FUJITSU MICROELECTRONICS
DATA SHEET

DS07-12618-2E

8-bit Microcontroller

CMOS

F²MC-8FX MB95160 Series

MB95F166D/166D/FV100D-101

■ DESCRIPTION

The MB95160 series is general-purpose, single-chip microcontrollers. In addition to a compact instruction set, the microcontrollers contain a variety of peripheral functions.

Note : F²MC is the abbreviation of FUJITSU Flexible Microcontroller.

■ FEATURE

- F²MC-8FX CPU core
  Instruction set optimized for controllers
  - Multiplication and division instructions
  - 16-bit arithmetic operations
  - Bit test branch instruction
  - Bit manipulation instructions etc.
- Clock
  - Main clock
  - Main PLL clock
  - Sub clock
  - Sub PLL clock
- Timer
  - 8/16-bit compound timer × 2 channels
    Can be used to interval timer, PWC timer, PWM timer and input capture.
  - 8/16-bit PPG × 2 channels
  - 16-bit PPG × 1 channel
  - Timebase timer × 1 channel
  - Watch prescaler × 1 channel
- LIN-UART × 1 channel
  - LIN function, clock asynchronous (UART) or clock synchronous (SIO) serial data transfer capable
  - Full duplex double buffer

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

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

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- UART/SIO × 1 channel
  - Clock asynchronous (UART) or clock synchronous (SIO) serial data transfer capable
  - Full duplex double buffer
  -
- I^2C × 1 channel
  Built-in wake-up function
- External interrupt × 8 channels
  - Interrupt by edge detection (rising, falling, or both edges can be selected)
  - Can be used to recover from low-power consumption (standby) modes.
- 8/10-bit A/D converter × 8 channels
  8-bit or 10-bit resolution can be selected.
- LCD controller (LCDC)
  - 32 SEG × 4 COM (Max 128 pixels) (Built-in internal division resistance product)
  - With blinking function
- Low-power consumption (standby) mode
  - Stop mode
  - Sleep mode
  - Watch mode
  - Timebase timer mode
- I/O port
  - The number of maximum ports : Max 53
  - Port configuration
    - General-purpose I/O ports (N-ch open drain) : 2 ports
    - General-purpose I/O ports (CMOS) : 51 ports
- Programmable input voltage levels of port
  CMOS input level/hysteresis input level
- Flash memory security function (Flash memory device only)
  Protects the content of Flash memory

■ PRODUCT LINEUP

Parameter \ Part number		MB95F166D	MB95166D
Type		Flash memory product	Mask ROM product
ROM capacity		32 Kbytes	
RAM capacity		1 Kbyte	
Reset output		No	
Option*	Clock system	Dual clock	
	Low voltage detection reset	No	
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 : 61.5 ns (at machine clock frequency 16.25 MHz) Interrupt processing time : 0.6 µs (at machine clock frequency 16.25 MHz)	
Peripheral functions	Ports (Max 53 ports)	General-purpose I/O port (N-ch open drain) : 2 ports General-purpose I/O port (CMOS) : 51 ports Programmable input voltage levels of port. CMOS input level/hysteresis input level.	
	Timebase timer (1 channel)	Interrupt cycle : 0.5 ms, 2.1 ms, 8.2 ms, 32.8 ms (at main oscillation clock 4 MHz)	
	Watchdog timer	Reset generated cycle At main oscillation clock 10 MHz : Min 105 ms At sub oscillation clock 32.768 kHz (for dual clock product) : Min 250 ms	
	Wild register	Capable of replacing 3 bytes of ROM data	
	I^2C (1 channel)	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 (1 channel)	Data transfer capable in UART/SIO Full duplex double buffer, variable data length (5/6/7/8-bit), built-in baud rate generator NRZ type transfer format, error detected function LSB-first or MSB-first can be selected. Clock synchronous (SIO) or clock asynchronous (UART) serial data transfer capable	
	LIN-UART (1 channel)	Dedicated reload timer allowing a wide range of communication speeds to be set. Full duplex double buffer. Capable of serial data transfer synchronous or asynchronous to clock signal. LIN functions available as the LIN master or LIN slave.	

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Parameter \ Part number		MB95F166D	MB95166D
Peripheral functions	8/10-bit A/D converter (8 channels)	8-bit or 10-bit resolution can be selected.	
	LCD controller (LCDC)	COM output : 4 (Max) SEG output : 32 (Max) LCD drive power supply (bias) pin : 4 32 SEG × 4 COM : 128 pixels can be displayed. (Built-in internal division resistance product) Duty LCD mode Operable in LCD standby mode Built-in internal division resistance With blinking function	
	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 wave form output Count clock : 7 internal clocks and external clock can be selected.	
	16-bit PPG (1 channel)	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	Count clock : Four selectable clock sources (125 ms, 250 ms, 500 ms, or 1 s) Counter value can be set from 0 to 63. (Capable of counting for 1 minute when selecting clock source 1 second and setting counter value to 60)	
	Watch prescaler (1 channel)	4 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.	
Flash memory		Supports automatic programming, Embedded Algorithm Write/Erase/Erase-Suspend/Resume commands A flag indicating completion of the algorithm Number of write/erase cycles (Min) : 10000 times Data retention time : 20 years Erase can be performed on each block Block protection with external programming voltage Flash Security Feature for protecting the content of the Flash	
Standby mode		Sleep, stop, watch, and timebase timer	

* : For details of option, refer to “■ MASK OPTION”.

Note : Part number of the evaluation product in MB95160 series is MB95FV100D-101 (internal division resistance included) . When using it, the MCU board (MB2146-301A) is required.

■ OSCILLATION STABILIZATION WAIT TIME

For the MASK ROM 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 evaluation and Flash memory products are fixed their initial value of main clock oscillation stabilization wait time at the maximum value.

Select 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

Package \ Part number	MB95F166D	MB95FV100D-101	MB95166D
FPT-64P-M23	○	×	○
FPT-64P-M24	○	×	○
BGA-224P-M08	×	○	×

○ : Available
× : Unavailable

■ DIFFERENCES AMONG PRODUCTS AND NOTES ON SELECTING PRODUCTS

- Notes on Using Evaluation Products

  The evaluation product has not only the functions of the MB95160 series but also those of other products to support software development for multiple series and models of the F²MC-8FX family. The I/O addresses for peripheral resources not used by the MB95160 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.

  Particularly, do not use word access to odd numbered byte address in the prohibited areas (If these access are used, the address may be read or written unexpectedly).

  Also, as the read values of prohibited addresses on the evaluation product are different to the values on the Flash memory products and Mask ROM products, do not use these values in the program.

  The functions corresponding to certain bits in single-byte registers may not be supported on some Flash memory products and Mask ROM products. However, reading or writing to these bits will not cause malfunction of the hardware. Also, as the evaluation, Flash memory products and Mask ROM products are designed to have identical software operation, no particular precautions are required.

- Difference of Memory Spaces

  If the amount of memory on the evaluation product is different from that of the Flash memory products and Mask ROM products, carefully check the difference in the amount of memory from the model to be actually used when developing software.

  For details of memory space, refer to “■ CPU CORE”.

- Current Consumption

  For details of current consumption, refer to “■ ELECTRICAL CHARACTERISTICS”.

- Package

  For details of information on each package, refer to “■ PACKAGES AND CORRESPONDING PRODUCTS” and “■ PACKAGE DIMENSIONS”.

- Operating voltage

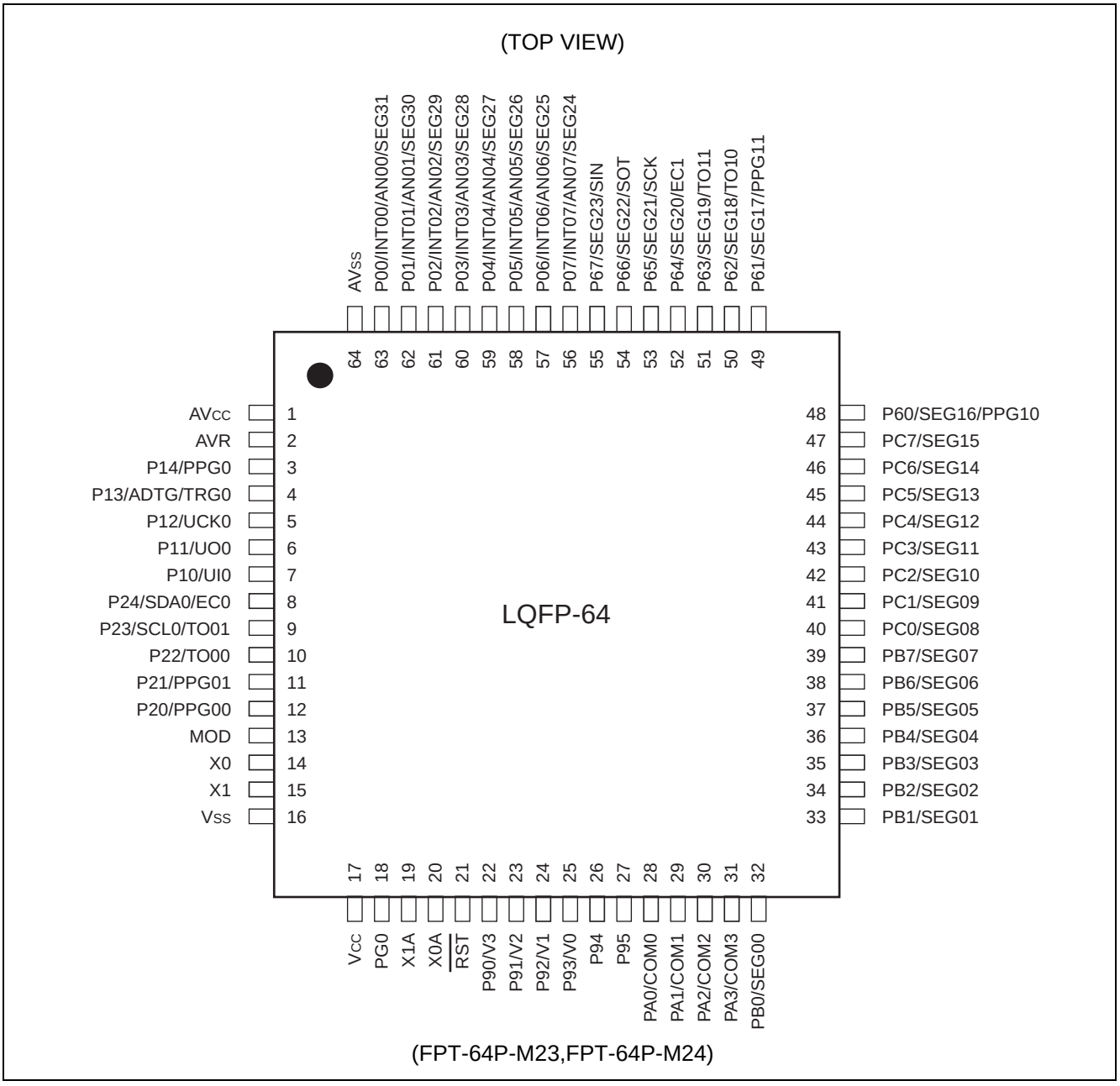
  The operating voltage is different among the evaluation, Flash memory products and Mask ROM products.

  For details of operating voltage, refer to “■ ELECTRICAL CHARACTERISTICS”

- Difference MOD pins

  A pull-down resistor is provided for the MOD pin of the Mask ROM product.

■ PIN ASSIGNMENT



■ PIN DESCRIPTION

Pin no.	Pin name	I/O circuit type*	Function
1	AV_{CC}	—	A/D converter power supply pin.
2	AVR	—	A/D converter reference input pin.
3	P14/PPG0	H	General-purpose I/O port. The pin is shared with 16-bit PPG ch.0 output.
4	P13/TRG0/ ADTG		General-purpose I/O port. The pin is shared with 16-bit PPG ch.0 trigger input (TRG0) and A/D trigger input (ADTG) .
5	P12/UCK0		General-purpose I/O port. The pin is shared with UART/SIO ch.0 clock I/O.
6	P11/UO0		General-purpose I/O port. The pin is shared with UART/SIO ch.0 data output.
7	P10/UI0	G	General-purpose I/O port. The pin is shared with UART/SIO ch.0 data input.
8	P24/EC0/ SDA0	I	General-purpose I/O port. The pin is shared with 8/16-bit compound timer ch.0 clock input (EC0) and I^2C ch.0 data I/O (SDA0) .
9	P23/TO01/ SCL0		General-purpose I/O port. The pin is shared with 8/16-bit compound timer ch.0 output (TO01) and I^2C ch.0 clock I/O (SCL0) .
10	P22/TO00	H	General-purpose I/O port. The pin is shared with 8/16-bit compound timer ch.0 output.
11	P21/PPG01		General-purpose I/O port. The pin is shared with 8/16-bit PPG ch.0 output.
12	P20/PPG00		General-purpose I/O port. The pin is shared with 8/16-bit PPG ch.0 output.
13	MOD	B	Operating mode designation pin.
14	X0	A	Main clock oscillation pins.
15	X1		
16	V_{SS}	—	Power supply pin (GND).
17	V_{CC}	—	Power supply pin.
18	PG0	H	General-purpose I/O port.
19	X1A	A	Sub clock oscillation pins (32 kHz).
20	X0A		
21	$\overline{RST}$	B’	Reset pin.
22	P90/V3	R	General-purpose I/O ports. The pins are shared with power supply pin for LCDC drive.
23	P91/V2		
24	P92/V1		
25	P93/V0		

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Pin no.	Pin name	I/O circuit type*	Function
26	P94	S	General-purpose I/O ports.
27	P95		
28	PA0/COM0	M	General-purpose I/O ports. The pins are shared with LCDC COM output (COM0 to COM3).
29	PA1/COM1		
30	PA2/COM2		
31	PA3/COM3		
32	PB0/SEG00	M	General-purpose I/O ports. The pins are shared with LCDC SEG output (SEG00 to SEG07).
33	PB1/SEG01		
34	PB2/SEG02		
35	PB3/SEG03		
36	PB4/SEG04		
37	PB5/SEG05		
38	PB6/SEG06		
39	PB7/SEG07		
40	PC0/SEG08	M	General-purpose I/O ports. The pins are shared with LCDC SEG output (SEG08 to SEG15).
41	PC1/SEG09		
42	PC2/SEG10		
43	PC3/SEG11		
44	PC4/SEG12		
45	PC5/SEG13		
46	PC6/SEG14		
47	PC7/SEG15		
48	P60/SEG16/ PPG10	M	General-purpose I/O ports. The pins are shared with LCDC SEG output (SEG16, SEG17) and 8/16-bit PPG ch.1 output (PPG10, PPG11) .
49	P61/SEG17/ PPG11		
50	P62/SEG18/ TO10		General-purpose I/O port. The pin is shared with LCDC SEG output (SEG18) and 8/16-bit compound timer ch.1 output (TO10) .

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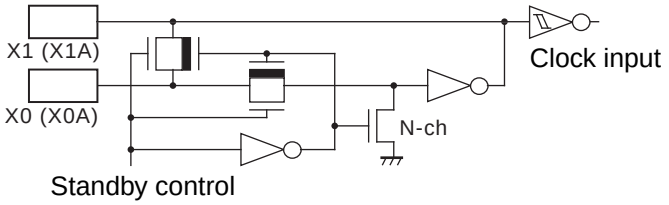
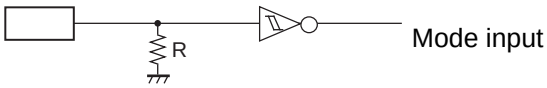
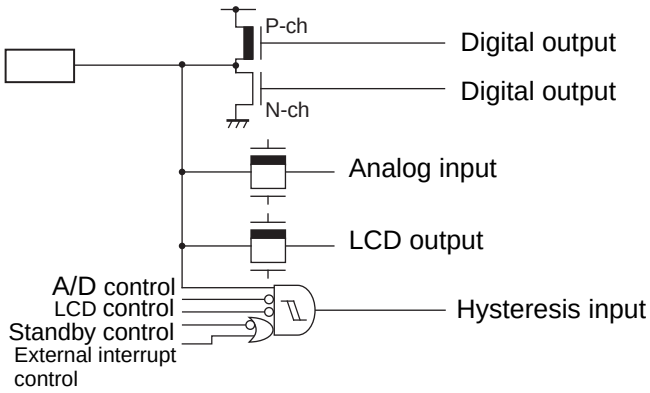
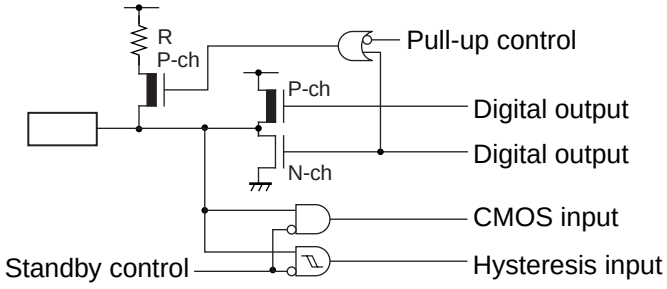
Pin no.	Pin name	I/O circuit type*	Function
51	P63/SEG19/ TO11	M	General-purpose I/O port. The pin is shared with LCDC SEG output (SEG19) and 8/16-bit compound timer ch.1 output (TO11) .
52	P64/SEG20/ EC1		General-purpose I/O port. The pin is shared with LCDC SEG output (SEG20) and 8/16-bit compound timer ch.1 clock input (EC1) .
53	P65/SEG21/ SCK		General-purpose I/O port. The pin is shared with LCDC SEG output (SEG21) and LIN-UART clock I/O (SCK) .
54	P66/SEG22/ SOT		General-purpose I/O port. The pin is shared with LCDC SEG output (SEG22) and LIN-UART data output (SOT) .
55	P67/SEG23/ SIN	N	General-purpose I/O port. The pin is shared with LCDC SEG output (SEG23) and LIN-UART data input (SIN) .
56	P07/INT07/ AN07/SEG24	F	General-purpose I/O port. The pins are shared with external interrupt input (INT00 to INT07) , A/D analog input (AN00 to AN07) and LCDC SEG output (SEG24 to SEG31) .
57	P06/INT06/ AN06/SEG25		
58	P05/INT05/ AN05/SEG26		
59	P04/INT04/ AN04/SEG27		
60	P03/INT03/ AN03/SEG28		
61	P02/INT02/ AN02/SEG29		
62	P01/INT01/ AN01/SEG30		
63	P00/INT00/ AN00/SEG31		
64	AV_{SS}	—	Power supply pin (GND) of A/D converter

* : For the I/O circuit type, refer to “■ I/O CIRCUIT TYPE”.

