FUJITSU SEMICONDUCTOR
DATA SHEET

DS07-13702-4E

16-bit Proprietary Microcontroller

CMOS

F²MC-16LX MB90520 Series

MB90522/523/F523/V520

■ DESCRIPTION

The MB90520 series is a general-purpose 16-bit microcontroller developed and designed by Fujitsu for process control applications in consumer products that require high-speed real-time processing.
The instruction set of the F²MC-16LX CPU core inherits AT architecture of the F²MC* family with additional instruction sets for high-level languages, extended addressing mode, enhanced multiplication/division instructions, and enhanced bit manipulation instructions. The microcontroller has a 32-bit accumulator for processing long word data.
The MB90520 series has peripheral resources of 8/10-bit A/D converter, 8-bit D/A converter, UART (SCI), extended I/O serial interfaces 0 and 1, 8/16-bit up/down counter/timers 0 and 1, 8/16-bit PPG timers 0 and 1, I/O timer (16-bit free-run timers 1 and 2, input captures 0 and 1 (ICU), output compares 0 and 1 (OCU)), and an LCD controller/driver.

*:F²MC stands for FUJITSU Flexible Microcontroller, a registered trademark of FUJITSU LIMITED.

■ FEATURES

- Clock
  Embedded PLL clock multiplication circuit
  Operating clock (PLL clock) can be selected from divided-by-2 of oscillation or one to four times the oscillation (at oscillation of 4 MHz, 4 MHz to 16 MHz).
  The system can be operated by a sub-clock (rated at 32.768 kHz).
  Minimum instruction execution time: 62.5 ns (at oscillation of 4 MHz, four times the oscillation clock, operation at V_{CC} of 5.0 V)

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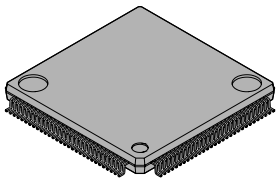
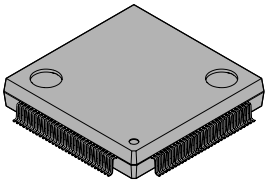
■ PACKAGES

120-pin Plastic LQFP



(FPT-120P-M05)

120-pin Plastic QFP



(FPT-120P-M13)

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- Maximum memory space
  16 Mbytes
- Instruction set optimized for controller applications
  Rich data types (bit, byte, word, long word)
  Rich addressing mode (23 types)
  Enhanced signed multiplication/division instruction and RETI instruction functions
  Enhanced precision calculation realized by 32-bit accumulator
- Instruction set designed for high level language (C) and multi-task operations
  Adoption of system stack pointer
  Enhanced pointer indirect instructions
  Barrel shift instructions
- Program patch function (for two address pointers)
- Enhanced execution speed
  4-byte instruction queue
- Enhanced interrupt function
  8 levels, 34 factors
- Automatic data transmission function independent of CPU operation
  Extended intelligent I/O service function (EI^{2}OS): Up to 16 channels
- Embedded ROM size and types
  Mask ROM: 64 kbytes/128 kbytes
  Flash ROM: 128 kbytes
- Embedded RAM size
  Mask ROM: 4 kbytes
  Flash ROM: 4 kbytes
  Evaluation product: 6 kbytes
- Low-power consumption (stand-by) mode
  Sleep mode (mode in which CPU operating clock is stopped)
  Stop mode (mode in which oscillation is stopped)
  CPU intermittent operation mode
  Hardware stand-by mode
  Clock mode (mode in which other than sub-clock and timebase timer are stopped)
- Process
  CMOS technology
- I/O port
  General-purpose I/O ports (CMOS): 53 ports
  General-purpose I/O ports (via pull-up resistors): 24 ports
  General-purpose I/O ports (open-drain): 8 ports
  Total: 85 ports
- Timer
  Timebase timer/watchdog timer: 1 channel
  8/16-bit PPG timers 0, 1: 8-bit $\times$ 2 channels or 16-bit $\times$ 1 channel
- 16-bit re-load timers 0, 1: 2 channels

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- 16-bit I/O timer
  16-bit free-run timers 1, 2: 2 channels
  Input captures 0, 1 (ICU): Generates an interrupt request by latching a 16-bit free-run timer counter value upon detection of an edge input to the pin.
  Output compares 0, 1 (OCU): Generates an interrupt request and reverses the output level upon detection of a match between the 16-bit free-run timer counter value and the compare setting value.
  8/16-bit up/down counter/timers 0, 1: 1 channel (8-bit × 2 channels)
- Extended I/O serial interfaces 0, 1: 1 channel
- UART (SCI)
  With full-duplex double buffer
  Clock asynchronized or clock synchronized transmission can be selectively used.
- DTP/external interrupt circuit (8 channels)
  A module for starting extended intelligent I/O service (EI^2OS) and generating an external interrupt triggered by an external input.
- Wake-up interrupt
  Receives external interrupt requests and generates an interrupt request upon an “L” level input.
- Delayed interrupt generation module
  Generates an interrupt request for switching tasks.
- 8/10-bit A/D converter (8 channels)
  8/10-bit resolution can be selectively used.
  Starting by an external trigger input.
  Conversion time: minimum 15.0 µs (at machine clock frequency of 16 MHz, including sampling time)
- 8-bit D/A converter (based on the R-2R system)
  8-bit resolution: 2 channels (independent)
  Setup time: 12.5 µs
- Clock timer: 1 channel
- LCD controller/driver
  A common driver and a segment driver that can directly drive the LCD (liquid crystal display) panel
- Clock output function

Note: Do not set external bus mode for the MB90520 series because it cannot be operated in this mode.

■ PRODUCT LINEUP

Item \ Part number	MB90522	MB90523	MB90F523	MB90V520
Classification	Mask ROM product		Flash ROM product	Evaluation product
ROM size	64 kbytes	128 kbytes		None
RAM size	4 kbytes			6 kbytes
CPU functions	Number of instructions: 351 Instruction bit length: 8 bits, 16 bits Instruction length: 1 byte to 7 bytes Data bit length: 1 bit, 8 bits, 16 bits			
	Minimum execution time: 62.5 ns (at machine clock frequency of 16 MHz)			
	Interrupt processing time: 1.5 μs (at machine clock frequency of 16 MHz, minimum value)			
Ports	General-purpose I/O ports (CMOS output): 53 General-purpose I/O ports (via pull-up resistor): 24 General-purpose I/O ports (N-ch open-drain output): 8 Total: 85			
UART (SCI)	Clock synchronized transmission (62.5 kbps to 1 Mbps) Clock asynchronized transmission (1202 bps to 9615 bps) Transmission can be performed by bi-directional serial transmission or by master/slave connection.			
8/10-bit A/D converter	Conversion precision: 8/10-bit can be selectively used. Number of inputs: 8 One-shot conversion mode (converts selected channel only once) Scan conversion mode (converts two or more successive channels and can program up to 8 channels.) Continuous conversion mode (converts selected channel continuously) Stop conversion mode (converts selected channel and stop operation repeatedly)			
8/16-bit PPG timers 0, 1	Number of channels: 1 (8-bit × 2 channels) PPG operation of 8-bit or 16-bit Pulse wave of given intervals and given duty ratios can be output. Pulse interval: 62.5 ns to 1 μs (at machine clock frequency of 16 MHz)			
8/16-bit up/down counter/ timers 0, 1	Number of channels: 1 (8-bit × 2 channels) Event input: 6 channels 8-bit up/down counter/timer used: 2 channels 8-bit re-load/compare function supported: 1 channel			
16-bit I/O timer: 16-bit free-run timers 1, 2	Number of channels: 2 Overflow interrupts			

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Item \ Part number		MB90523	MB90523	MB90F523	MB90V520
16-bit I/O timer	Output compares 0, 1 (OCU)	Number of channels: 8 Pin input factor: Match signal of compare register			
	Input captures 0, 1 (ICU)	Number of channels: 2 Rewriting register value upon pin input (rising, falling, or both edges)			
DTP/external interrupt circuit		Number of inputs: 8 Started by rising edge, falling edge, “H” level input, or “L” level input. External interrupt circuit or extended intelligent I/O service (EI^{2}OS) can be used.			
Wake-up intrrupt		Number of inputs: 8 Started by “L” level input.			
Delayed interrupt generation module		Interrupt generation module for switching tasks Used in real-time operating systems.			
Extended I/O serial interfaces 0, 1		Clock synchronized transmission (3125 bps to 1 Mbps) LSB first/MSB first			
Timebase timer		18-bit counter Interrupt interval: 1.024 ms, 4.096 ms, 16.384 ms, 131.072 ms (at oscillation of 4 MHz)			
8-bit D/A converter		8-bit resolution Number of channels: 2 channels Based on R-2R system			
LCD controller/driver		Number of common output pins: 4 Number of segment output pins: 32 Number of power supply pins for LCD drive: 4 RAM for LCD indication: 16 bytes Booster for LCD drive: Internal Split resistor for LCD drive: Internal			
Watchdog timer		Reset generation interval: 3.58 ms, 14.33 ms, 57.23 ms, 458.75 ms (at oscillation of 4 MHz, minimum value)			
Low-power consumption (stand-by) mode		Sleep/stop/CPU intermittent operation/clock timer/hardware stand-by			
Process		CMOS			
Power supply voltage for operation*		3.0 V to 5.5 V		4.0 V to 5.5 V	3.0 V to 5.5 V

* : Varies with conditions such as the operating frequency. (See section “■ Electrical Characteristics.”)
Assurance for the MB90V520 is given only for operation with a tool at a power voltage of 3.0 V to 5.5 V, an operating temperature of 0 to 55 degrees centigrade, and an operating frequency of 1 MHz to 16 MHz.

■ PACKAGE AND CORRESPONDING PRODUCTS

Package	MB90522	MB90523	MB90F523
FPT-120P-M05	○	○	○
FPT-120P-M13	○	○	○

○ : Available × : Not available

Note: For more information about each package, see section "■ Package Dimensions."

■ DIFFERENCES AMONG PRODUCTS

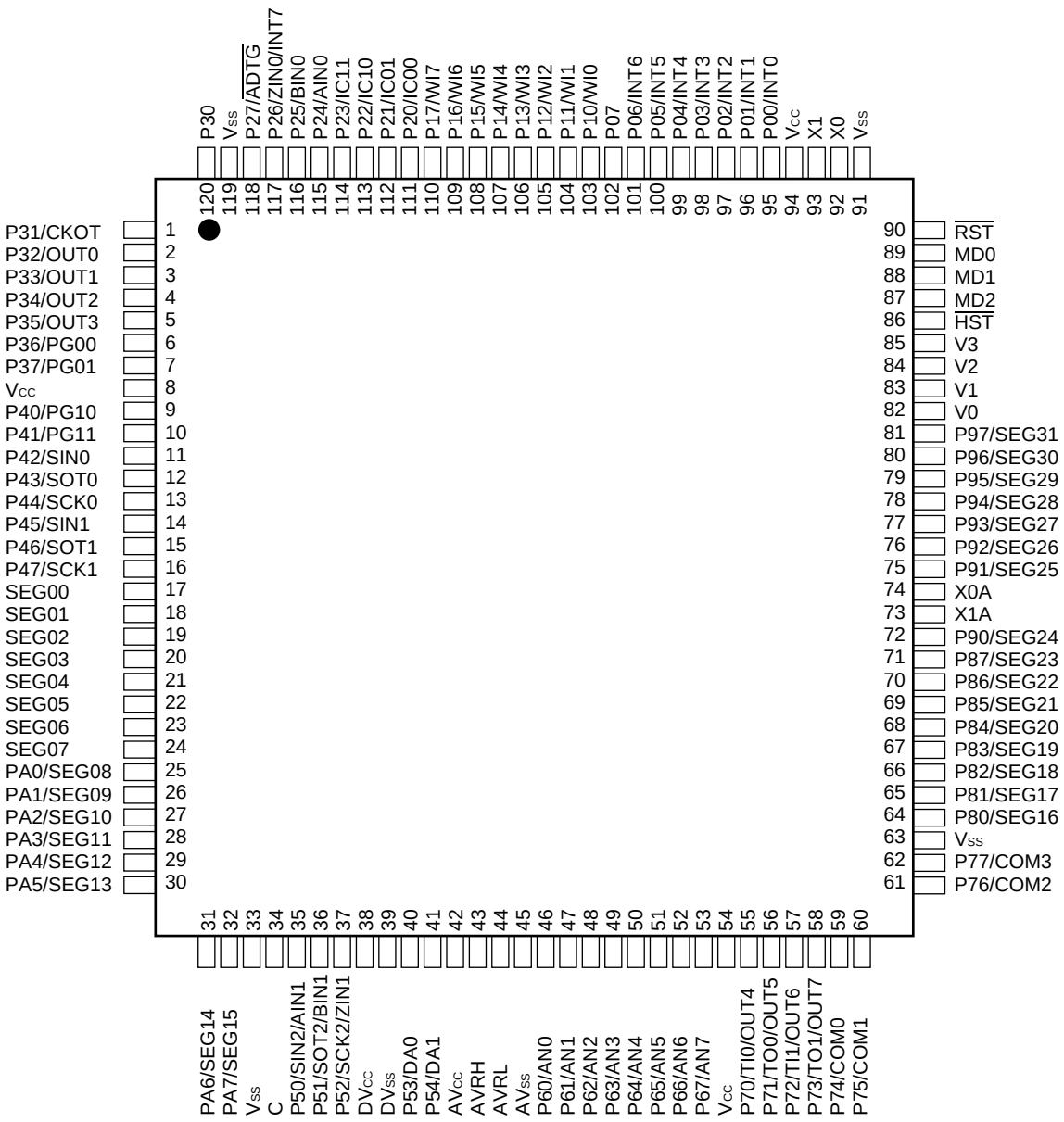
Memory Size

In evaluation with an evaluation chip, note the difference between the evaluation chip and the chip actually used. The following items must be taken into consideration.

- The MB90V520 does not have an internal ROM. However, operations equivalent to those performed by a chip with an internal ROM can be evaluated by using a dedicated development tool, enabling selection of ROM size by setting the development tool.
- In the MB90V520, images from $FF4000_H$ to $FFFFFF_H$ are mapped to bank 00, and $FE0000_H$ to $FF3FFF_H$ are mapped to bank FE and FF only. (This setting can be changed by configuring the development tool.)
- In the MB90522, images from $FF4000_H$ to $FFFFFF_H$ are mapped to bank 00, and $FF0000_H$ to $FF3FFF_H$ to bank FF only.
- In the MB90523/F523, images from $FF4000_H$ to $FFFFFF_H$ are mapped to bank 00, and $FE0000_H$ to $FF3FFF_H$ to bank FE and bank FF.

■ PIN ASSIGNMENT

(Top view)



(FPT-120P-M05)
(FPT-120P-M13)

■ PIN DESCRIPTION

Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
92, 93	X0, X1	A	This is a high-speed crystal oscillator pin.
74, 73	X0A, X1A	B	This is a low-speed crystal oscillator pin.
89 to 87	MD0 to MD2	C	This is an input pin for selecting operation modes. Connect directly to V_{CC} or V_{SS}.
90	$\overline{RST}$	C	This is an external reset request signal input pin.
86	$\overline{HST}$	C	This is a hardware stand-by input pin.
95 to 101	P00 to P06	D	This is a general-purpose I/O port. This function can be set by the port 0 input pull-up resistor setup register (RDR0) for input. For output, however, this function is invalid.
	INT0 to INT6		This is a request input pin of the DTP/external interrupt circuit ch.0 to ch.6.
102	P07	D	This is a general-purpose I/O port. This function can be set by the port 0 input pull-up resistor setup register (RDR0) for input. For output, however, this function is invalid.
103 to 110	P10 to 17	D	This is a general-purpose I/O port. This function can be set by the port 1 input pull-up resistor setup register (RDR1) for input. For output, however, this function is invalid.
	WI0 to WI7		This is an I/O pin for wake-up interrupts.
111, 112, 113, 114	P20, P21, P22, P23	E	This is a general-purpose I/O port.
	IC00, IC01, IC10, IC11		This is a trigger input pin for input capture (ICU) 0 and 1. Since this input is used as required for input capture 0 and 1 (ICU) ch.0, ch.01, ch.10 and ch.11 input operation, output by other functions must be suspended except for intentional operation.
115	P24	E	This is a general-purpose I/O port.
	AIN0		This port can be used as count clock A input for 8/16-bit up/down counter/timer 0.
116	P25	E	This is a general-purpose I/O port.
	BIN0		This port can be used as count clock B input for 8/16-bit up/down counter/timer 0.

*1: FPT-120P-M05
*2: FPT-120P-M13

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Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
117	P26	E	This is a general-purpose I/O port.
	ZIN0		This port can be used as count clock Z input for 8/16-bit up/down counter/timer 0.
	INT7		This is a request input pin of the DTP/external interrupt circuit ch.7.
118	P27	E	This is a general-purpose I/O port.
	$\overline{\text{ADTG}}$		This is an external trigger input pin of the 8/10-bit A/D converter. Since this input is used as required for 8/10-bit A/D converter input operation, output by other functions must be suspended except for intentional operation.
120	P30	E	This is a general-purpose I/O port.
1	P31	E	This is a general-purpose I/O port.
	CKOT		This is a clock monitor function output pin. This function is valid when clock monitor output is enabled.
2	P32	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the OUT0 is disabled.
	OUT0		This is an event output pin for output compare 0 (OCU) ch.0. This function is valid when output for each channel is enabled.
3	P33	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the OUT1 is disabled.
	OUT1		This is an event output pin for output compare 0 (OCU) ch.1. This function is valid when output for each channel is enabled.
4	P34	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the OUT2 is disabled.
	OUT2		This is an event output pin for output compare 0 (OCU) ch.2. This function is valid when output for each channel is enabled.
5	P35	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the OUT3 is disabled.
	OUT3		This is an event output pin for output compare 0 (OCU) ch.3. This function is valid when output for each channel is enabled.
6	P36	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the PG00 is disabled.
	PG00		This is an output pin of 8/16-bit PPG timer 0. This function becomes valid when waveform output from PG00 is enabled.

*1: FPT-120P-M05
*2: FPT-120P-M13

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Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
7	P37	E	This is a general-purpose I/O port. This function becomes valid when waveform output from the PG01 is disabled.
	PG01		This is an output pin of 8/16-bit PPG timer 0. This function becomes valid when waveform output from PG01 is enabled.
9, 10	P40, P41	D	This is a general-purpose I/O port. This function becomes valid when waveform output from the PG10 and PG11 are disabled. This function can be set by the pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	PG10, PG11		This is an output pin of 8/16-bit PPG timer 1. This function becomes valid when waveform outputs from PG10 and PG11 are enabled.
11	P42	D	This is a general-purpose I/O port. This function can be set by the pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SIN0		This is a serial data input pin of UART (SCI). Because this input is used as required when UART (SCI) is performing input operations, it is necessary to stop outputs by other functions unless such outputs are made intentionally. When using other output functions as well, disable output during SIN operation.
12	P43	D	This is a general-purpose I/O port. This function can be set by the pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SOT0		This is a serial data output pin of UART (SCI). This function becomes valid when serial data output from UART (SCI) is enabled.
13	P44	D	This is a general-purpose I/O port. This function can be set by the pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SCK0		This is a serial clock I/O pin of UART (SCI). This function becomes valid when serial clock output from UART (SCI) is enabled.
14	P45	D	This is a general-purpose I/O port. This function can be set by the port 4 input pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SIN1		This is a data input pin for extended I/O serial interface 0. Since this input is used as required for serial data input operation, output by other functions must be suspended except for intentional operation. When using other output functions as well, disable output during SIN operation.

*1: FPT-120P-M05
*2: FPT-120P-M13

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Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
15	P46	D	This is a general-purpose I/O port. This function can be set by the port 4 input pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SOT1		This is a data output pin for extended I/O serial interface 0. This function becomes valid when serial data output from SOT1 is enabled.
16	P47	D	This is a general-purpose I/O port. This function can be set by the port 4 input pull-up resistor setup register (RDR4) for input. For output, however, this function is invalid.
	SCK1		This is a serial clock I/O pin for extended I/O serial interface 0. This function becomes valid when serial clock output from SCK1 is enabled.
35	P50	D	This is a general-purpose I/O port.
	SIN2		This is a data input pin for extended I/O serial interface 1. Since this input is used as required for serial data input operation, output by other functions must be suspended except for intentional operation.
	AIN1		This port can be used as count clock A input for 8/16-bit up/down counter/timer 1.
36	P51	D	This is a general-purpose I/O port.
	SOT2		This is a data output pin for extended I/O serial interface 1. This function becomes valid when serial data output from SOT2 is enabled.
	BIN1		This port can be used as count clock B input for 8/16-bit up/down counter/timer 1.
37	P52	D	This is a general-purpose I/O port.
	SCK2		This is a serial clock I/O pin for extended I/O serial interface 1. This function becomes valid when serial clock output from serial SCK2 is enabled.
	ZIN1		This port can be used as control clock Z input for 8/16-bit up/down counter/timer 1.
40, 41	P53, P54	I	This is a general-purpose I/O port.
	DA0, DA1		These are analog signal output pins for 8-bit D/A converter ch.0 and ch.1.
46 to 53	P60 to P67	K	This is a general-purpose I/O port. The input function become valid when the analog input enable register (ADER) is set to select a port.
	AN0 to AN7		These are analog input pins of the 8/10-bit A/D converter. This function is valid when the analog input enable register (ADER) is enabled.

*1: FPT-120P-M05
*2: FPT-120P-M13

(Continued)

Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
55, 57	P70, P72	E	This is a general-purpose I/O port.
	TI0, TI1		These are event input pins for 16-bit re-load timers 0 and 1. Since this input is used as required for 16-bit re-load timers 0 and 1 operation, output by other functions must be suspended except for intentional operation.
	OUT4, OUT6		These are event output pins for output compare 1 (OCU) ch.4 and ch.6. This function is valid when output for each channel is enabled.
56, 58	P71, P73	E	This is a general-purpose I/O port. This function is valid when TO0 and TO1 output are disabled.
	TO0, TO1		These are output pins for 16-bit re-load timers 0 and 1. This function is valid when TO0 and TO1 output are enabled.
	OUT5, OUT7		These are event output pins for output compare 1 (OCU) ch.5 and ch.7. This function is valid when output for each channel is enabled.
59 to 62	P74 to P77	L	This is a general-purpose I/O port. This function is valid with port output specified for the LCD controller/driver control register.
	COM0 to COM3		These are common pins for the LCD controller/driver. This function is valid with common output specified for the LCD controller/driver control register.
64 to 71	P80 to P87	L	This is a general-purpose I/O port. This function is valid with port output specified for the LCD controller/driver control register.
	SEG16 to SEG23		These are segment outputs for the LCD controller/driver. This function is valid with segment output specified for the LCD controller/driver control register.
72, 75 to 81	P90, P91 to P97	M	This is a general-purpose I/O port. The maximum I_{OL} can be 10mA. This function is valid with port output specified for the LCD controller/driver control register.
	SEG24, SEG25 to SEG31		These are segment outputs for the LCD controller/driver. This function is valid with port output specified for the LCD controller/driver control register.
17 to 24	SEG00 to SEG07	F	These are pins dedicated to LCD segments 00 to 07 for the LCD controller/driver.
25 to 32	PA0 to PA7	L	This is a general-purpose I/O port. This function is valid with port output specified for the LCD controller/driver control register.
	SEG08 to SEG15		These are pins for LCD segments 08 to 15 for the LCD controller/driver. Units of four ports or segments can be selected by the internal register in the LCD controller.

*1: FPT-120P-M05
*2: FPT-120P-M13

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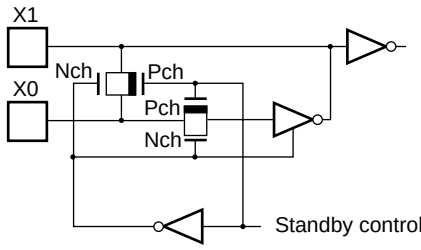
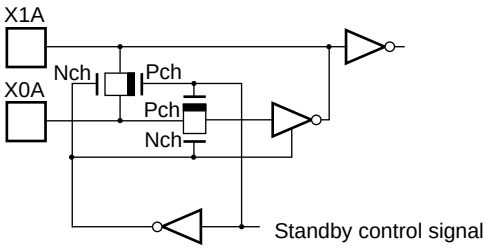
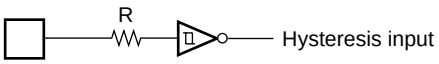
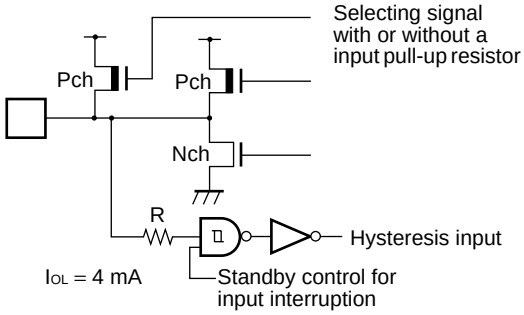
Pin no. LQFP-120*1 QFP-120*2	Pin name	Circuit type	Function
34	C	G	This is a capacitance pin for power supply stabilization. Connect an external ceramic capacitor rated at about 0.1 µF. This capacitor is not, however, required for the M90F523 (flash product).
82 to 85	V0 to V3	N	This is a pin for the reference power supply for the LCD controller/ driver.
8, 54, 94	V_{CC}	Power supply	This is a power supply (5.0 V) input pin to the digital circuit.
33, 63, 91, 119	V_{SS}	Power supply	This provides the GND level (0.0 V) input pin for the digital circuit.
42	AV_{CC}	H	This is a power supply for the analog circuit. Make sure to turn on/turn off this power supply with a voltage exceeding AV_{CC} applied to V_{CC}.
43	AVRH	J	This is a reference voltage input to the analog circuit. Make sure to turn on/turn off this power supply with a voltage exceeding AVRH applied to AV_{CC}.
44	AVRL	H	This is a reference voltage input to the analog circuit.
45	AV_{SS}	H	This is a GND level of the analog circuit.
38	DV_{CC}	H	This is the Vref input pin for the D/A converter. The voltage to be applied must not exceed V_{CC}.
39	DV_{SS}	H	This is the GND level pin for the D/A converter. The potential must be the same as V_{SS}.

*1: FPT-120P-M05
*2: FPT-120P-M13

■ I/O CIRCUIT TYPE

Type	Circuit	Remarks
A		• High-speed oscillation feedback resistor approx. 1MΩ
B		• Low-speed oscillation feedback resistor approx. 1MΩ
C		• Hysteresis input
D		• Hysteresis input (can be set with the input pull-up resistor) CMOS level output • Pull-up resistor approx. 50 kΩ • Provided with a standby control function for input interruption

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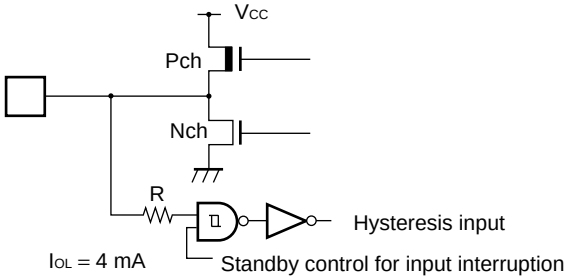
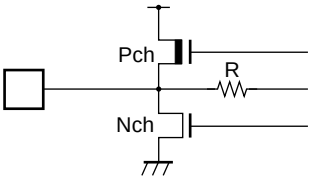
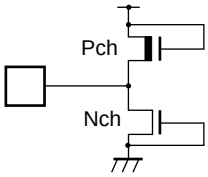
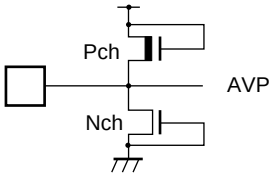
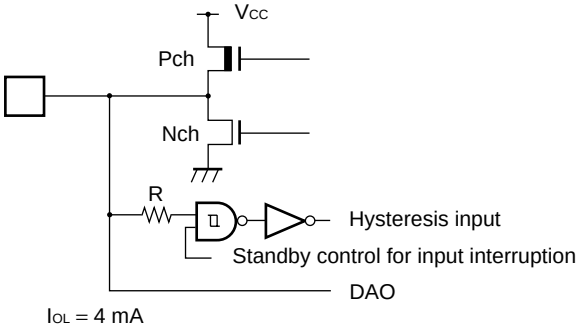
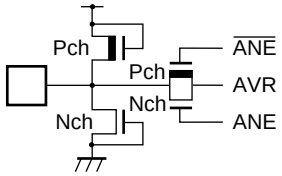
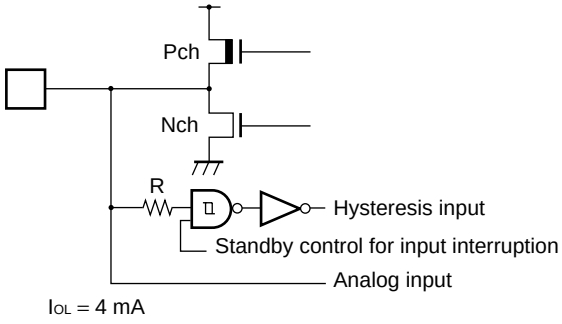
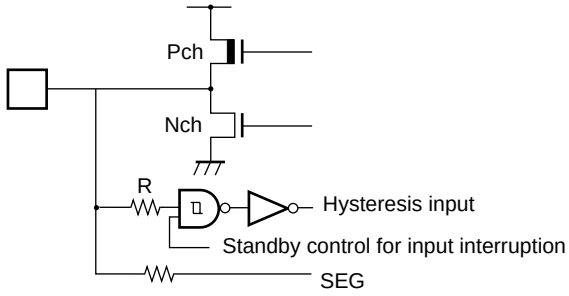
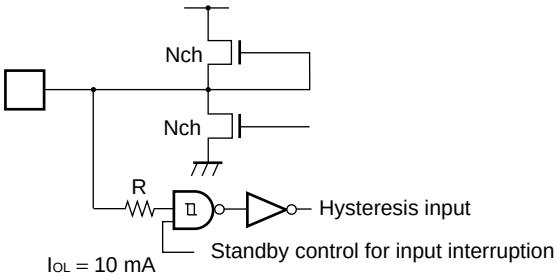
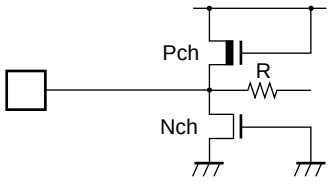
Type	Circuit	Remarks
E		• CMOS hysteresis input/output • CMOS level output • Provided with a standby control function for input interruption
F		• Pins dedicated to segment output
G		• C pin output (Pin for capacitor connection) N.C. pin for the MB90F523
H		• Analog power input protector
I		• CMOS hysteresis input/output • Pin for analog output/CMOS output (During analog output, CMOS output is not produced.) (Analog output has priority over CMOS output: DAE = 1) • Provided with a standby control function for input interruption

(Continued)

Type	Circuit	Remarks
J		• Input pin for ref+ power for the A/D converter Provided with power protection
K	 I_{OL} = 4 mA	• Hysteresis input/analog input • CMOS output • Provided with a standby control for input interruption
L	 I_{OL} = 4 mA	• CMOS hysteresis input/output • Segment input • Standby control to cut off the input is available in segment input operation
M	 I_{OL} = 10 mA	• Hysteresis input • Nch open-drain output (High current for LCD drive) • Standby control to cut off the input is available in segment input operation
N	 I_{OL} = 10 mA	• Reference power supply pin for the LCD controller

■ HANDLING DEVICES

1. Ensuring that the Voltage does not exceed the Maximum Rating (to Avoid a Latch-up).

In CMOS ICs, a latch-up phenomenon is caused when a voltage exceeding VCC or below VSS is applied to input or output pins or if a voltage exceeding the rating is applied across VCC and VSS.
When a latch-up is caused, the power supply current may be dramatically increased, resulting in thermal breakdown of devices. To avoid the latch-up, make sure that the voltage does not exceed the maximum rating.
In turning on/turning off the analog power supply, make sure the analog power voltages (AVCC, AVRH, DVCC) and analog input voltages do not exceed the digital voltage (V_{CC}).
And also make sure the voltages applied to the LCD power supply pins (V3 to V0) do not exceed the power supply voltage (V_{CC}).

