltage charged to the internal sample and hold capacitor is insufficient, adversely affecting A/D conversion precision.

● Analog input circuit model



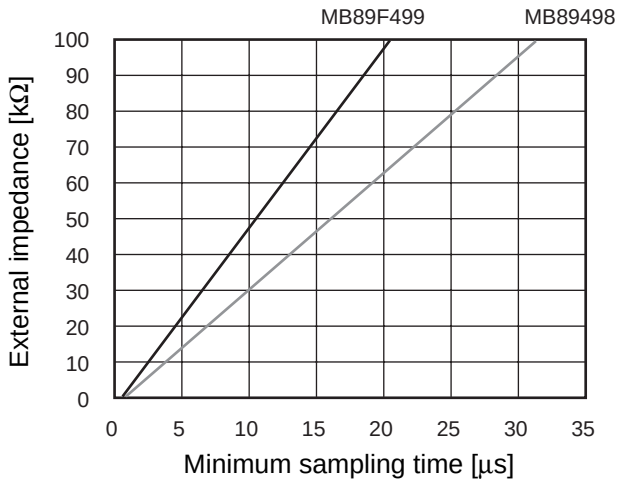
	R	C
MB89498	2.4 kΩ (Max)	44.0 pF (Max)
MB89F499	2.4 kΩ (Max)	28.6 pF (Max)

Note : The values are reference values.

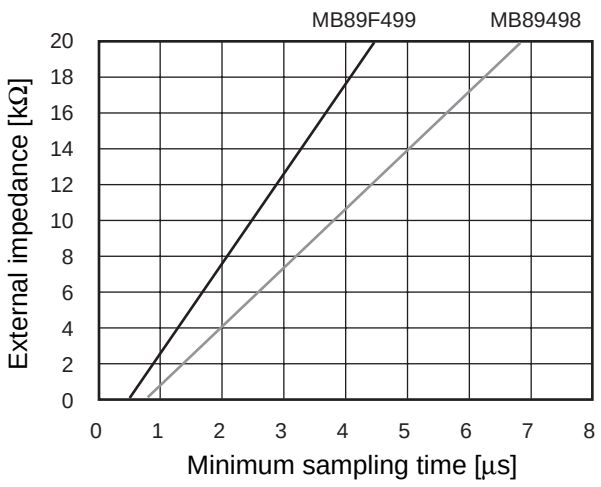
- To satisfy the A/D conversion precision standard, consider the relationship between the external impedance and minimum sampling time and either adjust the resistor value and operating frequency or decrease the external impedance so that the sampling time is longer than the minimum value.

● The relationship between external impedance and minimum sampling time

(External impedance = 0 kΩ to 100 kΩ)



(External impedance = 0 kΩ to 20 kΩ)



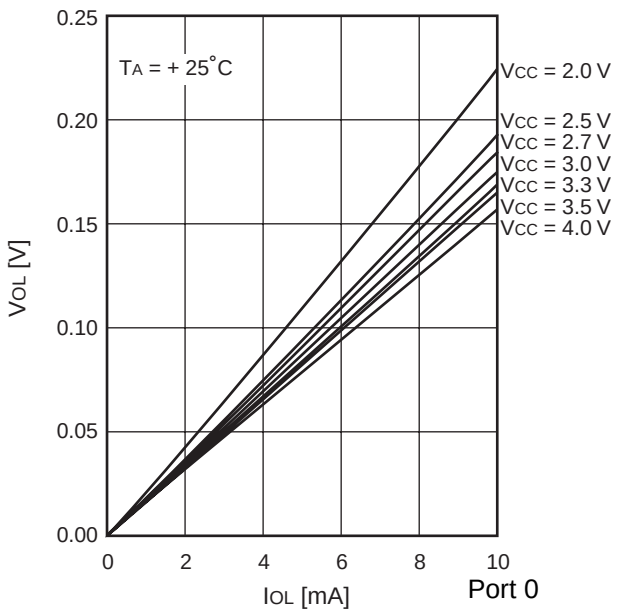
- If the sampling time cannot be sufficient, connect a capacitor of about 0.1 µF to the analog input pin.

- About errors
  As |AVRH − AV_{SS}| becomes smaller, values of relative errors grow larger.

