

# 8-bit Microcontroller

CMOS

## F<sup>2</sup>MC-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 : F<sup>2</sup>MC is the abbreviation of FUJITSU Flexible Microcontroller.

### ■ FEATURE

- F<sup>2</sup>MC-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://edevic.fujitsu.com/micom/en-support/>

# MB95160 Series

(Continued)

- UART/SIO × 1 channel
  - Clock asynchronous (UART) or clock synchronous (SIO) serial data transfer capable
  - Full duplex double buffer
  -
- I<sup>2</sup>C × 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

| Part number          |  | MB95F166D  | MB95166D         |
|----------------------|--|--|------------------|
| Parameter            |  |  |                  |
| 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<br>Instruction bit length : 8 bits<br>Instruction length : 1 to 3 bytes<br>Data bit length : 1, 8, and 16 bits<br>Minimum instruction execution time : 61.5 ns (at machine clock frequency 16.25 MHz)<br>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<br>General-purpose I/O port (CMOS) : 51 ports<br>Programmable input voltage levels of port.<br>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<br>At main oscillation clock 10 MHz : Min 105 ms<br>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 <sup>2</sup> C (1 channel)   | Master/slave sending and receiving<br>Bus error function and arbitration function<br>Detecting transmitting direction function<br>Start condition repeated generation and detection functions<br>Built-in wake-up function   |                  |
|                      | UART/SIO (1 channel)   | Data transfer capable in UART/SIO<br>Full duplex double buffer,<br>variable data length (5/6/7/8-bit), built-in baud rate generator<br>NRZ type transfer format, error detected function<br>LSB-first or MSB-first can be selected.<br>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.<br>Full duplex double buffer.<br>Capable of serial data transfer synchronous or asynchronous to clock signal.<br>LIN functions available as the LIN master or LIN slave. |  |                  |

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# MB95160 Series

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| Part number          |  | MB95F166D   | MB95166D |
|----------------------|--|---|----------|
| Parameter            |  |   |          |
| 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)<br>SEG output : 32 (Max)<br>LCD drive power supply (bias) pin : 4<br>32 SEG × 4 COM : 128 pixels can be displayed. (Built-in internal division resistance product)<br>Duty LCD mode<br>Operable in LCD standby mode<br>Built-in internal division resistance<br>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”.<br>Built-in timer function, PWC function, PWM function, capture function, and square wave form output<br>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.<br>Counter operating clock : Eight selectable clock sources<br>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”.<br>Counter operating clock : Eight selectable clock sources  |          |
|                      | Watch counter  | Count clock : Four selectable clock sources (125 ms, 250 ms, 500 ms, or 1 s)<br>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.)<br>Can be used to recover from standby modes.   |          |
| Flash memory         | Supports automatic programming, Embedded Algorithm<br>Write/Erase/Erase-Suspend/Resume commands<br>A flag indicating completion of the algorithm<br>Number of write/erase cycles (Min) : 10000 times<br>Data retention time : 20 years<br>Erase can be performed on each block<br>Block protection with external programming voltage<br>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 $\mu$ s (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 F<sup>2</sup>MC-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

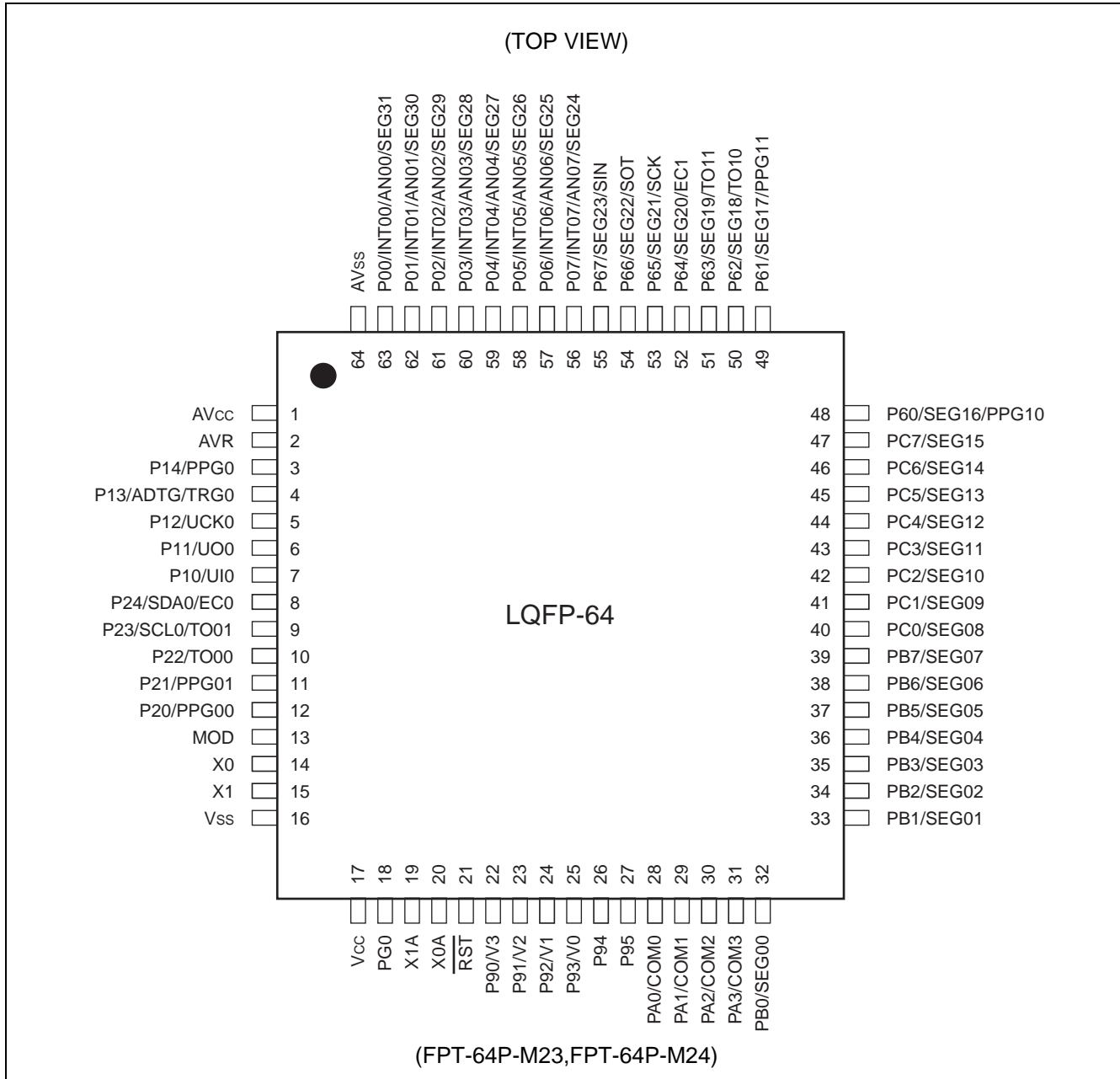
The operating voltage is different among the evaluation, Flash memory products and Mask ROM products.

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



# MB95160 Series

## ■ PIN DESCRIPTION

| Pin no. | Pin name                | I/O circuit type* | Function   |
|---------|-------------------------|-------------------|--|
| 1       | AV <sub>cc</sub>        | —                 | A/D converter power supply pin.  |
| 2       | AVR                     | —                 | A/D converter reference input pin.   |
| 3       | P14/PPG0                | H                 | General-purpose I/O port.<br>The pin is shared with 16-bit PPG ch.0 output.  |
| 4       | P13/TRG0/<br>ADTG       |                   | General-purpose I/O port.<br>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.<br>The pin is shared with UART/SIO ch.0 clock I/O.   |
| 6       | P11/UO0                 |                   | General-purpose I/O port.<br>The pin is shared with UART/SIO ch.0 data output.   |
| 7       | P10/UI0                 | G                 | General-purpose I/O port.<br>The pin is shared with UART/SIO ch.0 data input.  |
| 8       | P24/EC0/<br>SDA0        | I                 | General-purpose I/O port.<br>The pin is shared with 8/16-bit compound timer ch.0 clock input (EC0) and I <sup>2</sup> C ch.0 data I/O (SDA0) . |
| 9       | P23/TO01/<br>SCL0       |                   | General-purpose I/O port.<br>The pin is shared with 8/16-bit compound timer ch.0 output (TO01) and I <sup>2</sup> C ch.0 clock I/O (SCL0) .    |
| 10      | P22/TO00                | H                 | General-purpose I/O port.<br>The pin is shared with 8/16-bit compound timer ch.0 output.   |
| 11      | P21/PPG01               |                   | General-purpose I/O port.<br>The pin is shared with 8/16-bit PPG ch.0 output.  |
| 12      | P20/PPG00               |                   | General-purpose I/O port.<br>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 <sub>ss</sub>         | —                 | Power supply pin (GND).  |
| 17      | V <sub>cc</sub>         | —                 | Power supply pin.  |
| 18      | PG0                     | H                 | General-purpose I/O port.  |
| 19      | X1A                     | A                 | Sub clock oscillation pins (32 kHz).   |
| 20      | X0A                     |                   |  |
| 21      | $\overline{\text{RST}}$ | B'                | Reset pin.   |
| 22      | P90/V3                  | R                 | General-purpose I/O ports.<br>The pins are shared with power supply pin for LCDC drive.  |
| 23      | P91/V2                  |                   |  |
| 24      | P92/V1                  |                   |  |
| 25      | P93/V0                  |                   |  |

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# MB95160 Series

| 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.<br>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.<br>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.<br>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/<br>PPG10 | M                 | General-purpose I/O ports.<br>The pins are shared with LCDC SEG output (SEG16, SEG17) and 8/16-bit PPG ch.1 output (PPG10, PPG11) . |
| 49      | P61/SEG17/<br>PPG11 |                   |   |
| 50      | P62/SEG18/<br>TO10  |                   |   |

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# MB95160 Series

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| Pin no. | Pin name                 | I/O circuit type* | Function   |
|---------|--------------------------|-------------------|--|
| 51      | P63/SEG19/<br>TO11       | M                 | General-purpose I/O port.<br>The pin is shared with LCDC SEG output (SEG19) and 8/16-bit compound timer ch.1 output (TO11) .   |
| 52      | P64/SEG20/<br>EC1        |                   | General-purpose I/O port.<br>The pin is shared with LCDC SEG output (SEG20) and 8/16-bit compound timer ch.1 clock input (EC1) .   |
| 53      | P65/SEG21/<br>SCK        |                   | General-purpose I/O port.<br>The pin is shared with LCDC SEG output (SEG21) and LIN-UART clock I/O (SCK) .   |
| 54      | P66/SEG22/<br>SOT        |                   | General-purpose I/O port.<br>The pin is shared with LCDC SEG output (SEG22) and LIN-UART data output (SOT) .   |
| 55      | P67/SEG23/<br>SIN        | N                 | General-purpose I/O port.<br>The pin is shared with LCDC SEG output (SEG23) and LIN-UART data input (SIN) .  |
| 56      | P07/INT07/<br>AN07/SEG24 | F                 | General-purpose I/O port.<br>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/<br>AN06/SEG25 |                   |  |
| 58      | P05/INT05/<br>AN05/SEG26 |                   |  |
| 59      | P04/INT04/<br>AN04/SEG27 |                   |  |
| 60      | P03/INT03/<br>AN03/SEG28 |                   |  |
| 61      | P02/INT02/<br>AN02/SEG29 |                   |  |
| 62      | P01/INT01/<br>AN01/SEG30 |                   |  |
| 63      | P00/INT00/<br>AN00/SEG31 |                   |  |
| 64      | AV <sub>SS</sub>         | —                 | 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    |         | <ul style="list-style-type: none"> <li>• Oscillation circuit</li> <li>• High-speed side<br/>Feedback resistance : approx. 1 MΩ</li> <li>• Low-speed side<br/>- Feedback resistance : approx. 24 MΩ (Evaluation product : approx. 10 MΩ)<br/>- Dumping resistance : approx. 144 kΩ (Evaluation product : without dumping resistance)</li> </ul> |
| B    |         | <ul style="list-style-type: none"> <li>• Only for input</li> <li>• Hysteresis input only for Mask ROM product</li> <li>• Pull-down resistor only for MODE pin of Mask ROM product</li> </ul>   |
| B'   |         | Hysteresis input   |
| F    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• LCD output</li> <li>• Hysteresis input</li> <li>• Analog input</li> </ul>  |
| G    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• CMOS input</li> <li>• Hysteresis input</li> <li>• With pull-up control</li> </ul>  |

(Continued)

# MB95160 Series

| Type | Circuit | Remarks   |
|------|---------|---|
| H    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• Hysteresis input</li> <li>• With pull-up control</li> </ul>             |
| I    |         | <ul style="list-style-type: none"> <li>• N-ch open drain output</li> <li>• CMOS input</li> <li>• Hysteresis input</li> </ul>            |
| M    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• LCD output</li> <li>• Hysteresis input</li> </ul>                       |
| N    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• LCD output</li> <li>• CMOS input</li> <li>• Hysteresis input</li> </ul> |
| R    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• LCD power supply</li> <li>• Hysteresis input</li> </ul>                 |

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| Type | Circuit | Remarks   |
|------|---------|---|
| S    |         | <ul style="list-style-type: none"> <li>• CMOS output</li> <li>• Hysteresis input</li> </ul> |

## ■ 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  $V_{CC}$  power-supply voltage.

For stabilization, in principle, keep the variation in  $V_{CC}$  ripple (p-p value) in a commercial frequency range (50/60 Hz) not to exceed 10% of the standard  $V_{CC}$  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 k $\Omega$ . 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  $\mu$ F 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  $\mu$ F ceramic capacitor as a bypass capacitor between  $AV_{CC}$  and  $AV_{SS}$  pins in the vicinity of this device.

# MB95160 Series

## ■ 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)   |
| FPT-64P-M24 | TEF110-95F168HPMC1       | AF9709/B (Ver 02.35G or more)<br>AF9723+AF9834 (Ver 02.08E or more) |

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:

| Flash memory | CPU address       | Programmer address* |
|--------------|-------------------|---------------------|
| 32 Kbytes    | 8000 <sub>H</sub> | 18000 <sub>H</sub>  |
|              | FFFF <sub>H</sub> | 1FFFF <sub>H</sub>  |

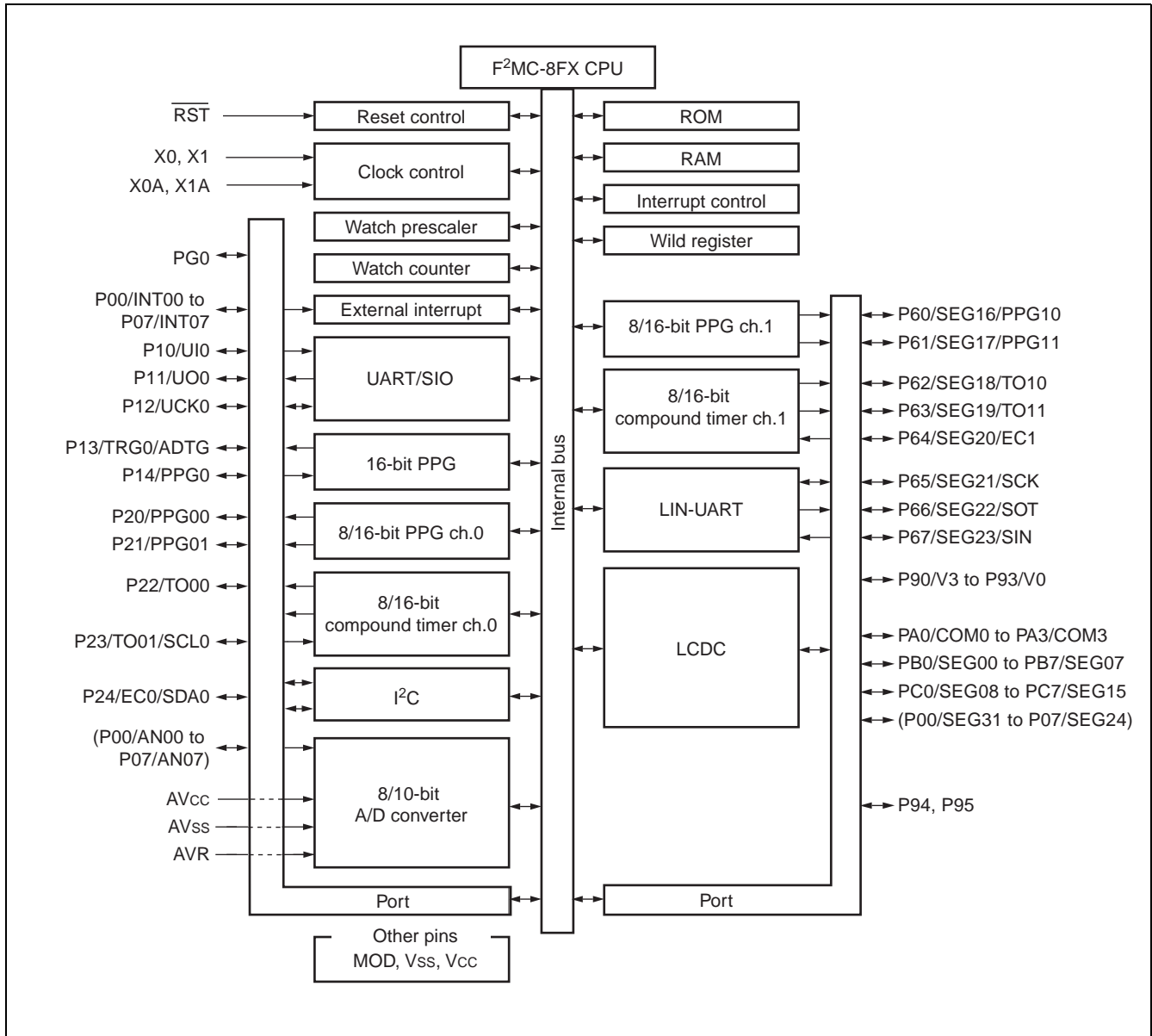
\*: Programmer addresses are corresponding to CPU addresses, used when the parallel programmer programs data into Flash memory.  
These programmer addresses are used for the parallel programmer to program or erase data in Flash memory.

