

32-bit RISC Microcontroller

CMOS

FR30 Series

MB91101/MB91101A

■ DESCRIPTION

The MB91101 is a standard single-chip microcontroller constructed around the 32-bit RISC CPU (FR* family) core with abundant I/O resources and bus control functions optimized for high-performance/high-speed CPU processing for embedded controller applications. To support the vast memory space accessed by the 32-bit CPU, the MB91101 normally operates in the external bus access mode and executes instructions on the internal 1 Kbyte cache memory and 2 Kbytes RAM for enhanced performance.

The MB91101 is optimized for applications requiring high-performance CPU processing such as navigation systems, high-performance FAXs and printer controllers.

*: FR Family stands for FUJITSU RISC controller.

■ FEATURES

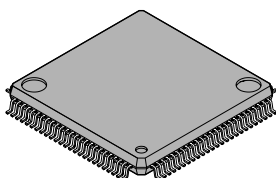
FR CPU

- 32-bit RISC, load/store architecture, 5-stage pipeline
- Operating clock frequency: Internal 50 MHz/external 25 MHz (PLL used at source oscillation 12.5 MHz)
- General purpose registers: 32 bits × 16
- 16-bit fixed length instructions (basic instructions), 1 instruction/1 cycle
- Memory to memory transfer, bit processing, barrel shifter processing: Optimized for embedded applications
- Function entrance/exit instructions, multiple load/store instructions of register contents, instruction systems supporting high level languages
- Register interlock functions, efficient assembly language coding
- Branch instructions with delay slots: Reduced overhead time in branch executions

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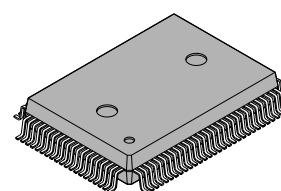
■ PACKAGE

100-pin Plastic LQFP



(FPT-100P-M05)

100-pin Plastic QFP



(FPT-100P-M06)

MB91101/MB91101A

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- Internal multiplier/supported at instruction level
 - Signed 32-bit multiplication: 5 cycles
 - Signed 16-bit multiplication: 3 cycles
- Interrupt (push PC and PS): 6 cycles, 16 priority levels

External bus interface

- Clock doubler: Internal 50 MHz, external bus 25 MHz operation
- 25-bit address bus (32 Mbytes memory space)
- 8/16-bit data bus
- Basic external bus cycle: 2 clock cycles
- Chip select outputs for setting down to a minimum memory block size of 64 Kbytes: 6
- Interface supported for various memory technologies
 - DRAM interface (area 4 and 5)
- Automatic wait cycle insertion: Flexible setting, from 0 to 7 for each area
- Unused data/address pins can be configured as input/output ports
- Little endian mode supported (Select 1 area from area 1 to 5)

DRAM interface

- 2 banks independent control (area 4 and 5)
- Normal mode (double CAS DRAM)/high-speed page mode (single CAS DRAM)/Hyper DRAM
- Basic bus cycle: Normally 5 cycles, 2-cycle access possible in high-speed page mode
- Programmable waveform: Automatic 1-cycle wait insertion to RAS and CAS cycles
- DRAM refresh
 - CBR refresh (interval time configurable by 6-bit timer)
 - Self-refresh mode
- Supports 8/9/10/12-bit column address width
- 2CAS/1WE, 2WE/1CAS selective

Cache memory

- 1-Kbyte instruction cache memory
- 32 block/way, 4 entry(4 word)/block
- 2 way set associative
- Lock function: For specific program code to be resident in cache memory

DMA controller (DMAC)

- 8 channels
- Transfer incident/external pins/internal resource interrupt requests
- Transfer sequence: Step transfer/block transfer/burst transfer/continuous transfer
- Transfer data length: 8 bits/16 bits/32 bits selective
- NMI/interrupt request enables temporary stop operation

UART

- 3 independent channels
- Full-duplex double buffer
- Data length: 7 bits to 9 bits (non-parity), 6 bits to 8 bits (parity)
- Asynchronous (start-stop system), CLK-synchronized communication selective
- Multi-processor mode
- Internal 16-bit timer (U-TIMER) operating as a proprietary baud rate generator: Generates any given baud rate
- Use external clock can be used as a transfer clock
- Error detection: Parity, frame, overrun

(Continued)

10-bit A/D converter (successive approximation conversion type)

- 10-bit resolution, 4 channels
- Successive approximation type: Conversion time of 5.6 μ s at 25 MHz
- Internal sample and hold circuit
- Conversion mode: Single conversion/scanning conversion/repeated conversion/stop conversion selective
- Start: Software/external trigger/internal timer selective

16-bit reload timer

- 3 channels
- Internal clock: 2 clock cycle resolution, divide by 2/8/32 selective

Other interval timers

- 16-bit timer: 3 channels (U-TIMER)
- PWM timer: 4 channels
- Watchdog timer: 1 channel

Bit search module

First bit transition “1” or “0” from MSB can be detected in 1 cycle

Interrupt controller

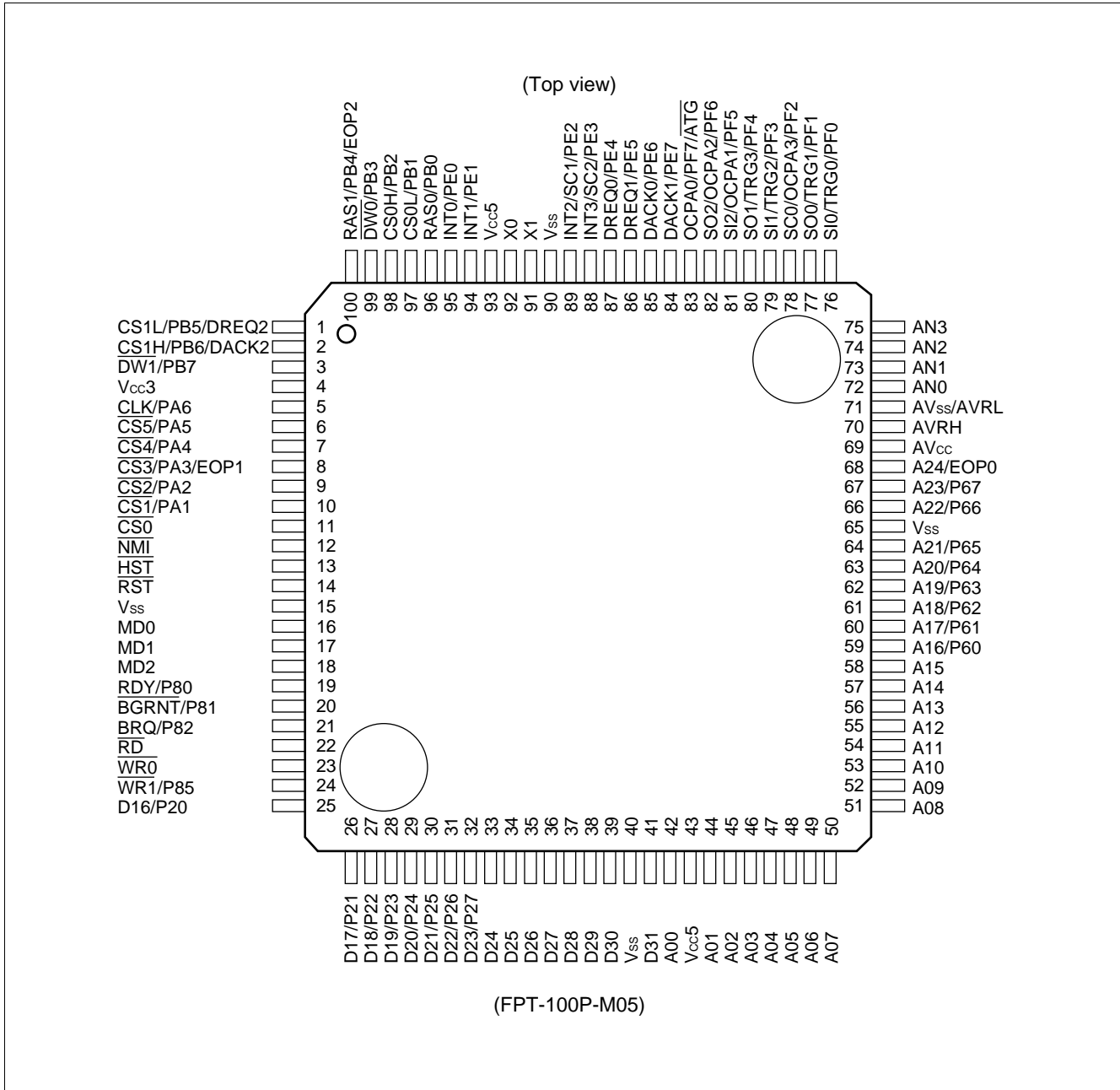
- External interrupt input: Non-maskable interrupt ($\overline{\text{NMI}}$), normal interrupt \times 4 (INT0 to INT3)
- Internal interrupt incident: UART, DMA controller (DMAC), A/D converter, U-TIMER and delayed interrupt module
- Priority levels of interrupts are programmable except for non-maskable interrupt (in 16 steps)

Others

- Reset cause: Power-on reset/hardware standby/watchdog timer/software reset/external reset
- Low-power consumption mode: Sleep mode/stop mode
- Clock control
 - Gear function: Operating clocks for CPU and peripherals are independently selective
 - Gear clock can be selected from 1/1, 1/2, 1/4 and 1/8 (or 1/2, 1/4, 1/8 and 1/16)
 - However, operating frequency for peripherals is less than 25 MHz.
- Packages: LQFP-100 and QFP-100
- CMOS technology (0.35 μ m)
- Power supply voltage
 - 5 V: CPU power supply 5.0 V \pm 10% (internal regulator)
 - A/D power supply 2.7 V to 3.6 V
 - 3 V: CPU power supply 2.7 V to 3.6 V (without internal regulator)
 - A/D power supply 2.7 V to 3.6 V

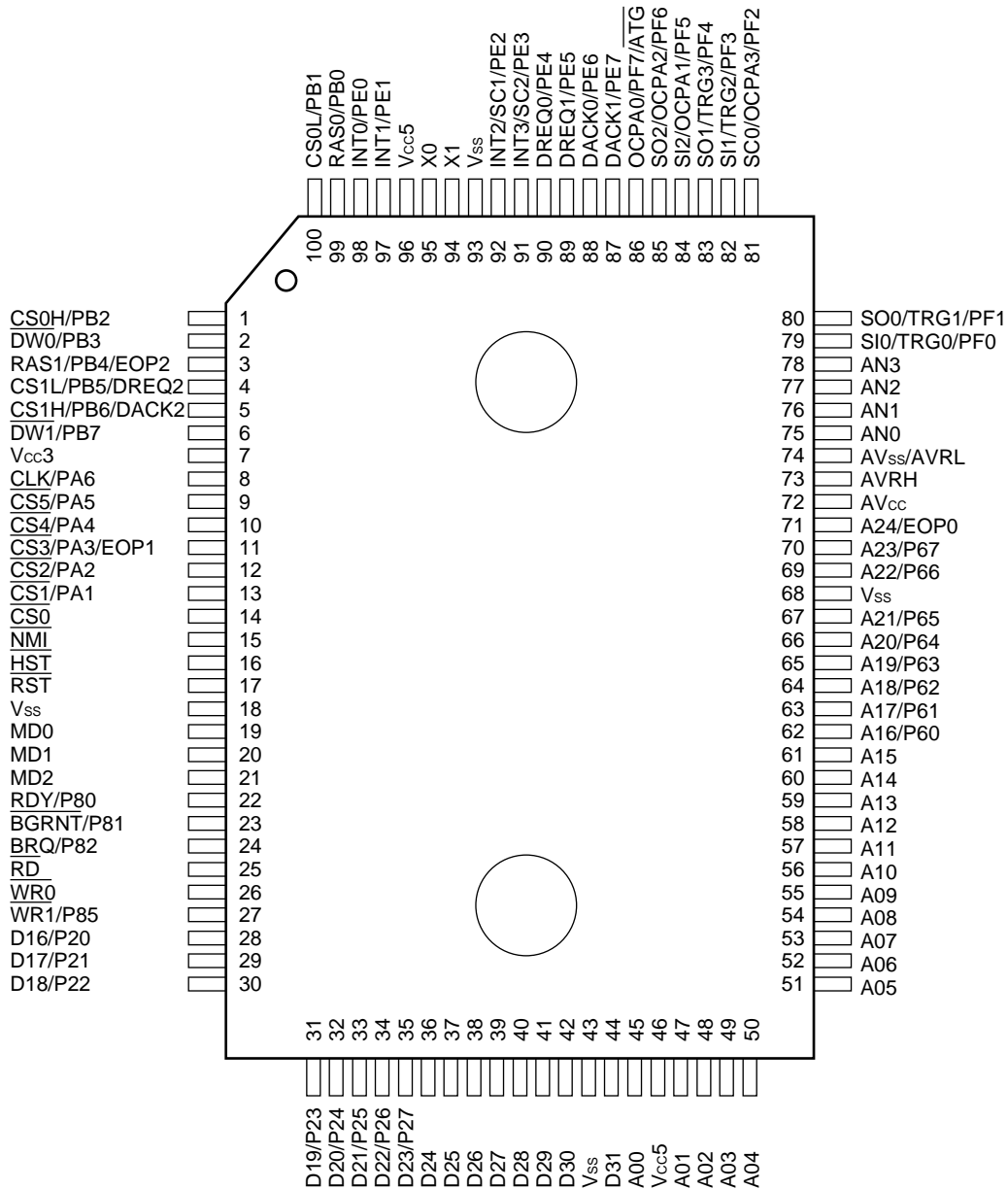
MB91101/MB91101A

■ PIN ASSIGNMENT



MB91101/MB91101A

(Top view)



(FPT-100P-M06)

MB91101/MB91101A

■ PIN DESCRIPTION

Pin no.		Pin name	Circuit type	Function									
LQFP*1	QFP*2												
25 to 32	28 to 35	D16 to D23	C	Bit 16 to bit 23 of external data bus									
		P20 to P27		Can be configured as I/O ports when external data bus width is set to 8-bit.									
33 to 39, 41	36 to 42, 44	D24 to D30, D31	C	Bit 24 to bit 31 of external data bus									
42, 44 to 58	45, 47 to 61	A00, A01 to A15	F	Bit 00 to bit 15 of external address bus									
59 to 64, 66, 67	62 to 67, 69, 70	A16 to A21, A22, A23	F	Bit 16 to bit 23 of external address bus									
		P60 to P65, P66, P67		Can be configured as I/O ports when not used as address bus.									
68	71	A24	L	Bit 24 of external address bus									
		EOP0		Can be configured as DMAC EOP output (ch. 0) when DMAC EOP output is enabled.									
19	22	RDY	C	External ready input Inputs "0" when bus cycle is being executed and not completed.									
		P80		Can be configured as a port when RDY is not used.									
20	23	$\overline{\text{BGRNT}}$	F	External bus release acknowledge output Outputs "L" level when external bus is released.									
		P81		Can be configured as a port when $\overline{\text{BGRNT}}$ is not used.									
21	24	BRQ	C	External bus release request input Inputs "1" when release of external bus is required.									
		P82		Can be configured as a port when BRQ is not used.									
22	25	$\overline{\text{RD}}$	L	Read strobe output pin for external bus									
23	26	$\overline{\text{WR0}}$	L	Write strobe output pin for external bus Relation between control signals and effective byte locations is as follows:									
24	27	$\overline{\text{WR1}}$	F	<table border="1"> <thead> <tr> <th></th> <th>16-bit bus width</th> <th>8-bit bus width</th> </tr> </thead> <tbody> <tr> <td>D15 to D08</td> <td>$\overline{\text{WR0}}$</td> <td>$\overline{\text{WR0}}$</td> </tr> <tr> <td>D07 to D00</td> <td>$\overline{\text{WR1}}$</td> <td>(I/O port enabled)</td> </tr> </tbody> </table>		16-bit bus width	8-bit bus width	D15 to D08	$\overline{\text{WR0}}$	$\overline{\text{WR0}}$	D07 to D00	$\overline{\text{WR1}}$	(I/O port enabled)
					16-bit bus width	8-bit bus width							
D15 to D08	$\overline{\text{WR0}}$	$\overline{\text{WR0}}$											
D07 to D00	$\overline{\text{WR1}}$	(I/O port enabled)											
		P85		Note: $\overline{\text{WR1}}$ is Hi-Z during resetting. Attach an external pull-up resistor when using at 16-bit bus width. Can be configured as a port when $\overline{\text{WR1}}$ is not used.									

*1: FPT-100P-M05

*2: FPT-100P-M06

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MB91101/MB91101A

Pin no.		Pin name	Circuit type	Function
LQFP*1	QFP*2			
11	14	$\overline{CS0}$	L	Chip select 0 output ("L" active)
10	13	$\overline{CS1}$	F	Chip select 1 output ("L" active)
		PA1		Can be configured as a port when $\overline{CS1}$ is not used.
9	12	$\overline{CS2}$	F	Chip select 2 output ("L" active)
		PA2		Can be configured as a port when $\overline{CS2}$ is not used.
8	11	$\overline{CS3}$	F	Chip select 3 output ("L" active)
		PA3		Can be configured as a port when $\overline{CS3}$ and EOP1 are not used.
		EOP1		EOP output pin for DMAC (ch. 1) This function is available when EOP output for DMAC is enabled.
7	10	$\overline{CS4}$	F	Chip select 4 output ("L" active)
		PA4		Can be configured as a port when $\overline{CS4}$ is not used.
6	9	$\overline{CS5}$	F	Chip select 5 output ("L" active)
		PA5		Can be configured as a port when $\overline{CS5}$ is not used.
5	8	CLK	F	System clock output Outputs clock signal of external bus operating frequency.
		PA6		Can be configured as a port when CLK is not used.
96	99	RAS0	F	RAS output for DRAM bank 0 Refer to the DRAM interface for details.
		PB0		Can be configured as a port when RAS0 is not used.
97	100	CS0L	F	CASL output for DRAM bank 0 Refer to the DRAM interface for details.
		PB1		Can be configured as a port when CS0L is not used.
98	1	CS0H	F	CASH output for DRAM bank 0 Refer to the DRAM interface for details.
		PB2		Can be configured as a port when CS0H is not used.
99	2	$\overline{DW0}$	F	\overline{WE} output for DRAM bank 0 ("L" active) Refer to the DRAM interface for details.
		PB3		Can be configured as a port when $\overline{DW0}$ is not used.
100	3	RAS1	F	RAS output for DRAM bank 1 Refer to the DRAM interface for details.
		PB4		Can be configured as a port when RAS1 and EOP2 are not used.
		EOP2		DMAC EOP output (ch. 2) This function is available when DMAC EOP output is enabled.

*1: FPT-100P-M05

*2: FPT-100P-M06

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MB91101/MB91101A

Pin no.		Pin name	Circuit type	Function
LQFP*1	QFP*2			
1	4	CS1L	F	CASL output for DRAM bank 1 Refer to the DRAM interface for details.
		PB5		Can be configured as a port when CS1L and DREQ2 are not used.
		DREQ2		External transfer request input pin for DMA This pin is used for input when external trigger is selected to cause DMAC operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
2	5	CS1H	F	CASH output for DRAM bank 1 Refer to the DRAM interface for details.
		PB6		Can be configured as a port when CS1H and DACK2 are not used.
		DACK2		External transfer request acknowledge output pin for DMAC (ch. 2) This function is available when transfer request output for DMAC is enabled.
3	6	$\overline{DW1}$	F	\overline{WE} output for DRAM bank 1 ("L" active) Refer to the DRAM interface for details.
		PB7		Can be configured as a port when $\overline{DW1}$ is not used.
16 to 18	19 to 21	MD0 to MD2	G	Mode pins 0 to 2 MCU basic operation mode is set by these pins. Directly connect these pins with V_{CC} or V_{SS} for use.
92	95	X0	A	Clock (oscillator) input
91	94	X1	A	Clock (oscillator) output
14	17	\overline{RST}	B	External reset input
13	16	\overline{HST}	H	Hardware standby input ("L" active)
12	15	\overline{NMI}	H	NMI (non-maskable interrupt pin) input ("L" active)
95, 94	98, 97	INT0, INT1	F	External interrupt request input pins These pins are used for input during corresponding interrupt is enabled, and it is necessary to disable output for other functions from these pins unless such output is made intentionally.
		PE0, PE1		Can be configured as a I/O port when INT0, INT1 are not used.
89	92	INT2	F	External interrupt request input pin This pin is used for input during corresponding interrupt is enabled, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		SC1		Clock I/O pin for UART1 Clock output is available when clock output of UART1 is enabled.
		PE2		Can be configured as a I/O port when INT2 and SC1 are not used. This function is available when UART1 clock output is disabled.

*1: FPT-100P-M05

*2: FPT-100P-M06

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MB91101/MB91101A

Pin no.		Pin name	Circuit type	Function
LQFP*1	QFP*2			
88	91	INT3	F	External interrupt request input pin This pin is used for input during corresponding interrupt is enabled, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		SC2		UART2 clock I/O pin Clock output is available when UART2 clock output is enabled.
		PE3		Can be configured as a I/O port when INT3 and SC2 are not used. This function is available when UART2 clock output is disabled.
87, 86	90, 89	DREQ0, DREQ1	F	External transfer request input pins for DMA These pins are used for input when external trigger is selected to cause DMAC operation, and it is necessary to disable output for other functions from these pins unless such output is made intentionally.
		PE4, PE5		Can be configured as a I/O port when DREQ0, DREQ1 are not used.
85	88	DACK0	F	External transfer request acknowledge output pin for DMAC (ch. 0) This function is available when transfer request output for DMAC is enabled.
		PE6		Can be configured as a I/O port when DACK0 is not used. This function is available when transfer request acknowledge output for DMAC or DACK0 output is disabled.
84	87	DACK1	F	External transfer request acknowledge output pin for DMAC (ch. 1) This function is available when transfer request output for DMAC is enabled.
		PE7		Can be configured as a I/O port when DACK1 is not used. This function is available when transfer request output for DMAC or DACK1 output is disabled.
76	79	SI0	F	UART0 data input pin This pin is used for input during UART0 is in input operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		TRG0		PWM timer external trigger input pin This pin is used for input during PWM timer external trigger is in input operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		PF0		Can be configured as a I/O port when SI0 and TRG0 are not used.

*1: FPT-100P-M05

*2: FPT-100P-M06

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MB91101/MB91101A

Pin no.		Pin name	Circuit type	Function
LQFP*1	QFP*2			
77	80	SO0	F	UART0 data output pin This function is available when UART0 data output is enabled.
		TRG1		PWM timer external trigger input pin This function is available when serial data output of PF1, UART0 are disabled.
		PF1		Can be configured as a I/O port when SO0 and TRG1 are not used. This function is available when serial data output of UART0 is disabled.
78	81	SC0	F	UART0 clock I/O pin Clock output is available when UART0 clock output is enabled.
		OCPA3		PWM timer output pin This function is available when PWM timer output is enabled.
		PF2		Can be configured as a I/O port when SC0 and OCPA3 are not used. This function is available when UART0 clock output is disabled.
79	82	SI1	F	UART1 data input pin This pin is used for input during UART1 is in input operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		TRG2		PWM timer external trigger input pin This pin is used for input during PWM timer external trigger is in input operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		PF3		Can be configured as a I/O port when SI1 and TRG2 are not used.
80	83	SO1	F	UART1 data output pin This function is available when UART1 data output is enabled.
		TRG3		PWM timer external trigger input pin This function is available when PF4, UART1 data outputs are disabled.
		PF4		Can be configured as a I/O port when SO1 and TRG3 are not used. This function is available when UART1 data output is disabled.
81	84	SI2	F	UART2 data input pin This pin is used for input during UART2 is in input operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
		OCPA1		PWM timer output pin This function is available when PWM timer output is enabled.
		PF5		Can be configured as a I/O port when SI2 and OCPA1 are not used.

*1: FPT-100P-M05

*2: FPT-100P-M06

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MB91101/MB91101A

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Pin no.		Pin name	Circuit type	Function
LQFP*1	QFP*2			
82	85	SO2	F	UART2 data output pin This function is available when UART2 data output is enabled.
		OCPA2		PWM timer output pin This function is available when PWM timer output is enabled.
		PF6		Can be configured as a I/O port when SO2 and OCPA2 are not used. This function is available when UART2 data output is disabled.
83	86	OCPA0	F	PWM timer output pin This function is available when PWM timer output is enabled.
		PF7		Can be configured as a I/O port when OCPA0 and \overline{ATG} are not used. This function is available when PWM timer output is disabled.
		\overline{ATG}		External trigger input pin for A/D converter This pin is used for input when external trigger is selected to cause A/D converter operation, and it is necessary to disable output for other functions from this pin unless such output is made intentionally.
72 to 75	75 to 78	AN0 to AN3	D	Analog input pins of A/D converter This function is available when AIC register is set to specify analog input mode.
69	72	AV _{cc}	—	Power supply pin (V _{cc}) for A/D converter
70	73	AVRH	—	Reference voltage input (high) for A/D converter Make sure to turn on and off this pin with potential of AVRH or more applied to V _{cc} .
71	74	AV _{ss} / AVRL	—	Power supply pin (V _{ss}) for A/D converter and reference voltage input pin (low)
43, 93	46, 96	V _{cc5}	—	5 V power supply pin (V _{cc}) for digital circuit Always two pins must be connected to the power supply (connect to 3 V power supply when operating at 3 V).
4	7	V _{cc3}	—	Bypass capacitor pin for internal capacitor. Also connect this pin to 3 V power supply when operating at 3 V.
15, 40, 65, 90	18, 43, 68, 93	V _{ss}	—	Earth level (V _{ss}) for digital circuit

*1: FPT-100P-M05

*2: FPT-100P-M06

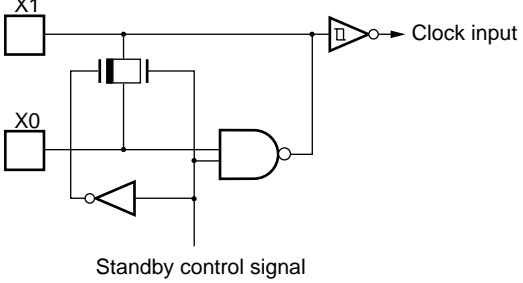
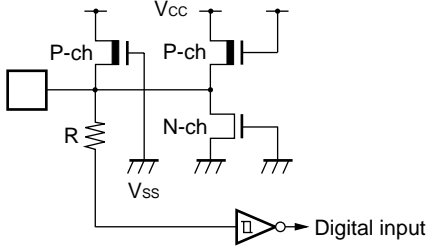
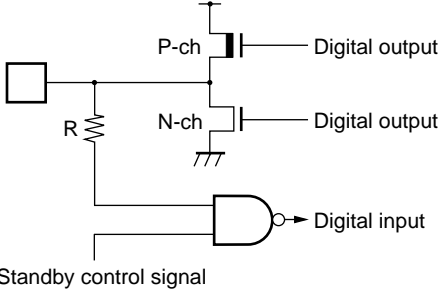
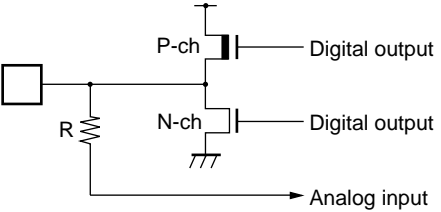
Note: In most of the above pins, I/O port and resource I/O are multiplexed e.g. P82 and BRQ. In case of conflict between output of I/O port and resource I/O, priority is always given to the output of resource I/O.

MB91101/MB91101A

■ DRAM CONTROL PIN

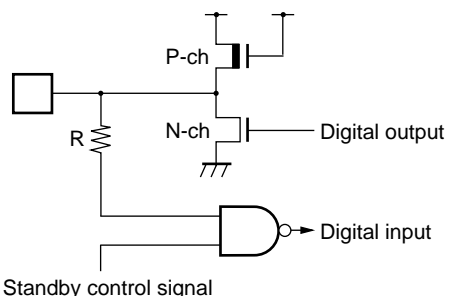
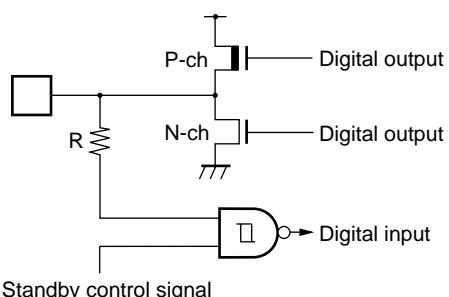
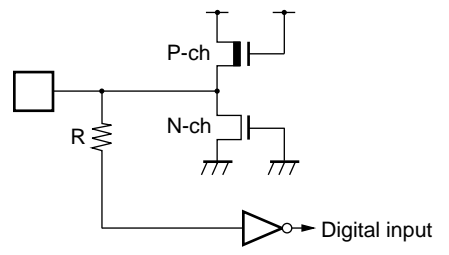
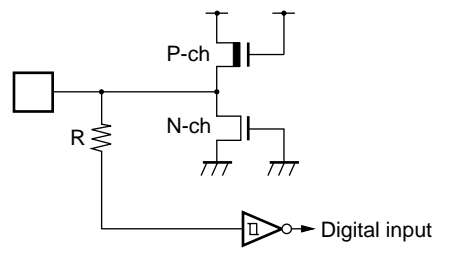
Pin name	Data bus 16-bit mode		Data bus 8-bit mode	Remarks
	2CAS/1WR mode	1CAS/2WR mode	—	
RAS0	Area 4 RAS	Area 4 RAS	Area 4 RAS	Correspondence of “L” “H” to lower address 1 bit (A0) in data bus 16- bit mode “L”: “0” “H”: “1” CASL: CAS which A0 corresponds to “0” area CASH: CAS which A0 corresponds to “1” area \overline{WEL} : \overline{WE} which A0 corresponds to “0” area \overline{WEH} : \overline{WE} which A0 corresponds to “1” area
RAS1	Area 5 RAS	Area 5 RAS	Area 5 RAS	
CS0L	Area 4 CASL	Area 4 CAS	Area 4 CAS	
CS0H	Area 4 CASH	Area 4 \overline{WEL}	Area 4 CAS	
CS1L	Area 5 CASL	Area 5 CAS	Area 5 CAS	
CS1H	Area 5 CASH	Area 5 \overline{WEL}	Area 5 CAS	
$\overline{CW0}$	Area 4 \overline{WE}	Area 4 \overline{WEH}	Area 4 \overline{WE}	
$\overline{DW1}$	Area 5 \overline{WE}	Area 5 \overline{WEH}	Area 5 \overline{WE}	

■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A		<ul style="list-style-type: none"> Oscillation feedback resistance 1 MΩ approx. With standby control
B		<ul style="list-style-type: none"> CMOS level Hysteresis input Without standby control With pull-up resistance
C		<ul style="list-style-type: none"> CMOS level I/O With standby control
D		<ul style="list-style-type: none"> Analog input

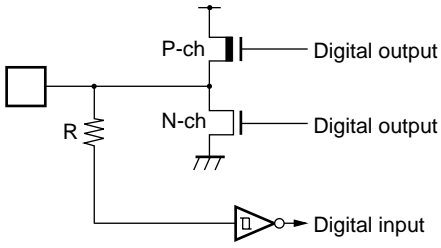
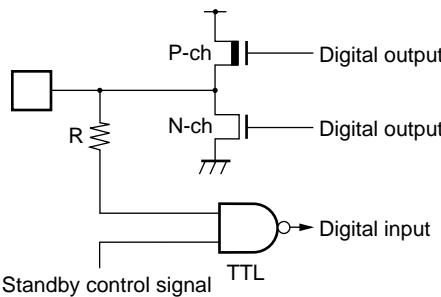
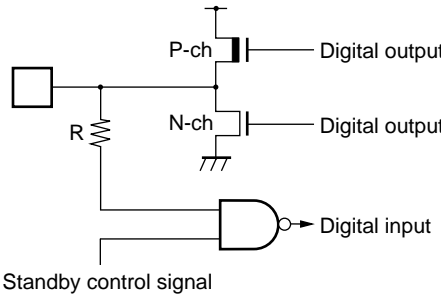
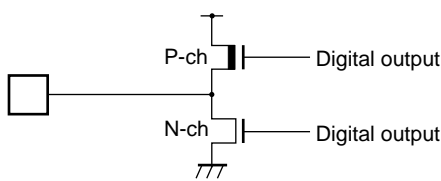
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MB91101/MB91101A

Type	Circuit	Remarks
E		<ul style="list-style-type: none"> • N-ch open-drain output • CMOS level input • With standby control
F		<ul style="list-style-type: none"> • CMOS level output • CMOS level Hysteresis input • With standby control
G		<ul style="list-style-type: none"> • CMOS level input • Without standby control
H		<ul style="list-style-type: none"> • CMOS level Hysteresis input • Without standby control

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Type	Circuit	Remarks
I		<ul style="list-style-type: none"> • CMOS level output • CMOS level Hysteresis input Without standby control
J		<ul style="list-style-type: none"> • CMOS level output • TTL level input With standby control
K		<ul style="list-style-type: none"> • CMOS level input/output With standby control • Large current drive
L		<ul style="list-style-type: none"> • CMOS level output

MB91101/MB91101A

■ HANDLING DEVICES

1. Preventing Latchup

In CMOS ICs, applying voltage higher than V_{CC} or lower than V_{SS} to input/output pin or applying voltage over rating across V_{CC} and V_{SS} may cause latchup.

This phenomenon rapidly increases the power supply current, which may result in thermal breakdown of the device. Make sure to prevent the voltage from exceeding the maximum rating.

Take care that the analog power supply (AV_{CC} , AVR) and the analog input do not exceed the digital power supply (V_{CC}) when the analog power supply turned on or off.

2. Treatment of Unused Pins

Unused pins left open may cause malfunctions. Make sure to connect them to pull-up or pull-down resistors.

3. External Reset Input

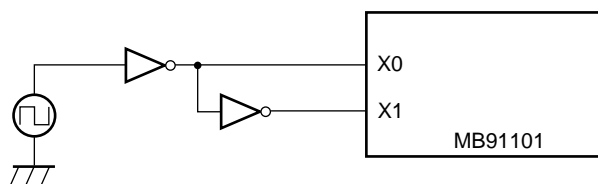
It takes at least 5 machine cycle to input "L" level to the \overline{RST} pin and to ensure inner reset operation properly.

4. Remarks for External Clock Operation

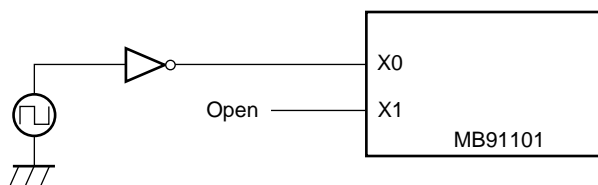
When external clock is selected, supply it to X0 pin generally, and simultaneously the opposite phase clock to X0 must be supplied to X1 pin. However, in this case the stop mode must not be used (because X1 pin stops at "H" output in stop mode).

And can be used to supply only to X0 pin with 5 V power supply at 12.5 MHz and less than.

• Using an external clock



Using an external clock (normal)
Note: Can not be used stop mode (oscillation stop mode).



Using an external clock (can be used at 12.5 MHz and less than.)
(5 V power supply only)

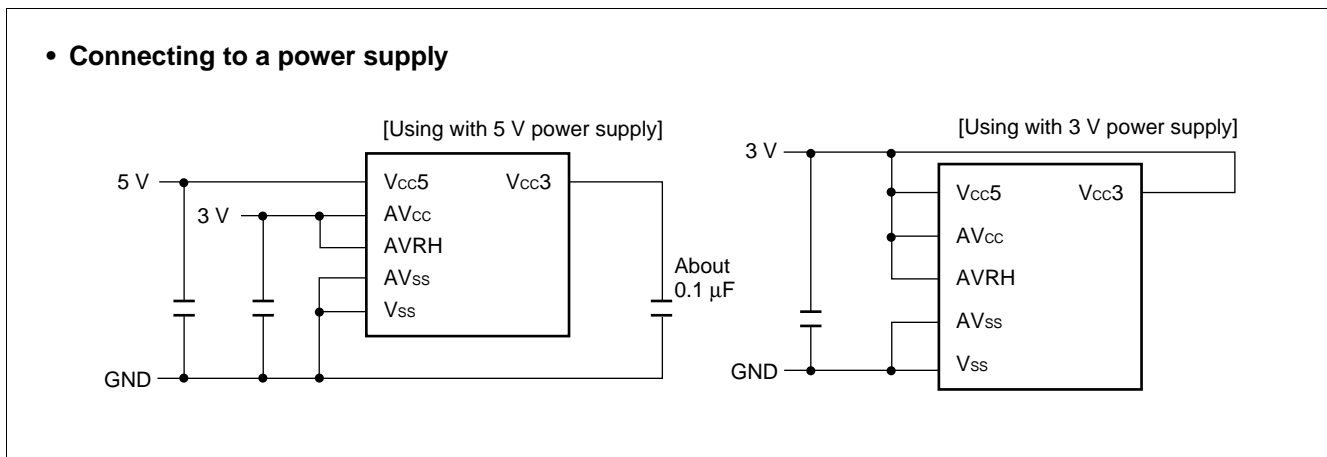
5. Power Supply Pins

When there are several V_{CC} and V_{SS} pins, each of them is equipotentially connected to its counterpart inside of the device, minimizing the risk of malfunctions such as latch up. To further reduce the risk of malfunctions, to prevent EMI radiation, to prevent strobe signal malfunction resulting from creeping-up of ground level and to observe the total output current standard, connect all V_{CC} and V_{SS} pins to the power supply or GND.

