8-bit Proprietary Microcontrollers

CMOS

F²MC-8FX MB95110A Series

## MB95116A/F118AS/F118AW/FV100A-101

■ DESCRIPTION

The MB95110A series is general-purpose, single-chip microcontrollers. In addition to a compact instruction set, the microcontrollers contain a variety of peripheral functions.

■ FEATURES

- F²MC-8FX CPU core
  Instruction set that is optimum to the controllers
  - Multiplication and division instructions
  - 16-bit arithmetic operation
  - Bit test branch instruction
  - Bit manipulation instructions etc.
- Clock
  - Main clock
  - Main PLL clock
  - Subclock (for dual clock product)
  - Sub PLL clock (for dual clock product)

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■ PACKAGES

48-pin plastic BCC   48-pin plastic-LQFP

(LCC-48P-M09)   (FPT-48P-M26)

Fujitsu
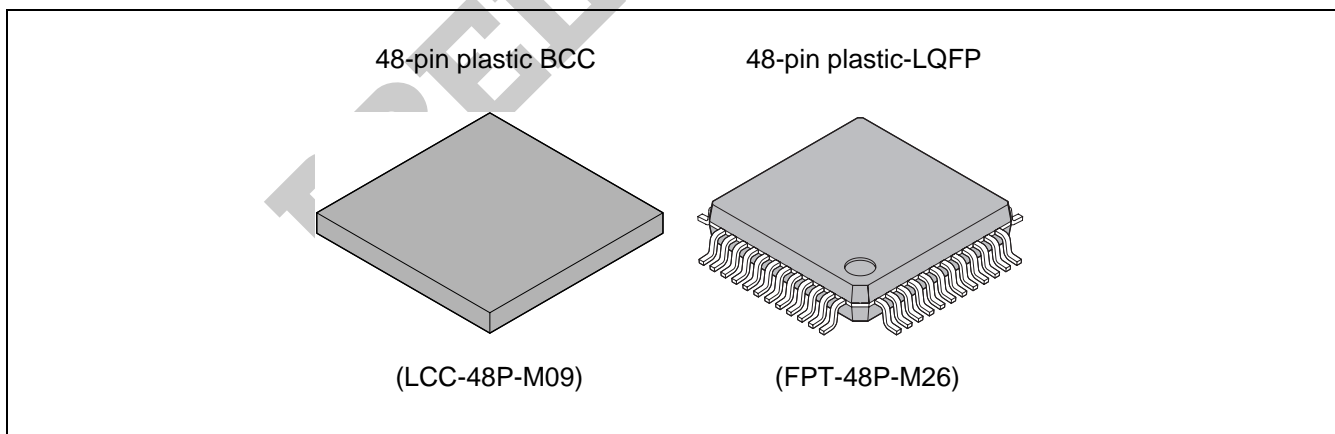
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- Timer
  - 8/16-bit compound timer $\times$ 2 channels
  - 8/16-bit PPG $\times$ 2 channels
  - 16-bit PPG
  - Timebase timer
  - Watch prescaler (for dual clock product)
- LIN-UART
  - Full duplex double buffer
  - Clock asynchronous or synchronous serial transfer capable
- UART/SIO
  - Clock asynchronous or synchronous serial transfer capable
- I^2C*
  - Built-in wake-up function
- External interrupt
  - Interrupt by edge detection (rising, falling, or both edges can be selected)
  - Can be used to recover from low-power consumption modes.
- 10-bit A/D converter
  - 10-bit resolution
- Low-power consumption (standby mode)
  - Stop mode
  - Sleep mode
  - Watch mode (for dual clock product)
  - Timebase timer mode
- I/O port: Max 40
  - General-purpose I/O ports (Nch open drain)   : 2 ports
  - General-purpose I/O ports (CMOS)   : 38 ports

* : Purchase of Fujitsu I^2C components conveys a license under the Philips I^2C Patent Rights to use, these components in an I^2C system provided that the system conforms to the I^2C Standard Specification as defined by Philips.

■ PRODUCT LINEUP

Parameter \ Part number	MB95116A	MB95F118AS	MB95F118AW	MB95FV100A-101
Type	MASK product	FLASH product		EVA product
ROM capacity	32 Kbytes	60 Kbytes		
RAM capacity	1 Kbytes	2 Kbytes		3.75 Kbytes
Reset output	No			
Option	Selectable single/dual -system*2	Single-system	Dual-system	Selectable single/dual -system*1
CPU functions	Number of basic instructions : 136 Instruction bit length : 8 bits Instruction length : 1 to 3 bytes Data bit length : 1, 8, and 16 bits Minimum instruction execution time : 0.1 μs (at internal 10 MHz) Interrupt processing time : 0.9 μs (at internal 10 MHz)			

Peripheral functions	Ports (Max 40 ports)	General-purpose I/O port (Nch open drain) : 2 ports General-purpose I/O port (CMOS) : 38 ports
	Timebase timer	Interrupt cycle : 0.5 ms, 2.05 ms, 8.2 ms, 32.8 ms (at main oscillation clock 4 MHz)
	Watchdog timer	Reset generated cycle At main oscillation clock 10 MHz : Minimum 105 ms At sub oscillation clock 32.768 kHz (for dual clock product) : Minimum 250 ms
	Wild register	Capable of replacing 3 bytes of data
	I²C bus	Master/slave sending and receiving Bus error function and arbitration function Detecting transmitting direction function Start condition repeated generation and detection functions Built-in wake-up function
	UART/SIO	Data transfer capable in UART/SIO Full duplex double buffer, variable data length (5/6/7/8-bit), built-in baud rate generator Transfer rate : 2400 bps to 125000 bps (at machine clock 10 MHz) NRZ type transfer format, error detected function LSB-first or MSB-first can be selected. Clock synchronous (SIO) or clock asynchronous (UART) data transfer capable
	LIN-UART	Dedicated reload timer allowing a wide range of communication speeds to be set. Capable of data transfer synchronous or asynchronous to clock signal. LIN functions available as the LIN master or LIN slave.
	A/D converter (8 channels)	8-bit or 10-bit resolution can be selected.
	8/16-bit compound timer (2 channels)	Each channel of the timer can be used as "8-bit timer × 2 channels" or "16-bit timer × 1 channel". Built-in timer function, PWC function, PWM function, capture function and square waveform output Count clock : 7 internal clocks and external clock can be selected.

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Part number Parameter		MB95116A	MB95F118AS	MB95F118AW	MB95FV100A-101
Peripheral functions	16-bit PPG	PWM mode or one-shot mode can be selected. Counter operating clock : Eight selectable clock sources Support for external trigger start			
	8/16-bit PPG (2 channels)	Each channel of the PPG can be used as "8-bit PPG × 2 channels" or "16-bit PPG × 1 channel". Counter operating clock : Eight selectable clock sources			
	Watch counter (for dual clock product)	Count clock : Four selectable clock sources (125ms, 250ms, 500ms, or 1s) Counter value can be set from 0 to 63. (Capable of counting for 1 minute)			
	Watch prescaler (for dual clock product)	Four selectable interval times (125 ms, 250 ms, 500 ms, or 1 s)			
	External interrupt (8 channels)	Interrupt by edge detection (rising, falling, or both edges can be selected) Can be used to recover from standby modes.			
Standby mode		Sleep, stop, watch, and timebase timer			

*1 : Change by the switch on MCU board.

*2 : Specify clock mode when ordering MASK ROM.

■ SELECT OF OSCILLATION STABILIZATION WAIT TIME (MASK PRODUCT ONLY)

For the MASK product, you can set the mask option when ordering MASK ROM to select the initial value of main clock oscillation stabilization wait time from among the following four values.

Note that the EVA and FLASH products are fixed their initial value of main clock oscillation stabilization wait time at the maximum value.

Selection of oscillation stabilization wait time	Remarks
$(2^2 - 2)/F_{CH}$	0.5 μs (at main oscillation clock 4 MHz)
$(2^{12} - 2)/F_{CH}$	Approx. 1.02 ms (at main oscillation clock 4 MHz)
$(2^{13} - 2)/F_{CH}$	Approx. 2.05 ms (at main oscillation clock 4 MHz)
$(2^{14} - 2)/F_{CH}$	Approx. 4.10 ms (at main oscillation clock 4 MHz)

■ PACKAGES AND CORRESPONDING PRODUCTS

Part number / Package	MB95116A	MB95F118AS	MB95F118AW	MB95FV100A-101
LCC-48P-M09	◯	◯	◯	✕
FPT-48P-M26	◯	◯	◯	✕
BGA-224P-M08	✕	✕	✕	◯

◯ : Available
✕ : Unavailable

■ DIFFERENCES AMONG PRODUCTS AND NOTES ON SELECTING PRODUCTS

- Notes on Using EVA Products

    The EVA product has not only the functions of the MB95110A series but also those of other products to support software development for multiple series and products of F^{2}MC-8FX family. The I/O addresses for peripheral resources not used by the MB95110A series are therefore access-barred. Read/write access to these access-barred addresses may cause peripheral resources supposed to be unused to operate, resulting in unexpected malfunctions of hardware or software.

    Take particular care not to use word, long word, or similar access to read or write odd numbered bytes in the prohibited areas.

    Note that the values read from barred addresses are different between the EVA product and the FLASH or MASK product. Therefore, the data must not be used for software processing.

    The EVA product does not support the functions of some bits in single-byte registers. Read/write access to these bits does not cause hardware malfunctions. Since the EVA, FLASH, and MASK products are designed to behave completely the same way in terms of hardware and software, you do not have to pay special attention to specific products.

- Difference of Memory Spaces

    If the amount of memory on the EVA product is different from that of the FLASH or MASK product, carefully check the difference in the amount of memory from the product to be actually used when developing software.

- Current Consumption
    • The current consumption of FLASH product is typically greater than for MASK product.
    • For details of current consumption, refer to "■ ELECTRICAL CHARACTERISTICS".

- Package

    For details of information on each package, see "■ PACKAGE DIMENSIONS".

- Operating voltage

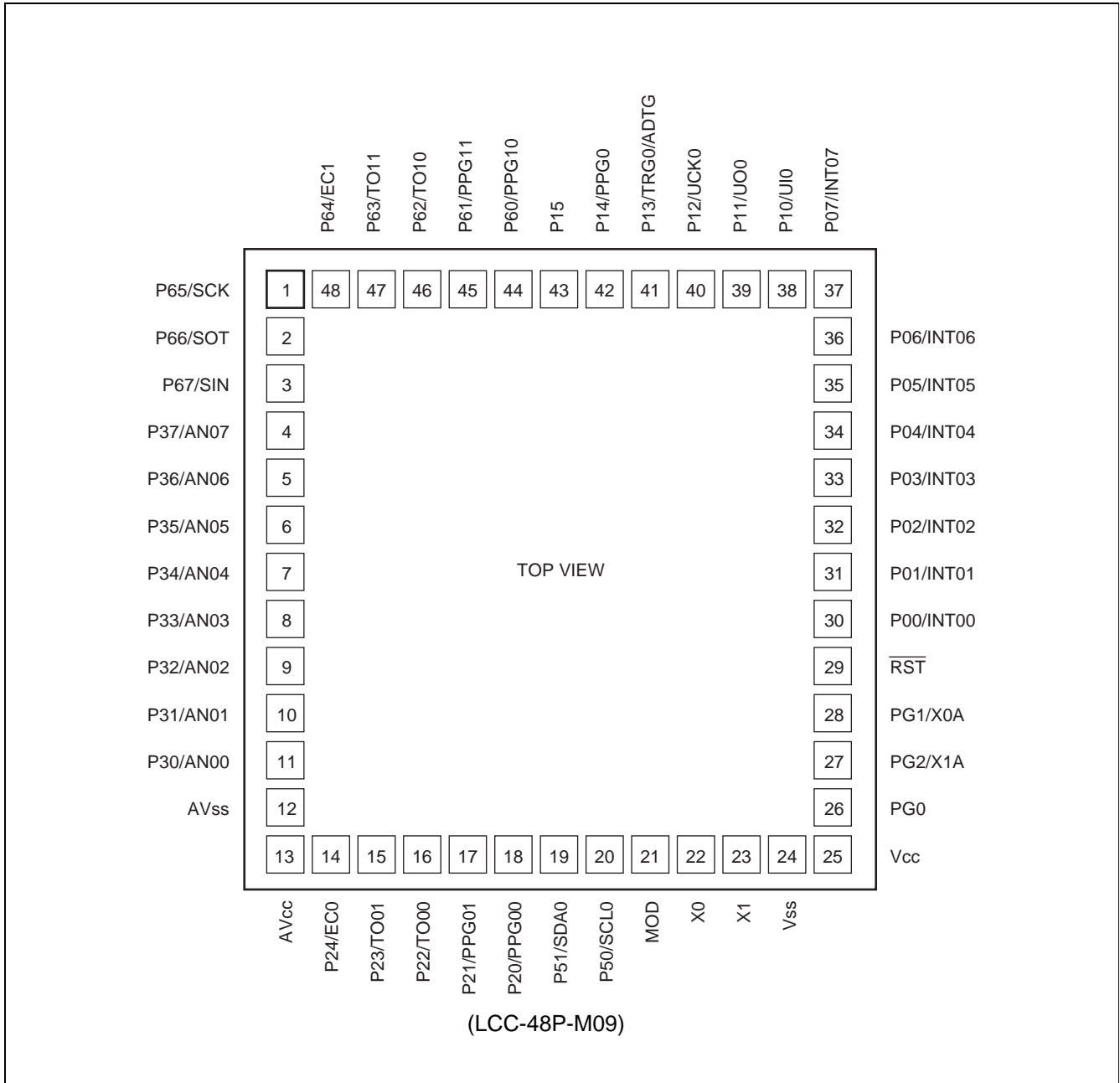   The operating voltage are different among the EVA, FLASH and MASK products.

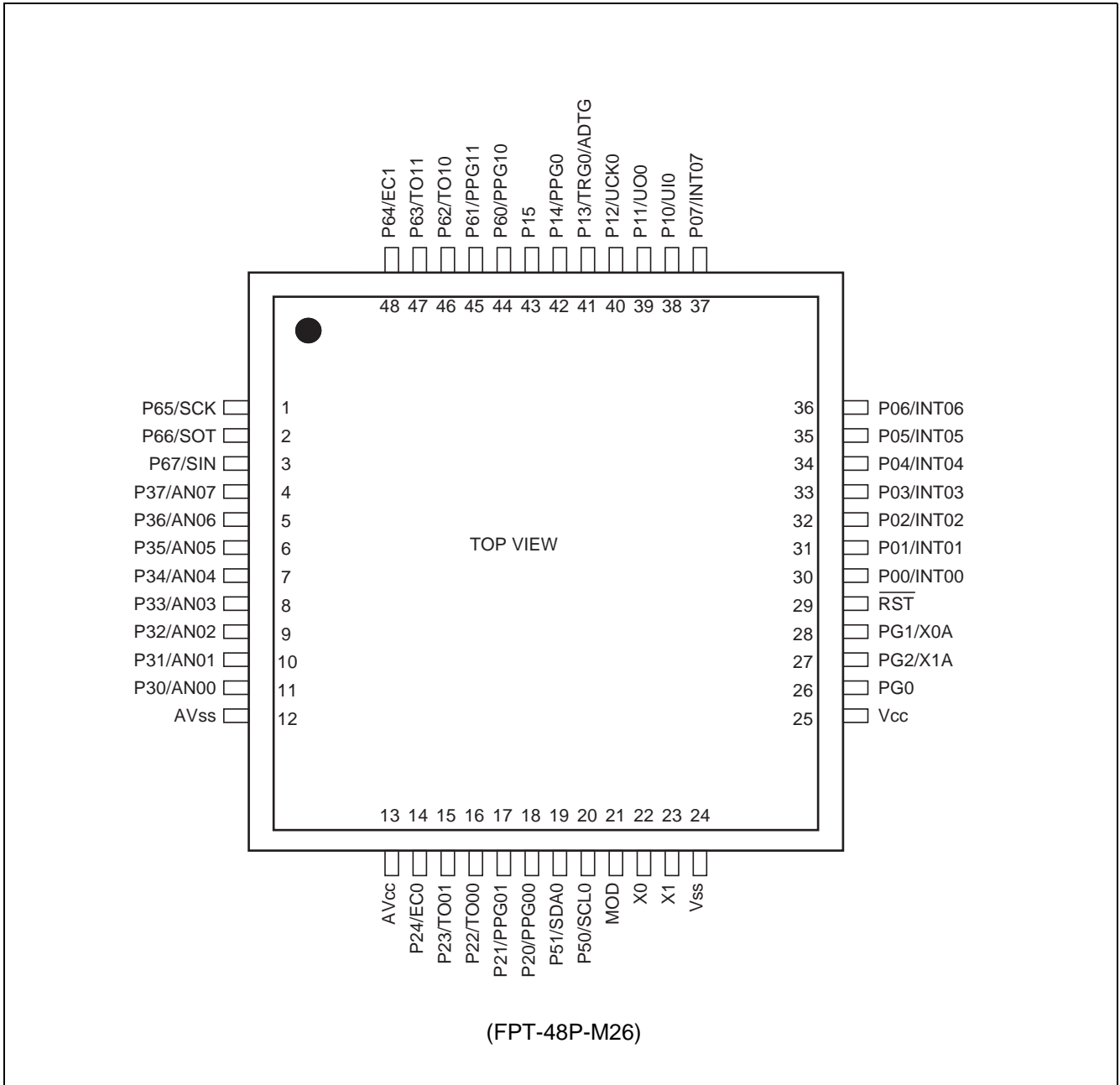   For details of operating voltage, refer to "■ ELECTRICAL CHARACTERISTICS"

- Difference between $\overline{\text{RST}}$ and MOD pins

    The $\overline{\text{RST}}$ and MOD pins are hysteresis inputs on the MASK product. A pull-down resistor is provided for the MOD pin of the MASK product.

