FUJITSU SEMICONDUCTOR
DATA SHEET

DS07-13707-3E

16-bit Proprietary Microcontroller

CMOS

F²MC-16LX MB90520A/520B Series

MB90522A/523A/522B/523B/F523B/V520A

■ DESCRIPTION

The MB90520A/520B series is a general-purpose 16-bit microcontroller designed for process control applications in consumer products that require high-speed real-time processing.

The microcontroller instruction set is based on the AT architecture of the F²MC* family with additional instructions for high-level languages, extended addressing modes, enhanced multiplication and division instructions, and a complete range of bit manipulation instructions. The microcontroller has a 32-bit accumulator for processing long word (32-bit) data.

The MB90520A/520B series peripheral resources include an 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, a range of I/O timers (16-bit free-run timers 1 and 2, input capture (ICU) 0 and 1, and output compare (OCU) 0 and 1) , an LCD controller/driver, 8 external interrupt inputs, and 8 wakeup interrupts.

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

■ FEATURES

- **Clock**
- Internal PLL clock multiplication circuit
- Selectable machine clock (PLL clock) : Base oscillation divided by two or multiplied by one to four
  (For a 4 MHz base oscillation, the machine clock range is 4 MHz to 16 MHz) .

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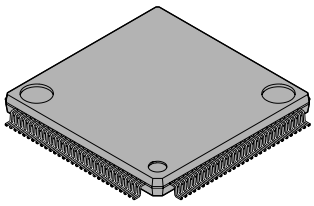
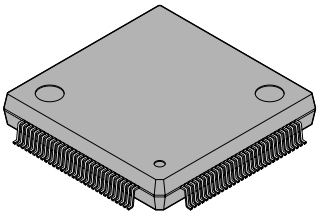
■ PACKAGES

120-pin, Plastic, LQFP	120-pin, Plastic, QFP
	
(FPT-120P-M05)	(FPT-120P-M13)

FUJITSU

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- Sub-clock (32.768 KHz) operation available
  Minimum instruction execution time : 62.5 ns (for oscillation = 4 MHz, PLL clock setting = ×4, V_{CC} = 5.0 V)
- **16MB CPU memory space**
  Internal 24-bit addressing
- **Instruction set optimized for controller applications**
  Rich data types (bit, byte, word, long-word)
  Extended addressing modes (23 types)
  Enhanced signed multiplication and division instructions and RETI instruction
  Enhanced calculation precision using a 32-bit accumulator
- **Instruction set designed for high-level language** (**C**) **and multi-tasking**
  System stack pointer
  Enhanced pointer-indirect instructions and barrel shift instructions
- **Faster execution speed**
  4-byte instruction queue
  ROM mirror function (48 Kbytes of bank FF is mirrored in bank 00)
- **Program patch function** : **An address match detection function** (**2** × **addresses**)
- **Interrupt function**
  32 programmable interrupts with 8 levels
- **Automatic data transmission function independent of CPU operation**
  Extended intelligent I/O service function (EI^2OS) : Up to 16 channels
- **Low-power consumption** (**stand-by**) **modes**
  Sleep mode (CPU operating clock stops, peripherals continue to operate.)
  Pseudo-clock mode (Only oscillation clock and timebase timer continue to operate.)
  Clock mode (Main oscillation clock stops, sub-clock and clock timer continue to operate.)
  Stop mode (Main oscillation and sub-clock both stop.)
  CPU intermittent operation mode
  Hardware stand-by mode (Change to stop mpde by operating hardware stand-by pins.)
- **Process**
  CMOS technology
- **I/O ports**
  General-purpose I/O ports (CMOS input/output) : 53 ports
  General-purpose I/O ports (inputs with pull-up resistors) : 24 ports
  General-purpose I/O ports (Nch open-drain outputs) : 8 ports
- **Timers**
  Timebase timer, clock timer, watchdog timer : 1 channel each
  8/16-bit PPG timers 0 and 1 : 8-bit × 2 channels or 16-bit × 1 channel
  16-bit reload timers 0 and 1 : 2 channels
  16-bit I/O timers :
    16-bit free-run timers 0 and 1 : 2 channels
    16-bit input capture 0 : 2 channels (2 channels per unit)
    16-bit output compare 0 and 1 : 8 channels (4 channels per unit)
  8/16-bit up/down counter/timers 0 and 1 : 8-bit × 2 channels or 16-bit × 1 channel
  Clock output function : 1 channel
- **Communications macro** (**communication interface**)
  Extended I/O serial interfaces 0 and 1 : 2 channels
  UART (full-duplex, double-buffered, SCI : Can also be used for synchronous serial transfer) : 1 channel

- **External event interrupt control function**
  DTP/external interrupts : 8 channels (Can be set to detect rising edges, falling edges, “H” levels, or “L” levels)
  Wake-up interrupts : 8 channels (Detects “L” levels only)
  Delayed interrupt generation module : 1 channel (for task switching)
- **Analog/digital conversion**
  8/10-bit A/D converter : 8 channels (Can be initiated by an external trigger. Minimum conversion time = 10.2 μs for a 16 MHz machine clock)
  8-bit D/A converter : 2 channels (R-2R type. Settling time = 12.5 μs for a 16 MHz machine clock)
- **Display function**
  LCD controller/driver : 32 × segment drivers + 4 × common drivers
- **Other**
  Supports serial writing to flash memory. (Only on versions with on-board flash memory.)

Note : The MB90520A and 520B series cannot be used in external bus mode. Always set these devices to single-chip mode.

■ PRODUCT LINEUP

Parameter \ Part Number	MB90522A	MB90523A	MB90522B	MB90523B	MB90F523B	MB90V520A
Classification	Mask ROM				Flash ROM	Evaluation product
ROM size	64 Kbytes	128 Kbytes	64 Kbytes	128 Kbytes	128 Kbytes	—
RAM size	4 Kbytes					6 Kbytes
Separate emulator power supply[*1]	—	—	—	—	—	No
Process	CMOS					
Operating power supply voltage[*2]	3.0 V to 5.5 V		2.7 V to 5.5 V		3.0 V to 5.5 V	
Internal regulator circuit	not mounted				mounted	
CPU functions	Number of instructions : 340 Instruction sizes : 8-bit, 16-bit Instruction length : 1 byte to 7 bytes Data sizes : 1-bit, 8-bit, 16-bit					
	Minimum instruction execution time : 62.5 ns (for a 16 MHz machine clock)					
	Interrupt processing time : 1.5 µs min. (for a 16 MHz machine clock)					
Low power operation (standby modes)	Sleep mode, clock mode, pseudo-clock mode, stop mode, hardware standby mode, and CPU intermittent operation mode					
I/O ports	General-purpose I/O ports (CMOS outputs) : 53 General-purpose I/O ports (inputs with pull-up resistors) : 24 General-purpose I/O ports (Nch open drain outputs) : 8 Total : 85					
Timebase timer	18-bit counter Interrupt interval : 1.024 ms, 4.096 ms, 16.384 ms, 131.072 ms (for a 4 MHz base oscillation)					
Watchdog timer	Reset trigger period • For a 4 MHz base oscillation : 3.58, 14.33, 57.23, 458.75 ms • For 32.768 sub-clock operation : 0.438, 3.500, 7.000, 14.000 s					
16-bit I/O timers — 16-bit freerun timer	Number of channels : 2 Generates an interrupt on overflow					
16-bit I/O timers — 16-bit output compare	Number of channels : 8 Pin change timing : Free run timer register value equals output compare register value.					
16-bit I/O timers — 16-bit input capture	Number of channels : 2 Saves the value of the freerun timer register when a pin input occurs (rising edge, falling edge, either edge) .					
16-bit reload timer	Number of channels : 2 Count clock frequency : 0.125, 0.5, or 2.0 µs for a 16 MHz machine clock Can be used to count an external event clock.					

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Parameter \ Part Number	MB90522A	MB90523A	MB90522B	MB90523B	MB90F523B	MB90V520A
Clock timer	15-bit timer Interrupt interval : 0.438, 0.5, or 2.0 μs for sub-clock frequency = 32.768 kHz					
8/16-bit PPG timer	Number of channels : 1 (Can be used in 2 × 8-bit channel mode) Can generate a pulse waveform output with specified period and 0 to 100% duty ratio.					
8/16 -bit up/down counter/timers	Number of channels : 1 (Can be used in 2 × 8-bit channel mode) External event inputs : 6 channels Reload/compare function : 8-bit × 2 channels					
Clock monitor	Clock output frequency : Machine clock/2^1 to machine clock/2^8					
Delayed interrupt generation module	Interrupt generation module for task switching. (Used by REALOS.)					
DTP/External interrupts	Input channels : 8 Generates interrupts to the CPU on rising edges, falling edges with input “H” level, or “L” level. Can be used for external event interrupts and to activate EI^2OS.					
Wakeup interrupts	Input channels : 8 Triggered by “L” level.					
8/10-bit A/D converter (successive approximation type)	Number of channels : 8 Resolution : 8-bit or 10-bit selectable Conversion can be performed sequentially for multiple consecutive channels. • Single-shot conversion mode : Converts specified channel once only. • Continuous conversion mode : Repeatedly converts specified channel. • Intermittent conversion mode : Converts specified channel then halts temporarily.					
8-bit D/A converter (R-2R type)	Number of channels : 2 Resolution : 8-bit					
UART (SCI)	Number of channels : 1 Clock synchronous transfer : 62.5 Kbps to 1 Mbps Clock asynchronous transfer : 1202 bps to 31250 bps Supports bi-directional and master-slave communications.					
Extended I/O serial interface	Number of channels : 2 Clock synchronous transfer : 31.25 Kbps to 1 Mbps (Using internal shift clock) Transmission format : Selectable LSB-first or MSB-first					
LCD controller/driver	Number of common outputs : 4 Number of segment outputs : 32 Number of power supply pins for LCD drive : 4 LCD display memory : 16 bytes Divider resistor for LCD drive : Internal					

*1 : As for the necessity of a DIP switch setting (S2) when using the emulation pod (MB2145-507) . Refer to the hardware manual for the emulation pod (MB2145-507) fomr details.

*2 : Take note of the maximum operating frequency and A/D converter precision restrictions when operating at 3.0 V to 3.6 V. See the “Electrical Characteristics” section for details.

■ PACKAGES AND CORRESPONDING PRODUCTS

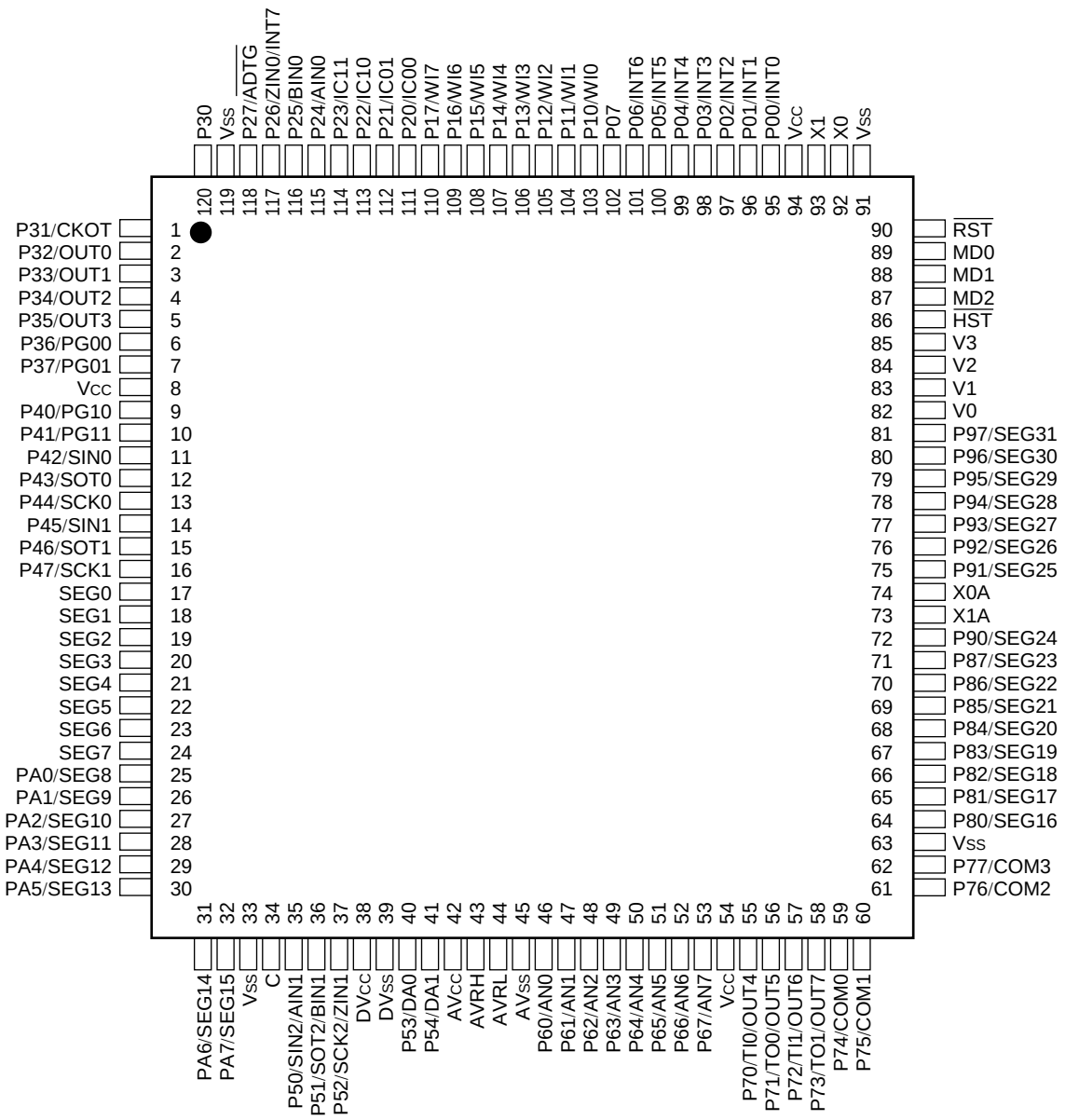
Package	MB90522A	MB90523A	MB90522B	MB90523B	MB90F523B	MB90V520A
FPT-120P-M05 (LQFP)	○	○	○	○	○	×
FPT-120P-M13 (QFP)	○	○	○	○	○	×
PGA-256C-A01 (PGA)	×	×	×	×	×	○

○ : Available, × : Not available

Note : See the “■ PACKAGE DIMENSIONS” section for more details.

■ PIN ASSIGNMENT

(TOP VIEW)



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

■ PIN DESCRIPTIONS

Pin No. LQFP-120*1 QFP-120*2	Pin Name	Circuit Type	Function
92, 93	X0, X1	A	Oscillator pin
74, 73	X0A, X1A	B	Sub-oscillator pin
89 to 87	MD0 to MD2	C	Input pins for setting the operation mode. Connect directly to V_{CC} or V_{SS}.
90	$\overline{RST}$	C	External reset input pin
86	$\overline{HST}$	C	Hardware standby input pin
95 to 101	P00 to P06	D	General-purpose I/O ports The settings in the pull-up resistor setup register (RDR0) are enabled when ports are set as inputs. The RDR0 settings are ignored when ports are set as outputs.
	INT0 to INT6		Event input pins for ch.0 to ch.6 of the DTP/external interrupt circuit
102	P07	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR0) are enabled when ports are set as inputs. The RDR0 settings are ignored when ports are set as outputs.
103 to 110	P10 to P17	D	General-purpose I/O ports The settings in the pull-up resistor setup register (RDR1) are enabled when ports are set as inputs. The RDR1 settings are ignored when ports are set as outputs.
	WI0 to WI7		Event input pins for the wakeup interrupts.
111, 112, 113, 114	P20, P21, P22, P23	E	General-purpose I/O ports
	IC00, IC01, IC10, IC11		Trigger input pins for input capture units (ICU) 0 and 1. Input operates continuously when channels 0 and 1 of input capture units (ICU) 0 and 1 are operating. Accordingly, output to the pins from other functions that share this pin must be suspended unless performed intentionally.
115	P24	E	General-purpose I/O port
	AIN0		Also can be used as the count clock A input to 8/16-bit up/down counter/timer 0.
116	P25	E	General-purpose I/O port
	BIN0		Also can be used as the count clock B input to 8/16-bit up/down counter/timer 0.
117	P26	E	General-purpose I/O port
	ZIN0		Also can be used as the control clock Z input to 8/16-bit up/down counter/timer 0.
	INT7		Event input pin for ch.7 of the DTP/external interrupt circuit

*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
118	P27	E	General-purpose I/O port
	$\overline{\text{ADTG}}$		External trigger input to the 8/10-bit A/D converter Input operates continuously when the 8/10-bit A/D converter is performing input. Accordingly, output to the pin from other functions that share this pin must be suspended unless performed intentionally.
120	P30	E	General-purpose I/O port
1	P31	E	General-purpose I/O port
	CKOT		Output pin for clock monitor function The clock monitor is output when clock monitor output is enabled.
2	P32	E	General-purpose I/O port Only available when waveform output from output compare 0 is disabled.
	OUT0		Event output pin for ch.0 of output compare unit 0 (OCU) Only available when event output is enabled for output compare unit 0.
3	P33	E	General-purpose I/O port Only available when waveform output from output compare 1 is disabled.
	OUT1		Event output pin for ch.1 of output compare unit 0 (OCU) Only available when event output is enabled for output compare unit 0.
4	P34	E	General-purpose I/O port Only available when waveform output from output compare 2 is disabled.
	OUT2		Event output pin for ch.2 of output compare unit 0 (OCU) Only available when event output is enabled for output compare unit 0.
5	P35	E	General-purpose I/O port Only available when waveform output from output compare 3 is disabled.
	OUT3		Event output pin for ch.3 of output compare unit 0 (OCU) Only available when event output is enabled for output compare unit 0.
6	P36	E	General-purpose I/O port Only available when waveform output from PG00 is disabled.
	PG00		Output pin for 8/16-bit PPG timer 0 Only available when waveform output is enabled for PG00.
7	P37	E	General-purpose I/O port Only available when waveform output from PG01 is disabled.
	PG01		Output pin for 8/16-bit PPG timer 0 Only available when waveform output is enabled for PG01.

*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
9, 10	P40, P41	D	General-purpose I/O ports Only available when waveform outputs from PG10 and PG11 are disabled. The settings in the pull-up resistor setup register (RDR4) are enabled when ports are set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	PG10, PG11		Output pins for 8/16-bit PPG timer 1 Only available when waveform output is enabled for PG10 and PG11.
11	P42	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports are set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	SIN0		UART (SCI) serial data input pin Input operates continuously when the UART is performing input. Accordingly, output to the pin from other functions that share this pin must be suspended unless performed intentionally.
12	P43	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports are set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	SOT0		UART (SCI) serial data output pin Only available when serial data output is enabled for the UART (SCI) .
13	P44	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports are set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	SCK0		UART (SCI) serial clock input/output pin Only available when serial clock output is enabled for the UART (SCI) .
14	P45	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports set as inputs. The RDR4 settings are ignored when ports set are as outputs.
	SIN1		Data input pin for extended I/O serial interface 1 Input operates continuously when the performing serial input. Accordingly, output to the pin from other functions that share this pin must be suspended unless performed intentionally.
15	P46	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	SOT1		Data output pin for extended I/O serial interface 1 Only available when serial data output is enabled for SOT1.

*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
16	P47	D	General-purpose I/O port The settings in the pull-up resistor setup register (RDR4) are enabled when ports are set as inputs. The RDR4 settings are ignored when ports are set as outputs.
	SCK1		Serial clock input/output pin for extended I/O serial interface 1 Only available when serial clock output is enabled for SCK1.
35	P50	E	General-purpose I/O port
	SIN2		Data input pin for extended I/O serial interface 2 Input operates continuously when the performing serial input. Accordingly, output to the pin from other functions that share this pin must be suspended unless performed intentionally.
	AIN1		Also can be used as the count clock A input to 8/16-bit up/down counter/timer 1.
36	P51	E	General-purpose I/O port
	SOT2		Data output pin for extended I/O serial interface 2 Only available when serial data output is enabled for SOT2.
	BIN1		Also can be used as the count clock B input to 8/16-bit up/down counter/timer 1.
37	P52	E	General-purpose I/O port
	SCK2		Serial clock input/output pin for extended I/O serial interface 2 Only available when serial clock output is enabled for SCK2.
	ZIN1		Also can be used as the control clock Z input to 8/16-bit up/down counter/timer 1.
40, 41	P53, P54	I	General-purpose I/O ports
	DA0, DA1		Analog output pins for ch.0 and ch.1 of the 8-bit D/A converter
46 to 53	P60 to P67	K	General-purpose I/O ports Port input is enabled when the analog input enable register (ADER) is set to the ports.
	AN0 to AN7		Analog inputs for the 8/10-bit A/D converter Analog input is enabled when the analog input enable register (ADER) is set.
55, 57	P70, P72	E	General-purpose I/O ports
	TI0, TI1		Event input pins for 16-bit reload timers 0 and 1 Input operates continuously when 16-bit reload timers 0 and 1 input an external clock. Accordingly, output to these pins from other functions that share the pins must be suspended unless performed intentionally.
	OUT4, OUT6		Event output pins for ch. 4 and ch. 6 of output compare unit 1 (OCU) Only available when event output from output compare 1 is enabled.

*1 : FPT-120P-M05

*2 : FPT-120P-M13

(Continued)

Pin No. LQFP-120*1 QFP-120*2	Pin Name	Circuit Type	Function
56, 58	P71, P73	E	General-purpose I/O ports Only available when event outputs from 16-bit reload timers 0 and 1 are disabled.
	TO0, TO1		Output pins for 16-bit reload timers 0 and 1. Only available when output is enabled for 16-bit reload timers 0 and 1.
	OUT5, OUT7		Event output pins for ch. 5 and ch. 7 of output compare unit 1 (OCU) Only available when event output from output compare 1 is enabled.
59 to 62	P74 to P77	L	General-purpose I/O ports Only available when the LCD controller/driver control register is set to the ports.
	COM0 to COM3		Common pins for the LCD controller/driver Only available when the LCD controller/driver control register is set to the common outputs.
64 to 71	P80 to P87	L	General-purpose I/O ports Only available when the LCD controller/driver control register is set to the ports.
	SEG16 to SEG23		LCD segment output pins for the LCD controller/driver Only available when the LCD controller/driver control register is set to the segment outputs.
72, 75 to 81	P90, P91 to P97	M	General-purpose I/O ports (Support up to I_{OL} = 10 mA) Only available when the LCD controller/driver control register is set to the ports.
	SEG24, SEG25 to SEG31		LCD segment output pins for the LCD controller/driver Only available when the LCD controller/driver control register is set to the segment outputs.
17 to 24	SEG0 to SEG7	F	LCD segment 00 to 07 pins for the LCD controller/driver
25 to 32	PA0 to PA7	L	General-purpose I/O ports Only available when the LCD controller/driver control register is set up to the ports.
	SEG8 to SEG15		LCD segment 08 to 15 pins for the LCD controller/driver Only available when the LCD controller/driver control register is set to the segment outputs.

*1 : FPT-120P-M05

*2 : FPT-120P-M13

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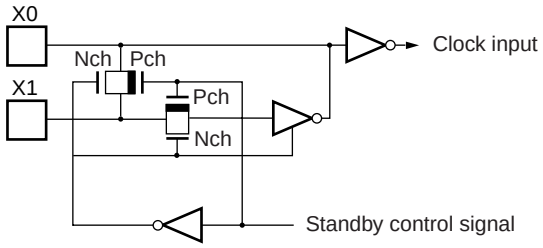
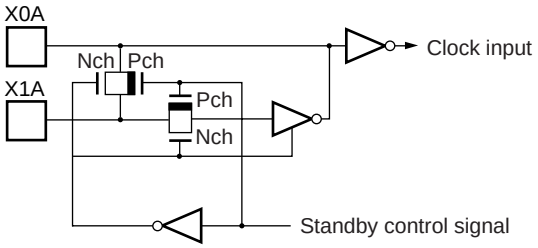
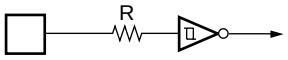
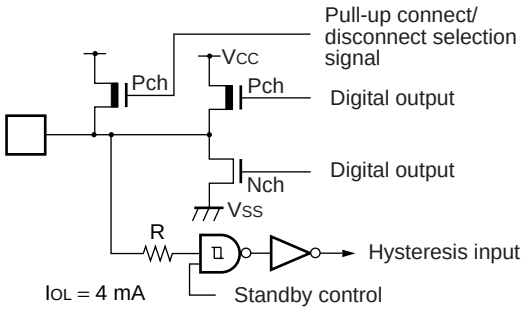
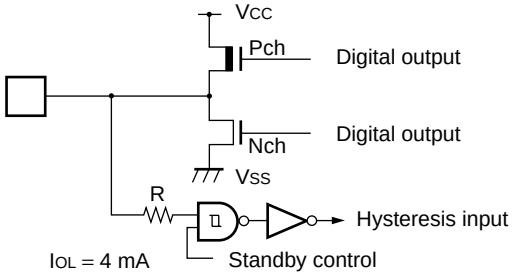
Pin No. LQFP-120*1 QFP-120*2	Pin Name	Circuit Type	Function
34	C	G	Capacitor connection pin for stabilizing power supply Connect an external ceramic capacitor of approximately 0.1 μF. If operating at 3.3 V or lower, connect to V_{CC}.
82 to 85	V0 to V3	N	Power supply input pins for the LCD controller/driver
8, 54, 94	V_{CC}	Power supply	Power supply input pins for the digital circuit
33, 63, 91, 119	V_{SS}	Power supply	GND level power supply input pins for the digital circuit
42	AV_{CC}	H	Power supply input for the analog circuit Ensure that a voltage greater than AV_{CC} is applied to V_{CC} before turning the analog power supply on or off.
43	AVRH	J	“H” reference voltage for the A/D converter Ensure that a voltage greater than AVRH is applied to AV_{CC} before turning the power supply to this pin on or off.
44	AVRL	H	“L” reference voltage for the A/D converter
45	AV_{SS}	H	GND level power supply input pin for the analog circuit
38	DV_{CC}	H	“H” reference voltage for the D/A converter Ensure that this voltage does not exceed V_{CC}.
39	DV_{SS}	H	“L” reference voltage for the D/A converter Apply the same voltage level 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. 1 MΩ
B		• Low-speed oscillation feedback resistor Approx. 10 MΩ
C		• Hysteresis input
D		• Selectable pull-up option • CMOS hysteresis input • CMOS level output • With standby control
E		• CMOS hysteresis input • CMOS level output • With standby control

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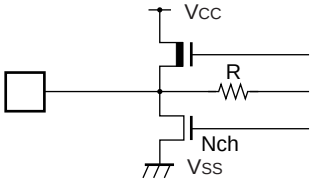
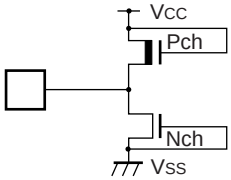
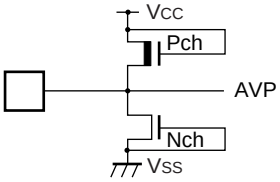
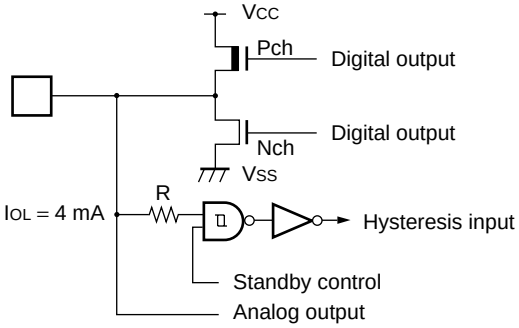
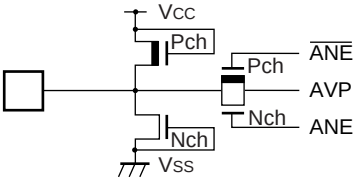
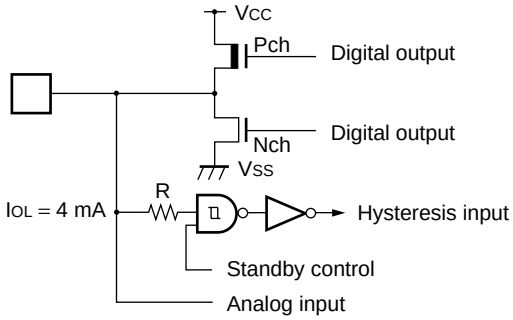
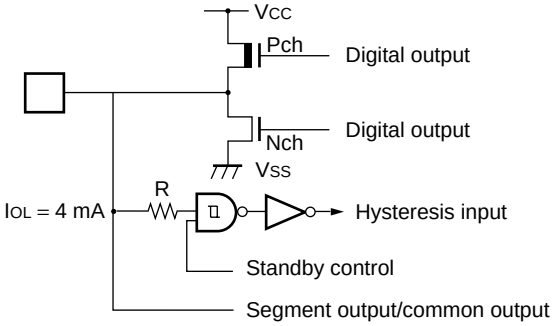
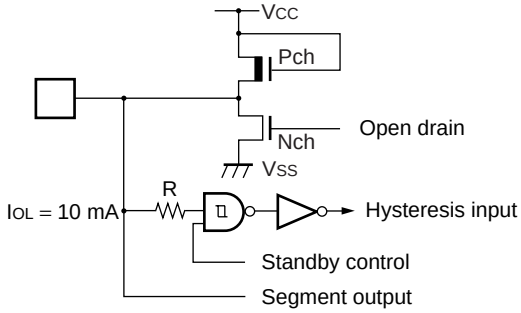
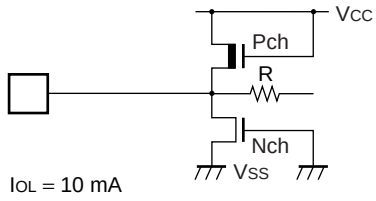
Type	Circuit	Remarks
F		• Segment output pins
G		• Capacitor connection pin (This is an N.C. pin on the MB90522A and MB90523A.)
H		• Analog power supply input protection circuit
I		• CMOS hysteresis input • CMOS level output (CMOS output is not available when analog output is operating.) • Also used as analog output (Analog output has priority) • With standby control
J		• A/D converter ref+ power supply input pin (Incorporates power supply protection circuit.)