It is preferred to connect V_{CC} and V_{SS} of MB91101 to power supply with minimal impedance possible.

It is also recommended to connect a ceramic capacitor as a bypass capacitor of about $0.1 \mu\text{F}$ between V_{CC} and V_{SS} at a position as close as possible to MB91101.

MB91101 has an internal regulator. When using with 5 V power supply, supply 5 V to V_{CC5} pin and make sure to connect about $0.1 \mu\text{F}$ bypass capacitor to V_{CC3} pin for regulator. And another 3 V power supply is needed for the A/D converter. When using with 3 V power supply, connect both V_{CC5} pin and V_{CC3} pin to the 3 V power supply.



6. Crystal Oscillator Circuit

Noises around X0 and X1 pins may cause malfunctions of MB91101. In designing the PC board, layout X0, X1 and crystal oscillator (or ceramic oscillator) and bypass capacitor for grounding as close as possible.

It is strongly recommended to design PC board so that X1 and X0 pins are surrounded by grounding area for stable operation.

7. Turning-on Sequence of A/D Converter Power Supply and Analog Input

Make sure to turn on the digital power supply (V_{CC}) before turning on the A/D converter (AV_{CC} , $AVRH$) and applying voltage to analog input ($AN0$ to $AN3$).

Make sure to turn off digital power supply after power supply to A/D converters and analog inputs have been switched off. (There are no such limitations in turning on power supplies. Analog and digital power supplies may be turned on simultaneously.) Make sure that $AVRH$ never exceeds AV_{CC} when turning on/off power supplies.

8. Treatment of N.C. Pins

Make sure to leave N.C. pins open.

MB91101/MB91101A

9. Fluctuation of Power Supply Voltage

Warranty range for normal operation against fluctuation of power supply voltage V_{CC} is as given in rating. However, sudden fluctuation of power supply voltage within the warranty range may cause malfunctions. It is recommended to make every effort to stabilize the power supply voltage to IC. It is also recommended that by controlling power supply as a reference of stabilizing, V_{CC} ripple fluctuation (P-P value) at the commercial frequency (50 Hz to 60 Hz) should be less than 10% of the standard V_{CC} value and the transient regulation should be less than 0.1 V/ms at instantaneous deviation like turning off the power supply.

10. Mode Setting Pins (MD0 to MD2)

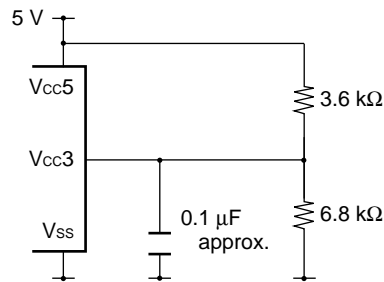
Connect mode setting pins (MD0 to MD2) directly to V_{CC} or V_{SS} .

Arrange each mode setting pin and V_{CC} or V_{SS} patterns on the printed circuit board as close as possible and make the impedance between them minimal to prevent mistaken entrance to the test mode caused by noises.

11. Internal DC Regulator

Internal DC regulator stops in stop mode. When the regulator stops owing to the increase of inner leakage current (ICCH) in stop mode, malfunction caused by noise or any troubles about power supply in normal operation, the internal 3 V power supply voltage may decrease less than the warranty range for normal operation. So when using the internal regulator and stop mode with 5 V power supply, never fail to support externally so that 3 V power supply voltage might not decrease. However, even in such a case, the internal regulator can be restarted by inputting the reset procedure. (In this case, set the reset to "L" level within the oscillation stabilizing waiting time.)

• Using STOP mode with 5 V power supply



12. Turning on the Power Supply

When turning on the power supply, never fail to start from setting the \overline{RST} pin to "L" level. And after the power supply voltage goes to V_{CC} level, at least after ensuring the time for 5 machine cycle, then set to "H" level.

13. Pin Condition at Turning on the Power Supply

The pin condition at turning on the power supply is unstable. The circuit starts being initialized after turning on the power supply and then starting oscillation and then the operation of the internal regulator becomes stable. So it takes about 42 ms for the pin to be initialized from the oscillation starting at the source oscillation 12.5 MHz. Take care that the pin condition may be output condition at initial unstable condition. (With the MB91101A, however, initialization can be achieved in less than about 42 ms after turning on the internal power supply by maintaining the \overline{RST} pin at "L" level.)

14. Source Oscillation Input at Turning on the Power Supply

At turning on the power supply, never fail to input the clock before cancellation of the oscillation stabilizing waiting.

15. Hardware Stand-by at Turning on the Power Supply

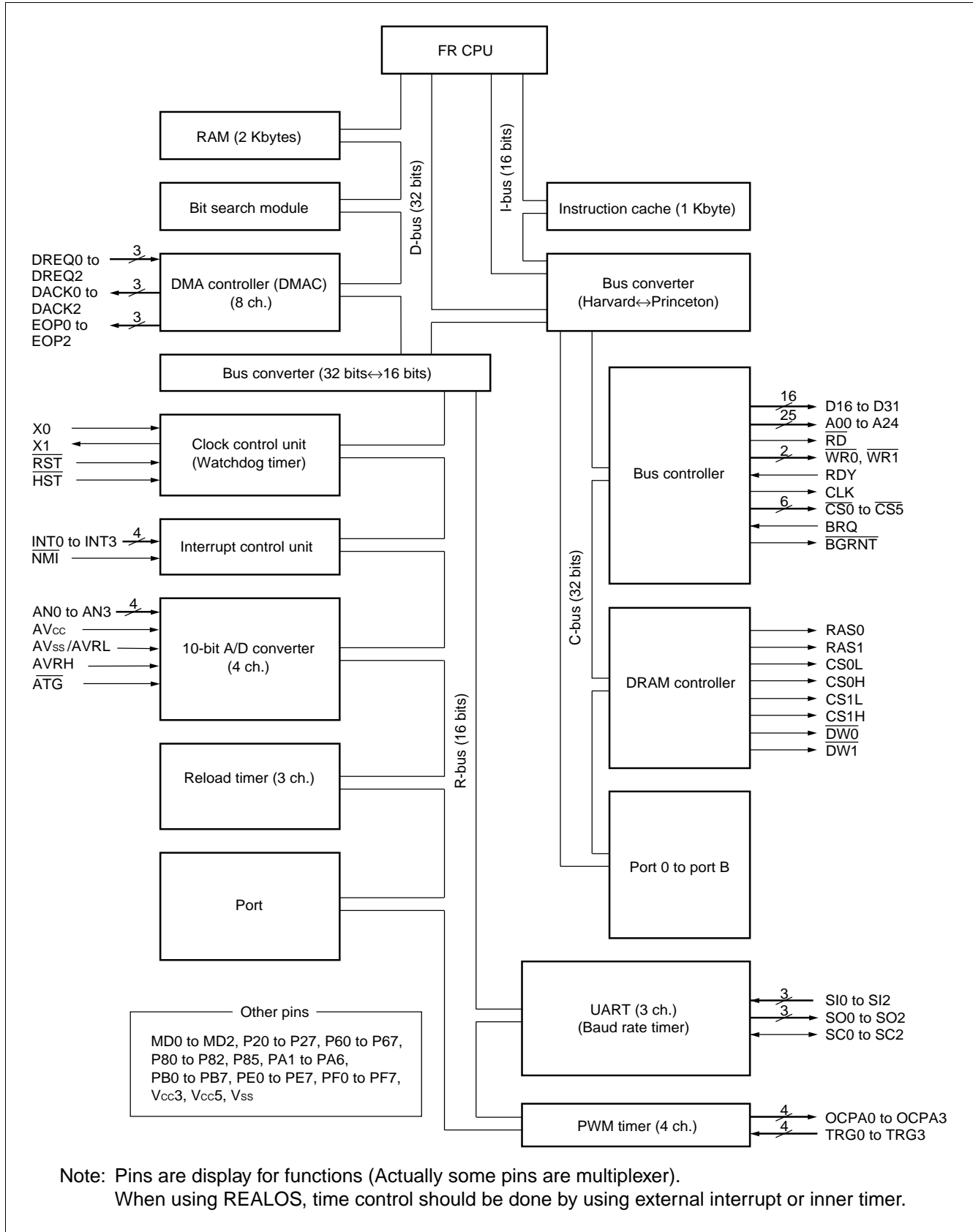
When turning on the power supply with the $\overline{\text{HST}}$ pin being set to “L” level, the hardware doesn’t stand by. However the $\overline{\text{HST}}$ pin becomes available after the reset cancellation, the $\overline{\text{HST}}$ pin must once be back to “H” level.

16. Power on Reset

Make sure to make power on reset at turning on the power supply or returning on the power supply when the power supply voltage is below the warranty range for normal operation.

MB91101/MB91101A

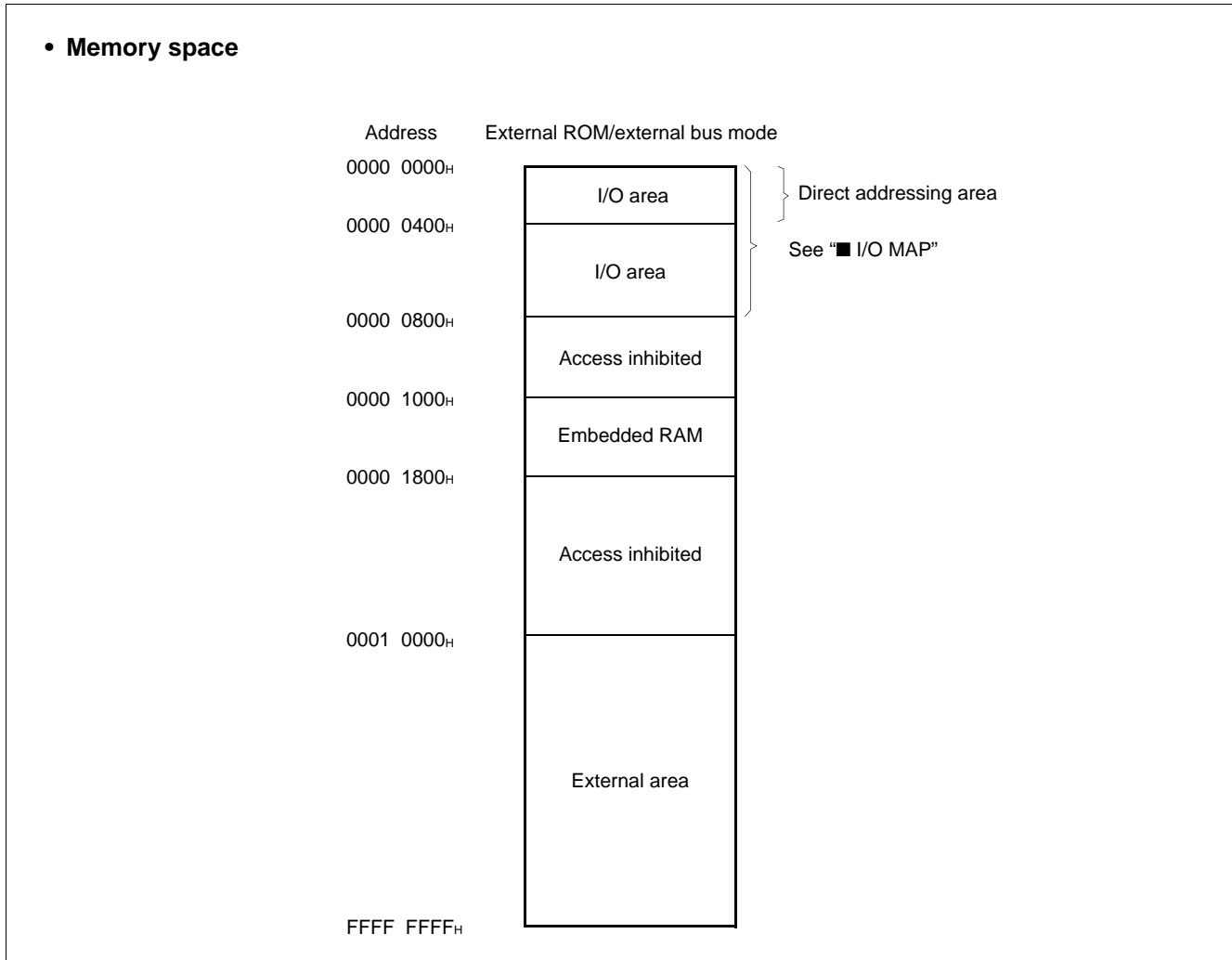
■ BLOCK DIAGRAM



■ CPU CORE

1. Memory Space

The FR family has a logical address space of 4 Gbytes (2^{32} bytes) and the CPU linearly accesses the memory space.



• Direct addressing area

The following areas on the memory space are assigned to direct addressing area for I/O. In these areas, an address can be specified in a direct operand of a code.

Direct areas consists of the following areas dependent on accessible data sizes.

Byte data access: 000_H to 0FF_H

Half word data access: 000_H to 1FF_H

Word data access: 000_H to 3FF_H

MB91101/MB91101A

2. Registers

The FR family has two types of registers; dedicated registers embedded on the CPU and general-purpose registers on memory.

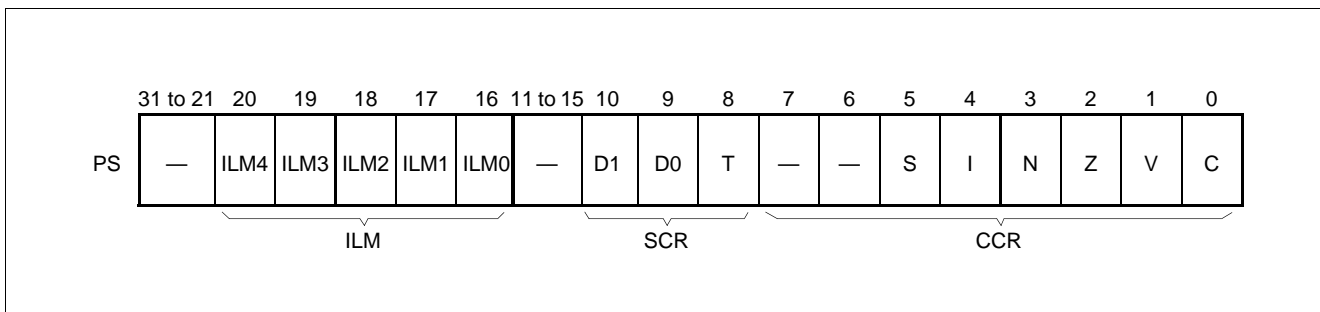
• Dedicated registers

- Program counter (PC): 32-bit length, indicates the location of the instruction to be executed.
- Program status (PS): 32-bit length, register for storing register pointer or condition codes
- Table base register (TBR): Holds top address of vector table used in EIT (Exceptional/Interrupt/Trap) processing.
- Return pointer (RP): Holds address to resume operation after returning from a subroutine.
- System stack pointer (SSP): Indicates system stack space.
- User's stack pointer (USP): Indicates user's stack space.
- Multiplication/division result register (MDH/MDL): 32-bit length, register for multiplication/division

Register Name	Description	Initial value
PC	Program counter	XXXX XXXXH Indeterminate
PS	Program status	
TBR	Table base register	000F FC00H
RP	Return pointer	XXXX XXXXH Indeterminate
SSP	System stack pointer	0000 0000H
USP	User's stack pointer	XXXX XXXXH Indeterminate
MDH	Multiplication/division result register	XXXX XXXXH Indeterminate
MDL		XXXX XXXXH Indeterminate

• Program status (PS)

The PS register is for holding program status and consists of a condition code register (CCR), a system condition code register (SCR) and a interrupt level mask register (ILM).



- **Condition code register (CCR)**

- S-flag: Specifies a stack pointer used as R15.
- I-flag: Controls user interrupt request enable/disable.
- N-flag: Indicates sign bit when division result is assumed to be in the 2's complement format.
- Z-flag: Indicates whether or not the result of division was "0".
- V-flag: Assumes the operand used in calculation in the 2's complement format and indicates whether or not overflow has occurred.
- C-flag: Indicates if a carry or borrow from the MSB has occurred.

- **System condition code register (SCR)**

- T-flag: Specifies whether or not to enable step trace trap.

- **Interrupt level mask register (ILM)**

ILM4 to ILM0: Register for holding interrupt level mask value. The value held by this register is used as a level mask. When an interrupt request issued to the CPU is higher than the level held by ILM, the interrupt request is accepted.

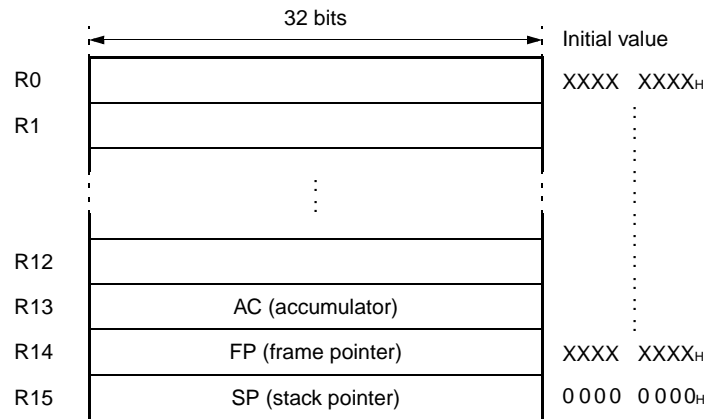
ILM4	ILM3	ILM2	ILM1	ILM0	Interrupt level	High-low
0	0	0	0	0	0	<div style="display: flex; align-items: center; justify-content: center;"> High ↑ ↕ ↓ Low </div>
					⋮	
0	1	0	0	0	15	
					⋮	
1	1	1	1	1	31	

MB91101/MB91101A

■ GENERAL-PURPOSE REGISTERS

R0 to R15 are general-purpose registers embedded on the CPU. These registers functions as an accumulator and a memory access pointer (field for indicating address).

• Register bank structure



Of the above 16 registers, following registers have special functions. To support the special functions, part of the instruction set has been sophisticated to have enhanced functions.

- R13: Virtual accumulator (AC)
- R14: Frame pointer (FP)
- R15: Stack pointer (SP)

Upon reset, values in R0 to R14 are not fixed. Value in R15 is initialized to be 0000 0000H (SSP value).

■ SETTING MODE

1. Pin

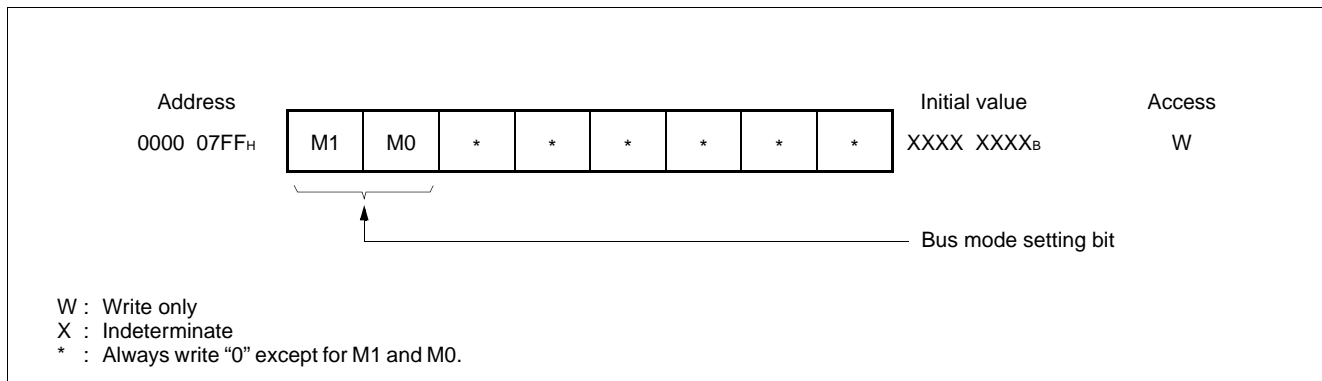
• Mode setting pins and modes

Mode setting pins			Mode name	Reset vector access area	External data bus width	Bus mode
MD2	MD1	MD0				
0	0	0	External vector mode 0	External	8 bits	External ROM/external bus mode
0	0	1	External vector mode 1	External	16 bits	
0	1	0	—	—	—	Inhibited
0	1	1	Internal vector mode	Internal	(Mode register)	Single-chip mode*
1	—	—	—	—	—	Inhibited

* : MB91101 does not support single-chip mode.

2. Registers

• Mode setting registers (MODR) and modes



• Bus mode setting bits and functions

M1	M0	Functions	Note
0	0	Single-chip mode	
0	1	Internal ROM/external bus mode	
1	0	External ROM/external bus mode	
1	1	—	Inhibited

Note: Because of without internal ROM, MB91101 allows "10_B" setting value only.

MB91101/MB91101A

■ I/O MAP

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0000H	(Vacancy)			
0001H	PDR2	Port 2 data register	R/W	XXXXXXXX _B
0002H to 0004H	(Vacancy)			
0005H	PDR6	Port 6 data register	R/W	XXXXXXXX _B
0006H 0007H	(Vacancy)			
0008H	PDRB	Port B data register	R/W	XXXXXXXX _B
0009H	PDRA	Port A data register	R/W	-XXXXXXXX _B
000AH	(Vacancy)			
000BH	PDR8	Port 8 data register	R/W	--X--XX _B
000CH to 0011H	(Vacancy)			
0012H	PDRE	Port E data register	R/W	XXXXXXXX _B
0013H	PDRF	Port F data register	R/W	XXXXXXXX _B
0014H to 001BH	(Vacancy)			
001CH	SSR0	Serial status register 0	R/W	00001-00 _B
001DH	SIDR0/SODR0	Serial input register 0/serial output register 0	R/W	XXXXXXXX _B
001EH	SCR0	Serial control register 0	R/W	00000100 _B
001FH	SMR0	Serial mode register 0	R/W	00--0-00 _B
0020H	SSR1	Serial status register 1	R/W	00001-00 _B
0021H	SIDR1/SODR1	Serial input register 1/serial output register 1	R/W	XXXXXXXX _B
0022H	SCR1	Serial control register 1	R/W	00000100 _B
0023H	SMR2	Serial mode register 1	R/W	00--0-00 _B
0024H	SSR2	Serial status register 2	R/W	00001-00 _B
0025H	SIDR2/SODR2	Serial input register 2/serial output register 2	R/W	XXXXXXXX _B
0026H	SCR2	Serial control register 2	R/W	00000100 _B
0027H	SMR2	Serial mode register 2	R/W	00--0-00 _B

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0028 _H	TMRLR0	16-bit reload register ch. 0	W	XXXXXXXX _B
0029 _H				XXXXXXXX _B
002A _H	TMR0	16-bit timer register ch. 0	R	XXXXXXXX _B
002B _H				XXXXXXXX _B
002C _H	(Vacancy)			
002D _H				
002E _H	TMCSR0	16-bit reload timer control status register ch. 0	R/W	----0000 _B
002F _H				00000000 _B
0030 _H	TMRLR1	16-bit reload register ch. 1	W	XXXXXXXX _B
0031 _H				XXXXXXXX _B
0032 _H	TMR1	16-bit timer register ch. 1	R	XXXXXXXX _B
0033 _H				XXXXXXXX _B
0034 _H	(Vacancy)			
0035 _H				
0036 _H	TMCSR1	16-bit reload timer control status register ch. 1	R/W	----0000 _B
0037 _H				00000000 _B
0038 _H	ADCR	A/D converter data register	R	-----XX _B
0039 _H				XXXXXXXX _B
003A _H	ADCS	A/D converter control status register	R/W	00000000 _B
003B _H				00000000 _B
003C _H	TMRLR2	16-bit reload register ch. 2	W	XXXXXXXX _B
003D _H				XXXXXXXX _B
003E _H	TMR2	16-bit timer register ch. 2	R	XXXXXXXX _B
003F _H				XXXXXXXX _B
0040 _H	(Vacancy)			
0041 _H				
0042 _H	TMCSR2	16-bit reload timer control status register ch. 2	R/W	----0000 _B
0043 _H				00000000 _B
0044 _H to 0077 _H	(Vacancy)			

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0078 _H	UTIM0/UTIMR0	U-TIMER register ch. 0/reload register ch. 0	R/W	0 0 0 0 0 0 0 0 _B
0079 _H				0 0 0 0 0 0 0 0 _B
007A _H	(Vacancy)			
007B _H	UTIMC0	U-TIMER control register ch. 0	R/W	0 -- 0 0 0 0 1 _B
007C _H	UTIM1/UTIMR1	U-TIMER register ch. 1/reload register ch. 1	R/W	0 0 0 0 0 0 0 0 _B
007D _H				0 0 0 0 0 0 0 0 _B
007E _H	(Vacancy)			
007F _H	UTIMC1	U-TIMER control register ch. 1	R/W	0 -- 0 0 0 0 1 _B
0080 _H	UTIM2/UTIMR2	U-TIMER register ch. 2/reload register ch. 0	R/W	0 0 0 0 0 0 0 0 _B
0081 _H				0 0 0 0 0 0 0 0 _B
0082 _H	(Vacancy)			
0083 _H	UTIMC2	U-TIMER control register ch. 2	R/W	0 -- 0 0 0 0 1 _B
0084 _H to 0093 _H	(Vacancy)			
0094 _H	EIRR	External interrupt cause register	R/W	0 0 0 0 0 0 0 0 _B
0095 _H	ENIR	Interrupt enable register	R/W	0 0 0 0 0 0 0 0 _B
0096 _H to 0098 _H	(Vacancy)			
0099 _H	ELVR	External interrupt request level setting register	R/W	0 0 0 0 0 0 0 0 _B
009A _H to 00D1 _H	(Vacancy)			
00D2 _H	DDRE	Port E data direction register	W	0 0 0 0 0 0 0 0 _B
00D3 _H	DDRF	Port F data direction register	W	0 0 0 0 0 0 0 0 _B
00D4 _H to 00DB _H	(Vacancy)			
00DC _H	GCN1	General control register 1	R/W	0 0 1 1 0 0 1 0 _B
00DD _H				0 0 0 1 0 0 0 0 _B
00DE _H	(Vacancy)			
00DF _H	GCN2	General control register 2	R/W	0 0 0 0 0 0 0 0 _B

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
00E0 _H	PTMR0	Ch. 0 timer register	R	1 1 1 1 1 1 1 1 _B
00E1 _H				1 1 1 1 1 1 1 1 _B
00E2 _H	PCSR0	Ch. 0 cycle setting register	W	XXXXXXXX _B
00E3 _H				XXXXXXXX _B
00E4 _H	PDUT0	Ch. 0 duty setting register	W	XXXXXXXX _B
00E5 _H				XXXXXXXX _B
00E6 _H	PCNH0	Ch. 0 control status register H	R/W	0 0 0 0 0 0 0 - _B
00E7 _H	PCNL0	Ch. 0 control status register L	R/W	0 0 0 0 0 0 0 0 _B
00E8 _H	PTMR1	Ch. 1 timer register	R	1 1 1 1 1 1 1 1 _B
00E9 _H				1 1 1 1 1 1 1 1 _B
00EA _H	PCSR1	Ch. 1 cycle setting register	W	XXXXXXXX _B
00EB _H				XXXXXXXX _B
00EC _H	PDUT1	Ch. 1 duty setting register	W	XXXXXXXX _B
00ED _H				XXXXXXXX _B
00EE _H	PCNH1	Ch. 1 control status register H	R/W	0 0 0 0 0 0 0 - _B
00EF _H	PCNL1	Ch. 1 control status register L	R/W	0 0 0 0 0 0 0 0 _B
00F0 _H	PTMR2	Ch. 2 timer register	R	1 1 1 1 1 1 1 1 _B
00F1 _H				1 1 1 1 1 1 1 1 _B
00F2 _H	PCSR2	Ch. 2 cycle setting register	W	XXXXXXXX _B
00F3 _H				XXXXXXXX _B
00F4 _H	PDUT2	Ch. 2 duty setting register	W	XXXXXXXX _B
00F5 _H				XXXXXXXX _B
00F6 _H	PCNH2	Ch. 2 control status register H	R/W	0 0 0 0 0 0 0 - _B
00F7 _H	PCNL2	Ch. 2 control status register L	R/W	0 0 0 0 0 0 0 0 _B
00F8 _H	PTMR3	Ch. 3 timer register	R	1 1 1 1 1 1 1 1 _B
00F9 _H				1 1 1 1 1 1 1 1 _B
00FA _H	PCSR3	Ch. 3 cycle setting register	W	XXXXXXXX _B
00FB _H				XXXXXXXX _B
00FC _H	PDUT3	Ch. 3 duty setting register	W	XXXXXXXX _B
00FD _H				XXXXXXXX _B
00FE _H	PCNH3	Ch. 3 control status register H	R/W	0 0 0 0 0 0 0 - _B
00FF _H	PCNL3	Ch. 3 control status register L	R/W	0 0 0 0 0 0 0 0 _B

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0100 _H to 01FF _H	(Vacancy)			
0200 _H	DPDP	DMAC parameter descriptor pointer	R/W	XXXXXXXX _B
0201 _H				XXXXXXXX _B
0202 _H				XXXXXXXX _B
0203 _H				X0000000 _B
0204 _H	DACSR	DMAC control status register	R/W	00000000 _B
0205 _H				00000000 _B
0206 _H				00000000 _B
0207 _H				00000000 _B
0208 _H	DATCR	DMAC pin control register	R/W	XXXXXXXX _B
0209 _H				XXXX0000 _B
020A _H				XXXX0000 _B
020B _H				XXXX0000 _B
020C _H to 03E3 _H	(Vacancy)			
03E4 _H	ICHCR	Instruction cache control register	R/W	----- _B
03E5 _H				----- _B
03E6 _H				----- _B
03E7 _H				--000000 _B
03E8 _H to 03EF _H	(Vacancy)			
03F0 _H	BSD0	Bit search module 0-detection data register	W	XXXXXXXX _B
03F1 _H				XXXXXXXX _B
03F2 _H				XXXXXXXX _B
03F3 _H				XXXXXXXX _B
03F4 _H	BSD1	Bit search module 1-detection data register	R/W	XXXXXXXX _B
03F5 _H				XXXXXXXX _B
03F6 _H				XXXXXXXX _B
03F7 _H				XXXXXXXX _B

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
03F8 _H	BSDC	Bit search module transition-detection data register	W	XXXXXXXX _B
03F9 _H				XXXXXXXX _B
03FA _H				XXXXXXXX _B
03FB _H				XXXXXXXX _B
03FC _H	BSRR	Bit search module detection result register	R	XXXXXXXX _B
03FD _H				XXXXXXXX _B
03FE _H				XXXXXXXX _B
03FF _H				XXXXXXXX _B
0400 _H	ICR00	Interrupt control register 0	R/W	---1111 _B
0401 _H	ICR01	Interrupt control register 1	R/W	---1111 _B
0402 _H	ICR02	Interrupt control register 2	R/W	---1111 _B
0403 _H	ICR03	Interrupt control register 3	R/W	---1111 _B
0404 _H	ICR04	Interrupt control register 4	R/W	---1111 _B
0405 _H	ICR05	Interrupt control register 5	R/W	---1111 _B
0406 _H	ICR06	Interrupt control register 6	R/W	---1111 _B
0407 _H	ICR07	Interrupt control register 7	R/W	---1111 _B
0408 _H	ICR08	Interrupt control register 8	R/W	---1111 _B
0409 _H	ICR09	Interrupt control register 9	R/W	---1111 _B
040A _H	ICR10	Interrupt control register 10	R/W	---1111 _B
040B _H	ICR11	Interrupt control register 11	R/W	---1111 _B
040C _H	ICR12	Interrupt control register 12	R/W	---1111 _B
040D _H	ICR13	Interrupt control register 13	R/W	---1111 _B
040E _H	ICR14	Interrupt control register 14	R/W	---1111 _B
040F _H	ICR15	Interrupt control register 15	R/W	---1111 _B
0410 _H	ICR16	Interrupt control register 16	R/W	---1111 _B
0411 _H	ICR17	Interrupt control register 17	R/W	---1111 _B
0412 _H	ICR18	Interrupt control register 18	R/W	---1111 _B
0413 _H	ICR19	Interrupt control register 19	R/W	---1111 _B
0414 _H	ICR20	Interrupt control register 20	R/W	---1111 _B
0415 _H	ICR21	Interrupt control register 21	R/W	---1111 _B
0416 _H	ICR22	Interrupt control register 22	R/W	---1111 _B

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0417 _H	ICR23	Interrupt control register 23	R/W	---11111 _B
0418 _H	ICR24	Interrupt control register 24	R/W	---11111 _B
0419 _H	ICR25	Interrupt control register 25	R/W	---11111 _B
041A _H	ICR26	Interrupt control register 26	R/W	---11111 _B
041B _H	ICR27	Interrupt control register 27	R/W	---11111 _B
041C _H	ICR28	Interrupt control register 28	R/W	---11111 _B
041D _H	ICR29	Interrupt control register 29	R/W	---11111 _B
041E _H	ICR30	Interrupt control register 30	R/W	---11111 _B
041F _H	ICR31	Interrupt control register 31	R/W	---11111 _B
042F _H	ICR47	Interrupt control register 47	R/W	---11111 _B
0430 _H	DICR	Delayed interrupt control register	R/W	-----0 _B
0431 _H	HRCL	Hold request cancel request level setting register	R/W	---11111 _B
0432 _H to 047F _H	(Vacancy)			
0480 _H	RSRR/WTCR	Reset cause register/ watchdog peripheral control register	R/W	1XXXX-00 _B
0481 _H	STCR	Standby control register	R/W	000111-- _B
0482 _H	PDRR	DMA controller request squelch register	R/W	----0000 _B
0483 _H	CTBR	Timebase timer clear register	W	XXXXXXXX _B
0484 _H	GCR	Gear control register	R/W	110011-1 _B
0485 _H	WPR	Watchdog reset occurrence postpone register	W	XXXXXXXX _B
0486 _H 0487 _H	(Vacancy)			
0488 _H	PCTR	PLL control register	R/W	00--0--- _B
0489 _H to 0600 _H	(Vacancy)			
0601 _H	DDR2	Port 2 data direction register	W	00000000 _B
0602 _H to 0604 _H	(Vacancy)			
0605 _H	DDR6	Port 6 data direction register	W	00000000 _B
0606 _H 0607 _H	(Vacancy)			

(Continued)

MB91101/MB91101A

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0608 _H	DDRB	Port B data direction register	W	0 0 0 0 0 0 0 0 _B
0609 _H	DDRA	Port A data direction register	W	- 0 0 0 0 0 0 - _B
060A _H	(Vacancy)			
060B _H	DDR8	Port 8 data direction register	W	-- 0 -- 0 0 0 _B
060C _H	ASR1	Area select register 1	W	0 0 0 0 0 0 0 0 _B
060D _H				0 0 0 0 0 0 0 1 _B
060E _H	AMR1	Area mask register 1	W	0 0 0 0 0 0 0 0 _B
060F _H				0 0 0 0 0 0 0 0 _B
0610 _H	ASR2	Area select register 2	W	0 0 0 0 0 0 0 0 _B
0611 _H				0 0 0 0 0 0 1 0 _B
0612 _H	AMR2	Area mask register 2	W	0 0 0 0 0 0 0 0 _B
0613 _H				0 0 0 0 0 0 0 0 _B
0614 _H	ASR3	Area select register 3	W	0 0 0 0 0 0 0 0 _B
0615 _H				0 0 0 0 0 0 1 1 _B
0616 _H	AMR3	Area mask register 3	W	0 0 0 0 0 0 0 0 _B
0617 _H				0 0 0 0 0 0 0 0 _B
0618 _H	ASR4	Area select register 4	W	0 0 0 0 0 0 0 0 _B
0619 _H				0 0 0 0 0 1 0 0 _B
061A _H	AMR4	Area mask register 4	W	0 0 0 0 0 0 0 0 _B
061B _H				0 0 0 0 0 0 0 0 _B
061C _H	ASR5	Area select register 5	W	0 0 0 0 0 0 0 0 _B
061D _H				0 0 0 0 0 1 0 1 _B
061E _H	AMR5	Area mask register 5	W	0 0 0 0 0 0 0 0 _B
061F _H				0 0 0 0 0 0 0 0 _B
0620 _H	AMD0	Area mode register 0	R/W	- - - 0 0 1 1 1 _B
0621 _H	AMD1	Area mode register 1	R/W	0 - - 0 0 0 0 0 _B
0622 _H	AMD32	Area mode register 32	R/W	0 0 0 0 0 0 0 0 _B
0623 _H	AMD4	Area mode register 4	R/W	0 - - 0 0 0 0 0 _B
0624 _H	AMD5	Area mode register 5	R/W	0 - - 0 0 0 0 0 _B
0625 _H	DSCR	DRAM signal control register	W	0 0 0 0 0 0 0 0 _B
0626 _H	RFCR	Refresh control register	R/W	- - X X X X X _B
0627 _H				0 0 - - - 0 0 0 _B

(Continued)

MB91101/MB91101A

(Continued)

Address	Register name (abbreviated)	Register name	Read/write	Initial value
0628 _H	EPCR0	External pin control register 0	W	----1100 _B
0629 _H				-1111111 _B
062A _H	(Vacancy)			
062B _H	EPCR1	External pin control register 1	W	11111111 _B
062C _H	DMCR4	DRAM control register 4	R/W	00000000 _B
062D _H				0000000- _B
062E _H	DMCR5	DRAM control register 5	R/W	00000000 _B
062F _H				0000000- _B
0630 _H to 07FD _H	(Vacancy)			
07FE _H	LER	Little endian register	W	-----000 _B
07FF _H	MODR	Mode register	W	XXXXXXXX _B

Note: Do not use (vacancy).