■ PIN ASSIGNMENTS

```
                    P64/EC1  P63/TO11  P62/TO10  P61/PPG11  P60/PPG10  P15  P14/PPG0  P13/TRG0/ADTG  P12/UCK0  P11/UO0  P10/UI0  P07/INT07

P65/SCK     1  48  47  46  45  44  43  42  41  40  39  38  37
P66/SOT     2                                                  36   P06/INT06
P67/SIN     3                                                  35   P05/INT05
P37/AN07    4                                                  34   P04/INT04
P36/AN06    5                                                  33   P03/INT03
P35/AN05    6                                                  32   P02/INT02
P34/AN04    7               TOP VIEW                           31   P01/INT01
P33/AN03    8                                                  30   P00/INT00
P32/AN02    9                                                  29   RST
P31/AN01   10                                                  28   PG1/X0A
P30/AN00   11                                                  27   PG2/X1A
AVss       12                                                  26   PG0
           13  14  15  16  17  18  19  20  21  22  23  24  25  Vcc

        AVcc  P24/EC0  P23/TO01  P22/TO00  P21/PPG01  P20/PPG00  P51/SDA0  P50/SCL0  MOD  X0  X1  Vss
```

(LCC-48P-M09)

(FPT-48P-M26)

■ PIN DESCRIPTION

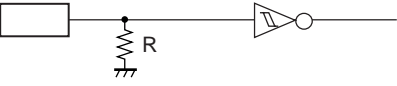| Pin no.	Pin name	Circuit type	Description
1	P65/SCK	K	General-purpose I/O port. The pin is shared with LIN-UART clock I/O.
2	P66/SOT		General-purpose I/O port. The pin is shared with LIN-UART data output.
3	P67/SIN	L	General-purpose I/O port. The pin is shared with LIN-UART data input.
4	P37/AN07	J	General-purpose I/O port. The pins are shared with A/D analog input.
5	P36/AN06		
6	P35/AN05		
7	P34/AN04		
8	P33/AN03		
9	P32/AN02		
10	P31/AN01		
11	P30/AN00		
12	AVss	—	A/D power supply pin (GND)
13	AVcc	—	A/D power supply pin
14	P24/EC0	H	General-purpose I/O port. The pin is shared with 8/16-bit compound timer ch0 clock input.
15	P23/TO01		General-purpose I/O port. The pins are shared with 8/16-bit compound timer ch0 output.
16	P22/TO00		
17	P21/PPG01		General-purpose I/O port. The pins are shared with 8/16-bit PPG ch0 output.
18	P20/PPG00		
19	P51/SDA0	I	General-purpose I/O port. The pin is shared with I^2C ch0 data I/O.
20	P50/SCL0		General-purpose I/O port. The pin is shared with I^2C ch0 clock I/O.
21	MOD	B	Operating mode designation pin
22	X0	A	Crystal oscillation pin
23	X1		
24	Vss	—	Power supply pin (GND)
25	Vcc	—	Power supply pin
26	PG0	H	General-purpose I/O port.
27	PG2/X1A	H/A	Single-system product is general-purpose port. Dual-system product is Crystal oscillation pin (32 kHz).
28	PG1/X0A		
29	$\overline{RST}$	B'	Reset pin

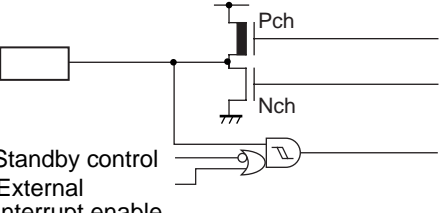*(Continued)*

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Pin no.	Pin name	Circuit type	Description
30	P00/INT00	C	General-purpose I/O port. The pins are shared with external interrupt input. Large current port.
31	P01/INT01		
32	P02/INT02		
33	P03/INT03		
34	P04/INT04		
35	P05/INT05		
36	P06/INT06		
37	P07/INT07		
38	P10/UI0	G	General-purpose I/O port. The pin is shared with UART/SIO ch0 data input.
39	P11/UO0	H	General-purpose I/O port. The pin is shared with UART/SIO ch0 data output.
40	P12/UCK0		General-purpose I/O port. The pin is shared with UART/SIO ch0 clock I/O.
41	P13/TRG0/ ADTG		General-purpose I/O port. The pin is shared with 16-bit PPG ch0 trigger input (TRG0) and A/D trigger input (ADTG).
42	P14/PPG0		General-purpose I/O port. The pin is shared with 16-bit PPG ch0 output.
43	P15		General-purpose I/O port.
44	P60/PPG10	K	General-purpose I/O port. The pins are shared with 8/16-bit PPG ch1 output.
45	P61/PPG11		
46	P62/TO10		General-purpose I/O port. The pins are shared with 8/16-bit compound timer ch1 output.
47	P63/TO11		
48	P64/EC1		General-purpose I/O port. The pin is shared with 8/16-bit compound timer ch1 clock input.

■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A	X1 (X1A) / X0 (X0A) / Standby control	• Oscillation circuit • High-speed side Feedback resistance value : approx. 1 MΩ • Low-speed side Feedback resistance : approx. 24 MΩ (EVA product : approx. 10 MΩ) Dumping resistance : approx. 144 kΩ (EVA product : without dumping resistance)
B	R	• Only for input • Hysteresis input only for MASK product • With pull-down resistor only for MASK product
B'		• Hysteresis input only for MASK product
C	Pch / Nch / Standby control / External interrupt enable	• CMOS output • Hysteresis input
G	R / Pull-up control / Pch / Nch / Standby control	• CMOS output • CMOS input • Hysteresis input • With pull-up control

(Continued)

MB95110A Series

Type	Circuit	Remarks
H	R, Pull-up control, Pch, Nch, Standby control	• CMOS output • Hysteresis input • With pull-up control
I	Nch, Standby control	• Nch open drain output • CMOS input • Hysteresis input
J	R, Pull-up control, Pch, Nch, Analog input, A/D control, Standby control	• CMOS output • Hysteresis input • Analog input • With pull-up control
K	Pch, Nch, Standby control	• CMOS output • Hysteresis input
L	Pch, Nch, Standby control	• CMOS output • CMOS input • Hysteresis input

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■ HANDLING DEVICES

• Preventing Latchup

Care must be taken to ensure that maximum voltage ratings are not exceeded when it is used.

Latchup may occur on CMOS ICs if voltage higher than V_{CC} or lower than V_{SS} is applied to input and output pins other than medium- and high-withstand voltage pins or if higher than the rating voltage is applied between V_{CC} and V_{SS}.

When latchup occurs, power supply current increases rapidly and might thermally damage elements.

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

• Stable Supply Voltage

Supply voltage should be stabilized.

A sudden change in power-supply voltage may cause a malfunction even within the guaranteed operating range of the Vcc power-supply voltage.

For stabilization, in principle, keep the variation in Vcc ripple (p-p value) in a commercial frequency range (50 Hz to 60 Hz) not to exceed 10% of the Vcc value and suppress the voltage variation so that the transient variation rate does not exceed 0.1 V/ms during a momentary change such as when the power supply is switched.

• Treatment of Unused Input Pin

An unused input pin may cause a malfunction if it is left open. It should be connected to a pull-up or pull-down resistor.

• Treatment of Power Supply Pins on A/D Converter

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

• Precautions for Use of External Clock

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

• Precaution against Noise to the External Reset Pin ($\overline{RST}$)

An input of a reset pulse below the specified level to the external reset pin ($\overline{RST}$) may cause malfunctions. Be sure not to allow an input of a reset pulse below the specified level to the external reset pin ($\overline{RST}$).

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■ PROGRAMMING FLASH MICROCONTROLLERS USING PARALLEL PROGRAMMER

● **Supported Parallel Programmers and Adapters**

The following table lists supported parallel programmers and adapters.

Package	Applicable adapter model	Parallel programmers
FPT-48P-M26	TEF110-108F37AP	AF9708 (Ver 02.35G or more) AF9709/B (Ver 02.35G or more) AF9723+AF9834 (Ver 02.08E or more)
LCC-48P-M09	TEF100-108F41AP	

Notes: ● Set all of the J1 to J3 switches on the adapter to "95F108".
 ● For information on applicable adapter models and parallel programmers, contact the following:
  Flash Support Group, Inc. TEL: 053-428-8380

● **Sector Configuration**

The individual sectors of flash memory correspond to addresses used for CPU access and programming by the parallel programmer as follows:

Flash memory	CPU address	Writer address*	
SA1 (4 Kbytes)	1000$_H$ – 1FFF$_H$	71000$_H$ – 71FFF$_H$	Lower bank
SA2 (4 Kbytes)	2000$_H$ – 2FFF$_H$	72000$_H$ – 72FFF$_H$	
SA3 (4 Kbytes)	3000$_H$ – 3FFF$_H$	73000$_H$ – 73FFF$_H$	
SA4 (16 Kbytes)	4000$_H$ – 7FFF$_H$	74000$_H$ – 77FFF$_H$	Upper bank
SA5 (16 Kbytes)	8000$_H$ – BFFF$_H$	78000$_H$ – 7BFFF$_H$	
SA6 (4 Kbytes)	C000$_H$ – CFFF$_H$	7C000$_H$ – 7CFFF$_H$	
SA7 (4 Kbytes)	D000$_H$ – DFFF$_H$	7D000$_H$ – 7DFFF$_H$	
SA8 (4 Kbytes)	E000$_H$ – EFFF$_H$	7E000$_H$ – 7EFFF$_H$	
SA9 (4 Kbytes)	F000$_H$ – FFFF$_H$	7F000$_H$ – 7FFFF$_H$	

*: Programmer addresses are equivalent to CPU addresses, used when the parallel programmer programs data into flash memory.
These programmer addresses are used for the parallel programmer to program or erase data in flash memory.

● **Programming Method**

1) Set the type code of the parallel programmer to 17226.

2) Load program data to programmer addresses 71000$_H$ to 7FFFF$_H$.

3) Programmed by parallel programmer

■ BLOCK DIAGRAM

* : Single-system product is general-purpose port, and dual-system product is subclock oscillation.
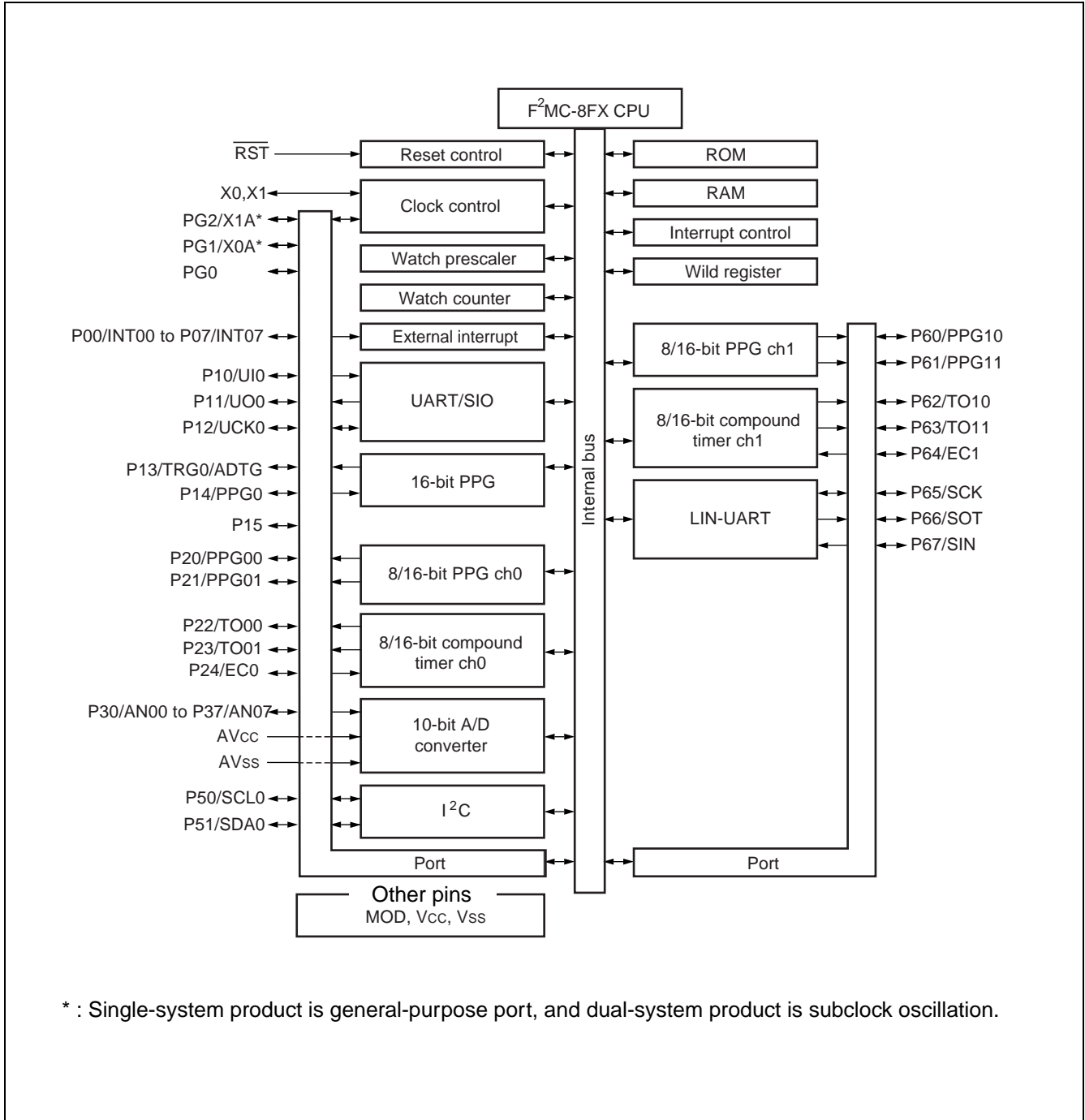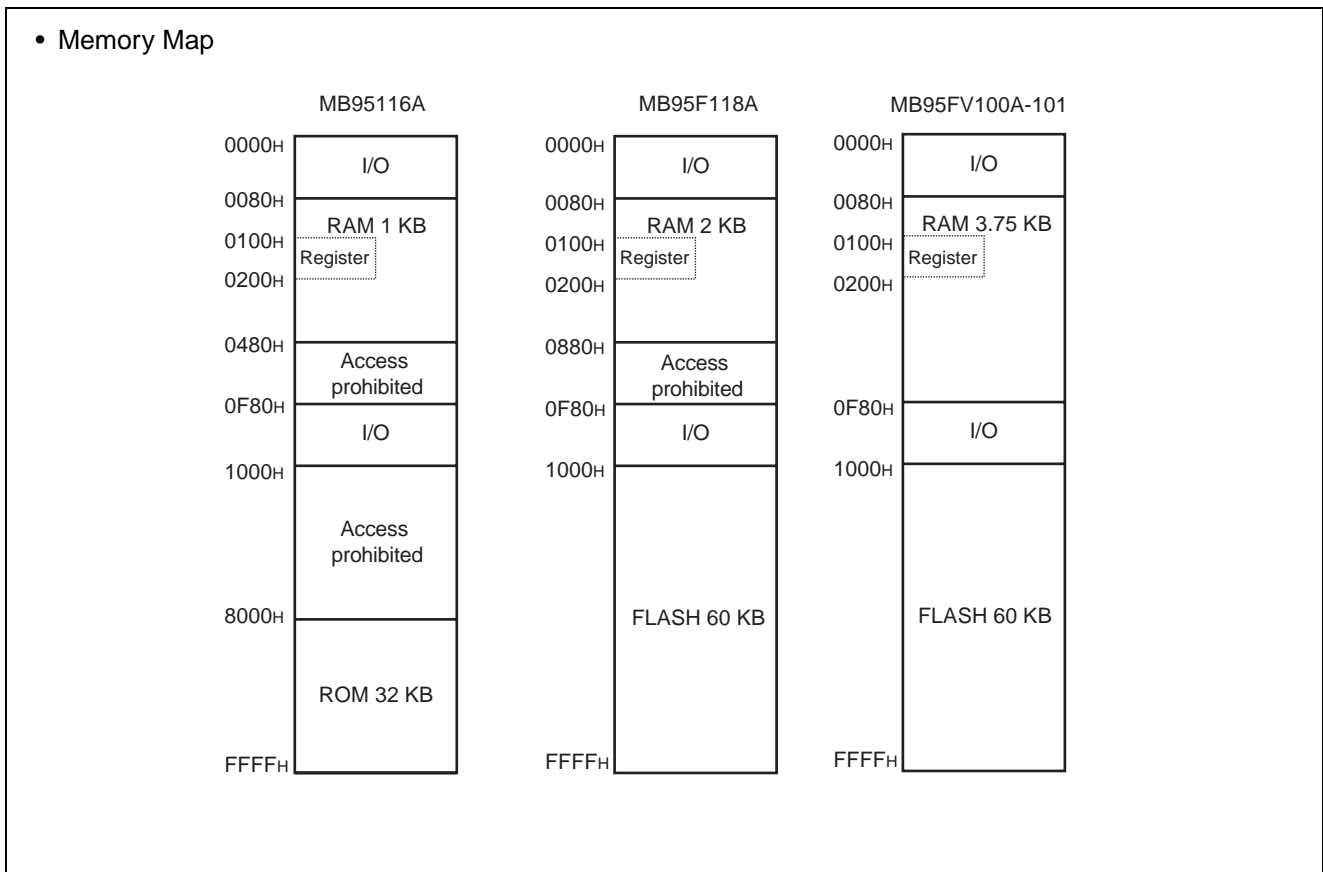
MB95110A Series