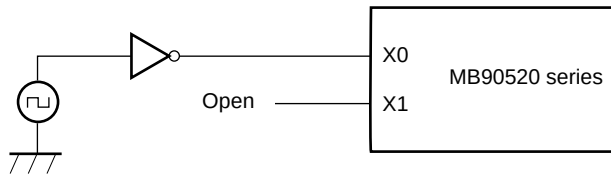
2. Handling Unused Pins

- Unused input pins left open may cause abnormal operation, or latch-up leading to permanent damage. Unused input pins should be pulled-up or pull-down through at least 2 kΩ resistance.
- Unused input/output pins may be left open in output state, but if such pins are in input state they should be handled in the same way as input pins.

3. Notes on Using External Clock

In using the external clock, drive X0 pin only and leave X1 pin unconnected.

- **Using external clock**



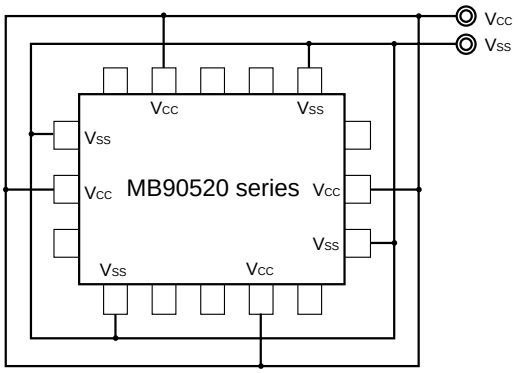
4. Unused Sub Clock Mode

If sub clock modes are not used, the oscillator should be connected to the X0A pin and X1A pin.

5. Power Supply Pins

In products with multiple V_{cc} or V_{ss} pins, pins with the same potential are internally connected in the device to avoid abnormal operations including latch-ups. However, the pins should be connected to external powers and ground lines to lower the electro-magnetic emission level, to prevent abnormal operation of strobe signals caused by the rise in the ground level, and to conform to the total current rating.
Make sure to connect V_{cc} and V_{ss} pins via lowest impedance to power lines.
It is recommended that a bypass capacitor of around 0.1 µF be placed between the V_{cc} and V_{ss} pins near the device.

- **Using power supply pins**



6. Crystal Oscillator Circuit

Noise around the X0 and X1 pins may cause abnormal operation in this device. In designing printed circuit boards, the X0 and X1 pins and crystal oscillator (or ceramic oscillator), as well as the bypass capacitor to the ground, should be placed as close as possible, and the related wiring should have as few crossings with other wiring as possible.
Circuit board artwork in which the area of the X0 and X1 pins is surrounded by grounding is recommended for stabilizing the operation.

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

Make sure to turn on the A/D converter power supply, D/A converter power supply (AV_{CC}, AVRH, AVRL, DV_{CC}, DV_{SS}) and analog inputs (AN0 to AN7) after turning on the digital power supply (V_{CC}).
Turn off the digital power after turning off the A/D converter supply and analog inputs. In this case, make sure that AVRH and DV_{CC} do not exceed AV_{CC} (turning on/off the analog and digital supplies simultaneously is acceptable).

8. Connection of Unused Pins of A/D Converter

Connect unused pins of A/D converter and those of D/A converter to $AV_{CC} = DV_{CC} = V_{CC}$, AV_{SS} = AVRH = AVRL = V_{SS}.

9. N.C. Pin

The N.C. (internally connected) pin must be opened for use.

10. Notes on Energization

To prevent the internal regulator circuit from malfunctioning, set the voltage rise time during energization at 50 µs or more (0.2 V to 2.7 V).

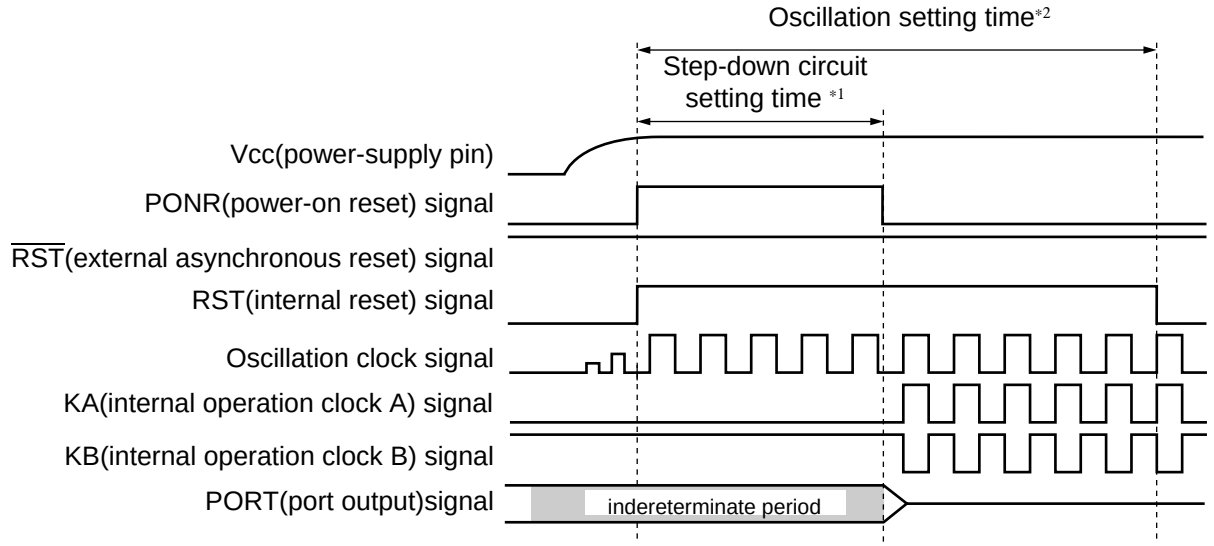
11. Use of SEG/COM Pins for the LCD Controller/Driver as Ports

In MB90520 series, pins SEG08 to SEG31, and COM0 to COM3 can also be used as general-purpose ports. The electrical standard is such that pins SEG08 to SEG23, and COM0 to COM3 have the same ratings as the CMOS output port, while pins SEG24 to SEG31 have the same ratings as the open-drain type.

12.Indeterminate outputs from ports 0 and 1

The outputs from ports 0 and 1 become indeterminate during oscillation setting time of step-down circuit (during a power-on reset) after the power is turned on.
Pay attention to the port output timing shown as follow

- **Timming chart of indeterminate outputs from ports o and 1**



* : 1:Step-down circuit setting time : 2^{17}/oscillation clock frequency (oscillation clock frequency of 16 MHz: 8.19 ms)

* : 2:Oscillation setting time: 2^{18}/oscillation clock frequency (oscillation cllock frequency of 16 MHz: 16.38 ms)

13.Initialization

The device contains internal registers that can be initialized only by a power-on reset. To initialize the internal registers, restart the power supply.

14. Interrupt Recovery from Standby

If an external interrupt is used for recovery from standby, use an “H” level input request. An “L” level request causes abnormal operation.

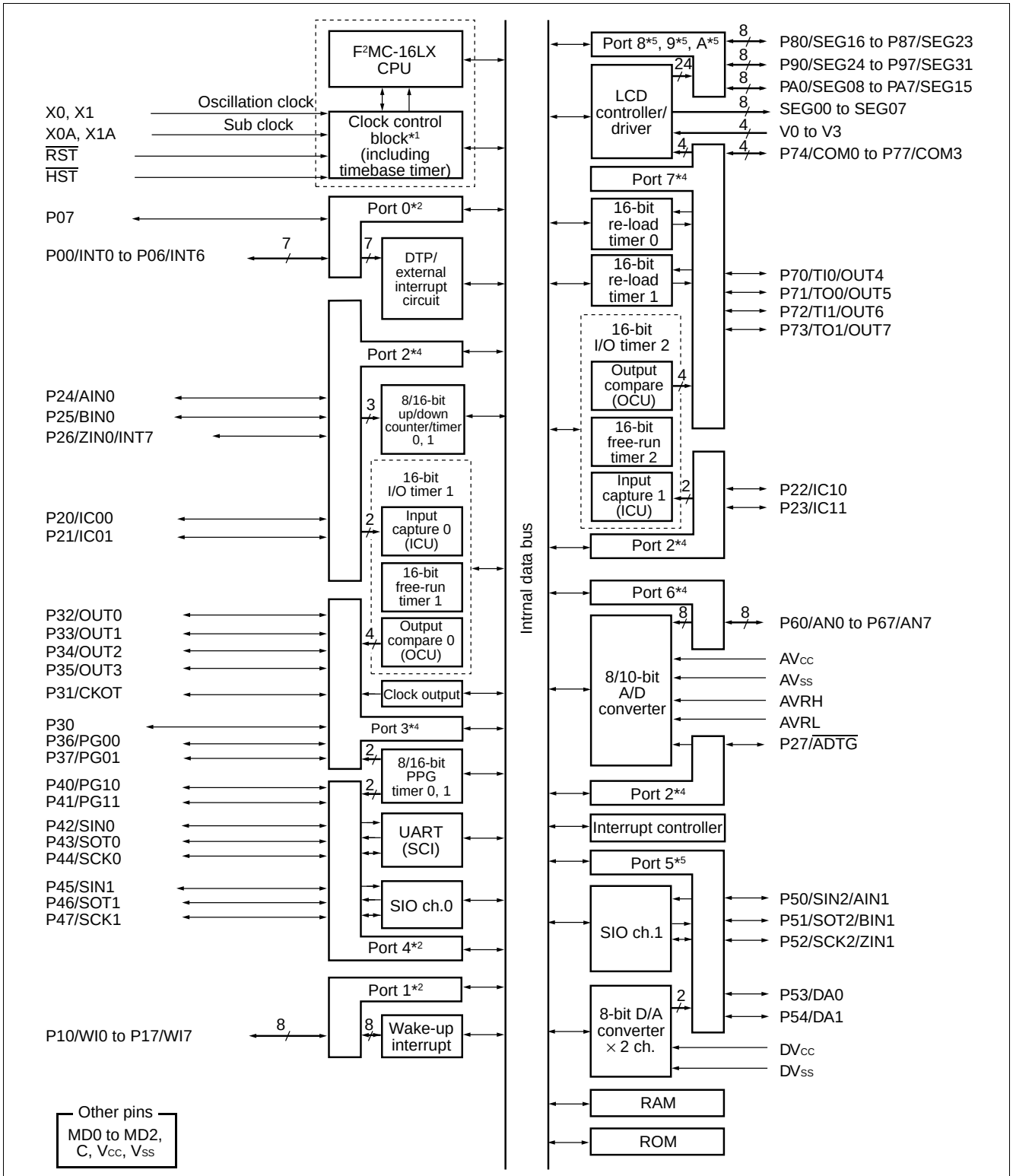
15.Precautions for Use of “DIV A, Ri”, and “DIVW A, Ri” Instructions

The signed multiplication-division instructions “DIV A, Ri”, and “DIVW A, RWi” should be used when the corresponding bank registers (DTB, ADB, USB, SSB) are set to value “00h”. If the corresponding bank registers (DTB, ADB, USB, SSB) are set to a value other than “00h,” then the remainder obtained after the execution of the instruction will not be placed in the instruction operand register.

16. Precautions for Use of REALOS

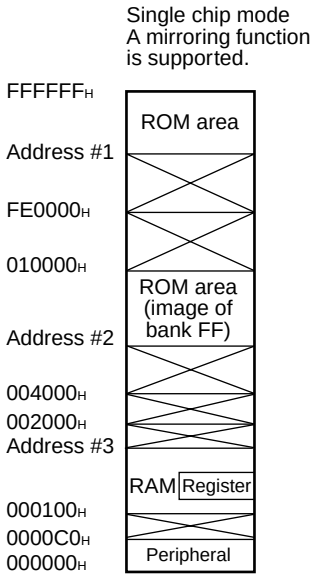
Extended intelligent I/O service(EI^{2}OS) cannot be used, when REALOS is used.

■ BLOCK DIAGRAM



Notes: Actually 16-bit free-run timer 1 is supported although two free-run timers are seemingly supported.
*1: The clock control circuit comprises a watchdog timer, a timebase timer, and a power consumption controller.
*2: A register for setting a pull-up resistor is supported.
*3: This is a high-current port for an LCD drive.
*4: A register for setting a pull-up resistor is supported. Signals in the CMOS level are input and output.
*5: Also used for LCD output. With this port used as is, Nch open-drain output develops. A register for setting a pull-up resistor is supported.

■ MEMORY MAP



Part number	Address #1*	Address #2*	Address #3*
MB90522	FF0000H	004000H	001100H
MB90523	FE0000H	004000H	001100H
MB90F523	FE0000H	004000H	001100H

: Internal access memory

: Access prohibited

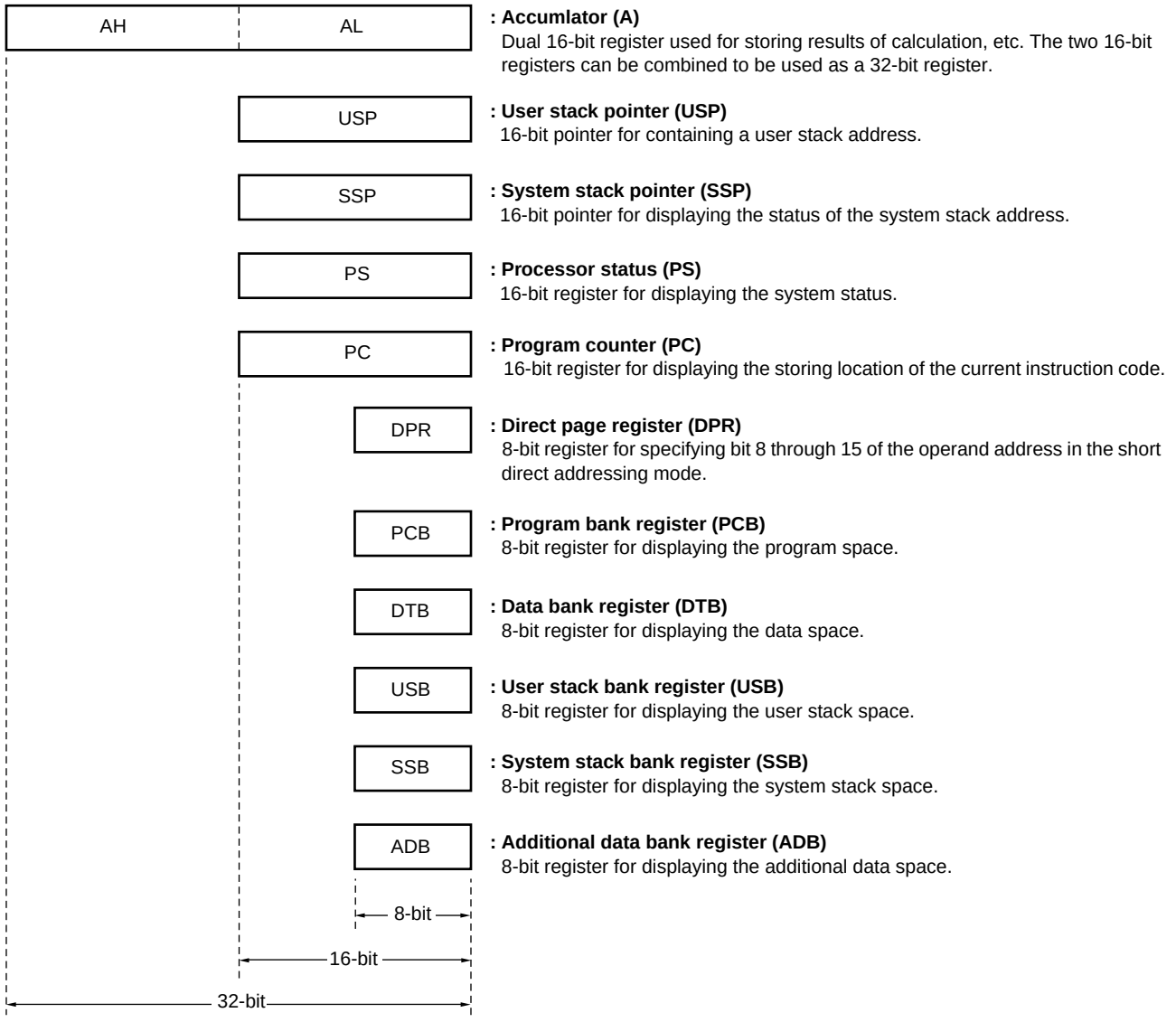
*: Addresses #1, #2 and #3 vary with product type.

Note: The ROM data of bank FF is reflected in the upper address of bank 00, realizing effective use of the C compiler small model. The lower 16-bit of bank FF and the lower 16-bit of bank 00 are assigned to the same address, enabling reference of the table on the ROM without stating “far.”

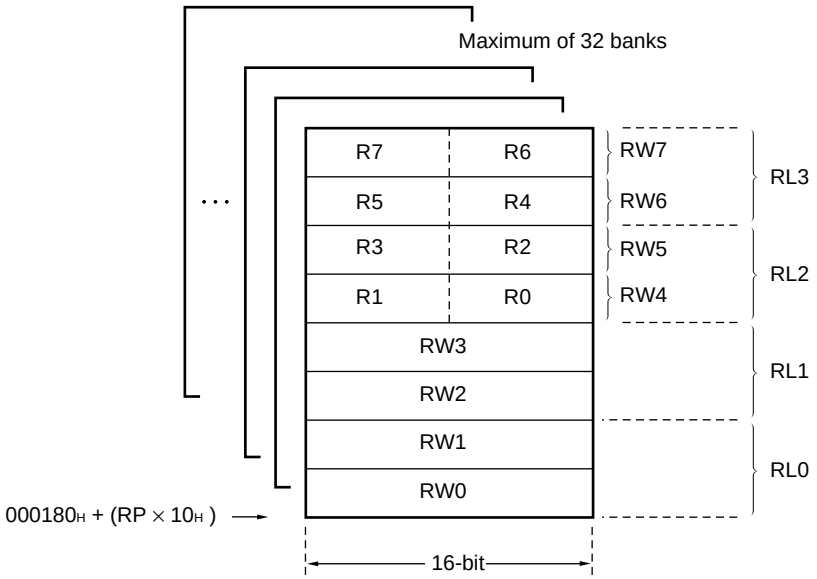
For example, if an attempt has been made to access 00C000H, the contents of the ROM at FFC000H are actually accessed. Since the ROM area of the FF bank exceeds 48k bytes, the whole area cannot be reflected in the image for the 00 bank. The ROM data at FF4000H to FFFFFFH looks, therefore, as if it were the image for 00400H to 00FFFFH. Thus, it is recommended that the ROM data table be stored in the area of FF4000H to FFFFFFH.

■ F²MC-16LX CPU PROGRAMMING MODEL

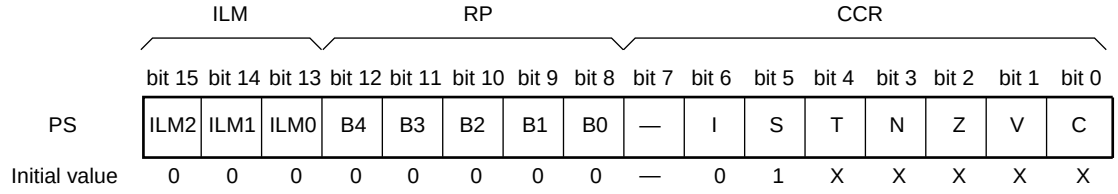
- **Dedicated registers**



- **General-purpose registers**



- **Processor status (PS)**



— : Unused
X : Indeterminate

■ I/O MAP

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
000000H	PDR0	Port 0 data register	R/W	Port 0	XXXXXXXXB
000001H	PDR1	Port 1 data register	R/W	Port 1	XXXXXXXXB
000002H	PDR2	Port 2 data register	R/W	Port 2	XXXXXXXXB
000003H	PDR3	Port 3 data register	R/W	Port 3	XXXXXXXXB
000004H	PDR4	Port 4 data register	R/W	Port 4	XXXXXXXXB
000005H	PDR5	Port 5 data register	R/W	Port 5	XXXXXXXXB
000006H	PDR6	Port 6 data register	R/W	Port 6	XXXXXXXXB
000007H	PDR7	Port 7 data register	R/W	Port 7	XXXXXXXXB
000008H	PDR8	Port 8 data register	R/W	Port 8	XXXXXXXXB
000009H	PDR9	Port 9 data register	R/W	Port 9	XXXXXXXXB
00000AH	PDRA	Port A data register	R/W	Port A	XXXXXXXXB
00000BH	LCDCMR	Port 7/COM pin selection register	R/W	Port 7, LCD controller/driver	XXXX0000B
00000CH	OCP4	OCU compare register ch.4	R/W	16-bit I/O timer (output compare 1 (OCU) section)	XXXXXXXXB
00000DH					XXXXXXXXB
00000EH	(Disabled)				
00000FH	EIFR	Wake-up interrupt flag register	R/W	Wake-up interrupt	XXXXXXX0B
000010H	DDR0	Port 0 direction register	R/W	Port 0	00000000B
000011H	DDR1	Port 1 direction register	R/W	Port 1	00000000B
000012H	DDR2	Port 2 direction register	R/W	Port 2	00000000B
000013H	DDR3	Port 3 direction register	R/W	Port 3	00000000B
000014H	DDR4	Port 4 direction register	R/W	Port 4	00000000B
000015H	DDR5	Port 5 direction register	R/W	Port 5	XXX00000B
000016H	DDR6	Port 6 direction register	R/W	Port 6	00000000B
000017H	DDR7	Port 7 direction register	R/W	Port 7	00000000B
000018H	DDR8	Port 8 direction register	R/W	Port 8	00000000B
000019H	DDR9	Port 9 direction register	R/W	Port 9	00000000B
00001AH	DDRA	Port A direction register	R/W	Port A	00000000B
00001BH	ADER	Analog input enable register	R/W	Port 6, A/Dconverter	11111111B
00001CH	OCP5	OCU compare register ch.5	R/W	16-bit I/O timer (output compare 1 (OCU) section)	XXXXXXXXB
00001DH					XXXXXXXXB
00001EH	(Disabled)				
00001FH	EICR	Wake-up interrupt enable register	W	Wake-up interrupt	00000000B

(Continued)

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
000020H	SMR	Serial mode register	R/W	UART (SCI)	0 0 0 0 0 0 0 0B
000021H	SCR	Serial control register	R/W or W		0 0 0 0 0 1 0 0B
000022H	SIDR/ SODR	Serial input data register/ serial output data register	R W		XXXXXXXXB
000023H	SSR	Serial status register	R/W or R		0 0 0 0 1 X 0 0B
000024H	SMCSL0	Serial mode control lower status register 0	R/W	Extended I/O serial interface 0	XXXX0000B
000025H	SMCSH0	Serial mode control upper status register 0	R/W		0 0 0 0 0 0 1 0B
000026H	SDR0	Serial data register 0	R/W		XXXXXXXXB
000027H	CDCR	Communications prescaler control register	R/W	Communica-tions prescaler control register	0XXX1111B
000028H	SMCSL1	Serial mode control lower status register 1	R/W	Extended I/O serial interface 1	XXXX0000B
000029H	SMCSH1	Serial mode control upper status register 1	R/W		0 0 0 0 0 0 1 0B
00002AH	SDR1	Serial data register 1	R/W		XXXXXXXXB
00002BH	(Disabled)				
00002CH	OCS45	OCU control status register ch.45	R/W	16-bit I/O timer (output com-pare 1 (OCU) section)	0 0 0 0 X X 0 0B
00002DH					XXX00000B
00002EH	OCS67	OCU control status register ch.67	R/W		0 0 0 0 X X 0 0B
00002FH					XXX00000B
000030H	ENIR	DTP/interrupt enable register	R/W	DTP/external interrupt circuit	0 0 0 0 0 0 0 0B
000031H	EIRR	DTP/interrupt factor register	R/W		XXXXXXXXB
000032H	ELVR	Request level setting register	R/W		0 0 0 0 0 0 0 0B
000033H					0 0 0 0 0 0 0 0B
000034H	OCP6	OCU compare register ch.6	R/W	16-bit I/O timer (output com-pare 1 (OCU) section)	XXXXXXXXB
000035H					XXXXXXXXB
000036H	ADCS1	A/D control status register lower digits	R/W	8/10-bit A/D converter	0 0 0 0 0 0 0 0B
000037H	ADCS2	A/D control status register upper digits	R/W		0 0 0 0 0 0 0 0B
000038H	ADCR1	A/D data register lower digits	R		XXXXXXXXB
000039H	ADCR2	A/D data register upper digits	R or W		0 0 0 0 1 XXXB
00003AH	DADR0	D/A converter data register ch.0	R/W	8-bit D/A converter	XXXXXXXXB
00003BH	DADR1	D/A converter data register ch.1	R/W		XXXXXXXXB
00003CH	DACR0	D/A control register 0	R/W		XXXXXXX0B
00003DH	DACR1	D/A control register 1	R/W		XXXXXXX0B
00003EH	CLKR	Clock output enable register	R/W	Clock monitor function	XXXX0000B

(Continued)

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
00003FH	(Disabled)				
000040H	PRLL0	PPG0 re-load register L	R/W	8/16-bit PPG timer 0, 1	XXXXXXXXB
000041H	PRLH0	PPG0 re-load register H	R/W		XXXXXXXXB
000042H	PRLL1	PPG1 re-load register L	R/W		XXXXXXXXB
000043H	PRLH1	PPG1 re-load register H	R/W		XXXXXXXXB
000044H	PPGC0	PPG0 operating mode control register	R/W		0X0000XX1B
000045H	PPGC1	PPG1 operating mode control register	R/W		0X0000001B
000046H	PPGOE0/ PPGOE1	PPG0 and 1 output control registers	R/W		00000000B
000047H	(Disabled)				
000048H	TMCSR0	Timer control status register lower ch.0	R/W	16-bit re-load timer 0	00000000B
000049H		Timer control status register upper ch.0			XXXX0000B
00004AH	TMR0/ TMRLR0	16-bit timer register upper, lower ch.0/ 16-bit re-load register upper, lower ch.0	R/W		XXXXXXXXB
00004BH					XXXXXXXXB
00004CH	TMCSR1	Timer control status register lower ch.1	R/W	16-bit re-load timer 1	00000000B
00004DH		Timer control status register upper ch.1			XXXX0000B
00004EH	TMR1/ TMRLR1	16-bit timer register upper, lower ch.1/ 16-bit re-load register upper, lower ch.1	R/W		XXXXXXXXB
00004FH					XXXXXXXXB
000050H	IPCP0	ICU data register ch.0	R	16-bit I/O timer (input compare 0, 1 (ICU) section)	XXXXXXXXB
000051H					XXXXXXXXB
000052H	IPCP1	ICU data register ch.1	R		XXXXXXXXB
000053H					XXXXXXXXB
000054H	ICS01	ICU control status register	R/W		00000000B
000055H	(Disabled)				
000056H	TCDT1	Free-run timer data register 1	R/W	16-bit I/O timer (16-bit free-run timer 1 section)	00000000B
000057H					00000000B
000058H	TCCS1	Free-run timer control status register 1	R/W		00000000B
000059H	(Disabled)				
00005AH	OCP0	OCU compare register ch.0	R/W	16-bit I/O timer (output compare 0 (OCU) section)	XXXXXXXXB
00005BH					XXXXXXXXB
00005CH	OCP1	OCU compare register ch.1	R/W		XXXXXXXXB
00005DH					XXXXXXXXB
00005EH	OCP2	OCU compare register ch.2	R/W		XXXXXXXXB
00005FH					XXXXXXXXB
000060H	OCP3	OCU compare register ch.3	R/W		XXXXXXXXB
000061H					XXXXXXXXB

(Continued)

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
000062H	OCS01	OCU control status register ch.01	R/W	16-bit I/O timer (output compare 0 (OCU) section)	0 0 0 0 X X 0 0 B
000063H					X X X 0 0 0 0 0 B
000064H	OCS23	OCU control status register ch.23	R/W		0 0 0 0 X X 0 0 B
000065H					X X X 0 0 0 0 0 B
000066H	TCDT2	Free-run timer data register 2	R/W	16-bit I/O timer (16-bit free-run timer 2 section)	0 0 0 0 0 0 0 0 B
000067H					0 0 0 0 0 0 0 0 B
000068H	TCCS2	Free-run timer control status register 2	R/W		0 0 0 0 0 0 0 0 B
000069H	(Disabled)				
00006AH	LCR0	LCDC control registers 0 and 1	R/W	LCD controller/ driver	0 0 0 1 0 0 0 0 B
00006BH	LCR1		R/W		0 0 0 0 0 0 0 0 B
00006CH	OCP7	OCU compare register ch.7	R/W	16-bit I/O timer (output compare 1 (OCU) section)	X X X X X X X X B
00006DH					X X X X X X X X B
00006EH	(Disabled)				
00006FH	ROMM	ROM mirroring function selection register	W	ROM mirroring function selection module	X X X X X X 1 B
000070H to 00007FH	VRAM	RAM for LCD indication	R/W	LCD controller/ driver	X X X X X X X X B
000080H	UDCR0	Up/down count register 0	R	8/16-bit up/down counter/timer 0, 1	0 0 0 0 0 0 0 0 B
000081H	UDCR1	Up/down count register 1	R		0 0 0 0 0 0 0 0 B
000082H	RCR0	Re-load compare register 0	W		0 0 0 0 0 0 0 0 B
000083H	RCR1	Re-load compare register 1	W		0 0 0 0 0 0 0 0 B
000084H	CSR0	Counter status register 0	R/W		0 0 0 0 0 0 0 0 B
000085H	(Reserved area)*3				
000086H	CCRL0	Counter control register 0	R/W	8/16-bit up/down counter/timer 0, 1	X 0 0 0 0 0 0 0 B
000087H	CCRH0				0 0 0 0 0 0 0 0 B
000088H	CSR1	Counter status register 1	R/W		0 0 0 0 0 0 0 0 B
000089H	(Reserved area)*3				
00008AH	CCRL1	Counter control register 1	R/W	8/16-bit up/down counter/timer 0, 1	X 0 0 0 0 0 0 0 B
00008BH	CCRH1				X 0 0 0 0 0 0 0 B
00008CH	RDR0	Port 0 input pull-up resistor setup register	R/W	Port 0	0 0 0 0 0 0 0 0 B
00008DH	RDR1	Port 1 input pull-up resistor setup register	R/W	Port 1	0 0 0 0 0 0 0 0 B
00008EH	RDR4	Port 4 input pull-up resistor setup register	R/W	Port 4	0 0 0 0 0 0 0 0 B

(Continued)

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
00008F$_H$ to 00009D$_H$	(Area used by the system)*3				
00009E$_H$	PACSR	Program address detection control status register	R/W	Address match detection function	0 0 0 0 0 0 0 0 $_B$
00009F$_H$	DIRR	Delayed interrupt factor generation/ cancellation register	R/W	Delayed interrupt generation module	X X X X X X X 0 $_B$
0000A0$_H$	LPMCR	Low-power consumption mode control register	R/W or W	Low-power consumption (stand-by) mode	0 0 0 1 1 0 0 0 $_B$
0000A1$_H$	CKSCR	Clock select register	R/W or R		1 1 1 1 1 1 0 0 $_B$
0000A2$_H$ to 0000A7$_H$	(Disabled)				
0000A8$_H$	WDTC	Watchdog timer control register	R or W	Watchdog timer	X X X X X X X X $_B$
0000A9$_H$	TBTC	Timebase timer control register	R/W	Timebase timer	1 X X 0 0 0 0 0 $_B$
0000AA$_H$	WTC	Clock timer control register	R/W or R	Clock timer	1 X 0 0 1 0 0 0 $_B$
0000AB$_H$ to 0000AD$_H$	(Disabled)				
0000AE$_H$	FMCS	Flash control register	R/W	Flash interface	1 X X 0 0 1 0 0 $_B$
0000AF$_H$	(Disabled)				
0000B0$_H$	ICR00	Interrupt control register 00	R/W	Interrupt controller	0 0 0 0 0 1 1 1 $_B$
0000B1$_H$	ICR01	Interrupt control register 01	R/W		0 0 0 0 0 1 1 1 $_B$
0000B2$_H$	ICR02	Interrupt control register 02	R/W		0 0 0 0 0 1 1 1 $_B$
0000B3$_H$	ICR03	Interrupt control register 03	R/W		0 0 0 0 0 1 1 1 $_B$
0000B4$_H$	ICR04	Interrupt control register 04	R/W		0 0 0 0 0 1 1 1 $_B$
0000B5$_H$	ICR05	Interrupt control register 05	R/W		0 0 0 0 0 1 1 1 $_B$
0000B6$_H$	ICR06	Interrupt control register 06	R/W		0 0 0 0 0 1 1 1 $_B$
0000B7$_H$	ICR07	Interrupt control register 07	R/W		0 0 0 0 0 1 1 1 $_B$
0000B8$_H$	ICR08	Interrupt control register 08	R/W		0 0 0 0 0 1 1 1 $_B$
0000B9$_H$	ICR09	Interrupt control register 09	R/W		0 0 0 0 0 1 1 1 $_B$
0000BA$_H$	ICR10	Interrupt control register 10	R/W		0 0 0 0 0 1 1 1 $_B$
0000BB$_H$	ICR11	Interrupt control register 11	R/W		0 0 0 0 0 1 1 1 $_B$
0000BC$_H$	ICR12	Interrupt control register 12	R/W		0 0 0 0 0 1 1 1 $_B$
0000BD$_H$	ICR13	Interrupt control register 13	R/W		0 0 0 0 0 1 1 1 $_B$

(Continued)

(Continued)

Address	Abbreviated register name	Register name	Read/ write	Resource name	Initial value
0000BE$_H$	ICR14	Interrupt control register 14	R/W	Interrupt controller	0 0 0 0 0 1 1 1 $_B$
0000BF$_H$	ICR15	Interrupt control register 15	R/W		0 0 0 0 0 1 1 1 $_B$
0000C0$_H$ to 0000FF$_H$	(External area)*1				
000100$_H$ to 00####$_H$	(RAM area)*2				
00####$_H$ to 001FEF$_H$	(Reserved area)*3				
001FF0$_H$	PADR0	Program address detection register 0	R/W	Address match detection function	X X X X X X X X $_B$
001FF1$_H$		Program address detection register 1	R/W		X X X X X X X X $_B$
001FF2$_H$		Program address detection register 2	R/W		X X X X X X X X $_B$
001FF3$_H$	PADR1	Program address detection register 3	R/W		X X X X X X X X $_B$
001FF4$_H$		Program address detection register 4	R/W		X X X X X X X X $_B$
001FF5$_H$		Program address detection register 5	R/W		X X X X X X X X $_B$
001FF6$_H$ to 001FFF$_H$	(Reserved area)*3				

Descriptions for read/write
R/W: Readable and writable
R: Read only
W: Write only

Descriptions for initial value
0 : The initial value is “0.”
1 : The initial value is “1.”
X : The initial value is indeterminate.