■ INTERRUPT CAUSES, INTERRUPT VECTORS AND INTERRUPT CONTROL REGISTER ALLOCATIONS

Interrupt causes	Interrupt number		Interrupt level		TBR default address
	Decimal	Hexadecimal	Register	Offset	
Reset	0	00	—	3FC _H	000FFFFC _H
Reserved for system	1	01	—	3F8 _H	000FFFF8 _H
Reserved for system	2	02	—	3F4 _H	000FFFF4 _H
Reserved for system	3	03	—	3F0 _H	000FFFF0 _H
Reserved for system	4	04	—	3EC _H	000FFFE _C
Reserved for system	5	05	—	3E8 _H	000FFFE8 _H
Reserved for system	6	06	—	3E4 _H	000FFFE4 _H
Reserved for system	7	07	—	3E0 _H	000FFFE0 _H
Reserved for system	8	08	—	3DC _H	000FFFD _C
Reserved for system	9	09	—	3D8 _H	000FFFD8 _H
Reserved for system	10	0A	—	3D4 _H	000FFFD4 _H
Reserved for system	11	0B	—	3D0 _H	000FFFD0 _H
Reserved for system	12	0C	—	3CC _H	000FFFC _C
Reserved for system	13	0D	—	3C8 _H	000FFFC8 _H
Exception for undefined instruction	14	0E	—	3C4 _H	000FFFC4 _H
NMI request	15	0F	F _H fixed	3C0 _H	000FFFC0 _H
External interrupt 0	16	10	ICR00	3BC _H	000FFFB _C
External interrupt 1	17	11	ICR01	3B8 _H	000FFFB8 _H
External interrupt 2	18	12	ICR02	3B4 _H	000FFFB4 _H
External interrupt 3	19	13	ICR03	3B0 _H	000FFFB0 _H
UART0 receive complete	20	14	ICR04	3AC _H	000FFFA _C
UART1 receive complete	21	15	ICR05	3A8 _H	000FFFA8 _H
UART2 receive complete	22	16	ICR06	3A4 _H	000FFFA4 _H
UART0 transmit complete	23	17	ICR07	3A0 _H	000FFFA0 _H
UART1 transmit complete	24	18	ICR08	39C _H	000FFF9 _C
UART2 transmit complete	25	19	ICR09	398 _H	000FFF98 _H
DMAC0 (complete, error)	26	1A	ICR10	394 _H	000FFF94 _H
DMAC1 (complete, error)	27	1B	ICR11	390 _H	000FFF90 _H
DMAC2 (complete, error)	28	1C	ICR12	38C _H	000FFF8 _C
DMAC3 (complete, error)	29	1D	ICR13	388 _H	000FFF88 _H
DMAC4 (complete, error)	30	1E	ICR14	384 _H	000FFF84 _H
DMAC5 (complete, error)	31	1F	ICR15	380 _H	000FFF80 _H

(Continued)

MB91101/MB91101A

Interrupt causes	Interrupt number		Interrupt level		TBR default address
	Decimal	Hexadecimal	Register	Offset	
DMAC6 (complete, error)	32	20	ICR16	37C _H	000FFF7C _H
DMAC7 (complete, error)	33	21	ICR17	378 _H	000FFF78 _H
A/D converter (successive approximation conversion type)	34	22	ICR18	374 _H	000FFF74 _H
16-bit reload timer 0	35	23	ICR19	370 _H	000FFF70 _H
16-bit reload timer 1	36	24	ICR20	36C _H	000FFF6C _H
16-bit reload timer 2	37	25	ICR21	368 _H	000FFF68 _H
PWM 0	38	26	ICR22	364 _H	000FFF64 _H
PWM 1	39	27	ICR23	360 _H	000FFF60 _H
PWM 2	40	28	ICR24	35C _H	000FFF5C _H
PWM 3	41	29	ICR25	358 _H	000FFF58 _H
U-TIMER 0	42	2A	ICR26	354 _H	000FFF54 _H
U-TIMER 1	43	2B	ICR27	350 _H	000FFF50 _H
U-TIMER 2	44	2C	ICR28	34C _H	000FFF4C _H
Reserved for system	45	2D	ICR29	348 _H	000FFF48 _H
Reserved for system	46	2E	ICR30	344 _H	000FFF44 _H
Reserved for system	47	2F	ICR31	340 _H	000FFF40 _H
Reserved for system	48	30	ICR32	33C _H	000FFF3C _H
Reserved for system	49	31	ICR33	338 _H	000FFF38 _H
Reserved for system	50	32	ICR34	334 _H	000FFF34 _H
Reserved for system	51	33	ICR35	330 _H	000FFF30 _H
Reserved for system	52	34	ICR36	32C _H	000FFF2C _H
Reserved for system	53	35	ICR37	328 _H	000FFF28 _H
Reserved for system	54	36	ICR38	324 _H	000FFF24 _H
Reserved for system	55	37	ICR39	320 _H	000FFF20 _H
Reserved for system	56	38	ICR40	31C _H	000FFF1C _H
Reserved for system	57	39	ICR41	318 _H	000FFF18 _H
Reserved for system	58	3A	ICR42	314 _H	000FFF14 _H
Reserved for system	59	3B	ICR43	310 _H	000FFF10 _H
Reserved for system	60	3C	ICR44	30C _H	000FFF0C _H
Reserved for system	61	3D	ICR45	308 _H	000FFF08 _H
Reserved for system	62	3E	ICR46	304 _H	000FFF04 _H
Delayed interrupt cause bit	63	3F	ICR47	300 _H	000FFF00 _H

(Continued)

(Continued)

Interrupt causes	Interrupt number		Interrupt level		TBR default address
	Decimal	Hexadecimal	Register	Offset	
Reserved for system (used in REALOS*)	64	40	—	2FC _H	000FFEFC _H
Reserved for system (used in REALOS*)	65	41	—	2F8 _H	000FFE8 _H
Used in INT instructions	66 to 255	42 to FF	—	2F4 _H to 000 _H	000FEF4 _H to 000FFC0 _H

* : When using in REALOS/FR, interrupt 0x40, 0x41 for system code.

MB91101/MB91101A

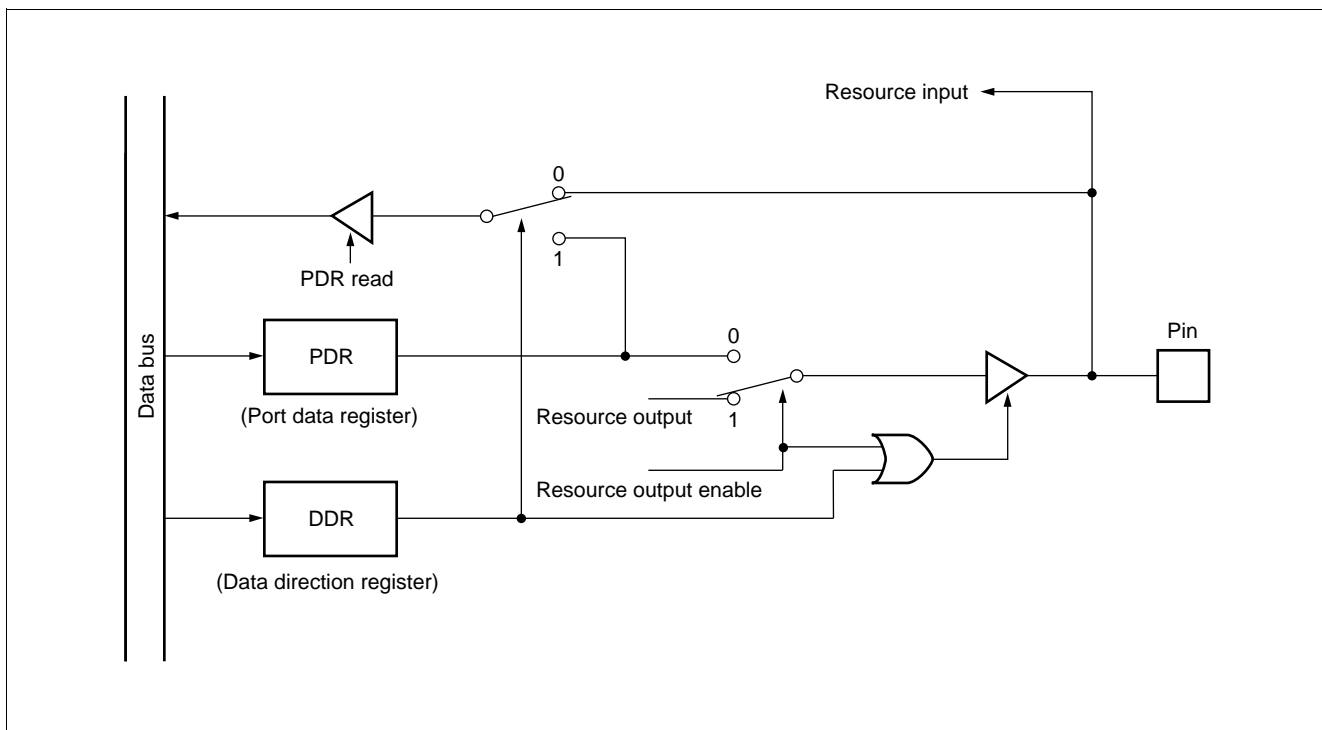
■ PERIPHERAL RESOURCES

1. I/O Ports

There are 2 types of I/O port register structure; port data register (PDR0 to PDRF) and data direction register (DDR0 to DDRF), where bits PDR0 to PDRF and bits DDR0 to DDRF corresponds respectively. Each bit on the register corresponds to an external pin. In port registers input/output register of the port configures input/output function of the port, while corresponding bit (pin) configures input/output function in data direction registers. Bit "0" specifies input and "1" specifies output.

- For input (DDR = "0") setting;
PDR reading operation: reads level of corresponding external pin.
PDR writing operation: writes set value to PDR.
- For output (DDR = "1") setting;
PDR reading operation: reads PDR value.
PDR writing operation: outputs PDR value to corresponding external pin.

• Block diagram



• Port data register

Address	bit 7	bit 0	Initial value	
000001H	PDR2		X X X X X X X B	(R/W)
000005H	PDR6		X X X X X X X B	(R/W)
00000BH	PDR8		- - X - - X X X B	(R/W)
000009H	PDRA		- X X X X X X - B	(R/W)
000008H	PDRB		X X X X X X X B	(R/W)
000012H	PDRE		X X X X X X X B	(R/W)
000013H	PDRF		X X X X X X X B	(R/W)

() : Access
 R/W : Readable and writable
 X : Indeterminate

• Data direction register

Address	bit 7	bit 0	Initial value	
000601H	DDR2		0 0 0 0 0 0 0 0 B	(W)
000605H	DDR6		0 0 0 0 0 0 0 0 B	(W)
00060BH	DDR8		- - 0 - - 0 0 0 B	(W)
000609H	DDRA		- 0 0 0 0 0 0 - B	(W)
000608H	DDRB		0 0 0 0 0 0 0 0 B	(W)
0000D2H	DDRE		0 0 0 0 0 0 0 0 B	(W)
0000D3H	DDRF		0 0 0 0 0 0 0 0 B	(W)

() : Access
 W : Write only
 - : Unused

MB91101/MB91101A

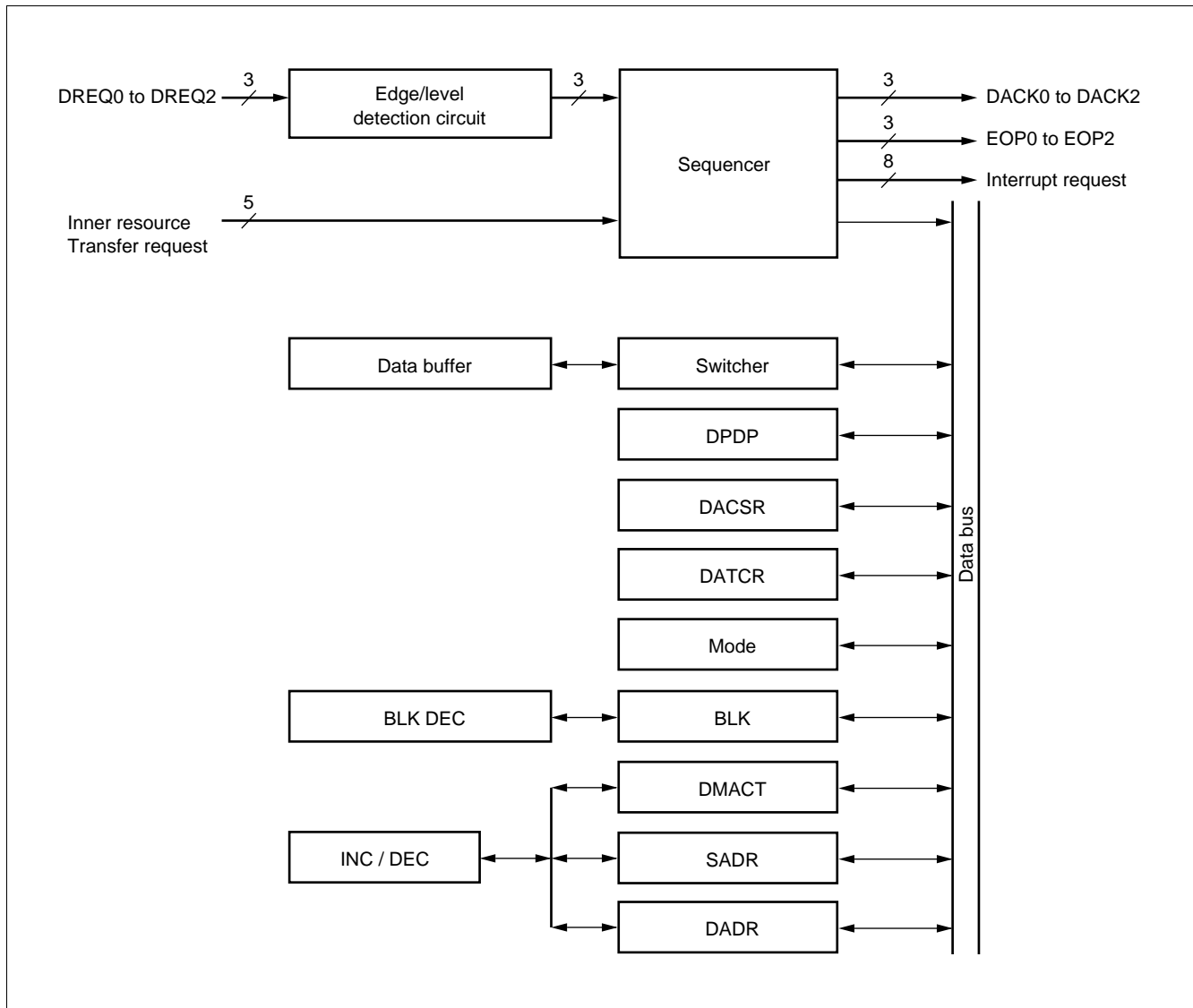
2. DMA Controller (DMAC)

The DMA controller is a module embedded in FR family devices, and performs DMA (direct memory access) transfer.

DMA transfer performed by the DMA controller transfers data without intervention of CPU, contributing to enhanced performance of the system.

- 8 channels
- Mode: single/block transfer, burst transfer and continuous transfer: 3 kinds of transfer
- Transfer all through the area
- Max. 65536 of transfer cycles
- Interrupt function right after the transfer
- Selectable for address transfer increase/decrease by the software
- External transfer request input pin, external transfer request accept output pin, external transfer complete output pin three pins for each

• Block diagram



• Registers (DMAC internal registers)

Address	bit 31	bit 16	bit 0	Initial value	
00000200H	DPDP			XXXXXXXXXB	(R/W)
00000201H				XXXXXXXXXB	
00000202H				XXXXXXXXXB	
00000203H				X0000000B	
00000204H	DACSR			00000000B	(R/W)
00000205H				00000000B	
00000206H				00000000B	
00000207H				00000000B	
00000208H	DATCR			XXXXXXXXXB	(R/W)
00000209H				XXXX0000B	
0000020AH				XXXX0000B	
0000020BH				XXXX0000B	

() : Access
 R/W : Readable and writable
 X : Indeterminate

• Registers (DMA descriptor)

Address	bit 31	bit 0	
DPDP + 0H	DMA ch.0 Descriptor		DMA ch.0 Descriptor
DPDP + 0CH				DMA ch.1 Descriptor
DPDP + 54H	DMA ch.7 Descriptor		DMA ch.7 Descriptor

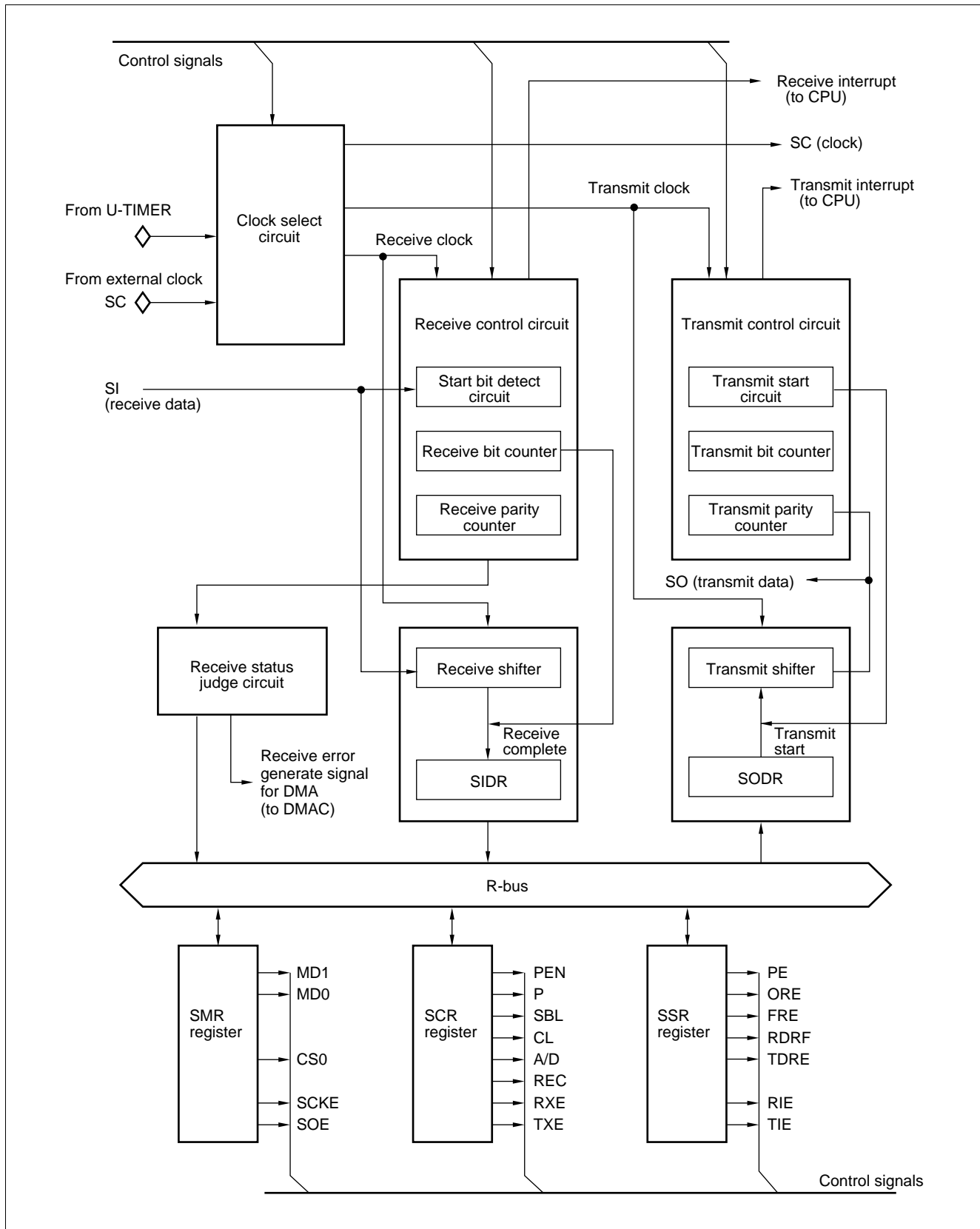
3. UART

The UART is a serial I/O port for supporting asynchronous (start-stop system) communication or CLK synchronous communication, and it has the following features.

The MB91101 consists of 3 channels of UART.

- Full double double buffer
- Both a synchronous (start-stop system) communication and CLK synchronous communication are available.
- Supporting multi-processor mode
- Perfect programmable baud rate
 - Any baud rate can be set by internal timer (refer to section “4. U-TIMER”).
- Any baud rate can be set by external clock.
- Error checking function (parity, framing and overrun)
- Transfer signal: NRZ code
- Enable DMA transfer/start by interrupt.

• Block diagram



MB91101/MB91101A

• Register configuration

Address	bit 15	bit 8	bit 0	Initial value
0000001EH	SCR0			0 0 0 0 0 1 0 0 _B (R/W)
00000022H	SCR1			0 0 0 0 0 1 0 0 _B (R/W)
00000026H	SCR2			0 0 0 0 0 1 0 0 _B (R/W)
0000001FH		SMR0		0 0 - - 0 - 0 0 _B (R/W)
00000023H		SMR1		0 0 - - 0 - 0 0 _B (R/W)
00000027H		SMR2		0 0 - - 0 - 0 0 _B (R/W)
0000001CH	SSR0			0 0 0 0 1 - 0 0 _B (R/W)
00000020H	SSR1			0 0 0 0 1 - 0 0 _B (R/W)
00000024H	SSR2			0 0 0 0 1 - 0 0 _B (R/W)
0000001DH		SIDR0/SODR0		X X X X X X X X _B (R/W)
00000021H		SIDR1/SIDR1		X X X X X X X X _B (R/W)
00000002H		SIDR2/SIDR2		X X X X X X X X _B (R/W)

() : Access
R/W : Readable and writable
- : Unused
X : Indeterminate

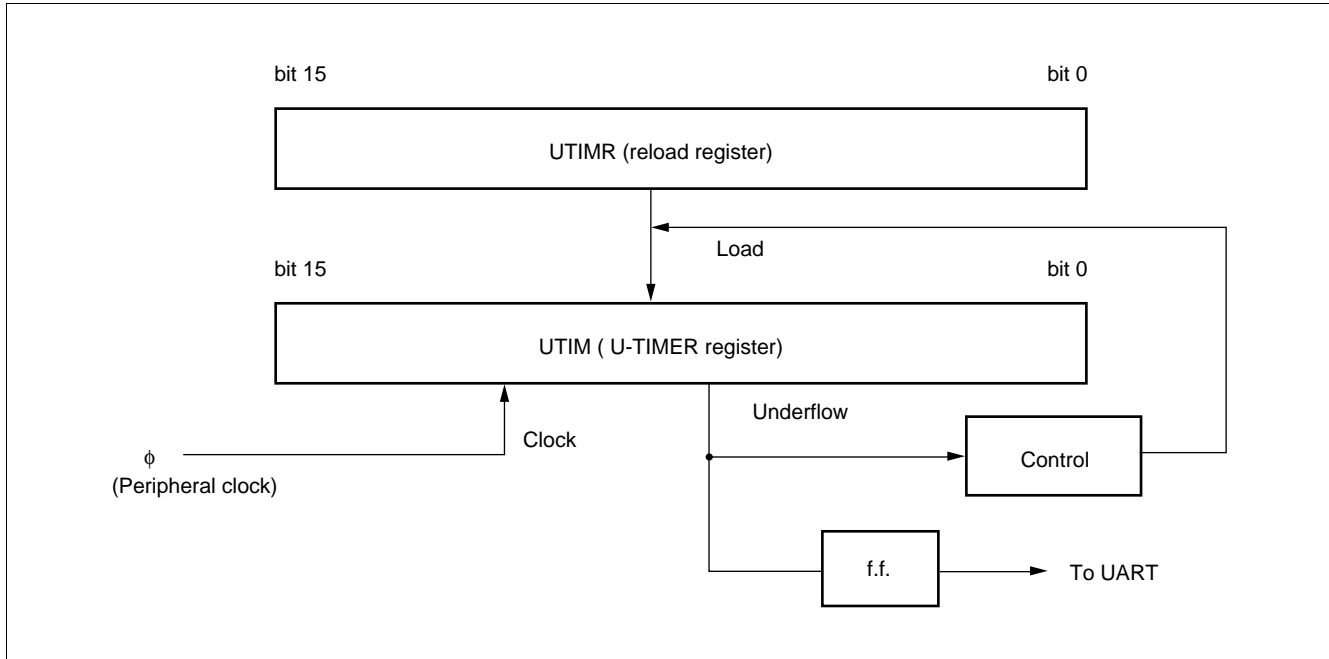
4. U-TIMER (16-bit Timer for UART Baud Rate Generation)

The U-TIMER is a 16-bit timer for generating UART baud rate. Combination of chip operating frequency and reload value of U-TIMER allows flexible setting of baud rate.

The U-TIMER operates as an interval timer by using interrupt issued on counter underflow.

The MB91101 has 3 channel U-TIMER embedded on the chip. An interval of up to $2^{16} \times \phi$ can be counted.

• Block diagram



• Register configuration

Address	bit 15	bit 0	Initial value	
00000078H 00000079H	UTIM0/UTIMR0		0 0 0 0 0 0 0 0 B 0 0 0 0 0 0 0 0 B	(R/W)
0000007CH 0000007DH	UTIM1/UTIMR1		0 0 0 0 0 0 0 0 B 0 0 0 0 0 0 0 0 B	(R/W)
00000080H 00000081H	UTIM2/UTIMR2		0 0 0 0 0 0 0 0 B 0 0 0 0 0 0 0 0 B	(R/W)
0000007BH	UTIMC0		0 - - 0 0 0 0 1 B	(R/W)
0000007FH	UTIMC1		0 - - 0 0 0 0 1 B	(R/W)
00000083H	UTIMC2		0 - - 0 0 0 0 1 B	(R/W)

() : Access
R/W : Readable and writable
- : Unused

MB91101/MB91101A

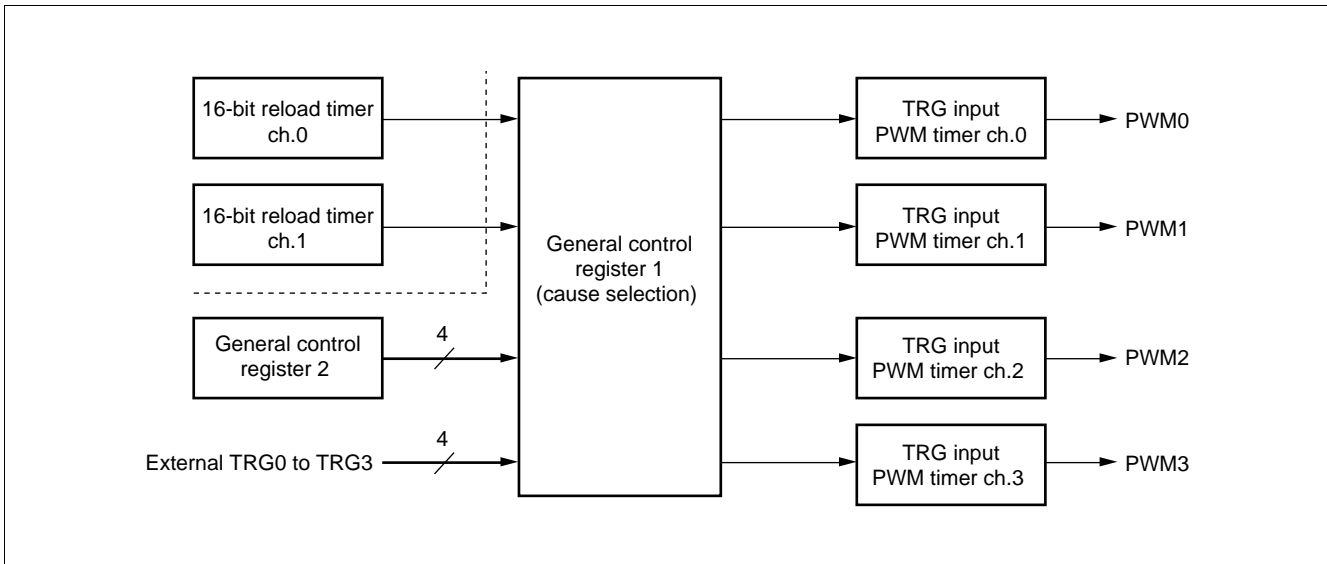
5. PWM Timer

The PWM timer can output high accurate PWM waves efficiently.

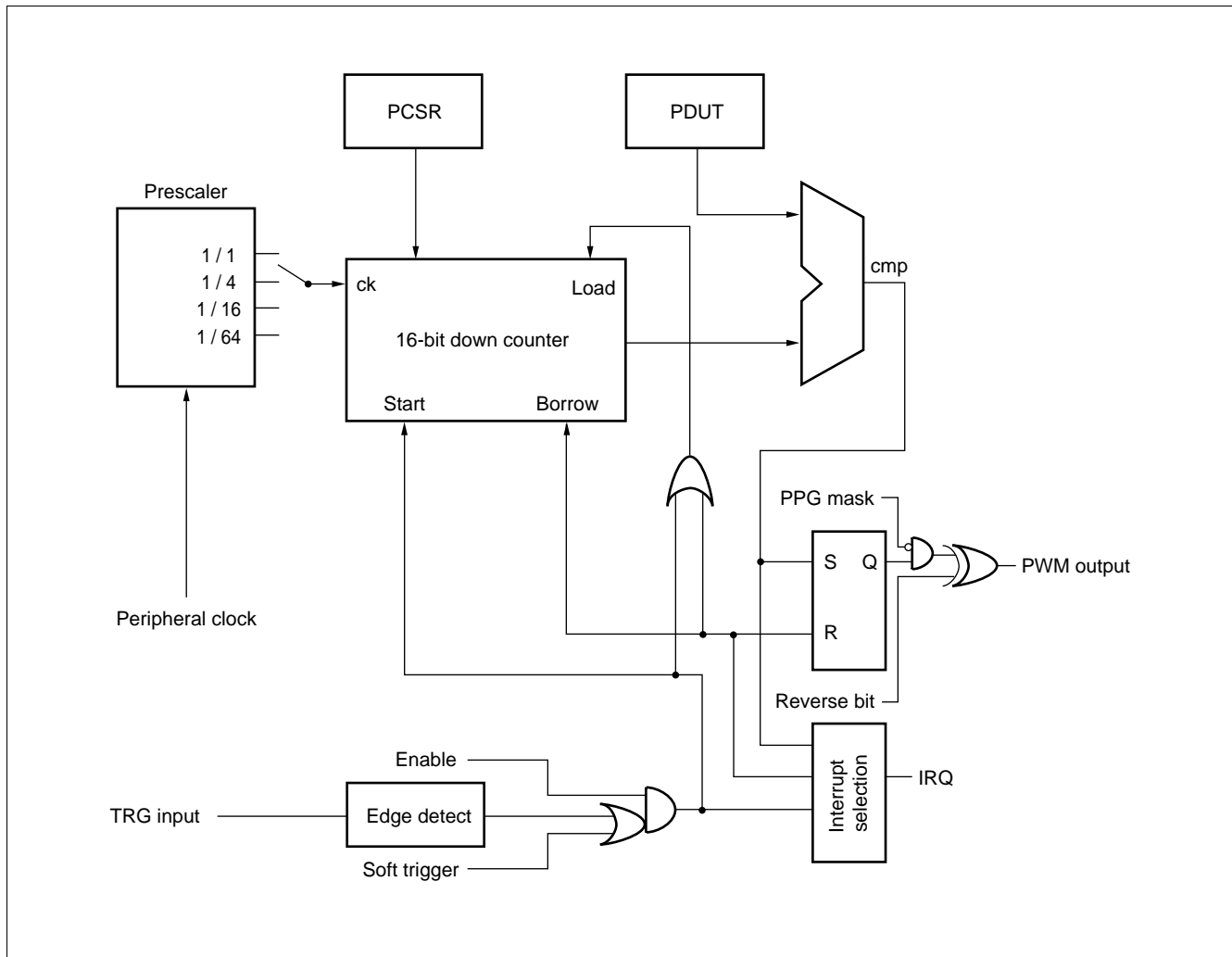
MB91101 has inner 4-channel PWM timers, and has the following features.

