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M306H7MG-XXXFP/MC-XXXFP/FGFP

SINGLE-CHIP 16-BIT CMOS MICROCOMPUTER
with DATA ACQUISITION CONTROLLER

REJ03B0152-0210
Rev.2.10
Oct 25, 2006

1. DESCRIPTION

The M306H7MG/MC-XXXFP and M306H7FGFP are single-chip microcomputers using the high-performance silicon gate CMOS process using M16C/62 Series CPU core and is packaged in a 100-pin plastic molded QFP. This single-chip microcomputer operates using sophisticated instructions featuring a high level of instruction efficiency. With 1M bytes of address space, this is capable of executing instructions at high speed. This also features a built-in data slicer, making this correspondence to Global broadcasting service.

1.1 Features

• Memory capacity	ROM	Mask version : 256 K/128 K bytes Flash memory version : 256 K bytes
	RAM	Mask version : 8 K/5 K bytes Flash memory version : 8 K bytes
• Shortest instruction execution time	62.5 ns ($f(X_{IN})$=16 MHz)	
• Supply voltage	V_{CC1}=3.00 V to V_{CC2}, V_{CC2}=4.5 V to 5.5 V(at $f(X_{IN})$=16 MHz) V_{CC1}=2.00 V to V_{CC2}, V_{CC2}=2.00 V to 5.5 V(at $f(X_{CIN})$=32 kHz) *V_{CC2}=2.0 V to 2.9 V: Operates only in the low power dissipation mode	
• Interrupts	25 internal and 8 external interrupt sources, 4 software interrupt sources; 7 levels	
• Multifunction 16-bit timer	5 output timers + 6 input timers	
• Serial I/O	6 channels UART/clock synchronous: 3 Clock synchronous: 2 Multi-master I^2C: 1	
• DMAC	2 channels (trigger: 24 sources)	
• A/D converter	8 bits X 8 channels (Expandable up to 10 channels)	
• CRC calculation circuit	1 circuit	
• Watchdog timer	1 line	
• Programmable I/O	79 lines (P6 to P7, $P8_0$ to $P8_4$: Can be used as 3.3 V interface)	
• Input port	1 port ($P8_5$ shared with $\overline{NMI}$ pin)	
• Clock generating circuit	2 built-in circuits (built-in feedback resistor, external crystal oscillator is required)	
• Data slicer	For PDC, VPS, WSS, EPG-J, CC, CC2X, ID-1	

1.2 Applications

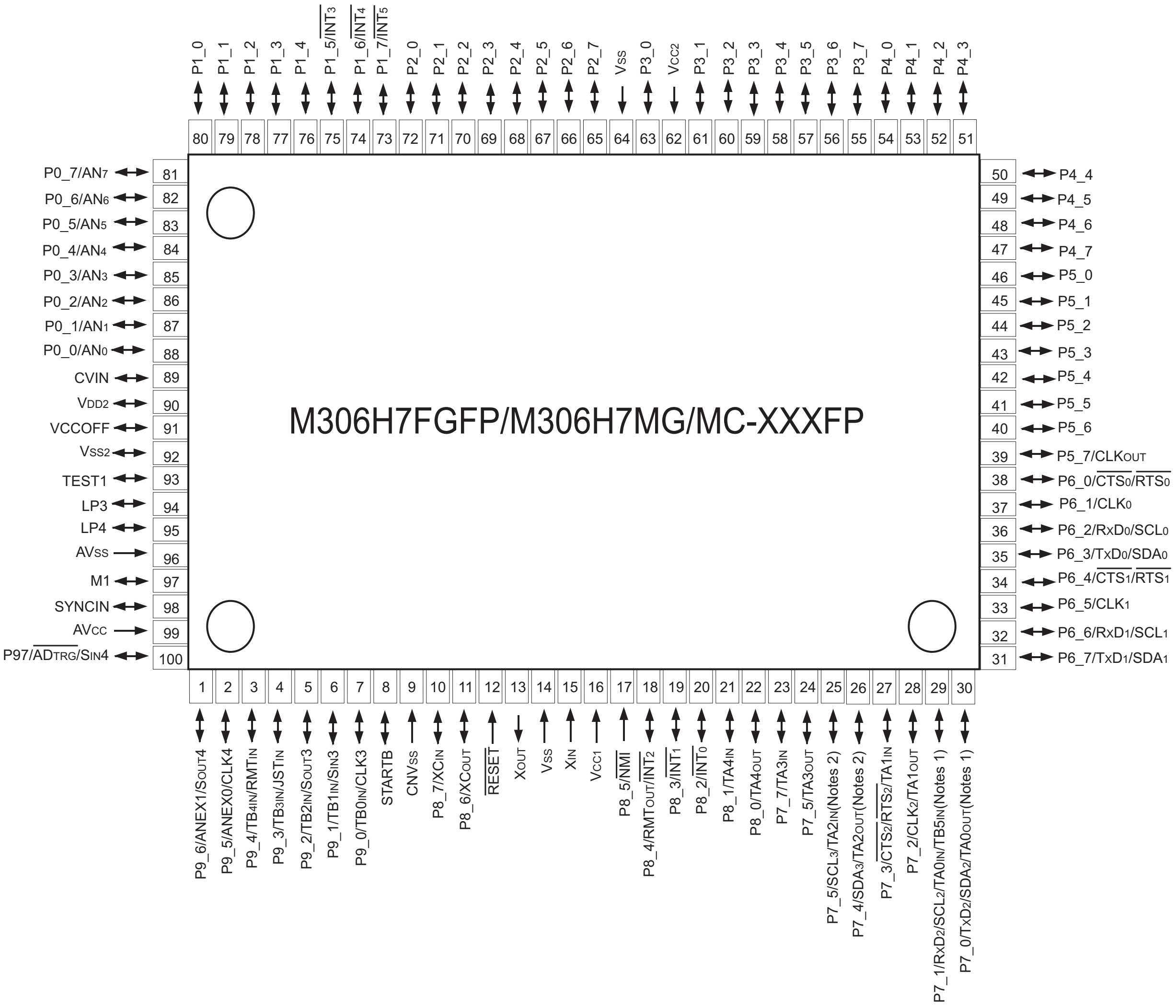
DVD recorder, HDD recorder

------Table of Contents------

1.3 Pin Configuration

Figures 1.1 shows the pin configuration (top view).

Pin configuration (top view)



Notes 1: N channel open-drain output pins.

Notes 2: When using Multi-master I^{2}C, N channel open-drain output pins.

100P6S-A

Figure 1.1 Pin configuration (top view)

1.4 Performance Outline

Performance outline is shown in Table 1.1.

Table 1.1 Performance outline

Item		Performance
Number of basic instructions		91 instructions
Shortest instruction execution time		62.5 ns (f(XIN)= 16MHZ, VCC= 4.5V to 5.5V)
Memory capacity	ROM	Refer to the Product table (Table 1.2)
	RAM	Refer to the Product table (Table 1.2)
I/O port	P0 to P5, P86 to P87, P9	8-bit x 7, 2-bit x 1 : VCC2 system
	P6 to P7, P80 to P84	8-bit x 2, 5-bit x 1 : VCC1 system
Input port	P85	1-bit x 1 (NMI pin VCC2 level judgment) : VCC2 system
Multi function timer	TA0, TA1, TA2, TA3, TA4	16-bit x 5 channels
	TB0, TB1, TB2, TB3, TB4, TB5	16-bit x 6 channels
Serial I/O		3 channels Clock synchronous serial I/O, Clock asynchronous serial I/O, I^{2}C bus[1.], or IEBus[2.] 2 channels Clock synchronous serial I/O
Serial I/O	Multi-master I^{2}C	I^{2}C bus x 1
A/D converter		8 bits x (8 + 2) channels
DMAC		2 channels (trigger: 24 sources)
CRC calculation circuit		CRC-CCITT
Watchdog timer		15 bits x 1 (with prescaler)
Interrupt		25 internal and 8 external sources, 4 software sources, 7 levels
Clock generation circuit		2 circuits • Main clock • Sub-clock (These circuits contain a built-in feedback resistor and external crystal oscillator)
Power supply voltage		VCC1=3.00 V to VCC2, VCC2= 4.5 V to 5.5 V (at f(XIN)=16MHZ)
		VCC1=3.00 V to VCC2, VCC2= 4.00 V to 5.5 V (at f(XIN)=16MHZ)[3.]
		VCC1=2.90 V to VCC2, VCC2= 2.90 V to 5.5 V (at f(XIN)=16MHZ, at divide-by-8 or 16)[3.]
		VCC1=2.0 V to VCC2, VCC2=2.0 V to 5.5 V (at f(XCIN)=32kHZ, only low-power consumption mode) [3.4.]
Flash memory	Program/erase voltage	5.0 V ± 0.25 V
	Number of program/erase	100 times
Device configuration		CMOS high performance silicon gate
Package		100-pin plastic mold QFP
Data slicer	Slice RAM	864 bytes (48 x 18 x 8-bit)
	Data slicer	Corresponds to PDC, VPS, WSS, EPG-J, CC, CC2X and ID-1

NOTES:

1. I^2C bus is a registered trademark of Koninklijke Philips Electronics N.V. If you desire this option, please so specify.
2. IEBus is a registered trademark of NEC Electronics Corporation.
3. If the V_{CC2} supply voltage is less than 4.50 V, the A/D converter, data slicer cannot be used.
4. If the V_{CC2} supply voltage is less than 2.60 V, be aware that only the CPU, RAM, clock timer, interrupt, and I/O ports can be used. Other control circuits (e.g., timers A and B, serial I/O, UART) cannot be used.

Table 1.2 Product table

Type No.	ROM capacity	RAM capacity	Package type	Remarks
M306H7MG-XXXFP	256K bytes	8K bytes	100P6S-A	Mask ROM version
M306H7MC-XXXFP	128K bytes	5K bytes		Mask ROM version
M306H7FGFP	256K bytes	8K bytes		Flash Memory version

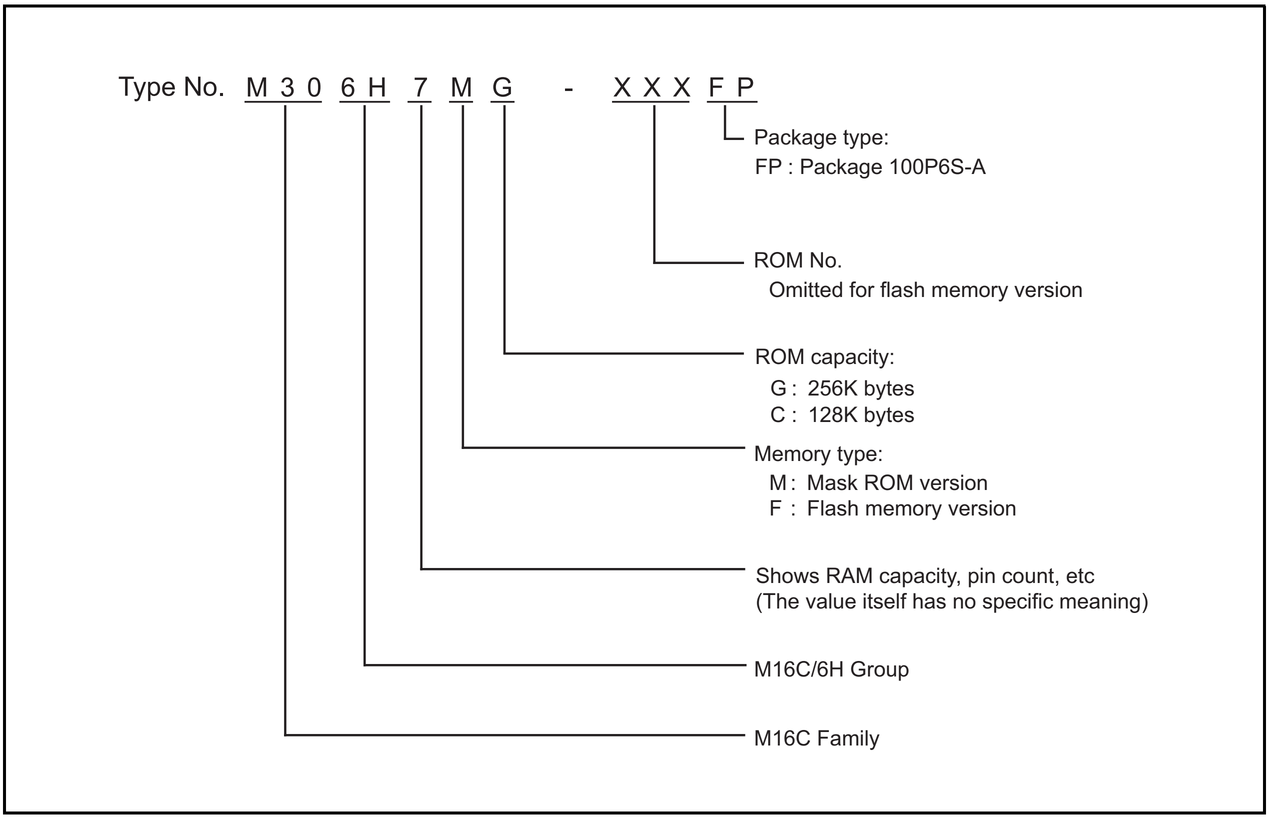


Figure 1.2 Type No, Memory Size, and Package

1.5 Block Diagram

Figure 1.3 is a block diagram.

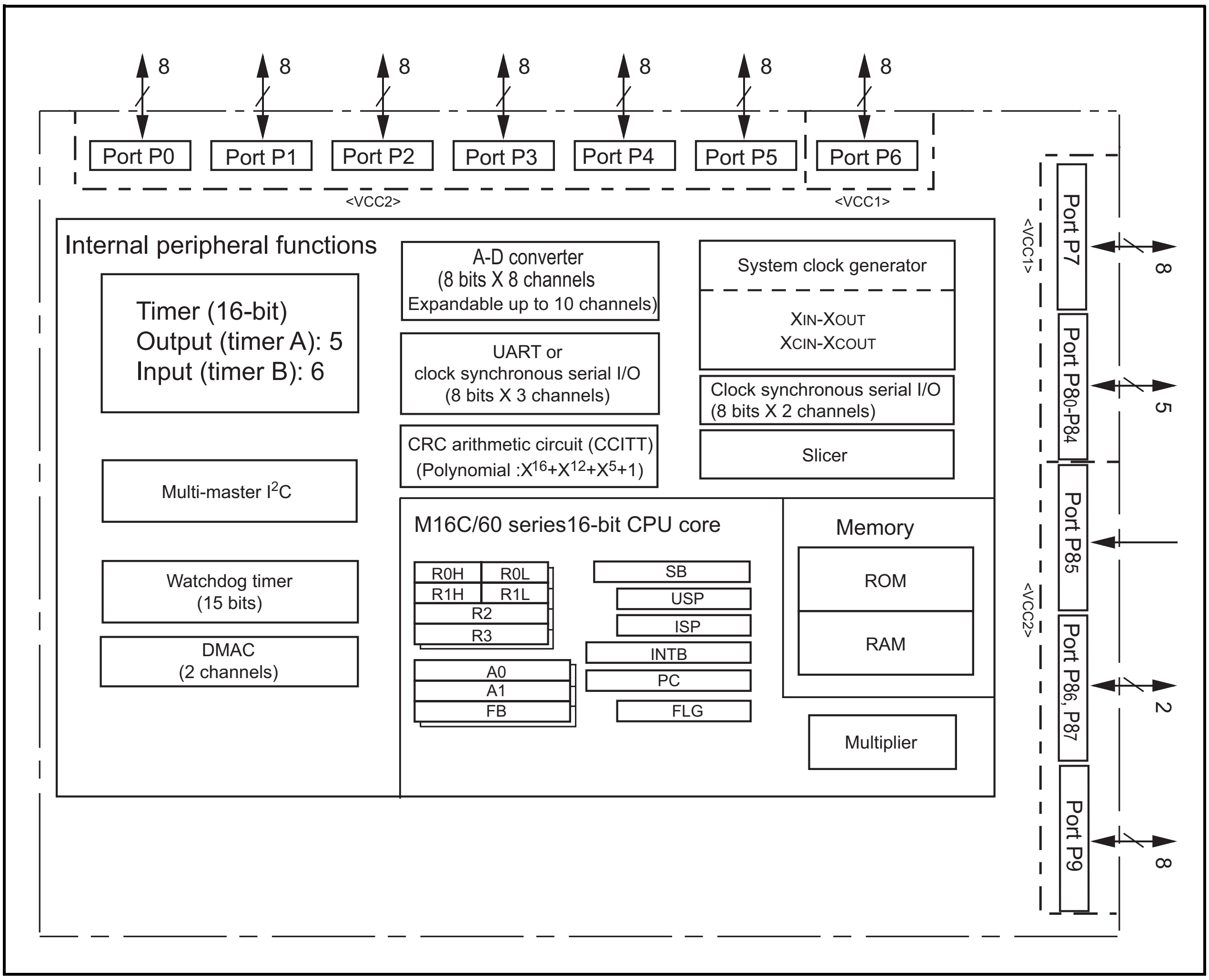


Figure 1.3 Block diagram

Table 1.3 Pin Description (1)

Pin name	Signal name	I/O type	Power supply	Function
VCC1, VCC2, VSS	Power supply input			Apply 2.00 V to 5.5 V to the Vcc1 and Vcc2 pins. Apply 0 V to the Vss pin. Input condition of Vcc1 and Vcc2 are Vcc1 ≤ Vcc2. (1.)
CNVSS	CNVSS	Input	VCC2	Connect this pin to VSS.
$\overline{\text{RESET}}$	Reset input	Input	VCC2	"L" on this input resets the microcomputer.
XIN XOUT	Clock input Clock output	Input Output	VCC2	These are I/O pins provided for main clock oscillation circuit. Connect ceramic resonator or crystal oscillator between pins XIN and XOUT. To use an externally derived clock, input it to XIN pin and leave XOUT pin open.
AVCC	Analog power supply input			This pin is a power supply input for the A/D converter. Connect this pin to VCC.
AVSS	Analog power supply input			This pin is a power supply input for the A/D converter. Connect this pin to VSS.
P0$_0$ to P0$_7$	I/O port P0	Input/output	VCC2	This is an 8-bit CMOS I/O port. This port has an I/O select direction register, allowing each pin in that port to be directed for input or output individually. If any port is set for input, selection can be made for it in a program whether or not to have a pull-up resistor in 4 bit units. Pins in this oprt also function as A/D converter input pins as selected by Program.
P1$_0$ to P1$_7$	I/O port P1	Input/output	VCC2	This is an 8-bit I/O port equivalent to P0. Pins P1$_5$ to P1$_7$ in this port also functionas $\overline{\text{INT}}$ interrupt input pins as selected by software.
P2$_0$ to P2$_7$	I/O port P2	Input/output	VCC2	This is an 8-bit I/O port equivalent to P0.

Note 1: In this datasheet, hereafter, VCC refers to VCC2 unless otherwise noted.

Table 1.4 Pin Description (2)

Pin name	Signal name	I/O type	Power supply	Function
$P3_0$ to $P3_7$	I/O port P3	Input/output	V_{CC2}	This is an 8-bit I/O port equivalent to P0.
$P4_0$ to $P4_7$	I/O port P4	output	V_{CC2}	This is an 8-bit I/O port equivalent to P0.
$P5_0$ to $P5_7$	I/O port P5	Input/output	V_{CC2}	This is an 8-bit I/O port equivalent to P0. The same frequency as divide-by-8, 32 of X_{IN} from P57 or X_{CIN} are output by program selecting.
$P6_0$ to $P6_7$	I/O port P6	Input/output	V_{CC1}	This is an 8-bit I/O port equivalent to P0. These pins function as I/O pin of UART0 and UART1 by selecting it by the program.
$P7_0$ to $P7_7$	I/O port P7	Input/output	V_{CC1}	This is an 8-bit I/O port equivalent to P0 ($P7_0$ and $P7_1$ are N channel open-drain output). This port can function as I/O pins for timers A_0 to A_3 when so selected in a program. Furthermore, $P7_0$ to $P7_3$ function as I/O pins of UART2, $P7_1$ function as input pin of timer B5, and $P7_4$ and $P7_5$ function as I/O pin of multi-master I_2C bus.
$P8_0$ to $P8_4$	I/O port $P8_0$ to $P8_4$	Input/output	V_{CC1} ($P8_0$ to $P8_4$)	$P8_0$ to $P8_4$, $P8_6$, and $P8_7$ are I/O ports with the same functions as P0. When selected by a program, $P8_0$ to $P8_1$ function as I/O pins of timer A4, $P8_2$ to $P8_4$ function input pin of $\overline{INT}$ interrupt. And, $P8_4$ also function as output pin for remote control.

Table 1.5 Pin Description (3)

Pin name	Signal name	I/O type	Power supply	Function
P86, P87, P85	I/O port P86 I/O port P87 I/O port P85	Input/output Input/output Input	VCC2 (P85 to P87)	P86 and P87 that when selected in a program, both can function as I/O pins for sub clock oscillation circuit. In that case, connect crystal resonator between P86 (XCOUT pin) and P87 (XCIN pin). P85 is an input-only port shared with $\overline{\text{NMI}}$. $\overline{\text{NMI}}$ interrupt is generated when input on this pin changes state from high to low. $\overline{\text{NMI}}$ function cannot be disabled in a program. Pull-up resistor cannot be set for this pin.
P90 to P97	I/O port P9	Input/output	VCC2	This is an 8-bit I/O port equivalent to P0. Pins in this port also function as SI/O3 and SI/O4 of I/O pins, Timer B0 to B4 input pins, A/D converter input pins, A/D trigger input pins, or remote control input pins as selected by program.
VDD2, VSS2	Power supply input			Analog power supply pin. Apply the same potential as VCC2 to the VDD2 pin. Apply 0 V to the VSS2 pin.
CVIN	Composite video signal input 1	Input	VCC2	This pin inputs the external composite video signal. Data-acquisition slices this signal internally by setting.
SYNCIN	Composite video signal input 2	Input	VCC2	This pin inputs the external composite video signal. Sync.-separate circuit devides this signal internally.
STARTB	Oscillation selection input	Input	VCC2	This pin selects the oscillation circuit. XIN-XOUT circuit is selected when this pin is "L"; XCIN-XCOUT circuit is selected when this pin is "H".
LP3	Filter output 2	output	VDD2	This is a filter output pin 2 (for VPS).
LP4	Filter output 3	output	VDD2	This is a filter output pin 3 (for PDC).
VCC OFF	VCC1 Power supply input select	Input	VCC2	Normally, please input "L" level. When VCC1 power supply is off, please input "H" level.
M1	Mode selection input (M1 input)	Input	VCC2	Connect it to the VSS.In the mask ROM version, connect this pin to the VSS or the VCC2.
TEST1	Test input	Input	VCC2	This is a test pin. Connect a capacitor.

1.6 Memory

Figure 1.4 is a memory map of M306H7MG-XXXFP/MC-XXXFP/FCFP. The address space extends the 1M bytes from address 00000_{16} to $FFFFF_{16}$.

The internal ROM is allocated in a lower address direction beginning with address $FFFFF_{16}$. An internal ROM of M306H7MC-XXXFP, for instance, is allocated to the addresses from $E0000_{16}$ to $FFFFF_{16}$.

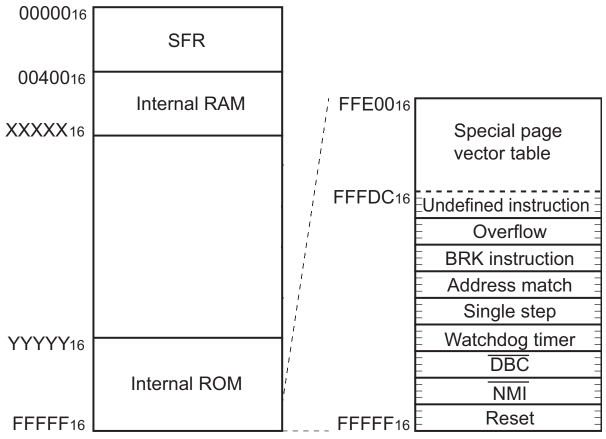
The fixed interrupt vector table is allocated to the addresses from $FFFDC_{16}$ to $FFFFF_{16}$. Therefore, store the start address of each interrupt routine here.

The internal RAM is allocated in an upper address direction beginning with address 00400_{16}. An internal RAM of M306H7MC-XXXFP, for instance, is allocated to the addresses from 00400_{16} to $017FF_{16}$. In addition to storing data, the internal RAM also stores the stack used when calling subroutines and when interrupts are generated.

SFR is allocated to the addresses from 00000_{16} to $003FF_{16}$. Peripheral function control registers are located here. Of SFR, any area which has no functions allocated is reserved for future use and cannot be used by users.

The special page vector table is allocated to the addresses from $FFE00_{16}$ to $FFFDB_{16}$. This vector is used by the JMPS or JSRS instruction. For details, refer to the “M16C/60 and M16C/20 Series Software Manual.”

In memory expansion and microprocessor modes, some areas are reserved for future use and cannot be used by users.

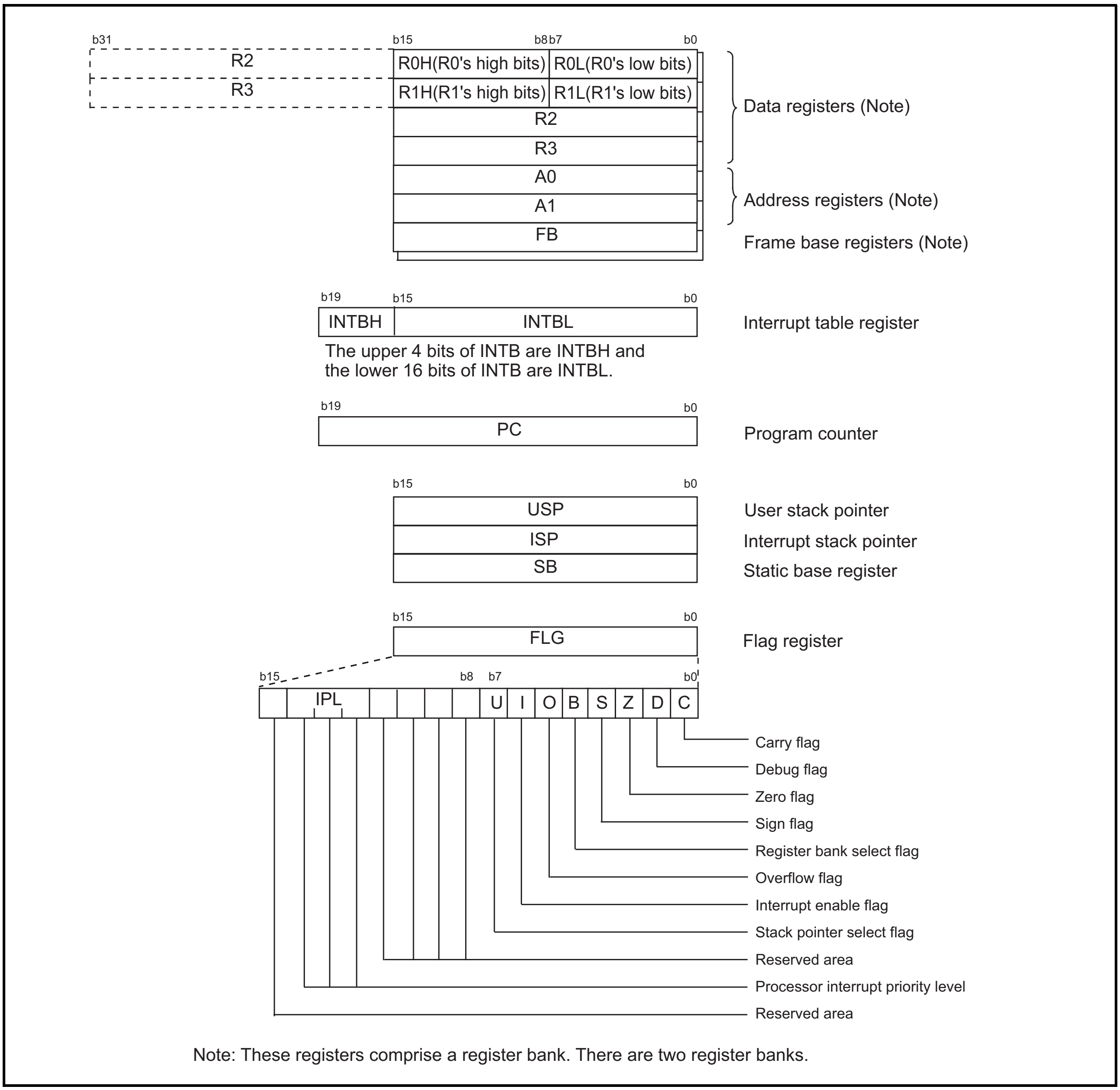


Internal RAM		Internal ROM	
Size	Address $XXXXX_{16}$	Size	Address $YYYYY_{16}$
5K bytes	$17FF_{16}$	128K bytes	$E0000_{16}$
8K bytes	$23FF_{16}$	256K bytes	$C0000_{16}$

Figure 1.4 Memory Map

2. Central Processing Unit (CPU)

Figure 2.1 shows the CPU registers. The CPU has 13 registers. Of these, R0, R1, R2, R3, A0, A1 and FB comprise a register bank. There are two register banks.



Note: These registers comprise a register bank. There are two register banks.

Figure 2.1 CPU registers

2.1 Data Registers (R0, R1, R2 and R3)

The R0 register consists of 16 bits, and is used mainly for transfers and arithmetic/logic operations. R1 to R3 are the same as R0.
The R0 register can be separated between high (R0H) and low (R0L) for use as two 8-bit data registers.
R1H and R1L are the same as R0H and R0L. Conversely, R2 and R0 can be combined for use as a 32- bit data register (R2R0). R3R1 is the same as R2R0.

2.2 Address Registers (A0 and A1)

The register A0 consists of 16 bits, and is used for address register indirect addressing and address register relative addressing. They also are used for transfers and logic/logic operations. A1 is the same as A0.
In some instructions, registers A1 and A0 can be combined for use as a 32-bit address register (A1A0).

2.3 Frame Base Register (FB)

FB is configured with 16 bits, and is used for FB relative addressing.

2.4 Interrupt Table Register (INTB)

INTB is configured with 20 bits, indicating the start address of an interrupt vector table.

2.5 Program Counter (PC)

PC is configured with 20 bits, indicating the address of an instruction to be executed.

2.6 User Stack Pointer (USP) and Interrupt Stack Pointer (ISP)

Stack pointer (SP) comes in two types: USP and ISP, each configured with 16 bits.
Your desired type of stack pointer (USP or ISP) can be selected by the U flag of FLG.

2.7 Static Base Register (SB)

SB is configured with 16 bits, and is used for SB relative addressing.

2.8 Flag Register (FLG)

FLG consists of 11 bits, indicating the CPU status.

- Carry Flag (C Flag)
  This flag retains a carry, borrow, or shift-out bit that has occurred in the arithmetic/logic unit.
- Debug Flag (D Flag)
  The D flag is used exclusively for debugging purpose. During normal use, it must be set to “0”.
- Zero Flag (Z Flag)
  This flag is set to “1” when an arithmetic operation resulted in 0; otherwise, it is “0”.
- Sign Flag (S Flag)
  This flag is set to “1” when an arithmetic operation resulted in a negative value; otherwise, it is “0”.
- Register Bank Select Flag (B Flag)
  Register bank 0 is selected when this flag is “0” ; register bank 1 is selected when this flag is “1”.
- Overflow Flag (O Flag)
  This flag is set to “1” when the operation resulted in an overflow; otherwise, it is “0”.
- Interrupt Enable Flag (I Flag)
  This flag enables a maskable interrupt.
  Maskable interrupts are disabled when the I flag is “0”, and are enabled when the I flag is “1”. The I flag is cleared to “0” when the interrupt request is accepted.
- Stack Pointer Select Flag (U Flag)
  ISP is selected when the U flag is “0”; USP is selected when the U flag is “1”.
  The U flag is cleared to “0” when a hardware interrupt request is accepted or an INT instruction for software interrupt Nos. 0 to 31 is executed.
- Processor Interrupt Priority Level (IPL)
  IPL is configured with three bits, for specification of up to eight processor interrupt priority levels from level 0 to level 7.
  If a requested interrupt has priority greater than IPL, the interrupt is enabled.
- Reserved Area
  When write to this bit, write "0". When read, its content is indeterminate.

3. Reset

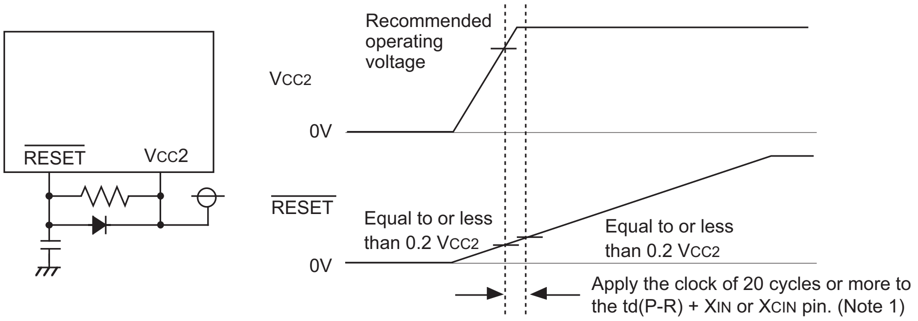
There are three types of resets: a hardware reset, a software reset, and a watchdog timer reset.

3.1 Hardware Reset

A reset is applied using the $\overline{\text{RESET}}$ pin. When an “L” signal is applied to the $\overline{\text{RESET}}$ pin while the power supply voltage is within the recommended operating condition, the pins are initialized (see Table 3.1).
The oscillation circuit is initialized and the main clock starts oscillating. When the input level at the $\overline{\text{RESET}}$ pin is released from “L” to “H”, the CPU and SFR are initialized, and the program is executed starting from the address indicated by the reset vector. The internal RAM is not initialized. If the $\overline{\text{RESET}}$ pin is pulled “L” while writing to the internal RAM, the internal RAM becomes indeterminate.
Figure 3.1 shows the example reset circuit. Figure 3.2 shows the reset sequence. Table 3.1 shows the statuses of the other pins while the $\overline{\text{RESET}}$ pin is “L”. Figure 3.3 shows the CPU register status after reset.
Refer to “SFR” for SFR status after reset.

1. When the power supply is stable
   - When STARTB pin = “L”
     (1) Apply an “L” signal to the $\overline{\text{RESET}}$ pin.
     (2) Apply a clock for 20 cycles or more to the XIN pin.
     (3) Apply an “H” signal to the $\overline{\text{RESET}}$ pin.
   - When STARTB pin = “H”
     (1) Apply an “L” signal to the $\overline{\text{RESET}}$ pin.
     (2) Apply a clock for 20 cycles or more to the XCIN pin.
     (3) Apply an “H” signal to the $\overline{\text{RESET}}$ pin.

2. Power on
   - When STARTB pin = “L”
     (1) Apply an “L” signal to the $\overline{\text{RESET}}$ pin.
     (2) Let the power supply voltage increase until it meets the recommended operating condition.
     (3) Wait td(P-R) or more until the internal power supply is stabilized.
     (4) Apply a clock for 20 cycles or more to the XIN pin.
     (5) Apply an “H” signal to the $\overline{\text{RESET}}$ pin.
   - When STARTB pin = “H”
     (1) Apply an “L” signal to the $\overline{\text{RESET}}$ pin.
     (2) Let the power supply voltage increase until it meets the recommended operating condition.
     (3) Wait td(P-R) or more until the internal power supply is stabilized.
     (4) Apply a clock for 20 cycles or more to the XCIN pin.
     (5) Apply an “H” signal to the $\overline{\text{RESET}}$ pin.



Notes 1: When the STARTB pin=L, apply the clock of 20 cycles or more to the XIN pin.
When the STARTB pin=H, apply the clock of 20 cycles or more to the XCIN pin.
Notes 2: If VCC1 ≤ VCC2, the VCC1 voltage must be lower than that of VCC2 when the power is being turned on or off.

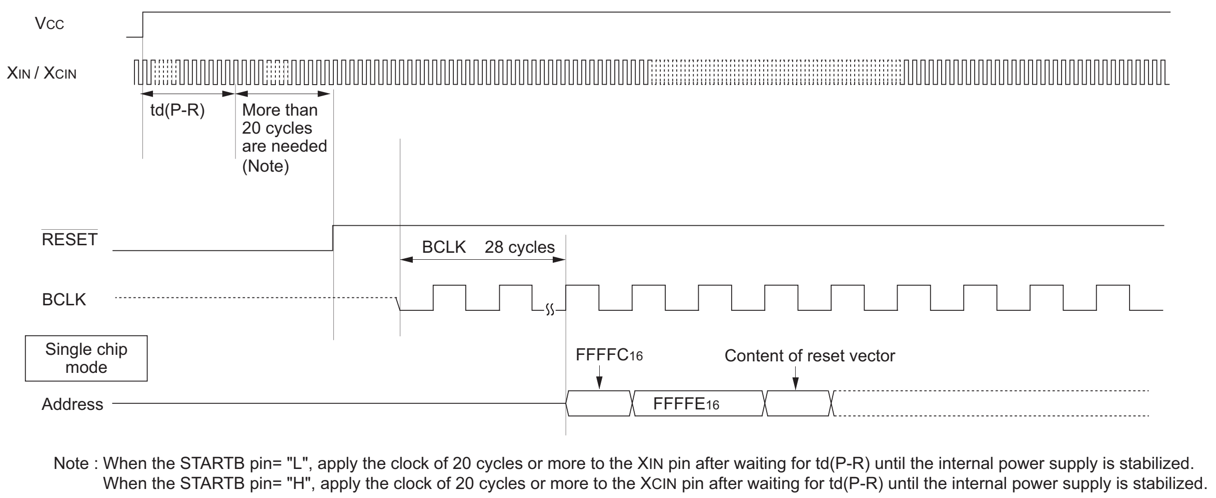
Figure 3.1 Example Reset Circuit

3.2 Software Reset

When the PM03 bit in the PM0 register is set to “1” (microcomputer reset), the microcomputer has its pins, CPU, and SFR initialized. Then the program is executed starting from the address indicated by the reset vector. Select the main clock for the CPU clock source, and set the PM03 bit to “1” with main clock oscillation satisfactorily stable.
At software reset, some SFR’s are not initialized. Refer to “SFR”. Also, since the PM01 to PM00 bits in the PM0 register are not initialized, the processor mode remains unchanged.

3.3 Watchdog Timer Reset

Where the PM12 bit in the PM1 register is “1” (reset when watchdog timer underflows), the microcomputer initializes its pins, CPU and SFR if the watchdog timer underflows. Then the program is executed starting from the address indicated by the reset vector.
At watchdog timer reset, some SFR’s are not initialized. Refer to “SFR”. Also, since the PM01 to PM00 bits in the PM0 register are not initialized, the processor mode remains unchanged.



Note : When the STARTB pin= "L", apply the clock of 20 cycles or more to the XIN pin after waiting for td(P-R) until the internal power supply is stabilized.
When the STARTB pin= "H", apply the clock of 20 cycles or more to the XCIN pin after waiting for td(P-R) until the internal power supply is stabilized.

Figure 3.2 Reset Sequence

Table 3.1 Pin Status When RESET Pin Level is “L

Pin name	Status		
	CNVss = Vss	CNVss = Vcc (Note)	
		BYTE = Vss	BYTE = Vcc
P0	Input port	Data input	Data input
P1	Input port	Data input	Input port
P2, P3, P4$_0$ to P4$_3$	Input port	Address output (undefined)	Address output (undefined)
P4$_4$	Input port	$\overline{\text{CS0}}$ output ("H" is output)	$\overline{\text{CS0}}$ output ("H" is output)
P4$_5$ to P4$_7$	Input port	Input port (Pulled high)	Input port (Pulled high)
P5$_0$	Input port	$\overline{\text{WR}}$ output ("H" is output)	$\overline{\text{WR}}$ output ("H" is output)
P5$_1$	Input port	$\overline{\text{BHE}}$ output (undefined)	$\overline{\text{BHE}}$ output (undefined)
P5$_2$	Input port	$\overline{\text{RD}}$ output ("H" is output)	$\overline{\text{RD}}$ output ("H" is output)
P5$_3$	Input port	BCLK output	BCLK output
P5$_4$	Input port	$\overline{\text{HLDA}}$ output (The output value depends on the input to the $\overline{\text{HOLD}}$ pin)	$\overline{\text{HLDA}}$ output (The output value depends on the input to the $\overline{\text{HOLD}}$ pin)
P5$_5$	Input port	$\overline{\text{HOLD}}$ input	$\overline{\text{HOLD}}$ input
P5$_6$	Input port	ALE output ("L" is output)	ALE output ("L" is output)
P5$_7$	Input port	$\overline{\text{RDY}}$ input	$\overline{\text{RDY}}$ input
P6, P7, P8$_0$ to P8$_4$, P8$_6$, P8$_7$, P9	Input port	Input port	Input port

Note : Do not set CNVss=Vcc for this product.

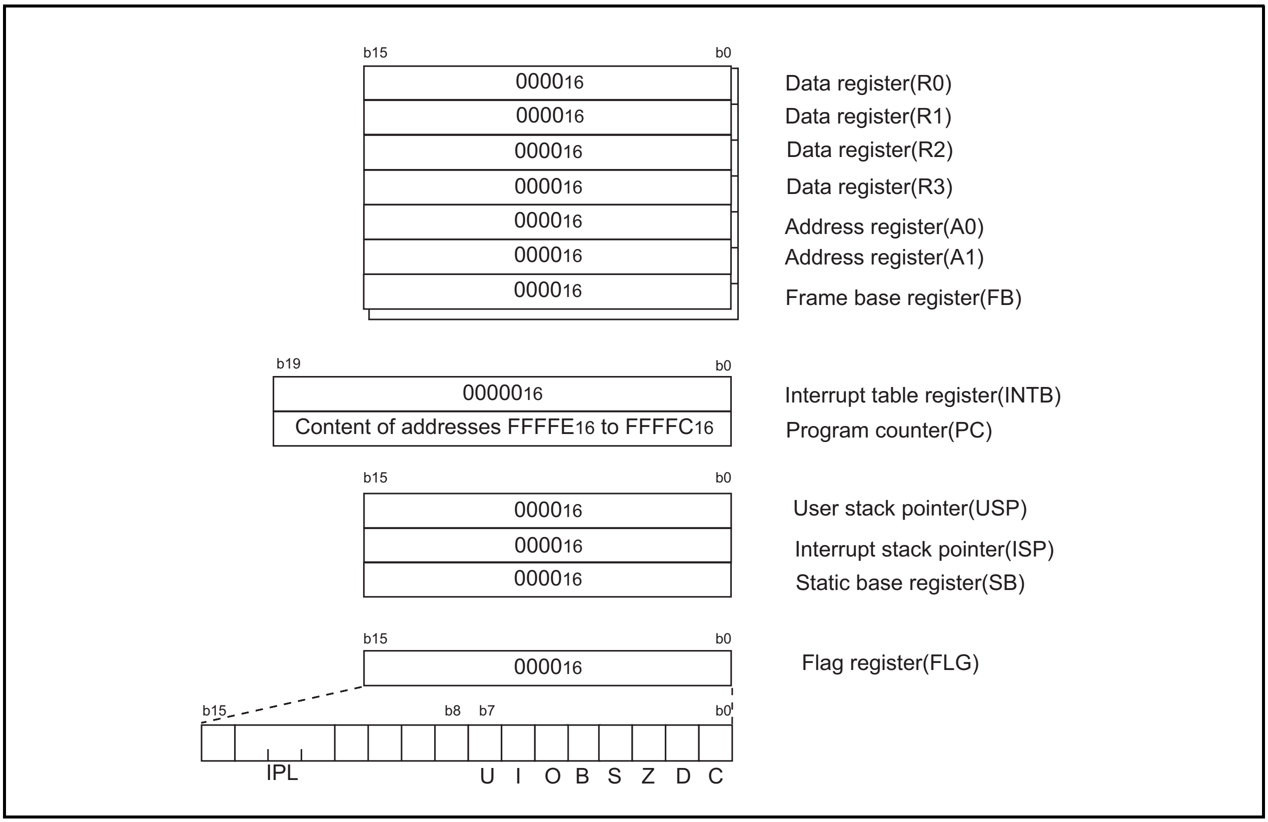


Figure 3.3 CPU Register Status After Reset

3.4 SFR

Address	Register (Note 1)	Symbol	After reset
0000_{16}			
0001_{16}			
0002_{16}			
0003_{16}			
0004_{16}	Processor mode register 0 (Note 2)	PM0	00000000_2
0005_{16}	Processor mode register 1	PM1	00001000_2
0006_{16}	System clock control register 0	CM0	01001000_2(the STARTB pin is "L") 01111000_2(the STARTB pin is "H")
0007_{16}	System clock control register 1	CM1	00100000_2
0008_{16}			
0009_{16}	Address match interrupt enable register	AIER	$XXXXXX00_2$
$000A_{16}$	Protect register	PRCR	$XX000000_2$
$000B_{16}$			
$000C_{16}$			
$000D_{16}$			
$000E_{16}$	Watchdog timer start register	WDTS	XX_{16}
$000F_{16}$	Watchdog timer control register	WDC	$00XXXXXX_2$(Note 3)
0010_{16}	Address match interrupt register 0	RMAD0	00_{16}
0011_{16}			00_{16}
0012_{16}			$X0_{16}$
0013_{16}			
0014_{16}	Address match interrupt register 1	RMAD1	00_{16}
0015_{16}			00_{16}
0016_{16}			$X0_{16}$
0017_{16}			
0018_{16}			
0019_{16}			
$001A_{16}$			
$001B_{16}$			
$001C_{16}$			
$001D_{16}$			
$001E_{16}$	Processor mode register 2	PM2	$XXX00000_2$
$001F_{16}$			
0020_{16}	DMA0 source pointer	SAR0	XX_{16}
0021_{16}			XX_{16}
0022_{16}			XX_{16}
0023_{16}			
0024_{16}	DMA0 destination pointer	DAR0	XX_{16}
0025_{16}			XX_{16}
0026_{16}			XX_{16}
0027_{16}			
0028_{16}	DMA0 transfer counter	TCR0	XX_{16}
0029_{16}			XX_{16}
$002A_{16}$			
$002B_{16}$			
$002C_{16}$	DMA0 control register	DM0CON	$00000X00_2$
$002D_{16}$			
$002E_{16}$			
$002F_{16}$			
0030_{16}	DMA1 source pointer	SAR1	XX_{16}
0031_{16}			XX_{16}
0032_{16}			XX_{16}
0033_{16}			
0034_{16}	DMA1 destination pointer	DAR1	XX_{16}
0035_{16}			XX_{16}
0036_{16}			XX_{16}
0037_{16}			
0038_{16}	DMA1 transfer counter	TCR1	XX_{16}
0039_{16}			XX_{16}
$003A_{16}$			
$003B_{16}$			
$003C_{16}$	DMA1 control register	DM1CON	$00000X00_2$
$003D_{16}$			
$003E_{16}$			
$003F_{16}$			

Note 1: The blank areas are reserved and cannot be accessed by users.
Note 2: The PM00 and PM01 bits do not change at software reset, watchdog timer reset and oscillation stop detection reset.
Note 3: The WDC5 bit is "0" (cold start) immediately after power-on. It can only be set to "1" in a program.

X : Undefined

Address	Register	Symbol	After reset
0040_{16}			
0041_{16}			
0042_{16}			
0043_{16}			
0044_{16}	INT3 interrupt control register	INT3IC	$XX00X000_2$
0045_{16}	Timer B5/SLICE ON interrupt control register	TB5IC	$XXXXX000_2$
0046_{16}	Timer B4/Remote control interrupt control register, UART1 BUS collision detection interrupt control register	TB4IC, U1BCNIC	$XXXXX000_2$
0047_{16}	Timer B3/HINT interrupt control register, UART0 BUS collision detection interrupt control register	TB3IC, U0BCNIC	$XXXXX000_2$
0048_{16}	SI/O4 interrupt control register, INT5 interrupt control register	S4IC, INT5IC	$XX00X000_2$
0049_{16}	SI/O3 interrupt control register, INT4 interrupt control register	S3IC, INT4IC	$XX00X000_2$
$004A_{16}$	UART2 Bus collision detection interrupt control register	BCNIC	$XXXXX000_2$
$004B_{16}$	DMA0 interrupt control register	DM0IC	$XXXXX000_2$
$004C_{16}$	DMA1 interrupt control register	DM1IC	$XXXXX000_2$
$004D_{16}$			
$004E_{16}$	A/D conversion interrupt control register	ADIC	$XXXXX000_2$
$004F_{16}$	UART2 transmit interrupt control register	S2TIC	$XXXXX000_2$
0050_{16}	UART2 receive interrupt control register	S2RIC	$XXXXX000_2$
0051_{16}	UART0 transmit interrupt control register	S0TIC	$XXXXX000_2$
0052_{16}	UART0 receive interrupt control register	S0RIC	$XXXXX000_2$
0053_{16}	UART1 transmit interrupt control register	S1TIC	$XXXXX000_2$
0054_{16}	UART1 receive interrupt control register	S1RIC	$XXXXX000_2$
0055_{16}	Timer A0 interrupt control register	TA0IC	$XXXXX000_2$
0056_{16}	Timer A1 interrupt control register	TA1IC	$XXXXX000_2$
0057_{16}	Timer A2 interrupt control register	TA2IC	$XXXXX000_2$
0058_{16}	Timer A3 interrupt control register	TA3IC	$XXXXX000_2$
0059_{16}	Timer A4 interrupt control register	TA4IC	$XXXXX000_2$
$005A_{16}$	Timer B0 interrupt control register	TB0IC	$XXXXX000_2$
$005B_{16}$	Timer B1 interrupt control register	TB1IC	$XXXXX000_2$
$005C_{16}$	Timer B2/Clock timer interrupt control register	TB2IC	$XXXXX000_2$
$005D_{16}$	INT0 interrupt control register	INT0IC	$XX00X000_2$
$005E_{16}$	INT1 interrupt control register	INT1IC	$XX00X000_2$
$005F_{16}$	INT2 interrupt control register	INT2IC	$XX00X000_2$
0060_{16}			
0061_{16}			
0062_{16}			
0063_{16}			
0064_{16}			
0065_{16}			
0066_{16}			
0067_{16}			
0068_{16}			
0069_{16}			
$006A_{16}$			
$006B_{16}$			
$006C_{16}$			
$006D_{16}$			
$006E_{16}$			
$006F_{16}$			
0070_{16}			
0071_{16}			
0072_{16}			
0073_{16}			
0074_{16}			
0075_{16}			
0076_{16}			
0077_{16}			
0078_{16}			
0079_{16}			
$007A_{16}$			
$007B_{16}$			
$007C_{16}$			
$007D_{16}$			
$007E_{16}$			
$007F_{16}$			

Note :The blank areas are reserved and cannot be accessed by users.

X : Undefined

Address	Register	Symbol	After reset
0080_{16}			
0081_{16}			
0082_{16}			
0083_{16}			
0084_{16}			
0085_{16}			
0086_{16}			
≈			≈
$01B0_{16}$			
$01B1_{16}$			
$01B2_{16}$			
$01B3_{16}$			
$01B4_{16}$			
$01B5_{16}$	Flash memory control register 1 (Note 2)	FMR1	$0X00XX0X_2$
$01B6_{16}$			
$01B7_{16}$	Flash memory control register 0 (Note 2)	FMR0	$XX000001_2$
$01B8_{16}$	Address match interrupt register 2	RMAD2	00_{16}
$01B9_{16}$			00_{16}
$01BA_{16}$			$X0_{16}$
$01BB_{16}$	Address match interrupt enable register 2	AIER2	$XXXXXX00_2$
$01BC_{16}$	Address match interrupt register 3	RMAD3	00_{16}
$01BD_{16}$			00_{16}
$01BE_{16}$			$X0_{16}$
$01BF_{16}$			
≈			≈
0200_{16} 0201_{16}	Remote control transmission buffer register	RMTTMHL	00_{16} 00_{16}
≈			≈
$020E_{16}$ $020F_{16}$	Slice RAM address control register	SA	00_{16}
0210_{16} 0211_{16}	Slice RAM data control register	SD	00_{16}
0212_{16} 0213_{16}	Address control register for CRC registers	CA	00_{16}
0214_{16} 0215_{16}	Data control register for CRC registers	CD	00_{16}
0216_{16} 0217_{16}	Address control register for extended registers	DA	00_{16}
0218_{16} 0219_{16}	Data control register for extended registers	DD	00_{16}
$021A_{16}$ $021B_{16}$	Humming 8/4 register	HM8	00_{16}
$021C_{16}$ $021D_{16}$	Humming 24/18 register 0	HM0	00_{16}
$021E_{16}$ $021F_{16}$	Humming 24/18 register 1	HM1	00_{16}
0250_{16}			
≈			≈
0259_{16}			
$025A_{16}$			
$025B_{16}$			
$025C_{16}$			
$025D_{16}$			
$025E_{16}$	Peripheral clock select register	PCLKR	00000011_2
$025F_{16}$			
≈			≈
$02D6_{16}$	I^{2}C0 interrupt control register	EXTIICINT	00_{16}
$02D7_{16}$	Reserved register	EXTREG02D7	00_{16}
≈			
$02E0_{16}$	I^{2}C data shift register	IIC0S0	Undefined
$02E1_{16}$	I^{2}C address register	IIC0S0D	00_{16}
$02E2_{16}$	I^{2}C states register	IIC0S1	$0001000?_2$
$02E3_{16}$	I^{2}C control register	IIC0S1D	00_{16}
$02E4_{16}$	I^{2}C clock control register	IIC0S2	00_{16}
$02E5_{16}$	Reserved register	REVREG02E5	$00?00000_2$
$02E6_{16}$	I^{2}C transmit buffer register	IIC0S0S	Undefined
≈			
0330_{16}			
0331_{16}			
0332_{16}			
0333_{16}			

Note 1: The blank areas are reserved and cannot be accessed by users.
Note 2: This register is included in the flash memory version.

X : Undefined

Address	Register	Symbol	After reset
0340_{16}	Timer B3, 4, 5 count start flag	TBSR	$000XXXXX_2$
0341_{16}			
0342_{16} 0343_{16}			
0344_{16} 0345_{16}			
0346_{16} 0347_{16}			
0348_{16}			
0349_{16}			
$034A_{16}$			
$034B_{16}$			
$034C_{16}$			
$034D_{16}$			
$034E_{16}$			
$034F_{16}$			
0350_{16} 0351_{16}	Timer B3 register	TB3	XX_{16} XX_{16}
0352_{16} 0353_{16}	Timer B4 register	TB4	XX_{16} XX_{16}
0354_{16} 0355_{16}	Timer B5 register	TB5	XX_{16} XX_{16}
0356_{16}			
0357_{16}			
0358_{16}			
0359_{16}			
$035A_{16}$			
$035B_{16}$	Timer B3 mode register	TB3MR	$00XX0000_2$
$035C_{16}$	Timer B4 mode register	TB4MR	$00XX0000_2$
$035D_{16}$	Timer B5 mode register	TB5MR	$00XX0000_2$
$035E_{16}$	Interrupt cause select register 2	IFSR2A	$00XXXXXX_2$
$035F_{16}$	Interrupt cause select register	IFSR	00_{16}
0360_{16}	SI/O3 transmit/receive register	S3TRR	XX_{16}
0361_{16}			
0362_{16}	SI/O3 control register	S3C	01000000_2
0363_{16}	SI/O3 bit rate generator register	S3BRG	XX_{16}
0364_{16}	SI/O4 transmit/receive register	S4TRR	XX_{16}
0365_{16}			
0366_{16}	SI/O4 control register	S4C	01000000_2
0367_{16}	SI/O4 bit rate generator register	S4BRG	XX_{16}
0368_{16}			
0369_{16}			
$036A_{16}$			
$036B_{16}$			
$036C_{16}$	UART0 special mode register 4	U0SMR4	00_{16}
$036D_{16}$	UART0 special mode register 3	U0SMR3	$000X0X0X_2$
$036E_{16}$	UART0 special mode register 2	U0SMR2	$X0000000_2$
$036F_{16}$	UART0 special mode register	U0SMR	$X0000000_2$
0370_{16}	UART1 special mode register 4	U1SMR4	00_{16}
0371_{16}	UART1 special mode register 3	U1SMR3	$000X0X0X_2$
0372_{16}	UART1 special mode register 2	U1SMR2	$X0000000_2$
0373_{16}	UART1 special mode register	U1SMR	$X0000000_2$
0374_{16}	UART2 special mode register 4	U2SMR4	00_{16}
0375_{16}	UART2 special mode register 3	U2SMR3	$000X0X0X_2$
0376_{16}	UART2 special mode register 2	U2SMR2	$X0000000_2$
0377_{16}	UART2 special mode register	U2SMR	$X0000000_2$
0378_{16}	UART2 transmit/receive mode register	U2MR	00_{16}
0379_{16}	UART2 bit rate generator	U2BRG	XX_{16}
$037A_{16}$ $037B_{16}$	UART2 transmit buffer register	U2TB	$XXXXXXXX_2$ $XXXXXXXX_2$
$037C_{16}$	UART2 transmit/receive control register 0	U2C0	00001000_2
$037D_{16}$	UART2 transmit/receive control register 1	U2C1	00000010_2
$037E_{16}$ $037F_{16}$	UART2 receive buffer register	U2RB	$XXXXXXXX_2$ $XXXXXXXX_2$

Note : The blank areas are reserved and cannot be accessed by users.
X : Undefined

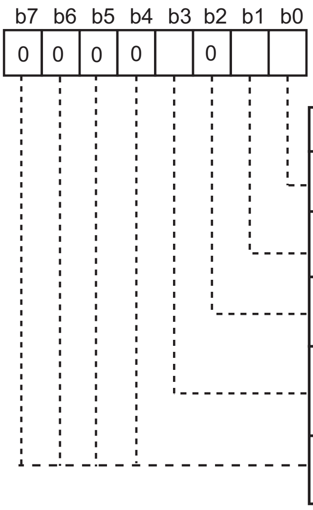
Address	Register	Symbol	After reset
0380_{16}	Count start flag	TABSR	00_{16}
0381_{16}	Clock prescaler reset flag	CPSRF	$0XXXXXXX_2$
0382_{16}	One-shot start flag	ONSF	00_{16}
0383_{16}	Trigger select register	TRGSR	00_{16}
0384_{16}	Up-down flag	UDF	00_{16}
0385_{16}			
0386_{16}	Timer A0 register	TA0	XX_{16}
0387_{16}			XX_{16}
0388_{16}	Timer A1 register	TA1	XX_{16}
0389_{16}			XX_{16}
$038A_{16}$	Timer A2 register	TA2	XX_{16}
$038B_{16}$			XX_{16}
$038C_{16}$	Timer A3 register	TA3	XX_{16}
$038D_{16}$			XX_{16}
$038E_{16}$	Timer A4 register	TA4	XX_{16}
$038F_{16}$			XX_{16}
0390_{16}	Timer B0 register	TB0	XX_{16}
0391_{16}			XX_{16}
0392_{16}	Timer B1 register	TB1	XX_{16}
0393_{16}			XX_{16}
0394_{16}	Timer B2 register	TB2	XX_{16}
0395_{16}			XX_{16}
0396_{16}	Timer A0 mode register	TA0MR	00_{16}
0397_{16}	Timer A1 mode register	TA1MR	00_{16}
0398_{16}	Timer A2 mode register	TA2MR	00_{16}
0399_{16}	Timer A3 mode register	TA3MR	00_{16}
$039A_{16}$	Timer A4 mode register	TA4MR	00_{16}
$039B_{16}$	Timer B0 mode register	TB0MR	$00XX0000_2$
$039C_{16}$	Timer B1 mode register	TB1MR	$00XX0000_2$
$039D_{16}$	Timer B2 mode register	TB2MR	$00XX0000_2$
$039E_{16}$			
$039F_{16}$			
$03A0_{16}$	UART0 transmit/receive mode register	U0MR	00_{16}
$03A1_{16}$	UART0 bit rate generator register	U0BRG	XX_{16}
$03A2_{16}$	UART0 transmit buffer register	U0TB	$XXXXXXXX_2$
$03A3_{16}$			$XXXXXXXX_2$
$03A4_{16}$	UART0 transmit/receive control register 0	U0C0	00001000_2
$03A5_{16}$	UART0 transmit/receive control register 1	U0C1	00000010_2
$03A6_{16}$	UART0 receive buffer register	U0RB	$XXXXXXXX_2$
$03A7_{16}$			$XXXXXXXX_2$
$03A8_{16}$	UART1 transmit/receive mode register	U1MR	00_{16}
$03A9_{16}$	UART1 bit rate generator	U1BRG	XX_{16}
$03AA_{16}$	UART1 transmit buffer register	U1TB	$XXXXXXXX_2$
$03AB_{16}$			$XXXXXXXX_2$
$03AC_{16}$	UART1 transmit/receive control register 0	U1C0	00001000_2
$03AD_{16}$	UART1 transmit/receive control register 1	U1C1	00000010_2
$03AE_{16}$	UART1 receive buffer register	U1RB	$XXXXXXXX_2$
$03AF_{16}$			$XXXXXXXX_2$
$03B0_{16}$	UART transmit/receive control register 2	UCON	$X0000000_2$
$03B1_{16}$			
$03B2_{16}$			
$03B3_{16}$			
$03B4_{16}$			
$03B5_{16}$			
$03B6_{16}$			
$03B7_{16}$			
$03B8_{16}$	DMA0 request cause select register	DM0SL	00_{16}
$03B9_{16}$			
$03BA_{16}$	DMA1 request cause select register	DM1SL	00_{16}
$03BB_{16}$			
$03BC_{16}$	CRC data register	CRCD	XX_{16}
$03BD_{16}$			XX_{16}
$03BE_{16}$	CRC input register	CRCIN	XX_{16}
$03BF_{16}$			

Note : The blank areas are reserved and cannot be accessed by users.
X : Undefined

Address	Register	Symbol	After reset
$03C0_{16}$	A/D register 0	AD0	$XXXXXXXX_2$
$03C1_{16}$			
$03C2_{16}$	A/D register 1	AD1	$XXXXXXXX_2$
$03C3_{16}$			
$03C4_{16}$	A/D register 2	AD2	$XXXXXXXX_2$
$03C5_{16}$			
$03C6_{16}$	A/D register 3	AD3	$XXXXXXXX_2$
$03C7_{16}$			
$03C8_{16}$	A/D register 4	AD4	$XXXXXXXX_2$
$03C9_{16}$			
$03CA_{16}$	A/D register 5	AD5	$XXXXXXXX_2$
$03CB_{16}$			
$03CC_{16}$	A/D register 6	AD6	$XXXXXXXX_2$
$03CD_{16}$			
$03CE_{16}$	A/D register 7	AD7	$XXXXXXXX_2$
$03CF_{16}$			
$03D0_{16}$			
$03D1_{16}$			
$03D2_{16}$			
$03D3_{16}$			
$03D4_{16}$	A/D control register 2	ADCON2	00_{16}
$03D5_{16}$			
$03D6_{16}$	A/D control register 0	ADCON0	$00000XXX_2$
$03D7_{16}$	A/D control register 1	ADCON1	00_{16}
$03D8_{16}$			
$03D9_{16}$			
$03DA_{16}$			
$03DB_{16}$			
$03DC_{16}$			
$03DD_{16}$			
$03DE_{16}$			
$03DF_{16}$			
$03E0_{16}$	Port P0 register	P0	XX_{16}
$03E1_{16}$	Port P1 register	P1	XX_{16}
$03E2_{16}$	Port P0 direction register	PD0	00_{16}
$03E3_{16}$	Port P1 direction register	PD1	00_{16}
$03E4_{16}$	Port P2 register	P2	XX_{16}
$03E5_{16}$	Port P3 register	P3	XX_{16}
$03E6_{16}$	Port P2 direction register	PD2	00_{16}
$03E7_{16}$	Port P3 direction register	PD3	00_{16}
$03E8_{16}$	Port P4 register	P4	XX_{16}
$03E9_{16}$	Port P5 register	P5	XX_{16}
$03EA_{16}$	Port P4 direction register	PD4	00_{16}
$03EB_{16}$	Port P5 direction register	PD5	00_{16}
$03EC_{16}$	Port P6 register	P6	XX_{16}
$03ED_{16}$	Port P7 register	P7	XX_{16}
$03EE_{16}$	Port P6 direction register	PD6	00_{16}
$03EF_{16}$	Port P7 direction register	PD7	00_{16}
$03F0_{16}$	Port P8 register	P8	XX_{16}
$03F1_{16}$	Port P9 register	P9	XX_{16}
$03F2_{16}$	Port P8 direction register	PD8	$00X00000_2$
$03F3_{16}$	Port P9 direction register	PD9	00_{16}
$03F4_{16}$	Port P10 register	P10	XX_{16}
$03F5_{16}$			
$03F6_{16}$			
$03F7_{16}$			
$03F8_{16}$			
$03F9_{16}$			
$03FA_{16}$			
$03FB_{16}$			
$03FC_{16}$	Pull-up control register 0	PUR0	00_{16}
$03FD_{16}$	Pull-up control register 1	PUR1	00000000_2
$03FE_{16}$	Pull-up control register 2	PUR2	00_{16}
$03FF_{16}$	Port control register	PCR	00_{16}

Note 1: The blank areas are reserved and cannot be accessed by users.