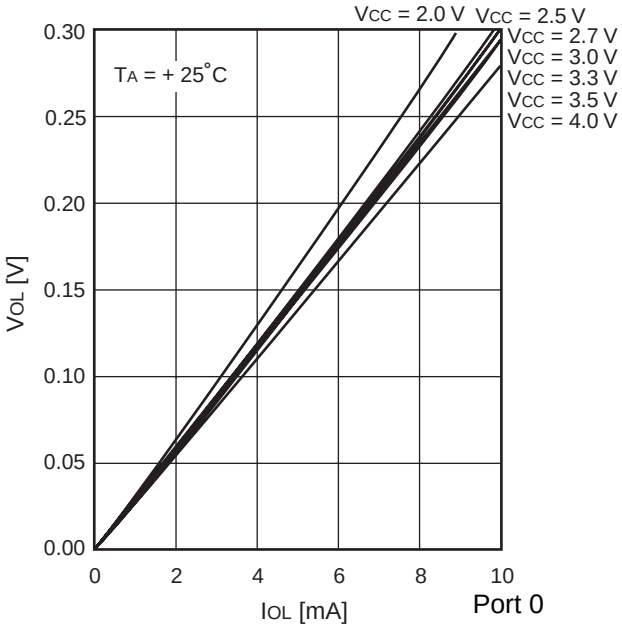
■ EXAMPLE CHARACTERISTICS

(1) “L” level output voltage

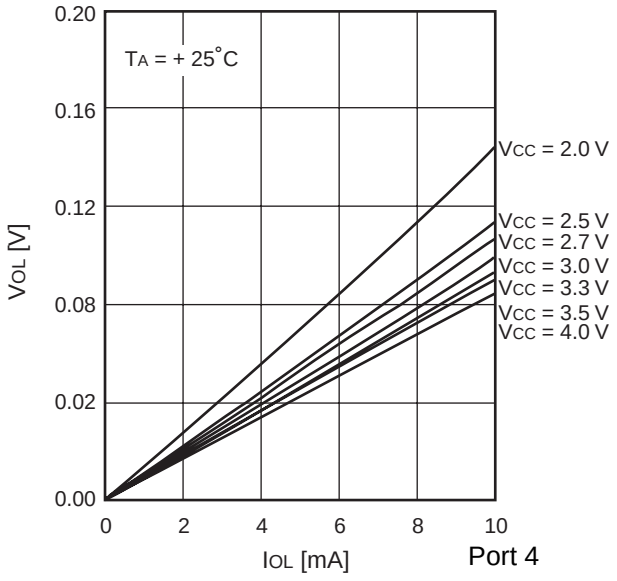
V_{OL} vs I_{OL} (MB89498)



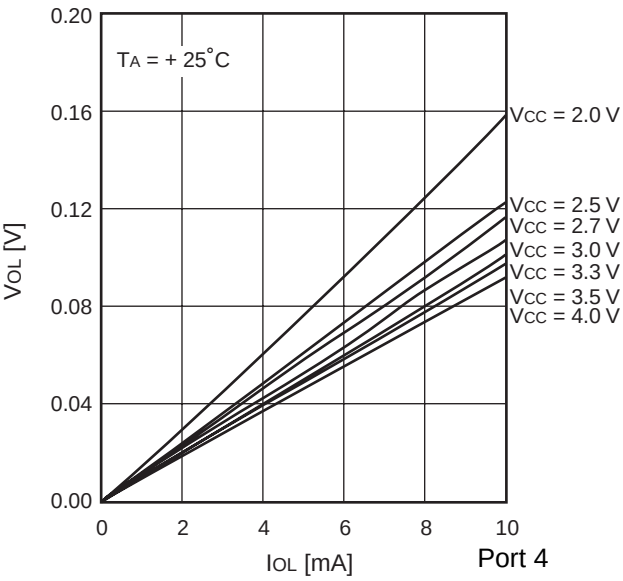
V_{OL} vs I_{OL} (MB89F499)



V_{OL} vs I_{OL} (MB89498)



V_{OL} vs I_{OL} (MB89F499)



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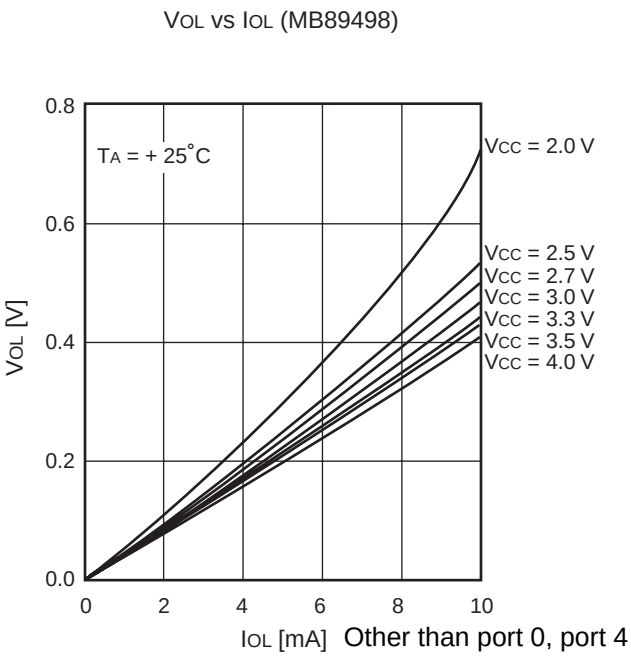
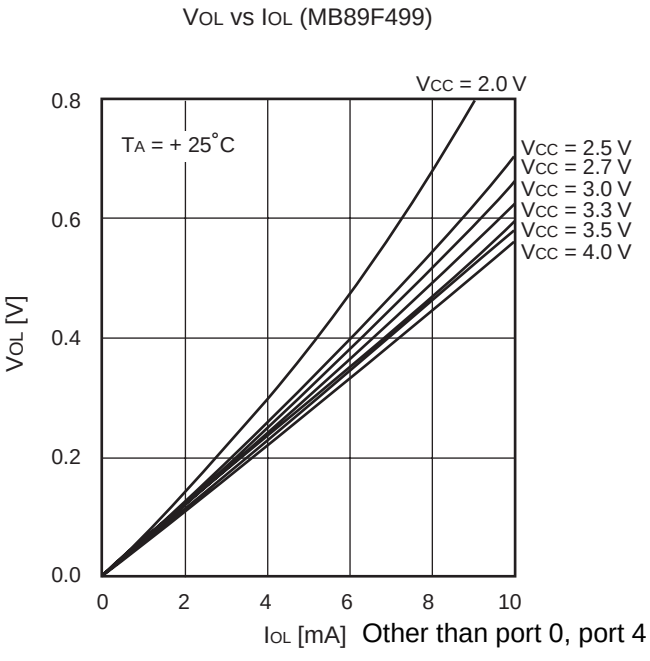
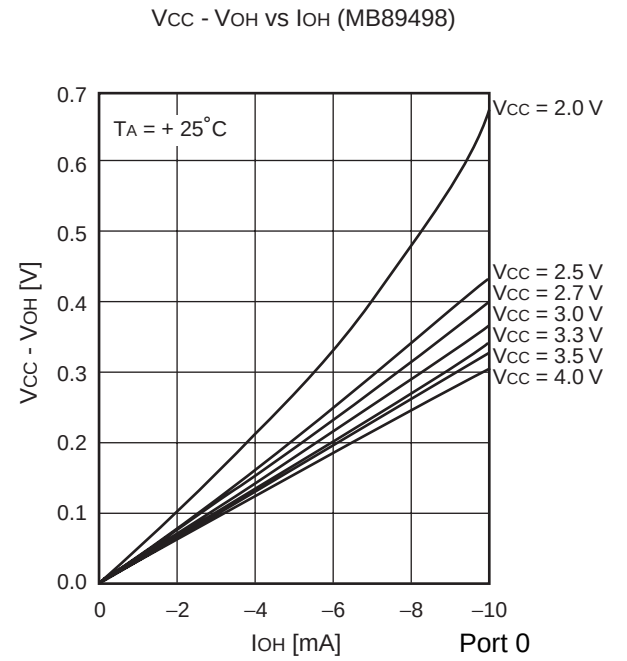
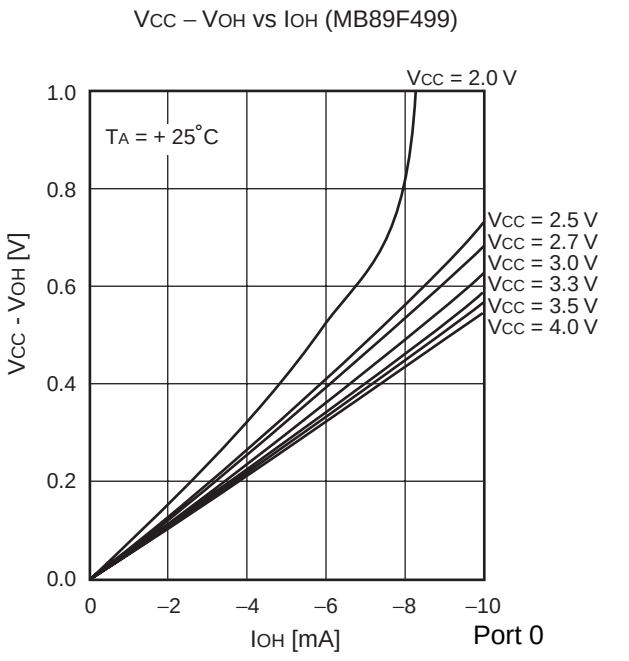