*1: This area is the only external access area having an address of 0000FF$_H$ or lower. An access operation to this area is handled as that to external I/O area.
*2: For details of the “RAM area”, see the memory map.
*3: The “reserved area” is basically disabled because it is used in the system.
*4: “Area used by the system” is the area set by the resistor for evaluating tool.

Notes: • For bits initialized by reset operations, the initial value set by the reset operation is listed as an initial value. Note that the values are different from reading results.
For LPMCR/CKSCR/WDTC, there are cases in which initialization is performed or not performed, depending on the types of the reset. The value listed is the initial value in cases where initialization is per formed.
• The addresses following 0000FF$_H$ are reserved. No external bus access signal is generated.
• Boundary ####$_H$ between the “RAM area” and the“ reserved area” varies with the product models.
• Channels 0 to 3 of the OCU compare register use 16-bit free-run timer 2, while channels 4 to 7 of the OCU compare register use 16-bit free-run timer 1. 16-bit free-run timer 1 is also used by input captures (ICU) 0 and 1.

■ INTERRUPT FACTORS, INTERRUPT VECTORS, INTERRUPT CONTROL REGISTERS

Interrupt source	EI²OS support	Interrupt vector		Interrupt control register		Priority
		Number	Address	ICR	Address	
Reset	×	# 08	FFFFDC$_H$	—	—	High
INT9 instruction	×	# 09	FFFFD8$_H$	—	—	
Exception	×	# 10	FFFFD4$_H$	—	—	
8/10-bit A/D converter	○	# 11	FFFFD0$_H$	ICR00	0000B0$_H$	
Timebase timer	×	# 12	FFFFCC$_H$			
DTP0/DTP1 (external interrupt 0/ external interrupt 1)	○	# 13	FFFFC8$_H$	ICR01	0000B1$_H$	
16-bit free-run timer 1 overflow	×	# 14	FFFFC4$_H$			
Extended I/O serial interface 0	○	# 15	FFFFC0$_H$	ICR02	0000B2$_H$	
Wake-up interrupt	×	# 16	FFFFBC$_H$			
Extended I/O serial interface 1	○	# 17	FFFFB8$_H$	ICR03	0000B3$_H$	
DTP2/DTP3 (external interrupt 2/ external interrupt 3)	○	# 18	FFFFB4$_H$			
8/16-bit PPG timer 0 counter borrow	×	# 19	FFFFB0$_H$	ICR04	0000B4$_H$	
DTP4/DTP5 (external interrupt 4/ external interrupt 5)	○	# 20	FFFFAC$_H$			
8/16-bit up/down counter/timer 0 compare match	○	# 21	FFFFA0$_H$	ICR05	0000B5$_H$	
8/16-bit up/down counter/timer 0 overflow up/down inversion	○	# 22	FFFFA4$_H$			
8/16-bit PPG timer 1 counter borrow	×	# 23	FFFFA0$_H$	ICR06	0000B6$_H$	
DTP6/DTP7 (external interrupt 6/ external interrupt 7)	○	# 24	FFFF9C$_H$			
Output compare 1 (OCU) ch.4/ch.5 match	○	# 25	FFFF98$_H$	ICR07	0000B7$_H$	
Clock prescaler	×	# 26	FFFF94$_H$			
Output compare 1 (OCU) ch.6/ch.7 match	○	# 27	FFFF90$_H$	ICR08	0000B8$_H$	
16-bit free-run timer 2 overflow	×	# 28	FFFF8C$_H$			
8/16-bit up/down counter/timer 1 compare match	○	# 29	FFFF88$_H$	ICR09	0000B9$_H$	
8/16-bit up/down counter/timer 1 overflow, up/down inversion	○	# 30	FFFF84$_H$			
Input capture 0 (ICU) include	○	# 31	FFFF80$_H$	ICR10	0000BA$_H$	
Input capture 1 (ICU) include	○	# 32	FFFF7C$_H$			Low

(Continued)

(Continued)

Interrupt source	EI²OS support	Interrupt vector		Interrupt control register		Priority
		Number	Address	ICR	Address	
Output compare 0 (OCU) ch.0 match	○	# 33	FFFF78H	ICR11	0000BBH	High
Output compare 0 (OCU) ch.1 match	○	# 34	FFFF74H			
Output compare 0 (OCU) ch.2 match	○	# 35	FFFF70H	ICR12	0000BCH	
Output compare 0 (OCU) ch.3 match	○	# 36	FFFF6CH			
UART (SCI) reception complete	◎	# 37	FFFF68H	ICR13	0000BDH	
16-bit re-load timer 0	○	# 38	FFFF64H			
UART (SCI) transmission complete	◎	# 39	FFFF60H	ICR14	0000BEH	
16-bit re-load timer 1	○	# 40	FFFF5CH			
Reserved	×	# 41	FFFF58H	ICR15	0000BFH	
Delayed interrupt generation module	×	# 42	FFFF54H			Low

○ : Can be used

× : Can not be used

◎ : Can be used with EI²OS stop function

■ PERIPHERALS

1. I/O Port

(1) Input/Output Port

Port 0 through A are general-purpose I/O ports having a combined function as a resource input. The I/O ports can be used as general-purpose I/O ports only in the single-chip mode.

- Operation as output port
  The pin is configured as an output port by setting the corresponding bit of the DDR register to “1”.
  Writing data to PDR register when the port is configured as output, the data is retained in the output latch in the PDR and directly output to the pin.
  The value of the pin (the same value retained in the output latch of PDR) can be read out by reading the PDR register.

Note: When a read-modify-write type instruction (e.g. bit set instruction) is performed to the port data register, the destination bit of the operation is set to the specified value, not affecting the bits configured by the DDR register for output. However, values of bits configured as inputs by the DDR register are changed because input values to the pins are written into the output latch. To avoid this situation, configure the pins by the DDR register as output after writing output data to the PDR register when switching the bit used as input to output.

- Operation as input port
  The pin is configured as input by setting the corresponding bit of the DDR register to “0.”
  When the pin is configured as an input, the output buffer is turned off and the pin is put into a high-impedance status.
  When data is written into the PDR register, the data is retained in the output latch of the PDR, but pin outputs are unaffected.
  Reading the PDR register reads out the pin level (“0” or “1”).

(2) Register Configuration

- Port 0 data register (PDR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000000H	P07	P06	P05	P04	P03	P02	P01	P00	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 1 data register (PDR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000001H	P17	P16	P15	P14	P13	P12	P11	P10	XXXXXXXXB
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 2 data register (PDR2)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000002H	P27	P26	P25	P24	P23	P22	P21	P20	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 3 data register (PDR3)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000003H	P37	P36	P35	P34	P33	P32	P31	P30	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 4 data register (PDR4)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000004H	P47	P46	P45	P44	P43	P42	P41	P40	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 5 data register (PDR5)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000005H	—	—	—	P54	P53	P52	P51	P50	XXXXXXXXB
	—	—	—	R/W	R/W	R/W	R/W	R/W	

- Port 6 data register (PDR6)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000006H	P67	P66	P65	P64	P63	P62	P61	P60	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 7 data register (PDR7)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000007H	P77	P76	P75	P74	P73	P72	P71	P70	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 8 data register (PDR8)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000008H	P87	P86	P85	P84	P83	P82	P81	P80	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 9 data register (PDR9)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000009H	P97	P96	P95	P94	P93	P92	P91	P90	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

(Continued)

• Port A data register (PDRA)

Address: 00000A$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
PA7	PA6	PA5	PA4	PA3	PA2	PA1	PA0	XXXXXXXX$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 0 direction register (DDR0)

Address: 000010$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
D07	D06	D05	D04	D03	D02	D01	D00	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 1 direction register (DDR1)

Address: 000011$_H$

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
D17	D16	D15	D14	D13	D12	D11	D10	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 2 direction register (DDR2)

Address: 000012$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
D27	D26	D25	D24	D23	D22	D21	D20	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 3 direction register (DDR3)

Address: 000013$_H$

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
D37	D36	D35	D34	D33	D32	D31	D30	00000000$_B$
			R/W	R/W	R/W	R/W	R/W	

• Port 4 direction register (DDR4)

Address: 000014$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
D47	D46	D45	D44	D43	D42	D41	D40	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 5 direction register (DDR5)

Address: 000015$_H$

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
—	—	—	D54	D53	D52	D51	D50	XXX00000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 6 direction register (DDR6)

Address: 000016$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
D67	D66	D65	D64	D63	D62	D61	D60	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 7 direction register (DDR7)

Address: 000017$_H$

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
D77	D76	D75	D74	D73	D72	D71	D70	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

• Port 8 direction register (DDR8)

Address: 000018$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
D87	D86	D85	D84	D83	D82	D81	D80	00000000$_B$
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

(Continued)

(Continued)

- Port 9 direction register (DDR9)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000019H	D97	D96	D95	D94	D93	D92	D91	D90	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port A direction register (DDRA)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00001AH	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 0 input pull-up resistor setup register (RDR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00008CH	RD07	RD06	RD05	RD04	RD03	RD02	RD01	RD00	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 1 input pull-up resistor setup register (RDR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00008DH	RD17	RD16	RD15	RD14	RD13	RD12	RD11	RD10	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 4 input pull-up resistor setup register (RDR4)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00008EH	RD47	RD46	RD45	RD44	RD43	RD42	RD41	RD40	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Analog input enable register (ADER)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00001BH	ADE7	ADE6	ADE5	ADE4	ADE3	ADE2	ADE1	ADE0	11111111B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

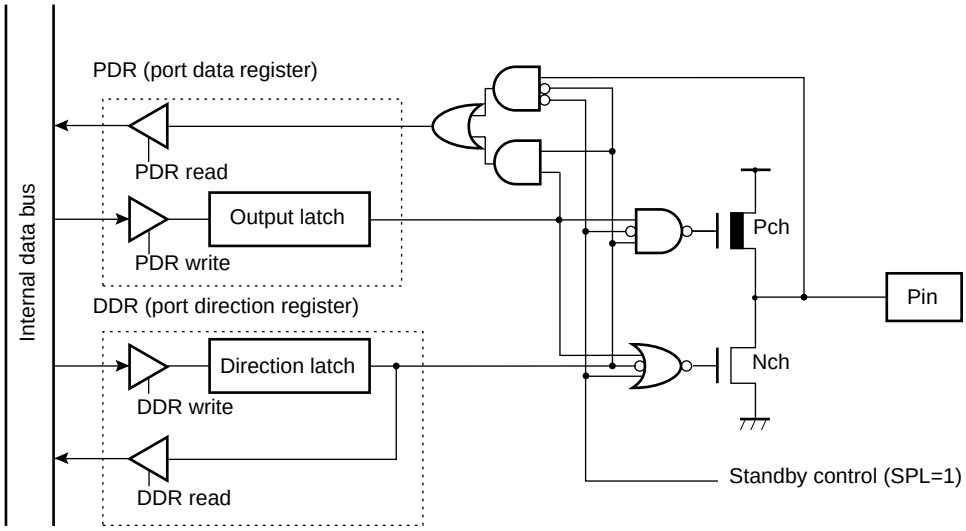
- Port 7/COM pin selection register (LCDCMR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00000BH	—	—	—	—	COM3	COM2	COM1	COM0	XXXX0000B
	—	—	—	—	R/W	R/W	R/W	R/W	

R/W : Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

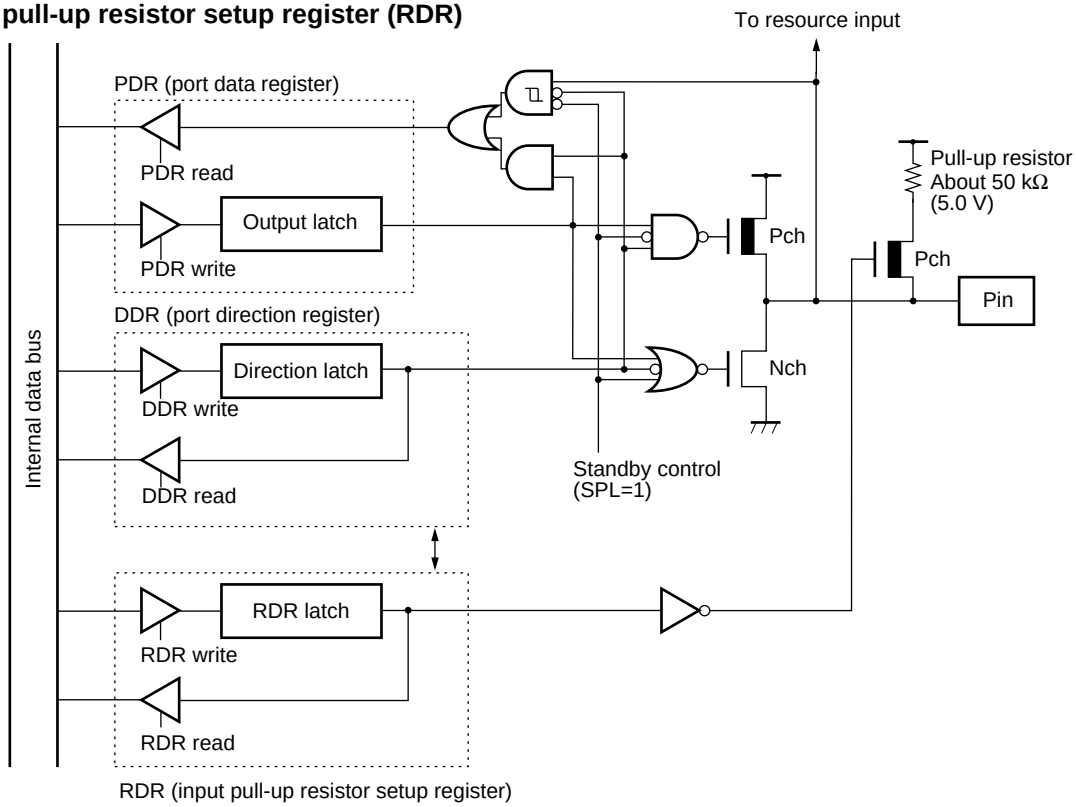
(3) Block Diagram

- **Input/output port**



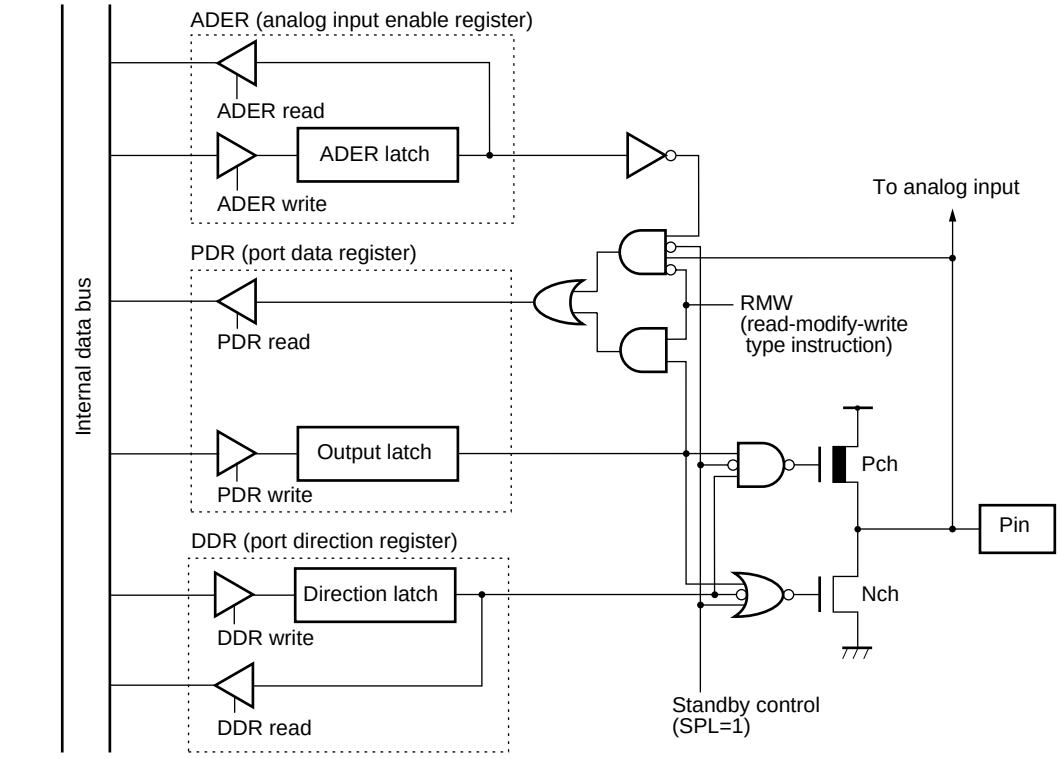
Standby control: Stop, timebase timer mode and SPL=1, or hardware standby mode

- **Input pull-up resistor setup register (RDR)**



Standby control: Stop, timebase timer mode and SPL=1

- **Analog input enable register (ADER)**



Standby control: Stop, timebase timer mode and SPL=1

2. Timebase Timer

The timebase timer is a 18-bit free-run counter (timebase counter) for counting up in synchronization to the internal count clock (divided-by-2 of oscillation) with an interval timer function for selecting an interval time from four types : 2^{12}/HCLK, 2^{14}/HCLK, 2^{16}/HCLK, and 2^{19}/HCLK.

The timebase timer also has a function for supplying operating clocks for the timer output for the oscillation stabilization time or the watchdog timer, etc.

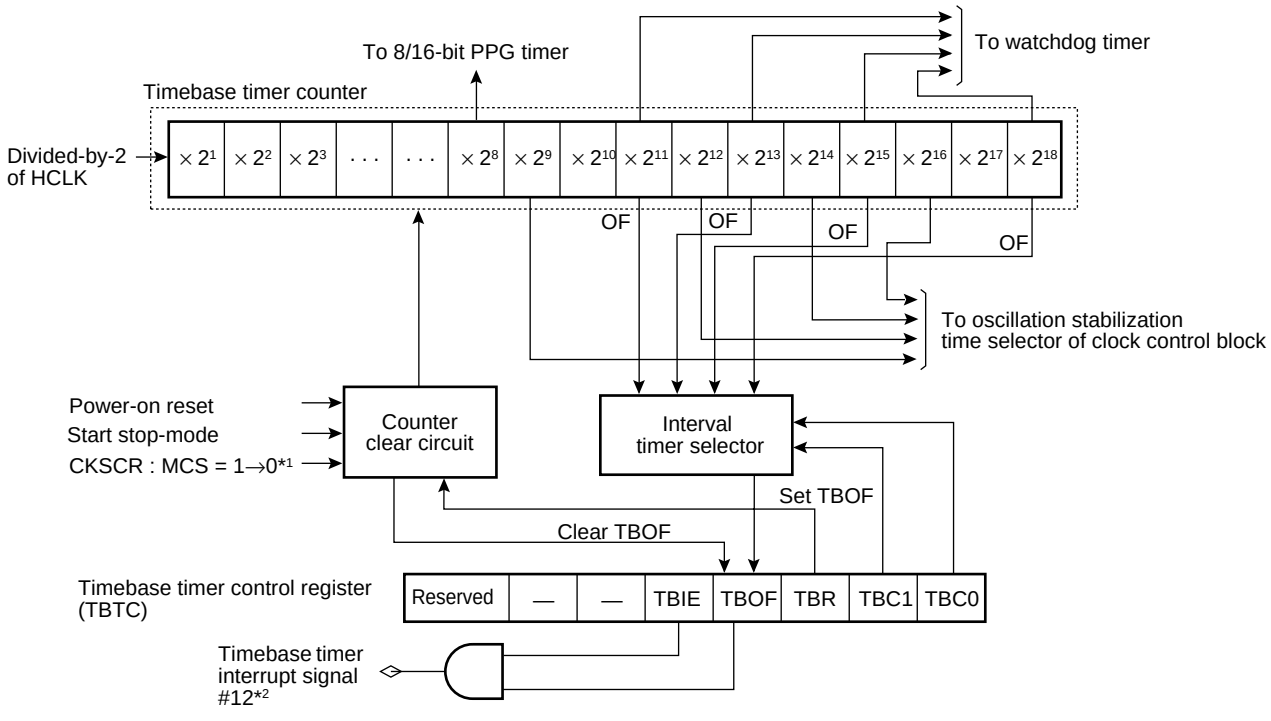
(1) Register Configuration

- Timebase timer control register (TBTC)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
0000A9H	Reserved	—	—	TBIE	TBOF	TBR	TBC1	TBC0	1XX00000B
	R/W	—	—	R/W	R/W	R/W	R/W	R/W	

R/W: Readable and writable
— : Undefined bits (read value undefined)

(2) Block Diagram



*1: Switch machine clock from oscillation clock to PLL clock
*2: Interrupt number
OF : Overflow
HCLK : Oscillation clock frequency

3. Watchdog Timer

The watchdog timer is a 2-bit counter operating with an output of the timebase timer and resets the CPU when the counter is not cleared for a preset period of time.

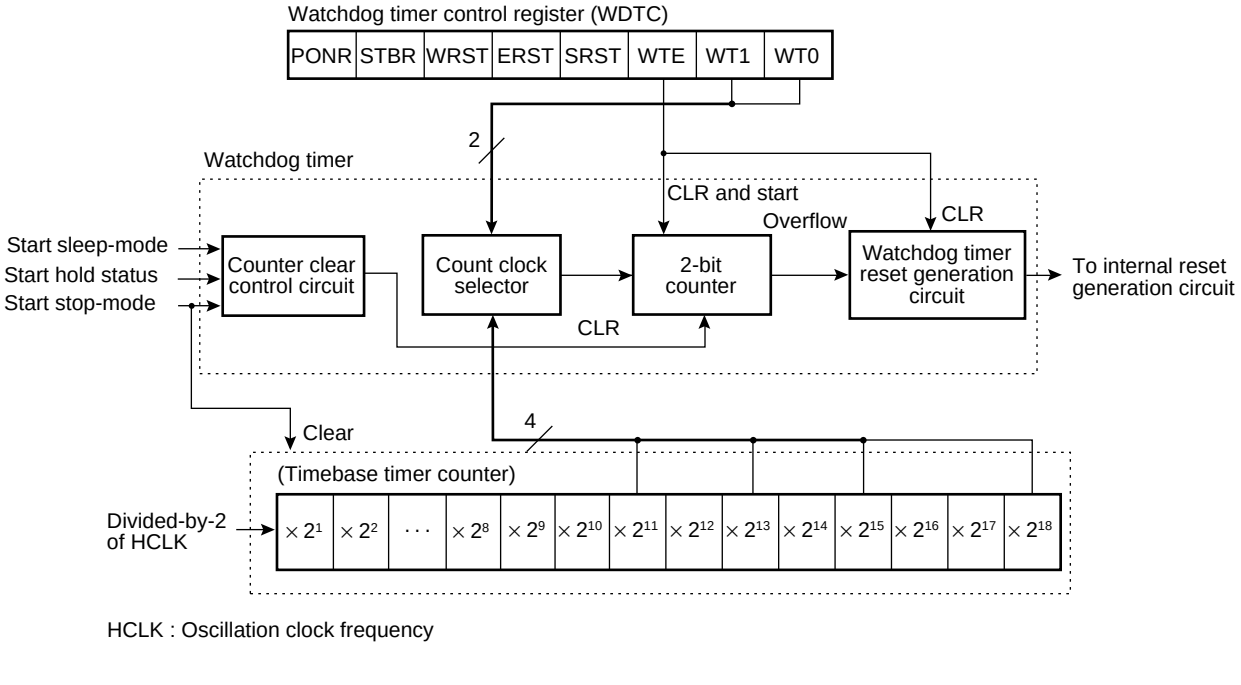
(1) Register Configuration

- Watchdog timer control register (WDTC)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
0000A8H	PONR	STBR	WRST	ERST	SRST	WTE	WT1	WT0	XXXXXXXXB
	R	R	R	R	R	W	W	W	

R : Read only
W: Write only
X : Indeterminate

(2) Block Diagram



HCLK : Oscillation clock frequency

4. 8/16-bit PPG Timer 0, 1

The 8/16-bit PPG timer is a 2-CH re-load timer module for outputting pulse having given frequencies/duty ratios. The two modules perform the following operation by combining functions.

- 8-bit PPG timer output 2-CH independent output mode
  This is a mode for operating independent 2-CH 8-bit PPG timers, in which PG00 and PG10 pins correspond to outputs from PPG0 and PPG1 respectively.
- 16-bit PPG timer output operation mode
  In this mode, PPG0 and PPG1 are combined to be operated as a 1-CH 8/16-bit PPG timer 0 and 1 operating as a 16-bit timer. Because outputs during 16-bit PPG timer output operation mode are reversed by an underflow from PPG1, the same output pulses are output from PG10 and PG11 pins.
- 8 + 8-bit PPG timer output operation mode
  In this mode, PPG0 is operated as an 8-bit prescaler register, in which an underflow output of PPG0 is used as a clock source for PPG1.
  A prescaler output of PPG0 is output from PG00 and PG01 pins. PPG output of PPG1 is output from PG10 and PG11 pins.
- PPG output operation
  A pulse wave with any period/duty ratio is output. The module can also be used as a D/A converter with an external add-on circuit.