Processor mode register 0 (Note 1)



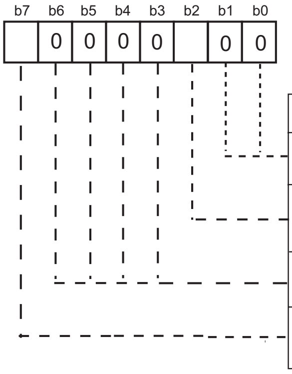
Symbol	Address	After reset
PM0	0004_{16}	00000000_2 (CNV$_{SS}$ pin = "L")

Bit symbol	Bit name	Function	RW
PM00	Processor mode bit	b1 b0 0 0: Single-chip mode 0 1: Memory expansion mode 1 0: Must not be set 1 1: Microprocessor mode	RW
PM01			RW
(b2)	Reserved bit	Must set to "0".	RW
PM03	Software reset bit	Setting this bit to “1” resets the microcomputer. When read, its content is "0".	RW
(b7-b4)	Reserved bits	Must set to "0".	RW

Note 1: Write to this register after setting the PRC1 bit in the PRCR register to "1" (write enable).

Figure 3.4 PM0 Register

Processor mode register 1 (Note 1)



Symbol	Address	After reset
PM1	0005_{16}	$0X001000_2$

Bit symbol	Bit name	Function	RW
— (b1-b0)	Reserved bit	Must set to "0".	RW
PM12	Watchdog timer function select bit	0 : Watchdog timer interrupt 1 : Watchdog timer reset (Note 2)	RW
— (b6-b3)	Reserved bit	Must set to "0".	RW
PM17	Wait bit (Note 3)	0 : No wait state 1 : With wait state (1 wait)	RW

Note 1: Write to this register after setting the PRC1 bit in the PRCR register to “1” (write enable).
Note 2: PM12 bit is set to “1” by writing a “1” in a program. (Writing a “0” has no effect.)
Note 3: When PM17 bit is set to “1” (with wait state), one wait state is inserted when accessing internal RAM or internal ROM.

Figure 3.5 PM1 Register

4. Clock Generation Circuit

The clock generation circuit contains two oscillator circuits as follows:

(1) Main clock oscillation circuit

(2) Sub clock oscillation circuit

Table 4.1 lists the clock generation circuit specifications. Figure 4.1 shows the clock generation circuit. Figures 4.2 to 4.4 show the clock-related registers.

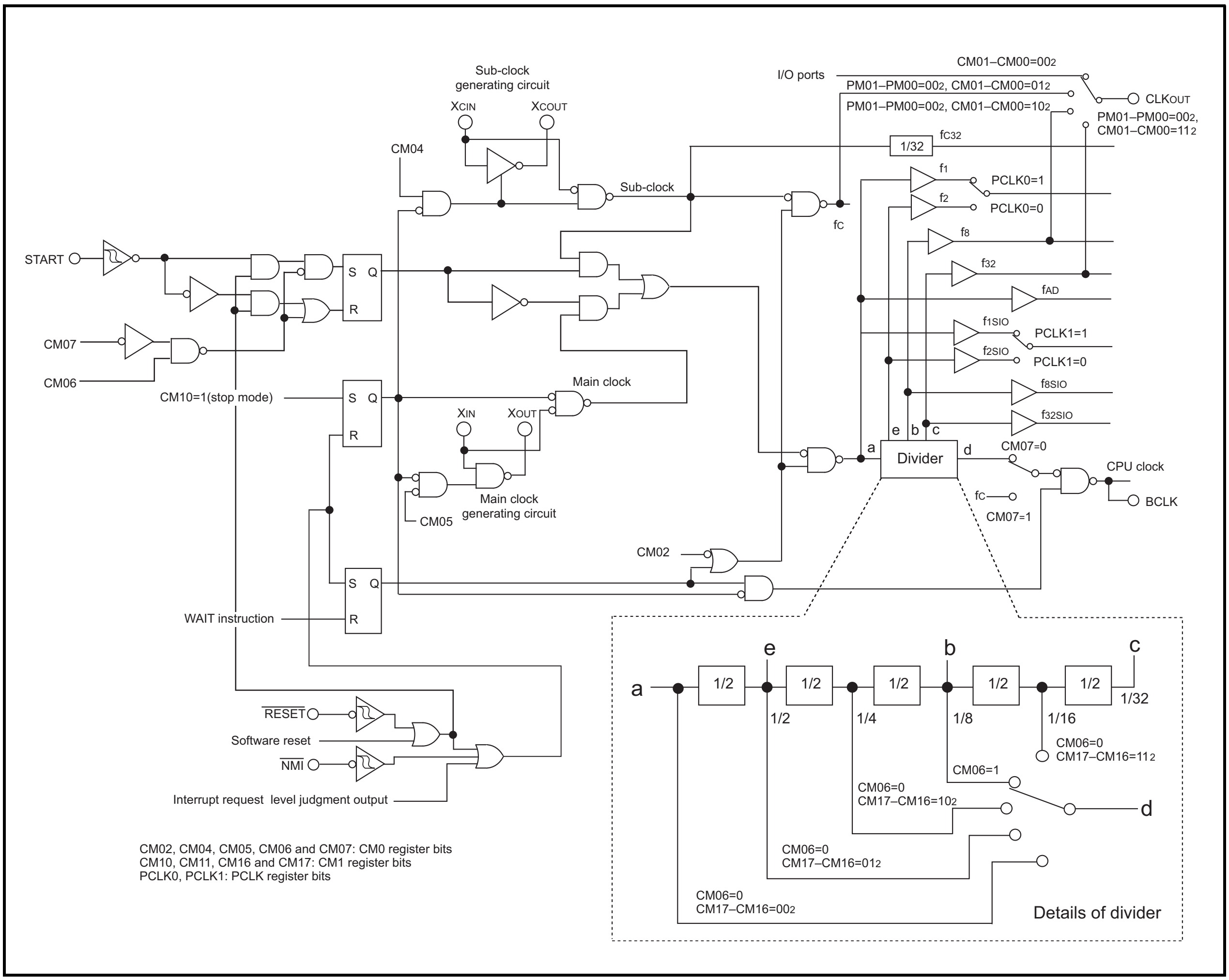
Table 4.1 CPU registers

Item	Main clock oscillation circuit	Sub clock oscillation circuit
Use of clock	• CPU clock source • Peripheral function clock source	•CPU clock source • Timer A, B's clock source
Clock frequency	0 to 16 MHz (Note 3)	32.768 kHz
Usable oscillator	• Ceramic oscillator • Crystal oscillator (Note 2)	• Crystal oscillator
Pins to connect oscillator	X_{IN}, X_{OUT}	X_{CIN}, X_{COUT}
Oscillation stop, restart function	Presence	Presence
Oscillator status after reset (Note1)	Oscillating	Stopped
Other	Externally derived clock can be input	

Note 1. The state that the STARTB pin is held "L" after reset is shown.
The state that the STARTB pin is held "H" after reset is following.
Main clock oscillation circuit: Stopped
Sub clock oscillation circuit: Oscillating

Note 2. If you use "14 Expansion Function (Data acquisition)", be sure to connect a crystal oscillator between the X_{IN} and X_{OUT} pins.

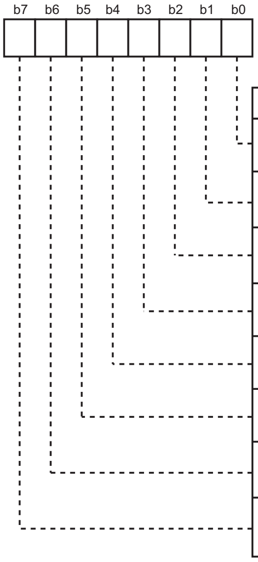
Note 3. If you use "14 Expansion Function (Data acquisition)", connect a crystal of 10MHz, 12MHz, 14MHz, or 16MHz.



CM02, CM04, CM05, CM06 and CM07: CM0 register bits
CM10, CM11, CM16 and CM17: CM1 register bits
PCLK0, PCLK1: PCLK register bits

Figure 4.1 Clock Generation Circuit

System clock control register 0 (Note 1)



Symbol CM0

Address 0006_{16}

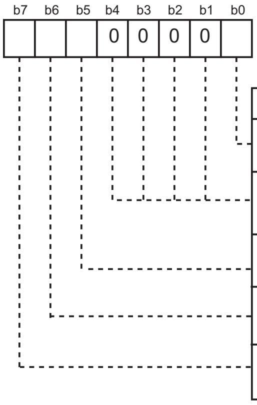
After reset (Note 14)
01111000_2 (STARTB pin = Vcc)
01001000_2 (STARTB pin = Vss)

Bit symbol	Bit name	Function	RW
CM00	Clock output function select bit (Valid only in single-chip mode)	b1 b0 0 0 : I/O port P5_7 0 1 : f_C output 1 0 : f_8 output 1 1 : f_{32} output	RW
CM01			RW
CM02	WAIT peripheral function clock stop bit (Note 10)	0 : Do not stop peripheral function clock in wait mode 1 : Stop peripheral function clock in wait mode (Note 8)	RW
CM03	XCIN-XCOUT drive capacity select bit (Note 2)	0 : LOW 1 : HIGH	RW
CM04	Port XC select bit (Note 2)	0 : I/O port P8_6, P8_7 1 : XCIN-XCOUT generation function(Note 9)	RW
CM05	Main clock stop bit (Notes 3, 10, 12, 13)	0 : On 1 : Off (Note 4, Note5)	RW
CM06	Main clock division select bit 0 (Notes 7, 13)	0 : CM16 and CM17 valid 1 : Division by 8 mode	RW
CM07	System clock select bit (Notes 6, 10, 11, 12)	0 : Main clock 1 : Sub-clock	RW

Note 1: Write to this register after setting the PRC0 bit of PRCR register to “1” (write enable).
Note 2: The CM03 bit is set to “1” (high) when the CM04 bit is set to “0” (I/O port) or the microcomputer goes to a stop mode.
Note 3: This bit is provided to stop the main clock when the low power dissipation mode is selected. This bit cannot be used for detection as to whether the main clock stopped or not. To stop the main clock, the following setting is required:
(1) Set the CM07 bit to “1” (Sub-clock select) with the sub-clock stably oscillating.
(2) Set the CM05 bit to “1” (Stop).
Note 4: During external clock input, only the clock oscillation buffer is turned off and clock input is accepted if the sub clock is not chosen as a CPU clock.
Note 5: When CM05 bit is set to “1, the XOUT pin goes “H”. Furthermore, because the internal feedback resistor remains connected, the XIN pin is pulled “H” to the same level as XOUT via the feedback resistor.
Note 6: After setting the CM04 bit to “1” (XCIN-XCOUT oscillator function), wait until the sub-clock oscillates stably before switching the CM07 bit from “0” to “1” (sub-clock).
Note 7: When entering stop mode from high or middle speed mode, the CM06 bit is set to “1” (divide-by-8 mode).
Note 8: The f_{C32} clock does not stop. During low speed or low power dissipation mode, do not set this bit to “1” (peripheral clock turned off when in wait mode).
Note 9: To use a sub-clock, set this bit to “1”. Also make sure ports P8_6 and P8_7 are directed for input, with no pull-ups.
Note 10: When the PM21 bit of PM2 register is set to “1” (clock modification disable), writing to the CM02, CM05, and CM07 bits has no effect.
Note 11: If the PM21 bit needs to be set to “1”, set the CM07 bit to “0”(main clock) before setting it.
Note 12: To use the main clock as the clock source for the CPU clock, follow the procedure below.
(1) Set the CM05 bit to “0” (oscillate).
(2) Wait until td(M-L) elapses or the main clock oscillation stabilizes, whichever is longer.
(3) Set the CM07 bit all to “0”.
Note 13: When the CM05 bit is set to “1” (main clock turned off), the CM06 bit is fixed to “1” (divide-by-8 mode) and the CM15 bit is fixed to “1” (drive capability high).
Note 14: Keep in mind that the values after reset differ by the input voltage at the STARTB pin.

Figure 4.2 CM0 Register

System clock control register 1 (Note 1)



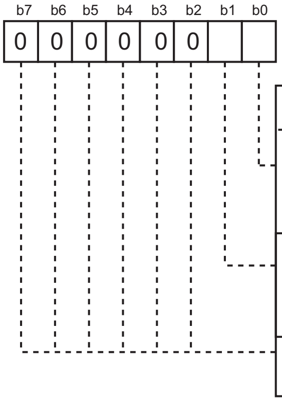
Symbol	Address	After reset
CM1	0007$_{16}$	00100000$_2$

Bit symbol	Bit	Function	RW
CM10	All clock stop control bit (Notes 4, 5)	0 : Clock on 1 : All clocks off (stop mode)	RW
—— (b4-b1)	Reserved bit	Must set to “0”	RW
CM15	XIN-XOUT drive capacity select bit (Note 2)	0 : LOW 1 : HIGH	RW
CM16	Main clock division select bit 1 (Note 3)	b7 b6 0 0 : No division mode 0 1 : Division by 2 mode 1 0 : Division by 4 mode 1 1 : Division by 16 mode	RW
CM17			RW

Note 1: Write to this register after setting the PRC0 bit of PRCR register to “1” (write enable).
Note 2: When entering stop mode from high or middle speed mode, or when the CM05 bit is set to “1” (main clock turned off) in low speed mode, the CM15 bit is set to “1” (drive capability high).
Note 3: Effective when the CM06 bit is “0” (CM16 and CM17 bits enable).
Note 4: If the CM10 bit is “1” (stop mode), XOUT goes “H” and the internal feedback resistor is disconnected. The XCIN and XCOUT pins are placed in the high-impedance state.
Note 5: When the PM21 bit of PM2 register is set to “1” (clock modification disable), writing to the CM10 bits has no effect.

Figure 4.3 CM1 Register

Peripheral clock select register (Note)

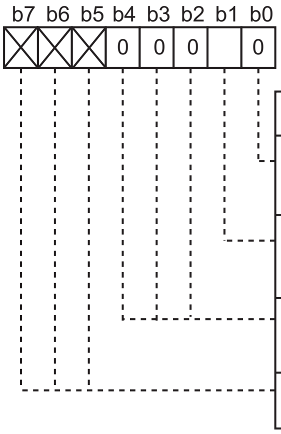


Symbol	Address	When reset
PCLKR	025E$_{16}$	00000011$_2$

Bit symbol	Bit name	Function	RW
PCLK0	Timers A, B clock select bit (Clock source for the timers A and B	0 : f_2 1 : f_1	RW
PCLK1	SI/O clock select bit (Clock source for UART0 to UART2, SI/O3, SI/O4)	0 : f_{2SIO} 1 : f_{1SIO}	RW
— (b7-b2)	Reserved bit	Must set to “0”	RW

Note: Write to this register after setting the PRC0 bit of PRCR register to “1” (write enable).

Processor mode register 2 (Note 1)



Symbol	Address	After reset
PM2	001E$_{16}$	XXX00000$_2$

Bit symbol	Bit name	Function	RW
— (b0)	Reserved bit	Must set to “0”	RW
PM21	System clock protective bit (Note 2, Note 3)	0 : Clock is protected by PRCR register 1 : Clock modification disabled	RW
— (b4-b2)	Reserved bit	Must set to “0”	RW
— (b7-b5)	Nothing is assigned. When write, set to “0”. When read, its content is indeterminate.		—

Note 1: Write to this register after setting the PRC1 bit of PRCR register to “1” (write enable).
Note 2: Once this bit is set to “1”, it cannot be cleared to “0” in a program.
Note 3: If the PM21 bit is set to “1,” writing to the following bits has no effect.
CM02 bit of CM0 register
CM05 bit of CM0 register (main clock is not halted)
CM07 bit of CM0 register (CPU clock source does not change)
CM10 bit of CM1 register (stop mode is not entered)

Figure 4.4 PCLKR Register and PM2 Register

4.1 Oscillator Circuit

The following describes the clocks generated by the clock generation circuit.
Two oscillation circuits are built in the clock generating circuit, and a main clock or a sub clock can be chosen as a CPU clock by setup of the STARTB pin after reset.

4.1.1 Main Clock

This clock is used as the clock source for the CPU and peripheral function clocks. The main clock oscillator circuit is configured by connecting a resonator between the XIN and XOUT pins. The main clock oscillator circuit contains a feedback resistor, which is disconnected from the oscillator circuit during stop mode in order to reduce the amount of power consumed in the chip. The main clock oscillator circuit may also be configured by feeding an externally generated clock to the XIN pin. Figure 4.5 shows the examples of main clock connection circuit.
When the level on the STARTB pin is "L", the main clock divided by 8 is selected for the CPU clock (Sub clock turned off) after reset.
The power consumption in the chip can be reduced by setting the CM05 bit of CM0 register to "1" (main clock oscillator circuit turned off) after switching the clock source for the CPU clock to a sub clock. In this case, XOUT goes "H". Furthermore, because the internal feedback resistor remains on, XIN is pulled "H" to XOUT via the feedback resistor. Note that if an externally generated clock is fed into the XIN pin, the main clock cannot be turned off by setting the CM05 bit to "1" without selecting sub clock for the CPU clock. If necessary, use an external circuit to turn off the clock.
During stop mode, all clocks including the main clock are turned off. Refer to "power control".

Note: Insert a damping resistor if required. The resistance will vary depending on the oscillator and the oscillation drive capacity setting. Use the value recommended by the maker of the oscillator.
When the oscillation drive capacity is set to low, check that oscillation is stable. Also, if the oscillator manufacturer's data sheet specifies that a feedback resistor be added external to the chip, insert a feedback resistor between XIN and XOUT following the instruction.

Figure 4.5 Examples of Main Clock Connection Circuit

4.1.2 Sub Clock

The sub clock is generated by the sub clock oscillation circuit. This clock is used as the clock source for the CPU clock, as well as the timer A and timer B count sources. In addition, an fc clock with the same frequency as that of the sub clock can be output from the CLKOUT pin.

The sub clock oscillator circuit is configured by connecting a crystal resonator between the XCIN and XCOUT pins. The sub clock oscillator circuit contains a feedback resistor, which is disconnected from the oscillator circuit during stop mode in order to reduce the amount of power consumed in the chip. The sub clock oscillator circuit may also be configured by feeding an externally generated clock to the XCIN pin.

Figure 4.6 shows the examples of sub clock connection circuit.

When the level on the STARTB pin is “L ”, the sub clock is turned off after reset. At this time, the feedback resistor is disconnected from the oscillator circuit.

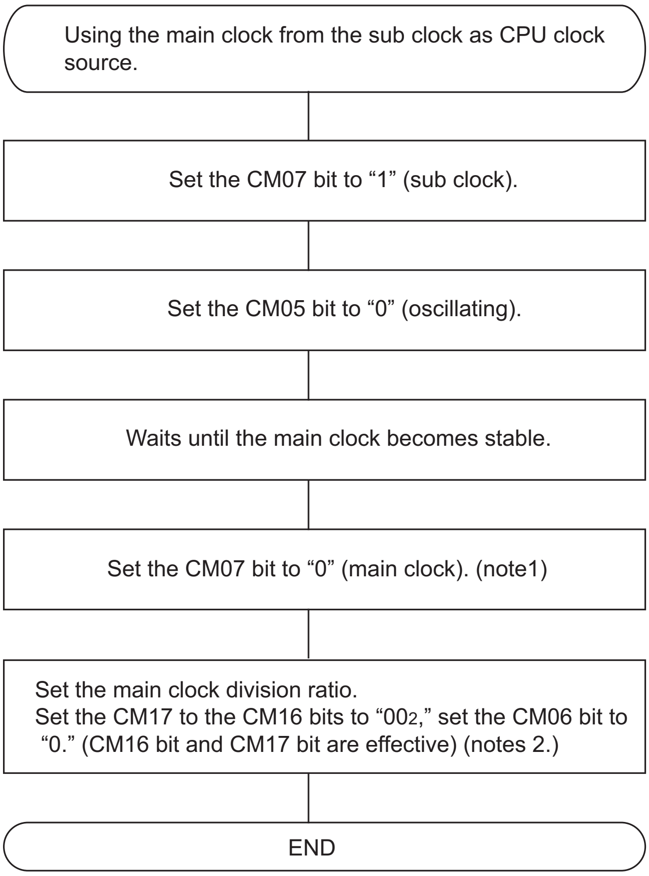
To use the sub clock for the CPU clock, set the CM07 bit of CM0 register to “1 ” (sub clock) after the sub clock becomes oscillating stably.

When a STARTB pin is “H ”, the sub clock (XCIN) divided by 8 becomes the CPU clock after reset (the main clock stops). When you use a main clock after this, please shift according to the procedure shown in Fig. 4.7.

During stop mode, all clocks including the sub clock are turned off. Refer to “power control”.

Note: Insert a damping resistor if required. The resistance will vary depending on the oscillator and the oscillation drive capacity setting. Use the value recommended by the maker of the oscillator.
When the oscillation drive capacity is set to low, check that oscillation is stable. Also, if the oscillator manufacturer's data sheet specifies that a feedback resistor be added external to the chip, insert a feedback resistor between XCIN and XCOUT following the instruction.

Figure 4.6 Examples of Sub Clock Connection Circuit



Note 1: Change After the oscillation of the main clock becomes stable enough.
Note 2: Setting No division of the main clock is shown.
Change CM06 after changing CM17 and CM16.

Figure 4.7 Procedure to Use the Main Clock from the Sub Clock as CPU Clock Source

4.2 CPU Clock and Peripheral Function Clock

Two type clocks: CPU clock to operate the CPU and peripheral function clocks to operate the peripheral functions.

4.2.1 CPU Clock and BCLK

These are operating clocks for the CPU and watchdog timer.

The clock source for the CPU clock can be chosen to be the main clock or sub clock.

If the main clock is selected as the clock source for the CPU clock, the selected clock source can be divided by 1 (undivided), 2, 4, 8 or 16 to produce the CPU clock. Use the CM06 bit in CM0 register and the CM17 to CM16 bits in CM1 register to select the divide-by-n value.

When the level on the STARTB pin is “H”, the main clock divided by 8 provides the CPU clock after reset.

When the level on the STARTB pin is “L”, the sub clock of frequency divided by 8 provides the CPU clock after reset.

At this time, the CM04 bit and the CM05 bit of CM0 register become “1” .

Note that when entering stop mode from high or middle speed mode, or when the CM05 bit of CM0 register is set to “1” (main clock turned off) in low-speed mode, the CM06 bit of CM0 register is set to “1” (divide-by-8 mode).

4.2.2 Peripheral Function Clock(f_1, f_2, f_8, f_{32}, f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}, f_{AD}, f_{C32})

These are operating clocks for the peripheral functions.

Of these, fi (i = 1, 2, 8, 32) and f_{iSIO} are derived from the main clock by dividing them by i. The clock fi is used for timers A and B, and f_{iSIO} is used for serial I/O. The f_8 and f_{32} clocks can be output from the CLK_{OUT} pin.

The f_{AD} clock is produced from the main clock, and is used for the A/D converter.

When the WAIT instruction is executed after setting the CM02 bit of CM0 register to “1” (peripheral function clock turned off during wait mode), or when the microcomputer is in low power dissipation mode, the fi, f_{iSIO} and f_{AD} clocks are turned off.

The f_{C32} clock is produced from the sub clock, and is used for timers A and B. This clock can be used when the sub clock is on.

4.3 Clock Output Function

During single-chip mode, the f_8, f_{32} or f_C clock can be output from the CLK_{OUT} pin. Use the CM01 to CM00 bits of CM0 register to select.

4.4 Power Control

There are three power control modes. For convenience' sake, all modes other than wait and stop modes are referred to as normal operation mode here.

4.4.1 Normal Operation Mode

Normal operation mode is further classified into four modes.

In normal operation mode, because the CPU clock and the peripheral function clocks both are on, the CPU and the peripheral functions are operating. Power control is exercised by controlling the CPU clock frequency. The higher the CPU clock frequency, the greater the processing capability. The lower the CPU clock frequency, the smaller the power consumption in the chip. If the unnecessary oscillator circuits are turned off, the power consumption is further reduced.

Before the clock sources for the CPU clock can be switched over, the new clock source to which switched must be oscillating stably. If the new clock source is the main clock or sub clock, allow a sufficient wait time in a program until it becomes oscillating stably.

- High-speed Mode

  The main clock divided by 1 provides the CPU clock. If the sub clock is on, fC32 can be used as the count source for timers A and B.
- Medium-speed Mode

  The main clock divided by 2, 4, 8 or 16 provides the CPU clock. If the sub clock is on, fC32 can be used as the count source for timers A and B.
- Low-speed Mode

  The sub clock provides the CPU clock. The main clock is used as the clock source for the peripheral function clock.

  The fC32 clock can be used as the count source for timers A and B.
- Low Power Dissipation Mode

  In this mode, the main clock is turned off after being placed in low speed mode. The sub clock provides the CPU clock. The fC32 clock can be used as the count source for timers A and B.

  Simultaneously when this mode is selected, the CM06 bit of CM0 register becomes “1” (divided by 8 mode). In the low power dissipation mode, do not change the CM06 bit. Consequently, the medium speed (divided by 8) mode is to be selected when the main clock is operated next.

4.4.2 Wait Mode

In wait mode, the CPU clock is turned off, so are the CPU (because operated by the CPU clock) and the watchdog timer. Because the main clock and sub clock are on, the peripheral functions using these clocks keep operating.

- Peripheral Function Clock Stop Function

  If the CM02 bit is "1" (peripheral function clocks turned off during wait mode), the f_1, f_2, f_8, f_{32}, f_{1SIO}, f_{8SIO}, f_{32SIO} and f_{AD} clocks are turned off when in wait mode, with the power consumption reduced that much. However, f_{C32} remains on.

- Entering Wait Mode

  The microcomputer is placed into wait mode by executing the WAIT instruction.

- Pin Status During Wait Mode

  Pin Status During Wait Mode is shown in Table 4.2.

- Exiting Wait Mode

  The microcomputer is moved out of wait mode by a hardware reset, $\overline{\text{NMI}}$ interrupt or peripheral function interrupt.

  If the microcomputer is to be moved out of exit wait mode by a hardware reset or $\overline{\text{NMI}}$ interrupt, set the peripheral function interrupt priority ILVL2 to ILVL0 bits to "000_2" (interrupts disabled) before executing the WAIT instruction.

  The peripheral function interrupts are affected by the CM02 bit. If CM02 bit is "0" (peripheral function clocks not turned off during wait mode), all peripheral function interrupts can be used to exit wait mode. If CM02 bit is "1" (peripheral function clocks turned off during wait mode), the peripheral functions using the peripheral function clocks stop operating, so that only the peripheral functions clocked by external signals can be used to exit wait mode.

Table 4.2 Pin Status During Wait Mode

Pin		Single-chip mode
A_0 to A_{19}, D_0 to D_{15}, $\overline{CS0}$ to $\overline{CS3}$, $\overline{BHE}$		
$\overline{RD}$, $\overline{WR}$, $\overline{WRL}$, $\overline{WRH}$		
$\overline{HLDA}$,BCLK		
ALE		
I/O ports		Retains status before wait mode
CLKOUT	When f_C selected	Does not stop
	When f_8, f_{32} selected	Does not stop when the CM02 bit is “0”. When the CM02 bit is “1”, the status immediately prior to entering wait mode is maintained.

Table 4.3 Interrupts to Exit Wait Mode

Interrupt	CM02=0	CM02=1
$\overline{NMI}$ interrupt	Can be used	Can be used
Serial I/O interrupt	Can be used when operating with internal or external clock	Can be used when operating with external clock
A-D conversion interrupt	Can be used in one-shot mode or single sweep mode	— (Do not use)
Timer A interrupt Timer B interrupt	Can be used in all modes	Can be used in event counter mode or when the count source is fC32
$\overline{INT}$ interrupt	Can be used	Can be used

Table 4.3 lists the interrupts to exit wait mode.
If the microcomputer is to be moved out of wait mode by a peripheral function interrupt, set up the following before executing the WAIT instruction.

(1) In the ILVL2 to ILVL0 bits of interrupt control register, set the interrupt priority level of the peripheral function interrupt to be used to exit wait mode. Also, for all of the peripheral function interrupts not used to exit wait mode, set the ILVL2 to ILVL0 bits to “000_2” (interrupt disable).
(2) Set the I flag to “1”.
(3) Enable the peripheral function whose interrupt is to be used to exit wait mode. In this case, when an interrupt request is generated and the CPU clock is thereby turned on, an interrupt routine is executed.

The CPU clock turned on when exiting wait mode by a peripheral function interrupt is the same CPU clock that was on when the WAIT instruction was executed.

4.4.3 Stop Mode

In stop mode, all oscillator circuits are turned off, so are the CPU clock and the peripheral function clocks. Therefore, the CPU and the peripheral functions clocked by these clocks stop operating. The least amount of power is consumed in this mode. If the voltage applied to Vcc pins is VRAM or more, the internal RAM is retained.

However, the peripheral functions clocked by external signals keep operating. The following interrupts can be used to exit stop mode.

- $\overline{\text{NMI}}$ interrupt
- $\overline{\text{INT}}$ interrupt
- Timer A, Timer B interrupt (when counting external pulses in event counter mode)
- Serial I/O interrupt (when external clock is selected)

The internal oscillator circuit of expansion function (Data acquisition / humming function) stops oscillation when expansion register XTAL_VCO, PDC_VCO_ON, VPS_VCO_ON = "L".

- Entering Stop Mode

  The microcomputer is placed into stop mode by setting the CM10 bit of CM1 register to “1” (all clocks turned off). At the same time, the CM06 bit of CM0 register is set to “1” (divide-by-8 mode) and the CM15 bit of CM1 register is set to “1” (main clock oscillator circuit drive capability high).

- Pin Status in Stop Mode

  Table 4.4 lists pin status during stop mode

- Exiting Stop Mode

The microcomputer is moved out of stop mode by a hardware reset, $\overline{\text{NMI}}$ interrupt or peripheral function interrupt.

If the microcomputer is to be moved out of stop mode by a hardware reset or $\overline{\text{NMI}}$ interrupt, set the peripheral function interrupt priority ILVL2 to ILVL0 bits to “000_2” (interrupts disable) before setting the CM10 bit to “1”.

If the microcomputer is to be moved out of stop mode by a peripheral function interrupt, set up the following before setting the CM10 bit to “1”.

(1) In the ILVL2 to ILVL0 bits of interrupt control register, set the interrupt priority level of the peripheral function interrupt to be used to exit stop mode.
Also, for all of the peripheral function interrupts not used to exit stop mode, set the ILVL2 to ILVL0 bits to “000_2”.

(2) Set the I flag to “1”.

(3) Enable the peripheral function whose interrupt is to be used to exit stop mode.
In this case, when an interrupt request is generated and the CPU clock is thereby turned on, an interrupt service routine is executed.

Which CPU clock will be used after exiting stop mode by a peripheral function or NMI interrupt is determined by the CPU clock that was on when the microcomputer was placed into stop mode as follows:
If the CPU clock before entering stop mode was derived from the sub clock: sub clock
If the CPU clock before entering stop mode was derived from the main clock: main clock divide-by-8

Table 4.4 Pin Status in Stop Mode

Pin		Single-chip mode
A_0 to A_{19}, D_0 to D_{15}, $\overline{\text{CS0}}$ to $\overline{\text{CS3}}$, $\overline{\text{BHE}}$		
$\overline{\text{RD}}$, $\overline{\text{WR}}$, $\overline{\text{WRL}}$, $\overline{\text{WRH}}$		
$\overline{\text{HLDA}}$, BCLK		
ALE		
I/O ports		Retains status before stop mode
CLKOUT	When fc selected	“H”
	When f_8, f_{32} selected	Retains status before stop mode

Figure 4.8 shows the state transition from normal operation mode to stop mode and wait mode.
Figure 4.9 shows the state transition in normal operation mode.

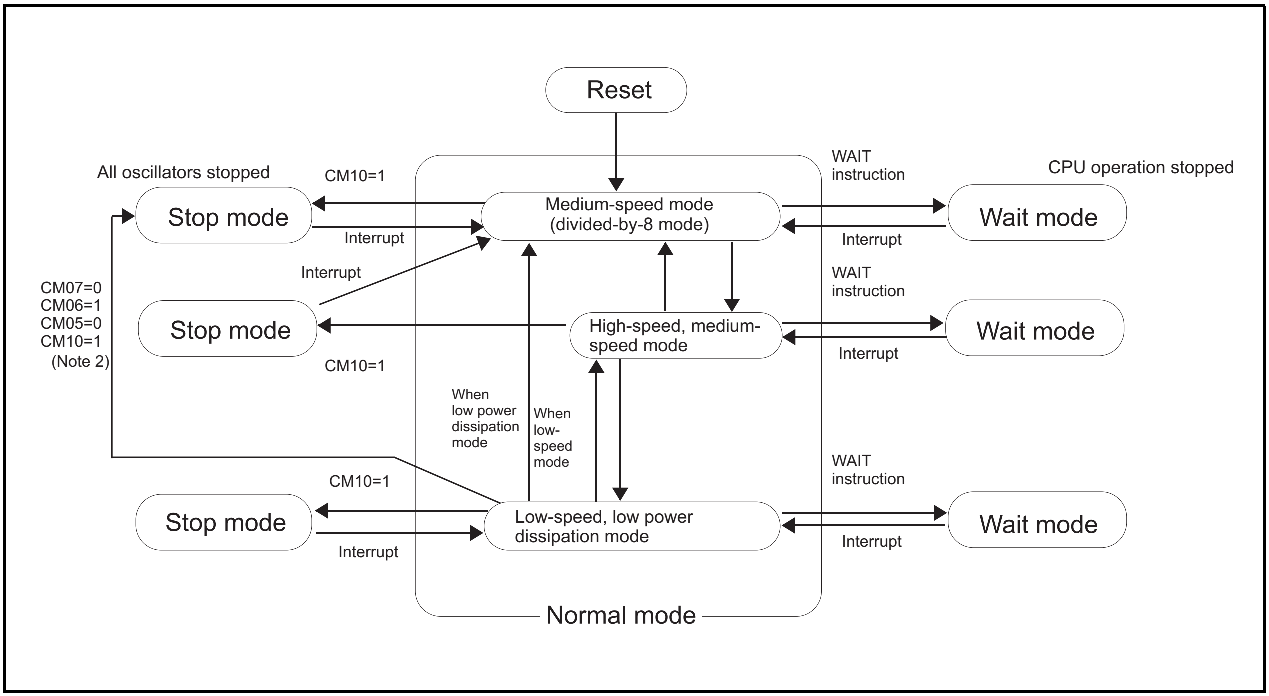
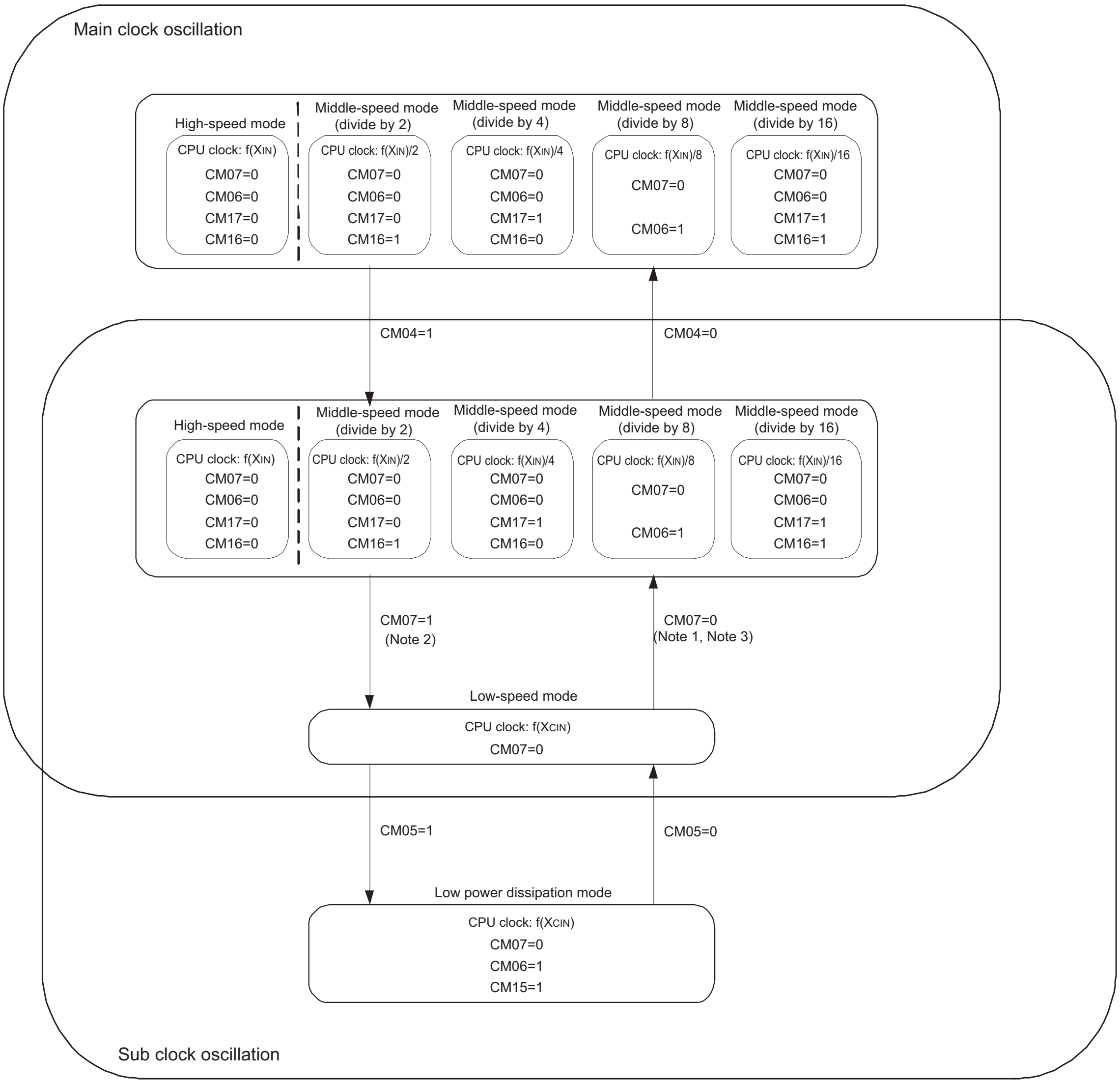


Figure 4.8 State Transition to Stop Mode and Wait Mode



Notes:
1: Switch clock after oscillation of main clock is sufficiently stable.
2: Switch clock after oscillation of sub-clock is sufficiently stable.
3: Change CM17 and CM16 before changing CM06.
4: Transit in accordance with arrow.

Figure 4.9 State Transition in Normal Mode

4.5 System Clock Protective Function

When the main clock is selected for the CPU clock source, this function disables the clock against modifications in order to prevent the CPU clock from becoming halted by run-away.
If the PM21 bit of PM2 register is set to “1” (clock modification disabled), the following bits are protected against writes:

- CM02, CM05, and CM07 bits in CM0 register
- CM10, CM11 bits in CM1 register

Before the system clock protective function can be used, the following register settings must be made while the CM05 bit of CM0 register is “0” (main clock oscillating) and CM07 bit is “0” (main clock selected for the CPU clock source):

(1) Set the PRC1 bit of PRCR register to “1” (enable writes to PM2 register).
(2) Set the PM21 bit of PM2 register to “1” (disable clock modification).
(3) Set the PRC1 bit of PRCR register to “0” (disable writes to PM2 register).

Do not execute the WAIT instruction when the PM21 bit is “1”.

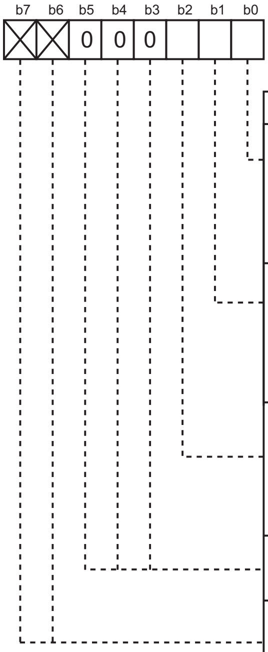
5. Protection

In the event that a program runs out of control, this function protects the important registers so that they will not be rewritten easily. Figure 5.1 shows the PRCR register. The following lists the registers protected by the PRCR register.

- Registers protected by PRC0 bit: CM0, CM1 and PCLKR registers
- Registers protected by PRC1 bit: PM0, PM1 and PM2 registers
- Registers protected by PRC2 bit: PD9, S3C and S4C registers

Set the PRC2 bit to “1” (write enabled) and then write to any address, and the PRC2 bit will be cleared to “0” (write protected). The registers protected by the PRC2 bit should be changed in the next instruction after setting the PRC2 bit to “1”. Make sure no interrupts or DMA transfers will occur between the instruction in which the PRC2 bit is set to “1” and the next instruction. The PRC0 and PRC1 bits are not automatically cleared to “0” by writing to any address. They can only be cleared in a program.

Protect register



Symbol PRCR

Address $000A_{16}$

After reset $XX000000_2$

Bit symbol	Bit name	Function	RW
PRC0	Protect bit 0	Enable write to CM0, CM1 and PCLKR registers 0 : Write protected 1 : Write enabled	RW
PRC1	Protect bit 1	Enable write to PM0, PM1 and PM2 registers 0 : Write protected 1 : Write enabled	RW
PRC2	Protect bit 2	Enable write to PD9, S3C and S4C registers 0 : Write protected 1 : Write enabled	RW
——— (b5-b3)	Reserved bit	Must set to “0”	RW
——— (b7-b6)	Nothing is assigned. When write, set to “0”. When read, its content is interdeterminate.		——

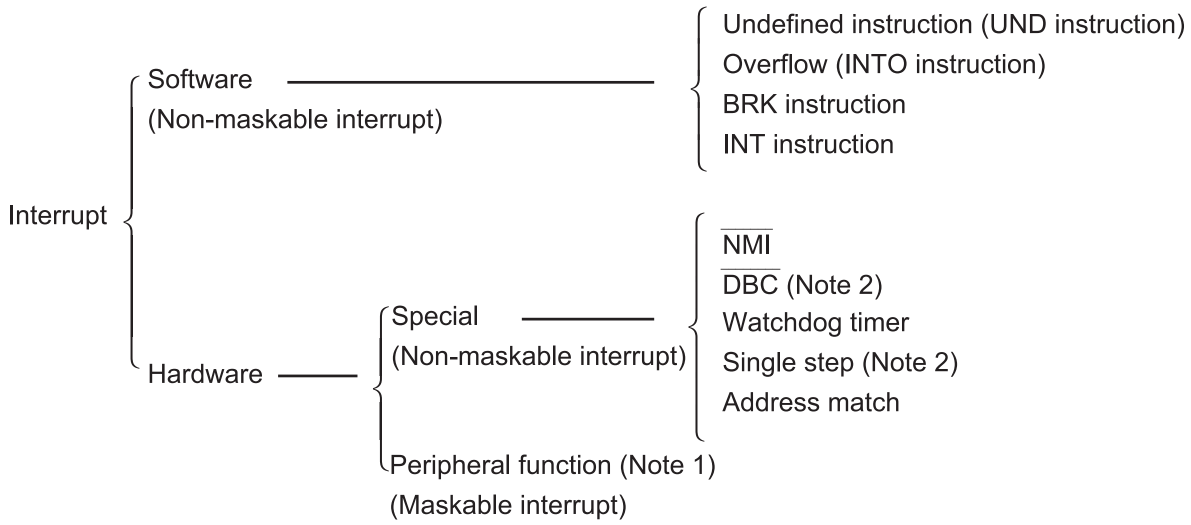
Note: The PRC2 bit is set to “0” by writing to any address after setting it to “1”. Other bits are not set to “0” by writing to any address, and must therefore be set in a program.

Figure 5.1 PRCR Register

6. Interrupts

6.1 Type of Interrupts

Figure 6.1 shows types of interrupts.



Note 1: Peripheral function interrupts are generated by the microcomputer's internal functions.

Note 2: Do not normally use this interrupt because it is provided exclusively for use by development support tools.

Figure 6.1 Interrupts

- Maskable Interrupt: An interrupt which can be enabled (disabled) by the interrupt enable flag (I flag) or whose interrupt priority can be changed by priority level.
- Non-maskable Interrupt: An interrupt which cannot be enabled (disabled) by the interrupt enable flag (I flag) or whose interrupt priority cannot be changed by priority level.

6.2 Software Interrupts

A software interrupt occurs when executing certain instructions. Software interrupts are non-maskable interrupts.

- Undefined Instruction Interrupt
  An undefined instruction interrupt occurs when executing the UND instruction.
- Overflow Interrupt
  An overflow interrupt occurs when executing the INTO instruction with the O flag set to “1” (the operation resulted in an overflow). The following are instructions whose O flag changes by arithmetic:
  ABS, ADC, ADCF, ADD, CMP, DIV, DIVU, DIVX, NEG, RMPA, SBB, SHA, SUB
- BRK Interrupt
  A BRK interrupt occurs when executing the BRK instruction.
- INT Instruction Interrupt
  An INT instruction interrupt occurs when executing the INT instruction. Software interrupt Nos. 0 to 63 can be specified for the INT instruction. Because software interrupt Nos. 4 to 31 are assigned to peripheral function interrupts, the same interrupt routine as for peripheral function interrupts can be executed by executing the INT instruction.
  In software interrupt Nos. 0 to 31, the U flag is saved to the stack during instruction execution and is cleared to “0” (ISP selected) before executing an interrupt sequence. The U flag is restored from the stack when returning from the interrupt routine. In software interrupt Nos. 32 to 63, the U flag does not change state during instruction execution, and the SP then selected is used.

6.3 Hardware Interrupts

Hardware interrupts are classified into two types — special interrupts and peripheral function interrupts.

- Special Interrupts

  Special interrupts are non-maskable interrupts.

(1) $\overline{\text{NMI}}$ Interrupt

An $\overline{\text{NMI}}$ interrupt is generated when input on the $\overline{\text{NMI}}$ pin changes state from high to low. For details about the $\overline{\text{NMI}}$ interrupt, refer to the section "NMI interrupt".

(2) $\overline{\text{DBC}}$ Interrupt

Do not normally use this interrupt because it is provided exclusively for use by development support tools.

(3) Watchdog Timer Interrupt

Generated by the watchdog timer. Once a watchdog timer interrupt is generated, be sure to initialize the watchdog timer. For details about the watchdog timer, refer to the section "watchdog timer".

(4) Single-step Interrupt

Do not normally use this interrupt because it is provided exclusively for use by development support tools.

(5) Address Match Interrupt

An address match interrupt is generated immediately before executing the instruction at the address indicated by the RMAD0 to RMAD3 register that corresponds to one of the AIER register’s AIER0 or AIER1 bit or the AIER2 register’s AIER20 or AIER21 bit which is "1" (address match interrupt enabled). For details about the address match interrupt, refer to the section "address match interrupt".

- Peripheral Function Interrupts

  Peripheral function interrupts are maskable interrupts and generated by the microcomputer's internal functions. The interrupt sources for peripheral function interrupts are listed in Table 6.2. For details about the peripheral functions, refer to the description of each peripheral function in this manual.

6.4 Interrupts and Interrupt Vector

One interrupt vector consists of 4 bytes. Set the start address of each interrupt routine in the respective interrupt vectors. When an interrupt request is accepted, the CPU branches to the address set in the corresponding interrupt vector. Figure 6.2 shows the interrupt vector.

Figure 6.2 Interrupt Vector

- Fixed Vector Tables

  The fixed vector tables are allocated to the addresses from FFFDC$_{16}$ to FFFFF$_{16}$. Table 6.1 lists the fixed vector tables. In the flash memory version of microcomputer, the vector addresses (H) of fixed vectors are used by the ID code check function. For details, refer to the section "flash memory rewrite disabling function".

Table 6.1 Fixed Vector Tables

Interrupt source	Vector table addresses Address (L) to address (H)	Remarks	Reference
Undefined instruction	FFFDC$_{16}$ to FFFDF$_{16}$	Interrupt on UND instruction	M16C/60, M16C/20 series software manual
Overflow	FFFE0$_{16}$ to FFFE3$_{16}$	Interrupt on INTO instruction	
BRK instruction	FFFE4$_{16}$ to FFFE7$_{16}$	If the contents of address FFFE7$_{16}$ is FF$_{16}$, program execution starts from the address shown by the vector in the relocatable vector table.	
Address match	FFFE8$_{16}$ to FFFEB$_{16}$		Address match interrupt
Single step (Note)	FFFEC$_{16}$ to FFFEF$_{16}$		
Watchdog timer	FFFF0$_{16}$ to FFFF3$_{16}$		Watchdog timer
$\overline{\text{DBC}}$ (Note)	FFFF4$_{16}$ to FFFF7$_{16}$		
NMI	FFFF8$_{16}$ to FFFFB$_{16}$		$\overline{\text{NMI}}$ interrupt
Reset	FFFFC$_{16}$ to FFFFF$_{16}$		Reset

Note: Do not normally use this interrupt because it is provided exclusively for use by development support tools.

- Relocatable Vector Tables

  The 256 bytes beginning with the start address set in the INTB register comprise a reloacatable vector table area. Table 6.2 lists the relocatable vector tables. Setting an even address in the INTB register results in the interrupt sequence being executed faster than in the case of odd addresses.

Table 6.2 Relocatable Vector Tables

Interrupt source	Vector address (Note 1) Address (L) to address (H)	Software interrupt number	Reference
BRK instruction (Note 5)	+0 to +3 (0000_{16} to 0003_{16})	0	M16C/60, M16C/20 series software manual
——— (Reserved)		1 to 3	
$\overline{\mathrm{INT3}}$	+16 to +19 (0010_{16} to 0013_{16})	4	$\overline{\mathrm{INT}}$ interrupt
Timer B5/SLICE ON (Note 7)	+20 to +23 (0014_{16} to 0017_{16})	5	Timer
Timer B4/Remote control, UART1 bus collision detect (Note 4, Note 6, Note 7)	+24 to +27 (0018_{16} to $001B_{16}$)	6	Timer Serial I/O
Timer B3/HINT, UART0 bus collision detect (Note 4, Note 6, Note 7)	+28 to +31 ($001C_{16}$ to $001F_{16}$)	7	
SI/O4, $\overline{\mathrm{INT5}}$ (Note 2)	+32 to +35 (0020_{16} to 0023_{16})	8	$\overline{\mathrm{INT}}$ interrupt Serial I/O
SI/O3, $\overline{\mathrm{INT4}}$ (Note 2)	+36 to +39 (0024_{16} to 0027_{16})	9	
UART 2 bus collision detection	+40 to +43 (0028_{16} to $002B_{16}$)	10	Serial I/O
DMA0	+44 to +47 ($002C_{16}$ to $002F_{16}$)	11	DMAC
DMA1	+48 to +51 (0030_{16} to 0033_{16})	12	
A/D	+56 to +59 (0038_{16} to $003B_{16}$)	14	A/D converter
UART2 transmit, NACK2 (Note 3)	+60 to +63 ($003C_{16}$ to $003F_{16}$)	15	Serial I/O
UART2 receive, ACK2 (Note 3)	+64 to +67 (0040_{16} to 0043_{16})	16	
UART0 transmit, NACK0 (Note 3)	+68 to +71 (0044_{16} to 0047_{16})	17	
UART0 receive, ACK0 (Note 3)	+72 to +75 (0048_{16} to $004B_{16}$)	18	
UART1 transmit, NACK1 (Note 3)	+76 to +79 ($004C_{16}$ to $004F_{16}$)	19	
UART1 receive, ACK1 (Note 3)	+80 to +83 (0050_{16} to 0053_{16})	20	
Timer A0	+84 to +87 (0054_{16} to 0057_{16})	21	Timer
Timer A1	+88 to +91 (0058_{16} to $005B_{16}$)	22	
Timer A2	+92 to +95 ($005C_{16}$ to $005F_{16}$)	23	
Timer A3	+96 to +99 (0060_{16} to 0063_{16})	24	
Timer A4/Multi-master I^{2}C (Note 9)	+100 to +103 (0064_{16} to 0067_{16})	25	
Timer B0	+104 to +107 (0068_{16} to $006B_{16}$)	26	
Timer B1	+108 to +111 ($006C_{16}$ to $006F_{16}$)	27	
Timer B2/Clock timer (Note 7)	+112 to +115 (0070_{16} to 0073_{16})	28	
$\overline{\mathrm{INT0}}$	+116 to +119 (0074_{16} to 0077_{16})	29	$\overline{\mathrm{INT}}$ interrupt
$\overline{\mathrm{INT1}}$	+120 to +123 (0078_{16} to $007B_{16}$)	30	
$\overline{\mathrm{INT2}}$/Remote control transmission (Note 8)	+124 to +127 ($007C_{16}$ to $007F_{16}$)	31	
Software interrupt (Note 5)	+128 to +131 (0080_{16} to 0083_{16}) to +252 to +255 ($00FC_{16}$ to $00FF_{16}$)	32 to 63	M16C/60, M16C/20 series software manual

Notes 1: Address relative to address in INTB

Notes 2: Use the IFSR register's IFSR6 and IFSR7 bits to select.

Notes 3: During I^{2}C mode, NACK and ACK interrupts comprise the interrupt source.

Notes 4: Use the IFSR2A register's IFSR26 and IFSR27 bits to select.

Notes 5: These interrupts cannot be disabled using the I flag.

Notes 6: Bus collision detection : During IE mode, this bus collision detection constitutes the cause of an interrupt. During I^{2}C mode, however, a start condition or a stop condition detection constitutes the cause of an interrupt.

Notes 7: When you use SLICEON, remote control, HINT and clock timer interruption, refer to address 36_{16} expansion register of "14. Expansion Function"

Notes 8: Please refer to address $3E_{16}$ of the expansion register of "14. Expansion Function" when you use the remote control transmission interrupt.

Notes 9: Please refer to the I^{2}C0 interrupt control register of "11 multi-master I^{2}C-BUS interface" (address $02D6_{16}$) when you use multi master I^{2}C interrupt.

6.5 Interrupt Control

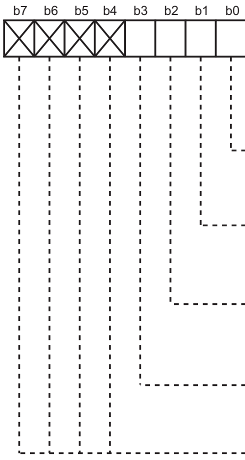
The following describes how to enable/disable the maskable interrupts, and how to set the priority in which order they are accepted. What is explained here does not apply to nonmaskable interrupts.

Use the FLG register's I flag, IPL, and each interrupt control register's ILVL2 to ILVL0 bits to enable/disable the maskable interrupts. Whether an interrupt is requested is indicated by the IR bit in each interrupt control register.

Figure 6.3 shows the interrupt control registers.

Interrupt control register (Note 2)

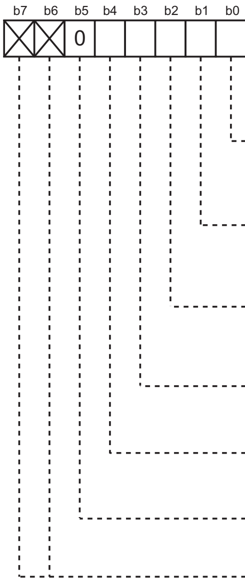
Symbol	Address	After reset
TB5IC	0045$_{16}$	XXXXX000$_2$
TB4IC/U1BCNIC (Note 3)	0046$_{16}$	XXXXX000$_2$
TB3IC/U0BCNIC (Note 3)	0047$_{16}$	XXXXX000$_2$
BCNIC	004A$_{16}$	XXXXX000$_2$
DM0IC, DM1IC	004B$_{16}$, 004C$_{16}$	XXXXX000$_2$
ADIC	004E$_{16}$	XXXXX000$_2$
S0TIC to S2TIC	0051$_{16}$, 0053$_{16}$, 004F$_{16}$	XXXXX000$_2$
S0RIC to S2RIC	0052$_{16}$, 0054$_{16}$, 0050$_{16}$	XXXXX000$_2$
TA0IC to TA4IC	0055$_{16}$ to 0059$_{16}$	XXXXX000$_2$
TB0IC to TB2IC	005A$_{16}$ to 005C$_{16}$	XXXXX000$_2$



Bit symbol	Bit name	Function	RW
ILVL0	Interrupt priority level select bit	b2 b1 b0 0 0 0 : Level 0 (interrupt disabled) 0 0 1 : Level 1 0 1 0 : Level 2 0 1 1 : Level 3 1 0 0 : Level 4 1 0 1 : Level 5 1 1 0 : Level 6 1 1 1 : Level 7	RW
ILVL1			RW
ILVL2			RW
IR	Interrupt request bit	0 : Interrupt not requested 1 : Interrupt requested	RW (Note 1)
—— (b7-b4)	No functions are assigned. When writing to these bits, write “0”. The values in these bits when read are indeterminate.		——

Note 1: This bit can only be reset by writing "0" (Do not write "1").
Note 2: To rewrite the interrupt control registers, do so at a point that does not generate the interrupt request for that register. For details, see the precautions for interrupts.
Note 3: Use the IFSR2A register to select.

Symbol	Address	After reset
INT3IC	0044$_{16}$	XX00X000$_2$
S4IC/INT5IC	0048$_{16}$	XX00X000$_2$
S3IC/INT4IC	0049$_{16}$	XX00X000$_2$
INT0IC to INT2IC	005D$_{16}$ to 005F$_{16}$	XX00X000$_2$



Bit symbol	Bit name	Function	RW
ILVL0	Interrupt priority level select bit	b2 b1 b0 0 0 0 : Level 0 (interrupt disabled) 0 0 1 : Level 1 0 1 0 : Level 2 0 1 1 : Level 3 1 0 0 : Level 4 1 0 1 : Level 5 1 1 0 : Level 6 1 1 1 : Level 7	RW
ILVL1			RW
ILVL2			RW
IR	Interrupt request bit	0: Interrupt not requested 1: Interrupt requested	RW (Note 1)
POL	Polarity select bit	0 : Selects falling edge (Notes 3, 4) 1 : Selects rising edge	RW
——	Reserved bit	Must always be set to “0”	RW
—— (b7-b6)	No functions are assigned. When writing to these bits, write “0”. The values in these bits when read are indeterminate.		RW

Note 1: This bit can only be reset by writing "0" (Do not write "1").
Note 2: To rewrite the interrupt control register, do so at a point that does not generate the interrupt request for that register. For details, see the precautions for interrupts.
Note 3: If the IFSR register’s IFSRi bit (i = 0 to 5) is "1" (both edges), set the INTiIC register’s POL bit to "0 "(falling edge).
Note 4: Set the S3IC or S4IC register’s POL bit to "0" (falling edge) when the IFSR register’s IFSR6 bit = 0 (SI/O3 selected) or IFSR7 bit = 0 (SI/O4 selected), respectively

.

Figure 6.3 Interrupt Control Registers

6.6 I Flag

The I flag enables or disables the maskable interrupt. Setting the I flag to “1” (= enabled) enables the maskable interrupt. Setting the I flag to “0” (= disabled) disables all maskable interrupts.

6.7 IR Bit

The IR bit is set to “1” (= interrupt requested) when an interrupt request is generated. Then, when the interrupt request is accepted and the CPU branches to the corresponding interrupt vector, the IR bit is cleared to “0” (= interrupt not requested).
The IR bit can be cleared to “0” in a program. Note that do not write “1” to this bit.

6.8 ILVL2 to ILVL0 Bits and IPL

Interrupt priority levels can be set using the ILVL2 to ILVL0 bits.
Table 6.3 shows the settings of interrupt priority levels and Table 6.4 shows the interrupt priority levels enabled by the IPL.

The following are conditions under which an interrupt is accepted:

- I flag = “1”
- IR bit = “1”
- interrupt priority level > IPL

The I flag, IR bit, ILVL2 to ILVL0 bits and IPL are independent of each other. In no case do they affect one another.

Table 6.3 Settings of Interrupt Priority Levels

ILVL2 to ILVL0 bits	Interrupt priority level	Priority order
000_2	Level 0 (interrupt disabled)	—
001_2	Level 1	Low
010_2	Level 2	
011_2	Level 3	
100_2	Level 4	
101_2	Level 5	
110_2	Level 6	
111_2	Level 7	High

Table 6.4 Interrupt Priority Levels Enabled by IPL

IPL	Enabled interrupt priority levels
000_2	Interrupt levels 1 and above are enabled
001_2	Interrupt levels 2 and above are enabled
010_2	Interrupt levels 3 and above are enabled
011_2	Interrupt levels 4 and above are enabled
100_2	Interrupt levels 5 and above are enabled
101_2	Interrupt levels 6 and above are enabled
110_2	Interrupt levels 7 and above are enabled
111_2	All maskable interrupts are disabled

6.9 Interrupt Sequence

An interrupt sequence — what are performed over a period from the instant an interrupt is accepted to the instant the interrupt routine is executed — is described here.

If an interrupt occurs during execution of an instruction, the processor determines its priority when the execution of the instruction is completed, and transfers control to the interrupt sequence from the next cycle. If an interrupt occurs during execution of either the SMOVB, SMOVF, SSTR or RMPA instruction, the processor temporarily suspends the instruction being executed, and transfers control to the interrupt sequence.