(Continued)

(Continued)

Type	Circuit	Remarks
K		• CMOS hysteresis input • CMOS level output • Also used as analog input. • With standby control
L		• CMOS hysteresis input • CMOS level output • Also used as segment output pin. • With standby control (only available when segment output is not operating.)
M		• CMOS hysteresis input • N-ch open-drain output • Also used as segment output pin. • With standby control (only available when segment output is not operaing.)
N		• Reference voltage pin for LCD controller

■ HANDLING DEVICES

Take note of the following points when handling devices :

- Do not exceed maximum rated voltage (to prevent latch-up)
- Supply voltage stability
- Power-on precautions
- Power supply pins
- Crystal oscillator circuit
- Notes on using an external clock
- Precautions when not using sub-clock mode
- Treatment of unused pins
- Treatment of N.C. pins
- Treatment of pins when A/D converter is not used
- Sequence for connecting and disconnecting the A/D converter power supply and analog input pins
- Shared use of general-purpose I/O ports and LCD controller/driver SEG/COM pins
- Conditions when output from ports 0 and 1 is undefined
- Initialization
- Notes on using the DIV A, Ri and DIVW A, RWi instructions
- Notes on using REALOS

Device Handling Precautions

- **Do not exceed maximum rated voltage** (**to prevent latch-up**)
  Latch-up occurs in CMOS ICs if a voltage greater than V_{CC} or less than V_{SS} is applied to an input or output pin (other than a high or medium withstand voltage pin) or if the voltage applied between V_{CC} and V_{SS} exceeds the rating. If latch-up occurs, the power supply current increases rapidly resulting in thermal damage to circuit elements. Therefore, ensure that maximum ratings are not exceeded in circuit operation.
  Similarly, when turning the analog power supply on or off, ensure the analog power supply voltages (AV_{CC}, AVRH, DV_{CC}) and analog input voltages do not exceed the digital voltage (V_{CC}) .
  Also ensure that the voltages applied to the LCD power supply pins (V3 to V0) do not exceed the power supply voltage (V_{CC}) .

- **Supply voltage stability**
  Rapid changes in supply voltage may cause the device to misoperate, even if the voltage remains within the allowed operating range. Accordingly, ensure that the V_{CC} supply is stable.
  The standard for power supply voltage stability is a peak-to-peak V_{CC} ripple voltage at the mains supply frequency (50 to 60 Hz) of 10% or less of V_{CC} and a transient voltage change rate of 0.1 V/ms or less when turning the power supply on or off.

- **Power-on precautions**
  To prevent misoperation of the internal regulator circuit at power-on, ensure that the power supply rising time (0.2 V to 2.7 V) is at least 50 µs.

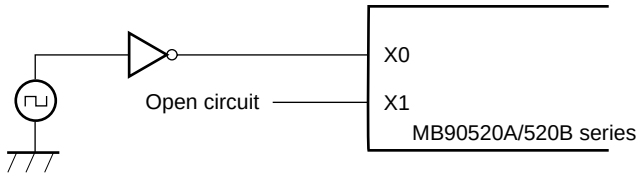
- **Power supply pins**
  When multiple V_{CC} and V_{SS} pins are provided, connect all V_{CC} and V_{SS} pins to power supply or ground externally. Although pins at the same potential are connected together in the internal device design so as to prevent misoperation such as latch-up, connecting all V_{CC} and V_{SS} pins appropriately minimizes unwanted radiation, prevents misoperation of strobe signals due to increases in the ground level, and keeps the overall output current rating.
  Also, ensure that the impedance of the V_{CC} and V_{SS} connections to the power supply are as low as possible.

Connection of a bypass capacitor of approximately 0.1 µF between V_{CC} and V_{SS} is recommended to prevent power supply noise. Connect the capacitor close to the V_{CC} and V_{SS} pins.

- **Crystal oscillator circuit**
  Noise on the X0 and X1 pins can be a cause of device misoperation. Place the X0 and X1 pins, crystal oscillator (or ceramic oscillator) , and bypass capacitor to ground as close together as possible. Also, design the circuit board so that the X0 and X1 pin wiring does not cross other wiring.
  Surrounding the X0/X1 and X0A/X1A pins with ground in the printed circuit board design is recommended to ensure stable operation.

- **Notes on using an external clock**
  When using an external clock, drive the X0 pin only and leave the X1 pin open.
  The figure below shows an example of how to use an external clock.

Example of how to use an external clock



- **Precautions when not using sub-clock mode**
  Connect an oscillator to X0A and X1A, even if not using sub-clock mode.

- **Treatment of unused pins**
  Leaving unused input pins unconnected can cause misoperation or permanent damage to the device due to latchup. Always pull-up or pull-down unused pins using a 2 kΩ or larger resistor.
  If some I/O pins are unused, either set as outputs and leave open circuit or set as inputs and treat in the same way as input pins.

- **Treatment of N.C. pins**
  Always leave N.C. (non connect) pins open circuit.

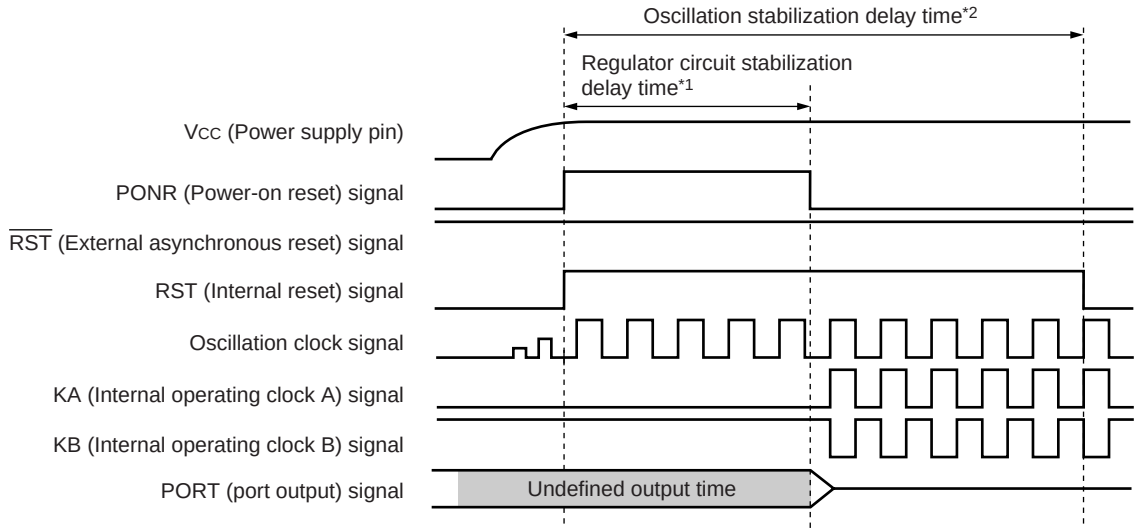
- **Treatment of pins when A/D converter not used**
  When not using the A/D converter and D/A converter, always connect AV_{CC} = DV_{CC} = AVRH = V_{CC} and AV_{SS} = AVRL = V_{SS}.

- **Sequence for connecting and disconnecting the A/D converter power supply and analog input pins**
  Do not apply voltage to the A/D and D/A converter power supply (AV_{CC}, AVRH, AVRL, DV_{CC}, DV_{SS}) or analog inputs (AN0 to AN7) until the digital power supply (V_{CC}) is turned on.
  When turning the device off, turn off the digital power supply after disconnecting the A/D converter power supply and analog inputs. When turning the power on or off, ensure that AVRH and DV_{CC} do not exceed AV_{CC} (turning the analog and digital power supplies on and off simultaneously is OK) .

- **Shared use of general-purpose I/O ports and LCD controller/driver SEG/COM pins**
  The SEG08 to SEG31 and COM0 to COM3 pins are shared with general-purpose I/O ports. The electrical ratings for SEG08 to SEG23 and COM0 to COM3 are the same as for CMOS outputs and the electrical ratings for SEG24 to SEG31 are the same as for N-ch open-drain ports.

- **Conditions when output from ports 0 and 1 is undefined**
  After turning on the power supply, the outputs from ports 0 and 1 are undefined during the oscillation stabilization delay time controlled by the regulator circuit (during the power-on reset) . The figure below shows the timing.
  Note that this undefined output period does not occur on products without an internal regulator circuit as these products do not have an oscillation stabilization delay time.

Timing chart for undefined output from ports 0 and 1



*1 : Regulator circuit oscillation stabilization delay time : 2^{17}/Oscillation clock frequency
(approx. 8.19 ms for a 16 MHz oscillation clock frequency)

*2 : Oscillation stabilization delay time : 2^{18}/Oscillation clock frequency
(approx. 16.38 ms for a 16 MHz oscillation clock frequency)

Note : See the "■ PRODUCT LINEUP" section for details of which MB90520A/520B series products have an internal regulator circuit.

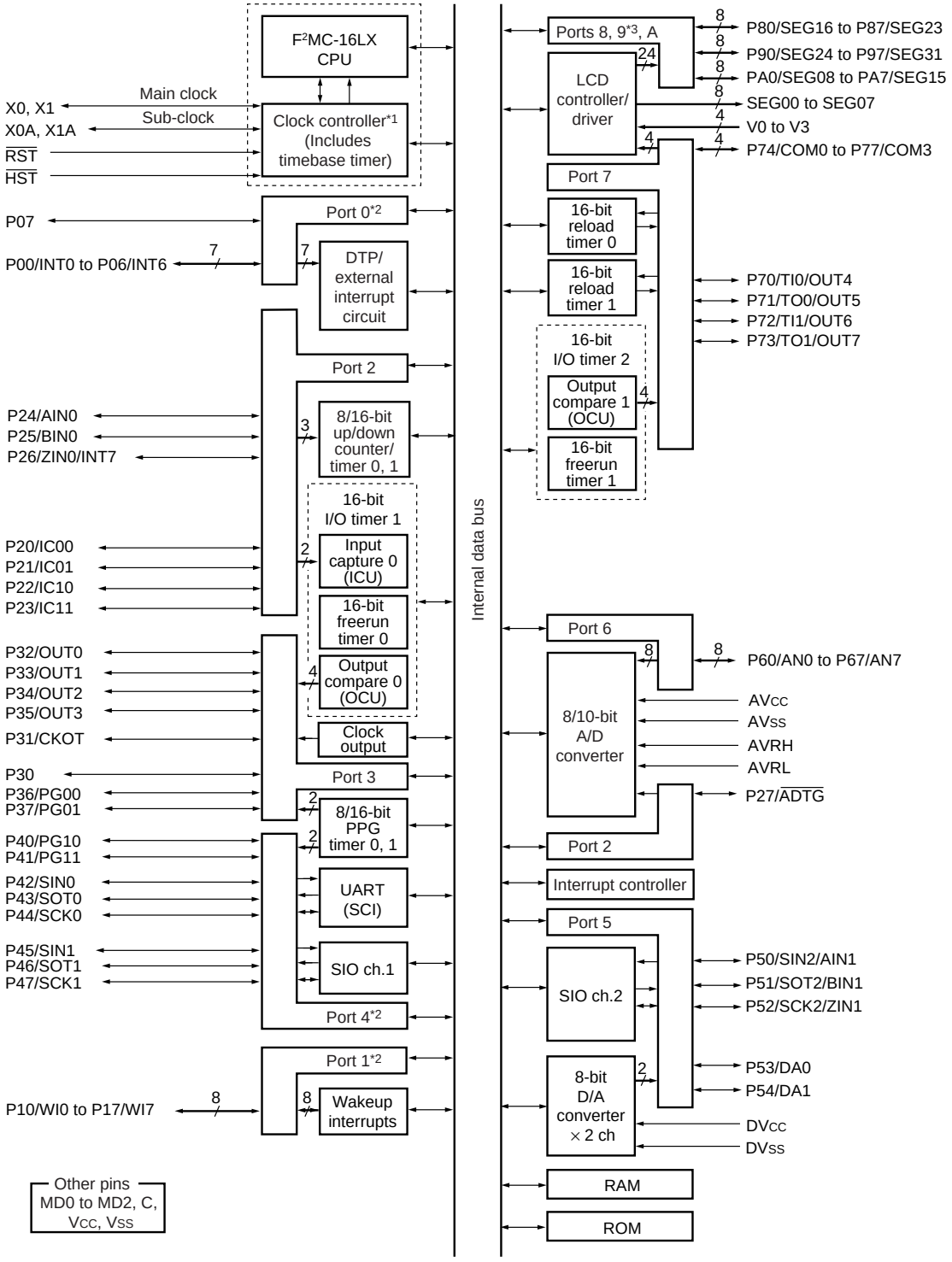
- **Initialization**
  The device contains internal registers that are only initialized by a power-on reset. To initialize these registers, restart the power supply.

- **Notes on using the DIV A, Ri and DIVW A, RWi instructions**
  Set the corresponding bank registers (DTB, ADB, USB, SSB) to "00_H" when using the signed division instructions "DIV A, Ri" and "DIVW A, RWi".
  If the corresponding bank registers (DTB, ADB, USB, SSB) are set to other than "00_H", the remainder value produced by the instruction is not stored in the instruction operand register.

- **Notes on using REALOS**
  The extended intelligent I/O service (EI^{2}OS) cannot be used when using REALOS.

Caution on Operations during PLL Clock Mode
If the PLL clock mode is selected, the microcontroller attempt to be working with the self-oscillating circuit even when there is no external oscillator or external clock input is stopped. Performance of this operation, however, cannot be guaranteed.

• BLOCK DIAGRAM



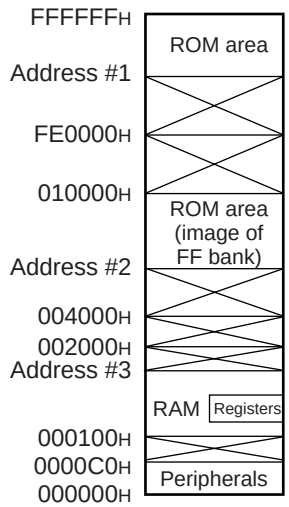
*1 : The clock control circuit includes the watchdog timer and timebase timer low power consumption control circuits.

*2 : Incorporates a pull-up register setting register. CMOS level input and output.

*3 : As this port shares pins with the LCD output, the port uses N-ch open-drain circuits.

■ MEMORY MAP

Single chip mode with mirror function



Part No.	Address #1*	Address #2*	Address #3*
MB90522A/B	FF0000H	004000H	001100H
MB90523A/B	FE0000H	004000H	001100H
MB90F523B	FE0000H	004000H	001100H
MB90V520A	—	—	001900H

: Internal memory access

: Access prohibited

* : The values of addresses #1, #2, and #3 vary by product.

Note : The upper part of 00 bank contains a mirror of the ROM data in FF bank. This is called the mirror ROM function and enables use of the C compiler's small memory model. As the lower 16 bits of the FF bank and 00 bank addresses are the same, tables located in ROM can be referenced without needing to declare far pointers.

For example, accessing 00C000H actually accesses the contents of ROM at FFC000H. Note that, as the FF bank ROM area exceeds 48 KBytes, the entire ROM image cannot be mirrored in 00 bank. Accordingly, as ROM data from FF4000H to FFFFFFH is mirrored in 004000H to 00FFFFH, always locate ROM data tables in the range FF4000H to FFFFFFH.

■ I/O MAP

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

(Continued)

Address	Abbreviated Register Name	Register Name	Peripheral Name	Initial Value
000020H	SMR	Serial mode register	UART (SCI)	00000000B
000021H	SCR	Serial control register		00000100B
000022H	SIDR/ SODR	Serial input data register/ Serial output data register		XXXXXXXXB
000023H	SSR	Serial status register		00001X00B
000024H	SMCS1	Serial mode control status register 1	Extended I/O serial interface 1	XXXX0000B
000025H				00000010B
000026H	SDR1	Serial data register 1		XXXXXXXXB
000027H	CDCR	Communication prescaler control register	Communication prescaler register	0XXX1111B
000028H	SMCS2	Serial mode control status register 2	Extended I/O serial interface 2	XXXX0000B
000029H				00000010B
00002AH	SDR2	Serial data register 2		XXXXXXXXB
00002BH	(Access prohibited)			
00002CH	OCS45	OCU control status register ch.45	16-bit I/O timer	0000XX00B
00002DH				XXX00000B
00002EH	OCS67	OCU control status register ch.67		0000XX00B
00002FH				XXX00000B
000030H	ENIR	DTP/interrupt enable register	DTP /external interrupt circuit	00000000B
000031H	EIRR	DTP/interrupt request register		XXXXXXXXB
000032H	ELVR	Request level setting register		00000000B
000033H				00000000B
000034H	OCP6	OCU compare register ch.6	16-bit I/O timer	XXXXXXXXB
000035H				XXXXXXXXB
000036H	ADCS	A/D control status register	8/10-bit A/D converter	00000000B
000037H				00000000B
000038H	ADCR	A/D data register		XXXXXXXXB
000039H				00001XXXB
00003AH	DADR0	D/A converter data register ch.0	8-bit D/A converter	XXXXXXXXB
00003BH	DADR1	D/A converter data register ch.1		XXXXXXXXB
00003CH	DACR0	D/A control register 0		XXXXXXX0B
00003DH	DACR1	D/A control register 1		XXXXXXX0B
00003EH	CLKR	Clock output enable register	Clock monitor function	XXXX0000B

(Continued)

Address	Abbreviated Register Name	Register Name	Peripheral Name	Initial Value
00003F$_H$	(Access prohibited)			
000040$_H$	PRLL0	PPG0 reload register L	8/16-bit PPG timer 0, 1	XXXXXXXX$_B$
000041$_H$	PRLH0	PPG0 reload register H		XXXXXXXX$_B$
000042$_H$	PRLL1	PPG1 reload register L		XXXXXXXX$_B$
000043$_H$	PRLH1	PPG1 reload register H		XXXXXXXX$_B$
000044$_H$	PPGC0	PPG0 operation mode control register		0X000XX1$_B$
000045$_H$	PPGC1	PPG1 operation mode control register		0X000001$_B$
000046$_H$	PPGOE	PPG0, 1 output control register		00000000$_B$
000047$_H$	(Access prohibited)			
000048$_H$	TMCSR0	Timer control status register ch.0	16-bit reload timer 0	00000000$_B$
000049$_H$				XXXX0000$_B$
00004A$_H$	TMR0/ TMRLR0	16-bit timer register ch.0/ 16-bit reload register ch.0		XXXXXXXX$_B$
00004B$_H$				XXXXXXXX$_B$
00004C$_H$	TMCSR1	Timer control status register ch.1	16-bit reload timer 1	00000000$_B$
00004D$_H$				XXXX0000$_B$
00004E$_H$	TMR1/ TMRLR1	16-bit timer register ch.1/ 16-bit reload register ch.1		XXXXXXXX$_B$
00004F$_H$				XXXXXXXX$_B$
000050$_H$	IPCP0	ICU data register ch.0	16-bit I/O timer	XXXXXXXX$_B$
000051$_H$				XXXXXXXX$_B$
000052$_H$	IPCP1	ICU data register ch.1		XXXXXXXX$_B$
000053$_H$				XXXXXXXX$_B$
000054$_H$	ICS01	ICU control status register		00000000$_B$
000055$_H$	(Access prohibited)			
000056$_H$	TCDT0	Freerun timer data register 0	16-bit I/O timer	00000000$_B$
000057$_H$				00000000$_B$
000058$_H$	TCCS0	Freerun timer control status register 0		00000000$_B$
000059$_H$	(Access prohibited)			
00005A$_H$	OCP0	OCU compare register ch.0	16-bit I/O timer	XXXXXXXX$_B$
00005B$_H$				XXXXXXXX$_B$
00005C$_H$	OCP1	OCU compare register ch.1		XXXXXXXX$_B$
00005D$_H$				XXXXXXXX$_B$
00005E$_H$	OCP2	OCU compare register ch.2		XXXXXXXX$_B$
00005F$_H$				XXXXXXXX$_B$

(Continued)

Address	Abbreviated Register Name	Register Name	Peripheral Name	Initial Value
000060H	OCP3	OCU compare register ch.3	16-bit I/O timer	XXXXXXXXB
000061H				XXXXXXXXB
000062H	OCS01	OCU control status register ch.0, ch.1		0000XX00B
000063H				XXX00000B
000064H	OCS23	OCU control status register ch.2, ch.3		0000XX00B
000065H				XXX00000B
000066H	TCDT1	Freerun timer data register 1	16-bit I/O timer	00000000B
000067H				00000000B
000068H	TCCS1	Freerun timer control status register 1		00000000B
000069H	(Access prohibited)			
00006AH	LCR0	LCDC control register 0	LCD controller/driver	00010000B
00006BH	LCR1	LCDC control register 1		00000000B
00006CH	OCP7	OCU compare register ch.7	16-bit I/O timer	XXXXXXXXB
00006DH				XXXXXXXXB
00006EH	(Access prohibited)			
00006FH	ROMM	ROM mirror function selection register	ROM mirror function selection module	XXXXXXX1B
000070H to 00007FH	VRAM	Data memory for LCD display	LCD controller/driver	XXXXXXXXB
000080H	UDCR0	Up/down count register 0	8/16-bit up/down counter/timer 0, 1	00000000B
000081H	UDCR1	Up/down count register 1		00000000B
000082H	RCR0	Reload compare register 0		00000000B
000083H	RCR1	Reload compare register 1		00000000B
000084H	CSR0	Counter status register 0		00000000B
000085H	(Reserved) *3			
000086H	CCR0	Counter control register 0	8/16-bit up/down counter/timer 0, 1	X0000000B
000087H				00000000B
000088H	CSR1	Counter status register 1		00000000B
000089H	(Reserved) *3			
00008AH	CCR1	Counter control register 1	8/16-bit up/down counter/timer 0, 1	X0000000B
00008BH				X0000000B
00008CH	RDR0	Port 0 input pull-up resistor setup register	Port 0	00000000B
00008DH	RDR1	Port 1 input pull-up resistor setup register	Port 1	00000000B

(Continued)

Address	Abbreviated Register Name	Register Name	Peripheral Name	Initial Value
00008E$_H$	RDR4	Port 4 input pull-up resistor setup register	Port 4	00000000$_B$
00008F$_H$ to 00009D$_H$	(Access prohibited) (Area reserved for system use) *4			
00009E$_H$	PACSR	Address detection control register	Address match detection function	00000000$_B$
00009F$_H$	DIRR	Delayed interrupt request output/clear register	Delayed interrupt generation module	XXXXXXX0$_B$
0000A0$_H$	LPMCR	Low power consumption mode control register	Low power consumption (standby) mode	00011000$_B$
0000A1$_H$	CKSCR	Clock selection register		11111100$_B$
0000A2$_H$ to 0000A7$_H$	(Access prohibited)			
0000A8$_H$	WDTC	Watchdog timer control register	Watchdog timer	XXXXXXXX$_B$
0000A9$_H$	TBTC	Timebase timer control register	Timebase timer	1XX00000$_B$
0000AA$_H$	WTC	Clock timer control register	Clock timer	1X001000$_B$
0000AB$_H$ to 0000AD$_H$	(Access prohibited)			
0000AE$_H$	FMCS	Flash memory control status register	1 Mbit flash memory	000X0000$_B$
0000AF$_H$	(Access prohibited)			
0000B0$_H$	ICR00	Interrupt control register 00	Interrupt controller	00000111$_B$
0000B1$_H$	ICR01	Interrupt control register 01		00000111$_B$
0000B2$_H$	ICR02	Interrupt control register 02		00000111$_B$
0000B3$_H$	ICR03	Interrupt control register 03		00000111$_B$
0000B4$_H$	ICR04	Interrupt control register 04		00000111$_B$
0000B5$_H$	ICR05	Interrupt control register 05		00000111$_B$
0000B6$_H$	ICR06	Interrupt control register 06		00000111$_B$
0000B7$_H$	ICR07	Interrupt control register 07		00000111$_B$
0000B8$_H$	ICR08	Interrupt control register 08		00000111$_B$
0000B9$_H$	ICR09	Interrupt control register 09		00000111$_B$
0000BA$_H$	ICR10	Interrupt control register 10		00000111$_B$
0000BB$_H$	ICR11	Interrupt control register 11		00000111$_B$
0000BC$_H$	ICR12	Interrupt control register 12		00000111$_B$
0000BD$_H$	ICR13	Interrupt control register 13		00000111$_B$

(Continued)

(Continued)

Address	Abbreviated Register Name	Register Name	Peripheral Name	Initial Value
0000BE$_H$	ICR14	Interrupt control register 14	Interrupt controller	00000111$_B$
0000BF$_H$	ICR15	Interrupt control register 15		00000111$_B$
0000C0$_H$ to 0000FF$_H$	(Access prohibited) *1			
000100$_H$ to 00####$_H$	(RAM area) *2			
00####$_H$ to 001FEF$_H$	(Reserved area) *3			
001FF0$_H$	PADR0	Detection address setting register 0 (low byte)	Address match detection function	XXXXXXXX$_B$
001FF1$_H$		Detection address setting register 0 (middle byte)		XXXXXXXX$_B$
001FF2$_H$		Detection address setting register 0 (high byte)		XXXXXXXX$_B$
001FF3$_H$	PADR1	Detection address setting register 1 (low byte)		XXXXXXXX$_B$
001FF4$_H$		Detection address setting register 1 (middle byte)		XXXXXXXX$_B$
001FF5$_H$		Detection address setting register 1 (high byte)		XXXXXXXX$_B$
001FF6$_H$ to 001FFF$_H$	(Reserved area) *3			

Initial value notation

0 : Initial value of bit is “0”.

1 : Initial value of bit is “1”.

X : Initial value of bit is undefined.

*1 : Access is prohibited to the address range 0000C0$_H$ to 0000FF$_H$. See the “■ MEMORY MAP” section.

*2 : See the “■ MEMORY MAP” section for details of the “ (RAM area) ”.

*3 : “ (Reserved areas) ” are addresses used internally by the system and may not be used.

*4 : The “ (Area reserved for system use) ” contains setting registers used by the evaluation tools.

Notes : • LPMCR, CKSCR, and WDTC are initialized by some types of reset and not by others. The initial values listed are for the case when the registers are initialized.

• The boundary address “####$_H$” between the “ (RAM area) ” and “ (Reserved area) ” differs depending on the product. See the “■ MEMORY MAP” section for details.

• OCU compare registers ch.0 to ch.3 use 16-bit freerun timer 0 and OCU compare registers ch.4 to ch.7 use 16-bit freerun timer 1. Note that 16-bit freerun timer 0 is also used by input capture 0 and 1 (ICU) .

■ INTERRUPTS, INTERRUPT VECTORS, AND INTERRUPT CONTROL REGISTERS

Interrupt	EI²OS Support	Interrupt Vector		Interrupt Control Register		Priority
		No.	Address	ICR	Address	
Reset	×	#08	FFFFDC$_H$	—	—	High
INT 9 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 freerun timer 0 overflow	×	#14	FFFFC4$_H$			
Extended I/O serial interface 1	○	#15	FFFFC0$_H$	ICR02	0000B2$_H$	
Wakeup interrupt	×	#16	FFFFBC$_H$			
Extended I/O serial interface 2	○	#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	FFFFA8$_H$	ICR05	0000B5$_H$	
8/16-bit up/down counter/timer 0 overflow, up/down direction change	○	#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 timer	×	#26	FFFF94$_H$			
Output compare 1 (OCU) ch.6, ch.7 match	○	#27	FFFF90$_H$	ICR08	0000B8$_H$	
16-bit freerun timer 1 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 direction change	○	#30	FFFF84$_H$			
Input capture 0 (ICU) capture	○	#31	FFFF80$_H$	ICR10	0000BA$_H$	
Input capture 1 (ICU) capture	○	#32	FFFF7C$_H$			
Output compare 0 (OCU) ch.0 match	○	#33	FFFF78$_H$	ICR11	0000BB$_H$	
Output compare 0 (OCU) ch.1 match	○	#34	FFFF74$_H$			

(Continued)

(Continued)

Interrupt	EI²OS Support	Interrupt Vector		Interrupt Control Register		Priority
		No.	Address	ICR	Address	
Output compare 0 (OCU) ch.2 match	○	#35	FFFF70H	ICR12	0000BCH	↓
Output compare 0 (OCU) ch.3 match	○	#36	FFFF6CH			
UART (SCI) receive complete	◎	#37	FFFF68H	ICR13	0000BDH	
16-bit reload timer 0	○	#38	FFFF64H			
UART (SCI) send complete	◎	#39	FFFF60H	ICR14	0000BEH	
16-bit reload timer 1	○	#40	FFFF5CH			
Flash memory	×	#41	FFFF58H	ICR15	0000BFH	
Delayed interrupt generation module	×	#42	FFFF54H			Low

○ : Supported

× : Not supported

◎ : Supported, includes EI²OS stop function

■ PERIPHERAL RESOURCES

1. I/O Ports

- The I/O ports can be used as general-purpose I/O ports (parallel I/O ports) . The MB90520A and 520B series have 11 ports (85 pins) . The ports share pins with the inputs and outputs of the peripheral functions.
- The port data registers (PDR) are used to output data to the I/O pins and capture the input signals from the I/O ports.
  Similarly, the port direction registers (DDR) set the I/O direction (input or output) for each individual port bit.
- The following tables list the I/O ports and peripheral functions with which they share pins.