■ CPU CORE

1. Memory space

Memory space of the MB95110A series is 64 Kbytes and consists of I/O area, data area, and program area. The memory space includes special-purpose areas such as the general-purpose registers and vector table. Memory map of the MB95110A series shown in below.
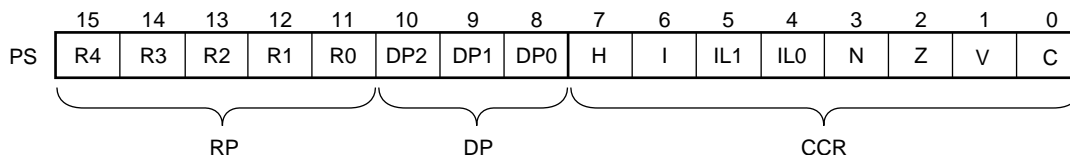
• Memory Map

	MB95116A		MB95F118A		MB95FV100A-101
0000H	I/O	0000H	I/O	0000H	I/O
0080H	RAM 1 KB	0080H	RAM 2 KB	0080H	RAM 3.75 KB
0100H	Register	0100H	Register	0100H	Register
0200H		0200H		0200H	
0480H	Access prohibited	0880H	Access prohibited		
0F80H	I/O	0F80H	I/O	0F80H	I/O
1000H	Access prohibited	1000H	FLASH 60 KB	1000H	FLASH 60 KB
8000H	ROM 32 KB				
FFFFH		FFFFH		FFFFH	

2. Register

The MB95110A series has two types of registers; dedicated registers in the CPU and general-purpose registers in the memory. The dedicated registers are as follows:

Program counter (PC)   : A 16-bit register to indicate locations where instructions are stored.

Accumulator (A)   : A 16-bit register for temporary storage of arithmetic operations. In the case of an 8-bit data processing instruction, the lower one byte is used.

Temporary accumulator (T) : A 16-bit register which performs arithmetic operations with the accumulator. In the case of an 8-bit data processing instruction, the lower one byte is used.

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

Extra pointer (EP)   : A 16-bit pointer to point to a memory address.

Stack pointer (SP)   : A 16-bit register to indicate a stack area.

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

	16-bit		Initial Value
PC	: Program counter	FFFD_H
A	: Accumulator	0000_H
T	: Temporary accumulator	0000_H
IX	: Index register	0000_H
EP	: Extra pointer	0000_H
SP	: Stack pointer	0000_H
PS	: Program status	0030_H

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

• Structure of the program status

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PS	R4	R3	R2	R1	R0	DP2	DP1	DP0	H	I	IL1	IL0	N	Z	V	C
			RP				DP					CCR				

The RP indicates the address of the register bank currently being used. The relationship between the content of RP and the real address conforms to the conversion rule illustrated below:

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

		RP upper	OP code lower
"0" "0" "0" "0" "0" "0" "0" "1"	R4 R3 R2 R1 R0	b2 b1 b0	
Generated address	A15 A14 A13 A12 A11 A10 A9 A8	A7 A6 A5 A4 A3 A2 A1 A0	
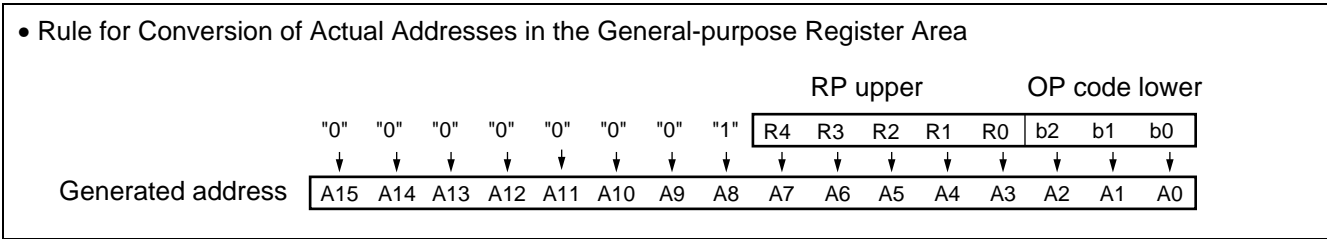
The DP specifies the area for mapping instructions (16 different instructions such as MOV A, dir) using direct addresses to 0080_H to $00FF_H$.

Direct bank pointer (DP2 to DP0)	Specified address area	Mapping area
Don't care	0000_H to $007F_H$	0000_H to $007F_H$ (without mapping)
000_B (initial value)	0080_H to $00FF_H$	0080_H to $00FF_H$ (without mapping)
001_B		0100_H to $017F_H$
010_B		0180_H to $01FF_H$
011_B		0200_H to $027F_H$
100_B		0280_H to $02FF_H$
101_B		0300_H to $037F_H$
110_B		0380_H to $03FF_H$
111_B		0400_H to $047F_H$

The CCR consists of the bits indicating arithmetic operation results or transfer data contents and the bits that control CPU operations at 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. Cleared to "0" otherwise. This flag is for decimal adjustment instructions.

I flag : Interrupt is enabled when this flag is set to "1". Interrupt is disabled when this flag is set to "0". The flag is set to "0" when reset.

IL1, IL0 : Indicates the level of the interrupt currently enabled. Processes an interrupt only if its request level is higher than the value indicated by this bit.

IL1	IL0	Interrupt level	Priority
0	0	0	High
0	1	1	
1	0	2	
1	1	3	Low = no interruption

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

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

V flag : Set to "1" if the complement on 2 overflows as a result of an arithmetic operation. Cleared to "0" otherwise.

C flag : Set to "1" when a carry or a borrow from bit 7 occurs as a 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 data storage registers

The general-purpose registers are 8 bits and located in the register banks on the memory. One bank contains eight registers. Up to a total of 32 banks can be used on the MB95110A series. The bank currently in use is indicated by the register bank pointer (RP).

• Register Bank Configuration

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

R0
R1
R2
R3
R4
R5
R6
R7

32 banks

Memory area
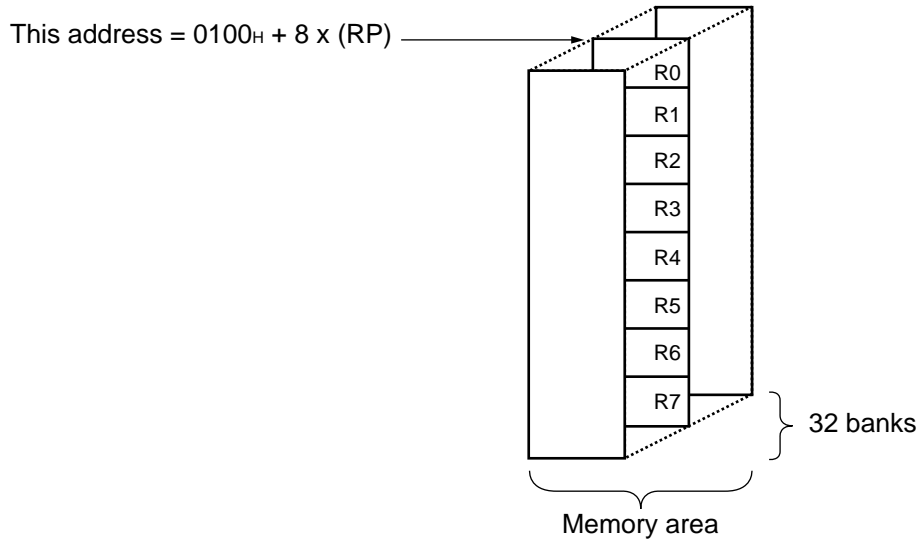
■ I/O MAP

Address	Register abbreviation	Register name	R/W	Initial value
0000$_H$	PDR0	Port 0 data register	R/W	00000000$_B$
0001$_H$	DDR0	Port 0 direction register	R/W	00000000$_B$
0002$_H$	PDR1	Port 1 data register	R/W	00000000$_B$
0003$_H$	DDR1	Port 1 direction register	R/W	00000000$_B$
0004$_H$	—	(Vacancy)	—	—
0005$_H$	WATR	Oscillation stabilization wait time setting register	R/W	11111111$_B$
0006$_H$	PLLC	PLL control register	R/W	00000000$_B$
0007$_H$	SYCC	System clock control register	R/W	1010X011$_B$
0008$_H$	STBC	Standby control register	R/W	00000000$_B$
0009$_H$	RSRR	Reset source register	R	XXXXXXXX$_B$
000A$_H$	TBTC	Timebase timer control register	R/W	00000000$_B$
000B$_H$	WPCR	Watch prescaler control register	R/W	00000000$_B$
000C$_H$	WDTC	Watchdog timer control register	R/W	00000000$_B$
000D$_H$	—	(Vacancy)	—	—
000E$_H$	PDR2	Port 2 data register	R/W	00000000$_B$
000F$_H$	DDR2	Port 2 direction register	R/W	00000000$_B$
0010$_H$	PDR3	Port 3 data register	R/W	00000000$_B$
0011$_H$	DDR3	Port 3 direction register	R/W	00000000$_B$
0012$_H$ 0013$_H$	—	(Vacancy)	—	—
0014$_H$	PDR5	Port 5 data register	R/W	00000000$_B$
0015$_H$	DDR5	Port 5 direction register	R/W	00000000$_B$
0016$_H$	PDR6	Port 6 data register	R/W	00000000$_B$
0017$_H$	DDR6	Port 6 direction register	R/W	00000000$_B$
0018$_H$ to 0029$_H$	—	(Vacancy)	—	—
002A$_H$	PDRG	Port G data register	R/W	00000000$_B$
002B$_H$	DDRG	Port G direction register	R/W	00000000$_B$
002C$_H$	—	(Vacancy)	—	—
002D$_H$	PUL1	Port 1 pull-up register	R/W	00000000$_B$
002E$_H$	PUL2	Port 2 pull-up register	R/W	00000000$_B$
002F$_H$	PUL3	Port 3 pull-up register	R/W	00000000$_B$
0030$_H$ to 0034$_H$	—	(Vacancy)	—	—

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
0035$_H$	PULG	Port G pull-up register	R/W	00000000$_B$
0036$_H$	T01CR1	8/16-bit compound timer 01 control status register 1 ch0	R/W	00000000$_B$
0037$_H$	T00CR1	8/16-bit compound timer 00 control status register 1 ch0	R/W	00000000$_B$
0038$_H$	T11CR1	8/16-bit compound timer 11 control status register 1 ch1	R/W	00000000$_B$
0039$_H$	T10CR1	8/16-bit compound timer 10 control status register 1 ch1	R/W	00000000$_B$
003A$_H$	PC01	8/16-bit PPG1 control register ch0	R/W	00000000$_B$
003B$_H$	PC00	8/16-bit PPG0 control register ch0	R/W	00000000$_B$
003C$_H$	PC11	8/16-bit PPG1 control register ch1	R/W	00000000$_B$
003D$_H$	PC10	8/16-bit PPG0 control register ch1	R/W	00000000$_B$
003E$_H$ to 0041$_H$	—	(Vacancy)	—	—
0042$_H$	PCNTH0	16-bit PPG status control register (Upper byte) ch0	R/W	00000000$_B$
0043$_H$	PCNTL0	16-bit PPG status control register (Lower byte) ch0	R/W	00000000$_B$
0044$_H$ to 0047$_H$	—	(Vacancy)	—	—
0048$_H$	EIC00	External interrupt circuit control register ch0/1	R/W	00000000$_B$
0049$_H$	EIC10	External interrupt circuit control register ch2/3	R/W	00000000$_B$
004A$_H$	EIC20	External interrupt circuit control register ch4/5	R/W	00000000$_B$
004B$_H$	EIC30	External interrupt circuit control register ch6/7	R/W	00000000$_B$
004C$_H$ to 004F$_H$	—	(Vacancy)	—	—
0050$_H$	SCR	LIN-UART serial control register	R/W	00000000$_B$
0051$_H$	SMR	LIN-UART serial mode register	R/W	00000000$_B$
0052$_H$	SSR	LIN-UART serial status register	R/W	00001000$_B$
0053$_H$	RDR/TDR	LIN-UART reception/transmission data register	R/W	00000000$_B$
0054$_H$	ESCR	LIN-UART extended status control register	R/W	00000100$_B$
0055$_H$	ECCR	LIN-UART extended communication control register	R/W	000000XX$_B$
0056$_H$	SMC10	UART/SIO serial mode control register 1 ch0	R/W	00000000$_B$
0057$_H$	SMC20	UART/SIO serial mode control register 2 ch0	R/W	00100000$_B$
0058$_H$	SSR0	UART/SIO serial status register ch0	R/W	00000001$_B$
0059$_H$	TDR0	UART/SIO serial output data register ch0	R/W	00000000$_B$
005A$_H$	RDR0	UART/SIO serial input data register ch0	R	00000000$_B$
005B$_H$ to 005F$_H$	—	(Vacancy)	—	—