The CPU behavior during the interrupt sequence is described below. Figure 6.4 shows time required for executing the interrupt sequence.

(1) The CPU gets interrupt information (interrupt number and interrupt request priority level) by reading the address 00000_{16}. Then it clears the IR bit for the corresponding interrupt to "0" (interrupt not requested).

(2) The FLG register immediately before entering the interrupt sequence is saved to the CPU's internal temporary register(Note 1).

(3) The I, D and U flags in the FLG register become as follows:

The I flag is cleared to "0" (interrupts disabled).

The D flag is cleared to "0" (single-step interrupt disabled).

The U flag is cleared to "0" (ISP selected).

However, the U flag does not change state if an INT instruction for software interrupt Nos. 32 to 63 is executed.

(4) The CPU's internal temporary register (Note 1) is saved to the stack.

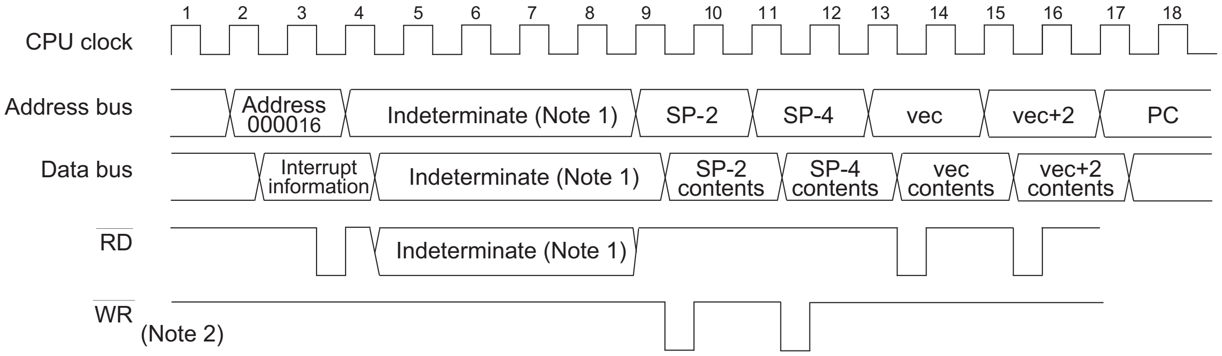
(5) The PC is saved to the stack.

(6) The interrupt priority level of the accepted interrupt is set in the IPL.

(7) The start address of the relevant interrupt routine set in the interrupt vector is stored in the PC.

After the interrupt sequence is completed, the processor resumes executing instructions from the start address of the interrupt routine.

Note: This register cannot be used by user.



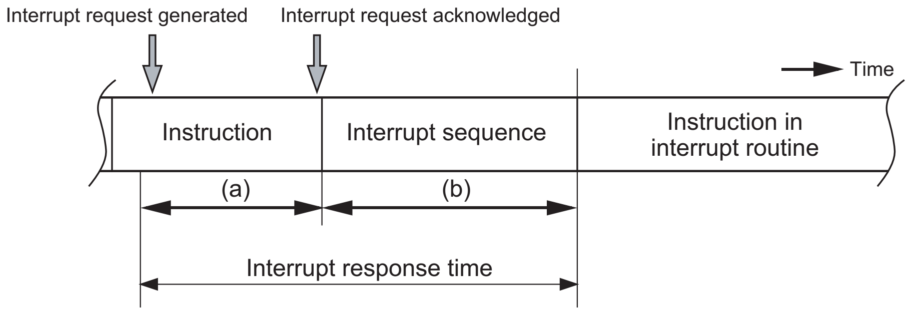
Note 1 : The indeterminate state depends on the instruction queue buffer. A read cycle occurs when the instruction queue buffer is ready to accept instructions.

Note 2 : The $\overline{WR}$ signal timing shown here is for the case where the stack is located in the internal RAM.

Figure 6.4 Time Required for Executing Interrupt Sequence

6.10 Interrupt Response Time

Figure 6.5 shows the interrupt response time. The interrupt response or interrupt acknowledge time denotes a time from when an interrupt request is generated till when the first instruction in the interrupt routine is executed. Specifically, it consists of a time from when an interrupt request is generated till when the instruction then executing is completed ((a) in Figure 6.5) and a time during which the interrupt sequence is executed ((b) in Figure 6.5).



(a) A time from when an interrupt request is generated till when the instruction then executing is completed. The length of this time varies with the instruction being executed. The DIVX instruction requires the longest time, which is equal to 30 cycles (without wait state, the divisor being a register).

(b) A time during which the interrupt sequence is executed. For details, see the table below. Note, however, that the values in this table must be increased 2 cycles for the $\overline{\text{DBC}}$ interrupt and 1 cycle for the address match and single-step interrupts.

Interrupt vector address	SP value	16-Bit bus, without wait	8-Bit bus, without wait
Even	Even	18 cycles	20 cycles
Even	Odd	19 cycles	20 cycles
Odd	Even	19 cycles	20 cycles
Odd	Odd	20 cycles	20 cycles

Figure 6.5 Interrupt response time

6.11 Variation of IPL when Interrupt Request is Accepted

When a maskable interrupt request is accepted, the interrupt priority level of the accepted interrupt is set in the IPL. When a software interrupt or special interrupt request is accepted, one of the interrupt priority levels listed in Table 6.5 is set in the IPL. Shown in Table 6.5 are the IPL values of software and special interrupts when they are accepted.

Table 6.5 IPL Level That is Set to IPL When A Software or Special Interrupt Is Accepted

Interrupt sources	Level that is set to IPL
Watchdog timer, $\overline{\text{NMI}}$	7
Software, address match, $\overline{\text{DBC}}$, single-step	Not changed

6.12 Saving Registers

In the interrupt sequence, the FLG register and PC are saved to the stack.
At this time, the 4 high-order bits of the PC and the 4 high-order (IPL) and 8 low-order bits of the FLG register, 16 bits in total, are saved to the stack first. Next, the 16 low-order bits of the PC are saved. Figure 6.6 shows the stack status before and after an interrupt request is accepted.
The other necessary registers must be saved in a program at the beginning of the interrupt routine. Use the PUSHM instruction, and all registers except SP can be saved with a single instruction.

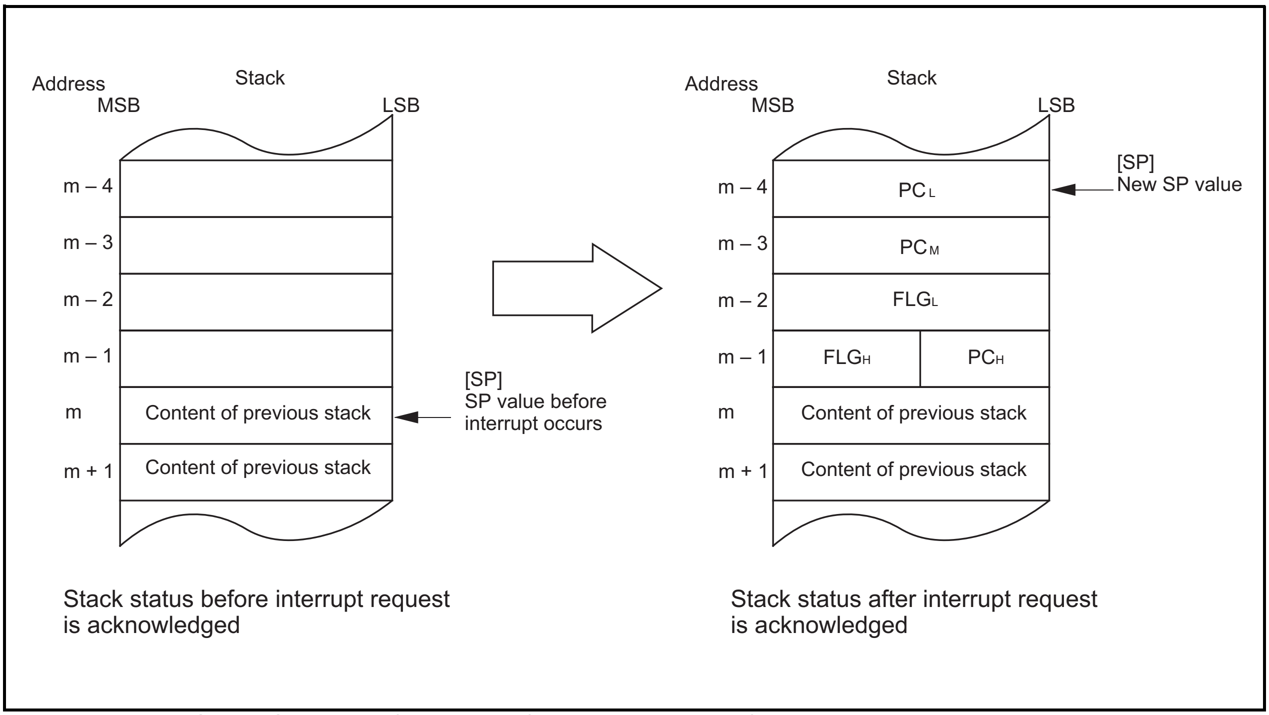
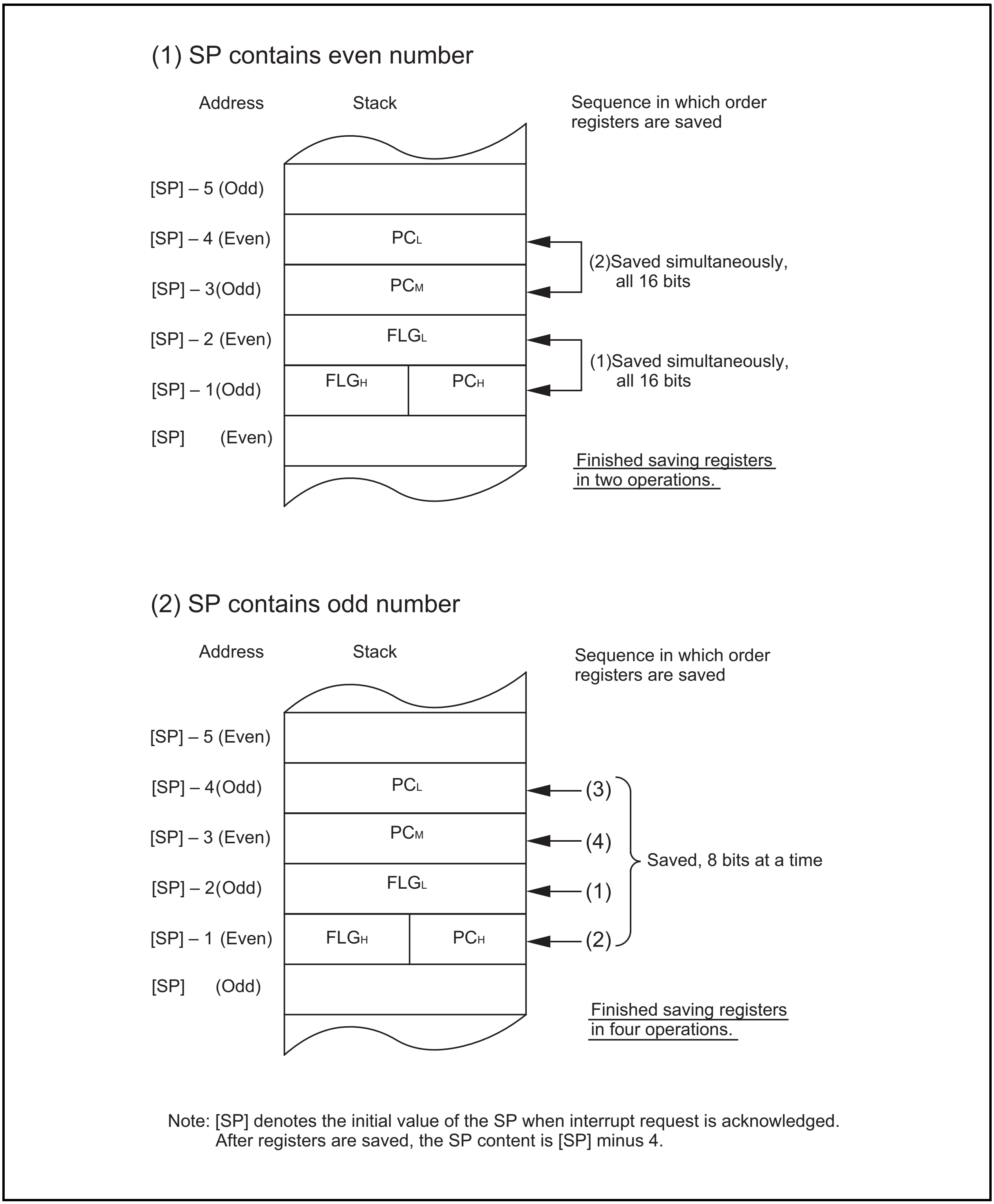


Figure 6.6 Stack Status Before and After Acceptance of Interrupt Request

The operation of saving registers carried out in the interrupt sequence is dependent on whether the SP(Note), at the time of acceptance of an interrupt request, is even or odd. If the stack pointer (Note) is even, the FLG register and the PC are saved, 16 bits at a time. If odd, they are saved in two steps, 8 bits at a time. Figure 6.7 shows the operation of the saving registers.

Note: When any INT instruction in software numbers 32 to 63 has been executed, this is the SP indicated by the U flag. Otherwise, it is the ISP.



Note: [SP] denotes the initial value of the SP when interrupt request is acknowledged. After registers are saved, the SP content is [SP] minus 4.

Figure 6.7 Operation of Saving Register

6.13 Returning from an Interrupt Routine

The FLG register and PC in the state in which they were immediately before entering the interrupt sequence are restored from the stack by executing the REIT instruction at the end of the interrupt routine.
Thereafter the CPU returns to the program which was being executed before accepting the interrupt request.
Return the other registers saved by a program within the interrupt routine using the POPM or similar instruction before executing the REIT instruction

6.14 Interrupt Priority

If two or more interrupt requests are generated while executing one instruction, the interrupt request that has the highest priority is accepted.
For maskable interrupts (peripheral functions), any desired priority level can be selected using the ILVL2 to ILVL0 bits. However, if two or more maskable interrupts have the same priority level, their interrupt priority is resolved by hardware, with the highest priority interrupt accepted.
The watchdog timer and other special interrupts have their priority levels set in hardware. Figure 6.8 shows the priorities of hardware interrupts.
Software interrupts are not affected by the interrupt priority. If an instruction is executed, control branches invariably to the interrupt routine.

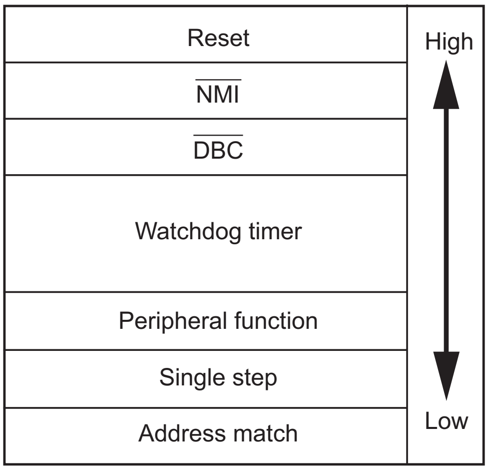


Figure 6.8 Hardware Interrupt Priority

6.15 Interrupt Priority Resolution Circuit

The interrupt priority resolution circuit is used to select the interrupt with the highest priority among those requested.
Figure 6.9 shows the circuit that judges the interrupt priority level.

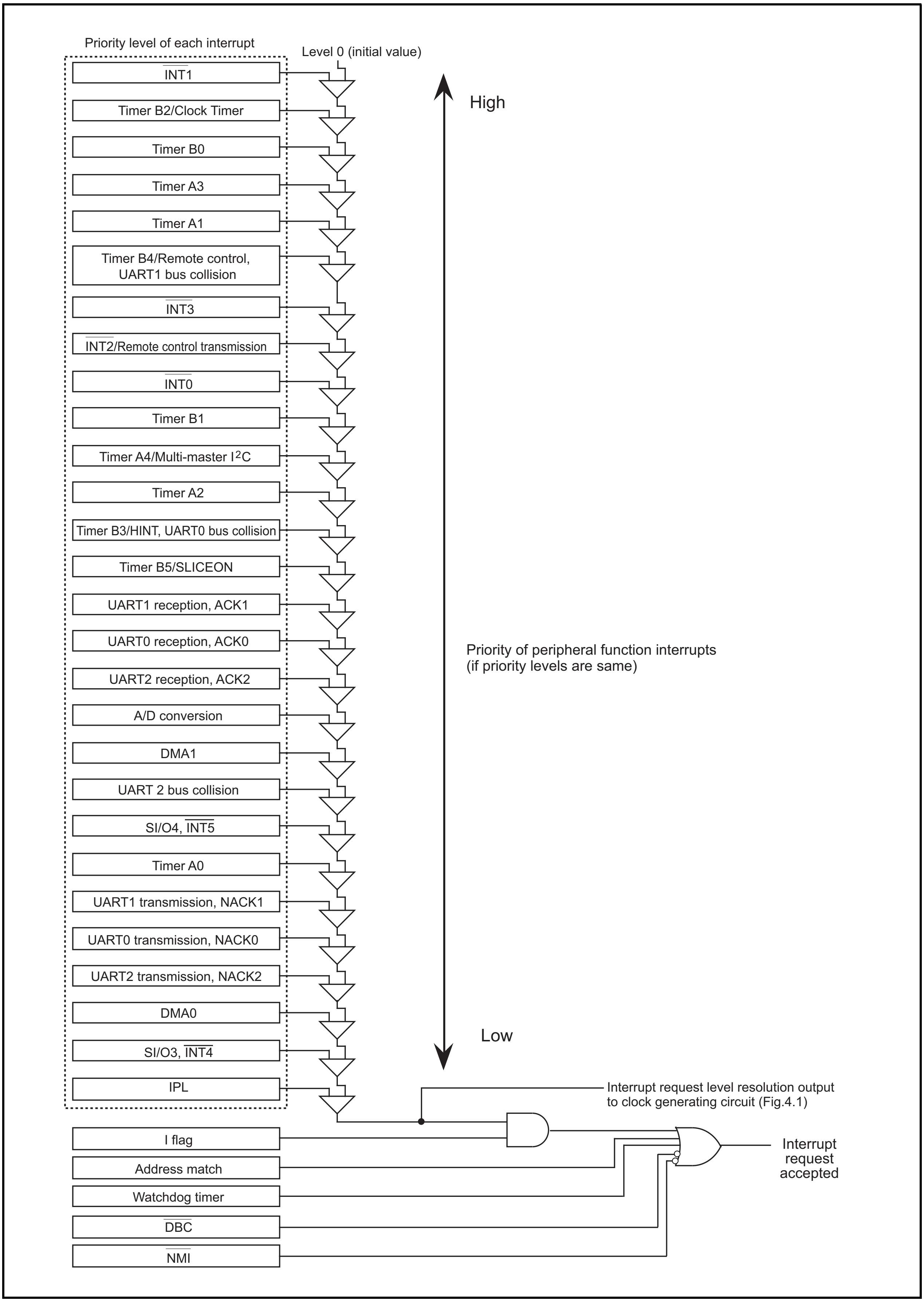
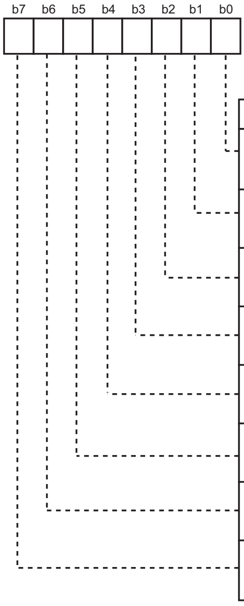


Figure 6.9 **Interrupts Priority Select Circuit**

6.16 $\overline{\text{INT}}$ Interrupt

$\overline{\text{INT}}$i interrupt (i = 0 to 5) is triggered by the edges of external inputs. The edge polarity is selected using the IFSR register's IFSRi bit.
$\overline{\text{INT4}}$ and $\overline{\text{INT5}}$ share the interrupt vector and interrupt control register with SI/O3 and SI/O4, respectively.
To use the $\overline{\text{INT4}}$ interrupt, set the IFSR register's IFSR6 bit to "1" (= $\overline{\text{INT4}}$). To use the $\overline{\text{INT5}}$ interrupt, set the IFSR register's IFSR7 bit to "1" (= $\overline{\text{INT5}}$).
After modifying the IFSR6 or IFSR7 bit, clear the corresponding IR bit to "0" (= interrupt not requested) before enabling the interrupt.
$\overline{\text{INT2}}$ and the remote control transmission, the vector and the interrupt control register are shared. (Please refer to "14. Expansion Function" for details.)
Figure 6.10 shows the IFSR and IFSR2A registers.

Interrupt request cause select register

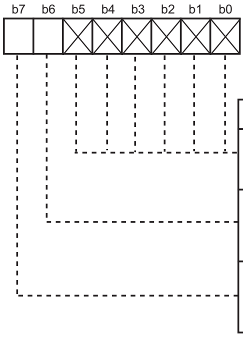


Symbol IFSR | Address 035F16 | After reset 0016

Bit symbol	Bit name	Function	RW
IFSR0	INT0 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR1	INT1 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR2	INT2 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR3	INT3 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR4	INT4 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR5	INT5 interrupt polarity switching bit	0 : One edge 1 : Both edges (Note 1)	RW
IFSR6	Interrupt request cause select bit	0 : SI/O3 (Note 2) 1 : INT4	RW
IFSR7	Interrupt request cause select bit	0 : SI/O4 (Note 2) 1 : INT5	RW

Note 1: When setting this bit to "1" (= both edges), make sure the INT0IC to INT5IC register's POL bit is set to "0" (= falling edge).
Note 2: When setting this bit to "0" (= SI/O3, SI/O4), make sure the S3IC and S4IC registers' POL bit is set to "0" (= falling edge).

Interrupt request cause select register 2



Symbol IFSR2A | Address 035E16 | After reset 00XXXXXX2

Bit symbol	Bit name	Function	RW
— (b5-b0)	Nothing is assigned. When write, set to "0". When read, their contents are indeterminate.		—
IFSR26	Interrupt request cause select bit (Note 1)	0 : Timer B3/HINT 1 : UART0 bus collision detection	RW
IFSR27	Interrupt request cause select bit (Note 2)	0 : Timer B4/Remote control 1 : UART1 bus collision detection	RW

Note 1: Timer B3/HINT and UART0 bus collision detection share the vector and interrupt control register. When using the timer B3/HINT interrupt, clear the IFSR26 bit to "0" (timer B3/HINT). When using UART0 bus collision detection, set the IFSR26 bit to "1".
Note 2: Timer B4/Remote control and UART1 bus collision detection share the vector and interrupt control register. When using the timer B4/Remote control interrupt, clear the IFSR27 bit to "0" (timer B4/Remote control). When using UART1 bus collision detection, set the IFSR27 bit to "1".

Figure 6.10 IFSR Register and IFSR2A Register

6.17 $\overline{\text{NMI}}$ Interrupt

An $\overline{\text{NMI}}$ interrupt is generated when input on the $\overline{\text{NMI}}$ pin changes state from high to low. The $\overline{\text{NMI}}$ interrupt is a non-maskable interrupt.
The input level of this $\overline{\text{NMI}}$ interrupt input pin can be read by accessing the P8 register's P8_5 bit.
This pin cannot be used as an input port.

6.18 Address Match Interrupt

An address match interrupt request is generated immediately before executing the instruction at the address indicated by the RMADi register (i = 0 to 3). Set the start address of any instruction in the RMADi register. Use the AIER register's AIER0 and AIER1 bits and the AIER2 register's AIER20 and AIER21 bits to enable or disable the interrupt. Note that the address match interrupt is unaffected by the I flag and IPL.
For address match interrupts, the value of the PC that is saved to the stack area varies depending on the instruction being executed (refer to "Saving Registers").
(The value of the PC that is saved to the stack area is not the correct return address.) Therefore, follow one of the methods described below to return from the address match interrupt.

- Rewrite the content of the stack and then use the REIT instruction to return.
- Restore the stack to its previous state before the interrupt request was accepted by using the POP or similar other instruction and then use a jump instruction to return.

Table 6.6 shows the value of the PC that is saved to the stack area when an address match interrupt request is accepted.
Note that when using the external bus in 8 bits width, no address match interrupts can be used for externa areas.
Figure 6.11 shows the AIER, AIER2, and RMAD0 to RMAD3 registers.

Table 6.6 Instruction Just Before Execution and Address Stored in Stack When There Occurs Interrupts

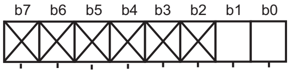
Instruction at the address indicated by the RMADi register	Value of the PC that is saved to the stack area
• 16-bit op-code instruction • Instruction shown below among 8-bit operation code instructions ADD.B:S #IMM8,dest SUB.B:S #IMM8,dest AND.B:S #IMM8,dest OR.B:S #IMM8,dest MOV.B:S #IMM8,dest STZ.B:S #IMM8,dest STNZ.B:S #IMM8,dest STZX.B:S #IMM81,#IMM82,dest CMP.B:S #IMM8,dest PUSHM src POPM dest JMPS #IMM8 JSRS #IMM8 MOV.B:S #IMM,dest (However, dest=A0 or A1)	The address indicated by the RMADi register +2
Instructions other than the above	The address indicated by the RMADi register +1

Value of the PC that is saved to the stack area : Refer to "Saving Registers".

Table 6.7 Relationship Between Address Match Interrupt Sources and Associated Registers

Address match interrupt sources	Address match interrupt enable bit	Address match interrupt register
Address match interrupt 0	AIER0	RMAD0
Address match interrupt 1	AIER1	RMAD1
Address match interrupt 2	AIER20	RMAD2
Address match interrupt 3	AIER21	RMAD3

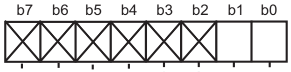
Address match interrupt enable register



Symbol	Address	After reset
AIER	0009_{16}	$XXXXXX00_2$

Bit symbol	Bit name	Function	RW
AIER0	Address match interrupt 0 enable bit	0 : Interrupt disabled 1 : Interrupt enabled	
AIER1	Address match interrupt 1 enable bit	0 : Interrupt disabled 1 : Interrupt enabled	RW
—— (b7-b2)	Nothing is assigned. When write, set to “0”. When read, their contents are indeterminate.		—

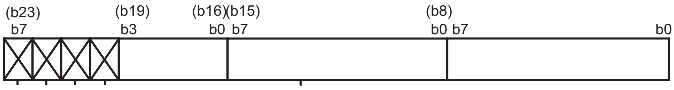
Address match interrupt enable register 2



Symbol	Address	After reset
AIER2	$01BB_{16}$	$XXXXXX00_2$

Bit symbol	Bit name	Function	RW
AIER20	Address match interrupt 2 enable bit	0 : Interrupt disable 1 : Interrupt enabled	RW
AIER21	Address match interrupt 3 enable bit	0 : Interrupt disabled 1 : Interrupt enable	RW
—— (b7-b2)	Nothing is assigned. When write, set to “0”. When read, their contents are indeterminate.		—

Address match interrupt register i (i = 0 to 3)



Symbol	Address	After reset
RMAD0	0012_{16} to 0010_{16}	$X00000_{16}$
RMAD1	0016_{16} to 0014_{16}	$X00000_{16}$
RMAD2	$01BA_{16}$ to $01B8_{16}$	$X00000_{16}$
RMAD3	$01BE_{16}$ to $01BC_{16}$	$X00000_{16}$

Function	Setting range	RW
Address setting register for address match interrupt	00000_{16} to $FFFFF_{16}$	RW
Nothing is assigned. When write, set to “0”. When read, their contents are indeterminate.		—

Figure 6.11 AIER Register, AIER2 Register and RMAD0 to RMAD3 Registers

7. Watchdog Timer

The watchdog timer is the function of detecting when the program is out of control. Therefore, we recommend using the watchdog timer to improve reliability of a system. The watchdog timer contains a 15-bit counter which counts down the clock derived by dividing the CPU clock using the prescaler. Whether to generate a watchdog timer interrupt request or apply a watchdog timer reset as an operation to be performed when the watchdog timer underflows after reaching the terminal count can be selected using the PM12 bit of PM1 register. The PM12 bit can only be set to “1” (reset). Once this bit is set to “1”, it cannot be set to “0” (watchdog timer interrupt) in a program.
Refer to “Watchdog Timer Reset” for the details of watchdog timer reset.
When the main clock is selected for CPU clock, the divide-by-N value for the prescaler can be chosen to be 16 or 128 using the WDC7 bit of WDC register. If a sub-clock is selected for CPU clock, the divide-by- N value for the prescaler is always 2 no matter how the WDC7 bit is set. The period of watchdog timer can be calculated as given below. The period of watchdog timer is, however, subject to an error due to the prescaler.

With main clock chosen for CPU clock

$$\text{Watchdog timer period} = \frac{\text{Prescaler dividing (16 or 128) X Watchdog timer count (32768)}}{\text{CPU clock}}$$

With sub-clock chosen for CPU clock

$$\text{Watchdog timer period} = \frac{\text{Prescaler dividing (2) X Watchdog timer count (32768)}}{\text{CPU clock}}$$

For example, when CPU clock = 10 MHz and the divide-by-N value for the prescaler= 16, the watchdog timer period is approx. 52.4 ms.

The watchdog timer is initialized by writing to the WDTS register. The prescaler is initialized after reset.
Note that the watchdog timer and the prescaler both are inactive after reset, so that the watchdog timer is activated to start counting by writing to the WDTS register.
In stop mode, wait mode and hold state, the watchdog timer and prescaler are stopped. Counting is resumed from the held value when the modes or state are released.
Figure 7.1 shows the block diagram of the watchdog timer. Figure 7.2 shows the watchdog timer-related registers.

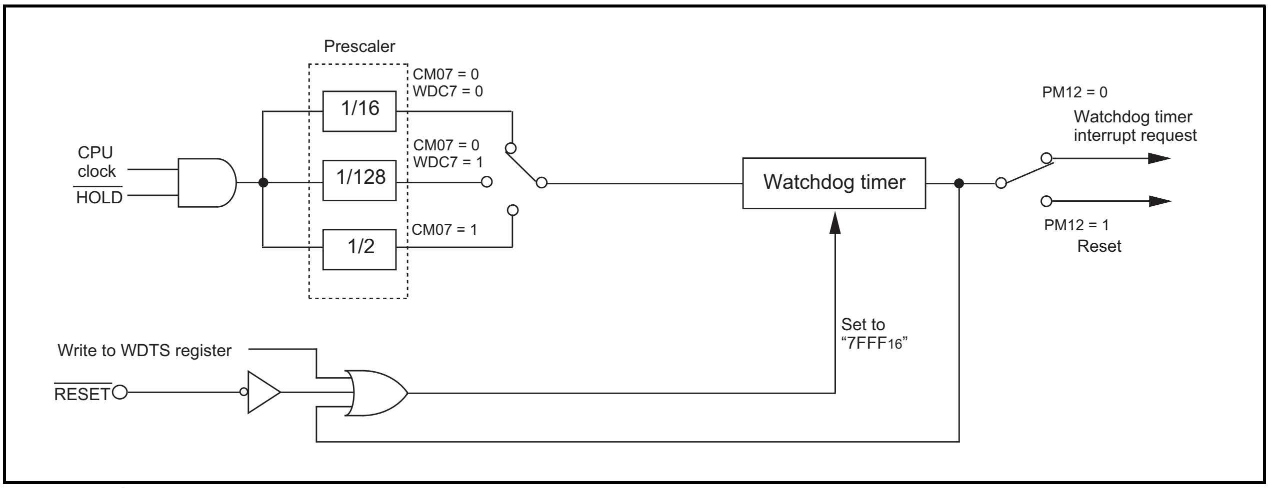


Figure 7.1 **Watchdog Timer Block Diagram**

Watchdog timer control register

b7	b6	b5	b4	b3	b2	b1	b0
	0						

Symbol WDC

Address 000F16

After reset 00XXXXXX2(Note2)

Bit symbol	Bit name	Function	RW
(b4-b0)	High-order bit of watchdog timer		RO
WDC5	Cold start / warm start discrimination flag (Note 1)	0 : Cold start 1 : Warm start	RW
(b6)	Reserved bit	Must set to "0"	RW
WDC7	Prescaler select bit	0 : Divided by 16 1 : Divided by 128	RW

Note 1: The WDC5 bit is always "1" (warm start) no matter how it is set by writing a "0" or "1".
Note 2: The WDC5 bit is "0" (cold start) immediately after power-on. It can only be set to "1" in a program.

Watchdog timer start register (Note)

b7	b0

Symbol WDTS

Address 000E16

After reset Indeterminate

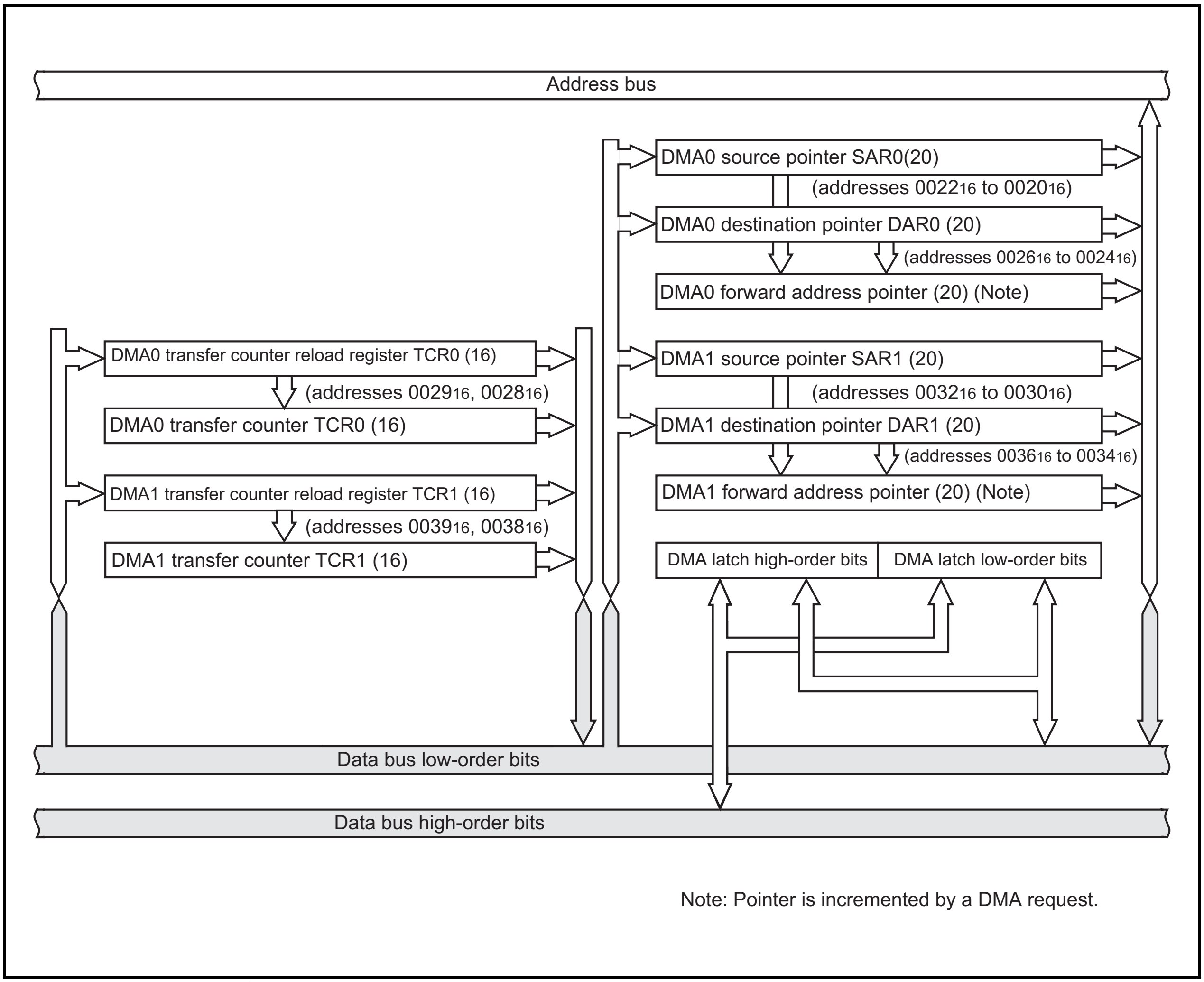
Function	RW
The watchdog timer is initialized and starts counting after a write instruction to this register. The watchdog timer value is always initialized to "7FFF16" regardless of whatever value is written.	WO

Note : Write to the WDTS register after the watchdog timer interrupt occurs.

Figure 7.2 **WDC Register and WDTS Register**

8. DMAC

The DMAC (Direct Memory Access Controller) allows data to be transferred without the CPU intervention.
Two DMAC channels are included. Each time a DMA request occurs, the DMAC transfers one (8 or 16-bit) data from the source address to the destination address. The DMAC uses the same data bus as used by the CPU. Because the DMAC has higher priority of bus control than the CPU and because it makes use of a cycle steal method, it can transfer one word (16 bits) or one byte (8 bits) of data within a very short time after a DMA request is generated. Figure 8.1 shows the block diagram of the DMAC.
Table 8.1 shows the DMAC specifications. Figures 8.2 to 8.4 show the DMAC-related registers.



Note: Pointer is incremented by a DMA request.

Figure 8.1 DMAC Block Diagram

A DMA request is generated by a write to the DMiSL register (i = 0 to 1)'s DSR bit, as well as by an interrupt request which is generated by any function specified by the DMiSL register's DMS and DSEL3 to DSEL0 bits. However, unlike in the case of interrupt requests, DMA requests are not affected by the I flag and the interrupt control register, so that even when interrupt requests are disabled and no interrupt request can be accepted, DMA requests are always accepted. Furthermore, because the DMAC does not affect interrupts, the interrupt control register's IR bit does not change state due to a DMA transfer.
A data transfer is initiated each time a DMA request is generated when the DMiCON register's DMAE bit = "1" (DMA enabled). However, if the cycle in which a DMA request is generated is faster than the DMA transfer cycle, the number of transfer requests generated and the number of times data is transferred may not match. For details, refer to "DMA Requests".

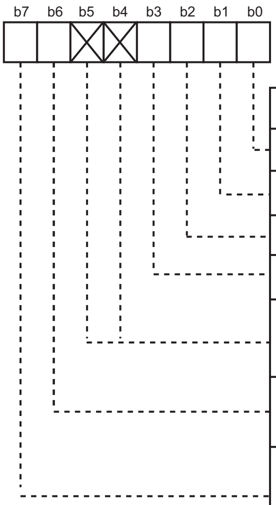
Table 8.1 DMAC Specifications

Item		Specification
No. of channels		2 (cycle steal method)
Transfer memory space		• From any address in the 1M bytes space to a fixed address • From a fixed address to any address in the 1M bytes space • From a fixed address to a fixed address
Maximum No. of bytes transferred		128K bytes (with 16-bit transfers) or 64K bytes (with 8-bit transfers)
DMA request factors (Note 1, Note 2)		Falling edge of $\overline{\text{INT0}}$ or $\overline{\text{INT1}}$ Both edge of $\overline{\text{INT0}}$ or $\overline{\text{INT1}}$ Timer A0 to timer A4 interrupt requests Timer B0 to timer B5 interrupt requests UART0 transfer, UART0 reception interrupt requests UART1 transfer, UART1 reception interrupt requests UART2 transfer, UART2 reception interrupt requests SI/O3, SI/O4 interrpt requests A/D conversion interrupt requests Software triggers
Channel priority		DMA0 > DMA1 (DMA0 takes precedence)
Transfer unit		8 bits or 16 bits
Transfer address direction		forward or fixed (The source and destination addresses cannot both be in the forward direction.)
Transfer mode	•Single transfer	Transfer is completed when the DMAi transfer counter (i = 0–1) underflows after reaching the terminal count.
	•Repeat transfer	When the DMAi transfer counter underflows, it is reloaded with the value of the DMAi transfer counter reload register and a DMA transfer is continued with it.
DMA interrupt request generation timing		When the DMAi transfer counter underflowed
DMA startup		Data transfer is initiated each time a DMA request is generated when the DMAiCON register’s DMAE bit = “1” (enabled).
DMA shutdown	•Single transfer	• When the DMAE bit is set to “0” (disabled) • After the DMAi transfer counter underflows
	•Repeat transfer	When the DMAE bit is set to “0” (disabled)
Reload timing for forward address pointer and transfer counter		When a data transfer is started after setting the DMAE bit to “1” (enabled), the forward address pointer is reloaded with the value of the SARi or the DARi pointer whichever is specified to be in the forward direction and the DMAi transfer counter is reloaded with the value of the DMAi transfer counter reload register.

Notes:

1. DMA transfer is not effective to any interrupt. DMA transfer is affected neither by the I flag nor by the interrupt control register.
2. The selectable causes of DMA requests differ with each channel.
3. Make sure that no DMAC-related registers (addresses 0020_{16} to $003F_{16}$) are accessed by the DMAC.

DMA0 request cause select register



Symbol	Address	After reset
DM0SL	$03B8_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
DSEL0	DMA request cause select bit	Refer to note	RW
DSEL1			RW
DSEL2			RW
DSEL3			RW
— (b5-b4)	Nothing is assigned. When write, set to “0”. When read, its content is “0”.		—
DMS	DMA request cause expansion select bit	0: Basic cause of request 1: Extended cause of request	RW
DSR	Software DMA request bit	A DMA request is generated by setting this bit to “1” when the DMS bit is “0” (basic cause) and the DSEL3 to DSEL0 bits are “0001_2” (software trigger). The value of this bit when read is “0” .	RW

Note 1: The causes of DMA0 requests can be selected by a combination of DMS bit and DSEL3 to DSEL0 bits in the manner described below.

DSEL3 to DSEL0	DMS=0 (basic cause of request)	DMS=1 (extended cause of request)
0 0 0 0_2	Falling edge of $\overline{\text{INT0}}$ pin	–
0 0 0 1_2	Software trigger	–
0 0 1 0_2	Timer A0	–
0 0 1 1_2	Timer A1	–
0 1 0 0_2	Timer A2	–
0 1 0 1_2	Timer A3	–
0 1 1 0_2	Timer A4 (Note 4)	Two edges of $\overline{\text{INT0}}$ pin
0 1 1 1_2	Timer B0	Timer B3
1 0 0 0_2	Timer B1	Timer B4
1 0 0 1_2	Timer B2 (Note 3)	Timer B5
1 0 1 0_2	UART0 transmit	–
1 0 1 1_2	UART0 receive	–
1 1 0 0_2	UART2 transmit	–
1 1 0 1_2	UART2 receive	–
1 1 1 0_2	A-D conversion	–
1 1 1 1_2	UART1 transmit	–

Note 2: In VINTi, INTRMTi, and HINTi (i = 0 to 3) of address 36_{16} expansion register of expansion function, when use them by the following setup, DMA request cause extension select bit = "1" (extended cause of request) cannot be used.

- VINTi = 1011_2
- INTRMTi = 1010_2
- HINTi = 1001_2

(i = 0 to 3)

Note 3: Please change SECINTi (i = 0 to 3) in address 36_{16} expansion registers of the expansion feature to the following settings when you use the DMA forwarding by timer B2 interrupt request.

- SECINTi = 0000_2

The DMA forwarding by the clock timer interrupt request cannot be used.

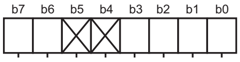
Note 4: Please change EXTIICINTi (i = 0 to 3) in address $02D6_{16}$ I^{2}C0 interrupt control register to the following settings when you use the DMA forwarding by timer A4 interrupt request.

- EXTIICINTi = 0000_2

The DMA forwarding by the Multi-master I^{2}C interrupt request cannot be used.

Figure 8.2 DM0SL Register

DMA1 request cause select register



Symbol	Address	After reset
DM1SL	03BA$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
DSEL0	DMA request cause select bit	Refer to note	RW
DSEL1			RW
DSEL2			RW
DSEL3			RW
— (b5-b4)	Nothing is assigned. When write, set to “0”. When read, its content is “0”.		—
DMS	DMA request cause expansion select bit	0: Basic cause of request 1: Extended cause of request	RW
DSR	Software DMA request bit	A DMA request is generated by setting this bit to “1” when the DMS bit is “0” (basic cause) and the DSEL3 to DSEL0 bits are “0001$_2$” (software trigger). The value of this bit when read is “0” .	RW

Note 1: The causes of DMA1 requests can be selected by a combination of DMS bit and DSEL3 to DSEL0 bits in the manner described below.

DSEL3 to DSEL0	DMS=0(basic cause of request)	DMS=1(extended cause of request)
0 0 0 0$_2$	Falling edge of $\overline{INT1}$ pin	–
0 0 0 1$_2$	Software trigger	–
0 0 1 0$_2$	Timer A0	–
0 0 1 1$_2$	Timer A1	–
0 1 0 0$_2$	Timer A2	–
0 1 0 1$_2$	Timer A3	SI/O3
0 1 1 0$_2$	Timer A4 (Note 3)	SI/O4
0 1 1 1$_2$	Timer B0	Two edges of $\overline{INT1}$
1 0 0 0$_2$	Timer B1	–
1 0 0 1$_2$	Timer B2 (Note 2)	–
1 0 1 0$_2$	UART0 transmit	–
1 0 1 1$_2$	UART0 receive/ACK0	–
1 1 0 0$_2$	UART2 transmit	–
1 1 0 1$_2$	UART2 receive/ACK2	–
1 1 1 0$_2$	A/D conversion	–
1 1 1 1$_2$	UART1 receive/ACK1	–

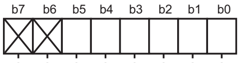
Note 2: Please change SECINTi (i = 0 to 3) in address 36$_{16}$ enhancing registers of the enhanced feature to the following settings when you use the DMA forwarding by timer B2 interrupt request.
- SECINTi = 0000$_2$

The DMA forwarding by the clock timer interrupt request cannot be used.

Note 3: Please change EXTIICINTi (i = 0 to 3) in address 02D6$_{16}$ I^{2}C0 interrupt control register to the following settings when you use the DMA forwarding by timer A4 interrupt request.
- EXTIICINTi = 0000$_2$

The DMA forwarding by the Multi-master I^{2}C interrupt request cannot be used.

DMAi control register (i = 0,1)



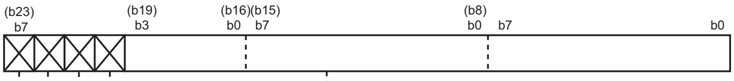
Symbol	Address	After reset
DM0CON	002C$_{16}$	00000X00$_2$
DM1CON	003C$_{16}$	00000X00$_2$

Bit symbol	Bit name	Function	RW
DMBIT	Transfer unit bit select bit	0 : 16 bits 1 : 8 bits	RW
DMASL	Repeat transfer mode select bit	0 : Single transfer 1 : Repeat transfer	RW
DMAS	DMA request bit	0 : DMA not requested 1 : DMA requested	RW (Note 1)
DMAE	DMA enable bit	0 : Disabled 1 : Enabled	RW
DSD	Source address direction select bit (Note 2)	0 : Fixed 1 : Forward	RW
DAD	Destination address direction select bit (Note 2)	0 : Fixed 1 : Forward	RW
— (b7-b6)	Nothing is assigned. When write, set to “0”. When read, its content is “0”.		—

Note 1: The DMAS bit can be set to “0” by writing “0” in a program (This bit remains unchanged even if “1” is written).
Note 2: At least one of the DAD and DSD bits must be “0” (address direction fixed).

Figure 8.3 DM1SL Register, DM0CON Register, and DM1CON Registers

DMAi source pointer (i = 0, 1) (Note)

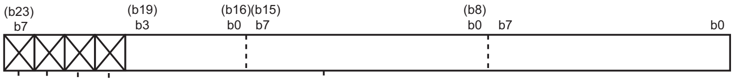


Symbol	Address	After reset
SAR0	0022_{16} to 0020_{16}	Indeterminate
SAR1	0032_{16} to 0030_{16}	Indeterminate

Function	Setting range	RW
Set the source address of transfer	00000_{16} to $FFFFF_{16}$	RW
Nothing is assigned. When write, set "0". When read, these contents are "0".		—

Note: If the DSD bit of DMiCON register is "0" (fixed), this register can only be written to when the DMAE bit of DMiCON register is "0" (DMA disabled).
If the DSD bit is "1" (forward direction), this register can be written to at any time.
If the DSD bit is "1" and the DMAE bit is "1" (DMA enabled), the DMAi forward address pointer can be read from this register. Otherwise, the value written to it can be read.

DMAi destination pointer (i = 0, 1)(Note)

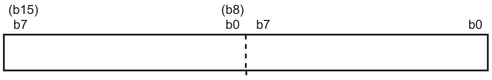


Symbol	Address	After reset
DAR0	0026_{16} to 0024_{16}	Indeterminate
DAR1	0036_{16} to 0034_{16}	Indeterminate

Function	Setting range	RW
Set the destination address of transfer	00000_{16} to $FFFFF_{16}$	RW
Nothing is assigned. When write, set "0". When read, these contents are "0".		—

Note: If the DAD bit of DMiCON register is "0" (fixed), this register can only be written to when the DMAE bit of DMiCON register is "0"(DMA disabled).
If the DAD bit is "1" (forward direction), this register can be written to at any time.
If the DAD bit is "1" and the DMAE bit is "1" (DMA enabled), the DMAi forward address pointer can be read from this register. Otherwise, the value written to it can be read.

DMAi transfer counter (i = 0, 1)



Symbol	Address	After reset
TCR0	0029_{16}, 0028_{16}	Indeterminate
TCR1	0039_{16}, 0038_{16}	Indeterminate

Function	Setting range	RW
Set the transfer count minus 1. The written value is stored in the DMAi transfer counter reload register, and when the DMAE bit of DMiCON register is set to "1" (DMA enabled) or the DMAi transfer counter underflows when the DMASL bit of DMiCON register is "1" (repeat transfer), the value of the DMAi transfer counter reload register is transferred to the DMAi transfer counter. When read, the DMAi transfer counter is read.	0000_{16} to $FFFF_{16}$	RW

Figure 8.4 SAR0, SAR1, DAR0, DAR1, TCR0, and TCR1 Registers

8.1 Transfer Cycles

The transfer cycle consists of a memory or SFR read (source read) bus cycle and a write (destination write) bus cycle. The number of read and write bus cycles is affected by the source and destination addresses of transfer.

(a) Effect of Source and Destination Addresses

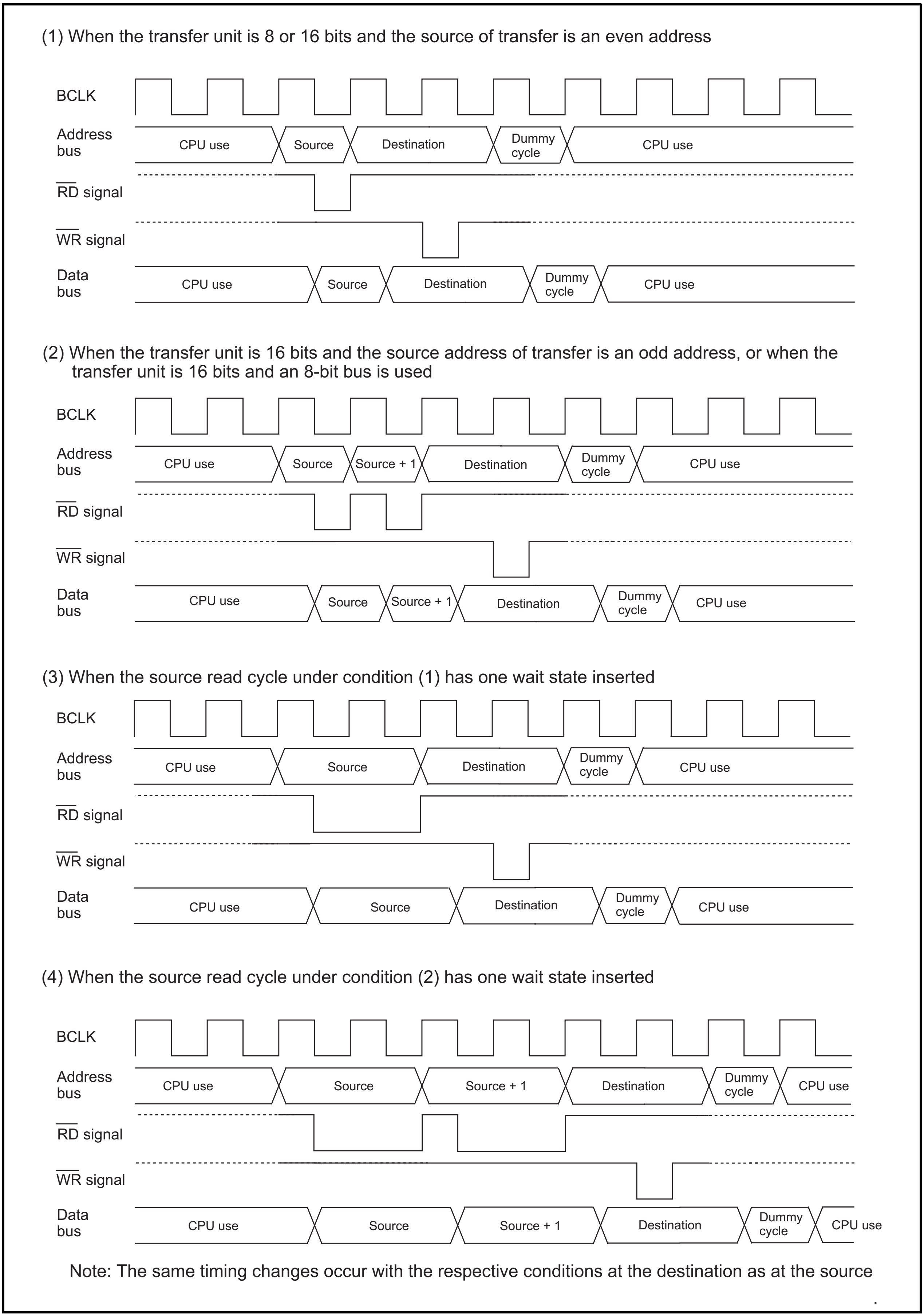
If the transfer unit and data bus both are 16 bits and the source address of transfer begins with an odd address, the source read cycle consists of one more bus cycle than when the source address of transfer begins with an even address.

Similarly, if the transfer unit and data bus both are 16 bits and the destination address of transfer begins with an odd address, the destination write cycle consists of one more bus cycle than when the destination address of transfer begins with an even address.

(b) Effect of Software Wait

For memory or SFR accesses in which one or more software wait states are inserted, the number of bus cycles required for that access increases by an amount equal to software wait states.

Figure 8.5 shows the example of the cycles for a source read. For convenience, the destination write cycle is shown as one cycle and the source read cycles for the different conditions are shown. In reality, the destination write cycle is subject to the same conditions as the source read cycle, with the transfer cycle changing accordingly. When calculating transfer cycles, take into consideration each condition for the source read and the destination write cycle, respectively. For example, when data is transferred in 16 bit units using an 8-bit bus ((2) in Figure 8.5), two source read bus cycles and two destination write bus cycles are required.


(1) When the transfer unit is 8 or 16 bits and the source of transfer is an even address

(2) When the transfer unit is 16 bits and the source address of transfer is an odd address, or when the transfer unit is 16 bits and an 8-bit bus is used

(3) When the source read cycle under condition (1) has one wait state inserted

(4) When the source read cycle under condition (2) has one wait state inserted

Note: The same timing changes occur with the respective conditions at the destination as at the source

Figure 8.5 Transfer Cycles for Source Read

8.2 Number of DMA Transfer Cycles

Any combination of even or odd transfer read and write addresses is possible. Table 8.2 shows the number of DMA transfer cycles. Table 8.3 shows the Coefficient j, k.
The number of DMAC transfer cycles can be calculated as follows:

No. of transfer cycles per transfer unit = No. of read cycles x j + No. of write cycles x k

Table 8.2 Number of DMA Transfer Cycles

Transfer unit	Bus width	Access address	Single-chip mode	
			No. of read cycles	No. of write cycles
8-bit transfers (DMBIT= “1”)	16-bit (BYTE= “L”)	Even	1	1
		Odd	1	1
16-bit transfers (DMBIT= “0”)	16-bit (BYTE = “L”)	Even	1	1
		Odd	2	2

Table 8.3 Coefficient j, k

	Internal area		
	Internal ROM, RAM		SFR
	No wait	With wait	
j	1	2	2
k	1	2	2

8.3 DMA Enable

When a data transfer starts after setting the DMAE bit in DMiCON register (i = 0, 1) to “1” (enabled), the DMAC operates as follows:

(1) Reload the forward address pointer with the SARi register value when the DSD bit in DMiCON register is “1” (forward) or the DARi register value when the DAD bit of DMiCON register is “1” (forward).
(2) Reload the DMAi transfer counter with the DMAi transfer counter reload register value.

If the DMAE bit is set to “1” again while it remains set, the DMAC performs the above operation. However, if a DMA request may occur simultaneously when the DMAE bit is being written, follow the steps below.
Step 1: Write “1” to the DMAE bit and DMAS bit in DMiCON register simultaneously.
Step 2: Make sure that the DMAi is in an initial state as described above (1) and (2) in a program.
If the DMAi is not in an initial state, the above steps should be repeated.

8.4 DMA Request

The DMAC can generate a DMA request as triggered by the cause of request that is selected with the DMS and DSEL3 to DSEL0 bits of DMiSL register (i = 0, 1) on either channel. Table 8.4 shows the timing at which the DMAS bit changes state.

Whenever a DMA request is generated, the DMAS bit is set to “1” (DMA requested) regardless of whether or not the DMAE bit is set. If the DMAE bit was set to “1” (enabled) when this occurred, the DMAS bit is set to “0” (DMA not requested) immediately before a data transfer starts. This bit cannot be set to “1” in a program (it can only be set to “0”).

The DMAS bit may be set to “1” when the DMS or the DSEL3 to DSEL0 bits change state. Therefore, always be sure to set the DMAS bit to “0” after changing the DMS or the DSEL3 to DSEL0 bits.

Because if the DMAE bit is “1”, a data transfer starts immediately after a DMA request is generated, the DMAS bit in almost all cases is “0” when read in a program. Read the DMAE bit to determine whether the DMAC is enabled.

Table 8.4 Timing at Which the DMAS Bit Changes State

DMA factor	DMAS bit of the DMiCON register	
	Timing at which the bit is set to “1”	Timing at which the bit is set to “0”
Software trigger	When the DSR bit of DMiSL register is set to “1”	• Immediately before a data transfer starts • When set by writing “0” in a program
Peripheral function	When the interrupt control register for the peripheral function that is selected by the DSEL3 to DSEL0 and DMS bits of DMiSL register has its IR bit set to “1”	

8.5 Channel Priority and DMA Transfer Timing

If both DMA0 and DMA1 are enabled and DMA transfer request signals from DMA0 and DMA1 are detected active in the same sampling period (one period from a falling edge to the next falling edge of BCLK), the DMAS bit on each channel is set to “1” (DMA requested) at the same time. In this case, the DMA requests are arbitrated according to the channel priority, DMA0 > DMA1. The following describes DMAC operation when DMA0 and DMA1 requests are detected active in the same sampling period.

Figure 8.6 shows an example of DMA transfer effected by external factors.

DMA0 request having priority is received first to start a transfer when a DMA0 request and DMA1 request are generated simultaneously. After one DMA0 transfer is completed, a bus arbitration is returned to the CPU. When the CPU has completed one bus access, a DMA1 transfer starts. After one DMA1 transfer is completed, the bus arbitration is again returned to the CPU.

In addition, DMA requests cannot be counted up since each channel has one DMAS bit. Therefore, when DMA requests, as DMA1 in Figure 8.6, occurs more than one time, the DMAS bit is set to “0” as soon as getting the bus arbitration. The bus arbitration is returned to the CPU when one transfer is completed.