■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A		• Oscillation circuit • High-speed side Feedback resistance : approx. 1 MΩ • Low-speed side - Feedback resistance : approx. 24 MΩ (Evaluation product : approx. 10 MΩ) - Dumping resistance : approx.144 kΩ (Evaluation product : without dumping resistance)
B		• Only for input • Hysteresis input only for Mask ROM product • Pull-down resistor only for MODE pin of Mask ROM product
B'		Hysteresis input
F		• CMOS output • LCD output • Hysteresis input • Analog input
G		• CMOS output • CMOS input • Hysteresis input • With pull-up control

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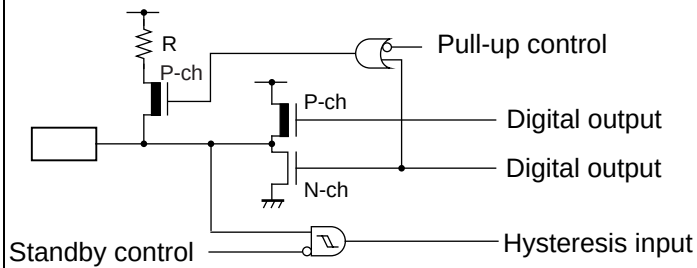
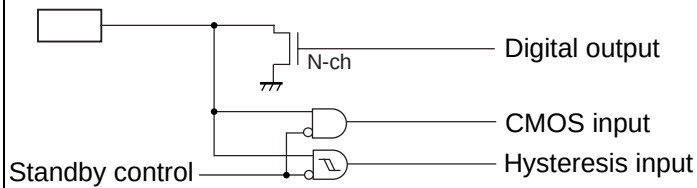
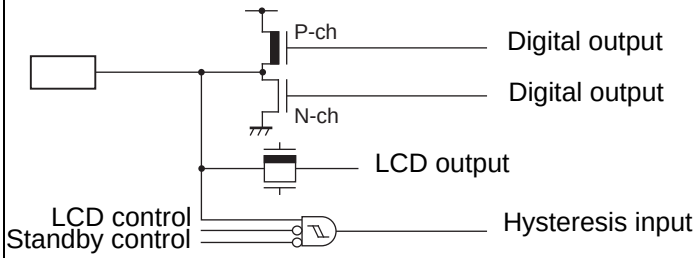
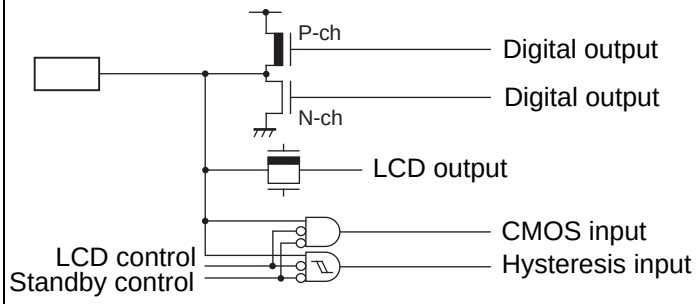
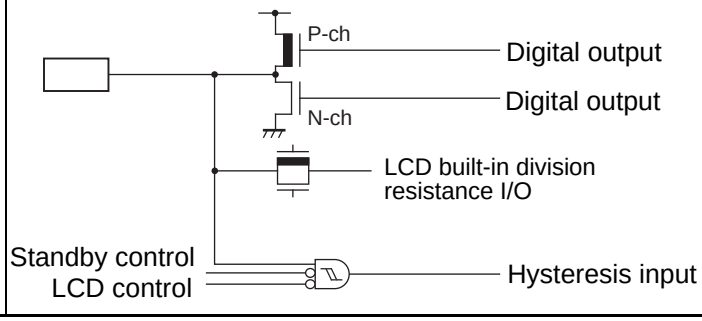
Type	Circuit	Remarks
H		• CMOS output • Hysteresis input • With pull-up control
I		• N-ch open drain output • CMOS input • Hysteresis input
M		• CMOS output • LCD output • Hysteresis input
N		• CMOS output • LCD output • CMOS input • Hysteresis input
R		• CMOS output • LCD power supply • Hysteresis input

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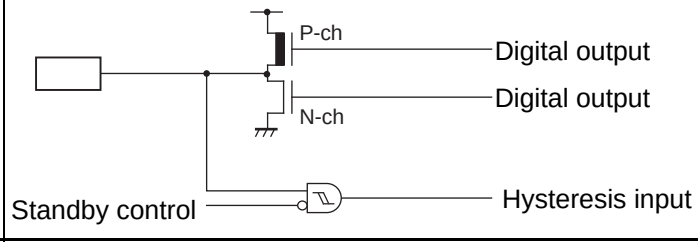
Type	Circuit	Remarks
S		• CMOS output • Hysteresis input

■ HANDLING DEVICES

• Preventing Latch-up

Care must be taken to ensure that maximum voltage ratings are not exceeded when they are used.
Latch-up 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} pin and V_{SS} pin.
When latch-up occurs, power supply current increases rapidly and might thermally damage elements.

• 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 (50/60 Hz) not to exceed 10% of the standard 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.

• 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 sub clock mode or stop mode.

• Serial Communication

There is a possibility to receive wrong data due to the noise or other causes on the serial communication.
Therefore, design a printed circuit board so as to avoid noise.
Retransmit the data if an error occurs because of applying the checksum to the last data in consideration of receiving wrong data due to the noise.

PIN CONNECTION

• Treatment of Unused Pin

Leaving unused input pins unconnected can cause abnormal operation or latch-up, leaving to permanent damage. Unused input pins should always be pulled up or down through resistance of at least 2 kΩ. Any unused input/output pins may be set to output mode and left open, or set to input mode and treated the same as unused input pins. If there is unused output pin, make it to open.

• Power Supply Pins

In products with multiple V_{CC} or V_{SS} pins, the pins of the same potential are internally connected in the device to avoid abnormal operations including latch-up. However, you must connect the pins to external power supply and a ground line to lower the electro-magnetic emission level, to prevent abnormal operation of strobe signals caused by the rise in the ground level, and to conform to the total output current rating.
Moreover, connect the current supply source with the V_{CC} and V_{SS} pins of this device at the low impedance.

It is also advisable to connect a ceramic bypass capacitor of approximately 0.1 µF between V_{CC} and V_{SS} pins near this device.

• Mode Pin (MOD)

Connect the MOD pin directly to V_{CC} or V_{SS}.

To prevent the device unintentionally entering test mode due to noise, lay out the printed circuit board so as to minimize the distance from the MOD pin to V_{CC} or V_{SS} and to provide a low-impedance connection.

- Analog Power Supply

  Always set the same potential to AV_{CC} and V_{CC} pins. When $V_{CC} > AV_{CC}$, the current may flow through the AN00 to AN07 pins.

- Treatment of Power Supply Pins on A/D Converter

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

  Noise riding on the AV_{CC} pin may cause accuracy degradation. So, connect approx. 0.1 μF ceramic capacitor as a bypass capacitor between AV_{CC} and AV_{SS} pins in the vicinity of this device.

■ PROGRAMMING FLASH MEMORY MICROCONTROLLERS USING PARALLEL PROGRAMMER

- **Supported Parallel Programmers and Adapters**

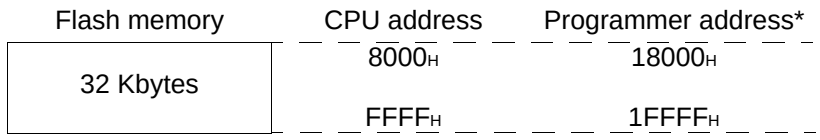
The following table lists supported parallel programmers and adapters.

Package	Applicable adapter model	Parallel programmers
FPT-64P-M23	TEF110-95F168HPMC	AF9708 (Ver 02.35G or more) AF9709/B (Ver 02.35G or more) AF9723+AF9834 (Ver 02.08E or more)
FPT-64P-M24	TEF110-95F168HPMC1	

Note : For information on applicable adapter models and parallel programmers, contact the following:
Flash Support Group, Inc. TEL: +81-53-428-8380

- **Sector Configuration**

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

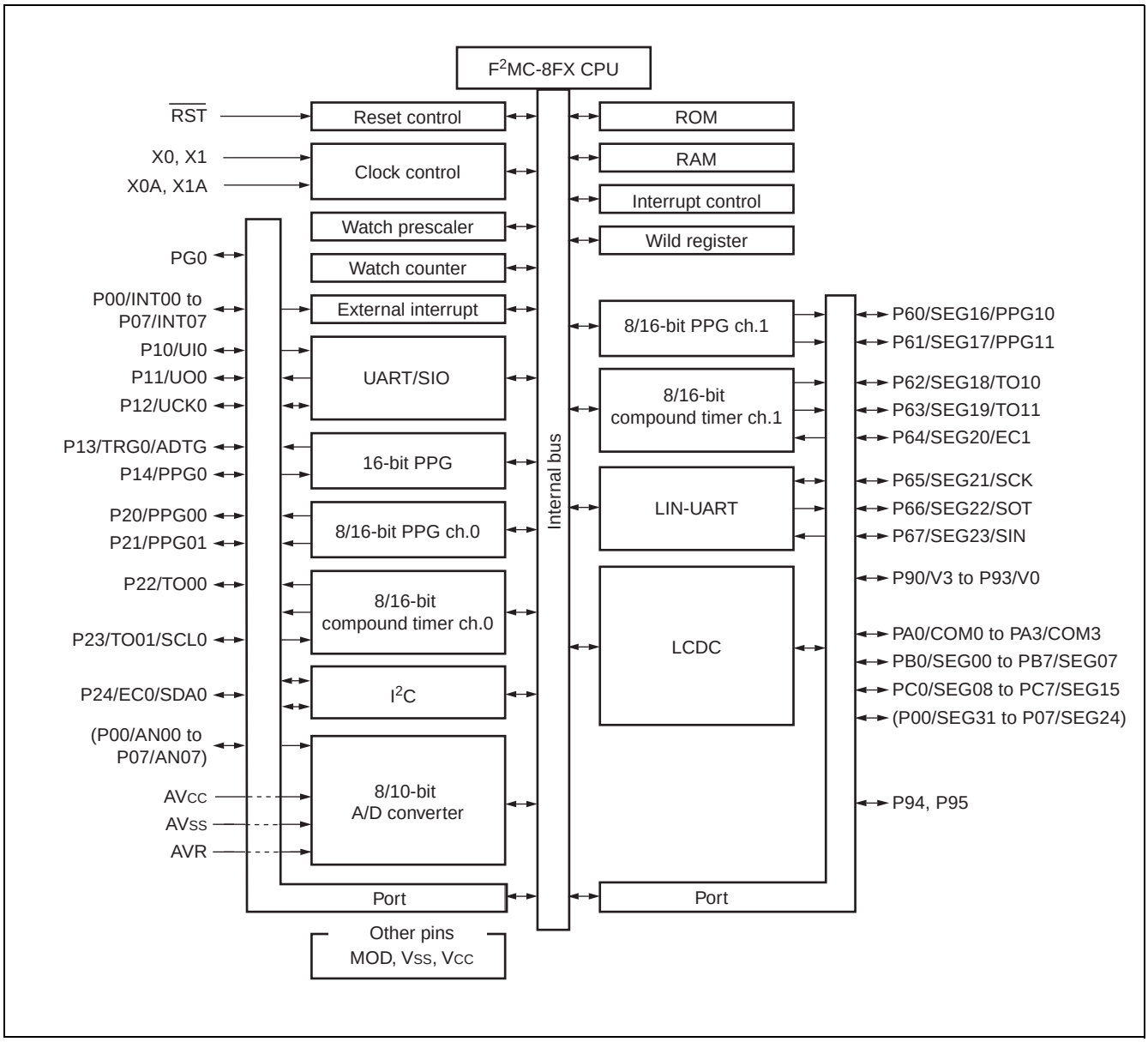


*: Programmer addresses are corresponding to CPU addresses, used when the parallel programmer programs data into Flash memory.
These programmer addresses are used for the parallel programmer to program or erase data in Flash memory.

- **Programming Method**

1) Set the type code of the parallel programmer to “17222”.
2) Load program data to programmer addresses 18000_H to $1FFFF_H$.
3) Programmed by parallel programmer

■ BLOCK DIAGRAM

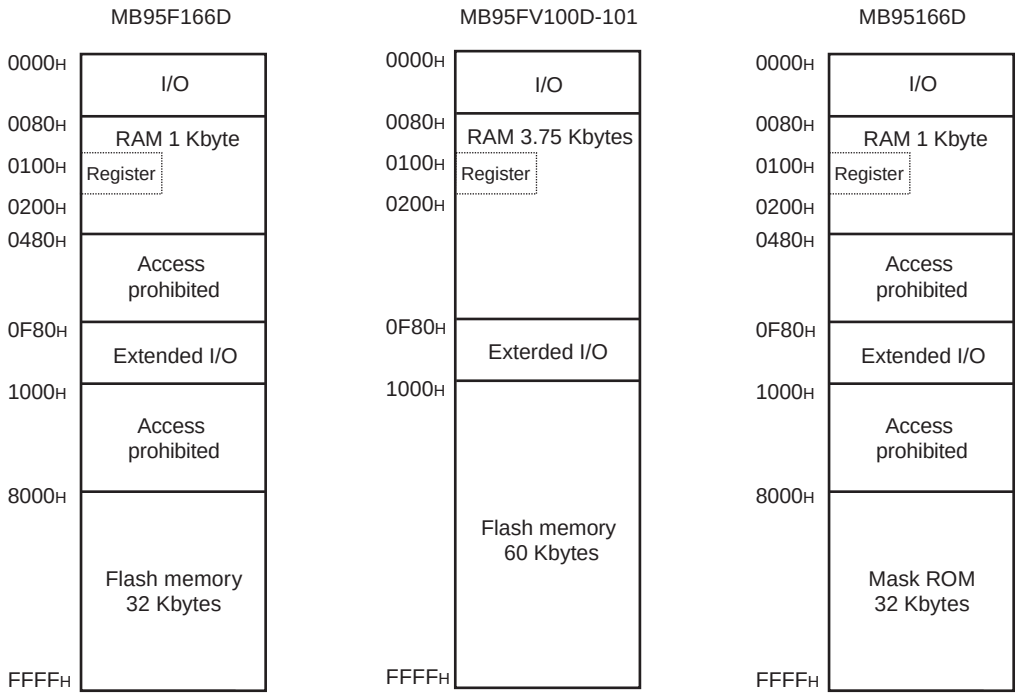


■ CPU CORE

1. Memory space

Memory space of the MB95160 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.

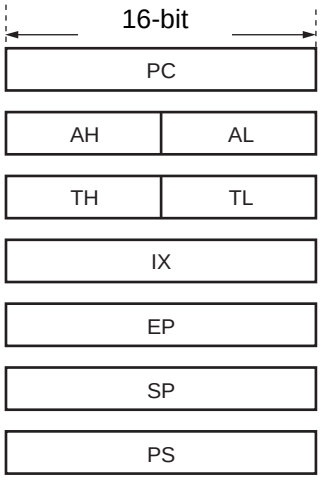
- Memory Map



2. Register

The MB95160 series has two types of registers; dedicated registers in the CPU and general-purpose registers in the memory. The dedicated registers are as follows:

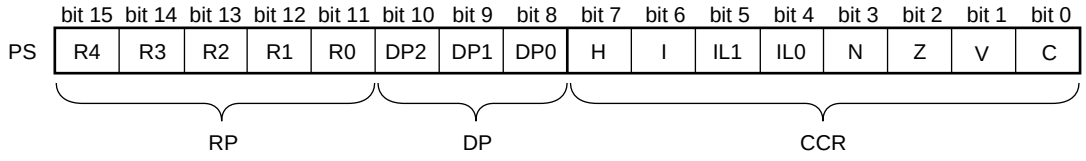
Program counter (PC)	:	A 16-bit register to indicate locations where instructions are stored.
Accumulator (A)	:	A 16-bit register for temporary storage of arithmetic operations. In the case of an 8-bit data processing instruction, the lower 1 byte is used.
Temporary accumulator (T)	:	A 16-bit register which performs arithmetic operations with the accumulator. In the case of an 8-bit data processing instruction, the lower 1 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.