(2) “H” level output voltage





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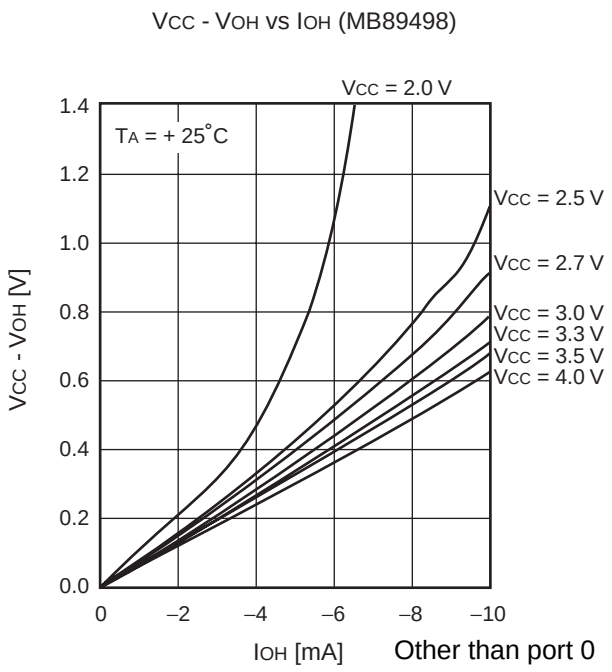
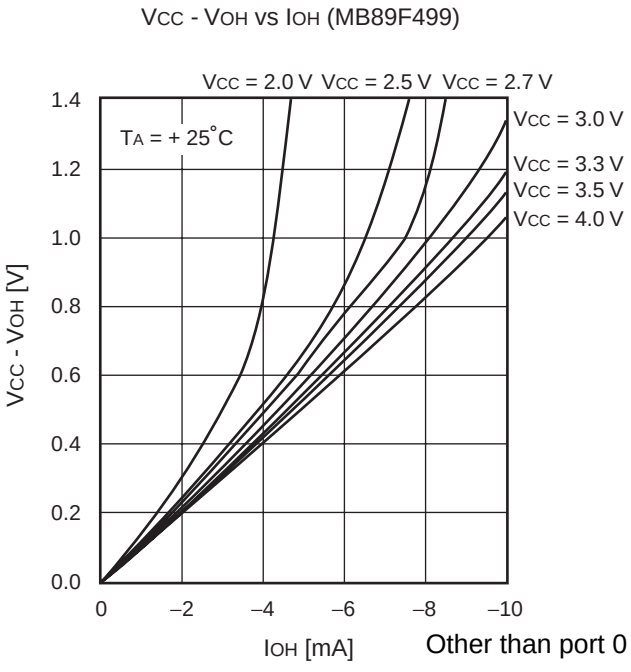
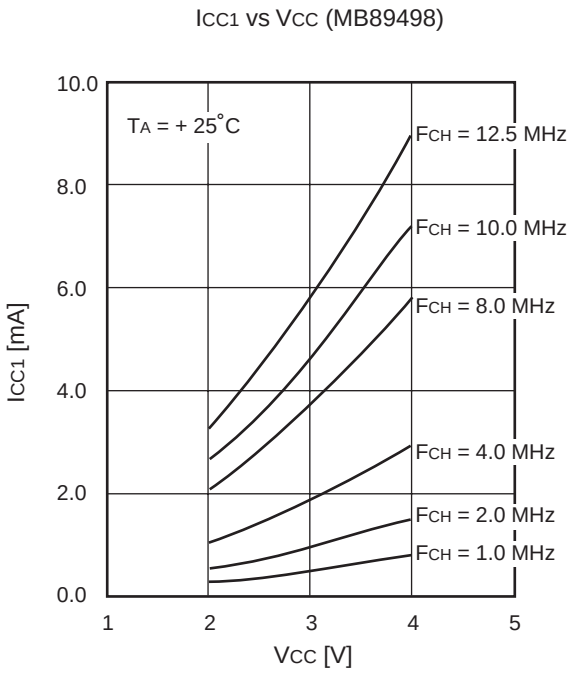
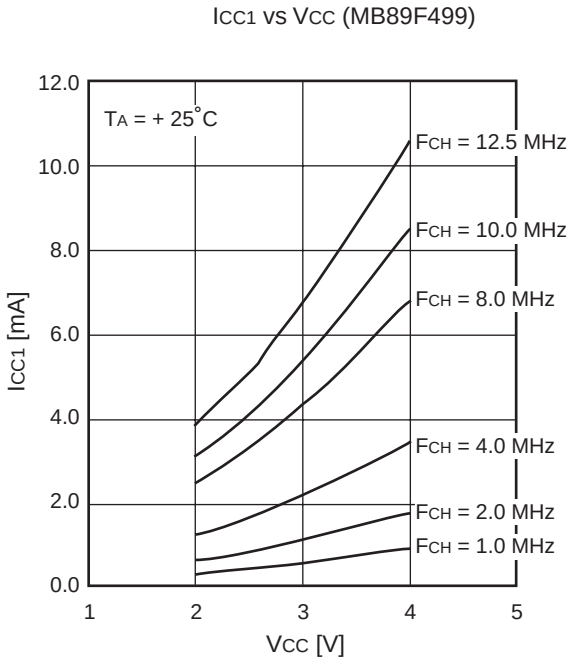