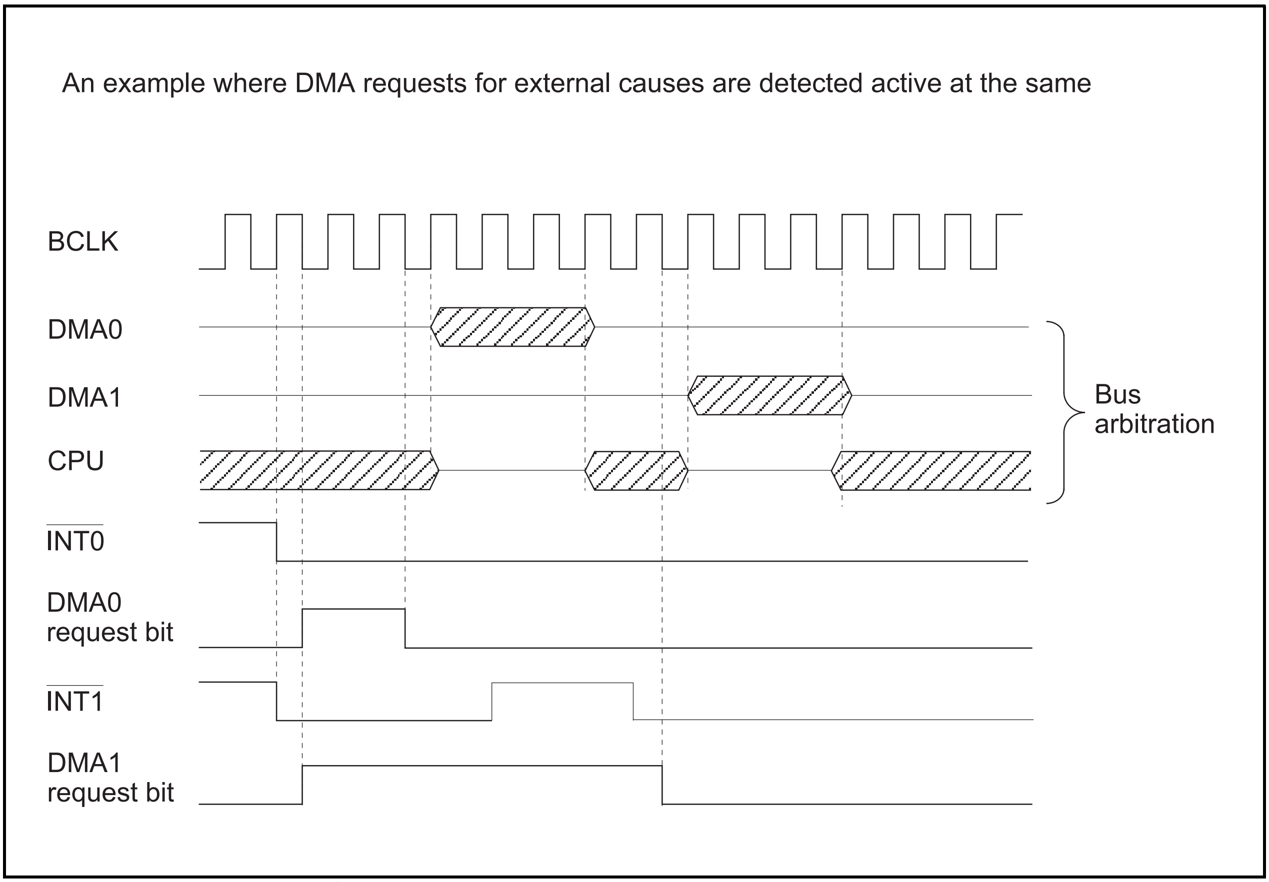
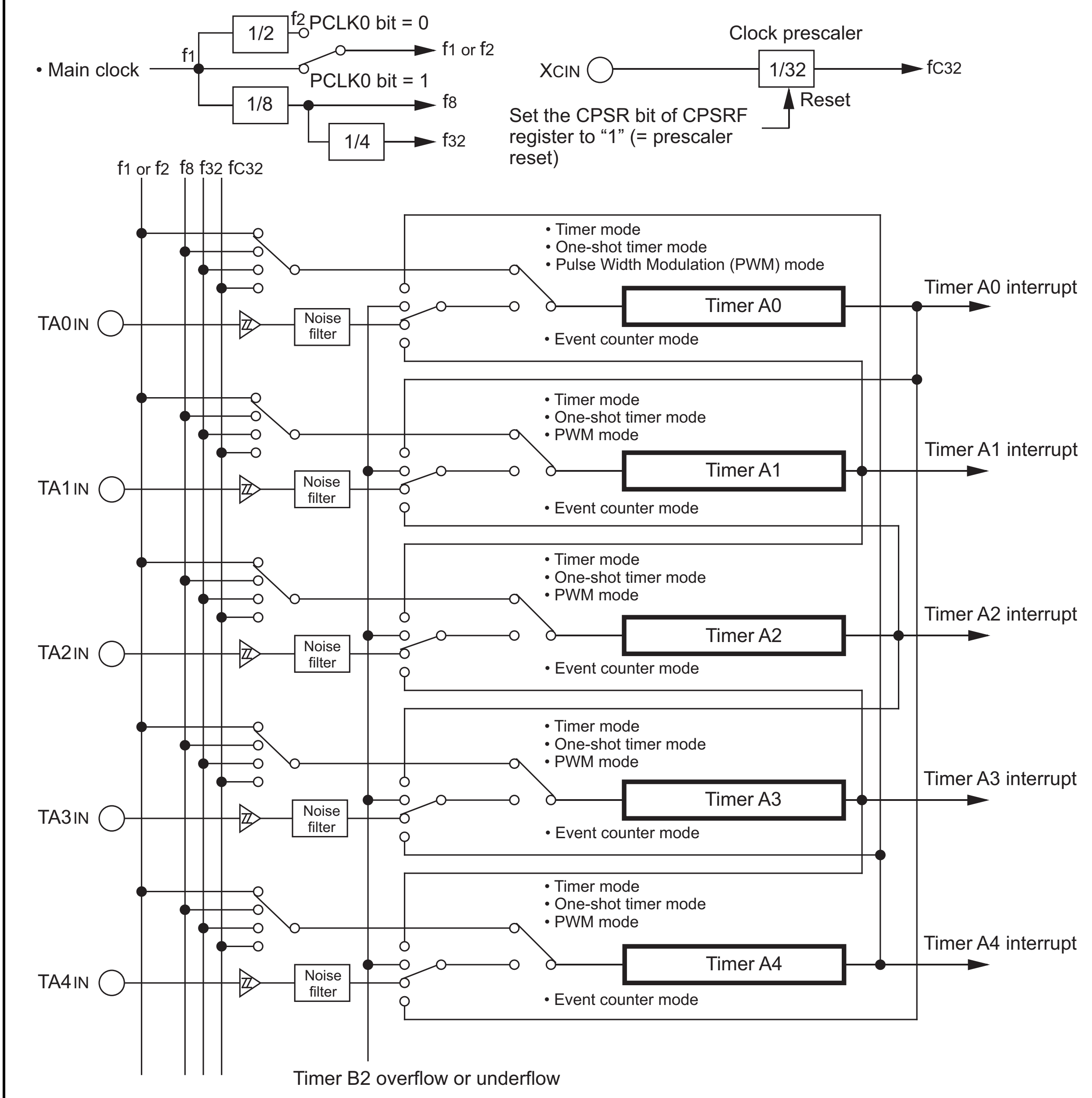


Figure 8.6 DMA Transfer by External Factors

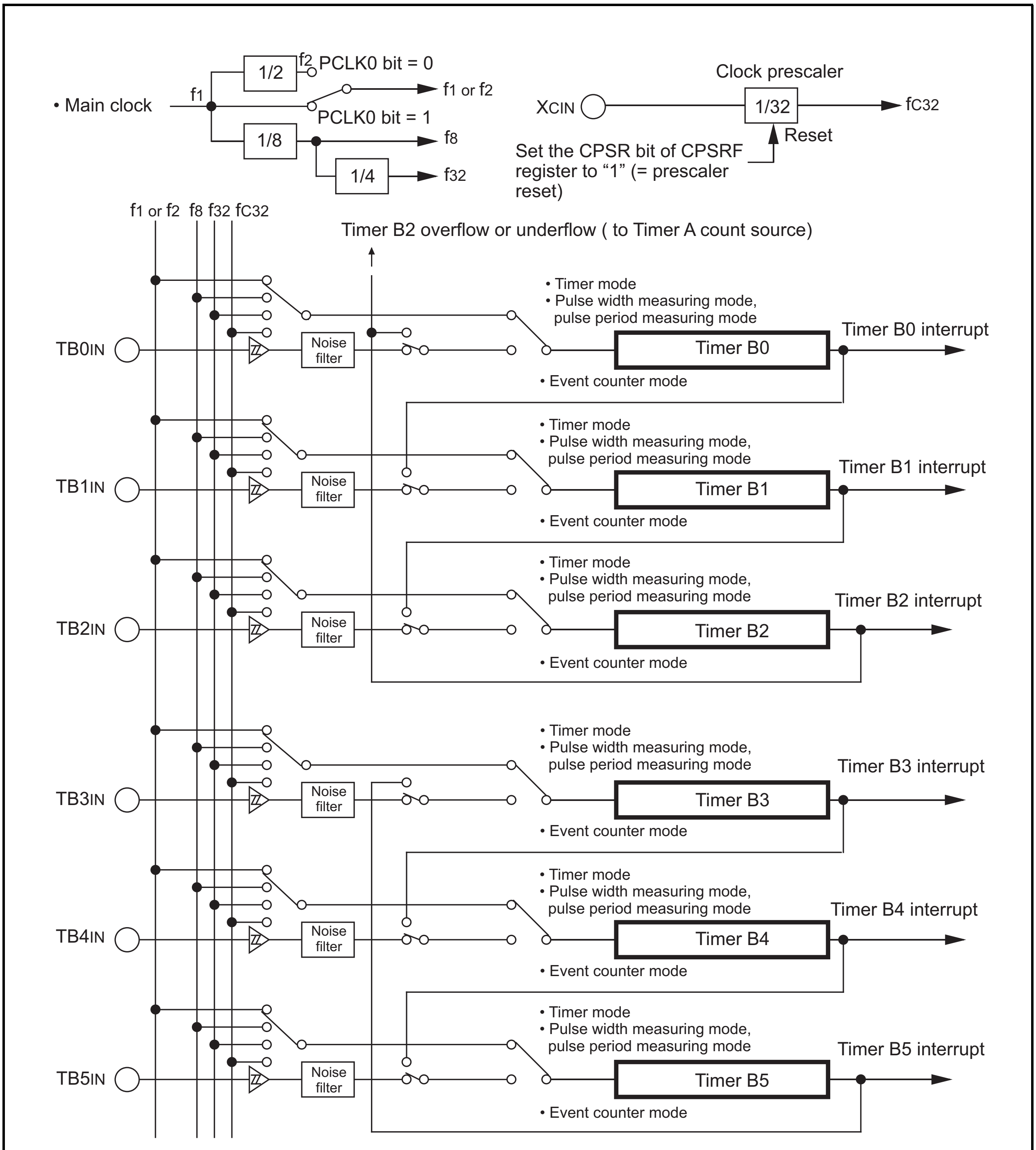
9. Timers

Eleven 16-bit timers, each capable of operating independently of the others, can be classified by function as either timer A (five) and timer B (six). The count source for each timer acts as a clock, to control such timer operations as counting, reloading, etc. Figures 9.1 and 9.2 show block diagrams of timer A and timer B configuration, respectively.



Note: Be aware that TA0IN shares the pin with RxD2 and TB5IN.

Figure 9.1 Timer A Configuration



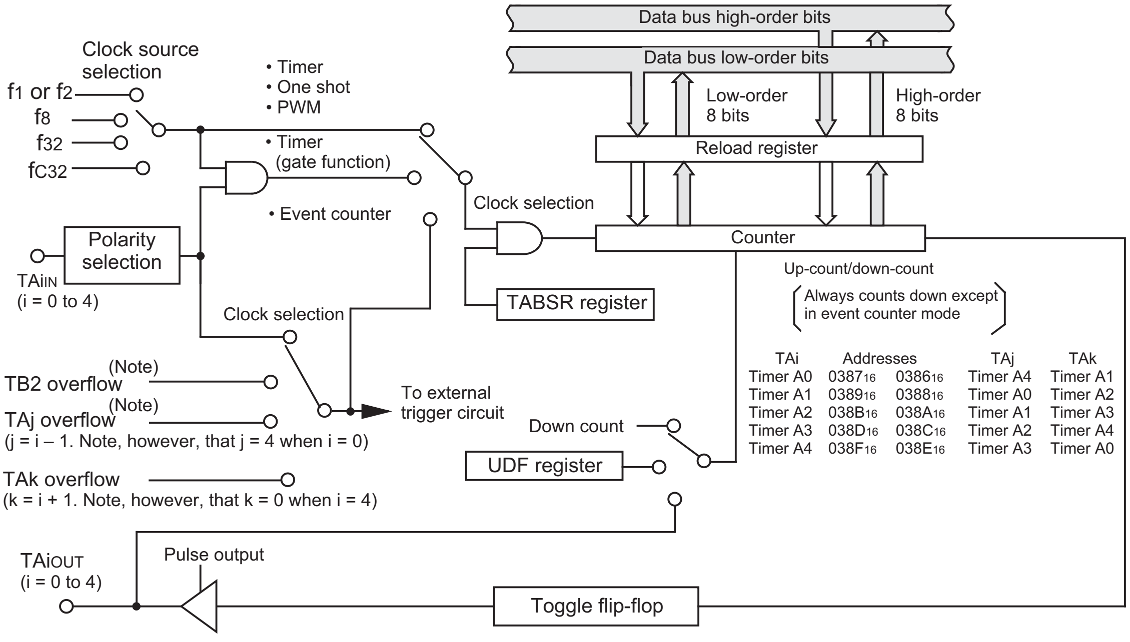
Note: Be aware that TB5IN shares the pin with RxD2 and TA0IN.

Figure 9.2 Timer B Configuration

9.1 Timer A

Figure 9.3 shows a block diagram of the timer A. Figures 9.4 to 9.6 show registers related to the timer A.
The timer A supports the following four modes. Except in event counter mode, timers A0 to A4 all have the same function. Use the TMOD1 to TMOD0 bits of TAiMR register (i = 0 to 4) to select the desired mode.

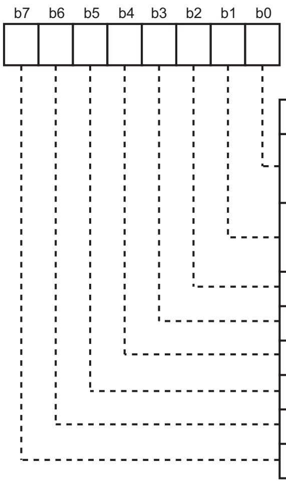
- Timer mode: The timer counts an internal count source.
- Event counter mode: The timer counts pulses from an external device or overflows and underflows of other timers.
- One-shot timer mode: The timer outputs a pulse only once before it reaches the minimum count “0000$_{16}$.”
- Pulse width modulation (PWM) mode: The timer outputs pulses in a given width successively.



Note: Overflow or underflow

Figure 9.3 Timer A Block Diagram

Timer Ai mode register (i=0 to 4)

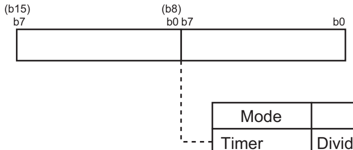


Symbol	Address	After reset
TA0MR to TA4MR	0396$_{16}$ to 039A$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 0 : Timer mode 0 1 : Event counter mode 1 0 : One-shot timer mode 1 1 : Pulse width modulation (PWM) mode	RW
TMOD1			RW
MR0	————	Function varies with each operation mode	RW
MR1			RW
MR2			RW
MR3			RW
TCK0	Count source select bit	Function varies with each operation mode	RW
TCK1			RW

Figure 9.4 TA0MR to TA4MR Registers

Timer Ai register (i= 0 to 4) (Note 1)

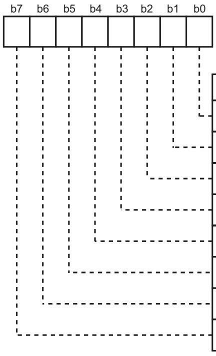


Symbol	Address	After reset
TA0	0387_{16}, 0386_{16}	Indeterminate
TA1	0389_{16}, 0388_{16}	Indeterminate
TA2	$038B_{16}$, $038A_{16}$	Indeterminate
TA3	$038D_{16}$, $038C_{16}$	Indeterminate
TA4	$038F_{16}$, $038E_{16}$	Indeterminate

Mode	Function	Setting range	RW
Timer mode	Divide the count source by n + 1 where n = set value	0000_{16} to $FFFF_{16}$	RW
Event counter mode	Divide the count source by $FFFF_{16}$ – n + 1 where n = set value when counting up or by n + 1 when counting down (Note 5)	0000_{16} to $FFFF_{16}$	RW
One-shot timer mode	Divide the count source by n where n = set value and cause the timer to stop	0000_{16} to $FFFF_{16}$ (Notes 2, 4)	WO
Pulse width modulation mode (16-bit PWM)	Modify the pulse width as follows: PWM period: $(2^{16} – 1) / fj$ High level PWM pulse width: n / fj where n = set value, fj = count source frequency	0000_{16} to $FFFE_{16}$ (Note 3, 4)	WO
Pulse width modulation mode (8-bit PWM)	Modify the pulse width as follows: PWM period: $(2^8 – 1) \times (m + 1)/ fj$ High level PWM pulse width: $(m + 1)n / fj$ where n = high-order address set value, m = low-order address set value, fj = count source frequency	00_{16} to FE_{16} (High-order address) 00_{16} to FF_{16} (Low-order address) (Note 3, 4)	WO

Note 1: The register must be accessed in 16 bit units.
Note 2: If the TAi register is set to ‘0000_{16},’ the counter does not work and timer Ai interrupt requests are not generated either. Furthermore, if “pulse output” is selected, no pulses are output from the TAiOUT pin.
Note 3: If the TAi register is set to ‘0000_{16},’ the pulse width modulator does not work, the output level on the TAiOUT pin remains low, and timer Ai interrupt requests are not generated either. The same applies when the 8 high-order bits of the timer TAi register are set to ‘001 6’ while operating as an 8-bit pulse width modulator.
Note 4: Use the MOV instruction to write to the TAi register.
Note 5: The timer counts pulses from an external device or overflows or underflows in other timers.

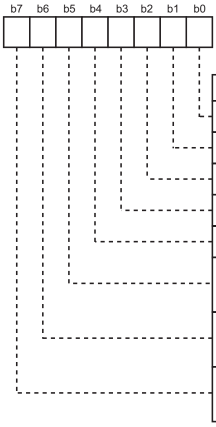
Count start flag



Symbol	Address	After reset
TABSR	0380_{16}	00_{16}

Bit symbol	Bit name	Function	RW
TA0S	Timer A0 count start flag	0 : Stops counting 1 : Starts counting	RW
TA1S	Timer A1 count start flag		RW
TA2S	Timer A2 count start flag		RW
TA3S	Timer A3 count start flag		RW
TA4S	Timer A4 count start flag		RW
TB0S	Timer B0 count start flag		RW
TB1S	Timer B1 count start flag		RW
TB2S	Timer B2 count start flag		RW

Up/down flag (Note 1)



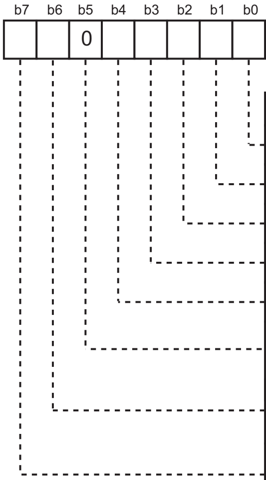
Symbol	Address	After reset
UDF	0384_{16}	00_{16}

Bit symbol	Bit name	Function	RW
TA0UD	Timer A0 up/down flag	0 : Down count 1 : Up count Enabled by setting the TAiMR register’s MR2 bit to “0” (= switching source in UDF register) during event counter mode.	RW
TA1UD	Timer A1 up/down flag		RW
TA2UD	Timer A2 up/down flag		RW
TA3UD	Timer A3 up/down flag		RW
TA4UD	Timer A4 up/down flag		RW
TA2P	Timer A2 two-phase pulse signal processing select bit	0 : two-phase pulse signal processing disabled 1 : two-phase pulse signal processing enabled (Notes 2, 3)	WO
TA3P	Timer A3 two-phase pulse signal processing select bit		WO
TA4P	Timer A4 two-phase pulse signal processing select bit		WO

Note 1: Use MOV instruction to write to this register.
Note 2: Make sure the port direction bits for the TA2IN to TA4IN and TA2OUT to TA4OUT pins are set to “0” (input mode).
Note 3: When not using the two-phase pulse signal processing function, set the bit corresponding to timer A2 to timer A4 to “0”

Figure 9.5 TA0 to TA4 Registers, TABSR Register, and UDF Register

One-shot start flag

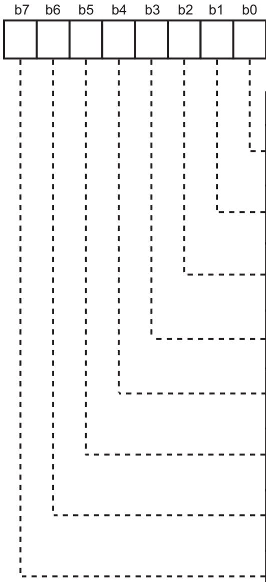


Symbol	Address	After reset
ONSF	0382_{16}	00_{16}

Bit symbol	Bit name	Function	RW
TA0OS	Timer A0 one-shot start flag	The timer starts counting by setting this bit to “1” while the TMOD1 to TMOD0 bits of TAiMR register (i = 0 to 4) = ‘10_2’ (= one-shot timer mode) and the MR2 bit of TAiMR register = “0” (=TAiOS bit enabled). When read, its content is “0”.	RW
TA1OS	Timer A1 one-shot start flag		RW
TA2OS	Timer A2 one-shot start flag		RW
TA3OS	Timer A3 one-shot start flag		RW
TA4OS	Timer A4 one-shot start flag		RW
—— (b5)	Reserved bit	Must be set to “0”	RW
TA0TGL	Timer A0 event/trigger select bit	b7 b6 0 0 : Input on TA0$_{IN}$ is selected (Note 1) 0 1 : TB2 overflow is selected (Note 2) 1 0 : TA4 overflow is selected (Note 2) 1 1 : TA1 overflow is selected (Note 2)	RW
TA0TGH			RW

Note 1: Make sure the PD7_1 bit of PD7 register is set to “0” (= input mode).
Note 2: Overflow or underflow

Trigger select register

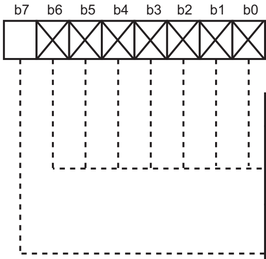


Symbol	Address	After reset
TRGSR	0383_{16}	00_{16}

Bit symbol	Bit name	Function	RW
TA1TGL	Timer A1 event/trigger select bit	b1 b0 0 0 : Input on TA1$_{IN}$ is selected (Note 1) 0 1 : TB2 is selected 1 0 : TA0 is selected 1 1 : TA2 is selected	RW
TA1TGH			RW
TA2TGL	Timer A2 event/trigger select bit	b3 b2 0 0 : Input on TA2$_{IN}$ is selected (Note 1) 0 1 : TB2 is selected 1 0 : TA1 is selected 1 1 : TA3 is selected	RW
TA2TGH			RW
TA3TGL	Timer A3 event/trigger select bit	b5 b4 0 0 : Input on TA3$_{IN}$ is selected (Note 1) 0 1 : TB2 is selected 1 0 : TA2 is selected 1 1 : TA4 is selected	RW
TA3TGH			RW
TA4TGL	Timer A4 event/trigger select bit	b7 b6 0 0 : Input on TA4$_{IN}$ is selected (Note 1) 0 1 : TB2 is selected 1 0 : TA3 is selected 1 1 : TA0 is selected	RW
TA4TGH			RW

Note 1: Make sure the port direction bits for the TA1$_{IN}$ to TA4$_{IN}$ pins are set to “0” (= input mode).

Clock prescaler reset flag



Symbol	Address	After reset
CPSRF	0381_{16}	$0XXXXXXX_2$

Bit symbol	Bit name	Function	RW
—— (b6-b0)	Nothing is assigned. When write, set to “0”. When read, their contents are indeterminate.		—
CPSR	Clock prescaler reset flag	Setting this bit to “1” initializes the prescaler for the timekeeping clock. (When read, its content is “0”.)	RW

Figure 9.6 ONSF Register, TRGSR Register, and CPSRF Register

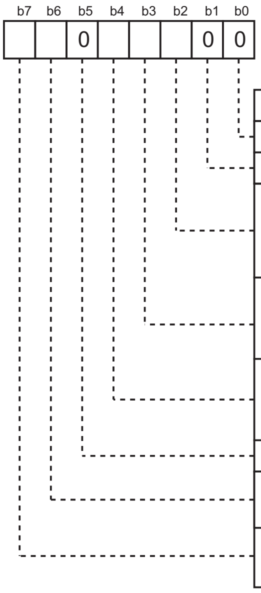
9.1.1 Timer Mode

In timer mode, the timer counts a count source generated internally (see Table 9.1). Figure 9.7 shows TAiMR register in timer mode.

Table 9.1 Specifications in Timer Mode

Item	Specification
Count source	f_1, f_2, f_8, f_{32}, f_{C32}
Count operation	• Down-count • When the timer underflows, it reloads the reload register contents and continues counting
Divide ratio	1/(n+1) n: set value of TAi register (i= 0 to 4) 0000_{16} to $FFFF_{16}$
Count start condition	Set TAiS bit of TABSR register to “1” (= start counting)
Count stop condition	Set TAiS bit to “0” (= stop counting)
Interrupt request generation timing	Timer underflow
TAiIN pin function	I/O port or gate input
TAiOUT pin function	I/O port or pulse output
Read from timer	Count value can be read by reading TAi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TAi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TAi register is written to only reload register (Transferred to counter when reloaded next)
Select function	• Gate function Counting can be started and stopped by an input signal to TAiIN pin • Pulse output function Whenever the timer underflows, the output polarity of TAiOUT pin is inverted. When not counting, the pin outputs a low.

Timer Ai mode register (i=0 to 4)



Symbol	Address	After reset
TA0MR to TA4MR	0396_{16} to $039A_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 0 : Timer mode	RW
TMOD1			RW
MR0	Pulse output function select bit	0 : Pulse is not output (TAiOUT pin is a normal port pin) 1 : Pulse is output (Note 1) (TAiOUT pin is a pulse output pin)	RW
MR1	Gate function select bit	b4 b3 0 0 : } Gate function not available 0 1 : } (TAiIN pin functions as I/O port) 1 0 : Counts while input on the TAiIN pin is low (Note 2) 1 1 : Counts while input on the TAiIN pin is high (Note 2)	RW
MR2			RW
MR3	Must be set to “0” in timer mode		RW
TCK0	Count source select bit	b7 b6 0 0 : f_1 or f_2 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	RW
TCK1			RW

Note 1: TA0OUT pin is N-channel open drain output.
Note 2: The port direction bit for the TAiIN pin must be set to “0” (= input mode).

Figure 9.7 Timer Ai Mode Register in Timer Mode

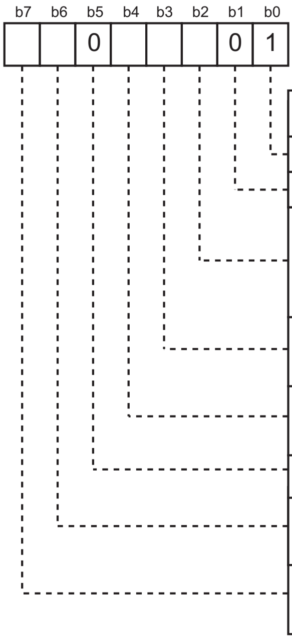
9.1.2 Event Counter Mode

In event counter mode, the timer counts pulses from an external device or overflows and underflows of other timers. Timers A2, A3 and A4 can count two-phase external signals. Table 9.2 lists specifications in event counter mode (when not processing two-phase pulse signal). Table 9.3 lists specifications in event counter mode (when processing two-phase pulse signal with the timers A2, A3 and A4). Figure 9.8 shows TAiMR register in event counter mode (when not processing two-phase pulse signal). Figure 9.9 shows TA2MR to TA4MR registers in event counter mode (when processing two-phase pulse signal with the timers A2, A3 and A4).

Table 9.2 Specifications in Event Counter Mode (when not processing two-phase pulse signal)

Item	Specification
Count source	• External signals input to TAiIN pin (i=0 to 4) (effective edge can be selected in program) • Timer B2 overflows or underflows, timer Aj (j=i-1, except j=4 if i=0) overflows or underflows, timer Ak (k=i+1, except k=0 if i=4) overflows or underflows
Count operation	• Up-count or down-count can be selected by external signal or program • When the timer overflows or underflows, it reloads the reload register contents and continues counting. When operating in free-running mode, the timer continues counting without reloading.
Divided ratio	1/ ($FFFF_{16}$ - n + 1) for up-count 1/ (n + 1) for down-count n : set value of TAi register 0000_{16} to $FFFF_{16}$
Count start condition	Set TAiS bit of TABSR register to “1” (= start counting)
Count stop condition	Set TAiS bit to “0” (= stop counting)
Interrupt request generation timing	Timer overflow or underflow
TAiIN pin function	I/O port or count source input
TAiOUT pin function	I/O port, pulse output, or up/down-count select input
Read from timer	Count value can be read by reading TAi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TAi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TAi register is written to only reload register (Transferred to counter when reloaded next)
Select function	• Free-run count function Even when the timer overflows or underflows, the reload register content is not reloaded to it • Pulse output function Whenever the timer overflows or underflows, the output polarity of TAiOUT pin is inverted . When not counting, the pin outputs a low.

Timer Ai mode register (i=0 to 4)
(When not using two-phase pulse signal processing)



Symbol	Address	After reset
TA0MR to TA4MR	0396_{16} to $039A_{16}$	00_{16}

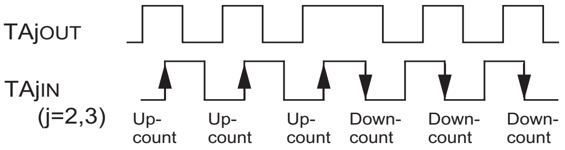
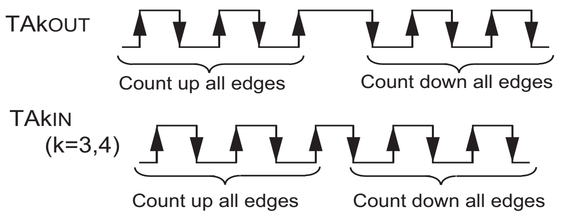
Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 1 : Event counter mode (Note 1)	RW
TMOD1			RW
MR0	Pulse output function select bit	0 : Pulse is not output (TAiOUT pin functions as I/O port) 1 : Pulse is output (Note 2) (TAiOUT pin functions as pulse output pin)	RW
MR1	Count polarity select bit (Note 3)	0 : Counts external signal's falling edge 1 : Counts external signal's rising edge	RW
MR2	Up/down switching cause select bit	0 : UDF register 1 : Input signal to TAiOUT pin (Note 4)	RW
MR3	Must be set to “0” in event counter mode		RW
TCK0	Count operation type select bit	0 : Reload type 1 : Free-run type	RW
TCK1	Can be “0” or “1” when not using two-phase pulse signal processing		RW

Note 1: During event counter mode, the count source can be selected using the ONSF and TRGSR registers.
Note 2: TA0OUT pin is N-channel open drain output.
Note 3: Effective when the TAiGH and TAiGL bits of ONSF or TRGSR register are ‘00_2’ (TAiIN pin input).
Note 4: Count down when input on TAiOUT pin is low or count up when input on that pin is high. The port direction bit for TAiOUT pin must be set to “0” (= input mode).

Figure 9.8 TAiMR Register in Event Counter Mode (when not using two-phase pulse signal processing)

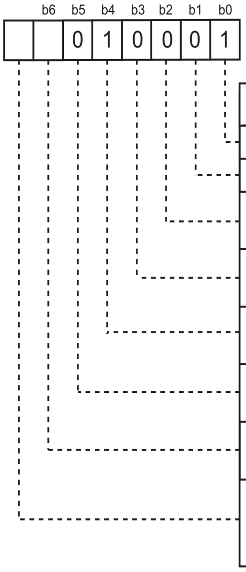
The use of the event counter mode (When you use two aspect pulse signal processing with Timer A2, A3, and A4) is shown in Table 9.3.
Figure 9.9 shows from TA2MR register to TA4MR register (When you use two aspect pulse signal processing with timer A2, A3, and A4) at event counter mode.

Table 9.3 Specifications in Event Counter Mode (when processing two-phase pulse signal with timers A2, A3 and A4))

Item	Specification
Count source	• Two-phase pulse signals input to TAiIN or TAiOUT pins (i = 2 to 4)
Count operation	• Up-count or down-count can be selected by two-phase pulse signal • When the timer overflows or underflows, it reloads the reload register contents and continues counting. When operating in free-running mode, the timer continues counting without reloading.
Divide ratio	1/ ($FFFF_{16}$ - n + 1) for up-count 1/ (n + 1) for down-count n : set value of TAi register 0000_{16} to $FFFF_{16}$
Count start condition	Set TAiS bit of TABSR register to “1” (= start counting)
Count stop condition	Set TAiS bit to “0” (= stop counting)
Interrupt request generation timing	Timer overflow or underflow
TAiIN pin function	Two-phase pulse input
TAiOUT pin function	Two-phase pulse input
Read from timer	Count value can be read by reading timer A2, A3 or A4 register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TAi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TAi register is written to reload register (Transferred to counter when reloaded next)
Select function (Note)	• Normal processing operation (timer A2 and timer A3) The timer counts up rising edges or counts down falling edges on TAjIN pin when input signals on TAjOUT pin is “H”.  • Multiply-by-4 processing operation (timer A3 and timer A4) If the phase relationship is such that TAkIN(k=3, 4) pin goes “H” when the input signal on TAkOUT pin is “H”, the timer counts up rising and falling edges on TAkOUT and TAkIN pins. If the phase relationship is such that TAkIN pin goes “L” when the input signal on TAkOUT pin is “H”, the timer counts down rising and falling edges on TAkOUT and TAkIN pins. 

Notes:
1. Only timer A3 is selectable. Timer A2 is fixed to normal processing operation, and timer A4 is fixed to multiply-by-4 processing operation.

Timer Ai mode register (i=2 to 4)
(When using two-phase pulse signal processing)



Symbol	Address	After reset
TA2MR to TA4MR	0398_{16} to $039A_{16}$	00_{16}

	Bit name	Function	RW
TMOD0 TMOD1	Operation mode select bit	b1 b0 0 1 : Event counter mode	RW RW
MR0	To use two-phase pulse signal processing, set this bit to "0".		RW
MR1	To use two-phase pulse signal processing, set this bit to "0".		RW
MR2	To use two-phase pulse signal processing, set this bit to "1".		RW
MR3	To use two-phase pulse signal processing, set this bit to "0".		RW
TCK0	Count operation type select bit	0 : Reload type 1 : Free-run type	RW
TCK1	Two-phase pulse signal processing operation select bit (Note 1)(Note 2)	0 : Normal processing operation 1 : Multiply-by-4 processing operation	RW

Note 1: TCK1 bit is valid for timer A3 mode register. No matter how this bit is set, timers A2 and A4 always operate in normal processing mode and x4 processing mode, respectively.

Note 2: If two-phase pulse signal processing is desired, following register settings are required:

- Set the UDF register's TAiP bit to "1" (two-phase pulse signal processing function enabled) .
- Set the TRGSR register's TAiGH and TAiGL bits to "00_2" (TAiIN pin input).
- Set the port direction bits for TA $_{\text{iIN}}$ and TAi$_{\text{OUT}}$ to "0" (input mode).

Figure 9.9 **TA2MR to TA4MR Registers in Event Counter Mode (when using two-phase pulsesignal processing with timer A2, A3 or A4)**

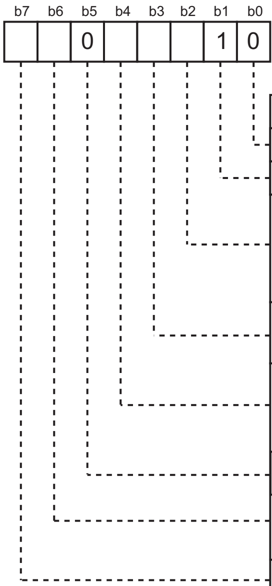
9.1.3 One-shot Timer Mode

In one-shot timer mode, the timer is activated only once by one trigger. (See Table 9.4.) When the trigger occurs, the timer starts up and continues operating for a given period. Figure 9.10 shows the TAiMR register in one-shot timer mode.

Table 9.4 Specifications in One-shot Timer Mode

Item	Specification
Count source	f_1, f_2, f_8, f_{32}, fC_{32}
Count operation	• Down-count • When the counter reaches 0000_{16}, it stops counting after reloading a new value • If a trigger occurs when counting, the timer reloads a new count and restarts counting
Divide ratio	1/n n : set value of TAi register 0000_{16} to $FFFF_{16}$ However, the counter does not work if the divide-by-n value is set to 0000_{16}.
Count start condition	TAiS bit of TABSR register = "1" (start counting) and one of the following triggers occurs. • External trigger input from the TAiIN pin • Timer B2 overflow or underflow, timer Aj (j=i-1, except j=4 if i=0) overflow or underflow, timer Ak (k=i+1, except k=0 if i=4) overflow or underflow • The TAiOS bit of ONSF register is set to "1" (= timer starts)
Count stop condition	• When the counter is reloaded after reaching "0000_{16}" • TAiS bit is set to "0" (= stop counting)
Interrupt request generation timing	When the counter reaches "0000_{16}"
TAiIN pin function	I/O port or trigger input
TAiOUT pin function	I/O port or pulse output
Read from timer	An indeterminate value is read by reading TAi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TAi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TAi register is written to only reload register (Transferred to counter when reloaded next)
Select function	• Pulse output function The timer outputs a low when not counting and a high when counting.

Timer Ai mode register (i=0 to 4)



Symbol	Address	After reset
TA0MR to TA4MR	0396_{16} to $039A_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 1 0 : One-shot timer mode	RW
TMOD1			RW
MR0	Pulse output function select bit	0 : Pulse is not output (TAiOUT pin functions as I/O port) 1 : Pulse is output (Note 1) (TAiOUT pin functions as a pulse output pin)	RW
MR1	External trigger select bit (Note 2)	0 : Falling edge of input signal to TAiIN pin (Note 3) 1 : Rising edge of input signal to TAiIN pin (Note 3)	RW
MR2	Trigger select bit	0 : TAiOS bit is enabled 1 : Selected by TAiTGH to TAiTGL bits	RW
MR3	Must be set to “0” in one-shot timer mode		RW
TCK0	Count source select bit	b7 b6 0 0 : f_1 or f_2 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	RW
TCK1			RW

Note 1: TA0OUT pin is N-channel open drain output.
Note 2: Effective when the TAiTGH and TAiTGL bits of ONSF or TRGSR register are ‘00_2’ (TAiIN pin input).
Note 3: The port direction bit for the TAiIN pin must be set to “0” (= input mode).

Figure 9.10 TAiMR Register in One-shot Timer Mode

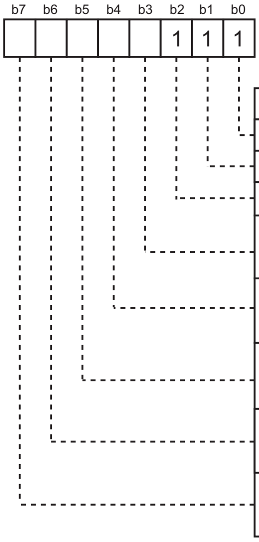
9.1.4 Pulse Width Modulation (PWM) Mode

In PWM mode, the timer outputs pulses of a given width in succession (see Table 9.5). The counter functions as either 16-bit pulse width modulator or 8-bit pulse width modulator. Figure 9.11 shows TAiMR register in pulse width modulation mode. Figures 9.12 and 9.13 show examples of how a 16-bit pulse width modulator operates and how an 8-bit pulse width modulator operates.

Table 9.5 Specifications in PWM Mode

Item	Specification
Count source	f_1, f_2, f_8, f_{32}, f_{C32}
Count operation	• Down-count (operating as an 8-bit or a 16-bit pulse width modulator) • The timer reloads a new value at a rising edge of PWM pulse and continues counting • The timer is not affected by a trigger that occurs during counting
16-bit PWM	• High level width n / fj n : set value of TAi register (i=o to 4) • Cycle time $(2^{16}-1)$ / fj fixed fj: count source frequency (f_1, f_2, f_8, f_{32}, f_{C32})
8-bit PWM	• High level width n x (m+1) / fj n : set value of TAi register high-order address • Cycle time (2^8-1) x (m+1) / fj m : set value of TAi register low-order address
Count start condition	• TAiS bit of TABSR register is set to “1” (= start counting) • The TAiS bit = 1 and external trigger input from the TAiIN pin • The TAiS bit = 1 and one of the following external triggers occurs • Timer B2 overflow or underflow, timer Aj (j=i-1, except j=4 if i=0) overflow or underflow, timer Ak (k=i+1, except k=0 if i=4) overflow or underflow
Count stop condition	TAiS bit is set to “0” (= stop counting)
Interrupt request generation timing	PWM pulse goes “L”
TAiIN pin function	I/O port or trigger input
TAiOUT pin function	Pulse output
Read from timer	An indeterminate value is read by reading TAi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TAi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TAi register is written to only reload register (Transferred to counter when reloaded next)

Timer Ai mode register (i= 0 to 4)

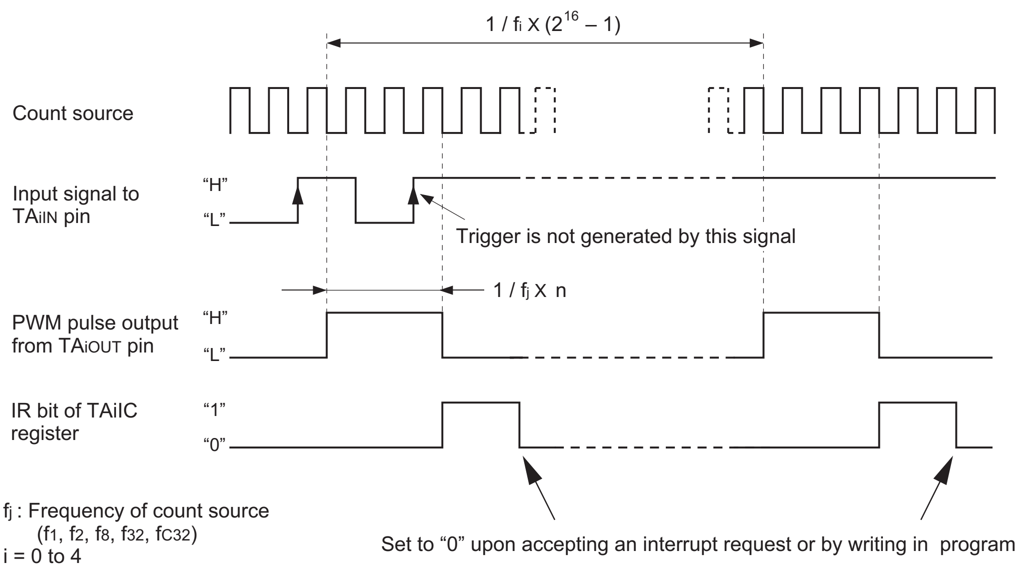


Symbol	Address	After reset
TA0MR to TA4MR	0396_{16} to $039A_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 1 1 : PWM mode (Note 1)	RW
TMOD1			RW
MR0	Must be set to “1” in PWM mode		RW
MR1	External trigger select bit (Note 2)	0: Falling edge of input signal to TAiIN pin(Note 3) 1: Rising edge of input signal to TAiIN pin(Note 3)	RW
MR2	Trigger select bit	0 : Write “1” to TAiS bit in the TABSR register 1 : Selected by TAiTGH to TAiTGL bits	RW
MR3	16/8-bit PWM mode select bit	0: Functions as a 16-bit pulse width modulator 1: Functions as an 8-bit pulse width modulator	RW
TCK0	Count source select bit	b7 b6 0 0 : f_1 or f_2 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	RW
TCK1			RW

Note 1: TA0OUT pin is N-channel open drain output.
Note 2: Effective when the TAiTGH and TAiTGL bits of ONSF or TRGSR register are “00”$_2$ (TAi IN pin input).
Note 3: The port direction bit for the TAiIN pin must be set to “0” (= input mode).

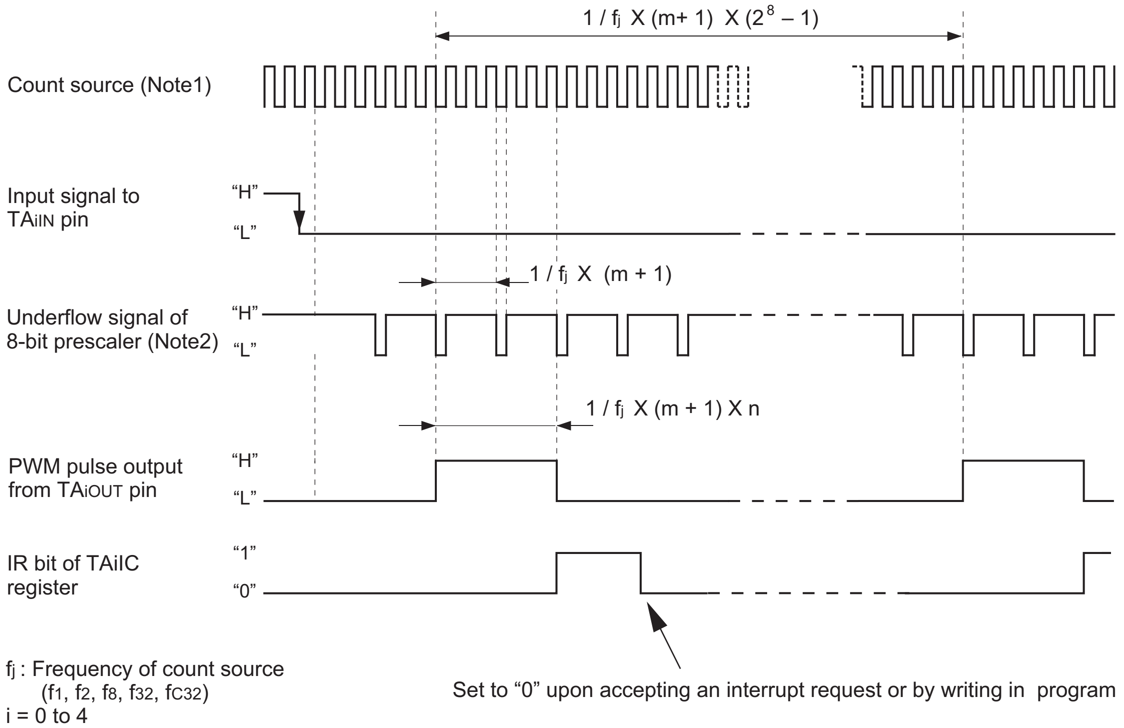
Figure 9.11 TAiMR Register in PWM Mode



fj : Frequency of count source
(f1, f2, f8, f32, fC32)
i = 0 to 4

Note 1: n = 0000_{16} to $FFFE_{16}$.
Note 2: This timing diagram is for the case where the TAi register is '0003_{16},' the TAiTGH and TAiTGL bits of ONSF or TRGSR register = '00_2' (TAiIN pin input), the MR1 bit of TAiMR register = 1 (rising edge), and the MR2 bit of TAiMR register = 1 (trigger selected by TAiTGH and TAiTGL bits).

Figure 9.12 Example of 16-bit Pulse Width Modulator Operation



fj : Frequency of count source
(f1, f2, f8, f32, fC32)
i = 0 to 4

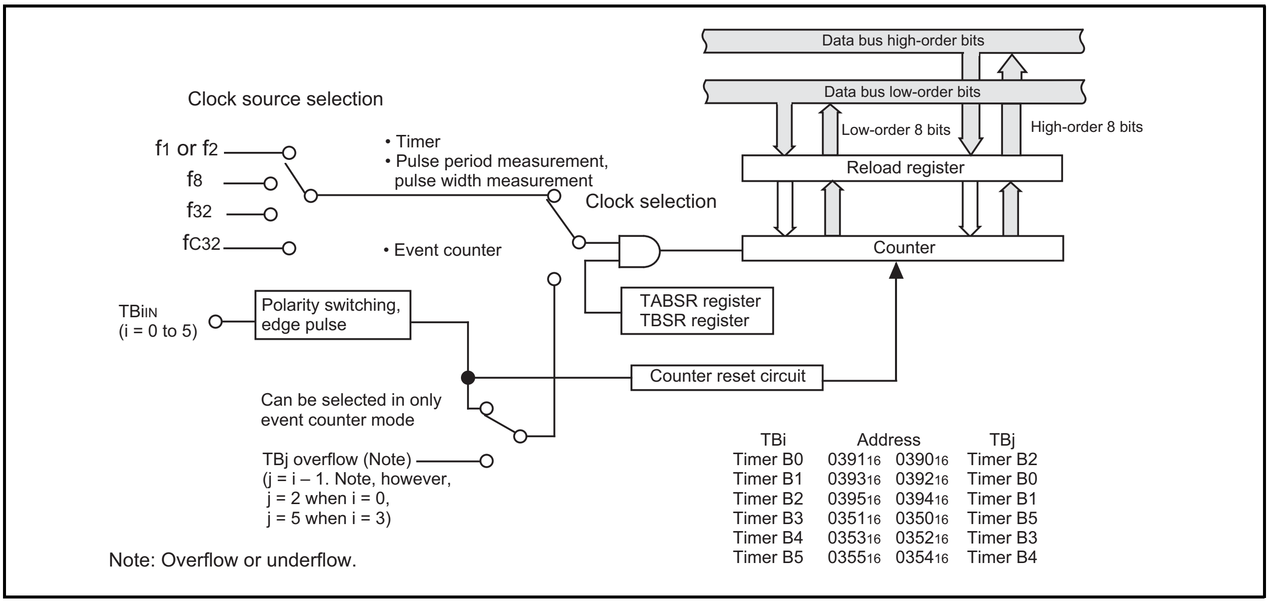
Note 1: The 8-bit prescaler counts the count source.
Note 2: The 8-bit pulse width modulator counts the 8-bit prescaler's underflow signal.
Note 3: m = 00_{16} to FF_{16}; n = 00_{16} to FE_{16}.
Note 4: This timing diagram is for the case where the TAi register is '0202_{16},' the TAiTGH and TAiTGL bits of ONSF or TRGSR register = '00_2' (TAiIN pin input), the MR1 bit of TAiMR register = 0 (falling edge), and the MR2 bit of TAiMR register = 1 (trigger selected by TAiTGH and TAiTGL bits).

Figure 9.13 Example of 8-bit Pulse Width Modulator Operation

9.2 Timer B

Figure 9.14 shows a block diagram of the timer B. Figures 9.15 and 9.16 show registers related to the timer B. Timer B supports the following three modes. Use the TMOD1 and TMOD0 bits of TBiMR register (i = 0 to 5) to select the desired mode.

- Timer mode: The timer counts an internal count source.
- Event counter mode: The timer counts pulses from an external device or overflows or underflows of other timers.
- Pulse period/pulse width measuring mode: The timer measures an external signal's pulse period or pulse width.



TBi	Address		TBj
Timer B0	0391_{16}	0390_{16}	Timer B2
Timer B1	0393_{16}	0392_{16}	Timer B0
Timer B2	0395_{16}	0394_{16}	Timer B1
Timer B3	0351_{16}	0350_{16}	Timer B5
Timer B4	0353_{16}	0352_{16}	Timer B3
Timer B5	0355_{16}	0354_{16}	Timer B4

Figure 9.14 Timer B Block Diagram

Timer Bi mode register (i=0 to 5)

b7 b6 b5 b4 b3 b2 b1 b0

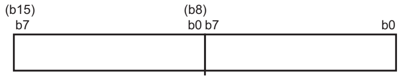
Symbol	Address	After reset
TB0MR to TB2MR	$039B_{16}$ to $039D_{16}$	$00XX0000_2$
TB3MR to TB5MR	$035B_{16}$ to $035D_{16}$	$00XX0000_2$

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 0 : Timer mode 0 1 : Event counter mode 1 0 : Pulse period measurement mode, pulse width measurement mode 1 1 : Must not be set	RW
TMOD1			RW
MR0	———	Function varies with each operation mode	RW
MR1			RW
MR2			RW (Note 1) — (Note 2)
MR3			RO
TCK0	Count source select bit	Function varies with each operation mode	RW
TCK1			RW

Note 1: Timer B0, timer B3.
Note 2: Timer B1, timer B2, timer B4, timer B5.

Figure 9.15 TB0MR to TB5MR Registers

Timer Bi register (i=0 to 5)(Note 1)

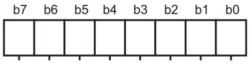


Symbol	Address	After reset
TB0	0391_{16}, 0390_{16}	Indeterminate
TB1	0393_{16}, 0392_{16}	Indeterminate
TB2	0395_{16}, 0394_{16}	Indeterminate
TB3	0351_{16}, 0350_{16}	Indeterminate
TB4	0353_{16}, 0352_{16}	Indeterminate
TB5	0355_{16}, 0354_{16}	Indeterminate

Mode	Function	Setting range	RW
Timer mode	Divide the count source by n + 1 where n = set value	0000_{16} to $FFFF_{16}$	RW
Event counter mode	Divide the count source by n + 1 where n = set value (Note 2)	0000_{16} to $FFFF_{16}$	RW
Pulse period modulation mode, Pulse width modulation mode	Measures a pulse period or width	——	RO

Note 1: The register must be accessed in 16 bit units.
Note 2: The timer counts pulses from an external device or overflows or underflows of other timers.

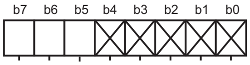
Count start flag



Symbol	Address	After reset
TABSR	0380_{16}	00_{16}

Bit symbol	Bit name	Function	RW
TA0S	Timer A0 count start flag	0 : Stops counting 1 : Starts counting	RW
TA1S	Timer A1 count start flag		RW
TA2S	Timer A2 count start flag		RW
TA3S	Timer A3 count start flag		RW
TA4S	Timer A4 count start flag		RW
TB0S	Timer B0 count start flag		RW
TB1S	Timer B1 count start flag		RW
TB2S	Timer B2 count start flag		RW

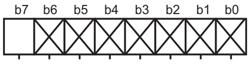
Timer B3, B4, B5 count start flag



Symbol	Address	After reset
TBSR	0340_{16}	$000XXXXX_2$

Bit symbol	Bit name	Function	RW
—— (b4-b0)	Nothing is assigned. When write, set to "0". When read, their contents are indeterminate.		—
TB3S	Timer B3 count start flag	0 : Stops counting 1 : Starts counting	RW
TB4S	Timer B4 count start flag		RW
TB5S	Timer B5 count start flag		RW

Clock prescaler reset flag



Symbol	Address	After reset
CPSRF	0381_{16}	$0XXXXXXX_2$

Bit symbol	Bit name	Function	RW
—— (b6-b0)	Nothing is assigned. When write, set to "0". When read, their contents are indeterminate.		—
CPSR	Clock prescaler reset flag	Setting this bit to "1" initializes the prescaler for the timekeeping clock. (When read, the value of this bit is "0".)	RW

Figure 9.16 TB0 to TB5 Registers, TABSR Register, TBSR Register, CPSRF Register

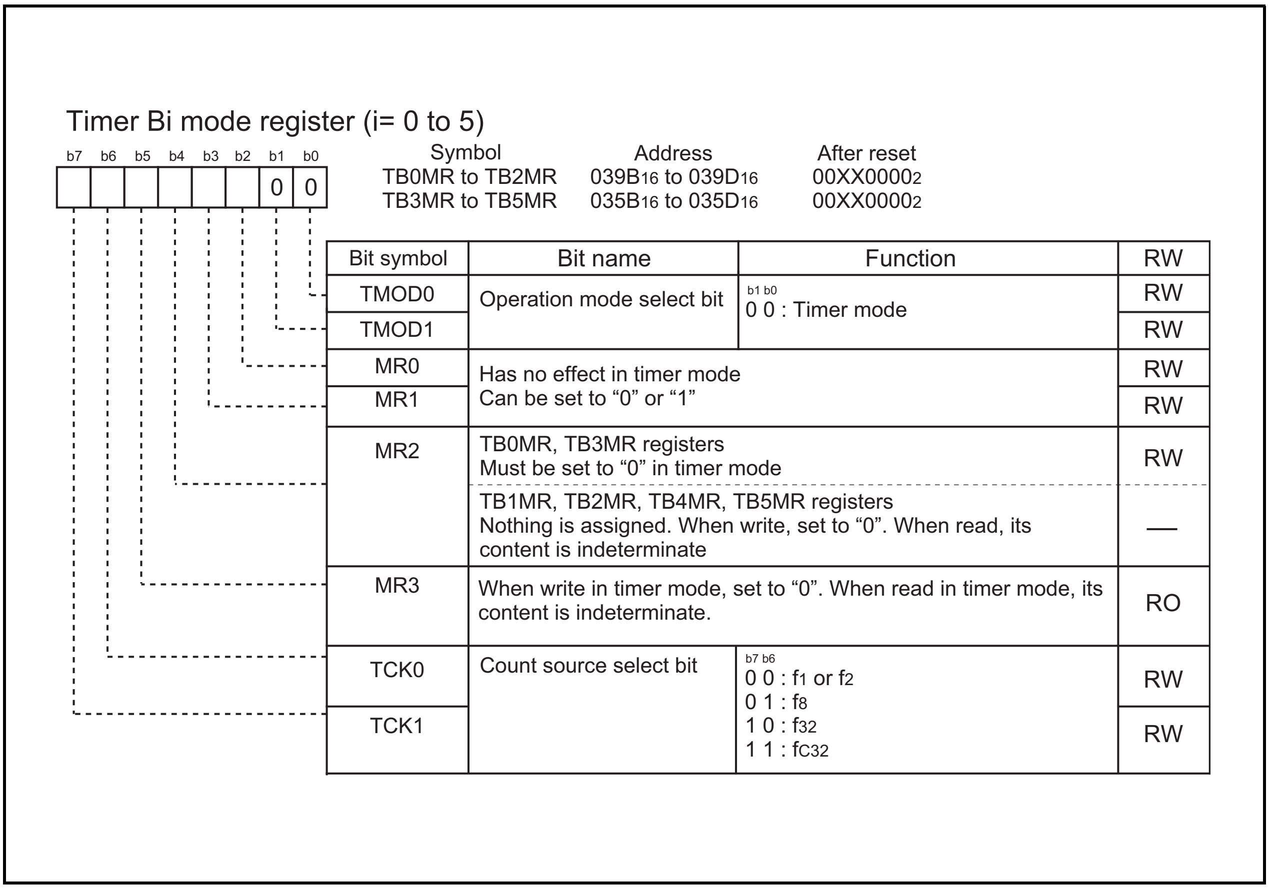
9.2.1 Timer Mode

In timer mode, the timer counts a count source generated internally (see Table 9.6). Figure 9.17 shows TBiMR register in timer mode.

Table 9.6 Specifications in Timer Mode

Item	Specification
Count source	f_1, f_2, f_8, f_{32}, f_{C32}
Count operation	• Down-count • When the timer underflows, it reloads the reload register contents and continues counting
Divide ratio	1/(n+1) n: set value of TBi register (i= 0 to 5) 0000_{16} to $FFFF_{16}$
Count start condition	Set TBiS bit(Note) to “1” (= start counting)
Count stop condition	Set TBiS bit to “0” (= stop counting)
Interrupt request generation timing	Timer underflow
TBiIN pin function	I/O port
Read from timer	Count value can be read by reading TBi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TBi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TBi register is written to only reload register (Transferred to counter when reloaded next)

Note : The TB0S to TB2S bits are assigned to the TABSR register bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register bit 5 to bit 7.



Timer Bi mode register (i= 0 to 5)

Symbol	Address	After reset
TB0MR to TB2MR	$039B_{16}$ to $039D_{16}$	$00XX0000_2$
TB3MR to TB5MR	$035B_{16}$ to $035D_{16}$	$00XX0000_2$

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 0 : Timer mode	RW
TMOD1			RW
MR0	Has no effect in timer mode Can be set to “0” or “1”		RW
MR1			RW
MR2	TB0MR, TB3MR registers Must be set to “0” in timer mode		RW
	TB1MR, TB2MR, TB4MR, TB5MR registers Nothing is assigned. When write, set to “0”. When read, its content is indeterminate		—
MR3	When write in timer mode, set to “0”. When read in timer mode, its content is indeterminate.		RO
TCK0	Count source select bit	b7 b6 0 0 : f_1 or f_2 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	RW
TCK1			RW

Figure 9.17 TBiMR Register in Timer Mode

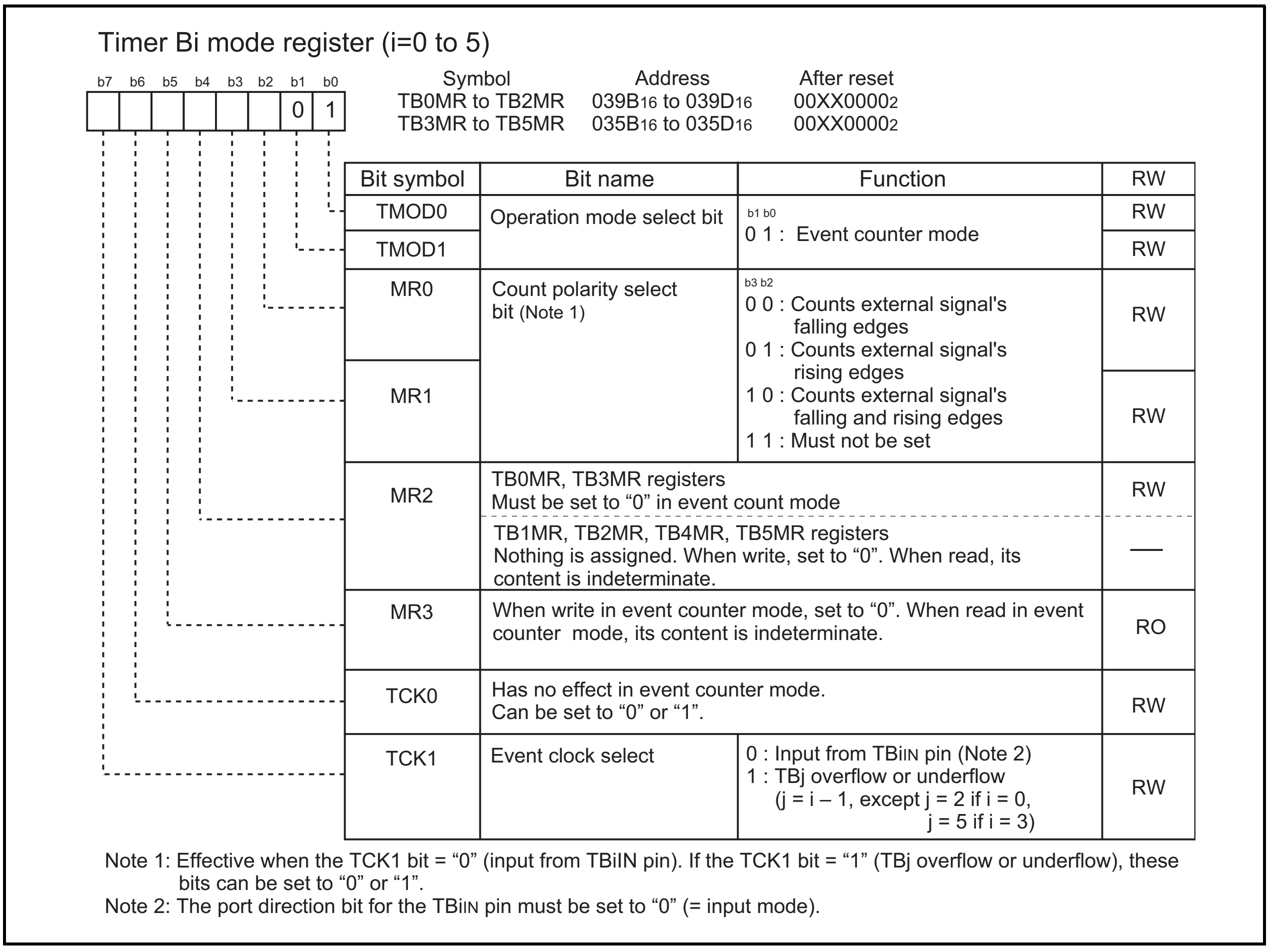
9.2.2 Event Counter Mode

In event counter mode, the timer counts pulses from an external device or overflows and underflows of other timers (see Table 9.7) . Figure 9.18 shows TBiMR register in event counter mode.

Table 9.7 Specifications in Event Counter Mode

Item	Specification
Count source	• External signals input to TBiIN pin (i=0 to 5) (effective edge can be selected in program) • Timer Bj overflow or underflow (j=i-1, except j=2 if i=0, j=5 if i=3)
Count operation	• Down-count • When the timer underflows, it reloads the reload register contents and continues counting
Divide ratio	1/(n+1) n: set value of TBi register 0000_{16} to $FFFF_{16}$
Count start condition	Set TBiS bit[1] to “1” (= start counting)
Count stop condition	Set TBiS bit to “0” (= stop counting)
Interrupt request generation timing	Timer underflow
TBiIN pin function	Count source input
Read from timer	Count value can be read by reading TBi register
Write to timer	• When not counting and until the 1st count source is input after counting start Value written to TBi register is written to both reload register and counter • When counting (after 1st count source input) Value written to TBi register is written to only reload register (Transferred to counter when reloaded next)

Notes:
1. The TB0S to TB2S bits are assigned to the TABSR register bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register bit 5 to bit 7.