	Initial Value
: Program counter	$FFFD_H$
: Accumulator	0000_H
: Temporary accumulator	0000_H
: Index register	0000_H
: Extra pointer	0000_H
: Stack pointer	0000_H
: Program status	0030_H

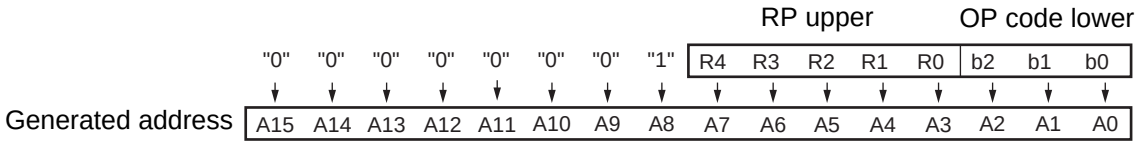
The PS can further be divided into higher 8 bits for use as a register bank pointer (RP) and a direct bank pointer (DP) and the lower 8 bits for use as a condition code register (CCR) .

- Structure of the Program Status



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



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
XXX_B (no effect to mapping)	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 these bits.

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.

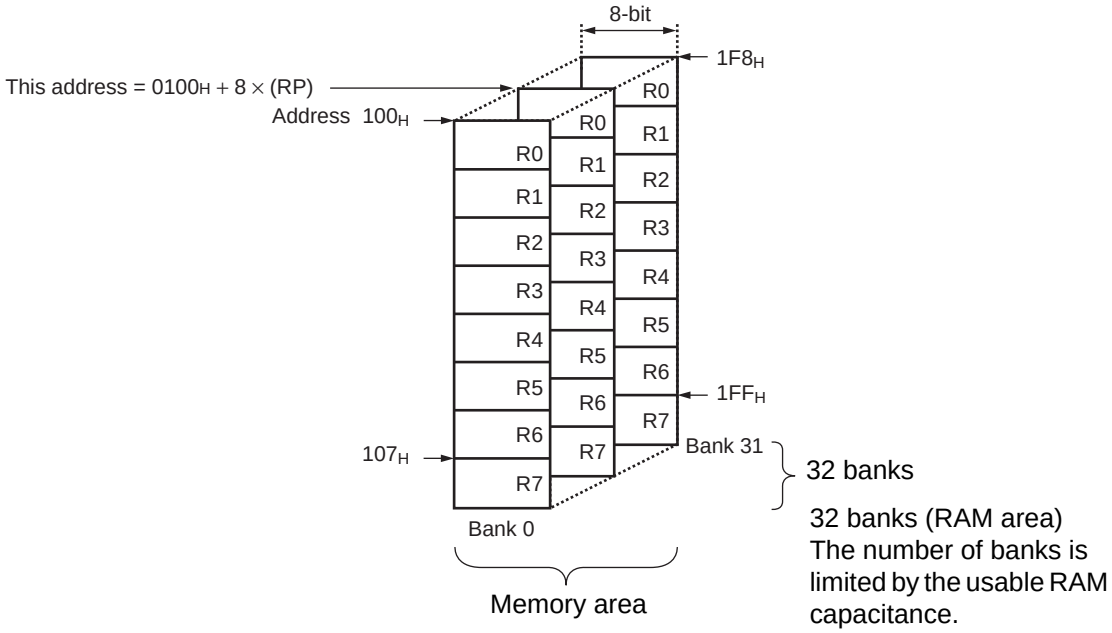
C flag : Set to “1” when a carry or a borrow from bit 7 occurs as a result of an arithmetic operation. Cleared to “0” otherwise. Set to the shift-out value in the case of a shift instruction.

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. 1-bank contains 8-register. Up to a total of 32 banks can be used on the MB95160 series. The bank currently in use is specified by the register bank pointer (RP), and the lower 3 bits of OP code indicates the general-purpose register 0 (R0) to general-purpose register 7 (R7).

- Register Bank Configuration



■ I/O MAP

Address	Register abbreviation	Register name	R/W	Initial value
0000H	PDR0	Port 0 data register	R/W	00000000B
0001H	DDR0	Port 0 direction register	R/W	00000000B
0002H	PDR1	Port 1 data register	R/W	00000000B
0003H	DDR1	Port 1 direction register	R/W	00000000B
0004H	—	(Disabled)	—	—
0005H	WATR	Oscillation stabilization wait time setting register	R/W	11111111B
0006H	PLLC	PLL control register	R/W	00000000B
0007H	SYCC	System clock control register	R/W	1010X011B
0008H	STBC	Standby control register	R/W	00000000B
0009H	RSRR	Reset factor register	R/W	XXXXXXXXB
000AH	TBTC	Timebase timer control register	R/W	00000000B
000BH	WPCR	Watch prescaler control register	R/W	00000000B
000CH	WDTC	Watchdog timer control register	R/W	00000000B
000DH	—	(Disabled)	—	—
000EH	PDR2	Port 2 data register	R/W	00000000B
000FH	DDR2	Port 2 direction register	R/W	00000000B
0010H to 0015H	—	(Disabled)	—	—
0016H	PDR6	Port 6 data register	R/W	00000000B
0017H	DDR6	Port 6 direction register	R/W	00000000B
0018H to 001BH	—	(Disabled)	—	—
001CH	PDR9	Port 9 data register	R/W	00000000B
001DH	DDR9	Port 9 direction register	R/W	00000000B
001EH	PDRA	Port A data register	R/W	00000000B
001FH	DDRA	Port A direction register	R/W	00000000B
0020H	PDRB	Port B data register	R/W	00000000B
0021H	DDRB	Port B direction register	R/W	00000000B
0022H	PDRC	Port C data register	R/W	00000000B
0023H	DDRC	Port C direction register	R/W	00000000B
0024H to 0029H	—	(Disabled)	—	—

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
002A$_H$	PDRG	Port G data register	R/W	00000000$_B$
002B$_H$	DDRG	Port G direction register	R/W	00000000$_B$
002C$_H$	—	(Disabled)	—	—
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$_H$ to 0034$_H$	—	(Disabled)	—	—
0035$_H$	PULG	Port G pull-up control register	R/W	00000000$_B$
0036$_H$	T01CR1	8/16-bit compound timer 01 control status register 1 ch.0	R/W	00000000$_B$
0037$_H$	T00CR1	8/16-bit compound timer 00 control status register 1 ch.0	R/W	00000000$_B$
0038$_H$	T11CR1	8/16-bit compound timer 11 control status register 1 ch.1	R/W	00000000$_B$
0039$_H$	T10CR1	8/16-bit compound timer 10 control status register 1 ch.1	R/W	00000000$_B$
003A$_H$	PC01	8/16-bit PPG1 control register ch.0	R/W	00000000$_B$
003B$_H$	PC00	8/16-bit PPG0 control register ch.0	R/W	00000000$_B$
003C$_H$	PC11	8/16-bit PPG1 control register ch.1	R/W	00000000$_B$
003D$_H$	PC10	8/16-bit PPG0 control register ch.1	R/W	00000000$_B$
003E$_H$ to 0041$_H$	—	(Disabled)	—	—
0042$_H$	PCNTH0	16-bit PPG status control register (upper byte) ch.0	R/W	00000000$_B$
0043$_H$	PCNTL0	16-bit PPG status control register (lower byte) ch.0	R/W	00000000$_B$
0044$_H$ to 0047$_H$	—	(Disabled)	—	—
0048$_H$	EIC00	External interrupt circuit control register ch.0/ch.1	R/W	00000000$_B$
0049$_H$	EIC10	External interrupt circuit control register ch.2/ch.3	R/W	00000000$_B$
004A$_H$	EIC20	External interrupt circuit control register ch.4/ch.5	R/W	00000000$_B$
004B$_H$	EIC30	External interrupt circuit control register ch.6/ch.7	R/W	00000000$_B$
004C$_H$ to 004F$_H$	—	(Disabled)	—	—
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$_B$

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
0055H	ECCR	LIN-UART extended communication control register	R/W	000000XXB
0056H	SMC10	UART/SIO serial mode control register 1 ch.0	R/W	00000000B
0057H	SMC20	UART/SIO serial mode control register 2 ch.0	R/W	00100000B
0058H	SSR0	UART/SIO serial status register ch.0	R/W	00000001B
0059H	TDR0	UART/SIO serial output data register ch. 0	R/W	00000000B
005AH	RDR0	UART/SIO serial input data register ch.0	R	00000000B
005BH to 005FH	—	(Disabled)	—	—
0060H	IBCR00	I²C bus control register 0 ch.0	R/W	00000000B
0061H	IBCR10	I²C bus control register 1 ch.0	R/W	00000000B
0062H	IBSR0	I²C bus status register ch.0	R	00000000B
0063H	IDDR0	I²C data register ch.0	R/W	00000000B
0064H	IAAR0	I²C address register ch.0	R/W	00000000B
0065H	ICCR0	I²C clock control register ch.0	R/W	00000000B
0066H to 006BH	—	(Disabled)	—	—
006CH	ADC1	8/10-bit A/D converter control register 1	R/W	00000000B
006DH	ADC2	8/10-bit A/D converter control register 2	R/W	00000000B
006EH	ADDH	8/10-bit A/D converter data register (upper byte)	R/W	00000000B
006FH	ADDL	8/10-bit A/D converter data register (lower byte)	R/W	00000000B
0070H	WCSR	Watch counter status register	R/W	00000000B
0071H	—	(Disabled)	—	—
0072H	FSR*	Flash memory status register	R/W	000X0000B
0073H	—	(Disabled)	—	—
0074H	—	(Disabled)	—	—
0075H	—	(Disabled)	—	—
0076H	WREN	Wild register address compare enable register	R/W	00000000B
0077H	WROR	Wild register data test setting register	R/W	00000000B
0078H	—	Register bank pointer (RP) , Mirror of direct bank pointer (DP)	—	—
0079H	ILR0	Interrupt level setting register 0	R/W	11111111B
007AH	ILR1	Interrupt level setting register 1	R/W	11111111B
007BH	ILR2	Interrupt level setting register 2	R/W	11111111B
007CH	ILR3	Interrupt level setting register 3	R/W	11111111B

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
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$_H$	—	(Disabled)	—	—
0F80$_H$	WRARH0	Wild register address setting register (upper byte) ch.0	R/W	00000000$_B$
0F81$_H$	WRARL0	Wild register address setting register (lower byte) ch.0	R/W	00000000$_B$
0F82$_H$	WRDR0	Wild register data setting register ch.0	R/W	00000000$_B$
0F83$_H$	WRARH1	Wild register address setting register (upper byte) ch.1	R/W	00000000$_B$
0F84$_H$	WRARL1	Wild register address setting register (lower byte) ch.1	R/W	00000000$_B$
0F85$_H$	WRDR1	Wild register data setting register ch.1	R/W	00000000$_B$
0F86$_H$	WRARH2	Wild register address setting register (upper byte) ch.2	R/W	00000000$_B$
0F87$_H$	WRARL2	Wild register address setting register (lower byte) ch.2	R/W	00000000$_B$
0F88$_H$	WRDR2	Wild register data setting register ch.2	R/W	00000000$_B$
0F89$_H$ to 0F91$_H$	—	(Disabled)	—	—
0F92$_H$	T01CR0	8/16-bit compound timer 01 control status register 0 ch.0	R/W	00000000$_B$
0F93$_H$	T00CR0	8/16-bit compound timer 00 control status register 0 ch.0	R/W	00000000$_B$
0F94$_H$	T01DR	8/16-bit compound timer 01 data register ch.0	R/W	00000000$_B$
0F95$_H$	T00DR	8/16-bit compound timer 00 data register ch.0	R/W	00000000$_B$
0F96$_H$	TMCR0	8/16-bit compound timer 00/01 timer mode control register ch.0	R/W	00000000$_B$
0F97$_H$	T11CR0	8/16-bit compound timer 11 control status register 0 ch.1	R/W	00000000$_B$
0F98$_H$	T10CR0	8/16-bit compound timer 10 control status register 0 ch.1	R/W	00000000$_B$
0F99$_H$	T11DR	8/16-bit compound timer 11 data register ch.1	R/W	00000000$_B$
0F9A$_H$	T10DR	8/16-bit compound timer 10 data register ch.1	R/W	00000000$_B$
0F9B$_H$	TMCR1	8/16-bit compound timer 10/11 timer mode control register ch.1	R/W	00000000$_B$
0F9C$_H$	PPS01	8/16-bit PPG1 cycle setting buffer register ch.0	R/W	11111111$_B$
0F9D$_H$	PPS00	8/16-bit PPG0 cycle setting buffer register ch.0	R/W	11111111$_B$
0F9E$_H$	PDS01	8/16-bit PPG1 duty setting buffer register ch.0	R/W	11111111$_B$
0F9F$_H$	PDS00	8/16-bit PPG0 duty setting buffer register ch.0	R/W	11111111$_B$
0FA0$_H$	PPS11	8/16-bit PPG1 cycle setting buffer register ch.1	R/W	11111111$_B$
0FA1$_H$	PPS10	8/16-bit PPG0 cycle setting buffer register ch.1	R/W	11111111$_B$
0FA2$_H$	PDS11	8/16-bit PPG1 duty setting buffer register ch.1	R/W	11111111$_B$
0FA3$_H$	PDS10	8/16-bit PPG0 duty setting buffer register ch.1	R/W	11111111$_B$
0FA4$_H$	PPGS	8/16-bit PPG start register	R/W	00000000$_B$

(Continued)

Address	Register abbreviation	Register name	R/W	Initial value
0FA5H	REVC	8/16-bit PPG output inversion register	R/W	00000000B
0FA6H to 0FA9H	—	(Disabled)	—	—
0FAAH	PDCRH0	16-bit PPG down counter register (upper byte) ch.0	R	00000000B
0FABH	PDCRL0	16-bit PPG down counter register (lower byte) ch.0	R	00000000B
0FACH	PCSRH0	16-bit PPG cycle setting buffer register (upper byte) ch.0	R/W	11111111B
0FADH	PCSRL0	16-bit PPG cycle setting buffer register (lower byte) ch.0	R/W	11111111B
0FAEH	PDUTH0	16-bit PPG duty setting buffer register (upper byte) ch.0	R/W	11111111B
0FAFH	PDUTL0	16-bit PPG duty setting buffer register (lower byte) ch.0	R/W	11111111B
0FB0H to 0FBBH	—	(Disabled)	—	—
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 dedicated baud rate generator prescaler selecting register ch.0	R/W	00000000B
0FBFH	BRSR0	UART/SIO dedicated baud rate generator setting register ch.0	R/W	00000000B
0FC0H to 0FC2H	—	(Disabled)	—	—
0FC3H	AIDRL	A/D input disable register (lower byte)	R/W	00000000B
0FC4H	LCDCC	LCDC control register	R/W	00010000B
0FC5H	LCDCE1	LCDC enable register 1	R/W	00110000B
0FC6H	LCDCE2	LCDC enable register 2	R/W	00000000B
0FC7H	LCDCE3	LCDC enable register 3	R/W	00000000B
0FC8H	LCDCE4	LCDC enable register 4	R/W	00000000B
0FC9H	LCDCE5	LCDC enable register 5	R/W	00000000B
0FCAH	—	(Disabled)	—	—
0FCBH	LCDCB1	LCDC blinking setting register 1	R/W	00000000B
0FCCH	LCDCB2	LCDC blinking setting register 2	R/W	00000000B
0FCDH to 0FDCH	LCDRAM	LCDC display RAM	R/W	00000000B
0FDDH to 0FE2H	—	(Disabled)	—	—
0FE3H	WCDR	Watch counter data register	R/W	00111111B

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Address	Register abbreviation	Register name	R/W	Initial value
0FE4H to 0FEDH	—	(Disabled)	—	—
0FEEH	ILSR	Input level selecting register	R/W	00000000B
0FEFH	WICR	Interrupt pin control register	R/W	01000000B
0FF0H to 0FFFH	—	(Disabled)	—	—

- R/W access symbols
  - R/W : Readable/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.

Note : Do not write to the “ (Disabled) ”. Reading the “ (Disabled) ” returns an undefined value.