- Each channel consists of a 16-bit down counter, a 16-bit data register with a buffer for scyde setting, a 16-bit compare register with a buffer for duty setting, and a pin controller.
- The count clock of a 16-bit down counter can be selected from the following four inner clocks.
Inner clock ϕ , $\phi/4$, $\phi/16$, $\phi/64$
- The counter value can be initialized “FFFF_H” by the resetting or the counter borrow.
- PWM output (each channel)
- Resister description

• Block diagram (general construction)



• Block diagram (for one channel)



MB91101/MB91101A

• Register configuration

Address	bit 15	bit 8	bit 0	Initial value	
000000DC _H 000000DD _H	GCN1			0 0 1 1 0 0 1 0 _B 0 0 0 1 0 0 0 0 _B	(R/W)
000000DF _H		GCN2		0 0 0 0 0 0 0 0 _B	(R/W)
000000E0 _H 000000E1 _H	PTMR0			1 1 1 1 1 1 1 1 _B 1 1 1 1 1 1 1 1 _B	(R)
000000E2 _H 000000E3 _H	PCSR0			X X X X X X X X _B X X X X X X X X _B	(W)
000000E4 _H 000000E5 _H	PDUT0			X X X X X X X X _B X X X X X X X X _B	(W)
000000E6 _H	PCNH0			0 0 0 0 0 0 0 - _B	(R/W)
000000E7 _H		PCNL0		0 0 0 0 0 0 0 0 _B	(R/W)
000000E8 _H 000000E9 _H	PTMR1			1 1 1 1 1 1 1 1 _B 1 1 1 1 1 1 1 1 _B	(R)
000000EA _H 000000EB _H	PCSR1			X X X X X X X X _B X X X X X X X X _B	(W)
000000EC _H 000000ED _H	PDUT1			X X X X X X X X _B X X X X X X X X _B	(W)
000000EE _H	PCNH1			0 0 0 0 0 0 0 - _B	(R/W)
000000EF _H		PCNL1		0 0 0 0 0 0 0 0 _B	(R/W)
000000F0 _H 000000F1 _H	PTMR2			1 1 1 1 1 1 1 1 _B 1 1 1 1 1 1 1 1 _B	(R)
000000F2 _H 000000F3 _H	PCSR2			X X X X X X X X _B X X X X X X X X _B	(W)
000000F4 _H 000000F5 _H	PDUT2			X X X X X X X X _B X X X X X X X X _B	(W)
000000F6 _H	PCNH2			0 0 0 0 0 0 0 - _B	(R/W)
000000F7 _H		PCNL2		0 0 0 0 0 0 0 0 _B	(R/W)
000000F8 _H 000000F9 _H	PTMR3			1 1 1 1 1 1 1 1 _B 1 1 1 1 1 1 1 1 _B	(R)
000000FA _H 000000FB _H	PCSR3			X X X X X X X X _B X X X X X X X X _B	(W)
000000FC _H 000000FD _H	PDUT3			X X X X X X X X _B X X X X X X X X _B	(W)
000000FE _H	PCNH3			0 0 0 0 0 0 0 - _B	(R/W)
000000FF _H		PCNL3		0 0 0 0 0 0 0 0 _B	(R/W)

() : Access
R/W : Readable and writable
R : Read only
W : Write only
- : Unused
X : Indeterminate

MB91101/MB91101A

• Register configuration

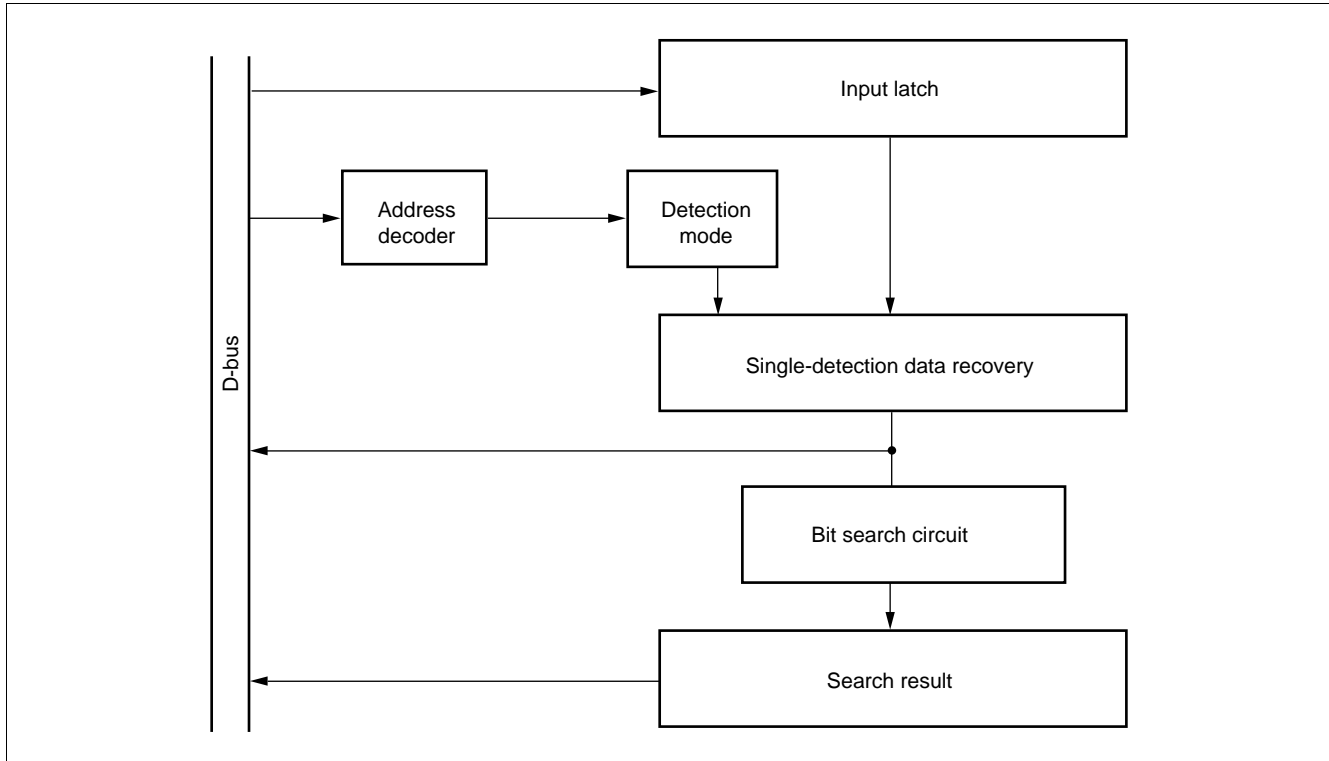
Address	bit 15	bit 0	Initial value	
0000002E _H 0000002F _H	TMCSR0		- - - 0 0 0 0 _B 0 0 0 0 0 0 0 0 _B	(R/W)
00000036 _H 00000037 _H	TMCSR1		- - - 0 0 0 0 _B 0 0 0 0 0 0 0 0 _B	(R/W)
00000042 _H 00000043 _H	TMCSR2		- - - 0 0 0 0 _B 0 0 0 0 0 0 0 0 _B	(R/W)
0000002A _H 0000002B _H	TMR0		X X X X X X X X _B X X X X X X X X _B	(R)
00000032 _H 00000033 _H	TMR1		X X X X X X X X _B X X X X X X X X _B	(R)
0000003E _H 0000003F _H	TMR2		X X X X X X X X _B X X X X X X X X _B	(R)
00000028 _H 00000029 _H	TMRLR0		X X X X X X X X _B X X X X X X X X _B	(W)
00000030 _H 00000031 _H	TMRLR1		X X X X X X X X _B X X X X X X X X _B	(W)
0000003C _H 0000003D _H	TMRLR2		X X X X X X X X _B X X X X X X X X _B	(W)

() : Access
 R/W : Readable and writable
 R : Read only
 W : Write only
 - : Unused
 X : Indeterminate

7. Bit Search Module

The bit search module detects transitions of data (0 to 1/1 to 0) on the data written on the input registers and returns locations of the transitions.

• Block diagram



• Register configuration

Address	bit 31	bit 16	bit 0	Initial value	
000003F0 _H 000003F1 _H 000003F2 _H 000003F3 _H	[BSD0]			XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B	(W)
000003F4 _H 000003F5 _H 000003F6 _H 000003F7 _H	[BSD1]			XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B	(W)
000003F8 _H 000003F9 _H 000003FA _H 000003FB _H	[BSDC]			XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B	(W)
000003FC _H 000003FE _H 000003FD _H 000003FF _H	[BSRR]			XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B XXXXXXXX _B	(W)

() : Access
 R/W : Readable and writable
 R : Read only
 W : Write only
 X : Indeterminate

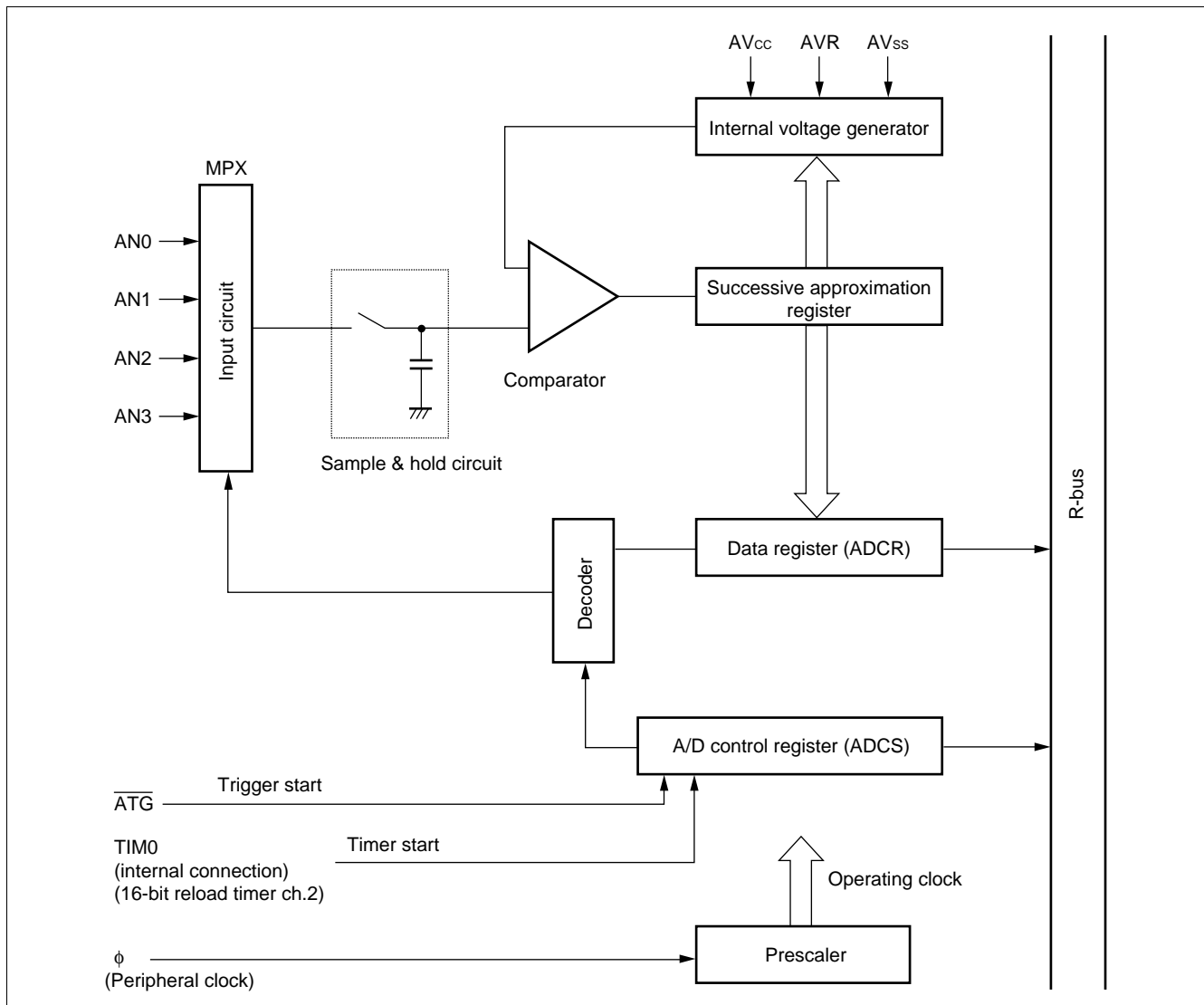
MB91101/MB91101A

8. 10-bit A/D Converter (Successive Approximation Conversion Type)

The A/D converter is the module which converts an analog input voltage to a digital value, and it has following features.

- Minimum converting time: 5.6 $\mu\text{s}/\text{ch.}$ (system clock: 25 MHz)
- Inner sample and hold circuit
- Resolution: 10 bits
- Analog input can be selected from 4 channels by program.
 - Single convert mode: 1 channel is selected and converted.
 - Scan convert mode: Converting continuous channels. Maximum 4 channels are programmable.
 - Continuous convert mode: Converting the specified channel repeatedly.
 - Stop convert mode: After converting one channel then stop and wait till next activation synchronising at the beginning of conversion can be performed.
- DMA transfer operation is available by interruption.
- Operating factor can be selected from the software, the external trigger (falling edge), and 16-bit reload timer (rising edge).

• Block diagram



• Register configuration

Address	bit 15	bit 0	Initial value
0000003A _H 0000003B _H	ADCS		0 0 0 0 0 0 0 0 _B (R/W) 0 0 0 0 0 0 0 0 _B
00000038 _H 00000039 _H	ADCR		- - - - - X X _B (R) X X X X X X X X _B

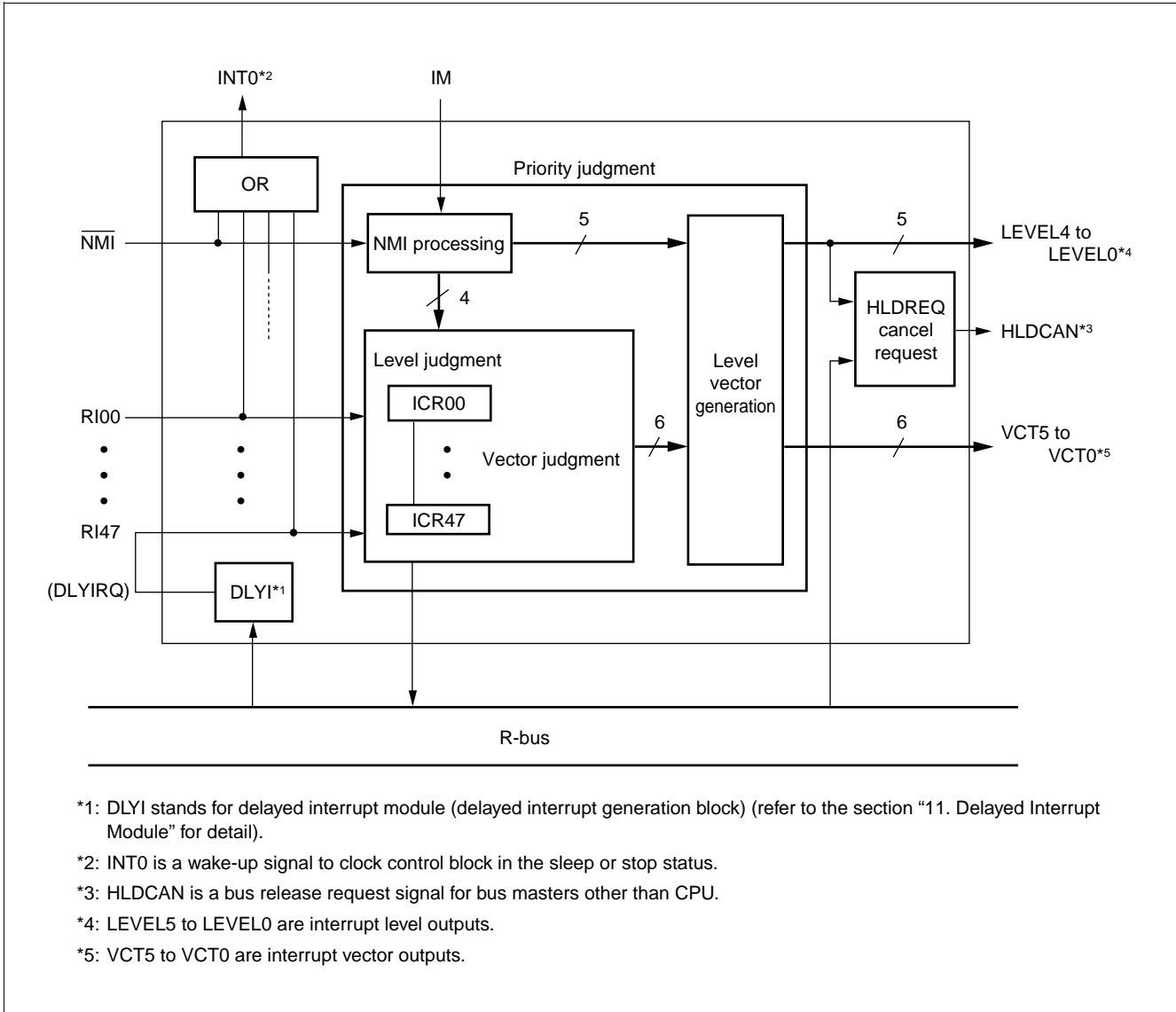
() : Access
 R/W : Readable and writable
 R : Read only
 - : Unused
 X : Indeterminate

MB91101/MB91101A

9. Interrupt Controller

The interrupt controller processes interrupt acknowledgments and arbitration between interrupts.

- Block diagram



• Register configuration

Address	bit 7	bit 0	Initial value	Address	bit 7	bit 0	Initial value
00000400H	[	ICR00	--- 11111 B (R/W)	00000411H	[	ICR17	--- 11111 B (R/W)
00000401H	[	ICR01	--- 11111 B (R/W)	00000412H	[	ICR18	--- 11111 B (R/W)
00000402H	[	ICR02	--- 11111 B (R/W)	00000413H	[	ICR19	--- 11111 B (R/W)
00000403H	[	ICR03	--- 11111 B (R/W)	00000414H	[	ICR20	--- 11111 B (R/W)
00000404H	[	ICR04	--- 11111 B (R/W)	00000415H	[	ICR21	--- 11111 B (R/W)
00000405H	[	ICR05	--- 11111 B (R/W)	00000416H	[	ICR22	--- 11111 B (R/W)
00000406H	[	ICR06	--- 11111 B (R/W)	00000417H	[	ICR23	--- 11111 B (R/W)
00000407H	[	ICR07	--- 11111 B (R/W)	00000418H	[	ICR24	--- 11111 B (R/W)
00000408H	[	ICR08	--- 11111 B (R/W)	00000419H	[	ICR25	--- 11111 B (R/W)
00000409H	[	ICR09	--- 11111 B (R/W)	0000041AH	[	ICR26	--- 11111 B (R/W)
0000040AH	[	ICR10	--- 11111 B (R/W)	0000041BH	[	ICR27	--- 11111 B (R/W)
0000040BH	[	ICR11	--- 11111 B (R/W)	0000041CH	[	ICR28	--- 11111 B (R/W)
0000040CH	[	ICR12	--- 11111 B (R/W)	0000041DH	[	ICR29	--- 11111 B (R/W)
0000040DH	[	ICR13	--- 11111 B (R/W)	0000041EH	[	ICR30	--- 11111 B (R/W)
0000040EH	[	ICR14	--- 11111 B (R/W)	0000041FH	[	ICR31	--- 11111 B (R/W)
0000040FH	[	ICR15	--- 11111 B (R/W)	0000042FH	[	ICR47	--- 11111 B (R/W)
00000410H	[	ICR16	--- 11111 B (R/W)	00000431H	[	HRCL	--- 11111 B (R/W)
				00000430H	[	DICR	----- 0 B (R/W)

() : Access
 R/W : Redable and writable
 - : Unused

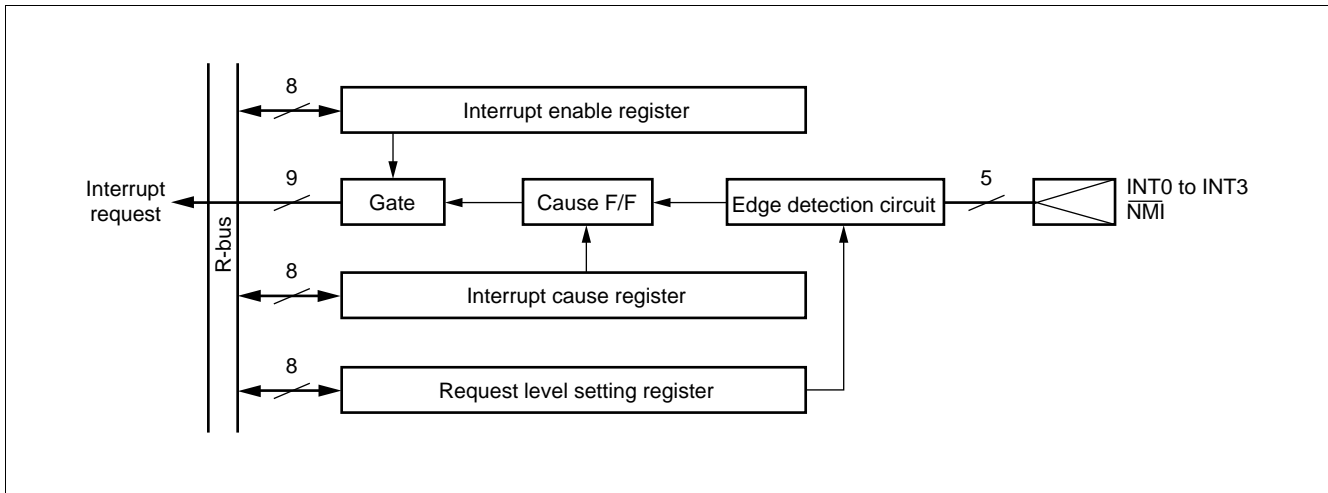
MB91101/MB91101A

10. External Interrupt/NMI Control Block

The external interrupt/NMI control block controls external interrupt request signals input to $\overline{\text{NMI}}$ pin and INT0 to INT3 pins.

Detecting levels can be selected from "H", "L", rising edge and falling edge (not for $\overline{\text{NMI}}$ pin).

• Block diagram



• Register configuration

Address	bit 15	bit 8	bit 0	Initial value	
00000095 _H		ENIR		00000000 _B	(R/W)
00000094 _H	EIRR			00000000 _B	(R/W)
00000099 _H	ELVR			00000000 _B	(R/W)

() : Access
R/W : Redable and writable

11. Delayed Interrupt Module

Delayed interrupt module is a module which generates a interrupt for changing a task. By using this delayed interrupt module, an interrupt request to CPU can be generated/cancelled by the software.

Refer to the section "9. Interrupt Controller" for delayed interrupt module block diagram.

- Register configuration

Address	bit 7	bit 0	Initial value
00000430H	DICR		- - - - - 0 B (R/W)

() : Access
R/W : Redable and writable
- : Unused

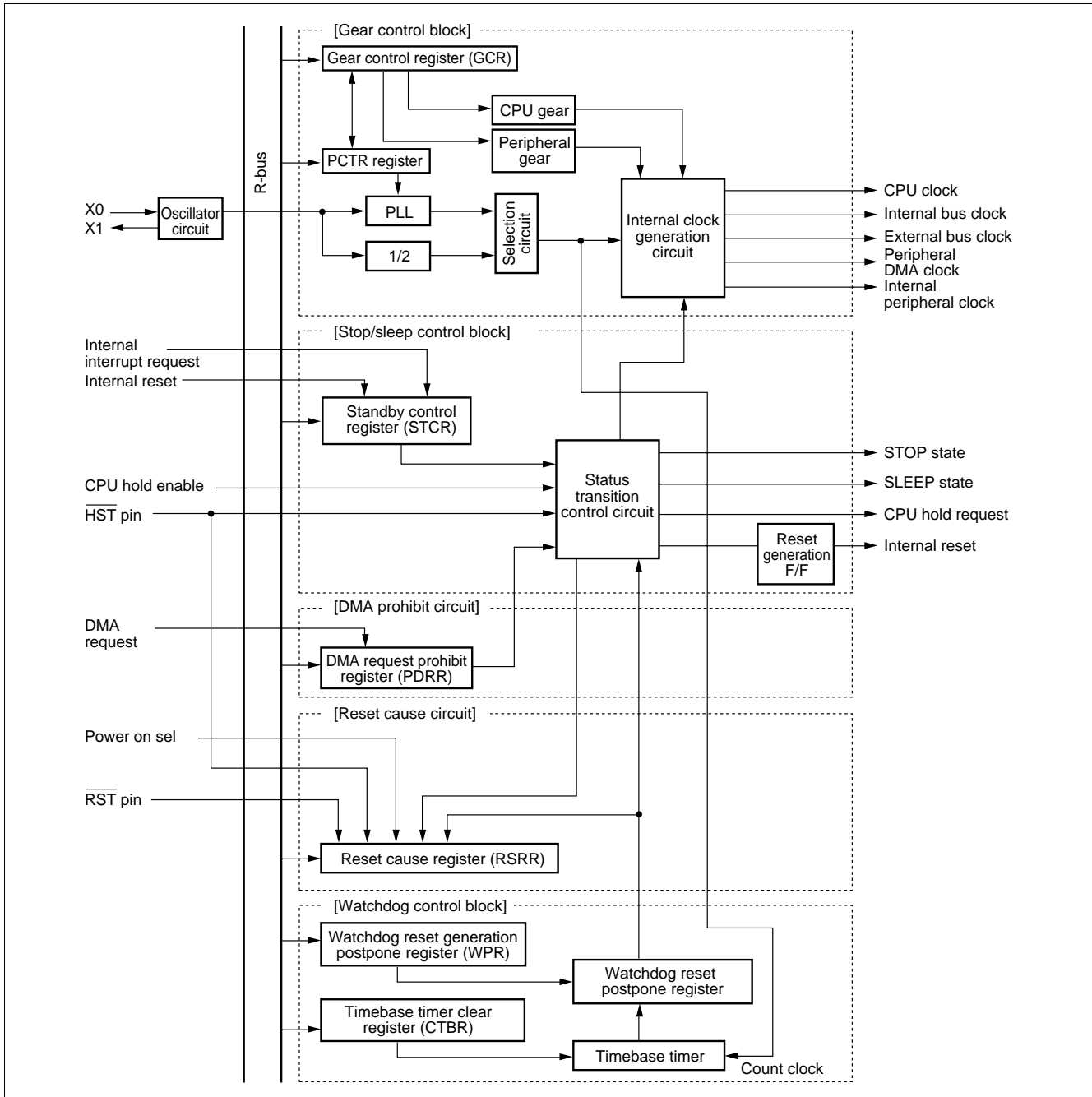
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12. Clock Generation (Low-power consumption mechanism)

The clock control block is a module which undertakes the following functions.

- CPU clock generation (including gear function)
- Peripheral clock generation (including gear function)
- Reset generation and cause hold
- Standby function (including hardware standby)
- DMA request prohibit
- PLL (multiplier circuit) embedded

• Block diagram



• Register configuration

Address	bit 15	bit 8	bit 0	Initial value	
00000480 _H	RSRR/WTCR			1 X X X X - 0 0 _B	(R/W)
00000481 _H		STCR		0 0 0 1 1 1 - - _B	(R/W)
00000482 _H	PDRR			- - - - 0 0 0 0 _B	(R/W)
00000483 _H		CTBR		X X X X X X X X _B	(W)
00000484 _H	GCR			1 1 0 0 1 1 - 1 _B	(R/W)
00000485 _H		WPR		X X X X X X X X _B	(W)
00000488 _H	PCTR			0 0 - - 0 - - - _B	(R/W)

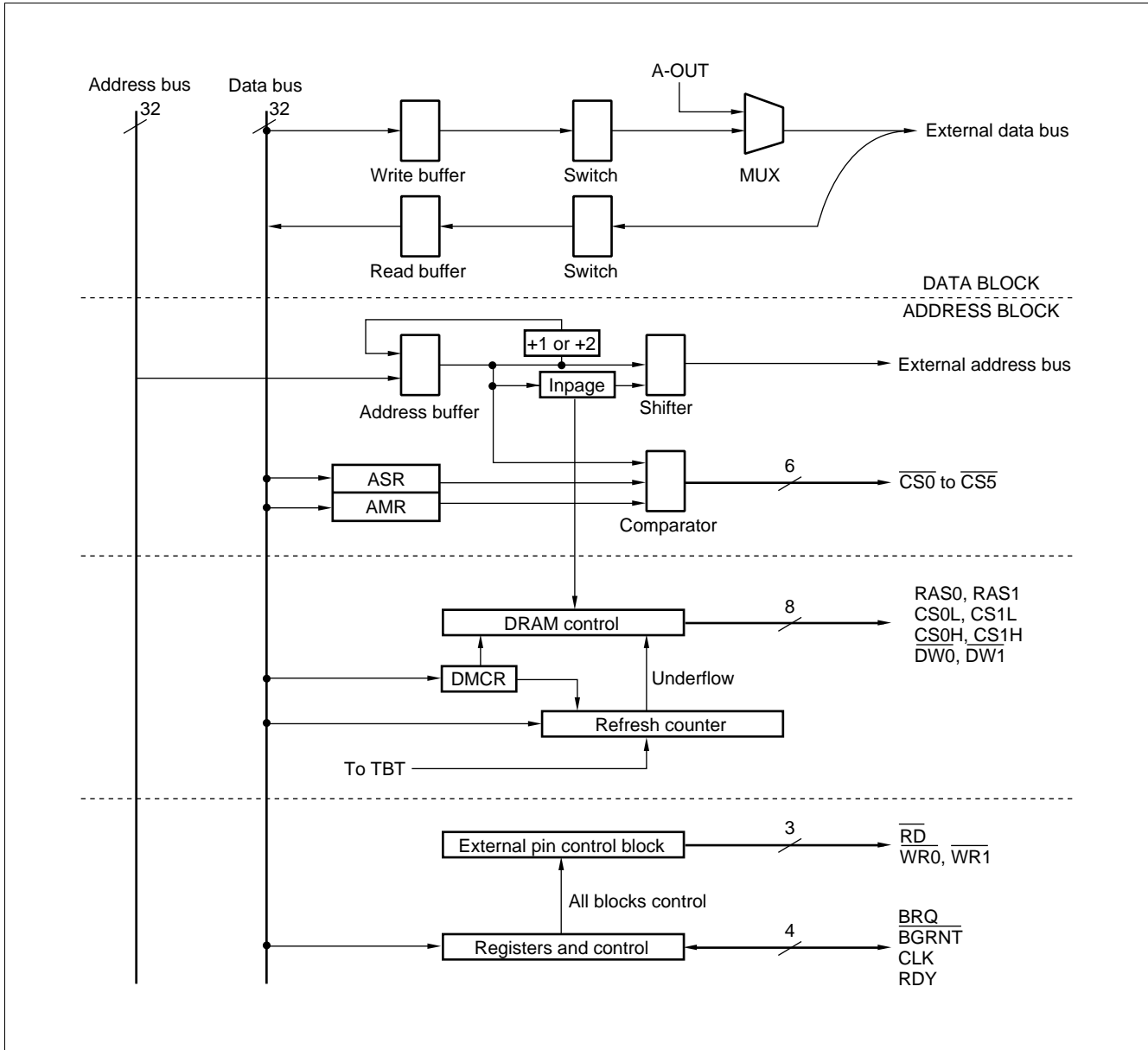
() : Access
 R/W : Redable and writable
 W : Write only
 - : Unused
 X : Indeterminate

13. External Bus Interface

The external bus interface controls the interface between the device and the external memory and also the external I/O, and has the following features.

- 25-bit (32 Mbytes) address output
- 6 independent banks owing to the chip select function.
Can be set to anywhere on the logical address space for minimum unit 64 Kbytes.
Total 32 Mbytes × 6 area setting is available by the address pin and the chip select pin.
- 8/16-bit bus width setting are available for every chip select area.
- Programmable automatic memory wait (max. for 7 cycles) can be inserted.
- DRAM interface support
Three kinds of DRAM interface: Double CAS DRAM (normally DRAM I/F)
Single CAS DRAM
Hyper DRAM
2 banks independent control (RAS, CAS, etc. control signals)
DRAM select is available from 2CAS/1WE and 1CAS/2WE.
Hi-speed page mode supported
CBR/self refresh supported
Programmable wave form
- Unused address/data pin can be used for I/O port.
- Little endian mode supported
- Clock doubler: Internal bus 50 MHz, external bus 25 MHz

• Block diagram



MB91101/MB91101A

• Register configuration

Address	bit 31	bit 16	bit 0	Initial value
0000060CH 0000060DH	ASR1			0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 1 _B (W)
0000060EH 0000060FH		AMR1		0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 0 _B (W)
00000610H 00000611H	ASR2			0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 1 0 _B (W)
00000612H 00000613H		AMR2		0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 0 _B (W)
00000614H 00000615H	ASR3			0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 1 1 _B (W)
00000616H 00000617H		AMR3		0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 0 _B (W)
00000618H 00000619H	ASR4			0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 1 0 0 _B (W)
0000061AH 0000061BH		AMR4		0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 0 _B (W)
0000061CH 0000061DH	ASR5			0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 1 0 1 _B (W)
0000061EH 0000061FH		AMR5		0 0 0 0 0 0 0 0 _B (W) 0 0 0 0 0 0 0 0 _B (W)
00000620H	AMD0			- - - 0 0 1 1 1 _B (R/W)
00000621H		AMD1		0 - - 0 0 0 0 0 _B (R/W)
00000622H			AMD32	0 0 0 0 0 0 0 0 _B (R/W)
00000623H			AMD4	0 - - 0 0 0 0 0 _B (R/W)
00000624H	AMD5			0 - - 0 0 0 0 0 _B (R/W)
00000625H		DSCR		0 0 0 0 0 0 0 0 _B (W)
00000626H 00000627H		RFCR		- - X X X X X X _B (R/W) 0 0 - - - 0 0 0 _B (R/W)
00000628H 00000629H	EPCR0			- - - - 1 1 0 0 _B (W) - 1 1 1 1 1 1 1 1 _B (W)
0000062BH			EPCR1	1 1 1 1 1 1 1 1 _B (W)
0000062CH 0000062DH	DMCR4			0 0 0 0 0 0 0 0 _B (R/W) 0 0 0 0 0 0 0 - _B (R/W)
0000062EH 0000062FH		DMCR5		0 0 0 0 0 0 0 0 _B (R/W) 0 0 0 0 0 0 0 - _B (R/W)
000007FEH		LER		- - - - - 0 0 0 _B (W)
000007FFH			MODR	X X X X X X X X _B (W)

() : Access
R/W : Redable and writable
W : Write only
- : Unused
X : Indeterminate

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

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

Parameter		Symbol	Value		Unit	Remarks
			Min.	Max.		
Power supply voltage	At 5 V power supply	V_{CC5}	$V_{SS} - 0.3$	$V_{SS} + 6.5$	V	
		V_{CC3}	—	—	V	
	At 3 V power supply	V_{CC5}	$V_{CC3} - 0.3$	$V_{SS} + 6.5$	V	*1
		V_{CC3}	$V_{SS} - 0.3$	$V_{SS} + 3.6$	V	*1
Analog supply voltage		AV_{CC}	$V_{SS} - 0.3$	$V_{SS} + 3.6$	V	*2
Analog reference voltage		AV_{RH}	$V_{SS} - 0.3$	$V_{SS} + 3.6$	V	*2
Analog pin input voltage		V_{IA}	$V_{SS} - 0.3$	$AV_{CC} + 0.3$	V	
Input voltage		V_I	$V_{SS} - 0.3$	$V_{CC5} + 0.3$	V	
Output voltage		V_O	$V_{SS} - 0.3$	$V_{CC5} + 0.3$	V	
“L” level maximum output current		I_{OL}	—	10	mA	*3
“L” level average output current		I_{OLAV}	—	4	mA	*4
“L” level maximum total output current		ΣI_{OL}	—	100	mA	
“L” level average total output current		ΣI_{OLAV}	—	50	mA	*5
“H” level maximum output current		I_{OH}	—	-10	mA	*3
“H” level average output current		I_{OHAV}	—	-4	mA	*4
“H” level maximum total output current		ΣI_{OH}	—	-50	mA	
“H” level average total output current		ΣI_{OHAV}	—	-20	mA	*5
Power consumption		P_D	—	500	mW	
Operating temperature		T_A	0	+70	°C	
Storage temperature		T_{stg}	-55	+150	°C	

*1: V_{CC5} must not be less than $V_{SS} - 0.3\text{ V}$.

*2: Make sure that the voltage does not exceed $V_{CC5} + 0.3\text{ V}$, such as when turning on the device.

*3: Maximum output current is a peak current value measured at a corresponding pin.

*4: Average output current is an average current for a 100 ms period at a corresponding pin.

*5: Average total output current is an average current for a 100 ms period for all corresponding pins.

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.

MB91101/MB91101A

2. Recommended Operating Conditions

(1) At 5 V operation (4.5 V to 5.5 V)

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

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC5}	4.5	5.5	V	Normal operation
	V_{CC5}	*1	*1	V	Retaining the RAM state in stop mode
	V_{CC3}	—	—	V	*2
Analog supply voltage	AV_{CC}	$V_{SS} + 2.7$	$V_{CC} + 3.6$	V	
Analog reference voltage	$AVRH$	$V_{SS} - 0.3$	AV_{CC}	V	
Operating temperature	T_A	0	+70	°C	
Smoothing capacitor	C_S	0.1	1.0	μF	V_{CC3} pin *2

*1: At V_{CC5} , the RAM state holding is not warranted in stop mode.

*2: V_{CC3} is used for the bypass capacitor pin.

*3: Use the ceramic capacitor or the capacitor whose frequency characteristic is equivalent to that of the ceramic capacitor.