(3) Power supply current (External clock)





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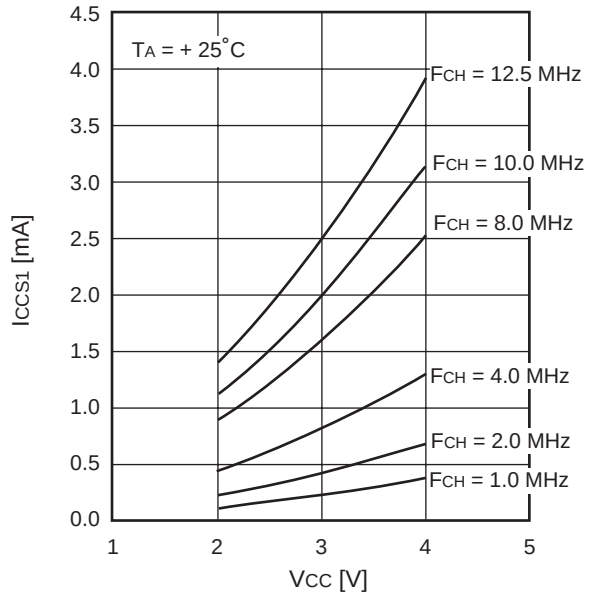
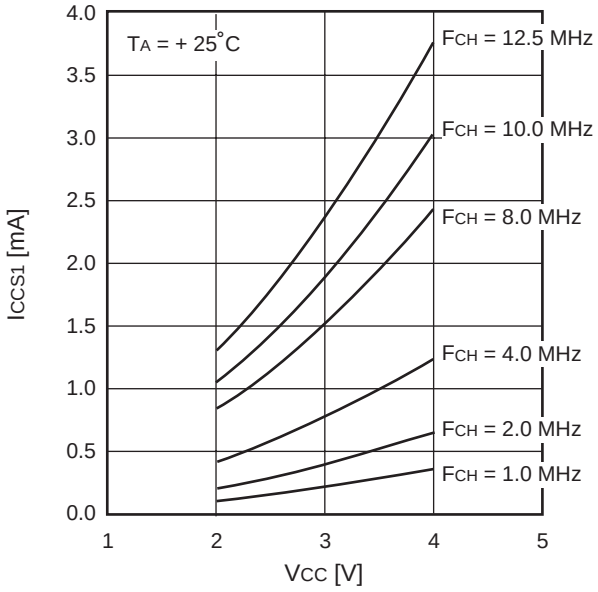
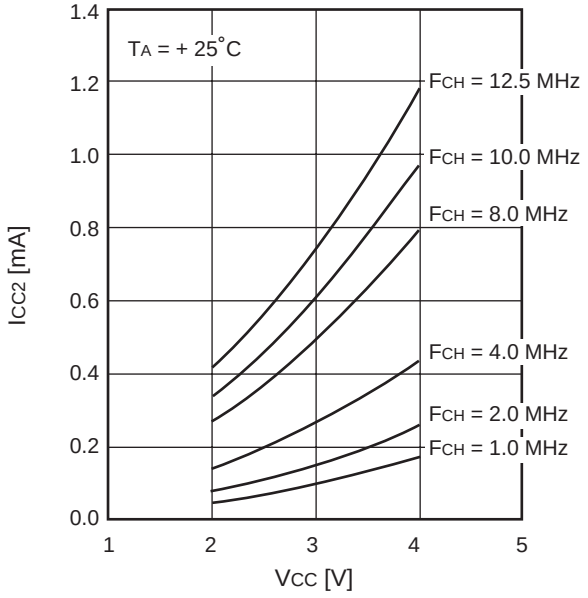
I_{CCS1} vs V_{CC} (MB89498)



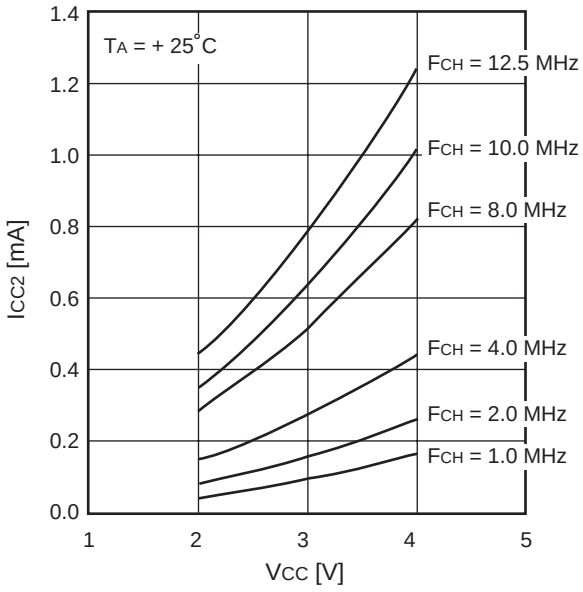
I_{CCS1} vs V_{CC} (MB89F499)