### • Programming Method

- 1) Set the type code of the parallel programmer to "17222".
- 2) Load program data to programmer addresses 18000<sub>H</sub> to 1FFFF<sub>H</sub>.
- 3) Programmed by parallel programmer



## ■ BLOCK DIAGRAM



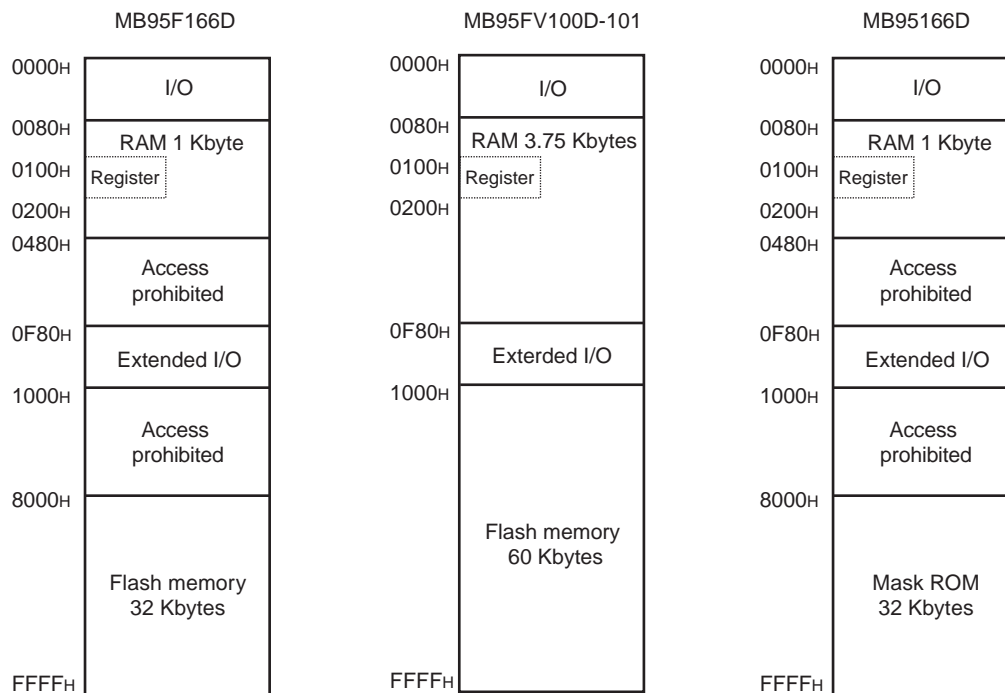
# MB95160 Series

## ■ 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.

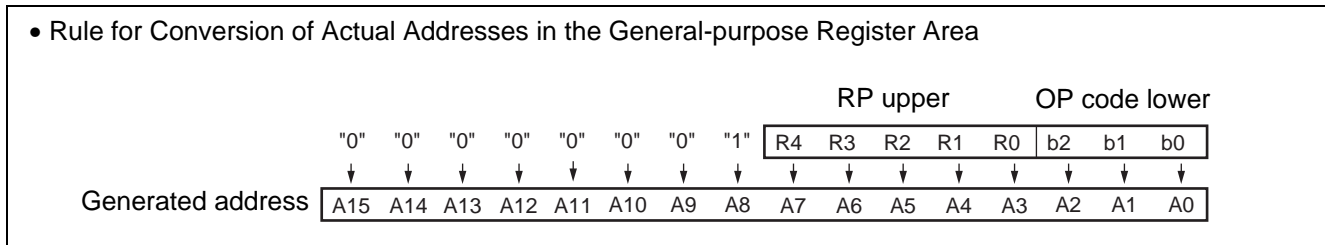
#### • Memory Map





# MB95160 Series

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:



The DP specifies the area for mapping instructions (16 different instructions such as MOV A, dir) using direct addresses to 0080H to 00FFH.

| Direct bank pointer (DP2 to DP0)        | Specified address area                 | Mapping area   |
|---|--|--|
| XXX <sub>B</sub> (no effect to mapping) | 0000 <sub>H</sub> to 007F <sub>H</sub> | 0000 <sub>H</sub> to 007F <sub>H</sub> (without mapping) |
| 000 <sub>B</sub> (initial value)        | 0080 <sub>H</sub> to 00FF <sub>H</sub> | 0080 <sub>H</sub> to 00FF <sub>H</sub> (without mapping) |
| 001 <sub>B</sub>                        |  | 0100 <sub>H</sub> to 017F <sub>H</sub>                   |
| 010 <sub>B</sub>                        |  | 0180 <sub>H</sub> to 01FF <sub>H</sub>                   |
| 011 <sub>B</sub>                        |  | 0200 <sub>H</sub> to 027F <sub>H</sub>                   |
| 100 <sub>B</sub>                        |  | 0280 <sub>H</sub> to 02FF <sub>H</sub>                   |
| 101 <sub>B</sub>                        |  | 0300 <sub>H</sub> to 037F <sub>H</sub>                   |
| 110 <sub>B</sub>                        |  | 0380 <sub>H</sub> to 03FF <sub>H</sub>                   |
| 111 <sub>B</sub>                        |  | 0400 <sub>H</sub> to 047F <sub>H</sub>                   |

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<br>↑<br>↓<br>Low (no interruption) |
| 0   | 1   | 1               |   |
| 1   | 0   | 2               |   |
| 1   | 1   | 3               |   |

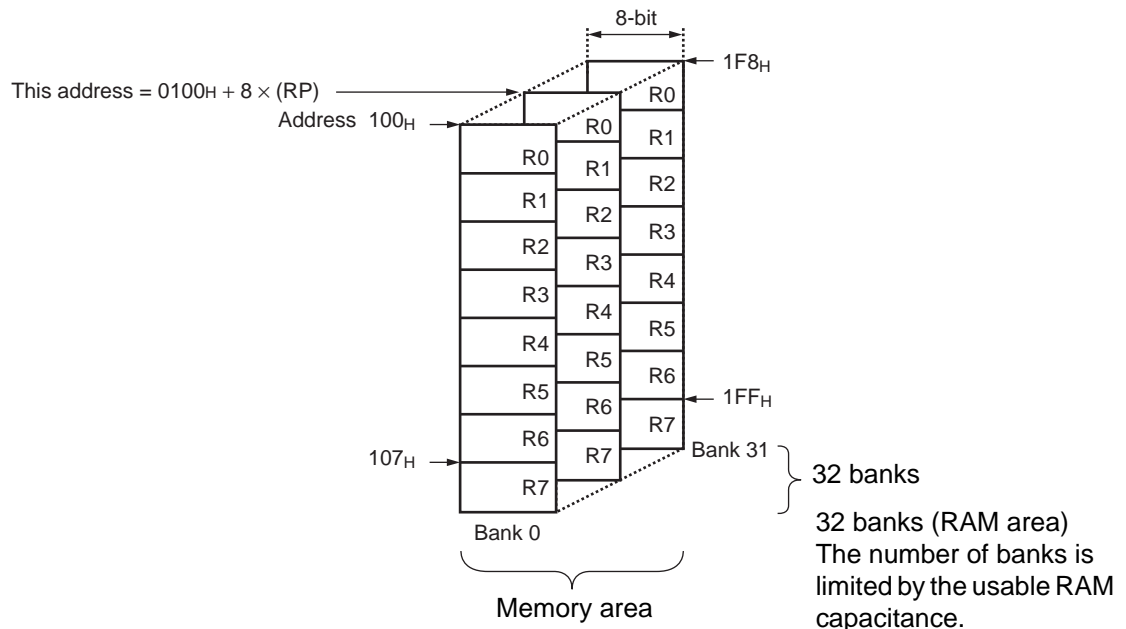
- N flag : Set to "1" if the MSB is set to "1" as the result of an arithmetic operation. Cleared to "0" when the bit is set to "0".
- Z flag : Set to "1" when an arithmetic operation results in "0". Cleared to "0" otherwise.
- V flag : Set to "1" if the complement on 2 overflows as a result of an arithmetic 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



# MB95160 Series

## ■ I/O MAP

| Address                                      | Register abbreviation | Register name  | R/W | Initial value         |
|--|-----------------------|--|-----|-----------------------|
| 0000 <sub>H</sub>                            | PDR0                  | Port 0 data register                                 | R/W | 00000000 <sub>B</sub> |
| 0001 <sub>H</sub>                            | DDR0                  | Port 0 direction register                            | R/W | 00000000 <sub>B</sub> |
| 0002 <sub>H</sub>                            | PDR1                  | Port 1 data register                                 | R/W | 00000000 <sub>B</sub> |
| 0003 <sub>H</sub>                            | DDR1                  | Port 1 direction register                            | R/W | 00000000 <sub>B</sub> |
| 0004 <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0005 <sub>H</sub>                            | WATR                  | Oscillation stabilization wait time setting register | R/W | 11111111 <sub>B</sub> |
| 0006 <sub>H</sub>                            | PLLC                  | PLL control register                                 | R/W | 00000000 <sub>B</sub> |
| 0007 <sub>H</sub>                            | SYCC                  | System clock control register                        | R/W | 1010X011 <sub>B</sub> |
| 0008 <sub>H</sub>                            | STBC                  | Standby control register                             | R/W | 00000000 <sub>B</sub> |
| 0009 <sub>H</sub>                            | RSRR                  | Reset factor register                                | R/W | XXXXXXXX <sub>B</sub> |
| 000A <sub>H</sub>                            | TBTC                  | Timebase timer control register                      | R/W | 00000000 <sub>B</sub> |
| 000B <sub>H</sub>                            | WPCR                  | Watch prescaler control register                     | R/W | 00000000 <sub>B</sub> |
| 000C <sub>H</sub>                            | WDTC                  | Watchdog timer control register                      | R/W | 00000000 <sub>B</sub> |
| 000D <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 000E <sub>H</sub>                            | PDR2                  | Port 2 data register                                 | R/W | 00000000 <sub>B</sub> |
| 000F <sub>H</sub>                            | DDR2                  | Port 2 direction register                            | R/W | 00000000 <sub>B</sub> |
| 0010 <sub>H</sub><br>to<br>0015 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0016 <sub>H</sub>                            | PDR6                  | Port 6 data register                                 | R/W | 00000000 <sub>B</sub> |
| 0017 <sub>H</sub>                            | DDR6                  | Port 6 direction register                            | R/W | 00000000 <sub>B</sub> |
| 0018 <sub>H</sub><br>to<br>001B <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 001C <sub>H</sub>                            | PDR9                  | Port 9 data register                                 | R/W | 00000000 <sub>B</sub> |
| 001D <sub>H</sub>                            | DDR9                  | Port 9 direction register                            | R/W | 00000000 <sub>B</sub> |
| 001E <sub>H</sub>                            | PDRA                  | Port A data register                                 | R/W | 00000000 <sub>B</sub> |
| 001F <sub>H</sub>                            | DDRA                  | Port A direction register                            | R/W | 00000000 <sub>B</sub> |
| 0020 <sub>H</sub>                            | PDRB                  | Port B data register                                 | R/W | 00000000 <sub>B</sub> |
| 0021 <sub>H</sub>                            | DDRB                  | Port B direction register                            | R/W | 00000000 <sub>B</sub> |
| 0022 <sub>H</sub>                            | PDRC                  | Port C data register                                 | R/W | 00000000 <sub>B</sub> |
| 0023 <sub>H</sub>                            | DDRC                  | Port C direction register                            | R/W | 00000000 <sub>B</sub> |
| 0024 <sub>H</sub><br>to<br>0029 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |

(Continued)

| Address                                      | Register abbreviation | Register name   | R/W | Initial value         |
|--|-----------------------|---|-----|-----------------------|
| 002A <sub>H</sub>                            | PDRG                  | Port G data register                                      | R/W | 00000000 <sub>B</sub> |
| 002B <sub>H</sub>                            | DDRG                  | Port G direction register                                 | R/W | 00000000 <sub>B</sub> |
| 002C <sub>H</sub>                            | —                     | (Disabled)  | —   | —                     |
| 002D <sub>H</sub>                            | PUL1                  | Port 1 pull-up register                                   | R/W | 00000000 <sub>B</sub> |
| 002E <sub>H</sub>                            | PUL2                  | Port 2 pull-up register                                   | R/W | 00000000 <sub>B</sub> |
| 002F <sub>H</sub><br>to<br>0034 <sub>H</sub> | —                     | (Disabled)  | —   | —                     |
| 0035 <sub>H</sub>                            | PULG                  | Port G pull-up control register                           | R/W | 00000000 <sub>B</sub> |
| 0036 <sub>H</sub>                            | T01CR1                | 8/16-bit compound timer 01 control status register 1 ch.0 | R/W | 00000000 <sub>B</sub> |
| 0037 <sub>H</sub>                            | T00CR1                | 8/16-bit compound timer 00 control status register 1 ch.0 | R/W | 00000000 <sub>B</sub> |
| 0038 <sub>H</sub>                            | T11CR1                | 8/16-bit compound timer 11 control status register 1 ch.1 | R/W | 00000000 <sub>B</sub> |
| 0039 <sub>H</sub>                            | T10CR1                | 8/16-bit compound timer 10 control status register 1 ch.1 | R/W | 00000000 <sub>B</sub> |
| 003A <sub>H</sub>                            | PC01                  | 8/16-bit PPG1 control register ch.0                       | R/W | 00000000 <sub>B</sub> |
| 003B <sub>H</sub>                            | PC00                  | 8/16-bit PPG0 control register ch.0                       | R/W | 00000000 <sub>B</sub> |
| 003C <sub>H</sub>                            | PC11                  | 8/16-bit PPG1 control register ch.1                       | R/W | 00000000 <sub>B</sub> |
| 003D <sub>H</sub>                            | PC10                  | 8/16-bit PPG0 control register ch.1                       | R/W | 00000000 <sub>B</sub> |
| 003E <sub>H</sub><br>to<br>0041 <sub>H</sub> | —                     | (Disabled)  | —   | —                     |
| 0042 <sub>H</sub>                            | PCNTH0                | 16-bit PPG status control register (upper byte) ch.0      | R/W | 00000000 <sub>B</sub> |
| 0043 <sub>H</sub>                            | PCNTL0                | 16-bit PPG status control register (lower byte) ch.0      | R/W | 00000000 <sub>B</sub> |
| 0044 <sub>H</sub><br>to<br>0047 <sub>H</sub> | —                     | (Disabled)  | —   | —                     |
| 0048 <sub>H</sub>                            | EIC00                 | External interrupt circuit control register ch.0/ch.1     | R/W | 00000000 <sub>B</sub> |
| 0049 <sub>H</sub>                            | EIC10                 | External interrupt circuit control register ch.2/ch.3     | R/W | 00000000 <sub>B</sub> |
| 004A <sub>H</sub>                            | EIC20                 | External interrupt circuit control register ch.4/ch.5     | R/W | 00000000 <sub>B</sub> |
| 004B <sub>H</sub>                            | EIC30                 | External interrupt circuit control register ch.6/ch.7     | R/W | 00000000 <sub>B</sub> |
| 004C <sub>H</sub><br>to<br>004F <sub>H</sub> | —                     | (Disabled)  | —   | —                     |
| 0050 <sub>H</sub>                            | SCR                   | LIN-UART serial control register                          | R/W | 00000000 <sub>B</sub> |
| 0051 <sub>H</sub>                            | SMR                   | LIN-UART serial mode register                             | R/W | 00000000 <sub>B</sub> |
| 0052 <sub>H</sub>                            | SSR                   | LIN-UART serial status register                           | R/W | 00001000 <sub>B</sub> |
| 0053 <sub>H</sub>                            | RDR/TDR               | LIN-UART reception/transmission data register             | R/W | 00000000 <sub>B</sub> |
| 0054 <sub>H</sub>                            | ESCR                  | LIN-UART extended status control register                 | R/W | 00000100 <sub>B</sub> |

(Continued)

# MB95160 Series

| Address                                      | Register abbreviation | Register name  | R/W | Initial value         |
|--|-----------------------|--|-----|-----------------------|
| 0055 <sub>H</sub>                            | ECCR                  | LIN-UART extended communication control register                   | R/W | 000000XX <sub>B</sub> |
| 0056 <sub>H</sub>                            | SMC10                 | UART/SIO serial mode control register 1 ch.0                       | R/W | 00000000 <sub>B</sub> |
| 0057 <sub>H</sub>                            | SMC20                 | UART/SIO serial mode control register 2 ch.0                       | R/W | 00100000 <sub>B</sub> |
| 0058 <sub>H</sub>                            | SSR0                  | UART/SIO serial status register ch.0                               | R/W | 00000001 <sub>B</sub> |
| 0059 <sub>H</sub>                            | TDR0                  | UART/SIO serial output data register ch. 0                         | R/W | 00000000 <sub>B</sub> |
| 005A <sub>H</sub>                            | RDR0                  | UART/SIO serial input data register ch.0                           | R   | 00000000 <sub>B</sub> |
| 005B <sub>H</sub><br>to<br>005F <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0060 <sub>H</sub>                            | IBCR00                | I <sup>2</sup> C bus control register 0 ch.0                       | R/W | 00000000 <sub>B</sub> |
| 0061 <sub>H</sub>                            | IBCR10                | I <sup>2</sup> C bus control register 1 ch.0                       | R/W | 00000000 <sub>B</sub> |
| 0062 <sub>H</sub>                            | IBSR0                 | I <sup>2</sup> C bus status register ch.0                          | R   | 00000000 <sub>B</sub> |
| 0063 <sub>H</sub>                            | IDDR0                 | I <sup>2</sup> C data register ch.0                                | R/W | 00000000 <sub>B</sub> |
| 0064 <sub>H</sub>                            | IAAR0                 | I <sup>2</sup> C address register ch.0                             | R/W | 00000000 <sub>B</sub> |
| 0065 <sub>H</sub>                            | ICCR0                 | I <sup>2</sup> C clock control register ch.0                       | R/W | 00000000 <sub>B</sub> |
| 0066 <sub>H</sub><br>to<br>006B <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 006C <sub>H</sub>                            | ADC1                  | 8/10-bit A/D converter control register 1                          | R/W | 00000000 <sub>B</sub> |
| 006D <sub>H</sub>                            | ADC2                  | 8/10-bit A/D converter control register 2                          | R/W | 00000000 <sub>B</sub> |
| 006E <sub>H</sub>                            | ADDH                  | 8/10-bit A/D converter data register (upper byte)                  | R/W | 00000000 <sub>B</sub> |
| 006F <sub>H</sub>                            | ADDL                  | 8/10-bit A/D converter data register (lower byte)                  | R/W | 00000000 <sub>B</sub> |
| 0070 <sub>H</sub>                            | WCSR                  | Watch counter status register                                      | R/W | 00000000 <sub>B</sub> |
| 0071 <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0072 <sub>H</sub>                            | FSR*                  | Flash memory status register                                       | R/W | 000X0000 <sub>B</sub> |
| 0073 <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0074 <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0075 <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0076 <sub>H</sub>                            | WREN                  | Wild register address compare enable register                      | R/W | 00000000 <sub>B</sub> |
| 0077 <sub>H</sub>                            | WROR                  | Wild register data test setting register                           | R/W | 00000000 <sub>B</sub> |
| 0078 <sub>H</sub>                            | —                     | Register bank pointer (RP) ,<br>Mirror of direct bank pointer (DP) | —   | —                     |
| 0079 <sub>H</sub>                            | ILR0                  | Interrupt level setting register 0                                 | R/W | 11111111 <sub>B</sub> |
| 007A <sub>H</sub>                            | ILR1                  | Interrupt level setting register 1                                 | R/W | 11111111 <sub>B</sub> |
| 007B <sub>H</sub>                            | ILR2                  | Interrupt level setting register 2                                 | R/W | 11111111 <sub>B</sub> |
| 007C <sub>H</sub>                            | ILR3                  | Interrupt level setting register 3                                 | R/W | 11111111 <sub>B</sub> |