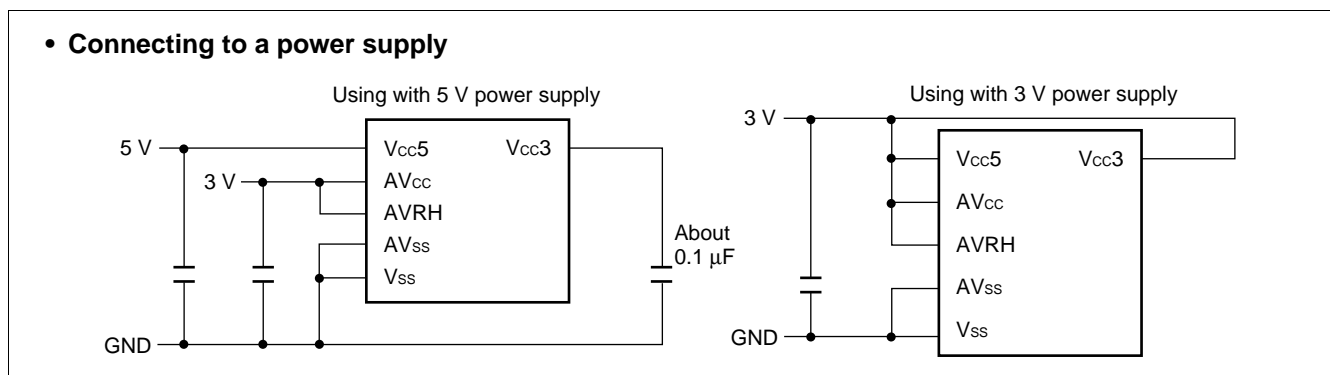
And select the larger capacity smoothing condenser to connect to the power supply (V_{CC5}) than C_S .

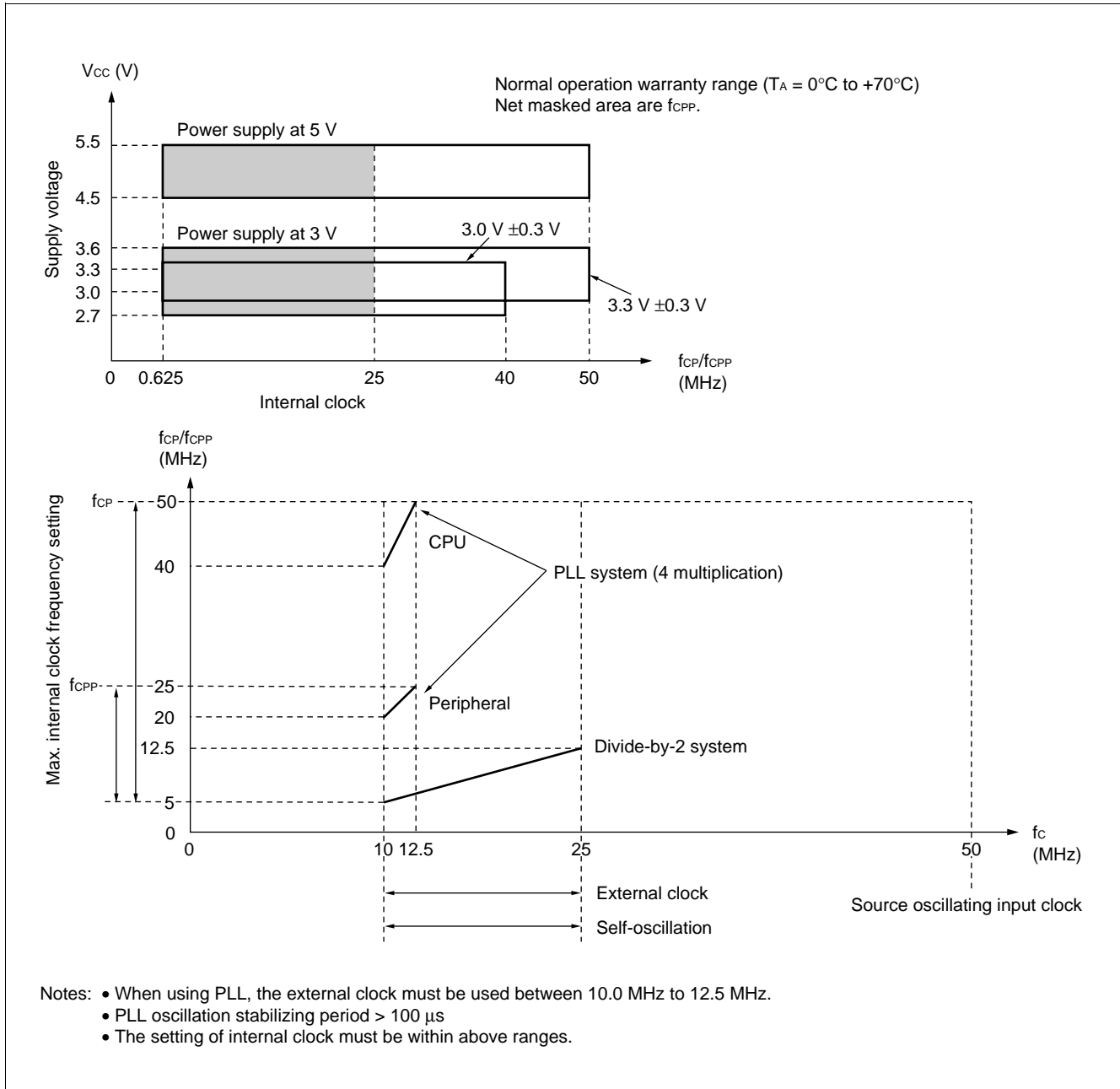
(2) At 3 V operation (2.7 V to 3.6 V)

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

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC5}	2.7	3.6	V	Normal operation
	V_{CC5}	2.7	3.6	V	Retaining the RAM state in stop mode
	V_{CC3}	2.7	3.6	V	*
Analog power supply voltage	AV_{CC}	$V_{SS} + 2.7$	$V_{CC} + 3.6$	V	
Analog reference voltage	$AVRH$	AV_{SS}	AV_{CC}	V	
Operating temperature	T_A	0	+70	°C	

* : Connect to V_{CC5} for the power supply pin.





WARNING: Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

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

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

MB91101/MB91101A

3. DC Characteristics

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
“H” level input voltage	V_{IH}	Input pin except for hysteresis input	—	$0.65 \times V_{CC3}$	—	$V_{CC5} + 0.3$	V	*
	V_{IHS}	\overline{HST} , \overline{NMI} , \overline{RST} , PA1 to PA6, PB0 to PB7, PE0 to PE7, PF0 to PF7	—	$0.8 \times V_{CC3}$	—	$V_{CC5} + 0.3$	V	Hysteresis input *
“L” level input voltage	V_{IL}	Input other than following symbols	—	$V_{SS} - 0.3$	—	$0.25 \times V_{CC3}$	V	*
	V_{ILS}	\overline{HST} , \overline{NMI} , \overline{RST} , PA1 to PA6, PB0 to PB7, PE0 to PE7, PF0 to PF7	—	$V_{SS} - 0.3$	—	$0.2 \times V_{CC3}$	V	Hysteresis input *
“H” level output voltage	V_{OH}	D16 to D31, A00 to A24, P6 to PF	$V_{CC5} = 4.5\text{ V}$ $I_{OH} = -4.0\text{ mA}$	$V_{CC} - 0.5$	—	—	V	
“L” level output voltage	V_{OL}	D16 to D31, A00 to A24, P6 to PF	$V_{CC5} = 4.5\text{ V}$ $I_{OL} = 4.0\text{ mA}$	—	—	0.4	V	
Input leakage current (Hi-Z output leakage current)	I_{LI}	D00 to D31, A00 to A23, P8 to PF	$V_{CC5} = 5.5\text{ V}$ $0.45\text{ V} < V_I < V_{CC}$	-5	—	+5	μA	
Pull-up resistance	R_{PULL}	\overline{RST}	$V_{CC5} = 5.5\text{ V}$ $V_I = 0.45\text{ V}$	25	50	100	$\text{k}\Omega$	
Power supply current	I_{CC}	V_{CC}	$F_C = 12.5\text{ MHz}$ $V_{CC5} = 5.5\text{ V}$	—	75	100	mA	(4 multiplication) Operation at 50 MHz
	I_{CCS}	V_{CC}	$F_C = 12.5\text{ MHz}$ $V_{CC5} = 5.5\text{ V}$	—	40	60	mA	Sleep mode
	I_{CCH}	V_{CC}	$T_A = +25^\circ\text{C}$ $V_{CC5} = 5.5\text{ V}$	—	10	100	μA	Stop mode
Input capacitance	C_{IN}	Except for V_{CC5} , V_{CC3} , AV_{CC} , AV_{SS} , V_{SS}	—	—	10	—	pF	

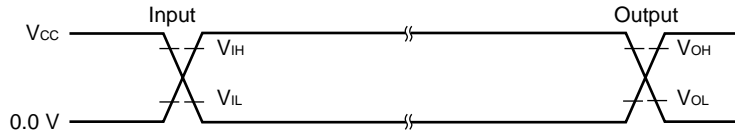
* : $V_{CC3} = 3.3 \pm 0.2\text{ V}$ (internal regulator output voltage) when using 5 V power supply, $V_{CC3} =$ power supply voltage when using 3 V power supply (internal regulator unused)

4. AC Characteristics

Measurement Conditions

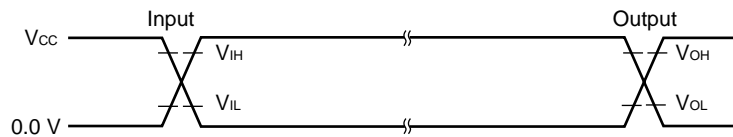
- $V_{CC} = 5.0\text{ V} \pm 10\%$

Parameter	Symbol	Value			Unit	Remarks
		Min.	Typ.	Max.		
"H" level input voltage	V_{IH}	—	2.4	—	V	
"L" level input voltage	V_{IL}	—	0.8	—	V	
"H" level output voltage	V_{OH}	—	2.4	—	V	
"L" level output voltage	V_{OL}	—	0.8	—	V	

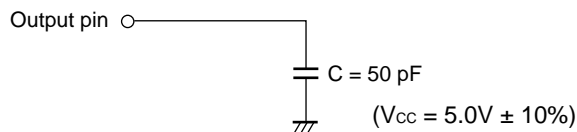


- $V_{CC} = 2.7\text{ V to }3.6\text{ V}$

Parameter	Symbol	Value			Unit	Remarks
		Min.	Typ.	Max.		
"H" level input voltage	V_{IH}	—	$1/2 \times V_{CC}$	—	V	
"L" level input voltage	V_{IL}	—	$1/2 \times V_{CC}$	—	V	
"H" level output voltage	V_{OH}	—	$1/2 \times V_{CC}$	—	V	
"L" level output voltage	V_{OL}	—	$1/2 \times V_{CC}$	—	V	

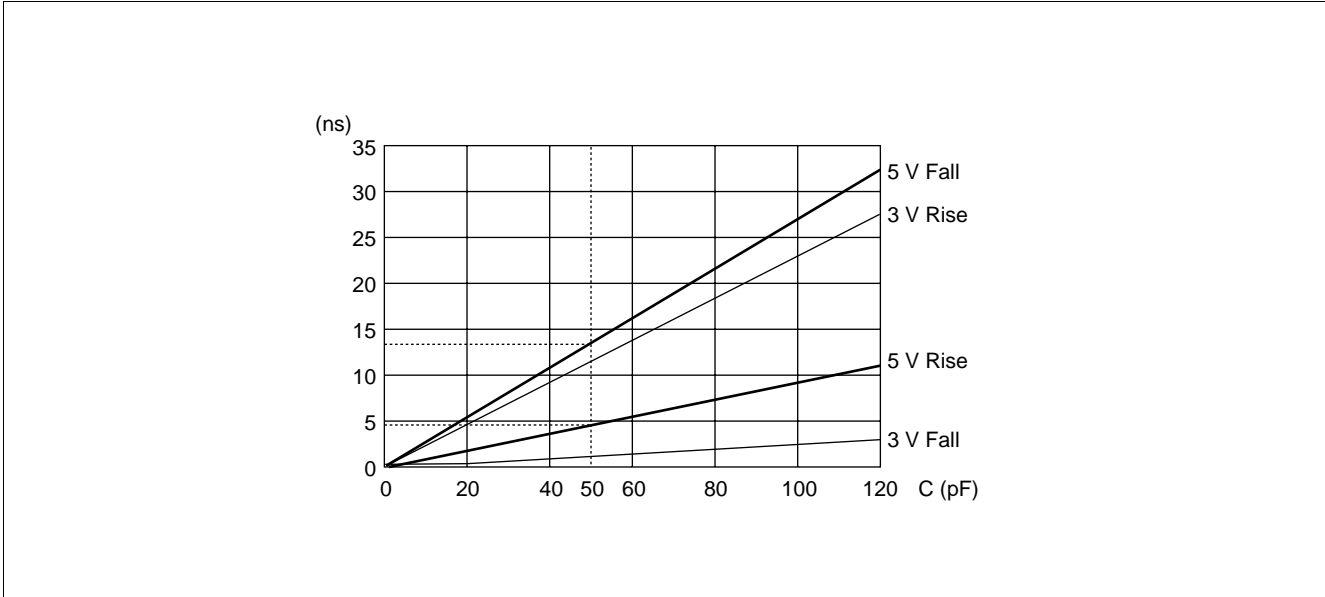


- Load conditions



MB91101/MB91101A

- Load capacitance - Delay characteristics (Output delay with reference to the internal)

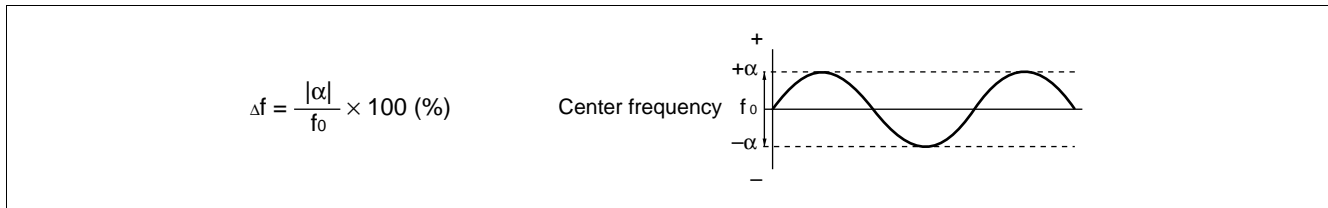


(1) Clock Timing Rating

(V_{cc5} = 5.0 V ±10%, V_{ss} = AV_{ss} = 0.0 V, T_A = 0°C to +70°C)
(V_{cc5} = V_{cc3} = 2.7 V to 3.6 V, V_{ss} = AV_{ss} = 0.0 V, T_A = 0°C to +70°C)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Clock frequency	f _c	X0, X1	When using PLL	10	12.5	MHz	
	f _c	X0, X1	Self-oscillation (divide-by-2 input)	10	25	MHz	
	f _c	X0, X1	External clock (divide-by-2 input)	10	25	MHz	
Clock cycle time	t _c	X0, X1	When using PLL	80	100	ns	
	t _c	X0, X1	—	40	100	ns	
Frequency shift ratio (when locked)	Δf	—	When using PLL	—	5	%	*1
Input clock pulse width	P _{WH} , P _{WL}	X0, X1	—	25	—	ns	Input to X0 only, when using 5 V power supply
	P _{WH} , P _{WL}	X0, X1		10	—	ns	Input to X0, X1
Input clock rising/falling time	t _{CR} , t _{CF}	X0, X1		—	8	ns	(t _{CR} + t _{CF})
Internal operating clock frequency	f _{CP}	—	CPU system	0.625*2	50	MHz	
	f _{CPB}	—	Bus system	0.625*2	25*3	MHz	
	f _{CPP}	—	Peripheral system	0.625*2	25	MHz	
Internal operating clock cycle time	t _{CP}	—	CPU system	20	1600*2	ns	
	t _{CPB}	—	Bus system	40*3	1600*2	ns	
	t _{CPP}	—	Peripheral system	40	1600*2	ns	

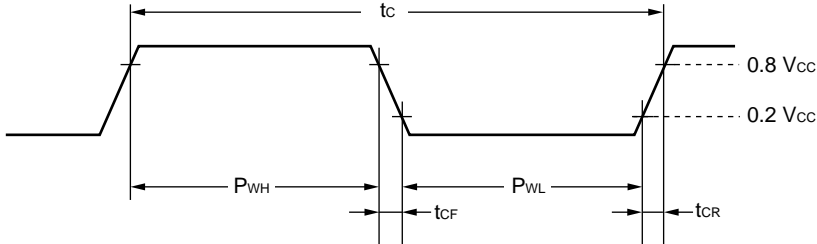
*1: Frequency shift ratio stands for deviation ratio of the operating clock from the center frequency in the clock multiplication system.



*2: These values are for a minimum clock of 10 MHz input to X0, a divide-by-2 system of the source oscillation and a 1/8 gear.

*3: Values when using the doubler and CPU operation at 50 MHz.

- Clock timing rating measurement conditions



(2) Clock Output Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Cycle time	t_{CYC}	CLK	—	t_{CP}	—	ns	*1
	t_{CYC}	CLK	Using the doubler	t_{CPB}	—	ns	
CLK $\uparrow \rightarrow$ CLK \downarrow	t_{CHCL}	CLK	—	$1/2 \times t_{CYC} - 10$	$1/2 \times t_{CYC} + 10$	ns	*2
CLK $\downarrow \rightarrow$ CLK \uparrow	t_{CLCH}	CLK		$1/2 \times t_{CYC} - 10$	$1/2 \times t_{CYC} + 10$	ns	*3

t_{CP} , t_{CPB} (internal operating clock cycle time): Refer to “(1) Clock Timing Rating.”

*1: t_{CYC} is a frequency for 1 clock cycle including a gear cycle.
 Use the doubler when CPU frequency is above 25 MHz.

*2: Rating at a gear cycle of $\times 1$.

When a gear cycle of 1/2, 1/4, 1/8 is selected, substitute “n” in the following equations with 1/2, 1/4, 1/8, respectively.

Min. : $(1 - n/2) \times t_{CYC} - 10$

Max. : $(1 - n/2) \times t_{CYC} + 10$

Select a gear cycle of $\times 1$ when using the doubler.

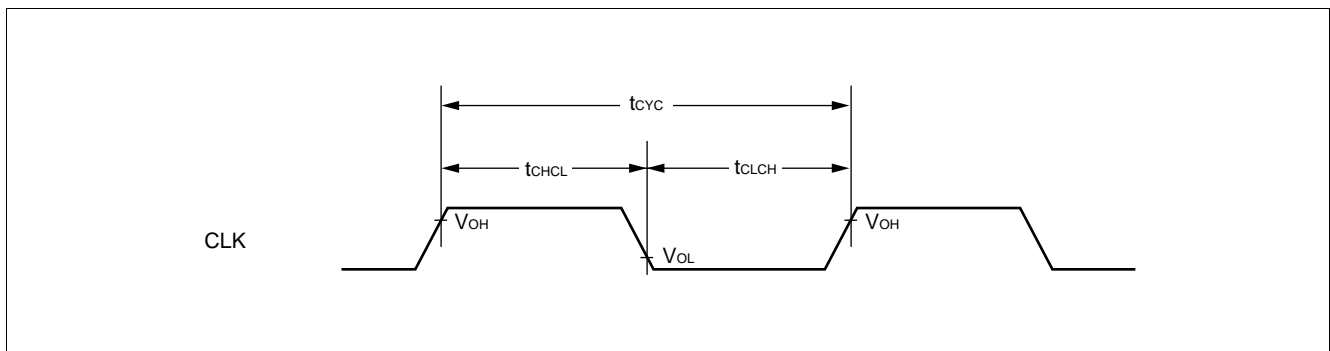
*3: Rating at a gear cycle of $\times 1$.

When a gear cycle of 1/2, 1/4, 1/8 is selected, substitute “n” in the following equations with 1/2, 1/4, 1/8, respectively.

Min. : $n/2 \times t_{CYC} - 10$

Max. : $n/2 \times t_{CYC} + 10$

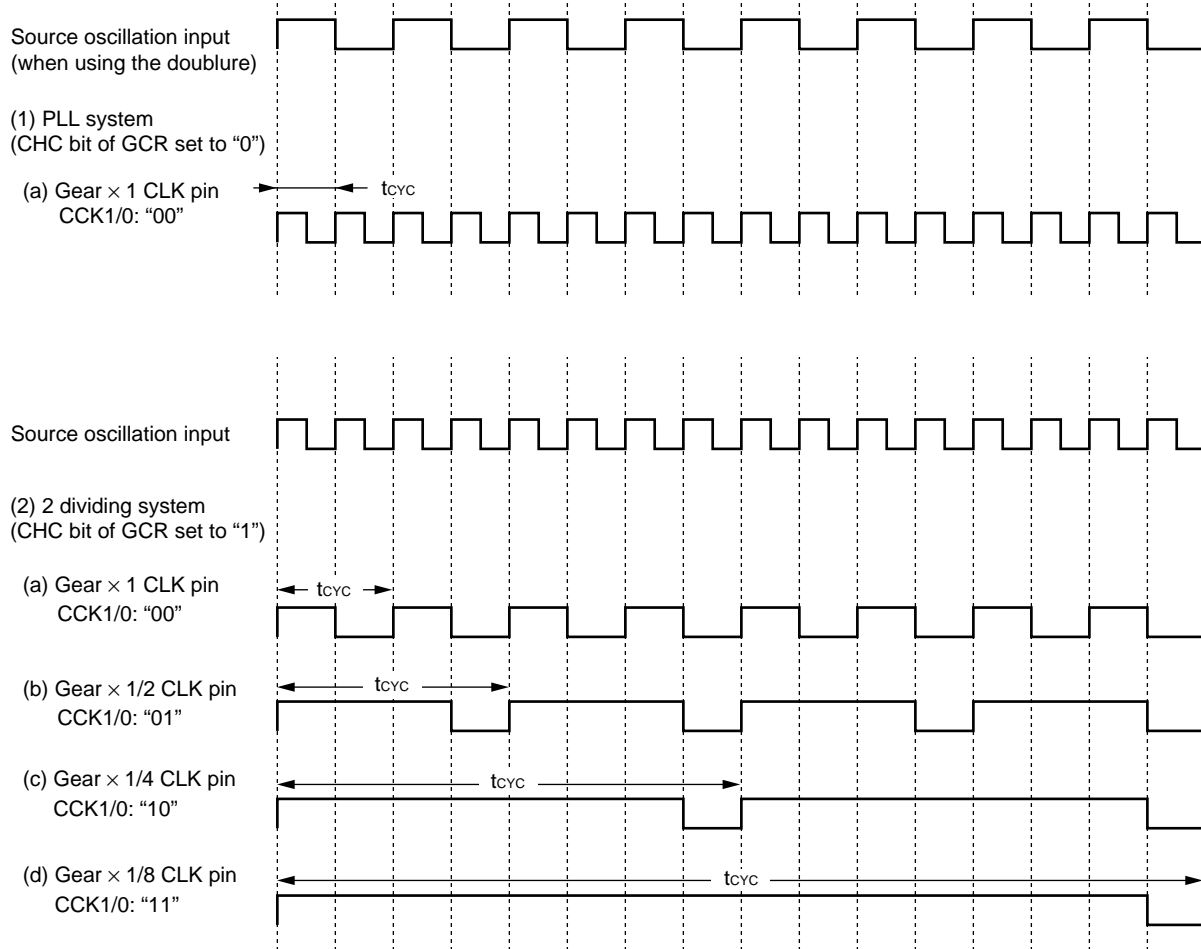
Select a gear cycle of $\times 1$ when using the doubler.



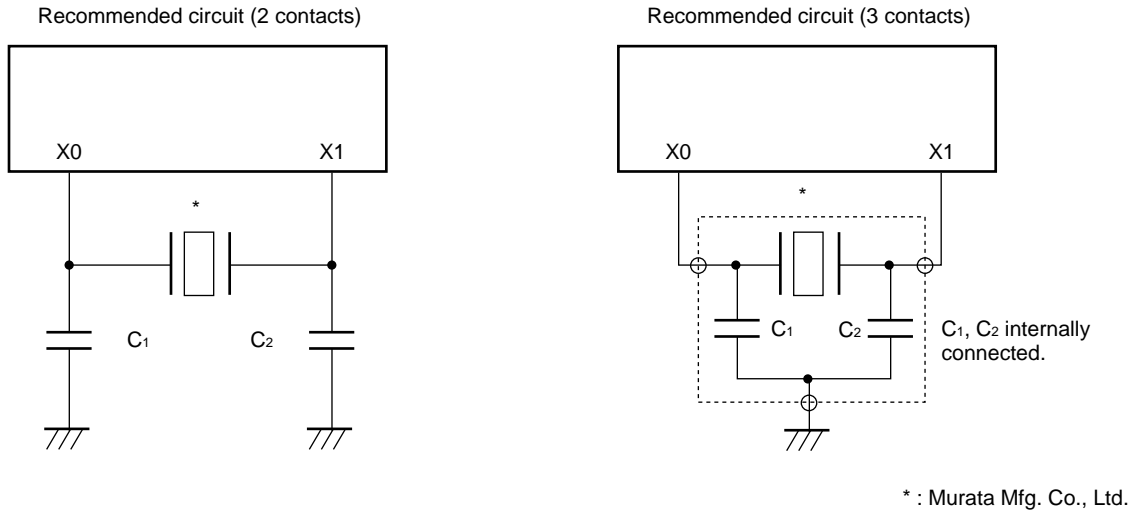
MB91101/MB91101A

The relation between source oscillation input and CLK pin for configured by CHC/CCK1/CCK0 settings of GCR (gear control register) is as follows:

However, in this chart source oscillation input means X0 input clock.



• Ceramic oscillator applications



• Discreet type

Oscillation frequency [MHz]	Model	Load capacitance $C_1 = C_2$ [pF]	Power supply voltage V_{cc5} [V]
5.00 to 6.30	CSA□□□MG	30	2.9 to 5.5
	CST□□□MGW	(30)	
	CSA□□□MG093	30	2.7 to 5.5
	CST□□□MGW093	(30)	
6.31 to 10.0	CSA□□□MTZ	30	2.9 to 5.5
	CST□□□MTW	(30)	
	CSA□□□MTZ093	30	2.7 to 5.5
	CST□□□MTW093	(30)	
10.1 to 13.0	CSA□□□MTZ	30	3.0 to 5.5
	CST□□□MTW	(30)	
	CSA□□□MTZ093	30	2.9 to 5.5
	CST□□□MTW093	(30)	
13.01 to 15.00	CSA□□□□MXZ040	15	3.2 to 5.5
	CST□□□□MXW0C3	(15)	

(): C_1 and C_2 internally connected 3 contacts type.

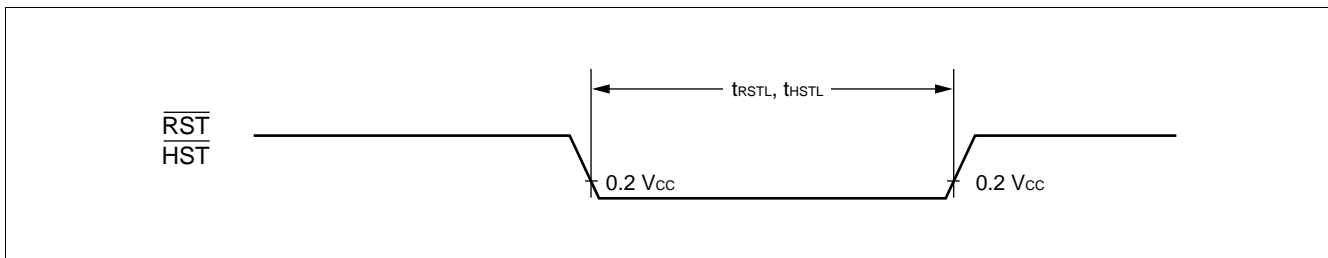
MB91101/MB91101A

(3) Reset/Hardware Standby Input Ratings

($V_{CC5} = 5.0 \text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0 \text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7 \text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0 \text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Reset input time	t_{RSTL}	$\overline{\text{RST}}$	—	$t_{CP} \times 5$	—	ns	
Hardware standby input time	t_{HSTL}	$\overline{\text{HST}}$		$t_{CP} \times 5$	—	ns	

t_{CP} (internal operating clock cycle time): Refer to “(1) Clock Timing Rating.”



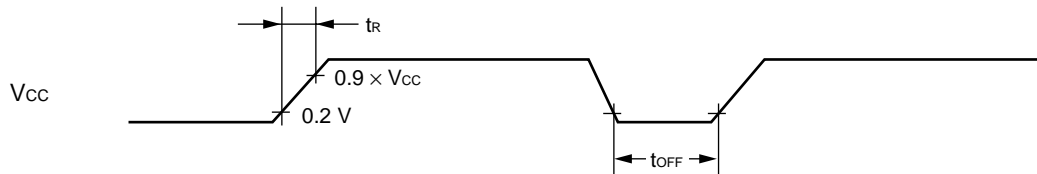
(4) Power on Supply Specifications (Power-on Reset)

($V_{CC5} = 5.0 \text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0 \text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7 \text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0 \text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

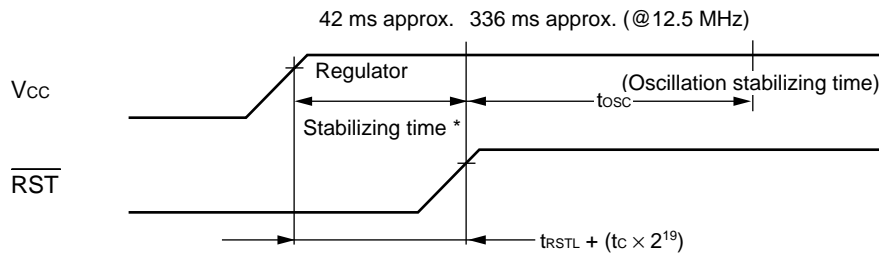
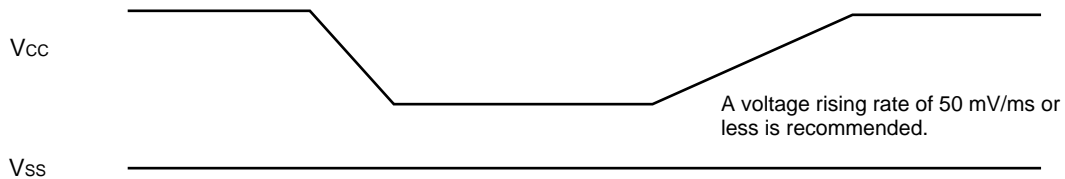
Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Power supply rising time	t_R	V_{CC}	$V_{CC} = 5.0 \text{ V}$	50	—	μs	*
	t_R	V_{CC}		—	30	ms	*
	t_R	V_{CC}	$V_{CC} = 3.0/3.3 \text{ V}$	50	—	μs	*
	t_R	V_{CC}		—	18	ms	*
Power supply shut off time	t_{OFF}	V_{CC}	—	1	—	ms	Repeated operations
Oscillation stabilizing time	t_{OSC}	—	—	$2 \times t_c \times 2^{21} + 100 \mu\text{s}$	—	ns	

t_c (clock cycle time): Refer to “(1) Clock Timing Rating.”

* : $V_{CC} < 0.2 \text{ V}$ before the power supply rising



Note: Sudden change in supply voltage during operation may initiate a power-on sequence. To change supply voltage during operation, it is recommended to smoothly raise the voltage to avoid rapid fluctuations in the supply voltage.



t_{RSTL} : Reset input time

*: Reset can't be done during regulator stabilizing time.

Note: Set $\overline{\text{RST}}$ pin to “L” level when turning on the device, at least the described above duration after the supply voltage reaches V_{CC} is necessary before turning the $\overline{\text{RST}}$ to “H” level.

MB91101/MB91101A

(5) Normal Bus Access Read/write Operation

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
$\overline{CS0}$ to $\overline{CS5}$ delay time	t_{CHCSL}	CLK, $\overline{CS0}$ to $\overline{CS5}$	—	—	15	ns	
	t_{CHCSH}	CLK, $\overline{CS0}$ to $\overline{CS5}$		—	15	ns	
Address delay time	t_{CHAV}	CLK, A24 to A00		—	15	ns	
Data delay time	t_{CHDV}	CLK, D31 to D16		—	15	ns	
\overline{RD} delay time	t_{CLRL}	CLK, \overline{RD}		—	6	ns	
	t_{CLRH}	CLK, \overline{RD}		—	6	ns	
$\overline{WR0}$, $\overline{WR1}$ delay time	t_{CLWL}	CLK, $\overline{WR0}$, $\overline{WR1}$		—	6	ns	
	t_{CLWH}	CLK, $\overline{WR0}$, $\overline{WR1}$		—	6	ns	
Valid address → valid data input time	t_{AVDV}	A24 to A00, D31 to D16		—	$\frac{3}{2} \times t_{CYC} - 25$	ns	*1 *2
$\overline{RD} \downarrow \rightarrow$ valid data input time	t_{RLDV}	\overline{RD} , D31 to D16		—	$t_{CYC} - 10$	ns	*1
Data set up → $\overline{RD} \uparrow$ time	t_{DSRH}	\overline{RD} , D31 to D16		10	—	ns	
$\overline{RD} \uparrow \rightarrow$ data hold time	t_{RHDX}	\overline{RD} , D31 to D16		0	—	ns	

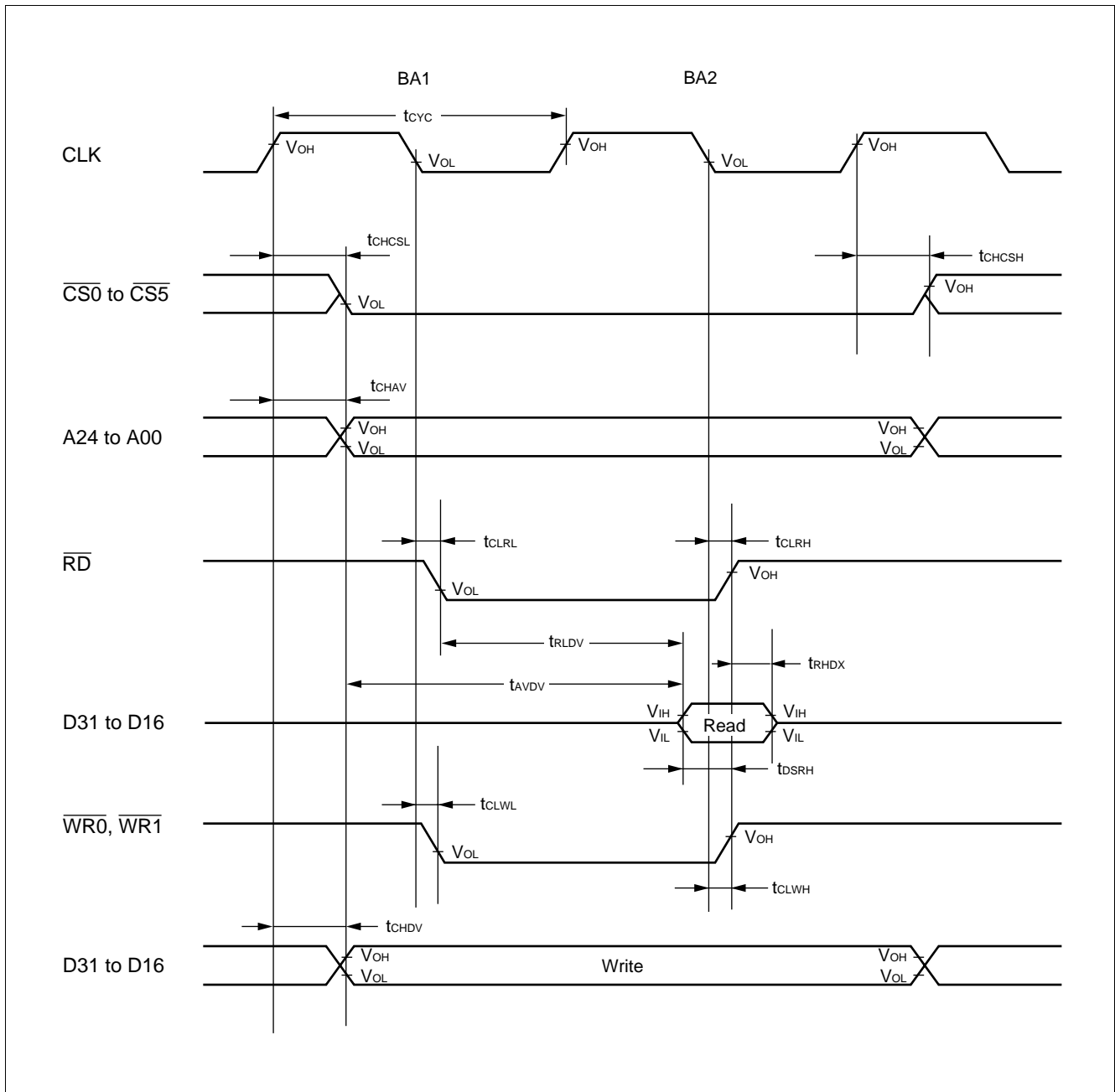
t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”

*1: When bus timing is delayed by automatic wait insertion or RDY input, add ($t_{CYC} \times$ extended cycle number for delay) to this rating.