I_{CC2} vs V_{CC} (MB89498)



I_{CC2} vs V_{CC} (MB89F499)



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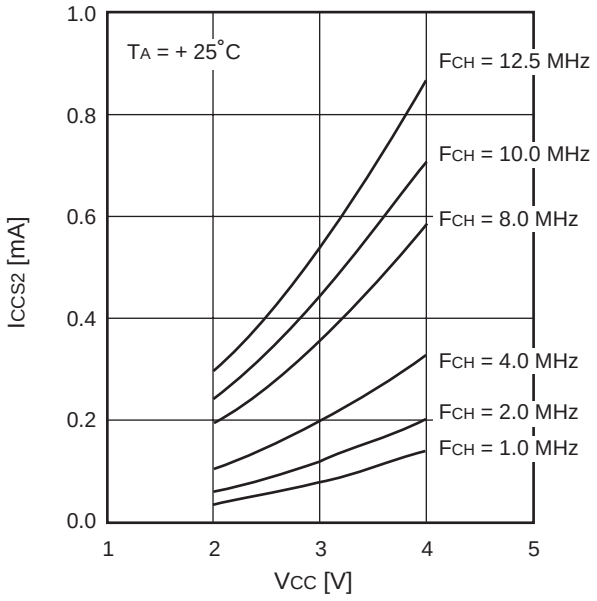
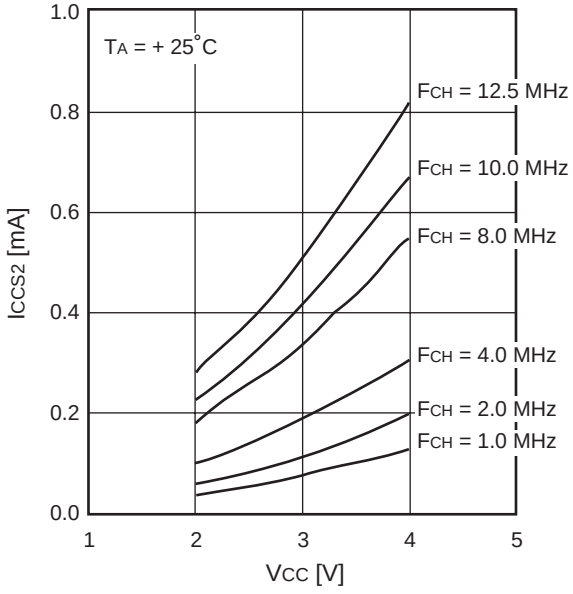
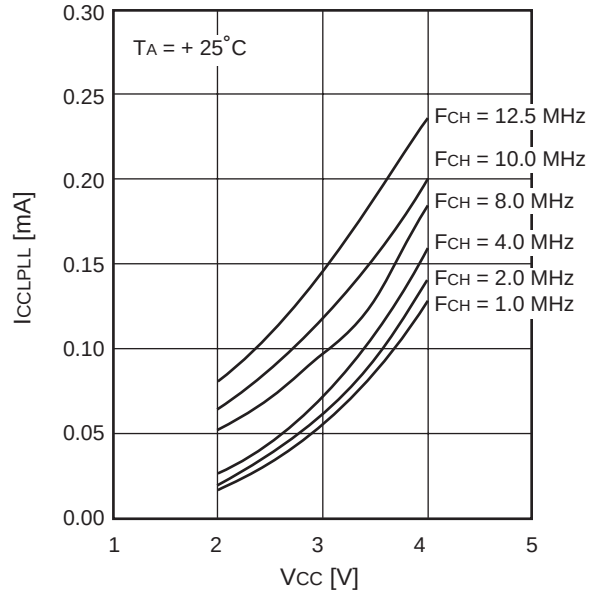
ICCS2 vs VCC (MB89498)



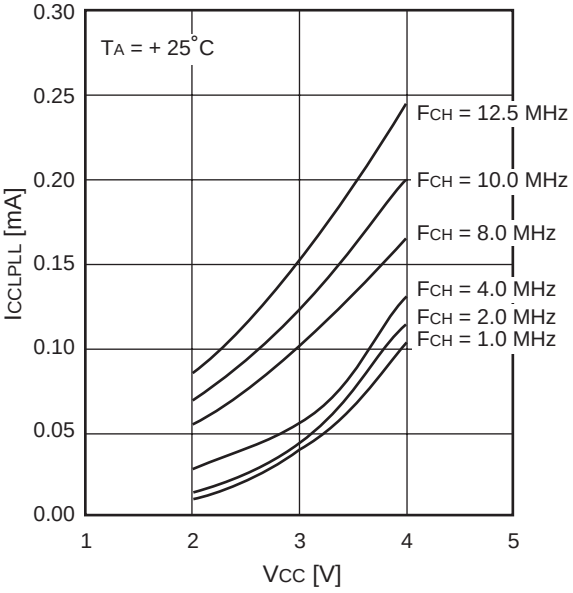
ICCS2 vs VCC (MB89F499)



ICCLPLL vs VCC (MB89498)



ICCLPLL vs VCC (MB89F499)