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
0060$_H$	IBCR00	I^{2}C bus control register 0 ch0	R/W	00000000$_B$
0061$_H$	IBCR10	I^{2}C bus control register 1 ch0	R/W	00000000$_B$
0062$_H$	IBSR0	I^{2}C bus status register ch0	R	00000000$_B$
0063$_H$	IDDR0	I^{2}C data register ch0	R/W	00000000$_B$
0064$_H$	IAAR0	I^{2}C address register ch0	R/W	00000000$_B$
0065$_H$	ICCR0	I^{2}C clock control register ch0	R/W	00000000$_B$
0066$_H$ to 006B$_H$	—	(Vacancy)	—	—
006C$_H$	ADC1	A/D control register 1	R/W	00000000$_B$
006D$_H$	ADC2	A/D control register 2	R/W	00000000$_B$
006E$_H$	ADDH	A/D data register (Upper byte)	R/W	00000000$_B$
006F$_H$	ADDL	A/D data register (Lower byte)	R/W	00000000$_B$
0070$_H$	WCSR	Watch counter status register	R/W	00000000$_B$
0071$_H$	—	(Vacancy)	—	—
0072$_H$	FSR	Flash memory status register	R/W	000X0000$_B$
0073$_H$	SWRE0	Flash memory sector writing control register 0	R/W	00000000$_B$
0074$_H$	SWRE1	Flash memory sector writing control register 1	R/W	00000000$_B$
0075$_H$	—	(Vacancy)	—	—
0076$_H$	WREN	Wild register address compare enable register	R/W	00000000$_B$
0077$_H$	WROR	Wild register data test setting register	R/W	00000000$_B$
0078$_H$	—	(Mirror of register bank pointer (RP) and direct bank pointer (DP))	—	—
0079$_H$	ILR0	Interrupt level setting register 0	R/W	11111111$_B$
007A$_H$	ILR1	Interrupt level setting register 1	R/W	11111111$_B$
007B$_H$	ILR2	Interrupt level setting register 2	R/W	11111111$_B$
007C$_H$	ILR3	Interrupt level setting register 3	R/W	11111111$_B$
007D$_H$	ILR4	Interrupt level setting register 4	R/W	11111111$_B$
007E$_H$	ILR5	Interrupt level setting register 5	R/W	11111111$_B$
007F$_H$	—	(Vacancy)	—	—
0F80$_H$	WRARH0	Wild register address setting register (Upper byte) ch0	R/W	00000000$_B$
0F81$_H$	WRARL0	Wild register address setting register (Lower byte) ch0	R/W	00000000$_B$
0F82$_H$	WRDR0	Wild register data setting register ch0	R/W	00000000$_B$
0F83$_H$	WRARH1	Wild register address setting register (Upper byte) ch1	R/W	00000000$_B$
0F84$_H$	WRARL1	Wild register address setting register (Lower byte) ch1	R/W	00000000$_B$
0F85$_H$	WRDR1	Wild register data setting register ch1	R/W	00000000$_B$

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
0F86H	WRARH2	Wild register address setting register (Upper byte) ch2	R/W	00000000B
0F87H	WRARL2	Wild register address setting register (Lower byte) ch2	R/W	00000000B
0F88H	WRDR2	Wild register data setting register ch2	R/W	00000000B
0F89H to 0F91H	—	(Vacancy)	—	—
0F92H	T01CR0	8/16-bit compound timer 01 control status register 0 ch0	R/W	00000000B
0F93H	T00CR0	8/16-bit compound timer 00 control status register 0 ch0	R/W	00000000B
0F94H	T01DR	8/16-bit compound timer 01 data register ch0	R/W	00000000B
0F95H	T00DR	8/16-bit compound timer 00 data register ch0	R/W	00000000B
0F96H	TMCR0	8/16-bit compound timer 00/01 timer mode control register ch0	R/W	00000000B
0F97H	T11CR0	8/16-bit compound timer 11 control status register 0 ch1	R/W	00000000B
0F98H	T10CR0	8/16-bit compound timer 10 control status register 0 ch1	R/W	00000000B
0F99H	T11DR	8/16-bit compound timer 11 data register ch1	R/W	00000000B
0F9AH	T10DR	8/16-bit compound timer 10 data register ch1	R/W	00000000B
0F9BH	TMCR1	8/16-bit compound timer 10/11 timer mode control register ch1	R/W	00000000B
0F9CH	PPS01	8/16-bit PPG1 cycle setting buffer register ch0	R/W	11111111B
0F9DH	PPS00	8/16-bit PPG0 cycle setting buffer register ch0	R/W	11111111B
0F9EH	PDS01	8/16-bit PPG1 duty setting buffer register ch0	R/W	11111111B
0F9FH	PDS00	8/16-bit PPG0 duty setting buffer register ch0	R/W	11111111B
0FA0H	PPS11	8/16-bit PPG1 cycle setting buffer register ch1	R/W	11111111B
0FA1H	PPS10	8/16-bit PPG0 cycle setting buffer register ch1	R/W	11111111B
0FA2H	PDS11	8/16-bit PPG1 duty setting buffer register ch1	R/W	11111111B
0FA3H	PDS10	8/16-bit PPG0 duty setting buffer register ch1	R/W	11111111B
0FA4H	PPGS	8/16-bit PPG starting register	R/W	00000000B
0FA5H	REVC	8/16-bit PPG output inversion register	R/W	00000000B
0FA6H to 0FA9H	—	(Vacancy)	—	—
0FAAH	PDCRH0	16-bit PPG down counter register (Upper byte) ch0	R	00000000B
0FABH	PDCRL0	16-bit PPG down counter register (Lower byte) ch0	R	00000000B
0FACH	PCSRH0	16-bit PPG cycle setting buffer register (Upper byte) ch0	R/W	11111111B
0FADH	PCSRL0	16-bit PPG cycle setting buffer register (Lower byte) ch0	R/W	11111111B
0FAEH	PDUTH0	16-bit PPG duty setting buffer register (Upper byte) ch0	R/W	11111111B
0FAFH	PDUTL0	16-bit PPG duty setting buffer register (Lower byte) ch0	R/W	11111111B

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Address	Register abbreviation	Register name	R/W	Initial value
0FB0H to 0FBBH	—	(Vacancy)	—	—
0FBCH	BGR1	LIN-UART baud rate generator register 1	R/W	00000000B
0FBDH	BGR0	LIN-UART baud rate generator register 0	R/W	00000000B
0FBEH	PSSR0	UART/SIO prescaler selection register ch0	R/W	00000000B
0FBFH	BRSR0	UART/SIO baud rate setting register ch0	R/W	00000000B
0FC0H to 0FC2H	—	(Vacancy)	—	—
0FC3H	AIDRL	A/D input disable register (Lower byte)	R/W	00000000B
0FC4H to 0FE2H	—	(Vacancy)	—	—
0FE3H	WCDR	Watch counter data register	R/W	00111111B
0FE4H to 0FEDH	—	(Vacancy)	—	—
0FEEH	ILSR	Input level select register	R/W	00000000B
0FEFH	WICR	Interrupt pin control register	R/W	01000000B
0FF0H to 0FFFH	—	(Vacancy)	—	—

• 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.

■ **INTERRUPT SOURCE TABLE**

Interrupt source	Interrupt request number	Vector table address		Bit name of interrupt level setting register	Same level priority order (at simultaneous occurrence)
		Upper	Lower		
External interrupt ch0	IRQ0	FFFA$_H$	FFFB$_H$	L00 [1 : 0]	High
External interrupt ch4					
External interrupt ch1	IRQ1	FFF8$_H$	FFF9$_H$	L01 [1 : 0]	
External interrupt ch5					
External interrupt ch2	IRQ2	FFF6$_H$	FFF7$_H$	L02 [1 : 0]	
External interrupt ch6					
External interrupt ch3	IRQ3	FFF4$_H$	FFF5$_H$	L03 [1 : 0]	
External interrupt ch7					
UART/SIO ch0	IRQ4	FFF2$_H$	FFF3$_H$	L04 [1 : 0]	
8/16-bit compound timer ch0 (Lower)	IRQ5	FFF0$_H$	FFF1$_H$	L05 [1 : 0]	
8/16-bit compound timer ch0 (Upper)	IRQ6	FFEE$_H$	FFEF$_H$	L06 [1 : 0]	
LIN-UART (reception)	IRQ7	FFEC$_H$	FFED$_H$	L07 [1 : 0]	
LIN-UART (transmission)	IRQ8	FFEA$_H$	FFEB$_H$	L08 [1 : 0]	
8/16-bit PPG ch1 (Lower)	IRQ9	FFE8$_H$	FFE9$_H$	L09 [1 : 0]	
8/16-bit PPG ch1 (Upper)	IRQ10	FFE6$_H$	FFE7$_H$	L10 [1 : 0]	
(Unused)	IRQ11	FFE4$_H$	FFE5$_H$	L11 [1 : 0]	
8/16-bit PPG ch0 (Upper)	IRQ12	FFE2$_H$	FFE3$_H$	L12 [1 : 0]	
8/16-bit PPG ch0 (Lower)	IRQ13	FFE0$_H$	FFE1$_H$	L13 [1 : 0]	
8/16-bit compound timer ch1 (Upper)	IRQ14	FFDE$_H$	FFDF$_H$	L14 [1 : 0]	
16-bit PPG ch0	IRQ15	FFDC$_H$	FFDD$_H$	L15 [1 : 0]	
I^{2}C ch0	IRQ16	FFDA$_H$	FFDB$_H$	L16 [1 : 0]	
(Unused)	IRQ17	FFD8$_H$	FFD9$_H$	L17 [1 : 0]	
10-bit A/D converter	IRQ18	FFD6$_H$	FFD7$_H$	L18 [1 : 0]	
Timebase timer	IRQ19	FFD4$_H$	FFD5$_H$	L19 [1 : 0]	
Watch prescaler/counter	IRQ20	FFD2$_H$	FFD3$_H$	L20 [1 : 0]	
(Unused)	IRQ21	FFD0$_H$	FFD1$_H$	L21 [1 : 0]	
8/16-bit compound timer ch1 (Lower)	IRQ22	FFCE$_H$	FFCF$_H$	L22 [1 : 0]	
FLASH	IRQ23	FFCC$_H$	FFCD$_H$	L23 [1 : 0]	Low

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

Parameter	Symbol	Rating		Unit	Remarks
		Min	Max		
Power supply voltage*1	Vcc, AVcc	Vss − 0.3	Vss + 4.0	V	*2
	AVR	Vss − 0.3	Vss + 4.0		*2 MB95FV100A-101 only
Input voltage*1	V_{I1}	Vss − 0.3	Vss + 4.0	V	Other than P50, P51*3
	V_{I2}	Vss − 0.3	Vss + 6.0		P50, P51
Output voltage*1	V_O	Vss − 0.3	Vss + 4.0	V	*3
Maximum clamp current	I_{CLAMP}	− 2.0	+ 2.0	mA	Applicable to pins*4
Total maximum clamp current	$\Sigma\|I_{CLAMP}\|$	—	20	mA	Applicable to pins*4
"L" level maximum output current	I_{OL1}	—	15	mA	Other than P00 to P07
	I_{OL2}		15		P00 to P07
"L" level average current	I_{OLAV1}	—	4	mA	Other than P00 to P07 Average output current = operating current × operating ratio (1 pin)
	I_{OLAV2}		12		P00 to P07 Average output current = operating current × operating ratio (1 pin)
"L" level total maximum output current	ΣI_{OL}	—	100	mA	
"L" level total average output current	ΣI_{OLAV}	—	50	mA	Total average output current = operating current × operating ratio (total of pins)
"H" level maximum output current	I_{OH1}	—	− 15	mA	Other than P00 to P07
	I_{OH2}		− 15		P00 to P07
"H" level average current	I_{OHAV1}	—	− 4	mA	Other than P00 to P07 Average output current = operating current × operating ratio (1 pin)
	I_{OHAV2}		− 8		P00 to P07 Average output current = operating current × operating ratio (1 pin)
"H" level total maximum output current	ΣI_{OH}	—	− 100	mA	
"H" level total average output current	ΣI_{OHAV}	—	− 50	mA	Total average output current = operating current × operating ratio (total of pins)
Power consumption	Pd	—	320	mW	
Operating temperature	T_A	− 40	+ 85	°C	Other than MB95FV100A-101
Storage temperature	Tstg	− 55	+ 150	°C	

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

*2 : Apply equal potential to AVcc and Vcc. AVR should not exceed AVcc + 0.3 V.

*3 : V_{I1} and V_O should not exceed V_{CC} + 0.3 V. V_{I1} must not exceed the rating voltage. However, if the maximum current to/from an input is limited by some means with external components, the I_{CLAMP} rating supersedes the V_{I1} rating.

*4 : • Applicable to pins : P00 to P07, P10 to P15, P20 to P24, P30 to P37, PG0
  • Use within recommended operating conditions.
  • Use at DC voltage (current).
  • The $+ $ B signal should always be applied 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.
  • 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 VCC pin, and this may affect other devices.
  • Note that if the $+ $ B signal is inputted when the microcontroller power supply 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 power supply voltage may not be sufficient to operate the power-on reset.
  • Care must be taken not to leave the $+ $ B input pin open.
  • Sample recommended circuits :

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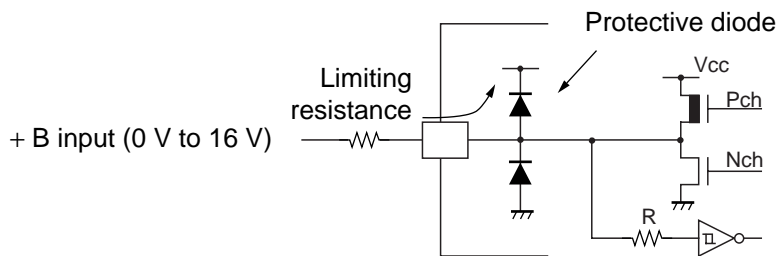
WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

2. Recommended Operating Conditions

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

Parameter	Symbol	Value Min	Value Max	Unit	Remarks
Power supply voltage	V_{CC}, AV_{CC}	1.8*1	3.3*2	V	At normal operating, FLASH product, $T_A = -10\ °C$ to $+85\ °C$
		1.8*1	3.6		At normal operating, MASK product, $T_A = -10\ °C$ to $+85\ °C$
		2.0*1	3.3*2		At normal operating, FLASH product, $T_A = -40\ °C$ to $+85\ °C$
		2.0*1	3.6		At normal operating, MASK product, $T_A = -40\ °C$ to $+85\ °C$
		2.6	3.6		MB95FV100A-101
		1.5	3.3*2		Retain status of stop operation, FLASH product
		1.5	3.6		Retain status of stop operation, MASK product
Operating temperature	T_A	− 40	+ 85	°C	Other than MB95FV100A-101

*1 : The values vary with the operating frequency.

*2 : Consult Fujitsu separately for a guarantee of a maximum value of 3.6 V.

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

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

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

3. DC Characteristics

(Vcc = AVcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = − 40 °C to + 85 °C [MB95FV100A-101 is T$_A$ = +25 °C])

Parameter	Symbol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
"H" level input voltage	V$_{IH1}$	P10, P67	*1	0.7 Vcc	—	Vcc + 0.3	V	At selecting of CMOS input level (hysteresis input)
	V$_{IH2}$	P50, P51	*1	0.7 Vcc	—	Vss + 5.5	V	At selecting of CMOS input level (hysteresis input)
	V$_{IHS1}$	P00 to P07, P10 to P15, P20 to P24, P30 to P37, P60 to P67, PG0, PG1*2, PG2*2	*1	0.8 Vcc	—	Vcc + 0.3	V	Hysteresis input
	V$_{IHS2}$	P50, P51	*1	0.8 Vcc	—	Vss + 5.5	V	Hysteresis input
	V$_{IHM}$	$\overline{RST}$, MOD	—	0.7 Vcc	—	Vcc + 0.3	V	CMOS input (FLASH product)
			—	0.8 Vcc	—	Vcc + 0.3	V	Hysteresis input (MASK product)
"L" level input voltage	V$_{IL}$	P10, P50, P51, P67	*1	Vss − 0.3	—	0.3 Vcc	V	At selecting of CMOS input level (hysteresis input)
	V$_{ILS}$	P00 to P07, P10 to P15, P20 to P24, P30 to P37, P50, P51, P60 to P67, PG0, PG1*2, PG2*2	*1	Vss − 0.3	—	0.2 Vcc	V	Hysteresis input
	V$_{ILM}$	$\overline{RST}$, MOD	—	Vss − 0.3	—	0.3 Vcc	V	CMOS input (FLASH product)
			—	Vss − 0.3	—	0.2 Vcc	V	Hysteresis input (MASK product)
Open drain output application voltage	V$_D$	P50, P51	—	Vss − 0.3	—	Vss + 5.5	V	
"H" level output voltage	V$_{OH1}$	Output pin other than P00 to P07	I$_{OH}$ = − 4.0 mA	2.4	—	—	V	MB95FV100A-101 a conditional : I$_{OH}$ = − 2.0 mA
	V$_{OH2}$	P00 to P07	I$_{OH}$ = − 8.0 mA	2.4	—	—	V	MB95FV100A-101 a conditional : I$_{OH}$ = − 5.0 mA

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(Vcc = AVcc = 3.3 V, AVss = Vss = 0.0 V, T_A = $-$ 40 °C to $+$ 85 °C [MB95FV100A-101 is T_A = +25 °C])