(Continued)



# MB95160 Series

| Address                                      | Register abbreviation | Register name  | R/W | Initial value         |
|--|-----------------------|--|-----|-----------------------|
| 007D <sub>H</sub>                            | ILR4                  | Interrupt level setting register 4                             | R/W | 11111111 <sub>B</sub> |
| 007E <sub>H</sub>                            | ILR5                  | Interrupt level setting register 5                             | R/W | 11111111 <sub>B</sub> |
| 007F <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0F80 <sub>H</sub>                            | WRARH0                | Wild register address setting register (upper byte) ch.0       | R/W | 00000000 <sub>B</sub> |
| 0F81 <sub>H</sub>                            | WRARL0                | Wild register address setting register (lower byte) ch.0       | R/W | 00000000 <sub>B</sub> |
| 0F82 <sub>H</sub>                            | WRDR0                 | Wild register data setting register ch.0                       | R/W | 00000000 <sub>B</sub> |
| 0F83 <sub>H</sub>                            | WRARH1                | Wild register address setting register (upper byte) ch.1       | R/W | 00000000 <sub>B</sub> |
| 0F84 <sub>H</sub>                            | WRARL1                | Wild register address setting register (lower byte) ch.1       | R/W | 00000000 <sub>B</sub> |
| 0F85 <sub>H</sub>                            | WRDR1                 | Wild register data setting register ch.1                       | R/W | 00000000 <sub>B</sub> |
| 0F86 <sub>H</sub>                            | WRARH2                | Wild register address setting register (upper byte) ch.2       | R/W | 00000000 <sub>B</sub> |
| 0F87 <sub>H</sub>                            | WRARL2                | Wild register address setting register (lower byte) ch.2       | R/W | 00000000 <sub>B</sub> |
| 0F88 <sub>H</sub>                            | WRDR2                 | Wild register data setting register ch.2                       | R/W | 00000000 <sub>B</sub> |
| 0F89 <sub>H</sub><br>to<br>0F91 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0F92 <sub>H</sub>                            | T01CR0                | 8/16-bit compound timer 01 control status register 0 ch.0      | R/W | 00000000 <sub>B</sub> |
| 0F93 <sub>H</sub>                            | T00CR0                | 8/16-bit compound timer 00 control status register 0 ch.0      | R/W | 00000000 <sub>B</sub> |
| 0F94 <sub>H</sub>                            | T01DR                 | 8/16-bit compound timer 01 data register ch.0                  | R/W | 00000000 <sub>B</sub> |
| 0F95 <sub>H</sub>                            | T00DR                 | 8/16-bit compound timer 00 data register ch.0                  | R/W | 00000000 <sub>B</sub> |
| 0F96 <sub>H</sub>                            | TMCR0                 | 8/16-bit compound timer 00/01 timer mode control register ch.0 | R/W | 00000000 <sub>B</sub> |
| 0F97 <sub>H</sub>                            | T11CR0                | 8/16-bit compound timer 11 control status register 0 ch.1      | R/W | 00000000 <sub>B</sub> |
| 0F98 <sub>H</sub>                            | T10CR0                | 8/16-bit compound timer 10 control status register 0 ch.1      | R/W | 00000000 <sub>B</sub> |
| 0F99 <sub>H</sub>                            | T11DR                 | 8/16-bit compound timer 11 data register ch.1                  | R/W | 00000000 <sub>B</sub> |
| 0F9A <sub>H</sub>                            | T10DR                 | 8/16-bit compound timer 10 data register ch.1                  | R/W | 00000000 <sub>B</sub> |
| 0F9B <sub>H</sub>                            | TMCR1                 | 8/16-bit compound timer 10/11 timer mode control register ch.1 | R/W | 00000000 <sub>B</sub> |
| 0F9C <sub>H</sub>                            | PPS01                 | 8/16-bit PPG1 cycle setting buffer register ch.0               | R/W | 11111111 <sub>B</sub> |
| 0F9D <sub>H</sub>                            | PPS00                 | 8/16-bit PPG0 cycle setting buffer register ch.0               | R/W | 11111111 <sub>B</sub> |
| 0F9E <sub>H</sub>                            | PDS01                 | 8/16-bit PPG1 duty setting buffer register ch.0                | R/W | 11111111 <sub>B</sub> |
| 0F9F <sub>H</sub>                            | PDS00                 | 8/16-bit PPG0 duty setting buffer register ch.0                | R/W | 11111111 <sub>B</sub> |
| 0FA0 <sub>H</sub>                            | PPS11                 | 8/16-bit PPG1 cycle setting buffer register ch.1               | R/W | 11111111 <sub>B</sub> |
| 0FA1 <sub>H</sub>                            | PPS10                 | 8/16-bit PPG0 cycle setting buffer register ch.1               | R/W | 11111111 <sub>B</sub> |
| 0FA2 <sub>H</sub>                            | PDS11                 | 8/16-bit PPG1 duty setting buffer register ch.1                | R/W | 11111111 <sub>B</sub> |
| 0FA3 <sub>H</sub>                            | PDS10                 | 8/16-bit PPG0 duty setting buffer register ch.1                | R/W | 11111111 <sub>B</sub> |
| 0FA4 <sub>H</sub>                            | PPGS                  | 8/16-bit PPG start register                                    | R/W | 00000000 <sub>B</sub> |

(Continued)

# MB95160 Series

| Address                                      | Register abbreviation | Register name  | R/W | Initial value         |
|--|-----------------------|--|-----|-----------------------|
| 0FA5 <sub>H</sub>                            | REVC                  | 8/16-bit PPG output inversion register                                   | R/W | 00000000 <sub>B</sub> |
| 0FA6 <sub>H</sub><br>to<br>0FA9 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0FAA <sub>H</sub>                            | PDCRH0                | 16-bit PPG down counter register (upper byte) ch.0                       | R   | 00000000 <sub>B</sub> |
| 0FAB <sub>H</sub>                            | PDCRL0                | 16-bit PPG down counter register (lower byte) ch.0                       | R   | 00000000 <sub>B</sub> |
| 0FAC <sub>H</sub>                            | PCSRH0                | 16-bit PPG cycle setting buffer register (upper byte) ch.0               | R/W | 11111111 <sub>B</sub> |
| 0FAD <sub>H</sub>                            | PCSRL0                | 16-bit PPG cycle setting buffer register (lower byte) ch.0               | R/W | 11111111 <sub>B</sub> |
| 0FAE <sub>H</sub>                            | PDUTH0                | 16-bit PPG duty setting buffer register (upper byte) ch.0                | R/W | 11111111 <sub>B</sub> |
| 0FAF <sub>H</sub>                            | PDUTL0                | 16-bit PPG duty setting buffer register (lower byte) ch.0                | R/W | 11111111 <sub>B</sub> |
| 0FB0 <sub>H</sub><br>to<br>0FBB <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0FBC <sub>H</sub>                            | BGR1                  | LIN-UART baud rate generator register 1                                  | R/W | 00000000 <sub>B</sub> |
| 0FBD <sub>H</sub>                            | BGR0                  | LIN-UART baud rate generator register 0                                  | R/W | 00000000 <sub>B</sub> |
| 0FBE <sub>H</sub>                            | PSSR0                 | UART/SIO dedicated baud rate generator prescaler selecting register ch.0 | R/W | 00000000 <sub>B</sub> |
| 0FBF <sub>H</sub>                            | BRSR0                 | UART/SIO dedicated baud rate generator setting register ch.0             | R/W | 00000000 <sub>B</sub> |
| 0FC0 <sub>H</sub><br>to<br>0FC2 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0FC3 <sub>H</sub>                            | AIDRL                 | A/D input disable register (lower byte)                                  | R/W | 00000000 <sub>B</sub> |
| 0FC4 <sub>H</sub>                            | LCDC                  | LCDC control register  | R/W | 00010000 <sub>B</sub> |
| 0FC5 <sub>H</sub>                            | LCDC1                 | LCDC enable register 1   | R/W | 00110000 <sub>B</sub> |
| 0FC6 <sub>H</sub>                            | LCDC2                 | LCDC enable register 2   | R/W | 00000000 <sub>B</sub> |
| 0FC7 <sub>H</sub>                            | LCDC3                 | LCDC enable register 3   | R/W | 00000000 <sub>B</sub> |
| 0FC8 <sub>H</sub>                            | LCDC4                 | LCDC enable register 4   | R/W | 00000000 <sub>B</sub> |
| 0FC9 <sub>H</sub>                            | LCDC5                 | LCDC enable register 5   | R/W | 00000000 <sub>B</sub> |
| 0FCA <sub>H</sub>                            | —                     | (Disabled)   | —   | —                     |
| 0FCB <sub>H</sub>                            | LCDCB1                | LCDC blinking setting register 1   | R/W | 00000000 <sub>B</sub> |
| 0FCC <sub>H</sub>                            | LCDCB2                | LCDC blinking setting register 2   | R/W | 00000000 <sub>B</sub> |
| 0FCD <sub>H</sub><br>to<br>0FDC <sub>H</sub> | LCDRAM                | LCDC display RAM   | R/W | 00000000 <sub>B</sub> |
| 0FDD <sub>H</sub><br>to<br>0FE2 <sub>H</sub> | —                     | (Disabled)   | —   | —                     |
| 0FE3 <sub>H</sub>                            | WCDR                  | Watch counter data register  | R/W | 00111111 <sub>B</sub> |

(Continued)

(Continued)

| Address                                      | Register abbreviation | Register name                  | R/W | Initial value         |
|--|-----------------------|--------------------------------|-----|-----------------------|
| 0FE4 <sub>H</sub><br>to<br>0FED <sub>H</sub> | —                     | (Disabled)                     | —   | —                     |
| 0FEE <sub>H</sub>                            | ILSR                  | Input level selecting register | R/W | 00000000 <sub>B</sub> |
| 0FEF <sub>H</sub>                            | WICR                  | Interrupt pin control register | R/W | 01000000 <sub>B</sub> |
| 0FF0 <sub>H</sub><br>to<br>0FFF <sub>H</sub> | —                     | (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".

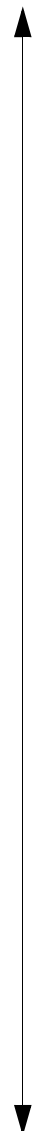
X : The initial value of this bit is undefined.

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

\* : Only for Flash product

# MB95160 Series

## ■ 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 <sub>H</sub>    | FFFB <sub>H</sub> | L00 [1 : 0]                                  | High<br><br>Low |
| External interrupt ch.4              |                          |                      |                   |  |   |
| External interrupt ch.1              | IRQ1                     | FFF8 <sub>H</sub>    | FFF9 <sub>H</sub> | L01 [1 : 0]                                  |   |
| External interrupt ch.5              |                          |                      |                   |  |   |
| External interrupt ch.2              | IRQ2                     | FFF6 <sub>H</sub>    | FFF7 <sub>H</sub> | L02 [1 : 0]                                  |   |
| External interrupt ch.6              |                          |                      |                   |  |   |
| External interrupt ch.3              | IRQ3                     | FFF4 <sub>H</sub>    | FFF5 <sub>H</sub> | L03 [1 : 0]                                  |   |
| External interrupt ch.7              |                          |                      |                   |  |   |
| UART/SIO ch.0                        | IRQ4                     | FFF2 <sub>H</sub>    | FFF3 <sub>H</sub> | L04 [1 : 0]                                  |   |
| 8/16-bit compound timer ch.0 (Lower) | IRQ5                     | FFF0 <sub>H</sub>    | FFF1 <sub>H</sub> | L05 [1 : 0]                                  |   |
| 8/16-bit compound timer ch.0 (Upper) | IRQ6                     | FFEE <sub>H</sub>    | FFEF <sub>H</sub> | L06 [1 : 0]                                  |   |
| LIN-UART (reception)                 | IRQ7                     | FFEC <sub>H</sub>    | FFED <sub>H</sub> | L07 [1 : 0]                                  |   |
| LIN-UART (transmission)              | IRQ8                     | FFEA <sub>H</sub>    | FFEB <sub>H</sub> | L08 [1 : 0]                                  |   |
| 8/16-bit PPG ch.1 (Lower)            | IRQ9                     | FFE8 <sub>H</sub>    | FFE9 <sub>H</sub> | L09 [1 : 0]                                  |   |
| 8/16-bit PPG ch.1 (Upper)            | IRQ10                    | FFE6 <sub>H</sub>    | FFE7 <sub>H</sub> | L10 [1 : 0]                                  |   |
| (Unused)                             | IRQ11                    | FFE4 <sub>H</sub>    | FFE5 <sub>H</sub> | L11 [1 : 0]                                  |   |
| 8/16-bit PPG ch.0 (Upper)            | IRQ12                    | FFE2 <sub>H</sub>    | FFE3 <sub>H</sub> | L12 [1 : 0]                                  |   |
| 8/16-bit PPG ch.0 (Lower)            | IRQ13                    | FFE0 <sub>H</sub>    | FFE1 <sub>H</sub> | L13 [1 : 0]                                  |   |
| 8/16-bit compound timer ch.1 (Upper) | IRQ14                    | FFDE <sub>H</sub>    | FFDF <sub>H</sub> | L14 [1 : 0]                                  |   |
| 16-bit PPG ch.0                      | IRQ15                    | FFDC <sub>H</sub>    | FFDD <sub>H</sub> | L15 [1 : 0]                                  |   |
| I <sup>2</sup> C ch.0                | IRQ16                    | FFDA <sub>H</sub>    | FFDB <sub>H</sub> | L16 [1 : 0]                                  |   |
| (Unused)                             | IRQ17                    | FFD8 <sub>H</sub>    | FFD9 <sub>H</sub> | L17 [1 : 0]                                  |   |
| 8/10-bit A/D converter               | IRQ18                    | FFD6 <sub>H</sub>    | FFD7 <sub>H</sub> | L18 [1 : 0]                                  |   |
| Timebase timer                       | IRQ19                    | FFD4 <sub>H</sub>    | FFD5 <sub>H</sub> | L19 [1 : 0]                                  |   |
| Watch prescaler/Watch counter        | IRQ20                    | FFD2 <sub>H</sub>    | FFD3 <sub>H</sub> | L20 [1 : 0]                                  |   |
| (Unused)                             | IRQ21                    | FFD0 <sub>H</sub>    | FFD1 <sub>H</sub> | L21 [1 : 0]                                  |   |
| 8/16-bit compound timer ch.1 (Lower) | IRQ22                    | FFCE <sub>H</sub>    | FFCF <sub>H</sub> | L22 [1 : 0]                                  |   |
| Flash memory                         | IRQ23                    | FFCC <sub>H</sub>    | FFCD <sub>H</sub> | L23 [1 : 0]                                  |   |

## ■ ELECTRICAL CHARACTERISTICS

### 1. Absolute Maximum Ratings

| Parameter                              | Symbol                                | Rating                |                       | Unit | Remarks  |
|--|---------------------------------------|-----------------------|-----------------------|------|--|
|  |                                       | Min                   | Max                   |      |  |
| Power supply voltage*1                 | V <sub>CC</sub> ,<br>AV <sub>CC</sub> | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 4.0 | V    | *2   |
|  | AVR                                   | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 4.0 |      | *2   |
| Power supply voltage for LCD           | V0 to V3                              | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 4.0 | V    | *3   |
| Input voltage*1                        | V <sub>I</sub>                        | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 6.0 | V    | P23, P24*4   |
|  |                                       | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 4.0 | V    | Other than P23, P24*4  |
| Output voltage*1                       | V <sub>O</sub>                        | V <sub>SS</sub> – 0.3 | V <sub>SS</sub> + 4.0 | V    | *4   |
| Maximum clamp current                  | I <sub>CLAMP</sub>                    | – 2.0                 | + 2.0                 | mA   | Applicable to pins*5   |
| Total maximum clamp current            | Σ I <sub>CLAMP</sub>                  | —                     | 20                    | mA   | Applicable to pins*5   |
| “L” level maximum output current       | I <sub>OL</sub>                       | —                     | 15                    | mA   | Applicable to pins*5   |
| “L” level average current              | I <sub>OLAV</sub>                     | —                     | 4                     | mA   | Applicable to pins*5<br>Average output current =<br>operating current × operating ratio<br>(1 pin) |
| “L” level total maximum output current | ΣI <sub>OL</sub>                      | —                     | 100                   | mA   |  |
| “L” level total average output current | ΣI <sub>OLAV</sub>                    | —                     | 50                    | mA   | Total average output current =<br>operating current × operating ratio<br>(Total of pins)           |
| “H” level maximum output current       | I <sub>OH</sub>                       | —                     | – 15                  | mA   | Applicable to pins*5   |
| “H” level average current              | I <sub>OHAV</sub>                     | —                     | – 4                   | mA   | Applicable to pins*5<br>Average output current =<br>operating current × operating ratio<br>(1 pin) |
| “H” level total maximum output current | ΣI <sub>OH</sub>                      | —                     | – 100                 | mA   |  |
| “H” level total average output current | ΣI <sub>OHAV</sub>                    | —                     | – 50                  | mA   | Total average output current =<br>operating current × operating ratio<br>(Total of pins)           |
| Power consumption                      | P <sub>d</sub>                        | —                     | 320                   | mW   |  |
| Operating temperature                  | T <sub>A</sub>                        | – 40                  | + 85                  | °C   |  |
| Storage temperature                    | T <sub>stg</sub>                      | – 55                  | + 150                 | °C   |  |

\*1 : The parameter is based on V<sub>SS</sub> = 0.0 V.

\*2 : Apply equal potential to AV<sub>CC</sub> and V<sub>CC</sub>. AVR should not exceed AV<sub>CC</sub> + 0.3 V.