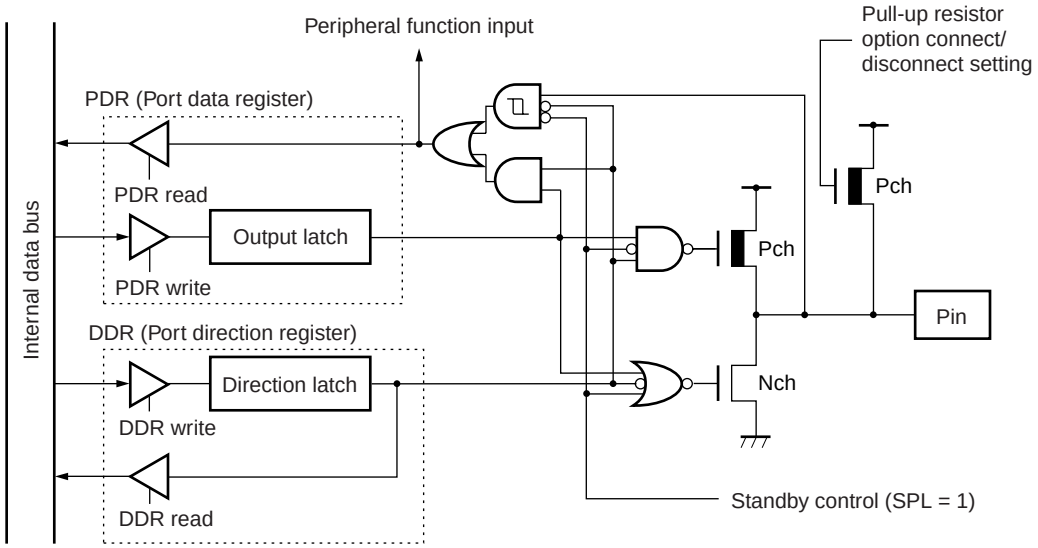
	Pin Name (Port)	Pin Name (Peripheral)	Peripheral Function that Shares Pin
Port 0	P00 – P06	INT0 – INT6	External interrupts
	P07	—	Not shared
Port 1	P10 – P17	WI0 – WI7	Wakeup interrupts
Port 2	P20 – P23	IN00 – IN11	Input capture (unit 0)
	P24, P25	AIN0, BIN0	8/16-bit up/down counter/timer 0
	P26	ZIN0/INT7	8/16-bit up/down counter/timer 0, external interrupt
Port 3	P30	—	Not shared
	P31	CKOT	Clock monitor function
	P32 – P35	OUT0 – OUT3	Output compare (unit 0)
	P36, P37	PPG00, PPG01	8/16-bit PPG timer 0
Port 4	P40, P41	PPG10, PPG11	8/16-bit PPG timer 1
	P42 – P44	SIN0, SOT0, SCK0	UART (SCI)
	P45 – P47	SIN1, SOT1, SCK1	Extended I/O serial interface 0
Port 5	P50 – P52	SIN2/AIN1, SOT1/BIN1, SCK1/ZIN1	8/16-bit up/down counter/timer 0 Extended I/O serial interface 1
	P53, P54	DA0, DA1	8-bit D/A converter
Port 6	P60 – P67	AN0 – AN7	8/16-bit A/D converter
Port 7	P70 – P73	TIN0/OUT4, TOT0/OUT5, TIN1/OUT6, TOT1/OUT7	16-bit reload timers 0, 1 Output compare (unit 1)
	P74 – P77	COM0 – COM3	LCD control driver common output
Port 8	P80 – P87	SEG16 – SEG23	LCD control driver segment output
Port 9	P90 – P97	SEG24 – SEG31	LCD control driver segment output
Port A	PA0 – PA7	SEG8 – SEG15	LCD control driver segment output

Notes

- Port 9 contains general-purpose I/O ports with N-ch open-drain output circuits.
- Connect an external pull-up resistor when using port 9 pins as outputs.
- Port 6 shares pins with the analog inputs. When using port 6 as a general-purpose port, ensure that the corresponding analog input enable register (ADER) bits are set to “0”. ADER is initialized to “FF_H” after a reset.

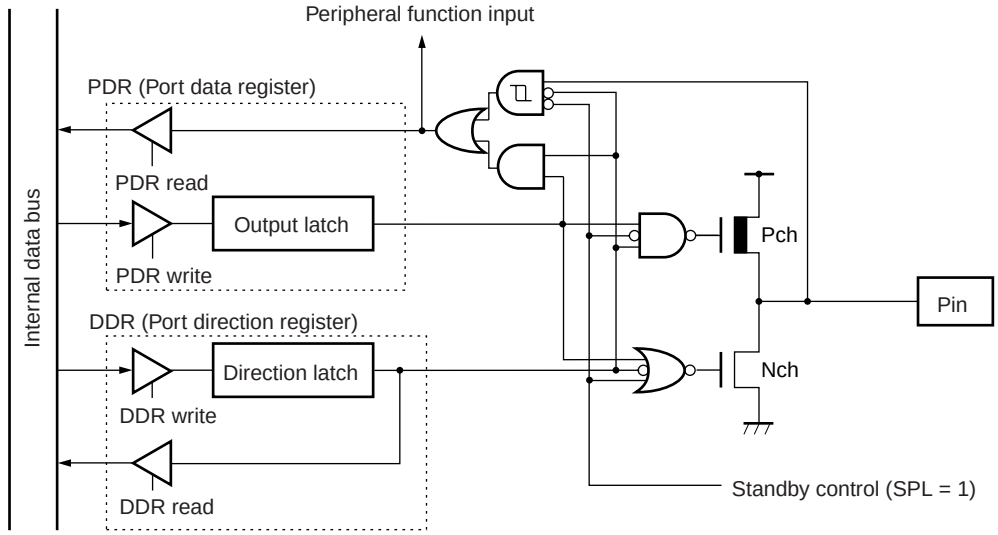
• **Block diagrams**

P00 to P07, P10 to P17



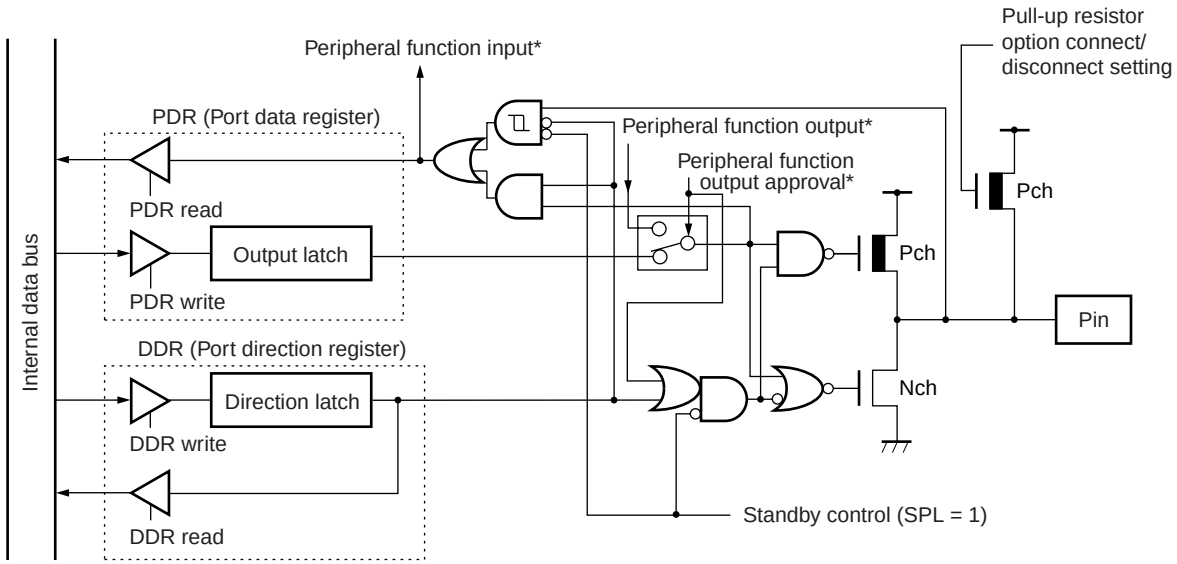
Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

P20 to P27



Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

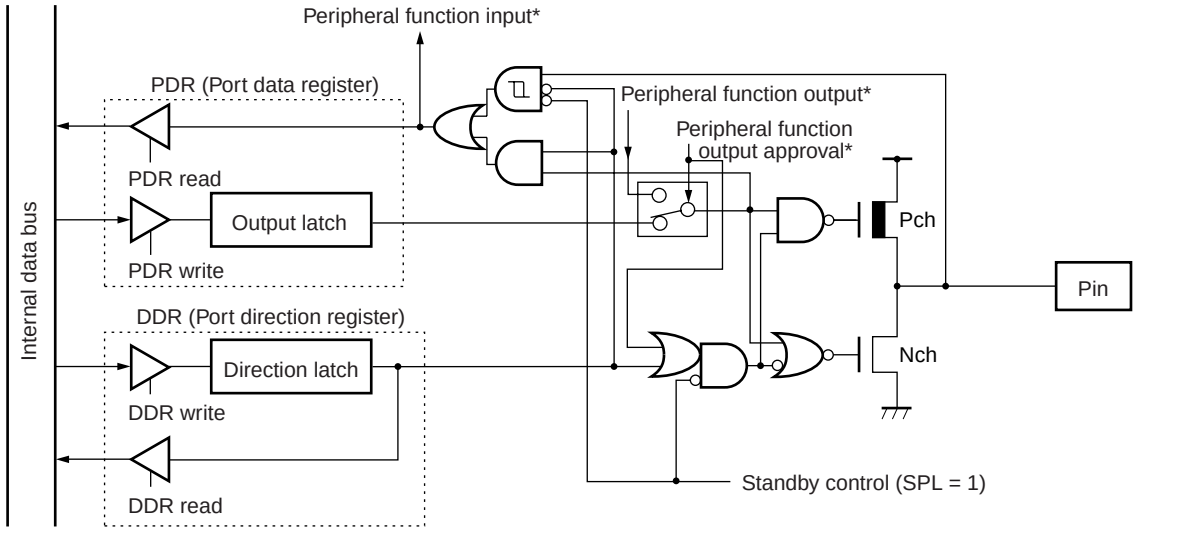
P40 to P47



Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

* : Peripheral function I/O is equivalent to I/O of peripheral function.

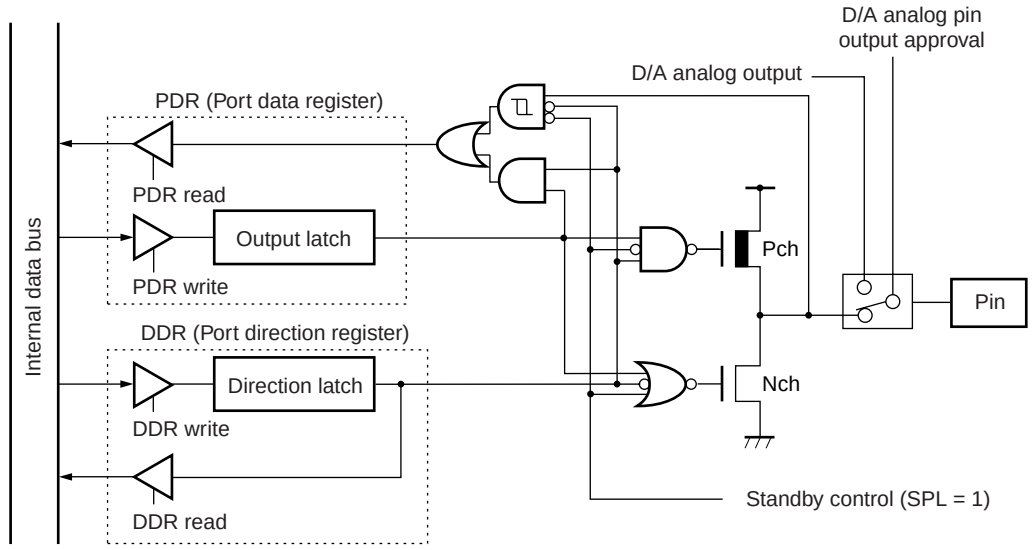
P30 to P37, P50 to P52, P70 to P73



Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

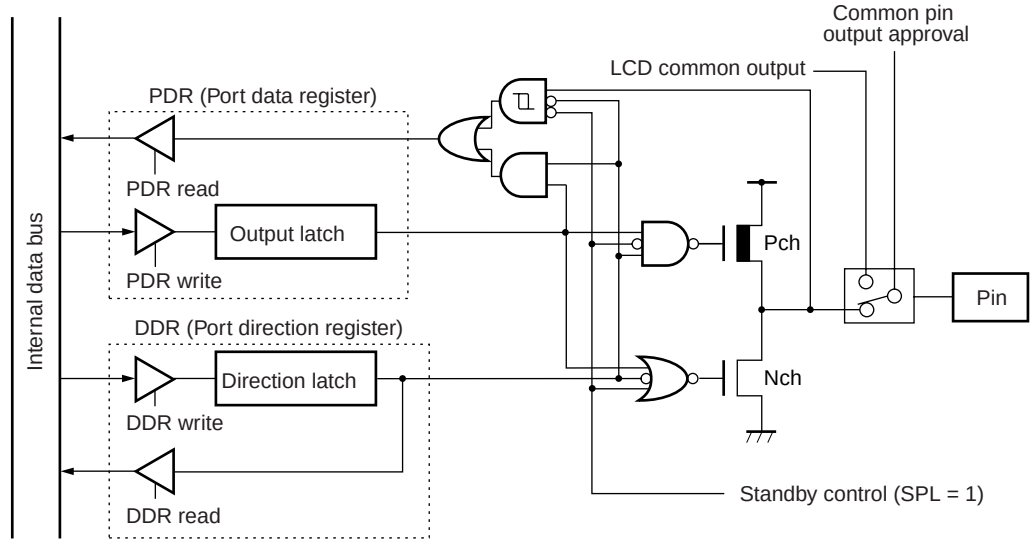
* : Peripheral function I/O is equivalent to I/O of peripheral function.

P53, P54



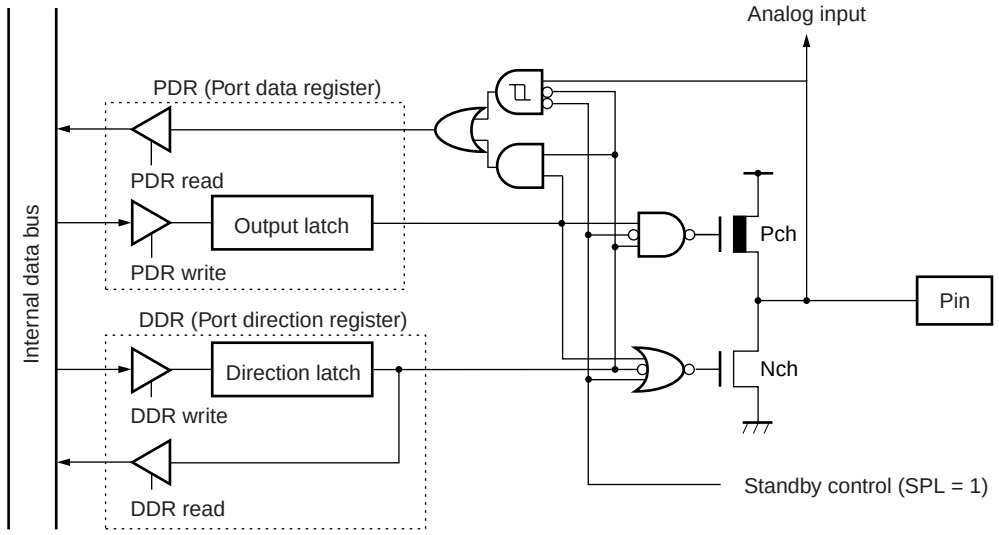
Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

P74 to P77



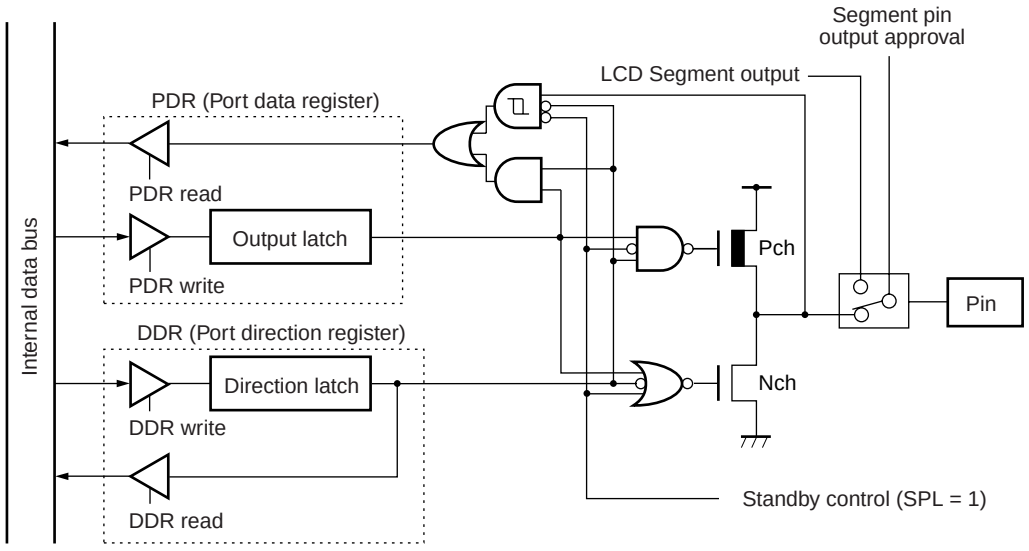
Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

P60 to P67



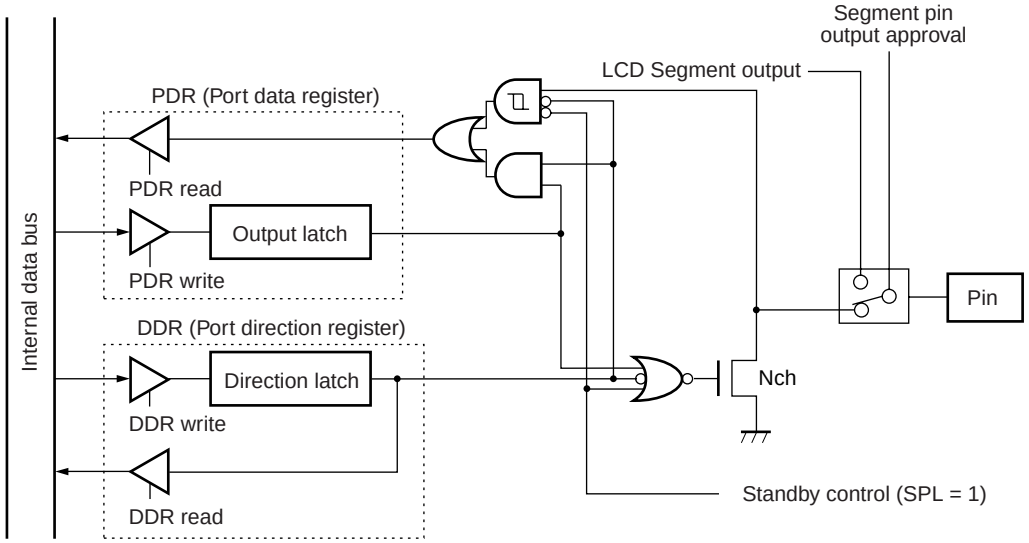
Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

P80 to P87, PA0 to PA7



Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

P90 to P97



Standby control : Controls stop mode (SPL = 1) , time-base-timer mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode

2. Timebase Timer

- The timebase timer is an 18-bit freerun timer (timebase timer/counter) that counts up synchronized with the main clock (oscillation clock : HCLK divided by 2) .
- The timer can generate interrupt requests at a specified interval, with four different interval time settings available.
- The timer supplies the operating clock for peripheral functions including the oscillation stabilization delay timer and watchdog timer.

• Timebase timer interval settings

Internal Count Clock Period	Interval Time
2/HCLK (0.5 µs)	2^{12}/HCLK (approx. 1.024 ms)
	2^{14}/HCLK (approx. 4.096 ms)
	2^{16}/HCLK (approx. 16.384 ms)
	2^{19}/HCLK (approx. 131.072 ms)

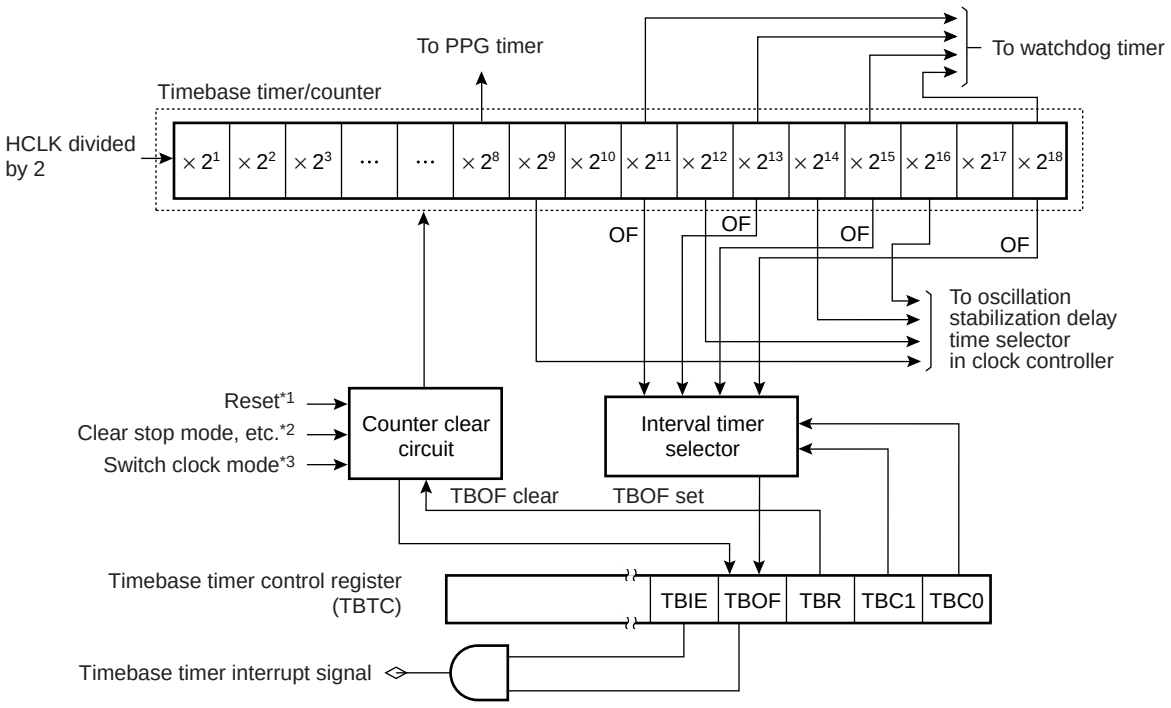
- HCLK : Oscillation clock frequency
- The values enclosed in ( ) indicate the times for a clock frequency of 4 MHz.

• Period of clocks supplied from timebase timer

Peripheral Function	Clock Period
Oscillation stabilization delay for the main clock	2^{10}/HCLK (approx. 0.256 ms)
	2^{13}/HCLK (approx. 2.048 ms)
	2^{15}/HCLK (approx. 8.192 ms)
	2^{17}/HCLK (approx. 32.768 ms)
Watchdog timer	2^{12}/HCLK (approx. 1.024 ms)
	2^{14}/HCLK (approx. 4.096 ms)
	2^{16}/HCLK (approx. 16.384 ms)
	2^{19}/HCLK (approx. 131.072 ms)
PPG timer	2^{9}/HCLK (approx. 0.128 ms)

- HCLK : Oscillation clock frequency
- The values enclosed in ( ) indicate the times for a clock frequency of 4 MHz.

• **Block diagram**



OF : Overflow
HCLK : Oscillation clock frequency
*1 : Power-on reset, release of hardware standby mode, watchdog reset
*2 : Clear stop mode, main clock mode, PLL clock mode, and pseudo-clock mode
*3 : Main → PLL clock, Sub → main clock, Sub → PLL clock

The actual interrupt request number for the timebase timer is :

Interrupt request number : #12 ($0C_H$)

3. Watchdog Timer

- The watchdog timer is a timer/counter used to detect faults such as program runaway.
- The watchdog timer is a 2-bit counter that counts the clock signal from the timebase timer or clock timer.
- Once started, the watchdog timer must be cleared before the 2-bit counter overflows. If an overflow occurs, the CPU is reset.

• Interval time for the watchdog timer

HCLK : Oscillation Clock (4 MHz)			SCLK : Sub-Clock (8.192 kHz)		
Min	**Max**	**Clock Period**	**Min**	**Max**	**Clock Period**
Approx. 3.58 ms	Approx. 4.61 ms	$2^{14} \pm 2^{11}$ / HCLK	Approx. 0.438 s	Approx. 0.563 s	$2^{12} \pm 2^{9}$ / SCLK
Approx. 14.33 ms	Approx. 18.30 ms	$2^{16} \pm 2^{13}$ / HCLK	Approx. 3.500 s	Approx. 4.500 s	$2^{15} \pm 2^{12}$ / SCLK
Approx. 57.23 ms	Approx. 73.73 ms	$2^{18} \pm 2^{15}$ / HCLK	Approx. 7.000 s	Approx. 9.000 s	$2^{16} \pm 2^{13}$ / SCLK
Approx. 458.75 ms	Approx. 589.82 ms	$2^{21} \pm 2^{18}$ / HCLK	Approx. 14.00 s	Approx. 18.00 s	$2^{17} \pm 2^{14}$ / SCLK

* : The difference between the maximum and minimum watchdog timer interval times is due to the timing when the counter is cleared.

* : As the watchdog timer is a 2-bit counter that counts the carry-up signal from the timebase timer or clock timer, clearing the timebase timer (when operating on HCLK) or the clock timer (when operating on SCLK) lengthens the time until the watchdog timer reset is generated.

• Watchdog timer count clock

WTC : WDCS	HCLK : Oscillation clock PCLK : PLL clock	SCLK : Sub-clock
“0”	Count the clock timer output.	Count the clock timer output.
“1”	Count the timebase timer output.	

• Events that stop the watchdog timer

1 : Stop due to a power-on reset

2 : Reset due to recovery from hardware standby mode

3 : Watchdog reset

• Events that clear the watchdog timer

1 : External reset input from the RST pin.

2 : Writing “0” to the software reset bit.

3 : Writing “0” to the watchdog control bit (second and subsequent times) .

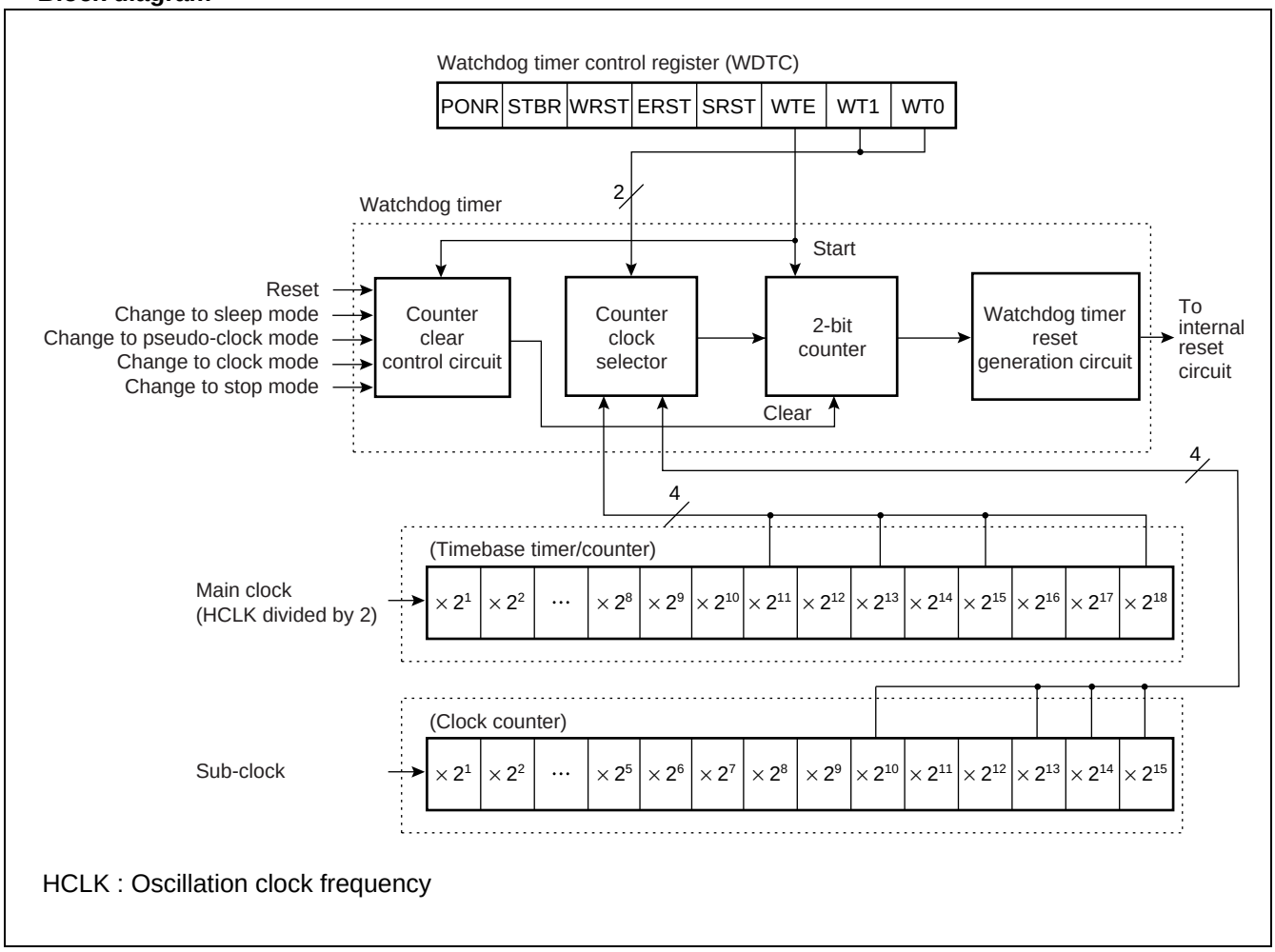
4 : Changing to sleep mode (clears the watchdog timer and temporarily halts the count) .