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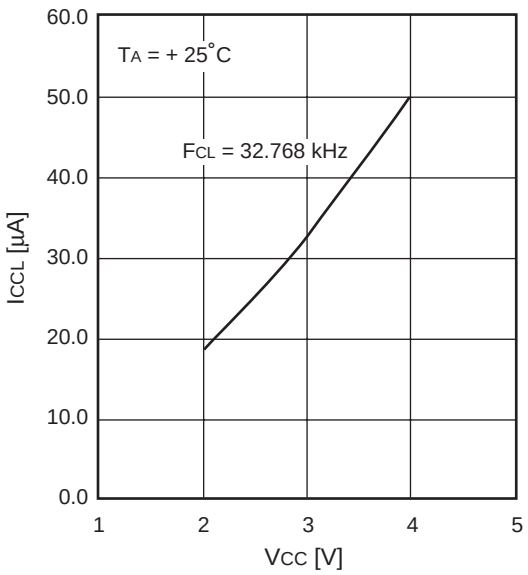
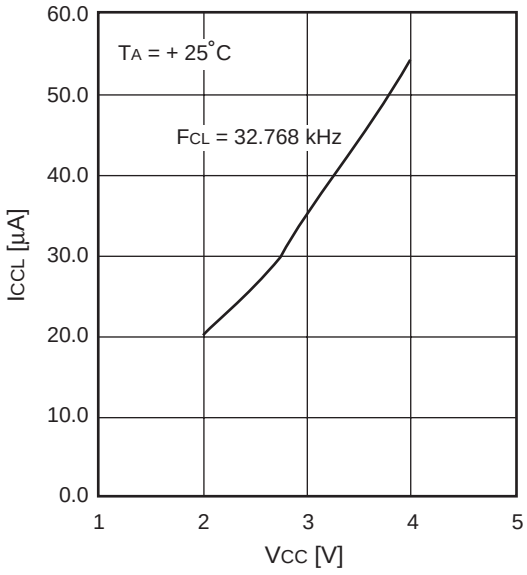
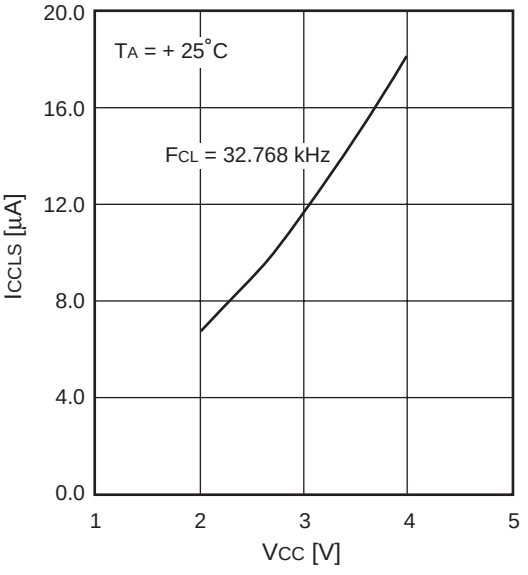
I_{CCL} vs V_{CC} (MB89498)



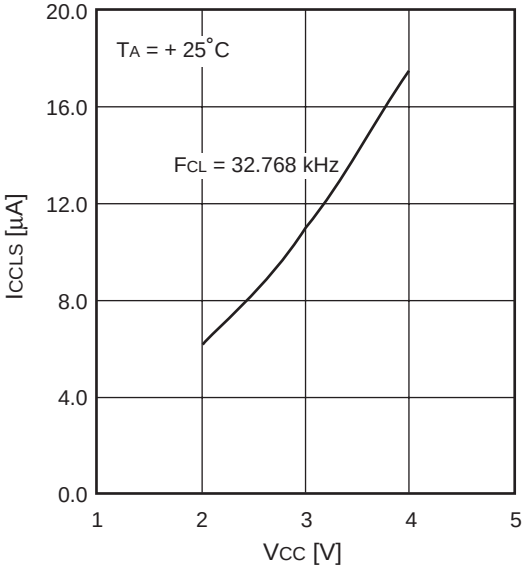
I_{CCL} vs V_{CC} (MB89F499)



I_{CCLS} vs V_{CC} (MB89498)



I_{CCLS} vs V_{CC} (MB89F499)



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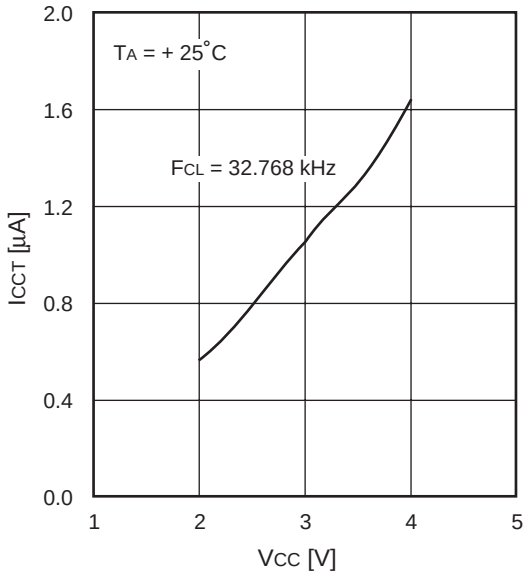
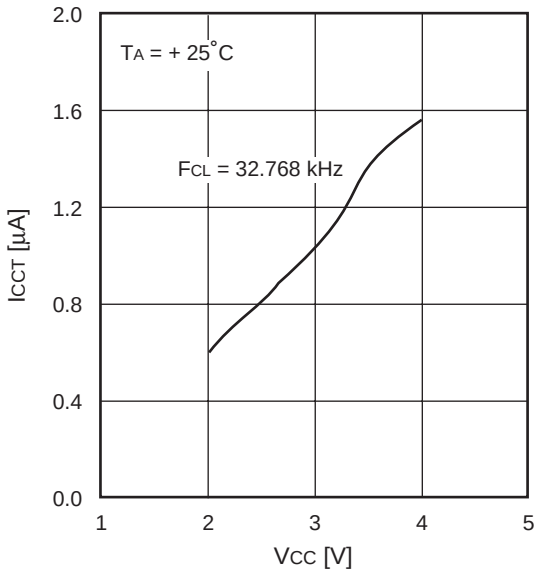
ICCT vs VCC (MB89498)