(Continued)

# MB95160 Series

(Continued)

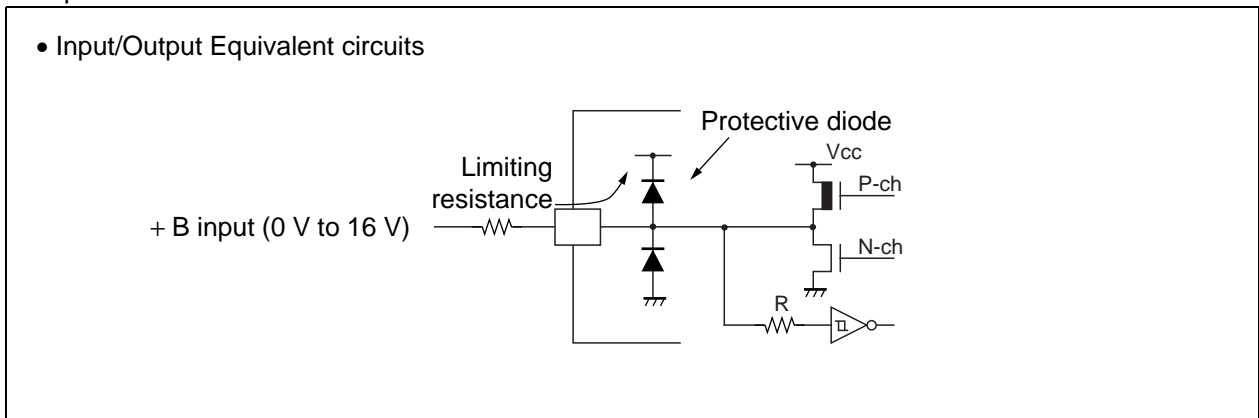
\*3 :  $V_0$  to  $V_3$  should not exceed  $V_{CC} + 0.3$  V.

\*4 :  $V_I$  and  $V_O$  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 :



**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

(V<sub>SS</sub> = 0.0 V)

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

# MB95160 Series

## 3. DC Characteristics

( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

| Parameter   | Symbol     | 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,<br>P10 to P14,<br>P20 to P22,<br>P60 to P67,<br>P90 to P95,<br>PA0 to PA3,<br>PB0 to PB7,<br>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             |                                      |
|   | $V_{IHM}$  | $\overline{\text{RST}}$ , 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,<br>P24,P67   | —                             | $V_{SS} - 0.3$ | —   | $0.3 V_{CC}$   | V             | When selecting CMOS input level      |
|   | $V_{ILS}$  | P00 to P07,<br>P10 to P14,<br>P20 to P24,<br>P60 to P67,<br>P90 to P95,<br>PA0 to PA3,<br>PB0 to PB7,<br>PC0 to PC7 | —                             | $V_{SS} - 0.3$ | —   | $0.2 V_{CC}$   | V             | Hysteresis input                     |
|   | $V_{ILM}$  | $\overline{\text{RST}}$ , 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   | $I_{OH} = 4.0\text{ mA}$      | 2.4            | —   | —              | V             |                                      |
| "L" level output voltage                            | $V_{OL}$   | Output pins other than $\overline{\text{RST}}$  | $I_{OL} = 4.0\text{ mA}$      | —              | —   | 0.4            | V             |                                      |
| Input leakage current (Hi-Z output leakage current) | $I_{LI}$   | Ports other than P23, P24   | $0.0\text{ V} < V_I < V_{CC}$ | -5             | —   | +5             | $\mu\text{A}$ | When the pull-up prohibition setting |

(Continued)



# MB95160 Series

( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

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

(Continued)

# MB95160 Series

(Continued)

( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ )

| Parameter                        | Symbol   | Pin name                                      | Conditions  | Value  |     |     | Unit | Remarks              |
|----------------------------------|--|---|---|--|-----|-----|------|----------------------|
|                                  |  |   |   | Min  | Typ | Max |      |                      |
| Power supply current*            | I <sub>CC</sub> T  | V <sub>CC</sub><br>(External clock operation) | F <sub>CL</sub> = 32 kHz<br>Watch mode  | —  | 2   | 10  | μA   | Flash memory product |
|                                  |  |   | Main stop mode<br>T <sub>A</sub> = +25 °C   | —  | 1   | 5   | μA   | MASK ROM product     |
|                                  | I <sub>CC</sub> MPLL   |   | F <sub>CH</sub> = 4 MHz<br>F <sub>MP</sub> = 10 MHz<br>Main PLL mode<br>(multiplied by 2.5)                             | —  | 10  | 14  | mA   | Flash memory product |
|                                  |  |   | F <sub>CH</sub> = 6.4 MHz<br>F <sub>MP</sub> = 16 MHz<br>Main PLL mode<br>(multiplied by 2.5)                           | —  | 6.7 | 10  | mA   | MASK ROM product     |
|                                  | I <sub>CC</sub> SPLL   |   | F <sub>CL</sub> = 32 kHz<br>F <sub>MPL</sub> = 128 kHz<br>Sub PLL mode<br>(multiplied by 4),<br>T <sub>A</sub> = +25 °C | —  | 190 | 250 | μA   |                      |
|                                  |  |   | I <sub>CTS</sub>  | F <sub>CH</sub> = 10 MHz<br>Timebase timer mode<br>T <sub>A</sub> = +25 °C | —   | 0.4 | 0.5  | mA                   |
|                                  | I <sub>CCH</sub>   |   | Sub stop mode<br>T <sub>A</sub> = +25 °C  | —  | 1   | 5   | μA   |                      |
|                                  | I <sub>A</sub>   |   | AV <sub>CC</sub>  | F <sub>CH</sub> = 16 MHz<br>At operating of A/D conversion                 | —   | 1.3 | 2.2  | mA                   |
| I <sub>AH</sub>                  | F <sub>CH</sub> = 16 MHz<br>At stopping of A/D conversion<br>T <sub>A</sub> = +25 °C | —   |   | 1  | 5   | μA  |      |                      |
| LCD internal division resistance | R <sub>LCD</sub>   | —   | Between V3 and V <sub>SS</sub>  | —  | 300 | —   | kΩ   |                      |
| COM0 to COM3 output impedance    | R <sub>VCOM</sub>  | COM0 to COM3                                  | V1 to V3 = 5.0 V  | —  | —   | 5   | kΩ   |                      |
| SEG00 to SEG31 output impedance  | R <sub>VSEG</sub>  | SEG00 to SEG31                                |   | —  | —   | 7   | kΩ   |                      |
| LCD leak current                 | I <sub>LCDL</sub>  | V0 to V3,<br>COM0 to COM3<br>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<sub>CH</sub> and F<sub>CL</sub>.
  - Refer to “4. AC Characteristics (2) Source Clock/Machine Clock” for F<sub>MP</sub> and F<sub>MPL</sub>.

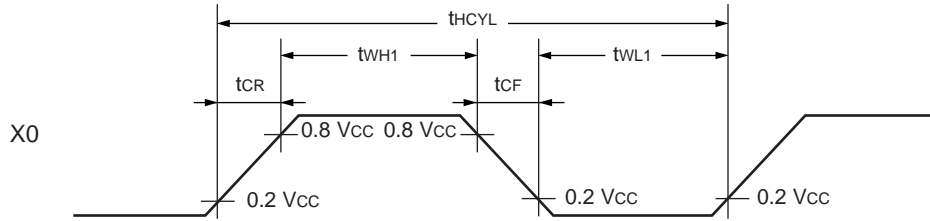
## 4. AC Characteristics

### (1) Clock Timing

(V<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to +85 °C)

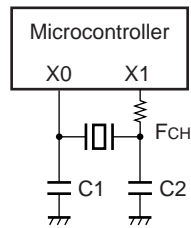
| Parameter                           | Symbol                               | Pin name | Conditions | Value  |        |       | Unit                      | Remarks  |
|-------------------------------------|--------------------------------------|----------|------------|--------|--------|-------|---------------------------|--|
|                                     |                                      |          |            | Min    | Typ    | Max   |                           |  |
| Clock frequency                     | F <sub>CH</sub>                      | 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 <sub>CL</sub>                      | X0A, X1A |            | —      | 32.768 | —     | kHz                       | When using sub oscillation circuit                           |
|                                     |                                      |          | —          | 32.768 | —      | kHz   | When using sub PLL        |  |
| Clock cycle time                    | t <sub>H CYL</sub>                   | X0, X1   | —          | 61.5   | —      | 1000  | ns                        | When using oscillation circuit                               |
|                                     |                                      |          |            | 30.8   | —      | 1000  | ns                        | When using external clock                                    |
|                                     | t <sub>L CYL</sub>                   | X0A, X1A |            | —      | 30.5   | —     | μs                        | When using sub clock,<br>When using external clock           |
| Input clock pulse width             | t <sub>WH1</sub><br>t <sub>WL1</sub> | X0       | —          | 61.5   | —      | —     | ns                        | When using external clock<br>Duty ratio is about 30% to 70%. |
|                                     | t <sub>WH2</sub><br>t <sub>WL2</sub> | X0A      |            | —      | 15.2   | —     | μs                        |  |
| Input clock rise time and fall time | t <sub>CR</sub><br>t <sub>CF</sub>   | X0, X0A  | —          | —      | 5      | ns    | When using external clock |  |

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

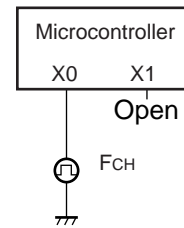


• Figure of Main Clock Input Port External Connection

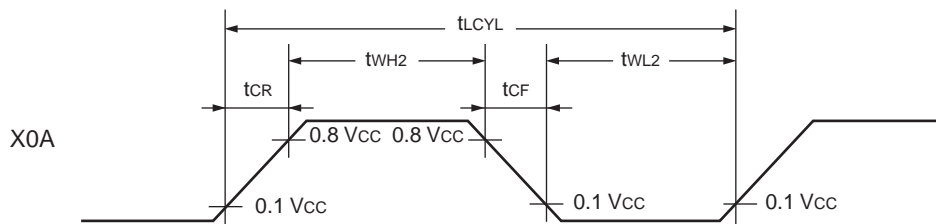
When using a crystal or ceramic oscillator



When using external clock

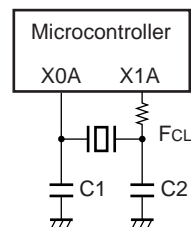


• Input wave form at external clock use (sub clock)

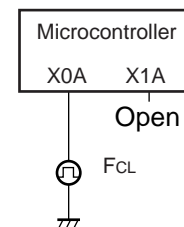


• Figure of Sub clock Input Port External Connection

When using a crystal or ceramic oscillator



When using external clock



## (2) Source Clock/Machine Clock

(V<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to +85 °C)

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

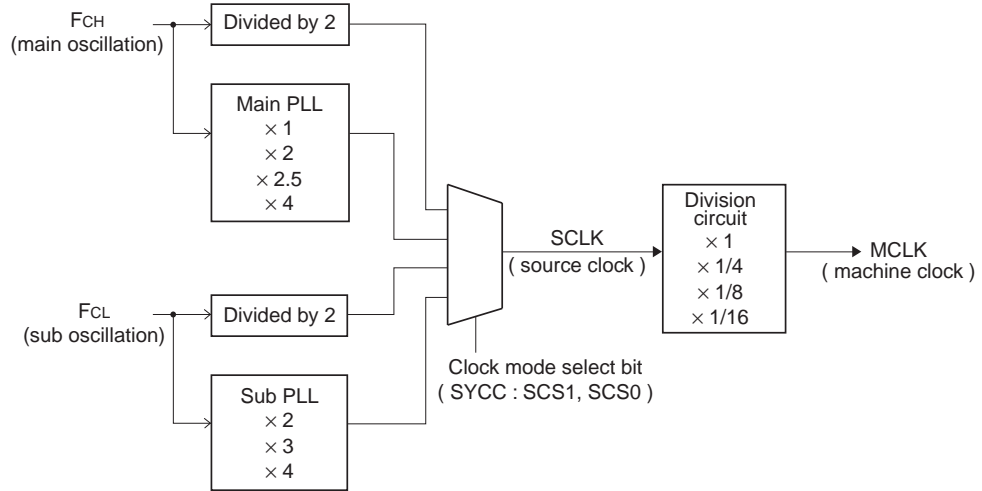
- Main clock divided by 2
- PLL multiplication of main clock (select from 1, 2, 2.5, 4 multiplication)
- Sub clock divided by 2
- PLL multiplication of sub clock (select from 2, 3, 4 multiplication)

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

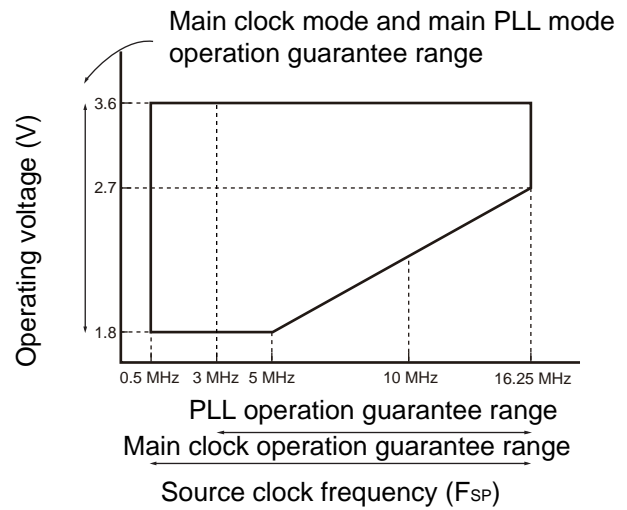
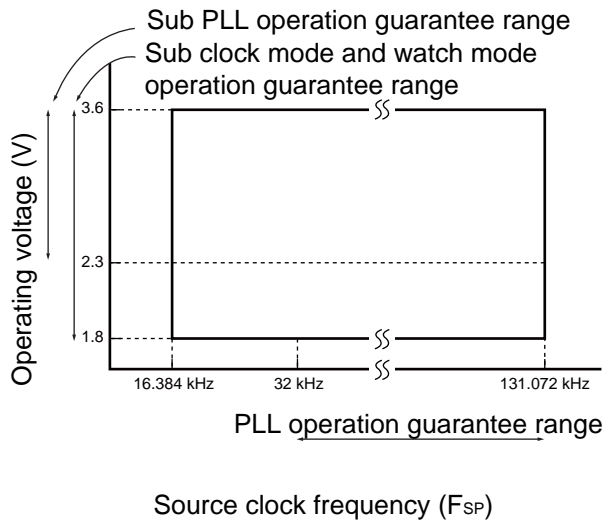
- Source clock (no division)
- Source clock divided by 4
- Source clock divided by 8
- Source clock divided by 16

# MB95160 Series

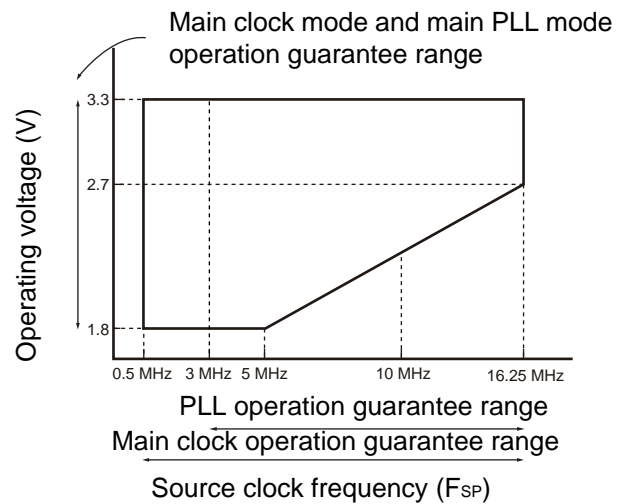
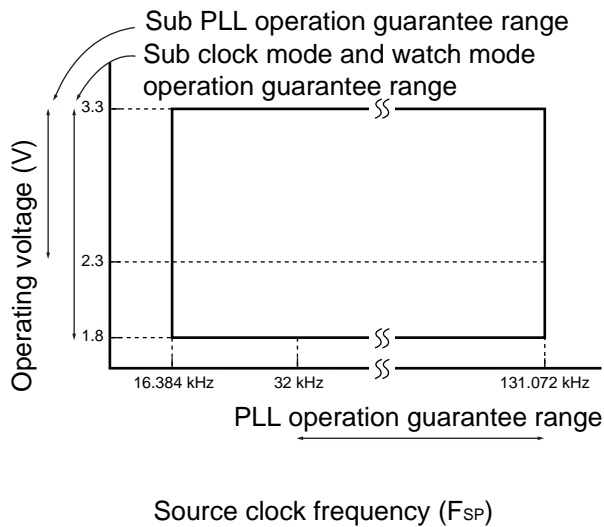
## • Outline of clock generation block



- Operating voltage - Operating frequency (When  $T_A = -10\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )
  - MB95166D

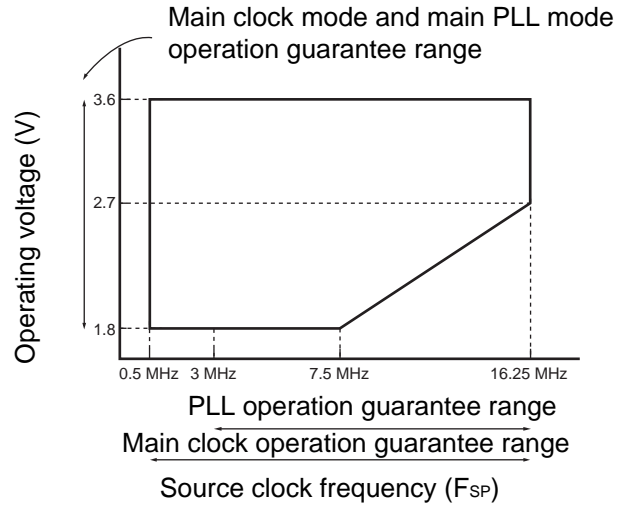
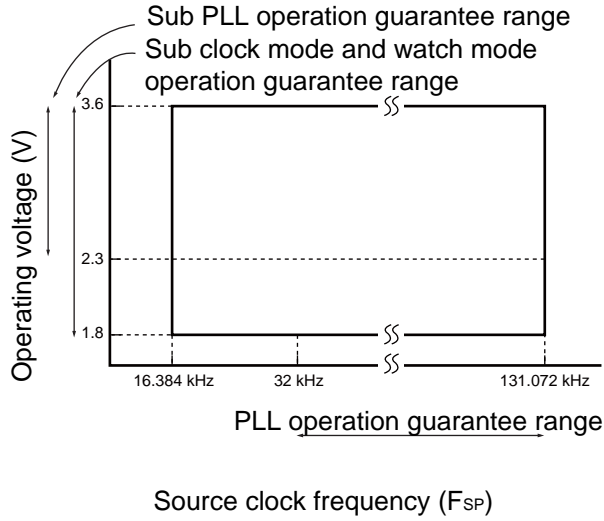