5 : Changing to pseudo-clock mode (clears the watchdog timer and temporarily halts the count) .

6 : Changing to clock mode (clears the watchdog timer and temporarily halts the count) .

7 : Changing to stop mode (clears the watchdog timer and temporarily halts the count) .

• **Block diagram**



HCLK : Oscillation clock frequency

4. 8/16-bit PPG (Programmable Pulse Generator) Timers 0 and 1

The 8/16-bit PPG timer is a two-channel reload timer module (PPG0 and PPG1) that can generate pulse outputs with the periods specified in the table below and with duty ratios between 0 and 100%. Note that the pulse periods are different depending on the operation mode.

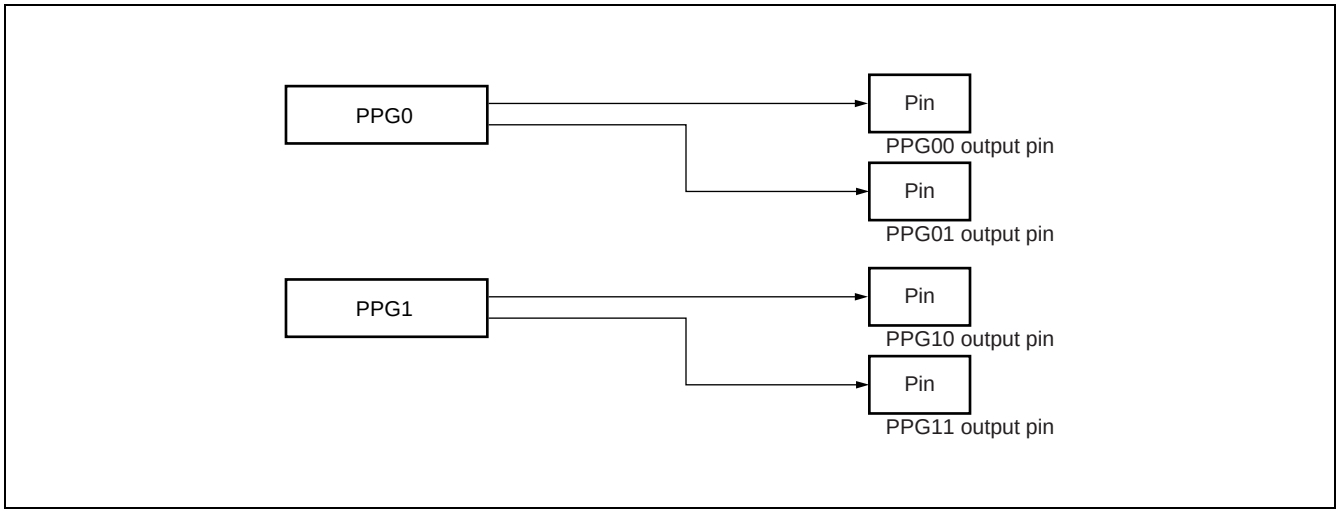
Operation Mode	Count Clock*2	PPG00, PPG01 (PPG ch0)		PPG10, PPG11 (PPG ch1)	
		Interval Time	Output Pulse Width	Interval Time	Output Pulse Width
8-bit PPG output Independent 2ch operation mode	φ/1 (62.5 ns)	1/φ to 2^8/φ	1/φ to 2^9/φ	1/φ to 2^8/φ	1/φ to 2^9/φ
	φ/2 (125 ns)	2/φ to 2^9/φ	2^2/φ to 2^{10}/φ	2/φ to 2^9/φ	2^2/φ to 2^{10}/φ
	φ/4 (250 ns)	2^2/φ to 2^{10}/φ	2^3/φ to 2^{11}/φ	2^2/φ to 2^{10}/φ	2^3/φ to 2^{11}/φ
	φ/8 (500 ns)	2^3/φ to 2^{11}/φ	2^4/φ to 2^{12}/φ	2^3/φ to 2^{11}/φ	2^4/φ to 2^{12}/φ
	φ/16 (1000 ns)	2^4/φ to 2^{12}/φ	2^5/φ to 2^{13}/φ	2^4/φ to 2^{12}/φ	2^5/φ to 2^{13}/φ
	HCLK/512 (128 µs)	2^9/HCLK to 2^{17}/HCLK	2^{10}/HCLK to 2^{18}/HCLK	2^9/HCLK to 2^{17}/HCLK	2^{10}/HCLK to 2^{18}/HCLK
16-bit PPG output operation mode	φ/1 (62.5 ns)	1/φ to 2^{16}/φ	1/φ to 2^{17}/φ	1/φ to 2^{16}/φ	1/φ to 2^{17}/φ
	φ/2 (125 ns)	2/φ to 2^{17}/φ	2^2/φ to 2^{18}/φ	2/φ to 2^{17}/φ	2^2/φ to 2^{18}/φ
	φ/4 (250 ns)	2^2/φ to 2^{18}/φ	2^3/φ to 2^{19}/φ	2^2/φ to 2^{18}/φ	2^3/φ to 2^{19}/φ
	φ/8 (500 ns)	2^3/φ to 2^{19}/φ	2^4/φ to 2^{20}/φ	2^3/φ to 2^{19}/φ	2^4/φ to 2^{20}/φ
	φ/16 (1000 ns)	2^4/φ to 2^{20}/φ	2^5/φ to 2^{21}/φ	2^4/φ to 2^{20}/φ	2^5/φ to 2^{21}/φ
	HCLK/512 (128 µs)	2^9/HCLK to 2^{25}/HCLK	2^{10}/HCLK to 2^{26}/HCLK	2^9/HCLK to 2^{25}/HCLK	2^{10}/HCLK to 2^{26}/HCLK
8 + 8-bit PPG output operation mode*1	φ/1 (62.5 ns)	1/φ to 2^6/φ	1/φ to 2^9/φ	1/φ to 2^{16}/φ	1/φ to 2^{17}/φ
	φ/2 (125 ns)	2/φ to 2^9/φ	2^2/φ to 2^{10}/φ	2/φ to 2^{17}/φ	2^2/φ to 2^{18}/φ
	φ/4 (250 ns)	2^2/φ to 2^{10}/φ	2^3/φ to 2^{11}/φ	2^2/φ to 2^{18}/φ	2^3/φ to 2^{19}/φ
	φ/8 (500 ns)	2^3/φ to 2^{11}/φ	2^4/φ to 2^{12}/φ	2^3/φ to 2^{19}/φ	2^4/φ to 2^{20}/φ
	φ/16 (1000 ns)	2^4/φ to 2^{12}/φ	2^5/φ to 2^{13}/φ	2^4/φ to 2^{20}/φ	2^5/φ to 2^{21}/φ
	HCLK/512 (128 µs)	2^9/HCLK to 2^{17}/HCLK	2^{10}/HCLK to 2^{18}/HCLK	2^9/HCLK to 2^{25}/HCLK	2^{10}/HCLK to 2^{26}/HCLK

*1 : 8 + 8-bit PPG output operation mode consists of using the lower 8 bits as a prescaler for the PPG timer.

*2 : The values enclosed in ( ) indicate the times for a machine clock frequency of 16 MHz.

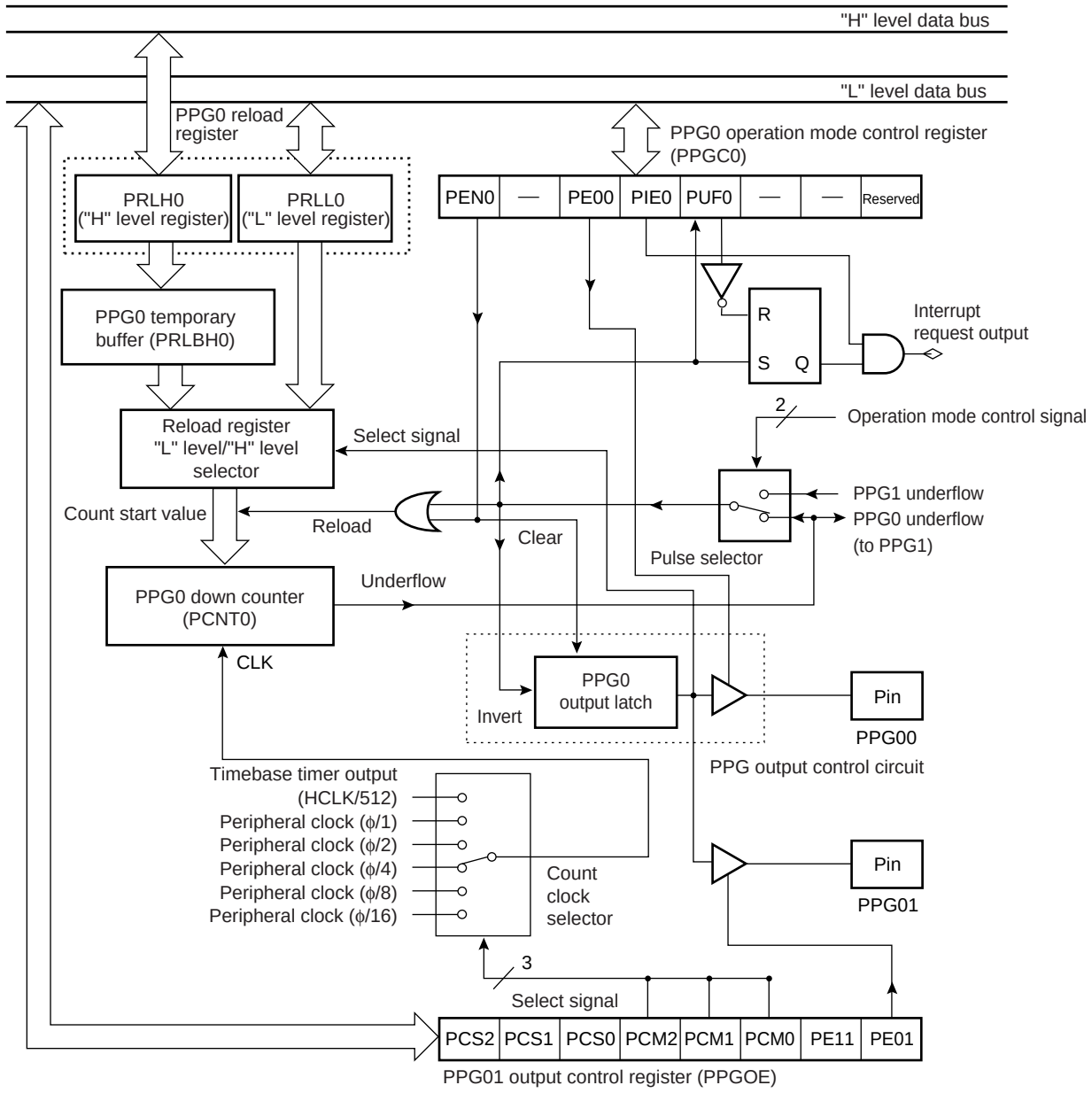
- **PPG timer channels and PPG pins**

The figure below shows the relationship between the 8/16-bit PPG channels and PPG pins on the MB90520A/520B series.



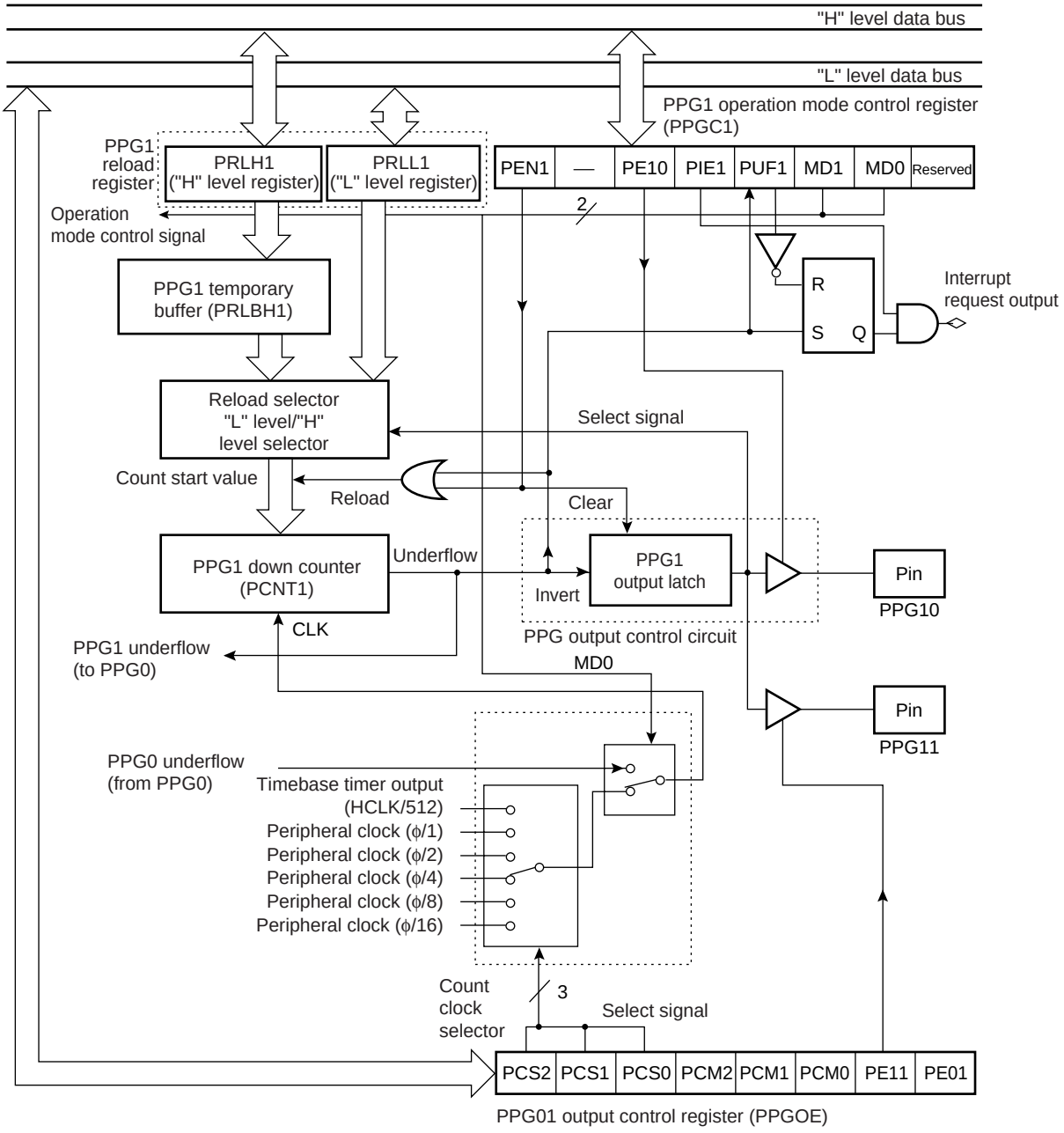
• **Block diagram**

8/16-bit PPG timer 0



— : Undefined
Reserved : Reserved bit
HCLK : Oscillation clock frequency
ϕ : Machine clock frequency

8/16-bit PPG timer 1



— : Undefined
Reserved : Reserved bit
HCLK : Oscillation clock frequency
ϕ : Machine clock frequency

5. 16-bit Reload Timers 0 and 1 (With Event Count Function)

The 16-bit reload timers have the following functions.

- The count clock can be selected from three internal clock and the external event clock.
- Either software trigger or external trigger can be selected as the start signals for 16-bit reload timers 0 and 1.
- An interrupt to the CPU can be generated when an underflow occurs on 16-bit reload timer 0 and 1. This interrupt allows the timers to be used as interval timers.
- Two different operation modes can be selected when an underflow occurs on 16-bit reload timer 0 and 1 : one-shot mode in which timer operation halts when an underflow occurs or reload mode in which the reload register value is loaded into the timer and counting continues.
- Extended intelligent I/O service (EI^{2}OS) is supported.
- The MB90520A/520B series contains two 16-bit reload timer channels.

• 16-bit reload timer operation modes

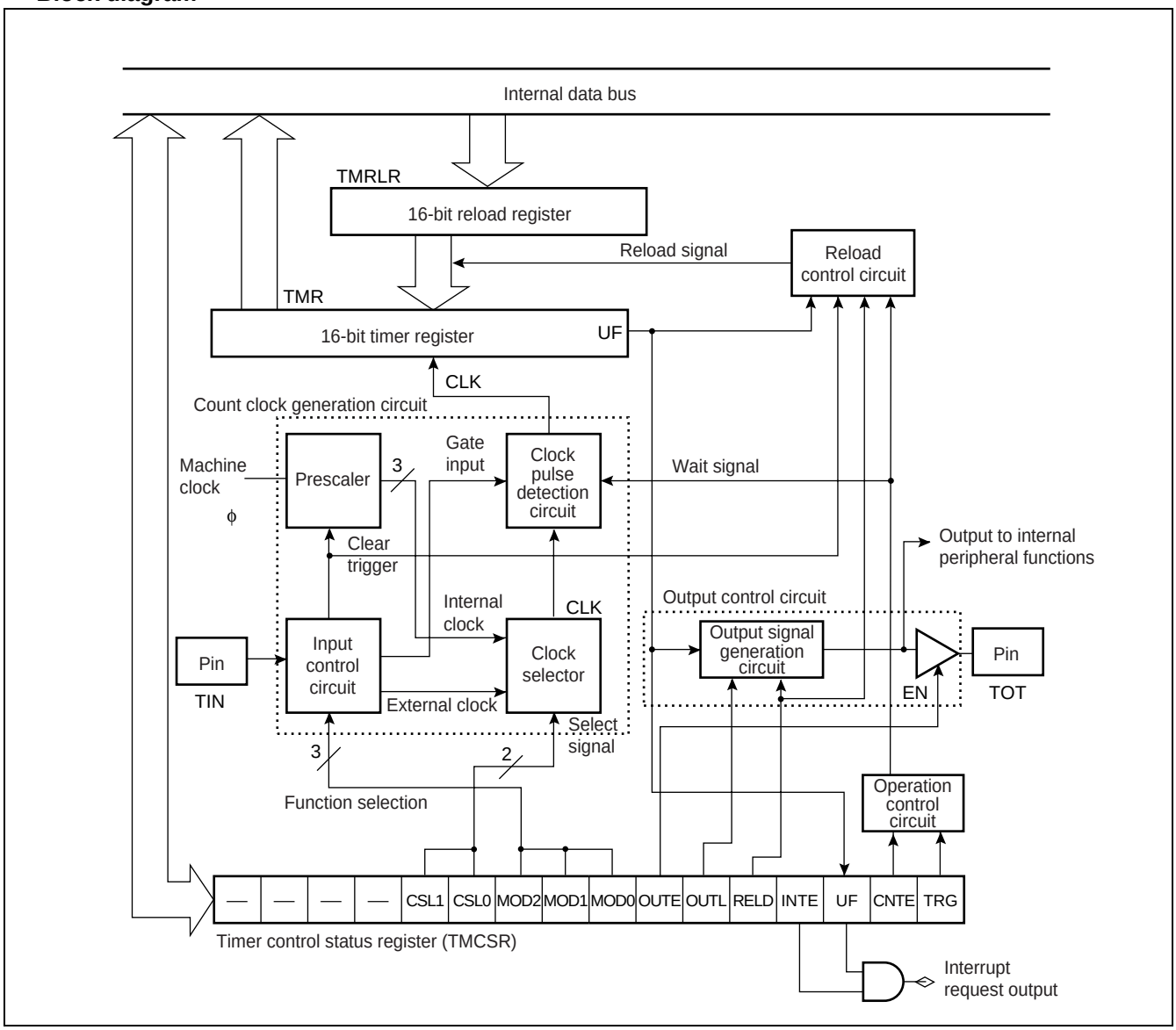
Count Clock	Start Trigger	Operation when an Underflow Occurs
Internal clock (3 clocks available)	Software trigger	One-shot mode
		Reload mode
	External trigger	One-shot mode
		Reload mode
Event clock	Software trigger	One-shot mode
		Reload mode
	External trigger	One-shot mode
		Reload mode

• Interval times for the 16-bit reload timers

Count Clock	Count Clock Period	Example Interval Times
Internal clock	2^1T (0.125 µs)	0.125 µs to 8.192 ms
	2^3T (0.5 µs)	0.5 µs to 32.768 ms
	2^5T (2.0 µs)	2.0 µs to 131.1 ms
Event clock	2^3T or longer	0.5 µs or longer

Note : The values enclosed in ( ) and the example interval times are for a machine clock frequency of 16 MHz.
"T" is the machine cycle and is 1/ (machine clock frequency) .

• **Block diagram**



6. 16-bit I/O Timers

The 16-bit I/O timers consist of a two-channel 16-bit freerun timer, two-channel input capture, and eight-channel output compare. The output compare channels can be used to generate eight independent waveform outputs based on the 16-bit freerun timer. The input capture channels can be used to measure input pulse widths and external clock periods.

• Structure of I/O timers in the MB90520A/520B series

	16-bit Freerun Timer	Output Compare	Input Capture
16-bit I/O timer (unit 0)	16-bit freerun timer 0	Output compare 0 to 3 (unit 0)	Input capture 0 and 1 (unit 0)
16-bit I/O timer (unit 1)	16-bit freerun timer 1	Output compare 4 to 8 (unit 1)	—

• 16-bit freerun timer functions

- The count value for the 16-bit freerun timer sets the base time for the input capture and output compare functions.
- An interrupt can be generated when the 16-bit freerun timer overflows.
- Extended intelligent I/O service (EI^{2}OS) can be generated.
- 16-bit freerun timers 0 and 1 can be cleared to "0000_H" when an external reset is input, on setting the timer clear bit (TCCS : CLR = 1) , and when a compare match occurs on output compare 0 to 4.
- The count clock frequency can be selected from the following four clocks :
  4/ϕ (250 ns) , 16/ϕ (1.0 µs) , 64/ϕ (4.0 µs) , 256/ϕ (16.0 µs)

Note : ϕ is the machine clock frequency. The values in ( ) are for 16 MHz machine clock.

• Input capture functions

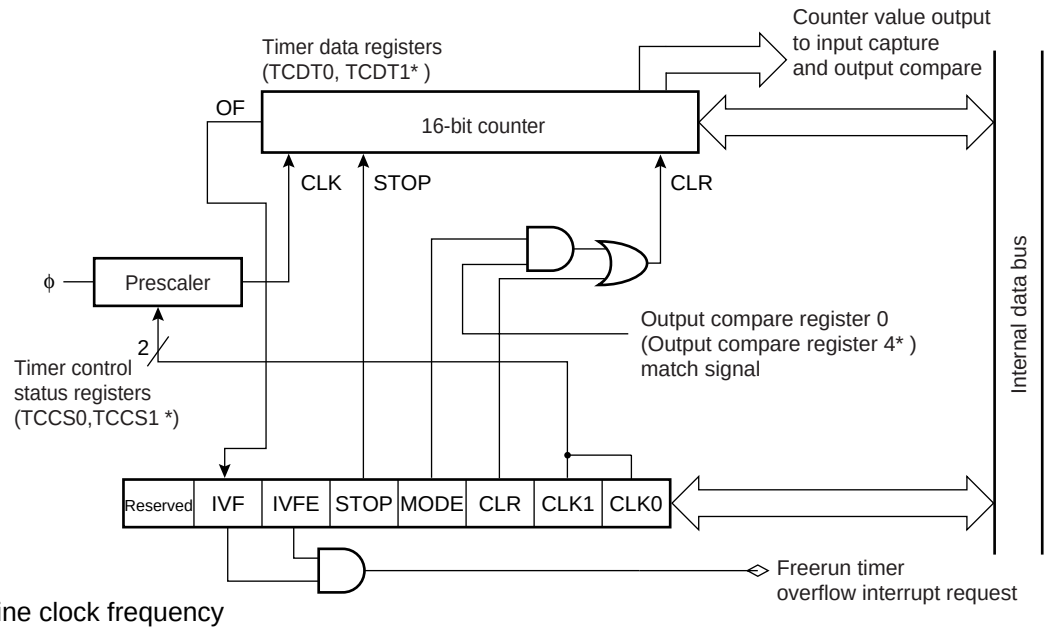
- The input capture saves the value of the 16-bit freerun timer and generates an interrupt request when the specified edge is detected on the trigger input from the external trigger input pin (IC00 or IC01/IC10 or IC11) .
- Input capture channels 0 and 1 can perform input capture and generate interrupt request independently.
- Extended intelligent I/O service (EI^{2}OS) can be generated.
- Detection of rising edges, falling edges, or either edge can be selected as the trigger edge.
- When using input capture 0, either the IC00 or IC01 pin can be used. Note, however, that masking one pin only is not possible.
- When using input capture 1, either the IC10 or IC11 pin can be used. Note, however, that masking one pin only is not possible.

• Output compare functions

- The output compare channels compare the values set in output compare registers 0 to 7 with the 16-bit freerun timers 0 and 1 count values and invert the level of the corresponding output compare pin and clear the 16-bit freerun timer to "0000_H" when a match is detected.
- Extended intelligent I/O service (EI^{2}OS) can be generated.
- The initial output levels at the output compare pins can be set after the microcontroller boots.
- The output levels from the eight output compare channels are controlled independently. Similarly, interrupt requests are also generated independently by each channel.