* : Only for Flash product

■ 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 ch.0	IRQ0	FFFA$_H$	FFFB$_H$	L00 [1 : 0]	High
External interrupt ch.4					
External interrupt ch.1	IRQ1	FFF8$_H$	FFF9$_H$	L01 [1 : 0]	
External interrupt ch.5					
External interrupt ch.2	IRQ2	FFF6$_H$	FFF7$_H$	L02 [1 : 0]	
External interrupt ch.6					
External interrupt ch.3	IRQ3	FFF4$_H$	FFF5$_H$	L03 [1 : 0]	
External interrupt ch.7					
UART/SIO ch.0	IRQ4	FFF2$_H$	FFF3$_H$	L04 [1 : 0]	
8/16-bit compound timer ch.0 (Lower)	IRQ5	FFF0$_H$	FFF1$_H$	L05 [1 : 0]	
8/16-bit compound timer ch.0 (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 ch.1 (Lower)	IRQ9	FFE8$_H$	FFE9$_H$	L09 [1 : 0]	
8/16-bit PPG ch.1 (Upper)	IRQ10	FFE6$_H$	FFE7$_H$	L10 [1 : 0]	
(Unused)	IRQ11	FFE4$_H$	FFE5$_H$	L11 [1 : 0]	
8/16-bit PPG ch.0 (Upper)	IRQ12	FFE2$_H$	FFE3$_H$	L12 [1 : 0]	
8/16-bit PPG ch.0 (Lower)	IRQ13	FFE0$_H$	FFE1$_H$	L13 [1 : 0]	
8/16-bit compound timer ch.1 (Upper)	IRQ14	FFDE$_H$	FFDF$_H$	L14 [1 : 0]	
16-bit PPG ch.0	IRQ15	FFDC$_H$	FFDD$_H$	L15 [1 : 0]	
I^2C ch.0	IRQ16	FFDA$_H$	FFDB$_H$	L16 [1 : 0]	
(Unused)	IRQ17	FFD8$_H$	FFD9$_H$	L17 [1 : 0]	
8/10-bit A/D converter	IRQ18	FFD6$_H$	FFD7$_H$	L18 [1 : 0]	
Timebase timer	IRQ19	FFD4$_H$	FFD5$_H$	L19 [1 : 0]	
Watch prescaler/Watch counter	IRQ20	FFD2$_H$	FFD3$_H$	L20 [1 : 0]	
(Unused)	IRQ21	FFD0$_H$	FFD1$_H$	L21 [1 : 0]	
8/16-bit compound timer ch.1 (Lower)	IRQ22	FFCE$_H$	FFCF$_H$	L22 [1 : 0]	
Flash memory	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	V_{CC}, AV_{CC}	Vss – 0.3	Vss + 4.0	V	*2
	AVR	Vss – 0.3	Vss + 4.0		*2
Power supply voltage for LCD	V0 to V3	V_{SS} – 0.3	V_{SS} + 4.0	V	*3
Input voltage*1	V_I	Vss – 0.3	Vss + 6.0	V	P23, P24*4
		Vss – 0.3	Vss + 4.0	V	Other than P23, P24*4
Output voltage*1	V_O	Vss – 0.3	Vss + 4.0	V	*4
Maximum clamp current	I_{CLAMP}	– 2.0	+ 2.0	mA	Applicable to pins*5
Total maximum clamp current	$\Sigma\lvert I_{CLAMP}\rvert$	—	20	mA	Applicable to pins*5
“L” level maximum output current	I_{OL}	—	15	mA	Applicable to pins*5
“L” level average current	I_{OLAV}	—	4	mA	Applicable to pins*5 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_{OH}	—	– 15	mA	Applicable to pins*5
“H” level average current	I_{OHAV}	—	– 4	mA	Applicable to pins*5 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	
Storage temperature	Tstg	– 55	+ 150	°C	

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

*2 : Apply equal potential to AV_{CC} and V_{CC}. AVR should not exceed AV_{CC} + 0.3 V.

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*3 : V0 to V3 should not exceed V_{CC} + 0.3 V.

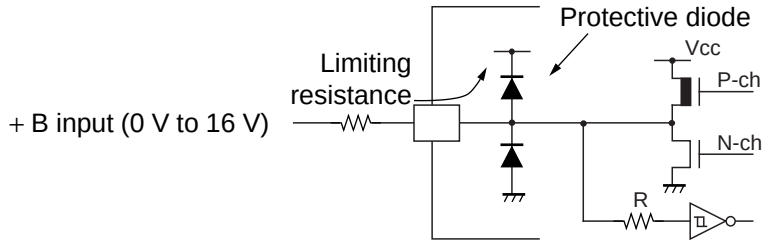
*4 : V_I and Vo should not exceed V_{CC} + 0.3 V. V_I must not exceed the rating voltage. However, if the maximum current to/from an input is limited by some means with external components, the I_{CLAMP} rating supersedes the V_I rating.

*5 : Applicable to pins :

P00 to P07, P10 to P14, P20 to P22,P60 to P67, P90 to P95, PA0 to PA3, PB0 to PB7, PC0 to PC7

- Use within recommended operating conditions.
- Use at DC voltage (current).
- +B signal is an input signal that exceeds V_{CC} voltage. 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 V_{CC} pin, and this affects 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.
- Note that analog system input/output pins other than the A/D input pins (LCD drive 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

(Vss = 0.0 V)

Parameter	Symbol	Conditions	Value			Unit	Remarks
			Min	Typ	Max		
Power supply voltage	V_{CC}, AV_{CC}	—	1.8*	—	3.3	V	At normal operating, T_A = − 10 °C to + 85 °C
			2.0*	—	3.3		At normal operating, T_A = − 40 °C to + 85 °C
			2.6	—	3.6		MB95FV100D-101, T_A = + 5 °C to + 35 °C
			1.5	—	3.3		Retain status of stop mode operation
Power supply voltage for LCD	V0 to V3		V_{SS}	—	V_{CC}	V	The optimal value depends on liquid crystal display elements used.
A/D converter reference input voltage	AVR		1.8	—	AV_{CC}	V	
Operating temperature	T_A		− 40	—	+ 85	°C	

* : The values vary with the operating frequency, machine clock or analog guarantee range.

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

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

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

3. DC Characteristics

(V_{CC} = 3.3 V, V_{SS} = 0.0 V, T_A = – 40 °C to + 85 °C)

Parameter	Sym-bol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
"H" level input voltage	V_{IH1}	P10, P67	—	0.7 V_{CC}	—	V_{CC} + 0.3	V	When selecting CMOS input level
	V_{IH2}	P23, P24	—	0.7 V_{CC}	—	V_{SS} + 6.0	V	
	V_{IHS1}	P00 to P07, P10 to P14, P20 to P22, P60 to P67, P90 to P95, PA0 to PA3, PB0 to PB7, PC0 to PC7	—	0.8 V_{CC}	—	V_{CC} + 0.3	V	Hysteresis input
	V_{IHS2}	P23, P24	—	0.8 V_{CC}	—	V_{SS} + 5.5	V	
	V_{IHM}	$\overline{RST}$, MOD	—	0.7 V_{CC}	—	V_{CC} + 0.3	V	CMOS input (Flash Memory product)
				0.8 V_{CC}	—	V_{CC} + 0.3	V	Hysteresis input (Mask ROM product)
"L" level input voltage	V_{IL}	P10,P23, P24,P67	—	V_{SS} – 0.3	—	0.3 V_{CC}	V	When selecting CMOS input level
	V_{ILS}	P00 to P07, P10 to P14, P20 to P24, P60 to P67, P90 to P95, PA0 to PA3, PB0 to PB7, PC0 to PC7	—	V_{SS} – 0.3	—	0.2 V_{CC}	V	Hysteresis input
	V_{ILM}	$\overline{RST}$, MOD	—	V_{SS} – 0.3	—	0.2 V_{CC}	V	Hysteresis input (Mask ROM product)
				V_{SS} – 0.3	—	0.3 V_{CC}	V	CMOS input (Flash Memory product)
"H" level output voltage	V_{OH}	Output pins other than P23, P24	I_{OH} = 4.0 mA	2.4	—	—	V	
"L" level output voltage	V_{OL}	Output pins other than $\overline{RST}$	I_{OL} = 4.0 mA	—	—	0.4	V	
Input leakage current (Hi-Z output leakage current)	I_{LI}	Ports other than P23, P24	0.0 V < V_I < V_{CC}	– 5	—	+ 5	µA	When the pull-up prohibition setting

(Continued)

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

Parameter	Symbol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Open-drain output leakage current	I_{LIOD}	P23, P24	0.0 V < V_I < V_{SS} + 5.5 V	—	—	5	µA	
Pull-up resistor	R_{PULL}	P10 to P14, P20 to P22	V_I = 0.0 V	25	50	100	kΩ	When the pull-up permission setting
Pull-down resistor	R_{MOD}	MOD	V_I = Vcc	25	50	100	kΩ	Mask ROM product
Input capacitance	C_{IN}	Other than AV_{CC}, AV_{SS}, AVR, V_{CC}, V_{SS}	f = 1 MHz	—	5	15	pF	
Power supply current*	I_{CC}	V_{CC} (External clock operation)	F_{CH} = 20 MHz F_{MP} = 10 MHz Main clock mode (divided by 2)	—	11.0	14.0	mA	MB95F166D At other than Flash memory writing and erasing
				—	30.0	35.0	mA	MB95F166D At Flash memory writing and erasing
				—	7.3	10.0	mA	MB95166D
			F_{CH} = 32 MHz F_{MP} = 16 MHz Main clock mode (divided by 2)	—	17.6	22.4	mA	MB95F166D At other than Flash memory writing and erasing
				—	38.1	44.9	mA	MB95F166D At Flash memory writing and erasing
				—	11.7	16.0	mA	MB95166D
	I_{CCS}		F_{CH} = 20 MHz F_{MP} = 10 MHz Main Sleep mode (divided by 2)	—	4.5	6.0	mA	
			F_{CH} = 32 MHz F_{MP} = 16 MHz Main Sleep mode (divided by 2)	—	7.2	9.6	mA	
	I_{CCL}		F_{CL} = 32 kHz F_{MPL} = 16 kHz Sub clock mode (divided by 2)	—	25	35	µA	
	I_{CCLS}		F_{CL} = 32 kHz F_{MPL} = 16 kHz Sub sleep mode (divided by 2)	—	7	15	µA	

(Continued)

(Continued)

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

Parameter	Sym-bol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current*	I_{CCT}	V_{CC} (External clock operation)	F_{CL} = 32 kHz Watch mode Main stop mode T_A = + 25 °C	—	2	10	µA	Flash memory product
				—	1	5	µA	MASK ROM product
	I_{CCMPLL}		F_{CH} = 4 MHz F_{MP} = 10 MHz Main PLL mode (multiplied by 2.5)	—	10	14	mA	Flash memory product
				—	6.7	10	mA	MASK ROM product
			F_{CH} = 6.4 MHz F_{MP} = 16 MHz Main PLL mode (multiplied by 2.5)	—	16.0	22.4	mA	Flash memory product
				—	10.8	16.0	mA	MASK ROM product
	I_{CCSPLL}		F_{CL} = 32 kHz F_{MPL} = 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}		Sub stop mode T_A = + 25 °C	—	1	5	µA	
	I_A	AV_{CC}	F_{CH} = 16 MHz At operating of A/D conversion	—	1.3	2.2	mA	
	I_{AH}		F_{CH} = 16 MHz At stopping of A/D conversion T_A = + 25 °C	—	1	5	µA	
LCD internal division resistance	R_{LCD}	—	Between V3 and V_{SS}	—	300	—	kΩ	
COM0 to COM3 output impedance	R_{VCOM}	COM0 to COM3	V1 to V3 = 5.0 V	—	—	5	kΩ	
SEG00 to SEG31 output impedance	R_{VSEG}	SEG00 to SEG31		—	—	7	kΩ	
LCD leak current	I_{LCDL}	V0 to V3, COM0 to COM3 SEG00 to SEG31	—	− 1	—	+ 1	µA	

* :
- 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 F_{MP} and F_{MPL}.

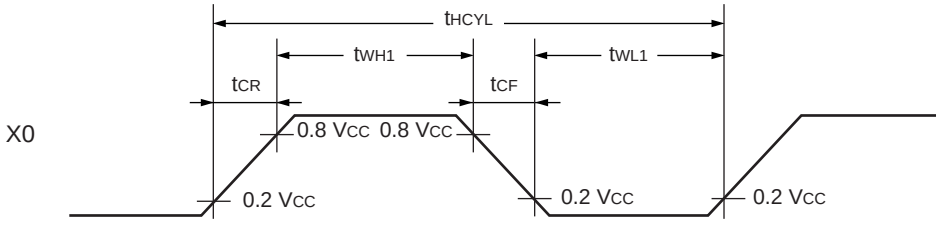
4. AC Characteristics

(1) Clock Timing

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

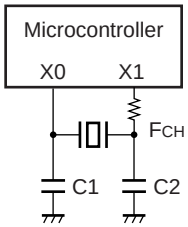
Parameter	Symbol	Pin name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Clock frequency	F_{CH}	X0, X1	—	1.00	—	16.25	MHz	When using main oscillation circuit
				1.00	—	32.50	MHz	When using external clock
				3.00	—	10.00	MHz	Main PLL multiplied by 1
				3.00	—	8.13	MHz	Main PLL multiplied by 2
				3.00	—	6.50	MHz	Main PLL multiplied by 2.5
				3.00	—	4.06	MHz	Main PLL multiplied by 4
	F_{CL}	X0A, X1A		—	32.768	—	kHz	When using sub oscillation circuit
				—	32.768	—	kHz	When using sub PLL
Clock cycle time	t_{HCYL}	X0, X1		61.5	—	1000	ns	When using oscillation circuit
				30.8	—	1000	ns	When using external clock
	t_{LCYL}	X0A, X1A		—	30.5	—	µs	When using sub clock, When using external clock
Input clock pulse width	t_{WH1} t_{WL1}	X0		61.5	—	—	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

- Input wave form at external clock use (main clock)

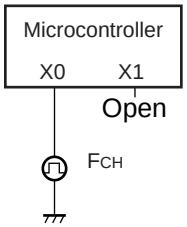


- Figure of Main Clock Input Port External Connection

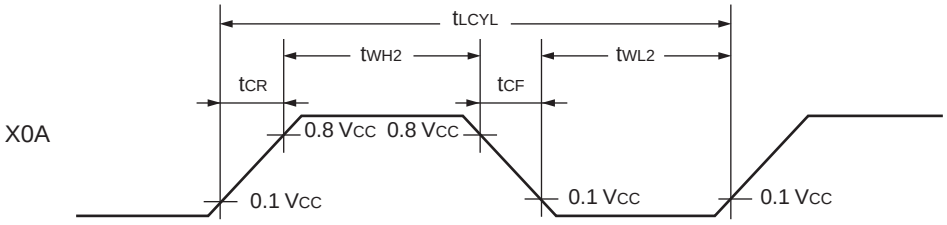
When using a crystal or ceramic oscillator



When using external clock

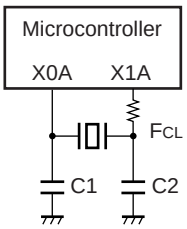


- Input wave form at external clock use (sub clock)

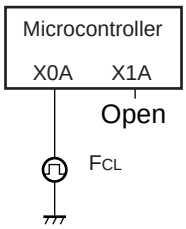


- Figure of Sub clock Input Port External Connection

When using a crystal or ceramic oscillator



When using external clock



(2) Source Clock/Machine Clock

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

Parameter	Symbol	Conditions	Value			Unit	Remarks
			Min	Typ	Max		
Source clock cycle time*1 (Clock before setting division)	t_{SCLK}	—	61.5	—	2000	ns	When using main clock Min : F_{CH} = 8.125 MHz, PLL multiplied by 2 Max : F_{CH} = 1 MHz, divided by 2
			7.6	—	61.0	µs	When using sub clock Min : F_{CL} = 32 kHz, PLL multiplied by 4 Max : F_{CL} = 32 kHz, divided by 2
Source clock frequency	F_{SP}		0.50	—	16.25	MHz	When using main clock
	F_{SPL}		16.384	—	131.072	kHz	When using sub clock
Machine clock cycle time*2 (Minimum instruction execution time)	t_{MCLK}		61.5	—	32000	ns	When using main clock Min : F_{SP} = 16.25 MHz, no division Max : F_{SP} = 0.5 MHz, divided by 16
			7.6	—	976.5	µs	When using sub clock Min : F_{SPL} = 131 kHz, no division Max : F_{SPL} = 16 kHz, divided by 16
Machine clock frequency	F_{MP}		0.031	—	16.250	MHz	When using main clock
	F_{MPL}		1.024	—	131.072	kHz	When using sub clock

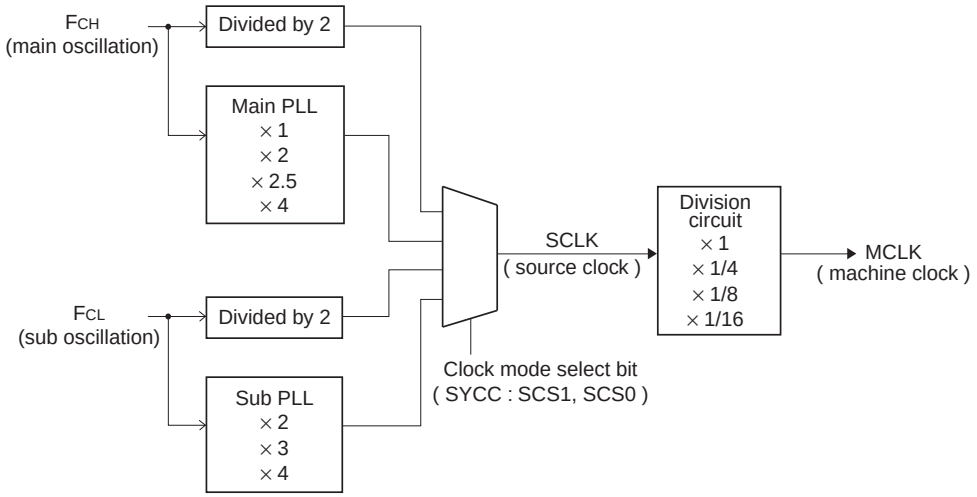
*1 : Clock before setting division due to machine clock division ratio selection bit (SYCC : DIV1 and DIV0) . This source clock is divided by the machine clock division ratio selection bit (SYCC : DIV1 and DIV0) , and it becomes the machine clock. Further, the source clock can be selected as follows.