Timer Bi mode register (i=0 to 5)

Symbol	Address	After reset
TB0MR to TB2MR	$039B_{16}$ to $039D_{16}$	$00XX0000_2$
TB3MR to TB5MR	$035B_{16}$ to $035D_{16}$	$00XX0000_2$

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 0 1 : Event counter mode	RW
TMOD1			RW
MR0	Count polarity select bit (Note 1)	b3 b2 0 0 : Counts external signal's falling edges 0 1 : Counts external signal's rising edges 1 0 : Counts external signal's falling and rising edges 1 1 : Must not be set	RW
MR1			RW
MR2	TB0MR, TB3MR registers Must be set to “0” in event count mode		RW
	TB1MR, TB2MR, TB4MR, TB5MR registers Nothing is assigned. When write, set to “0”. When read, its content is indeterminate.		—
MR3	When write in event counter mode, set to “0”. When read in event counter mode, its content is indeterminate.		RO
TCK0	Has no effect in event counter mode. Can be set to “0” or “1”.		RW
TCK1	Event clock select	0 : Input from TBiIN pin (Note 2) 1 : TBj overflow or underflow (j = i – 1, except j = 2 if i = 0, j = 5 if i = 3)	RW

Note 1: Effective when the TCK1 bit = “0” (input from TBiIN pin). If the TCK1 bit = “1” (TBj overflow or underflow), these bits can be set to “0” or “1”.
Note 2: The port direction bit for the TBiIN pin must be set to “0” (= input mode).

Figure 9.18 TBiMR Register in Event Counter Mode

9.2.3 Pulse Period and Pulse Width Measurement Mode

In pulse period and pulse width measurement mode, the timer measures pulse period or pulse width of an external signal (see Table 9.8). Figure 9.19 shows TBiMR register in pulse period and pulse width measurement mode. Figure 9.20 shows the operation timing when measuring a pulse period. Figure 9.21 shows the operation timing when measuring a pulse width.

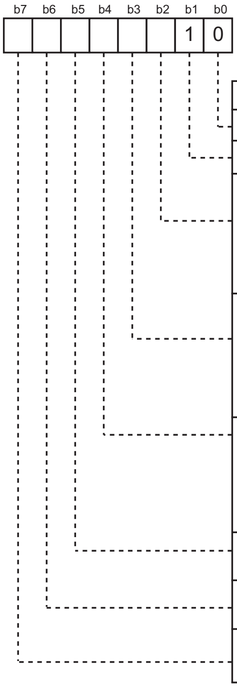
Table 9.8 Specifications in Pulse Period and Pulse Width Measurement Mode

Item	Specification
Count source	f_1, f_2, f_8, f_{32}, f_{C32}
Count operation	• Up-count • Counter value is transferred to reload register at an effective edge of measurement pulse. The counter value is set to “0000_{16}” to continue counting.
Count start condition	Set TBiS (i=0 to 5) bit[3] to “1” (= start counting)
Count stop condition	Set TBiS bit to “0” (= stop counting)
Interrupt request generation timing	• When an effective edge of measurement pulse is input[1] • Timer overflow. When an overflow occurs, MR3 bit of TBiMR register is set to “1” (overflowed) simultaneously. MR3 bit is cleared to “0” (no overflow) by writing to TBiMR register at the next count timing or later after MR3 bit was set to “1”. At this time, make sure TBiS bit is set to “1” (start counting).
TBi_{IN} pin function	Measurement pulse input
Read from timer	Contents of the reload register (measurement result) can be read by reading TBi register[2]
Write to timer	Value written to TBi register is written to neither reload register nor counter

Notes:

1. Interrupt request is not generated when the first effective edge is input after the timer started counting.
2. Value read from TBi register is indeterminate until the second valid edge is input after the timer starts counting.
3. The TB0S to TB2S bits are assigned to the TABSR register bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register bit 5 to bit 7.

Timer Bi mode register (i=0 to 5)

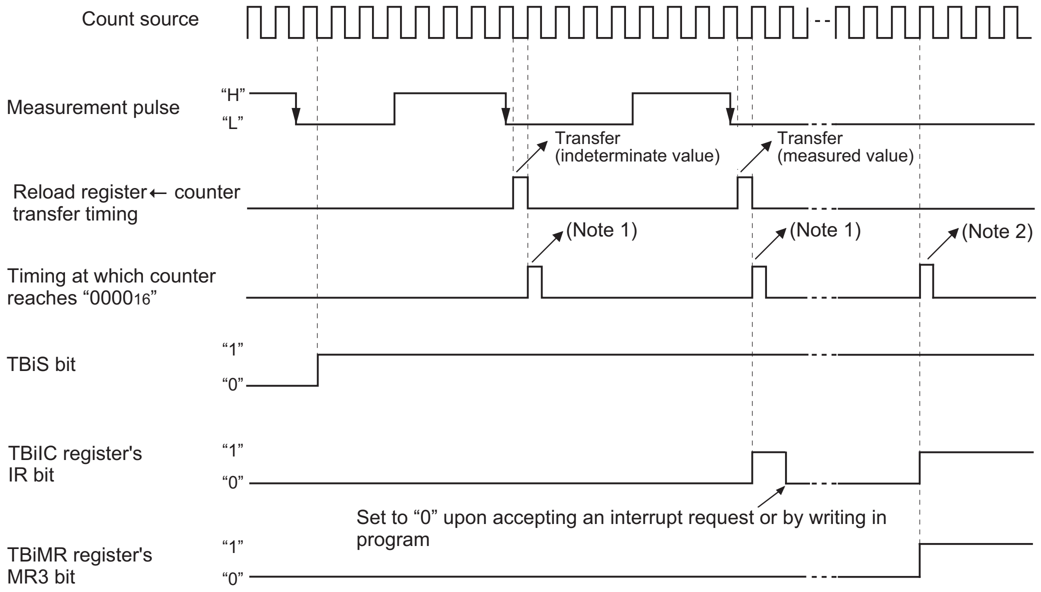


Symbol	Address	After reset
TB0MR to TB2MR	$039B_{16}$ to $039D_{16}$	$00XX0000_2$
TB3MR to TB5MR	$035B_{16}$ to $035D_{16}$	$00XX0000_2$

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 1 0 : Pulse period / pulse width measurement mode	RW
TMOD1			RW
MR0	Measurement mode select bit	b3 b2 0 0 : Pulse period measurement (Measurement between a falling edge and the next falling edge of measured pulse) 0 1 : Pulse period measurement (Measurement between a rising edge and the next rising edge of measured pulse) 1 0 : Pulse width measurement (Measurement between a falling edge and the next rising edge of measured pulse and between a rising edge and the next falling edge) 1 1 : Must not be set.	RW
MR1			RW
MR2	TB0MR and TB3MR registers Must be set to “0” in pulse period and pulse width measurement mode		RW
	TB1MR, TB2MR, TB4MR, TB5MR registers Nothing is assigned. When write, set to “0”. When read, its content turns out to be indeterminate.		—
MR3	Timer Bi overflow flag (Note)	0 : Timer did not overflow 1 : Timer has overflowed	RO
TCK0	Count source select bit	b7 b6 0 0 : f_1 or f_2 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	RW
TCK1			RW

Note: This flag is indeterminate after reset. When the TBiS bit = 1 (start counting), the MR3 bit is cleared to “0” (no overflow) by writing to the TBiMR register at the next count timing or later after the MR3 bit was set to “1” (overflowed). The MR3 bit cannot be set to “1” in a program. The TB0S to TB2S bits are assigned to the TABSR register's bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register's bit 5 to bit 7.

Figure 9.19 TBiMR Register in Pulse Period and Pulse Width Measurement Mode

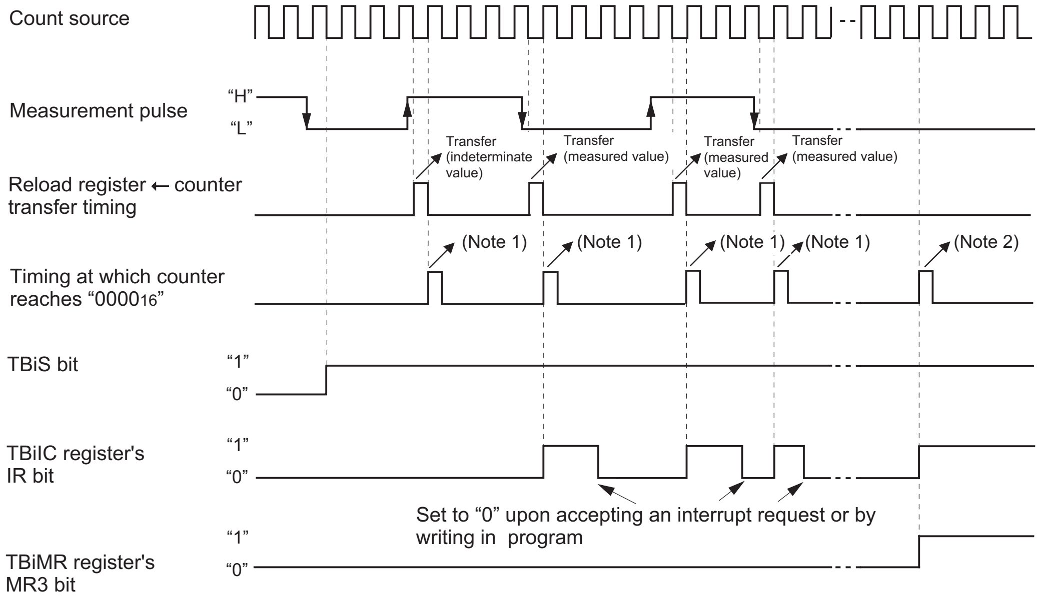


The TB0S to TB2S bits are assigned to the TABSR register's bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register's bit 5 to bit 7.

i = 0 to 5

Note 1: Counter is initialized at completion of measurement.
Note 2: Timer has overflowed.
Note 3: This timing diagram is for the case where the TBiMR register's MR1 to MR0 bits are "00_2" (measure the interval from falling edge to falling edge of the measurement pulse).

Figure 9.20 Operation timing when measuring a pulse period



The TB0S to TB2S bits are assigned to the TABSR register's bit 5 to bit 7, and the TB3S to TB5S bits are assigned to the TBSR register's bit 5 to bit 7.

i = 0 to 5

Note 1: Counter is initialized at completion of measurement.
Note 2: Timer has overflowed.
Note 3: This timing diagram is for the case where the TBiMR register's MR1 to MR0 bits are "10_2" (measure the interval from a falling edge to the next rising edge and the interval from a rising edge to the next falling edge of the measurement pulse).

Figure 9.21 Operation timing when measuring a pulse width

10. Serial I/O

Serial I/O is configured with five channels: UART0 to UART2, SI/O3 and SI/O4.

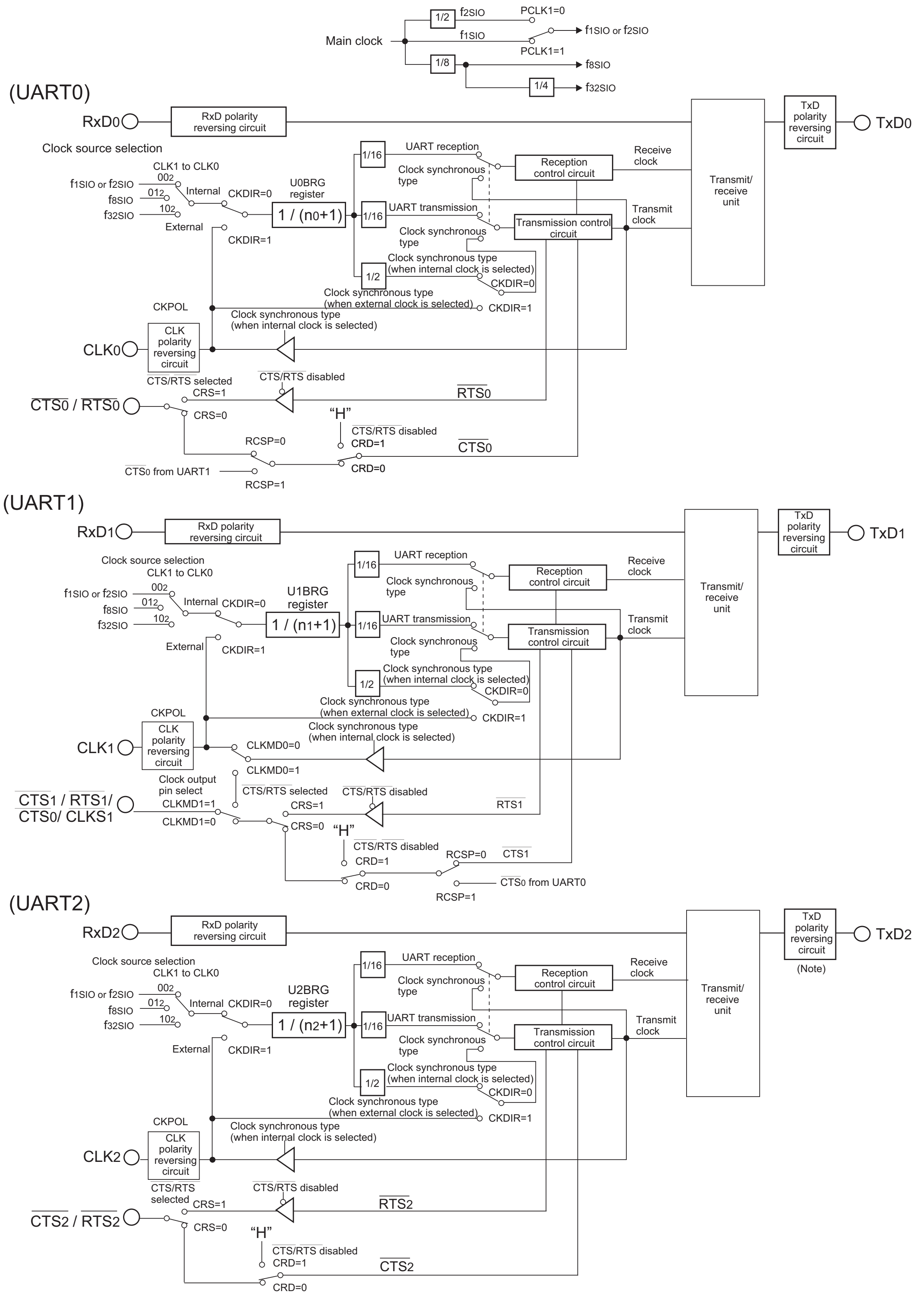
10.1 UARTi (i=0 to 2)

UARTi each have an exclusive timer to generate a transfer clock, so they operate independently of each other. Figure 10.1 shows the block diagram of UARTi. Figures 10.2 shows the block diagram of the UARTi transmit/ receive.

UARTi has the following modes:

- Clock synchronous serial I/O mode
- Clock asynchronous serial I/O mode (UART mode).
- Special mode 1 (I^2C mode)
- Special mode 2
- Special mode 3 (Bus collision detection function, IE mode) : UART0, UART1
- Special mode 4 (SIM mode) : UART2

Figures 10.3 to 10.8 show the UARTi-related registers.
Refer to tables listing each mode for register setting.



i = 0 to 2

n_i: Values set to the UiBRG register

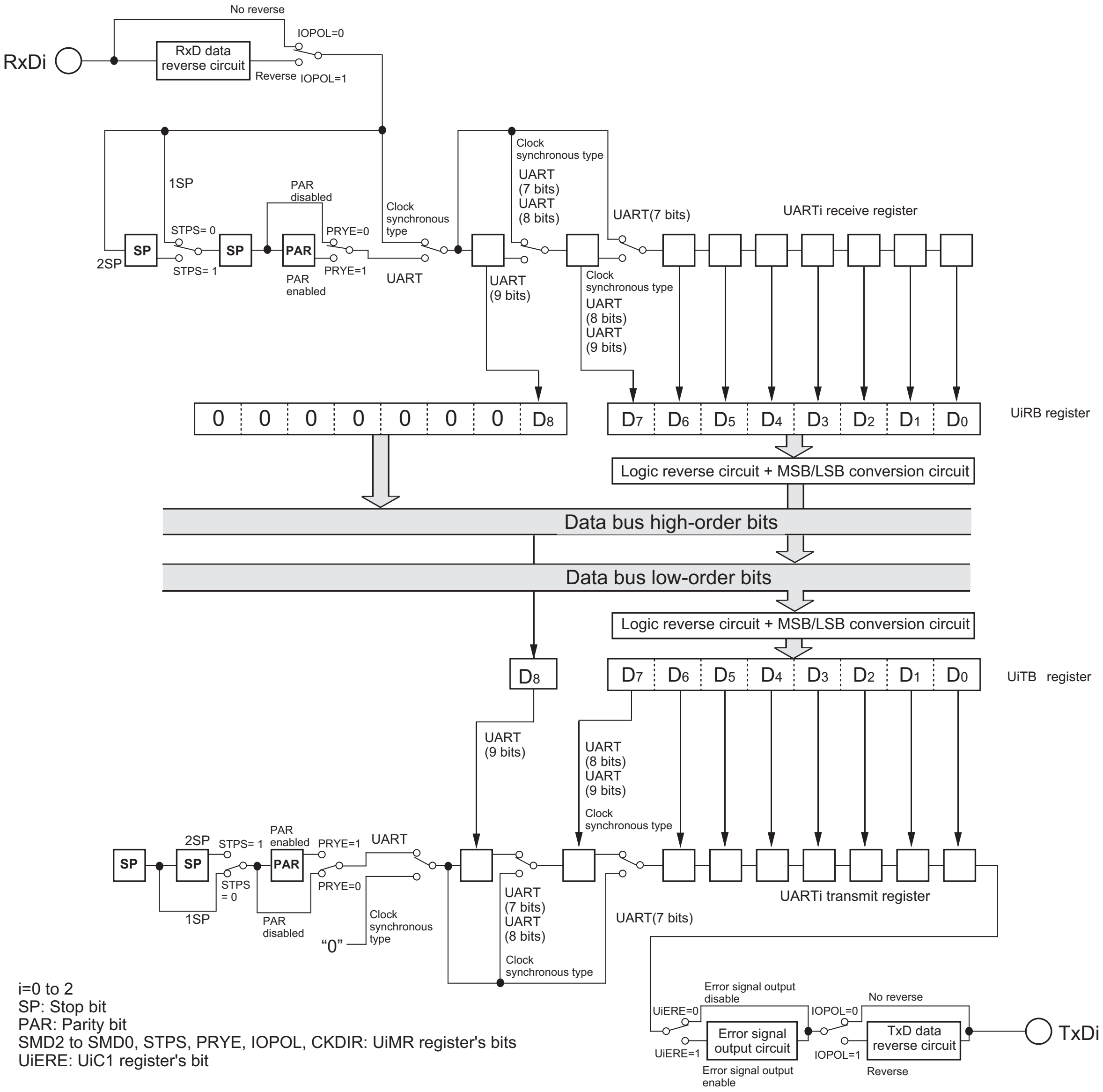
SMD2 to SMD0, CKDIR: UiMR register's bits

CLK1 to CLK0, CKPOL, CRD, CRS: UiC0 register's bits

CLKMD0, CLKMD1, RCSP: UCON register's bits

Note: UART2 is the N-channel open-drain output. Cannot be set to the CMOS output.

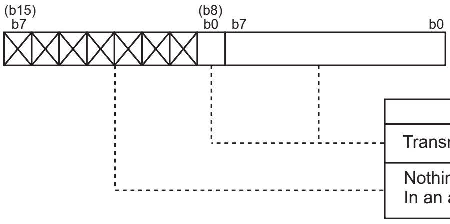
Figure 10.1 UARTi Block Diagram



i=0 to 2
SP: Stop bit
PAR: Parity bit
SMD2 to SMD0, STPS, PRYE, IOPOL, CKDIR: UiMR register's bits
UiERE: UiC1 register's bit

Figure 10.2 UARTi Transmit/Receive Unit

UARTi transmit buffer register (i=0 to 2)(Note)

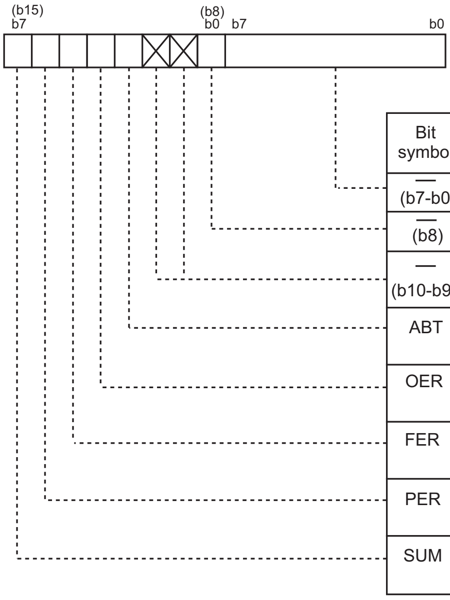


Symbol	Address	After reset
U0TB	$03A3_{16}$-$03A2_{16}$	Indeterminate
U1TB	$03AB_{16}$-$03AA_{16}$	Indeterminate
U2TB	$037B_{16}$-$037A_{16}$	Indeterminate

Function	RW
Transmit data	WO
Nothing is assigned. In an attempt to write to these bits, write “0”. The value, if read, turns out to be indeterminate.	—

Note: Use MOV instruction to write to this register.

UARTi receive buffer register (i=0 to 2)

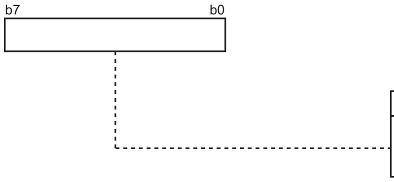


Symbol	Address	After reset
U0RB	$03A7_{16}$-$03A6_{16}$	Indeterminate
U1RB	$03AF_{16}$-$03AE_{16}$	Indeterminate
U2RB	$037F_{16}$-$037E_{16}$	Indeterminate

Bit symbol	Bit name	Function	RW
— (b7-b0)	——	Receive data (D_7 to D_0)	RO
— (b8)	——	Receive data (D_8)	RO
— (b10-b9)	Nothing is assigned. In an attempt to write to these bits, write “0”. The value, if read, turns out to be “0”.		—
ABT	Arbitration lost detecting flag (Note 2)	0 : Not detected 1 : Detected	RW
OER	Overrun error flag (Note 1)	0 : No overrun error 1 : Overrun error found	RO
FER	Framing error flag (Note 1)	0 : No framing error 1 : Framing error found	RO
PER	Parity error flag (Note 1)	0 : No parity error 1 : Parity error found	RO
SUM	Error sum flag (Note 1)	0 : No error 1 : Error found	RO

Note 1: When the UiMR register’s SMD2 to SMD0 bits = “000_2” (serial I/O disabled) or the UiC1 register’s RE bit = “0” (reception disabled), all of the SUM, PER, FER and OER bits are set to “0” (no error). The SUM bit is set to “0” (no error) when all of the PER, FER and OER bits = “0” (no error). Also, the PER and FER bits are set to “0” by reading the lower byte of the UiRB register.
Note 2: The ABT bit is set to “0” by writing “0” in a program. (Writing “1” has no effect.)

UARTi bit rate generator (i=0 to 2)(Notes 1, 2)



Symbol	Address	After reset
U0BRG	$03A1_{16}$	Indeterminate
U1BRG	$03A9_{16}$	Indeterminate
U2BRG	0379_{16}	Indeterminate

Function	Setting range	RW
Assuming that set value = n, UiBRG divides the count source by n + 1	00_{16} to FF_{16}	WO

Note 1: Write to this register while serial I/O is neither transmitting nor receiving.
Note 2: Use MOV instruction to write to this register.

Figure 10.3 U0TB to U2TB Register, U0RB to U2RB Register, and U0BRG to U2BRG Register

UARTi transmit/receive mode register (i=0 to 2)

b7 b6 b5 b4 b3 b2 b1 b0

Symbol	Address	After reset
U0MR to U2MR	03A0$_{16}$, 03A8$_{16}$, 0378$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
SMD0	Serial I/O mode select bit (Note 2)	b2 b1 b0 0 0 0 : Serial I/O disabled 0 0 1 : Clock synchronous serial I/O mode 0 1 0 : I^{2}C mode (Note 3) 1 0 0 : UART mode transfer data 7 bits long 1 0 1 : UART mode transfer data 8 bits long 1 1 0 : UART mode transfer data 9 bits long Must not be set except above	RW
SMD1			RW
SMD2			RW
CKDIR	Internal/external clock select bit	0 : Internal clock 1 : External clock (Note 1)	RW
STPS	Stop bit length select bit	0 : One stop bit 1 : Two stop bits	RW
PRY	Odd/even parity select bit	Effective when PRYE = 1 0 : Odd parity 1 : Even parity	RW
PRYE	Parity enable bit	0 : Parity disabled 1 : Parity enabled	RW
IOPOL	TxD, RxD I/O polarity reverse bit	0 : No reverse 1 : Reverse	RW

Note 1: Set the corresponding port direction bit for each CLKi pin to “0” (input mode).
Note 2: To receive data, set the corresponding port direction bit for each RxDi pin to “0” (input mode).
Note 3: Set the corresponding port direction bit for SCL and SDA pins to “0” (input mode).

UARTi transmit/receive control register 0 (i=0 to 2)

b7 b6 b5 b4 b3 b2 b1 b0

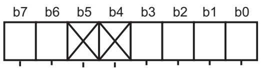
Symbol	Address	After reset
U0C0 to U2C0	03A4$_{16}$, 03AC$_{16}$, 037C$_{16}$	00001000$_2$

Bit symbol	Bit name	Function	RW
CLK0	BRG count source select bit	b1 b0 0 0 : f_{1SIO} or f_{2SIO} is selected 0 1 : f_{8SIO} is selected 1 0 : f_{32SIO} is selected 1 1 : Must not be set	RW
CLK1			RW
CRS	$\overline{\text{CTS}}$/$\overline{\text{RTS}}$ function select bit (Note 4)	Effective when CRD = 0 0 : $\overline{\text{CTS}}$ function is selected (Note 1) 1 : RTS function is selected	RW
TXEPT	Transmit register empty flag	0 : Data present in transmit register (during transmission) 1 : No data present in transmit register (transmission completed)	RO
CRD	$\overline{\text{CTS}}$/$\overline{\text{RTS}}$ disable bit	0 : $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ function enabled 1 : $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ function disabled (P6$_0$, P6$_4$ and P7$_3$ can be used as I/O ports)	RW
NCH	Data output select bit (Note 2)	0 : TxDi/SDAi and SCLi pins are CMOS output 1 : TxDi/SDAi and SCLi pins are N-channel open-drain output	RW
CKPOL	CLK polarity select bit	0 : Transmit data is output at falling edge of transfer clock and receive data is input at rising edge 1 : Transmit data is output at rising edge of transfer clock and receive data is input at falling edge	RW
UFORM	Transfer format select bit (Note 3)	0 : LSB first 1 : MSB first	RW

Note 1: Set the corresponding port direction bit for each $\overline{\text{CTSi}}$ pin to “0” (input mode).
Note 2: TxD$_2$/SDA$_2$ and SCL$_2$ are N-channel open-drain output. Cannot be set to the CMOS output. Set the NCH bit of the U2C0 register to “0”.
Note 3: Effective for clock synchronous serial I/O mode and UART mode transfer data 8 bits long.
Note 4: $\overline{\text{CTS}}_1$/$\overline{\text{RTS}}_1$ can be used when the UCON register’s CLKMD1 bit = “0” (only CLK$_1$ output) and the UCON register’s RCSP bit = “0” ($\overline{\text{CTS}}_0$/$\overline{\text{RTS}}_0$ not separated).

Figure 10.4 U0MR to U2MR Register and U0C0 to U2C0 Register

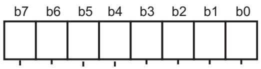
UARTi transmit/receive control register 1 (i=0, 1)



Symbol	Address	After reset
U0C1, U1C1	03A5$_{16}$,03AD$_{16}$	00000010$_2$

Bit symbol	Bit name	Function	RW
TE	Transmit enable bit	0 : Transmission disabled 1 : Transmission enabled	RW
TI	Transmit buffer empty flag	0 : Data present in UiTB register 1 : No data present in UiTB register	RO
RE	Receive enable bit	0 : Reception disabled 1 : Reception enabled	RW
RI	Receive complete flag	0 : No data present in UiRB register 1 : Data present in UiRB register	RO
— (b5-b4)	Nothing is assigned. When write, set “0”. When read, these contents are “0”.		—
UiLCH	Data logic select bit	0 : No reverse 1 : Reverse	RW
UiERE	Error signal output enable bit	0 : Output disabled 1 : Output enabled	RW

UART2 transmit/receive control register 1

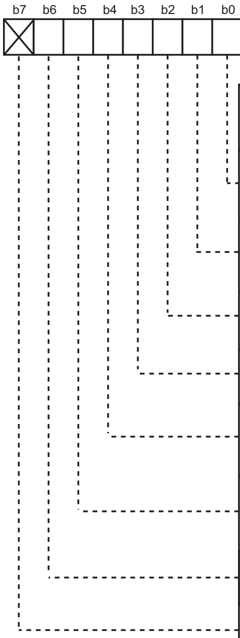


Symbol	Address	After reset
U2C1	037D$_{16}$	00000010$_2$

Bit symbol	Bit name	Function	RW
TE	Transmit enable bit	0 : Transmission disabled 1 : Transmission enabled	RW
TI	Transmit buffer empty flag	0 : Data present in U2TB register 1 : No data present in U2TB register	RO
RE	Receive enable bit	0 : Reception disabled 1 : Reception enabled	RW
RI	Receive complete flag	0 : No data present in U2RB register 1 : Data present in U2RB register	RO
U2IRS	UART2 transmit interrupt cause select bit	0 : Transmit buffer empty (TI = 1) 1 : Transmit is completed (TXEPT = 1)	RW
U2RRM	UART2 continuous receive mode enable bit	0 : Continuous receive mode disabled 1 : Continuous receive mode enabled	RW
U2LCH	Data logic select bit	0 : No reverse 1 : Reverse	RW
U2ERE	Error signal output enable bit	0 : Output disabled 1 : Output enabled	RW

Figure 10.5 U0C1 to U2C1 Registers

UART transmit/receive control register 2

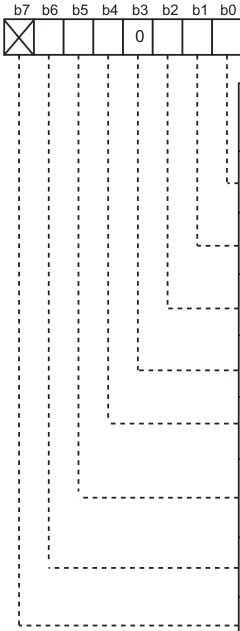


Symbol	Address	After reset
UCON	$03B0_{16}$	$X0000000_2$

Bit symbol	Bit name	Function	RW
U0IRS	UART0 transmit interrupt cause select bit	0 : Transmit buffer empty (TI = 1) 1 : Transmission completed (TXEPT = 1)	RW
U1IRS	UART1 transmit interrupt cause select bit	0 : Transmit buffer empty (TI = 1) 1 : Transmission completed (TXEPT = 1)	RW
U0RRM	UART0 continuous receive mode enable bit	0 : Continuous receive mode disabled 1 : Continuous receive mode enable	RW
U1RRM	UART1 continuous receive mode enable bit	0 : Continuous receive mode disabled 1 : Continuous receive mode enabled	RW
CLKMD0	UART1 CLK/CLKS select bit 0	Effective when CLKMD1 = “1” 0 : Clock output from CLK1 1 : Clock output from CLKS1	RW
CLKMD1	UART1 CLK/CLKS select bit 1 (Note)	0 : CLK output is only CLK1 1 : Transfer clock output from multiple pins function selected	RW
RCSP	Separate UART0 $\overline{CTS}/\overline{RTS}$ bit	0 : $\overline{CTS}/\overline{RTS}$ shared pin 1 : $\overline{CTS}/\overline{RTS}$ separated ($\overline{CTS_0}$ supplied from the $P6_4$ pin)	RW
— (b7)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—

Note: When using multiple transfer clock output pins, make sure the following conditions are met:
U1MR register’s CKDIR bit = “0” (internal clock)

UART2 special mode register (i=0 to 2)



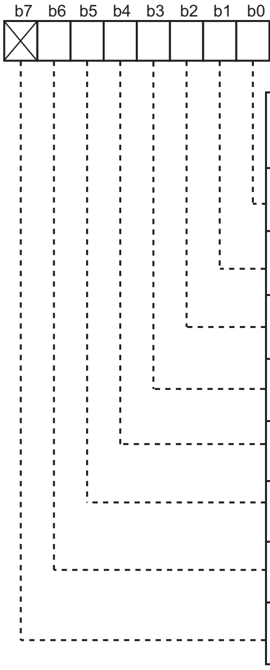
Symbol	Address	After reset
U0SMR to U2SMR	$036F_{16}$, 0373_{16}, 0377_{16}	$X0000000_2$

Bit symbol	Bit name	Function	RW
IICM	I^2C mode select bit	0 : Other than I^2C mode 1 : I^2C mode	RW
ABC	Arbitration lost detecting flag control bit	0 : Update per bit 1 : Update per byte	RW
BBS	Bus busy flag	0 : STOP condition detected 1 : START condition detected (busy)	RW (Note1)
— (b3)	Reserved bit	Set to “0”	RW
ABSCS	Bus collision detect sampling clock select bit	0 : Rising edge of transfer clock 1 : Underflow signal of timer Aj (Note 2)	RW
ACSE	Auto clear function select bit of transmit enable bit	0 : No auto clear function 1 : Auto clear at occurrence of bus collision	RW
SSS	Transmit start condition select bit	0 : Not synchronized to RxDi 1 : Synchronized to RxDi (Note 3)	RW
— (b7)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—

Note 1: The BBS bit is set to “0” by writing “0” in a program. (Writing “1” has no effect.).
Note 2: Underflow signal of timer A3 in UART0, underflow signal of timer A4 in UART1, underflow signal of timer A0 in UART2.
Note 3: When a transfer begins, the SSS bit is set to “0” (Not synchronized to RxDi)

Figure 10.6 UCON Register and U0SMR to U2SMR Registers

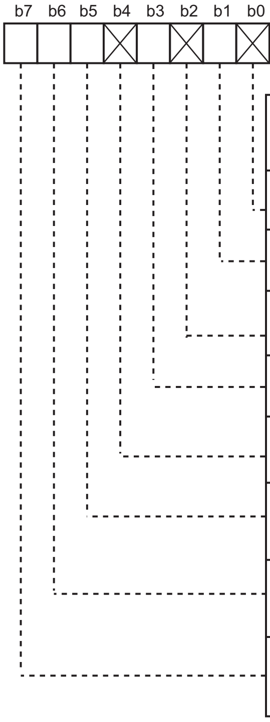
UARTi special mode register 2 (i=0 to 2)



Symbol	Address	After reset
U0SMR2 to U2SMR2	$036E_{16}$, 0372_{16}, 0376_{16}	$X0000000_2$

Bit symbol	Bit name	Function	RW
IICM2	I^2C mode select bit 2	Refer to Table 10.12	RW
CSC	Clock-synchronous bit	0 : Disabled 1 : Enabled	RW
SWC	SCL wait output bit	0 : Disabled 1 : Enabled	RW
ALS	SDA output stop bit	0 : Disabled 1 : Enabled	RW
STAC	UARTi initialization bit	0 : Disabled 1 : Enabled	RW
SWC2	SCL wait output bit 2	0: Transfer clock 1: “L” output	RW
SDHI	SDA output disable bit	0: Enabled 1: Disabled (high impedance)	RW
— (b7)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—

UARTi special mode register 3 (i=0 to 2)



Symbol	Address	After reset
U0SMR3 to U2SMR3	$036D_{16}$, 0371_{16}, 0375_{16}	$000X0X0X_2$

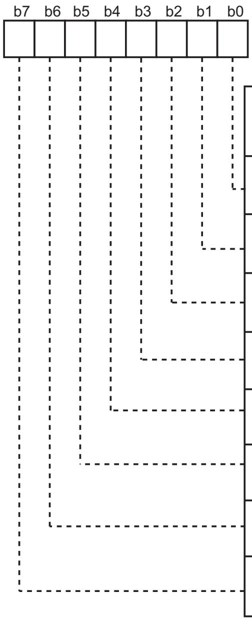
Bit symbol	Bit name	Function	RW
— (b0)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—
CKPH	Clock phase set bit	0 : Without clock delay 1 : With clock delay	RW
— (b2)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—
NODC	Clock output select bit	0 : CLKi is CMOS output 1 : CLKi is N-channel open drain output	RW
— (b4)	Nothing is assigned. When write, set “0”. When read, its content is indeterminate.		—
DL0	SDAi digital delay setup bit (Note 1, Note 2)	b7 b6 b5 0 0 0 : Without delay 0 0 1 : 1 to 2 cycle(s) of UiBRG count source 0 1 0 : 2 to 3 cycles of UiBRG count source 0 1 1 : 3 to 4 cycles of UiBRG count source 1 0 0 : 4 to 5 cycles of UiBRG count source 1 0 1 : 5 to 6 cycles of UiBRG count source 1 1 0 : 6 to 7 cycles of UiBRG count source 1 1 1 : 7 to 8 cycles of UiBRG count source	RW
DL1			RW
DL2			RW

Note 1 : The DL2 to DL0 bits are used to generate a delay in SDAi output by digital means during I^2C mode. In other than I^2C mode, set these bits to “000_2” (no delay).

Note 2 : The amount of delay varies with the load on SCLi and SDAi pins. Also, when using an external clock, the amount of delay increases by about 100 ns.

Figure 10.7 U0SMR2 to U2SMR2 Registers and U0SMR3 to U2SMR3 Registers

UARTi special mode register 4 (i=0 to 2)



Symbol	Address	After reset
U0SMR4 to U2SMR4	$036C_{16}$, 0370_{16}, 0374_{16}	00_{16}

Bit symbol	Bit name	Function	RW
STAREQ	Start condition generate bit (Note)	0 : Clear 1 : Start	RW
RSTAREQ	Restart condition generate bit (Note)	0 : Clear 1 : Start	RW
STPREQ	Stop condition generate bit (Note)	0 : Clear 1 : Start	RW
STSPSEL	SCL,SDA output select bit	0 : Start and stop conditions not output 1 : Start and stop conditions output	RW
ACKD	ACK data bit	0 : ACK 1 : NACK	RW
ACKC	ACK data output enable bit	0 : Serial I/O data output 1 : ACK data output	RW
SCLHI	SCL output stop enable bit	0 : Disabled 1 : Enabled	RW
SWC9	SCL wait bit 3	0 : SCL “L” hold disabled 1 : SCL “L” hold enabled	RW

Note: Set to “0” when each condition is generated.

Figure 10.8 U0SMR4 to U2SMR4 Registers

10.2 Clock Synchronous serial I/O Mode

The clock synchronous serial I/O mode uses a transfer clock to transmit and receive data. Table 10.1 lists the specifications of the clock synchronous serial I/O mode. Table 10.2 lists the registers used in clock synchronous serial I/O mode and the register values set.

Table 10.1 Clock Synchronous Serial I/O Mode Specifications

Item	Specification
Transfer data format	• Transfer data length: 8 bits
Transfer clock	• UiMR(i=0 to 2) register's CKDIR bit = "0" (internal clock) : fj/ 2(n+1) fj = f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}. n: Setting value of UiBRG register 00_{16} to FF_{16} • CKDIR bit = "1" (external clock) : Input from CLKi pin
Transmission, reception control	• Selectable from $\overline{CTS}$ function, $\overline{RTS}$ function or $\overline{CTS}/\overline{RTS}$ function disable
Transmission start condition	• Before transmission can start, the following requirements must be met (Note 1) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register = 0 (data present in UiTB register) – If $\overline{CTS}$ function is selected, input on the $\overline{CTS}$i pin = "L"
Reception start condition	• Before reception can start, the following requirements must be met (Note 1) – The RE bit of UiC1 register= 1 (reception enabled) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register= 0 (data present in the UiTB register)
Interrupt request generation timing	• For transmission, one of the following conditions can be selected – The UiIRS bit (Note 3) = 0 (transmit buffer empty): when transferring data from the UiTB register to the UARTi transmit register (at start of transmission) – The UiIRS bit =1 (transfer completed): when the serial I/O finished sending data from the UARTi transmit register • For reception When transferring data from the UARTi receive register to the UiRB register (at completion of reception)
Error detection	• Overrun error (Note 2) This error occurs if the serial I/O started receiving the next data before reading the UiRB register and received the 7th bit of the next data
Select function	• CLK polarity selection Transfer data input/output can be chosen to occur synchronously with the rising or the falling edge of the transfer clock • LSB first, MSB first selection Whether to start sending/receiving data beginning with bit 0 or beginning with bit 7 can be selected • Continuous receive mode selection Reception is enabled immediately by reading the UiRB register • Switching serial data logic This function reverses the logic value of the transmit/receive data • Transfer clock output from multiple pins selection (UART1) The output pin can be selected in a program from two UART1 transfer clock pins that have been set • Separate $\overline{CTS}/\overline{RTS}$ pins (UART0) $\overline{CTS_0}$ and $\overline{RTS_0}$ are input/output from separate pins

Note 1: When an external clock is selected, the conditions must be met while if the UiC0 register's CKPOL bit = "0" (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock), the external clock is in the high state; if the UiC0 register's CKPOL bit = "1" (transmit data output at the rising edge and the receive data taken in at the falling edge of the transfer clock), the external clock is in the low state.

Note 2: If an overrun error occurs, the value of UiRB register will be indeterminate. The IR bit of SiRIC register does not change.

Note 3: The U0IRS and U1IRS bits respectively are the UCON register bits 0 and 1; the U2IRS bit is the U2C1 register bit 4.

Table 10.2 Registers to Be Used and Settings in Clock Synchronous Serial I/O Mode

Register	Bit	Function
UiTB(Note3)	0 to 7	Set transmission data
UiRB(Note3)	0 to 7	Reception data can be read
	OER	Overrun error flag
UiBRG	0 to 7	Set a transfer rate
UiMR(Note3)	SMD2 to SMD0	Set to “001_2”
	CKDIR	Select the internal clock or external clock
	IOPOL	Set to “0”
UiC0	CLK1 to CLK0	Select the count source for the UiBRG register
	CRS	Select $\overline{\text{CTS}}$ or $\overline{\text{RTS}}$ to use
	TXEPT	Transmit register empty flag
	CRD	Enable or disable the $\overline{\text{CTS}}$ or $\overline{\text{RTS}}$ function
	NCH	Select TxDi pin output mode (Note 2)
	CKPOL	Select the transfer clock polarity
	UFORM	Select the LSB first or MSB first
UiC1	TE	Set this bit to “1” to enable transmission/reception
	TI	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception
	RI	Reception complete flag
	U2IRS (Note 1)	Select the source of UART2 transmit interrupt
	U2RRM (Note 1)	Set this bit to “1” to use continuous receive mode
	UiLCH	Set this bit to “1” to use inverted data logic
	UiERE	Set to “0”
UiSMR	0 to 7	Set to “0”
UiSMR2	0 to 7	Set to “0”
UiSMR3	0 to 2	Set to “0”
	NODC	Select clock output mode
	4 to 7	Set to “0”
UiSMR4	0 to 7	Set to “0”
UCON	U0IRS, U1IRS	Select the source of UART0/UART1 transmit interrupt
	U0RRM, U1RRM	Set this bit to “1” to use continuous receive mode
	CLKMD0	Select the transfer clock output pin when CLKMD1 = 1
	CLKMD1	Set this bit to “1” to output UART1 transfer clock from two pins
	RCSP	Set this bit to “1” to accept as input the UART0 $\overline{\text{CTS}_0}$ signal from the P6_4 pin
	7	Set to “0”

Note 1: Set the U0C1 and U1C1 register bit 4 and bit 5 to “0”. The U0IRS, U1IRS, U0RRM and U1RRM bits are in the UCON register.

Note 2: TxD2 pin is N channel open-drain output. Set the U2C0 register's NCH bit to “0”.

Note 3: Not all register bits are described above. Set those bits to “0” when writing to the registers in clock synchronous serial I/O mode.

i=0 to 2

Table 10.3 lists the functions of the input/output pins during clock synchronous serial I/O mode. Table 10.3 shows pin functions for the case where the multiple transfer clock output pin select function is deselected. Table 10.4 lists the $P6_4$ pin functions during clock synchronous serial I/O mode. Note that for a period from when the UARTi operation mode is selected to when transfer starts, the TxDi pin outputs an “H”. (If the N-channel open-drain output is selected, this pin is in a high-impedance state.)

Table 10.3 Pin Functions (When Not Select Multiple Transfer Clock Output Pin Function)

Pin name	Function	Method of selection
TxDi (i = 0 to 2) ($P6_3$, $P6_7$, $P7_0$)	Serial data output	(Outputs dummy data when performing reception only)
RxDi ($P6_2$, $P6_6$, $P7_1$)	Serial data input	PD6 register’s PD6_2 bit=0, PD6_6 bit=0, PD7 register’s PD7_1 bit=0 (Can be used as an input port when performing transmission only)
CLKi ($P6_1$, $P6_5$, $P7_2$)	Transfer clock output	UiMR register’s CKDIR bit=0
	Transfer clock input	UiMR register’s CKDIR bit=1 PD6 register’s PD6_1 bit=0, PD6_5 bit=0, PD7 register’s PD7_2 bit=0
$\overline{\text{CTSi}}$/$\overline{\text{RTSi}}$ ($P6_0$, $P6_4$, $P7_3$)	$\overline{\text{CTS}}$ input	UiC0 register’s CRD bit=0 UiC0 register’s CRS bit=0 PD6 register’s PD6_0 bit=0, PD6_4 bit=0, PD7 register’s PD7_3 bit=0
	$\overline{\text{RTS}}$ output	UiC0 register’s CRD bit=0 UiC0 register’s CRS bit=1
	I/O port	UiC0 register’s CRD bit=1

Table 10.4 $P6_4$ Pin Functions

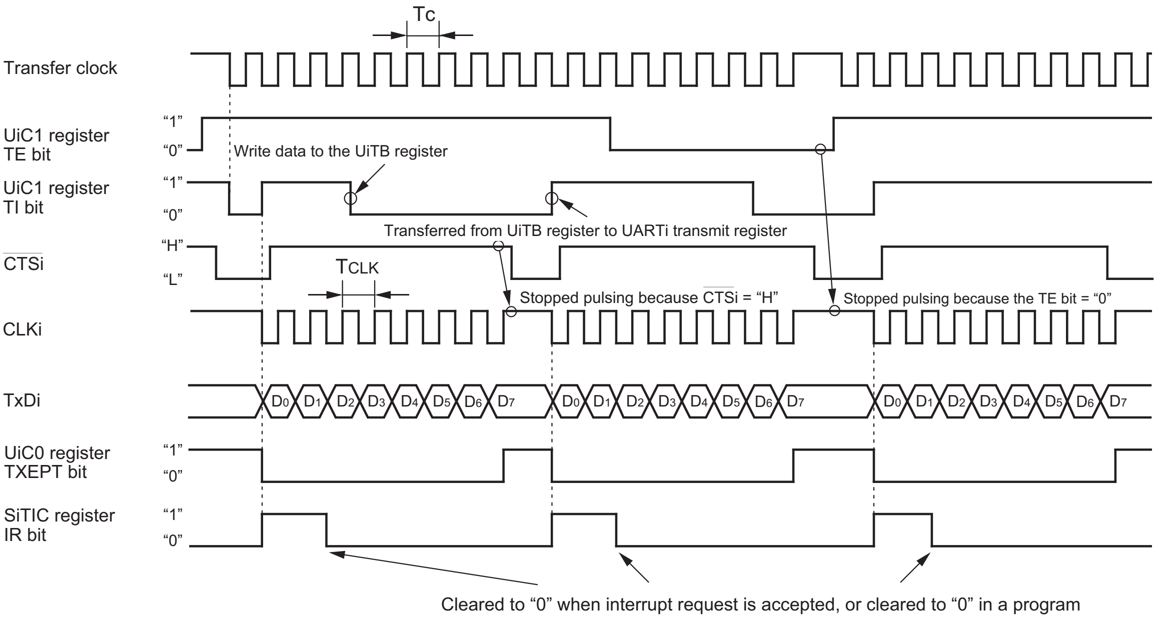
Pin function	Bit set value					
	U1C0 register		UCON register			PD6 register
	CRD	CRS	RCSP	CLKMD1	CLKMD0	PD6_4
$P6_4$	1	—	0	0	—	Input: 0, Output: 1
$\overline{\mathrm{CTS}_1}$	0	0	0	0	—	0
$\overline{\mathrm{RTS}_1}$	0	1	0	0	—	—
$\overline{\mathrm{CTS}_0}$(Note1)	0	0	1	0	—	0
CLKS_1	—	—	—	1(Note 2)	1	—

Note 1: In addition to this, set the U0C0 register’s CRD bit to “0” ($\overline{\mathrm{CTS}_0}$/$\overline{\mathrm{RTS}_0}$ enabled) and the U0C0 register’s CRS bit to “1” (RTS_0 selected).

Note 2: When the CLKMD1 bit = 1 and the CLKMD0 bit = 0, the following logic levels are output:

- High if the U1C0 register’s CLKPOL bit = 0
- Low if the U1C0 register’s CLKPOL bit = 1

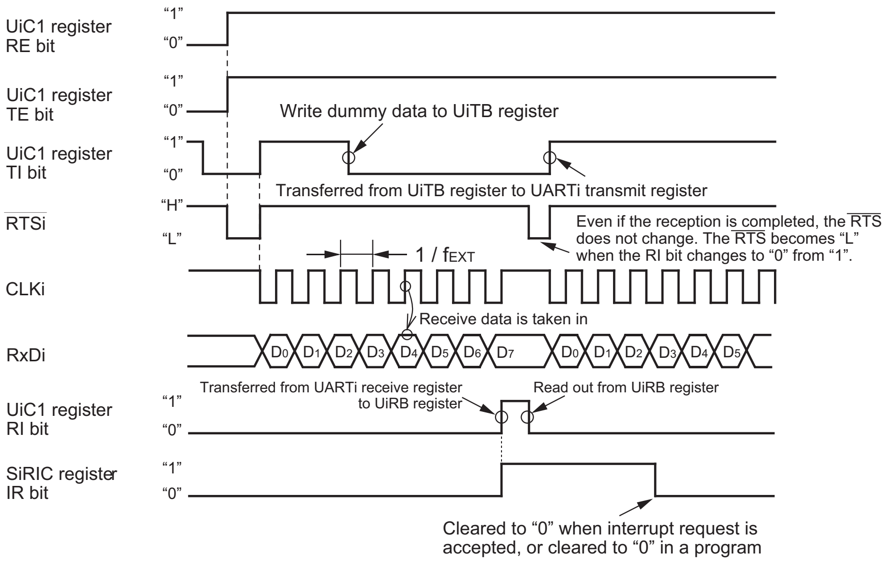
(1) Example of transmit timing (when internal clock is selected)



$T_c = T_{CLK} = 2(n + 1) / f_j$
fj: frequency of UiBRG count source (f1SIO, f2SIO, f8SIO, f32SIO)
n: value set to UiBRG register
i: 0 to 2

The above timing diagram applies to the case where the register bits are set as follows:
- UiMR register CKDIR bit = 0 (internal clock)
- UiC0 register CRD bit = 0 (CTS/RTS enabled), CRS bit = 0 (CTS selected)
- UiC0 register CKPOL bit = 0 (transmit data output at the falling edge and receive data taken in at the rising edge of the transfer clock)
- UiRS bit = 0 (an interrupt request occurs when the transmit buffer becomes empty): U0IRS bit is the UCON register bit 0, U1IRS bit is the UCON register bit 1, and U2IRS bit is the U2C1 register bit 4

(2) Example of receive timing (when external clock is selected)



The above timing diagram applies to the case where the register bits are set as follows:
- UiMR register CKDIR bit = 1 (external clock)
- UiC0 register CRD bit = 0 (CTS/RTS enabled), CRS bit = 1 (RTS selected)
- UiC0 register CKPOL bit = 0 (transmit data output at the falling edge and receive data taken in at the rising edge of the transfer clock)

fEXT: frequency of external clock

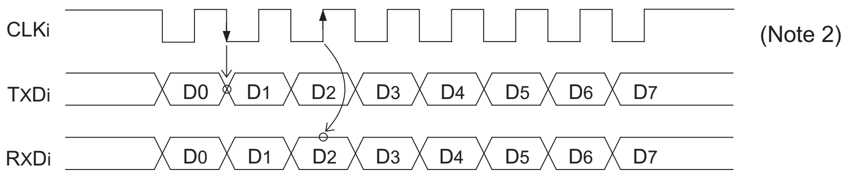
Make sure the following conditions are met when input to the CLKi pin before receiving data is high:
- UiC1 register TE bit = 1 (transmit enabled)
- UiC1 register RE bit = 1 (Receive enabled)
- Write dummy data to the UiTB register

Figure 10.9 Transmit and Receive Operation

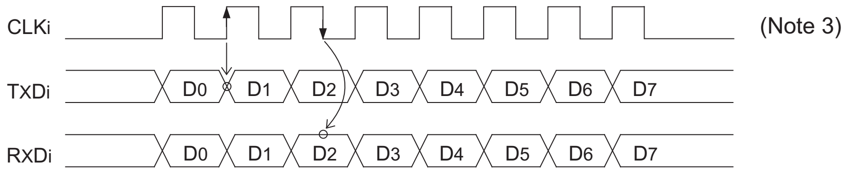
10.2.1 CLK Polarity Select Function

Use the UiC0 register (i = 0 to 2)'s CKPOL bit to select the transfer clock polarity. Figure 10.10 shows the polarity of the transfer clock.

(1) When the UiC0 register's CKPOL bit = 0 (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock)



(2) When the UiC0 register's CKPOL bit = 1 (transmit data output at the rising edge and the receive data taken in at the falling edge of the transfer clock)



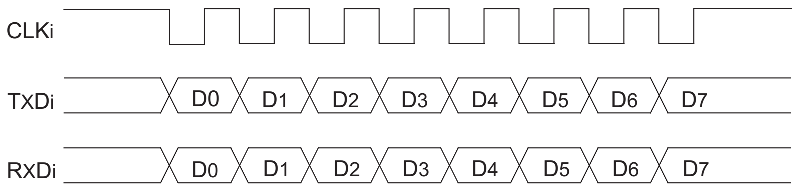
Note 1: This applies to the case where the UiC0 register's UFORM bit = 0 (LSB first) and UiC1 register's UiLCH bit = 0 (no reverse).
Note 2: When not transferring, the CLKi pin outputs a high signal.
Note 3: When not transferring, the CLKi pin outputs a low signal.
i = 0 to 2

Figure 10.10 Transfer Clock Polarity

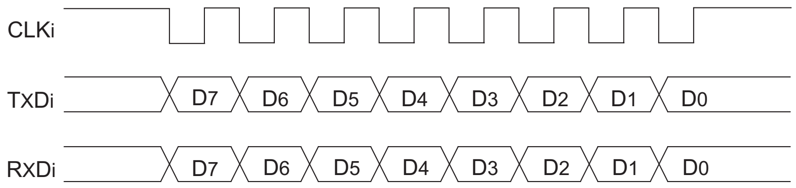
10.2.2 LSB First/MSB First Select Function

Use the UiC0 register (i = 0 to 2)'s UFORM bit to select the transfer format. Figure 10.11 shows the transfer format.

(1) When UiC0 register's UFORM bit = 0 (LSB first)



(2) When UiC0 register's UFORM bit = 1 (MSB first)



Note: This applies to the case where the UiC0 register's CKPOL bit = 0 (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock) and the UiC1 register's UiLCH bit = 0 (no reverse).
i = 0 to 2

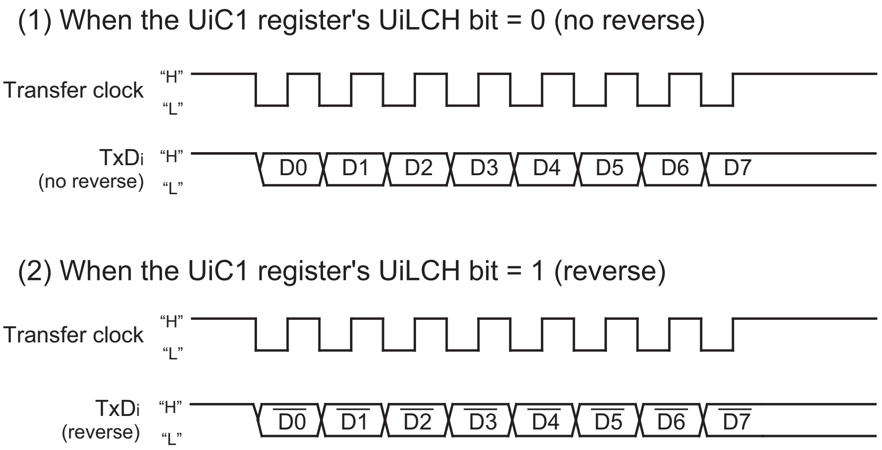
Figure 10.11 Transfer Format

10.2.3 Continuous Receive Mode

When the UiRRM bit (i = 0 to 2) = 1 (continuous receive mode), the UiC1 register's TI bit is set to "0" (data present in the UiTB register) by reading the UiRB register. In this case, i.e., UiRRM bit = 1, do not write dummy data to the UiTB register in a program. The U0RRM and U1RRM bits are the UCON register bit 2 and bit 3, respectively, and the U2RRM bit is the U2C1 register bit 5.

10.2.4 Serial Data Logic Switching Function

When the UiC1 register (i = 0 to 2)'s UiLCH bit = 1 (reverse), the data written to the UiTB register has its logic reversed before being transmitted. Similarly, the received data has its logic reversed when read from the UiRB register. Figure 10.12 shows serial data logic.

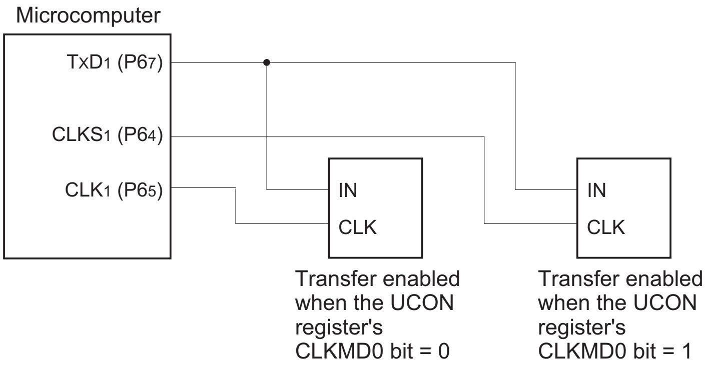


Note: This applies to the case where the UiC0 register's CKPOL bit = 0 (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock) and the UFORM bit = 0 (LSB first).
i = 0 to 2

Figure 10.12 Serial Data Logic Switching

10.2.5 Transfer Clock Output From Multiple Pins (UART1)

Use the UCON register's CLKMD1 to CLKMD0 bits to select one of the two transfer clock output pins. (See Figure 10.13.) This function can be used when the selected transfer clock for UART1 is an internal clock.



Note: This applies to the case where the U1MRregister's CKDIR bit = 0 (internal clock) and the UCON register's CLKMD1 bit = 1 (transfer clock output from multiple pins).

Figure 10.13 Transfer Clock Output From Multiple Pins

10.2.6 $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$ Separate Function (UART0)

This function separates $\overline{\mathrm{CTS0}}/\overline{\mathrm{RTS0}}$, outputs $\overline{\mathrm{RTS0}}$ from the P60 pin, and accepts as input the $\overline{\mathrm{CTS0}}$ from the P64 pin. To use this function, set the register bits as shown below.

- U0C0 register's CRD bit = 0 (enables UART0 $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$)
- U0C0 register's CRS bit = 1 (outputs UART0 $\overline{\mathrm{RTS}}$)
- U1C0 register's CRD bit = 0 (enables UART1 $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$)
- U1C0 register's CRS bit = 0 (inputs UART1 $\overline{\mathrm{CTS}}$)
- UCON register's RCSP bit = 1 (inputs $\overline{\mathrm{CTS0}}$ from the P64 pin)
- UCON register's CLKMD1 bit = 0 (CLKS1 not used)

Note that when using the $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$ separate function, UART1 $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$ function cannot be used.

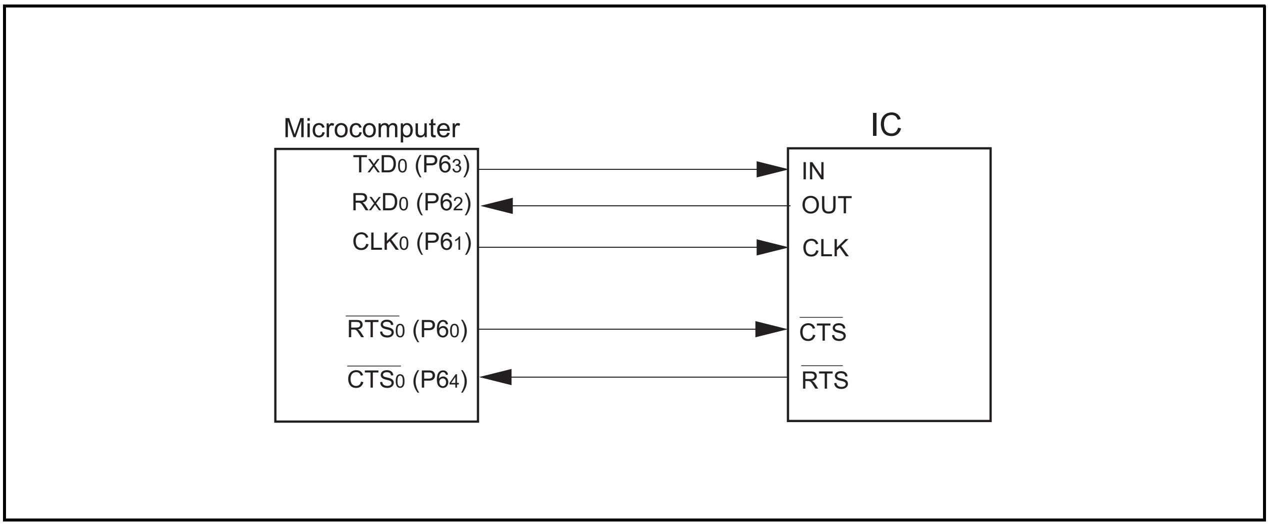


Figure 10.14 $\overline{\mathrm{CTS}}/\overline{\mathrm{RTS}}$ Separat Function

10.3 Clock Asynchronous Serial I/O (UART) Mode

The UART mode allows transmitting and receiving data after setting the desired transfer rate and transfer data format. Tables 10.5 lists the specifications of the UART mode.