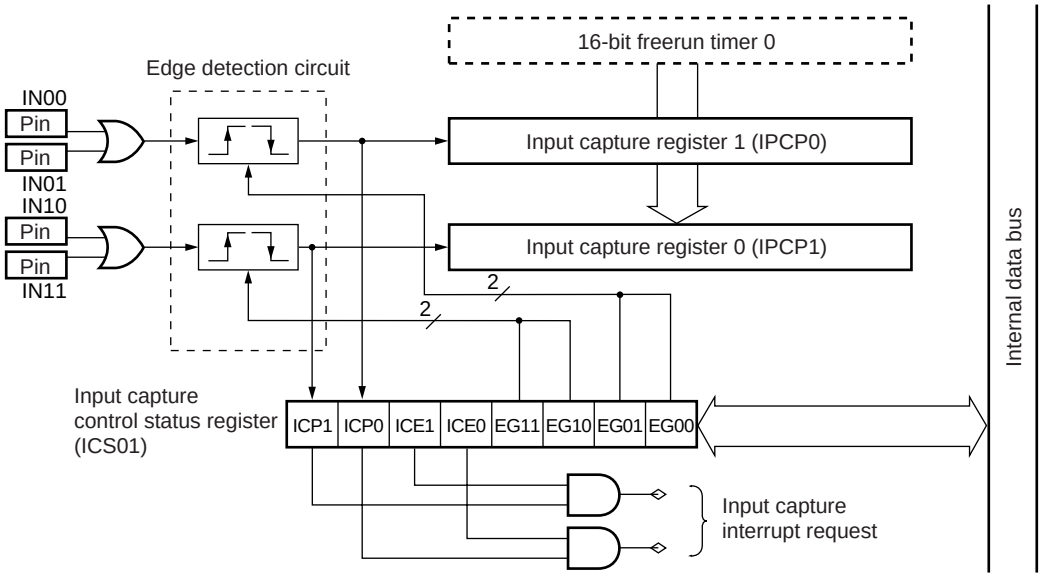
- **Block diagram**

16-bit freerun timer

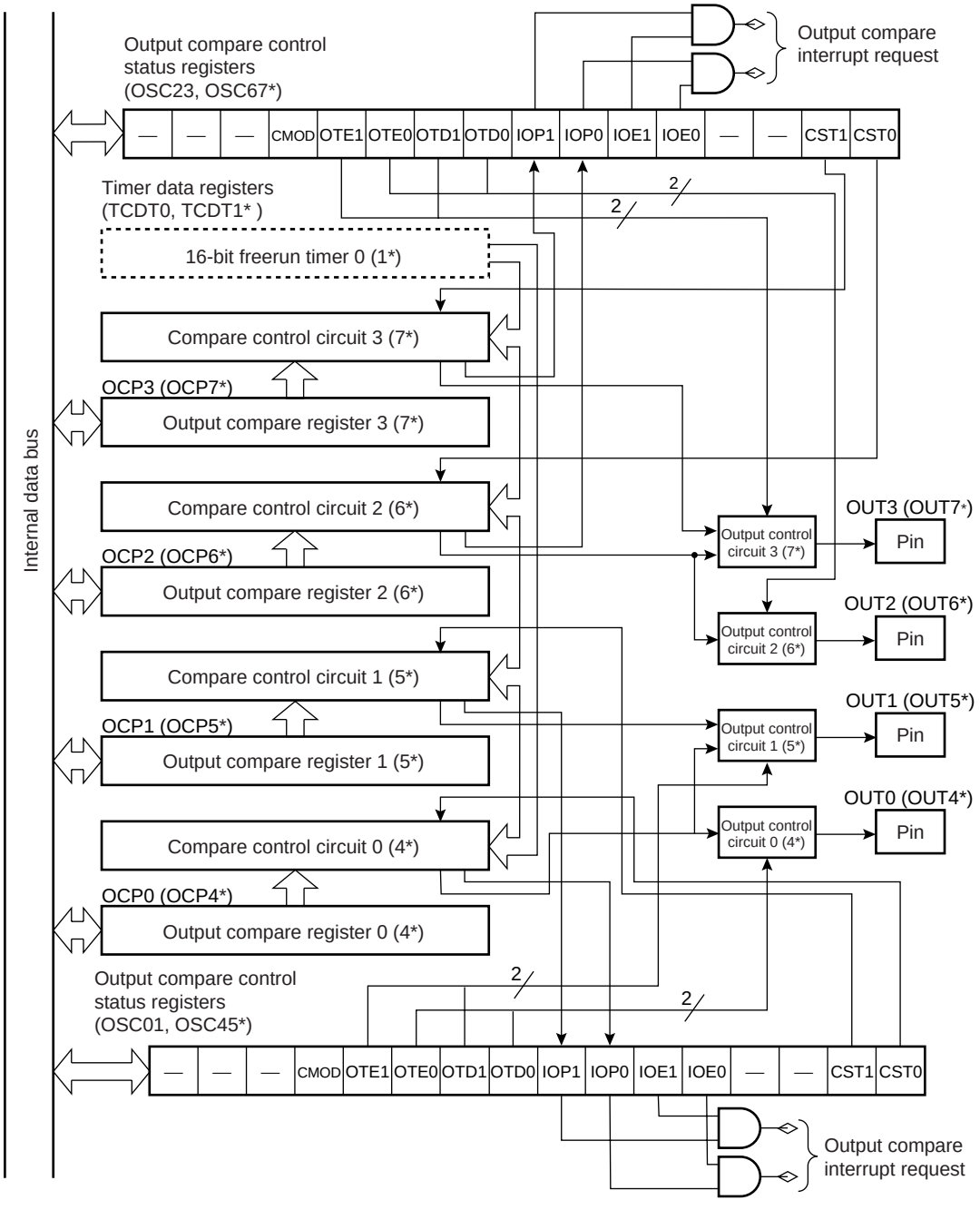


ϕ : Machine clock frequency
OF : Overflow
* : Name for 16-bit freerun timer channel 1

Input capture



Output compare



* : Name for output compare unit 1

7. 8/16-bit Up/Down Counter/Timers 0 and 1

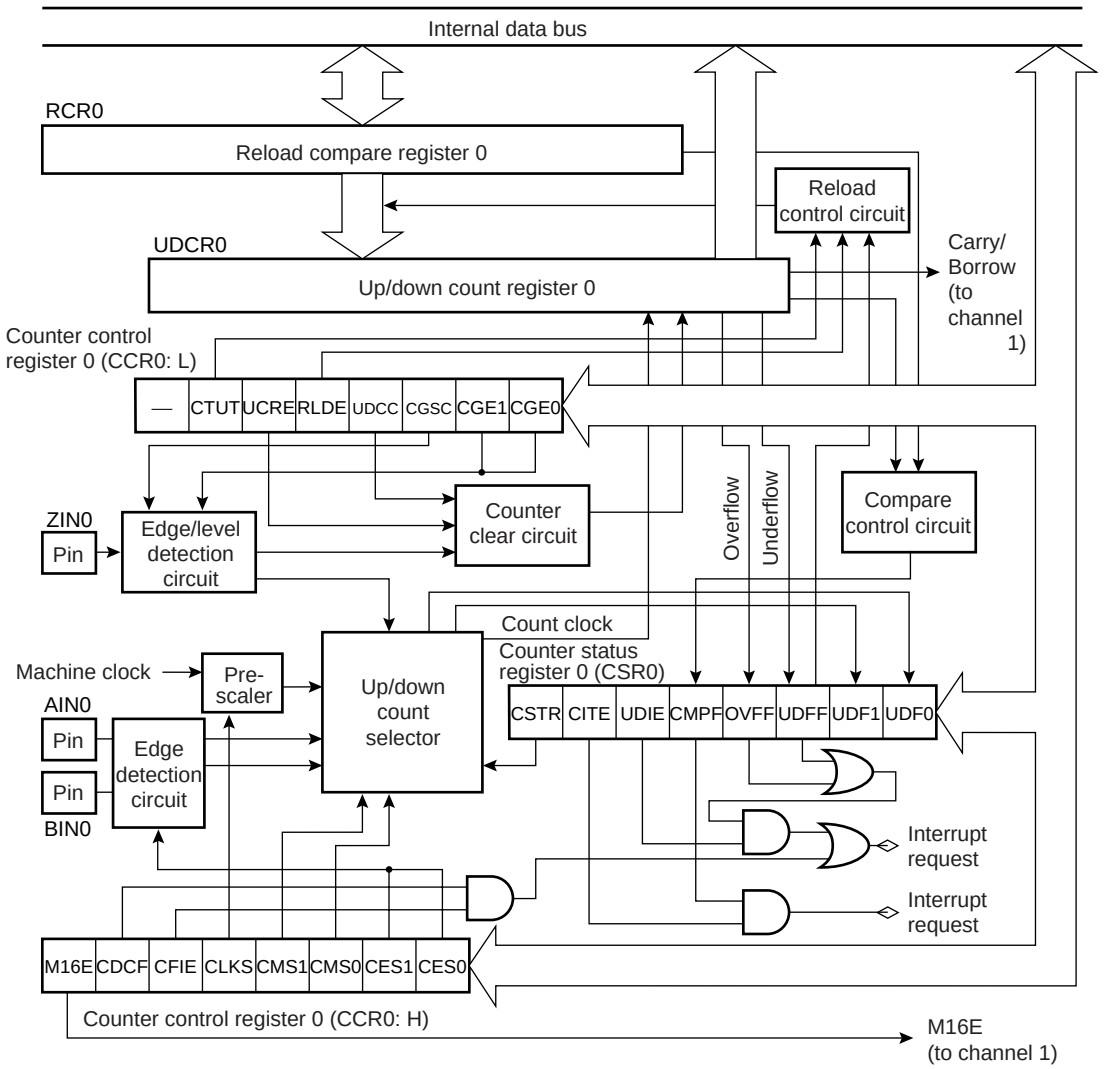
- The 8/16-bit up/down counter/timers can operate in timer mode, up/down count mode, and phase difference count mode.
- The unit can be used as either a 2-channel × 8-bit or 1-channel × 16-bit up/down counter/timer.

• 8/16-bit up/down counter/timer functions

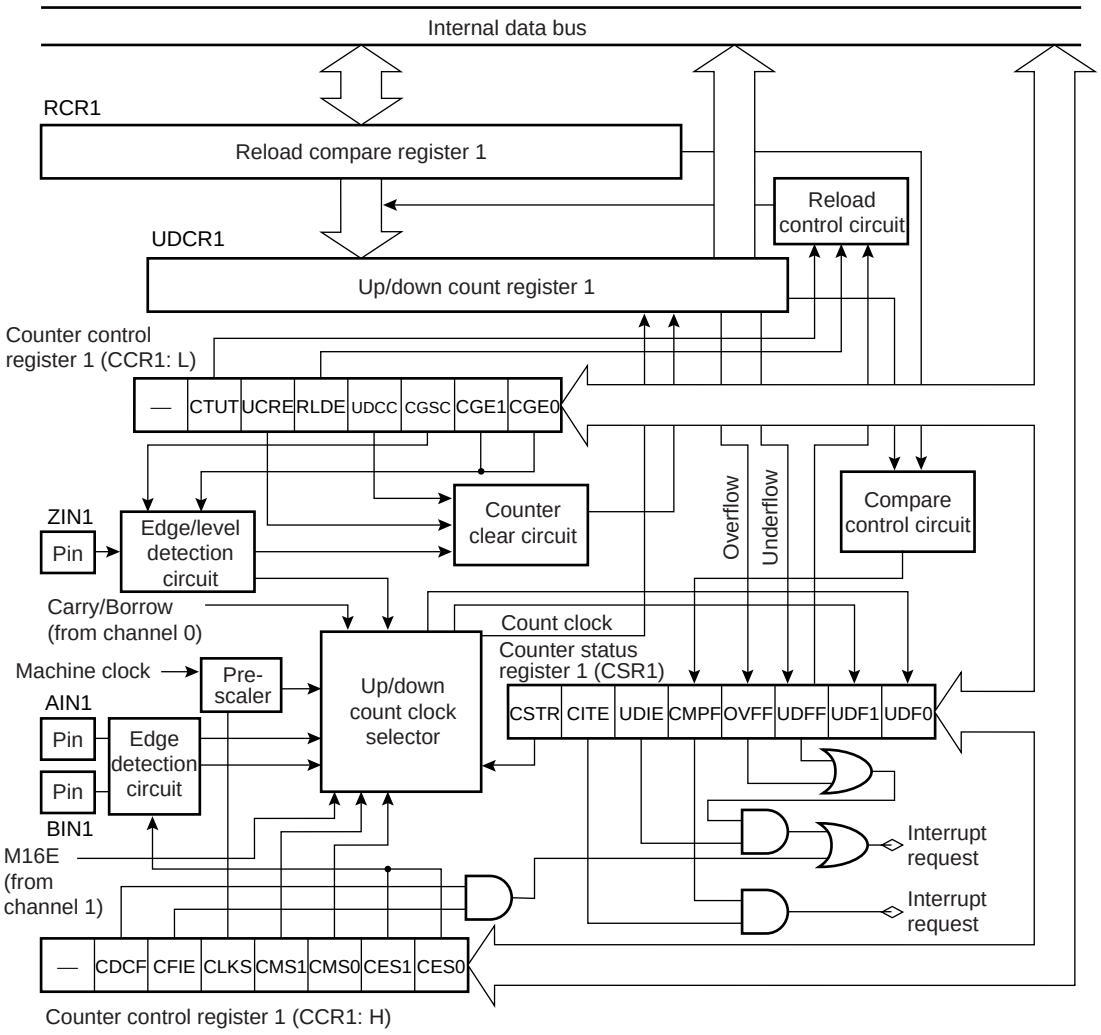
Operation Mode	Count Mode	Count Clock (Count Edge)	Function of ZIN Pin	Other Functions
8-bit × 2-channel mode	Timer mode	2/ϕ, 4/ϕ (ϕ : Machine clock frequency)	—	• Compare function • Reload function • Compare/reload function • Compare/reload prohibit • The direction of the previous count can be determined from the up/down flag. • Interrupt requests can be generated on the following conditions : 1 : Compare match 2 : Underflow or overflow 3 : Count direction change
	Up/down count mode	Counts up on detecting specified edge on the AIN pin. Counts down on detecting specified edge on the BIN pin.	Counter clear function	
			Gate function	
	Phase difference count mode (multiply by 2)	Reads the AIN pin input level on detecting a rising or falling edge on the BIN pin and counts up or counts down.	Counter clear function	
			Gate function	
	Phase difference count mode (multiply by 4)	Reads the AIN pin input level on detecting a rising or falling edge on the BIN pin and counts up or counts down. Similarly, reads the BIN pin input level on detecting a rising or falling edge on the AIN pin and counts up or counts down.	Counter clear function	
			Gate function	
16-bit × 1-channel mode	Timer mode	2/ϕ, 4/ϕ (ϕ : Machine clock frequency)	—	
	Up/down count mode	Counts up on detecting specified edge on the AIN pin. Counts down on detecting specified edge on the BIN pin.	Counter clear function	
			Gate function	
	Phase difference count mode (multiply by 2)	Reads the AIN pin input level on detecting a rising or falling edge on the BIN pin and counts up or counts down.	Counter clear function	
			Gate function	
	Phase difference count mode (multiply by 4)	Reads the AIN pin input level on detecting a rising or falling edge on the BIN pin and counts up or counts down. Similarly, reads the BIN pin input level on detecting a rising or falling edge on the AIN pin and counts up or counts down.	Counter clear function	
			Gate function	

- **Block diagram**

8/16-bit up/down counter/timer 0



8/16-bit up/down counter/timer 1



- **Pins and interrupt numbers**

8/16-bit up/down counter/timer 0
- AIN0 pin : P24/AIN0
- BIN0 pin : P25/BIN0
- ZIN0 pin : P26/ZIN0
- Compare match interrupt number : #21 (15_H)
- Interrupt number for underflow/overflow interrupt, count direction change interrupt : #2 (16_H)

8/16-bit up/down counter/timer 1
- AIN1 pin : P50/AIN1
- BIN1 pin : P51/BIN1
- ZIN1 pin : P52/ZIN1
- Compare match interrupt number : #29 ($1D_H$)
- Interrupt number for underflow/overflow interrupt, count direction change interrupt : #3 ($1E_H$)

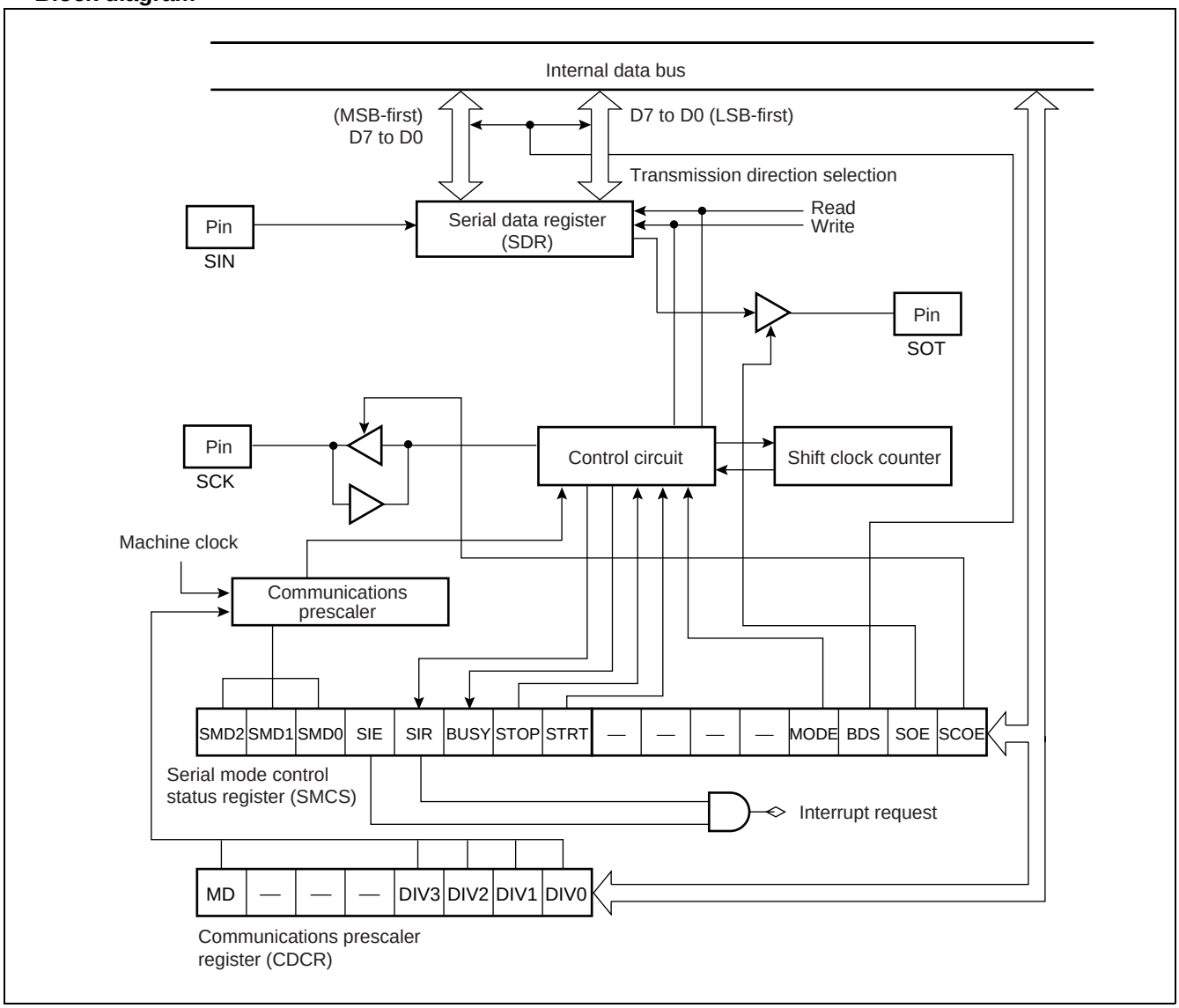
8. Extended I/O Serial Interfaces 0 and 1

- The extended I/O serial interfaces are serial I/O interfaces that perform clock-synchronized data transfer.
- The MB90520A/520B series contain two internal extended I/O serial interface channels.
- Either LSB-first or MSB-first data transmission format can be selected.

• Extended I/O serial interface functions

	Function
Transmission direction	• Transmit and receive can be handled simultaneously. (A setting is required to select transmit or receive.)
Transmission mode	• Clock synchronous (data transfer only)
Transmission clock	• Internal shift clock mode (Uses the communications prescaler output clock.) • External shift clock mode (Inputs the clock signal from SCK1 and SCK2.)
Transmission speed	• When using internal shift clock : Up to 1 MHz operation can be achieved (for a 16 MHz machine clock with the divisor setting for the communication prescaler set to 8) . Speeds faster than 1 MHz are not possible. • When using an external shift clock : As a minimum of 5 machine cycles are required, when the machine clock is 16 MHz the maximum input frequency for the external shift clock is 16 MHz / 5 = 3.2 MHz.
Data transmission format	• LSB-first or MSB-first, selectable • Data transfer only • Number of data bits = 8 (fixed)
Interrupt request generation	• Interrupt generated when transfer completes
EI²OS support	• Supports use of the extended intelligent I/O service.

• **Block diagram**



9. UART (SCI : Serial Communication Interface)

- The UART (SCI) is a general-purpose serial communications interface for performing synchronous or asynchronous communications with external devices.
- The interface provides bi-directional communications in both clock synchronous and clock asynchronous modes.
- Includes a master-slave communication function (multi-processor mode) .
- Can generate interrupt requests at receive complete, receive error detected, and transmit complete timings. Also supports EI^{2}OS.

• UART (SCI) functions

	Function
Data buffer	• Full-duplex double-buffered
Transmission modes	• Clock synchronous (with no start/stop bit, no parity bit) • Clock asynchronous (start-stop sync)
Baud rate	• Can use dedicated baud rate generator. • Can use external clock input. • Can use clock supplied by 16-bit reload timer 0. • For machine clock speeds of 6 MHz, 8 MHz, 10 MHz, 12 MHz, and 16 MHz : Available speeds for asynchronous communications : 31250 bps, 9615 bps, 4808 bps, 2404 bps, and 1202 bps Available speeds for synchronous communications : 1 Mbps, 500 Kbps, 250 Kbps, 125 Kbps, and 62.5 Kbps
Number of data bits	• 7 bits (when parity is used for asynchronous normal mode) • 8 bits (when parity is not used)
Signal format	• Non return to zero (NRZ) format
Receive error detection	• Framing errors (not available in clock synchronous mode) • Overrun errors • Parity errors (not available in clock synchronous mode and multi-processor mode)
Interrupt requests	• Receive interrupt (Receive complete or receive error detected) • Transmit interrupt (Transmission complete) • Both transmit and receive support the extended intelligent I/O service (EI^{2}OS) .
Master/slave communication function (multi-processor mode)	• Used for 1 (master) to n (slave) communications. (Can only be used as master)
EI^{2}OS support	• Supports the extended intelligent I/O service (EI^{2}OS)

• **UART (SCI) operation modes**

Operation Mode			No. of Data Bits		Parity Bit		No. of Stop Bits	
			7 bits	8 bits	None	Use	1 bit	2 bits
Mode 0	Asynchronous	Normal mode (1-to-1)	○	○	○	○	○	○
Mode 1	Asynchronous	Multi-processor mode (1-to-n)	×	○ (+1)	○	×	○	○
Mode 2	Clock synchronous	Clock synchronous mode (one-to-one)	×	○	○	×	×	×

○ : Available

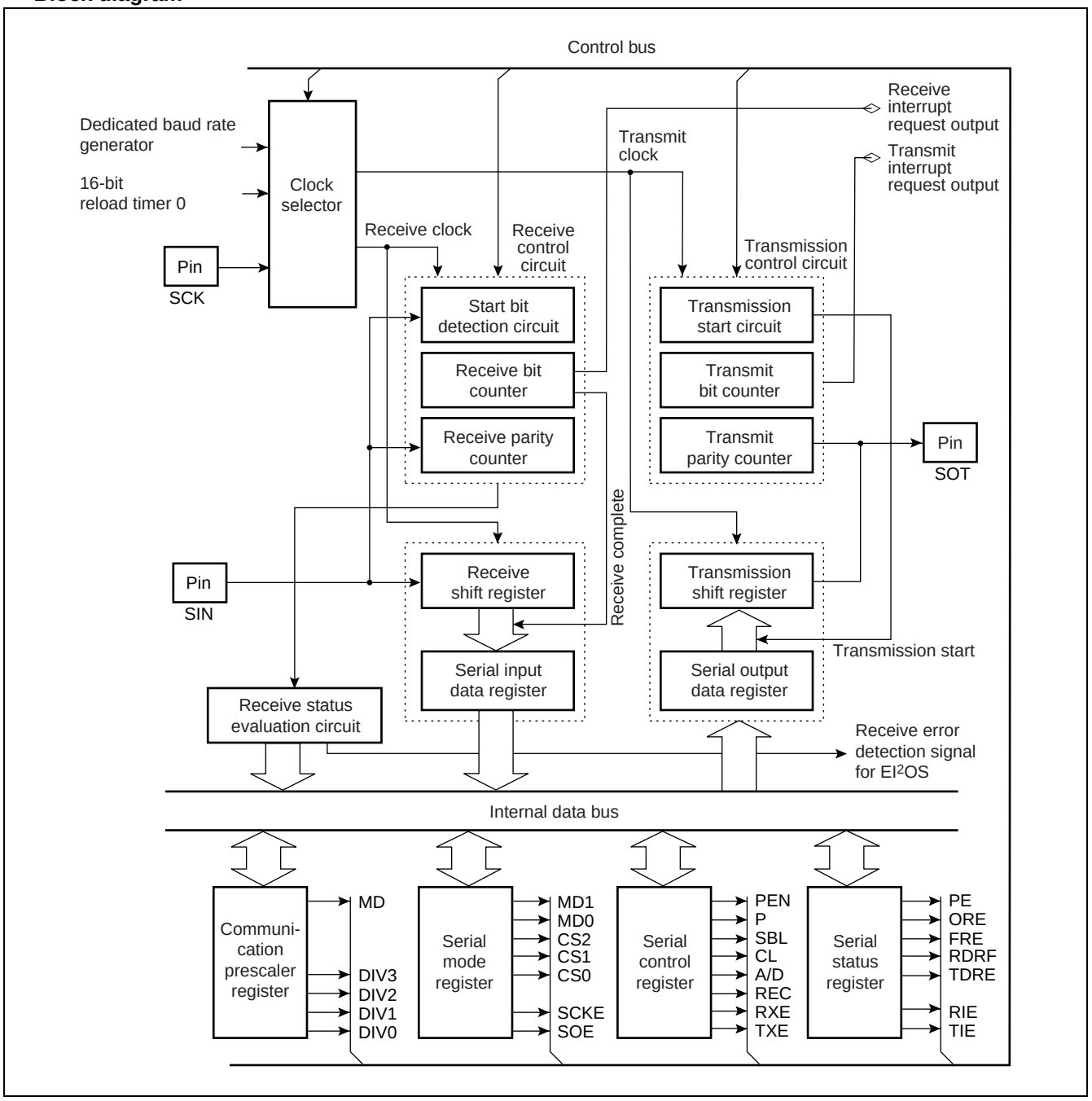
× : Not available

+1 : Address/data bit used for communication control

Notes :

- The number of data bits must be set to eight for multi-processor and clock synchronous modes.
- A parity bit cannot be used in multi-processor and clock synchronous modes.
- Only data can be transferred in clock synchronous mode. Start and stop bits cannot be added to the transmission data.

• **Block diagram**



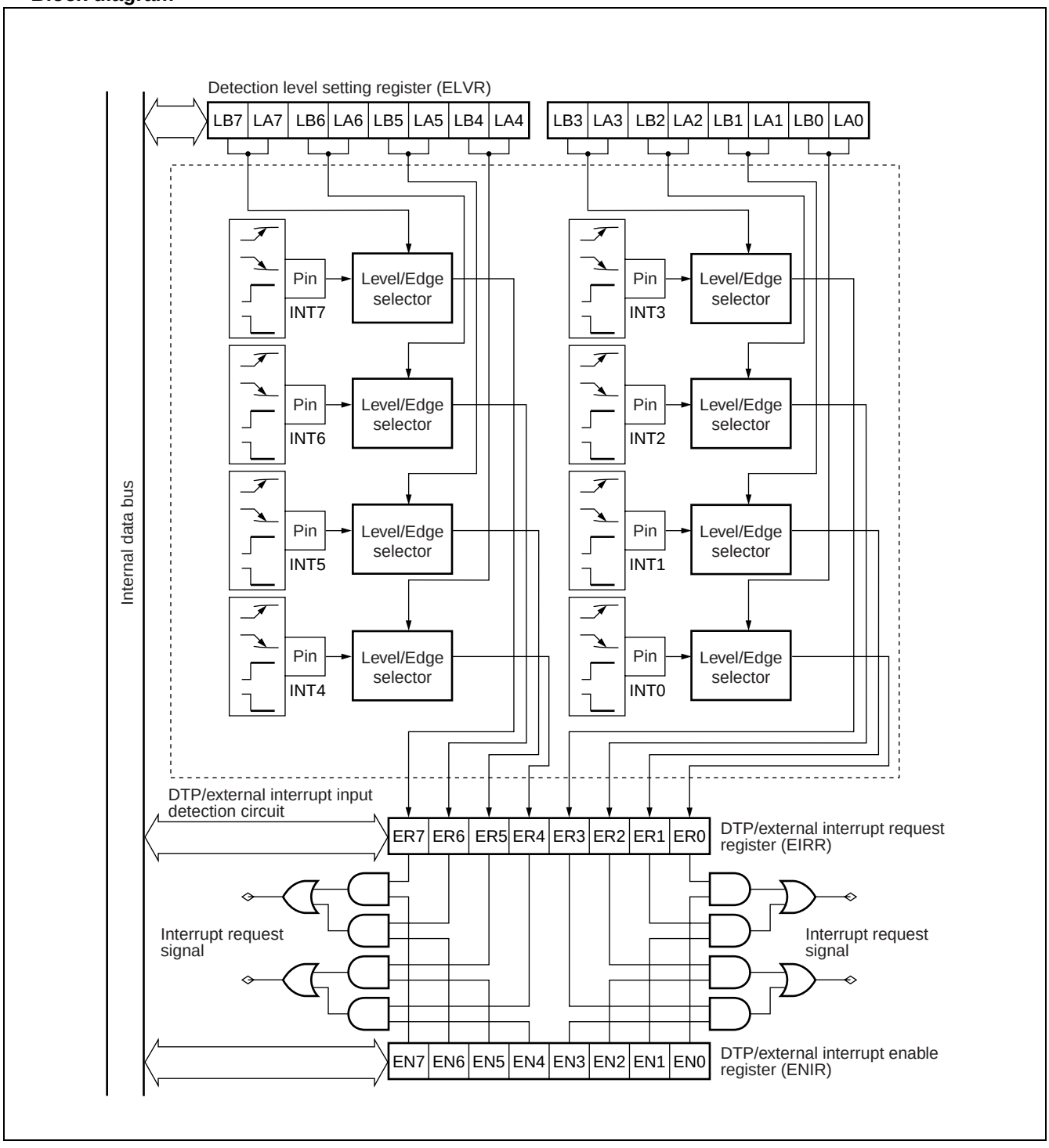
10. DTP (Data Transfer Peripheral) /External Interrupt Circuit

The DTP/external interrupt function detects interrupt requests and data transfer requests input from external devices and passes these to the CPU as external interrupt requests. This block can also activate the extended intelligent I/O service (EI^{2}OS) .