- Main clock divided by 2
- PLL multiplication of main clock (select from 1, 2, 2.5, 4 multiplication)
- Sub clock divided by 2
- PLL multiplication of sub clock (select from 2, 3, 4 multiplication)

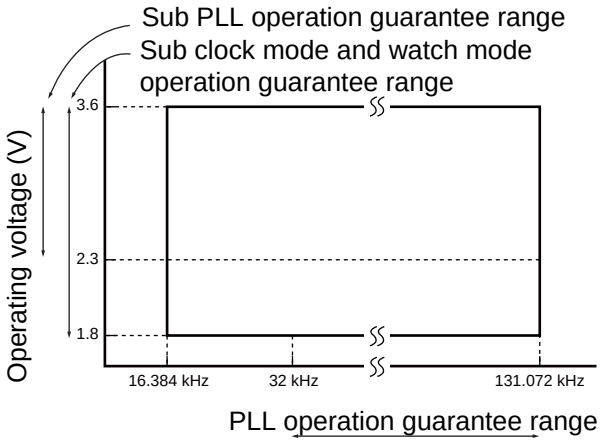
*2 : Operation clock of the microcontroller. Machine clock can be selected as follows.

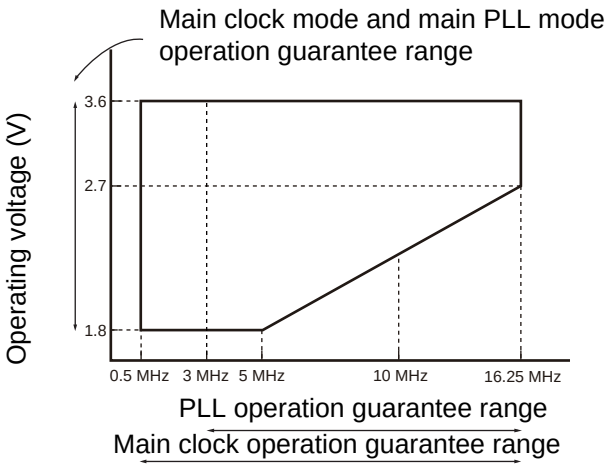
- Source clock (no division)
- Source clock divided by 4
- Source clock divided by 8
- Source clock divided by 16

• Outline of clock generation block

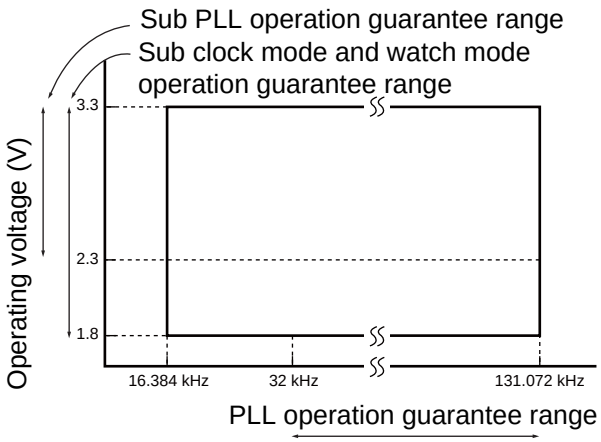


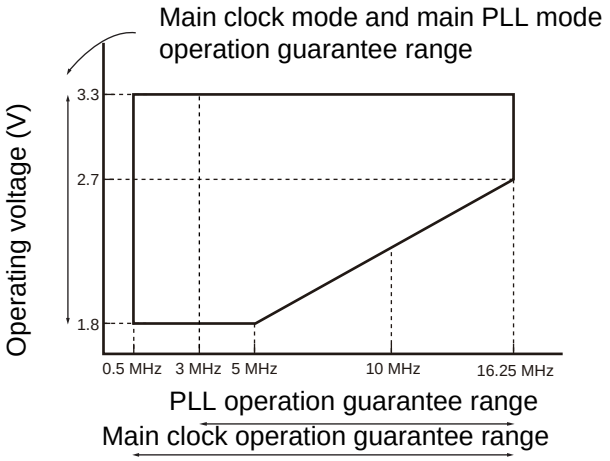
- Operating voltage - Operating frequency (When T_A = – 10 °C to + 85 °C)
  - MB95166D



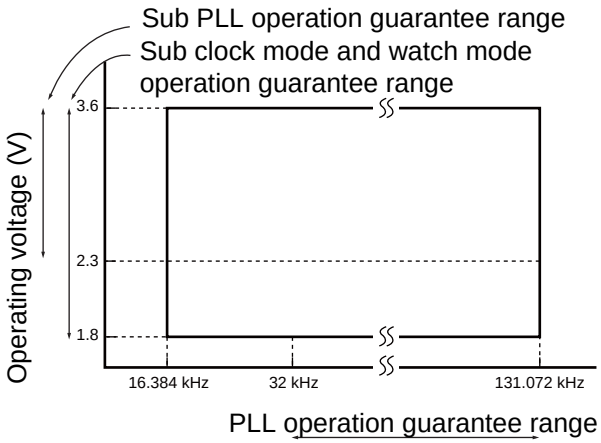


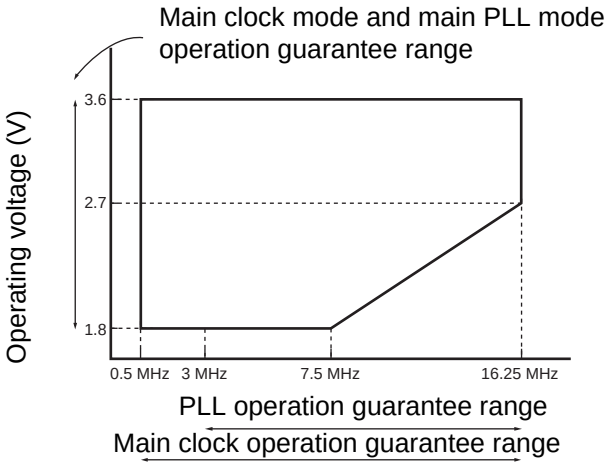
  - MB95F166D



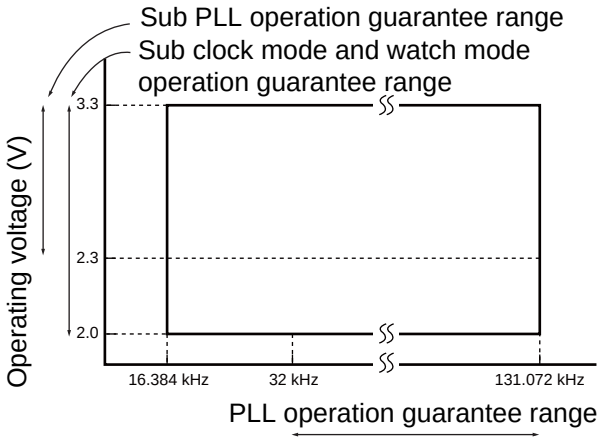


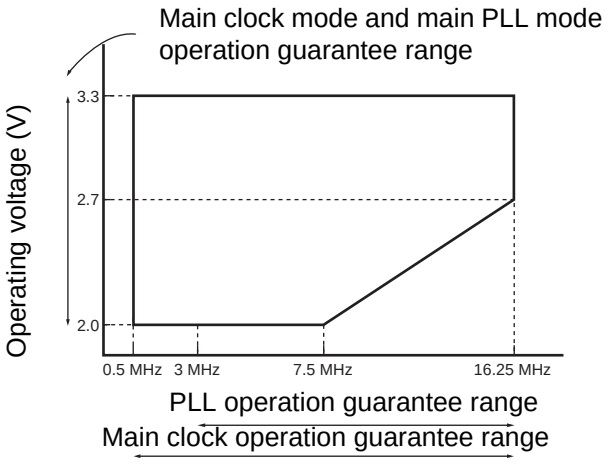
- Operating voltage - Operating frequency (When T_A = − 10 °C to + 85 °C)
  - MB95166D



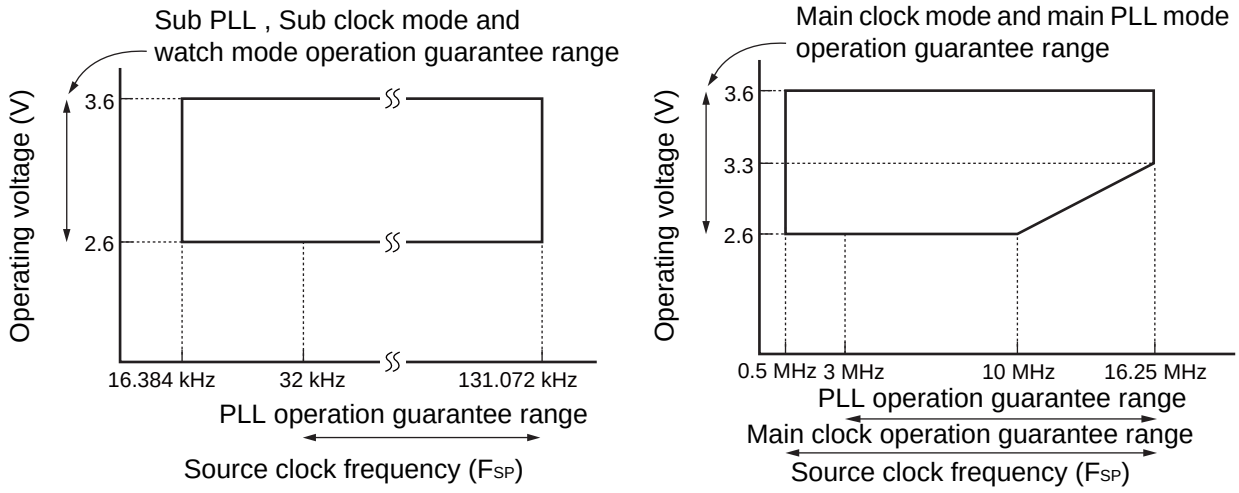


  - MB95F166D

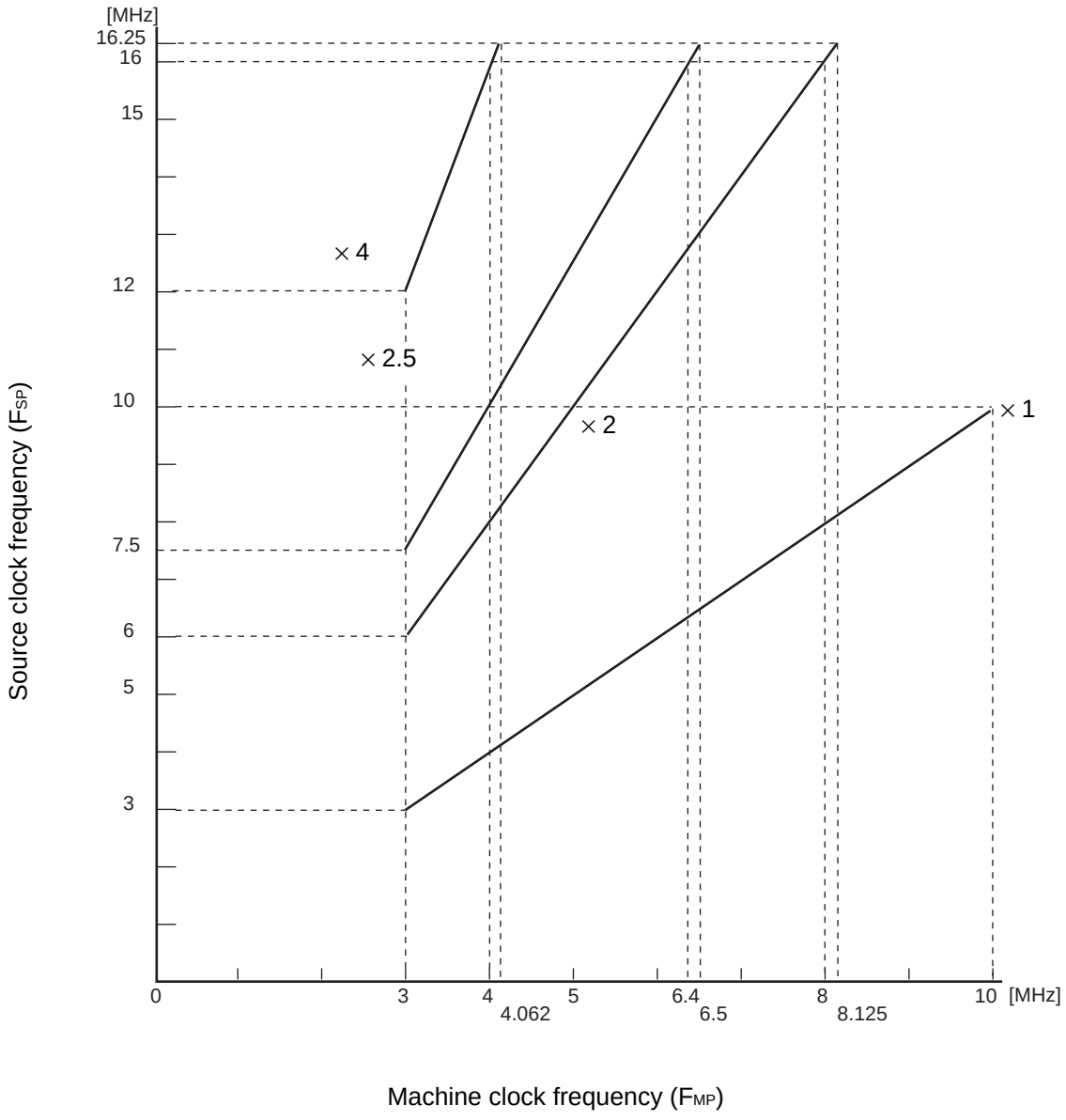




- Operating voltage - Operating frequency (When T_A = + 5 °C to + 35 °C)
  - MB95FV100D-101



• Main PLL operation frequency



(3) External Reset

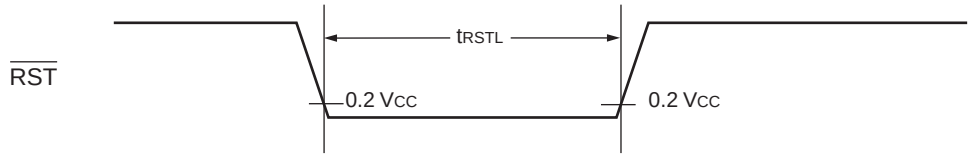
(Vcc = 3.3 V, Vss = 0.0 V, T_A = − 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Condi-tions	Value		Unit	Remarks
				Min	Max		
$\overline{RST}$ "L" level pulse width	t_{RSTL}	$\overline{RST}$	—	2 t_{MCLK}*1	—	ns	At normal operating
				Oscillation time of oscillator*2 + 100	—	µs	At stop mode, sub clock mode, sub sleep mode, and watch mode

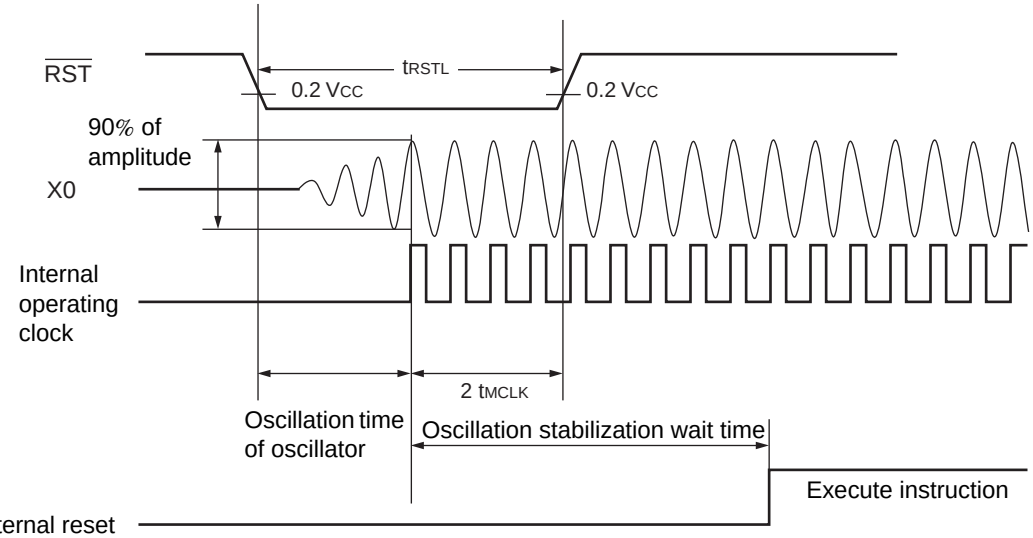
*1 : Refer to " (2) Source Clock/Machine Clock" for t_{MCLK}.

*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 ceramic oscillators, the oscillation time is between hundreds of µs and several ms. In the external clock, the oscillation time is 0 ms.