Table 10.5 UART Mode Specifications

Item	Specification
Transfer data format	• Character bit (transfer data): Selectable from 7, 8 or 9 bits • Start bit: 1 bit • Parity bit: Selectable from odd, even, or none • Stop bit: Selectable from 1 or 2 bits
Transfer clock	• UiMR(i=0 to 2) register's CKDIR bit = 0 (internal clock) : fj/ 16(n+1) fj = f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}. n: Setting value of UiBRG register 00_{16} to FF_{16} • CKDIR bit = "1" (external clock) : f_{EXT}/16(n+1) f_{EXT}: Input from CLKi pin. n :Setting value of UiBRG register 00_{16} to FF_{16}
Transmission, reception control	• Selectable from $\overline{\text{CTS}}$ function, $\overline{\text{RTS}}$ function or $\overline{\text{CTS}}/\overline{\text{RTS}}$ function disable
Transmission start condition	• Before transmission can start, the following requirements must be met – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register = 0 (data present in UiTB register) – If $\overline{\text{CTS}}$ function is selected, input on the $\overline{\text{CTSi}}$ pin = "L"
Reception start condition	• Before reception can start, the following requirements must be met – The RE bit of UiC1 register= 1 (reception enabled) – Start bit detection
Interrupt request generation timing	• For transmission, one of the following conditions can be selected – The UiIRS bit (Note 2) = 0 (transmit buffer empty): when transferring data from the UiTB register to the UARTi transmit register (at start of transmission) – The UiIRS bit =1 (transfer completed): when the serial I/O finished sending data from the UARTi transmit register • For reception When transferring data from the UARTi receive register to the UiRB register (at completion of reception)
Error detection	• Overrun error (Note 1) This error occurs if the serial I/O started receiving the next data before reading the UiRB register and received the bit one before the last stop bit of the next data • Framing error This error occurs when the number of stop bits set is not detected • Parity error This error occurs when if parity is enabled, the number of 1's in parity and character bits does not match the number of 1's set • Error sum flag This flag is set (= 1) when any of the overrun, framing, and parity errors is encountered
Select function	• LSB first, MSB first selection Whether to start sending/receiving data beginning with bit 0 or beginning with bit 7 can be selected • Serial data logic switch This function reverses the logic of the transmit/receive data. The start and stop bits are not reversed. • TxD, RxD I/O polarity switch This function reverses the polarities of hte TxD pin output and RxD pin input. The logic levels of all I/O data is reversed. • Separate $\overline{\text{CTS}}/\overline{\text{RTS}}$ pins (UART0) $\overline{\text{CTS}_0}$ and $\overline{\text{RTS}_0}$ are input/output from separate pins

Note 1: If an overrun error occurs, the value of UiRB register will be indeterminate. The IR bit of SiRIC register does not change.
Note 2: The U0IRS and U1IRS bits respectively are the UCON register bits 0 and 1; the U2IRS bit is the U2C1 register bit 4.

Table 10.6 Registers to Be Used and Settings in UART Mode

Register	Bit	Function
UiTB	0 to 8	Set transmission data (Note 1)
UiRB	0 to 8	Reception data can be read (Note 1)
	OER,FER,PER,SUM	Error flag
UiBRG	0 to 7	Set a transfer rate
UiMR	SMD2 to SMD0	Set these bits to ‘100_2’ when transfer data is 7 bits long Set these bits to ‘101_2’ when transfer data is 8 bits long Set these bits to ‘110_2’ when transfer data is 9 bits long
	CKDIR	Select the internal clock or external clock
	STPS	Select the stop bit
	PRY, PRYE	Select whether parity is included and whether odd or even
	IOPOL	Select the TxD/RxD input/output polarity
UiC0	CLK0, CLK1	Select the count source for the UiBRG register
	CRS	Select $\overline{\text{CTS}}$ or $\overline{\text{RTS}}$ to use
	TXEPT	Transmit register empty flag
	CRD	Enable or disable the $\overline{\text{CTS}}$ or $\overline{\text{RTS}}$ function
	NCH	Select TxDi pin output mode (Note 3)
	CKPOL	Set to “0”
	UFORM	LSB first or MSB first can be selected when transfer data is 8 bits long. Set this bit to “0” when transfer data is 7 or 9 bits long.
UiC1	TE	Set this bit to “1” to enable transmission
	TI	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception
	RI	Reception complete flag
	U2IRS (Note 2)	Select the source of UART2 transmit interrupt
	U2RRM (Note 2)	Set to “0”
	UiLCH	Set this bit to “1” to use inverted data logic
	UiERE	Set to “0”
UiSMR	0 to 7	Set to “0”
UiSMR2	0 to 7	Set to “0”
UiSMR3	0 to 7	Set to “0”
UiSMR4	0 to 7	Set to “0”
UCON	U0IRS, U1IRS	Select the source of UART0/UART1 transmit interrupt
	U0RRM, U1RRM	Set to “0”
	CLKMD0	Invalid because CLKMD1 = 0
	CLKMD1	Set to “0”
	RCSP	Set this bit to “1” to accept as input the UART0 $\overline{\text{CTS}_0}$ signal from the $P6_4$ pin
	7	Set to “0”

Note 1: The bits used for transmit/receive data are as follows: Bit 0 to bit 6 when transfer data is 7 bits long; bit 0 to bit 7 when transfer data is 8 bits long; bit 0 to bit 8 when transfer data is 9 bits long.

Note 2: Set the U0C1 and U1C1 registers bit 4 to bit 5 to “0”. The U0IRS, U1IRS, U0RRM and U1RRM bits are included in the UCON register.

Note 3: TxD2 pin is N channel open-drain output. Set the U2C0 register's NCH bit to “0”.

i=0 to 2

Table 10.7 lists the functions of the input/output pins during UART mode. Table 10.8 lists the P64 pin functions during UART mode. Note that for a period from when the UARTi operation mode is selected to when transfer starts, the TxDi pin outputs an "H". (If the N-channel open-drain output is selected, this pin is in a high-impedance state.)

Table 10.7 I/O Pin Functions

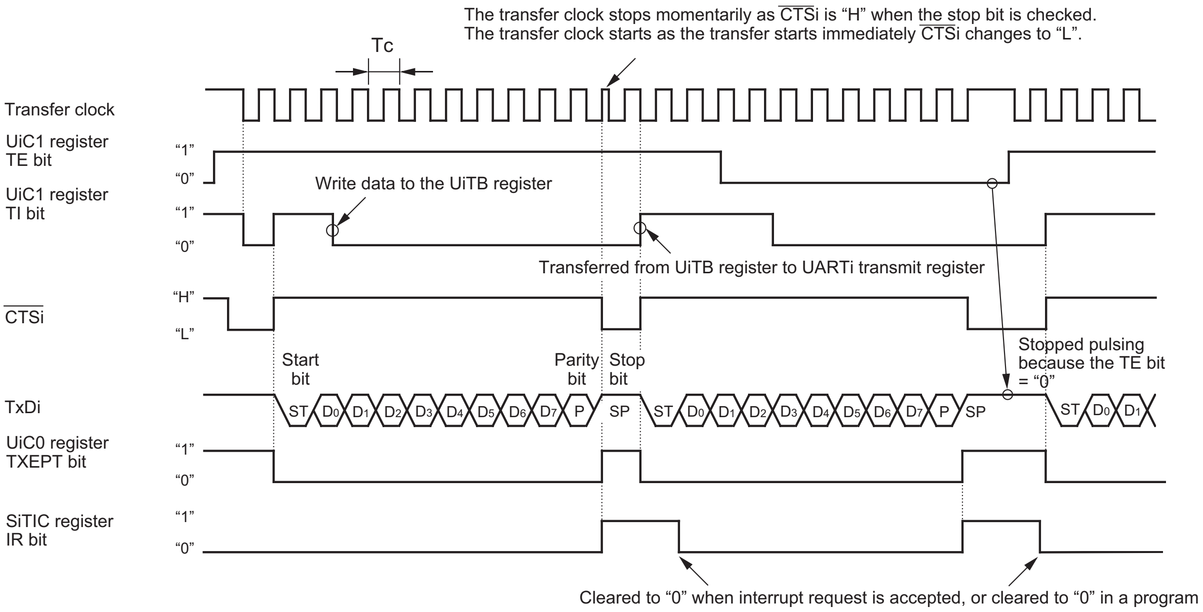
Pin name	Function	Method of selection
TxDi (i = 0 to 2) (P63, P67, P70)	Serial data output	(Outputs dummy data when performing reception only)
RxDi (P62, P66, P71)	Serial data input	PD6 register's PD6_2 bit=0, PD6_6 bit=0, PD7 register's PD7_1 bit=0 (Can be used as an input port when performing transmission only)
CLKi (P61, P65, P72)	Input/output port	UiMR register's CKDIR bit=0
	Transfer clock input	UiMR register's CKDIR bit=1 PD6 register's PD6_1 bit=0, PD6_5 bit=0, PD7 register's PD7_2 bit=0
$\overline{\text{CTSi}}$/$\overline{\text{RTSi}}$ (P60, P64, P73)	$\overline{\text{CTS}}$ input	UiC0 register's CRD bit=0 UiC0 register's CRS bit=0 PD6 register's PD6_0 bit=0, PD6_4 bit=0, PD7 register's PD7_3 bit=0
	$\overline{\text{RTS}}$ output	UiC0 register's CRD bit=0 UiC0 register's CRS bit=1
	Input/output port	UiC0 register's CRD bit=1

Table 10.8 P64 Pin Functions

Pin function	Bit set value				
	U1C0 register		UCON register		PD6 register
	CRD	CRS	RCSP	CLKMD1	PD6_4
P64	1	—	0	0	Input: 0, Output: 1
$\overline{\text{CTS1}}$	0	0	0	0	0
$\overline{\text{RTS1}}$	0	1	0	0	—
$\overline{\text{CTS0}}$ (Note)	0	0	1	0	0

Note: In addition to this, set the U0C0 register's CRD bit to "0" ($\overline{\text{CTS0}}$/$\overline{\text{RTS0}}$ enabled) and the U0C0 register's CRS bit to "1" ($\overline{\text{RTS0}}$ selected).

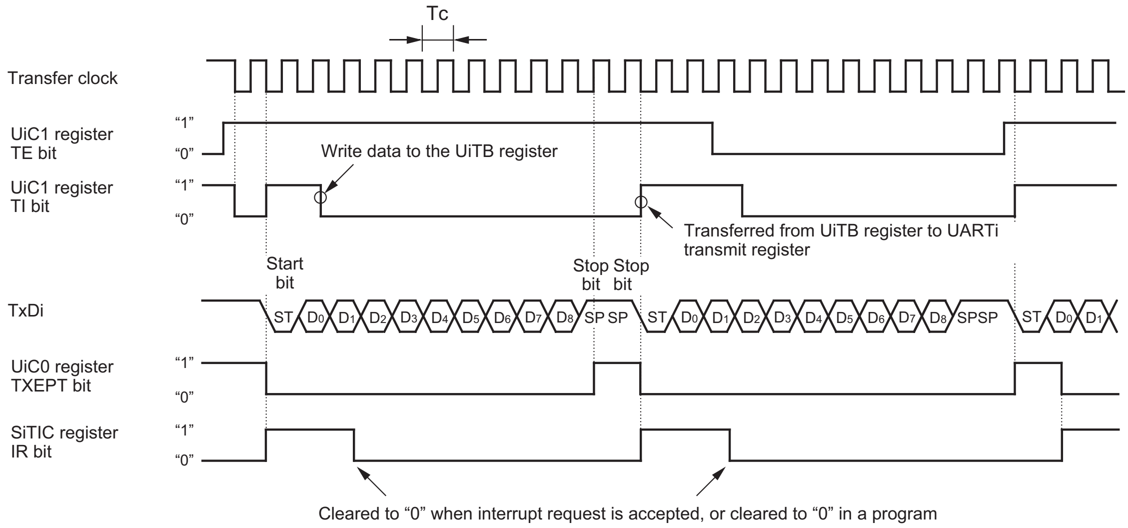
(1) Example of transmit timing when transfer data is 8 bits long (parity enabled, one stop bit)



The above timing diagram applies to the case where the register bits are set as follows:
- UiMR register PRYE bit = 1 (parity enabled)
- UiMR register STPS bit = 0 (1 stop bit)
- UiC0 register CRD bit = 0 ($\overline{CTS}/\overline{RTS}$ enabled), CRS bit = 0 ($\overline{CTS}$ selected)
- UiRS bit = 1 (an interrupt request occurs when transmit completed): U0IRS bit is the UCON register bit 0, U1IRS bit is the UCON register bit 1, and U2IRS bit is the U2C1 register bit 4

Tc = 16 (n + 1) / fj or 16 (n + 1) / fEXT
fj : frequency of UiBRG count source (f1SIO, f2SIO, f8SIO, f32SIO)
fEXT : frequency of UiBRG count source (external clock)
n : value set to UiBRG
i: 0 to 2

(2) Example of transmit timing when transfer data is 9 bits long (parity disabled, two stop bits)

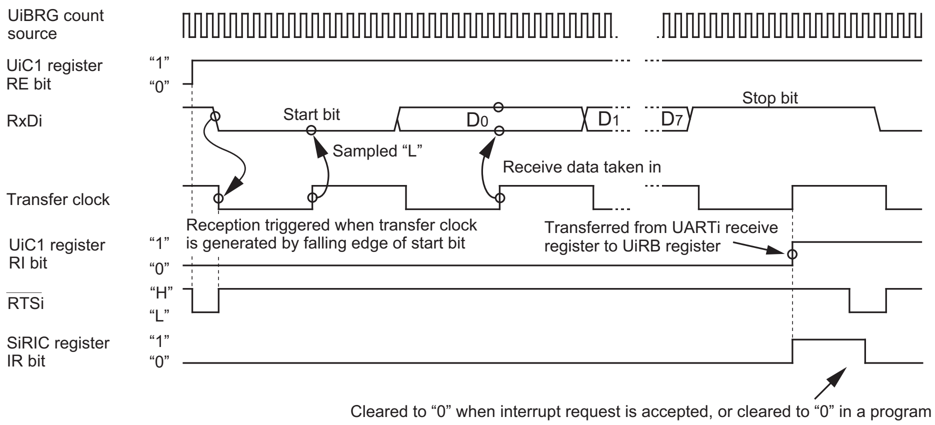


The above timing diagram applies to the case where the register bits are set as follows:
- UiMR register PRYE bit = 0 (parity disabled)
- UiMR register STPS bit = 1 (2 stop bits)
- UiC0 register CRD bit = 1 ($\overline{CTS}/\overline{RTS}$ disabled)
- UiRS bit = 0 (an interrupt request occurs when transmit buffer becomes empty): U0IRS bit is the UCON register bit 0, U1IRS bit is the UCON register bit 1, and U2IRS bit is the U2C1 register bit 4

Tc = 16 (n + 1) / fj or 16 (n + 1) / fEXT
fj : frequency of UiBRG count source (f1SIO, f2SIO, f8SIO, f32SIO)
fEXT : frequency of UiBRG count source (external clock)
n : value set to UiBRG
i: 0 to 2

Figure 10.15 Transmit Operation

• Example of receive timing when transfer data is 8 bits long (parity disabled, one stop bit)



The above timing diagram applies to the case where the register bits are set as follows:
- UiMR register PRYE bit = 0 (parity disabled)
- UiMR register STPS bit = 0 (1 stop bit)
- UiC0 register CRD bit = 0 (CTSi/RTSi enabled), CRS bit = 1 (RTSi selected)

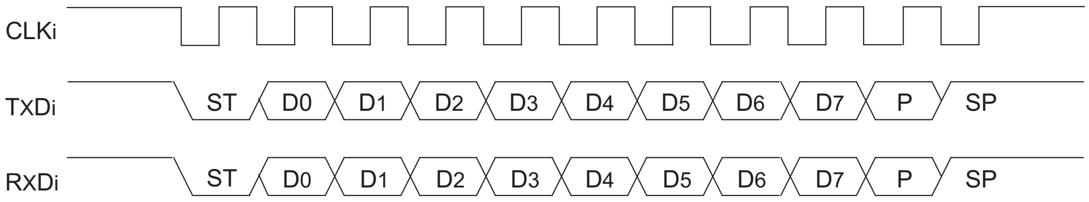
i = 0 to 2

Figure 10.16 Receive Operation

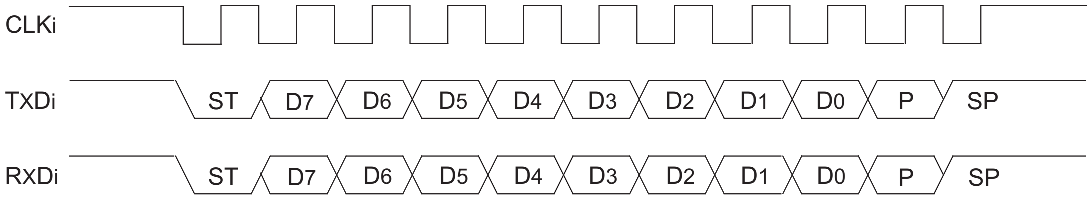
10.3.1 LSB First/MSB First Select Function

As shown in Figure 10.17, use the UiC0 register's UFORM bit to select the transfer format. This function is valid when transfer data is 8 bits long.

(1) When UiC0 register's UFORM bit = 0 (LSB first)



(2) When UiC0 register's UFORM bit = 1 (MSB first)



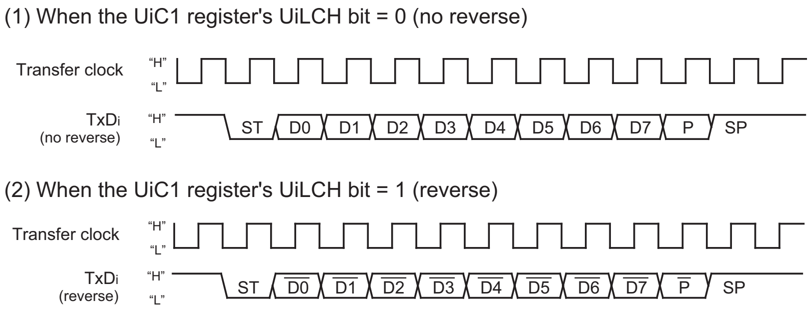
ST : Start bit
P : Parity bit
SP : Stop bit
i = 0 to 2

Note: This applies to the case where the UiC0 register's CKPOL bit = 0 (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock), the UiC1 register's UiLCH bit = 0 (no reverse), UiMR register's STPS bit = 0 (1 stop bit) and UiMR register's PRYE bit = 1 (parity enabled).

Figure 10.17 Transfer Format

10.3.2 Serial Data Logic Switching Function

The data written to the UiTB register has its logic reversed before being transmitted. Similarly, the received data has its logic reversed when read from the UiRB register. Figure 10.18 shows serial data logic.



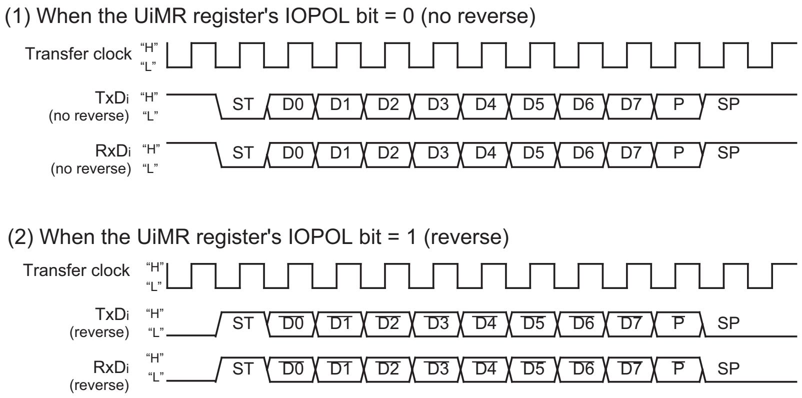
ST : Start bit
P : Parity bit
SP : Stop bit
i = 0 to 2

Note: This applies to the case where the UiC0 register’s CKPOL bit = 0 (transmit data output at the falling edge of the transfer clock), the UiC0 register's UFORM bit = 0 (LSB first), the UiMR register's STPS bit = 0 (1 stop bit) and UiMR register's PRYE bit = 1 (parity enabled).

Figure 10.18 Serial Data Logic Switching

10.3.3 TxD and RxD I/O Polarity Inverse Function

This function inverses the polarities of the TXDi pin output and RXDi pin input. The logic levels of all input/output data (including the start, stop and parity bits) are inversed. Figure 10.19 shows the TXD pin output and RXD pin input polarity inverse.



ST : Start bit
P : Parity bit
SP : Stop bit
i = 0 to 2

Note: This applies to the case where the UiC0 register's UFORM bit = 0 (LSB first), the UiMR register's STPS bit = 0 (1 stop bit) and the UiMR register's PRYE bit = 1 (parity enabled).

Figure 10.19 TxD and RxD I/O Polarity Inverse

10.3.4 $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ Separate Function (UART0)

This function separates $\overline{\text{CTS0}}$/$\overline{\text{RTS0}}$, outputs $\overline{\text{RTS0}}$ from the P60 pin, and accepts as input the $\overline{\text{CTS0}}$ from the P64 pin. To use this function, set the register bits as shown below.

- U0C0 register's CRD bit = 0 (enables UART0 $\overline{\text{CTS}}$/$\overline{\text{RTS}}$)
- U0C0 register's CRS bit = 1 (outputs UART0 $\overline{\text{RTS}}$)
- U1C0 register's CRD bit = 0 (enables UART1 $\overline{\text{CTS}}$/$\overline{\text{RTS}}$)
- U1C0 register's CRS bit = 0 (inputs UART1 $\overline{\text{CTS}}$)
- UCON register's RCSP bit = 1 (inputs CTS0 from the P64 pin)
- UCON register's CLKMD1 bit = 0 (CLKS1 not used)

Note that when using the $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ separate function, UART1 $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ function cannot be used.

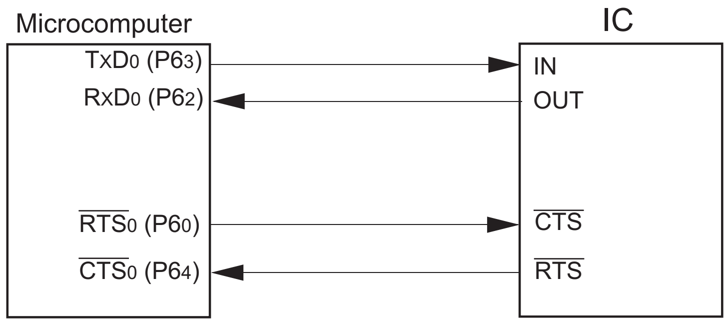


Figure 10.20 $\overline{\text{CTS}}$/$\overline{\text{RTS}}$ Separate Function

10.4 Special Mode 1 (I^2C mode)

I^2C mode is provided for use as a simplified I^2C interface compatible mode. Table 10.9 lists the specifications of the I^2C mode. Table 10.10 to 10.11 lists the registers used in the I^2C mode and the register values set, Table 10.12 lists the I^2C mode functions. Figure 10.21 shows the block diagram for I^2C mode. Figure 10.22 shows SCLi timing.

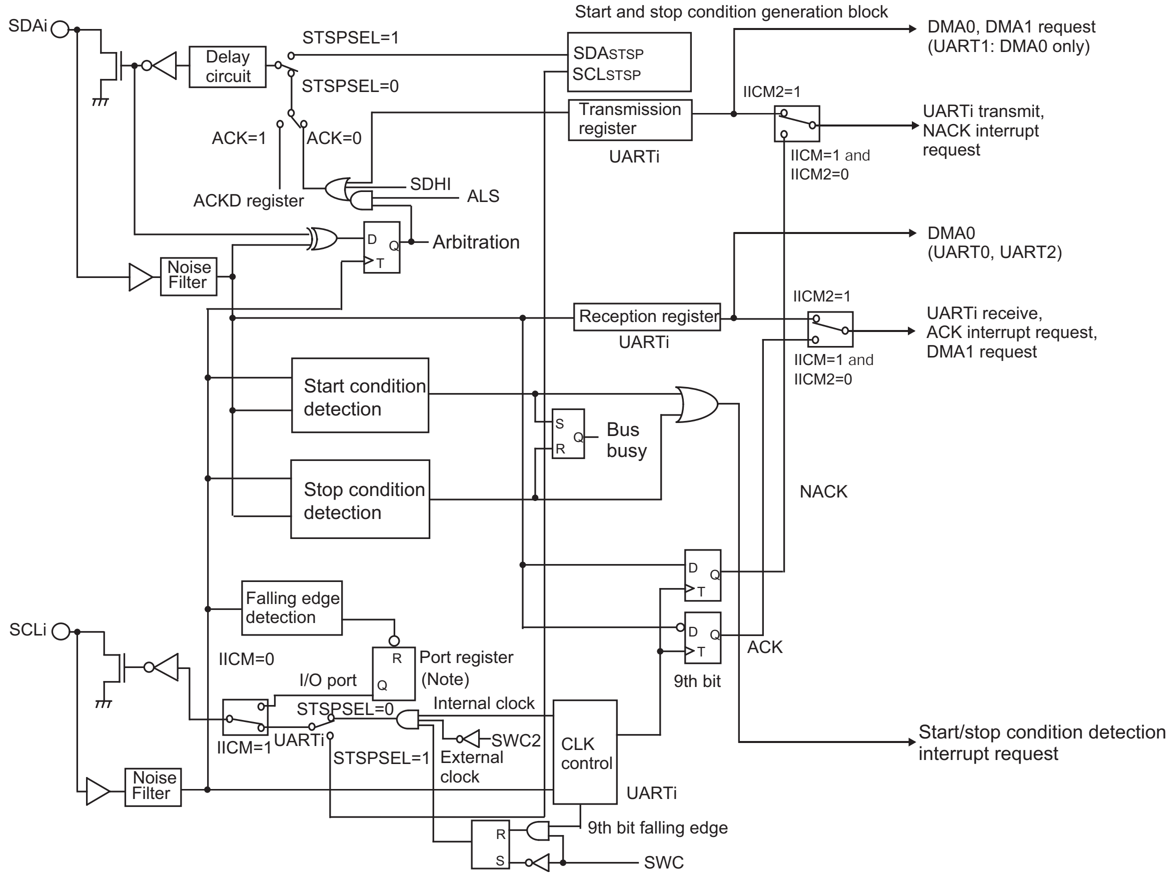
As shown in Table 10.12, the microcomputer is placed in I^2C mode by setting the SMD2 to SMD0 bits to ‘010_2’ and the IICM bit to “1”. Because SDAi transmit output has a delay circuit attached, SDAi output does not change state until SCLi goes low and remains stably low.

Table 10.9 I^2C Mode Specifications

Item	Specification
Transfer data format	• Transfer data length: 8 bits
Transfer clock	• During master UiMR(i=0 to 2) register’s CKDIR bit = “0” (internal clock) : fj/ 2(n+1) fj = f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}. n: Setting value of UiBRG register 00_{16} to FF_{16} • During slave CKDIR bit = “1” (external clock) : Input from SCLi pin
Transmission start condition	• Before transmission can start, the following requirements must be met (Note 1) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register = 0 (data present in UiTB register)
Reception start condition	• Before reception can start, the following requirements must be met (Note 1) – The RE bit of UiC1 register= 1 (reception enabled) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register= 0 (data present in the UiTB register)
Interrupt request generation timing	When start or stop condition is detected, acknowledge undetected, and acknowledge detected
Error detection	• Overrun error (Note 2) This error occurs if the serial I/O started receiving the next data before reading the UiRB register and received the 8th bit of the next data
Select function	• Arbitration lost Timing at which the UiRB register’s ABT bit is updated can be selected • SDAi digital delay No digital delay or a delay of 2 to 8 UiBRG count source clock cycles selectable • Clock phase setting With or without clock delay selectable

Note 1: When an external clock is selected, the conditions must be met while the external clock is in the high state.

Note 2: If an overrun error occurs, the value of UiRB register will be indeterminate. The IR bit of SiRIC register does not change.



This diagram applies to the case where the UiMR register's SMD2 to SMD0 bits = 010_2 and the UiSMR register's IICM bit = 1.

IICM : UiSMR register bit
IICM2, SWC, ALS, SWC2, SDHI : UiSMR2 register bit
STSPSEL, ACKD, ACKC : UiSMR4 register bit

i=0 to 2

Note: If the IICM bit = 1, the pin can be read even when the PD6_2, PD6_6 or PD7_1 bit = 1 (output mode).

Figure 10.21 I²C Mode Block Diagram

Table 10.10 Registers to Be Used and Settings in I$_2$C Mode (1) (Continued)

Register	Bit	Function	
		Master	Slave
UiTB (Note 3)	0 to 7	Set transmission data	Set transmission data
UiRB (Note 3)	0 to 7	Reception data can be read	Reception data can be read
	8	ACK or NACK is set in this bit	ACK or NACK is set in this bit
	ABT	Arbitration lost detection flag	Invalid
	OER	Overrun error flag	Overrun error flag
UiBRG	0 to 7	Set a transfer rate	Invalid
UiMR (Note 3)	SMD2 to SMD0	Set to ‘010$_2$’	Set to ‘010$_2$’
	CKDIR	Set to “0”	Set to “1”
	IOPOL	Set to “0”	Set to “0”
UiC0	CLK1, CLK0	Select the count source for the UiBRG register	Invalid
	CRS	Invalid because CRD = 1	Invalid because CRD = 1
	TXEPT	Transmit buffer empty flag	Transmit buffer empty flag
	CRD	Set to “1”	Set to “1”
	NCH	Set to “1” (Note 2)	Set to “1” (Note 2)
	CKPOL	Set to “0”	Set to “0”
	UFORM	Set to “1”	Set to “1”
UiC1	TE	Set this bit to “1” to enable transmission	Set this bit to “1” to enable transmission
	TI	Transmit buffer empty flag	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception	Set this bit to “1” to enable reception
	RI	Reception complete flag	Reception complete flag
	U2IRS (Note 1)	Invalid	Invalid
	U2RRM (Note 1), UiLCH, UiERE	Set to “0”	Set to “0”
UiSMR	IICM	Set to “1”	Set to “1”
	ABC	Select the timing at which arbitration-lost is detected	Invalid
	BBS	Bus busy flag	Bus busy flag
	3 to 7	Set to “0”	Set to “0”
UiSMR2	IICM2	Refer to Table 11.12	Refer to Table 11.12
	CSC	Set this bit to “1” to enable clock synchronization	Set to “0”
	SWC	Set this bit to “1” to have SCLi output fixed to “L” at the falling edge of the 9th bit of clock	Set this bit to “1” to have SCLi output fixed to “L” at the falling edge of the 9th bit of clock
	ALS	Set this bit to “1” to have SDAi output stopped when arbitration-lost is detected	Set to “0”
	STAC	Set to “0”	Set this bit to “1” to initialize UARTi at start condition detection
	SWC2	Set this bit to “1” to have SCLi output forcibly pulled low	Set this bit to “1” to have SCLi output forcibly pulled low
	SDHI	Set this bit to “1” to disable SDAi output	Set this bit to “1” to disable SDAi output
	7	Set to “0”	Set to “0”
UiSMR3	0, 2, 4 and NODC	Set to “0”	Set to “0”
	CKPH	Refer to Table 11.12	Refer to Table 11.12
	DL2 to DL0	Set the amount of SDAi digital delay	Set the amount of SDAi digital delay

i=0 to 2

Notes:

1. Set the U0C1 and U1C1 register bit 4 and bit 5 to “0”. The U0IRS, U1IRS, U0RRM and U1RRM bits are in the UCON register.
2. TxD2 pin is N channel open-drain output. Set the NCH bit in the U2C0 register to “0”.
3. Not all register bits are described above. Set those bits to “0” when writing to the registers in I^{2}C mode.

Table 10.11 Registers to Be Used and Settings in I2C Mode (2) (Continued)

Register	Bit	Function	
		Master	Slave
UiSMR4	STAREQ	Set this bit to “1” to generate start condition	Set to “0”
	RSTAREQ	Set this bit to “1” to generate restart condition	Set to “0”
	STPREQ	Set this bit to “1” to generate stop condition	Set to “0”
	STSPSEL	Set this bit to “1” to output each condition	Set to “0”
	ACKD	Select ACK or NACK	Select ACK or NACK
	ACKC	Set this bit to “1” to output ACK data	Set this bit to “1” to output ACK data
	SCLHI	Set this bit to “1” to have SCLi output stopped when stop condition is detected	Set to “0”
	SWC9	Set to “0”	Set this bit to “1” to set the SCLi to “L” hold at the next falling edge of the 9th bit of clock
IFSR2A	IFSR26, ISFR27	Set to “1”	Set to “1”
UCON	U0IRS, U1IRS	Invalid	Invalid
	2 to 7	Set to “0”	Set to “0”

i=0 to 2

Table 10.12 I2C Mode Functions

Function	Clock synchronous serial I/O mode (SMD2 to SMD0 = 001_2, IICM = 0)	I2C mode (SMD2 to SMD0 = 010_2, IICM = 1)			
		IICM2 = 0 (NACK/ACK interrupt)		IICM2 = 1 (UART transmit/ receive interrupt)	
		CKPH = 0 (No clock delay)	CKPH = 1 (Clock delay)	CKPH = 0 (No clock delay)	CKPH = 1 (Clock delay)
Factor of interrupt number 6, 7 and 10 (Note 1, 5, 7)	———	Start condition detection or stop condition detection (Refer to “Table 10.13. STSPSEL Bit Functions”)			
Factor of interrupt number 15, 17 and 19 (Note 1, 6)	UARTi transmission Transmission started or completed (selected by UiIRS)	No acknowledgment detection (NACK) Rising edge of SCLi 9th bit		UARTi transmission Rising edge of SCLi 9th bit	UARTi transmission Falling edge of SCLi next to the 9th bit
Factor of interrupt number 16, 18 and 20 (Note 1, 6)	UARTi reception When 8th bit received CKPOL = 0 (rising edge) CKPOL = 1 (falling edge)	Acknowledgment detection (ACK) Rising edge of SCLi 9th bit		UARTi reception Falling edge of SCLi 9th bit	
Timing for transferring data from the UART reception shift register to the UiRB register	CKPOL = 0 (rising edge) CKPOL = 1 (falling edge)	Rising edge of SCLi 9th bit		Falling edge of SCLi 9th bit	Falling and rising edges of SCLi 9th bit
UARTi transmission output delay	Not delayed	Delayed			
Functions of $P6_3$, $P6_7$ and $P7_0$ pins	TxDi output	SDAi input/output			
Functions of $P6_2$, $P6_6$ and $P7_1$ pins	RxDi input	SCLi input/output			
Functions of $P6_1$, $P6_5$ and $P7_2$ pins	CLKi input or output selected	——— (Cannot be used in I2C mode)			
Noise filter width	15ns	200ns			
Read RxDi and SCLi pin levels	Possible when the corresponding port direction bit = 0	Always possible no matter how the corresponding port direction bit is set			
Initial value of TxDi and SDAi outputs	CKPOL = 0 (H) CKPOL = 1 (L)	The value set in the port register before setting I2C mode (Note 2)			
Initial and end values of SCLi	———	H	L	H	L
DMA1 factor (Refer to Fig 10.22)	UARTi reception	Acknowledgment detection (ACK)		UARTi reception Falling edge of SCLi 9th bit	
Store received data	1st to 8th bits are stored in UiRB register bit 0 to bit 7	1st to 8th bits are stored in UiRB register bit 7 to bit 0		1st to 7th bits are stored in UiRB register bit 6 to bit 0, with 8th bit stored in UiRB register bit 8	1st to 8th bits are stored in UiRB register bit 7 to bit 0 (Note 3)
Read received data	UiRB register status is read directly as is				Read UiRB register Bit 6 to bit 0 as bit 7 to bit 1, and bit 8 as bit 0 (Note 4)

i = 0 to 2

Note 1: If the source or cause of any interrupt is changed, the IR bit in the interrupt control register for the changed interrupt may inadvertently be set to “1” (interrupt requested). (Refer to “precautions for interrupts” of the Usage Notes Reference Book.)
If one of the bits shown below is changed, the interrupt source, the interrupt timing, etc. change. Therefore, always be sure to clear the IR bit to “0” (interrupt not requested) after changing those bits.
SMD2 to SMD0 bits in the UiMR register, IICM bit in the UiSMR register, IICM2 bit in the UiSMR2 register, CKPH bit in the UiSMR3 register

Note 2: Set the initial value of SDAi output while the UiMR register’s SMD2 to SMD0 bits = ‘000_2’ (serial I/O disabled).

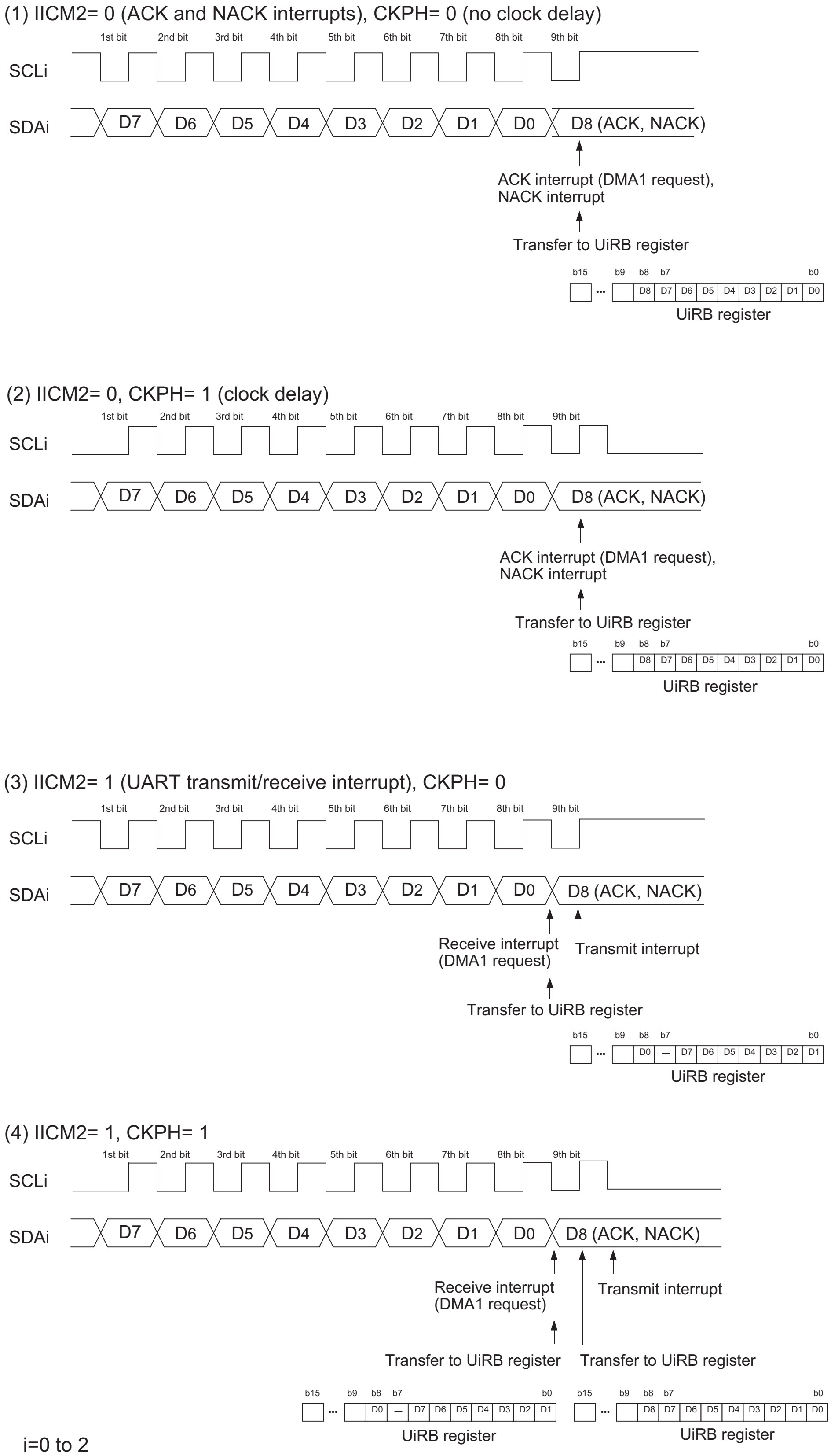
Note 3: Second data transfer to UiRB register (Rising edge of SCLi 9th bit)

Note 4: First data transfer to UiRB register (Falling edge of SCLi 9th bit)

Note 5: Refer to “Figure 10.13. STSPSEL Bit Functions”.

Note 6: Refer to “Figure 10.22. Transfer to UiRB Register and Interrupt Timing” .

Note 7: When using UART0, be sure to set the IFSR26 bit in the IFSR2A register to “1” (cause of interrupt: UART0 bus collision).
When using UART1, be sure to set the IFSR27 bit in the IFSR2A register to “1” (cause of interrupt: UART1 bus collision).



i=0 to 2

This diagram applies to the case where the following condition is met.
- UiMR register CKDIR bit = 0 (Slave selected)

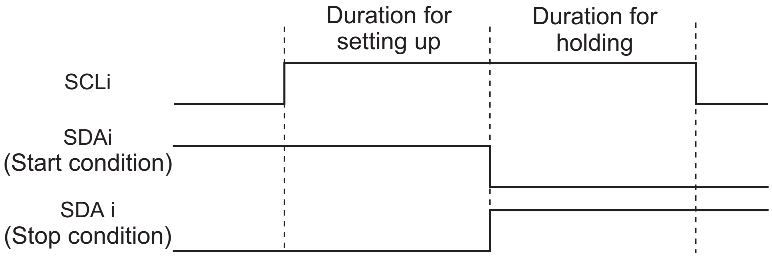
Figure 10.22 Transfer to UiRB Register and Interrupt Timing

10.4.1 Detection of Start and Stop Condtion

Whether a start or a stop condition has been detected is determined.
A start condition-detected interrupt request is generated when the SDAi pin changes state from high to low while the SCLi pin is in the high state. A stop condition-detected interrupt request is generated when the SDAi pin changes state from low to high while the SCLi pin is in the high state.
Because the start and stop condition-detected interrupts share the interrupt control register and vector, check the UiSMR register's BBS bit to determine which interrupt source is requesting the interrupt.

3 to 6 cycles < duration for setting-up (Note)

3 to 6 cycles < duration for holding (Note)



i = 0 to 2
Note: When the PCLKR register's PCLK1 bit = 1, this is the cycle number of f_{1SIO}, and the PCLK1 bit = 0, this is the cycle number of f_{2SIO}.

Figure 10.23 Detection of Start and Stop Condition

10.4.2 Output of Start and Stop Condition

A start condition is generated by setting the UiSMR4 register (i = 0 to 2)'s STAREQ bit to "1" (start).
A restart condition is generated by setting the UiSMR4 register's RSTAREQ bit to "1" (start).
A stop condition is generated by setting the UiSMR4 register's STPREQ bit to "1" (start).
The output procedure is described below.
Set the STAREQ bit, RSTAREQ bit or STPREQ bit to "1" (start).
Set the STSPSEL bit in the UiSMR4 register to "1" (output).
The function of the STSPSEL bit is shown in Table 10.13 and Figure 10.24.

Table 10.13 STSPSEL Bit Functions

Function	STSPSEL = 0	STSPSEL = 1
Output of SCLi and SDAi pins	Output of transfer clock and data Output of start/stop condition is accomplished by a program using ports (not automatically generated in hardware)	Output of a start/stop condition according to the STAREQ, RSTAREQ and STPREQ bit
Start/stop condition interrupt request generation timing	Start/stop condition detection	Finish generating start/stop condition

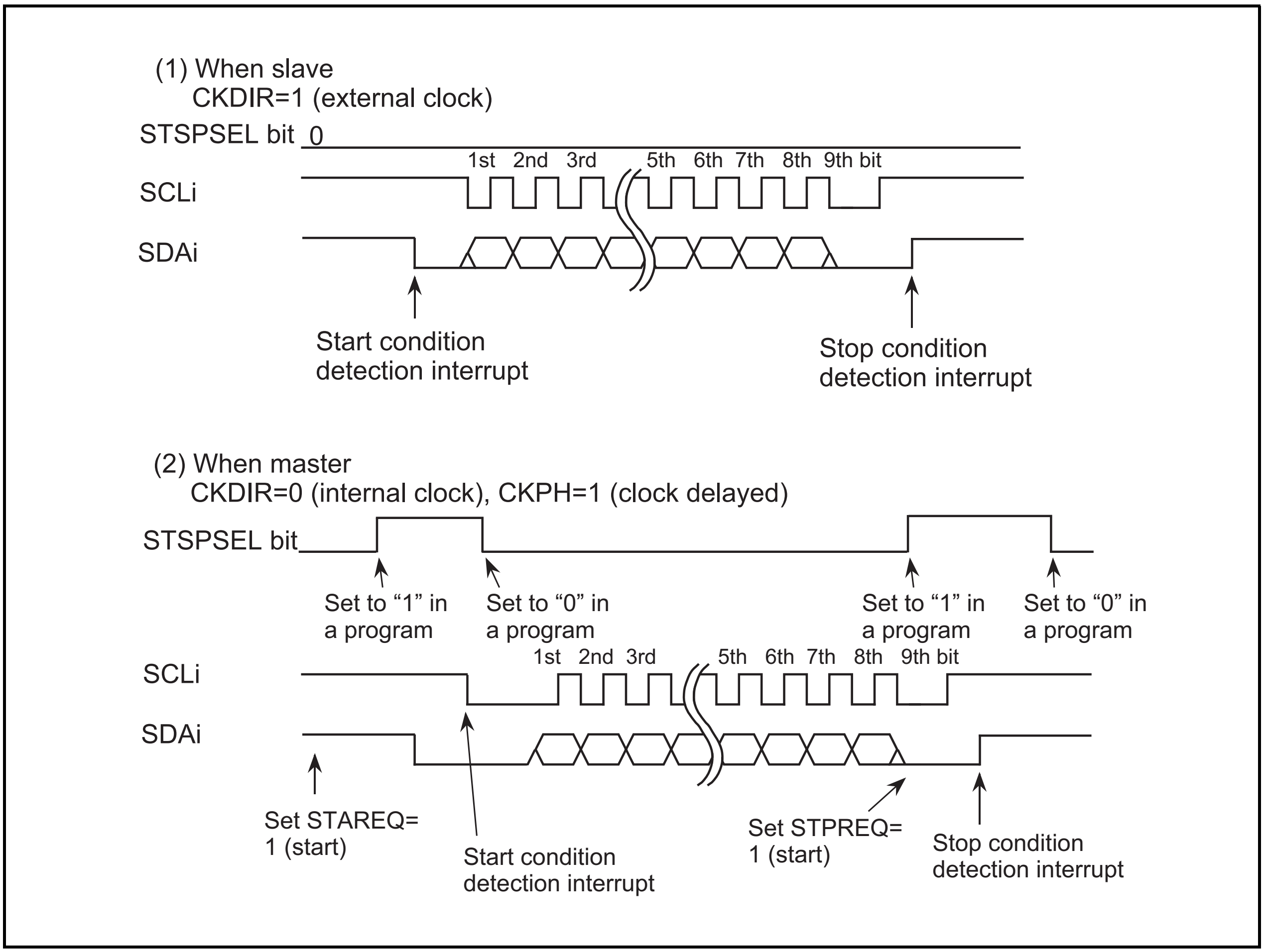


Figure 10.24 STSPSEL Bit Functions

10.4.3 Arbitration

Unmatching of the transmit data and SDAi pin input data is checked synchronously with the rising edge of SCLi. Use the UiSMR register's ABC bit to select the timing at which the UiRB register's ABT bit is updated. If the ABC bit = 0 (updated bitwise), the ABT bit is set to "1" at the same time unmatching is detected during check, and is cleared to "0" when not detected. In cases when the ABC bit is set to "1", if unmatching is detected even once during check, the ABT bit is set to "1" (unmatching detected) at the falling edge of the clock pulse of 9th bit. If the ABT bit needs to be updated bytewise, clear the ABT bit to "0" (undetected) after detecting acknowledge in the first byte, before transferring the next byte.
Setting the UiSMR2 register's ALS bit to "1" (SDA output stop enabled) causes arbitration-lost to occur, in which case the SDAi pin is placed in the high-impedance state at the same time the ABT bit is set to "1" (unmatching detected).

10.4.4 Transfer Clock

Data is transmitted/received using a transfer clock like the one shown in Figure 10.24.

The UiSMR2 register's CSC bit is used to synchronize the internally generated clock (internal SCLi) and an external clock supplied to the SCLi pin. In cases when the CSC bit is set to "1" (clock synchronization enabled), if a falling edge on the SCLi pin is detected while the internal SCLi is high, the internal SCLi goes low, at which time the UiBRG register value is reloaded with and starts counting in the low-level interval. If the internal SCLi changes state from low to high while the SCLi pin is low, counting stops, and when the SCLi pin goes high, counting restarts.

In this way, the UARTi transfer clock is comprised of the logical product of the internal SCLi and SCLi pin signal. The transfer clock works from a half period before the falling edge of the internal SCLi 1st bit to the rising edge of the 9th bit. To use this function, select an internal clock for the transfer clock.

The UiSMR2 register's SWC bit allows to select whether the SCLi pin should be fixed to or freed from low-level output at the falling edge of the 9th clock pulse.

If the UiSMR4 register's SCLHI bit is set to "1" (enabled), SCLi output is turned off (placed in the high impedance state) when a stop condition is detected.

Setting the UiSMR2 register's SWC2 bit = 1 (0 output) makes it possible to forcibly output a low-level signal from the SCLi pin even while sending or receiving data. Clearing the SWC2 bit to "0" (transfer clock) allows the transfer clock to be output from or supplied to the SCLi pin, instead of outputting a low-level signal.

If the UiSMR4 register's SWC9 bit is set to "1" (SCL hold low enabled) when the UiSMR3 register's CKPH bit = 1, the SCLi pin is fixed to low-level output at the falling edge of the clock pulse next to the ninth. Setting the SWC9 bit = 0 (SCL hold low disabled) frees the SCLi pin from low-level output.

10.4.5 SDA Output

The data written to the UiTB register bit 7 to bit 0 (D_7 to D_0) is sequentially output beginning with D_7.

The ninth bit (D_8) is ACK or NACK.

The initial value of SDAi transmit output can only be set when IICM = 1 (I^2C mode) and the UiMR register's SMD2 to SMD0 bits = '000_2' (serial I/O disabled).

The UiSMR3 register's DL2 to DL0 bits allow to add no delays or a delay of 2 to 8 UiBRG count source clock cycles to SDAi output.

Setting the UiSMR2 register's SDHI bit = 1 (SDA output disabled) forcibly places the SDAi pin in the high-impedance state. Do not write to the SDHI bit synchronously with the rising edge of the UARTi transfer clock. This is because the ABT bit may inadvertently be set to "1" (detected).

10.4.6 SDA Input

When the IICM2 bit = 0, the 1st to 8th bits (D_7 to D_0) of received data are stored in the UiRB register bit 7 to bit 0. The 9th bit (D_8) is ACK or NACK.

When the IICM2 bit = 1, the 1st to 7th bits (D_7 to D_1) of received data are stored in the UiRB register bit 6 to bit 0 and the 8th bit (D_0) is stored in the UiRB register bit 8. Even when the IICM2 bit = 1, providing the CKPH bit = 1, the same data as when the IICM2 bit = 0 can be read out by reading the UiRB register after the rising edge of the corresponding clock pulse of 9th bit.

10.4.7 ACK and NACK

If the STSPSEL bit in the UiSMR4 register is set to "0" (start and stop conditions not generated) and the ACKC bit in the UiSMR4 register is se to "1" (ACK data output), the value of the ACKD bit in the UiSMR4 register is output from the SDAi pin.

If the IICM2 bit = 0, a NACK interrupt request is generated if the SDAi pin remains high at the rising edge of the 9th bit of transmit clock pulse. An ACK interrupt request is generated if the SDAi pin is low at the rising edge of the 9th bit of transmit clock pulse.

If ACKi is selected for the cause of DMA1 request, a DMA transfer can be activated by detection of an acknowledge.

10.4.8 Initialization of Transmission/Reception

If a start condition is detected while the STAC bit = 1 (UARTi initialization enabled), the serial I/O operates as described below.

The transmit shift register is initialized, and the content of the UiTB register is transferred to the transmit shift register. In this way, the serial I/O starts sending data synchronously with the next clock pulse applied. However, the UARTi output value does not change state and remains the same as when a start condition was detected until the first bit of data is output synchronously with the input clock.

The receive shift register is initialized, and the serial I/O starts receiving data synchronously with the next clock pulse applied.

The SWC bit is set to “1” (SCL wait output enabled). Consequently, the SCLi pin is pulled low at the falling edge of the ninth clock pulse.

Note that when UARTi transmission/reception is started using this function, the TI does not change state. Note also that when using this function, the selected transfer clock should be an external clock.

10.5 Special Mode 2

Multiple slaves can be serially communicated from one master. Transfer clock polarity and phase are selectable. Table 10.14 lists the specifications of Special Mode 2. Table 10.15 lists the registers used in Special Mode 2 and the register values set. Figure 10.25 shows communication control example for Special Mode 2.

Table 10.14 Special Mode 2 Specifications

Item	Specification
Transfer data format	• Transfer data length: 8 bits
Transfer clock	• Master mode UiMR(i=0 to 2) register's CKDIR bit = "0" (internal clock) : fj/ 2(n+1) fj = f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}. n: Setting value of UiBRG register 00_{16} to FF_{16} • Slave mode CKDIR bit = "1" (external clock selected) : Input from CLKi pin
Transmit/receive control	Controlled by input/output ports
Transmission start condition	• Before transmission can start, the following requirements must be met (Note 1) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register = 0 (data present in UiTB register)
Reception start condition	• Before reception can start, the following requirements must be met (Note 1) – The RE bit of UiC1 register= 1 (reception enabled) – The TE bit of UiC1 register= 1 (transmission enabled) – The TI bit of UiC1 register= 0 (data present in the UiTB register)
Interrupt request generation timing	• For transmission, one of the following conditions can be selected – The UiIRS bit of UiC1 register = 0 (transmit buffer empty): when transferring data from the UiTB register to the UARTi transmit register (at start of transmission) – The UiIRS bit =1 (transfer completed): when the serial I/O finished sending data from the UARTi transmit register • For reception When transferring data from the UARTi receive register to the UiRB register (at completion of reception)
Error detection	• Overrun error (Note 2) This error occurs if the serial I/O started receiving the next data before reading the UiRB register and received the 7th bit of the next data
Select function	• Clock phase setting Selectable from four combinations of transfer clock polarities and phases

Note 1: When an external clock is selected, the conditions must be met while if the UiC0 register's CKPOL bit = "0" (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock), the external clock is in the high state; if the UiC0 register's CKPOL bit = "1" (transmit data output at the rising edge and the receive data taken in at the falling edge of the transfer clock), the external clock is in the low state.

Note 2: If an overrun error occurs, the value of UiRB register will be indeterminate. The IR bit of SiRIC register does not change.

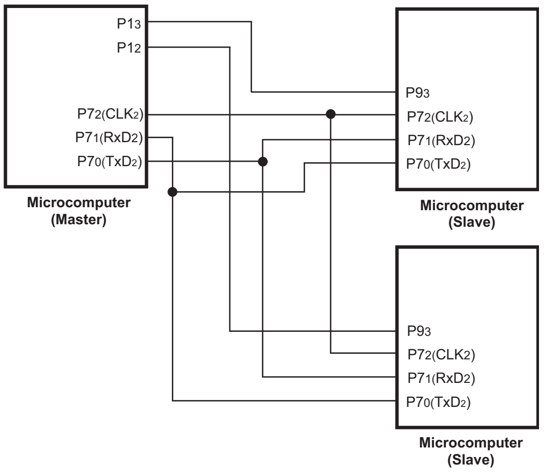


Figure 10.25 Serial Bus Communication Control Example (UART2)

Table 10.15 Registers to Be Used and Settings in Special Mode 2

Register	Bit	Function
UiTB(Note3)	0 to 7	Set transmission data
UiRB(Note3)	0 to 7	Reception data can be read
	OER	Overrun error flag
UiBRG	0 to 7	Set a transfer rate
UiMR(Note3)	SMD2 to SMD0	Set to ‘001$_2$’
	CKDIR	Set this bit to “0” for master mode or “1” for slave mode
	IOPOL	Set to “0”
UiC0	CLK1, CLK0	Select the count source for the UiBRG register
	CRS	Invalid because CRD = 1
	TXEPT	Transmit register empty flag
	CRD	Set to “1”
	NCH	Select TxDi pin output format(Note 2)
	CKPOL	Clock phases can be set in combination with the UiSMR3 register's CKPH bit
	UFORM	Set to “0”
UiC1	TE	Set this bit to “1” to enable transmission
	TI	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception
	RI	Reception complete flag
	U2IRS (Note 1)	Select UART2 transmit interrupt cause
	U2RRM(Note 1), U2LCH, UiERE	Set to “0”
UiSMR	0 to 7	Set to “0”
UiSMR2	0 to 7	Set to “0”
UiSMR3	CKPH	Clock phases can be set in combination with the UiC0 register's CKPOL bit
	NODC	Set to “0”
	0, 2, 4 to 7	Set to “0”
UiSMR4	0 to 7	Set to “0”
UCON	U0IRS, U1IRS	Select UART0 and UART1 transmit interrupt cause
	U0RRM, U1RRM	Set to “0”
	CLKMD0	Invalid because CLKMD1 = 0
	CLKMD1, RCSP, 7	Set to “0”

Note 1: Set the U0C0 and U1C1 register bit 4 and bit 5 to “0”. The U0IRS, U1IRS, U0RRM and U1RRM bits are in the UCON register.

Note 2: TxD2 pin is N channel open-drain output. Set the U2C0 register's NCH bit to “0”.

Note 3: Not all register bits are described above. Set those bits to “0” when writing to the registers in Special Mode 2.

i = 0 to 2

10.5.1 Clock Phase Setting Function

One of four combinations of transfer clock phases and polarities can be selected using the UiSMR3 register's CKPH bit and the UiC0 register's CKPOL bit.

Make sure the transfer clock polarity and phase are the same for the master and salves to be communicated.

- Master (Internal Clock)
  Figure 10.26 shows the transmission and reception timing in master (internal clock).
- Slave (External Clock)
  Figure 10.27 shows the transmission and reception timing (CKPH=0) in slave (external clock) while Figure 10.28 shows the transmission and reception timing (CKPH=1) in slave (external clock).

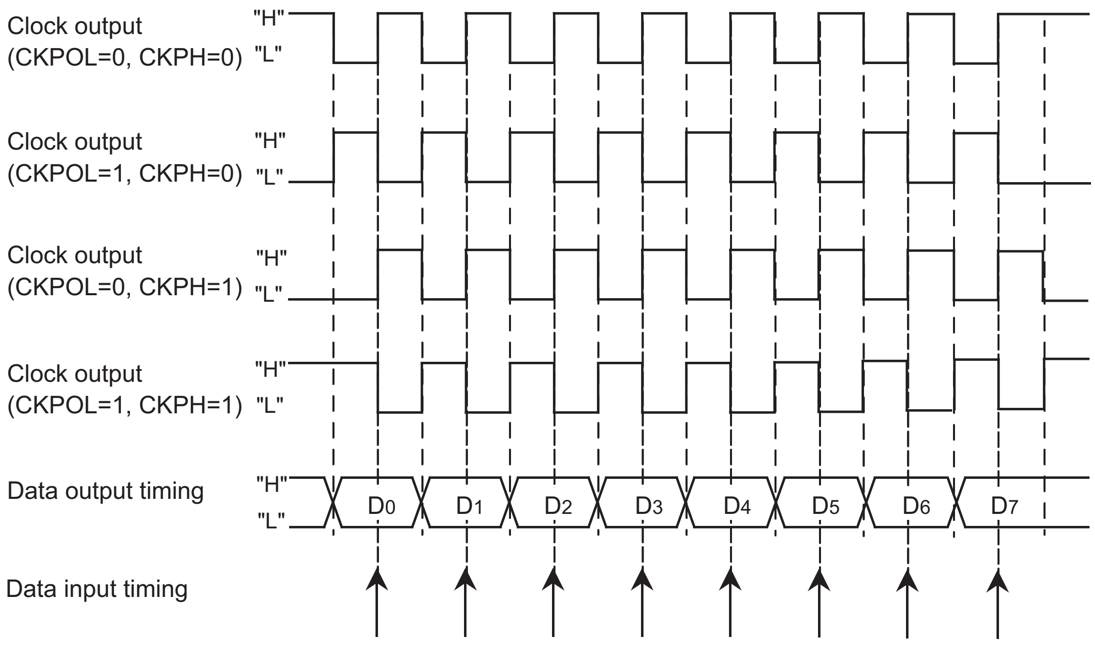
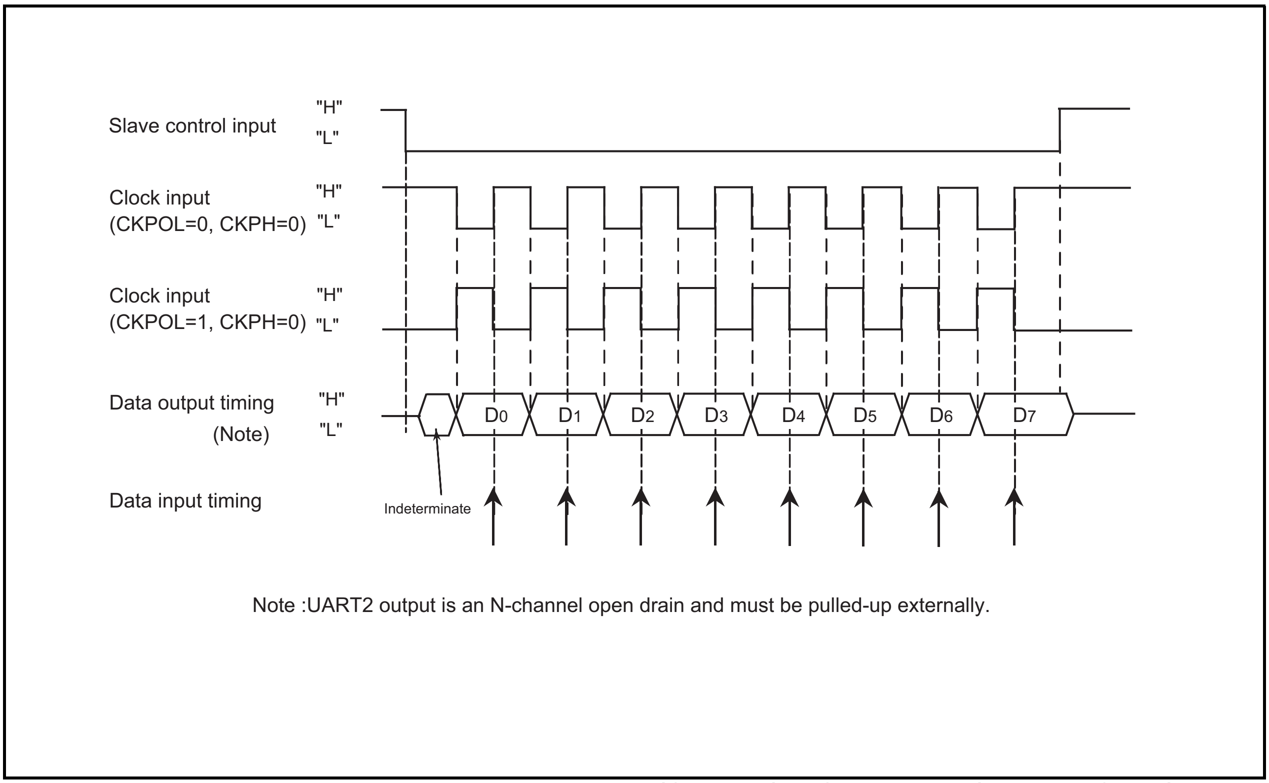
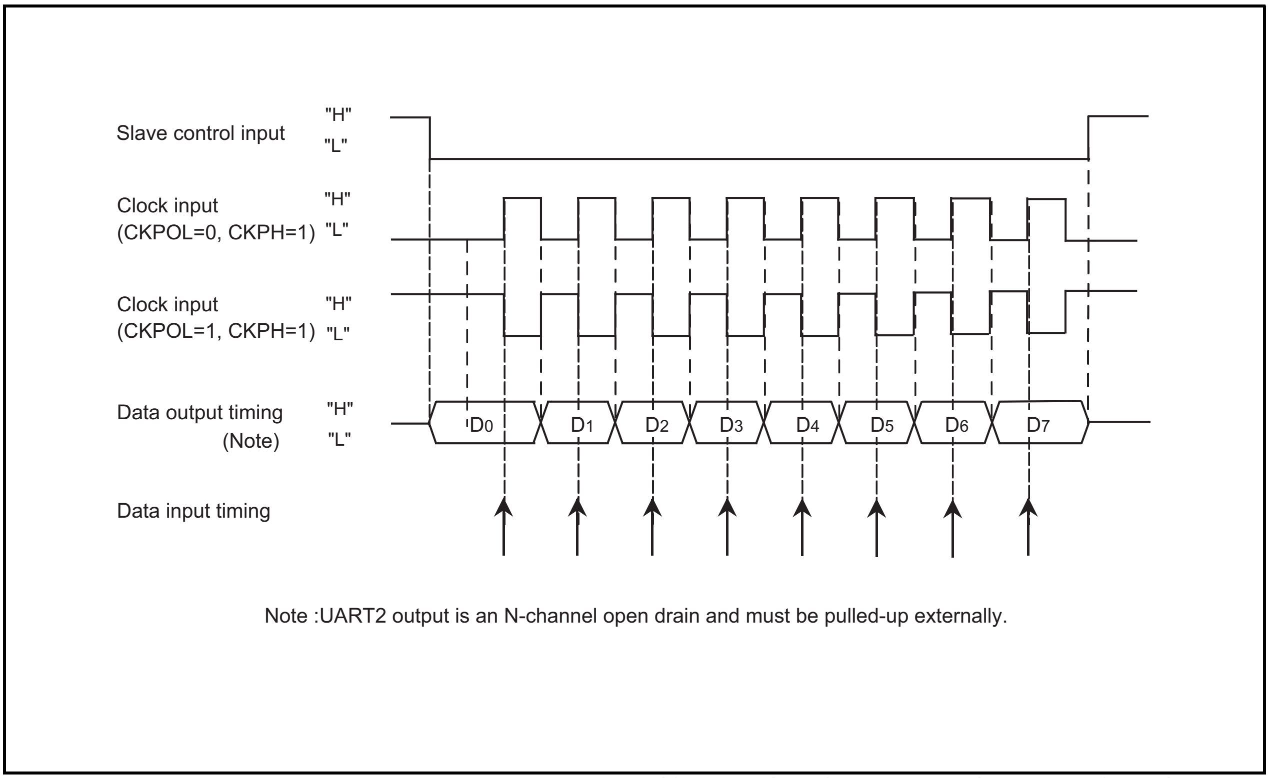


Figure 10.26 Transmission and Reception Timing in Master Mode (Internal Clock)



Note :UART2 output is an N-channel open drain and must be pulled-up externally.