*2: Rating at a gear cycle of $\times 1$.

When a gear cycle of 1/2, 1/4, 1/8 is selected, substitute “n” in the following equation with 1/2, 1/4, 1/8, respectively.

$$\text{Equation: } (2 - n/2) \times t_{CYC} - 25$$

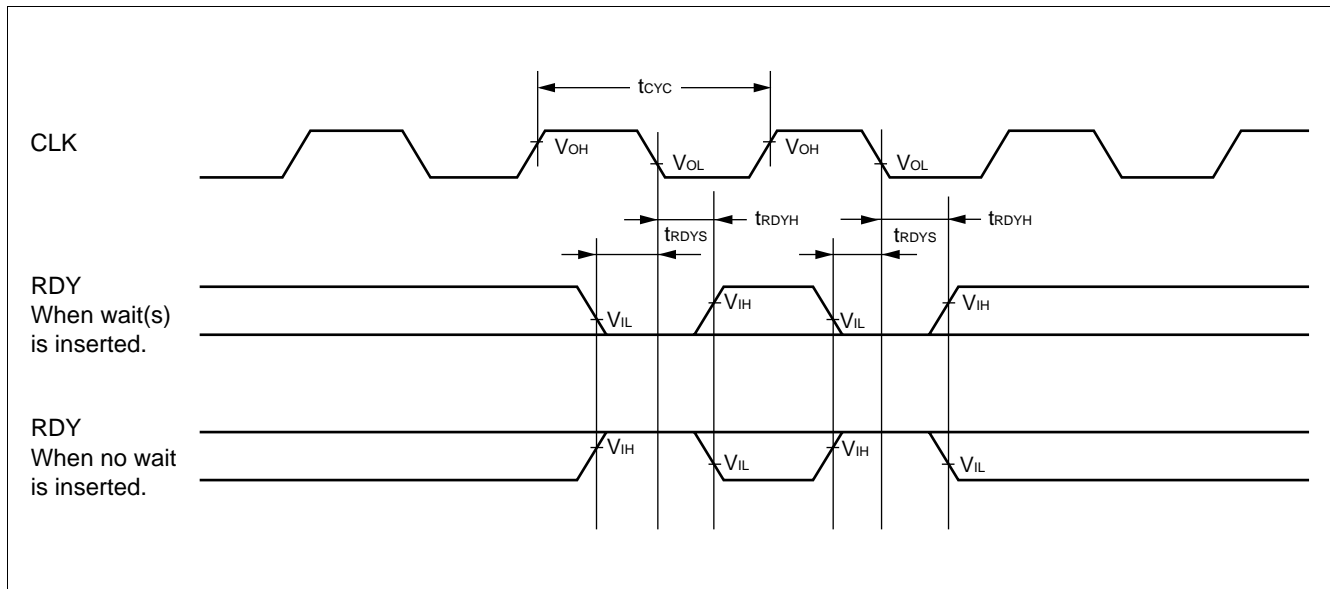


MB91101/MB91101A

(6) Ready Input Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RDY set up time → CLK ↓	t_{RDYS}	RDY, CLK	—	15	—	ns	
CLK ↓ → RDY hold time	t_{RDYH}	RDY, CLK	—	0	—	ns	



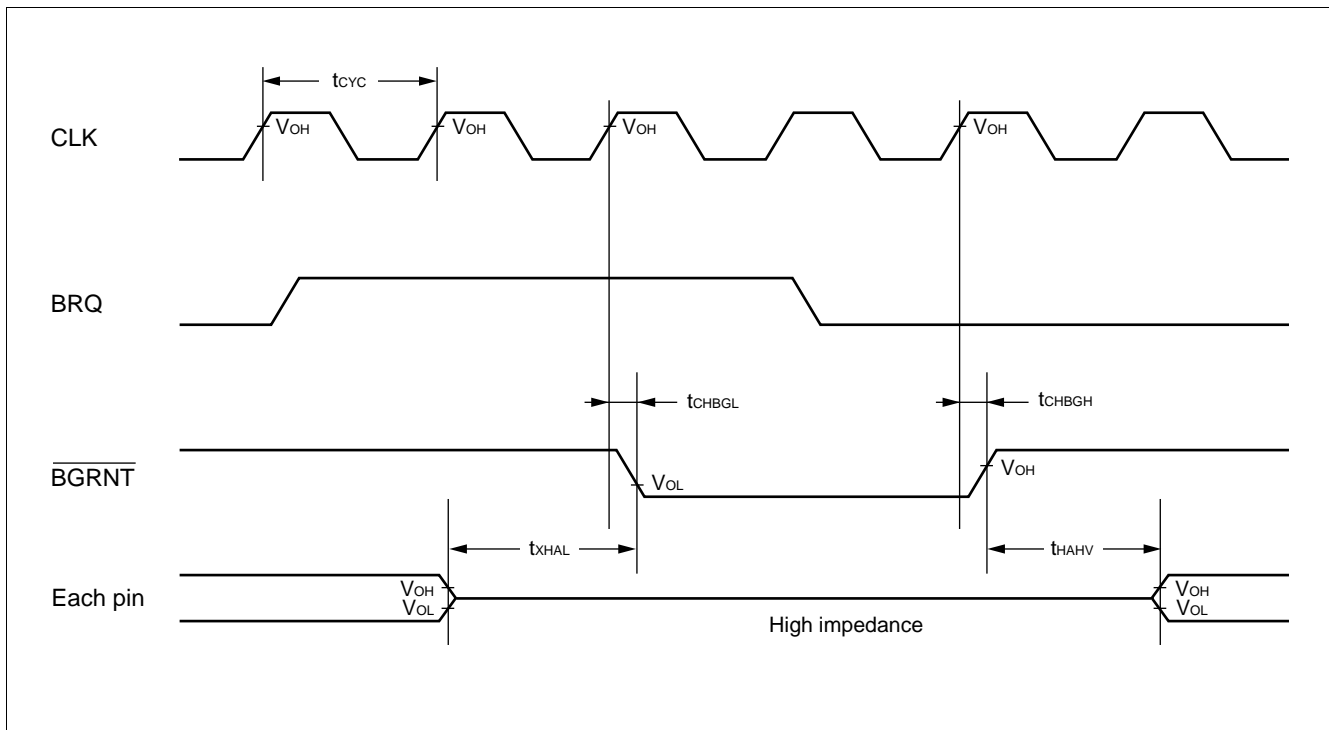
(7) Hold Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
$\overline{\text{BGRNT}}$ delay time	t_{CHBGL}	CLK, $\overline{\text{BGRNT}}$	—	—	6	ns	
	t_{CHBGH}	CLK, $\overline{\text{BGRNT}}$		—	6	ns	
Pin floating \rightarrow $\overline{\text{BGRNT}}$ \downarrow time	t_{XHAL}	$\overline{\text{BGRNT}}$		$t_{\text{CYC}} - 10$	$t_{\text{CYC}} + 10$	ns	
$\overline{\text{BGRNT}}$ \uparrow \rightarrow pin valid time	t_{HAHV}	$\overline{\text{BGRNT}}$		$t_{\text{CYC}} - 10$	$t_{\text{CYC}} + 10$	ns	

t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”

Note: There is a delay time of more than 1 cycle from BRQ input to $\overline{\text{BGRNT}}$ change.



MB91101/MB91101A

(8) Normal DRAM Mode Read/Write Cycle

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t _{CLRAH}	CLK, RAS	—	—	6	ns	
	t _{CHRAL}	CLK, RAS		—	6	ns	
CAS delay time	t _{CLCASL}	CLK, CAS		—	6	ns	
	t _{CLCASH}	CLK, CAS		—	6	ns	
ROW address delay time	t _{CHRAV}	CLK, A24 to A00		—	15	ns	
COLUMN address delay time	t _{CHCAV}	CLK, A24 to A00		—	15	ns	
\overline{DW} delay time	t _{CHDWL}	CLK, \overline{DW}		—	15	ns	
	t _{CHDWH}	CLK, \overline{DW}		—	15	ns	
Output data delay time	t _{CHDV1}	CLK, D31 to D16		—	15	ns	
RAS $\downarrow \rightarrow$ valid data input time	t _{RLDV}	RAS, D31 to D16		—	$\frac{5}{2} \times t_{CYC} - 16$	ns	*1 *2
CAS $\downarrow \rightarrow$ valid data input time	t _{CLDV}	CAS, D31 to D16		—	$t_{CYC} - 17$	ns	*1
CAS $\uparrow \rightarrow$ data hold time	t _{CADH}	CAS, D31 to D16		0	—	ns	

t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”

CAS: CS0L to CS1H pins are for CAS signal outputs.

\overline{DW} : $\overline{DW0}$, $\overline{DW1}$ and CS0H to CS1H are used for \overline{WE} outputs.

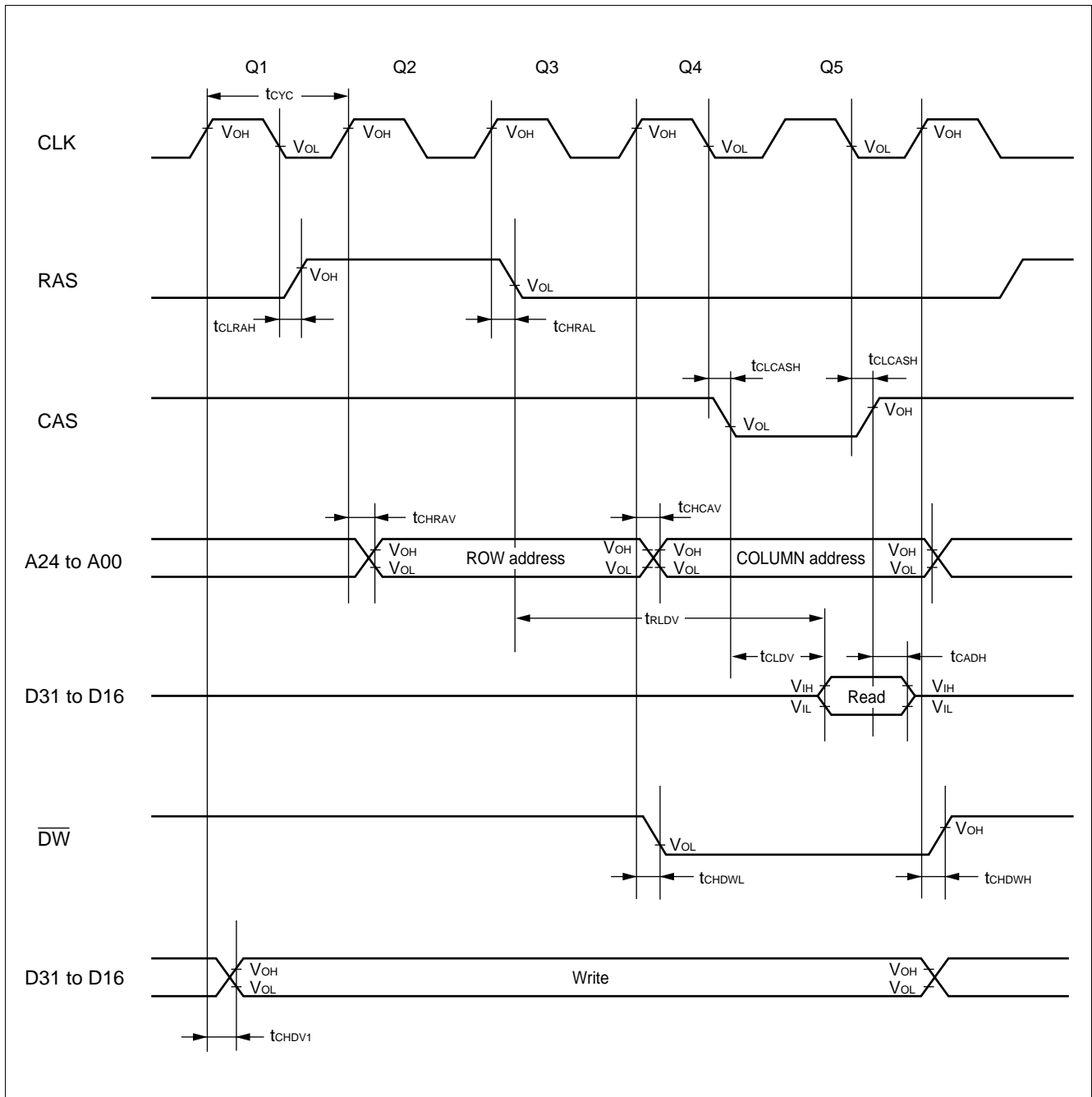
*1: When Q1 cycle or Q4 cycle is extended for 1 cycle, add t_{CYC} time to this rating.

*2: Rating at a gear cycle of $\times 1$.

When a gear cycle of 1/2, 1/4, 1/8 is selected, substitute “n” in the following equation with 1/2, 1/4, 1/8, respectively.

$$\text{Equation: } (3 - n/2) \times t_{CYC} - 16$$

MB91101/MB91101A



MB91101/MB91101A

(9) Normal DRAM Mode Fast Page Read/Write Cycle

($V_{cc5} = 5.0\text{ V} \pm 10\%$, $V_{ss} = AV_{ss} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

($V_{cc5} = V_{cc3} = 2.7\text{ V}$ to 3.6 V , $V_{ss} = AV_{ss} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

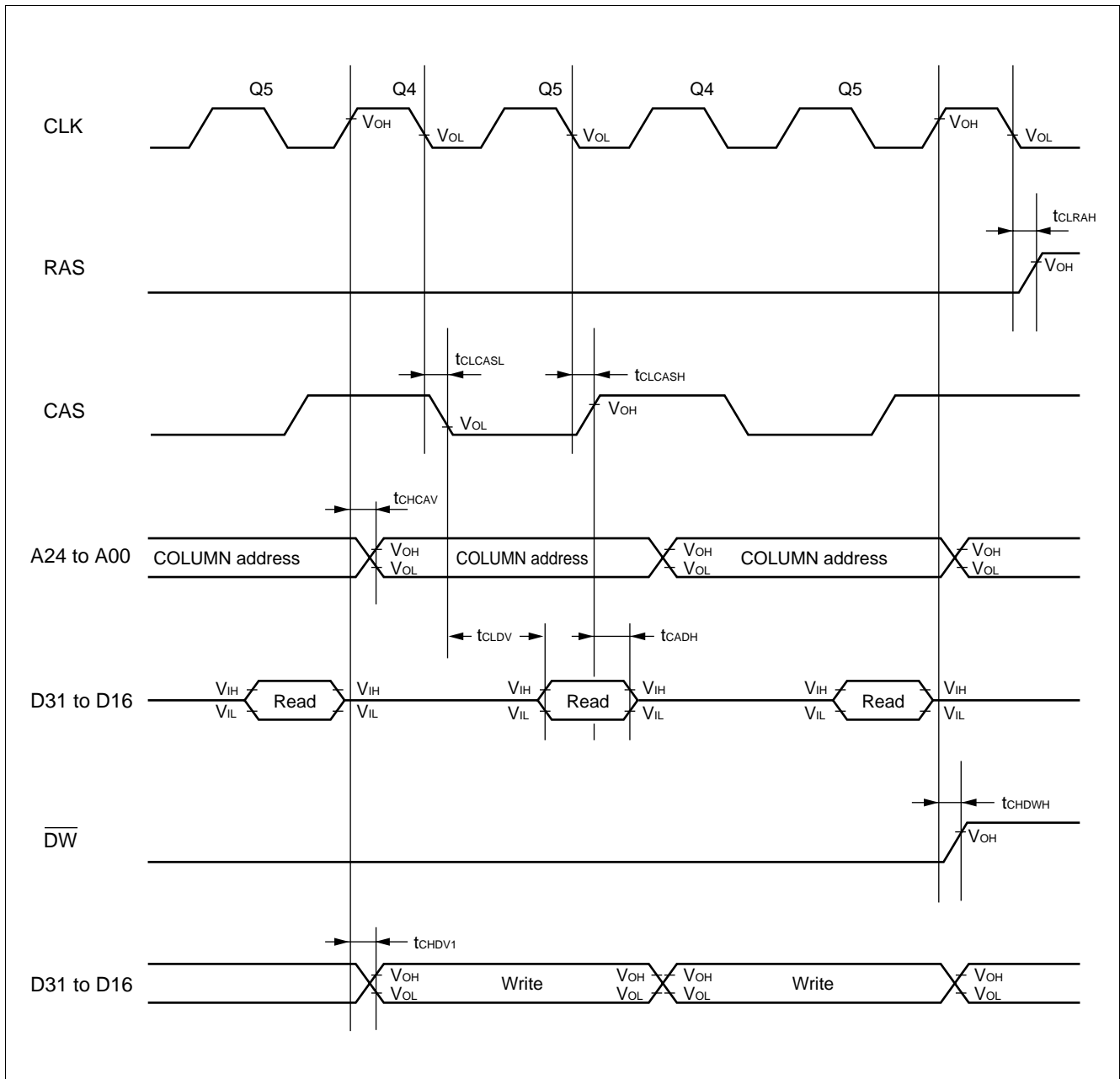
Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t_{CLRAH}	CLK, RAS	—	—	6	ns	
CAS delay time	t_{CLCASL}	CLK, CAS		—	6	ns	
	t_{CLCASH}	CLK, CAS		—	6	ns	
COLUMN address delay time	t_{CHCAV}	CLK, A24 to A00		—	15	ns	
\overline{DW} delay time	t_{CHDWH}	CLK, \overline{DW}		—	15	ns	
Output data delay time	t_{CHDV1}	CLK, D31 to D16		—	15	ns	
CAS $\downarrow \rightarrow$ valid data input time	t_{CLDV}	CAS, D31 to D16		—	$t_{cyc} - 17$	ns	*
CAS $\uparrow \rightarrow$ data hold time	t_{CADH}	CAS, D31 to D16	0	—	ns		

t_{cyc} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”

CAS: CS0L to CS1H pins are for CAS signal outputs.

\overline{DW} : $\overline{DW0}$, $\overline{DW1}$ and CS0H to CS1H are used for \overline{WE} outputs.

* : When Q4 cycle is extended for 1 cycle, add t_{cyc} time to this rating.



MB91101/MB91101A

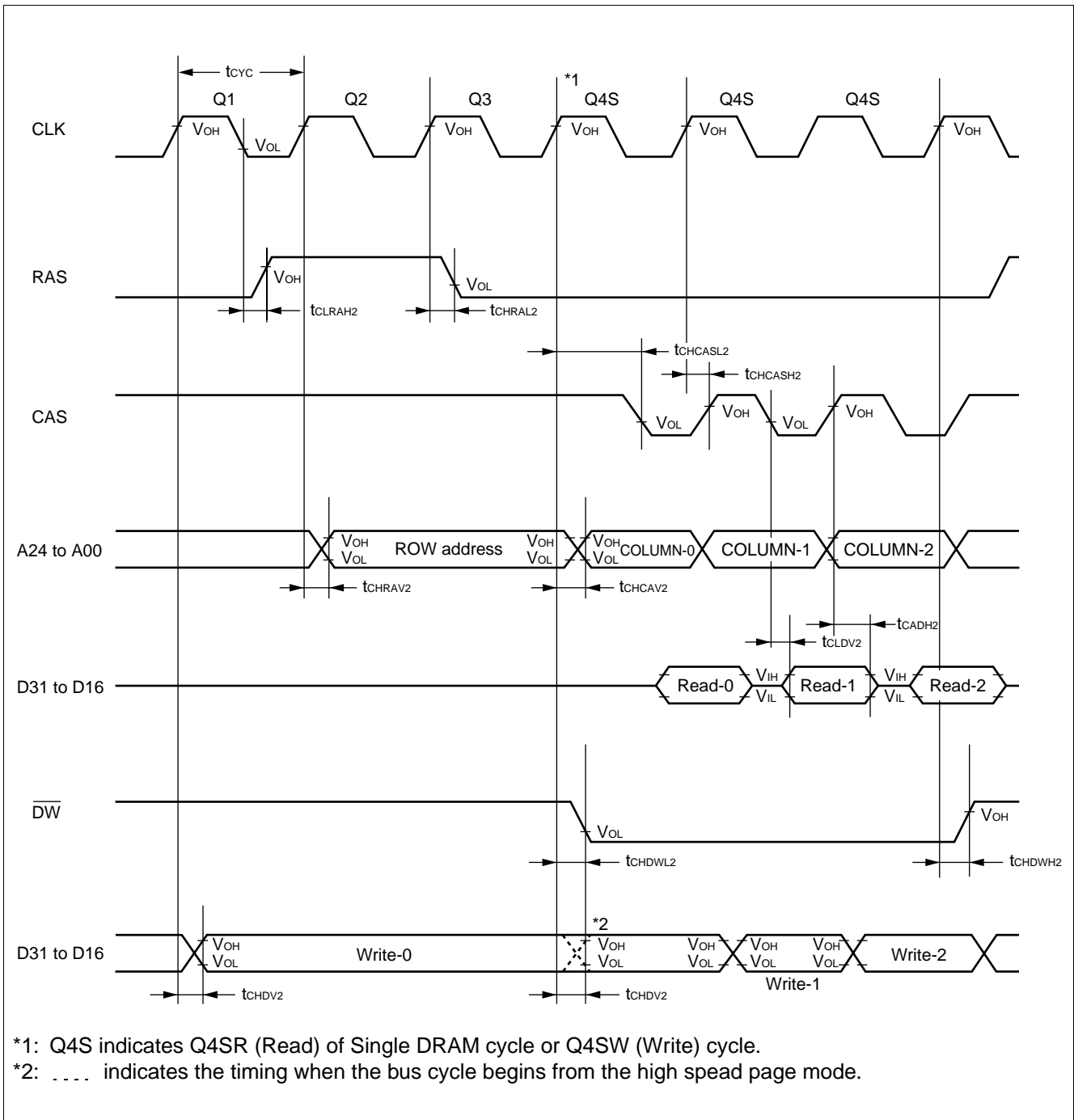
(10) Single DRAM Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t _{CLRAH2}	CLK, RAS	—	—	6	ns	
	t _{CHRAL2}	CLK, RAS			6	ns	
CAS delay time	t _{CHCASL2}	CLK, CAS		—	$n/2 \times t_{CYC}$	ns	
	t _{CHCASH2}	CLK, CAS		—	6	ns	
ROW address delay time	t _{CHRAV2}	CLK, A24 to A00		—	15	ns	
COLUMN address delay time	t _{CHCAV2}	CLK, A24 to A00		—	15	ns	
\overline{DW} delay time	t _{CHDWL2}	CLK, \overline{DW}		—	15	ns	
	t _{CHDWH2}	CLK, \overline{DW}		—	15	ns	
Output data delay time	t _{CHDV2}	CLK, D31 to D16		—	15	ns	
CAS $\downarrow \rightarrow$ Valid data input time	t _{CLDV2}	CAS, D31 to D16		—	$(1 - n/2) \times t_{CYC} - 17$	ns	
CAS $\uparrow \rightarrow$ data hold time	t _{CADH2}	CLK, D31 to D16	0	—	ns		

t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”

MB91101/MB91101A



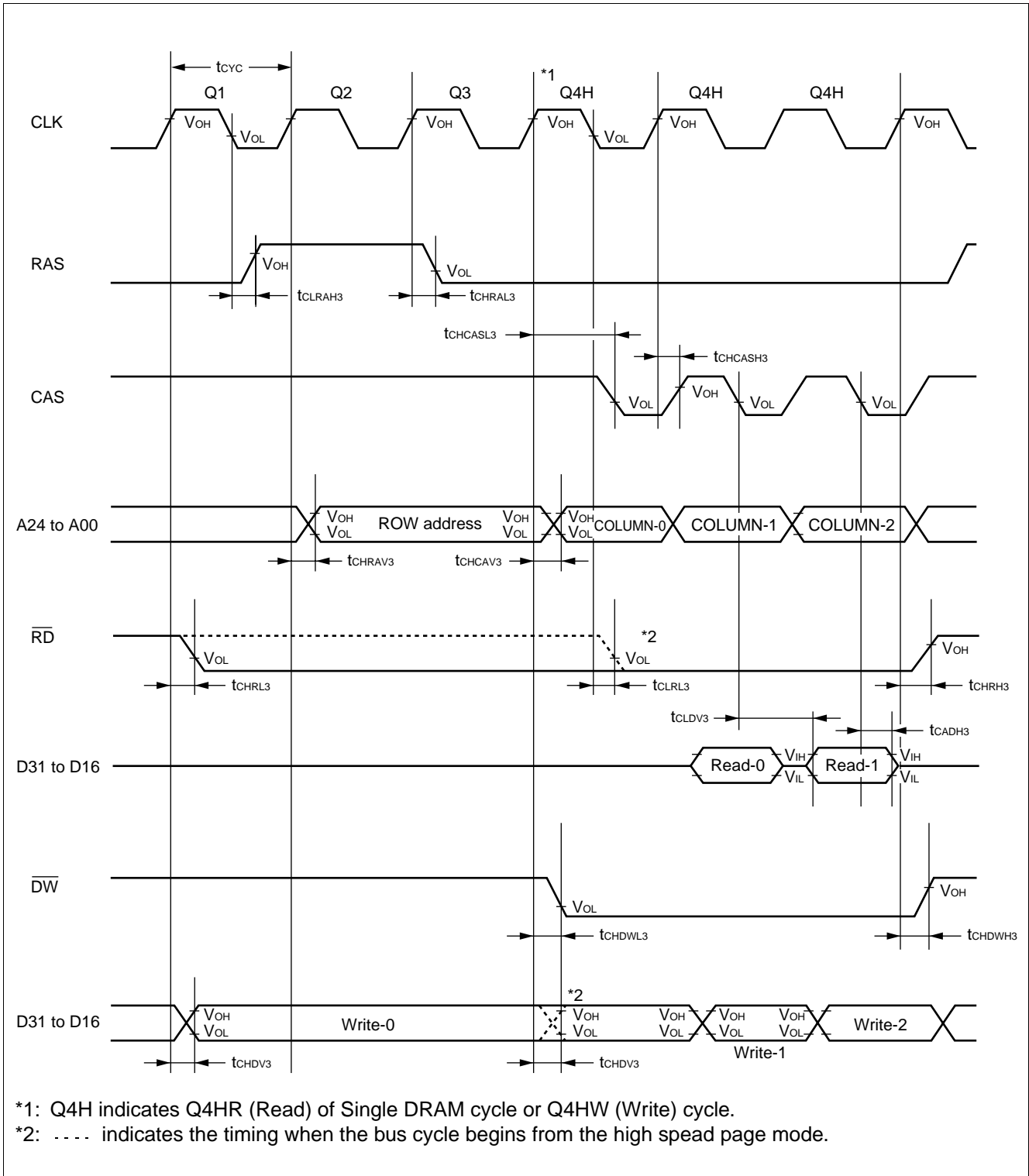
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(11) Hyper DRAM Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V}$ to 3.6 V , $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t _{CLRAH3}	CLK, RAS	—	—	6	ns	
	t _{CHRAL3}	CLK, RAS		—	6	ns	
CAS delay time	t _{CHCASL3}	CLK, CAS		—	$n/2 \times t_{CYC}$	ns	
	t _{CHCASH3}	CLK, CAS		—	6	ns	
ROW address delay time	t _{CHRAV3}	CLK, A24 to A00		—	15	ns	
COLUMN address delay time	t _{CHCAV3}	CLK, A24 to A00		—	15	ns	
$\overline{\text{RD}}$ delay time	t _{CHRL3}	CLK, $\overline{\text{RD}}$		—	15	ns	
	t _{CHRH3}	CLK, $\overline{\text{RD}}$		—	15	ns	
	t _{CLRL3}	CLK, $\overline{\text{RD}}$		—	15	ns	
$\overline{\text{DW}}$ delay time	t _{CHDWL3}	CLK, $\overline{\text{DW}}$		—	15	ns	
	t _{CHDWH3}	CLK, $\overline{\text{DW}}$		—	15	ns	
Output data delay time	t _{CHDV3}	CLK, D31 to D16		—	15	ns	
CAS $\downarrow \rightarrow$ valid data input time	t _{CLDV3}	CAS, D31 to D16		—	$t_{CYC} - 17$	ns	
CAS $\downarrow \rightarrow$ data hold time	t _{CADH3}	CLK, D31 to D16		0	—	ns	

t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”



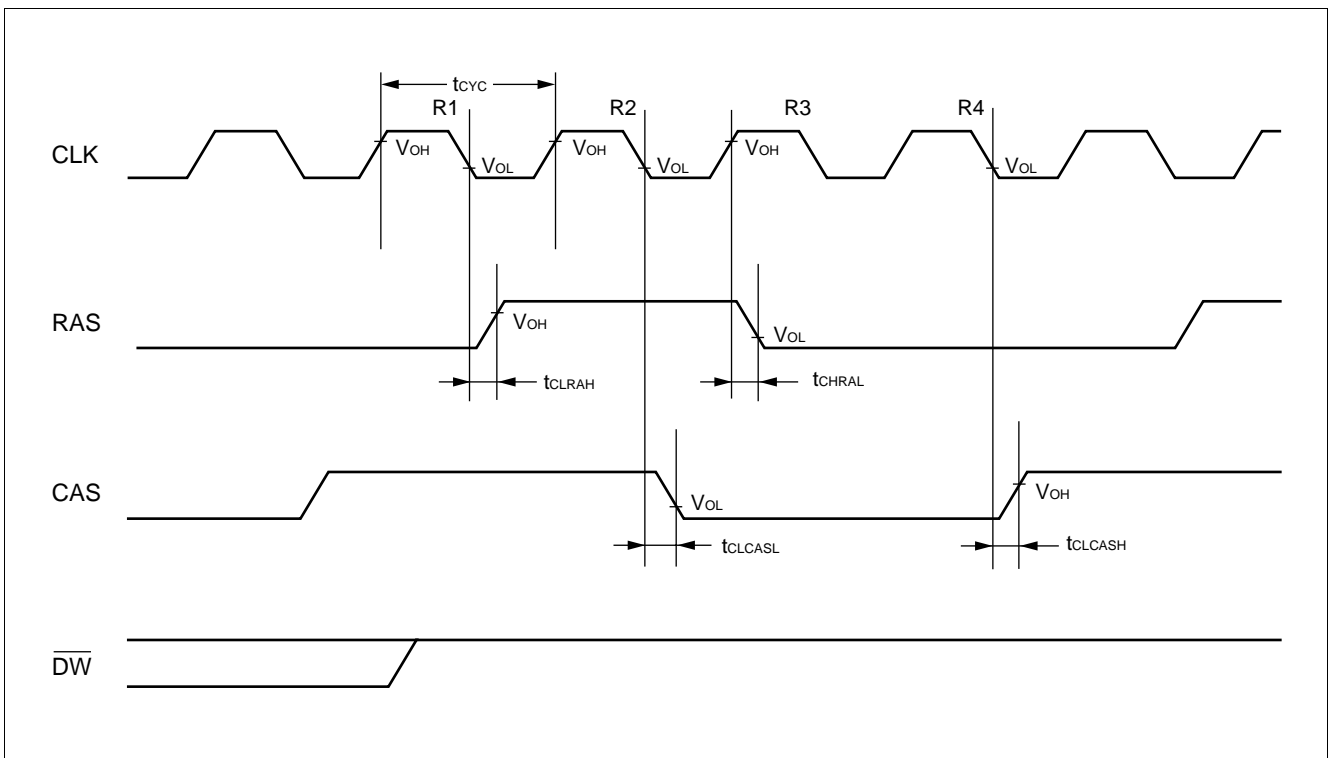
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(12) CBR Refresh

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t_{CLRAH}	CLK, RAS	—	—	6	ns	
	t_{CHRAL}	CLK, RAS		—	6	ns	
CAS delay time	t_{CLCASL}	CLK, CAS		—	6	ns	
	t_{CLCASH}	CLK, CAS		—	6	ns	

CAS: CS0L to CS1H pins are for CAS signal outputs.

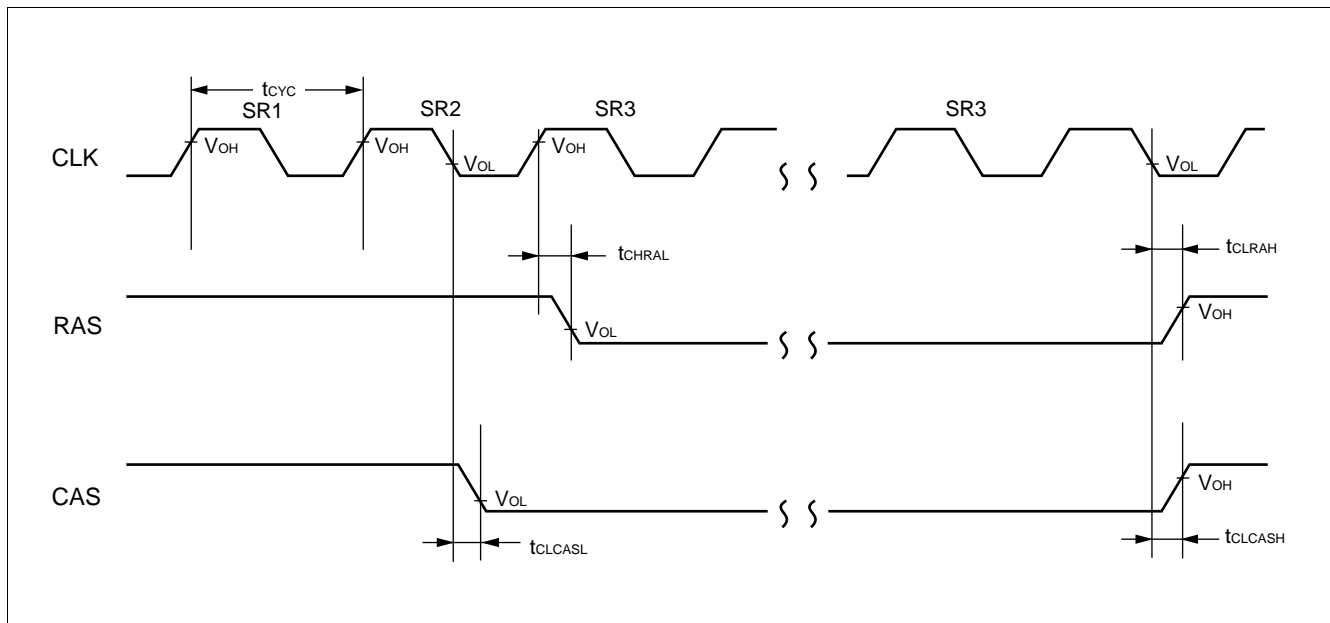


(13) Self Refresh

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
RAS delay time	t_{CLRAH}	CLK, RAS	—	—	6	ns	
	t_{CHRAL}	CLK, RAS		—	6	ns	
CAS delay time	t_{CLCASL}	CLK, CAS		—	6	ns	
	t_{CLCASH}	CLK, CAS		—	6	ns	

CAS: CS0L to CS1H pins are for CAS signal outputs.