• At normal operating



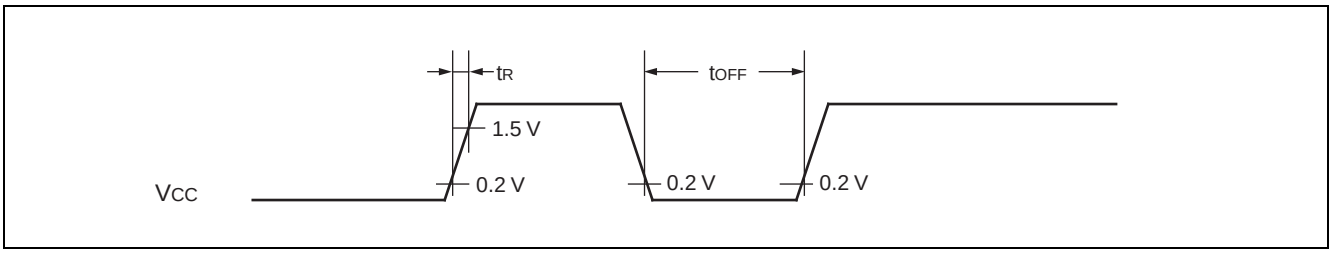
• At stop mode, sub clock mode, sub sleep mode, watch mode, and power-on



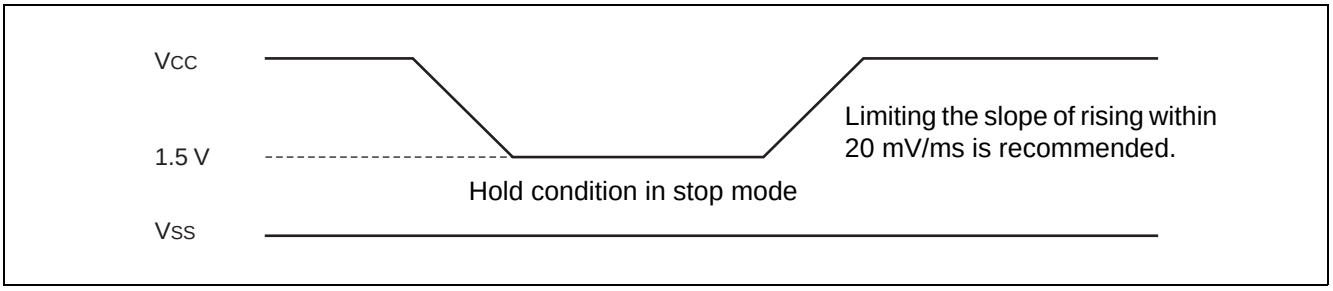
(4) Power-on Reset

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

Parameter	Symbol	Pin name	Conditions	Value		Unit	Remarks
				Min	Max		
Power supply rising time	t_R	V_{CC}	—	—	36	ms	
Power supply cutoff time	t_{OFF}			1	—	ms	Waiting time until power-on



Note : 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.

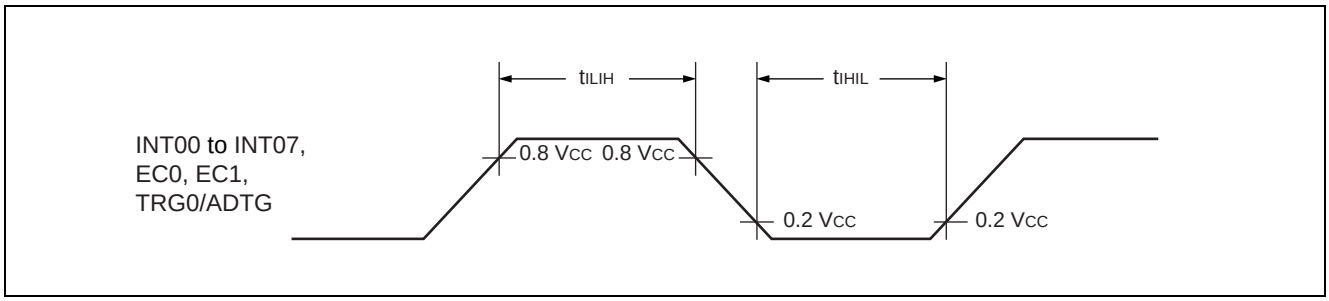


(5) Peripheral Input Timing

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

Parameter	Symbol	Pin name	Conditions	Value		Unit
				Min	Max	
Peripheral input “H” pulse width	t_{ILIH}	INT00 to INT07, EC0, EC1, TRG0/ADTG	—	2 t_{MCLK}*	—	ns
Peripheral input “L” pulse width	t_{IHIL}			2 t_{MCLK}*	—	ns

* : Refer to “ (2) Source Clock/Machine Clock” for t_{MCLK}.



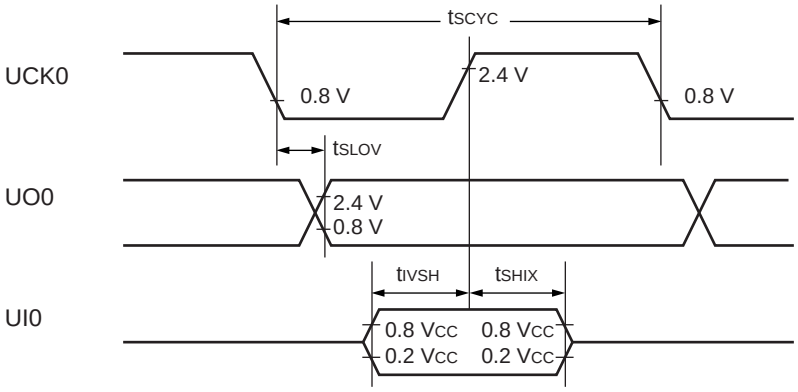
(6) UART/SIO, Serial I/O Timing

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

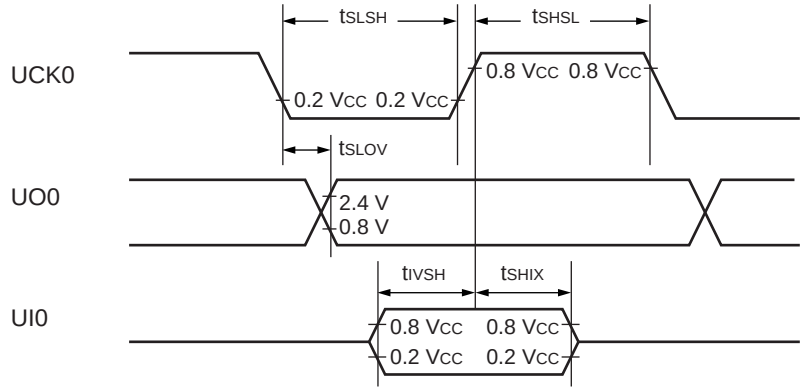
Parameter	Symbol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t_{SCYC}	UCK0	Internal clock operation output pin : C_L = 80 pF + 1TTL.	4 t_{MCLK}*	—	ns
UCK ↓ → UO time	t_{SLOV}	UCK0, UO0		− 190	+ 190	ns
Valid UI → UCK ↑	t_{IVSH}	UCK0, UI0		2 t_{MCLK}*	—	ns
UCK ↑ → valid UI hold time	t_{SHIX}	UCK0, UI0		2 t_{MCLK}*	—	ns
Serial clock “H” pulse width	t_{SHSL}	UCK0	External clock operation output pin : C_L = 80 pF + 1TTL.	4 t_{MCLK}*	—	ns
Serial clock “L” pulse width	t_{SLSH}	UCK0		4 t_{MCLK}*	—	ns
UCK ↓ → UO time	t_{SLOV}	UCK0, UO0		—	190	ns
Valid UI → UCK ↑	t_{IVSH}	UCK0, UI0		2 t_{MCLK}*	—	ns
UCK ↑ → valid UI hold time	t_{SHIX}	UCK0, UI0		2 t_{MCLK}*	—	ns

* : Refer to “ (2) Source Clock/Machine Clock” for t_{MCLK}.

• Internal shift clock mode



• External shift clock mode



(7) LIN-UART Timing

Sampling at the rising edge of sampling clock*1 and prohibited serial clock delay*2
(ESCR register : SCES bit = 0, ECCR register : SCDE bit = 0)

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

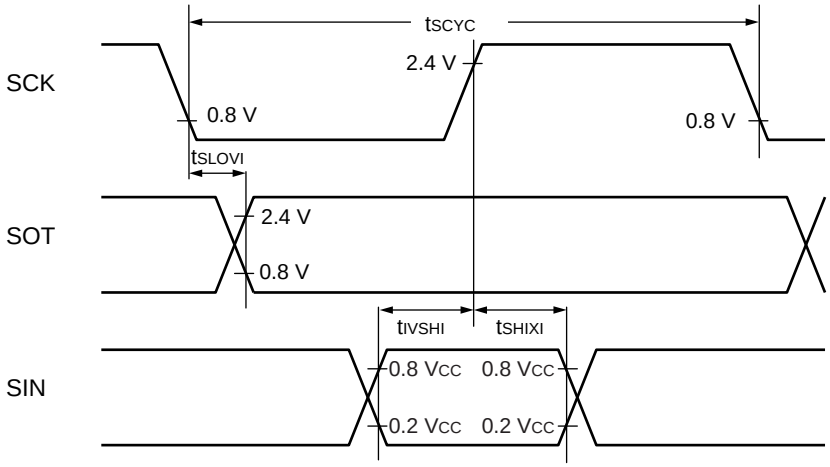
Parameter	Symbol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t_{SCYC}	SCK	Internal clock operation output pin : C_L = 80 pF + 1 TTL.	5 t_{MCLK}*3	—	ns
SCK ↓ → SOT delay time	t_{SLOVI}	SCK, SOT		–95	+ 95	ns
Valid SIN → SCK ↑	t_{IVSHI}	SCK, SIN		t_{MCLK}*3 + 190	—	ns
SCK ↑ → valid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

*1 : Provide switch function whether sampling of reception data is performed at rising edge or falling edge of the serial clock.

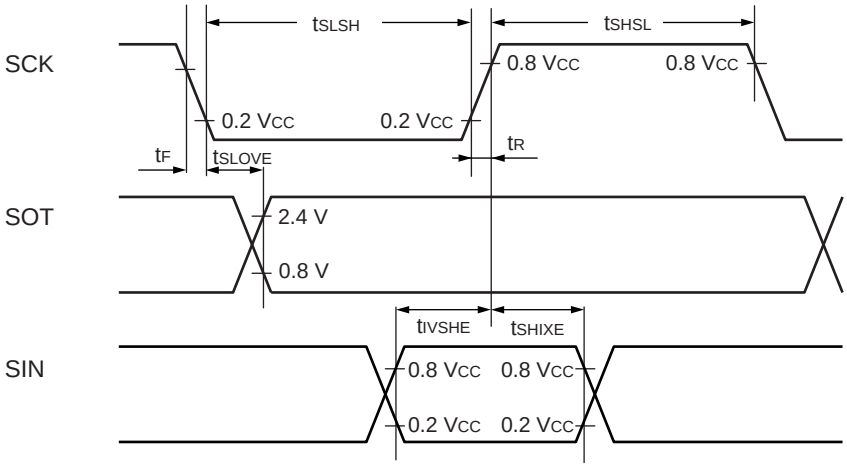
*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

*3 : Refer to “ (2) Source Clock/Machine Clock” for t_{MCLK}.

- Internal shift clock mode



- External shift clock mode



Sampling at the falling edge of sampling clock*1 and prohibited serial clock delay*2
(ESCR register : SCES bit = 1, ECCR register : SCDE bit = 0)

(V_{CC} = 3.3 V, V_{SS} = 0.0 V, T_A = –40 °C to + 85 °C)

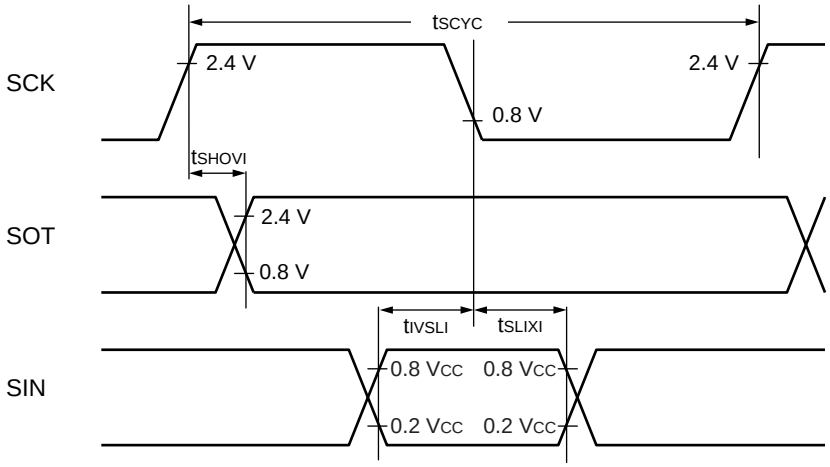
Parameter	Sym-bol	Pin name	Conditions	Value		Unit
				Min	Max	
Serial clock cycle time	t_{SCYC}	SCK	Internal clock operation output pin : C_L = 80 pF + 1 TTL.	5 t_{MCLK}*3	—	ns
SCK ↑ → SOT delay time	t_{SHOVI}	SCK, SOT		–95	+ 95	ns
Valid SIN → SCK ↓	t_{IVSLI}	SCK, SIN		t_{MCLK}*3 + 190	—	ns
SCK ↓ → valid 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 t_{MCLK}*3 – t_R	—	ns
Serial clock “L” pulse width	t_{SLSH}	SCK		t_{MCLK}*3 + 95	—	ns
SCK ↑ → SOT delay time	t_{SHOVE}	SCK, SOT		—	2 t_{MCLK}*3 + 95	ns
Valid SIN → SCK ↓	t_{IVSLE}	SCK, SIN		190	—	ns
SCK ↓ → valid SIN hold time	t_{SLIXE}	SCK, SIN		t_{MCLK}*3 + 95	—	ns
SCK fall time	t_F	SCK		—	10	ns
SCK rise time	t_R	SCK		—	10	ns

*1 : Provide switch function whether sampling of reception data is performed at rising edge or falling edge of the serial clock.

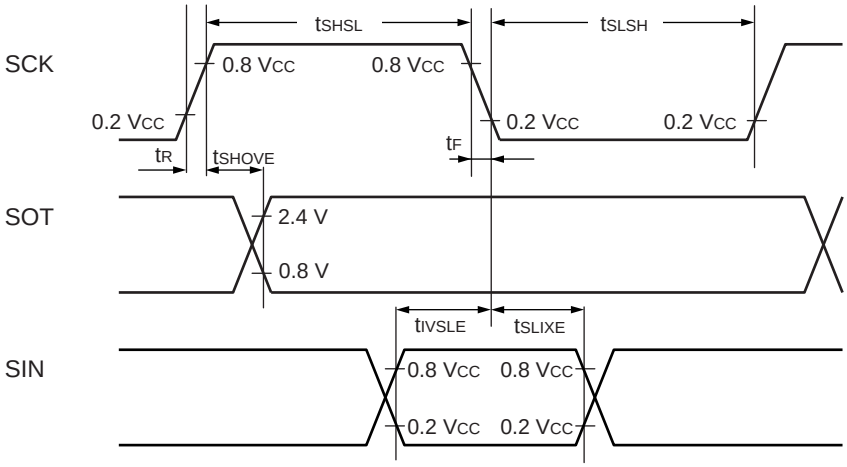
*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

*3 : Refer to “ (2) Source Clock/Machine Clock” for t_{MCLK}.

- Internal shift clock mode



- External shift clock mode



Sampling at the rising edge of sampling clock*1 and enabled serial clock delay*2
(ESCR register : SCES bit = 0, ECCR register : SCDE bit = 1)

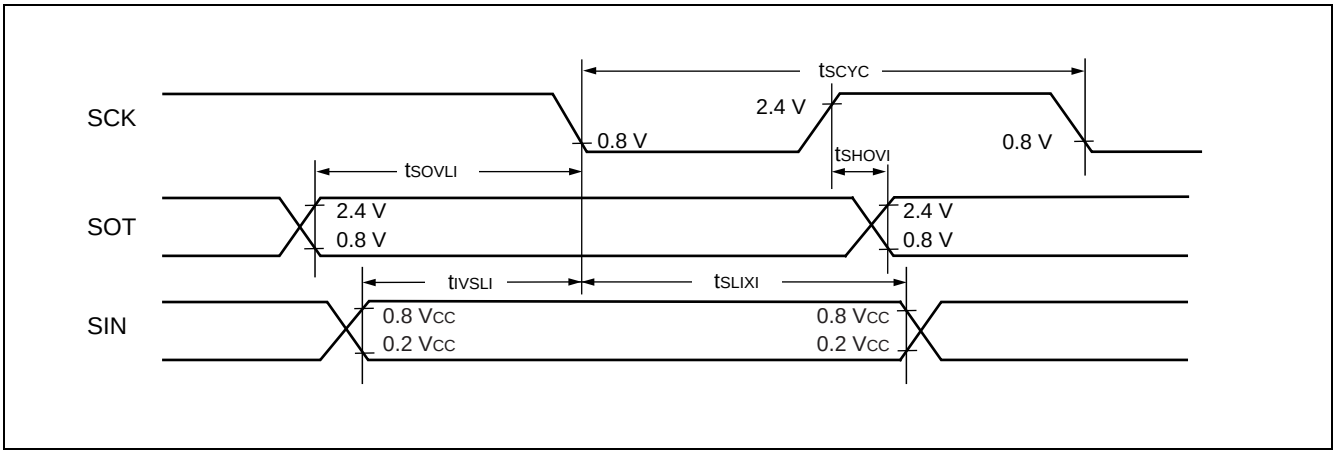
(V_{CC} = 3.3 V, V_{SS} = 0.0 V, T_A = –40 °C to + 85 °C)

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 t_{MCLK}*3	—	ns
SCK ↑ → SOT delay time	t_{SHOVI}	SCK, SOT		–95	+ 95	ns
Valid SIN → SCK ↓	t_{IVSLI}	SCK, SIN		t_{MCLK}*3 + 190	—	ns
SCK ↓ → valid SIN hold time	t_{SLIXI}	SCK, SIN		0	—	ns
SOT → SCK ↓ delay time	t_{SOVLI}	SCK, SOT		—	4 t_{MCLK}*3	ns

*1 : Provide switch function whether sampling of reception data is performed at rising edge or falling edge of the serial clock.