- MB95F166D

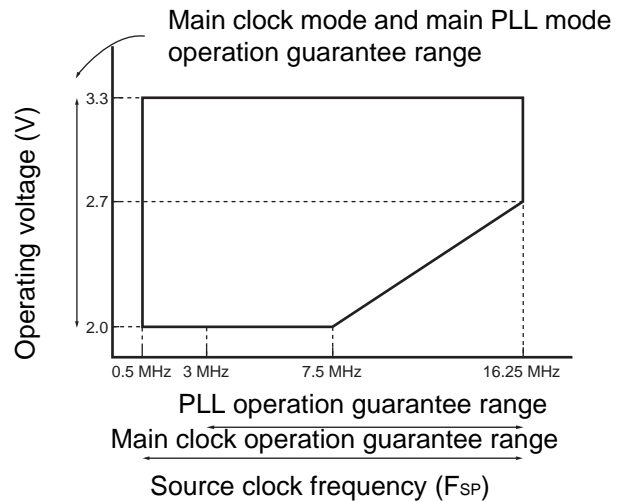
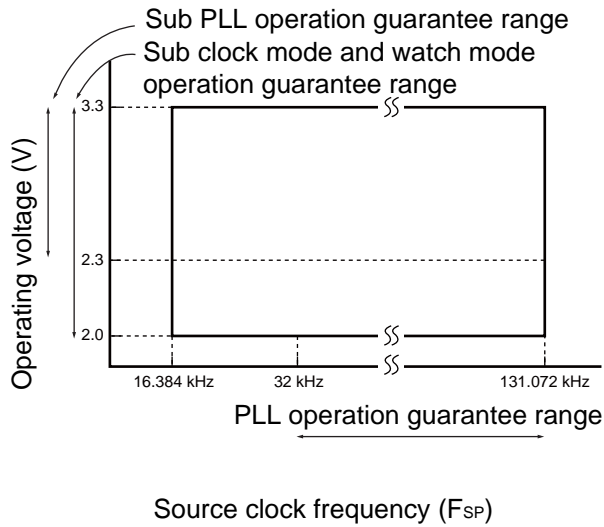


# MB95160 Series

- Operating voltage - Operating frequency (When  $T_A = -10\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )
  - MB95166D

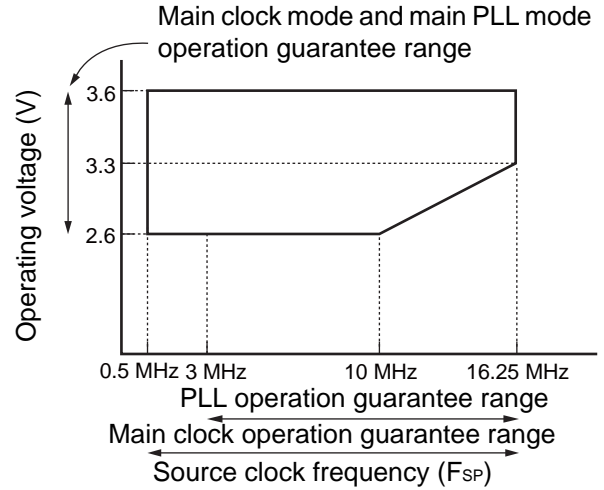
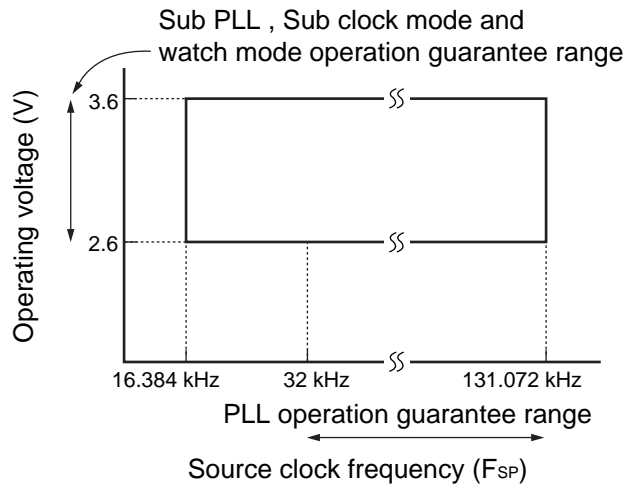


- MB95F166D



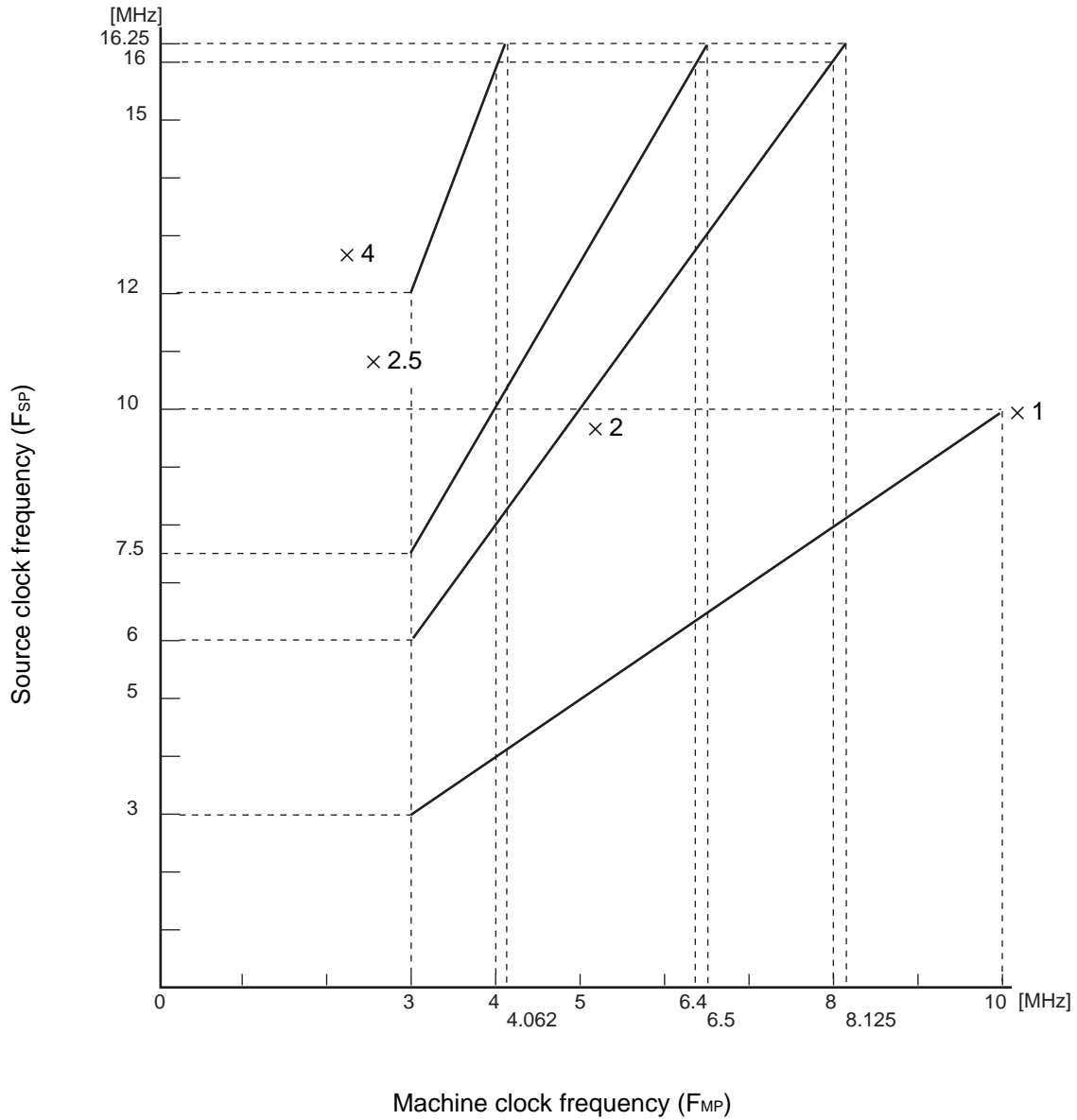


- Operating voltage - Operating frequency (When  $T_A = +5\text{ }^\circ\text{C}$  to  $+35\text{ }^\circ\text{C}$ )
  - MB95FV100D-101



# MB95160 Series

- Main PLL operation frequency



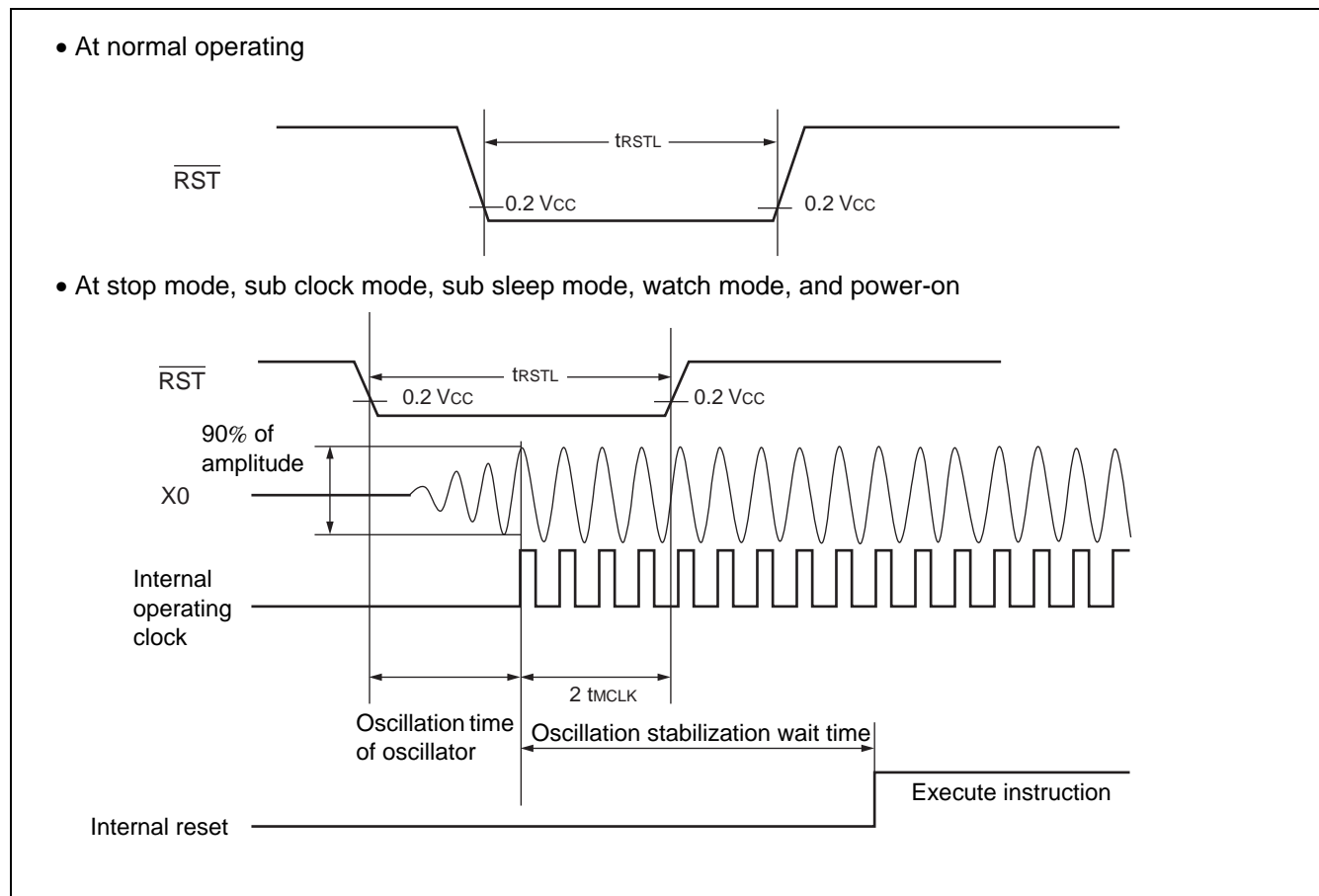
## (3) External Reset

( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ )

| Parameter                                     | Symbol            | Pin name                | Conditions | Value  |     | Unit          | Remarks  |
|---|-------------------|-------------------------|------------|--|-----|---------------|--|
|   |                   |                         |            | Min  | Max |               |  |
| $\overline{\text{RST}}$ "L" level pulse width | $t_{\text{RSTL}}$ | $\overline{\text{RST}}$ | —          | $2 t_{\text{MCLK}}^{*1}$                           | —   | ns            | At normal operating  |
|   |                   |                         |            | Oscillation time of oscillator <sup>*2</sup> + 100 | —   | $\mu\text{s}$ | At stop mode, sub clock mode, sub sleep mode, and watch mode |

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

\*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  $\mu\text{s}$  and several ms. In the external clock, the oscillation time is 0 ms.

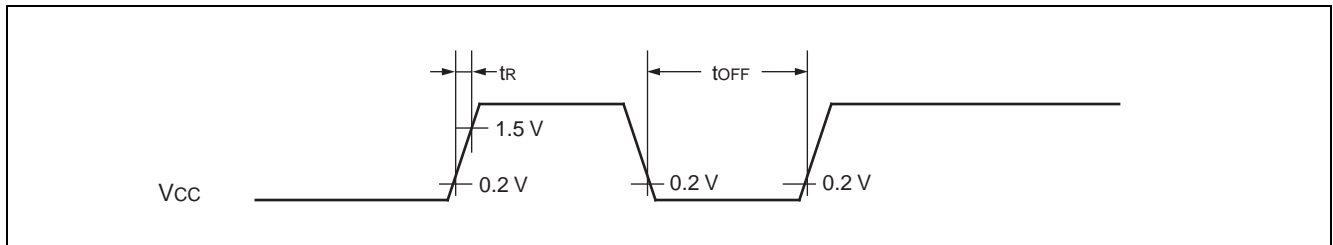


# MB95160 Series

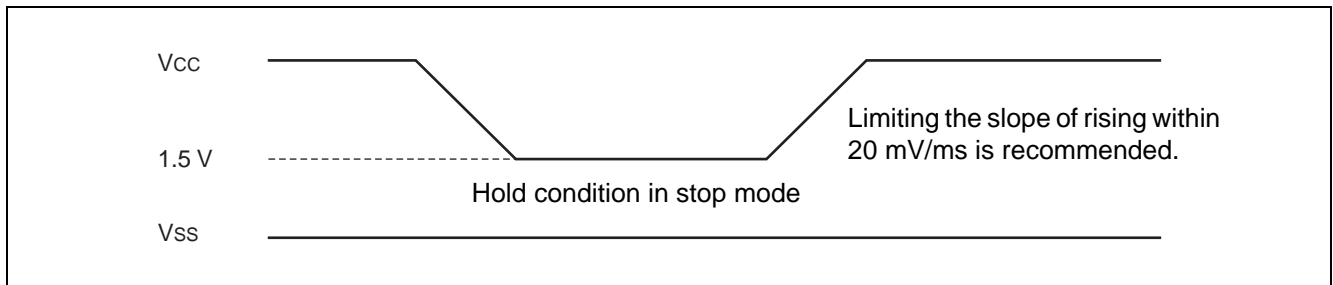
## (4) Power-on Reset

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

| 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.

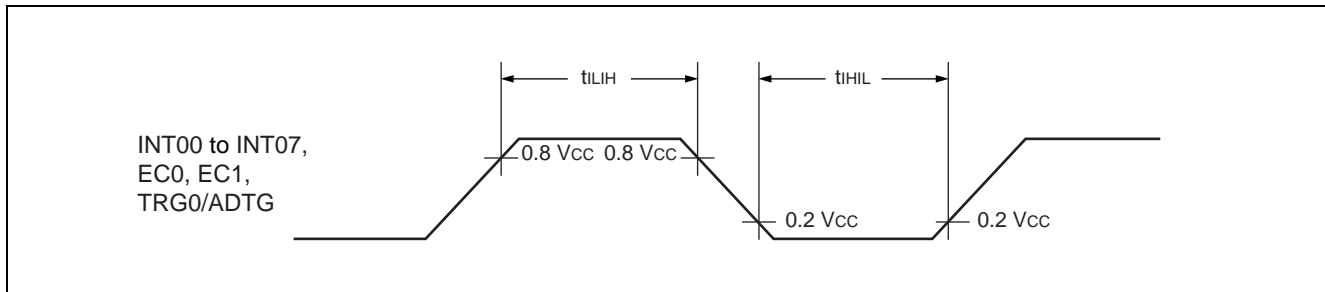


## (5) Peripheral Input Timing

(V<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to +85 °C)

| Parameter                           | Symbol           | Pin name                               | Conditions | Value                 |     | Unit |
|-------------------------------------|------------------|--|------------|-----------------------|-----|------|
|                                     |                  |  |            | Min                   | Max |      |
| Peripheral input<br>"H" pulse width | t <sub>LIH</sub> | INT00 to INT07,<br>EC0, EC1, TRG0/ADTG | —          | 2 t <sub>MCLK</sub> * | —   | ns   |
| Peripheral input<br>"L" pulse width | t <sub>HIL</sub> |  |            | 2 t <sub>MCLK</sub> * | —   | ns   |

\* : Refer to "(2) Source Clock/Machine Clock" for t<sub>MCLK</sub>.