• DTP/external interrupt functions

	External Interrupt	DTP Function
Input pins	• 8 channels (INT0 to INT7)	
Interrupt conditions	• Can be set independently for each channel (each pin) in the detection level setup register (ELVR) .	
	• “H” level, “L” level, rising edge, or falling edge input	“H” level or “L” level input
Interrupt control	• Interrupts can be enabled or disabled in the DTP/external interrupt enable register (ENIR) .	
Interrupt flag	• The DTP/external interrupt request register (EIRR) stores interrupt requests.	
Processing selection	• Set EI^{2}OS to be disabled (ICR : ISE = 0)	• Set EI^{2}OS to be enabled (ICR : ISE = 1)
Interrupt execution	• Jumps to interrupt handler routine	• Jumps to interrupt handler routine after automatic data transfer by EI^{2}OS completes.
EI^{2}OS support	• Supports the extended intelligent I/O service (EI^{2}OS)	

• **Block diagram**



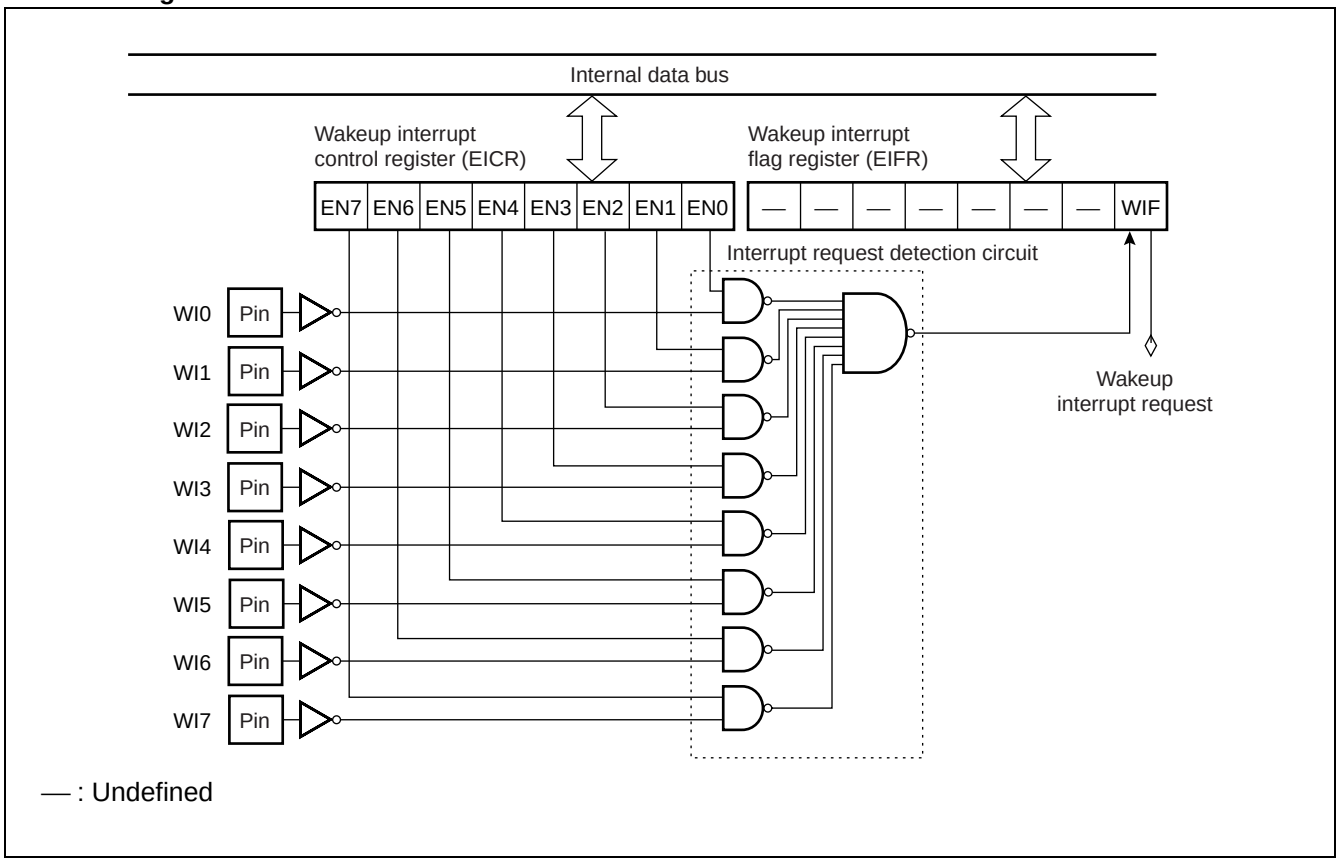
11. Wakeup Interrupts

- The wakeup interrupt function detects wakeup interrupt requests from external devices by detecting “L” levels input to the wakeup interrupt input pins (WI0 to WI7) and passes these to the CPU for interrupt processing.
- Wakeup interrupts can be used to wakeup the microcontroller from standby mode. (However, wakeup interrupts cannot be used to recover from hardware standby mode.)
- Not supported by the extended intelligent I/O service (EI²OS) .

• Wakeup interrupt functions

	Function and Control
Input pins	• 8 channels (8 pins : WI0 to WI7)
Interrupt trigger	• “L” level inputs. One interrupt flag is shared by all eight channels.
Interrupt control	• Interrupt requests can be enabled or disabled in the wakeup interrupt control register (EICR) .
Interrupt flag	• Interrupt requests are stored in the wakeup interrupt flag register (EIFR) .
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Block diagram



— : Undefined

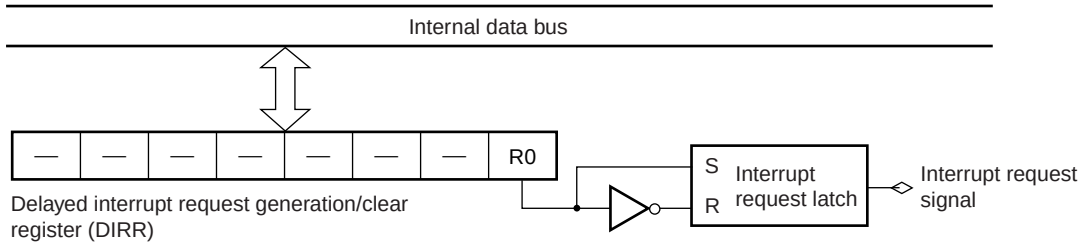
12. Delayed Interrupt Generation Module

The delayed interrupt generation module is used to generate the task switching interrupt. Generation of this hardware interrupt can be specified by software.

• Delayed interrupt generation module functions

	Function and Control
Interrupt trigger	• Writing “1” to bit R0 of the delayed interrupt request generation/clear register (DIRR : R0 = 1) generates an interrupt request. • Writing “0” to bit R0 of the delayed interrupt request generation/clear register (DIRR : R0 = 0) clears the interrupt request.
Interrupt control	• No enable/disable register is provided for this interrupt.
Interrupt flag	• Set in bit R0 of the delayed interrupt request generation/clear register (DIRR : R0) .
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Block diagram



— : Undefined

13. 8/10-bit A/D Converter

- The 8/10-bit A/D converter uses RC successive approximation to convert analog input voltages to an 8-bit or 10-bit digital value.
- The input signals can be selected from the eight analog input pin channels.
- Either a software trigger, internal timer output, or external pin trigger can be selected to trigger the start of A/D conversion.

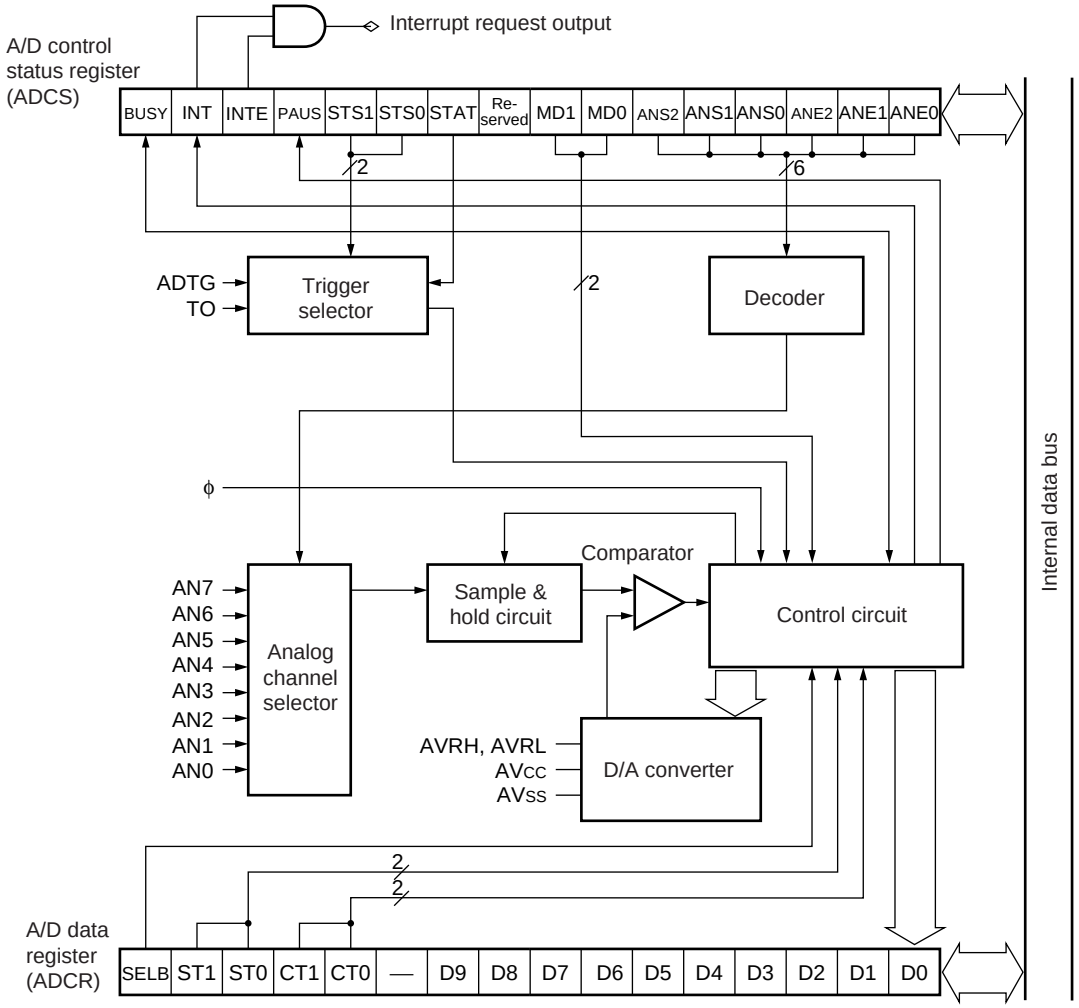
• 8/10-bit A/D converter functions

	Function
A/D conversion time	• Sampling time : Can be selected from 64, 128, or 4096 machine cycles. The minimum is 4 μs. • Compare time : Can be selected from 44, 99, or 176 machine cycles. The minimum is 4.4 μs. • A/D conversion time = sampling time + conversion time. The minimum A/D conversion time is 10.2 μs.
Conversion method	• RC successive approximation with sample & hold circuit
Resolution	• 8-bit or 10-bit, selectable
Analog input pins	• Up to eight channels can be used. However, two or more channels cannot be used simultaneously.
Interrupts	• An interrupt request can be generated when A/D conversion completes.
A/D conversion start trigger	• Selectable : software, internal timer output, or falling edge on input from external pin
EI²OS support	• Supported by the extended intelligent I/O service (EI²OS) .

• 8/10-bit A/D converter conversion modes

	Description
Single-shot conversion mode	Performs A/D conversion sequentially from the start channel to the end channel. A/D conversion halts after conversion completes for the end channel.
Continuous conversion mode	Performs A/D conversion sequentially from the start channel to the end channel. A/D conversion starts again from the start channel after conversion completes for the end channel.
Incremental conversion mode	A/D conversion is performed for one channel then halts until the next trigger. After conversion is performed for the end channel, the next conversion is performed for the start channel, and repeated this operation.

• **Block diagram**



TO : Internal timer output
— : Undefined
Reserved : Always set to “0”.
ϕ : Machine clock

14. 8-bit D/A Converter

- The 8-bit D/A converter performs R-2R D/A conversion with 8-bit resolution.
- Two D/A converter channels with independent analog outputs are provided.

• D/A converter functions

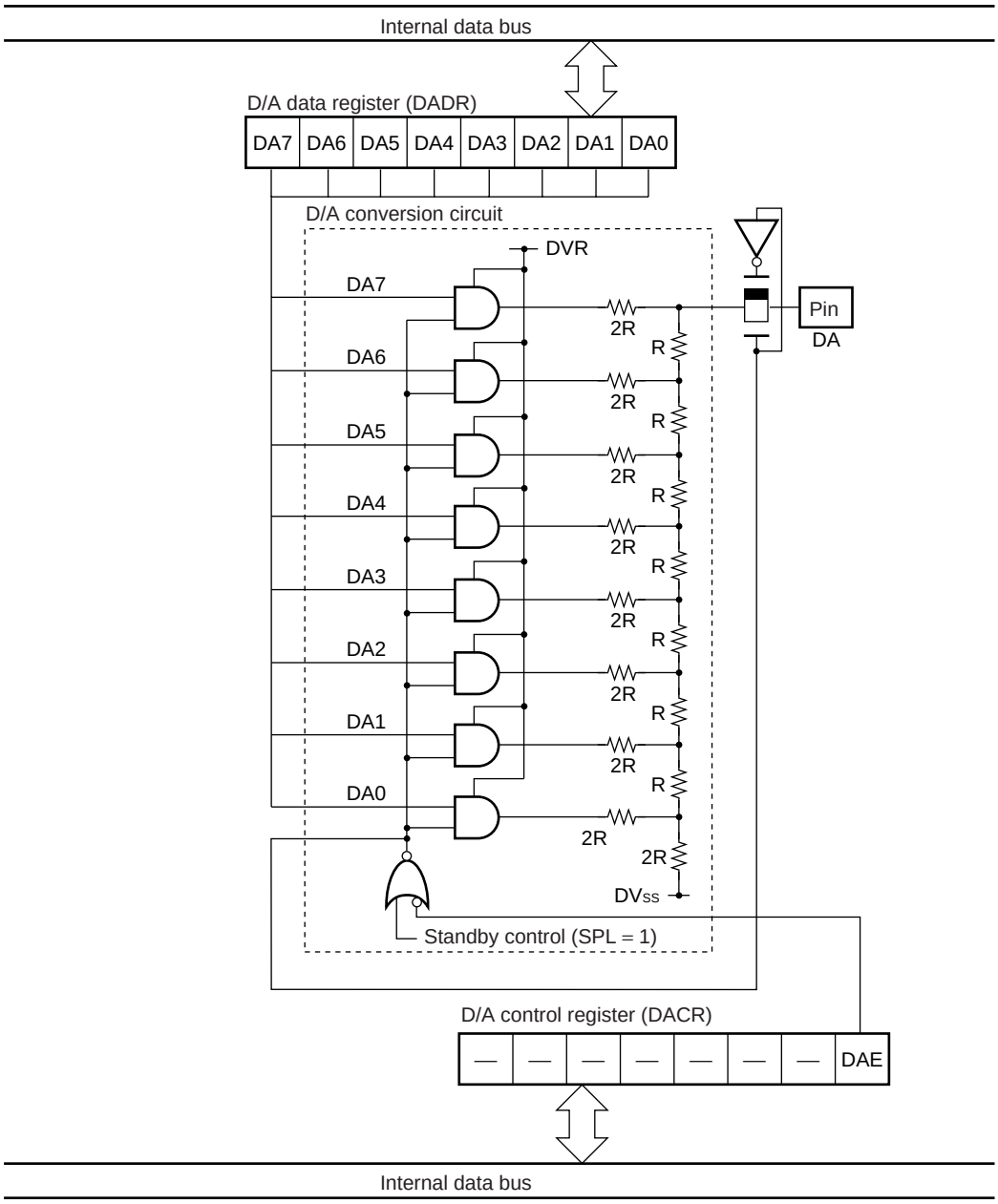
	Function
D/A conversion time	•The settling time is 12.5 μs. This is independent of the machine clock.
Conversion method	• R-2R conversion
Resolution	• 8-bit
Analog output pins	• Two output pins are provided. Both pins can be used simultaneously.
Interrupts	• None
D/A conversion trigger	• Set the digital value in the D/A data register (DADR) , then enable D/A output in the D/A control register (DACR) to start analog output from the D/A output pin.
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• D/A converter theoretical output voltage

D/A Data Register Setting	Theoretical Output Voltage Value
00_H	0 / 256 × DV_{CC} voltage (= 0 V)
00_H	1 / 256 × DV_{CC} voltage
•••	•••
FE_H	254 / 256 × DV_{CC} voltage
FF_H	255 / 256 × DV_{CC} voltage

Note : DV_{CC} voltage : D/A converter reference voltage. This must not exceed V_{CC}.
Also, always ensure that DV_{SS} is equipotential to V_{SS}.

• **Block diagram**



Standby control : Controls stop mode (SPL = 1) , pseudo-clock mode (SPL = 1) , clock mode (SPL = 1) , and hardware standby mode.

15. Clock Timer

- The clock timer is a 15-bit freerun timer that counts up synchronized with the sub-clock.
- Seven different interval time settings are available.
- This timer provides the clock for the sub-clock's oscillation stabilization delay timer and the watchdog timer.
- This timer always counts the sub-clock, regardless of the settings in the clock selection register (CKSC) .

• Clock timer functions

	Function
Interval time	• Selectable from the seven settings shown in the table below.
Clock timer size	• 15-bit
Clock supply	• Oscillation stabilization delay timer for sub-clock and watchdog timer
Source clock	• Sub-oscillation clock divided by four. (SCLK : Sub-clock)
Interrupts	• Interval time overflow
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Clock timer interval times

Sub-Clock Period	Interval Time
SCLK (122 µs)	2^9/SCLK (approx. 62.5 ms)
	2^{10}/SCLK (approx. 125.0 ms)
	2^{11}/SCLK (approx. 250.0 ms)
	2^{12}/SCLK (approx. 500.0 ms)
	2^{13}/SCLK (approx. 1.0 s)
	2^{14}/SCLK (approx. 2.0 s)
	2^{16}/SCLK (approx. 4.0 s)

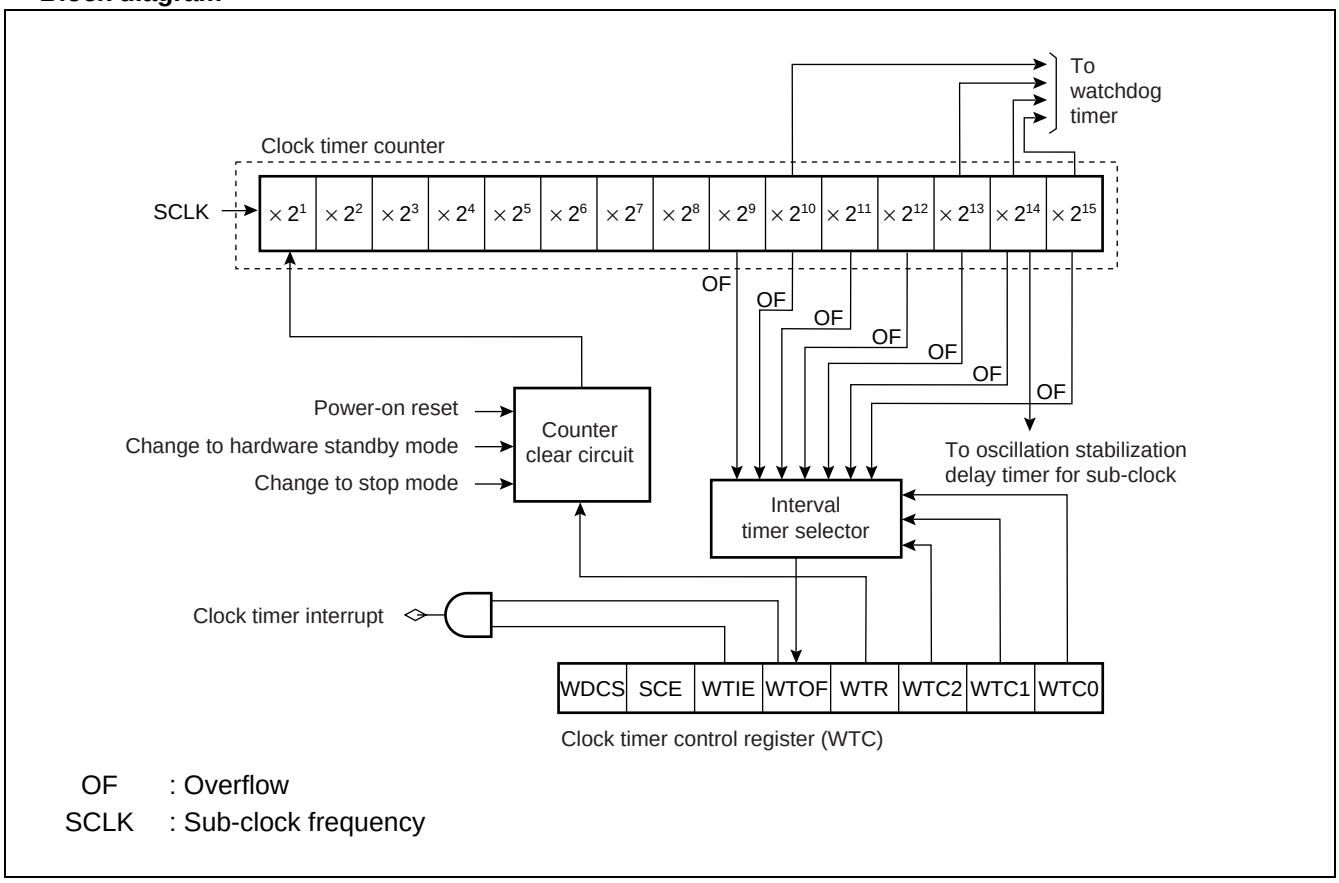
SCLK : Sub-clock frequency
The values enclosed in ( ) are the times for a sub-clock frequency of 8.192 kHz.
Note that the sub-oscillation clock is divided by four to generate the sub-clock frequency. The sub-oscillation clock operates at 32.768 kHz.

• Clock periods generated by clock timer

Clock Supply	Clock Period
Oscillation stabilization delay timer for sub-clock	2^{14}/SCLK (approx. 2.0 s)
Watchdog timer	2^{10}/SCLK (approx. 125.0 ms)
	2^{13}/SCLK (approx. 1.0 s)
	2^{14}/SCLK (approx. 2.0 s)
	2^{16}/SCLK (approx. 4.0 s)

SCLK : Sub-clock frequency
The values enclosed in ( ) are the times for a sub-clock frequency of 8.192 kHz.
Note that the sub-oscillation clock is divided by four to generate the sub-clock frequency. The sub-oscillation clock operates at 32.768 kHz.

• **Block diagram**



OF : Overflow
SCLK : Sub-clock frequency

16. LCD Controller/Driver

- The LCD controller/driver can drive an LCD (Liquid Crystal Display) directly.
- The LCD is driven by 4 common outputs and 32 segment outputs.
- The output mode can be set to 1/2, 1/3, or 1/4 duty.

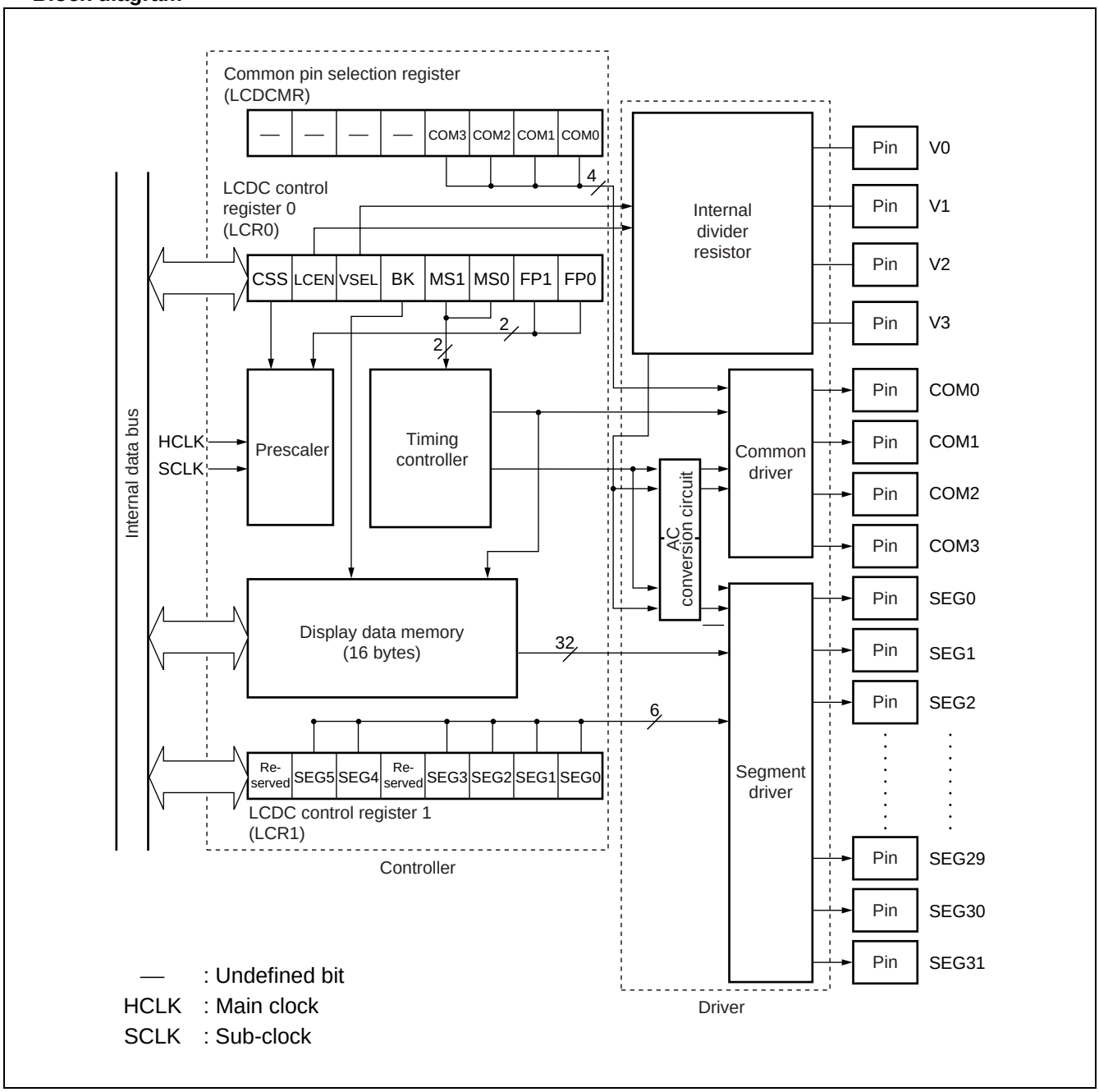
• LCD controller/driver functions

	Function
Divider resistor for LCD drive power	• Either the internal resistor (approx. 100 kΩ) or an externally connected resistor can be selected.
Common outputs	• Max 4 outputs (The corresponding pins cannot be used as I/O ports when using an LCD.)
Segment outputs	• Max 32 outputs (of these, 24 pins can be used as I/O ports in blocks of 8 pins.)
Display data memory	• 16 bytes of RAM for internal display are provided
Duty	• 1/2, 1/3, or 1/4 can be selected.
Bias	• 1/3 only supported
Drive clock	• Either the oscillation clock (HCLK) or sub-clock (SCLK) can be used.
Interrupts	• None
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Bias, duty, and common output combinations

Bias	1/2 Duty Output Mode	1/3 Duty Output Mode	1/4 Duty Output Mode
1/3 bias	COM0 and COM1 outputs used	COM0 to COM2 outputs used	COM0 to COM3 outputs used

• **Block diagram**



17. Communications Prescaler

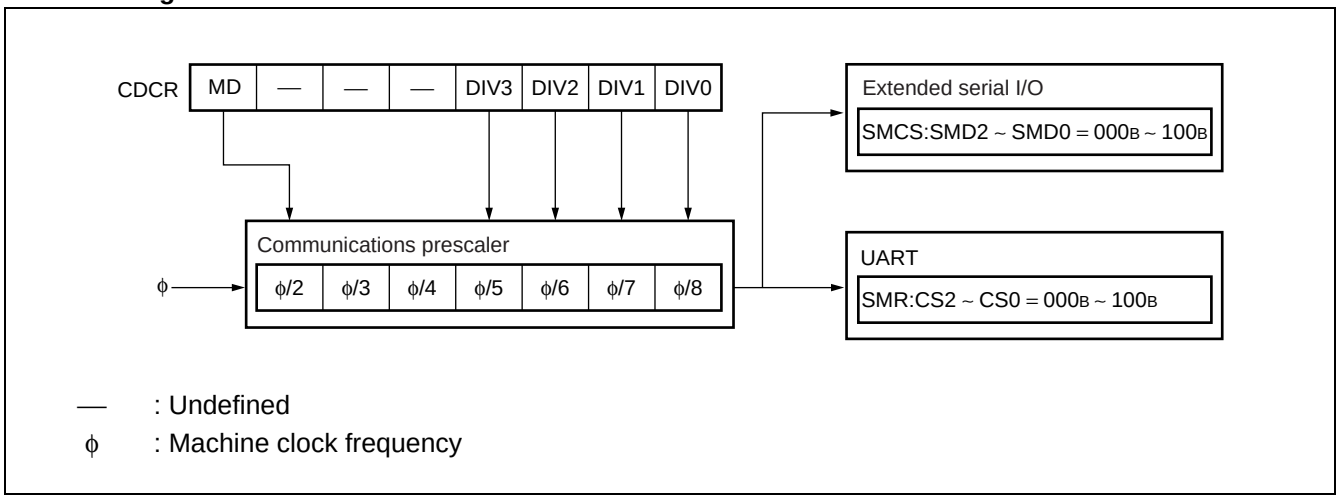
- Supplies the clock to the dedicated baud rate generator used by the UART (SCI) and extended I/O serial interfaces.
- By dividing the machine clock to produce the clock supply to the dedicated baud rate generator, the baud rate can be specified independently of the machine clock speed.
- The communications prescaler can divide the machine clock frequency ϕ by the following seven ratios to generate the clock supply to the dedicated baud rate generator and extended I/O serial interface :
  $\phi/2$, $\phi/3$, $\phi/4$, $\phi/5$, $\phi/6$, $\phi/7$, $\phi/8$

• Communications prescaler functions

	Function
Clock supply	• Dedicated baud rate generator for the UART (SCI) and the extended I/O serial interface. However, the same clock is supplied to both peripherals.
Divided clock frequency	• $\phi/2$, $\phi/3$, $\phi/4$, $\phi/5$, $\phi/6$, $\phi/7$, $\phi/8$ (ϕ : Machine clock frequency)
Interrupts	• None
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

Note : As the same output from the communications prescaler is supplied to both the UART (SCI) and the extended I/O serial interface, the transfer clock speed settings must be revised if the communications prescaler settings are changed.