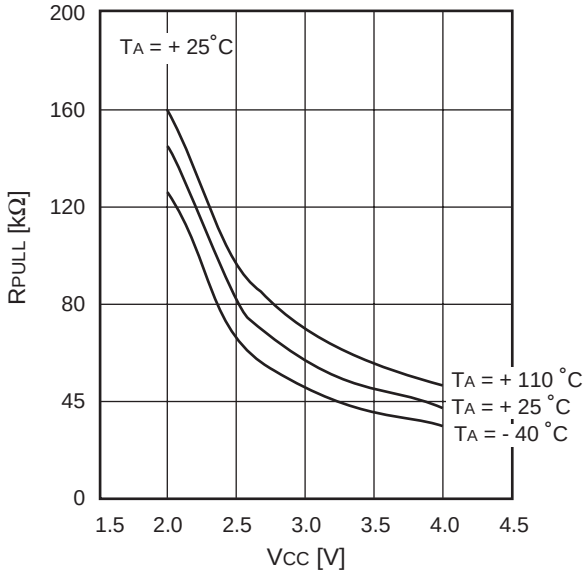


ICCT vs VCC (MB89F499)

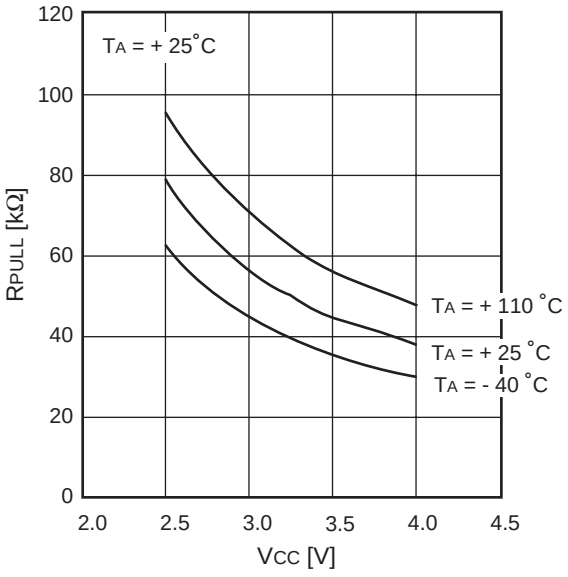


(4) Pull-up resistance

RPULL vs VCC (MB89498)



RPULL vs VCC (MB89F499)



■ MASK OPTIONS

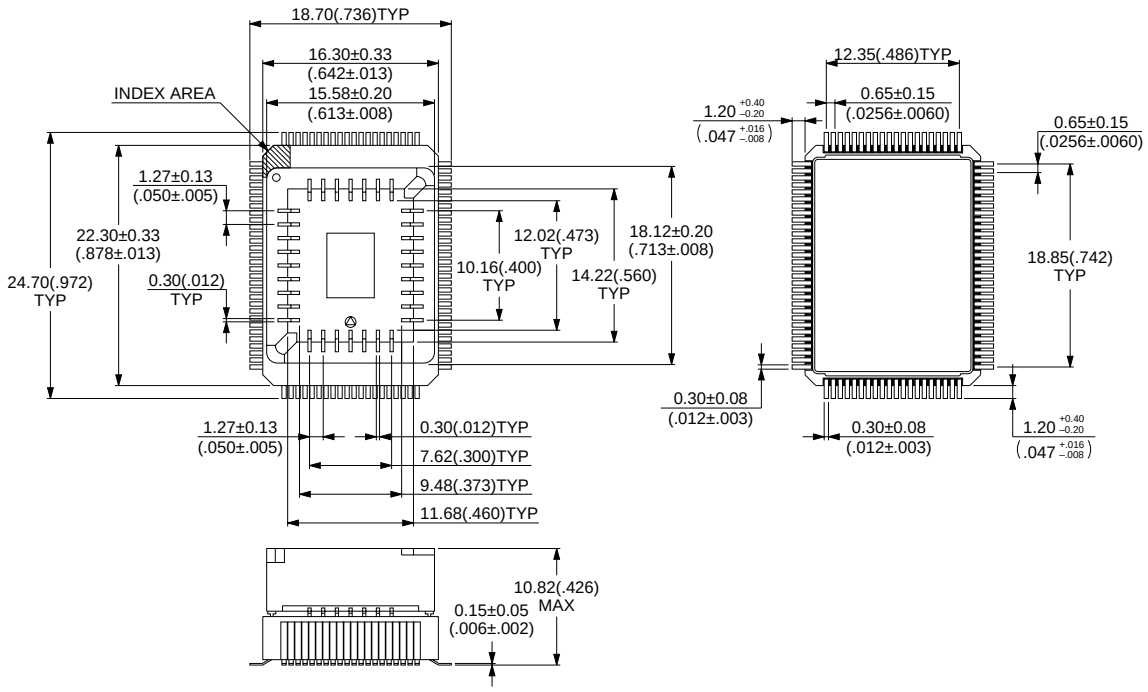
Part number	MB89498	MB89F499	MB89PV490
Specifying procedure	**Specify when ordering mask**	**Setting not possible**	
Main clock oscillation stabilizationtime selection $2^{10}/F_{CH}$ $2^{14}/F_{CH}$ $2^{18}/F_{CH}$	Selectable	Fixed to oscillation stabilization wait time of $2^{18}/F_{CH}$	

■ ORDERING INFORMATION

Part number	Package	Remarks
MB89498PF MB89F499PF	100-pin Plastic QFP (FPT-100P-M06)	
MB89498PFV MB89F499PFV	100-pin Plastic LQFP (FPT-100P-M05)	
MB89PV490CF	100-pin Ceramic MQFP (MQP-100C-P01)	