# MB95160 Series

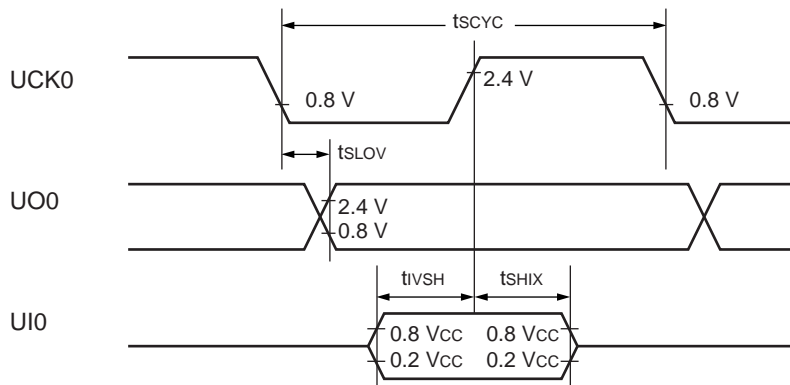
## (6) UART/SIO, Serial I/O Timing

(V<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to +85 °C)

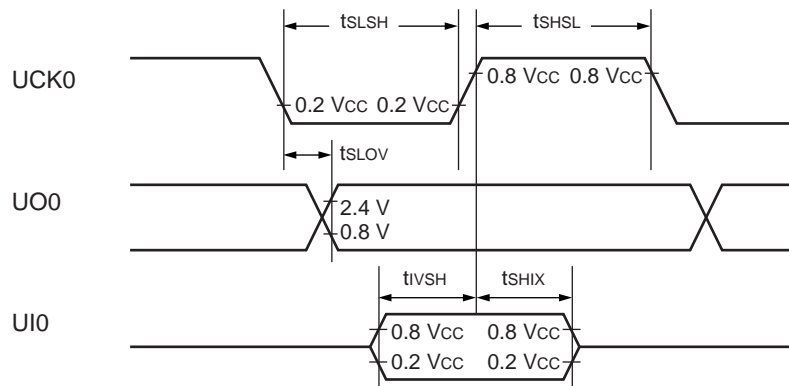
| Parameter                    | Symbol            | Pin name  | Conditions  | Value                 |       | Unit |
|------------------------------|-------------------|-----------|---|-----------------------|-------|------|
|                              |                   |           |   | Min                   | Max   |      |
| Serial clock cycle time      | t <sub>SCYC</sub> | UCK0      | Internal clock operation<br>output pin : C <sub>L</sub> = 80 pF + 1TTL. | 4 t <sub>MCLK</sub> * | —     | ns   |
| UCK ↓ → UO time              | t <sub>SLOV</sub> | UCK0, UO0 |   | - 190                 | + 190 | ns   |
| Valid UI → UCK ↑             | t <sub>IVSH</sub> | UCK0, UI0 |   | 2 t <sub>MCLK</sub> * | —     | ns   |
| UCK ↑ → valid UI hold time   | t <sub>SHIX</sub> | UCK0, UI0 |   | 2 t <sub>MCLK</sub> * | —     | ns   |
| Serial clock "H" pulse width | t <sub>SHSL</sub> | UCK0      | External clock operation<br>output pin : C <sub>L</sub> = 80 pF + 1TTL. | 4 t <sub>MCLK</sub> * | —     | ns   |
| Serial clock "L" pulse width | t <sub>SLSH</sub> | UCK0      |   | 4 t <sub>MCLK</sub> * | —     | ns   |
| UCK ↓ → UO time              | t <sub>SLOV</sub> | UCK0, UO0 |   | —                     | 190   | ns   |
| Valid UI → UCK ↑             | t <sub>IVSH</sub> | UCK0, UI0 |   | 2 t <sub>MCLK</sub> * | —     | ns   |
| UCK ↑ → valid UI hold time   | t <sub>SHIX</sub> | UCK0, UI0 | 2 t <sub>MCLK</sub> *   | —                     | ns    |      |

\* : Refer to "(2) Source Clock/Machine Clock" for t<sub>MCLK</sub>.

### • 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)

(V<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to + 85 °C)

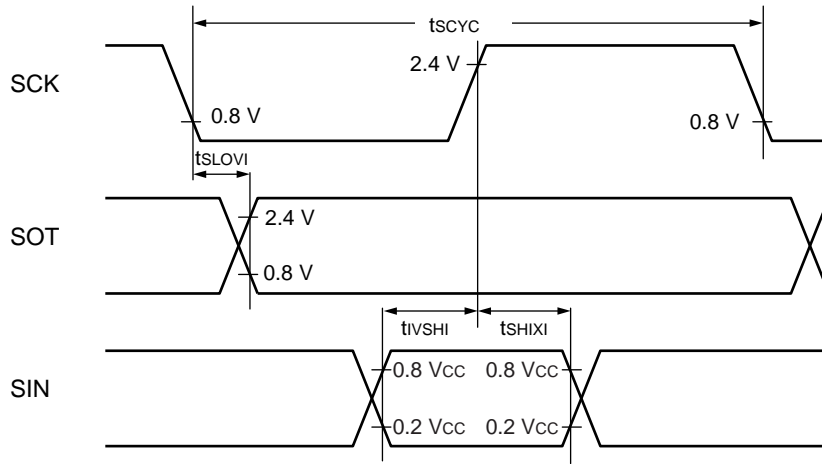
| Parameter                    | Symbol             | Pin name | Conditions  | Value                                   |                             | Unit |
|------------------------------|--------------------|----------|---|---|-----------------------------|------|
|                              |                    |          |   | Min                                     | Max                         |      |
| Serial clock cycle time      | t <sub>SCYC</sub>  | SCK      | Internal clock<br>operation output pin :<br>C <sub>L</sub> = 80 pF + 1 TTL. | 5 t <sub>MCLK</sub> *3                  | —                           | ns   |
| SCK ↓ → SOT delay time       | t <sub>SLOVI</sub> | SCK, SOT |   | -95                                     | + 95                        | ns   |
| Valid SIN → SCK ↑            | t <sub>IVSHI</sub> | SCK, SIN |   | t <sub>MCLK</sub> *3 + 190              | —                           | ns   |
| SCK ↑ → valid SIN hold time  | t <sub>SHIXI</sub> | SCK, SIN |   | 0                                       | —                           | ns   |
| Serial clock "L" pulse width | t <sub>SLSH</sub>  | SCK      | External clock<br>operation output pin :<br>C <sub>L</sub> = 80 pF + 1 TTL. | 3 t <sub>MCLK</sub> *3 - t <sub>R</sub> | —                           | ns   |
| Serial clock "H" pulse width | t <sub>SHSL</sub>  | SCK      |   | t <sub>MCLK</sub> *3 + 95               | —                           | ns   |
| SCK ↓ → SOT delay time       | t <sub>SLOVE</sub> | SCK, SOT |   | —                                       | 2 t <sub>MCLK</sub> *3 + 95 | ns   |
| Valid SIN → SCK ↑            | t <sub>IVSHE</sub> | SCK, SIN |   | 190                                     | —                           | ns   |
| SCK ↑ → valid SIN hold time  | t <sub>SHIXE</sub> | SCK, SIN |   | t <sub>MCLK</sub> *3 + 95               | —                           | ns   |
| SCK fall time                | t <sub>F</sub>     | SCK      |   | —                                       | 10                          | ns   |
| SCK rise time                | t <sub>R</sub>     | SCK      |   | —                                       | 10                          | ns   |

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

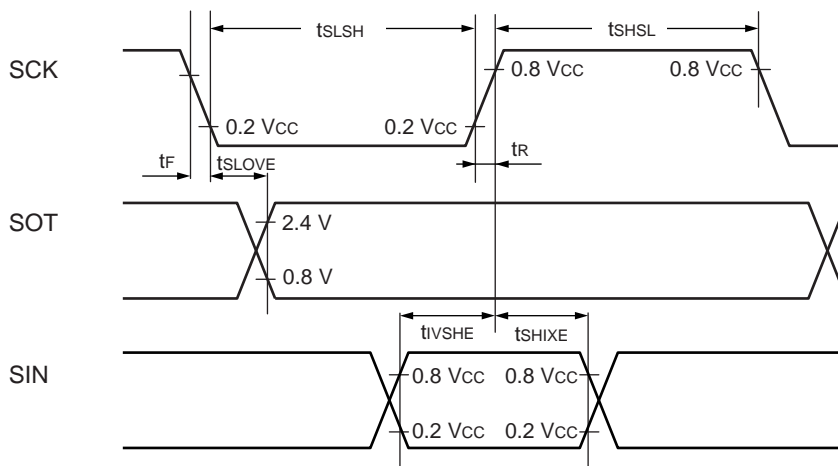
\*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

\*3 : Refer to " (2) Source Clock/Machine Clock" for t<sub>MCLK</sub>.

- 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<sub>CC</sub> = 3.3 V, V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to + 85 °C)

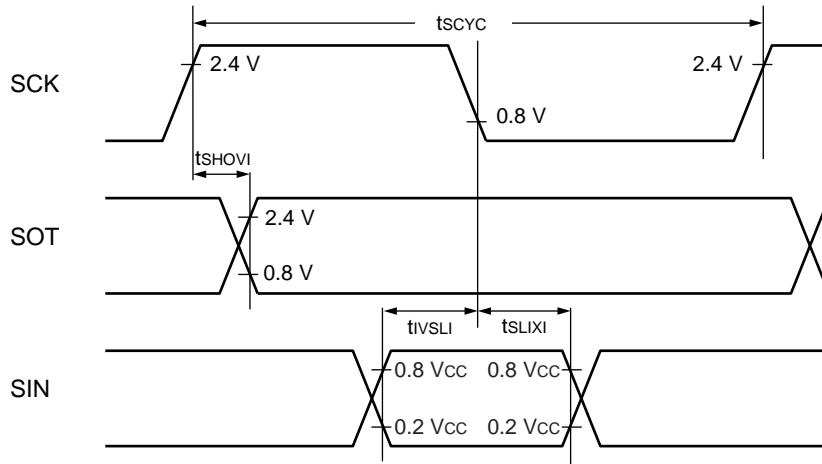
| Parameter                    | Symbol             | Pin name | Conditions  | Value                                   |                             | Unit |
|------------------------------|--------------------|----------|---|---|-----------------------------|------|
|                              |                    |          |   | Min                                     | Max                         |      |
| Serial clock cycle time      | t <sub>SCYC</sub>  | SCK      | Internal clock<br>operation output pin :<br>C <sub>L</sub> = 80 pF + 1 TTL. | 5 t <sub>MCLK</sub> *3                  | —                           | ns   |
| SCK ↑ → SOT delay time       | t <sub>SHOVI</sub> | SCK, SOT |   | -95                                     | + 95                        | ns   |
| Valid SIN → SCK ↓            | t <sub>IVSLI</sub> | SCK, SIN |   | t <sub>MCLK</sub> *3 + 190              | —                           | ns   |
| SCK ↓ → valid SIN hold time  | t <sub>SLIXI</sub> | SCK, SIN |   | 0                                       | —                           | ns   |
| Serial clock "H" pulse width | t <sub>SHSL</sub>  | SCK      | External clock<br>operation output pin :<br>C <sub>L</sub> = 80 pF + 1 TTL. | 3 t <sub>MCLK</sub> *3 - t <sub>R</sub> | —                           | ns   |
| Serial clock "L" pulse width | t <sub>SLSH</sub>  | SCK      |   | t <sub>MCLK</sub> *3 + 95               | —                           | ns   |
| SCK ↑ → SOT delay time       | t <sub>SHOVE</sub> | SCK, SOT |   | —                                       | 2 t <sub>MCLK</sub> *3 + 95 | ns   |
| Valid SIN → SCK ↓            | t <sub>IVSLE</sub> | SCK, SIN |   | 190                                     | —                           | ns   |
| SCK ↓ → valid SIN hold time  | t <sub>SLIXE</sub> | SCK, SIN |   | t <sub>MCLK</sub> *3 + 95               | —                           | ns   |
| SCK fall time                | t <sub>F</sub>     | SCK      |   | —                                       | 10                          | ns   |
| SCK rise time                | t <sub>R</sub>     | SCK      |   | —                                       | 10                          | ns   |

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

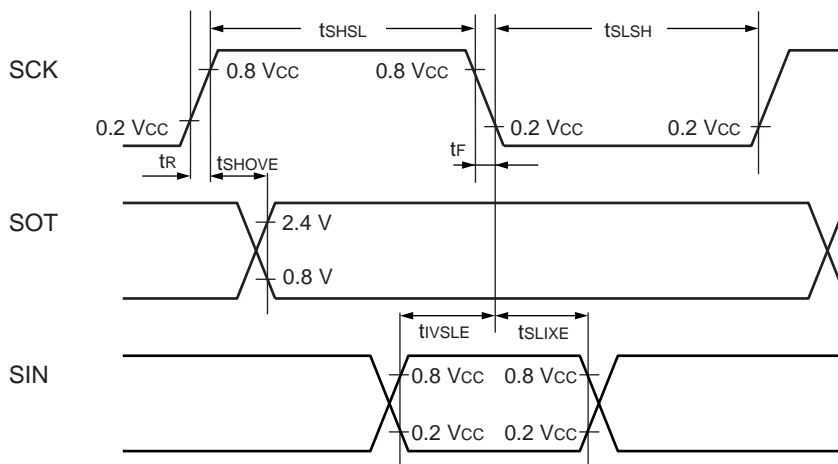
\*2 : Serial clock delay function is used to delay half clock for the output signal of serial clock.

\*3 : Refer to " (2) Source Clock/Machine Clock" for t<sub>MCLK</sub>.

- 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)**

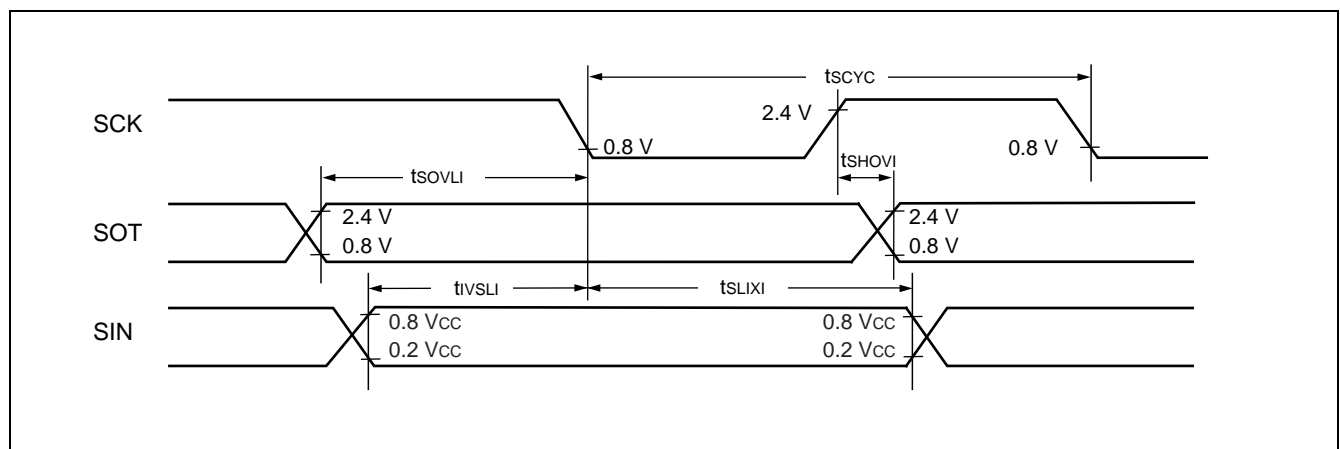
( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

| Parameter  | Sym-<br>bol | Pin name | Conditions  | Value                 |                   | Unit |
|--|-------------|----------|---|-----------------------|-------------------|------|
|  |             |          |   | Min                   | Max               |      |
| Serial clock cycle time                            | $t_{SCYC}$  | SCK      | Internal clock<br>operation output pin :<br>$C_L = 80\text{ pF} + 1\text{ TTL}$ . | $5 t_{MCLK}^{*3}$     | —                 | ns   |
| SCK $\uparrow$ $\rightarrow$ SOT delay time        | $t_{SHOVI}$ | SCK, SOT |   | -95                   | +95               | ns   |
| Valid SIN $\rightarrow$ SCK $\downarrow$           | $t_{IVSLI}$ | SCK, SIN |   | $t_{MCLK}^{*3} + 190$ | —                 | ns   |
| SCK $\downarrow$ $\rightarrow$ valid SIN hold time | $t_{SLIXI}$ | SCK, SIN |   | 0                     | —                 | ns   |
| SOT $\rightarrow$ SCK $\downarrow$ 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  $t_{MCLK}$ .



# MB95160 Series

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)

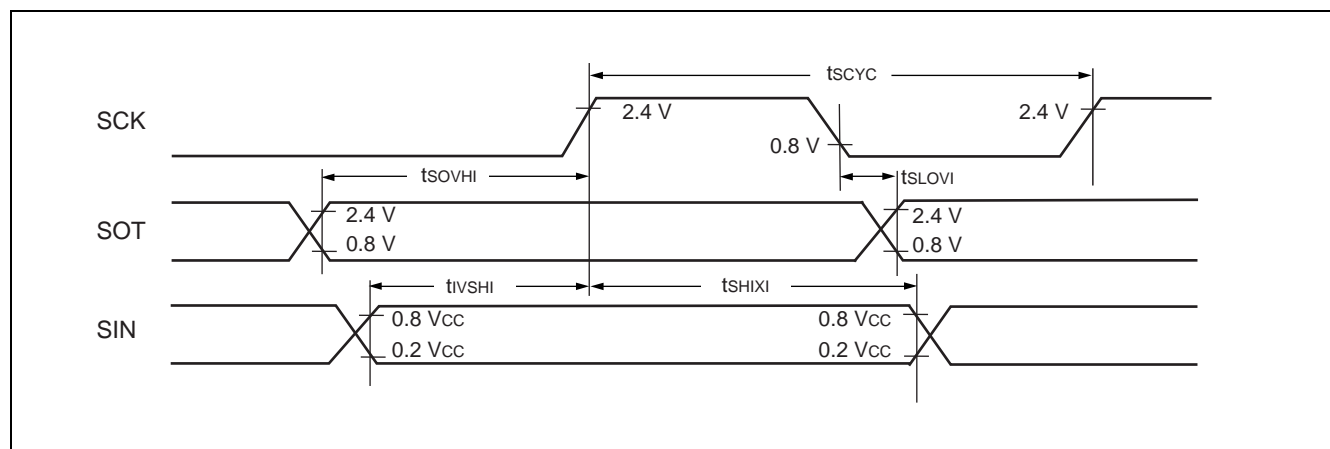
( $V_{CC} = 3.3\text{ V}$ ,  $V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ )

| Parameter  | Symbol      | Pin name | Conditions   | Value                 |                   | Unit |
|--|-------------|----------|--|-----------------------|-------------------|------|
|  |             |          |  | Min                   | Max               |      |
| Serial clock cycle time                          | $t_{SCYC}$  | SCK      | Internal clock<br>operation output pin :<br>$C_L = 80\text{ pF} + 1\text{ TTL.}$ | $5 t_{MCLK}^{*3}$     | —                 | ns   |
| SCK $\downarrow$ $\rightarrow$ SOT delay time    | $t_{SLOVI}$ | SCK, SOT |  | -95                   | +95               | ns   |
| Valid SIN $\rightarrow$ SCK $\uparrow$           | $t_{IVSHI}$ | SCK, SIN |  | $t_{MCLK}^{*3} + 190$ | —                 | ns   |
| SCK $\uparrow$ $\rightarrow$ valid SIN hold time | $t_{SHIXI}$ | SCK, SIN |  | 0                     | —                 | ns   |
| SOT $\rightarrow$ SCK $\uparrow$ 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) I<sup>2</sup>C Timing

(V<sub>CC</sub> = 3.3 V ± 10%, AV<sub>SS</sub> = V<sub>SS</sub> = 0.0 V, T<sub>A</sub> = -40 °C to +85 °C)