Figure 10.27 Transmission and Reception Timing (CKPH=0) in Slave Mode (External Clock)



Note :UART2 output is an N-channel open drain and must be pulled-up externally.

Figure 10.28 Transmission and Reception Timing (CKPH=1) in Slave Mode (External Clock)

10.6 Special Mode 3 (IE mode)

In this mode, one bit of IEBus is approximated with one byte of UART mode waveform.

Table 10.16 lists the registers used in IE mode and the register values set. Figure 10.29 shows the functions of bus collision detect function related bits.

If the TxDi pin (i = 0 to 2) output level and RxDi pin input level do not match, a UARTi bus collision detect interrupt request is generated.

Use the IFSR2A register’s IFSR26 and IFSR27 bits to enable the UART0/UART1 bus collision detect function.

Table 10.16 Registers to Be Used and Settings in IE Mode

Register	Bit	Function
UiTB	0 to 8	Set transmission data
UiRB(Note3)	0 to 8	Reception data can be read
	OER,FER,PER,SUM	Error flag
UiBRG	0 to 7	Set a transfer rate
UiMR	SMD2 to SMD0	Set to ‘110$_2$’
	CKDIR	Select the internal clock or external clock
	STPS	Set to “0”
	PRY	Invalid because PRYE=0
	PRYE	Set to “0”
	IOPOL	Select the TxD/RxD input/output polarity
UiC0	CLK1, CLK0	Select the count source for the UiBRG register
	CRS	Invalid because CRD=1
	TXEPT	Transmit register empty flag
	CRD	Set to “1”
	NCH	Select TxDi pin output mode (Note 2)
	CKPOL	Set to “0”
	UFORM	Set to “0”
UiC1	TE	Set this bit to “1” to enable transmission
	TI	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception
	RI	Reception complete flag
	U2IRS (Note 1)	Select the source of UART2 transmit interrupt
	UiRRM (Note 1), UiLCH, UiERE	Set to “0”
UiSMR	0 to 3, 7	Set to “0”
	ABSCS	Select the sampling timing at which to detect a bus collision
	ACSE	Set this bit to “1” to use the auto clear function of transmit enable bit
	SSS	Select the transmit start condition
UiSMR2	0 to 7	Set to “0”
UiSMR3	0 to 7	Set to “0”
UiSMR4	0 to 7	Set to “0”
IFSR2A	IFSR26, IFSR27	Set to “1”
UCON	U0IRS, U1IRS	Select the source of UART0/UART1 transmit interrupt
	U0RRM, U1RRM	Set to “0”
	CLKMD0	Invalid because CLKMD1 = 0
	CLKMD1,RCSP,7	Set to “0”

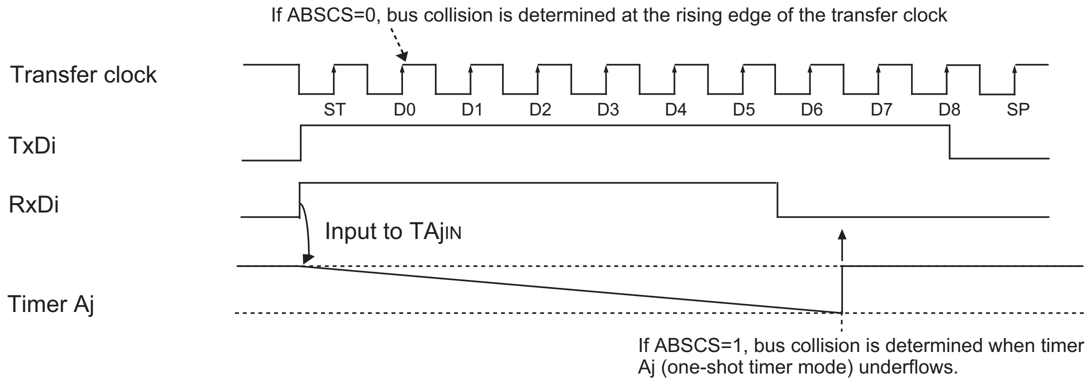
Note 1: Set the U0C0 and U1C1 registers bit 4 and bit 5 to “0”. The U0IRS, U1IRS, U0RRM and U1RRM bits are in the UCON register.

Note 2: TxD2 pin is N channel open-drain output. Set the U2C0 register's NCH bit to “0”.

Note 3: Not all register bits are described above. Set those bits to “0” when writing to the registers in IEmode.

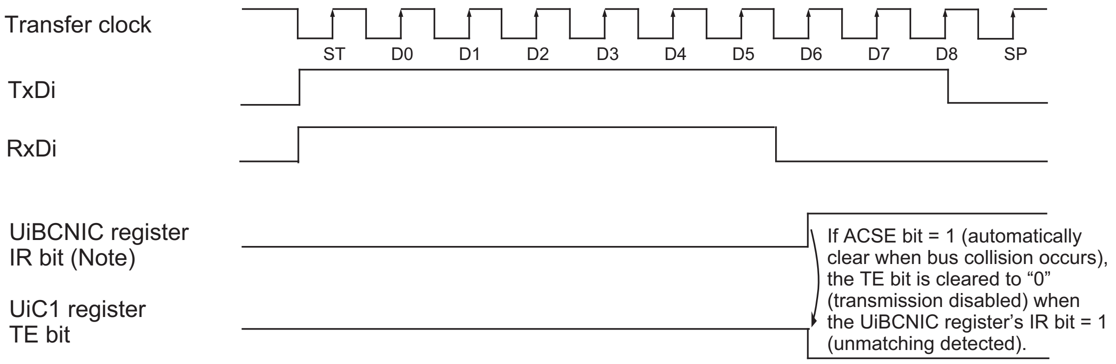
i= 0 to 2

(1) UiSMR register ABSCS bit (bus collision detect sampling clock select) (i=0 to 2)



Timer Aj: timer A3 when UART0; timer A4 when UART1; timer A0 when UART2

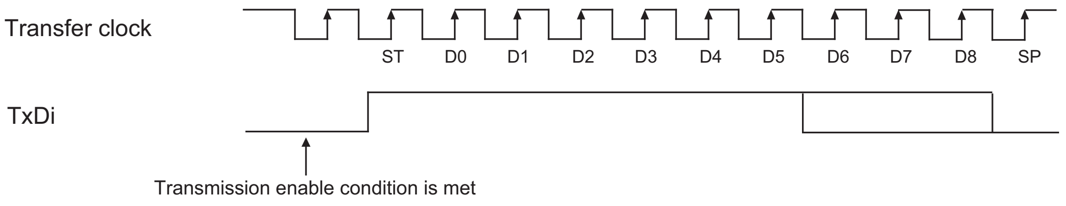
(2) UiSMR register ACSE bit (auto clear of transmit enable bit)



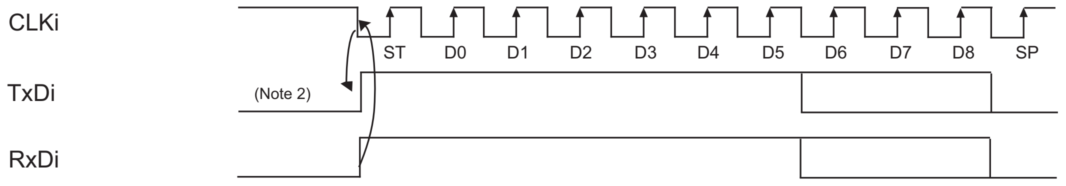
Note: BCNIC register when UART2.

(3) UiSMR register SSS bit (Transmit start condition select)

If SSS bit = 0, the serial I/O starts sending data one transfer clock cycle after the transmission enable condition is met.



If SSS bit = 1, the serial I/O starts sending data at the rising edge (Note 1) of RxDi



Note 1: The falling edge of RxDi when IOPOL=0; the rising edge of RxDi when IOPOL =1.
Note 2: The transmit condition must be met before the falling edge (Note 1) of RxD.

This diagram applies to the case where IOPOL=1 (reversed).

Figure 10.29 Bus Collision Detect Function-Related Bits

10.7 Special Mode 4 (SIM Mode) (UART2)

Based on UART mode, this is an SIM interface compatible mode. Direct and inverse formats can be implemented, and this mode allows to output a low from the TxD2 pin when a parity error is detected.
Tables 10.17 lists the specifications of SIM mode. Table 10.18 lists the registers used in the SIM mode and the register values set.

Table 10.17 SIM Mode Specifications

Item	Specification
Transfer data format	• Direct format • Inverse format
Transfer clock	• U2MR register's CKDIR bit = "0" (internal clock) : fi/ 16(n+1) fi = f_{1SIO}, f_{2SIO}, f_{8SIO}, f_{32SIO}. n: Setting value of U2BRG register 00_{16} to FF_{16} • CKDIR bit = "1" (external clock) : f_{EXT}/16(n+1) f_{EXT}: Input from CLK_2 pin. n: Setting value of U2BRG register 00_{16} to FF_{16}
Transmission start condition	• Before transmission can start, the following requirements must be met – The TE bit of U2C1 register= 1 (transmission enabled) – The TI bit of U2C1 register = 0 (data present in U2TB register)
Reception start condition	• Before reception can start, the following requirements must be met – The RE bit of U2C1 register= 1 (reception enabled) – Start bit detection
Interrupt request generation timing (Note 2)	• For transmission When the serial I/O finished sending data from the U2TB transfer register (U2IRS bit =1) • For reception When transferring data from the UART2 receive register to the U2RB register (at completion of reception)
Error detection	• Overrun error (Note 1) This error occurs if the serial I/O started receiving the next data before reading the U2RB register and received the bit one before the last stop bit of the next data • Framing error This error occurs when the number of stop bits set is not detected • Parity error During reception, if a parity error is detected, parity error signal is output from the TxD_2 pin. During transmission, a parity error is detected by the level of input to the RxD_2 pin when a transmission interrupt occurs • Error sum flag This flag is set (= 1) when any of the overrun, framing, and parity errors is encountered

Note 1: If an overrun error occurs, the value of U2RB register will be indeterminate. The IR bit of S2RIC register does not change.

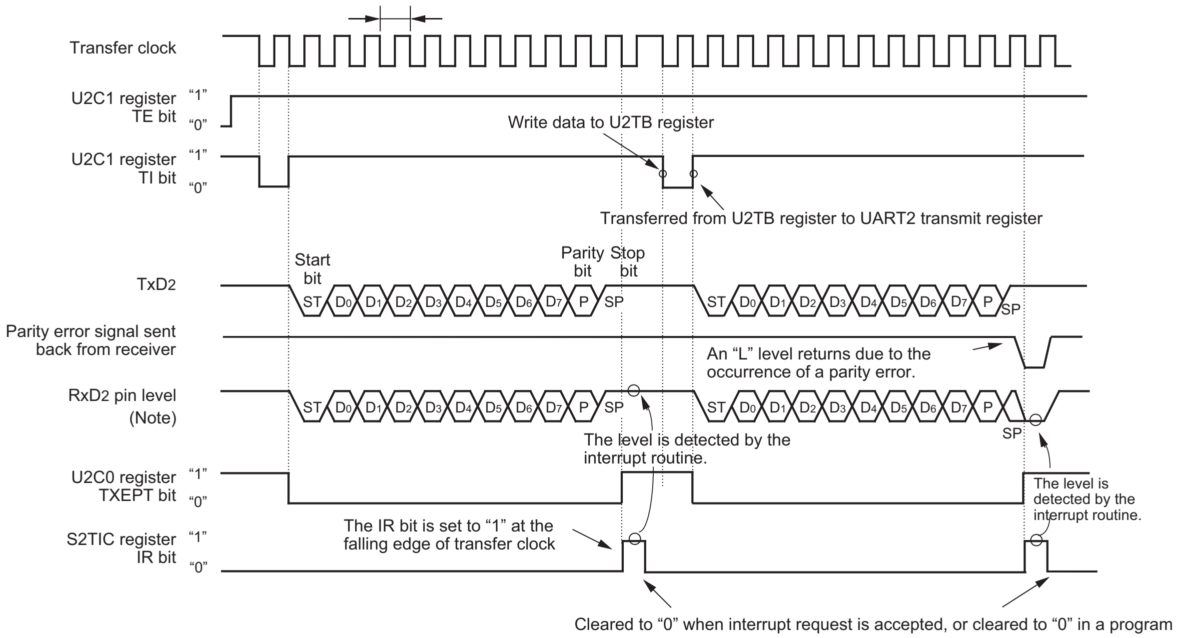
Note 2: A transmit interrupt request is generated by setting the U2C1 register U2IRS bit to "1" (transmission complete) and U2ERE bit to "1" (error signal output) after reset. Therefore, when using SIM mode, be sure to clear the IR bit to "0" (no interrupt request) after setting these bits.

Table 10.18 Registers to Be Used and Settings in SIM Mode

Register	Bit	Function
U2TB(Note)	0 to 7	Set transmission data
U2RB(Note)	0 to 7	Reception data can be read
	OER,FER,PER,SUM	Error flag
U2BRG	0 to 7	Set a transfer rate
U2MR	SMD2 to SMD0	Set to ‘101_2’
	CKDIR	Select the internal clock or external clock
	STPS	Set to “0”
	PRY	Set this bit to “1” for direct format or “0” for inverse format
	PRYE	Set to “1”
	IOPOL	Set to “0”
U2C0	CLK1, CLK0	Select the count source for the U2BRG register
	CRS	Invalid because CRD=1
	TXEPT	Transmit register empty flag
	CRD	Set to “1”
	NCH	Set to “0”
	CKPOL	Set to “0”
	UFORM	Set this bit to “0” for direct format or “1” for inverse format
U2C1	TE	Set this bit to “1” to enable transmission
	TI	Transmit buffer empty flag
	RE	Set this bit to “1” to enable reception
	RI	Reception complete flag
	U2IRS	Set “1”
	U2RRM	Set to “0”
	U2LCH	Set this bit to “0” for direct format or “1” for inverse format
	U2ERE	Set “1”
U2SMR(Note)	0 to 3	Set to “0”
U2SMR2	0 to 7	Set to “0”
U2SMR3	0 to 7	Set to “0”
U2SMR4	0 to 7	Set to “0”

Note: Not all register bits are described above. Set those bits to “0” when writing to the registers in SIM mode.

(1) Transmission



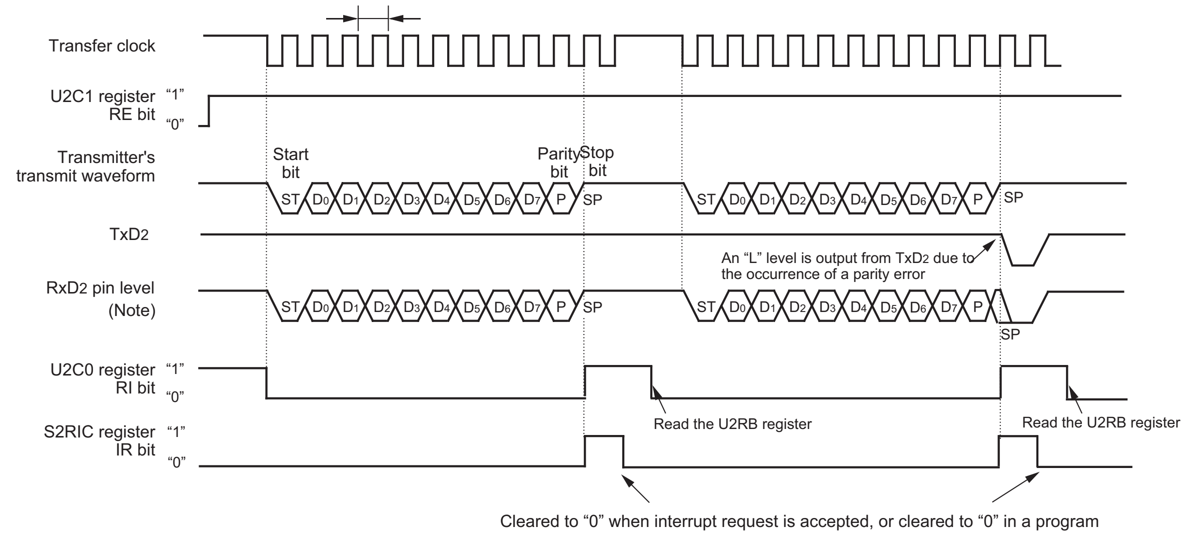
The above timing diagram applies to the case where data is transferred in the direct format.

- U2MR register STPS bit = 0 (1 stop bit)
- U2MR register PRY bit = 1 (even)
- U2C0 register UFORM bit = 0 (LSB first)
- U2C1 register U2LCH bit = 0 (no reverse)
- U2C1 register U2IRSCH bit = 1 (transmit is completed)

Tc = 16 (n + 1) / fi or 16 (n + 1) / fEXT
fi : frequency of U2BRG count source (f1SIO, f2SIO, f8SIO, f32SIO)
fEXT : frequency of U2BRG count source (external clock)
n : value set to U2BRG

Note : Because TxD2 and RxD2 are connected, this is composite waveform consisting of the TxD2 output and the parity error signal sent back from receiver.

(1) Reception



The above timing diagram applies to the case where data is received in direct format.

- U2MR register STPS bit = 0 (1 stop bit)
- U2MR register PRY bit = 1 (even)
- U2C0 register UFORM bit = 0 (LSB first)
- U2C1 register U2LCH bit = 0 (no reverse)
- U2C1 register U2IRSCH bit = 1 (transmit is completed)

Tc = 16 (n + 1) / fi or 16 (n + 1) / fEXT
fi : frequency of U2BRG count source (f1SIO, f2SIO, f8SIO, f32SIO)
fEXT : frequency of U2BRG count source (external clock)
n : value set to U2BRG

Note : Because TxD2 and RxD2 are connected, this is composite waveform consisting of the transmitter's transmit waveform and the parity error signal received.

Figure 10.30 Transmit and Receive Timing in SIM Mode

Figure 10.31 shows the example of connecting the SIM interface. Connect TXD2 and RXD2 and apply pull-up.

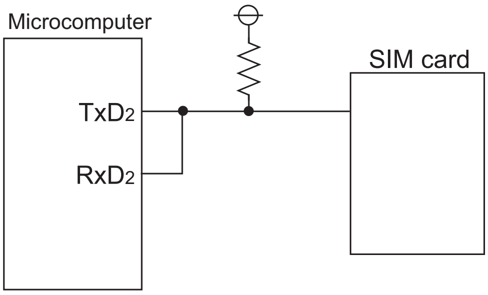
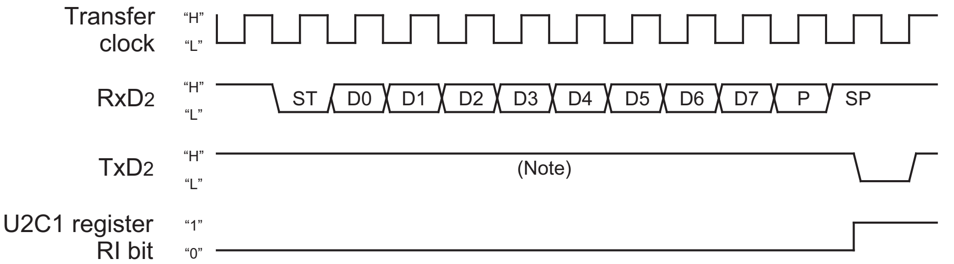


Figure 10.31 SIM Interface Connection

10.7.1 Parity Error Signal Output

The parity error signal is enabled by setting the U2C1 register's U2ERE bit to "1".

- When receiving
  The parity error signal is output when a parity error is detected while receiving data. This is achieved by pulling the TxD2 output low with the timing shown in Figure 10.32. If the U2RB register is read while outputting a parity error signal, the PER bit is cleared to "0" and at the same time the TxD2 output is returned high.
- When transmitting
  A transmission-finished interrupt request is generated at the falling edge of the transfer clock pulse that immediately follows the stop bit. Therefore, whether a parity signal has been returned can be determined by reading the port that shares the RxD2 pin in a transmission-finished interrupt service routine.



This timing diagram applies to the case where the direct format is implemented.

Note: The output of microcomputer is in the high-impedance state (pulled up externally).

ST : Start bit
P : Even Parity
SP : Stop bit

Figure 10.32 Parity Error Signal Output Timing

10.7.2 Format

- Direct Format
  Set the U2MR register's PRY bit to “1”, U2C0 register's UFORM bit to “0” and U2C1 register's U2LCH bit to “0”.
- Inverse Format
  Set the PRY bit to “0”, UFORM bit to “1” and U2LCH bit to “1”. Figure 10.33 shows the SIM interface format.

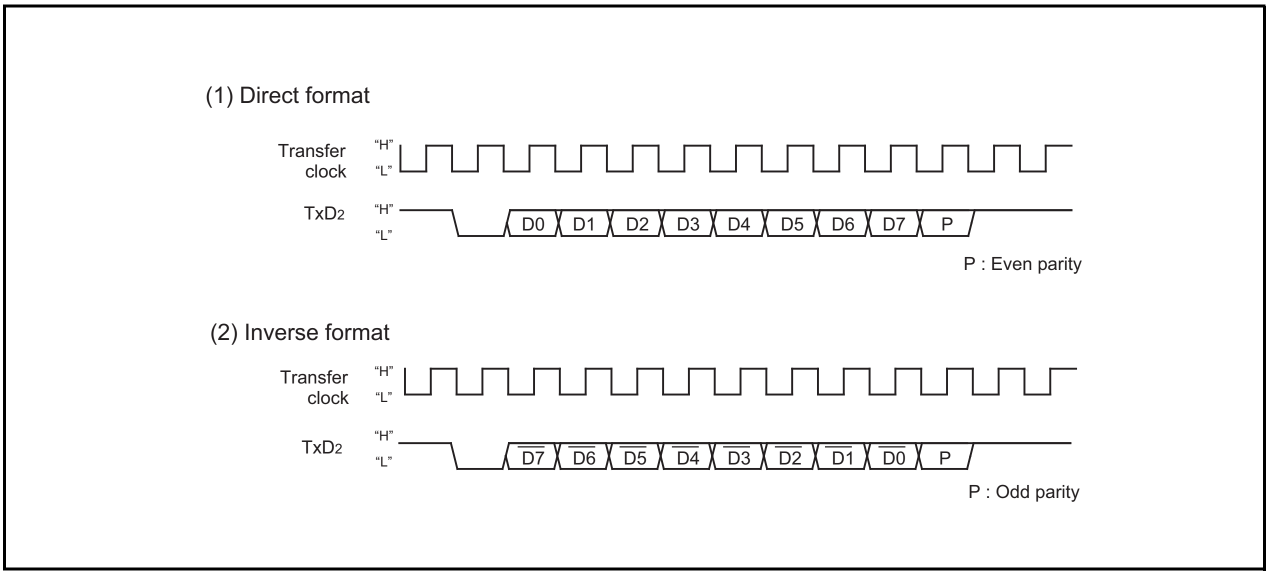
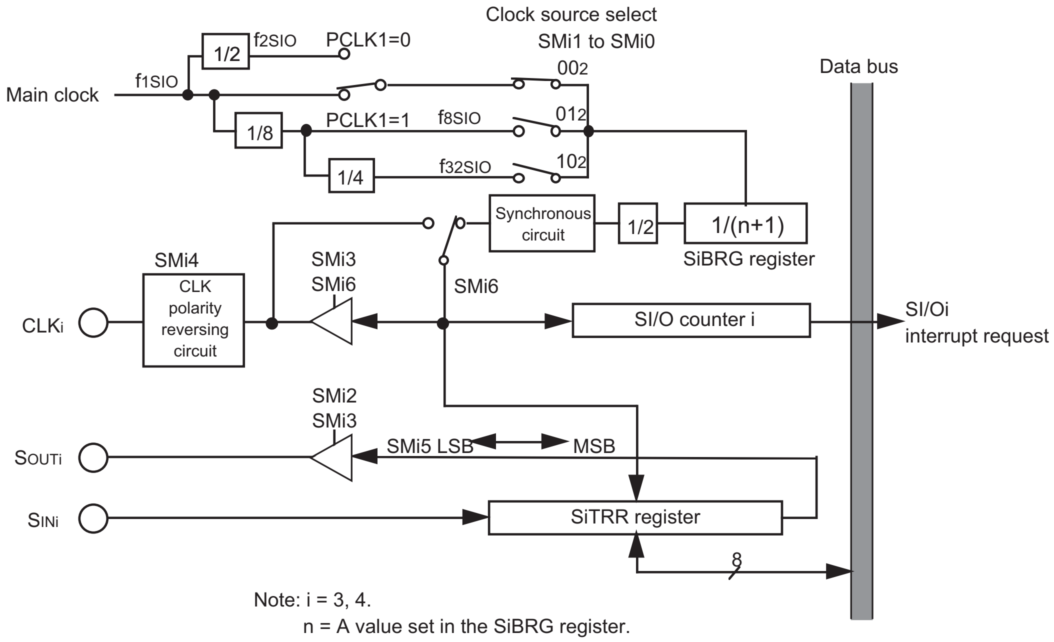


Figure 10.33 SIM Interface Format

10.8 SI/O3 and SI/O4

SI/O3 and SI/O4 are exclusive clock-synchronous serial I/Os.
Figure 10.34 shows the block diagram of SI/O3 and SI/O4, and Figure 10.35 shows the SI/O3 and SI/O4- related registers.
Table 10.19 shows the specifications of SI/O3 and SI/O4.



Note: i = 3, 4.
n = A value set in the SiBRG register.

Figure 10.34 SI/O3 and SI/O4 Block Diagram

S I/Oi control register (i = 3, 4) (Note 1)

b7 b6 b5 b4 b3 b2 b1 b0

Symbol	Address	After reset
S3C	0362_{16}	01000000_{16}
S4C	0366_{16}	01000000_{16}

Bit symbol	Bit name	Description	RW
SMi0	Internal synchronous clock select bit	b1 b0 0 0 : Selecting f_{1SIO} or f_{2SIO} 0 1 : Selecting f_{8SIO} 1 0 : Selecting f_{32SIO} 1 1 : Must not be set.	RW
SMi1			RW
SMi2	SOUTi output disable bit (Note 4)	0 : SOUTi output 1 : SOUTi output disable(high impedance)	RW
SMi3	S I/Oi port select bit	0 : Input/output port 1 : SOUTi output, CLKi function	RW
SMi4	CLK polarity select bit	0 : Transmit data is output at falling edge of transfer clock and receive data is input at rising edge 1 : Transmit data is output at rising edge of transfer clock and receive data is input at falling edge	RW
SMi5	Transfer direction select bit	0 : LSB first 1 : MSB first	RW
SMi6	Synchronous clock select bit	0 : External clock (Note 2) 1 : Internal clock (Note 3)	RW
SMi7	SOUTi initial value set bit	Effective when SMi3 = 0 0 : “L” output 1 : “H” output	RW

Note 1: Make sure this register is written to by the next instruction after setting the PRCR register's PRC2 bit to “1” (write enable).
Note 2: Set the SMi3 bit to “1” and the corresponding port direction bit to “0” (input mode).
Note 3: Set the SMi3 bit to “1” (SOUTi output, CLKi function).
Note 4: When the SMi2 bit is set to “1”, the target pin goes to a high-impedance state regardless of which function of the pin is being used.

SI/Oi bit rate generator (i = 3, 4) (Notes 1, 2)

b7 b0

Symbol	Address	After reset
S3BRG	0363_{16}	Indeterminate
S4BRG	0367_{16}	Indeterminate

Description	Setting range	RW
Assuming that set value = n, BRGi divides the count source by n + 1	00_{16} to FF_{16}	WO

Note 1: Write to this register while serial I/O is neither transmitting nor receiving.
Note 2: Use MOV instruction to write to this register.

SI/Oi transmit/receive register (i = 3, 4) (Note 1, 2)

b7 b0

Symbol	Address	After reset
S3TRR	0360_{16}	Indeterminate
S4TRR	0364_{16}	Indeterminate

Description	RW
Transmission/reception starts by writing transmit data to this register. After transmission/reception finishes, reception data can be read by reading this register.	RW

Note 1: Write to this register while serial I/O is neither transmitting nor receiving.
Note 2: To receive data, set the corresponding port direction bit for SINi to “0” (input mode).

Figure 10.35 S3C and S4C Registers, S3BRG and S4BRG Registers, and S3TRR and S4TRR Registers

Table 10.19 SI/O3 and SI/O4 Specifications

Item	Specification
Transfer data format	• Transfer data length: 8 bits
Transfer clock	• SiC (i=3, 4) register's SMi6 bit = "1" (internal clock) : fj/ 2(n+1) fj = f1SIO, f8SIO, f32SIO. n=Setting value of SiBRG register 0016 to FF16. • SMi6 bit = "0" (external clock) : Input from CLKi pin (Note 1)
Transmission/reception start condition	• Before transmission/reception can start, the following requirements must be met Write transmit data to the SiTRR register (Notes 2, 3)
Interrupt request generation timing	• When SiC register's SMi4 bit = 0 The rising edge of the last transfer clock pulse (Note 4) • When SMi4 = 1 The falling edge of the last transfer clock pulse (Note 4)
CLKi pin function	I/O port, transfer clock input, transfer clock output
SOUTi pin function	I/O port, transmit data output, high-impedance
SINi pin function	I/O port, receive data input
Select function	• LSB first or MSB first selection Whether to start sending/receiving data beginning with bit 0 or beginning with bit 7 can be selected • Function for setting an SOUTi initial value set function When the SiC register's SMi6 bit = 0 (external clock), the SOUTi pin output level while not transmitting can be selected • CLK polarity selection Whether transmit data is output/input timing at the rising edge or falling edge of transfer clock can be selected.

Note 1: To set the SiC register's SMi6 bit to "0" (external clock), follow the procedure described below.
- If the SiC register's SMi4 bit = 0, write transmit data to the SiTRR register while input on the CLKi pin is high. The same applies when rewriting the SiC register's SMi7 bit.
- If the SMi4 bit = 1, write transmit data to the SiTRR register while input on the CLKi pin is low. The same applies when rewriting the SMi7 bit.
- Because shift operation continues as long as the transfer clock is supplied to the SI/Oi circuit, stop the transfer clock after supplying eight pulses. If the SMi6 bit = 1 (internal clock), the transfer clock automatically stops.

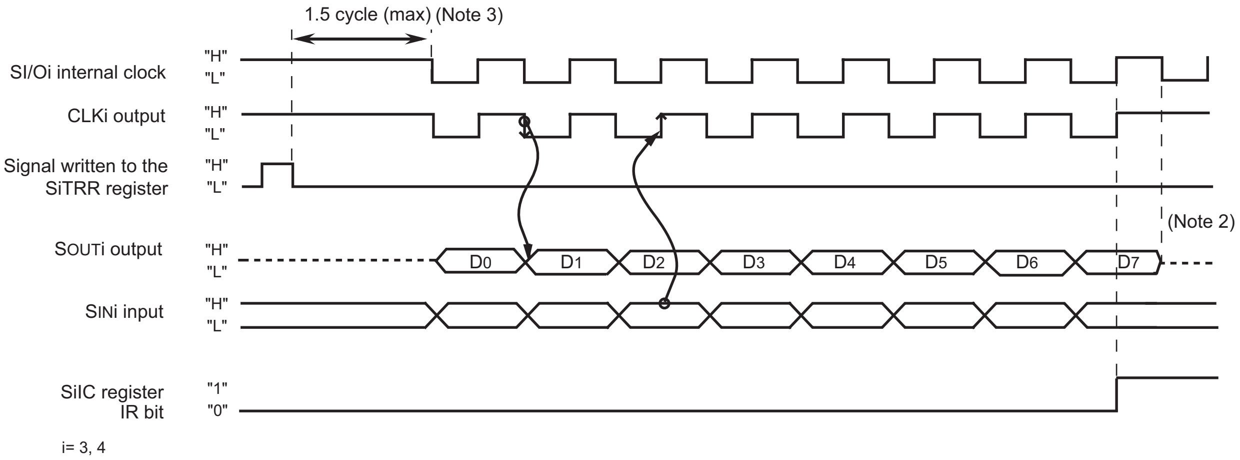
Note 2: Unlike UART0 to UART2, SI/Oi (i = 3 to 4) is not separated between the transfer register and buffer. Therefore, do not write the next transmit data to the SiTRR register during transmission.

Note 3: When the SiC register's SMi6 bit = 1 (internal clock), SOUTi retains the last data for a 1/2 transfer clock period after completion of transfer and, thereafter, goes to a high-impedance state. However, if transmit data is written to the SiTRR register during this period, SOUTi immediately goes to a high-impedance state, with the data hold time thereby reduced.

Note 4: When the SiC register's SMi6 bit = 1 (internal clock), the transfer clock stops in the high state if the SMi4 bit = 0, or stops in the low state if the SMi4 bit = 1.

10.8.1 SI/Oi Operation Timing

Figure 10.36 shows the SI/Oi operation timing



Note 1: This diagram applies to the case where the SiC register bits are set as follows:
SMi2=0 (SOUTi output), SMi3=1 (SOUTi output, CLKi function), SMi4=0 (transmit data output at the falling edge and receive data input at the rising edge of the transfer clock), SMi5=0 (LSB first) and SMi6=1 (internal clock)

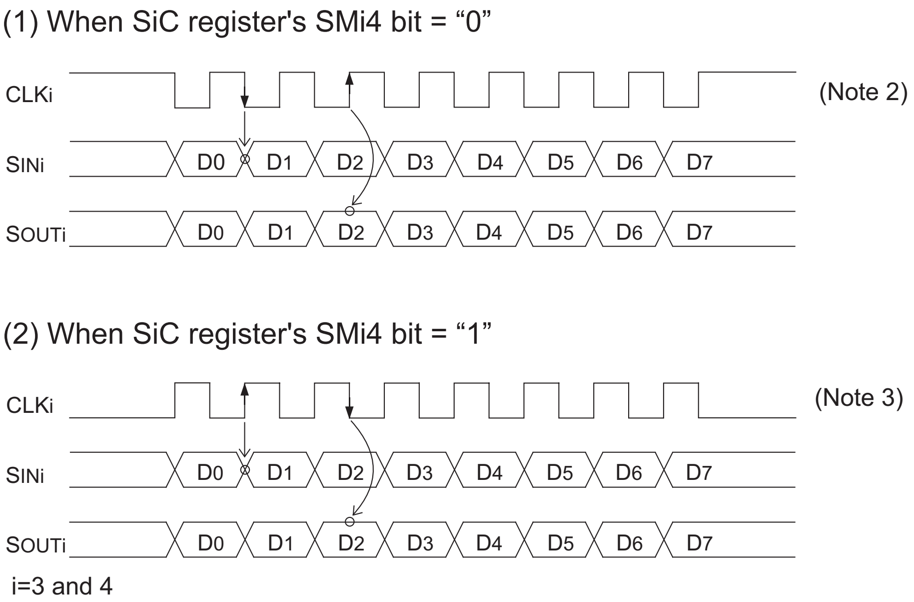
Note 2: When the SMi6 bit = 1 (internal clock), the SOUTi pin is placed in the high-impedance state after the transfer finishes.

Note 3: If the SMi6 bit=0 (internal clock), the serial I/O starts sending or receiving data a maximum of 1.5 transfer clock cycles after writing to the SiTRR register.

Figure 10.36 SI/Oi Operation Timing

10.8.2 CLK Polarity Selection

The SiC register's SMi4 bit allows selection of the polarity of the transfer clock. Figure 10.37 shows the polarity of the transfer clock.


(1) When SiC register's SMi4 bit = “0”

(2) When SiC register's SMi4 bit = “1”

Note 1: This diagram applies to the case where the SiC register bits are set as follows:
SMi5=0 (LSB first) and SMi6=1 (internal clock)

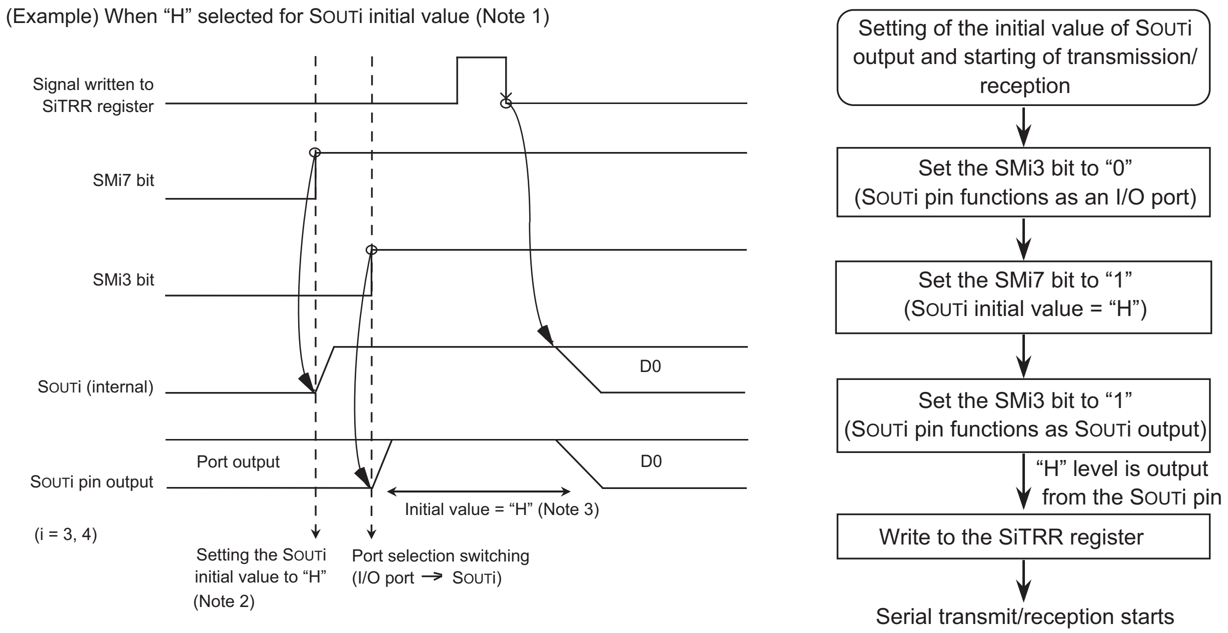
Note 2: When the SMi6 bit=1 (internal clock), a high level is output from the CLKi pin if not transferring data.

Note 3: When the SMi6 bit=1 (internal clock), a low level is output from the CLKi pin if not transferring data.

Figure 10.37 Polarity of Transfer Clock

10.8.3 Functions for Setting an SOUTi Initial Value

If the SiC register's SMi6 bit = 0 (external clock), the SOUTi pin output can be fixed high or low when not transferring. Figure 10.38 shows the timing chart for setting an SOUTi initial value and how to set it.



Note 1: This diagram applies to the case where the SiC register bits are set as follows: SMi2=0 (SOUTi output), SMi5=0 (LSB first) and SMi6=0 (external clock)

Note 2: SOUTi can only be initialized when input on the CLKi pin is in the high state if the SiC register's SMi4 bit = 0 (transmit data output at the falling edge of the transfer clock) or in the low state if the SMi4 bit = 1 (transmit data output at the rising edge of the transfer clock).

Note 3: If the SMi6 bit = 1 (internal clock) or if the SMi2 bit = 1 (SOUT output disabled), this output goes to the high-impedance state.

Figure 10.38 SOUTi's Initial Value Setting

11. Multi-master I2C-BUS Interface

The multi-master I2C-BUS interface have each dedicated circuit and operate independently.
The multi-master I2C-BUS interface is a serial communications circuit, conforming to the Philips I2C-BUS data transfer format. This interface i, offering both arbitration lost detection and a synchronous functions, is useful for the multi-master serial communications.
Table 11.1 shows multi-master I2C-BUS interface functions.
This multi-master I2C-BUS interface consists of I2C address register, I2C data shift register, I2C clock control register, I2C control register, I2C status register, I2C transmit buffer register and the other control circuits.

Table 11.1 Clock Generation Circuit Specifications

Item	Function
Format	In conformity with Philips I2C-BUS standard: 10-bit addressing format 7-bit addressing format High-speed clock mode Standard clock mode
Communication mode	In conformity with Philips I2C-BUS standard: Master transmission Master reception Slave transmission Slave reception
SCL clock frequency	16.1 kHz to 400 kHz (BCLK = 16 MHz)
Power supply voltage on bus line	(SCL3/SDA3) : VCC1

Note. Our company doesn't assume the responsibility of the patent of the third party who originates in the use of the function to control the connection of I2C-BUS interface and ports (SCL3, SDA3) and other infringements of right.

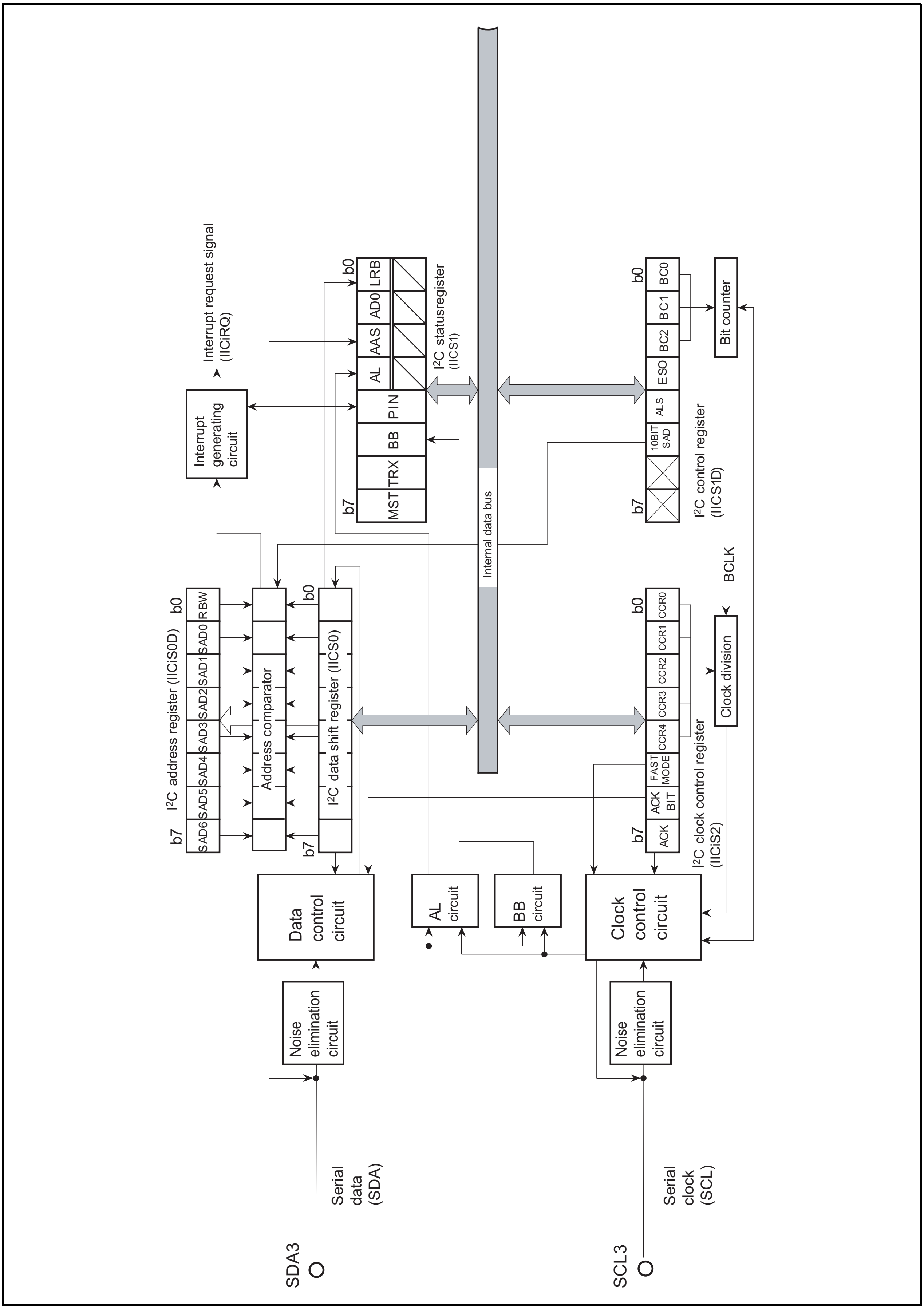
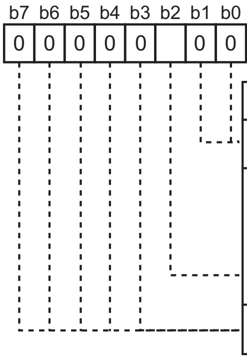


Figure 11.1 **Block Diagram of Multi-master I^2C-BUS interface**

(1) Reserved register

Reserved register



Symbol	Address	When reset
RSVREG02E5	$02E5_{16}$	$00?00000_2$

Bit Symbol	Bit name	Function	RW
Reserved bits		Must always be set to “0”	WO
RSVREG02E52	Multi-master I²C-BUS interface enable bit	0 = Non active 1 = Active	RW
Reserved bits		Must always be set to “0”	WO

Figure 11.2 Reserved register

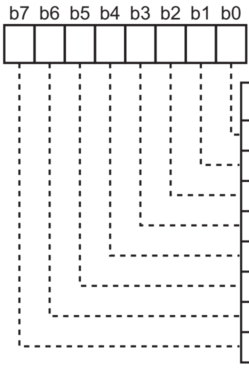
(2) I²C data shift register, I²C transmit buffer register

The I²C data shift register is an 8-bit shift register to store receive data and write transmit data.
When transmit data is written into this register, it is transferred to the outside from bit 7 in synchronization with the SCL clock, and each time one-bit data is output, the data of this register are shifted one bit to the left. When data is received, it is input to this register from bit 0 in synchronization with the SCL clock, and each time one-bit data is input, the data of this register are shifted one bit to the left.
The I²C data shift register is in a write enable status only when the ESO bit of the I²C control register is "1." The bit counter is reset by a write instruction to the I²C data shift register. When both the ESO bit and the MST bit of the I²C status register are "1," the SCL is output by a write instruction to the I²C data shift register. Reading data from the I²C data shift register is always enabled regardless of the ESO bit value.
The I²C transmit buffer register is a register to store transmit data (slave address) to the I²C data shift register before RESTART condition generation. That is, in master, transmit data written to the I²C transmit buffer register is written to the I²C data shift register simultaneously. However, the SCL is not output. The I²C transmit buffer register can be written only when the ESO bit is "1," reading data from the I²C transmit buffer register is disabled regardless of the ESO bit value.

Notes 1: To write data into the I²C data shift register or the I²C transmit buffer register after the MST bit value changes from "1" to "0" (slave mode), keep an interval of 20 BCLK or more.

2: To generate START/RESTART condition after the I²C data shift register or the I²C transmit buffer register is written, keep an interval of 4 BCLK or more.

I^{2}C data shift register



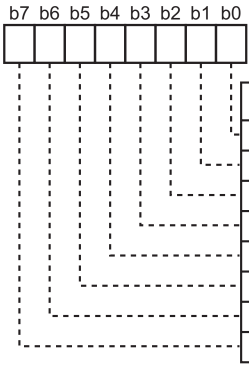
Symbol	Address	When reset
IIC0S0	02E0$_{16}$	Indeterminate

Bit Symbol	Bit name	Function	RW
D0	Data shift register	This is an 8-bit shift register to store receive data and write transmit data.	RW
D1			
D2			
D3			
D4			
D5			
D6			
D7			

Note: To write data into the I^{2}C data shift register after setting the MST bit to “0” (slave mode), keep an interval of 8 machine cycles or more.

Figure 11.3 I^{2}C data shift register

I^{2}C transmit buffer register



Symbol	Address	When reset
IIC0S0S	02E6$_{16}$	Indeterminate

Bit Symbol	Bit name	Function	RW
S0S0	Transmit buffer register	This is an 8-bit register to write transmit data to I^{2}C data shift register.	WO
S0S1			
S0S2			
S0S3			
S0S4			
S0S5			
S0S6			
S0S7			

Figure 11.4 I^{2}C transmit buffer register

(3) I^{2}C address register

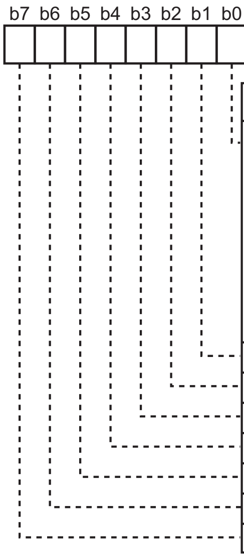
The I^{2}C address register consists of a 7-bit slave address and a $\overline{\text{read}}$/write bit. In the addressing mode, the slave address written in this register is compared with the address data to be received immediately after the START condition are detected.

- **Bit 0: $\overline{\text{read}}$/write bit (RBW)**

  Not used when comparing addresses, in the 7-bit addressing mode. In the 10-bit addressing mode, the first address data to be received is compared with the contents (SAD6 to SAD0 + RBW) of the I^{2}C address register.
  The RBW bit is cleared to "0" automatically when the stop condition is detected.
- **Bits 1 to 7: slave address (SAD0 to SAD6)**

  These bits store slave addresses. Regardless of the 7-bit addressing mode and the 10-bit addressing mode, the address data transmitted from the master is compared with the contents of these bits.

I^{2}C address register



Symbol	Address	When reset
IIC0S0D	02E1$_{16}$	00$_{16}$

Bit Symbol	Bit name	Function	RW
RBW	$\overline{\text{Read}}$/write bit	<Only in 10-bit addressing (in slave) mode> The last significant bit of address data is compared. 0 : Wait the first byte of slave address after START condition (read state) 1 : Wait the first byte of slave address after RESTART condition (write state)	RW
SAD0	Slave address	<In both modes> The address data is compared.	RW
SAD1			
SAD2			
SAD3			
SAD4			
SAD5			
SAD6			

Figure 11.5 I^{2}C address register

(4) I2C clock control register

The I2C clock control register is used to set ACK control, SCL mode and SCL frequency.

- **Bits 0 to 4: SCL frequency control bits (CCR0–CCR4)**

  These bits control the SCL frequency.

- **Bit 5: SCL mode specification bit (FAST MODE)**

  This bit specifies the SCL mode. When this bit is set to “0,” the standard clock mode is set. When the bit is set to “1,” the high-speed clock mode is set.

- **Bit 6: ACK bit (ACK BIT)**

  This bit sets the SDA status when an ACK clock∗ is generated. When this bit is set to “0,” the ACK return mode is set and SDA goes to LOW at the occurrence of an ACK clock. When the bit is set to “1,” the ACK non-return mode is set. The SDA is held in the HIGH status at the occurrence of an ACK clock.

  However, when the slave address matches the address data in the reception of address data at ACK BIT = “0,” the SDA is automatically made LOW (ACK is returned). If there is a mismatch between the slave address and the address data, the SDA is automatically made HIGH (ACK is not returned).

  ∗ACK clock: Clock for acknowledgement

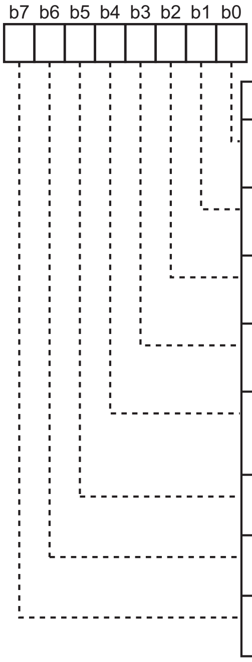
- **Bit 7: ACK clock bit (ACK)**

  This bit specifies a mode of acknowledgment which is an acknowledgment response of data transmission.

  When this bit is set to “0,” the no ACK clock mode is set. In this case, no ACK clock occurs after data transmission. When the bit is set to “1,” the ACK clock mode is set and the master generates an ACK clock upon completion of each 1-byte data transmission.The device for transmitting address data and control data releases the SDA at the occurrence of an ACK clock (make SDA HIGH) and receives the ACK bit generated by the data receiving device.

Note: Do not write data into the I2C clock control register during transmission. If data is written during transmission, the I2C clock generator is reset, so that data cannot be transmitted normally.

I^{2}C clock control register



Symbol	Address	When reset
IIC0S2	02E4$_{16}$	00$_{16}$

Bit Symbol	Bit name	Function			RW
CCR0 CCR1 CCR2 CCR3 CCR4	SCL frequency control bits	Setup value of CCR4–CCR0	Standard clock mode	High speed clock mode	RW
		00 to 02	Setup disabled	Setup disabled	
		03	Setup disabled	333	
		04	Setup disabled	250	
		05	100	400 (See note)	
		06	83.3	166	
		:	500/CCR value	1000/CCR value	
		1D	17.2	34.5	
		1E	16.6	33.3	
		1F	16.1	32.3	
		(at BCLK = 10 MHz, unit : kHz)			
FAST MODE	SCL mode specification bit	0 : Standard clock mode 1 : High-speed clock mode			RW
ACK BIT	ACK bit	0 : ACK is returned. 1 : ACK is not returned.			RW
ACK	ACK clock bit	0 : No ACK clock 1 : ACK clock			RW

Note: At 400 kHz in the high-speed clock mode, the duty is as below.
“0” period : “1” period = 3 : 2
In the other cases, the duty is as below.
“0” period : “1” period = 1 : 1

Figure 11.6 I^{2}C clock control register

(5) I2C control register

The I2C control register controls the data communication format.

• Bits 0 to 2: bit counter (BC0–BC2)

These bits decide the number of bits for the next 1-byte data to be transmitted. An interrupt request signal occurs immediately after the number of bits specified with these bits are transmitted.

When a START condition is received, these bits become "000_2" and the address data is always transmitted and received in 8 bits.

Note: When the bit counter value = "111_2," a STOP condition and START condition cannot be waited.

• Bit 3: I2C-BUS interface use enable bit (ESO)

This bit enables usage of the multimaster I2C-BUS interface i. When this bit is set to "0," the use disable status is provided, so the SDA and the SCL become high-impedance. When the bit is set to "1," use of the interface is enabled.

When ESO = "0," the following is performed.

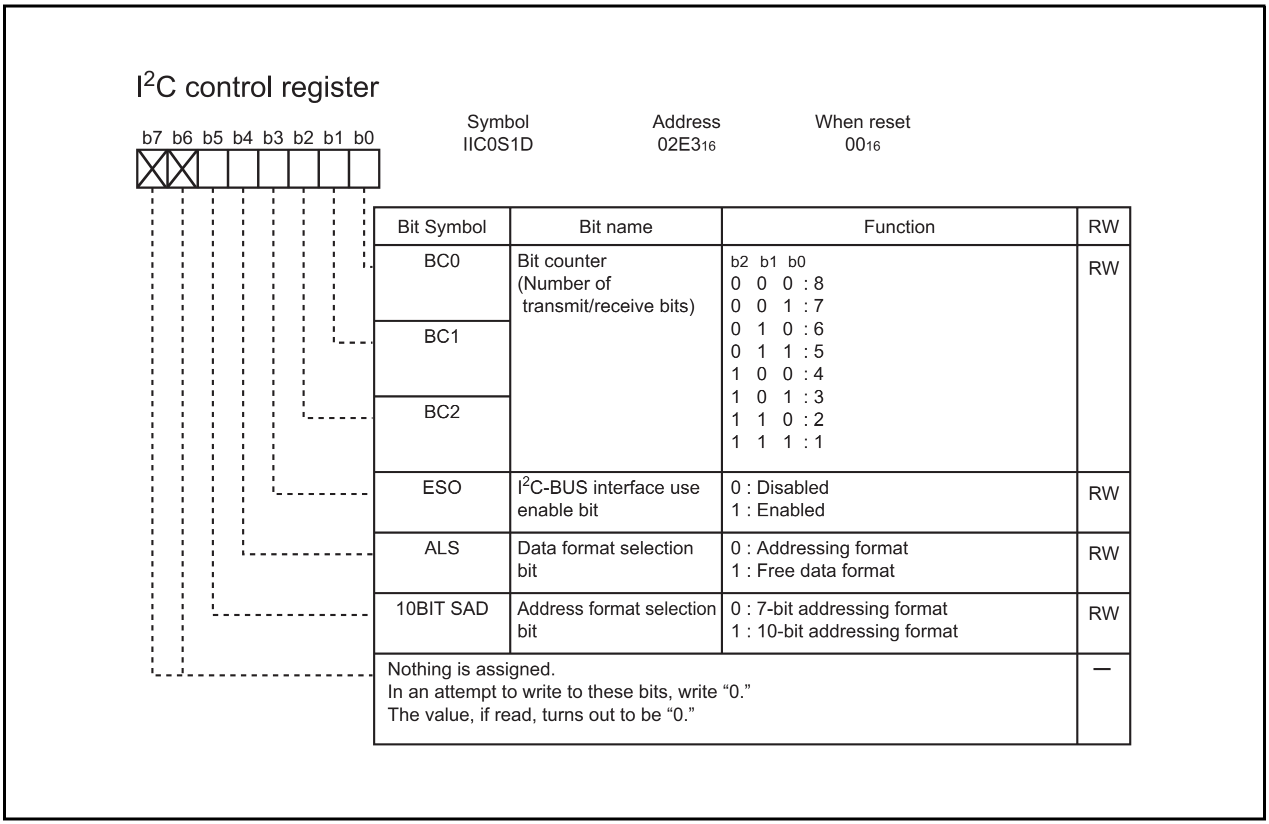
- PIN = "1," BB = "0" and AL = "0" are set (they are bits of the I2C status register).
- Writing data to the I2C data shift register and the I2C transmit buffer register is disabled.

• Bit 4: data format selection bit (ALS)

This bit decides whether or not to recognize slave addresses. When this bit is set to "0," the addressing format is selected, so that address data is recognized. When a match is found between a slave address and address data as a result of comparison or when a general call (refer to "(6) I2C status register," bit 1) is received, transmission processing can be performed. When this bit is set to "1," the free data format is selected, so that slave addresses are not recognized.

• Bit 5: addressing format selection bit (10BIT SAD)

This bit selects a slave address specification format. When this bit is set to "0," the 7-bit addressing format is selected. In this case, only the high-order 7 bits (slave address) of the I2C address register are compared with address data. When this bit is set to "1," the 10-bit addressing format is selected, all the bits of the I2C address register are compared with address data.



I²C control register

Symbol	Address	When reset
IIC0S1D	$02E3_{16}$	00_{16}

Bit Symbol	Bit name	Function	RW
BC0	Bit counter (Number of transmit/receive bits)	b2 b1 b0 0 0 0 : 8 0 0 1 : 7 0 1 0 : 6 0 1 1 : 5 1 0 0 : 4 1 0 1 : 3 1 1 0 : 2 1 1 1 : 1	RW
BC1			
BC2			
ESO	I²C-BUS interface use enable bit	0 : Disabled 1 : Enabled	RW
ALS	Data format selection bit	0 : Addressing format 1 : Free data format	RW
10BIT SAD	Address format selection bit	0 : 7-bit addressing format 1 : 10-bit addressing format	RW
Nothing is assigned. In an attempt to write to these bits, write “0.” The value, if read, turns out to be “0.”			—

Figure 11.7 I²C control register

(6) I2C status register

The I2C status register controls the I2C-BUS interface status. Bits 0 to 3, 5 are read-only bits and bits 4, 6, 7 can be read out and written to.

- **Bit 0: last receive bit (LRB)**

This bit stores the last bit value of received data and can also be used for ACK receive confirmation. If ACK is returned when an ACK clock occurs, the LRB bit is set to “0.” If ACK is not returned, this bit is set to “1.” Except in the ACK mode, the last bit value of received data is input. The state of this bit is changed from “1” to “0” by executing a write instruction to the I2C data shift register or the I2C transmit buffer register.

- **Bit 1: general call detecting flag (AD0)**

This bit is set to “1” when a general call∗ whose address data is all “0” is received in the slave mode.
By a general call of the master device, every slave device receives control data after the general call.
The AD0 bit is set to ì0î by detecting the STOP condition or START condition.
∗General call: The master transmits the general call address “00_{16}”to all slaves.

- **Bit 2: slave address comparison flag (AAS)**

This flag indicates a comparison result of address data.
<<In the slave receive mode, when the 7-bit addressing format is selected, this bit is set to “1” in one of the following conditions.>>

- The address data immediately after occurrence of a START condition matches the slave address stored in the high-order 7 bits of the I2C address register.
- A general call is received.