(1) Register Configuration

- PPG0 operating mode control register (PPGC0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000044H	PEN0	—	PE00	PIE0	PUF0	—	—	Reserved	0X000XX1B
	R/W	—	R/W	R/W	R/W	—	—	—	

- PPG1 operating mode control register (PPGC1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000045H	PEN1	—	PE10	PIE1	PUF1	MD1	MD0	Reserved	0X000001B
	R/W	—	R/W	R/W	R/W	R/W	R/W	R/W	

- PPG0 output control register (PPGOE0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000046H	PCS2	PCS1	PCS0	PCM2	PCM1	PCM0	PE11	PE01	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- PPG1 output control register (PPGOE1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000046H	PCS2	PCS1	PCS0	PCM2	PCM1	PCM0	PE11	PE01	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- PPG0 re-load register H (PRLH0)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000041H									XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- PPG1 re-load register H (PRLH1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000043H									XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- PPG0 re-load register L (PRLL0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000040H									XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

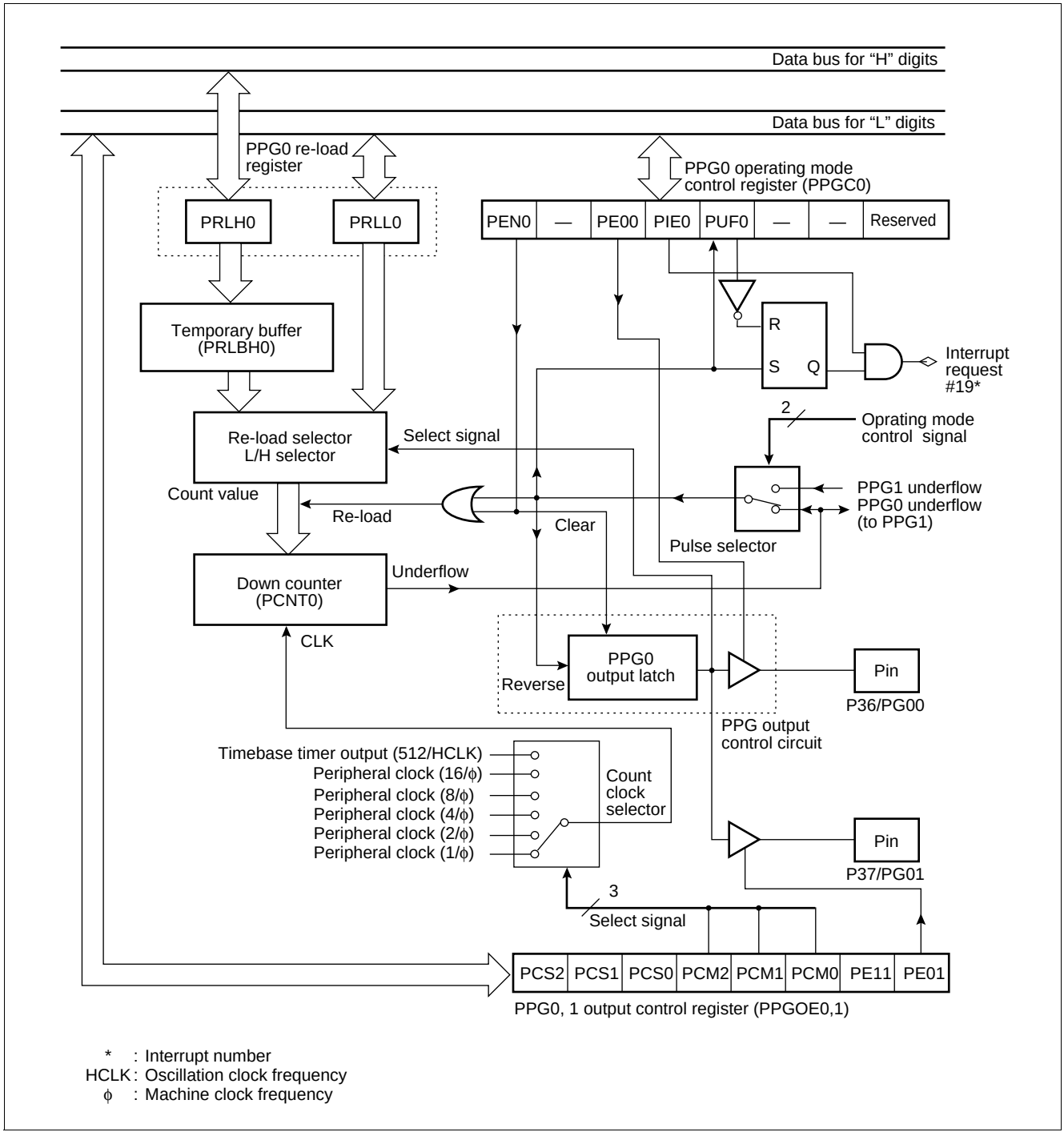
- PPG1 re-load register L (PRLL1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000042H									XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W:Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

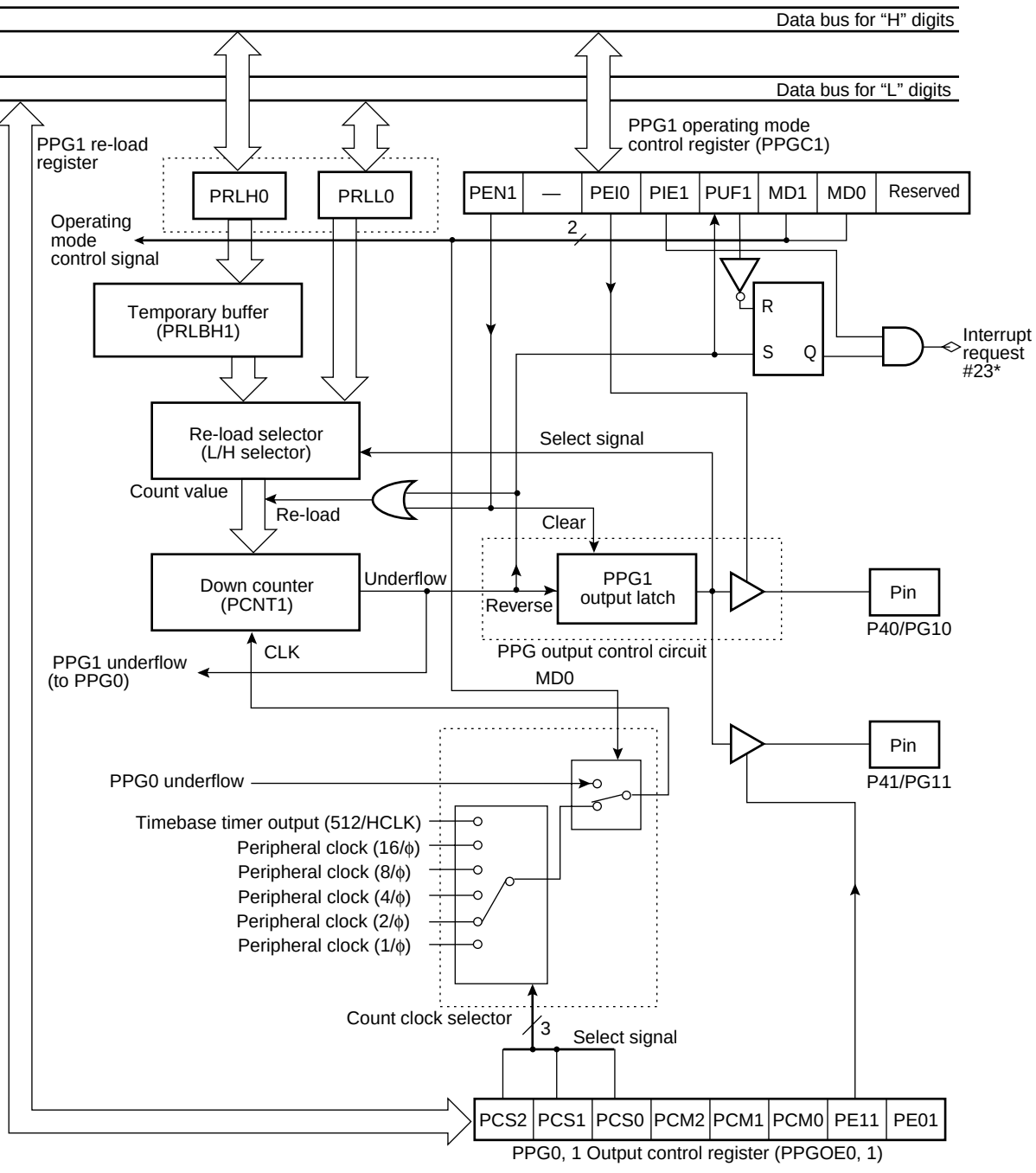
(2) Block Diagram

- **Block diagram of 8/16-bit PPG timer 0**



* : Interrupt number
HCLK : Oscillation clock frequency
ϕ : Machine clock frequency

- **Block diagram of 8/16-bit PPG timer 1**



* : Interrupt number
HCLK : Oscillation clock frequency
ϕ : Machine clock frequency

5. 16-bit Re-load Timer 0, 1 (With an Event Count Function)

The 16-bit re-load timer has an internal clock mode for counting down in synchronization to three types of internal clocks and an event count mode for counting down by detecting a given edge of the pulse input to the external bus pin. Either of the two functions can be selectively used.

For this timer, an “underflow” is defined as the timing of transition from the counter value of “0000_H” to “$FFFF_H$.” According to this definition, an underflow occurs after a counter value of [re-load register setting value + 1] .

In operating the counter, the re-load mode for repeating counting operation after re-loading a counter value after an underflow or the one-shot mode for stopping the counting operation after an underflow can be selectively used.

Because the timer can generate an interrupt upon an underflow, the timer conforms to the extended intelligent I/O service (EI^2OS).

The MB90520 series has 2 channels of 16-bit re-load timers.

(1) Register Configuration

- Timer control status register upper digits ch.0, ch.1 (TMCSR0, TMCSR1 : H)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
TMCSR0 : 000049_H TMCSR1 : $00004D_H$	—	—	—	—	CSL1	CSL0	MOD2	MOD1	XXXX0000B
	—	—	—	—	R/W	R/W	R/W	R/W	

- Timer control status register lower digits ch.0, ch.1 (TMCSR0, TMCSR1 : L)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
TMCSR0 : 000048_H TMCSR1 : $00004C_H$	MOD0	OUTE	OUTL	RELD	INTE	UF	CNTE	TRG	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- 16-bit timer register upper and lower digits ch.0, ch.1 (TMR0, TMR1)

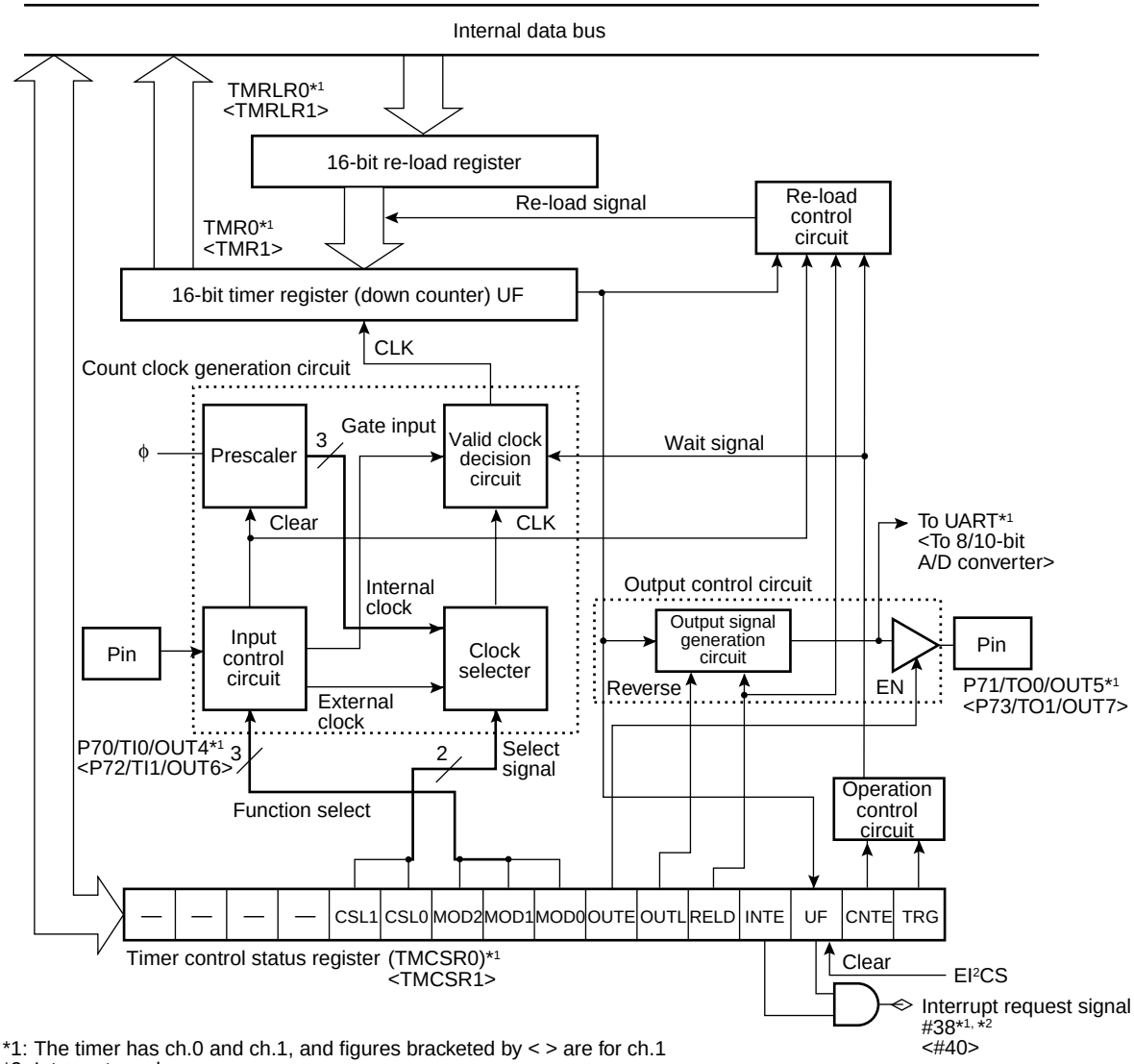
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
TMR0 : $00004B_H$																	XXXXXXXXB
$00004A_H$																	XXXXXXXXB
TMR1 : $00004E_H$																	XXXXXXXXB
$00004F_H$	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	XXXXXXXXB

- 16-bit re-load register upper and lower digits ch.0, ch.1 (TMRLR0, TMRLR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
TMRLR0 : $00004B_H$																	XXXXXXXXB
$00004A_H$																	XXXXXXXXB
TMRLR1 : $00004E_H$																	XXXXXXXXB
$00004F_H$	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	XXXXXXXXB

R/W : Readable and writable
R : Read only
W : Write only
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram

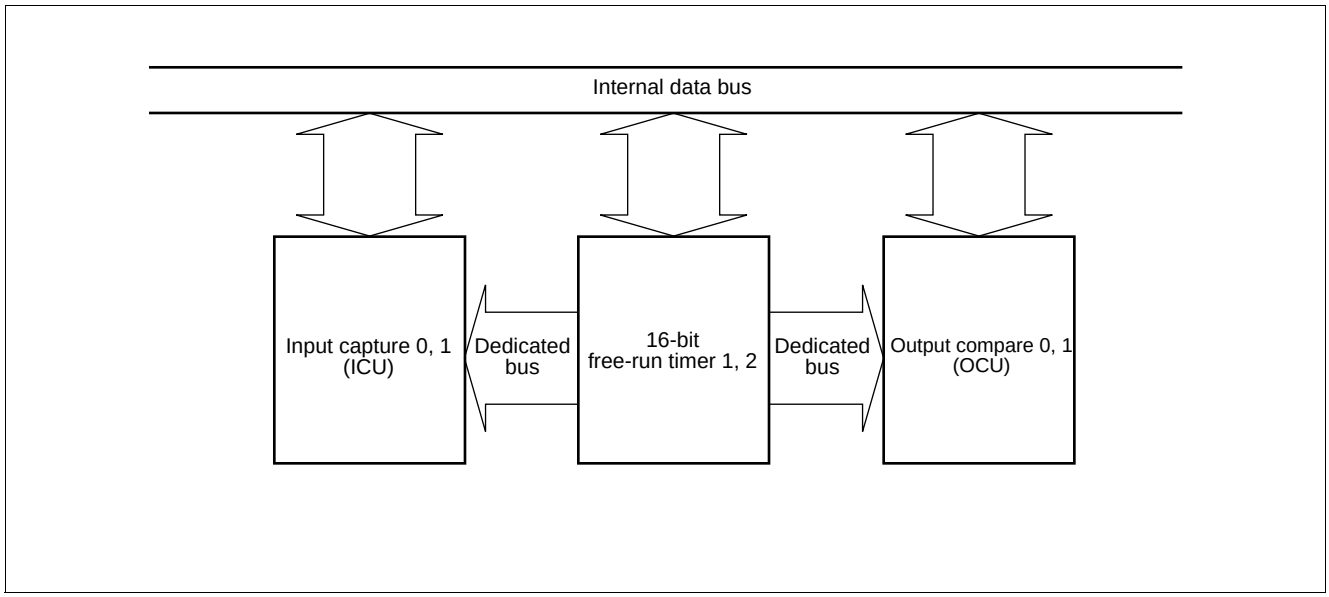


*1: The timer has ch.0 and ch.1, and figures bracketed by < > are for ch.1
*2: Interrupt number
ϕ: Machine clock frequency

6. 16-bit I/O Timer

The 16-bit I/O timer module consists of two 16-bit free-run timers, two input capture circuits (ICU), and eight output comparators (OCU). This module allows two independent waveforms to be output on the basis of the 16-bit free-run timer. Input pulse width and external clock periods can, therefore, be measured.

- **Block diagram**



(1) 16-bit Free-run Timer 1, 2

The 16-bit free-run timer consists of a 16-bit up counter, a control register and a communications prescaler register. The value output from the timer counter is used as basic time (base timer) for input capture (ICU) and output compare (OCU).

- A counter operation clock can be selected from four internal clocks (ϕ/4, ϕ/16, ϕ/64 and ϕ/256).
- An interrupt can be generated by overflow of counter value or compare match with OCU compare register 0 and 4. (Compare match requires mode settings.)
- The counter value can be initialized to "0000H" by a reset, software clear or compare match with OCU compare register 0 and 4.

- **Register configuration**

- Free-run timer data register 1, 2 (TCDT1, TCDT2)

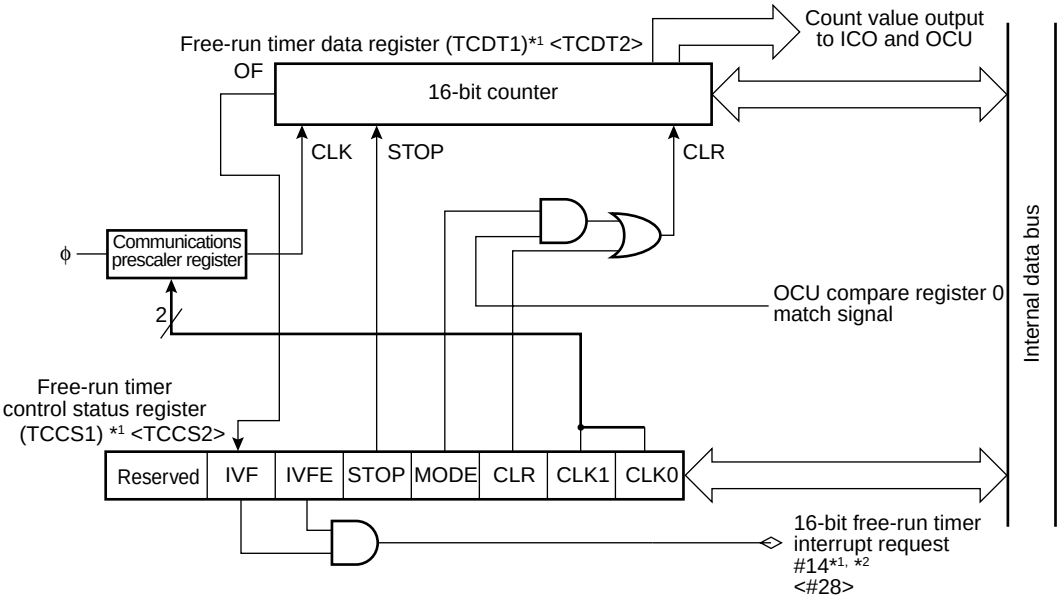
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
TCDT1 : 000057H	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	00000000B
000056H																	00000000B
TCDT2 : 000067H																	00000000B
000066H	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	00000000B

- Free-run timer control status register 1, 2 (TCCS1, TCCS2)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
TCCS1 : 000058H	Reserved	IVF	IVFE	STOP	MODE	CLR	CLK1	CLK0	00000000B
TCCS2 : 000068H	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	00000000B

R/W: Readable and writable

- **Block diagram**



*1: The timer has ch.1 and ch.2, and figures bracketed by < > are for ch.2.
*2: Interrupt number
ϕ : Machine clock frequency
OF : Overflow

(2) Input Capture 0, 1 (ICU)

The input capture (ICU) generates an interrupt request to the CPU while storing the current counter value of the 16-bit free-run timer to the ICU data register (IPCP) upon input of a trigger edge from the external pin.

There are two sets (two channels) of input capture external pins and ICU data registers, enabling measurements of a maximum of four events.

- The input capture has two sets of external input pins (IN0, IN1) and ICU registers (IPCP), enabling measurements of a maximum of four events.
- Trigger edge direction can be selected from rising/falling/both edges.
- The input capture can be set to generate an interrupt request at the storage timing of the counter value of the 16-bit free-run timer to the ICU data register (IPCP).
- The input compare conforms to the extended intelligent I/O service (EI^2OS).
- The input capture (ICU) function is suited for measurements of intervals (frequencies) and pulse-widths.

- **Register configuration**

- ICU data register ch.0 ch.1 (IPCP0, IPCP1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
IPCP0(upper) : 000051H IPCP1(upper) : 000053H	CP15	CP14	CP13	CP12	CP11	CP10	CP09	CP08	XXXXXXXXB
	R	R	R	R	R	R	R	R	

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
IPCP0(lower) : 000050H IPCP1(lower) : 000052H	CP07	CP06	CP05	CP04	CP03	CP02	CP01	CP00	XXXXXXXXB
	R	R	R	R	R	R	R	R	

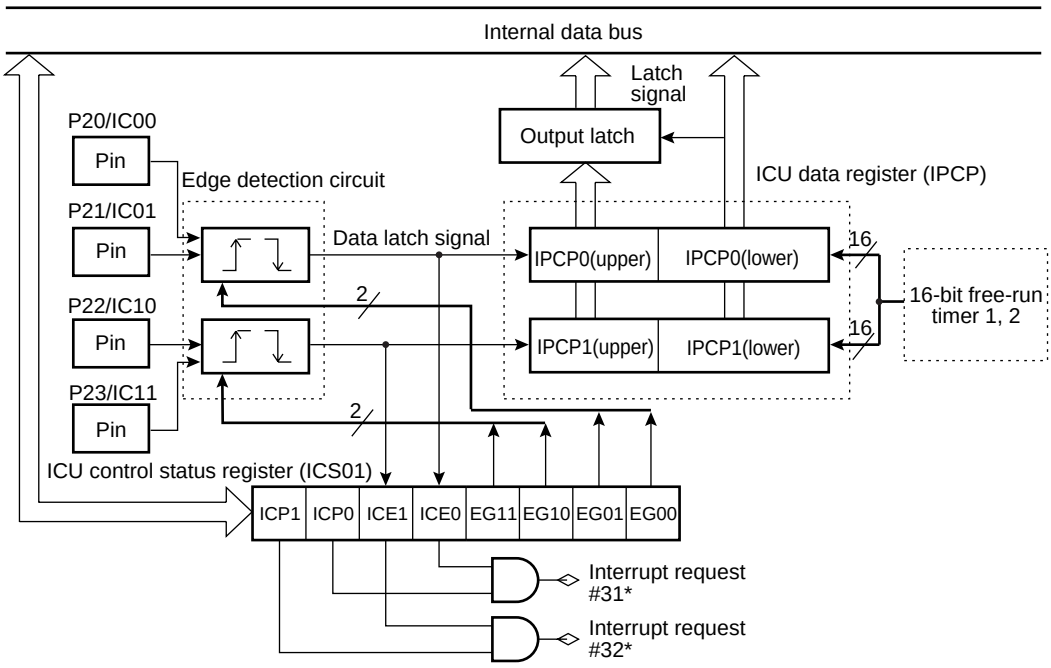
Note: This register holds a 16-bit free-run timer value when the valid edge of the corresponding external pin input waveform is detected. (This register can be word-accessed, but not programmed.)

- ICU control status register (ICS01)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000054H	ICP1	ICP0	ICE1	ICE0	EG11	EG10	EG01	EG00	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W : Readable and writable
R : Read only
X : Indeterminate

- **Block diagram**



* : Interrupt number

(3) Output Compare 0, 1 (OCU)

The output compare (OCU) is two sets of compare units each consisting of an eight-channel OCU compare register, a comparator and a control register.

An interrupt request can be generated for each channel upon a match detection by performing time-division comparison between the OCU compare data register setting value and the counter value of the 16-bit free-run timer.

The OUT pin can be used as a waveform output pin for reversing output upon a match detection or a general-purpose output port for directly outputting the setting value of the CMOD bit.

- **Register Configuration**

- OCU control status register ch.01, ch.23, ch.45, ch.67 (OCS01, OCS23, OCS45, OCS67)

Address
ch.01 : OCS01 (upper) : 0000063H
ch.23 : OCS23 (upper) : 0000065H
ch.45 : OCS45 (upper) : 000002DH
ch.67 : OCS67 (upper) : 000002FH

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
—	—	—	CMOD	OTE1	OTE0	OTD1	OTD0
—	—	—	R/W	R/W	R/W	R/W	R/W

Initial value
XXX00000B

Address
ch.01 : OCS01 (lower) : 000062H
ch.23 : OCS23 (lower) : 000064H
ch.45 : OCS45 (lower) : 00002CH
ch.67 : OCS67 (lower) : 00002EH

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
ICP1	ICP0	ICE1	ICE0	—	—	CST1	CST0
R/W	R/W	R/W	R/W	—	—	R/W	R/W

Initial value
0000XX00B

- OCU control status register ch.0 to ch.7 (OCS0 to OCS7)

Address
ch.0 : OCP0 (upper) : 00005BH
ch.1 : OCP1 (upper) : 00005DH
ch.2 : OCP2 (upper) : 00005FH
ch.3 : OCP3 (upper) : 000061H
ch.4 : OCP4 (upper) : 00000DH
ch.5 : OCP5 (upper) : 00001DH
ch.6 : OCP6 (upper) : 000035H
ch.7 : OCP7 (upper) : 00006DH

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
C15	C14	C13	C12	C11	C10	C09	C08
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Initial value
XXXXXXXXB

Address
ch.0 : OCP0 (lower) : 00005AH
ch.1 : OCP1 (lower) : 00005CH
ch.2 : OCP2 (lower) : 00005EH
ch.3 : OCP3 (lower) : 000060H
ch.4 : OCP4 (lower) : 00000CH
ch.5 : OCP5 (lower) : 00001CH
ch.6 : OCP6 (lower) : 000034H
ch.7 : OCP7 (lower) : 00006CH

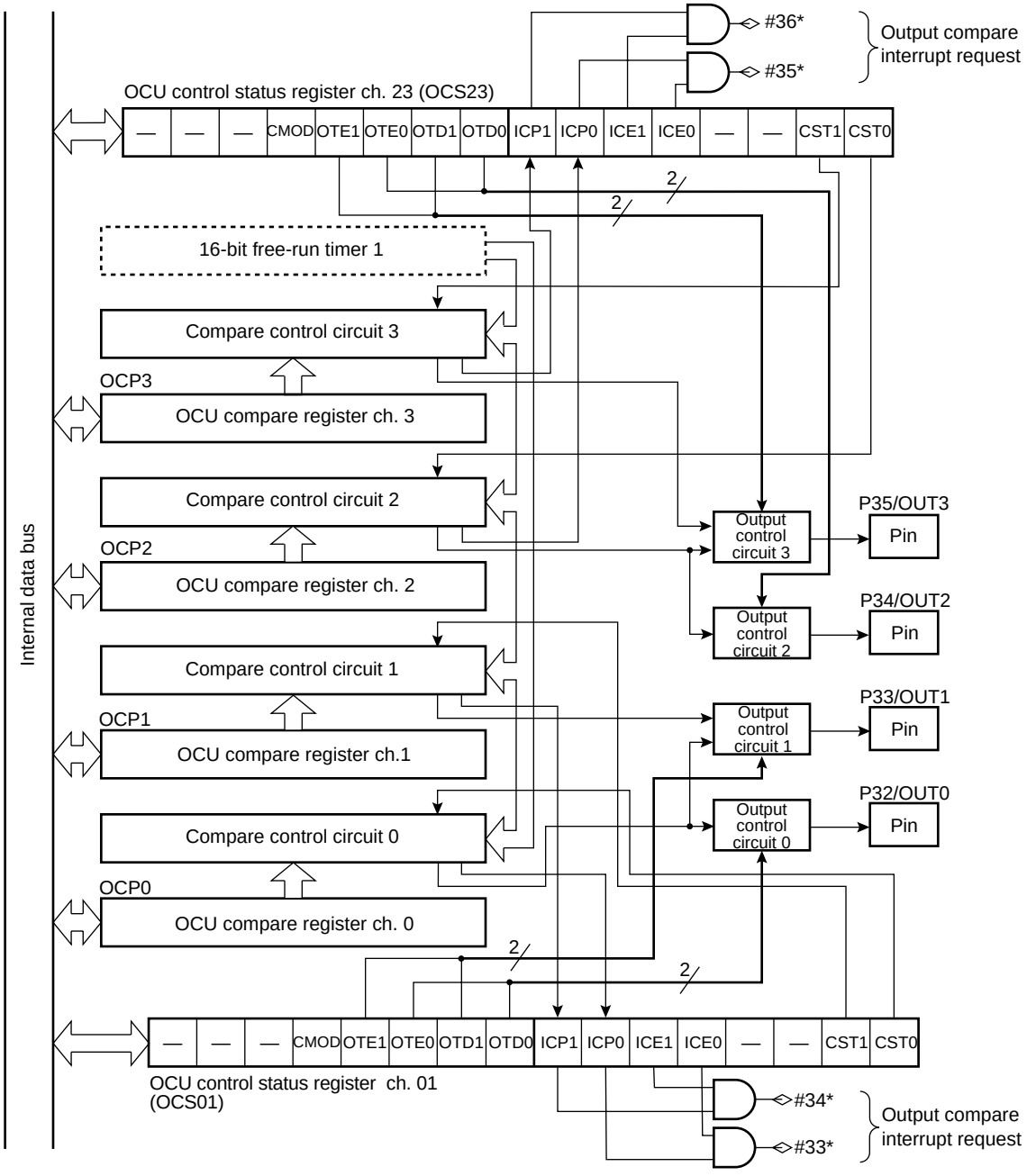
bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
C07	C06	C05	C04	C03	C02	C01	C00
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Initial value
XXXXXXXXB

R/W : Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

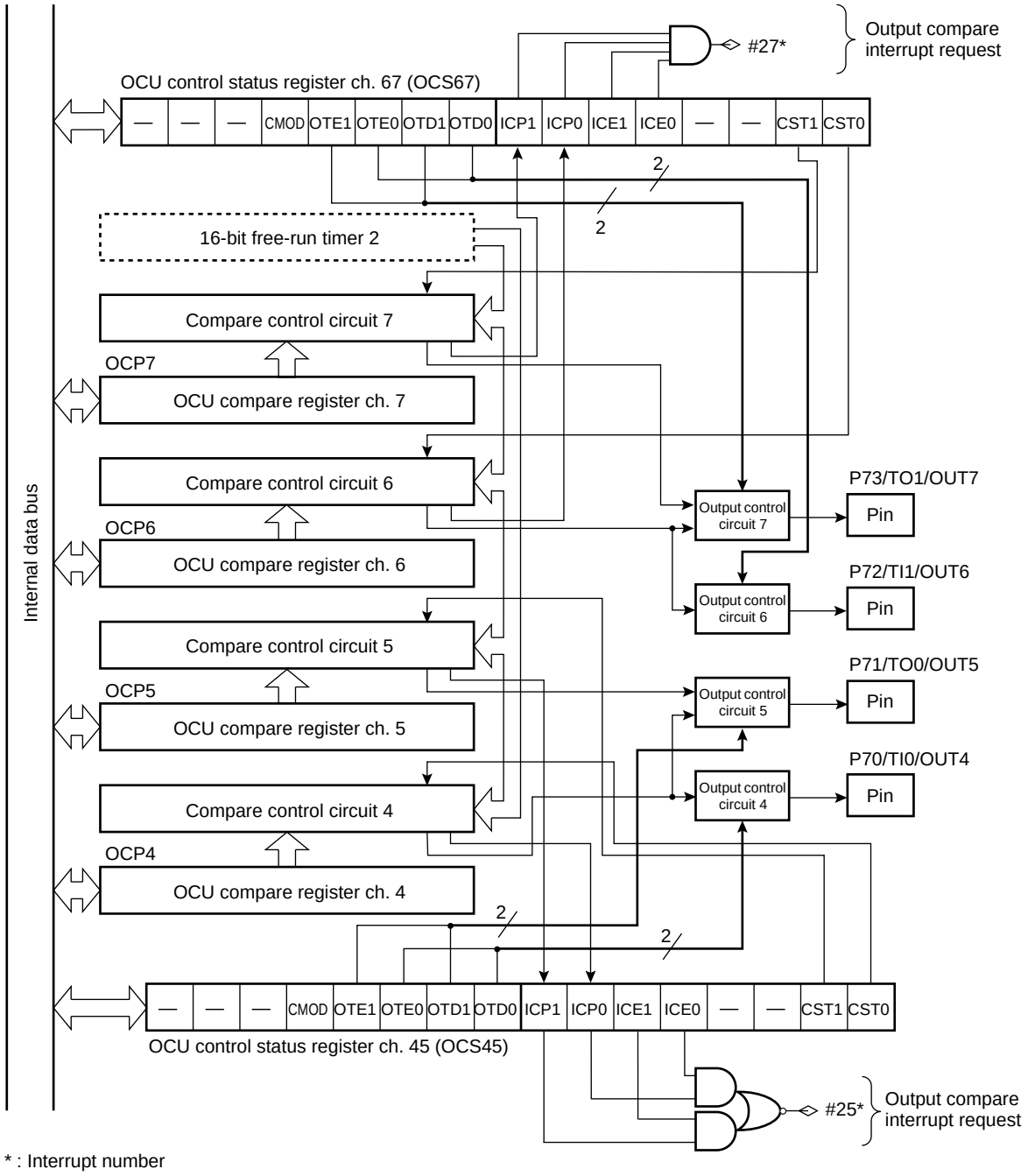
- **Block diagram**

- **Output compare 0 (OCU)**



* : Interrupt number

- **Output compare 1(OCU)**



7. 8/16-bit Up/Down Counter/Timer 0, 1

The 8/16-bit up/down counter/timer consists of six event input pins, two 8-bit up/down counters, two 8-bit re-load compare registers, and their controllers.