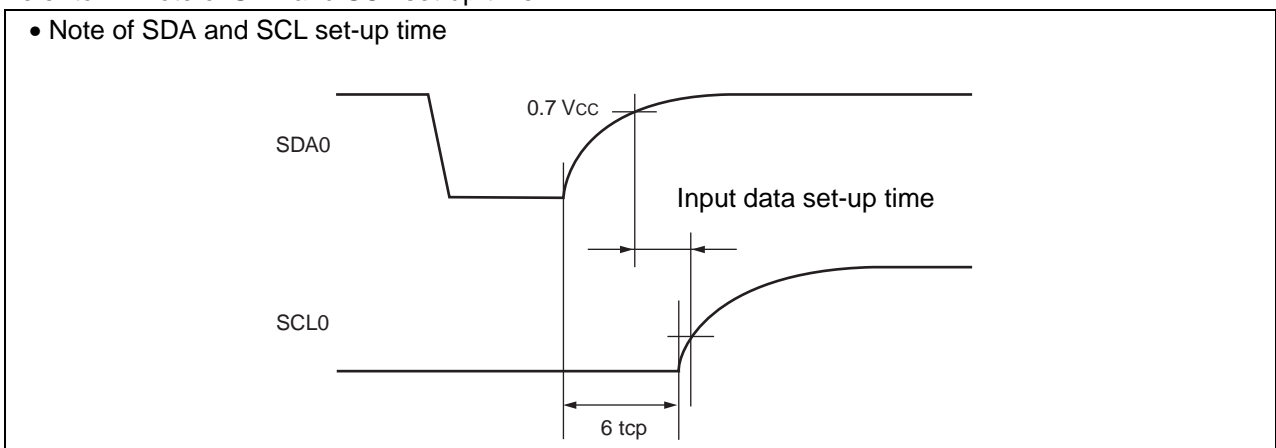
| Parameter   | Symbol              | Pin name     | Conditions                 | Value         |        |           |       | Unit |
|---|---------------------|--------------|----------------------------|---------------|--------|-----------|-------|------|
|   |                     |              |                            | Standard-mode |        | Fast-mode |       |      |
|   |                     |              |                            | Min           | Max    | Min       | Max   |      |
| SCL clock frequency   | f <sub>SCL</sub>    | SCL0         | R = 1.7 kΩ,<br>C = 50 pF*1 | 0             | 100    | 0         | 400   | kHz  |
| (Repeat) Start condition hold time<br>SDA ↓ → SCL ↓         | t <sub>HD,STA</sub> | SCL0<br>SDA0 |                            | 4.0           | —      | 0.6       | —     | μs   |
| SCL clock "L" width   | t <sub>LOW</sub>    | SCL0         |                            | 4.7           | —      | 1.3       | —     | μs   |
| SCL clock "H" width   | t <sub>HIGH</sub>   | SCL0         |                            | 4.0           | —      | 0.6       | —     | μs   |
| (Repeat) Start condition setup time<br>SCL ↑ → SDA ↓        | t <sub>SU,STA</sub> | SCL0<br>SDA0 |                            | 4.7           | —      | 0.6       | —     | μs   |
| Data hold time SCL ↓ → SDA ↓ ↑                              | t <sub>HD,DAT</sub> | SCL0<br>SDA0 |                            | 0             | 3.45*2 | 0         | 0.9*3 | μs   |
| Data setup time SDA ↓ ↑ → SCL ↑                             | t <sub>SU,DAT</sub> | SCL0<br>SDA0 |                            | 0.25*4        | —      | 0.1*4     | —     | μs   |
| Stop condition setup time SCL ↑ →<br>SDA ↑                  | t <sub>SU,STO</sub> | SCL0<br>SDA0 |                            | 4.0           | —      | 0.6       | —     | μs   |
| Bus free time between stop<br>condition and start condition | t <sub>BUF</sub>    | SCL0<br>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<sub>HD,DAT</sub> have only to be met if the device dose not stretch the "L" width (t<sub>LOW</sub>) of the SCL signal.

\*3 : A fast-mode I<sup>2</sup>C-bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement t<sub>SU,DAT</sub> ≥ 250 ns must then be met.

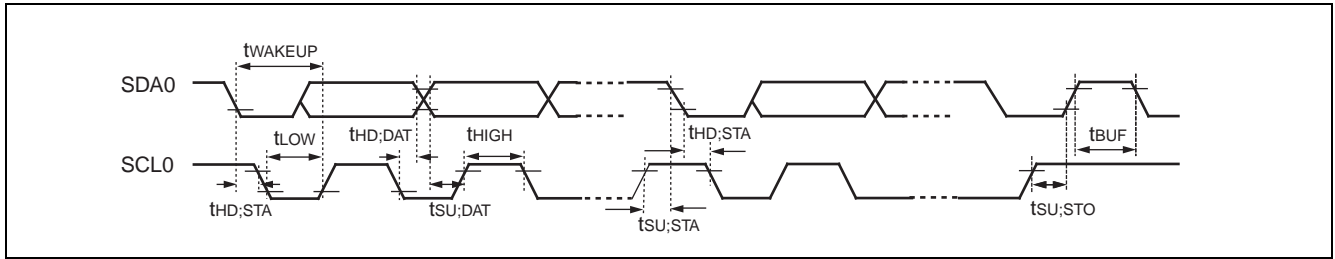
\*4 : Refer to "• Note of SDA and SCL set-up time".



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.

# MB95160 Series



# MB95160 Series

( $V_{CC} = 3.3\text{ V} \pm 10\%$ ,  $AV_{SS} = V_{SS} = 0.0\text{ V}$ ,  $T_A = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

| Parameter  | Symbol       | Pin name     | Conditions                          | Value*2                       |                               | Unit | Remarks  |
|--|--------------|--------------|-------------------------------------|-------------------------------|-------------------------------|------|--|
|  |              |              |                                     | Min                           | Max                           |      |  |
| SCL clock "L" width                                      | $t_{LOW}$    | SCL0         | R = 1.7 k $\Omega$ ,<br>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<br>SDA0 |                                     | $(-1 + nm / 2) t_{MCLK} - 20$ | $(-1 + nm) t_{MCLK} + 20$     | ns   | Master mode<br>Maximum value is applied when m, n = 1, 8. Otherwise, the minimum value is applied.   |
| Stop condition setup time                                | $t_{SU,STO}$ | SCL0<br>SDA0 |                                     | $(1 + nm / 2) t_{MCLK} - 20$  | $(1 + nm / 2) t_{MCLK} + 20$  | ns   | Master mode  |
| Start condition setup time                               | $t_{SU,STA}$ | SCL0<br>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<br>SDA0 |                                     | $(2 nm + 4) t_{MCLK} - 20$    | —                             | ns   |  |
| Data hold time   | $t_{HD,DAT}$ | SCL0<br>SDA0 |                                     | $3 t_{MCLK} - 20$             | —                             | ns   | Master mode  |
| Data setup time  | $t_{SU,DAT}$ | SCL0<br>SDA0 |                                     | $(-2 + nm / 2) t_{MCLK} - 20$ | $(-1 + nm / 2) t_{MCLK} + 20$ | ns   | Master mode<br>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 $\downarrow$ .<br>Maximum value is applied to interrupt at 8th SCL $\downarrow$ .                                   |
| 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<br>SDA0 |                                     | $2 t_{MCLK} - 20$             | —                             | ns   | Undetected when $1 t_{MCLK}$ is used at reception  |

(Continued)

# MB95160 Series

(Continued)

( $V_{CC} = 3.3 \text{ V} \pm 10\%$ ,  $AV_{SS} = V_{SS} = 0.0 \text{ V}$ ,  $T_A = -40 \text{ }^\circ\text{C}$  to  $+85 \text{ }^\circ\text{C}$ )

| Parameter   | Symbol       | Pin name     | Conditions                          | Value*2   |     | Unit | Remarks   |
|---|--------------|--------------|-------------------------------------|---|-----|------|---|
|   |              |              |                                     | Min   | Max |      |   |
| Stop condition detection  | $t_{SU;STO}$ | SCL0<br>SDA0 | R = 1.7 k $\Omega$ ,<br>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<br>SDA0 |                                     | $2 t_{MCLK} - 20$                                       | —   | ns   | Undetected when 1 $t_{MCLK}$ is used at reception |
| Bus free time   | $t_{BUF}$    | SCL0<br>SDA0 |                                     | $2 t_{MCLK} - 20$                                       | —   | ns   | At reception                                      |
| Data hold time  | $t_{HD;DAT}$ | SCL0<br>SDA0 |                                     | $2 t_{MCLK} - 20$                                       | —   | ns   | At slave transmission mode                        |
| Data setup time   | $t_{SU;DAT}$ | SCL0<br>SDA0 |                                     | $t_{LOW} - 3 t_{MCLK} - 20$                             | —   | ns   | At slave transmission mode                        |
| Data hold time  | $t_{HD;DAT}$ | SCL0<br>SDA0 |                                     | 0   | —   | ns   | At reception                                      |
| Data setup time   | $t_{SU;DAT}$ | SCL0<br>SDA0 |                                     | $t_{MCLK} - 20$   | —   | ns   | At reception                                      |
| SDA $\downarrow \rightarrow$ SCL $\uparrow$<br>(at wakeup function) | $t_{WAKEUP}$ | SCL0<br>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 I<sup>2</sup>C clock control register (ICCR) .
- n is CS2 bit to CS0 bit (bit 2 to bit 0) of I<sup>2</sup>C clock control register (ICCR) .
- Actual timing of I<sup>2</sup>C 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 :  $0.9 \text{ MHz} < t_{MCLK} \text{ (machine clock)} < 10 \text{ MHz}$ .  
Setting of m and n determines the machine clock that can be used below.
 

|  |  |
|--|--|
| (m, n) = (1, 8)                                  | : $0.9 \text{ MHz} < t_{MCLK} \leq 1 \text{ MHz}$  |
| (m, n) = (1, 22), (5, 4), (6, 4), (7, 4), (8, 4) | : $0.9 \text{ MHz} < t_{MCLK} \leq 2 \text{ MHz}$  |
| (m, n) = (1, 38), (5, 8), (6, 8), (7, 8), (8, 8) | : $0.9 \text{ MHz} < t_{MCLK} \leq 4 \text{ MHz}$  |
| (m, n) = (1, 98)                                 | : $0.9 \text{ MHz} < t_{MCLK} \leq 10 \text{ MHz}$ |
- Fast-mode :  
m and n can be set at the range :  $3.3 \text{ MHz} < t_{MCLK} \text{ (machine clock)} < 10 \text{ MHz}$ .  
Setting of m and n determines the machine clock that can be used below.
 

|                          |  |
|--------------------------|--|
| (m, n) = (1, 8)          | : $3.3 \text{ MHz} < t_{MCLK} \leq 4 \text{ MHz}$  |
| (m, n) = (1, 22), (5, 4) | : $3.3 \text{ MHz} < t_{MCLK} \leq 8 \text{ MHz}$  |
| (m, n) = (6, 4)          | : $3.3 \text{ MHz} < t_{MCLK} \leq 10 \text{ MHz}$ |



## 5. A/D Converter

### (1) A/D Converter Electrical Characteristics

( $AV_{CC} = V_{CC} = 1.8 \text{ V to } 3.3 \text{ V}$ ,  $AV_{SS} = V_{SS} = 0.0 \text{ V}$ ,  $T_A = -40 \text{ }^\circ\text{C to } +85 \text{ }^\circ\text{C}$ )

| Parameter                        | Symbol    | 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          | $V_{OT}$  | —          | $AV_{SS} - 1.5 \text{ LSB}$ | $AV_{SS} + 0.5 \text{ LSB}$ | $AV_{SS} + 2.5 \text{ LSB}$ | V             | $2.7 \text{ V} \leq AV_{CC} \leq 3.3 \text{ V}$   |
|                                  |           |            | $AV_{SS} - 0.5 \text{ LSB}$ | $AV_{SS} + 1.5 \text{ LSB}$ | $AV_{SS} + 3.5 \text{ LSB}$ | V             | $1.8 \text{ V} \leq AV_{CC} < 2.7 \text{ V}$  |
| Full-scale transition voltage    | $V_{FST}$ | —          | $AVR - 3.5 \text{ LSB}$     | $AVR - 1.5 \text{ LSB}$     | $AVR + 0.5 \text{ LSB}$     | V             | $2.7 \text{ V} \leq AV_{CC} \leq 3.3 \text{ V}$   |
|                                  |           |            | $AVR - 2.5 \text{ LSB}$     | $AVR - 0.5 \text{ LSB}$     | $AVR + 1.5 \text{ LSB}$     | V             | $1.8 \text{ V} \leq AV_{CC} < 2.7 \text{ V}$  |
| Compare time                     | —         | —          | 0.6                         | —                           | 140                         | $\mu\text{s}$ | $2.7 \text{ V} \leq AV_{CC} \leq 3.3 \text{ V}$   |
|                                  |           |            | 20                          | —                           | 140                         | $\mu\text{s}$ | $1.8 \text{ V} \leq AV_{CC} < 2.7 \text{ V}$  |
| Sampling time                    | —         | —          | 0.4                         | —                           | $\infty$                    | $\mu\text{s}$ | $2.7 \text{ V} \leq AV_{CC} \leq 3.3 \text{ V}$ ,<br>At external impedance < 1.8 k $\Omega$ |
|                                  |           |            | 30                          | —                           | $\infty$                    | $\mu\text{s}$ | $1.8 \text{ V} \leq AV_{CC} < 2.7 \text{ V}$ ,<br>At external impedance < 14.8 k $\Omega$   |
| Analog input current             | $I_{AIN}$ | —          | -0.3                        | —                           | +0.3                        | $\mu\text{A}$ |   |
| 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                         | $\mu\text{A}$ | AVR pin,<br>During A/D operation  |
|                                  | $I_{RH}$  | —          | —                           | —                           | 5                           | $\mu\text{A}$ | AVR pin,<br>At stop mode  |

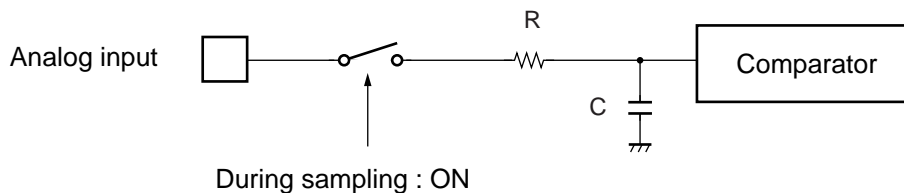
# MB95160 Series

## (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  $\mu\text{F}$  to the analog input pin.

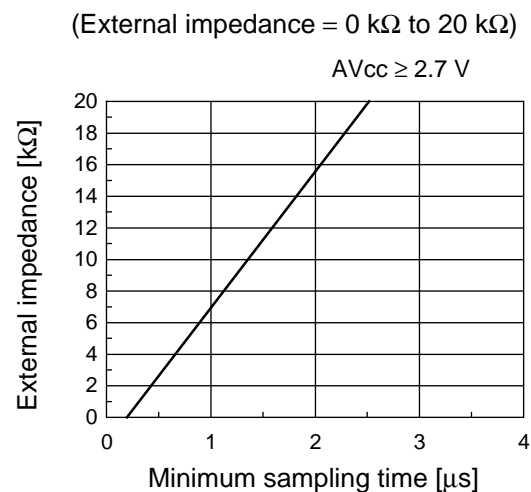
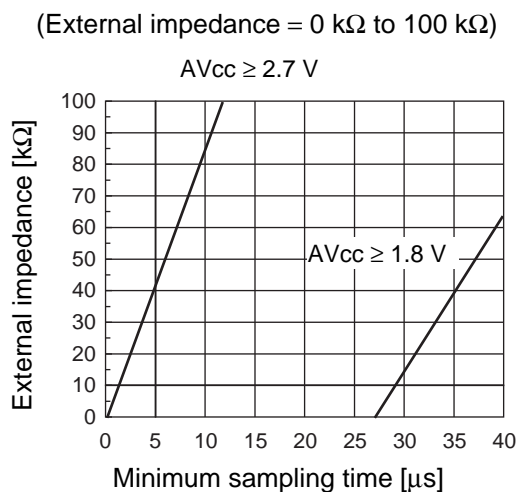
#### • Analog input equivalent circuit



|   | R                    | C             |
|---|----------------------|---------------|
| $2.7\text{ V} \leq V_{\text{CC}} \leq 3.6\text{ V}$ | 1.7 k $\Omega$ (Max) | 14.5 pF (Max) |
| $1.8\text{ V} \leq V_{\text{CC}} < 2.7\text{ V}$    | 84 k $\Omega$ (Max)  | 25.2 pF (Max) |

Note : The values are reference values.

#### • The relationship between external impedance and minimum sampling time

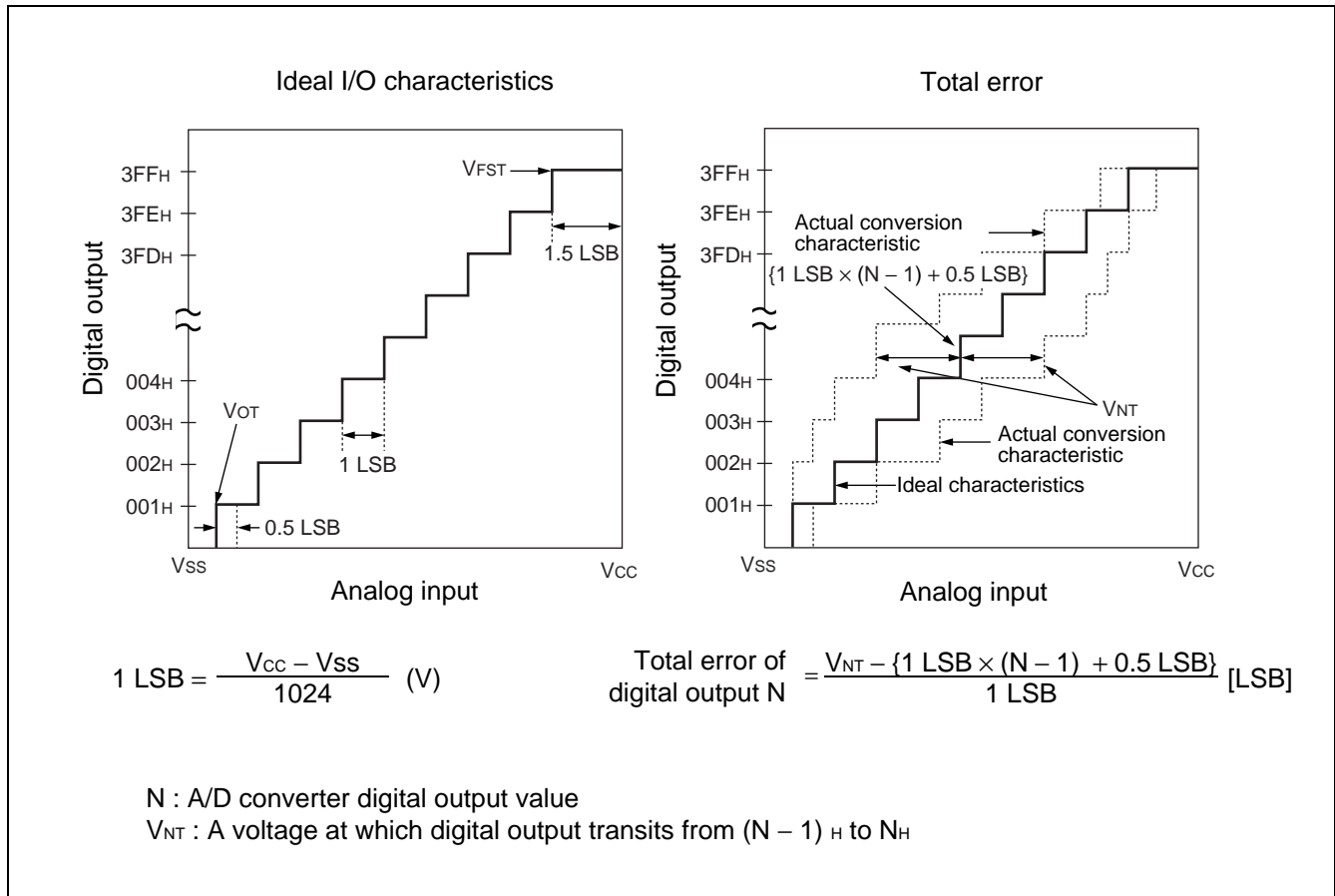


#### • About errors

As  $|V_{\text{CC}} - V_{\text{SS}}|$  becomes smaller, values of relative errors grow larger.