*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

*3 : Refer to " (2) Source Clock/Machine Clock" for t_{MCLK}.



Sampling at the falling edge of sampling clock*1 and enabled serial clock delay*2
(ESCR register : SCES bit = 1, ECCR register : SCDE bit = 1)

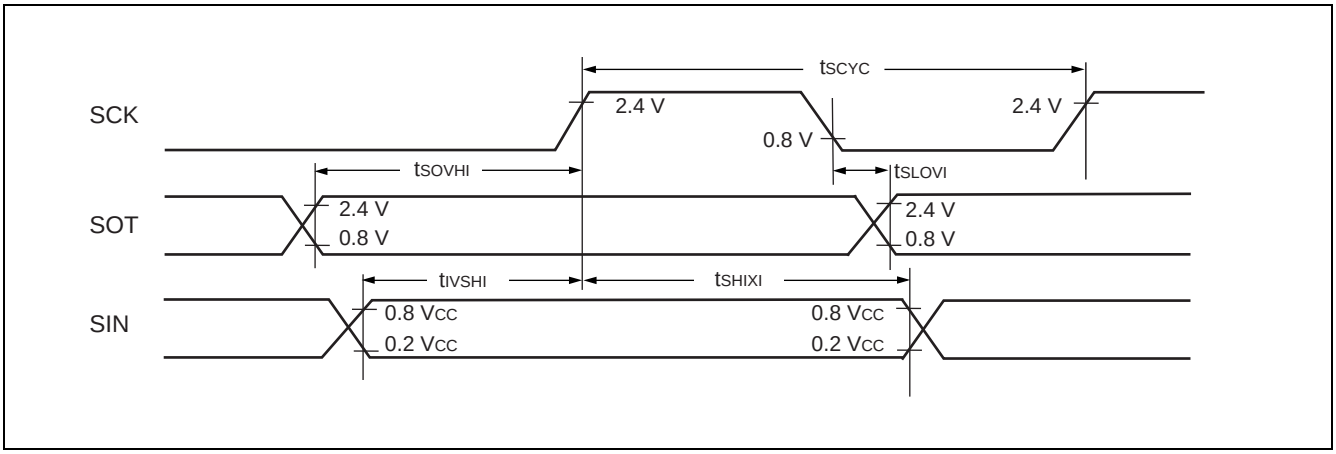
(V_{CC} = 3.3 V, V_{SS} = 0.0 V, T_A = –40 °C to + 85 °C)

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 t_{MCLK}*3	—	ns
SCK ↓ → SOT delay time	t_{SLOVI}	SCK, SOT		–95	+ 95	ns
Valid SIN → SCK ↑	t_{IVSHI}	SCK, SIN		t_{MCLK}*3 + 190	—	ns
SCK ↑ → valid SIN hold time	t_{SHIXI}	SCK, SIN		0	—	ns
SOT → SCK ↑ delay time	t_{SOVHI}	SCK, SOT		—	4 t_{MCLK}*3	ns

*1 : Provide switch function whether sampling of reception data is performed at rising edge or falling edge of the serial clock.

*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

*3 : Refer to " (2) Source Clock/Machine Clock" for t_{MCLK}.



(8) I²C Timing

(V_{CC} = 3.3 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = − 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Conditions	Value				Unit
				Standard-mode		Fast-mode		
				Min	Max	Min	Max	
SCL clock frequency	f_{SCL}	SCL0	R = 1.7 kΩ, C = 50 pF*1	0	100	0	400	kHz
(Repeat) Start condition hold time SDA ↓ → SCL ↓	$t_{HD;STA}$	SCL0 SDA0		4.0	—	0.6	—	µs
SCL clock “L” width	t_{LOW}	SCL0		4.7	—	1.3	—	µs
SCL clock “H” width	t_{HIGH}	SCL0		4.0	—	0.6	—	µs
(Repeat) Start condition setup time SCL ↑ → SDA ↓	$t_{SU;STA}$	SCL0 SDA0		4.7	—	0.6	—	µs
Data hold time SCL ↓ → SDA ↓ ↑	$t_{HD;DAT}$	SCL0 SDA0		0	3.45*2	0	0.9*3	µs
Data setup time SDA ↓ ↑ → SCL ↑	$t_{SU;DAT}$	SCL0 SDA0		0.25*4	—	0.1*4	—	µs
Stop condition setup time SCL ↑ → SDA ↑	$t_{SU;STO}$	SCL0 SDA0		4.0	—	0.6	—	µs
Bus free time between stop condition and start condition	t_{BUF}	SCL0 SDA0		4.7	—	1.3	—	µs

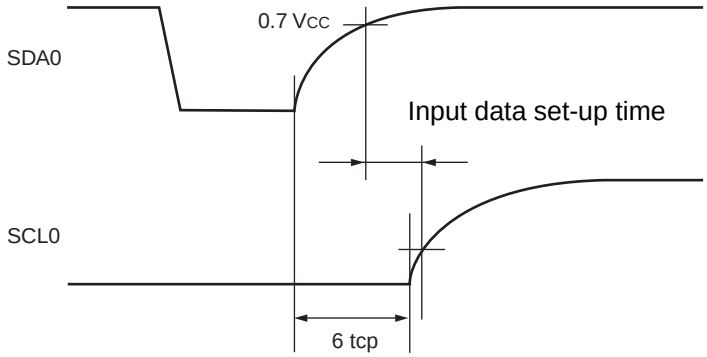
*1 : R, C : Pull-up resistor and load capacitor of the SCL and SDA lines.

*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.

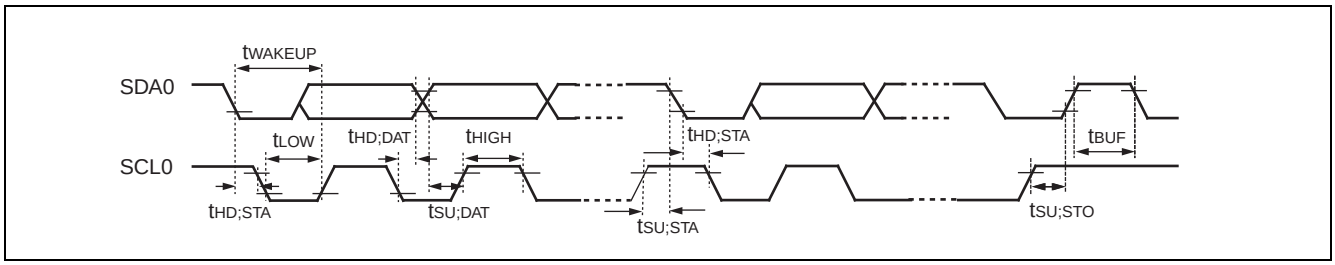
*3 : A fast-mode I²C-bus device can be used in a standard-mode I²C-bus system, but the requirement $t_{SU;DAT} \geq$ 250 ns must then be met.

*4 : Refer to “ • Note of SDA and SCL set-up time”.

• Note of SDA and SCL set-up time



Note : The rating of the input data set-up time in the device connected to the bus cannot be satisfied depending on the load capacitance or pull-up resistor.
Be sure to adjust the pull-up resistor of SDA and SCL if the rating of the input data set-up time cannot be satisfied.



(V_{CC} = 3.3 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = − 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Conditions	Value*2		Unit	Remarks
				Min	Max		
SCL clock “L” width	t_{LOW}	SCL0	R = 1.7 kΩ, C = 50 pF*1	(2 + nm / 2) t_{MCLK} – 20	—	ns	Master mode
SCL clock “H” width	t_{HIGH}	SCL0		(nm / 2) t_{MCLK} – 20	(nm / 2) t_{MCLK} + 20	ns	Master mode
Start condition hold time	$t_{HD;STA}$	SCL0 SDA0		(–1 + nm / 2) t_{MCLK} – 20	(–1 + nm) t_{MCLK} + 20	ns	Master mode Maximum value is applied when m, n = 1, 8. Otherwise, the minimum value is applied.
Stop condition setup time	$t_{SU;STO}$	SCL0 SDA0		(1 + nm / 2) t_{MCLK} – 20	(1 + nm / 2) t_{MCLK} + 20	ns	Master mode
Start condition setup time	$t_{SU;STA}$	SCL0 SDA0		(1 + nm / 2) t_{MCLK} – 20	(1 + nm / 2) t_{MCLK} + 20	ns	Master mode
Bus free time between stop condition and start condition	t_{BUF}	SCL0 SDA0		(2 nm + 4) t_{MCLK} – 20	—	ns	
Data hold time	$t_{HD;DAT}$	SCL0 SDA0		3 t_{MCLK} – 20	—	ns	Master mode
Data setup time	$t_{SU;DAT}$	SCL0 SDA0		(–2 + nm / 2) t_{MCLK} – 20	(–1 + nm / 2) t_{MCLK} + 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	$t_{SU;INT}$	SCL0		(nm / 2) t_{MCLK} – 20	(1 + nm / 2) t_{MCLK} + 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}	SCL0		4 t_{MCLK} – 20	—	ns	At reception
SCL clock “H” width	t_{HIGH}	SCL0		4 t_{MCLK} – 20	—	ns	At reception
Start condition detection	$t_{HD;STA}$	SCL0 SDA0		2 t_{MCLK} – 20	—	ns	Undetected when 1 t_{MCLK} is used at reception

(Continued)

(Continued)

(V_{CC} = 3.3 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = − 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Conditions	Value*2		Unit	Remarks
				Min	Max		
Stop condition detection	$t_{SU;STO}$	SCL0 SDA0	R = 1.7 kΩ, C = 50 pF*1	2 t_{MCLK} – 20	—	ns	Undetected when 1 t_{MCLK} is used at reception
Restart condition detection condition	$t_{SU;STA}$	SCL0 SDA0		2 t_{MCLK} – 20	—	ns	Undetected when 1 t_{MCLK} is used at reception
Bus free time	t_{BUF}	SCL0 SDA0		2 t_{MCLK} – 20	—	ns	At reception
Data hold time	$t_{HD;DAT}$	SCL0 SDA0		2 t_{MCLK} – 20	—	ns	At slave transmission mode
Data setup time	$t_{SU;DAT}$	SCL0 SDA0		t_{LOW} – 3 t_{MCLK} – 20	—	ns	At slave transmission mode
Data hold time	$t_{HD;DAT}$	SCL0 SDA0		0	—	ns	At reception
Data setup time	$t_{SU;DAT}$	SCL0 SDA0		t_{MCLK} – 20	—	ns	At reception
SDA ↓ → SCL ↑ (at wakeup function)	t_{WAKEUP}	SCL0 SDA0		Oscillation stabilization wait time + 2 t_{MCLK} – 20	—	ns	

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

*2 :
- Refer to " (2) Source Clock/Machine Clock" for t_{MCLK}.
- m is CS4 bit and CS3 bit (bit 4 and bit 3) of I²C clock control register (ICCR) .
- n is CS2 bit to CS0 bit (bit 2 to bit 0) of I²C clock control register (ICCR) .
- Actual timing of I²C is determined by m and n values set by the machine clock (t_{MCLK}) and CS4 to CS0 of ICCR0 register.
- Standard-mode :
  m and n can be set at the range : 0.9 MHz < t_{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 < t_{MCLK} ≤ 1 MHz
  (m, n) = (1, 22) , (5, 4) , (6, 4) , (7, 4) , (8, 4) : 0.9 MHz < t_{MCLK} ≤ 2 MHz
  (m, n) = (1, 38) , (5, 8) , (6, 8) , (7, 8) , (8, 8) : 0.9 MHz < t_{MCLK} ≤ 4 MHz
  (m, n) = (1, 98) : 0.9 MHz < t_{MCLK} ≤ 10 MHz
- Fast-mode :
  m and n can be set at the range : 3.3 MHz < t_{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 < t_{MCLK} ≤ 4 MHz
  (m, n) = (1, 22) , (5, 4) : 3.3 MHz < t_{MCLK} ≤ 8 MHz
  (m, n) = (6, 4) : 3.3 MHz < t_{MCLK} ≤ 10 MHz

5. A/D Converter

(1) A/D Converter Electrical Characteristics

(AV_{CC} = V_{CC} = 1.8 V to 3.3 V, AV_{SS} = V_{SS} = 0.0 V, T_A = − 40 °C to + 85 °C)

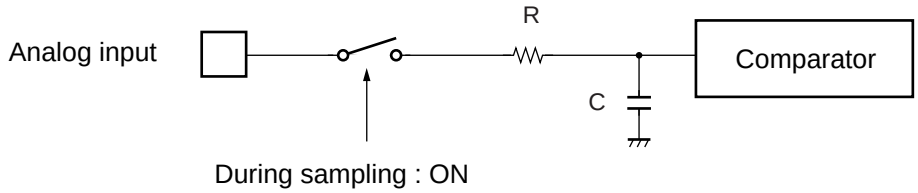
Parameter	Symbol	Conditions	Value			Unit	Remarks
			Min	Typ	Max		
Resolution	—	—	—	—	10	bit	
Total error			− 3.0	—	+ 3.0	LSB	
Linearity error			− 2.5	—	+ 2.5	LSB	
Differential linear error			− 1.9	—	+ 1.9	LSB	
Zero transition voltage	V_{OT}		AV_{SS} − 1.5 LSB	AV_{SS} + 0.5 LSB	AV_{SS} + 2.5 LSB	V	2.7 V ≤ AV_{CC} ≤ 3.3 V
			AV_{SS} − 0.5 LSB	AV_{SS} + 1.5 LSB	AV_{SS} + 3.5 LSB	V	1.8 V ≤ AV_{CC} < 2.7 V
Full-scale transition voltage	V_{FST}		AVR − 3.5 LSB	AVR − 1.5 LSB	AVR + 0.5 LSB	V	2.7 V ≤ AV_{CC} ≤ 3.3 V
			AVR − 2.5 LSB	AVR − 0.5 LSB	AVR + 1.5 LSB	V	1.8 V ≤ AV_{CC} < 2.7 V
Compare time	—		0.6	—	140	µs	2.7 V ≤ AVcc ≤ 3.3 V
			20	—	140	µs	1.8 V ≤ AVcc < 2.7 V
Sampling time	—	—	0.4	—	∞	µs	2.7 V ≤ AVcc ≤ 3.3 V, At external impedance < 1.8 kΩ
			30	—	∞	µs	1.8 V ≤ AVcc < 2.7 V, At external impedance < 14.8 kΩ
Analog input current	I_{AIN}		−0.3	—	+0.3	µA	
Analog input voltage	V_{AIN}		AV_{SS}	—	AVR	V	
Reference voltage	—		AV_{SS} + 1.8	—	AV_{CC}	V	AVR pin
Reference voltage supply current	I_R		—	400	600	µA	AVR pin, During A/D operation
	I_{RH}		—	—	5	µA	AVR 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 sample and hold capacitor is insufficient, adversely affecting A/D conversion precision. Therefore, to satisfy the A/D conversion precision standard, consider the relationship between the external impedance and minimum sampling time and either adjust the register value and operating frequency or decrease the external impedance so that the sampling time is longer than the minimum value. Also, if the sampling time cannot be sufficient, connect a capacitor of about 0.1 µF to the analog input pin.

- Analog input equivalent circuit

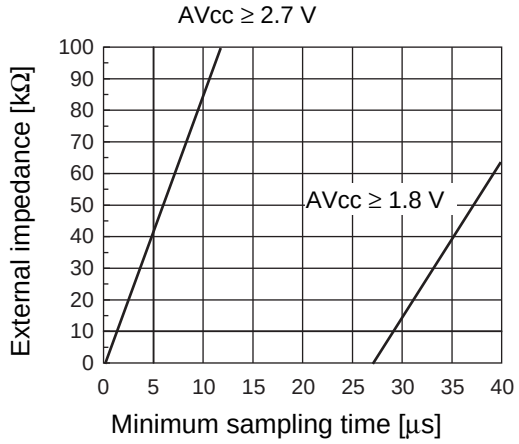


	R	C
2.7 V ≤ V_{CC} ≤ 3.6 V	1.7 kΩ (Max)	14.5 pF (Max)
1.8 V ≤ V_{CC} < 2.7 V	84 kΩ (Max)	25.2 pF (Max)

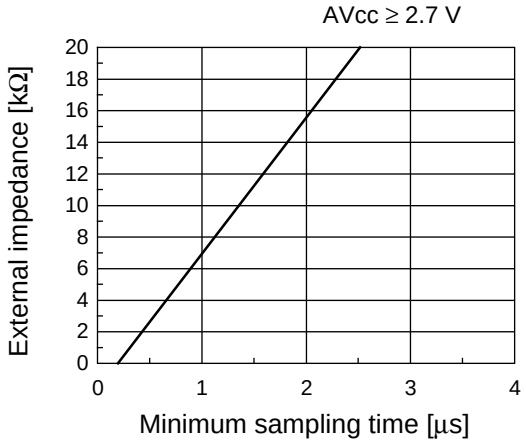
Note : The values are reference values.