Parameter	Sym-bol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
"L" level output voltage	V_{OL1}	Output pin other than P00 to P07	I_{OL} = 4.0 mA	—	—	0.4	V	MB95FV100A-101 a conditional : I_{OL} = 3.0 mA
	V_{OL2}	P00 to P07	I_{OL} = 12 mA	—	—	0.4	V	MB95FV100A-101 a conditional : I_{OL} = 8.0 mA
Input leakage current (High-Z output leakage current)	I_{LI}	Port other than P50, P51	0.0 V < V_I < Vcc	$-$ 5	—	$+$ 5	µA	When no pull-up resistor is specified
Open drain output leakage current	I_{LIOD}	P50, P51	0.0 V < V_I < Vss + 5.5 V	—	—	$+$ 5	µA	
Pull-up resistor	R_{PULL}	P10 to P15, P20 to P24, P30 to P37, PG0, PG1*2, PG2*2	V_I = 0.0 V	25	50	100	kΩ	When pull-up resistor is specified
Pull-down resistor	R_{MOD}	MOD	V_I = Vcc	50	100	200	kΩ	MASK product only
Power supply current*3	I_{CC}	V_{CC} (external clock operation)	F_{CH} = 20 MHz fmp = 10 MHz Main clock mode (divided by 2)	—	11	14	mA	FLASH product
				—	7.3	10	mA	MASK product
				—	30	35	mA	FLASH product (at FLASH writing and erasing)
	I_{CCS}		F_{CH} = 20 MHz fmp = 10 MHz Main Sleep mode (divided by 2)	—	4.5	6	mA	
	I_{CCL}		F_{CL} = 32 kHz fmpl = 16 kHz Subclock mode (divided by 2) , T_A = $+$ 25 °C	—	25	35	µA	
	I_{CCLS}		F_{CL} = 32 kHz fmpl = 16 kHz Sub sleep mode (divided by 2) , T_A = $+$ 25 °C	—	7	15	µA	

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(Vcc = AVcc = 3.3 V, AVss = Vss = 0.0 V, $T_A = -40\,°C$ to $+85\,°C$ [MB95FV100A-101 is $T_A = +25\,°C$])

Parameter	Sym-bol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current*3	I_{CCT}	V_{CC} (external clock operation)	$F_{CL} = 32$ kHz Watch mode Main stop mode $T_A = +25\,°C$	—	2	10	μA	FLASH product
				—	1	5	μA	MASK product
	I_{CCMPLL}		$F_{CH} = 4$ MHz fmp = 10 MHz Main PLL mode (multiplied by 2.5)	—	10	14	mA	FLASH product
				—	6.7	10	mA	MASK product
	I_{CCSPLL}		$F_{CL} = 32$ kHz fmpl = 128 kHz Sub PLL mode (multiplied by 4), $T_A = +25\,°C$	—	190	250	μA	
	I_{CTS}		$F_{CH} = 10$ MHz Timebase timer mode $T_A = +25\,°C$	—	0.4	0.5	mA	
	I_{CCH}		Substop mode $T_A = +25\,°C$	—	1	5	μA	
	I_A	AVcc	$F_{CH} = 10$ MHz At A/D converting	—	1.3	2.2	mA	
	I_{AH}		$F_{CH} = 10$ MHz At A/D converting stop $T_A = +25\,°C$	—	1	5	μA	
Input capacitance	C_{IN}	Other than AVcc, AVss, Vcc, and Vss	—	—	5	15	pF	

*1 : P10, P50, P51, and P67 can switch the input level to either the "CMOS input level" or "hysteresis input level". The switching of the input level can be set by the input level selection register (ILSR).

*2 : Single-clock products only

*3 : The power-supply current is determined by the external clock.
  - Refer to "4. AC characteristics (1) Clock Timing" for F_{CH} and F_{CL}.
  - Refer to "4. AC characteristics (2) Source Clock/Machine Clock" for fmp and fmpl.

4. AC Characteristics

(1) Clock Timing

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = $-$ 40 °C to $+$ 85 °C)

Parameter	Symbol	Pin	Conditions	Value Min	Value Typ	Value Max	Unit	Remarks
Clock frequency	F$_{CH}$	X0, X1	—	1	—	10	MHz	When using Main oscillation circuit
				1	—	20	MHz	When using external clock
				3	—	10	MHz	Main PLL multiplied by 1
				3	—	5	MHz	Main PLL multiplied by 2
				3	—	4	MHz	Main PLL multiplied by 2.5
	F$_{CL}$	X0A, X1A		—	32.768	—	kHz	When using Sub oscillation circuit
				—	32.768	—	kHz	When using sub PLL FLASH product : Vcc = 2.3 V to 3.3 V MASK product : Vcc = 2.3 V to 3.6 V
Clock cycle time	t$_{HCYL}$	X0, X1		100	—	1000	ns	When using Main oscillation circuit
				50	—	1000	ns	When using Sub oscillation circuit
	t$_{LCYL}$	X0A, X1A		—	30.5	—	µs	Subclock
Input clock pulse width	t$_{WH1}$ t$_{WL1}$	X0		10	—	—	ns	When using external clock Duty ratio is about 30% to 70%.
	t$_{WH2}$ t$_{WL2}$	X0A		—	15.2	—	µs	
Input clock rise time and fall time	t$_{CR}$ t$_{CF}$	X0, X0A		—	—	5	ns	When using external clock

- X0 and X1 Timing and Applying Conditions
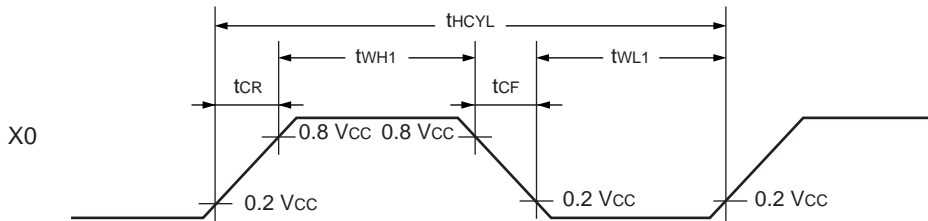
- Main Clock Applying Conditions

When using a crystal or ceramic oscillator
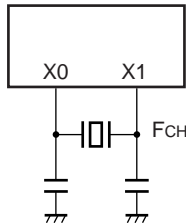
When using external clock
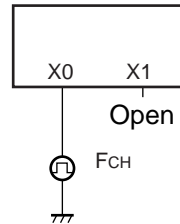
- X0A and X1A Timing and Applying Conditions
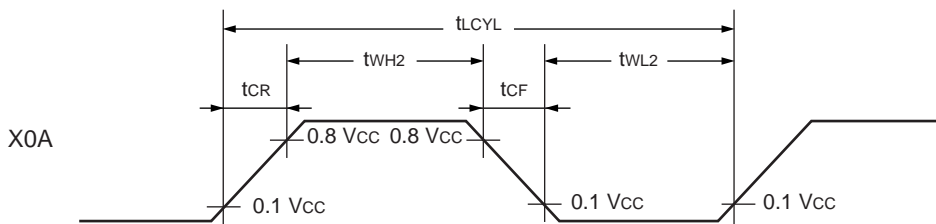
- Subclock Applying Conditions

When using a crystal or ceramic oscillator
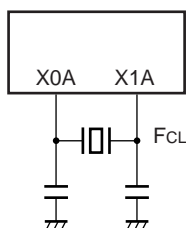
When using external clock
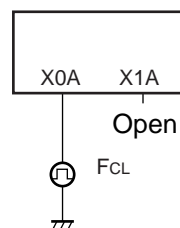
(2) Source Clock/Machine Clock

$(Vcc = 3.3\ V,\ AVss = Vss = 0.0\ V,\ T_A = -40\ °C\ to\ +85\ °C)$

Parameter	Sym-bol	Pin name	Value			Unit	Remarks
			Min	Typ	Max		
Source clock*1 (Clock before setting division)	SCLK	—	100	—	2000	ns	When using Main clock Min : F_{CH} = 10 MHz, PLL multiplied by 1 Max : F_{CH} = 1 MHz, divided by 2
			7.6	—	61.0	μs	When using Subclock Min : F_{CL} = 32 kHz, PLL multiplied by 4 Max : F_{CL} = 32 kHz, divided by 2
Source clock frequency	f_{sp}	—	0.5	—	10.0	MHz	When using Main clock
	f_{spl}	—	16.384	—	131.072	kHz	When using Subclock
Machine clock*2 (Minimum instruction execution time)	MCLK	—	100	—	32000	ns	When using Main clock Min : SLCK = 10 MHz, no division Max : SLCK = 0.5 MHz, divided by 16
			7.6	—	976.5	μs	When using Subclock Min : SLCK = 131 kHz, no division Max : SLCK = 16 kHz, divided by 16
Machine clock frequency	f_{mp}	—	0.031	—	10.000	MHz	When using Main clock
	f_{mpl}		1.024	—	131.072	kHz	When using Subclock

*1 : Clock before setting division due to machine clock division ratio selection bit (SYCC : DIV1 and DIV0) . This source clock is divided by the machine clock division ratio selection bit (SYCC : DIV1 and DIV0) , and it becomes the machine clock. Further, the source clock can be selected as follow.
- Main clock divided by 2
- PLL multiplication of main clock (select from 1, 2, 2.5 multiplication)
- Subclock divided by 2
- PLL multiplication of subclock (select from 2, 3, 4 multiplication)

*2 : Operation clock of the microcontroller. Machine clock can be selected as follow.
- Source clock (no division)
- Source clock divided by 4
- Source clock divided by 8
- Source clock divided by 16

- **Operating voltage − Operating frequency**

  - MASK product

  Sub PLL operation guarantee range
  (2.3 V to 3.6 V)

  A/D converter accuracy
  guarantee range

  Operating voltage (V)

  3.6

  Main PLL operation guarantee range

  2.2
  2.0
  1.8

  1.0

  0.5 MHz   3 MHz   5 MHz   10 MHz

  Source clock frequency (fsp)

  - FLASH product

  A/D converter accuracy
  guarantee range

  Sub PLL operation guarantee range
  (2.3 V to 3.3 V)

  3.3

  Operating voltage (V)

  Main PLL operation guarantee range

  2.2
  2.0
  1.8

  1.0

  0.5 MHz   3 MHz   5 MHz   10 MHz

  Source clock frequency (fsp)

  Note: In operating by 2.0 V or less, only "T_A = -10 °C to +85 °C" is guaranteed.

- Main PLL operation frequency

(3) Reset Timing

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = − 40 °C to + 85 °C)

Parameter	Symbol	Value		Unit	Remarks
		Min	Max		
RST "L" level pulse width	t$_{RSTL}$	2 MCLK[*1]	—	ns	At normal operating
		Oscillation time of oscillator[*2] + 2 MCLK[*1]	—	ns	At stop mode, subclock mode, Sub sleep mode, and watch mode

*1 : Refer to " (2) Source Clock/Machine Clock" for MCLK.

*2 : Oscillation time of oscillator is the time that the amplitude reaches 90 %. In the crystal oscillator, the oscillation time is between several ms and tens of ms. In FAR/ceramic oscillators, the oscillation time is between hundreds of μs and several ms. In the external clock, the oscillation time is 0 ms.
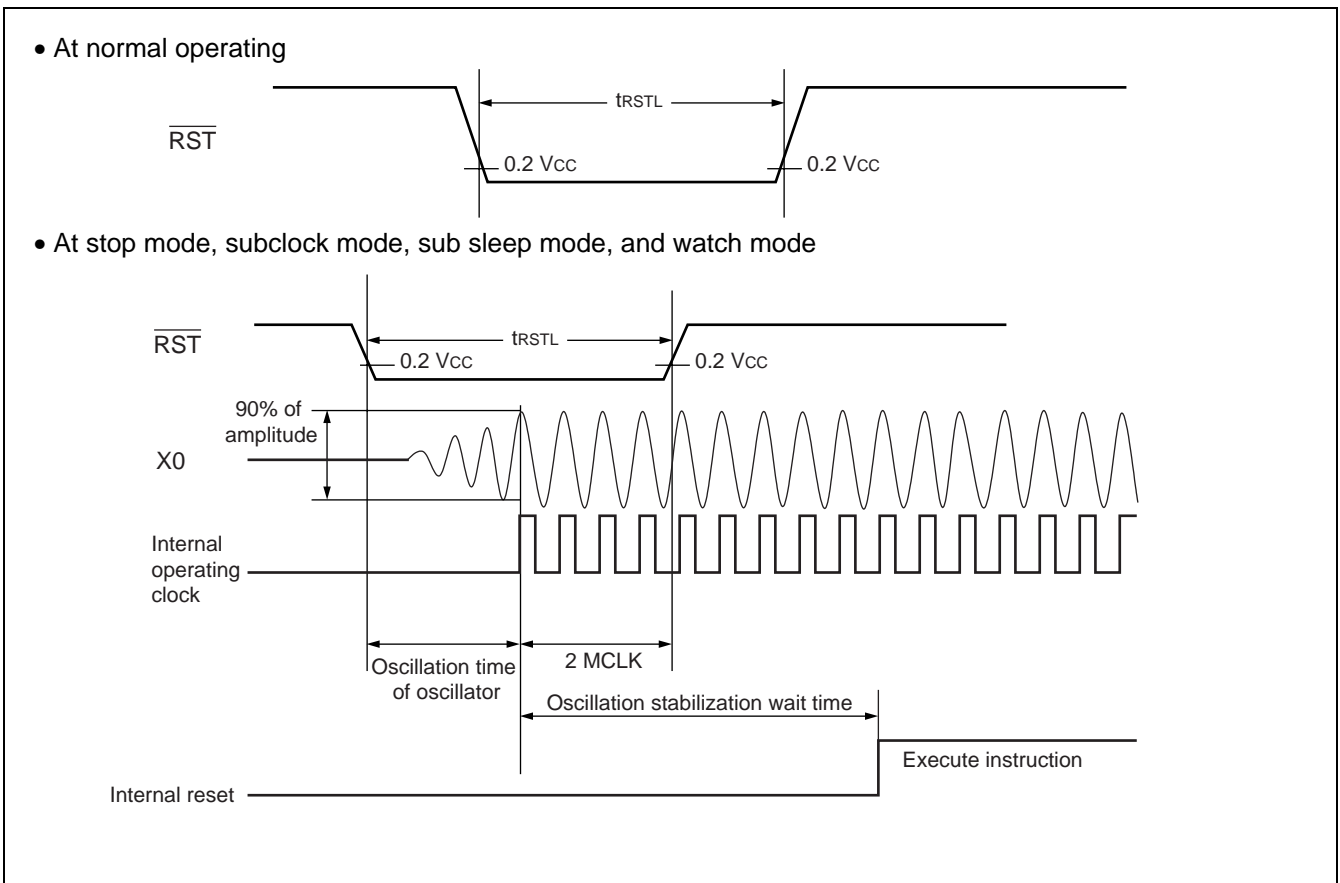
(4) Power-on Reset

$(AVss = Vss = 0.0 \text{ V}, T_A = -40 \text{ °C to } +85 \text{ °C})$

Parameter	Symbol	Conditions	Value		Unit	Remarks
			Min	Max		
Power supply rising time	t_R	—	—	36	ms	
Power supply cutoff time	t_{OFF}	—	1	—	ms	Due to repeated operations

Note : The power supply must be turned on within the selected oscillation stabilization time.
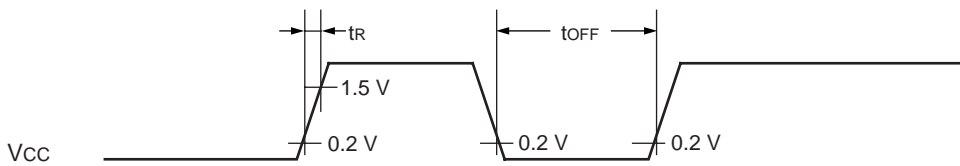
Sudden change of power supply voltage may activate the power-on reset function.
When changing power supply voltages during operation, set the slope of rising within
20 mV/ms as shown below. In this case, do not use PLL clock. However, if voltage
drop is 1V/s or less, use of PLL clock is allowed during operation.
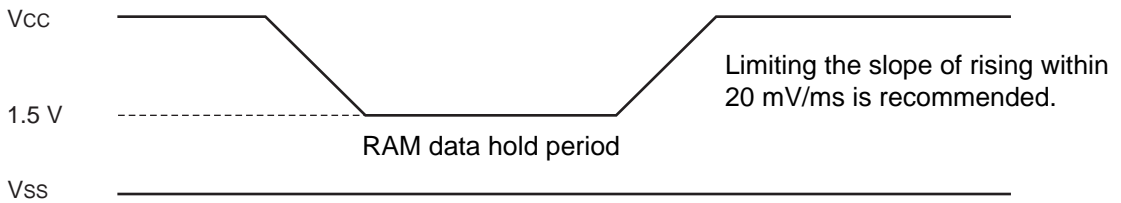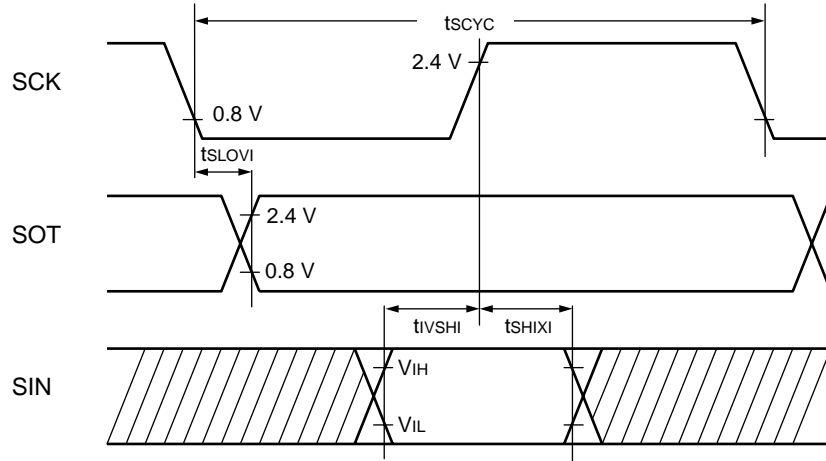
(5) Peripheral Input Timing