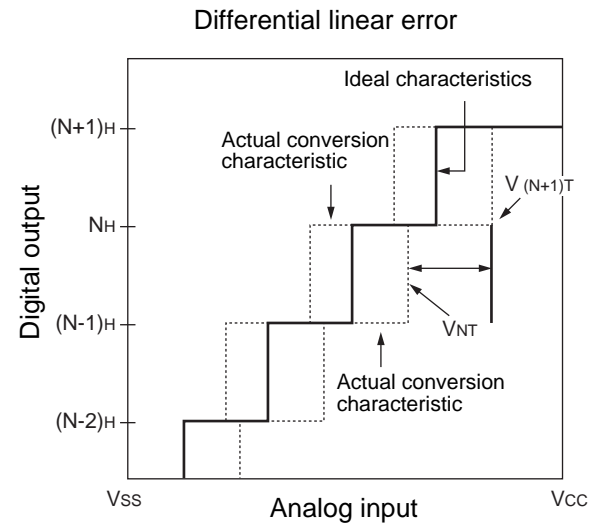
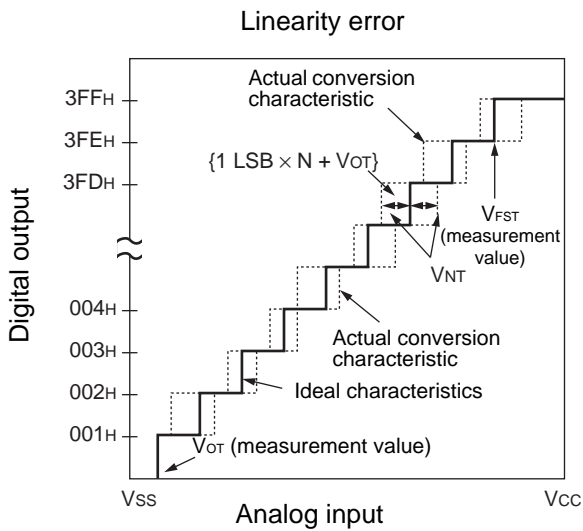
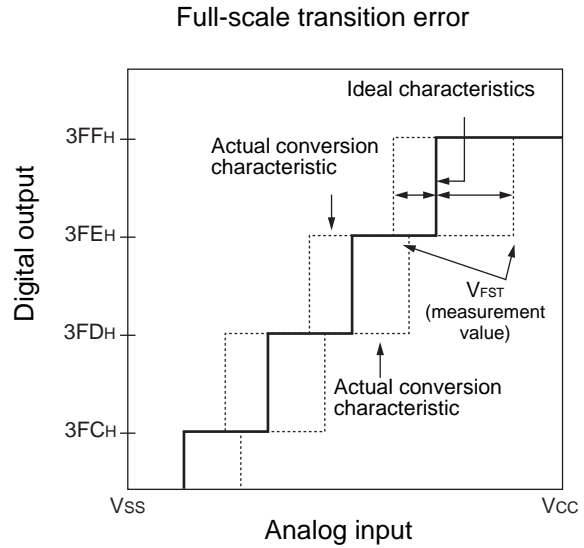
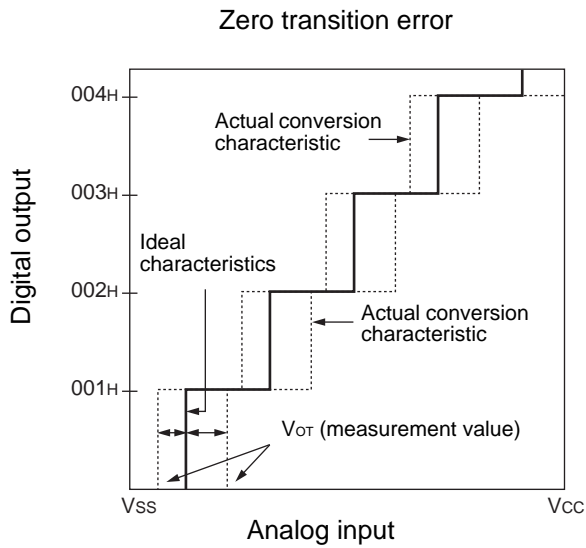
### (3) Definition of A/D Converter Terms

- 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.



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

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

N : A/D converter digital output value

$V_{NT}$  : A voltage at which digital output transits from (N - 1)<sub>H</sub> to N<sub>H</sub>

$V_{OT}$  (Ideal value) =  $V_{SS} + 0.5 \text{ LSB [V]}$

$V_{FST}$  (Ideal value) =  $V_{CC} - 1.5 \text{ LSB [V]}$

## 6. Flash Memory Program/Erase Characteristics

| Parameter                             | Value            |                 |                    | Unit  | Remarks   |
|---------------------------------------|------------------|-----------------|--------------------|-------|---|
|                                       | Min              | Typ             | Max                |       |   |
| Chip erase time                       | —                | 1* <sup>1</sup> | 15* <sup>2</sup>   | s     | Excludes 00 <sub>H</sub> programming prior erasure. |
| Byte programming time                 | —                | 32              | 3600* <sup>2</sup> | 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* <sup>3</sup> | —               | —                  | year  | Average T <sub>A</sub> = +85 °C                     |

\*1 : T<sub>A</sub> = + 25 °C, V<sub>CC</sub> = 3.0 V, 10000 cycles

\*2 : T<sub>A</sub> = + 85 °C, V<sub>CC</sub> = 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) .

# MB95160 Series

## ■ MASK OPTION

| No. | Part number  | MB95F166D   | MB95FV100D-101  | MB95166D   |
|-----|--|---|---|--|
|     | Specifying procedure   | Setting disabled  | Setting disabled  | Specifying when ordering MASK  |
| 1   | Clock mode select<br><ul style="list-style-type: none"> <li>• Single-system clock mode</li> <li>• Dual-system clock mode</li> </ul>  | Dual-system clock mode  | Changing by the switch on MCU board                                     | Dual-system clock mode   |
| 2   | Low voltage detection reset*<br><ul style="list-style-type: none"> <li>• With low voltage detection reset</li> <li>• Without low voltage detection reset</li> </ul>                    | No  | No  | No   |
| 3   | Clock supervisor*<br><ul style="list-style-type: none"> <li>• With clock supervisor</li> <li>• Without clock supervisor</li> </ul>   | No  | No  | No   |
| 4   | Selection of oscillation stabilization wait time<br><ul style="list-style-type: none"> <li>• Selectable the initial value of main clock oscillation stabilization wait time</li> </ul> | 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:<br>1 : $(2^2 - 2) / F_{CH}$<br>2 : $(2^{12} - 2) / F_{CH}$<br>3 : $(2^{13} - 2) / F_{CH}$<br>4 : $(2^{14} - 2) / F_{CH}$ |

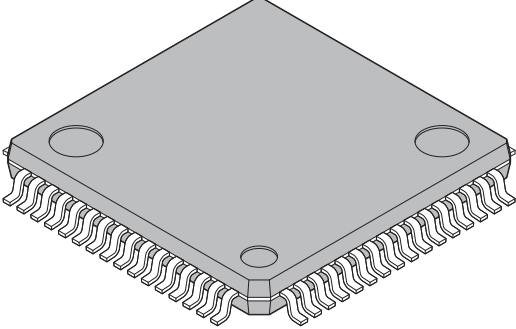
\* : Low voltage detection reset and clock supervisor are options of 5-V products.

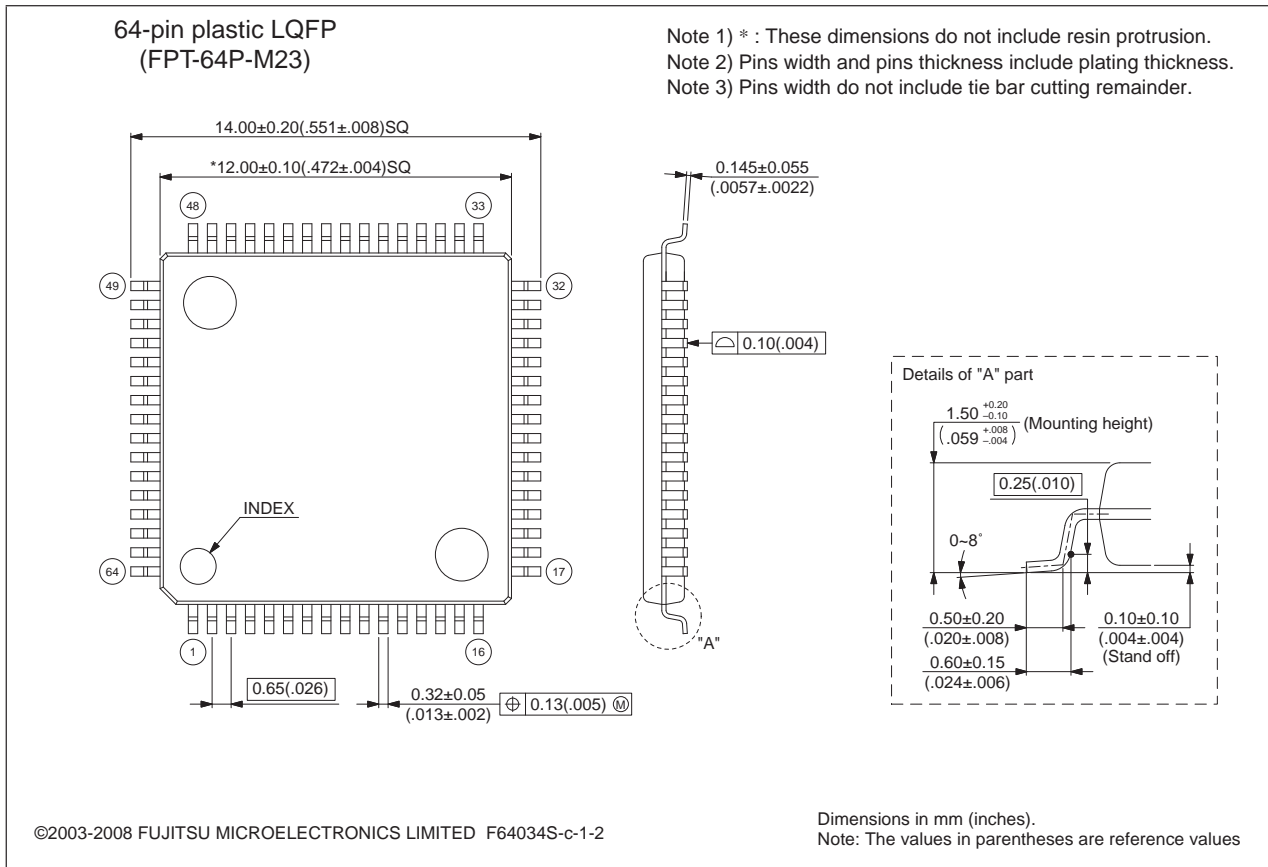
## ■ ORDERING INFORMATION

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

# MB95160 Series

## PACKAGE DIMENSIONS

|   |                                |                      |
|---|--------------------------------|----------------------|
| <p>64-pin plastic LQFP</p>  <p>(FPT-64P-M23)</p> | 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 |
|   |                                |                      |

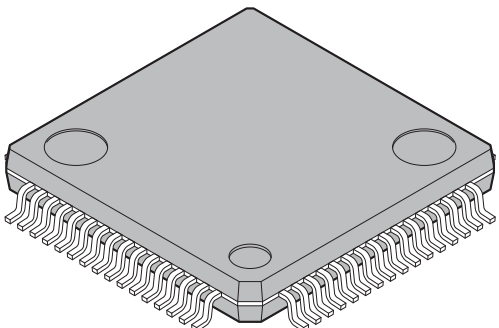


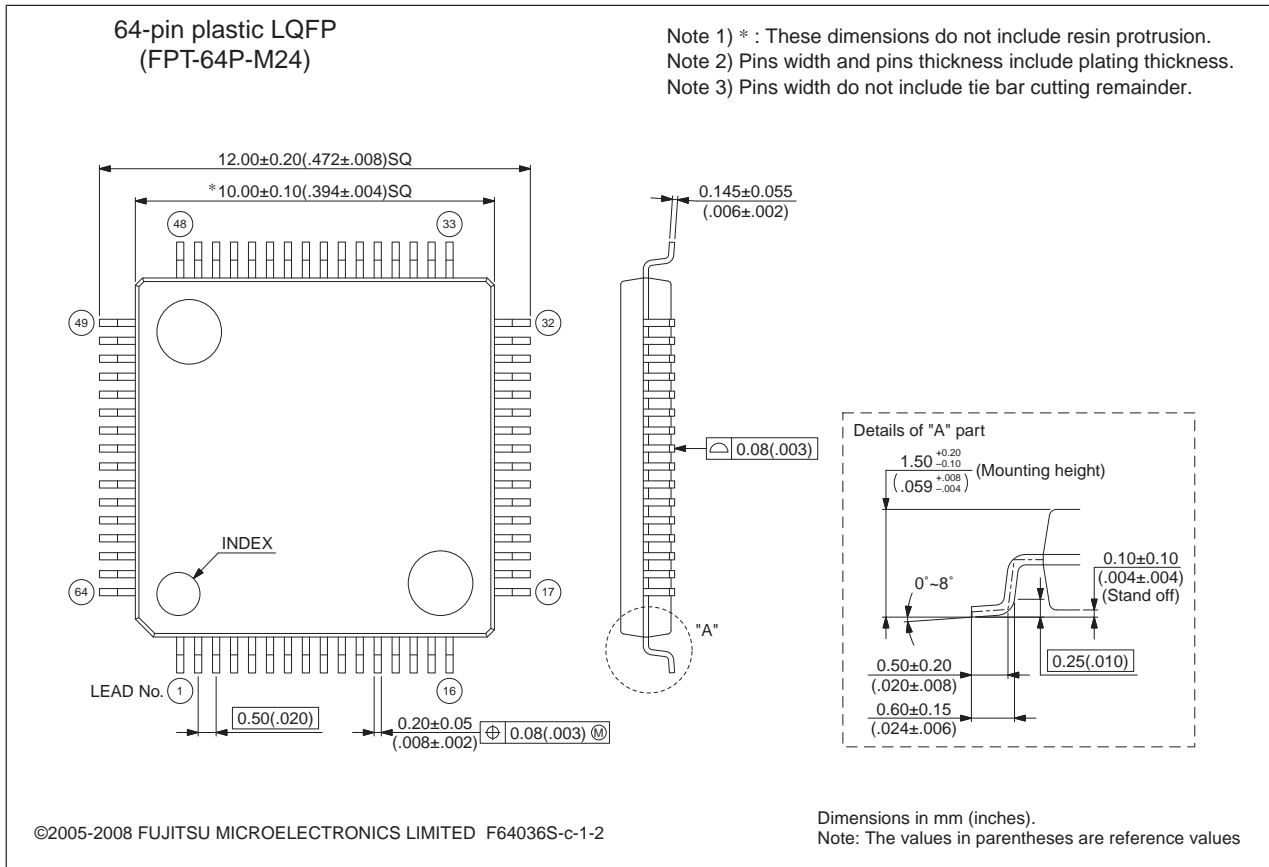
Please confirm the latest Package dimension by following URL.  
<http://edevic.fujitsu.com/package/en-search/>

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|   |                                |                      |
|---|--------------------------------|----------------------|
| <p>64-pin plastic LQFP</p>  <p>(FPT-64P-M24)</p> | 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               |
|   | Code (Reference)               | P-LFQFP64-10×10-0.50 |



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

# MB95160 Series

## ■ MAIN CHANGES IN THIS EDITION

| Page   | Section  | Change Results  |
|--------|--|---|
| —      | —  | Added the part number;<br>(MB95166D)  |
| 2      | ■ FEATURE  | Changed as follows.<br>(• Flash memory security function →<br>• Flash memory security function (Flash memory device only) )   |
| 3, 4   | ■ PRODUCT LINEUP   | Added the row of MB95166D.  |
| 3      |  | Changed the Reset output.<br>(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 | <ul style="list-style-type: none"> <li>• Changed the Notes on Using Evaluation Products</li> <li>• Changed the Difference of Memory Spaces</li> <li>• Changed the Operating voltage</li> <li>• Added the Difference MOD pins</li> </ul> |
| 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 <sub>H</sub> , 0074 <sub>H</sub> .   |
| 28     | ■ ELECTRICAL CHARACTERISTICS<br>1. Absolute Maximum Ratings  | Changed the Remarks of “Power supply voltage for LCD”<br>(Products with LCD internal division resistance* <sup>3</sup> → *3)  |
| 31     | 3. DC Characteristics  | Changed the row of Symbol V <sub>IHM</sub> and V <sub>ILM</sub> .   |
| 32     |  | Added the row of Pull-down resistor (R <sub>MOD</sub> ).  |
| 32, 33 |  | Changed the Power supply current.   |
| 38, 39 | 4. AC Characteristics<br>(2) Source Clock/Machine Clock      | <ul style="list-style-type: none"> <li>• Changed the Operating voltage - Operating frequency<br/>(When T<sub>A</sub> = -10 °C to +85 °C)<br/>(• Added the graph of MB95166D )</li> </ul>  |
| 61     | ■ MASK OPTION  | Added the row of MB95166D.  |
| 62     | ■ ORDERING INFORMATION                                       | Changed the part numbers.<br>(MB95F166DPMC → MB95F166DPMC/MB95166DPMC)<br>(MB95F166DPMC1 → MB95F166DPMC1/MB95166DPMC1)  |

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

**MEMO**

# MB95160 Series

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