MB91101/MB91101A

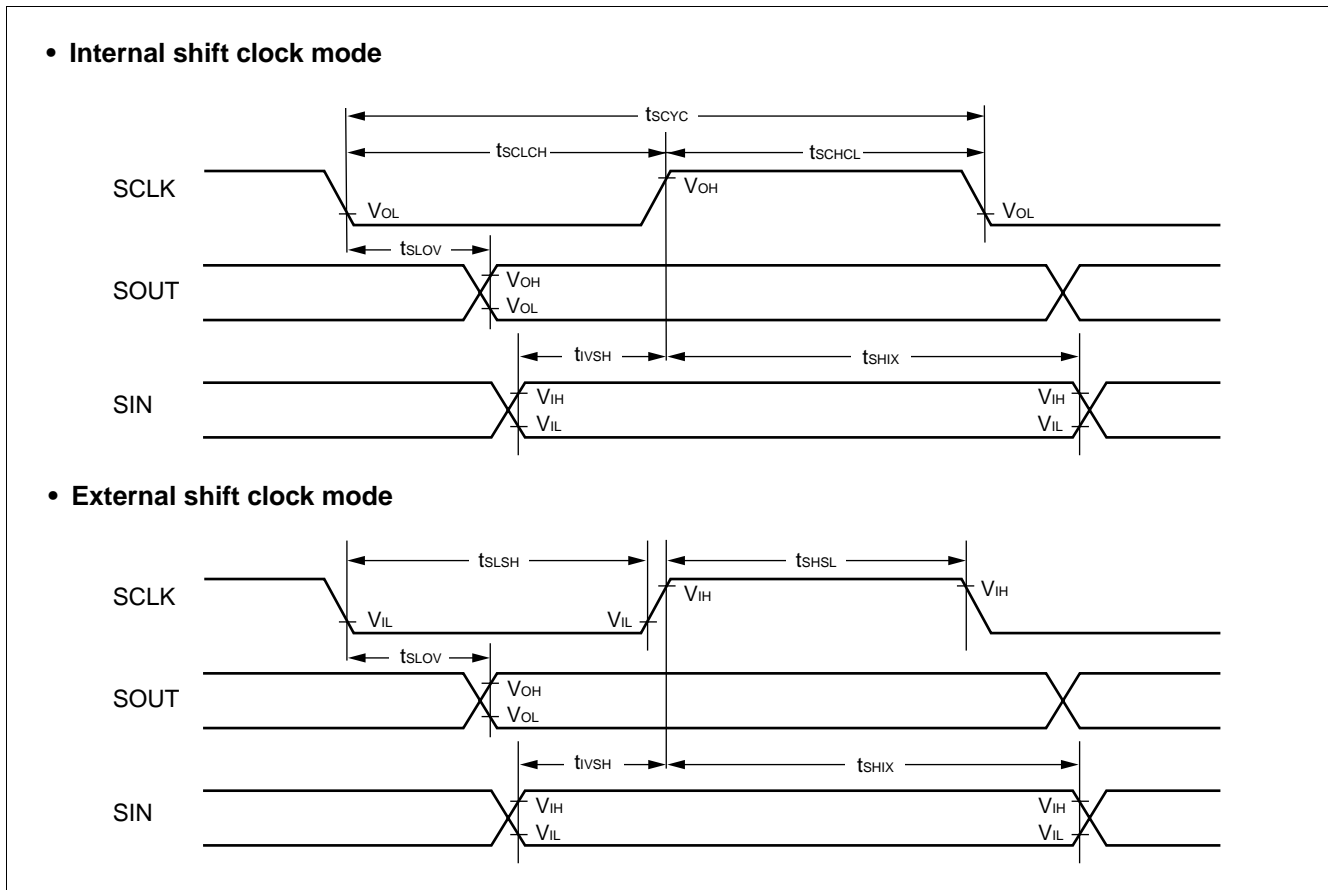
(14) UART Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Serial clock cycle time	t_{SCYC}	—	Internal shift clock mode	$8 \times t_{CYCP}$	—	ns	
SCLK $\downarrow \rightarrow$ SCLK \uparrow	t_{SCLCH}	—		$4 \times t_{CYCP} - 10$	$4 \times t_{CYCP} + 10$	ns	
SCLK $\uparrow \rightarrow$ SCLK \downarrow	t_{SCHCL}	—		$4 \times t_{CYCP} - 10$	$4 \times t_{CYCP} + 10$	ns	
SCLK $\downarrow \rightarrow$ SOUT delay time	t_{SLOV}	—		-80	80	ns	
Valid SIN \rightarrow SCLK \uparrow	t_{IVSH}	—		100	—	ns	
SCLK $\uparrow \rightarrow$ valid SIN hold time	t_{SHIX}	—		60	—	ns	
Serial clock "H" pulse width	t_{SHSL}	—	External shift clock mode	$4 \times t_{CYCP}$	—	ns	
Serial clock "L" pulse width	t_{SLSH}	—		$4 \times t_{CYCP}$	—	ns	
SCLK $\downarrow \rightarrow$ SOUT delay time	t_{SLOV}	—		—	150	ns	
Valid SIN \rightarrow SCLK \uparrow	t_{IVSH}	—		60	—	ns	
SCLK $\uparrow \rightarrow$ valid SIN hold time	t_{SHIX}	—		60	—	ns	

t_{CYCP} : A cycle time of peripheral system clock

Notes: This rating is for AC characteristics in CLK synchronous mode.

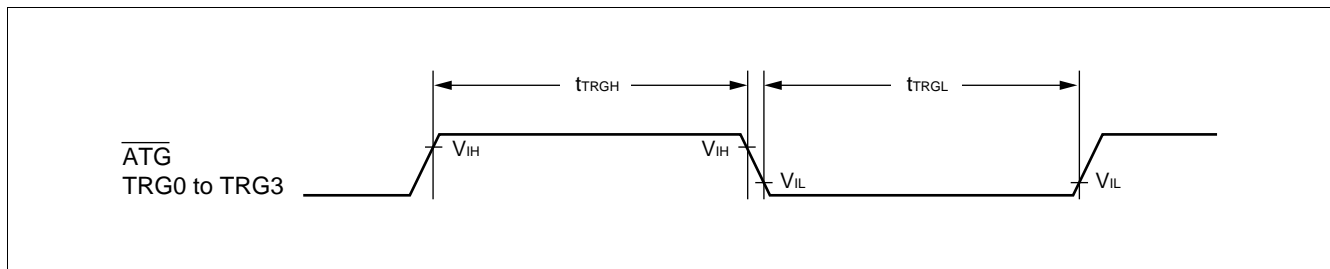


(15) Trigger System Input Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
A/D start trigger input time	t_{TRGH} , t_{TRGL}	\overline{ATG}	—	$5 \times t_{CYCP}$	—	ns	
PWM external trigger input time	t_{TRGH} , t_{TRGL}	TRG0 to TRG3		$5 \times t_{CYCP}$	—	ns	

t_{CYCP} : A cycle time of peripheral system clock



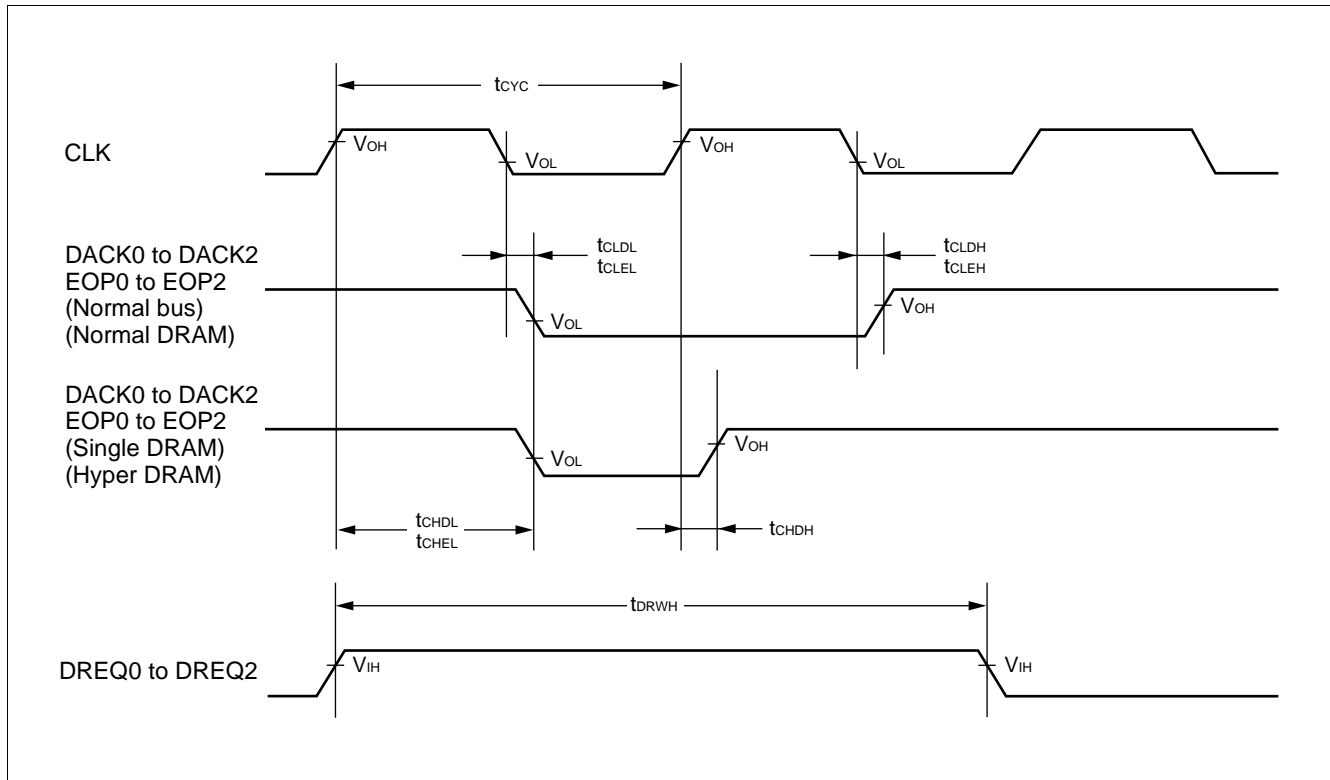
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(16) DMA Controller Timing

($V_{CC5} = 5.0\text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)
 ($V_{CC5} = V_{CC3} = 2.7\text{ V to } 3.6\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_A = 0^\circ\text{C to } +70^\circ\text{C}$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
DREQ input pulse width	t_{DRWH}	DREQ0 to DREQ2	—	$2 \times t_{CYC}$	—	ns	
DACK delay time (Normal bus) (Normal DRAM)	t_{CLDL}	CLK, DACK0 to DACK2		—	6	ns	
	t_{CLDH}	CLK, DACK0 to DACK2		—	6	ns	
EOP delay time (Normal bus) (Normal DRAM)	t_{CLEL}	CLK, EOP0 to EOP2		—	6	ns	
	t_{CLEH}	CLK, EOP0 to EOP2		—	6	ns	
DACK delay time (Single DRAM) (Hyper DRAM)	t_{CHDL}	CLK, DACK0 to DACK2		—	$n/2 \times t_{CYC}$	ns	
	t_{CHDH}	CLK, DACK0 to DACK2		—	6	ns	
EOP delay time (Single DRAM) (Hyper DRAM)	t_{CHEL}	CLK, EOP0 to EOP2		—	$n/2 \times t_{CYC}$	ns	
	t_{CHEH}	CLK, EOP0 to EOP2		—	6	ns	

t_{CYC} (a cycle time of peripheral system clock): Refer to “(2) Clock Output Timing.”



5. A/D Converter Block Electrical Characteristics

($V_{CC} = 2.7\text{ V to }3.6\text{ V}$, $V_{SS} = 0.0\text{ V}$, $V_{RH} = 2.7\text{ V}$, $T_A = 0^\circ\text{C to }+70^\circ\text{C}$)

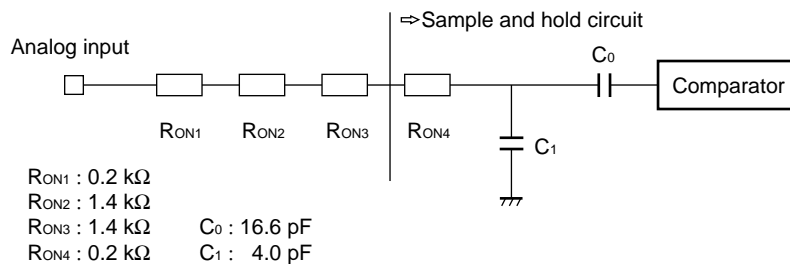
Parameter	Symbol	Pin name	Value			Unit
			Min.	Typ.	Max.	
Resolution	—	—	—	10	10	bit
Total error	—	—	—	—	± 4.0	LSB
Linearity error	—	—	—	—	± 3.5	LSB
Differentiation linearity error	—	—	—	—	± 2.0	LSB
Zero transition voltage	V_{OT}	AN0 to AN3	-1.5	+0.5	+2.5	LSB
Full-scale transition voltage	V_{FST}	AN0 to AN3	$V_{RH} - 4.5$	$V_{RH} - 1.5$	$V_{RH} + 0.5$	LSB
Conversion time	—	—	5.6 *1	—	—	μs
Analog port input current	I_{AIN}	AN0 to AN3	—	0.1	10	μA
Analog input voltage	V_{AIN}	AN0 to AN3	V_{SS}	—	V_{RH}	V
Reference voltage	—	V_{RH}	V_{SS}	—	V_{CC}	V
Power supply current	I_A	V_{CC}	—	4	—	mA
	I_{AH}	V_{CC}	—	—	5 *2	μA
Reference voltage supply current	I_R	V_{RH}	—	200	—	μA
	I_{RH}	V_{RH}	—	—	5 *2	μA
Conversion variance between channels	—	AN0 to AN3	—	—	4	LSB

*1: $V_{CC} = 2.7\text{ V} - 3.6\text{ V}$

*2: Current value for A/D converters not in operation, CPU stop mode ($V_{CC} = V_{RH} = 3.6\text{ V}$)

- Notes:
- As the absolute value of V_{RH} decreases, relative error increases.
 - Output impedance of external circuit of analog input under following conditions;
Output impedance of external circuit $< 10\text{ k}\Omega$.
If output impedance of external circuit is too high, analog voltage sampling time may be too short for accurate sampling (sampling time is $5.6\text{ }\mu\text{s}$ for a machine clock of 25 MHz).

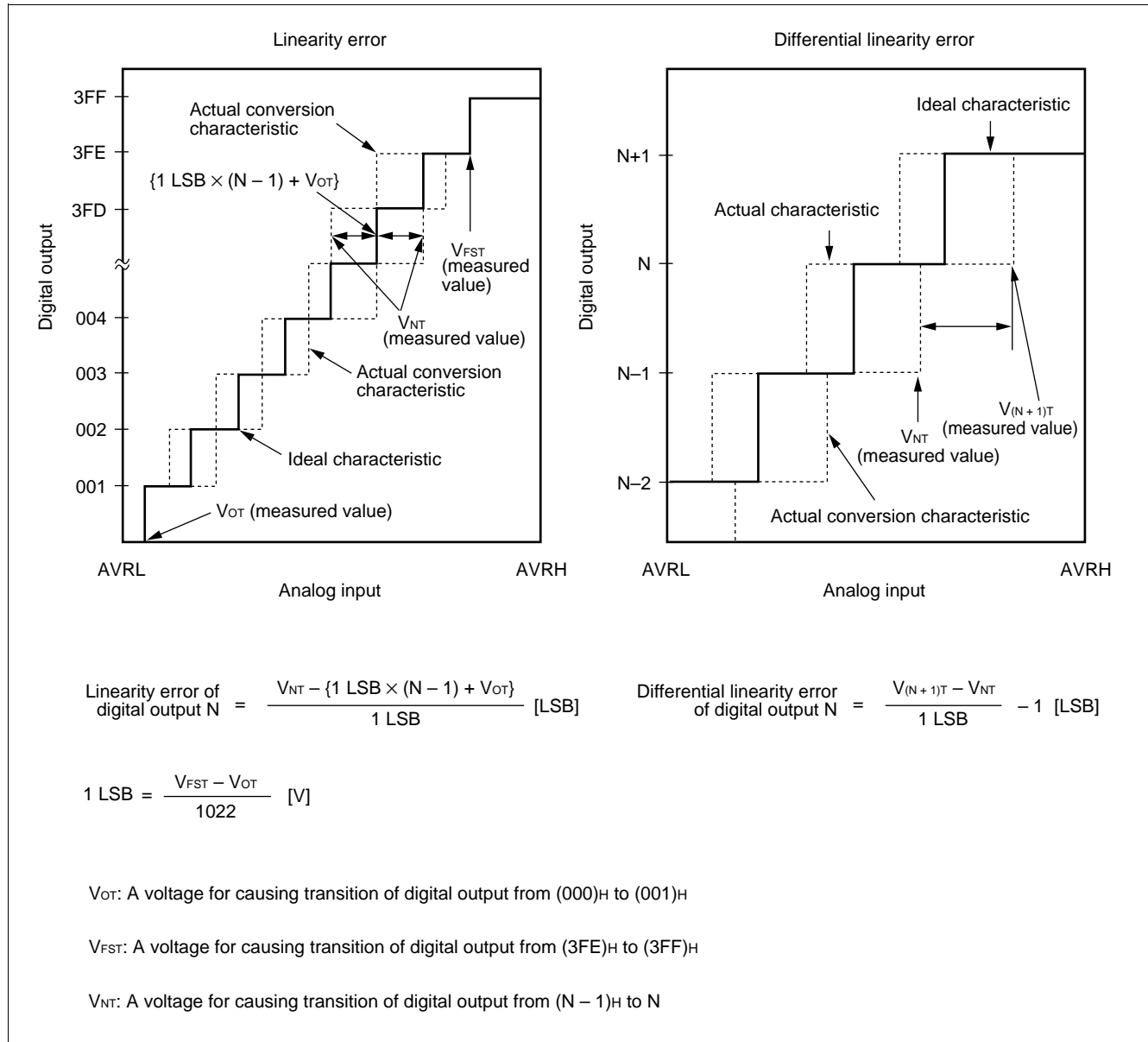
• Analog input circuit model plan



Note: Listed values are for reference purposes only.

6. A/D Converter Glossary

- Resolution
The smallest change in analog voltage detected by A/D converter.
- Linearity error
A deviation of actual conversion characteristic from a line connecting the zero-traction point (between “00 0000 0000” ↔ “00 0000 0001”) to the full-scale transition point (between “11 1111 1110” ↔ “11 1111 1111”).
- Differential linearity error
A deviation of a step voltage for changing the LSB of output code from ideal input voltage.

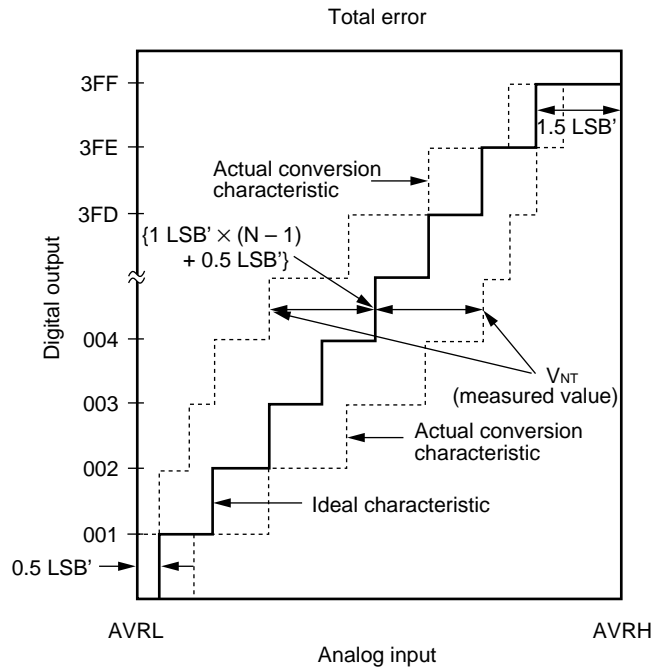


(Continued)

(Continued)

- Total error

A difference between actual value and theoretical value. The overall error includes zero-transition error, full-scale transition error and linearity error.



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

$$1 \text{ LSB}' \text{ (ideal value)} = \frac{\text{AVRH} - \text{AVRL}}{1024} \quad [\text{V}]$$

$$V_{OT}' \text{ (ideal value)} = \text{AVRL} + 0.5 \text{ LSB}' \quad [\text{V}]$$

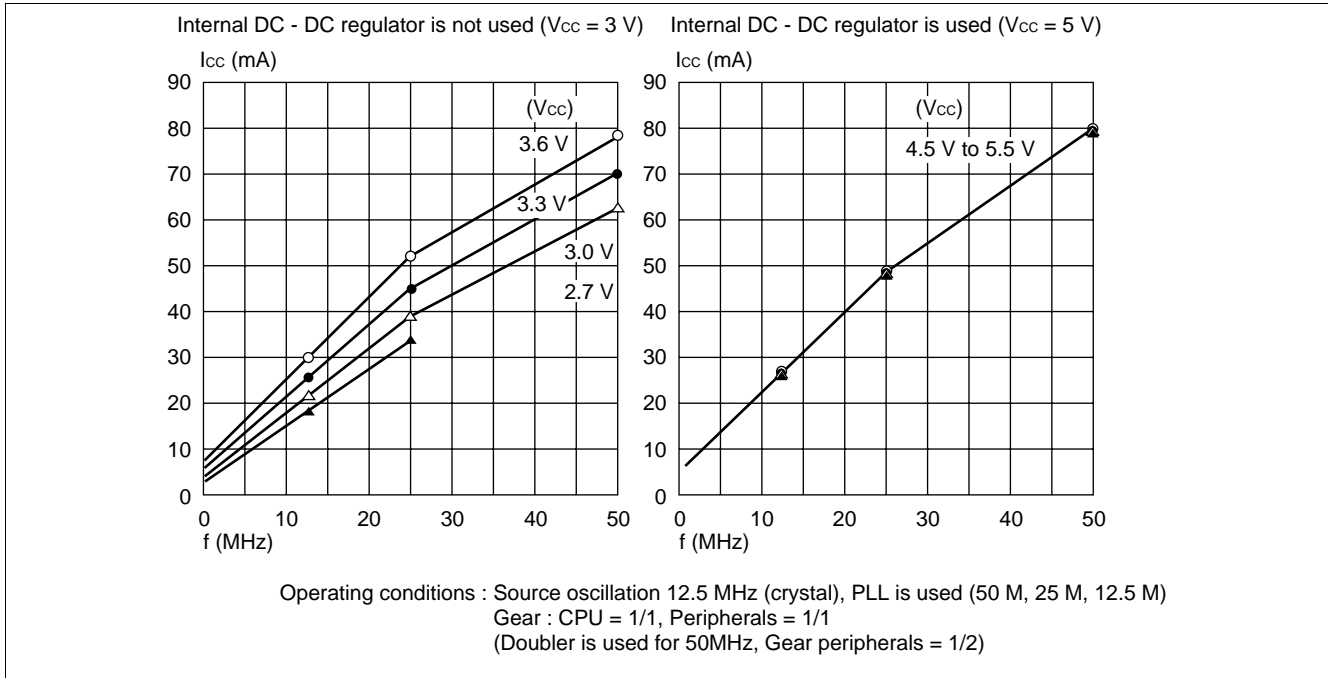
$$V_{FST}' \text{ (ideal value)} = \text{AVRH} - 1.5 \text{ LSB}' \quad [\text{V}]$$

V_{NT} : A voltage for causing transition of digital output from $(N - 1)$ to N

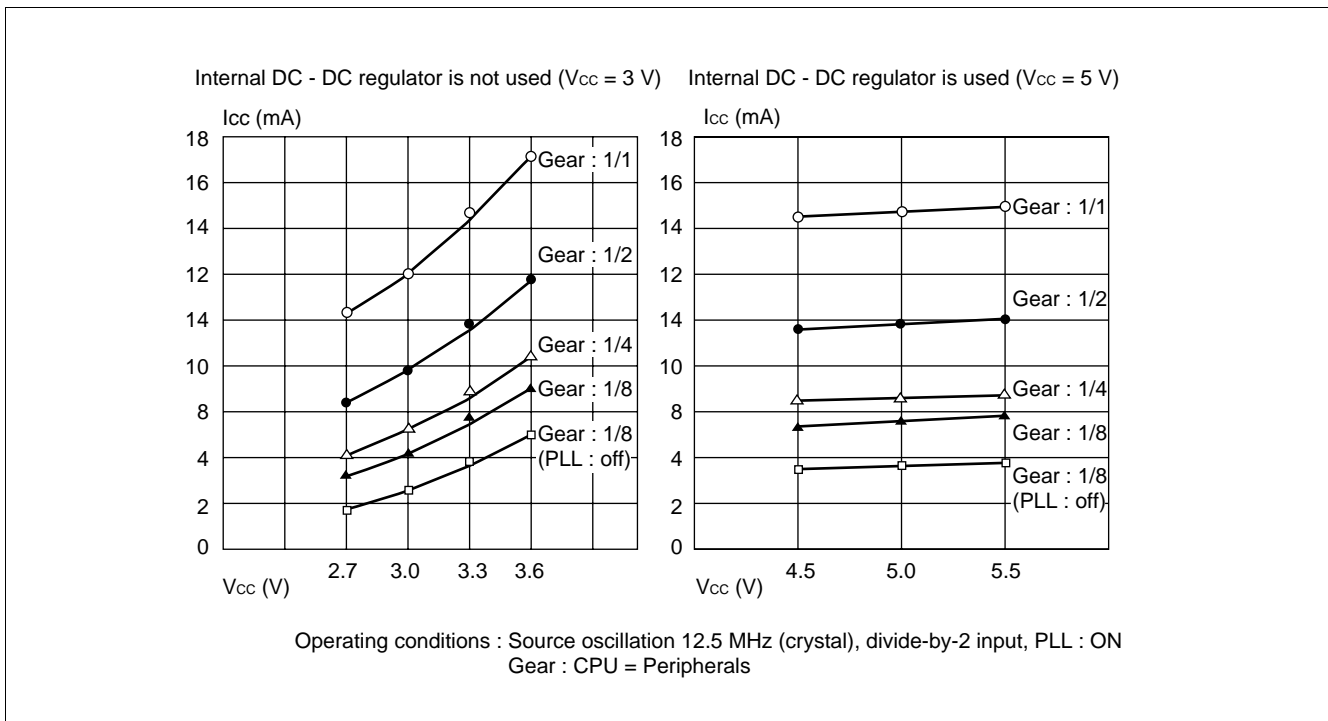
MB91101/MB91101A

REFERENCE DATA

1. Operating frequency vs. I_{CC} characteristics



2. V_{CC} vs. I_{CC} characteristics



■ INSTRUCTIONS (165 INSTRUCTIONS)

1. How to Read Instruction Set Summary

Mnemonic	Type	OP	CYC	NZVC	Operation	Remarks
ADD Rj, Ri	A	A6	1	CCCC	Ri + Rj → Ri	
* ADD #s5, Ri	C	A4	1	CCCC	Ri + s5 → Ri	
, ,	, ,	, ,	, ,	, ,	, ,	
↓ (1)	↓ (2)	↓ (3)	↓ (4)	↓ (5)	↓ (6)	↓ (7)

(1) Names of instructions

Instructions marked with * are not included in CPU specifications. These are extended instruction codes added/extended at assembly language levels.

(2) Addressing modes specified as operands are listed in symbols.

Refer to "2. Addressing mode symbols" for further information.

(3) Instruction types

(4) Hexa-decimal expressions of instructions

(5) The number of machine cycles needed for execution

a: Memory access cycle and it has possibility of delay by Ready function.

b: Memory access cycle and it has possibility of delay by Ready function.

If an object register in a LD operation is referenced by an immediately following instruction, the interlock function is activated and number of cycles needed for execution increases.

c: If an immediately following instruction operates to an object of R15, SSP or USP in read/write mode or if the instruction belongs to instruction format A group, the interlock function is activated and number of cycles needed for execution increases by 1 to make the total number of 2 cycles needed.

d: If an immediately following instruction refers to MDH/MDL, the interlock function is activated and number of cycles needed for execution increases by 1 to make the total number of 2 cycles needed.

For a, b, c and d, minimum execution cycle is 1.

(6) Change in flag sign

- Flag change

C : Change

– : No change

0 : Clear

1 : Set

- Flag meanings

N : Negative flag

Z : Zero flag

V : Over flag

C : Carry flag

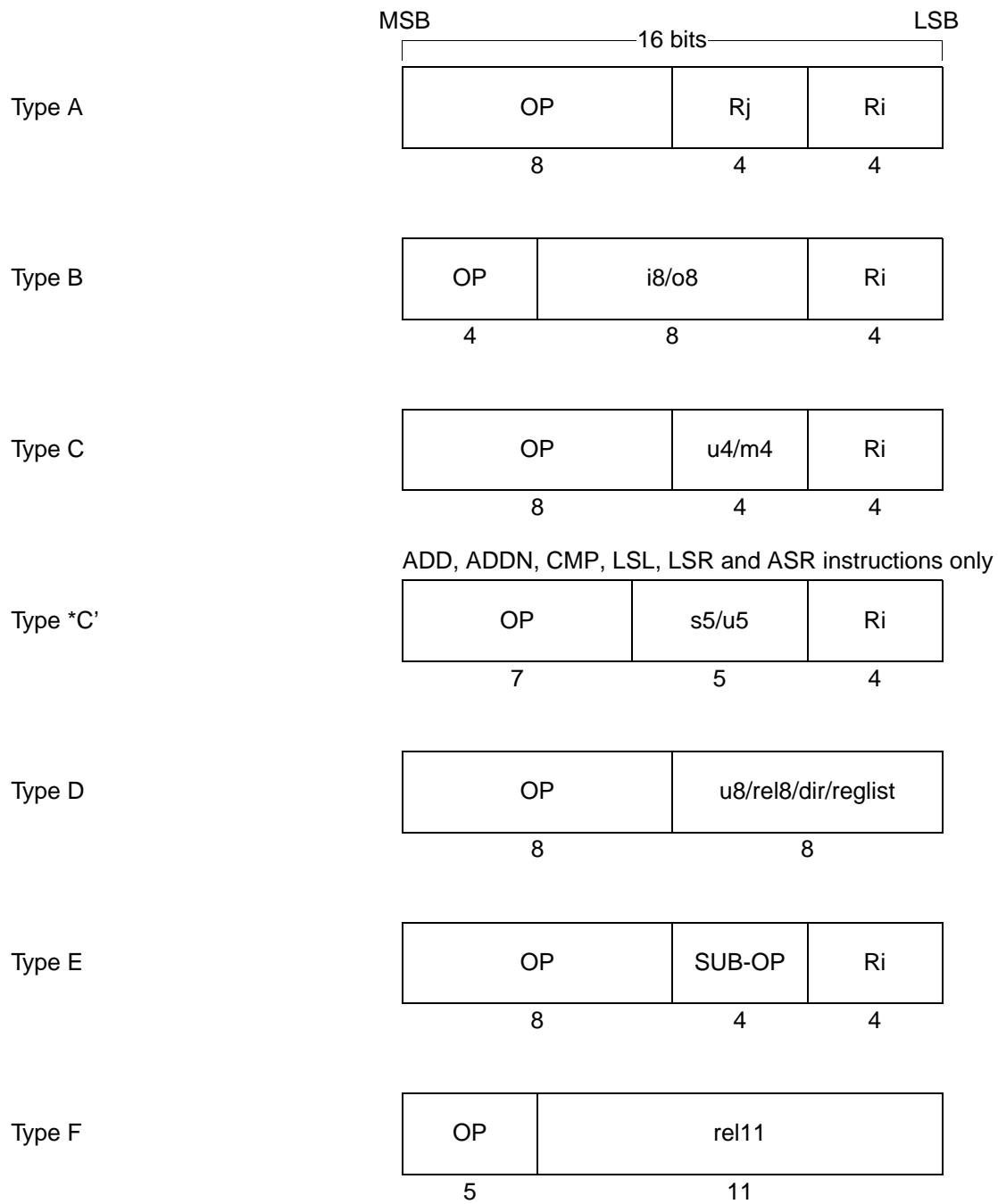
(7) Operation carried out by instruction

MB91101/MB91101A

2. Addressing Mode Symbols

Ri	: Register direct (R0 to R15, AC, FP, SP)
Rj	: Register direct (R0 to R15, AC, FP, SP)
R13	: Register direct (R13, AC)
Ps	: Register direct (Program status register)
Rs	: Register direct (TBR, RP, SSP, USP, MDH, MDL)
CRi	: Register direct (CR0 to CR15)
CRj	: Register direct (CR0 to CR15)
#i8	: Unsigned 8-bit immediate (–128 to 255) Note: –128 to –1 are interpreted as 128 to 255
#i20	: Unsigned 20-bit immediate (–0X80000 to 0XFFFFFF) Note: –0X7FFFF to –1 are interpreted as 0X7FFFF to 0XFFFFFF
#i32	: Unsigned 32-bit immediate (–0X80000000 to 0xFFFFFFFF) Note: –0X80000000 to –1 are interpreted as 0X80000000 to 0xFFFFFFFF
#s5	: Signed 5-bit immediate (–16 to 15)
#s10	: Signed 10-bit immediate (–512 to 508, multiple of 4 only)
#u4	: Unsigned 4-bit immediate (0 to 15)
#u5	: Unsigned 5-bit immediate (0 to 31)
#u8	: Unsigned 8-bit immediate (0 to 255)
#u10	: Unsigned 10-bit immediate (0 to 1020, multiple of 4 only)
@dir8	: Unsigned 8-bit direct address (0 to 0XFF)
@dir9	: Unsigned 9-bit direct address (0 to 0X1FE, multiple of 2 only)
@dir10	: Unsigned 10-bit direct address (0 to 0X3FC, multiple of 4 only)
label9	: Signed 9-bit branch address (–0X100 to 0XFC, multiple of 2 only)
label12	: Signed 12-bit branch address (–0X800 to 0X7FC, multiple of 2 only)
label20	: Signed 20-bit branch address (–0X80000 to 0X7FFFF)
label32	: Signed 32-bit branch address (–0X80000000 to 0X7FFFFFFF)
@Ri	: Register indirect (R0 to R15, AC, FP, SP)
@Rj	: Register indirect (R0 to R15, AC, FP, SP)
@(R13, Rj)	: Register relative indirect (Rj: R0 to R15, AC, FP, SP)
@(R14, disp10)	: Register relative indirect (disp10: –0X200 to 0X1FC, multiple of 4 only)
@(R14, disp9)	: Register relative indirect (disp9: –0X100 to 0XFE, multiple of 2 only)
@(R14, disp8)	: Register relative indirect (disp8: –0X80 to 0X7F)
@(R15, udisp6)	: Register relative (udisp6: 0 to 60, multiple of 4 only)
@Ri+	: Register indirect with post-increment (R0 to R15, AC, FP, SP)
@R13+	: Register indirect with post-increment (R13, AC)
@SP+	: Stack pop
@–SP	: Stack push
(reglist)	: Register list

3. Instruction Types



MB91101/MB91101A

4. Detailed Description of Instructions

• Add/subtract operation instructions (10 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
ADD Rj, Ri	A	A6	1	C C C C	$Ri + Rj \rightarrow Ri$	MSB is interpreted as a sign in assembly language
* ADD #s5, Ri	C'	A4	1	C C C C	$Ri + s5 \rightarrow Ri$	
ADD #i4, Ri	C	A4	1	C C C C	$Ri + \text{extu}(i4) \rightarrow Ri$	Zero-extension Sign-extension
ADD2 #i4, Ri	C	A5	1	C C C C	$Ri + \text{extu}(i4) \rightarrow Ri$	
ADDC Rj, Ri	A	A7	1	C C C C	$Ri + Rj + c \rightarrow Ri$	Add operation with sign
ADDN Rj, Ri	A	A2	1	- - - -	$Ri + Rj \rightarrow Ri$	MSB is interpreted as a sign in assembly language
* ADDN #s5, Ri	C'	A0	1	- - - -	$Ri + s5 \rightarrow Ri$	
ADDN #i4, Ri	C	A0	1	- - - -	$Ri + \text{extu}(i4) \rightarrow Ri$	Zero-extension Sign-extension
ADDN2 #i4, Ri	C	A1	1	- - - -	$Ri + \text{extu}(i4) \rightarrow Ri$	
SUB Rj, Ri	A	AC	1	C C C C	$Ri - Rj \rightarrow Ri$	
SUBC Rj, Ri	A	AD	1	C C C C	$Ri - Rj - c \rightarrow Ri$	Subtract operation with carry
SUBN Rj, Ri	A	AE	1	- - - -	$Ri - Rj \rightarrow Ri$	

• Compare operation instructions (3 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
CMP Rj, Ri	A	AA	1	C C C C	$Ri - Rj$	MSB is interpreted as a sign in assembly language
* CMP #s5, Ri	C'	A8	1	C C C C	$Ri - s5$	
CMP #i4, Ri	C	A8	1	C C C C	$Ri + \text{extu}(i4)$	Zero-extension Sign-extension
CMP2 #i4, Ri	C	A9	1	C C C C	$Ri + \text{extu}(i4)$	

• Logical operation instructions (12 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
AND Rj, Ri	A	82	1	C C - -	$Ri \& = Rj$	Word
AND Rj, @Ri	A	84	1 + 2a	C C - -	$(Ri) \& = Rj$	Word
ANDH Rj, @Ri	A	85	1 + 2a	C C - -	$(Ri) \& = Rj$	Half word
ANDB Rj, @Ri	A	86	1 + 2a	C C - -	$(Ri) \& = Rj$	Byte
OR Rj, Ri	A	92	1	C C - -	$Ri | = Rj$	Word
OR Rj, @Ri	A	94	1 + 2a	C C - -	$(Ri) | = Rj$	Word
ORH Rj, @Ri	A	95	1 + 2a	C C - -	$(Ri) | = Rj$	Half word
ORB Rj, @Ri	A	96	1 + 2a	C C - -	$(Ri) | = Rj$	Byte
EOR Rj, Ri	A	9A	1	C C - -	$Ri \wedge = Rj$	Word
EOR Rj, @Ri	A	9C	1 + 2a	C C - -	$(Ri) \wedge = Rj$	Word
EORH Rj, @Ri	A	9D	1 + 2a	C C - -	$(Ri) \wedge = Rj$	Half word
EORB Rj, @Ri	A	9E	1 + 2a	C C - -	$(Ri) \wedge = Rj$	Byte

• Bit manipulation arithmetic instructions (8 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
BANDL #u4, @Ri (u4: 0 to 0FH)	C	80	1 + 2a	--- --	(Ri) & = (F0H + u4)	Manipulate lower 4 bits
BANDH #u4, @Ri (u4: 0 to 0FH)	C	81	1 + 2a	--- --	(Ri) & = ((u4<<4) + 0FH)	Manipulate upper 4 bits
* BAND #u8, @Ri	*1		-	----	(Ri) & = u8	
BORL #u4, @Ri (u4: 0 to 0FH)	C	90	1 + 2a	--- --	(Ri) | = u4	Manipulate lower 4 bits
BORH #u4, @Ri (u4: 0 to 0FH)	C	91	1 + 2a	--- --	(Ri) | = (u4<<4)	Manipulate upper 4 bits
* BOR #u8, @Ri	*2		-	----	(Ri) | = u8	
BEORL #u4, @Ri (u4: 0 to 0FH)	C	98	1 + 2a	--- --	(Ri) ^ = u4	Manipulate lower 4 bits
BEORH #u4, @Ri (u4: 0 to 0FH)	C	99	1 + 2a	--- --	(Ri) ^ = (u4<<4)	Manipulate upper 4 bits
* BEOR #u8, @Ri	*3		-	----	(Ri) ^ = u8	
BTSTL #u4, @Ri (u4: 0 to 0FH)	C	88	2 + a	0 C --	(Ri) & u4	Test lower 4 bits
BTSTH #u4, @Ri (u4: 0 to 0FH)	C	89	2 + a	C C --	(Ri) & (u4<<4)	Test upper 4 bits

*1: Assembler generates BANDL if result of logical operation “u8&0x0F” leaves an active (set) bit and generates BANDH if “u8&0xF0” leaves an active bit. Depending on the value in the “u8” format, both BANDL and BANDH may be generated.