(1) Register Configuration

- Up/down count register 0 (UDCR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000080H	D07	D06	D05	D04	D03	D02	D01	D00	00000000B
	R	R	R	R	R	R	R	R	

- Up/down count register 1 (UDCR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000081H	D17	D16	D15	D14	D13	D12	D11	D10	00000000B
	R	R	R	R	R	R	R	R	

- Re-load compare register 0 (RCR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000082H	D07	D06	D05	D04	D03	D02	D01	D00	00000000B
	W	W	W	W	W	W	W	W	

- Re-load compare register 1 (RCR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000083H	D17	D16	D15	D14	D13	D12	D11	D10	00000000B
	W	W	W	W	W	W	W	W	

- Counter status register 0, 1 (CSR0, CSR1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
CSR0 : 000084H CSR1 : 000088H	CSTR	CITE	UDIE	CMPF	OVFF	UDFF	UDF1	UDF0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R	R	

- Counter control register 0, 1 (CCRL0, CCRL1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
CCRL0 : 000086H CCRL1 : 00008AH	—	CTUT	UCRE	RLDE	UDCC	CGSC	CGE1	CGE0	X0000000B
	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Counter control register 0 (CCRH0)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000087H	M16E	CDCF	CFIE	CLKS	CMS1	CMS0	CES1	CES0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

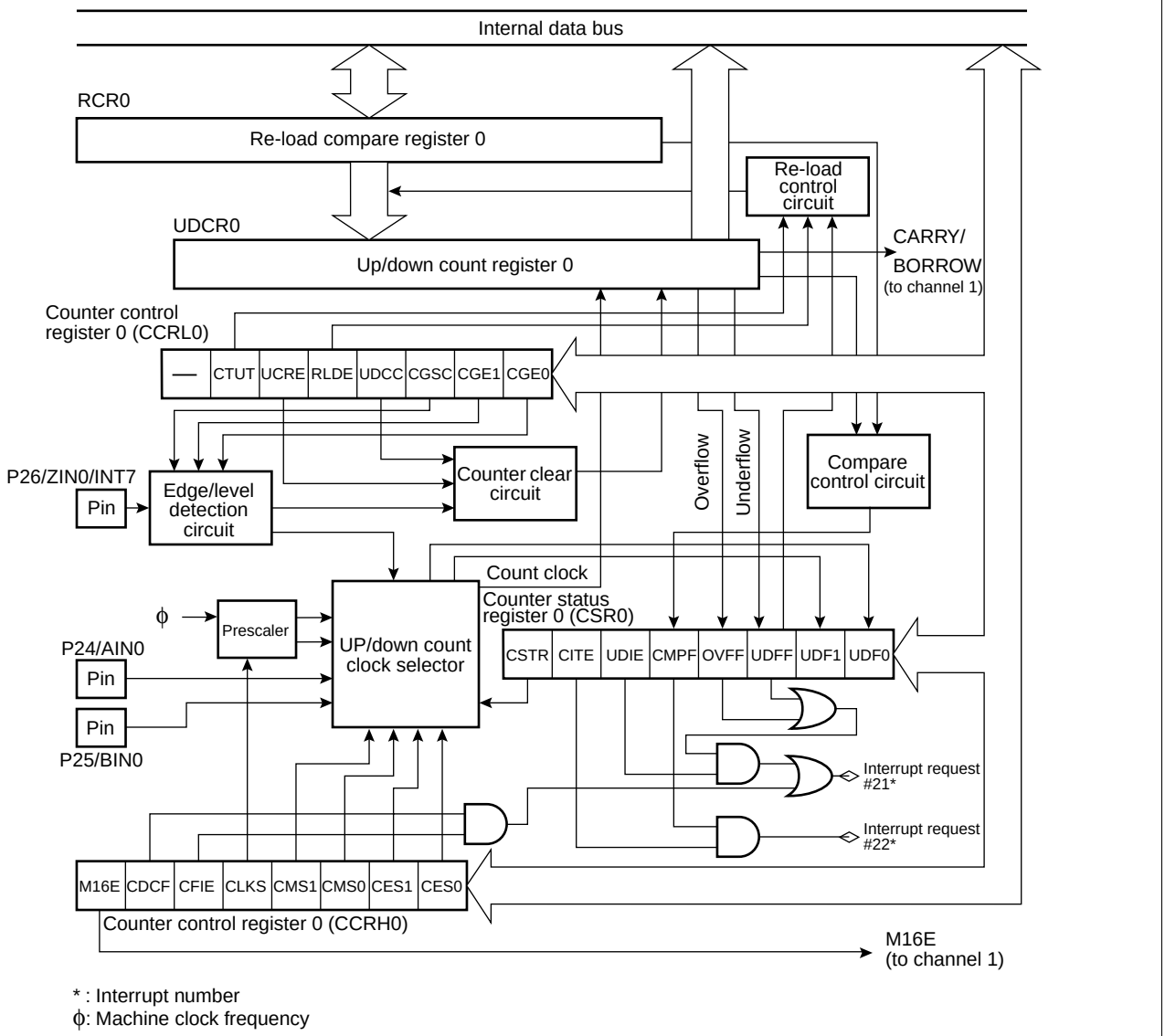
- Counter control register 1 (CCRH1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00008BH	—	CDCF	CFIE	CLKS	CMS1	CMS0	CES1	CES0	X0000000B
	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W : Readable and writable
R : Read only
W : Write only
— : Undefined bits (read value undefined)

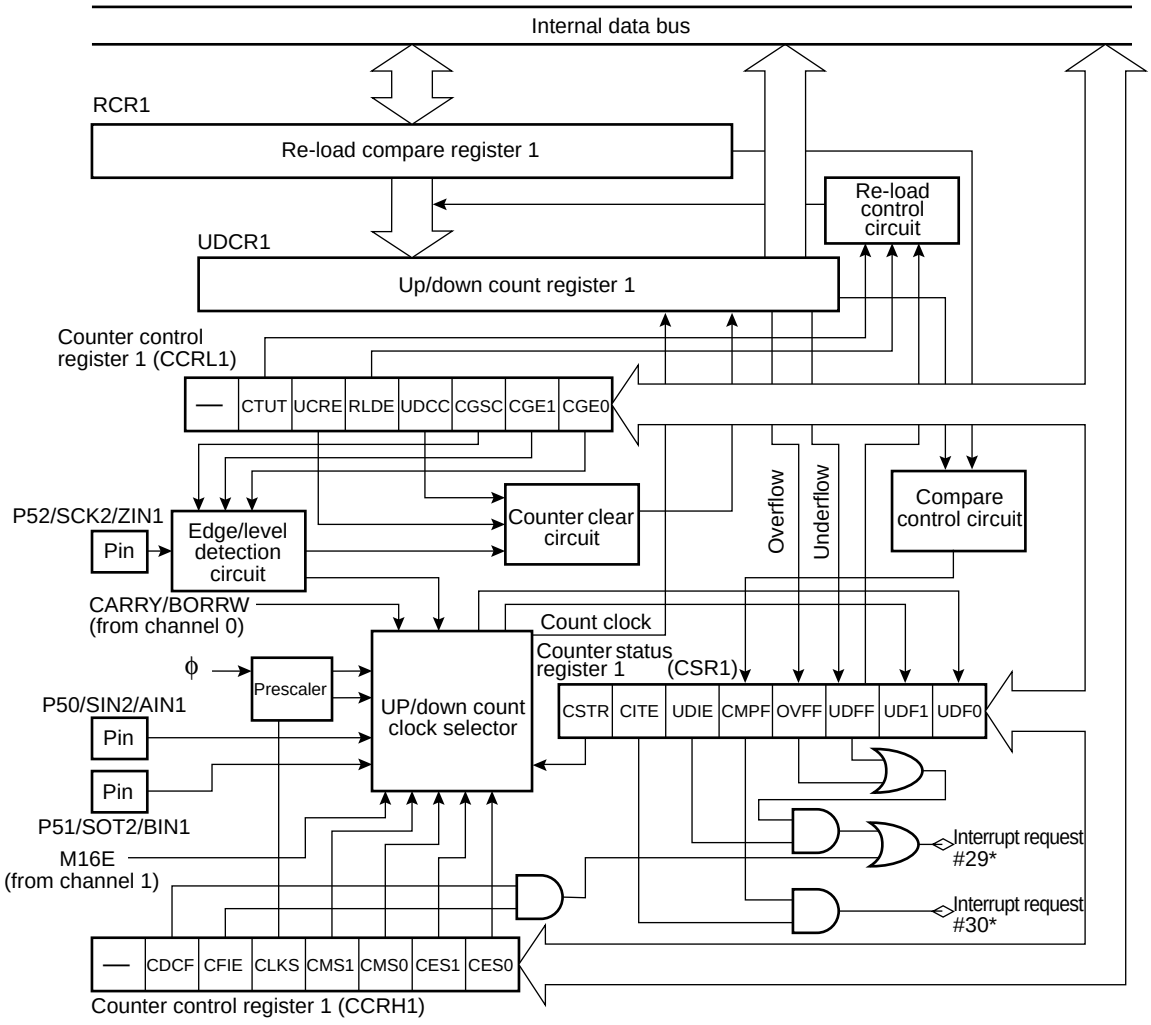
(2) Block Diagram

- **Block diagram of 8/16-bit up/down counter/timer 0**



* : Interrupt number
ϕ: Machine clock frequency

- **Block diagram of 8/16-bit up/down counter/timer 1**



* : Interrupt number
ϕ: Machine clock frequency

8. Extended I/O Serial Interface 0, 1

The extended I/O serial interface transfers data using a clock synchronization system having an 8-bit x 1 channel configuration.

For data transfer, you can select LSB first/MSB first.

(1) Register Configuration

- Serial mode control upper status register 0, 1 (SMCSH0, SMCSH1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
SMCSH0 : 000025H SMCSH1 : 000029H	SMD2	SMD1	SMD0	SIE	SIR	BUSY	STOP	STRT	00000010B
	R/W	R/W	R/W	R/W	R/W	R	R/W	R/W	

- Serial mode control lower status register 0, 1 (SMCSL0, SMCSL1)

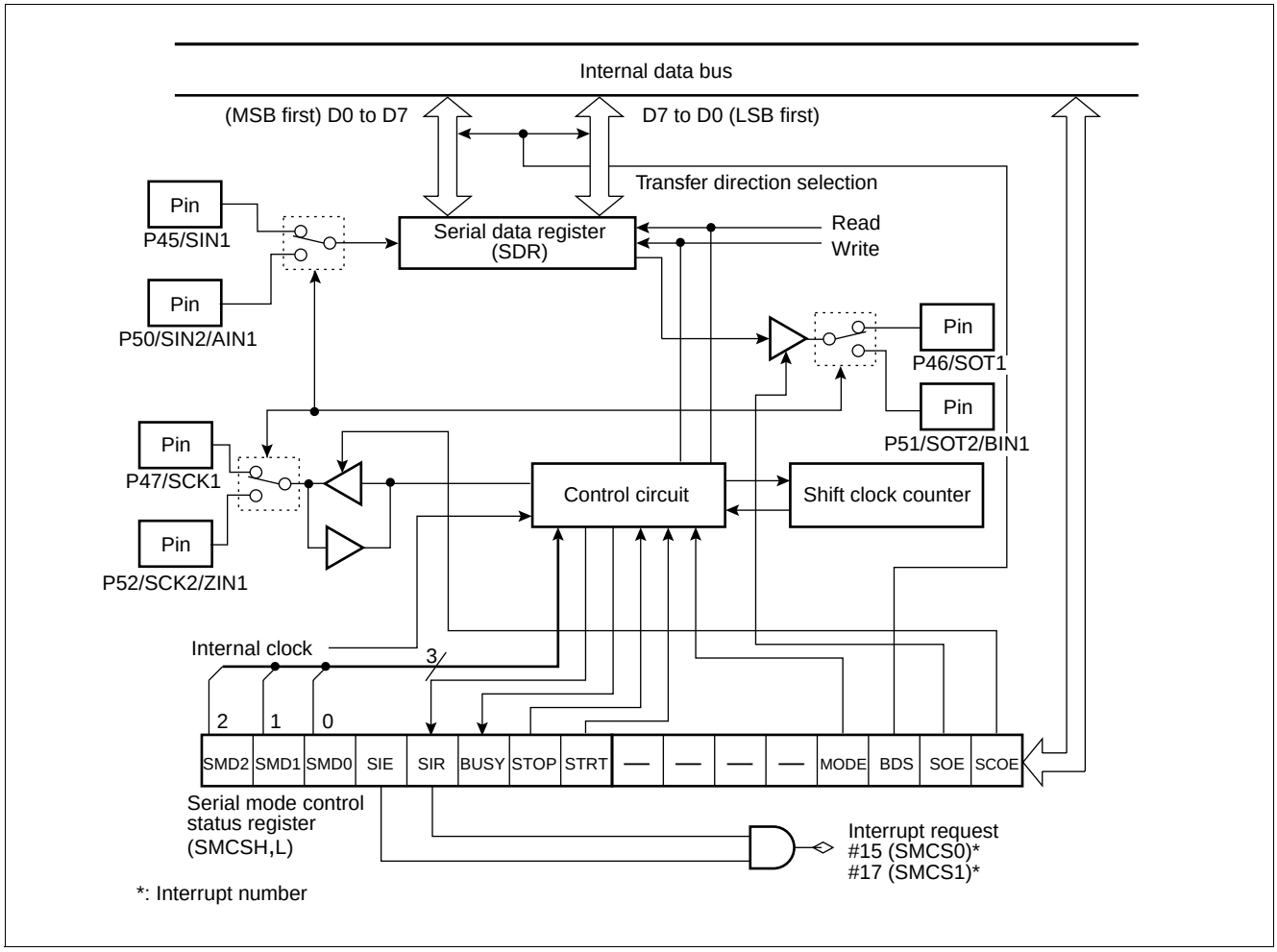
Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
SMCSL0 : 000024H SMCSL1 : 000028H	—	—	—	—	MODE	BDS	SOE	SCOE	XXXX0000B
	—	—	—	—	R/W	R/W	R/W	R/W	

- Serial data register 0, 1 (SDR0, SDR1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
SDR0 : 000026H SDR1 : 00002AH	D7	D6	D5	D4	D3	D2	D1	D0	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W : Readable and writable
R : Read only
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram



9. UART (SCI)

UART (SCI) is a general-purpose serial data communication interface for performing synchronous or asynchronous communication (start-stop synchronization system).

- Data buffer: Full-duplex double buffer
- Transfer mode: Clock synchronized (with start and stop bit)
  Clock asynchronized (start-stop synchronization system)
- Baud rate: Embedded dedicated baud rate generator
  External clock input possible
  Internal clock (a clock supplied from 16-bit re-load timer 0 can be used.)

  Asynchronization 9615 bps/31250 bps/4808 bps/2404 bps/1202 bps
  CLK synchronization 1 Mbps/500 kbps/250 kbps/125 kbps/62.5 kbps
  } Internal machine clock For 6 MHz, 8 MHz, 10 MHz, 12 MHz and 16 MHz
- Data length: 8 bit (without a parity bit)
  7 bit (with a parity bit)
- Signal format: NRZ (Non Return to Zero) system
- Reception error detection: Framing error
  Overrun error
  Parity error (multi-processor mode is supported, enabling setup of any baud rate by an external clock.)
- Interrupt request: Receive interrupt (reception complete, receive error detection)
  Transmit interrupt (transmisson complete)
  Transmit/receive conforms to extended intelligent I/O service (EI^{2}OS)

(1) Register Configuration

- Serial control register (SCR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000021H	PEN	P	SBL	CL	A/D	REC	RXE	TXE	00000100B
	R/W	R/W	R/W	R/W	R/W	W	R/W	R/W	

- Serial mode register (SMR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000020H	MD1	MD0	CS2	CS1	CS0	Reserved	SCKE	SOE	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Serial status register (SSR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000023H	PE	ORE	FRE	RDRF	TRDE	—	RIE	TIE	00001X00B
	R	R	R	R	R	—	R/W	R/W	

- Serial input data register (SIDR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000022H	D7	D6	D5	D4	D3	D2	D1	D0	XXXXXXXXB
	R	R	R	R	R	R	R	R	

- Serial output data register (SODR)

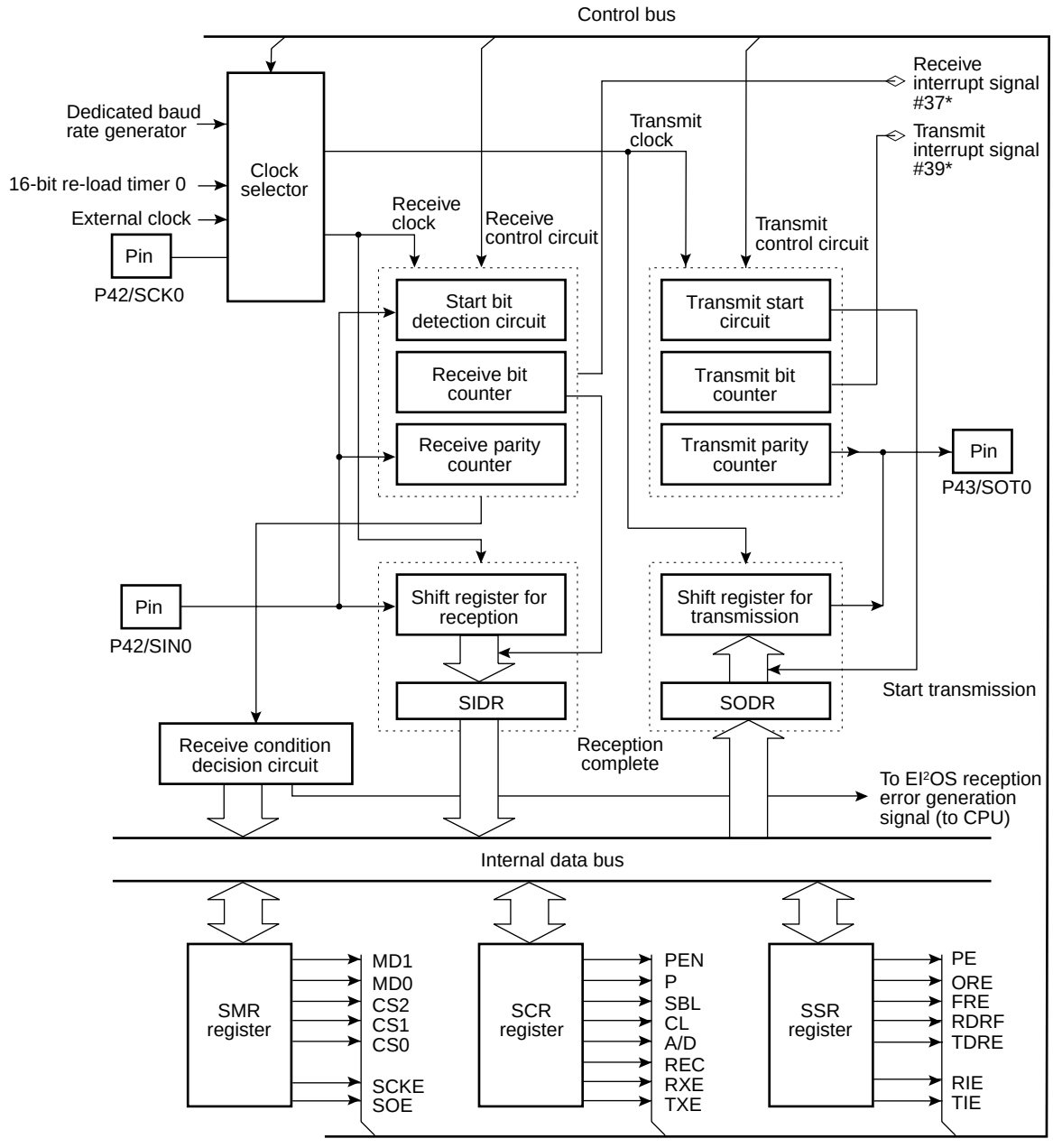
Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000022H	D7	D6	D5	D4	D3	D2	D1	D0	XXXXXXXXB
	W	W	W	W	W	W	W	W	

- Communications prescaler control register (CDCR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000027H	MD	—	—	—	DIV3	DIV2	DIV1	DIV0	0XXX1111B
	R/W	—	—	—	R/W	R/W	R/W	R/W	

R/W:Readable and writable
R : Read only
W : Write only
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram



* : Interrupt number

10. DTP/External Interrupt Circuit

The DTP (Data Transfer Peripheral), which is located between the peripheral circuit outside the device and the F²MC-16LX CPU, receives an interrupt request or DMA request generated by the external peripheral circuit* for transmission to the F²MC-16LX CPU. It is used to activate the intelligent I/O service or interrupt processing. As with request levels, two types of “H” and “L” can be selected for the intelligent I/O service. Rising and falling edges as well as “H” and “L” can be selected for an external interrupt request.

* : The external peripheral circuit is connected outside the MB90520 series device.

(1) Register Configuration

- DTP/interrupt factor register (EIRR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000031H	ER7	ER6	ER5	ER4	ER3	ER2	ER1	ER0	XXXXXXXXB
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- DTP/interrupt enable register (ENIR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000030H	EN7	EN6	EN5	EN4	EN3	EN2	EN1	EN0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

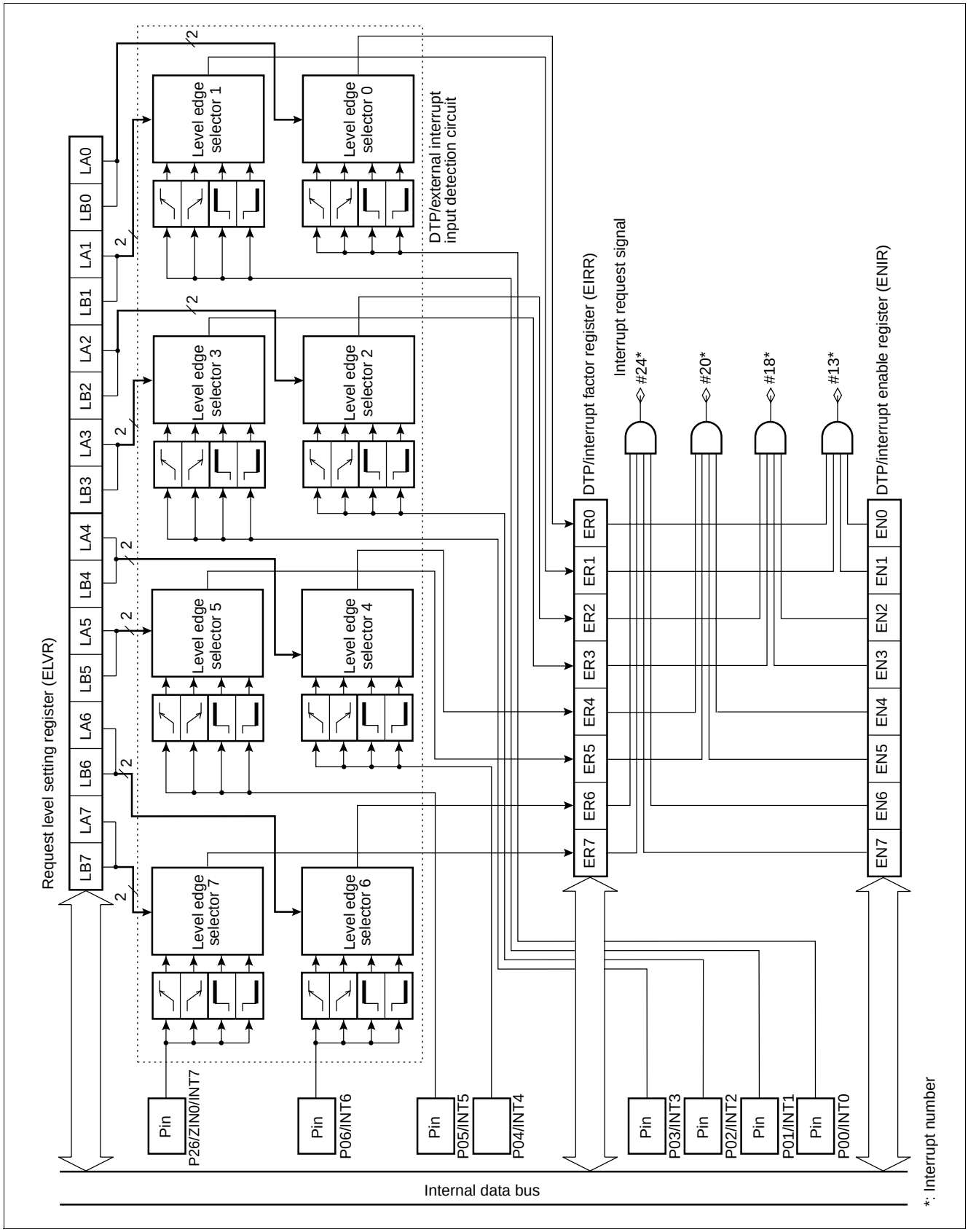
- Request level setting register (ELVR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
ELVR (lower) : 000032H	LB3	LA3	LB2	LA2	LB1	LA1	LB0	LA0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
ELVR (upper) : 000033H	LB7	LA7	LB6	LA6	LB5	LA5	LB4	LA4	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W: Readable and writable
X : Indeterminate

(2) Block Diagram



11. Wake-up Interrupt

Wake-up interrupts transmit interrupt request (“L” level) generated by peripheral equipment located between external peripheral devices and the F²MC-16LX CPU to the CPU and invoke interrupt processing.

The interrupt does not conform to the exterded intelligent I/O service (EI²OS).

(1) Register Configuration

- Wake-up interrupt flag register (EIFR)

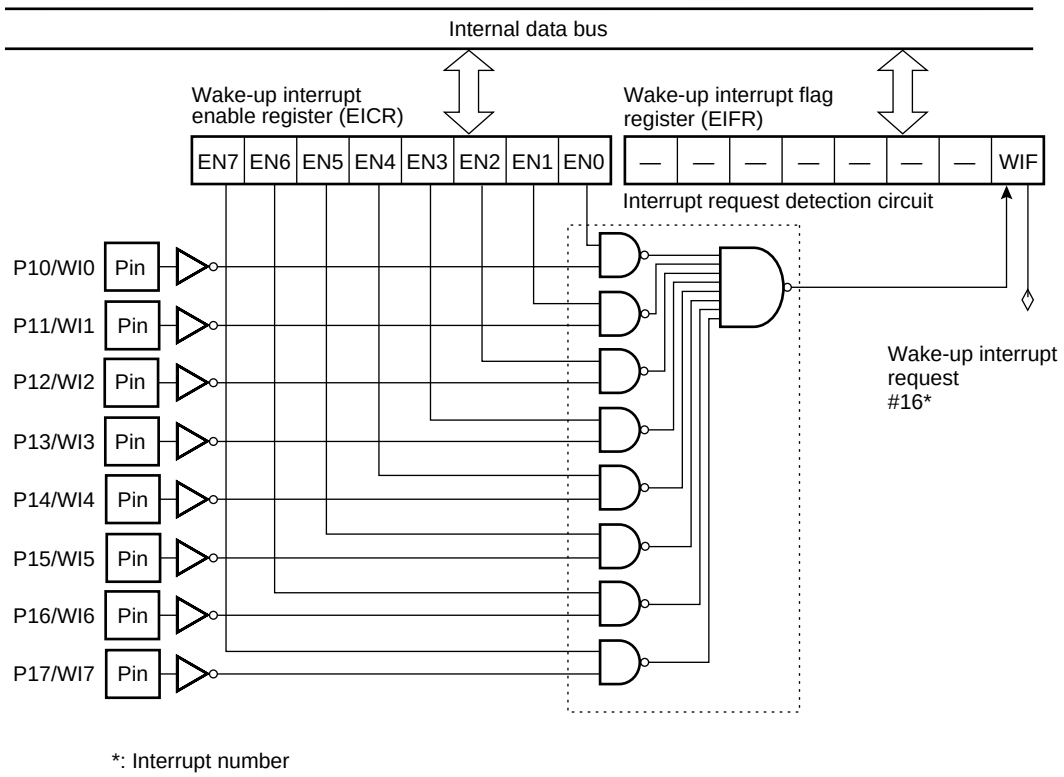
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00000F$_H$	—	—	—	—	—	—	—	WIF	XXXXXXX0$_B$
	—	—	—	—	—	—	—	R/W	

- Wake-up interrupt enable register (EICR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00001F$_H$	EN7	EN6	EN5	EN4	EN3	EN2	EN1	EN0	00000000$_B$
	W	W	W	W	W	W	W	W	

R/W: Readable and writable
W : Write only
— : Undefined bits (read value undefined)

(2) Block Diagram



12. Delayed Interrupt Generation Module

The delayed interrupt generation module generates interrupts for switching tasks. By using this module, hardware interrupt requests to the CPU can be generated and cancelled using software.

This module does not conform to the extended intelligent I/O service (EI^{2}OS).

(1) Register Configuration

- Delayed interrupt factor generation/cancellation register (DIRR)

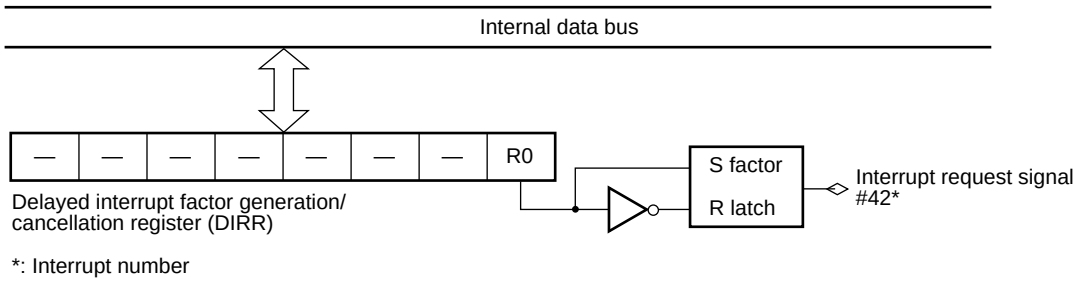
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00009F$_H$	—	—	—	—	—	—	—	R0	XXXXXXX0$_B$
	—	—	—	—	—	—	—	R/W	

Note: Upon a reset, an interrupt is cancelled.

R/W: Readable and writable
— : Undefined bits (read value undefined)

The DIRR is the register used to control delay interrupt request generation/cancellation. Programming this register with “1” generates a delay interrupt request. Programming this register with “0” cancels a delay interrupt request. Upon a reset, an interrupt is canceled. The undefined bit area can be programmed with either “0” or “1.” For future extension, however, it is recommended that bit set and clear instructions be used to access this register.

(2) Block Diagram



13. 8/10-bit A/D Converter

The 8/10-bit A/D converter converts analog voltage input to the analog input pins (input voltage) to digital values (A/D conversion) and has the following features:

- Minimum conversion time: minimum 15.0 μs (at machine clock frequency of 16 MHz, including sampling time)
- Minimum sampling period: 4 μs/8 μs (at machine clock frequency of 16 MHz)
- Compare time: 99/176 machine cycles per channel
  (99 machine cycles are used for a machine clock frequency below 10 MHz.)
- Conversion method: RC successive approximation method with a sample and hold circuit
- 8/10-bit resolution
- Analog input pins: Selectable from eight channels by software
  Single conversion mode: Selects and converts one channel.
  Scan conversion mode: Converts two or more successive channels. Up to eight channels can be programmed.
  Continuous conversion mode: Repeatedly converts specified channels.
  Stop conversion mode: Stops conversion after completing a conversion for one channel and wait for the next activation (conversion can be started synchronously).
- Interrupt requests can be generated and the extended intelligent I/O service (EI^{2}OS) can be started after the end of A/D conversion. Furthermore, A/D conversion result data can be transferred to the memory, enabling efficient continuous processing.
- When interrupts are enabled, there is no loss of data even in continuous operations because the conversion data protection function is in effect.
- Starting factors for conversion: Selectable from software activation, external trigger (falling edge) and timer (rising edge).