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = − 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Value		Unit	Remarks
			Min	Max		
Peripheral input "H" pulse width	t$_{ILIH}$	INT00 to INT07, EC0, EC1, TRG0/ADTG	2 MCLK*	—	ns	
Peripheral input "L" pulse width	t$_{IHIL}$		2 MCLK*	—	ns	

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.
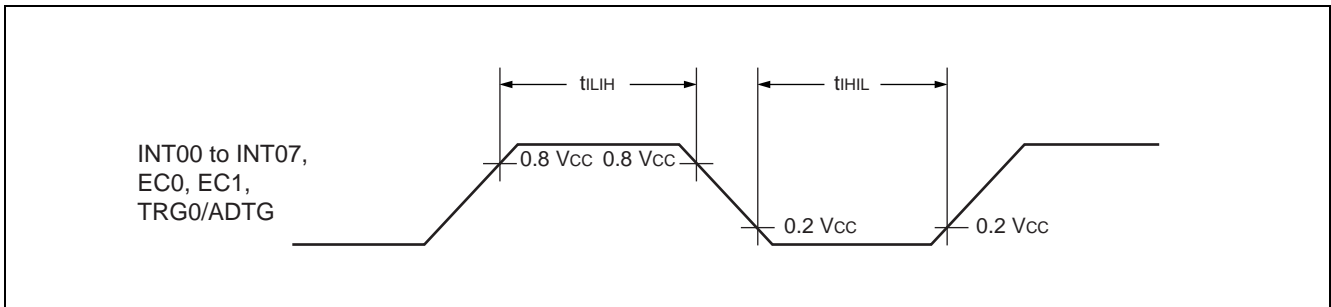
(6) UART/SIO, Serial I/O Timing

$(Vcc = 3.3 \text{ V}, AVss = Vss = 0.0 \text{ V}, T_A = -40 \text{ °C to } +85 \text{ °C})$

Parameter	Symbol	Pin name	Conditions	Value		Unit	Remarks
				Min	Max		
Serial clock cycle time	t_{SCYC}	UCK0	Internal clock operation	4 MCLK*	—	ns	
UCK ↓ → UO time	t_{SLOV}	UCK0, UO0		− 190	190	ns	
Valid UI → UCK ↑	t_{IVSH}	UCK0, UI0		2 MCLK*	—	ns	
UCK ↑ → valid UI hold time	t_{SHIX}	UCK0, UI0		2 MCLK*	—	ns	
Serial clock "H" pulse width	t_{SHSL}	UCK0	External clock operation	4 MCLK*	—	ns	
Serial clock "L" pulse width	t_{SLSH}	UCK0		4 MCLK*	—	ns	
UCK ↓ → UO time	t_{SLOV}	UCK0, UO0		—	190	ns	
Valid UI → UCK ↑	t_{IVSH}	UCK0, UI0		2 MCLK*	—	ns	
UCK ↑ → valid UI hold time	t_{SHIX}	UCK0, UI0		2 MCLK*	—	ns	

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.
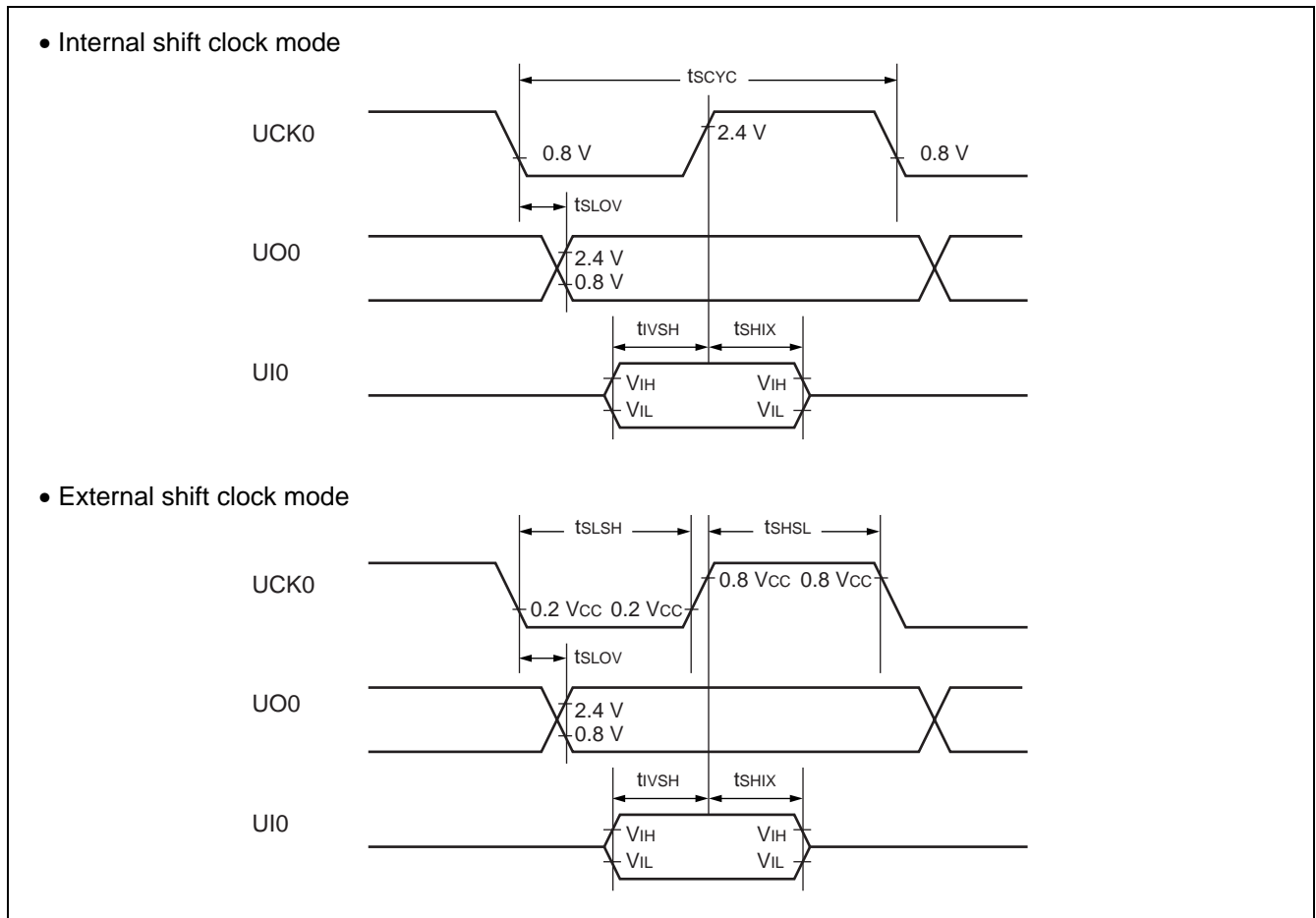
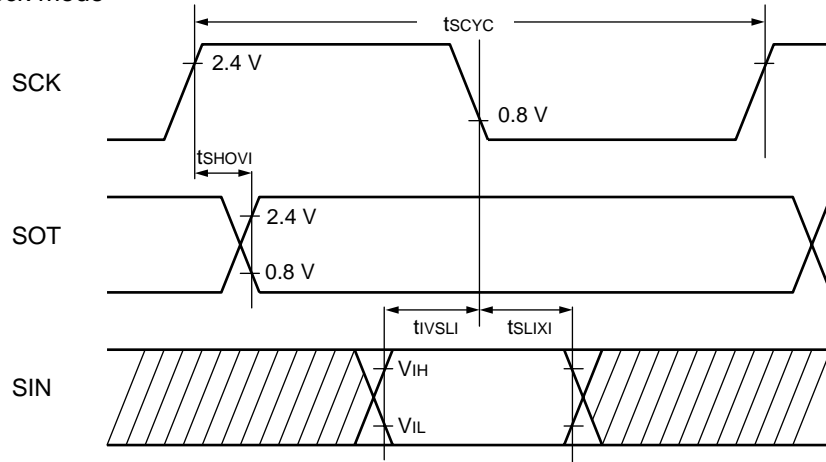 (7) LIN-UART Timing

ESCR : SCES = 0, ECCR : SCDE = 0

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T_A = −40 °C to + 85 °C)

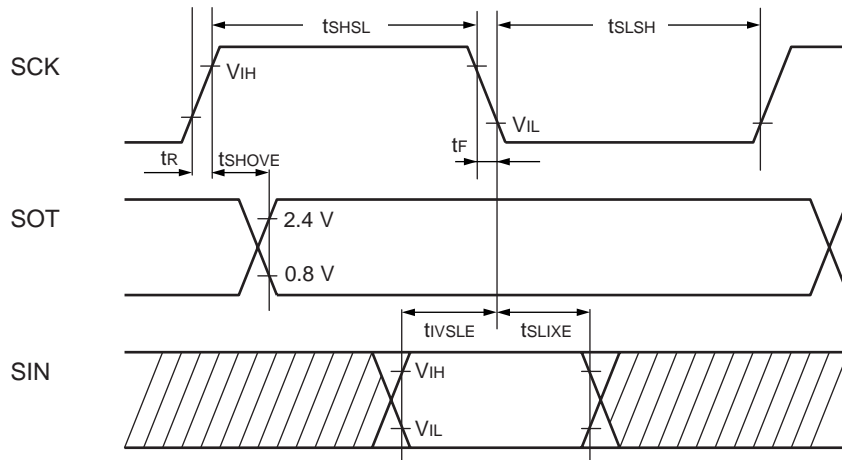| Parameter	Symbol	Pin name	Conditions	Value		Unit
				Min	**Max**	
Serial clock cycle time	t_{SCYC}	SCK	Internal clock operation output pin : C_L = 80 pF + 1 TTL.	5 MCLK*	—	ns
SCK ↑ → SOT delay time	t_{SLOVI}	SCK, SOT		−95	95	ns
Valid SIN → SCK ↑	t_{IVSHI}	SCK, SIN		MCLK* + 190	—	ns
SCK ↑→ valid SIN hold time	t_{SHIXI}	SCK, SIN		0	—	ns
Serial clock "L" pulse width	t_{SLSH}	SCK	External clock operation output pin : C_L = 80 pF + 1 TTL.	3 MCLK* − t_R	—	ns
Serial clock "H" pulse width	t_{SHSL}	SCK		MCLK* + 95	—	ns
SCK ↓ → SOT delay time	t_{SLOVE}	SCK, SOT		—	2 MCLK* + 95	ns
Valid SIN → SCK↑	t_{IVSHE}	SCK, SIN		190	—	ns
SCK ↑ → Valid SIN hold time	t_{SHIXE}	SCK, SIN		MCLK* + 95	—	ns
SCK fall time	t_F	SCK		—	10	ns
SCK rise time	t_R	SCK		—	10	ns

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.

- Internal shift clock mode

SCK

SOT

SIN

tSCYC

2.4 V

0.8 V

tSLOVI

2.4 V

0.8 V

tIVSHI   tSHIXI

VIH

VIL

- External shift clock mode

SCK

SOT

SIN

tSLSH   tSHSL

VIH

VIL

tF   tSLOVE

tR

2.4 V

0.8 V

tIVSHE   tSHIXE

VIH

VIL

ESCR : SCES $= 1$, ECCR : SCDE $= 0$

(Vcc $= 3.3$ V, AVss $=$ Vss $= 0.0$ V, T$_A = -40$ °C to $+ 85$ °C)

Parameter	Sym-bol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t$_{SCYC}$	SCK	Internal clock operation output pin : C$_L = 80$ pF $+ 1$ TTL.	5 MCLK*	—	ns
SCK $\uparrow \rightarrow$ SOT delay time	t$_{SHOVI}$	SCK, SOT		-95	95	ns
Valid SIN $\rightarrow$ SCK $\downarrow$	t$_{IVSLI}$	SCK, SIN		MCLK* $+$ 190	—	ns
SCK $\downarrow \rightarrow$ Valid SIN hold time	t$_{SLIXI}$	SCK, SIN		0	—	ns
Serial clock "H" pulse width	t$_{SHSL}$	SCK	External clock operation output pin : C$_L = 80$ pF $+ 1$ TTL.	3 MCLK* $-$ t$_R$	—	ns
Serial clock "L" pulse width	t$_{SLSH}$	SCK		MCLK* $+$ 95	—	ns
SCK $\uparrow \rightarrow$ SOT delay time	t$_{SHOVE}$	SCK, SOT		—	2 MCLK* $+$ 95	ns
Valid SIN $\rightarrow$ SCK $\downarrow$	t$_{IVSLE}$	SCK, SIN		190	—	ns
SCK $\downarrow \rightarrow$ Valid SIN hold time	t$_{SLIXE}$	SCK, SIN		MCLK* $+$ 95	—	ns
SCK fall time	t$_F$	SCK		—	10	ns
SCK rise time	t$_R$	SCK		—	10	ns

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.