• Block diagram



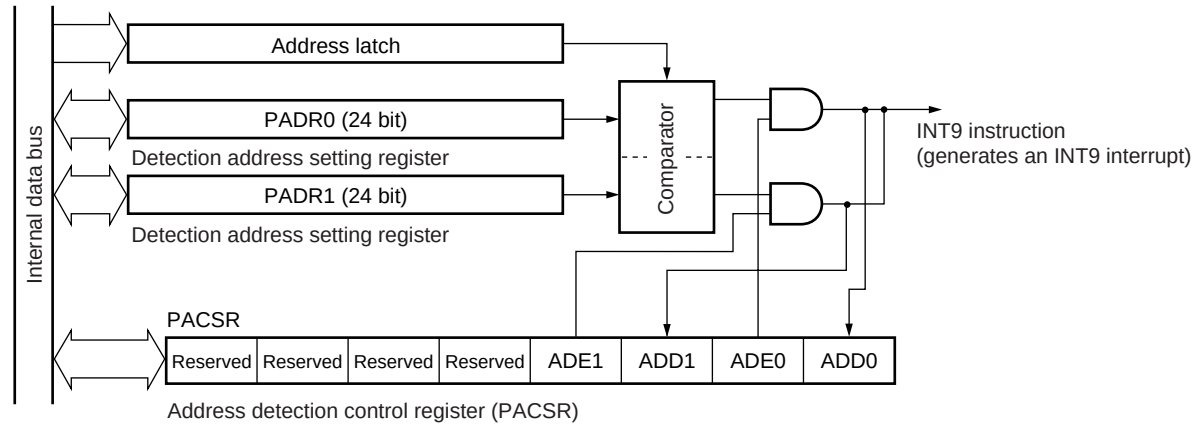
18. Address Match Detection Function

- If the program address during program execution matches the value set in one of the detection address setting registers (PADR) , the address match detection function replaces the instruction being executed with the INT9 instruction and executes the interrupt handler program.
- The address match detection function provides a simple method of correcting programming errors (patching) using RAM or similar.

• Address match detection functions

	Function
No. of address settings	• Two channels (two addresses can be set)
Interrupts	• An interrupt is generated when the program address matches the detection address setting register.
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Block diagram



Reserved : Always set to “0”.

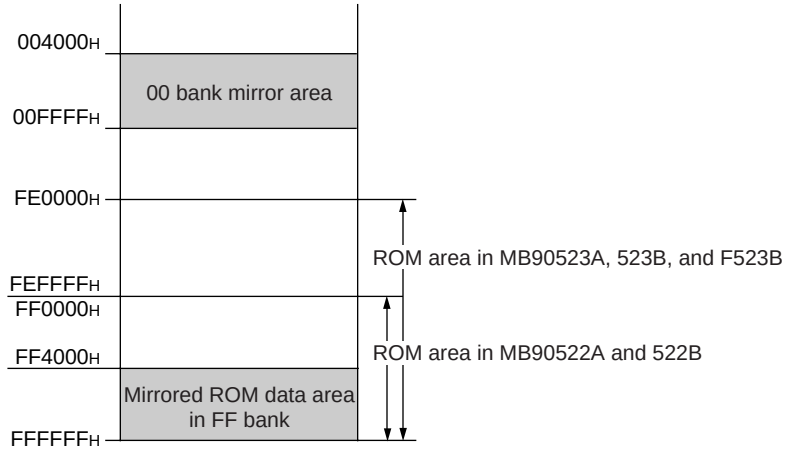
19. ROM Mirror Function Selection Module

The ROM mirror function selection module enables ROM data in FF bank to be read by accessing 00 bank.

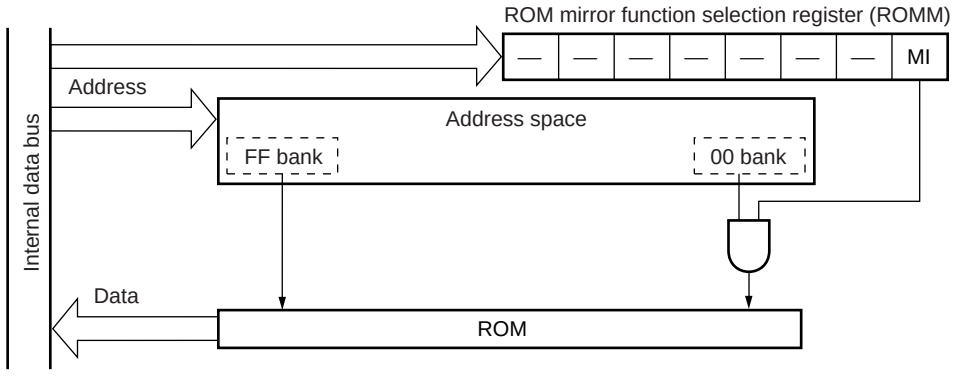
• ROM mirror function selection module functions

	Function
Mirror setting address	• Data in FFFFFF$_H$ to FF4000$_H$ in FF bank can be read from 00FFFF$_H$ to 004000$_H$ in 00 bank.
Interrupts	• None
EI^{2}OS support	• Not supported by the extended intelligent I/O service (EI^{2}OS) .

• Relationship between addresses in the ROM mirror function



• Block diagram



20. Low Power Consumption (Standby) Modes

The power consumption of F²MC-16LX devices can be reduced by various settings relating to the operating clock selection.

• Functions of each CPU operation mode

CPU Operation Clock	Operation Mode	Explanation
PLL clock	Normal run	The CPU and peripheral functions operate using the oscillation clock (HCLK) multiplied by the PLL circuit.
	Sleep	The peripheral functions only operate using the oscillation clock (HCLK) multiplied by the PLL circuit.
	Pseudo-clock	The timebase timer only operates using the oscillation clock (HCLK) multiplied by the PLL circuit.
	Stop	The oscillation clock is stopped and the CPU and peripherals halt operation.
Main clock	Normal run	The CPU and peripheral functions operate using the oscillation clock (HCLK) divided by 2.
	Sleep	The peripheral functions only operate using the oscillation clock (HCLK) divided by 2.
	Stop	The oscillation clock is stopped and the CPU and peripherals halt operation.
Sub-clock	Normal run	The CPU and peripheral functions operate using the sub-clock (SCLK) . The oscillation clock stops.
	Sleep	The peripheral functions only operate using the sub-clock (SCLK) . The oscillation clock stops.
	Clock	The clock timer only operates using the sub-clock (SCLK) . The oscillation clock stops.
	Stop	The oscillation clock and sub-clock are stopped and the CPU and peripherals halt operation.
CPU intermittent operation	Normal run	The oscillation clock (HCLK) divided by 2 operates intermittently for fixed time intervals.
Hardware standby	Stop	The oscillation clock and sub-clock are stopped and the CPU and peripherals halt operation.

21. Clock Monitor Function

The clock monitor function outputs the machine clock divided by a specified amount to the clock monitor pin (CKOT) .

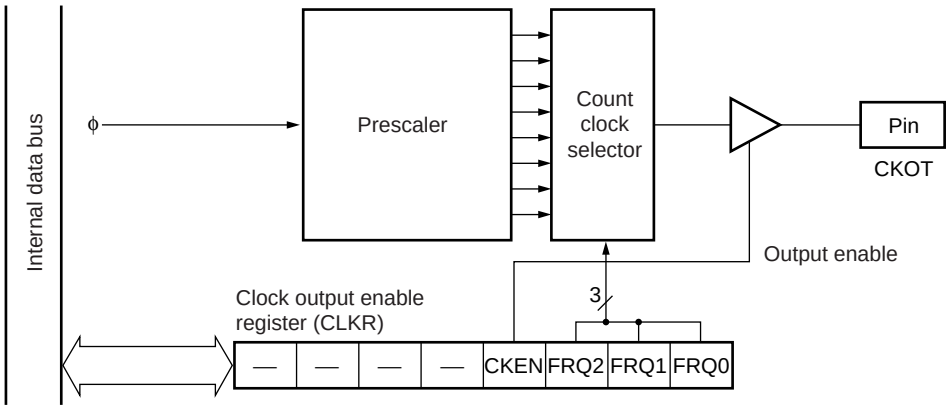
• Clock monitor functions

	Function
Output frequency	• Machine clock divided by 2 to 32 (8 settings available)
Interrupts	• None
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

• Output frequency of the clock monitor function

FRQ2 - 0 Bits	Machine Clock Divide Ratio	When ϕ = 16 MHz		When ϕ = 8 MHz		When ϕ = 4 MHz	
		Period	Frequency	Period	Frequency	Period	Frequency
000_B	$\phi/2^1$	125 ns	8 MHz	250 ns	4 MHz	500 ns	2 MHz
001_B	$\phi/2^2$	250 ns	4 MHz	500 ns	2 MHz	1.0 µs	1 MHz
010_B	$\phi/2^3$	500 ns	2 MHz	1.0 µs	1 MHz	2.0 µs	500 kHz
011_B	$\phi/2^4$	1.0 µs	1 MHz	2.0 µs	500 kHz	4.0 µs	250 kHz
100_B	$\phi/2^5$	2.0 µs	500 kHz	4.0 µs	250 kHz	8.0 µs	125 kHz
101_B	$\phi/2^6$	4.0 µs	250 kHz	8.0 µs	125 kHz	16.0 µs	62.5 kHz
110_B	$\phi/2^7$	8.0 µs	125 kHz	16.0 µs	62.5 kHz	32.0 µs	31.25 kHz
111_B	$\phi/2^8$	16.0 µs	62.5 kHz	32.0 µs	31.25 kHz	64.0 µs	15.625 kHz

• Block diagram



— : Undefined

ϕ : Machine clock frequency

22. 1 Mbit Flash Memory

- This section describes the flash memory on the MB90F523B and does not apply to evaluation products and MASK ROM versions.
- The flash memory is located in banks FE to FF in the CPU memory map.

• Flash memory functions

	Function
Memory size	• 1 Mbit (128 KBytes)
Memory configuration	• 128 KWords × 8 bits or 64 KWords × 16 bits
Sector configuration	• 16 KBytes + 8 KBytes + 8 KBytes + 32 KBytes + 64 KBytes
Sector protect function	• Selectable for each sector
Programming algorithm	• Automatic programming algorithm (Embedded Algorithm* : Equivalent to MBM29F400TA)
Operation commands	• Compatible with JEDEC standard commands • Includes an erase pause and restart function • Data polling and toggle bit write/erase completion • Erasing by sector available (sectors can be combined in any combination)
No. of write/erase cycles	• Min 10,000 guaranteed
Memory write/erase method	• Can be written and erased using a parallel writer (Minato Electronics model 1890A, Ando Denki AF9704, AF9705, AF9706, AF9708, and AF9709) • Can be written and erased using a dedicated serial writer (YDC AF200, AF210, AF120, and AF110) • Can be written and erased by the program
Interrupts	• Write and erase completion interrupts
EI²OS support	• Not supported by the extended intelligent I/O service (EI²OS) .

* : Embedded Algorithm is a trademark of Advanced Micro Devices.

• Sector configuration of flash memory

Flash memory	CPU address	Writer address*
SA0 (64 Kbyte)	FE0000H FEFFFH	60000H 6FFFFH
SA1 (32 Kbyte)	FF0000H FF7FFFH	70000H 77FFFH
SA2 (8 Kbyte)	FF8000H FF9FFFH	78000H 79FFFH
SA3 (8 Kbyte)	FFA000H FFBFFFH	7A000H 7BFFFH
SA4 (16 Kbyte)	FFC000H FEFFFFH	7C000H 7FFFFH

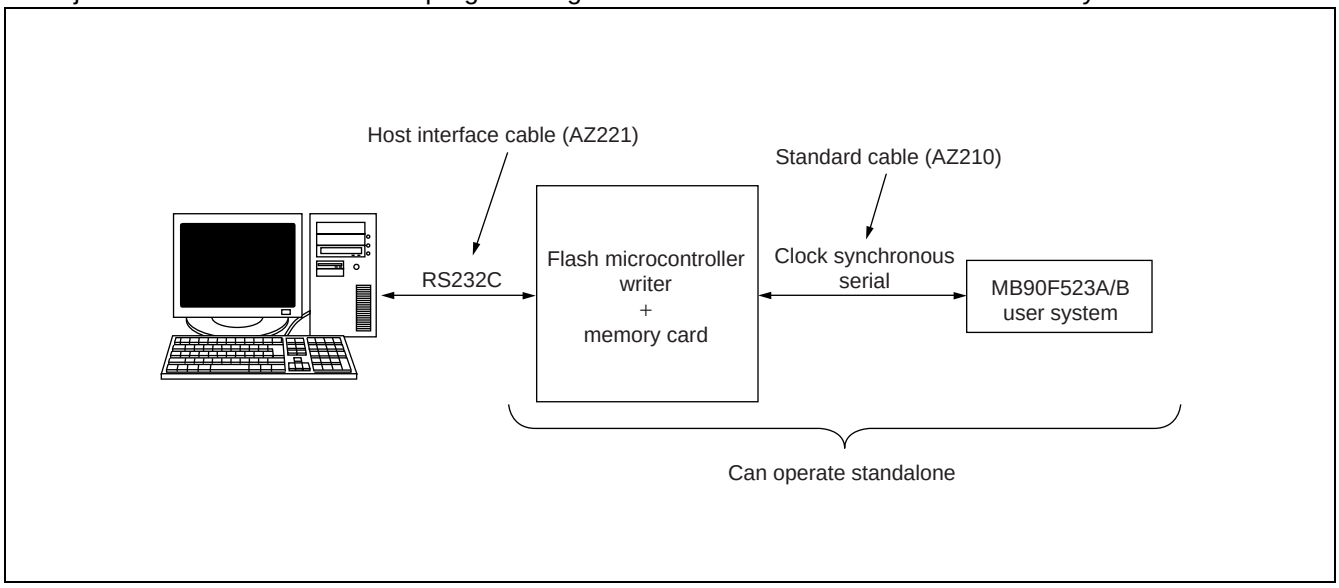
* : The writer address is the address to use instead of the CPU address when writing data from a parallel flash memory writer. Use the writer address when programming or erasing using a general-purpose parallel writer.

• **Pins used for Fujitsu standard serial on-board programming**

Pin	Function	Explanation
MD2, MD1, MD0	Mode pins	Setting MD2 = MD1 = 1, MD0 = 0 selects flash memory serial programming mode.
X0, X1	Oscillation input pin	Flash memory serial programming mode uses the PLL clock with the multiplier set to 1 as the machine clock. Set the oscillation frequency used for serial programming to between 3 MHz and 16 MHz.
P00, P01	Write program activation pins	Input P00 = 0 (“L” level) and P01 = 1 (“H” level)
RST	Reset pin	—
HST	Hardware standby pin	Input an “H” level during flash memory serial programming mode.
SIN0	Serial data input pin	Uses the UART (SCI) in clock synchronous mode.
SOT0	Serial data output pin	
SCK0	Serial clock input pin	
C	C pin	Capacitor pin for power supply stabilization. Connect an external capacitor of approx. 0.1 μF.
V_{CC}	Power supply voltage pins	If the user system can provide the programming voltage (5 V ± 10%) , do not need to connect to the flash microcontroller writer.
V_{SS}	GND pin	Connect to common GND with the flash microcontroller writer.

• **Overall configuration of connection between serial writer and MB90F523A**

Fujitsu standard serial on-board programming uses a flash microcontroller writer made by YDC.



Note : Contact YDC for details of the functions and operation of the flash microcontroller writer (AF220, AF210, AF120, or AF110) , standard connection cable (AZ210) , and connectors.

■ Electrical Characteristics\

1. Absolute Maximum Ratings

(V_{SS} = AV_{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_{SS} + 6.0	V	*3
Output voltage	V_O	V_{SS} – 0.3	V_{SS} + 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	Pd	—	400	mW	MB90522A/523A/ F523B
		—	300	mW	MB90522B/523B
Operating temperature	Ta	–40	+85	°C	
Storage temperature	Tstg	–55	+150	°C	

*1 : AV_{CC}, AVRH, AVRL, and DV_{CC} shall never exceed V_{CC} . AVRH and AVRL shall never exceed AV_{CC}. Also, AVRL shall never exceed AVRH.

*2 : $V_{CC} \geq AV_{CC} \geq DV_{CC} \geq 3.0$ V.

*3 : V_I and V_O shall never exceed V_{CC} + 0.3 V.

*4 : The maximum output current is the peak value for a single pin.

*5 : The average output current is the average current value for a single pin during a 100 ms period.

*6 : The total average current is the average current for all pins during a 100 ms period.

Note : Average output current = operating current × operating ratio

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

2. Recommended Operating Conditions

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

Parameter	Symbol	Value		Unit	Remarks
		Min	Max		
Power supply voltage	V_{CC}	3.0	5.5	V	
Smoothing capacitor	C_S	0.1	1.0	µF	
Operating temperature	Ta	−40	+85	°C	

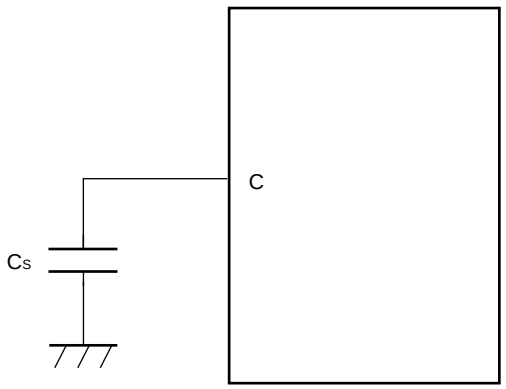
Note : Use a ceramic capacitor or other capacitor with equivalent frequency characteristics. The capacitance of the smoothing capacitor connected to the V_{CC} pin must be greater than C_S.

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 ± 10%, $AV_{SS} = V_{SS} = DV_{SS} = 0.0$ V, Ta = –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	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}	All output pins 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	
Input leak current	I_{IL}	All output pins other than P90 to P97	V_{CC} = 5.5 V, $V_{SS} < V_I < V_{CC}$	– 5	—	5	µA	
Open-drain output leak current	I_{leak}	P90 to P97 output pins	—	—	0.1	5	µA	
Pull-up resistor	R_{UP}	P00 to P07, P10 to P17 P40 to P47, MD0, MD1	—	50	100	200	kΩ	
Pull-down resistor	R_{DOWN}	MD2		50	100	200	kΩ	
Power supply current*	I_{CC}	V_{CC}	For V_{CC} = 5 V, internal frequency = 16 MHz, normal operation	—	40	65	mA	MB90522A/523A
				—	30	60	mA	MB90F523B
				—	30	40	mA	MB90522B/523B

(Continued)

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

Parameter	Sym-bol	Pin Name	Condition	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current*	I_{CC}	V_{CC}	For V_{CC} = 5 V, internal frequency = 8 MHz, normal operation	—	20	25	mA	MB90522A/523A
				—	15	20	mA	MB90F523B
				—	15	20	mA	MB90522B/523B
			For V_{CC} = 5 V, internal frequency = 16 MHz, A/D operation in progress	—	50	70	mA	MB90522A/523A
				—	45	65	mA	MB90F523B
				—	35	45	mA	MB90522B/523B
			For V_{CC} = 5 V, internal frequency = 8 MHz, A/D operation in progress	—	25	30	mA	MB90522A/523A
				—	20	25	mA	MB90F523B
				—	20	25	mA	MB90522B/523B
			For V_{CC} = 5 V, internal frequency = 16 MHz, D/A operation in progress	—	55	70	mA	MB90522A/523A
				—	50	70	mA	MB90F523B
				—	40	50	mA	MB90522B/523B
			For V_{CC} = 5 V, internal frequency = 8 MHz, D/A operation in progress	—	30	35	mA	MB90522A/523A
				—	25	30	mA	MB90F523B
				—	20	25	mA	MB90522B/523B
			Writing or erasing flash memory	—	50	75	mA	MB90F523B
	I_{CCS}		For V_{CC} = 5 V, internal frequency = 16 MHz, sleep mode	—	8	15	mA	MB90522A/523A
				—	15	20	mA	MB90F523B/522B/523B
			For V_{CC} = 5 V, internal frequency = 8 MHz, sleep mode	—	7	10	mA	MB90522A/523A
				—	12	18	mA	MB90F523B/522B/523B
	I_{CCL}		For V_{CC} = 5 V, internal frequency = 8 kHz, sub-clock mode, Ta = 25 °C	—	0.1	1.0	mA	MB90522A/523A/522B/523B
				—	4	7	mA	MB90F523B

(Continued)

(Continued)

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

Parameter	Symbol	Pin Name	Condition	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current*	I_{CCLS}	V_{CC}	For V_{CC} = 5 V, internal frequency = 8 kHz, sub-sleep mode, Ta = 25 °C	—	30	50	µA	
	I_{CCT}		For V_{CC} = 5 V, internal frequency = 8 kHz, clock mode, Ta = 25 °C	—	15	30	µA	
	I_{CCH}		Sleep mode, Ta = 25 °C	—	5	20	µA	
Input capacitance	C_{IN}	Other than AV_{CC}, AV_{SS}, C, V_{CC}, and V_{SS}	—	—	10	80	pF	
LCD divider resistor	R_{LCD}	V0 – V1, V1 – V2, V2 – 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, COM0 to COM3, SEG00 to SEG31	—	—	—	±5	µA	

* : Current values are provisional and are subject to change without notice to allow for improvements to the characteristics. The power supply current is measured with an external clock.

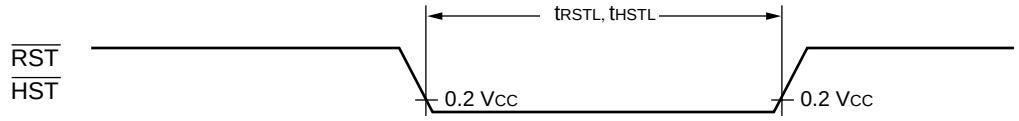
4. AC Characteristics

(1) Reset and Hardware Standby Input Timings

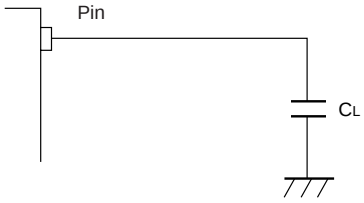
(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = DV_{SS} = 0.0 V, Ta = –40 °C to +85 °C)

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

* : See “ (3) Clock Timings” for more information about t_{CP} (internal operating clock cycle time) .



Measurement conditions for AC ratings



C_L is the load capacitance for the pin during testing.

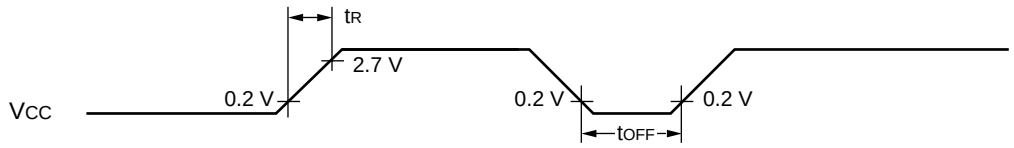
(2) Power-On Reset

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

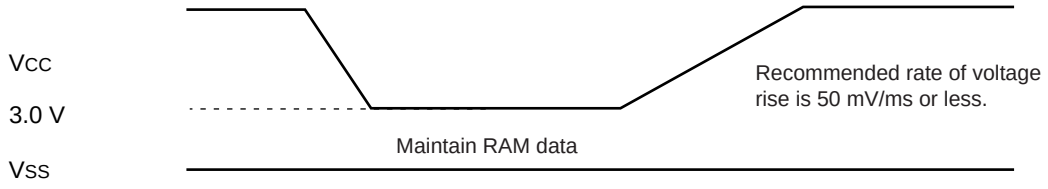
Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min	Typ		
Power supply rise time	t_R	V_{CC}	—	0.05	30	ms	*
Power supply cutoff time	t_{OFF}	V_{CC}		4	—	ms	For repeated operation

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

Notes : • The above rating values are for generating a power-on reset.
- When $\overline{HST}$ = "L", always apply the power supply in accordance with the above ratings regardless of whether a power-on reset is required.
- Some internal registers are only initialized by a power-on reset. Always apply the power supply in cordance with the above ratings if you wish to initialize these registers.



Sudden changes in the power supply voltage may cause a power-on reset.
The recommended practice if you wish to change the power supply voltage while the device is operating is to raise the voltage smoothly as shown below. Also, changes to the supply voltage should be performed when the PLL clock is not in use. The PLL clock may be used, however, if the rate of voltage change is 1 V/s or less.

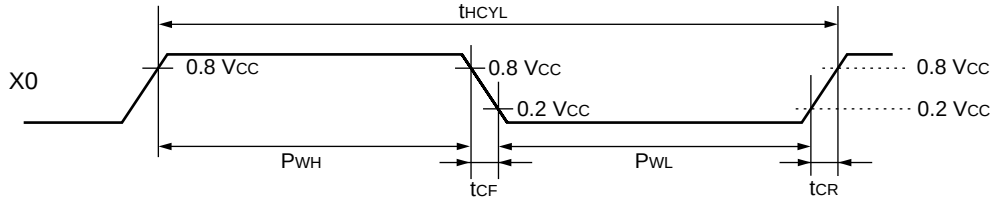


(3) Clock Timings

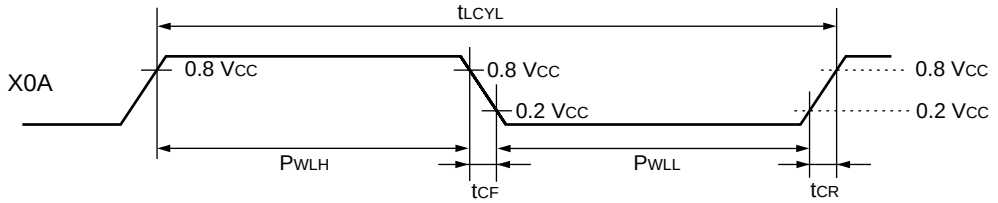
($AV_{CC} = V_{CC} = 5.0\ V \pm 10\%$, $AV_{SS} = V_{SS} = DV_{SS} = 0.0\ V$, $Ta = -40\ °C$ to $+85\ °C$)

Parameter	Symbol	Pin Name	Condition	Value			Unit	Remarks
				Min	Typ	Max		
Clock frequency	F_C	X0, X1	—	3	—	16	MHz	
	F_{CL}	X0A, X1A	—	—	32.768	—	kHz	
Clock cycle time	t_{HCYL}	X0, X1	—	62.5	—	333	ns	
	t_{LCYL}	X0A, X1A	—	—	30.5	—	µs	
Input clock pulse width	P_{WH} P_{WL}	X0	—	10	—	—	ns	Recommended duty ratio = 30% to 70%
	P_{WLH} P_{WLL}	X0A		—	15.2	—	µs	
Input clock rise/fall time	t_{CR} t_{CF}	X0	—	—	—	5	ns	When using an external clock
Internal operating clock frequency	f_{CP}	—	—	1.5	—	16	MHz	When using main clock
	f_{LCP}	—	—	—	8.192	—	kHz	When using sub-clock
Internal operating clock cycle time	t_{CP}	—	—	62.5	—	666	ns	When using main clock
	t_{LCP}	—	—	—	122.1	—	µs	When using sub-clock

X0 and X1 clock timing

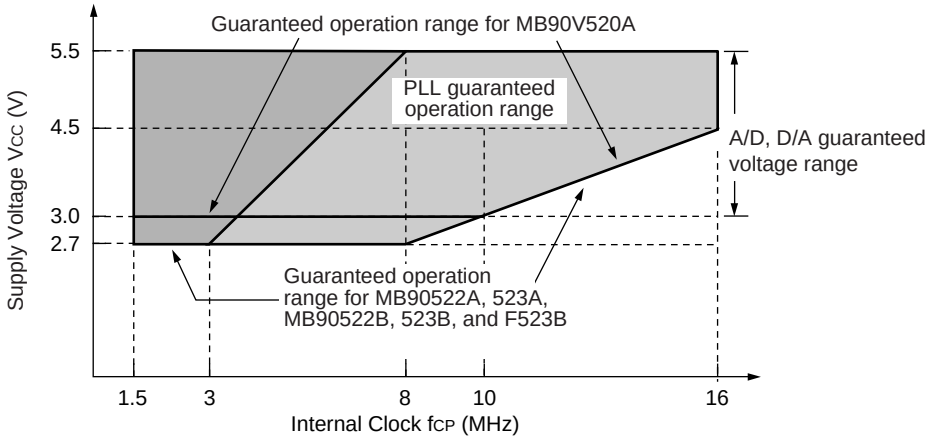


X0A and X1A clock timing

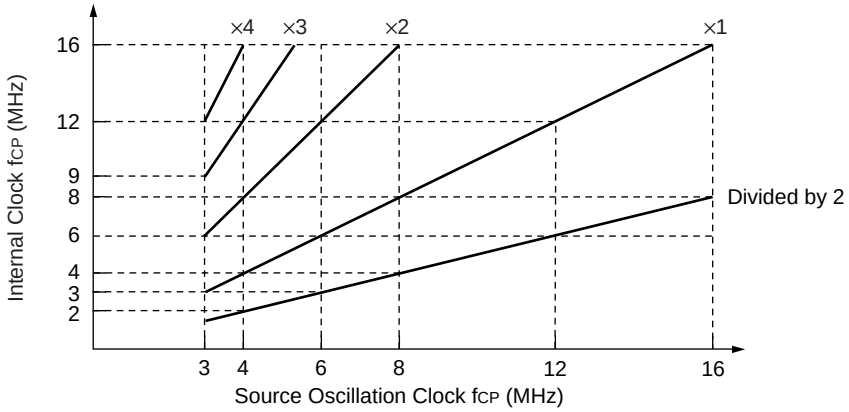


PLL guaranteed operation range

Relationship between internal operating clock frequency and power supply voltage



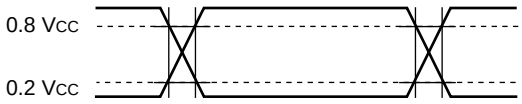
Relationship between oscillation frequency and internal operating clock frequency



The AC ratings are measured at the following reference voltages.