(1) Register Configuration

- A/D control status register upper digits (ADCS2)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000037H	BUSY	INT	INTE	PAUS	STS1	STS0	STRT	Reserved	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	W	R/W	

- A/D control status register lower digits (ADCS1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000036H	MD1	MD0	ANS2	ANS1	ANS0	ANE2	ANE1	ANE0	00000000B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- A/D data register upper digits (ADCR2)

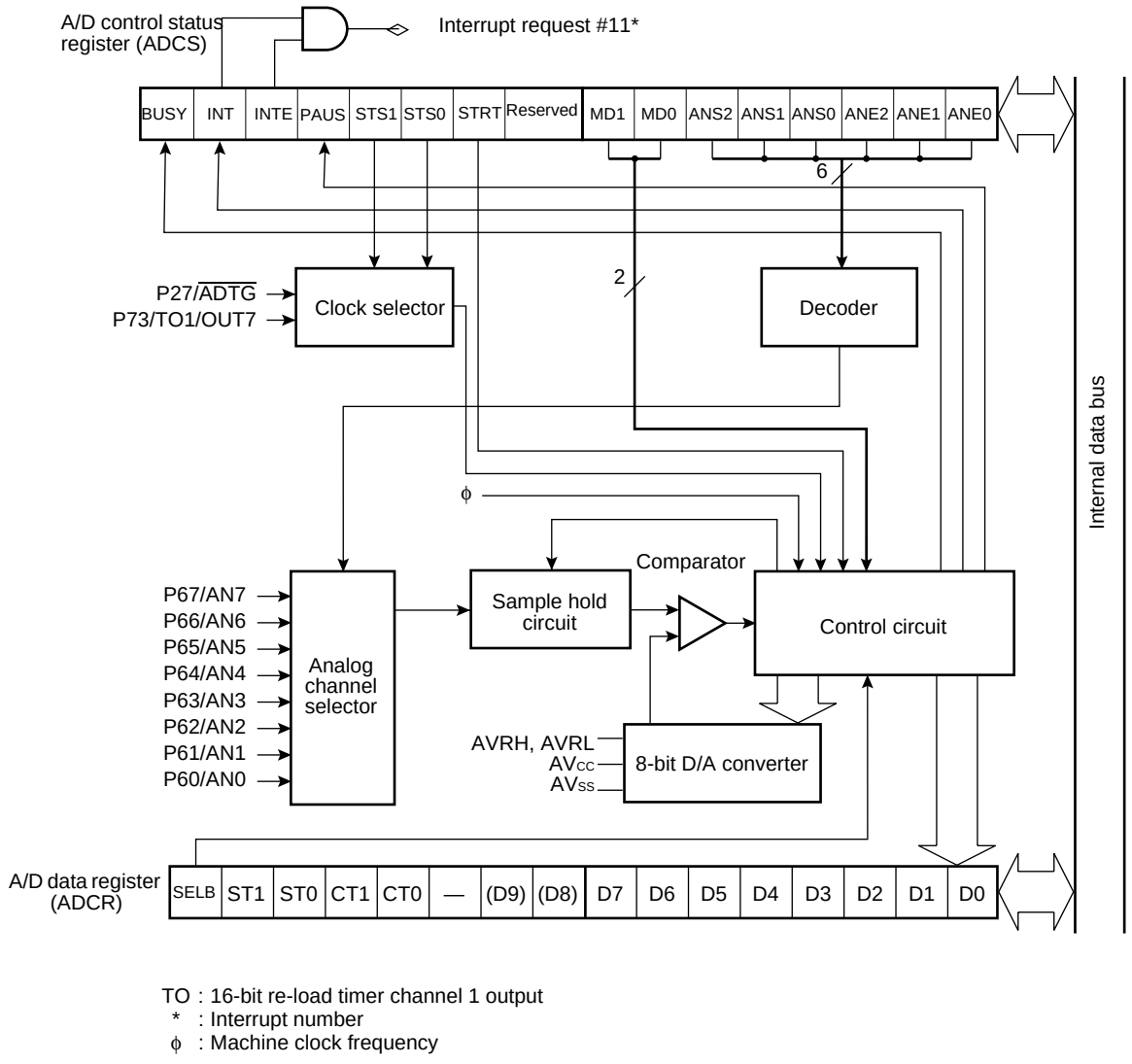
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000039H	SELB	ST1	ST0	CT1	CT0	—	(D9)	(D8)	00001XXXB
	W	W	W	W	W	—	R	R	

- A/D data register lower digits (ADCR1)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000038H	D7	D6	D5	D4	D3	D2	D1	D0	XXXXXXXXB
	R	R	R	R	R	R	R	R	

R/W: Readable and writable
R : Read only
W : Write only
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram



TO : 16-bit re-load timer channel 1 output
* : Interrupt number
ϕ : Machine clock frequency

14. 8-bit D/A Converter

The 8-bit D/A converter, which is based on the R-2R system, supports 8-bit resolution mode. It contains two channels, each of which can be controlled in terms of output by the D/A control register.

(1) Register Configuration

- D/A converter data register ch.0 (DADR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00003A$_H$	DA07	DA06	DA05	DA04	DA03	DA02	DA01	DA00	XXXXXXXX$_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- D/A converter data register ch.1 (DADR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00003B$_H$	DA17	DA16	DA15	DA14	DA13	DA12	DA11	DA10	XXXXXXXX$_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- D/A control register 0 (DACR0)

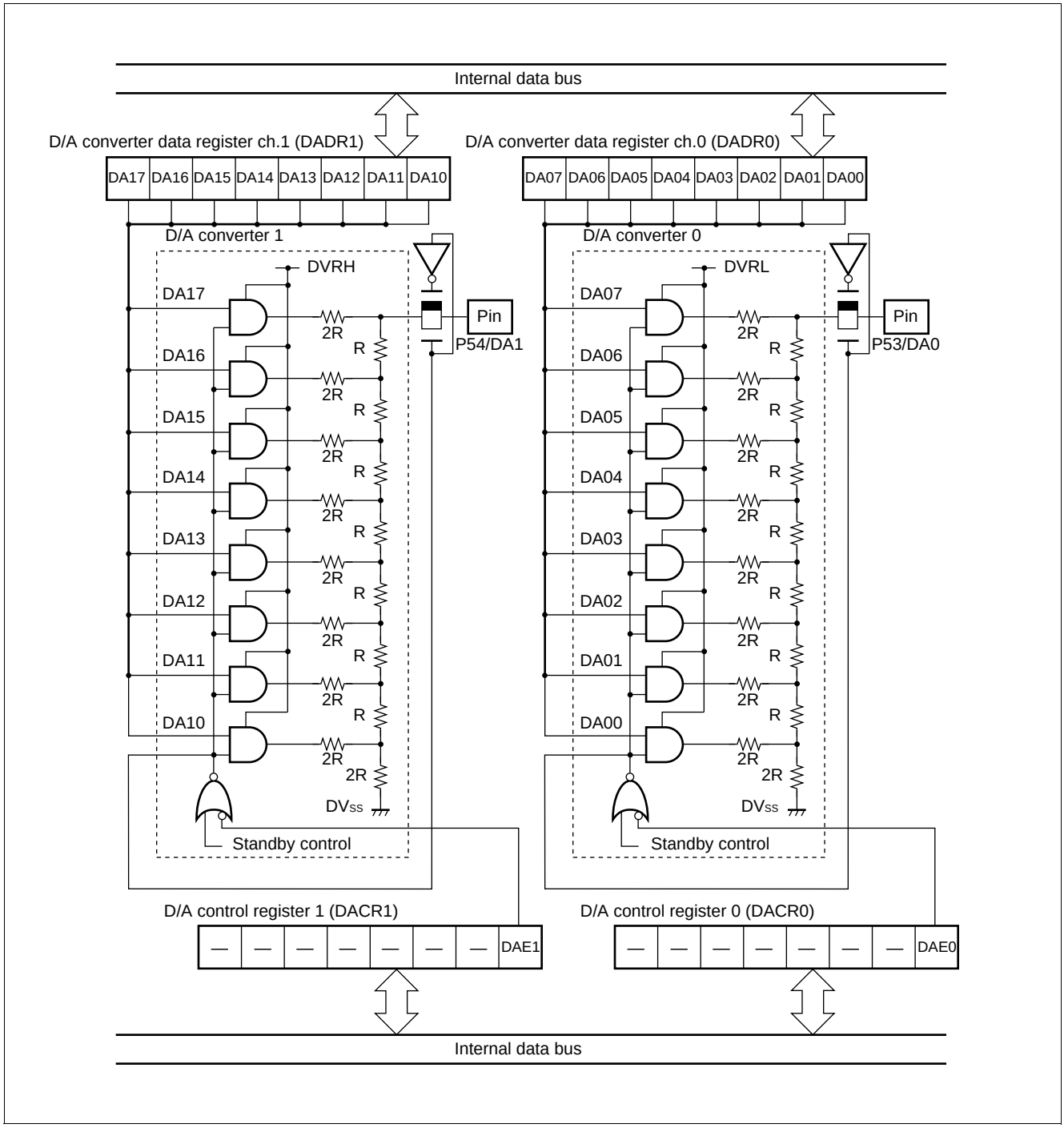
Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00003C$_H$	—	—	—	—	—	—	—	DAE0	XXXXXXX0$_B$
	—	—	—	—	—	—	—	R/W	

- D/A control register 1 (DACR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00003D$_H$	—	—	—	—	—	—	—	DAE1	XXXXXXX0$_B$
	—	—	—	—	—	—	—	R/W	

R/W: Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

- **Block Diagram**



15. Clock Timer

The clock timer control register (WTC) controls operation of the clock timer, and time for an interval interrupt.

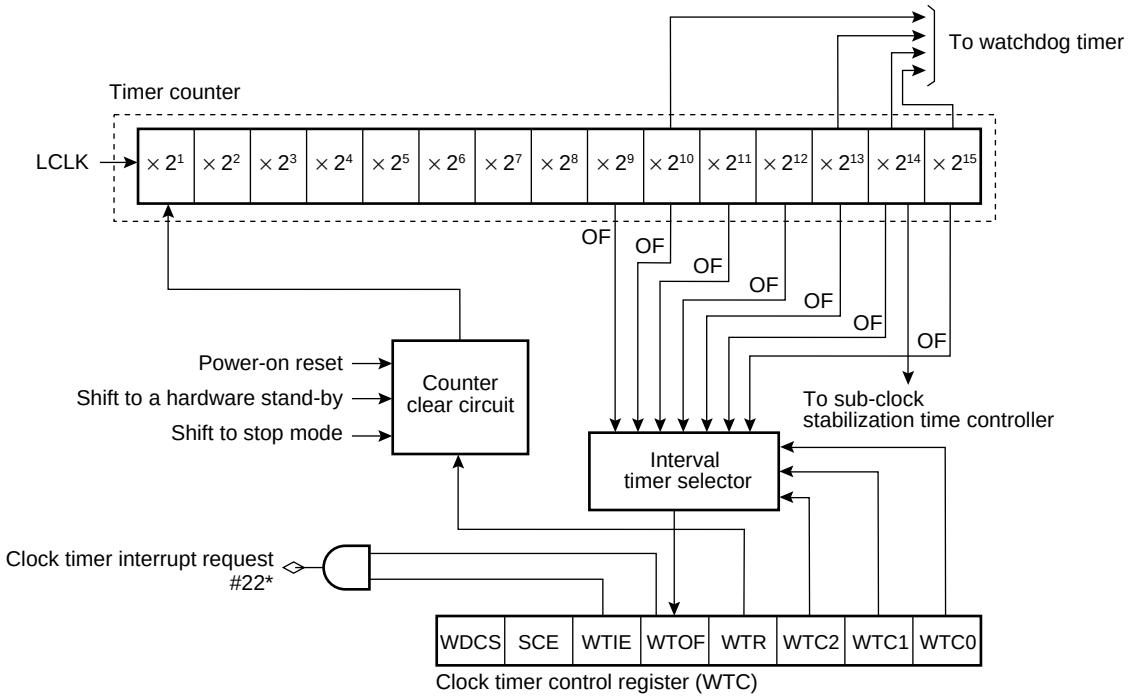
(1) Register Configuration

- Clock timer control register (WTC)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
0000AA$_H$	WDCS	SCE	WTIE	WTOF	WTR	WTC2	WTC1	WTC0	1X001000$_B$
	R/W	R	R/W	R/W	R/W	R/W	R/W	R/W	

R/W: Readable and writable
R : Read only
X : Indeterminate

(2) Block Diagram



* : Interrupt number
OF : Overflow
LCLK : Sub-clock frequency

16.LCD Controller/Driver

The LCD (liquid crystal display) controller/driver, which contains a 16-byte display data memory, controls LCD indication using four common output pins and 32 segment output pins. It can select three types of duty output and directly drive the LCD panel.

(1) Register Configuration

- LCDC control register 0 (LCR0)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
00006A$_H$	CSS	LCEN	VSEL	BK	MS1	MS0	FP1	FP0	00010000$_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- LCDC control register 1 (LCR1)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00006B$_H$	Reserved	SEG5	SEG4	Reserved	SEG3	SEG2	SEG1	SEG0	00000000$_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Port 7/COM pin selection register (LCDCMR)

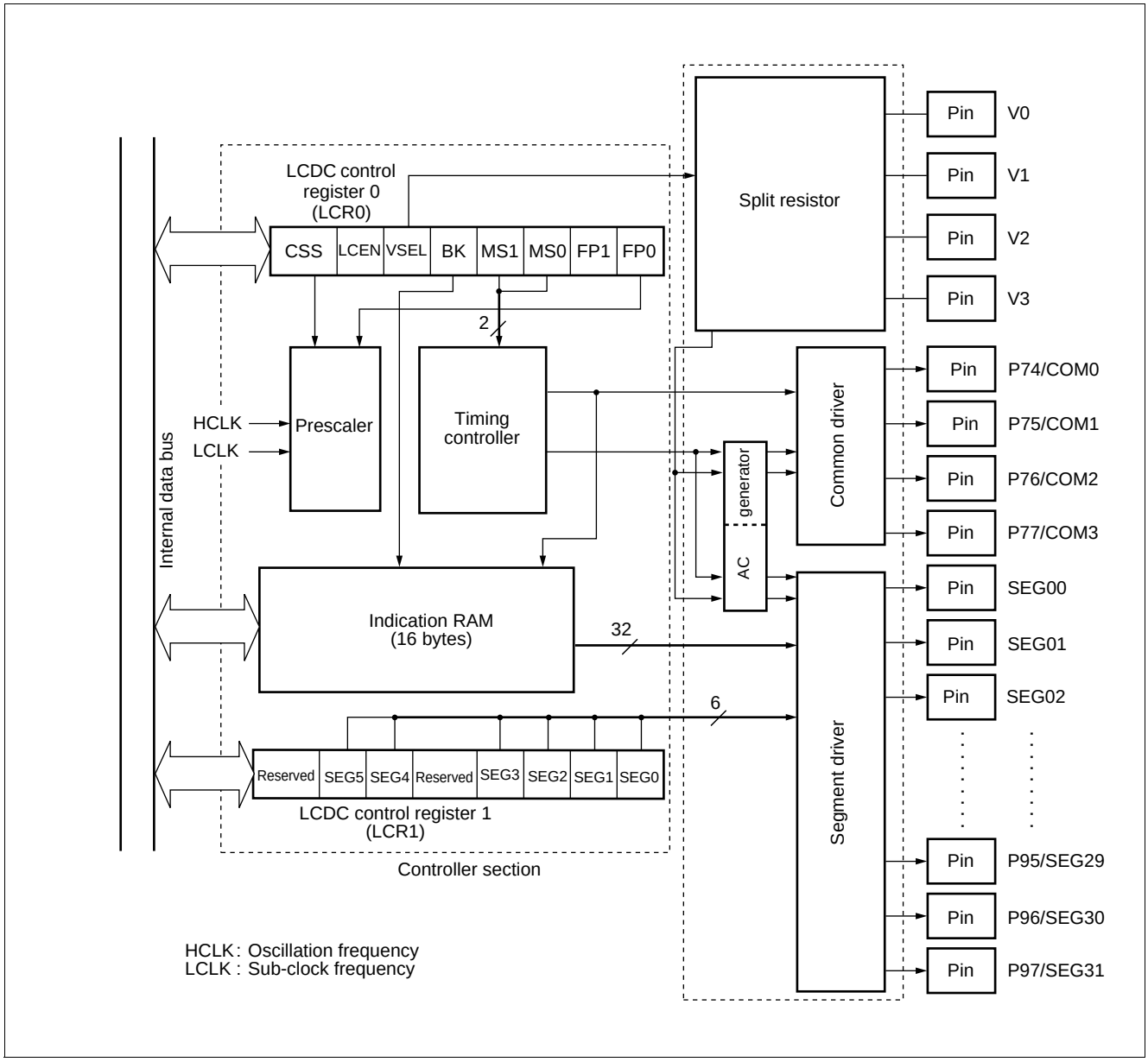
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00000B$_H$	—	—	—	—	COM3	COM2	COM1	COM0	XXXX0000$_B$
	—	—	—	—	R/W	R/W	R/W	R/W	

- RAM for LCD indication (VRAM)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
000070$_H$ to 00007F$_H$	b7	b6	b5	b4	b3	b2	b1	b0	XXXXXXXX$_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W: Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram



17. Communications Prescaler Register

This register controls machine clock division.
Output from the communications prescaler register is used for UART (SCI) and extended I/O serial interface.

The communications prescaler register is so designed that a constant baud rate may be acquired for various machine clocks.

(1) Register Configuration

- Communications prescaler control register (CDCR)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
000027H	MD	—	—	—	DIV3	DIV2	DIV1	DIV0	0XXX1111B
	R/W	—	—	—	R/W	R/W	R/W	R/W	

R/W: Readable and writable
— : Undefined bits (read value undefined)

18. Address Match Detection Function

When the address is equal to a value set in the address detection register, the instruction code loaded into the CPU is replaced forcibly with the INT9 instruction code (01H). As a result, when the CPU executes a set instruction, the INT9 instruction is executed. Processing by the INT#9 interrupt routine allows the program patching function to be implemented.

Two address detection registers are supported. An interrupt enable bit is prepared for each register. If the value set in the address detection register matches an address and if the interrupt enable bit is set at "1," the instruction code loaded into the CPU is replaced forcibly with the INT9 instruction code.

(1) Register Configuration

- Program address detection register 0 to 2 (PADR0)

Address	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16	Initial value
PADR0 (High order address) : $001FF2_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
PADR0 (Middle order address) : $001FF1_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
PADR0 (Low order address) : $001FF0_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Program address detection register 3 to 5 (PADR1)

Address	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16	Initial value
PADR1 (High order address) : $001FF5_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
PADR1 (Middle order address) : $001FF4_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

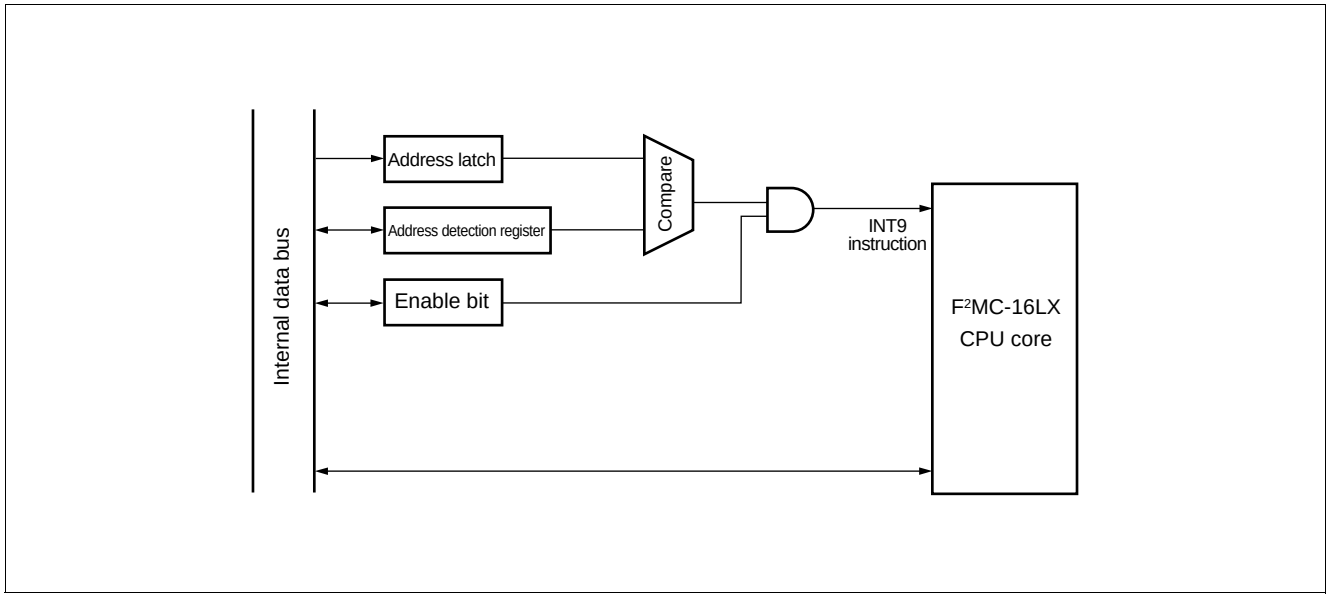
Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
PADR1 (Low order address) : $001FF3_H$									$XXXXXXXX_B$
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

- Program address detection control status register (PACSR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
$00009E_H$	Reserved	Reserved	Reserved	Reserved	AD1E	Reserved	AD0E	Reserved	00000000_B
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

R/W: Readable and writable
X : Indeterminate
— : Undefined bits (read value undefined)

(2) Block Diagram



19. ROM Mirroring Function Selection Module

The ROM mirror function select module enables the ROM data from the FF bank to be read also from the 00 bank.

(1) Register Configuration

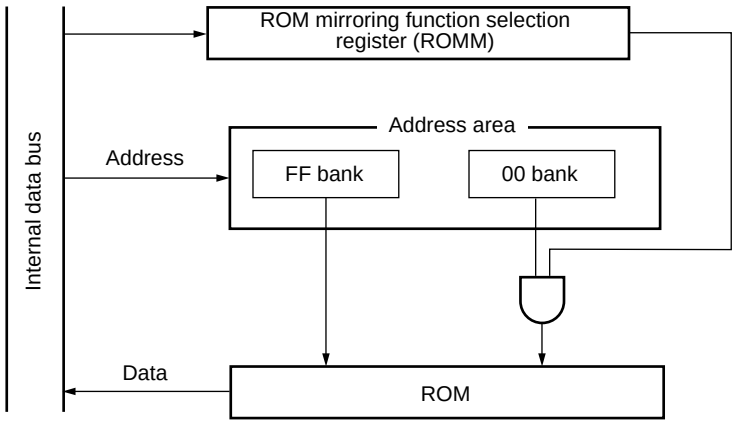
- ROM mirroring function selection register (ROMM)

Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
00006F$_H$	—	—	—	—	—	—	—	MI	XXXXXXX1$_B$
	—	—	—	—	—	—	—	W	

W : Write only
— : Undefined bits (read value undefined)

Note: Do not access this register during operation at addresses 004000$_H$ to 00FFFF$_H$.

(2) Block Diagram



20. Low-power Consumption (Stand-by) Mode

The F²MC-16LX has the following CPU operating modes configured by selection of an operating clock and clock operation control.

- **Clock mode**
  PLL clock mode : A mode in which the CPU and peripheral equipment are driven by PLL-multiplied oscillation clock.
  Main clock mode: A mode in which the CPU and peripheral equipment are driven by drivided-by-2 of the oscillation clock. The PLL multiplication circuits stops in the main clock mode.
- **Sub-clock mode**
  The sub-clock mode causes the CPU to operate only with the sub-clock. This mode uses the sub-clock frequency divided by four as the operating clock frequency while stopping the main clock and PLL clock.
- **CPU intermittent operation mode**
  The CPU intermittent operation mode is a mode for reducing power consumption by operating the CPU intermittently while external bus and peripheral functions are operated at a high speed.
- **Hardware stand-by mode**
  The hardware standby mode is a mode for reducing power consumption by stopping clock supply to the CPU by the low-power consumption control circuit (sleep mode), stopping clock supplies to the CPU and peripheral functions (timebase timer mode), and stopping oscillation clock (stop mode, hardware stand-by mode). Of these modes, modes other than the PLL clock mode are low power consumption modes.

(1) Register Configuration

- Clock select register (CKSCR)

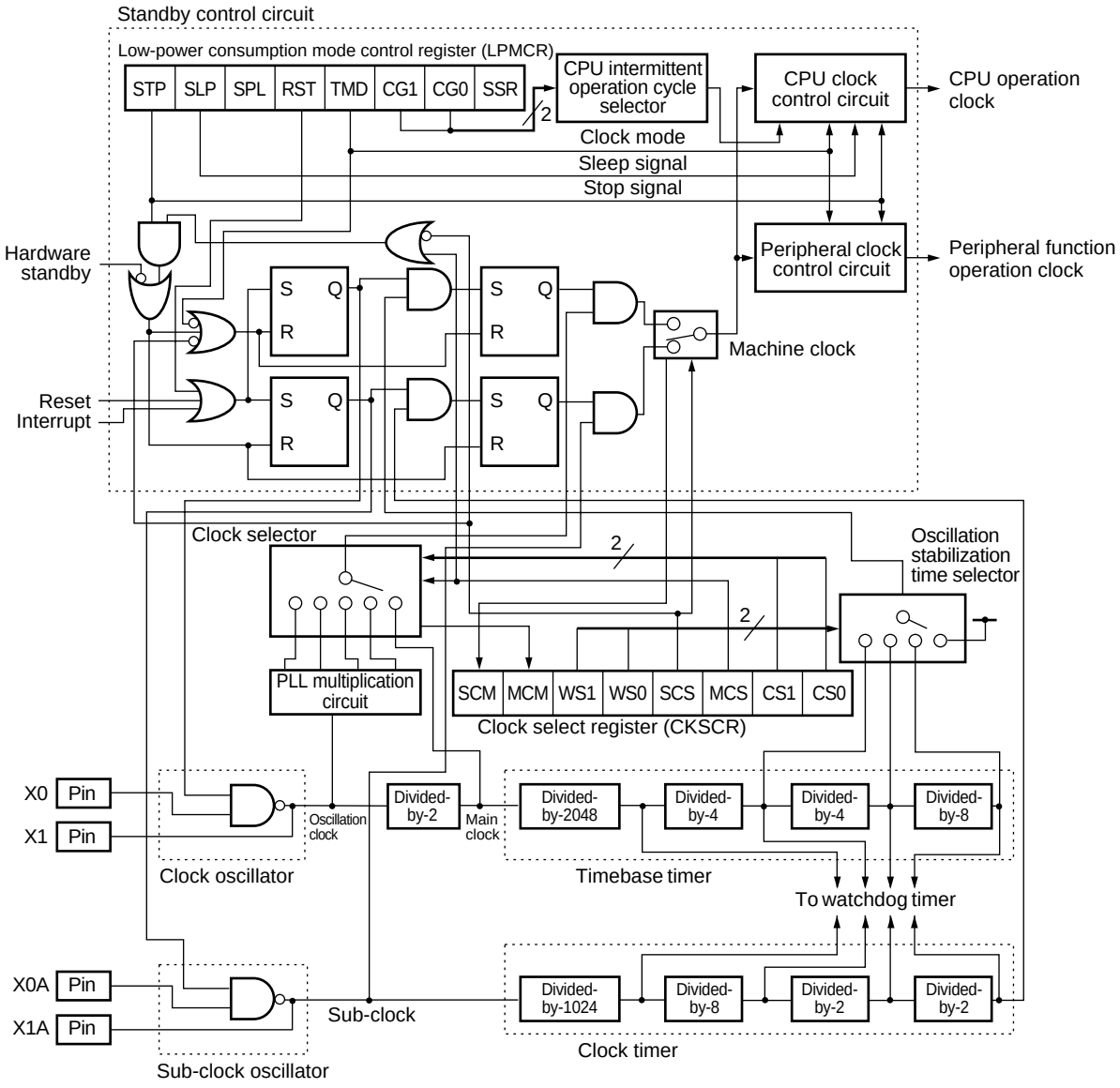
Address	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	Initial value
0000A1H	SCM	MCM	WS1	WS0	SCS	MCS	CS1	CS0	11111100B
	R	R	R/W	R/W	R/W	R/W	R/W	R/W	

- Low-power consumption mode control register (LPMCR)

Address	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Initial value
0000A0H	STP	SLP	SPL	RST	TMD	CG1	CG0	SSR	00011000B
	W	W	R/W	W	W	R/W	R/W	R/W	

R/W: Readable and writable
R : Read only
W : Write only

(2) Block Diagram



21.Clock Monitor Function

The clock monitor function outputs the frequency-divided machine clock signal (for monitoring purposes) from the CKOT pin.

(1) Register configuration

- Clock output enable register

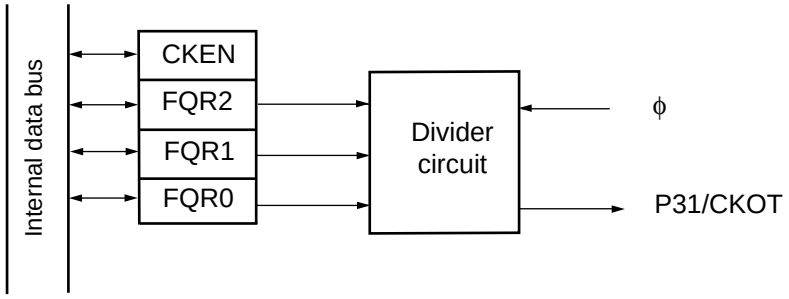
Address
00003E$_H$

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
—	—	—	—	CKEN	FRQ2	FRQ1	FRQ0
—	—	—	—	R/W	R/W	R/W	R/W

Initial value
XXXXXXX1$_B$

R/W:Readable and writable
—:Undefined bits (read value undefined)

(2) Block Diagram



ϕ : Machine clock frequency

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

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

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC}	V_{SS} – 0.3	V_{SS} + 6.0	V	
	AV_{CC}	V_{SS} – 0.3	V_{SS} + 6.0	V	*1
	AVRH, AVRL	V_{SS} – 0.3	V_{SS} + 6.0	V	*1
	DV_{CC}	V_{SS} – 0.3	V_{SS} + 6.0	V	*2
Input voltage	V_I	V_{SS} – 0.3	V_{CC} + 6.0	V	*3
Output voltage	V_O	V_{SS} – 0.3	V_{CC} + 6.0	V	*3
“L” level maximum output current	I_{OL}	—	15	mA	*4
“L” level average output current	I_{OLAV}	—	4	mA	*5
“L” level total maximum output current	ΣI_{OL}	—	100	mA	
“L” level total average output current	ΣI_{OLAV}	—	50	mA	*6
“H” level maximum output current	I_{OH}	—	–15	mA	*4
“H” level average output current	I_{OHAV}	—	–4	mA	*5
“H” level total maximum output current	ΣI_{OH}	—	–100	mA	
“H” level total average output current	ΣI_{OHAV}	—	–50	mA	*6
Power consumption	P_D	—	300	mW	
Operating temperature	T_A	–40	+85	°C	
Storage temperature	Tstg	–55	+150	°C	

*1: AV_{CC}, AVRH, AVRL, and DV_{CC} shall never exceed V_{CC}. AVRL shall never exceed AVRH.
*2: $V_{CC} \geq AV_{CC} \geq DV_{CC} \geq 3.0V$
*3: V_I and V_O shall never exceed V_{CC} + 0.3 V.
*4: The maximum output current is a peak value for a corresponding pin.
*5: Average output current is an average current value observed for a 100 ms period for a corresponding pin.
*6: Total average current is an average current value observed for a 100 ms period for all corresponding pins.