- Internal shift clock mode

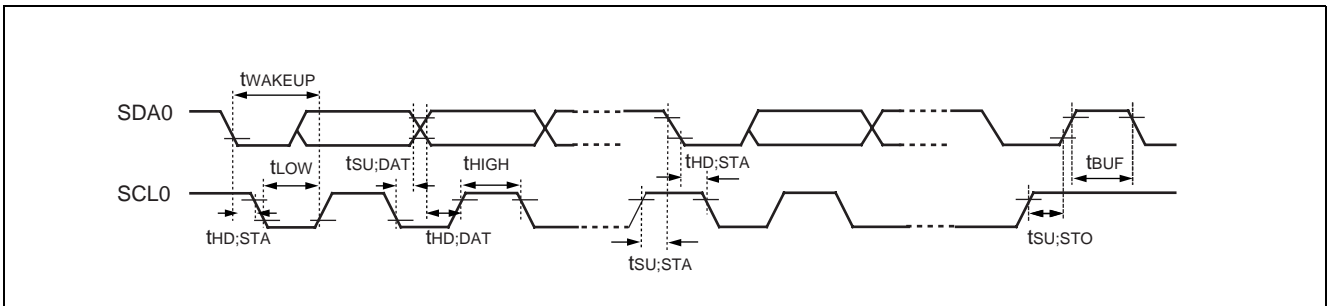- External shift clock mode

ESCR : SCES = 0, ECCR : SCDE = 1

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = −40 °C to + 85 °C)

Parameter	Sym-bol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t$_{SCYC}$	SCK	Internal clock operation output pin : C$_L$ = 80 pF + 1 TTL.	5 MCLK*	—	ns
SCK ↑ → SOT delay time	t$_{SHOVI}$	SCK, SOT		−95	95	ns
Valid SIN→SCK↓	t$_{IVSLI}$	SCK, SIN		MCLK* + 190	—	ns
SCK ↓ → valid SIN hold time	t$_{SLIXI}$	SCK, SIN		0	—	ns
SOT → SCK ↓ delay time	t$_{SOVLI}$	SCK, SOT		—	4 MCLK*	ns

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.
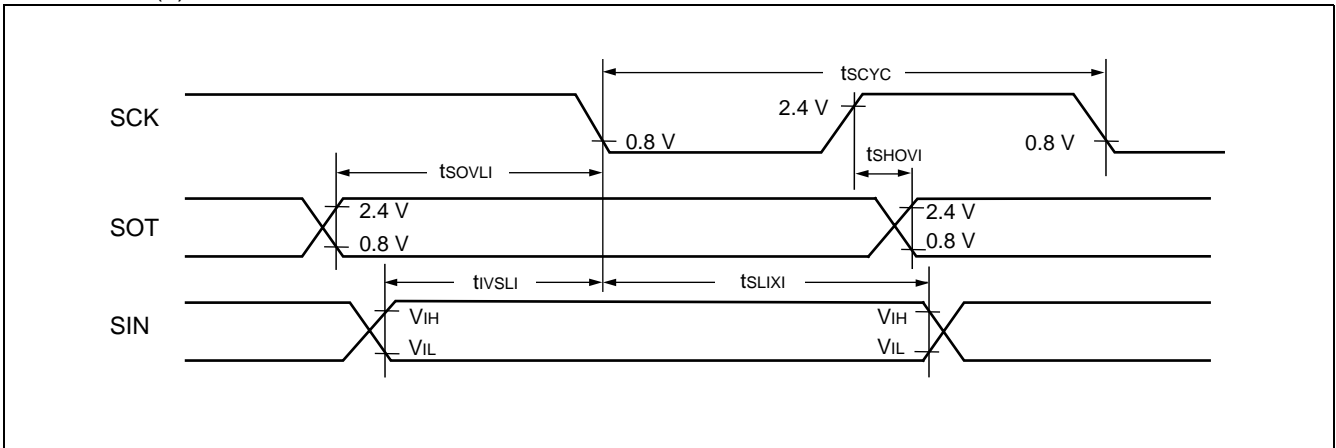
ESCR : SCES = 1, ECCR : SCDE = 1

$(Vcc = 3.3\ V, AVss = Vss = 0.0\ V, T_A = -40\ °C\ to\ +85\ °C)$

Parameter	Symbol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t_{SCYC}	SCK	Internal clock operation output pin : $C_L = 80\ pF + 1\ TTL.$	5 MCLK*	—	ns
SCK $\downarrow \rightarrow$ SOT delay time	t_{SLOVI}	SCK, SOT		−95	95	ns
Valid SIN $\rightarrow$ SCK $\uparrow$	t_{IVSHI}	SCK, SIN		MCLK* + 190	—	ns
SCK $\uparrow \rightarrow$ valid SIN hold time	t_{SHIXI}	SCK, SIN		0	—	ns
SOT $\rightarrow$ SCK $\uparrow$ delay time	tS_{OVHI}	SCK, SOT		—	4 MCLK*	ns

* : Refer to " (2) Source Clock/Machine Clock" for MCLK.
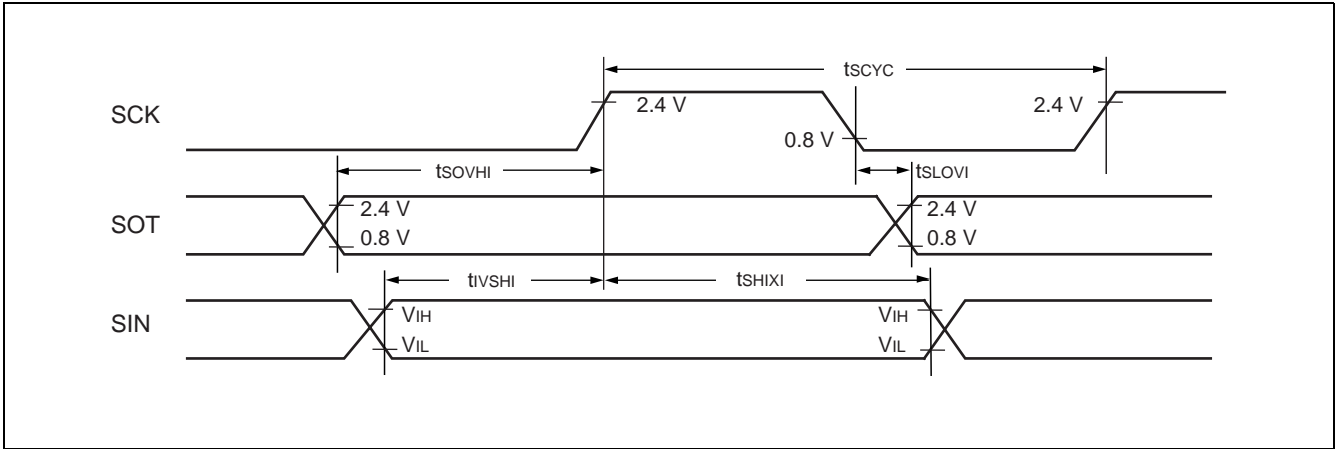
(8) I²C Timing

(Vcc = 3.3 V, AVss = Vss = 0.0 V, T$_A$ = $-$ 40 °C to $+$ 85 °C)

Parameter	Symbol	Conditions	Value				Unit	Remarks
			Standard-mode		Fast-mode			
			Min	Max	Min	Max		
SCL clock frequency	f$_{SCL}$		0	100	0	400	kHz	
(Repeat) Start condition hold time SDA ↓ → SCL ↓	t$_{HD;STA}$		4.0	—	0.6	—	μs	
SCL clock "L" width	t$_{LOW}$		4.7	—	1.3	—	μs	
SCL clock "H" width	t$_{HIGH}$		4.0	—	0.6	—	μs	
(Repeat) Start condition setup time SCL ↑ → SDA ↓	t$_{SU;STA}$	R = 1.7 kΩ, C = 50 pF*1	4.7	—	0.6	—	μs	
Data hold time SCL ↓ → SDA ↓ ↑	t$_{HD;DAT}$		0	3.45*2	0	0.9*3	μs	
Data setup time SDA ↓ ↑ → SCL ↑	t$_{SU;DAT}$		0.25	—	0.1	—	μs	
Stop condition setup time SCL ↑ → SDA ↑	t$_{SU;STO}$		4	—	0.6	—	μs	
Bus free time between stop condition and start condition	t$_{BUF}$		4.7	—	1.3	—	μs	

*1 : R, C : Pull-up resistor and load capacitor of the SCL and SDA lines.

*2 : The maximum t$_{HD;DAT}$ have only to be met if the device dose not stretch the "L" width (t$_{LOW}$) of the SCL signal.

*3 : A Fast-mode I²C-bus device can be used in a Standard-mode I²C-bus system, but the requirement t$_{SU;DAT}$ ≥ 250 ns must then be met.

$(Vcc = 3.3 \text{ V}, AVss = Vss = 0.0 \text{ V}, T_A = -40 \text{ °C to } + 85 \text{ °C})$

Parameter	Symbol	I/O Timing Min	I/O Timing Max	Unit	Remarks
SCL clock "L" width	t_{LOW}	$(2 + nm^{*2} / 2)$ MCLK^{*1} − 20	—	ns	Master mode
SCL clock "H" width	t_{HIGH}	$(nm^{*2} / 2)$ MCLK^{*1} − 20	$(nm^{*2} / 2)$ MCLK^{*1} + 20	ns	Master mode
Start condition hold time	$t_{HD;STA}$	$(-1 + nm^{*2} / 2)$ MCLK^{*1} − 20	$(-1 + nm^{*2})$ MCLK^{*1} + 20	ns	Master mode. Maximum value is applied when m, n = 1, 8. Otherwise, the minimum value is applied.
Stop condition setup time	$t_{SU;STO}$	$(1 + nm^{*2} / 2)$ MCLK^{*1} − 20	$(1 + nm^{*2} / 2)$ MCLK^{*1} + 20	ns	Master mode
Start condition setup time	$t_{SU;STA}$	$(1 + nm^{*2} / 2)$ MCLK^{*1} − 20	$(1 + nm^{*2} / 2)$ MCLK^{*1} + 20	ns	Master mode
Bus free time between stop condition and start condition	t_{BUF}	$(2 nm^{*2} + 4)$ MCLK^{*1} − 20	—	ns	
Data hold time	$t_{HD;DAT}$	3 MCLK^{*1} − 20	—	ns	Master mode
Data setup time	$t_{SU;DAT}$	$(-2 + nm^{*2} / 2)$ MCLK^{*1} − 20	$(-1 + nm^{*2} / 2)$ MCLK^{*1} + 20	ns	Master mode. When assuming that "L" of SCL is not extended, the minimum value is applied to first bit of continuous data. Otherwise, the maximum value is applied.
Setup time between clearing interrupt and SCL rising	$t_{SU;INT}$	$(nm^{*2} / 2)$ MCLK^{*1} − 20	$(1 + nm^{*2} / 2)$ MCLK^{*1} + 20	ns	Minimum value is applied to interrupt at 9th SCL↓. Maximum value is applied to interrupt at 8th SCL↓.
SCL clock "L" width	t_{LOW}	4 MCLK^{*1} − 20	—	ns	At reception
SCL clock "H" width	t_{HIGH}	4 MCLK^{*1} − 20	—	ns	At reception
Start condition detection	$t_{HD;STA}$	2 MCLK^{*1} − 20	—	ns	Undetected when 1 MCLK is used at reception
Stop condition detection	$t_{SU;STO}$	2 MCLK^{*1} − 20	—	ns	Undetected when 1 MCLK is used at reception
Restart condition detection condition	$t_{SU;STA}$	2 MCLK^{*1} − 20	—	ns	Undetected when 1 MCLK is used at reception
Bus free time	t_{BUF}	2 MCLK^{*1} − 20	—	ns	At reception
Data hold time	$t_{HD;DAT}$	2 MCLK^{*1} − 20	—	ns	At slave transmission mode
Data setup time	$t_{SU;DAT}$	$t_{LOW} - 3$ MCLK^{*1} − 20	—	ns	At slave transmission mode
Data hold time	$t_{HD;DAT}$	0	—	ns	At reception
Data setup time	$t_{SU;DAT}$	MCLK^{*1} − 20	—	ns	At reception

(Continued)

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(Continued)

Parameter	Sym-bol	I/O Timing		Unit	Remarks
		Min	Max		
SDA↓→SCL↑ (at wakeup function)	$t_{WAKE-UP}$	Oscillation stabilization wait time + 2 MCLK*1 − 20	—	ns	

*1 :   Refer to " (2) Source Clock/Machine Clock" for MCLK.

*2 :   • m is CS4 bit and CS3 bit (bit 4 and bit 3) of clock control register (ICCR) .
   • n is CS2 bit to CS0 bit (bit 2 to bit 0) of clock control register (ICCR) .
   • Actual timing of I2C is determined by m and n values set by the machine clock (MCLK) and ICCR [4 : 0].
   • Standard-mode :
     m and n can be set at the range : 0.9 MHz < MCLK (machine clock) < 10 MHz.
     Setting of m and n determines the machine clock that can be used below.
       (m, n) = (1, 8)   : 0.9 MHz < MCLK ≤ 1 MHz
       (m, n) = (1, 22) , (5, 4) , (6, 4) , (7, 4) , (8, 4)   : 0.9 MHz < MCLK ≤ 2 MHz
       (m, n) = (1, 38) , (5, 8) , (6, 8) , (7, 8) , (8, 8)   : 0.9 MHz < MCLK ≤ 4 MHz
       (m, n) = (1, 98)   : 0.9 MHz < MCLK ≤ 10 MHz

   • Fast-mode :
     m and n can be set at the range : 3.3 MHz < MCLK (machine clock) < 10 MHz.
     Setting of m and n determines the machine clock that can be used below.
      (m, n) = (1, 8)   : 3.3 MHz < MCLK ≤ 4 MHz
      (m, n) = (1, 22) , (5, 4) : 3.3 MHz < MCLK ≤ 8 MHz
      (m, n) = (6, 4)   : 3.3 MHz < MCLK ≤ 10 MHz

5.   A/D Converter

(1) A/D Converter Electrical Characteristics

(AVcc = Vcc = 1.8 V to 3.3 V [FLASH product], AVcc = Vcc = 1.8 V to 3.6 V [MASK product], AVss = Vss = 0.0 V,

$T_A = -40\ °C$ to $+85\ °C$)

Parameter	Symbol	Value			Unit	Remarks
		Min	Typ	Max		
Resolution	—	—	—	10	bit	
Total error		− 3.0	—	+ 3.0	LSB	
Linearity error		− 2.5	—	+ 2.5	LSB	
Differential linear error		− 1.9	—	+ 1.9	LSB	
Zero transition voltage	V_{OT}	AVss − 1.5 LSB	AVss + 0.5 LSB	AVss + 2.5 LSB	V	FLASH product : 2.7 V ≤ AVcc ≤ 3.3 V MASK product : 2.7 V ≤ AVcc ≤ 3.6 V
		AVss − 0.5 LSB	AVss + 1.5 LSB	AVss + 3.5 LSB	V	1.8 V ≤ AVcc < 2.7 V
Full-scale transition voltage	V_{FST}	AVcc − 3.5 LSB	AVcc − 1.5 LSB	AVcc + 0.5 LSB	V	FLASH product : 2.7 V ≤ AVcc ≤ 3.3 V MASK product : 2.7 V ≤ AVcc ≤ 3.6 V
		AVcc − 2.5 LSB	AVcc − 0.5 LSB	AVcc + 1.5 LSB	V	1.8 V ≤ AVcc < 2.7 V
Compare time	—	0.6	—	16,500	μs	FLASH product : 2.7 V ≤ AVcc ≤ 3.3 V MASK product : 2.7 V ≤ AVcc ≤ 3.6 V
		20	—	16,500	μs	1.8 V ≤ AVcc < 2.7 V
Sampling time	—	0.4	—	∞	μs	FLASH product : 2.7 V ≤ AVcc ≤ 3.3 V MASK product : 2.7 V ≤ AVcc ≤ 3.6 V external impedance < at 1.8 kΩ
		30	—	∞	μs	1.8 V ≤ AVcc < 2.7 V external impedance < at 14.8 kΩ
Analog input current	I_{AIN}	−0.3	—	0.3	μA	
Analog input voltage range	V_{AIN}	AVss	—	AVcc	V	
Reference voltage	—	AVss + 1.8	—	AVcc	V	AVcc pin
Reference voltage supply current	I_R	—	400	600	μA	AVcc pin, During A/D operation
	I_{RH}	—	—	5	μA	AVcc pin, at stop mode

(2) Notes on Using A/D Converter

• **About the external impedance of 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 sanple and hold capacitor is insufficient, adversely affecting A/D conversion precision.

• Analog input circuit model

Analog input pin   R   Comparator

C

During sampling : ON
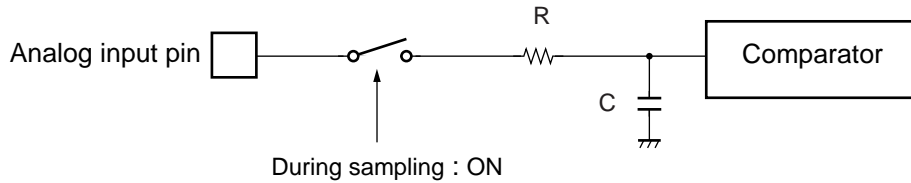
	R	C
2.7 V ≤ AVcc ≤ 3.6 V	1.7 kΩ (Max)	14.5 pF (Max)
1.8 V ≤ AVcc < 2.7 V	84 kΩ (Max)	25.2 pF (Max)

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)

AVcc ≥ 2.7 V   AVcc ≥ 2.7 V

AVcc ≥ 1.8 V
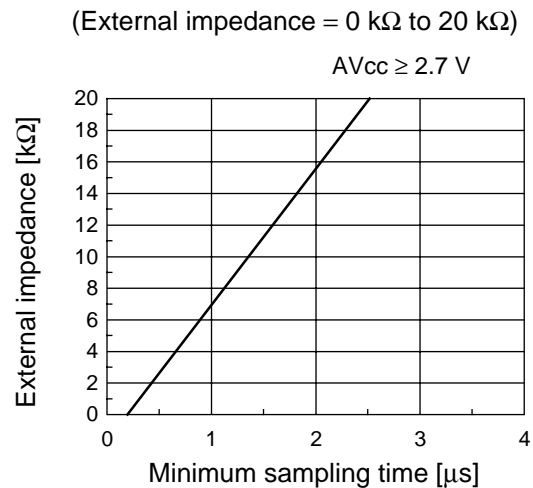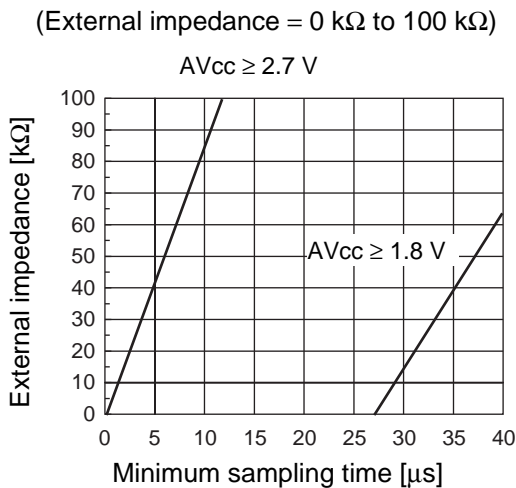
   • If the sampling time cannot be sufficient, connect a capacitor of about 0.1 μF to the analog input pin.