*2: Assembler generates BORL if result of logical operation “u8&0x0F” leaves an active (set) bit and generates BORH if “u8&0xF0” leaves an active bit.

*3: Assembler generates BEORL if result of logical operation “u8&0x0F” leaves an active (set) bit and generates BEORH if “u8&0xF0” leaves an active bit.

• Add/subtract operation instructions (10 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
MUL Rj, Ri	A	AF	5	C C C -	Rj × Ri → MDH, MDL	32-bit × 32-bit = 64-bit
MULU Rj, Ri	A	AB	5	C C C -	Rj × Ri → MDH, MDL	Unsigned
MULH Rj, Ri	A	BF	3	C C --	Rj × Ri → MDL	16-bit × 16-bit = 32-bit
MULUH Rj, Ri	A	BB	3	C C --	Rj × Ri → MDL	Unsigned
DIVOS Ri	E	97 - 4	1	----		Step calculation
DIVOU Ri	E	97 - 5	1	----		32-bit/32-bit = 32-bit
DIV1 Ri	E	97 - 6	d	- C - C		
DIV2 Ri	E	97 - 7	1	- C - C		
DIV3 Ri	E	9F - 6	1	----		
DIV4S Ri	E	9F - 7	1	----		
* DIV Ri	*1		-	- C - C	MDL/Ri → MDL, MDL%Ri → MDH	
* DIVU Ri	*2		-	- C - C	MDL/Ri → MDL, MDL%Ri → MDH	Unsigned

*1: DIVOS, DIV1 × 32, DIV2, DIV3 and DIV4S are generated. A total instruction code length of 72 bytes.

*2: DIVOU and DIV1 × 32 are generated. A total instruction code length of 66 bytes.

MB91101/MB91101A

• Shift arithmetic instructions (9 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
LSL Rj, Ri	A	B6	1	C C - C	$Ri \ll Rj \rightarrow Ri$	Logical shift
* LSL #u5, Ri	C'	B4	1	C C - C	$Ri \ll u5 \rightarrow Ri$	
LSL #u4, Ri	C	B4	1	C C - C	$Ri \ll u4 \rightarrow Ri$	
LSL2 #u4, Ri	C	B5	1	C C - C	$Ri \ll (u4 + 16) \rightarrow Ri$	
LSR Rj, Ri	A	B2	1	C C - C	$Ri \gg Rj \rightarrow Ri$	Logical shift
* LSR #u5, Ri	C'	B0	1	C C - C	$Ri \gg u5 \rightarrow Ri$	
LSR #u4, Ri	C	B0	1	C C - C	$Ri \gg u4 \rightarrow Ri$	
LSR2 #u4, Ri	C	B1	1	C C - C	$Ri \gg (u4 + 16) \rightarrow Ri$	
ASR Rj, Ri	A	BA	1	C C - C	$Ri \gg Rj \rightarrow Ri$	Logical shift
* ASR #u5, Ri	C'	B8	1	C C - C	$Ri \gg u5 \rightarrow Ri$	
ASR #u4, Ri	C	B8	1	C C - C	$Ri \gg u4 \rightarrow Ri$	
ASR2 #u4, Ri	C	B9	1	C C - C	$Ri \gg (u4 + 16) \rightarrow Ri$	

• Immediate value data transfer instruction (immediate value set/16-bit/32-bit immediate value transfer instruction) (3 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
LDI: 32 #i32, Ri	E	9F - 8	3	- - - -	$i32 \rightarrow Ri$	Upper 12 bits are zero-extended Upper 24 bits are zero-extended
LDI: 20 #i20, Ri	C	9B	2	- - - -	$i20 \rightarrow Ri$	
LDI: 8 #i8, Ri	B	C0	1	- - - -	$i8 \rightarrow Ri$	
* LDI # {i8 | i20 | i32}, Ri					{i8 | i20 | i32} $\rightarrow Ri$	

*1: If an immediate value is given in absolute, assembler automatically makes i8, i20 or i32 selection.
If an immediate value contains relative value or external reference, assembler selects i32.

• Memory load instructions (13 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
LD @Rj, Ri	A	04	b	- - - -	$(Rj) \rightarrow Ri$	Rs: Special-purpose register
LD @(R13, Rj), Ri	A	00	b	- - - -	$(R13 + Rj) \rightarrow Ri$	
LD @(R14, disp10), Ri	B	20	b	- - - -	$(R14 + disp10) \rightarrow Ri$	
LD @(R15, udisp6), Ri	C	03	b	- - - -	$(R15 + udisp6) \rightarrow Ri$	
LD @R15 +, Ri	E	07 - 0	b	- - - -	$(R15) \rightarrow Ri, R15 + = 4$	
LD @R15 +, Rs	E	07 - 8	b	- - - -	$(R15) \rightarrow Rs, R15 + = 4$	
LD @R15 +, PS	E	07 - 9	1 + a + b	C C C C	$(R15) \rightarrow PS, R15 + = 4$	
LDUH @Rj, Ri	A	05	b	- - - -	$(Rj) \rightarrow Ri$	Zero-extension
LDUH @(R13, Rj), Ri	A	01	b	- - - -	$(R13 + Rj) \rightarrow Ri$	Zero-extension
LDUH @(R14, disp9), Ri	B	40	b	- - - -	$(R14 + disp9) \rightarrow Ri$	Zero-extension
LDUB @Rj, Ri	A	06	b	- - - -	$(Rj) \rightarrow Ri$	Zero-extension
LDUB @(R13, Rj), Ri	A	02	b	- - - -	$(R13 + Rj) \rightarrow Ri$	Zero-extension
LDUB @(R14, disp8), Ri	B	60	b	- - - -	$(R14 + disp8) \rightarrow Ri$	Zero-extension

Note: The relations between o8 field of TYPE-B and u4 field of TYPE-C in the instruction format and assembler description from disp8 to disp10 are as follows:

disp8 \rightarrow o8 = disp8	} Each disp is a code extension.
disp9 \rightarrow o8 = disp9 >> 1	
disp10 \rightarrow o8 = disp10 >> 2	
udisp6 \rightarrow u4 = udisp6 >> 2	

udisp4 is a 0 extension.

• Memory store instructions (13 instructions)

Mnemonic		Type	OP	Cycle	N Z V C	Operation	Remarks
ST	Ri, @Rj	A	14	a	----	Ri → (Rj)	Word
ST	Ri, @(R13, Rj)	A	10	a	----	Ri → (R13 + Rj)	Word
ST	Ri, @(R14, disp10)	B	30	a	----	Ri → (R14 + disp10)	Word
ST	Ri, @(R15, udisp6)	C	13	a	----	Ri → (R15 + usidp6)	
ST	Ri, @-R15	E	17-0	a	----	R15 -= 4, Ri → (R15)	Rs: Special-purpose register
ST	Rs, @-R15	E	17-8	a	----	R15 -= 4, Rs → (R15)	
ST	PS, @-R15	E	17-9	a	----	R15 -= 4, PS → (R15)	
STH	Ri, @Rj	A	15	a	----	Ri → (Rj)	Half word
STH	Ri, @(R13, Rj)	A	11	a	----	Ri → (R13 + Rj)	Half word
STH	Ri, @(R14, disp9)	B	50	a	----	Ri → (R14 + disp9)	Half word
STB	Ri, @Rj	A	16	a	----	Ri → (Rj)	Byte
STB	Ri, @(R13, Rj)	A	12	a	----	Ri → (R13 + Rj)	Byte
STB	Ri, @(R14, disp8)	B	70	a	----	Ri → (R14 + disp8)	Byte

Note: The relations between o8 field of TYPE-B and u4 field of TYPE-C in the instruction format and assembler description from disp8 to disp10 are as follows:

disp8 → o8 = disp8	}	Each disp is a code extension.
disp9 → o8 = disp9>>1		
disp10 → o8 = disp10>>2		
udisp6 → u4 = udisp6>>2			udisp4 is a 0 extension.

• Transfer instructions between registers/special-purpose registers transfer instructions (5 instructions)

Mnemonic		Type	OP	Cycle	N Z V C	Operation	Remarks
MOV	Rj, Ri	A	8B	1	----	Rj → Ri	Transfer between general-purpose registers
MOV	Rs, Ri	A	B7	1	----	Rs → Ri	Rs: Special-purpose register
MOV	Ri, Rs	A	B3	1	----	Ri → Rs	Rs: Special-purpose register
MOV	PS, Ri	E	17-1	1	----	PS → Ri	
MOV	Ri, PS	E	07-1	c	CCCC	Ri → PS	

MB91101/MB91101A

• Non-delay normal branch instructions (23 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
JMP @Ri	E	97 - 0	2	- - - -	Ri → PC	
CALL label12	F	D0	2	- - - -	PC + 2 → RP, PC + 2 + rel11 × 2 → PC	
CALL @Ri	E	97 - 1	2	- - - -	PC + 2 → RP, Ri → PC	
RET	E	97 - 2	2	- - - -	RP → PC	Return
INT #u8	D	1F	3+3a	- - - -	SSP - = 4, PS → (SSP), SSP - = 4, PC + 2 → (SSP), 0 → I flag, 0 → S flag, (TBR + 3FC - u8 × 4) → PC	
INTE	E	9F - 3	3 + 3a	- - - -	SSP - = 4, PS → (SSP), SSP - = 4, PC + 2 → (SSP), 0 → S flag, (TBR + 3D8 - u8 × 4) → PC	For emulator
RETI	E	97 - 3	2 + 2a	C C C C	(R15) → PC, R15 - = 4, (R15) → PS, R15 - = 4	
BNO label9	D	E1	1	- - - -	Non-branch	
BRA label9	D	E0	2	- - - -	PC + 2 + rel8 × 2 → PC	
BEQ label9	D	E2	2/1	- - - -	PCif Z = = 1	
BNE label9	D	E3	2/1	- - - -	PCif Z = = 0	
BC label9	D	E4	2/1	- - - -	PCif C = = 1	
BNC label9	D	E5	2/1	- - - -	PCif C = = 0	
BN label9	D	E6	2/1	- - - -	PCif N = = 1	
BP label9	D	E7	2/1	- - - -	PCif N = = 0	
BV label9	D	E8	2/1	- - - -	PCif V = = 1	
BNV label9	D	E9	2/1	- - - -	PCif V = = 0	
BLT label9	D	EA	2/1	- - - -	PCif V xor N = = 1	
BGE label9	D	EB	2/1	- - - -	PCif V xor N = = 0	
BLE label9	D	EC	2/1	- - - -	PCif (V xor N) or Z = = 1	
BGT label9	D	ED	2/1	- - - -	PCif (V xor N) or Z = = 0	
BLS label9	D	EE	2/1	- - - -	PCif C or Z = = 1	
BHI label9	D	EF	2/1	- - - -	PCif C or Z = = 0	

- Notes:
- “2/1” in cycle sections indicates that 2 cycles are needed for branch and 1 cycle needed for non-branch.
 - The relations between rel8 field of TYPE-D and rel11 field of TYPE-F in the instruction format and assembler discription label9 and label12 are as follows.
 $label9 \rightarrow rel8 = (label9 - PC - 2)/2$
 $label12 \rightarrow rel11 = (label12 - PC - 2)/2$
 - RETI must be operated while S flag = 0.

• Branch instructions with delays (20 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
JMP:D @Ri	E	9F-0	1	----	Ri → PC	
CALL:D label12	F	D8	1	----	PC + 4 → RP, PC + 2 + rel11 × 2 → PC	
CALL:D @Ri	E	9F-1	1	----	PC + 4 → RP, Ri → PC	
RET:D	E	9F-2	1	----	RP → PC	Return
BNO:D label9	D	F1	1	----	Non-branch	
BRA:D label9	D	F0	1	----	PC + 2 + rel8 × 2 → PC	
BEQ:D label9	D	F2	1	----	PCif Z == 1	
BNE:D label9	D	F3	1	----	PCif Z == 0	
BC:D label9	D	F4	1	----	PCif C == 1	
BNC:D label9	D	F5	1	----	PCif C == 0	
BN:D label9	D	F6	1	----	PCif N == 1	
BP:D label9	D	F7	1	----	PCif N == 0	
BV:D label9	D	F8	1	----	PCif V == 1	
BNV:D label9	D	F9	1	----	PCif V == 0	
BLT:D label9	D	FA	1	----	PCif V xor N == 1	
BGE:D label9	D	FB	1	----	PCif V xor N == 0	
BLE:D label9	D	FC	1	----	PCif (V xor N) or Z == 1	
BGT:D label9	D	FD	1	----	PCif (V xor N) or Z == 0	
BLS:D label9	D	FE	1	----	PCif C or Z == 1	
BHI:D label9	D	FF	1	----	PCif C or Z == 0	

Notes: • The relations between rel8 field of TYPE-D and rel11 field of TYPE-F in the instruction format and assembler discription label9 and label12 are as follows.

$$\text{label9} \rightarrow \text{rel8} = (\text{label9} - \text{PC} - 2)/2$$

$$\text{label12} \rightarrow \text{rel11} = (\text{label12} - \text{PC} - 2)/2$$

- Delayed branch operation always executes next instruction (delay slot) before making a branch.
- Instructions allowed to be stored in the delay slot must meet one of the following conditions. If the other instruction is stored, this device may operate other operation than defined.
 - The instruction described “1” in the other cycle column than branch instruction.
 - The instruction described “a”, “b”, “c” or “d” in the cycle column.

MB91101/MB91101A

• Direct addressing instructions

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
DMOV @dir10, R13	D	08	b	----	(dir10) → R13	Word
DMOV R13, @dir10	D	18	a	----	R13 → (dir10)	Word
DMOV @dir10, @R13+	D	0C	2a	----	(dir10) → (R13), R13 += 4	Word
DMOV @R13+, @dir10	D	1C	2a	----	(R13) → (dir10), R13 += 4	Word
DMOV @dir10, @-R15	D	0B	2a	----	R15 -= 4, (dir10) → (R15)	Word
DMOV @R15+, @dir10	D	1B	2a	----	(R15) → (dir10), R15 += 4	Word
DMOVH @dir9, R13	D	09	b	----	(dir9) → R13	Half word
DMOVH R13, @dir9	D	19	a	----	R13 → (dir9)	Half word
DMOVH @dir9, @R13+	D	0D	2a	----	(dir9) → (R13), R13 += 2	Half word
DMOVH @R13+, @dir9	D	1D	2a	----	(R13) → (dir9), R13 += 2	Half word
DMOV B @dir8, R13	D	0A	b	----	(dir8) → R13	Byte
DMOV B R13, @dir8	D	1A	a	----	R13 → (dir8)	Byte
DMOV B @dir8, @R13+	D	0E	2a	----	(dir8) → (R13), R13 ++	Byte
DMOV B @R13+, @dir8	D	1E	2a	----	(R13) → (dir8), R13 ++	Byte

Note: The relations between the dir field of TYPE-D in the instruction format and the assembler description from disp8 to disp10 are as follows:

disp8 → dir + disp8 disp9 → dir = disp9>>1 disp10 → dir = disp10>>2	} Each disp is a code extension
---	---------------------------------

• Resource instructions (2 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
LDRES @Ri+, #u4	C	BC	a	----	(Ri) → u4 resource Ri += 4	u4: Channel number
STRES #u4, @Ri+	C	BD	a	----	u4 resource → (Ri) Ri += 4	u4: Channel number

• Co-processor instructions (4 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
COPOP #u4, #CC, CRj, CRi	E	9F - C	2 + a	----	Calculation	
COPLD #u4, #CC, Rj, CRi	E	9F - D	1 + 2a	----	Rj → CRi	
COPST #u4, #CC, CRj, Ri	E	9F - E	1 + 2a	----	CRj → Ri	
COPSV #u4, #CC, CRj, Ri	E	9F - F	1 + 2a	----	CRj → Ri	No error traps

• Other instructions (16 instructions)

Mnemonic	Type	OP	Cycle	N Z V C	Operation	Remarks
NOP	E	9F – A	1	– – – –	No changes	
ANDCCR #u8	D	83	c	C C C C	CCR and u8 → CCR	
ORCCR #u8	D	93	c	C C C C	CCR or u8 → CCR	
STILM #u8	D	87	1	– – – –	i8 → ILM	Set ILM immediate value
ADDSP #s10	^{*1} D	A3	1	– – – –	R15 += s10	ADD SP instruction
EXTSB Ri	E	97 – 8	1	– – – –	Sign extension 8 → 32 bits	
EXTUB Ri	E	97 – 9	1	– – – –	Zero extension 8 → 32 bits	
EXTSH Ri	E	97 – A	1	– – – –	Sign extension 16 → 32 bits	
EXTUH Ri	E	97 – B	1	– – – –	Zero extension 16 → 32 bits	
LDM0 (reglist)	D	8C	^{*4}	– – – –	(R15) → reglist, R15 increment	Load-multi R0 to R7
LDM1 (reglist)	D	8D	^{*4}	– – – –	(R15) → reglist, R15 increment	Load-multi R8 to R15
* LDM (reglist)	^{*3} D		–	– – – –	(R15 ++) → reglist,	Load-multi R0 to R15
STM0 (reglist)	D	8E	^{*6}	– – – –	R15 decrement, reglist → (R15)	Store-multi R0 to R7
STM1 (reglist)	D	8F	^{*6}	– – – –	R15 decrement, reglist → (R15)	Store-multi R8 to R15
* STM2 (reglist)	^{*5} D		–	– – – –	reglist → (R15 ++)	Store-multi R0 to R15
ENTER #u10	^{*2} D	0F	1+a	– – – –	R14 → (R15 – 4), R15 – 4 → R14, R15 – u10 → R15	Entrance processing of function
LEAVE	E	9F – 9	b	– – – –	R14 + 4 → R15, (R15 – 4) → R14	Exit processing of function
XCHB @Rj, Ri	A	8A	2a	– – – –	Ri → TEMP, (Rj) → Ri, TEMP → (Rj)	For SEMAFO management Byte data

- *1: In the ADDSP instruction, the reference between u8 of TYPE-D in the instruction format and assembler description s10 is as follows.
s10 → s8 = s10>>2
- *2: In the ENTER instruction, the reference between i8 of TYPE-C in the instruction format and assembler description u10 is as follows.
u10 → u8 = u10>>2
- *3: If either of R0 to R7 is specified in reglist, assembler generates LDM0. If either of R8 to R15 is specified, assembler generates LDM1. Both LDM0 and LDM1 may be generated.
- *4: The number of cycles needed for execution of LDM0 (reglist) and LDM1 (reglist) is given by the following calculation; $a \times (n - 1) + b + 1$ when “n” is number of registers specified.
- *5: If either of R0 to R7 is specified in reglist, assembler generates STM0. If either of R8 to R15 is specified, assembler generates STM1. Both STM0 and STM1 may be generated.
- *6: The number of cycles needed for execution of STM0 (reglist) and STM1 (reglist) is given by the following calculation; $a \times n + 1$ when “n” is number of registers specified.

MB91101/MB91101A

• 20-bit normal branch macro instructions

Mnemonic	Operation	Remarks
* CALL20 label20, Ri	Next instruction address → RP, label20 → PC	Ri: Temporary register *1
* BRA20 label20, Ri	label20 → PC	Ri: Temporary register *2
* BEQ20 label20, Ri	if (Z == 1) then label20 → PC	Ri: Temporary register *3
* BNE20 label20, Ri	ifs/Z == 0	Ri: Temporary register *3
* BC20 label20, Ri	ifs/C == 1	Ri: Temporary register *3
* BNC20 label20, Ri	ifs/C == 0	Ri: Temporary register *3
* BN20 label20, Ri	ifs/N == 1	Ri: Temporary register *3
* BP20 label20, Ri	ifs/N == 0	Ri: Temporary register *3
* BV20 label20, Ri	ifs/V == 1	Ri: Temporary register *3
* BNV20 label20, Ri	ifs/V == 0	Ri: Temporary register *3
* BLT20 label20, Ri	ifs/V xor N == 1	Ri: Temporary register *3
* BGE20 label20, Ri	ifs/V xor N == 0	Ri: Temporary register *3
* BLE20 label20, Ri	ifs/(V xor N) or Z == 1	Ri: Temporary register *3
* BGT20 label20, Ri	ifs/(V xor N) or Z == 0	Ri: Temporary register *3
* BLS20 label20, Ri	ifs/C or Z == 1	Ri: Temporary register *3
* BHI20 label20, Ri	ifs/C or Z == 0	Ri: Temporary register *3

*1: CALL20

(1) If label20 – PC – 2 is between –0x800 and +0x7fe, instruction is generated as follows;

```
CALL label12
```

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
LDI:20 #label20, Ri
CALL @Ri
```

*2: BRA20

(1) If label20 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

```
BRA label9
```

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
LDI:20 #label20, Ri
JMP @Ri
```

*3: Bcc20 (BEQ20 to BHI20)

(1) If label20 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

```
Bcc label9
```

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
Bxcc false xcc is a revolt condition of cc
LDI:20 #label20, Ri
JMP @Ri
```

false:

• 20-bit delayed branch macro instructions

Mnemonic	Operation	Remarks
* CALL20:D label20, Ri	Next instruction address + 2 → RP, label20 → PC	Ri: Temporary register *1
* BRA20:D label20, Ri	label20 → PC	Ri: Temporary register *2
* BEQ20:D label20, Ri	if (Z == 1) then label20 → PC	Ri: Temporary register *3
* BNE20:D label20, Ri	ifs/Z == 0	Ri: Temporary register *3
* BC20:D label20, Ri	ifs/C == 1	Ri: Temporary register *3
* BNC20:D label20, Ri	ifs/C == 0	Ri: Temporary register *3
* BN20:D label20, Ri	ifs/N == 1	Ri: Temporary register *3
* BP20:D label20, Ri	ifs/N == 0	Ri: Temporary register *3
* BV20:D label20, Ri	ifs/V == 1	Ri: Temporary register *3
* BNV20:D label20, Ri	ifs/V == 0	Ri: Temporary register *3
* BLT20:D label20, Ri	ifs/V xor N == 1	Ri: Temporary register *3
* BGE20:D label20, Ri	ifs/V xor N == 0	Ri: Temporary register *3
* BLE20:D label20, Ri	ifs/(V xor N) or Z == 1	Ri: Temporary register *3
* BGT20:D label20, Ri	ifs/(V xor N) or Z == 0	Ri: Temporary register *3
* BLS20:D label20, Ri	ifs/C or Z == 1	Ri: Temporary register *3
* BHI20:D label20, Ri	ifs/C or Z == 0	Ri: Temporary register *3

*1: CALL20:D

(1) If label20 – PC – 2 is between –0x800 and +0x7fe, instruction is generated as follows;

CALL:D label12

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

LDI:20 #label20, Ri

CALL:D @Ri

*2: BRA20:D

(1) If label20 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

BRA:D label9

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

LDI:20 #label20, Ri

JMP:D @Ri

*3: Bcc20:D (BEQ20:D to BHI20:D)

(1) If label20 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

Bcc:D label9

(2) If label20 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

Bxcc false xcc is a revolt condition of cc

LDI:20 #label20, Ri

JMP:D @Ri

false:

MB91101/MB91101A

• 32-bit normal macro branch instructions

Mnemonic	Operation	Remarks
* CALL32 label32, Ri	Next instruction address → RP, label32 → PC	Ri: Temporary register *1
* BRA32 label32, Ri	label32 → PC	Ri: Temporary register *2
* BEQ32 label32, Ri	if (Z == 1) then label32 → PC	Ri: Temporary register *3
* BNE32 label32, Ri	ifs/Z == 0	Ri: Temporary register *3
* BC32 label32, Ri	ifs/C == 1	Ri: Temporary register *3
* BNC32 label32, Ri	ifs/C == 0	Ri: Temporary register *3
* BN32 label32, Ri	ifs/N == 1	Ri: Temporary register *3
* BP32 label32, Ri	ifs/N == 0	Ri: Temporary register *3
* BV32 label32, Ri	ifs/V == 1	Ri: Temporary register *3
* BNV32 label32, Ri	ifs/V == 0	Ri: Temporary register *3
* BLT32 label32, Ri	ifs/V xor N == 1	Ri: Temporary register *3
* BGE32 label32, Ri	ifs/V xor N == 0	Ri: Temporary register *3
* BLE32 label32, Ri	ifs/(V xor N) or Z == 1	Ri: Temporary register *3
* BGT32 label32, Ri	ifs/(V xor N) or Z == 0	Ri: Temporary register *3
* BLS32 label32, Ri	ifs/C or Z == 1	Ri: Temporary register *3
* BHI32 label32, Ri	ifs/C or Z == 0	Ri: Temporary register *3

*1: CALL32

(1) If label32 – PC – 2 is between –0x800 and +0x7fe, instruction is generated as follows;

```
CALL label12
```

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
LDI:32 #label32, Ri
CALL @Ri
```

*2: BRA32

(1) If label32 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

```
BRA label9
```

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
LDI:32 #label32, Ri
JMP @Ri
```

*3: Bcc32 (BEQ32 to BHI32)

(1) If label32 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;

```
Bcc label9
```

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;

```
Bxcc false xcc is a revolt condition of cc
LDI:32 #label32, Ri
JMP @Ri
```

false:

• 32-bit delayed macro branch instructions

Mnemonic	Operation	Remarks
* CALL32:D label32, Ri	Next instruction address + 2 → RP, label32 → PC	Ri: Temporary register *1
* BRA32:D label32, Ri	label32 → PC	Ri: Temporary register *2
* BEQ32:D label32, Ri	if (Z == 1) then label32 → PC	Ri: Temporary register *3
* BNE32:D label32, Ri	ifs/Z == 0	Ri: Temporary register *3
* BC32:D label32, Ri	ifs/C == 1	Ri: Temporary register *3
* BNC32:D label32, Ri	ifs/C == 0	Ri: Temporary register *3
* BN32:D label32, Ri	ifs/N == 1	Ri: Temporary register *3
* BP32:D label32, Ri	ifs/N == 0	Ri: Temporary register *3
* BV32:D label32, Ri	ifs/V == 1	Ri: Temporary register *3
* BNV32:D label32, Ri	ifs/V == 0	Ri: Temporary register *3
* BLT32:D label32, Ri	ifs/V xor N == 1	Ri: Temporary register *3
* BGE32:D label32, Ri	ifs/V xor N == 0	Ri: Temporary register *3
* BLE32:D label32, Ri	ifs/(V xor N) or Z == 1	Ri: Temporary register *3
* BGT32:D label32, Ri	ifs/(V xor N) or Z == 0	Ri: Temporary register *3
* BLS32:D label32, Ri	ifs/C or Z == 1	Ri: Temporary register *3
* BHI32:D label32, Ri	ifs/C or Z == 0	Ri: Temporary register *3

*1: CALL32:D

(1) If label32 – PC – 2 is between –0x800 and +0x7fe, instruction is generated as follows;
CALL:D label12

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;
LDI:32 #label32, Ri
CALL:D @Ri

*2: BRA32:D

(1) If label32 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;
BRA:D label9

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;
LDI:32 #label32, Ri
JMP:D @Ri

*3: Bcc32:D (BEQ32:D to BHI32:D)

(1) If label32 – PC – 2 is between –0x100 and +0xfe, instruction is generated as follows;
Bcc:D label9

(2) If label32 – PC – 2 is outside of the range given in (1) or includes external reference symbol, instruction is generated as follows;
Bxcc false xcc is a revolt condition of cc
LDI:32 #label32, Ri
JMP:D @Ri
false:

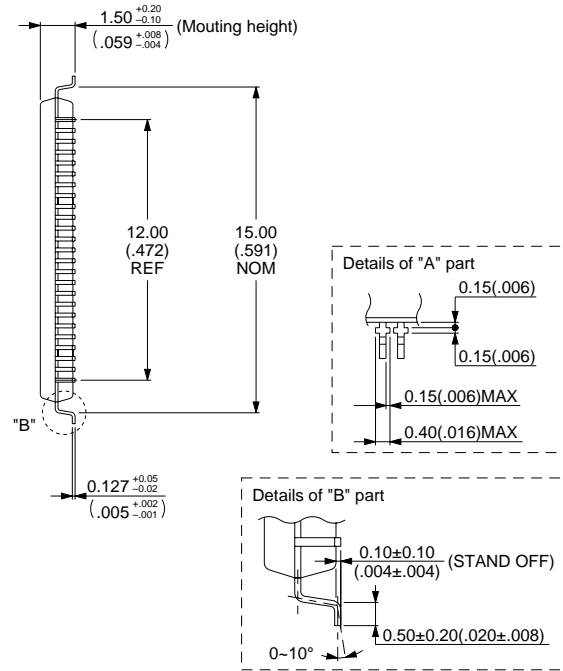
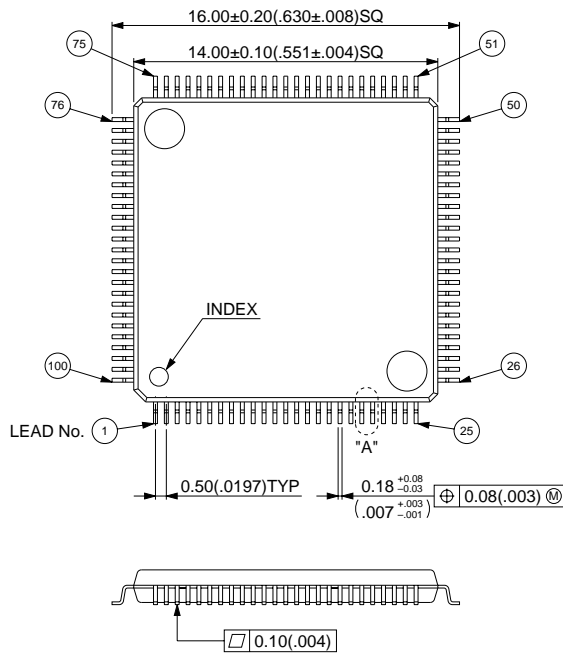
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■ ORDERING INFORMATION

Part number	Package	Remarks
MB91101APFV	100-pin Plastic LQFP (FPT-100P-M05)	
MB91101APF	100-pin Plastic QFP (FPT-100P-M06)	

PACKAGE DIMENSIONS

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



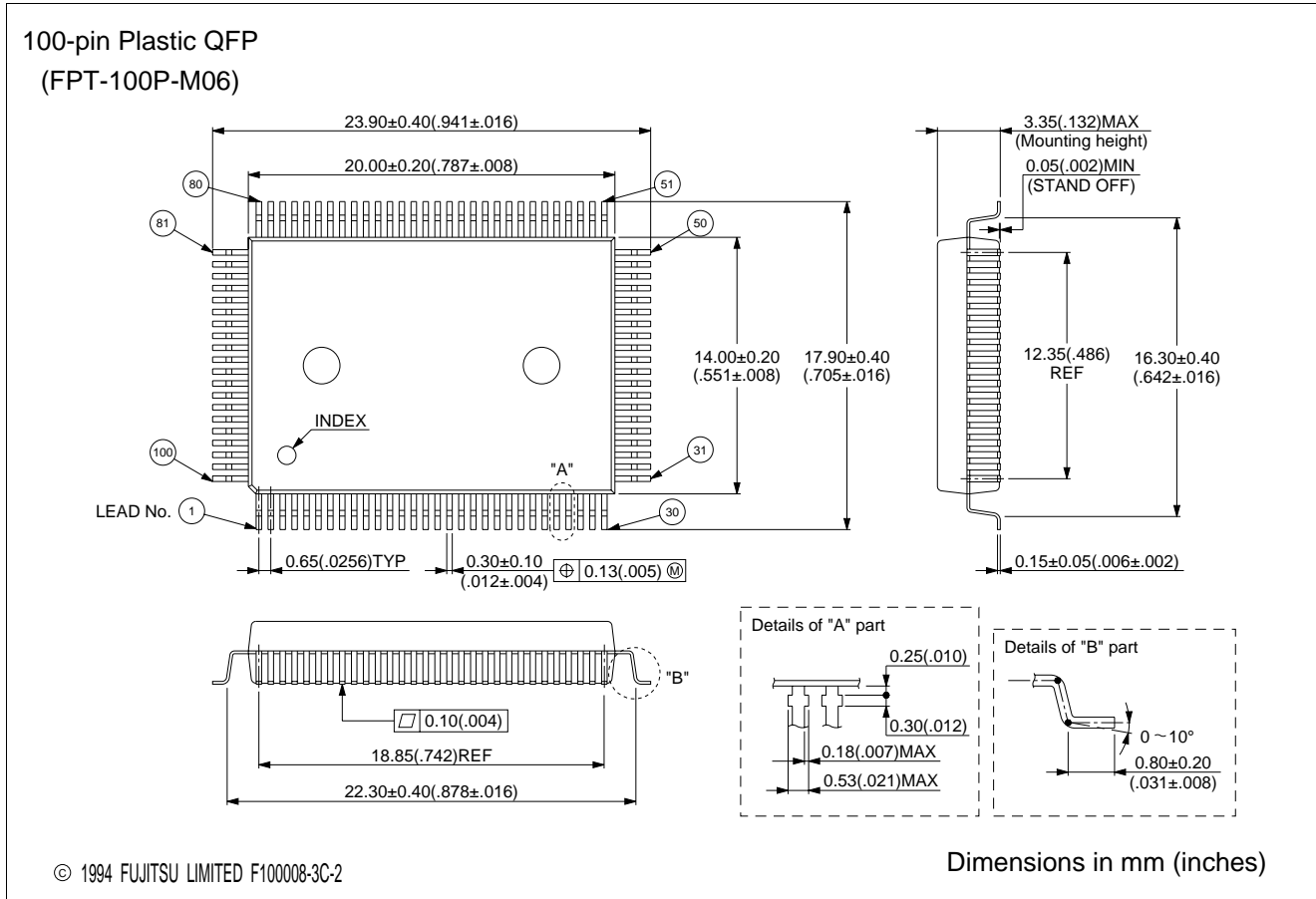
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Dimensions in mm (inches)

(Continued)

MB91101/MB91101A

(Continued)



Note: The design may be modified changed without notice, contact to Fujitsu sales division when using the device.

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