Note: Average output current = operating current × operating efficiency

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

2. Recommended Operating Conditions

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

Parameter	Symbol	Value		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC}	3.0	5.5	V	Normal operation (MB90522, MB90523)
	V_{CC}	4.0	5.5	V	Normal operation (MB90F523) Guaranteed frequency = 10 MHz at 4.0 V to 4.5V
	V_{CC}	3.0	5.5	V	Retains status at the time operation stops
Smoothing capacitor	C_S	0.1	1.0	µF	*
Operating temperature	T_A	–40	+85	°C	

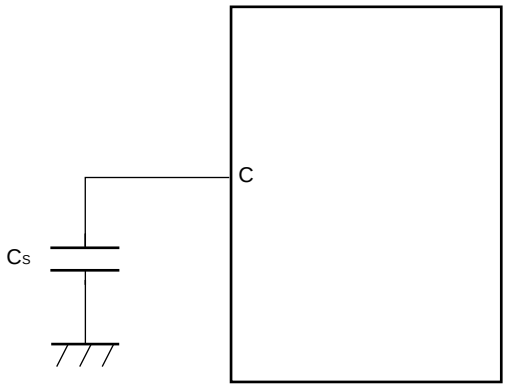
* : Use a ceramic capacitor or a capacitor with equivalent frequency characteristics. The smoothing capacitor to be connected to the V_{CC} pin must have a capacitance value higher than C_S.

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

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

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

- **C pin diagram**



3. DC Characteristics

($AV_{CC} = V_{CC} = 5.0\ V \pm 10\%$, $AV_{SS} = V_{SS} = 0.0\ V$, $T_A = -40°C$ to $+85°C$)

Parameter	Symbol	Pin name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
"H" level input voltage	V_{IHS}	P20 to P27, P30 to P37, P53, P54, P70 to P77, P80 to P87, PA0 to PA7,	V_{CC} = 3.0 V to 5.5 V (MB90523) V_{CC} = 4.0 V to 5.5 V (MB90F523)	0.8 V_{CC}	—	V_{CC} + 0.3	V	
	V_{IHM}	MD0 to MD2		V_{CC} – 0.3	—	V_{CC} + 0.3	V	
"L" level input voltage	V_{ILS}	P20 to P27, P30 to P37, P53, P54, P70 to P77, P80 to P87, PA0 to PA7,		V_{SS} – 0.3	—	0.2 V_{CC}	V	
	V_{ILM}	MD0 to MD2		V_{SS} – 0.3	—	V_{SS} + 0.3	V	
"H" level output voltage	V_{OH}	Other than P90 to P97	V_{CC} = 4.5 V, I_{OH} = –2.0 mA	V_{CC} – 0.5	—	—	V	
"L" level output voltage	V_{OL}	All output pins	V_{CC} = 4.5 V, I_{OL} = 2.0 mA	—	—	0.4	V	
Open-drain output leakage current	I_{leak}	Output pin P90 to P97	—	—	0.1	5	µA	
Input leakage current	I_{IL}	Other than P90 to P97	V_{CC} = 5.5 V, $V_{SS} < V_I < V_{CC}$	–5	—	5	µA	
Pull-up resistance	R_{UP}	P00 to P07, P10 to P17, P40 to P47, $\overline{RST}$, MD0, MD1	—	15	30	100	kΩ	
Pull-down resistance	R_{DOWN}	MD2	—	15	30	100	kΩ	

(Continued)

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Power supply current*	I_{CC}	V_{CC}	Internal operation at 16 MHz V_{CC} at 5.0 V Normal operation	—	30	40	mA	MB90522, MB90523
	I_{CC}	V_{CC}		—	85	130	mA	MB90F523
	I_{CC}	V_{CC}	Internal operation at 16 MHz V_{CC} at 5.0 V A/D converter operation	—	35	45	mA	MB90522, MB90523
	I_{CC}	V_{CC}		—	90	140	mA	MB90F523
	I_{CC}	V_{CC}	Internal operation at 16 MHz V_{CC} at 5.0 V D/A converter operation	—	40	50	mA	MB90522, MB90523
	I_{CC}	V_{CC}		—	95	145	mA	MB90F523
	I_{CC}	V_{CC}	When data is written or erased in flash mode	—	95	140	mA	MB90F523
	I_{CCS}	V_{CC}	Internal operation at 16 MHz V_{CC} at 5.0 V In sleep mode	—	7	12	mA	MB90522, MB90523
	I_{CCS}	V_{CC}		—	25	30	mA	MB90F523
	I_{CCL}	V_{CC}	Internal operation at 8 kHz V_{CC} at 5.0 V T_A = +25°C Subsystem operation	—	0.1	1.0	mA	MB90522, MB90523
	I_{CCL}	V_{CC}		—	4	7	mA	MB90F523
	I_{CCLS}	V_{CC}	Internal operation at 8 kHz V_{CC} at 5.0 V T_A = +25°C In subsleep mode	—	30	50	µA	MB90522, MB90523
	I_{CCLS}	V_{CC}		—	0.1	1	mA	MB90F523
	I_{CCT}	V_{CC}	Internal operation at 8 kHz V_{CC} at 5.0 V T_A = +25°C In clock mode	—	15	30	µA	MB90522, MB90523
	I_{CCT}	V_{CC}		—	30	50	µA	MB90F523
	I_{CCH}	V_{CC}	T_A = +25°C In stop mode	—	5	20	µA	MB90522, MB90523
	I_{CCH}	V_{CC}		—	0.1	10	µA	MB90F523
Input capacitance	C_{IN}	Other than AV_{CC}, AV_{SS}, C, V_{CC}, V_{SS}	—	—	10	80	pF	

(Continued)

(Continued)

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
LCD split resistor	R_{LCD}	V0 to V1, V1 to V2, V2 to V3	—	50	100	200	kΩ	
Output impedance for COM0 to COM3	R_{VCOM}	COM0 to COM3	V1 to V3 = 5.0 V	—	—	2.5	kΩ	
Output impedance for SEG00 to SEG31	R_{VSEG}	SEG00 to SEG31		—	—	15	kΩ	
LCDC leak current	I_{LCDC}	V0 to V3, COM1 to COM3, SEG00 to SEG31	—	—	—	±5	µA	

* : The current value is preliminary and may be subject to change for enhanced characteristics without previous notice.The power supply current is measured with an external clock.

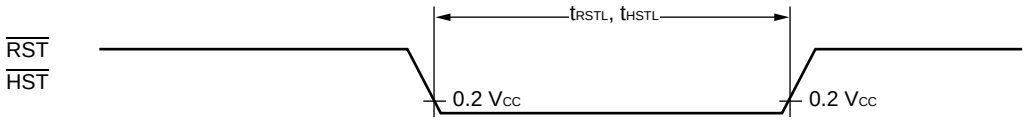
4. AC Characteristics

(1) Reset, Hardware Standby Input Timing

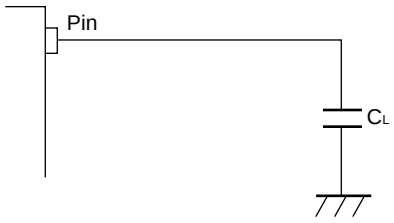
($AV_{CC} = V_{CC} = 5.0\ V \pm 10\%$, $AV_{SS} = V_{SS} = 0.0\ V$, $T_A = -40°C$ to $+85°C$)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Reset input time	t_{RSTL}	$\overline{RST}$	—	4 t_{CP}*	—	ns	
Hardware standby input time	t_{HSTL}	$\overline{HST}$		4 t_{CP}*	—	ns	

* : For t_{CP} (internal operating clock cycle time), refer to “(3) Clock Timings.”



- **Measurement conditions for AC ratings**



C_L is a load capacitance connected to a pin under test.
C_L of 80 pF must be connected to address data bus (AD15 to AD00).

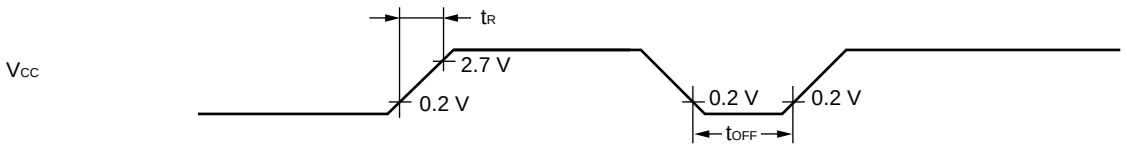
(2) Specification for Power-on Reset

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

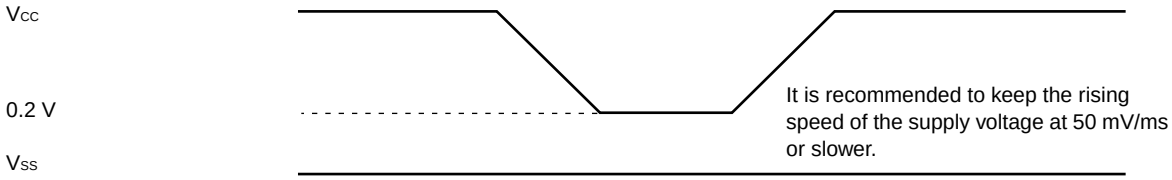
Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Power supply rising time	t_R	V_{CC}	—	0.05	30	ms	*
Power supply cut-off time	t_{OFF}	V_{CC}		4	—	ms	Due to repeated operations

* : V_{CC} must be kept lower than 0.2 V before power-on.

Notes: • The above ratings are values for causing a power-on reset.
• There are internal registers which can be initialized only by a power-on reset. Apply power according to this rating to ensure initialization of the registers.



Sudden changes in the power supply voltage may cause a power-on reset.
To change the power supply voltage while the device is in operation, it is recommended to raise the voltage smoothly to suppress fluctuations as shown below.
In this case, change the supply voltage when the PLL clock is not in use. If the voltage drops 1 V or less per second, however, the PLL clock may be used.



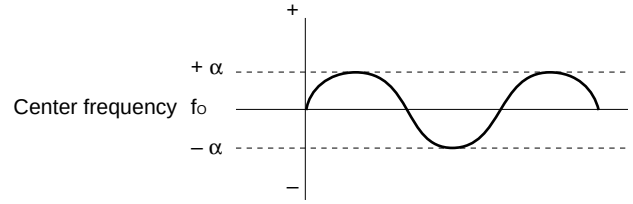
(3) Clock Timings

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value			Unit	Remarks
				Min.	Typ.	Max.		
Clock frequency	F_C	X0, X1	—	3	—	16	MHz	
	F_C	X0, X1	4.0 V to 4.5 V	3	—	10	MHz	MB90F523
	F_{CL}	X0A, X1A	—	—	32.768	—	kHz	
Clock cycle time	t_{HCYL}	X0, X1	—	62.5	—	333	ns	
	t_{HCYL}	X0, X1	4.0 V to 4.5 V	100	—	333	ns	MB90F523
	t_{LCYL}	X0A, X1A	—	—	30.5	—	µs	
Input clock pulse width	P_{WH}, P_{WL}	X0	—	10	—	—	ns	Recommended duty ratio of 30% to 70%
	P_{WLH}, P_{WLL}	X0A	—	—	15.2	—	µs	
Input clock rising/falling time	t_{CR}, t_{CF}	X0, X0A	—	—	—	5	ns	External clock operation
Internal operating clock frequency	f_{CP}	—	—	1.5	—	16	MHz	When the main clock is used
	f_{CP}	—	4.0 V to 4.5 V	1.5	—	10	MHz	When the main clock is used
	f_{LCP}	—	—	—	8.192	—	kHz	When the subclock is used
Internal operating clock cycle time	t_{CP}	—	—	62.5	—	333	ns	When the main clock is used
	t_{CP}	—	4.0 V to 4.5 V	100	—	333	ns	When the main clock is used
	t_{LCP}	—	—	—	122.1	—	µs	When the subclock is used
Frequency fluctuation rate locked	Δf	—	—	—	—	5	%	*

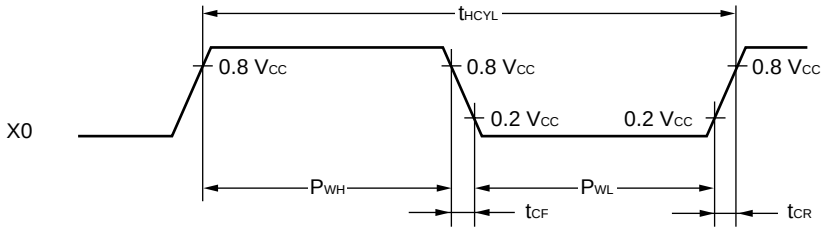
* : The frequency fluctuation rate is the maximum deviation rate of the preset center frequency when the multiplied PLL signal is locked.

$$\Delta f = \frac{|\alpha|}{f_O} \times 100\ (\%)$$

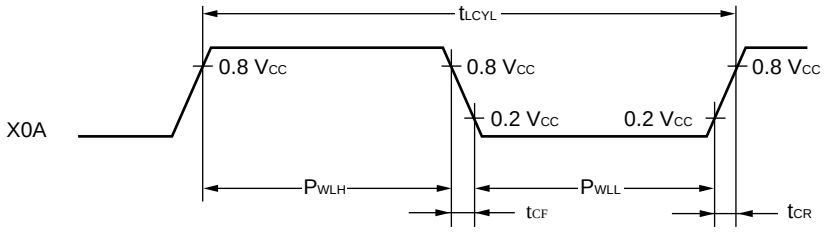


The PLL frequency deviation changes periodically from the preset frequency “(about CLK × (1CYC to 50 CYC),” thus minimizing the chance of worst values to be repeated (errors are minimal and negligible for pulses with long intervals).

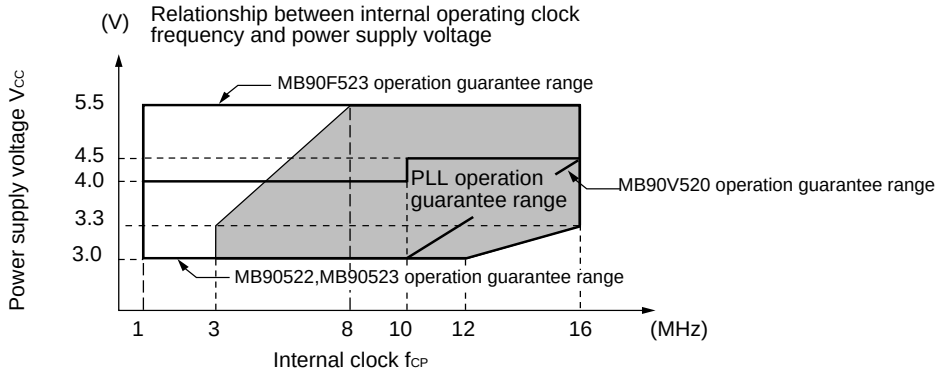
- **X0, X1 clock timing**

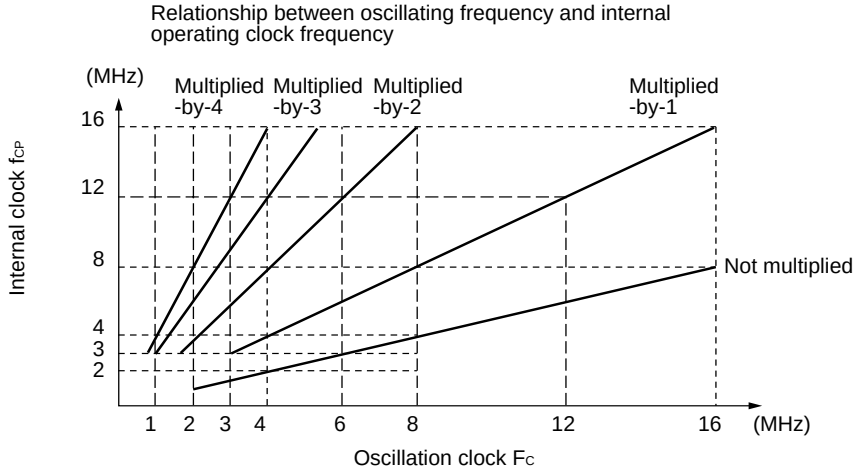


- **X0A, X1A clock timing**



- **PLL operation guarantee range**

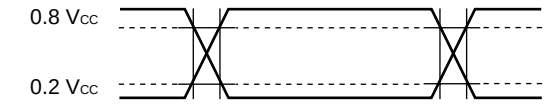




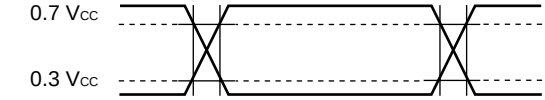
The AC ratings are measured for the following measurement reference voltages.

- **Input signal waveform**

Hystheresis input pin

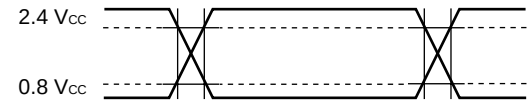


Pins other than hystheresis input/MD input



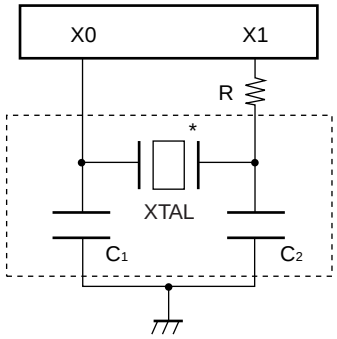
- **Output signal waveform**

Hystheresis input pin



(4) Recommended Resonator Manufacturers

- **Sample application of ceramic resonator**



- **Mask ROM product (MB90522, MB90523)**

Resonator manufacturer	Resonator	Frequency (MHz)	C_1 (pF)	C_2 (pF)	R
Murata Mfg. Co., Ltd.	CSA2.00MG040	2.00	100	100	Not required
	CSA4.00MG040	4.00	100	100	Not required
	CSA8.00MTZ	8.00	30	30	Not required
	CSA16.00MXZ040	16.00	15	15	Not required
	CSA32.00MXZ040	32.00	5	5	Not required
TDK Corporation	CCR3.52MC3 to CCR6.96MC3	3.52 to 6.96	Built-in	Built-in	Not required
	CCR7.0MC5 to CCR12.0MC5	7.00 to 12.00	Built-in	Built-in	Not required
	CCR20.0MSC6 to CCR32.0MSC6	20.00 to 32.00	Built-in	Built-in	Not required

(Continued)

(Continued)

- **Flash ROM product (MB90F523)**

Resonator manufacturer	Resonator	Frequency (MHz)	C_1 (pF)	C_2 (pF)	R
Murata Mfg. Co., Ltd.	CSA2.00MG040	2.00	100	100	Not required
	CSA4.00MG040	4.00	100	100	Not required
	CSA8.00MTZ	8.00	30	30	Not required
	CSA16.00MXZ040	16.00	15	15	Not required
	CSA32.00MXZ040	32.00	5	5	Not required
TDK Corporation	CCR3.52MC3 to CCR6.96MC3	3.52 to 6.96	Built-in	Built-in	Not required
	CCR7.0MC5 to CCR12.0MC5	7.0 to 12.0	Built-in	Built-in	Not required
	CCR20.0MSC6 to CCR32.0MSC6	20.0 to 32.0	Built-in	Built-in	Not required

Inquiry:Murata Mfg. Co., Ltd..

- Murata Electronics North America, Inc.: TEL 1-404-436-1300
- Murata Europe Management GmbH: TEL 49-911-66870
- Murata Electronics Singapore (Pte.): TEL 65-758-4233

TDK Corporation

- TDK Corporation of America
  Chicago Regional Office: TEL 1-708-803-6100
- TDK Electronics Europe GmbH
  Components Division: TEL 49-2102-9450
- TDK Singapore (PTE) Ltd.: TEL 65-273-5022
- TDK Hong Kong Co., Ltd.: TEL 852-736-2238
- Korea Branch, TDK Corporation: TEL 82-2-554-6636

(5) UART (SCI) Timing

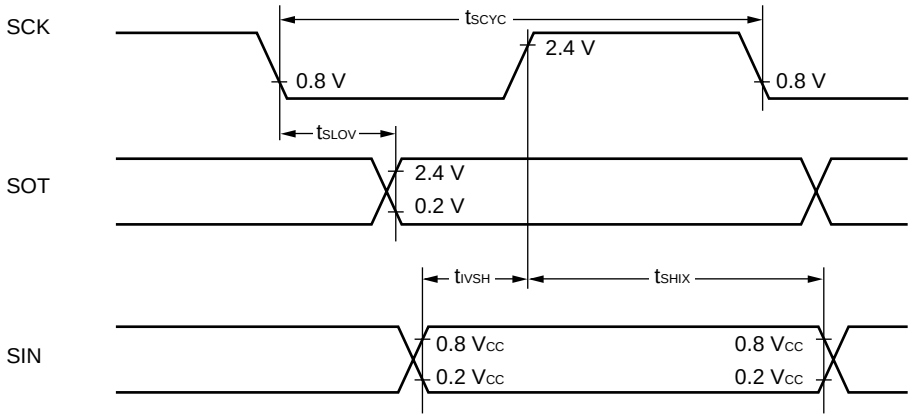
(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Serial clock cycle time	t_{SCYC}	SCK0 to SCK2	Internal shift clock mode C_L = 80 pF + 1 TTL for an output pin	8 t_{CP}*	—	ns	
SCK ↓ → SOT delay time	t_{SLOV}	SCK0 to SCK2, SOT0 to SOT2		– 80	80	ns	
Valid SIN → SCK ↑	t_{IVSH}	SCK0 to SCK2, SIN0 to SIN2		100	—	ns	
SCK ↑ → valid SIN hold time	t_{SHIX}	SCK0 to SCK2, SIN0 to SIN2		60	—	ns	
Serial clock “H” pulse width	t_{SHSL}	SCK0 to SCK2	External shift clock mode C_L = 80 pF + 1 TTL for an output pin	4 t_{CP}*	—	ns	
Serial clock “L” pulse width	t_{SLSH}	SCK0 to SCK2		4 t_{CP}*	—	ns	
SCK ↓ → SOT delay time	t_{SLOV}	SCK0 to SCK2 SOT0 to SOT2		—	150	ns	
Valid SIN → SCK ↑	t_{IVSH}	SCK0 to SCK2, SIN0 to SIN2		60	—	ns	
SCK ↑ → valid SIN hold time	t_{SHIX}	SCK0 to SCK2, SIN0 to SIN2		60	—	ns	

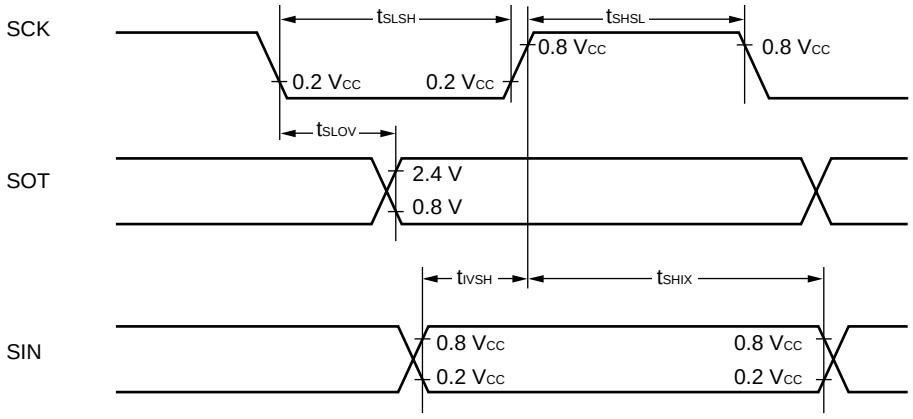
* : For t_{CP} (internal operating clock cycle time), refer to “(3) Clock Timings.”

Notes: • These are AC ratings in the CLK synchronous mode.
• C_L is the load capacitor value connected to pins while testing.

- **Internal shift clock mode**



- **External shift clock mode**

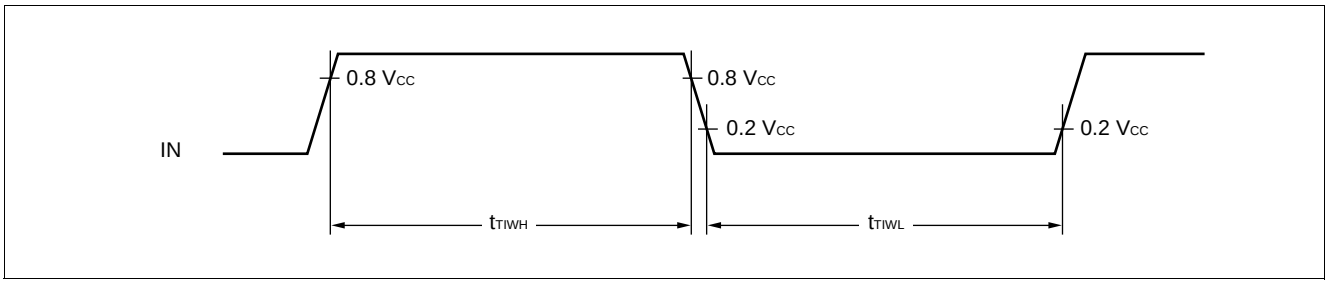


(6) Timer Input Timing

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
Input pulse width	t_{TIWH}, t_{TIWL}	IC00,IC01,IC10, IC11,TI0, TI1	—	4 t_{CP}*	—	ns	

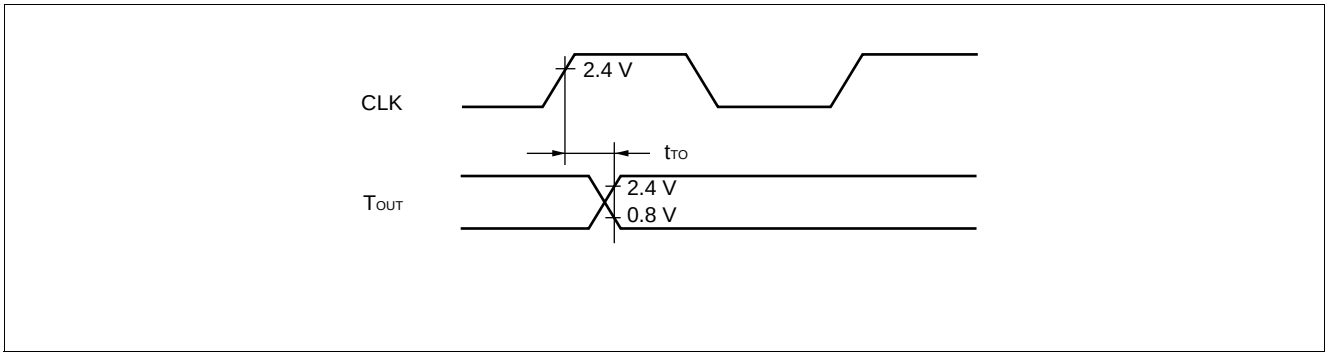
* : For t_{CP} (internal operating clock cycle time), refer to “(3) Clock Timings.”



(7) Timer Output Timing

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value		Unit	Remarks
				Min.	Max.		
CLK ↑ → T_{OUT} transition time	t_{TO}	OUT0 to OUT3, PG00, PG01,PG10, PG11	—	30	—	ns	



5. A/D Converter

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = 0.0 V, 3.0 V ≦ AVRH – AVRL, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Condition	Value			Unit
				Min.	Typ.	Max.	
Resolution	—	—	—	—	8/10	—	bit
Total error	—	—		—	—	±5.0	LSB
Non-linear error	—	—		—	—	±2.5	LSB
Differential linearity error	—	—		—	—	±1.9	LSB
Zero transition voltage	V_{OT}	AN0 to AN7		AV_{SS} –3.5 LSB	+0.5 LSB	AV_{SS} +4.5 LSB	mV
Full-scale transition voltage	V_{FST}	AN0 to AN7		AVRH –6.5LSB	AVRH –1.5 LSB	AVRH +1.5 LSB	mV
Conversion time	—	—	V_{CC} = 5.0 V ±10% at machine clock of 16 MHz	240 t_{CP}*	—	—	ns
Sampling time	—	—	V_{CC} = 5.0 V ±10% at machine clock of 16 MHz	64 t_{CP}*	—	—	ns
Analog port input current	I_{AIN}	AN0 to AN7	—	—	—	10	µA
Analog input voltage	V_{AIN}	AN0 to AN7		AVRL	—	AVRH	V
Reference voltage	—	AVRH		AVRL + 2.7	—	AV_{CC}	V
	—	AVRL		0	—	AVRH –2.7	V
Power supply current	I_A	AV_{CC}		—	5	—	mA
	I_{AH}	AV_{CC}	Supply current when CPU stopped and 8/10-bit A/D converter not in operation (V_{CC} = AV_{CC} = AVRH = 5.0 V)	—	—	5	µA
Reference voltage supply current	I_R	AVRH	—	—	400	—	µA
	I_{RH}	AVRH	Supply current when CPU stopped and 8/10-bit A/D converter not in operation (V_{CC} = AV_{CC} = AVRH = 5.0 V)	—	—	5	µA
Offset between channels	—	AN0 to AN7	—	—	—	4	LSB

* : For t_{CP} (internal operating clock cycle time), refer to “(3) Clock Timings.”

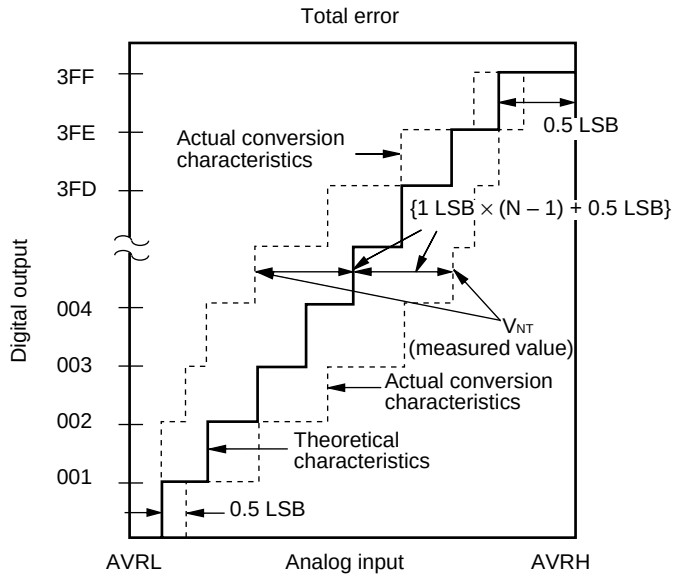
6. A/D Converter Glossary

Resolution: Analog changes that are identifiable with the A/D converter

Linearity error: The deviation of the straight line connecting the zero transition point (“00 0000 0000” ↔ “00 0000 0001”) with the full-scale transition point (“11 1111 1110” ↔ “11 1111 1111”) from actual conversion characteristics

Differential linearity error: The deviation of input voltage needed to change the output code by 1 LSB from the theoretical value

Total error: The total error is defined as a difference between the actual value and the theoretical value, which includes zero-transition error, full-scale transition error and linearity error.