• **About errors**

   As |AVcc − AVss| becomes smaller, values of relative errors grow larger.

(3) Definition of A/D Converter Terms

- Resolution

  The level of analog variation that can be distinguished by 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 between the value along a straight line connecting the zero transition point ("00 0000 0000" ← → "00 0000 0001") of a device and the full-scale transition point ("11 1111 1111" ← → "11 1111 1110") compared with the actual conversion values obtained.

- Differential linear error (Unit : LSB)

  Deviation of input voltage, which is required for changing output code by 1 LSB, from an ideal value.

- Total error (unit: LSB)

  Difference between actual and theoretical values, caused by a zero transition error, full-scale transition error, linearity error, quantum error, and noise.

$$1 \text{ LSB} = \frac{AV_{CC} - AV_{SS}}{1024} \text{ (V)}$$

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

V_{NT} : A voltage at which digital output transits from $(N - 1)$ to N.

(Continued)

(Continued)

Zero transition error

Full-scale transition error

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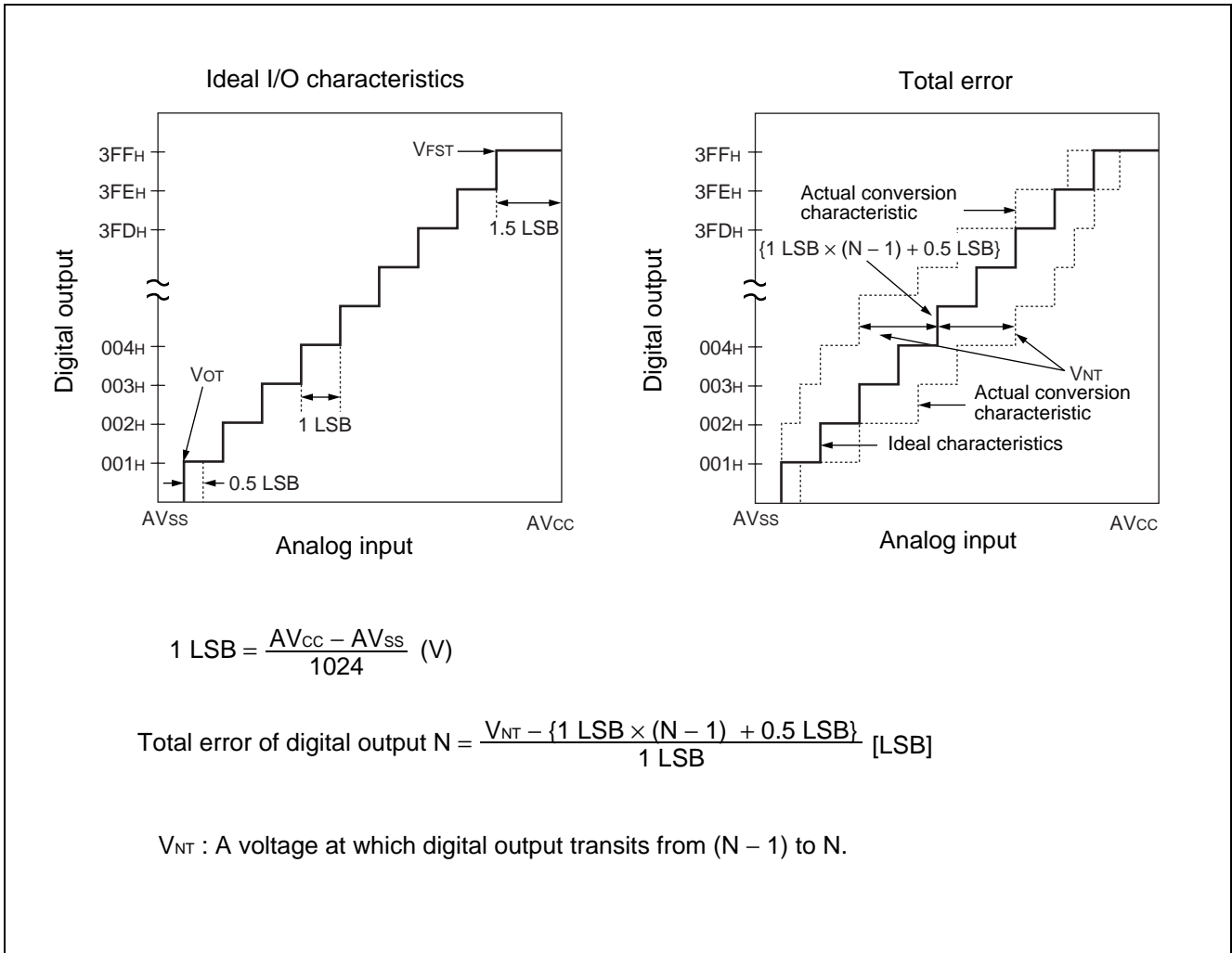
Differential linear error
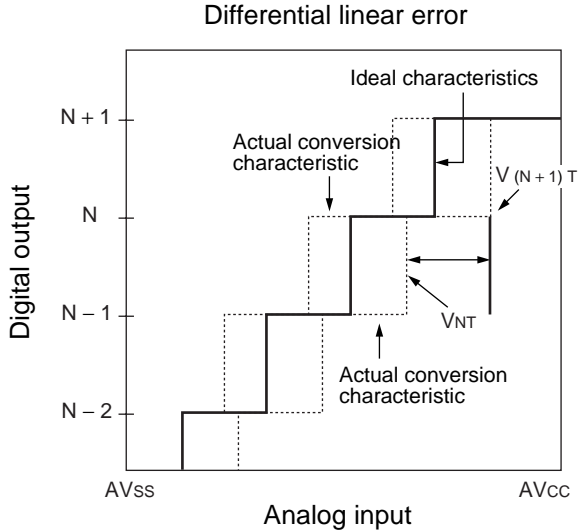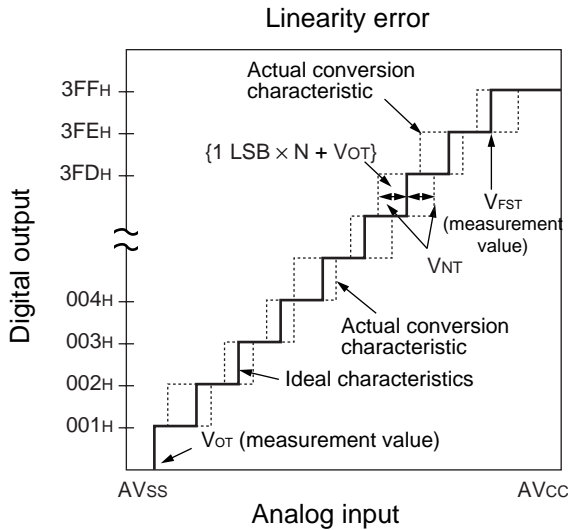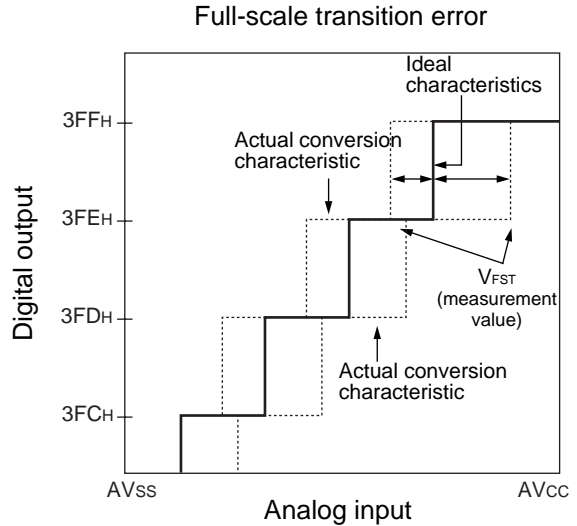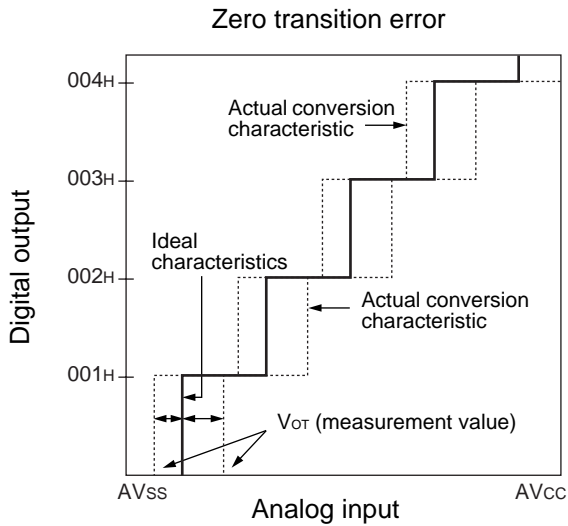
$$\text{Linear error in digital output N} = \frac{V_{NT} - \{1\ LSB \times N + V_{OT}\}}{1\ LSB}$$

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

V_{NT} : A voltage at which digital output transits from $(N-1)$ to N.
V_{OT} (Ideal value) $= AV_{SS} + 0.5\ LSB$ [V]
V_{FST} (Ideal value) $= AV_{CC} - 1.5\ LSB$ [V]

6. Flash Memory Program/Erase Characteristics

Parameter	Value			Unit	Remarks
	Min	**Typ**	**Max**		
Sector erase time (4 Kbytes sector)	—	0.2*1	3*2	s	Excludes 00$_H$ programming prior erasure
Sector erase time (16 Kbytes sector)	—	0.5*1	12*2	s	Excludes 00$_H$ programming prior erasure
Byte programming time	—	32	3600	μs	Excludes system-level overhead
Erase/program cycle	10,000	—	—	cycle	
Power supply voltage at erase/program	2.7	—	3.3	V	
Flash data retension time	20*3	—	—	year	Average T_A = +85 °C

*1 : T_A = +25 °C, Vcc = 3.0 V, 10,000 cycles

*2 : T_A = +85 °C, Vcc = 2.7 V, 10,000 cycles

*3 : This value comes from the technology qualification (using Arrhenius equation to translate high temperature measurements into normalized value at +85 °C) .

■ MASK OPTIONS

No	Part number	MB95116A	MB95F118AS	MB95F118AW	MB95FV100A-101
	Specifying procedure	**Specify when ordering MASK**	**Setting disabled**	**Setting disabled**	**Setting disabled**
1	Clock mode select • Single-system clock mode • Dual-system clock mode	Selectable	Single-system clock mode	Dual-system clock mode	Changing by the switch on MCU board
2	Selection of oscillation stabilization wait time • Selectable the initial value of main clock oscillation stabilization wait time	Selectable 1 : ($2^2 - 2$) /F_{CH} 2 : ($2^{12} - 2$) /F_{CH} 3 : ($2^{13} - 2$) /F_{CH} 4 : ($2^{14} - 2$) /F_{CH}	Fixed to oscillation stabilization wait time of (2^{14}-2) /F_{CH}	Fixed to oscillation stabilization wait time of (2^{14}-2) /F_{CH}	Fixed to oscillation stabilization wait time of (2^{14}-2) /F_{CH}

■ ORDERING INFORMATION

Part number	Package	Remarks
MB95116APV MB95F118ASPV MB95F118AWPV	48-pin plastic BCC (LCC-48P-M09)	
MB95116APMT MB95F118ASPMT MB95F118AWPMT	48-pin plastic LQFP (FPT-48P-M26)	
MB2146-301 (MB95FV100A-101PBT)	MCU board $\left(\begin{array}{c}\text{244-pin plastic PFBGA}\\\text{(BGA-244P-M08)}\end{array}\right)$	

■ PACKAGE DIMENSIONS

48-pin plastic BCC
(LCC-48P-M09)

7.00±0.10(.276±.004)

7.00±0.10
(.276±.004)

INDEX AREA

0.75±0.05
(.030±.002)
(Mount height)

0.075±0.025
(.003±.001)
(Stand off)

0.05(.002)

6.20(.244)TYP

0.50(.020)
TYP

0.50±0.10
(.020±.004)

6.15(.242)TYP

0.50(.020)
TYP

6.20(.244)
TYP

6.15(.242)
TYP

0.50±0.10
(.020±.004)

6.25(.246)
REF

5.00(.197)
REF

"A"

"C"

"B"

5.00(.197)REF

6.25(.246)REF

Details of "A" part

8-0.60±0.06
(8-.024±.002)

0.65±0.06
(.026±.002)

0.14(.006)
MIN

0.30±0.06
(.012±.002)

Details of "B" part

C0.2(.008)

0.55±0.06
(.022±.002)

0.55±0.06
(.022±.002)

Details of "C" part

0.55±0.06
(.022±.002)

0.55±0.06
(.022±.002)

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

(Continued)

(Continued)

48-pin plastic LQFP
(FPT-48P-M26)

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.

9.00±0.20(.354±.008)SQ

* 7.00 $^{+0.40}_{-0.10}$ (.276 $^{+.016}_{-.004}$)SQ

36   25
37   24

INDEX

48   13

LEAD No. 1   12

0.50(.020)

0.20±0.05
(.008±.002) $\oplus$ 0.08(.003) Ⓜ

0.145±0.055
(.006±.002)

0.08(.003)

"A"

Details of "A" part

1.50 $^{+0.20}_{-0.10}$ (Mounting height)
(.059 $^{+.008}_{-.004}$)

0°~8°

0.10±0.10
(.004±.004)
(Stand off)

0.25(.010)

0.60±0.15
(.024±.006)
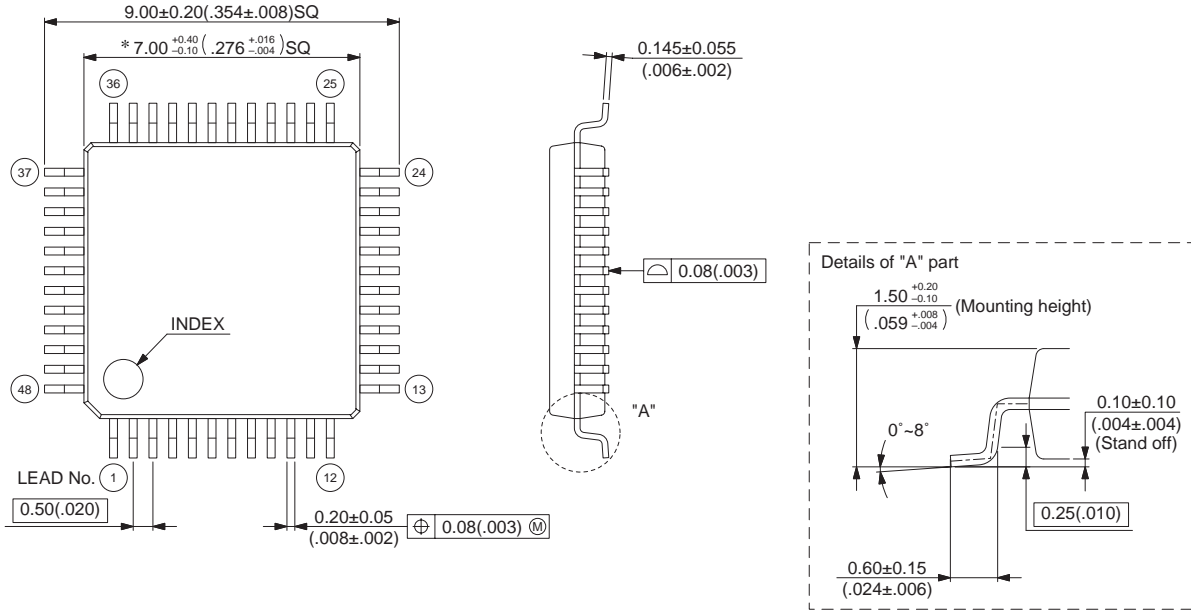
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Dimensions in mm (inches).
Note: The values in parentheses are reference values.

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