Input signal waveform

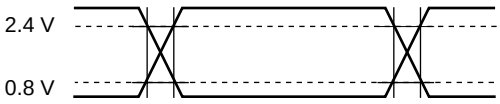
Hysteresis input pin



Pins other than hysteresis input or MD input pins

Output signal waveform

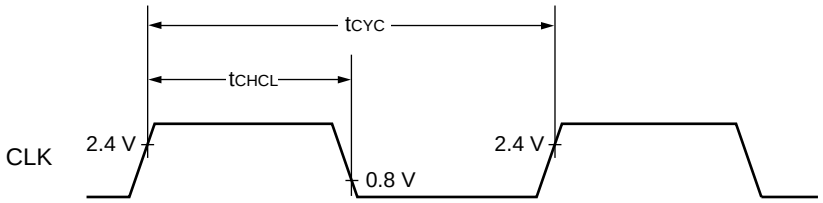
Output pin



(4) Clock Output Timings

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

Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min	Typ		
Cycle time	t_{CYC}	CLK	$V_{CC} = 5.0\ V \pm 10\%$	62.5	—	ns	
CLK ↑ → CLK ↓	t_{CHCL}			20	—	ns	



(5) UART (SCI) Timings

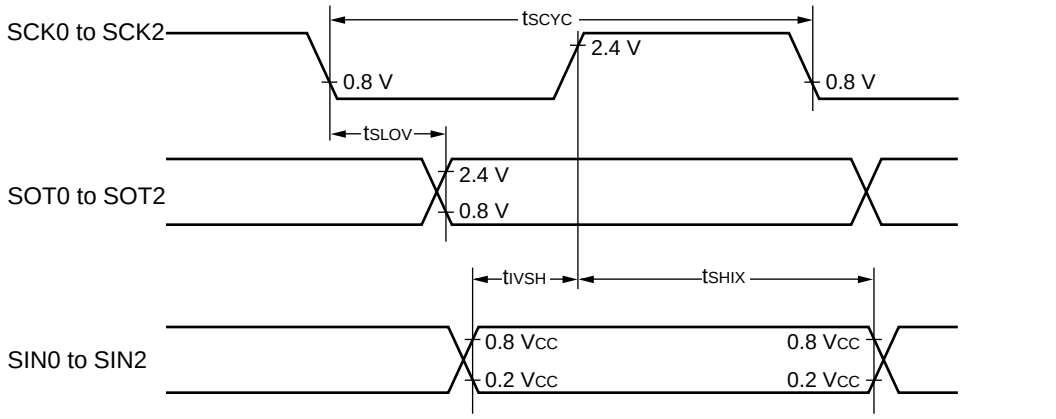
($AV_{CC} = V_{CC} = 5.0\ V \pm 10\%$, $AV_{SS} = V_{SS} = DV_{SS} = 0.0\ V$, $Ta = -40\ °C$ to $+85\ °C$)

Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min	Typ		
Serial clock cycle time	t_{SCYC}	SCK0 to SCK2	Internal shift clock mode, output pin load is C_L = 80 pF + 1 TTL	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, output pin load is C_L = 80 pF + 1 TTL	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	

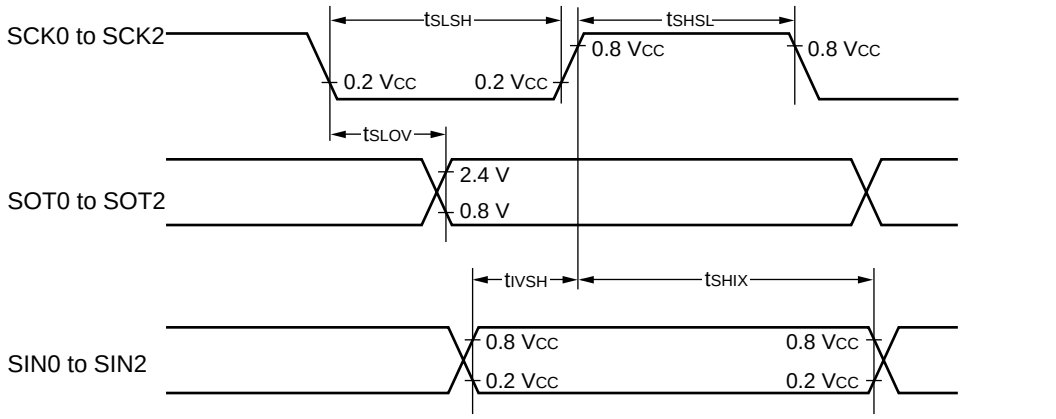
* : See “ (3) Clock Timings” for more information about t_{CP} (internal operating clock cycle time) .

Notes : • These are the AC ratings for CLK synchronous mode.
• C_L is the load capacitor connected to the pin for testing.

Internal shift clock mode



External shift clock mode

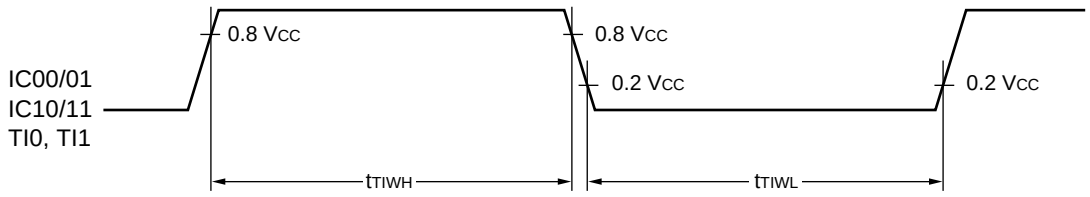


(6) Timer Input Timings

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

Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min	Typ		
Input pulse width	t_{TIWH} t_{TIWL}	IC00/01, IC10/11 TI0, TI1	—	4 t_{CP}*	—	ns	

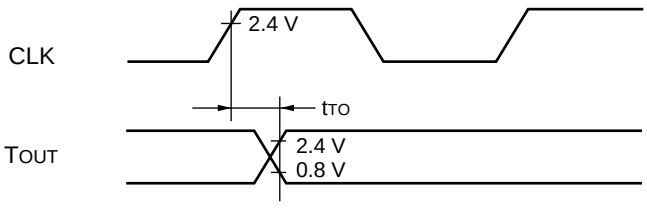
* : See “ (3) Clock Timings” for more information about t_{CP} (internal operating clock cycle time) .



(7) Timer Output Timings

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

Parameter	Symbol	Pin Name	Condition	Value		Unit	Remarks
				Min	Typ		
CLK ↑ → T_{OUT} change time	t_{TO}	OUT0 to OUT7 PG00/01 PG10/11 TO0, TO1	—	30	—	ns	



(T_{OUT} : OUT0 to OUT7, PG00/01, PG10/11, TO0, TO1)

5. Electrical Characteristics for the A/D Converter

($AV_{CC} = V_{CC} = 5.0\ V \pm 10\%$, $AV_{SS} = V_{SS} = DV_{SS} = 0.0\ V$, $3.0\ V \le AVRH - AVRL$, $Ta = -40\ °C$ to $+85\ °C$)

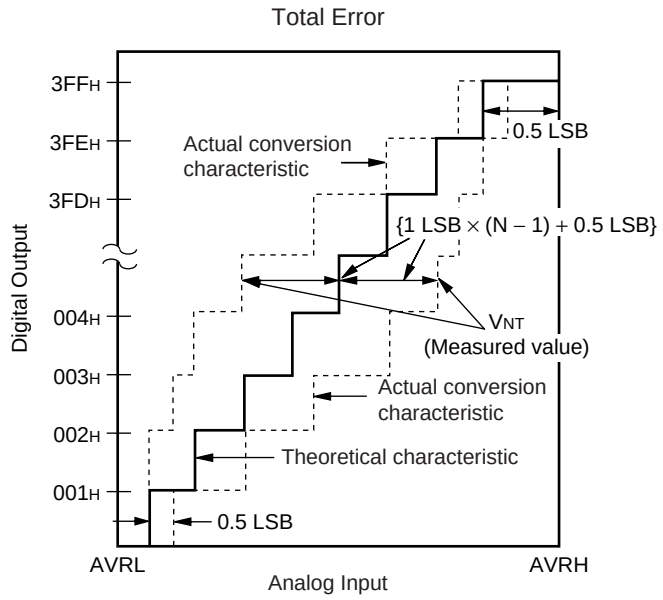
Parameter	Symbol	Pin Name	Value			Unit	Remarks
			Min	Typ	Max		
Resolution	—	—	—	8/10	—	bit	
Total error	—	—	—	—	±5.0	LSB	
Linearity error	—	—	—	—	±2.5	LSB	
Differential linearity error	—	—	—	—	±1.9	LSB	
Zero transition voltage	V_{OT}	AN0 to AN7	AV_{SS} − 3.5 LSB	AV_{SS} + 0.5 LSB	AV_{SS} + 4.5 LSB	mV	
Full-scale transition voltage	V_{FST}	AN0 to AN7	AVRH − 6.5 LSB	AVRH − 1.5 LSB	AVRH + 1.5 LSB	mV	
A/D conversion time	—	—	163 tcp	—	—	ns	At machine clock = 16 MHz
Compare time	—	—	99 tcp	—	—	ns	At machine clock = 16 MHz
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 + 3.0	—	AV_{CC}	V	
	—	AVRL	0	—	AVRH − 3.0	V	
Power supply current	I_A	AV_{CC}	—	5	—	mA	
	I_{AH}	AV_{CC}	—	—	5	µA	*
Reference voltage supply current	I_R	AVRH	—	400	—	µA	
	I_{RH}	AVRH	—	—	5	µA	*
Variation between channels	—	AN0 to AN7	—	—	4	LSB	

* : Current when 8/10-bit A/D converter not used and CPU in stop mode ($V_{CC} = AV_{CC} = AVRH = 5.0\ V$)

Note : See " (3) Clock Timings" in "4. AC Ratings" for more information about t_{CP} (internal operating clock cycle time) .

6. A/D Converter Glossary

Resolution	:	The change in analog voltage that can be recognized by the A/D converter.
Linearity error	:	The deviation between the actual conversion characteristics and the line linking the zero transition point (“00 0000 0000B” ⟷ “00 0000 0001B”) and the full scale transition point (“11 1111 1110B” ⟷ “11 1111 1111B”) .
Differential linearity error	:	The variation from the ideal input voltage required to change the output code by 1 LSB.
Total error	:	The total error is the difference between the actual value and the theoretical value. This includes the zero-transition error, full-scale transition error, and linearity error.



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

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

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

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

V_{NT} : Voltage at which digital output changes from (N – 1) to N

* : For 10-bit resolution, this value is 1024 (2^{10}) . For 8-bit resolution, this value is 256 (2^{8}) .

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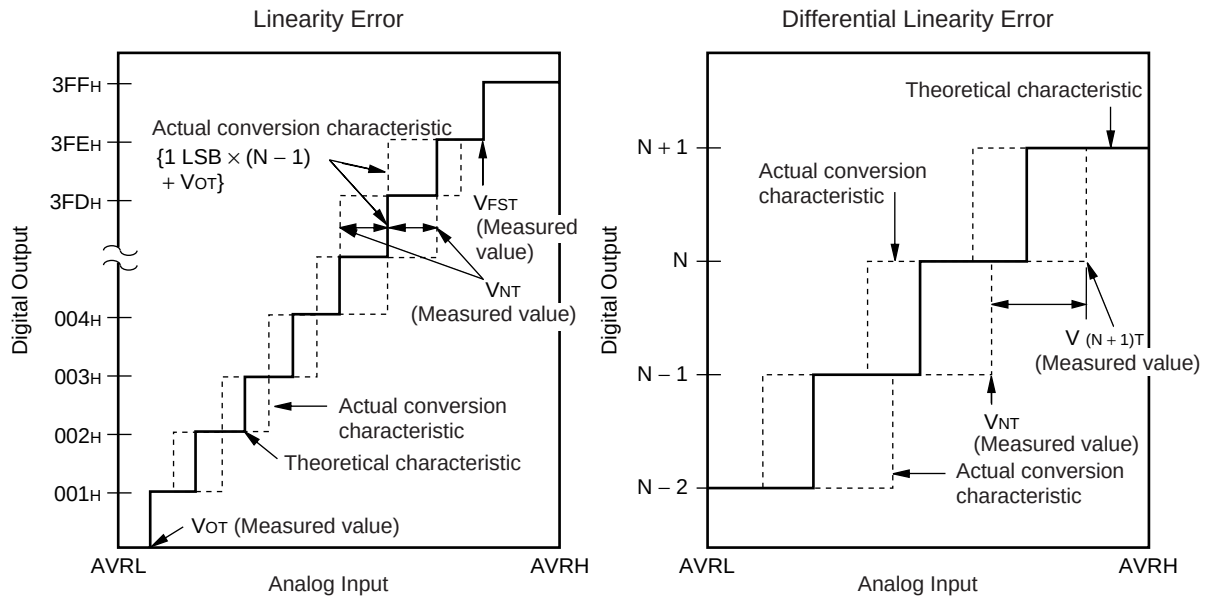


Linearity error for digital output N = $\frac{V_{NT} - \{1\ LSB \times (N - 1) + V_{OT}\}}{1\ LSB}$ [LSB]

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

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

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

* : For 10-bit resolution, this value is 1022 ($2^{10} - 2$) . For 8-bit resolution, this value is 254 ($2^8 - 2$) .

7. Notes for A/D Conversion

The recommended external circuit impedance of analog inputs for MB90V520 is approximately 5 kΩ or less, that for MB90F523B is approximately 15.5 kΩ or less, and that for MB90522A/523A/522B/523B is approximately 10 kΩ or less.

If using an external capacitor, the capacitance should be several thousand times the level of the chip's internal capacitor to allow for the 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 too short. (for sampling time = 4 µs, machine clock frequency = 16 MHz) .

- Block diagram of analog input circuit model

MB90522A/523A/522B/523B
R_{ON} = 2.2 kΩ approx.
C = 45 pF approx.
MB90F523B
R_{ON} = 2.6 kΩ approx.
C = 28 pF approx.

Note : The values listed are an indication only.

- **Error**

The relative error increases as |AVRH – AVRL| becomes smaller.

8. Electrical Characteristics for the D/A Converter

(AV_{CC} = V_{CC} = 5.0 V ± 10%, AV_{SS} = V_{SS} = DV_{SS} = 0.0 V, Ta = –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	For load capacitance = 20 pF
Analog reference voltage	—	DV_{CC}	V_{SS} + 3.0	—	AV_{CC}	V	
Current consumption for reference voltage	I_{DVR}	DV_{CC}	—	120	300	µA	
	I_{DVRS}		—	—	10	µA	Stop mode
Analog output impedance	—	—	—	20	—	kΩ	

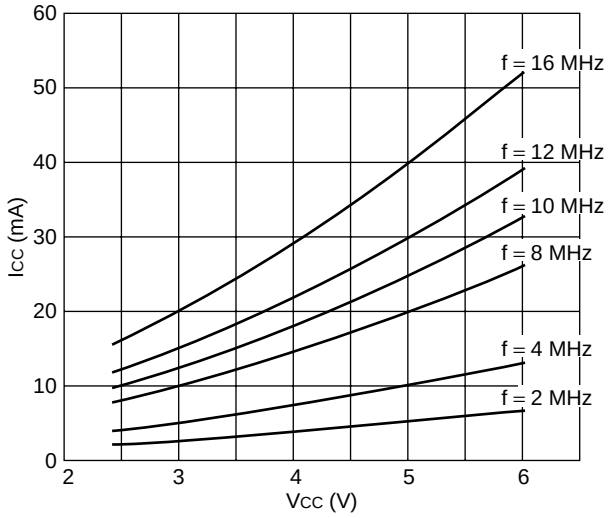
9. Flash Memory Program/Erase

Parameter	Condition	Value			Unit	Remarks
		Min	Typ	Max		
Sector erase time	Ta = + 25 °C V_{CC} = 5.0 V	—	1	15	s	Excludes 00H programming prior erasure
Chip erase time		—	5	—	s	Excludes 00H programming prior erasure
Word (16-bit width) programming time		—	16	3,600	µs	Excludes system-level overhead
Program/Erase cycle	—	10,000	—	—	cycle	
Data hold time	—	100 K	—	—	h	

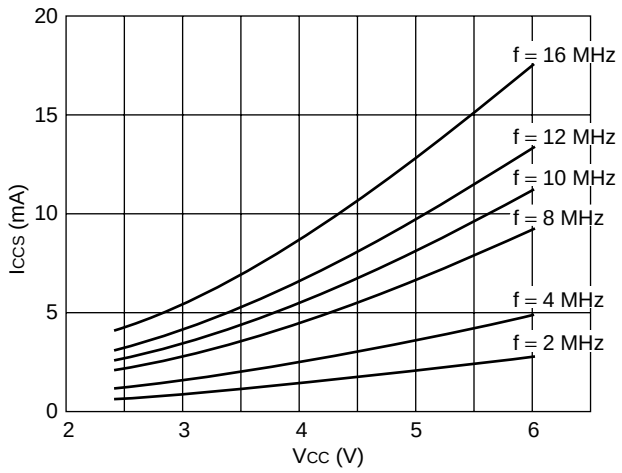
■ EXAMPLE CHARACTERISTICS

Power supply current (MB90523A)

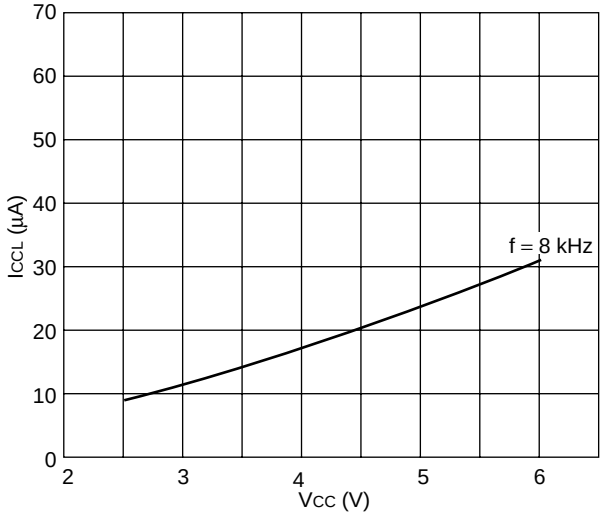
I_{CC} – V_{CC}
Ta = +25 °C, External clock input



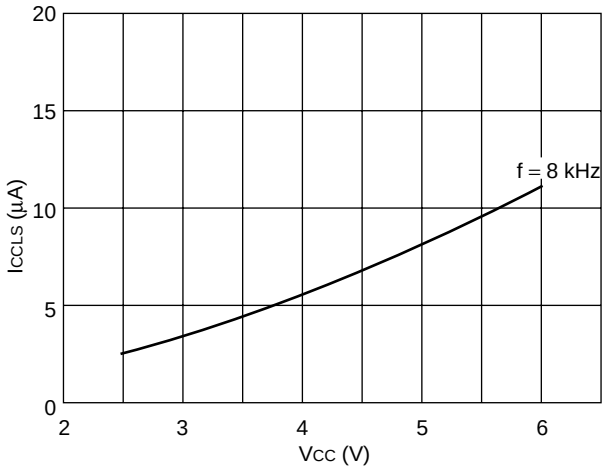
I_{CCS} – V_{CC}
Ta = +25 °C, External clock input



I_{CCL} – V_{CC}
Ta = +25 °C, External clock input



I_{CCLS} – V_{CC}
Ta = +25 °C, External clock input



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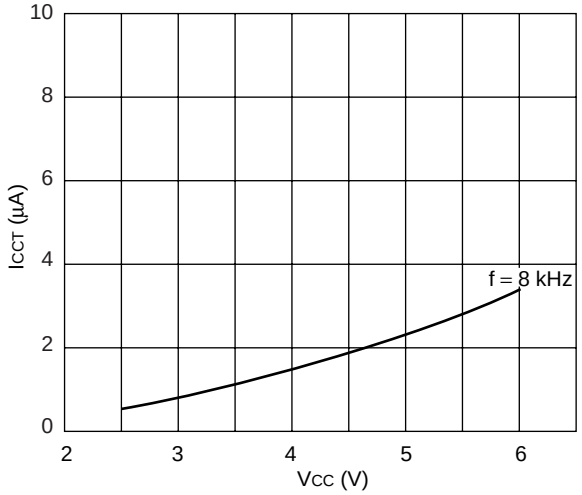
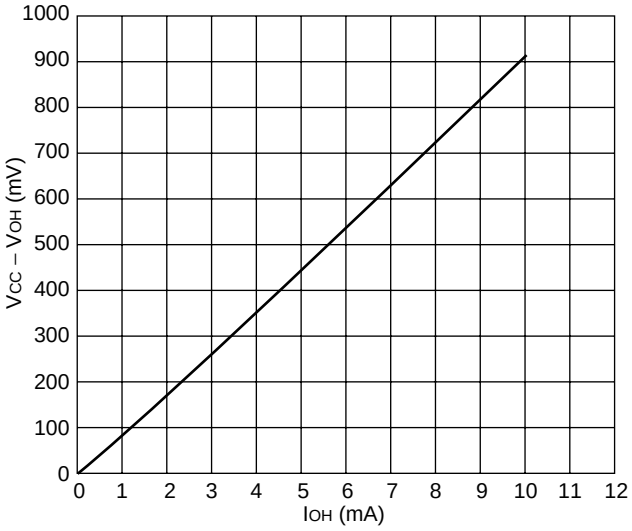
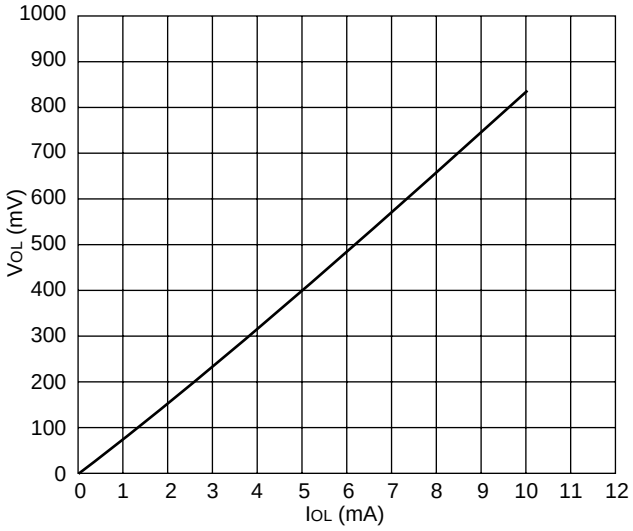
I_{CCT} – V_{CC}
Ta = +25 °C, External clock input



Example MB90523A V_{OH} – I_{OH} Characteristics
Ta = +25 °C, V_{CC} = 4.5 V



Example MB90523A V_{OL} – I_{OL} Characteristics
Ta = +25 °C, V_{CC} = 4.5 V



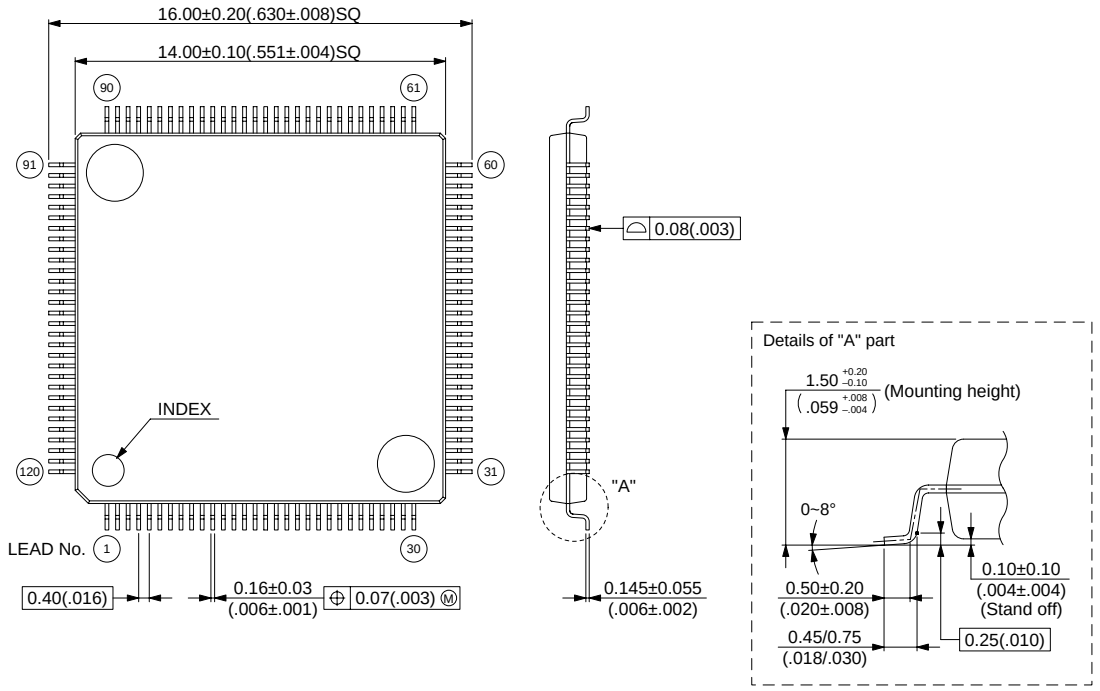
■ ORDERING INFORMATION

Part No.	Package	Remarks
MB90522APFF MB90523APFF MB90522BPFF MB90F523BPFF	120-pin, Plastic LQFP (FPT-120P-M05)	
MB90522APFV MB90523APFV MB90522BPFV MB90F523BPFV	120-pin, Plastic QFP (FPT-120P-M13)	

■ PACKAGE DIMENSIONS

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

* : Pins width and pins thickness include plating thickness.



Dimensions in mm (inches)

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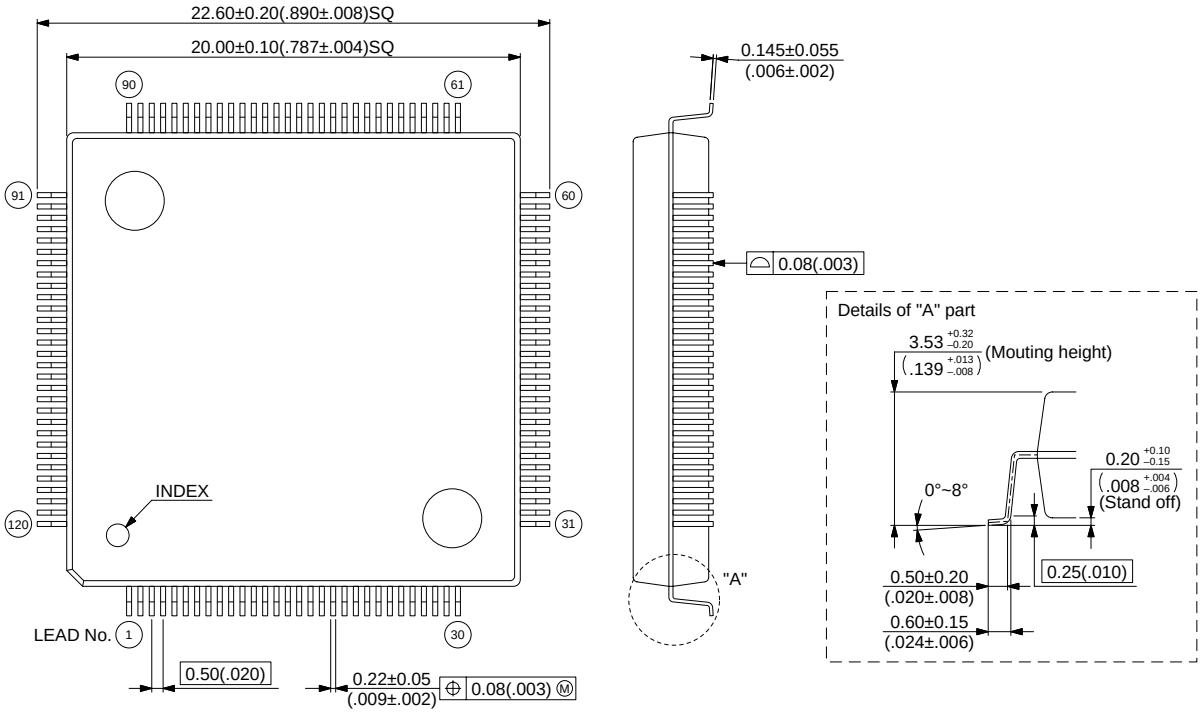
120-pin Plastic QFP
(FPT-120P-M13)

* : Pins width and pins thickness include plating thickness.



Dimensions in mm (inches)

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