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

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

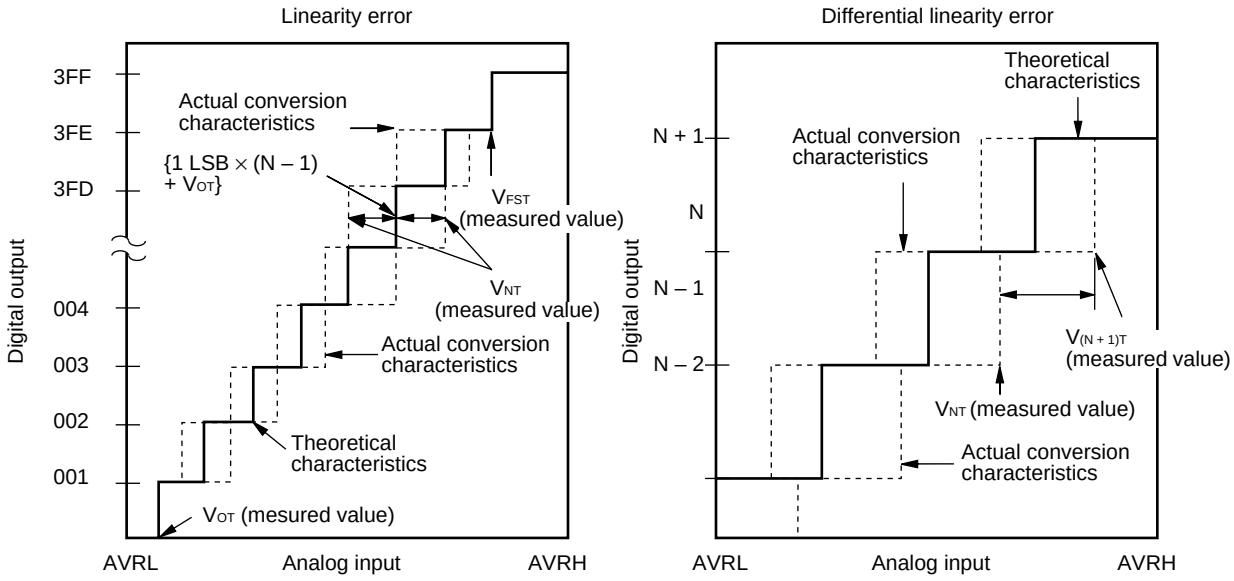
V_{OT} (Theoretical value) = AVRL + 0.5 LSB [V]

V_{NT}: Voltage at a transition of digital output from (N – 1) to N

V_{FST} (Theoretical value) = AVRH – 1.5 LSB [V]

(Continued)

(Continued)



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

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

$$1\ \text{LSB} = \frac{V_{FST} - V_{OT}}{1022}\ [\text{V}]$$

V_{OT}: Voltage at transition of digital output from "000_H" to "001_H"
V_{FST}: Voltage at transition of digital output from "$3FE_H$" to "$3FF_H$"

7. Notes for A/D Conversion

Analog inputs should have external circuit impedance of approximately 5 kΩ or less.
External capacitance, if used, should be several thousand times the level of the chip's internal capacitance in consideration of the effects of partial potential between the external and internal capacitance.

If the impedance of the external circuit is too high, the analog voltage sampling interval may be insufficient (using a sampling interval of 4.00 µs and a machine clock frequency of 16 MHz).

- **Block diagram of analog input circuit model**

MB90522, MB90523
R_{ON}: Approx. 1.5 kΩ
C: Approx. 30 pF
MB90F523
R_{ON}: Approx. 3.0 kΩ
C: Approx. 65 pF

Note: Listed values must be considered standards.

- **Error**

The smaller | AVRH – AVRL | is, the greater the error is.

8. D/A Converter

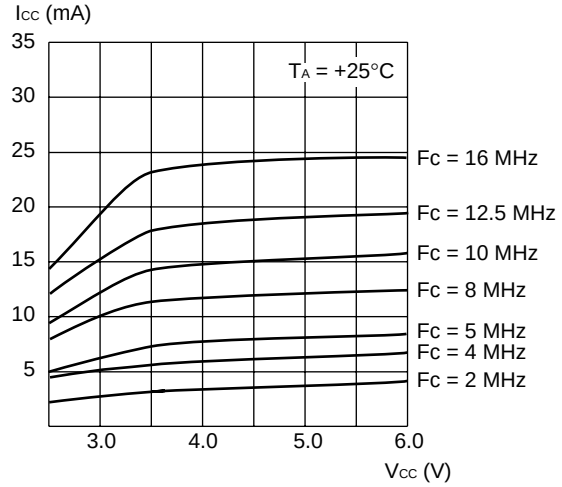
(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = DV_{SS} = 0.0 V, T_A = –40°C to +85°C)

Parameter	Symbol	Pin name	Value			Unit	Remarks
			Min.	Typ.	Max.		
Resolution	—	—	—	8	—	bit	
Differential linearity error	—	—	—	—	±0.9	LSB	
Absolute accuracy	—	—	—	—	±1.2	%	
Linearity error	—	—	—	—	±1.5	LSB	
Conversion time	—	—	—	10	20	µs	Load capacitance: 20 pF
Analog reference voltage	—	DV_{CC}	V_{SS} + 3.0	—	AV_{CC}	V	
Reference voltage supply current	I_{DVR}	DV_{CC}	—	—	300	µA	
	I_{DVRS}	DV_{CC}	—	—	10	µA	In sleep mode
Analog output impedance	—	—	—	20	—	kΩ	

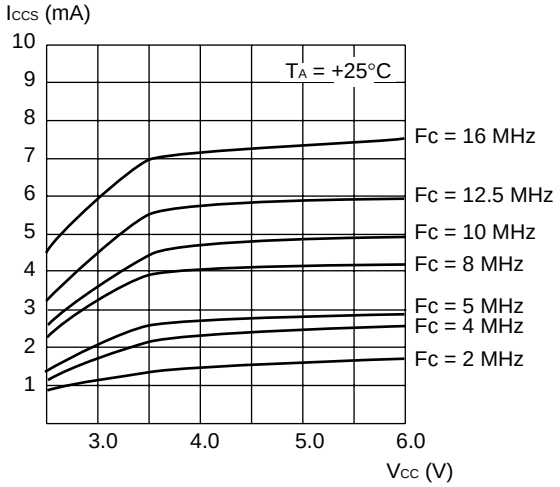
■ EXAMPLE CHARACTERISTICS

(1) Power Supply Current (MB90523)

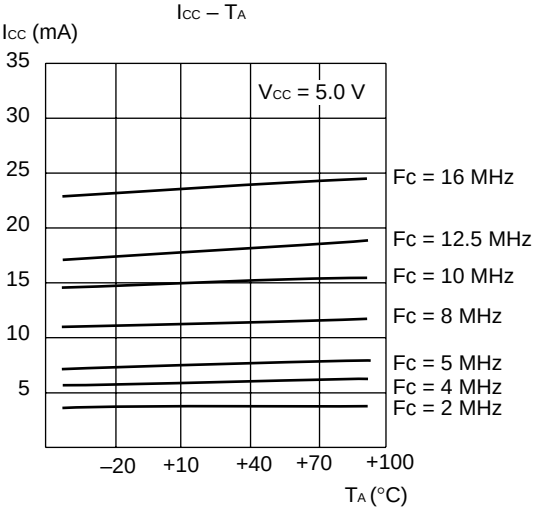
I_{CC} – V_{CC}



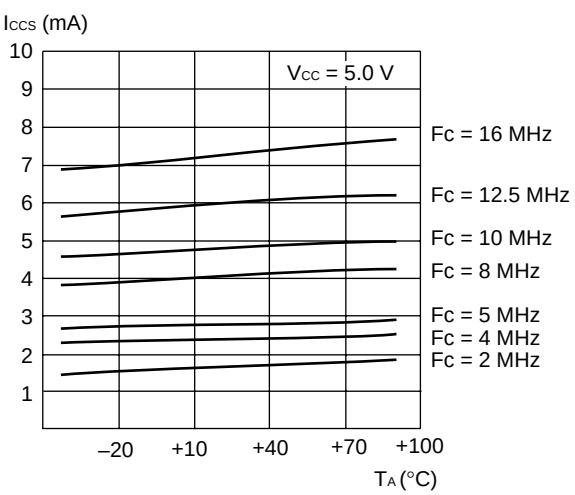
I_{CCS} – V_{CC}



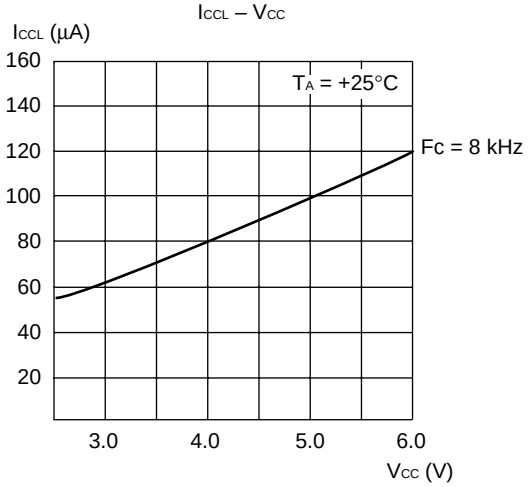
I_{CC} – T_A



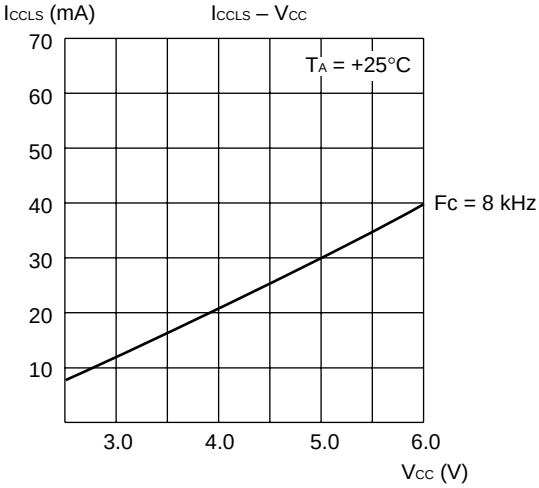
I_{CCS} – T_A



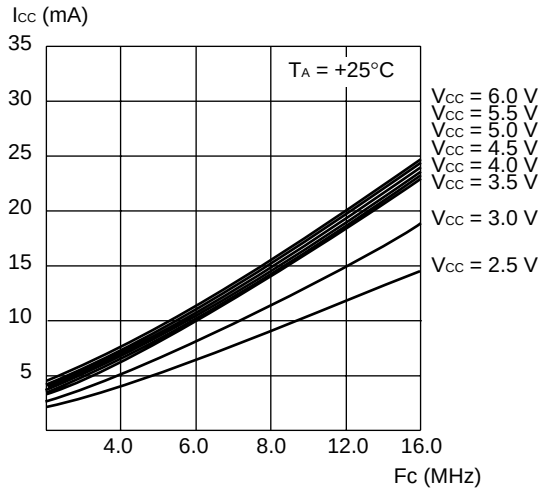
I_{CCL} – V_{CC}



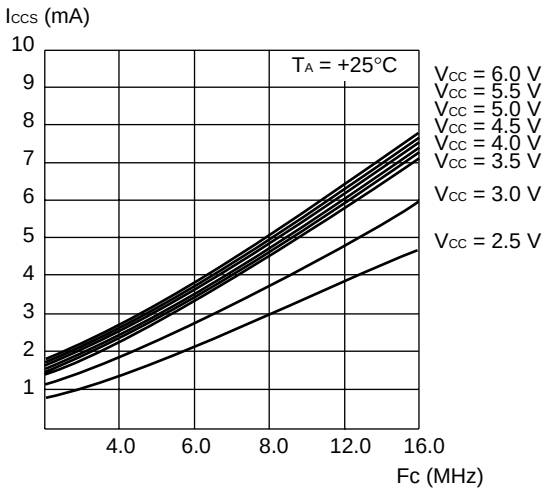
I_{CCLS} – V_{CC}



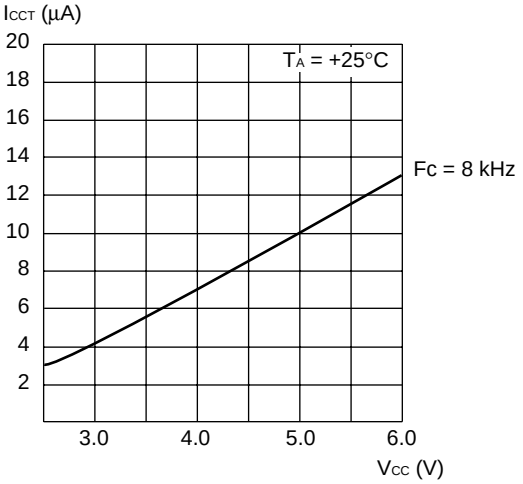
I_{CC} – Fc



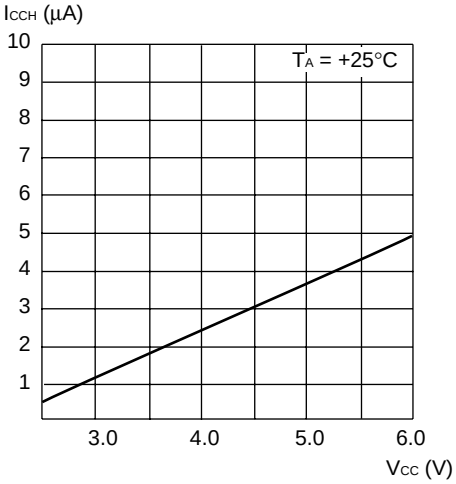
I_{CCS} – Fc



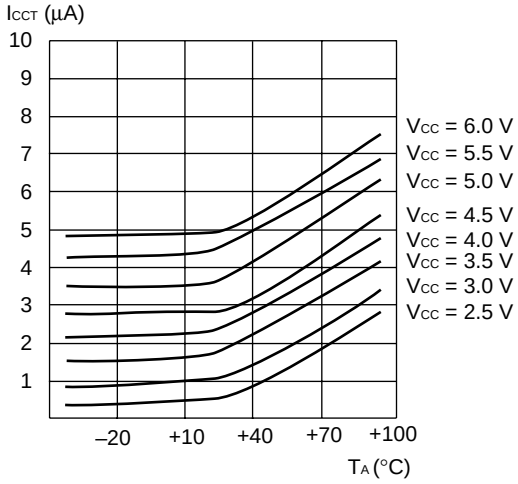
I_{CCT} – V_{CC}



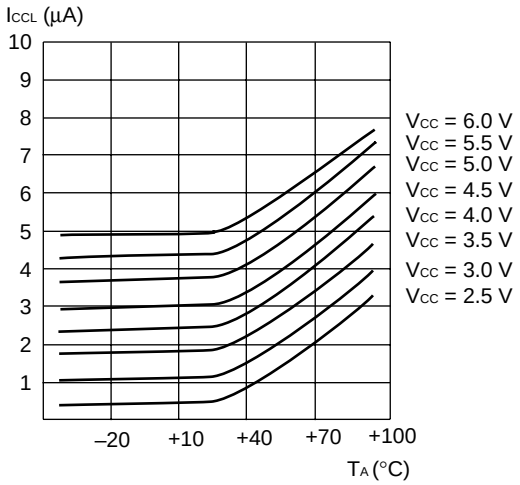
I_{CCH} – V_{CC}

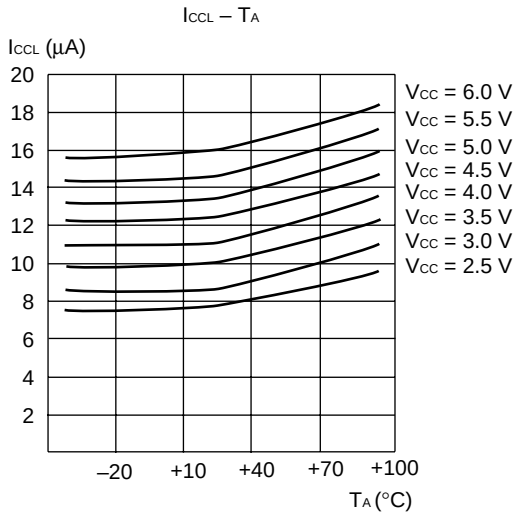


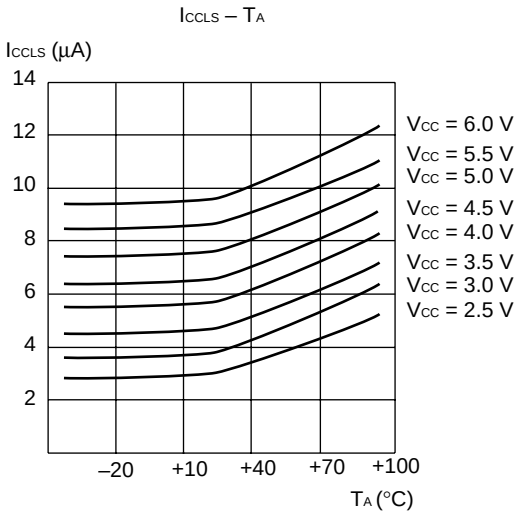
I_{CCT} – T_A



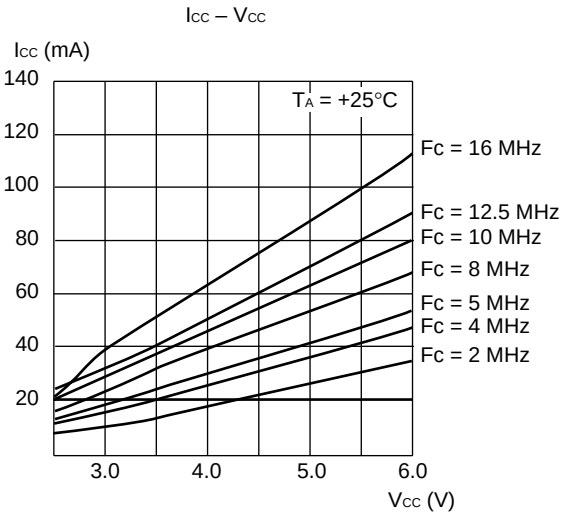
I_{CCH} – T_A

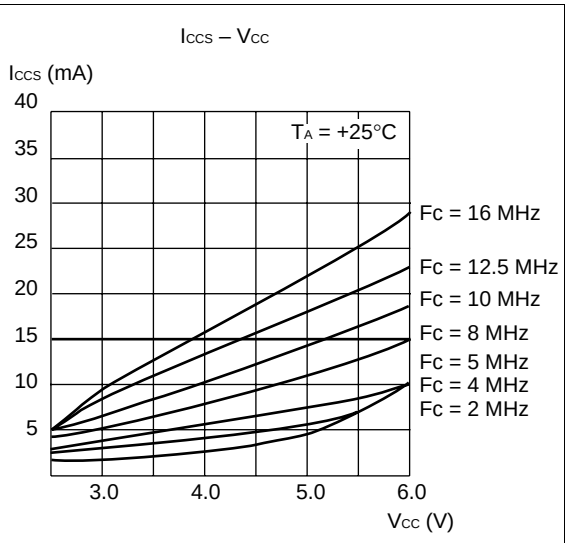


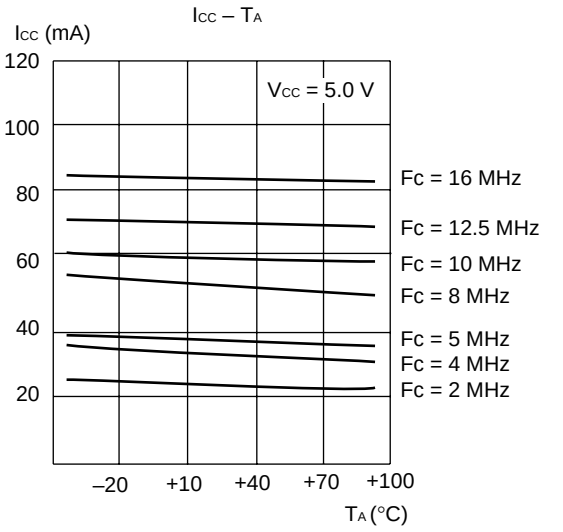


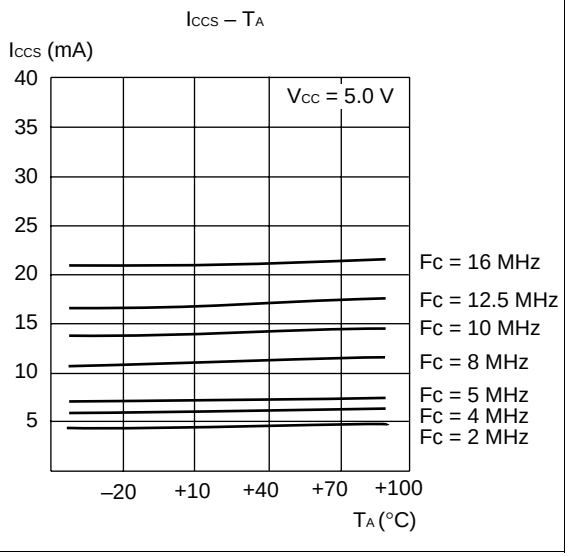


(2) Power Supply Current (MB90F523)

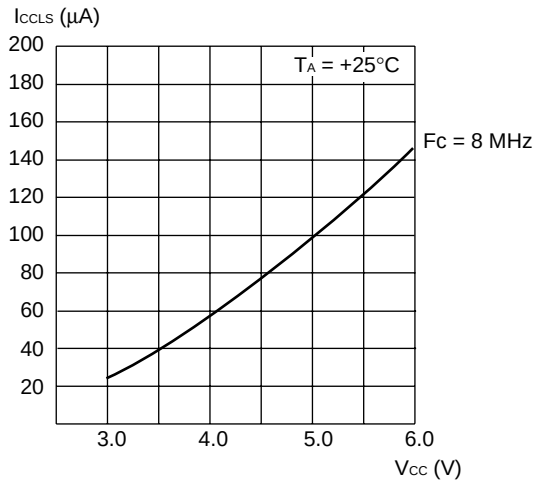




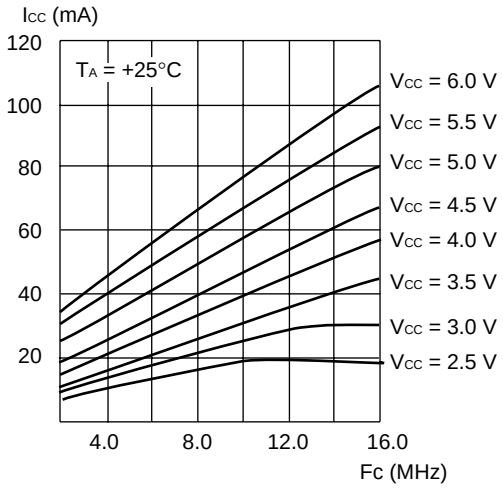




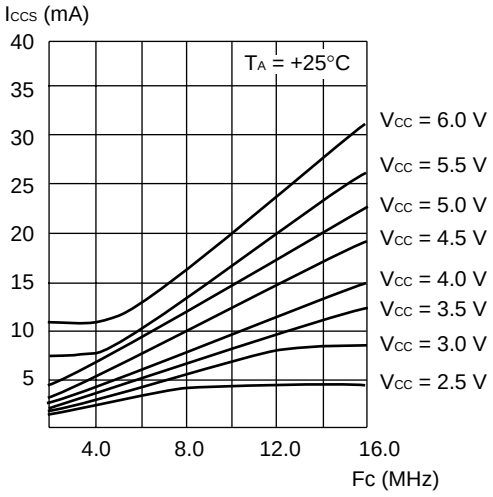
I_{CCS} – V_{CC}



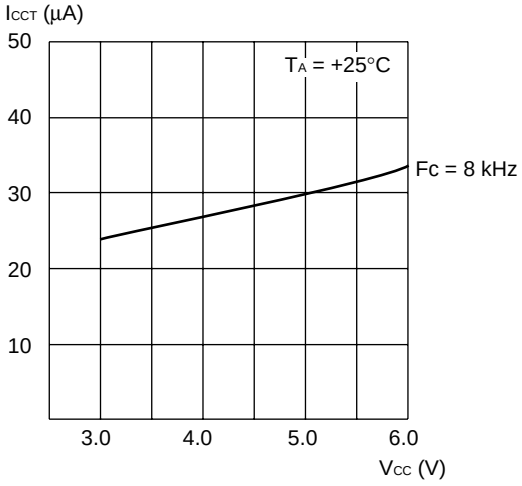
I_{CC} – Fc



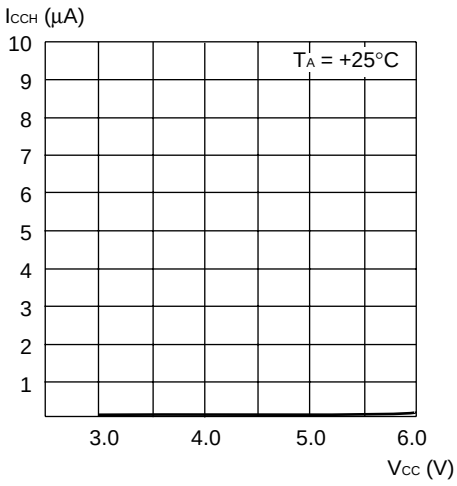
I_{CCS} – Fc



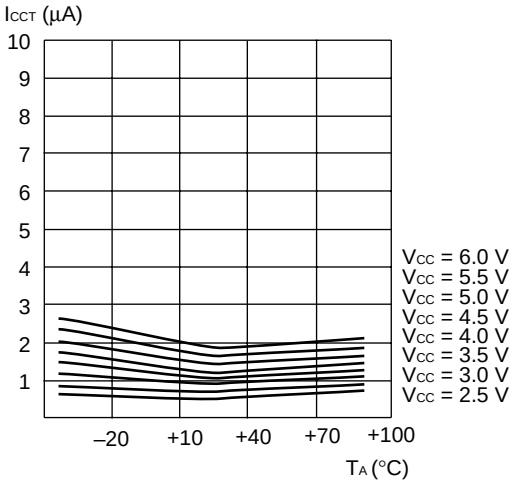
I_{CCT} – V_{CC}



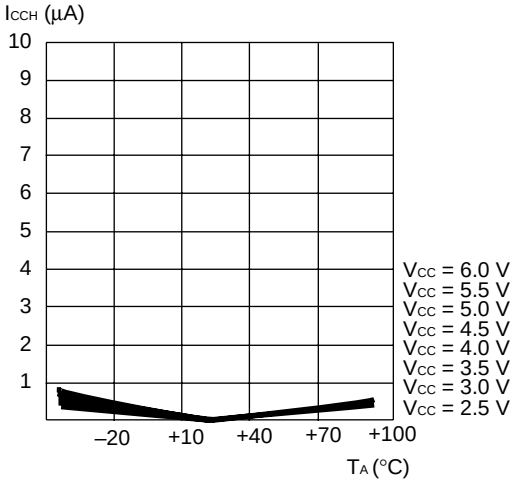
I_{CCH} – V_{CC}



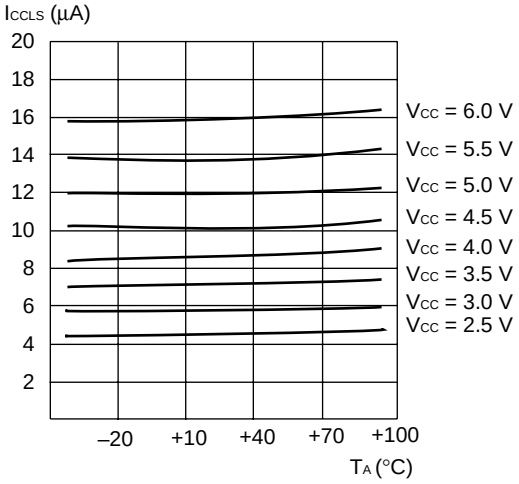
I_{CCT} – T_A



I_{CCH} – T_A



I_{CCLS} – T_A

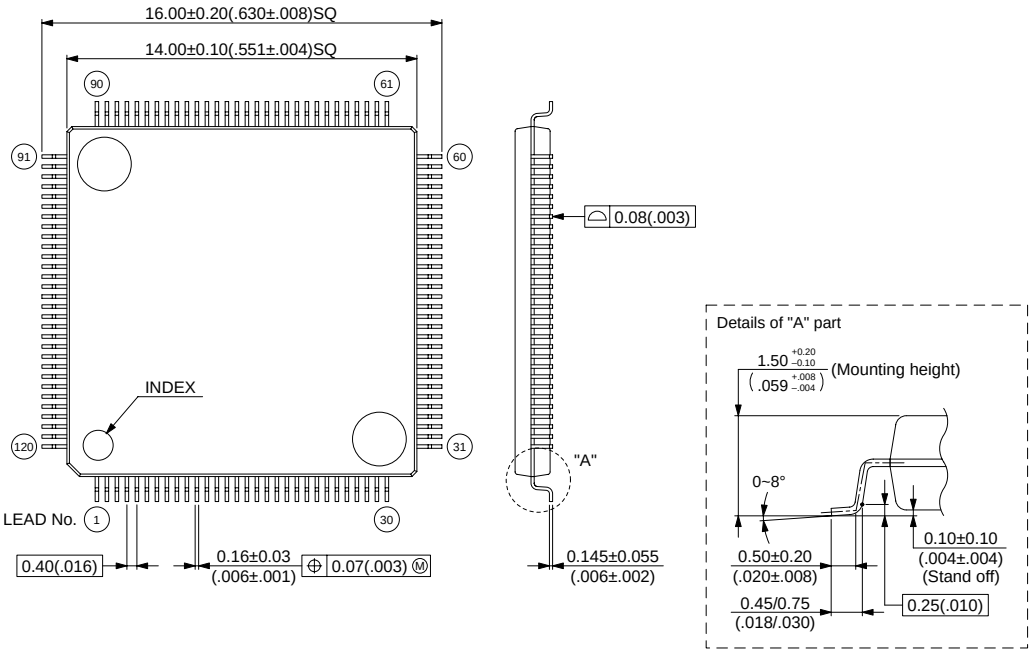


■ ORDERING INFORMATION

Part number	Package	Remarks
MB90523PFF MB90522PFF MB90F523PFF	120-pin Plastic LQFP (FPT-120P-M05)	
MB90523PFV MB90522PFV MB90F523PFV	120-pin Plastic QFP (FPT-120P-M13)	

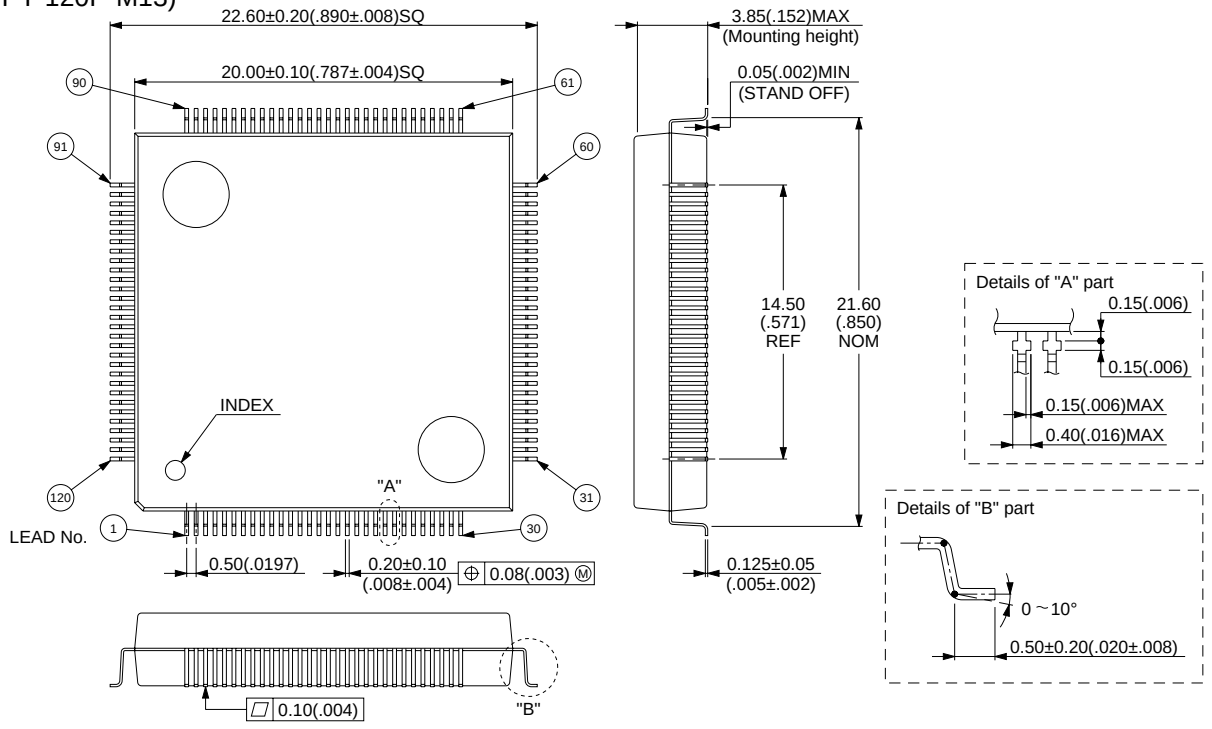
■ PACKAGE DIMENSIONS

120-pin Plastic LQFP
(FPT-120P-M05)



Dimensions in mm (inches)

120-pin Plastic QFP
(FPT-120P-M13)



Dimensions in mm (inches)

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