■ PACKAGE DIMENSIONS

100-pin Ceramic MQFP
(MQP-100C-P01)

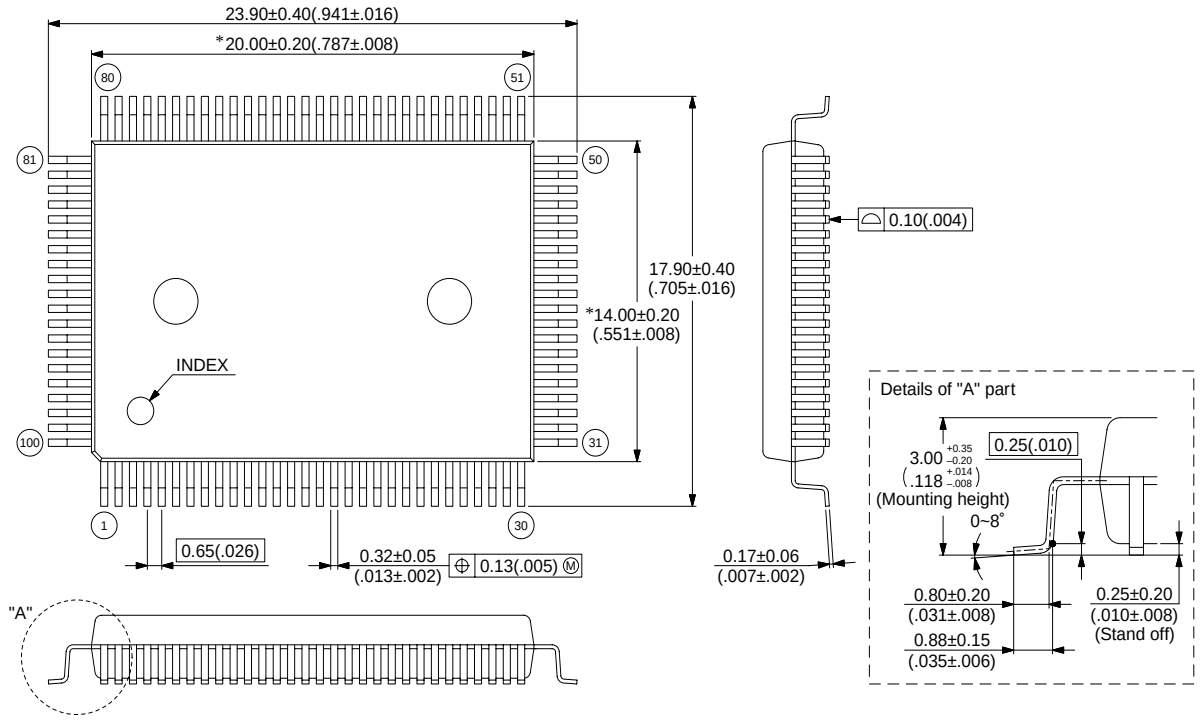


Dimensions in mm (inches) .
Note : The values in parentheses are reference values.

(Continued)

100-pin Plastic QFP
(FPT-100P-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.



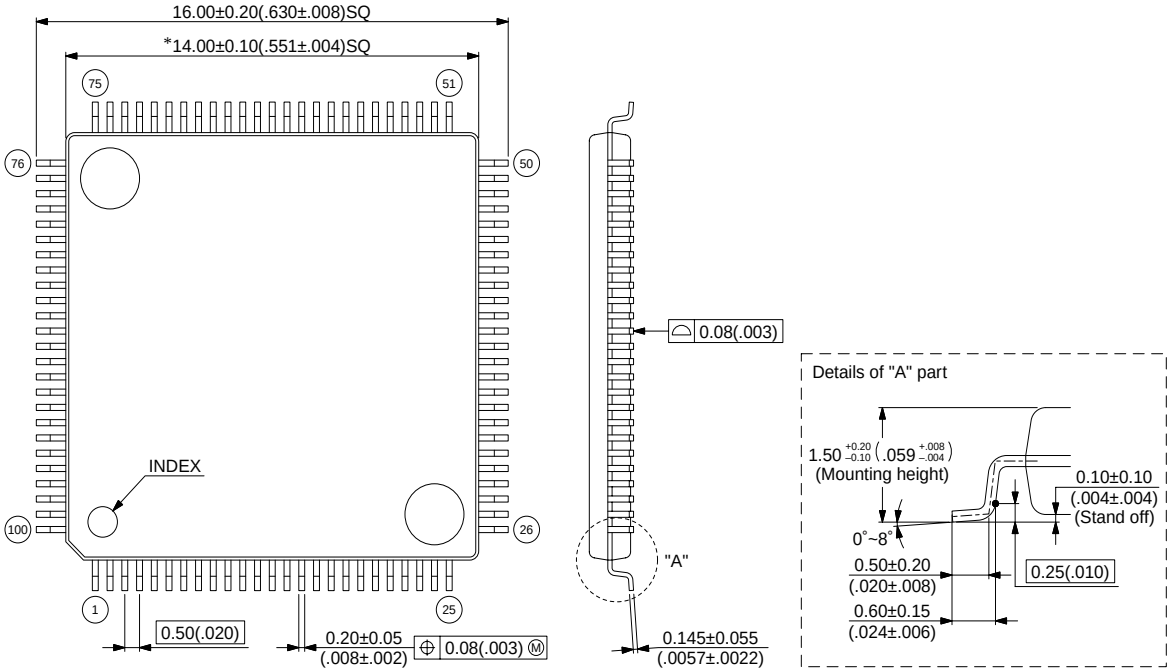
Dimensions in mm (inches) .
Note : The values in parentheses are reference values.

(Continued)

(Continued)

100-pin Plastic LQFP
(FPT-100P-M05)

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.



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

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