- The relationship between external impedance and minimum sampling time

(External impedance = 0 kΩ to 100 kΩ)



(External impedance = 0 kΩ to 20 kΩ)

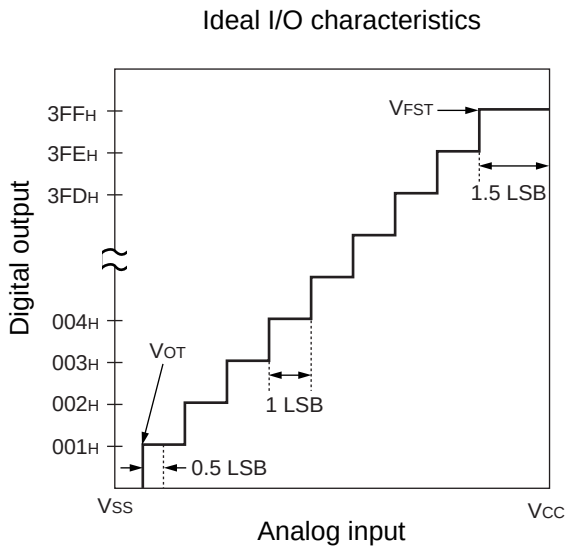


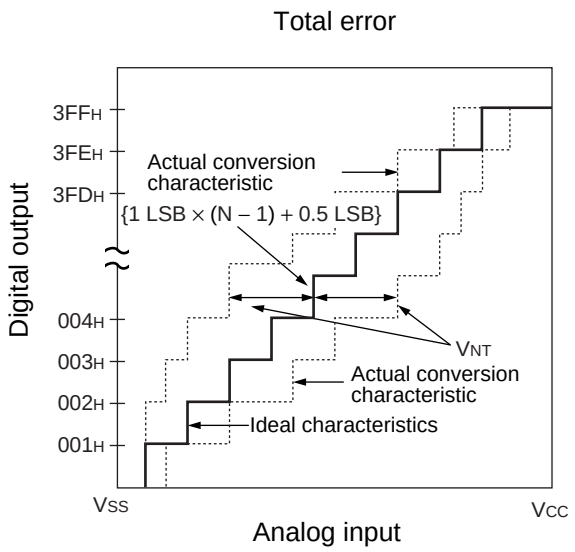
- **About errors**

As |V_{CC} – V_{SS}| becomes smaller, values of relative errors grow larger.

(3) Definition of A/D Converter Terms

- Resolution
  The analog quantity to be monitored 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.





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

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

N : A/D converter digital output value
V_{NT} : A voltage at which digital output transits from $(N - 1)_H$ to N_H

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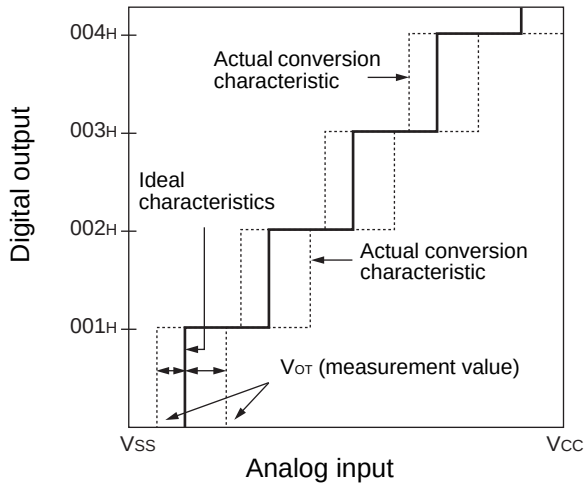
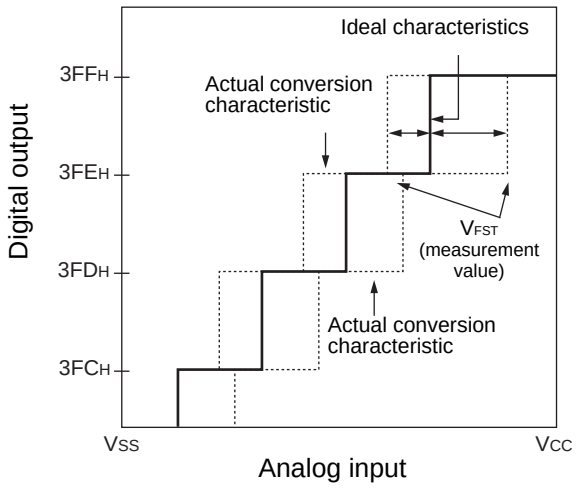
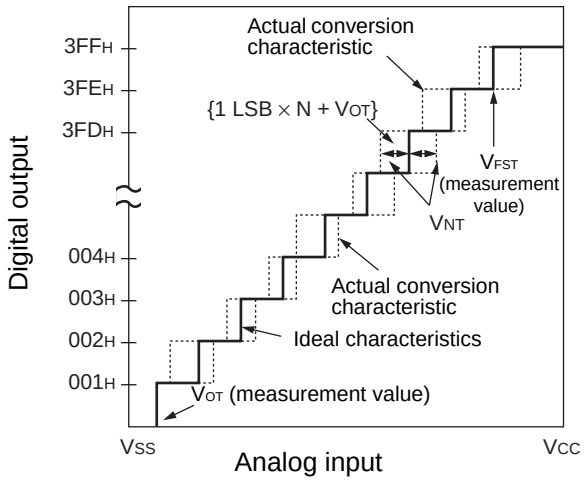
Zero transition error



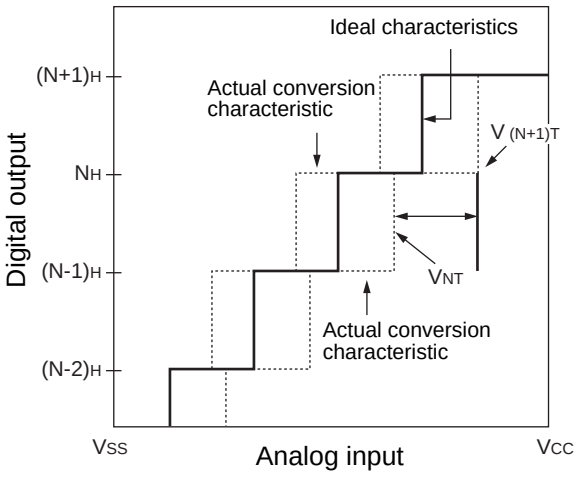
Full-scale transition error



Linearity error



Differential linear error



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

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

N : A/D converter digital output value
V_{NT} : A voltage at which digital output transits from $(N - 1)_H$ to N_H
V_{OT} (Ideal value) = V_{SS} + 0.5 LSB [V]
V_{FST} (Ideal value) = V_{CC} – 1.5 LSB [V]

6. Flash Memory Program/Erase Characteristics

Parameter	Value			Unit	Remarks
	Min	Typ	Max		
Chip erase time	—	1*1	15*2	s	Excludes 00_H programming prior erasure.
Byte programming time	—	32	3600*2	µs	Excludes system-level overhead.
Erase/program cycle	10000	—	—	cycle	
Power supply voltage at erase/ program	2.7	—	3.3	V	
Flash memory data retention time	20*3	—	—	year	Average T_A = +85 °C

*1 : T_A = + 25 °C, V_{CC} = 3.0 V, 10000 cycles

*2 : T_A = + 85 °C, V_{CC} = 2.7 V, 10000 cycles

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

■ MASK OPTION

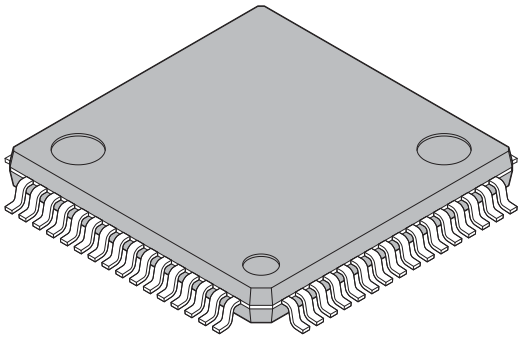
No.	Part number	MB95F166D	MB95FV100D-101	MB95166D
	Specifying procedure	Setting disabled	Setting disabled	Specifying when ordering MASK
1	Clock mode select • Single-system clock mode • Dual-system clock mode	Dual-system clock mode	Changing by the switch on MCU board	Dual-system clock mode
2	Low voltage detection reset* • With low voltage detection reset • Without low voltage detection reset	No	No	No
3	Clock supervisor* • With clock supervisor • Without clock supervisor	No	No	No
4	Selection of oscillation stabilization wait time • Selectable the initial value of main clock oscillation stabilization wait time	Fixed to oscillation stabilization wait time of $(2^{14} - 2) / F_{CH}$	Fixed to oscillation stabilization wait time of $(2^{14} - 2) / F_{CH}$	Selectable: 1 : $(2^{2} - 2) / F_{CH}$ 2 : $(2^{12} - 2) / F_{CH}$ 3 : $(2^{13} - 2) / F_{CH}$ 4 : $(2^{14} - 2) / F_{CH}$

* : Low voltage detection reset and clock supervisor are options of 5-V products.

■ ORDERING INFORMATION

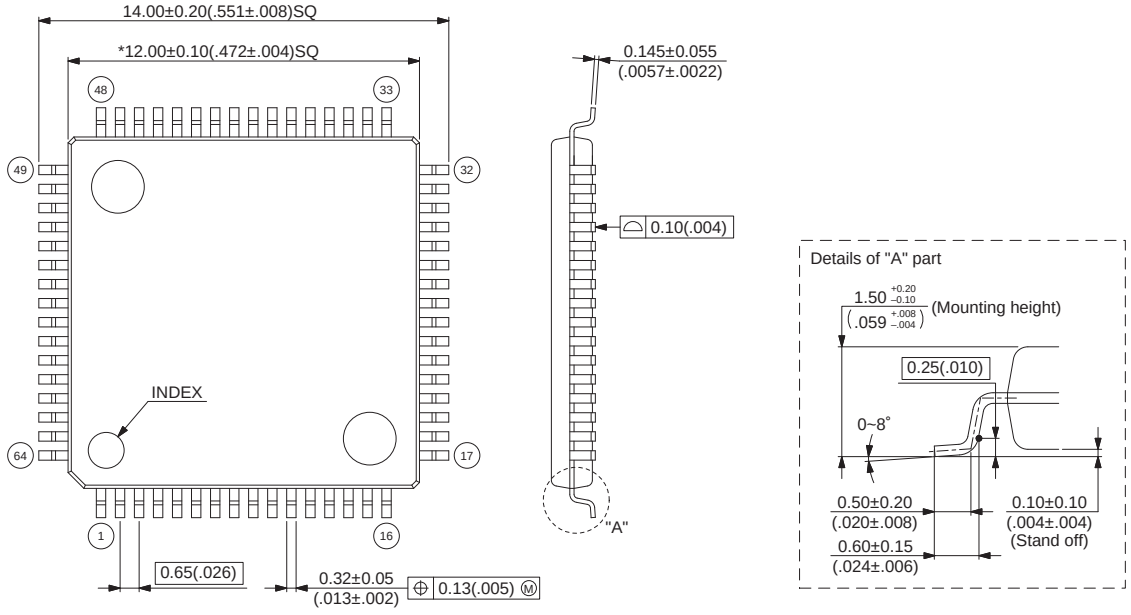
Part number	Package
MB95F166DPMC/MB95166DPMC	64-pin plastic LQFP (FPT-64P-M23)
MB95F166DPMC1/MB95166DPMC1	64-pin plastic LQFP (FPT-64P-M24)
MB2146-301A (MB95FV100D-101PBT)	MCU board (224-ball plastic PFBGA (BGA-224P-M08))

■ PACKAGE DIMENSIONS

64-pin plastic LQFP		
 (FPT-64P-M23)	Lead pitch	0.65 mm
	Package width × package length	12.0 × 12.0 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	1.70 mm MAX
	Code (Reference)	P-LFQFP64-12×12-0.65

64-pin plastic LQFP
(FPT-64P-M23)

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

Please confirm the latest Package dimension by following URL.
http://edevice.fujitsu.com/package/en-search/

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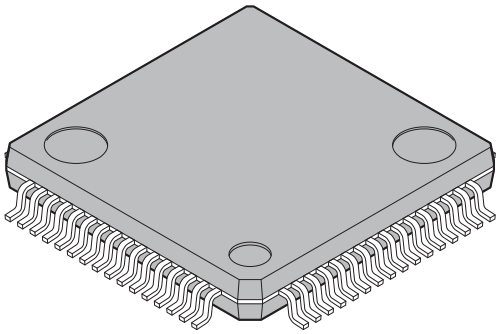
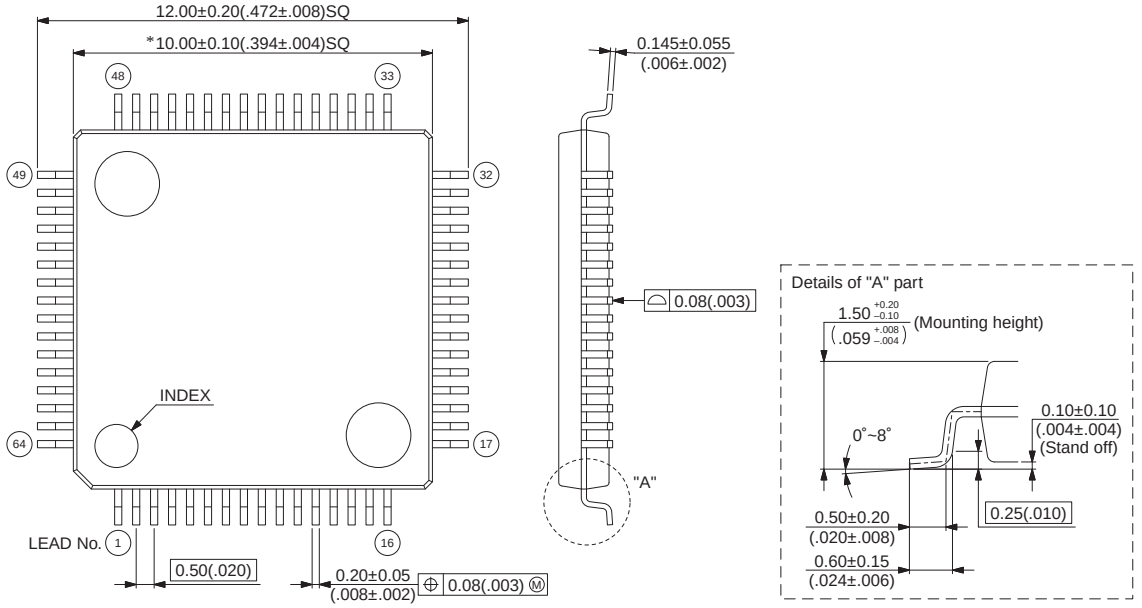
(Continued)

64-pin plastic LQFP		
	Lead pitch	0.50 mm
	Package width × package length	10.0 × 10.0 mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	1.70 mm MAX
	Weight	0.32 g
(FPT-64P-M24)	Code (Reference)	P-LFQFP64-10×10-0.50

64-pin plastic LQFP
(FPT-64P-M24)

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

Please confirm the latest Package dimension by following URL.
http://edevice.fujitsu.com/package/en-search/

■ MAIN CHANGES IN THIS EDITION

Page	Section	Change Results
—	—	Added the part number; (MB95166D)
2	■ FEATURE	Changed as follows. (• Flash memory security function → • Flash memory security function (Flash memory device only))
3, 4	■ PRODUCT LINEUP	Added the row of MB95166D.
3		Changed the Reset output. (Yes → No)
5	■ OSCILLATION STABILIZATION WAIT TIME	Changed the "■ OSCILLATION STABILIZATION WAIT TIME"
	■ PACKAGES AND CORRESPONDING PRODUCTS	Added the row of MB95166D.
6	■ DIFFERENCES AMONG PRODUCTS AND NOTES ON SELECTING PRODUCTS	• Changed the Notes on Using Evaluation Products • Changed the Difference of Memory Spaces • Changed the Operating voltage • Added the Difference MOD pins
11	■ I/O CIRCUIT TYPE	Changed the Type B
13		Changed the Type S (• LCD power supply was deleted)
14	■ HANDLING DEVICES	Added the item of "• Serial Communication".
17	■ CPU CORE	Added the MB95166D in "• Memory Map".
23	■ I/O MAP	Changed the Address 0073_H, 0074_H.
28	■ ELECTRICAL CHARACTERISTICS 1. Absolute Maximum Ratings	Changed the Remarks of "Power supply voltage for LCD" (Products with LCD internal division resistance*3 → *3)
31	3. DC Characteristics	Changed the row of Symbol V_{IHM} and V_{ILM}.
32		Added the row of Pull-down resistor (R_{MOD}).
32, 33		Changed the Power supply current.
38, 39	4. AC Characteristics (2) Source Clock/Machine Clock	• Changed the Operating voltage - Operating frequency (When T_A = –10 °C to +85 °C) (• Added the graph of MB95166D)
61	■ MASK OPTION	Added the row of MB95166D.
62	■ ORDERING INFORMATION	Changed the part numbers. (MB95F166DPMC → MB95F166DPMC/MB95166DPMC) (MB95F166DPMC1 → MB95F166DPMC1/MB95166DPMC1)

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

MEMO

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