<<In the slave reception mode, when the 10-bit addressing format is selected, this bit is set to “1” with the following condition.>>

- When the address data is compared with the I2C address register (8 bits consists of slave address and RBW), the first bytes match.

<<The state of this bit is changed from “1” to “0” by executing a write instruction to the I2C data shift register or the I2C transmit buffer register.>>

- **Bit 3: arbitration lost∗ detecting flag (AL)**

In the master transmission mode, when a device other than the microcomputer sets the SDA to “L,” arbitration is judged to have been lost, so that this bit is set to “1.” At the same time, the TRX bit is set to “0,” so that immediately after transmission of the byte whose arbitration was lost is completed, the MST bit is set to “0.” When arbitration is lost during slave address transmission, the TRX bit is set to “0” and the reception mode is set. Consequently, it becomes possible to receive and recognize its own slave address transmitted by another master device.
<<This bit changes “1” to “0” by writing instruction to I2C data shift register or I2C transmit buffer register.>>
∗Arbitration lost: The status in which communication as a master is disabled.

- **Bit 4: I2C-BUS interface interrupt request bit (PIN)**

  This bit generates an interrupt request signal. Each time 1-byte data is transmitted, the state of the PIN bit changes from "1" to "0." At the same time, an interrupt request signal is sent to the CPU. The PIN bit is set to "0" in synchronization with a falling edge of the last clock (including the ACK clock) of an internal clock and an interrupt request signal occurs in synchronization with a falling edge of the PIN bit. When detecting the STOP condition in slave, the multi-master I2C-BUS interface interrupt request bit (IR) is set to "1" (interrupt requested) regardless of falling of PIN bit. When the PIN bit is "0," the SCL is kept in the "0" state and clock generation is disabled. Figure 11.9 shows an interrupt request signal generating timing chart.

  The PIN bit is set to "1" in any one of the following conditions.

  - Writing "1" to the PIN bit
  - Executing a write instruction to the I2C data shift register or the I2C transmit buffer register (See note).
  - When the ESO bit is "0"
  - At reset

  Note: It takes 12 BCLK cycles or more until PIN bit becomes "1" after write instructions are executed to these registers.

  The conditions in which the PIN bit is set to "0" are shown below:

  - Immediately after completion of 1-byte data transmission (including when arbitration lost is detected)
  - Immediately after completion of 1-byte data reception
  - In the slave reception mode, with ALS = "0" and immediately after completion of slave address or general call address reception
  - In the slave reception mode, with ALS = "1" and immediately after completion of address data reception

- **Bit 5: bus busy flag (BB)**

  This bit indicates the status of use of the bus system. When this bit is set to "0," this bus system is not busy and a START condition can be generated. When this bit is set to "1," this bus system is busy and the occurrence of a START condition is disabled by the START condition duplication prevention function (See note).

  This flag cannot be written with software. In the other modes, this bit is set to "1" by detecting a START condition and set to "0" by detecting a STOP condition. When the ESO bit of the I2C control register is "0" and at reset, the BB flag is kept in the "0" state.

- **Bit 6: communication mode specification bit (transfer direction specification bit: TRX)**

  This bit decides the direction of transfer for data communication. When this bit is "0," the reception mode is selected and the data of a transmitting device is received. When the bit is "1," the transmission mode is selected and address data and control data are output into the SDA in synchronization with the clock generated on the SCL.

  When the ALS bit of the I2C control register is "0" in the slave reception mode is selected, the TRX bit is set to "1" (transmit) if the least significant bit (R/W bit) of the address data transmitted by the master is "1." When the ALS bit is "0" and the R/W bit is "0," the TRX bit is cleared to "0" (receive).

  The TRX bit is cleared to "0" in one of the following conditions.

  - When arbitration lost is detected.
  - When a STOP condition is detected.
  - When occurrence of a START condition is disabled by the START condition duplication prevention function (Note).
  - With MST = "0" and when a START condition is detected.
  - With MST = "0" and when ACK non-return is detected.
  - At reset

- **Bit 7: Communication mode specification bit (master/slave specification bit: MST)**

This bit is used for master/slave specification for data communication. When this bit is “0,” the slave is specified, so that a START condition and a STOP condition generated by the master are received, and data communication is performed in synchronization with the clock generated by the master.

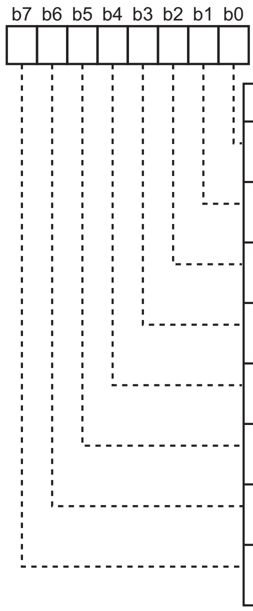
When this bit is “1,” the master is specified and a START condition and a STOP condition are generated, and also the clocks required for data communication are generated on the SCL.

The MST bit is cleared to “0” in one of the following conditions.

- Immediately after completion of 1-byte data transmission when arbitration lost is detected
- When a STOP condition is detected.
- When occurence of a START condition is disabled by the START condition duplication preventing function (See note).
- At reset

Note: The START condition duplication prevention function disables the following: the START condition generation; bit counter reset, and SCL output with the generation. This bit is valid from setting of BB flag to the completion of 1-byte transmission/reception (occurrence of transmission/ reception interrupt request) <IICRQ>.

I^{2}C status register



Symbol	Address	When reset
IIC0S1	$02E2_{16}$	$0001000?_2$

Bit Symbol	Bit name	Function	RW
LRB	Last receive bit	0 : Last bit = “0” 1 : Last bit = “1” (See note 1)	RO
AD0	General call detecting flag	0 : No general call detected 1 : General call detected (See note 1)	RO
AAS	Slave address comparison flag	0 : Address mismatch 1 : Address match (See note 1)	RO
AL	Arbitration lost detecting flag	0 : Not detected 1 : Detected (See note 1)	RO
PIN	I^{2}C-BUS interface interrupt request bit	0 : Interrupt request issued 1 : No interrupt request issued (See note 2)	RW
BB	Bus busy flag	0 : Bus free 1 : Bus busy (See note 1)	RO
TRX	Communication mode specification bits	b7b6 0 0 : Slave receive mode 0 1 : Slave transmit mode 1 0 : Master receive mode 1 1 : Master transmit mode	RW
MST			

Notes 1: These bits and flags can be read out, but cannot be written.
2: This bit can be written only “1.”

Figure 11.8 I^{2}C status register

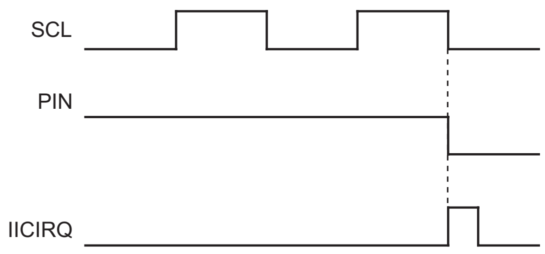


Figure 11.9 Interrupt request signal generation timing

(7) START condition generation method

When the ESO bit of the I2C control register is "1," execute a write instruction to the I2C status register to set the MST, TRX and BB bits to "1." A START condition will then be generated. After that, the bit counter becomes "000_2" and an SCL for 1 byte is output. The START condition generation timing and BB bit set timing are different in the standard clock mode and the high-speed clock mode. Refer to Figure 11.10 for the START condition generation timing diagram, and Table 11.2 for the START condition/STOP condition generation timing table.

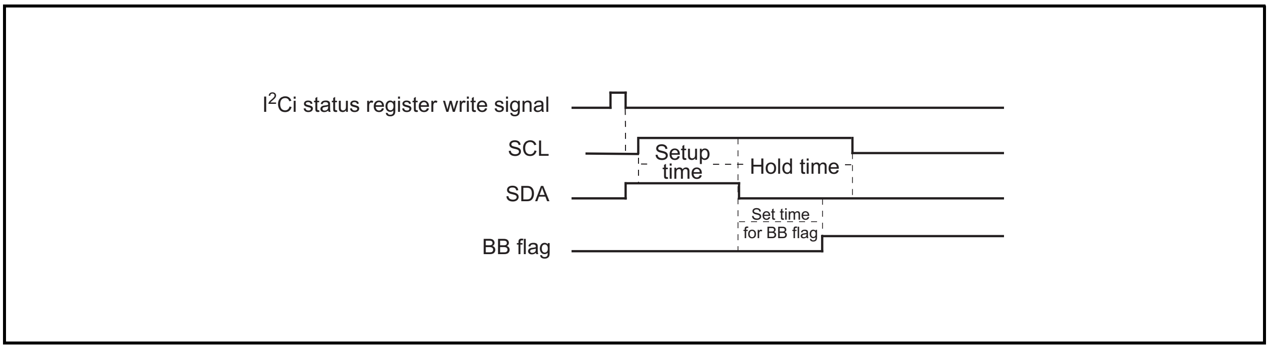


Figure 11.10 START condition generation timing diagram

(8) STOP condition generation method

When the ESO bit of the I2C control register is "1," execute a write instruction to the I2C status register for setting the MST bit and the TRX bit to "1" and the BB bit to "0". A STOP condition will then be generated. The STOP condition generation timing and the BB flag reset timing are different in the standard clock mode and the high-speed clock mode. Refer to Figure 11.11 for the STOP condition generation timing diagram, and Table 11.2 for the START condition/STOP condition generation timing table.

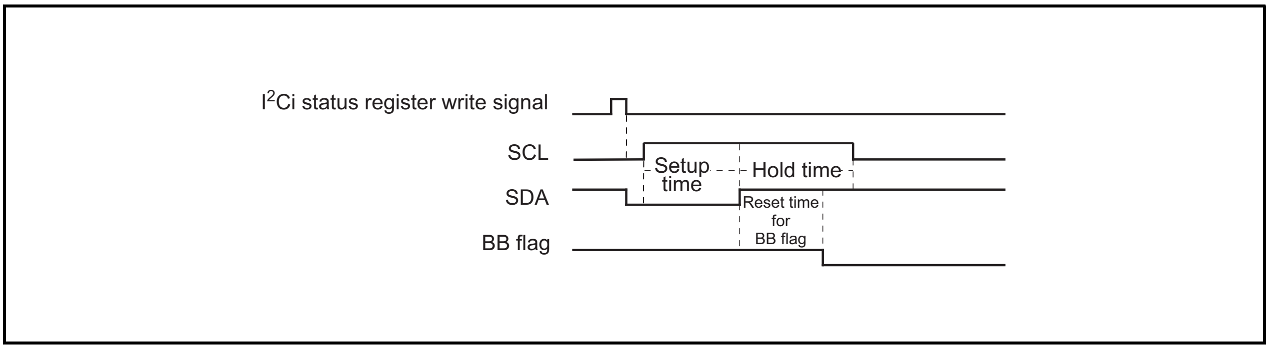


Figure 11.11 STOP condition generation timing diagram

Table 11.2 START condition/STOP condition generation timing table

Item	Standard Clock Mode	High-speed Clock Mode
Setup time (Min.)	5.6 µs	2.1 µs
Hold time (Min.)	4.8 µs	2.3 µs
Set/reset time for BB flag	3.5 µs	0.75 µs

(9) START/STOP condition detect conditions

The START/STOP condition detect conditions are shown in Figure 11.12 and Table 11.3.
Only when the 3 conditions of Table 11.3 are satisfied, a START/STOP condition can be detected.

Note: When a STOP condition is detected in the slave mode (MST = 0), an interrupt request signal <IICRQ> is generated to the CPU.

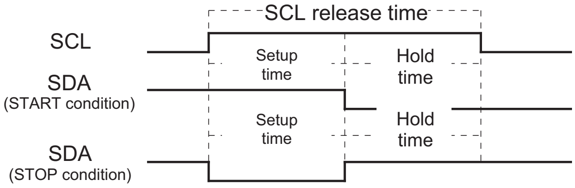


Figure 11.12 START condition/STOP condition detect timing diagram

Table 11.3 START condition/STOP condition detect conditions

Standard Clock Mode	High-speed Clock Mode
6.5 µs < SCL release time	1.0 µs < SCL release time
3.25 µs < Setup time	0.5 µs < Setup time
3.25 µs < Hold time	0.5 µs < Hold time

(10) Address data communication

There are two address data communication formats, namely, 7-bit addressing format and 10-bit addressing format. The respective address communication formats is described below.

- **7-bit addressing format**

  To meet the 7-bit addressing format, set the 10BIT SAD bit of the I^{2}C control register to “0.” The first 7-bit address data transmitted from the master is compared with the high-order 7-bit slave address stored in the I^{2}C address register. At the time of this comparison, address comparison of the RBW bit of the I^{2}C address register is not made. For the data transmission format when the 7-bit addressing format is selected, refer to Figure 11.13 (1) and (2).

- **10-bit addressing format**

  To meet the 10-bit addressing format, set the 10BIT SAD bit of the I^{2}C control register to “1.” An address comparison is made between the first-byte address data transmitted from the master and the 7-bit slave address stored in the I^{2}C address register. At the time of this comparison, an address comparison between the RBW bit of the I^{2}C address register and the R/$\overline{W}$ bit which is the last bit of the address data transmitted from the master is made. In the 10-bit addressing mode, the R/$\overline{W}$ bit which is the last bit of the address data not only specifies the direction of communication for control data but also is processed as an address data bit.

  When the first-byte address data matches the slave address, the AAS bit of the I^{2}C status register is set to “1.” After the second-byte address data is stored into the I^{2}C data shift register, make an address comparison between the second-byte data and the slave address by software. When the address data of the 2nd bytes matches the slave address, set the RBW bit of the I^{2}C address register to “1” by software. This processing can match the 7-bit slave address and R/$\overline{W}$ data, which are received after a RESTART condition is detected, with the value of the I^{2}C address register. For the data transmission format when the 10-bit addressing format is selected, refer to Figure 11.13, (3) and (4).

(11) Example of Master Transmission

An example of master transmission in the standard clock mode, at the SCL frequency of 100 kHz and in the ACK return mode is shown below.

(1) Set a slave address in the high-order 7 bits of the I2C address register and “0” in the RBW bit.
(2) Set the ACK return mode and SCL = 100 kHz by setting “85_{16}” in the I2C clock control register.
(3) Set “10_{16}” in the I2C status register and hold the SCL at the HIGH.
(4) Set a communication enable status by setting “08_{16}” in the I2C control register.
(5) Set the address data of the destination of transmission in the high-order 7 bits of the I2C data shift register and set “0” in the least significant bit.
(6) Set “$F0_{16}$” in the I2C status register to generate a START condition. At this time, an SCL for 1 byte and an ACK clock automatically occurs.
(7) Set transmit data in the I2C data shift register. At this time, an SCL and an ACK clock automatically occurs.
(8) When transmitting control data of more than 1 byte, repeat step (7).
(9) Set “$D0_{16}$” in the I2C status register. After this, if ACK is not returned or transmission ends, a STOP condition will be generated.

(12) Example of Slave Reception

An example of slave reception in the high-speed clock mode, at the SCL frequency of 400 kHz, in the ACK non-return mode, using the addressing format, is shown below.

(1) Set a slave address in the high-order 7 bits of the I2C address register and “0” in the RBW bit.
(2) Set the no ACK clock mode and SCL = 400 kHz by setting “25_{16}” in the I2C clock control register.
(3) Set “10_{16}” in the I2C status register and hold the SCL at the HIGH.
(4) Set a communication enable status by setting “08_{16}” in the I2C control register.
(5) When a START condition is received, an address comparison is made.
(6)
•When all transmitted address are“0” (general call):
AD0 of the I2C status register is set to “1”and an interrupt request signal occurs.
•When the transmitted addresses match the address set in (1):
ASS of the I2C status register is set to “1” and an interrupt request signal occurs.
•In the cases other than the above:
AD0 and AAS of the I2C status register are set to “0” and no interrupt request signal occurs.
(7) Set dummy data in the I2C data shift register.
(8) When receiving control data of more than 1 byte, repeat step (7).
(9) When a STOP condition is detected, the communication ends.

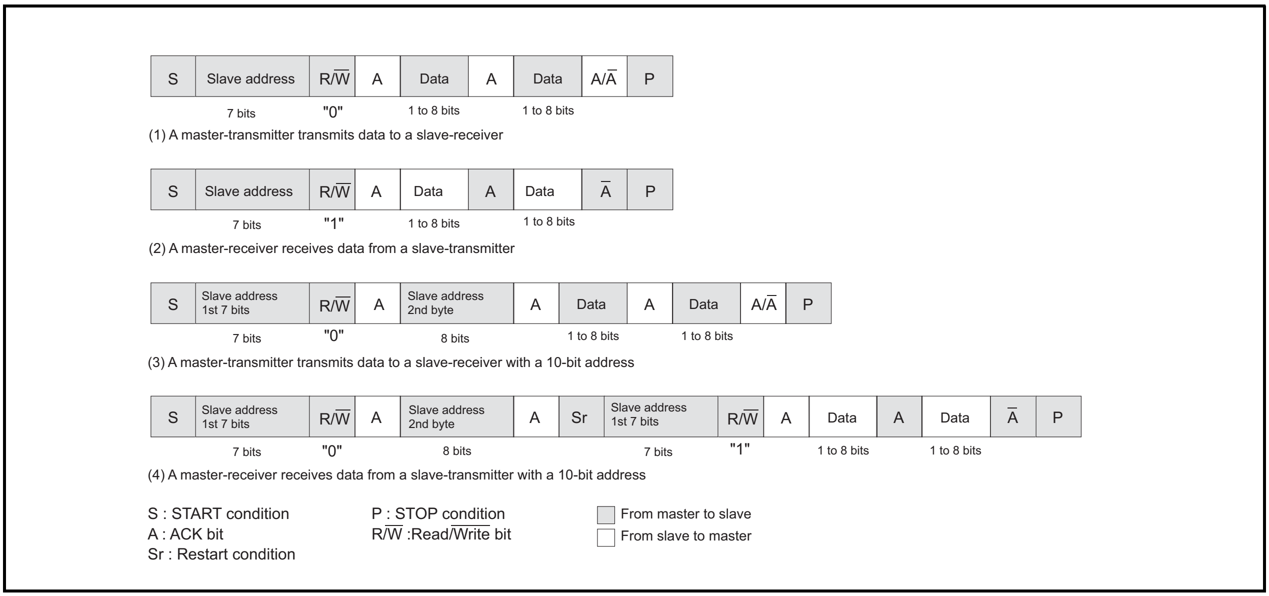


Figure 11.13 Address data communication format

(13) Precautions when using multi-master I^{2}C-BUS interface

- **BCLK operation mode**

  Select the no-division mode.
- **Used instructions**

  Specify byte (.B) as data size to access multi-master I^{2}C-BUS interface i-related registers.
- **Read-modify-write instruction**

  The precautions when the read-modify-write instruction such as BSET, BCLR etc. is executed for each register of the multi-master I^{2}C-BUS interface are described below.
  - I^{2}C data shift register (IICS0)

    When executing the read-modify-write instruction for this register during transfer, data may become a value not intended.
  - I^{2}C address register (IICS0D)

    When the read-modify-write instruction is executed for this register at detecting the STOP condition, data may become a value not intended. It is because hardware changes the read/$\overline{\text{write}}$ bit (RBW) at the above timing.
  - I^{2}C status register (IICS1)

    Do not execute the read-modify-write instruction for this register because all bits of this register are changed by hardware.
  - I^{2}C control register (IICS1D)

    When the read-modify-write instruction is executed for this register at detecting the START condition or at completing the byte transfer, data may become a value not intended. Because hardware changes the bit counter (BC0–BC2) at the above timing.
  - I^{2}C clock control register (IICS2)

    The read-modify-write instruction can be executed for this register.
  - I^{2}C port selection register (IICS2D)

    Since the read value of high-order 4 bits is indeterminate, the read-modify-write instruction cannot be used.
  - I^{2}C transmit buffer register (IICS0S)

    Since the value of all bits is indeterminate, the read-modify-write instruction cannot be used.

• START condition generating procedure using multi-master

```
                    :
         FCLR       I                  (Interrupt disabled)
         BTST       5, IICS1           (BB flag confirming and branch process)
         JC         BUSBUSY
BUSFREE:
         MOV.B      SA, IICS0          (Writing of slave address value <SA>)
         NOP
         NOP                                                                  (1)  (2)
         NOP
         NOP
         MOV.B      #F0H, IICS1        (Trigger of START condition generating)
         FSET       I                  (Interrupt enabled)
                    :
BUSBUSY:
         FSET       I                  (Interrupt enabled)
                    :
```

(1) Be sure to add NOP instruction × 4 between writing the slave address value and setting trigger of START condition generating shown the above procedure example.

(2) When using multi-master system, disable interrupts during the following three process steps:

- BB flag confirming
- Writing of slave address value
- Trigger of START condition generating

When the condition of the BB flag is bus busy, enable interrupts immediately.
When using single-master system, it is not necessary to disable interrupts above.

• RESTART condition generating procedure

```
         :
MOV.B    SA, IICS0S            (Writing of slave address value <SA>) ——— (1)
NOP
NOP
MOV.B    #F0H, IICS1           (Trigger of RESTART condition generating)
         :
```

(1) Use the I^{2}C transmit buffer register to write the slave address value to the I^{2}C data shift register. And also, be sure to add NOP instruction × 4.

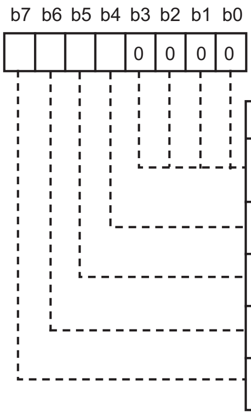
• Writing to I^{2}C status register

Do not execute an instruction to set the PIN bit to “1” from “0” and an instruction to set the MST and TRX bits to “0” from “1” simultaneously. It is because it may enter the state that the SCL pin is released and the SDA pin is released after about one machine cycle. Do not execute an instruction to set the MST and TRX bits to “0” from “1” simultaneously when the PIN bit is “1.” It is because it may become the same as above.

• Process of after STOP condition generating

Do not write data in the I^{2}C data shift register (IICS0) and the I^{2}C status register (IICS1) until the bus busy flag BB becomes “0” after generating the STOP condition in the master mode. It is because the STOP condition waveform might not be normally generated. Reading to the above registers do not have the problem.

I^{2}C0 Interrupt Control Register

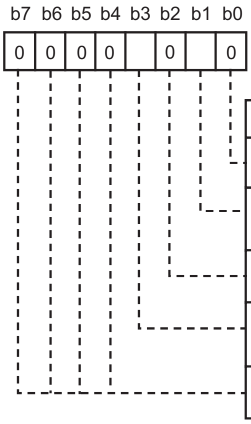


Symbol	Address	At reset
EXTIICINT	02D6$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	R	W
Reserved bits	Must set to "0."		○	○
EXTIICINT0	ACK interrupt control bit (Note 1)	0000: Interrupt prohibition (Note 2) 0101: Interrupt permission Other: Must not be set Please set TA4IC (Note 3) when you use it by "Interrupt permission".	○	○
EXTIICINT1				
EXTIICINT2				
EXTIICINT3				

Notes 1: Timer A4 and multi master I^{2}C (ACK) interrupt, the vector and the interrupt control register are shared. Please make it to (b7, b6, b5, b4) = (0, 1, 0, 1) when you use multi-master I^{2}C (ACK) interrupt.
Notes 2: Please set 0000$_2$ when you use the interrupt of timer A4.
Notes 3: Please refer to "Figure 6.3 interrupt control register" of "6.5 interrupt control".
Notes 4: Please change in the part where multi-master I^{2}C (ACK) and timer A4 interrupt request are not generated in the I^{2}C0 interrupt control register.
Notes 5: Please permit interrupt after making IR bit of timer A4 (TA4IC) "0" (the interrupt request none) after EXTIICINTi (i = 0 to 3) is changed.

Reserved Register



Symbol	Address	At reset
RSVREG02D7	02D7$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	R	W
Reserved bit	Must set to "0."		○	○
Reserved bit	When use multi-master I^{2}C-BUS interface, set this bit to "1."		○	○
Reserved bit	Must set to "0."		○	○
Reserved bit	When use multi-master I^{2}C-BUS interface, set this bit to "1."		○	○
Reserved bits	Must set to "0."		○	○

12. A/D Converter

The microcomputer contains one A/D converter circuit based on 8-bit successive approximation method configured with a capacitive-coupling amplifier. The analog inputs share the pins with P00 to P07, P95 and P96. Similarly, $\overline{\text{ADTRG}}$ input shares the pin with P97. Therefore, when using these inputs, make sure the corresponding port direction bits are set to “0” (= input mode).

When not using the A/D converter, set the VCUT bit to “0” (= Vref unconnected), so that no current will flow from the VREF pin into the resistor ladder, helping to reduce the power consumption of the chip.

The A/D conversion result is stored in the ADi register bits for ANi pins (i = 0 to 7).

Table 12.1 shows the performance of the A/D converter. Figure 12.1 shows the block diagram of the A/D converter, and Figures 12.2 and 12.3 show the A/D converter-related registers.

Table 12.1 Performance of A/D Converter

Item	Performance
Method of A/D conversion	Successive approximation (capacitive coupling amplifier)
Analog input voltage (Note 1)	0V to AVCC (VCC)
Operating clock φAD (Note 2)	f AD/divide-by-2 of fAD/divide-by-3 of f AD/divide-by-4 of f AD/divide-by-6 of f AD/divide-by-12 of f AD
Resolution	8-bit
Integral nonlinearity error	When AVCC = VREF = 5V • With 8-bit resolution: ±3LSB - ANEX0 and ANEX1 input (including mode in which external operation amp is connected) : ±4LSB
Operating modes	One-shot mode, repeat mode, single sweep mode, repeat sweep mode 0, and repeat sweep mode 1
Analog input pins	8 pins (AN0 to AN7) + 2 pins (ANEX0 and ANEX1)
A/D conversion start condition	• Software trigger The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • External trigger (retriggerable) Input on the $\overline{\text{ADTRG}}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
Conversion speed per pin	• Without sample and hold function 8-bit resolution: 49 φAD cycles • With sample and hold function 8-bit resolution: 28 φAD cycles

Note 1: Does not depend on use of sample and hold function.

Note 2: The φAD frequency must be 10 MHz or less.
Without sample-and-hold function, limit the φAD frequency to 250kHz or more.
With the sample and hold function, limit the φAD frequency to 1MHz or more.

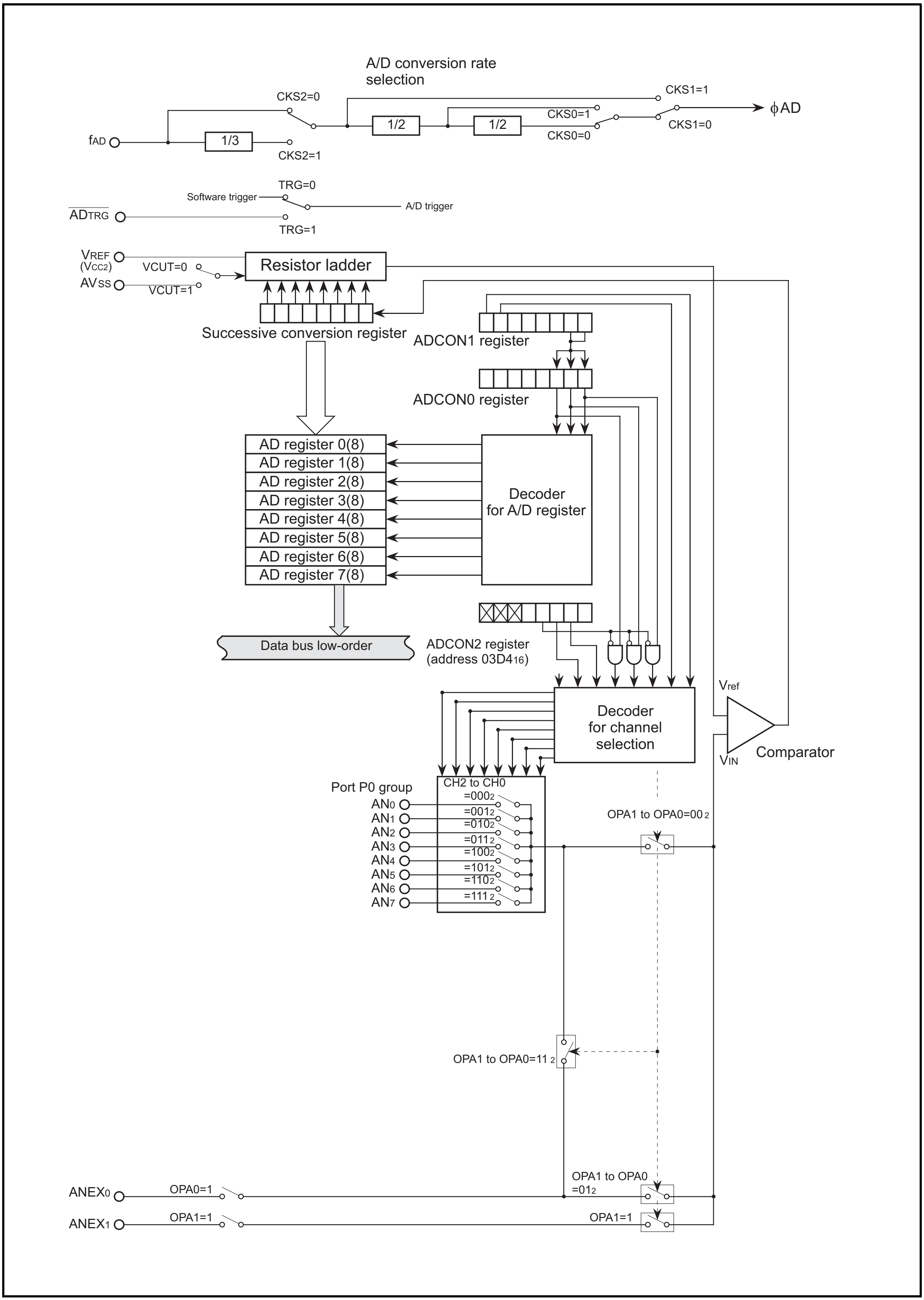


Figure 12.1 **A/D Converter Block Diagram**

A/D control register 0 (Note)

b7	b6	b5	b4	b3	b2	b1	b0

Symbol	Address	After reset
ADCON0	03D6₁₆	00000XXX₂

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	Function varies with each operation mode	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 0 0 : One-shot mode 0 1 : Repeat mode 1 0 : Single sweep mode 1 1 : Repeat sweep mode 0 or Repeat sweep mode 1	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : ADTRG trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.

A/D control register 1 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
				0			

Symbol	Address	After reset
ADCON1	03D7₁₆	00₁₆

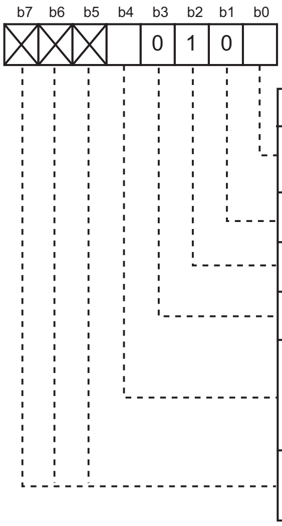
Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	Function varies with each operation mode	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	0 : Any mode other than repeat sweep mode 1 1 : Repeat sweep mode 1	RW
— (b3)	Reserved bit	Must always be set to “0”	RW
CKS1	Frequency select bit 1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	0 : Vref not connected 1 : Vref connected	RW
OPA0	External op-amp connection mode bit	Function varies with each operation mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: If the VCUT bit is reset from “0” (Vref unconnected) to “1” (Vref connected), wait for 1 μs or more before starting A/D conversion.

Figure 12.2 ADCON0 to ADCON1 Registers

A/D control register 2 (Note 1)

Symbol	Address	After reset
ADCON2	$03D4_{16}$	00_{16}



Bit symbol	Bit name	Function	RW
SMP	A/D conversion method select bit	0 : Without sample and hold 1 : With sample and hold	RW
$\overline{\ }$(b1)	Reserved bit	Must always be set to "0"	RW
$\overline{\ }$(b2)	Reserved bit	Must always be set to "1"	RW
$\overline{\ }$(b3)	Reserved bit	Must always be set to "0"	RW
CKS2	Frequency select bit 2 (Note 2)	0: Selects f_{AD}, f_{AD} divided by 2, or f_{AD} divided by 4. 1: Selects f_{AD} divided by 3, f_{AD} divided by 6, or f_{AD} divided by 12.	RW
$\overline{\ }$(b7-b5)	Nothing is assigned. In an attempt to write to these bits, write "0". The value, if read, turns out to be "0".		—

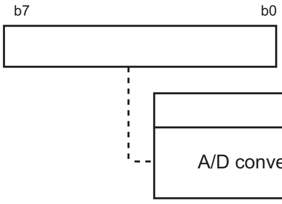
Note 1: If the ADCON2 register is rewritten during A-D conversion, the conversion result will be indeterminate.

Note 2: Adjust the frequency of ϕAD to 10MHZ or less. ϕAD can be selected by combining CKS0 bit of ADCON0 register, CKS1 bit of ADCON1 register and CKS2 bit of ADCON2 register.

CKS2	CKS1	CKS0	ϕAD
0	0	0	Divide-by-4 of f_{AD}
0	0	1	Divide-by-2 of f_{AD}
0	1	0	f_{AD}
0	1	1	
1	0	0	Ddivide-by-12 of f_{AD}
1	0	1	Divide-by-6 of f_{AD}
1	1	0	Divide-by-3 of f_{AD}
1	1	1	

A/D register i (i=0 to 7)

Symbol	Address	After reset
AD0	$03C0_{16}$	Indeterminate
AD1	$03C2_{16}$	Indeterminate
AD2	$03C4_{16}$	Indeterminate
AD3	$03C6_{16}$	Indeterminate
AD4	$03C8_{16}$	Indeterminate
AD5	$03CA_{16}$	Indeterminate
AD6	$03CC_{16}$	Indeterminate
AD7	$03CE_{16}$	Indeterminate



Function	RW
A/D conversion result	RO

Figure 12.3 ADCON2 Register, and AD0 to AD7 Registers

12.1 One-shot Mode

In this mode, the input voltage on one selected pin is A/D converted once. Table 12.2 shows the specifications of one-shot mode. Figure 12.4 shows the ADCON0 to ADCON1 registers in one-shot mode.

Table 12.2 One-shot Mode Specifications

Item	Specification
Function	The input voltage on one pin selected by the ADCON0 register's CH2 to CH0 bits and the ADCON1 register's OPA1 to OPA0 bits is A/D converted once.
A/D conversion start condition	• When the ADCON0 register's TRG bit is “0” (software trigger) The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • When the TRG bit is “1” ($\overline{\text{ADTRG}}$ trigger) Input on the $\overline{\text{ADTRG}}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
A/D conversion stop condition	• Completion of A/D conversion (If a software trigger is selected, the ADST bit is cleared to “0” (A/D conversion halted).) • Set the ADST bit to “0”
Interrupt request generation timing	Completion of A/D conversion
Analog input pin	Select one pin from AN0 to AN7, ANEX0 to ANEX1
Reading of result of A/D converter	Read one of the AD0 to AD7 registers that corresponds to the selected pin

A/D control register 0 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
			0	0			

Symbol ADCON0 | Address $03D6_{16}$ | After reset $00000XXX_2$

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	b2 b1 b0 0 0 0 : AN0 is selected 0 0 1 : AN1 is selected 0 1 0 : AN2 is selected 0 1 1 : AN3 is selected 1 0 0 : AN4 is selected 1 0 1 : AN5 is selected 1 1 0 : AN6 is selected 1 1 1 : AN7 is selected (Note 2)	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 0 0 : One-shot mode (Note 2)	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : $\overline{\text{ADTRG}}$ trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note 1: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: After rewriting the MD1 to MD0 bits, set the CH2 to CH0 bits over again using another instruction.

A/D control register 1 (Note)

b7	b6	b5	b4	b3	b2	b1	b0
		1		0	0		

Symbol ADCON1 | Address $03D7_{16}$ | After reset 00_{16}

Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	Invalid in one-shot mode	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	Set to “0” when one-shot mode is selected	RW
— (b3)	Reserved bit	Must always be set to “0”	RW
CKS1	Frequency select bit1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	1 : Vref connected	RW
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : ANEX0 input is A/D converted 1 0 : ANEX1 input is A/D converted 1 1 : External op-amp connection mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: If the VCUT bit is reset from “0” (Vref unconnected) to “1” (Vref connected), wait for 1 µs or more before starting A/D conversion.

Figure 12.4 ADCON0 Register and ADCON1 Register (One-shot Mode)

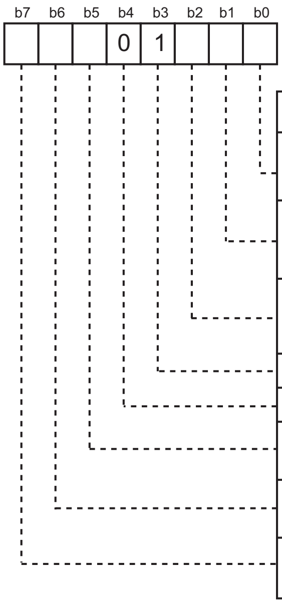
12.2 Repeat mode

In this mode, the input voltage on one selected pin is A/D converted repeatedly. Table 12.3 shows the specifications of repeat mode. Figure 12.5 shows the ADCON0 to ADCON1 registers in repeat mode.

Table 12.3 Repeat Mode Specifications

Item	Specification
Function	The input voltage on one pin selected by the ADCON0 register's CH2 to CH0 bits and the ADCON1 register's OPA1 to OPA0 bits is A/D converted repeatedly.
A/D conversion start condition	• When the ADCON0 register's TRG bit is “0” (software trigger) The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • When the TRG bit is “1” ($\overline{\text{ADTRG}}$ trigger) Input on the $\overline{\text{ADTRG}}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
A/D conversion stop condition	Set the ADST bit to “0” (A/D conversion halted)
Interrupt request generation timing	None generated
Analog input pin	Select one pin from AN_0 to AN_7, ANEX0 to ANEX1
Reading of result of A/D converter	Read one of the AD0 to AD7 registers that corresponds to the selected pin

A/D control register 0 (Note 1)

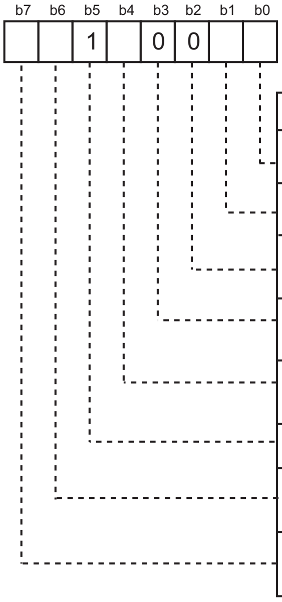


Symbol	Address	After reset
ADCON0	$03D6_{16}$	$00000XXX_2$

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	b2 b1 b0 0 0 0 : AN_0 is selected 0 0 1 : AN_1 is selected 0 1 0 : AN_2 is selected 0 1 1 : AN_3 is selected 1 0 0 : AN_4 is selected 1 0 1 : AN_5 is selected 1 1 0 : AN_6 is selected 1 1 1 : AN_7 is selected (Note 2)	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 0 1 : Repeat mode (Note 2)	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : ADTRG trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note 1: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: After rewriting the MD1 to MD0 bits, set the CH2 to CH0 bits over again using another instruction.

A/D control register 1 (Note)



Symbol	Address	After reset
ADCON1	$03D7_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	Invalid in repeat mode	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	Set to "0" when this mode is selected	RW
(b3)	Reserved bit	Must always be set to "0"	RW
CKS1	Frequency select bit 1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	1 : Vref connected	RW
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : ANEX0 input is A/D converted 1 0 : ANEX1 input is A/D converted 1 1 : External op-amp connection mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: If the VCUT bit is reset from "0" (Vref unconnected) to "1" (Vref connected), wait for 1 μs or more before starting A/D conversion.

Figure 12.5 ADCON0 Register and ADCON1 Register (Repeat Mode)

12.3 Single Sweep Mode

In this mode, the input voltages on selected pins are A/D converted, one pin at a time. Table 12.4 shows the specifications of single sweep mode. Figure 12.6 shows the ADCON0 to ADCON1 registers in single sweep mode.

Table 12.4 Single Sweep Mode Specifications

Item	Specification
Function	The input voltages on pins selected by the ADCON1 register's SCAN1 to SCAN0 bits are A/D converted, one pin at a time.
A/D conversion start condition	• When the ADCON0 register's TRG bit is “0” (software trigger) The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • When the TRG bit is “1” ($\overline{ADTRG}$ trigger) Input on the $\overline{ADTRG}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
A/D conversion stop condition	• Completion of A/D conversion (If a software trigger is selected, the ADST bit is cleared to “0” (A/D conversion halted).) • Set the ADST bit to “0”
Interrupt request generation timing	Completion of A/D conversion
Analog input pin	Select from AN_0 to AN_1 (2 pins), AN_0 to AN_3 (4 pins), AN_0 to AN_5 (6 pins), AN_0 to AN_7 (8 pins)
Reading of result of A/D converter	Read one of the AD0 to AD7 registers that corresponds to the selected pin

A/D control register 0 (Note)

b7	b6	b5	b4	b3	b2	b1	b0
			1	0			

Symbol	Address	After reset
ADCON0	$03D6_{16}$	$00000XXX_2$

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	Invalid in single sweep mode	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 1 0 : Single sweep mode	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : AD$_{TRG}$ trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.

A/D control register 1 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
		1		0	0		

Symbol	Address	After reset
ADCON1	$03D7_{16}$	00_{16}

Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	When single sweep mode is selected b1 b0 0 0 : AN$_0$ to AN$_1$ (2 pins) 0 1 : AN$_0$ to AN$_3$ (4 pins) 1 0 : AN$_0$ to AN$_5$ (6 pins) 1 1 : AN$_0$ to AN$_7$ (8 pins)	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	Set to “0” when single sweep mode is selected	RW
— (b3)	Reserved bit	Must always be set to “0”	RW
CKS1	Frequency select bit 1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	1 : Vref connected	RW
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : Must not be set 1 0 : Must not be set 1 1 : External op-amp connection mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.

Note 2: If the VCUT bit is reset from “0” (Vref unconnected) to “1” (Vref connected), wait for 1 µs or more before starting A/D conversion.

Figure 12.6 ADCON0 Register and ADCON1 Register (Single Sweep Mode)

12.4 Repeat Sweep Mode 0

In this mode, the input voltages on selected pins are A/D converted repeatedly. Table 12.5 shows the specifications of repeat sweep mode 0. Figure 12.7 shows the ADCON0 to ADCON1 registers in repeat sweep mode 0.

Table 12.5 Repeat Sweep Mode 0 Specifications

Item	Specification
Function	The input voltages on pins selected by the ADCON1 register's SCAN1 to SCAN0 bits are A/D converted repeatedly.
A/D conversion start condition	• When the ADCON0 register's TRG bit is “0” (software trigger) The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • When the TRG bit is “1” ($\overline{\text{ADTRG}}$ trigger) Input on the $\overline{\text{ADTRG}}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
A/D conversion stop condition	Set the ADST bit to “0” (A/D conversion halted)
Interrupt request generation timing	None generated
Analog input pin	Select from AN$_0$ to AN$_1$ (2 pins), AN$_0$ to AN$_3$ (4 pins), AN$_0$ to AN$_5$ (6 pins), AN$_0$ to AN$_7$ (8 pins)
Reading of result of A/D converter	Read one of the AD0 to AD7 registers that corresponds to the selected pin

A/D control register 0 (Note)

b7	b6	b5	b4	b3	b2	b1	b0
			1	1			

Symbol	Address	After reset
ADCON0	03D6$_{16}$	00000XXX$_2$

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	Invalid in repeat sweep mode 0	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 1 1 : Repeat sweep mode 0 or Repeat sweep mode 1	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : ADTRG trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.

A/D control register 1 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0
		1		0	0		

Symbol	Address	After reset
ADCON1	03D7$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	When repeat sweep mode 0 is selected b1 b0 0 0 : AN$_0$, AN$_1$ (2 pins) 0 1 : AN$_0$ to AN$_3$ (4 pins) 1 0 : AN$_0$ to AN$_5$ (6 pins) 1 1 : AN$_0$ to AN$_7$ (8 pins)	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	Set to “0” when repeat sweep mode 0 is selected	RW
(b3)	Reserved bit	Must always be set to “0”	RW
CKS1	Frequency select bit 1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	1 : Vref connected	RW
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : Must not be set 1 0 : Must not be set 1 1 : External op-amp connection mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: If the VCUT bit is reset from “0” (Vref unconnected) to “1” (Vref connected), wait for 1 μs or more before starting A/D conversion.

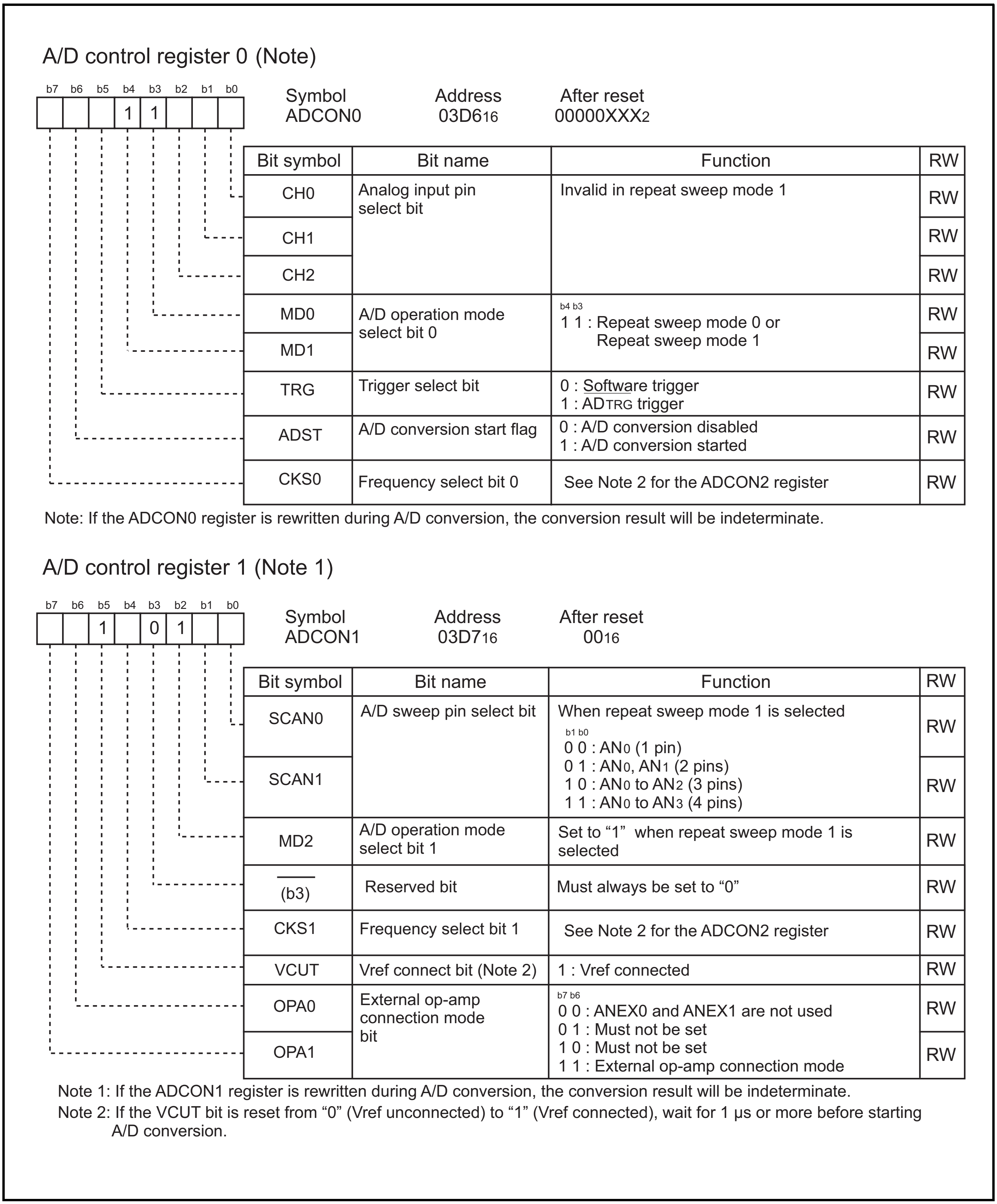
Figure 12.7 ADCON0 Register and ADCON1 Registers (Repeat Sweep Mode 0)

12.5 Repeat Sweep Mode 1

In this mode, the input voltages on all pins are A/D converted repeatedly, with priority given to the selected pins. Table 12.6 shows the specifications of repeat sweep mode 1. Figure 12.8 shows the ADCON0 to ADCON1 registers in repeat sweep mode 1.

Table 12.6 Repeat Sweep Mode 1 Specifications

Item	Specification
Function	The input voltages on all selected pins are A/D converted repeatedly,with priority given to pins selected by the ADCON1 register's SCAN1 to SCAN0 bits. Example : If AN0 selected, input voltages are A/D converted in order of AN0 → AN1 → AN0 → AN2 → AN0 → AN3, and so on.
A/D conversion start condition	• When the ADCON0 register's TRG bit is “0” (software trigger) The ADCON0 register's ADST bit is set to “1” (A/D conversion starts) • When the TRG bit is “1” ($\overline{\text{ADTRG}}$ trigger) Input on the $\overline{\text{ADTRG}}$ pin changes state from high to low after the ADST bit is set to “1” (A/D conversion starts)
A/D conversion stop condition	Set the ADST bit to “0” (A/D conversion halted)
Interrupt request generation timing	None generated
Analog input pins to be given priority when A/D converted	Select from AN0 (1 pins), AN0 to AN1 (2 pins), AN0 to AN2 (3 pins), AN0 to AN3 (4 pins)
Reading of result of A/D converter	Read one of the AD0 to AD7 registers that corresponds to the selected pin



A/D control register 0 (Note)

Symbol	Address	After reset
ADCON0	03D6$_{16}$	00000XXX$_2$

Bit symbol	Bit name	Function	RW
CH0	Analog input pin select bit	Invalid in repeat sweep mode 1	RW
CH1			RW
CH2			RW
MD0	A/D operation mode select bit 0	b4 b3 1 1 : Repeat sweep mode 0 or Repeat sweep mode 1	RW
MD1			RW
TRG	Trigger select bit	0 : Software trigger 1 : ADTRG trigger	RW
ADST	A/D conversion start flag	0 : A/D conversion disabled 1 : A/D conversion started	RW
CKS0	Frequency select bit 0	See Note 2 for the ADCON2 register	RW

Note: If the ADCON0 register is rewritten during A/D conversion, the conversion result will be indeterminate.

A/D control register 1 (Note 1)

Symbol	Address	After reset
ADCON1	03D7$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
SCAN0	A/D sweep pin select bit	When repeat sweep mode 1 is selected b1 b0 0 0 : AN$_0$ (1 pin) 0 1 : AN$_0$, AN$_1$ (2 pins) 1 0 : AN$_0$ to AN$_2$ (3 pins) 1 1 : AN$_0$ to AN$_3$ (4 pins)	RW
SCAN1			RW
MD2	A/D operation mode select bit 1	Set to “1” when repeat sweep mode 1 is selected	RW
— (b3)	Reserved bit	Must always be set to “0”	RW
CKS1	Frequency select bit 1	See Note 2 for the ADCON2 register	RW
VCUT	Vref connect bit (Note 2)	1 : Vref connected	RW
OPA0	External op-amp connection mode bit	b7 b6 0 0 : ANEX0 and ANEX1 are not used 0 1 : Must not be set 1 0 : Must not be set 1 1 : External op-amp connection mode	RW
OPA1			RW

Note 1: If the ADCON1 register is rewritten during A/D conversion, the conversion result will be indeterminate.
Note 2: If the VCUT bit is reset from “0” (Vref unconnected) to “1” (Vref connected), wait for 1 µs or more before starting A/D conversion.

Figure 12.8 ADCON0 Register and ADCON1 Register (Repeat Sweep Mode 1)

12.6 Sample and Hold

If the ADCON2 register’s SMP bit is set to “1” (with sample-and-hold), the conversion speed per pin is increased to 28 ϕ_{AD} cycles for 8-bit resolution. Sample-and-hold is effective in all operation modes.
Select whether or not to use the sample-and-hold function before starting A/D conversion.

12.7 Extended Analog Input Pins

In one-shot and repeat modes, the ANEX0 and ANEX1 pins can be used as analog input pins. Use the ADCON1 register’s OPA1 to OPA0 bits to select whether or not use ANEX0 and ANEX1.
The A/D conversion results of ANEX0 and ANEX1 inputs are stored in the AD0 and AD1 registers, respectively.

12.8 External Operation Amp Connection Mode

Multiple analog inputs can be amplified using a single external op-amp via the ANXE0 and ANEX1 pins.
Set the ADCON1 register’s OPA1 OPA0 bits to ‘11_2’ (external op-amp connection mode). The inputs from ANi (i = 0 to 7) are output from the ANEX0 pin. Amplify this output with an external op-amp before sending it back to the ANEX1 pin. The A/D conversion result is stored in the corresponding ADi register. The A/D conversion speed depends on the response characteristics of the external op-amp. Note that the ANXE0 and ANEX1 pins cannot be directly connected to each other. Figure 12.9 is an example of how to connect the pins in external operation amp.

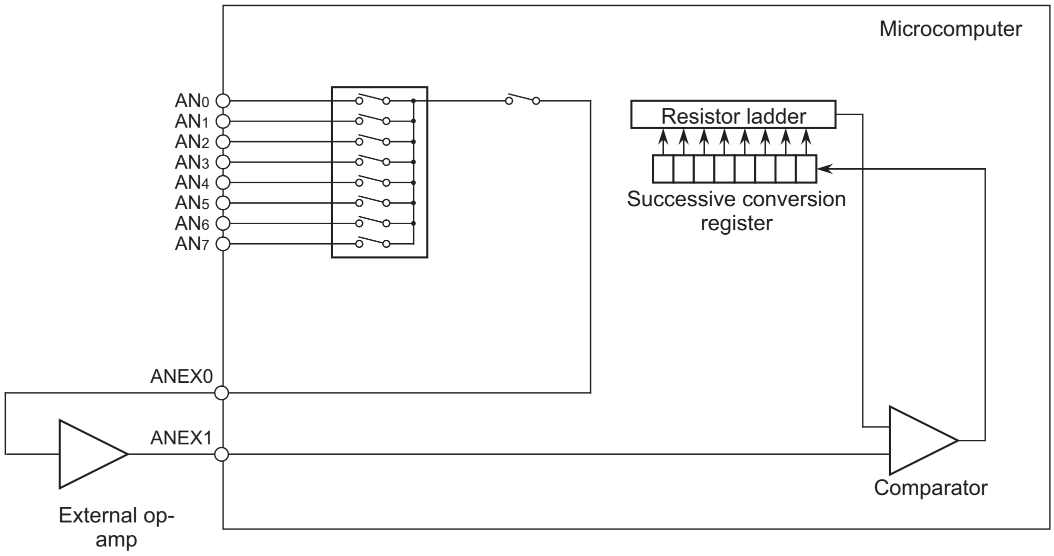


Figure 12.9 External Op-amp Connection

12.9 Current Consumption Reducing Function

When not using the A/D converter, its resistor ladder and reference voltage input pin (VREF) can be separated using the ADCON1 register's VCUT bit. When separated, no current will flow from the VREF pin into the resistor ladder, helping to reduce the power consumption of the chip.
To use the A/D converter, set the VCUT bit to "1" (VREF connected) and then set the ADCON0 register's ADST bit to "1" (A/D conversion start). The VCUT and ADST bits cannot be set to "1" at the same time.
Nor can the VCUT bit be set to "0" (VREF unconnected) during A/D conversion.

12.10 Analog Input Pin and External Sensor Equivalent Circuit Example

Figure 12.10 shows analog input pin and external sensor equivalent circuit example.

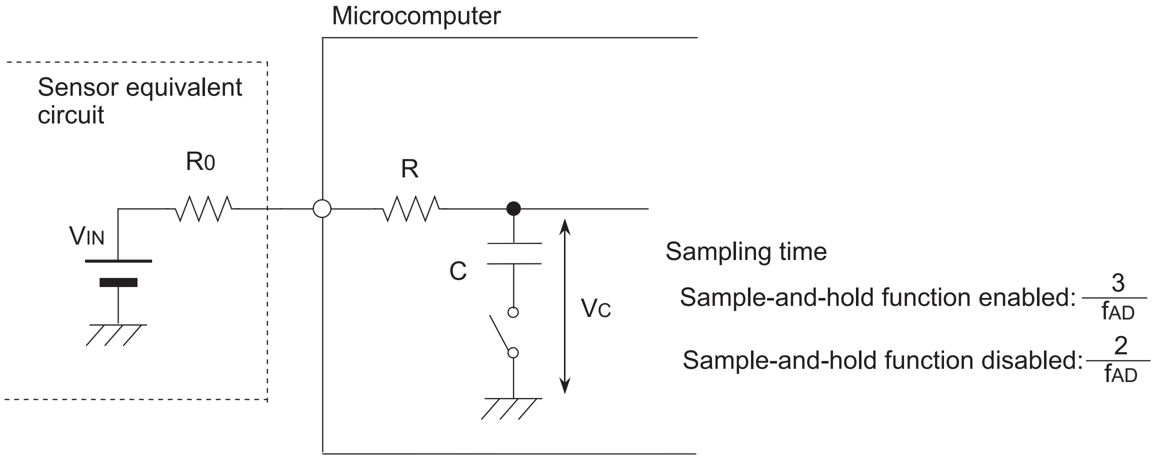


Figure 12.10 Analog Input Pin and External Sensor Equivalent Circuit

12.11 Caution of Using A/D Converter

(1) Make sure the port direction bits for those pins that are used as analog inputs are set to “0” (input mode). Also, if the ADCON0 register’s TGR bit = 1 (external trigger), make sure the port direction bit for the ADTRG pin is set to “0” (input mode).

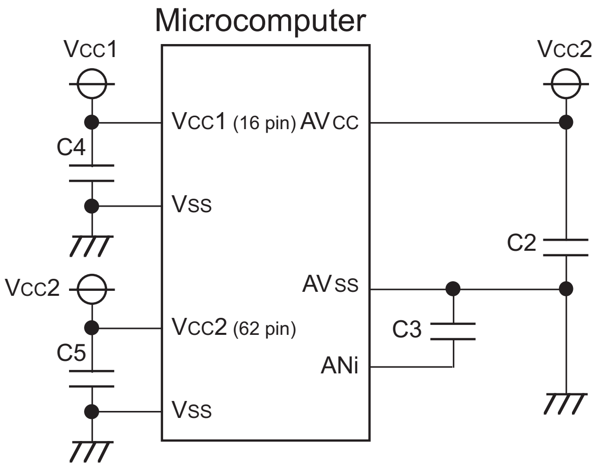
(2) To prevent noise-induced device malfunction or latchup, as well as to reduce conversion errors, insert capacitors between the AVCC, VREF, and analog input pins (ANi (i=0 to 7)) each and the AVSS pin. Similarly, insert a capacitor between the VCC pin and the VSS pin. Figure 12.11 is an example connection of each pin.

(3) If the CPU reads the ADi register (i = 0 to 7) at the same time the conversion result is stored in the ADi register after completion of A/D conversion, an incorrect value may be stored in the ADi register. This problem occurs when a divide-by-n clock derived from the main clock or a subclock is selected for CPU clock.

•When operating in one-shot or single-sweep mode
Check to see that A/D conversion is completed before reading the target ADi register. (Check the IR bit in the ADIC register to see if A/D conversion is completed.)

•When operating in repeat mode or repeat sweep mode 0 or 1
Use the main clock for CPU clock directly without dividing it.

(4) If A/D conversion is forcibly terminated while in progress by setting the ADCON0 register’s ADST bit to “0” (A/D conversion halted), the conversion result of the A/D converter is indeterminate. The contents of ADi registers irrelevant to A/D conversion may also become indeterminate. If while A/D conversion is underway the ADST bit is cleared to “0” in a program, ignore the values of all ADi registers.



ANi: ANi (i=0 to 7)

Note 1: C1≥0.47μF, C2 ≥0.47μF, C3 ≥100pF, C4 ≥0.1μF, C5≥0.1μF (reference)
Note 2: Use thick and shortest possible wiring to connect capacitors.

Figure 12.11 VCC, VSS, AVCC, AVSS, VREF and ANi Connection

13. CRC Calculation

The Cyclic Redundancy Check (CRC) operation detects an error in data blocks. The microcomputer uses a generator polynomial of CRC_CCITT ($X^{16} + X^{12} + X^5 + 1$) to generate CRC code.
The CRC code consists of 16 bits which are generated for each data block in given length, separated in 8 bit units. After the initial value is set in the CRCD register, the CRC code is set in that register each time one byte of data is written to the CRCIN register. CRC code generation for one-byte data is finished in two cycles.
Figure 13.1 shows the block diagram of the CRC circuit. Figure 13.2 shows the CRC-related registers.
Figure 13.3 shows the calculation example using the CRC operation.

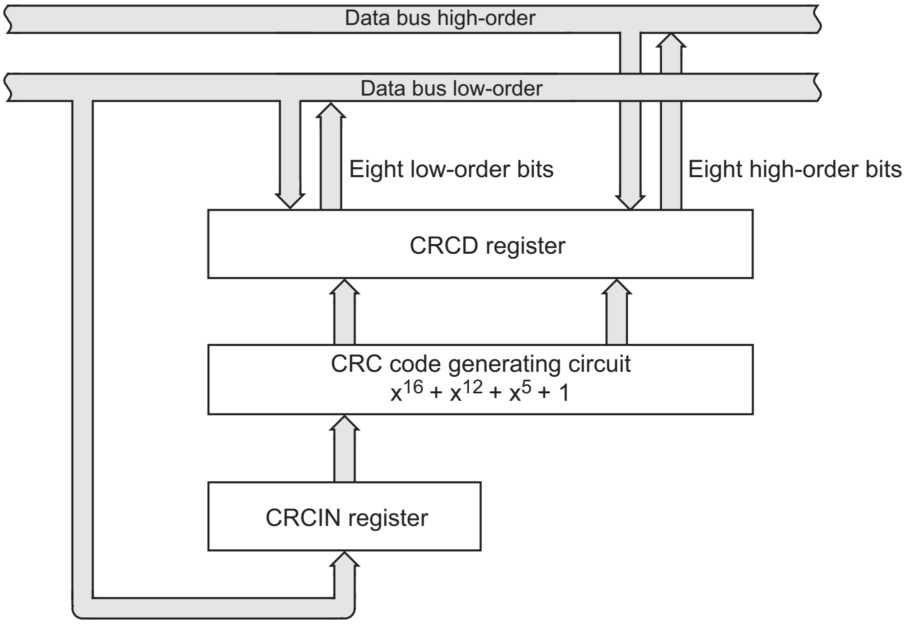
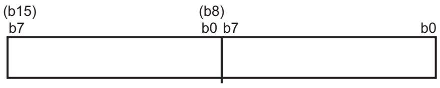


Figure 13.1 CRC Circuit Block Diagram

CRC data register



Symbol	Address	After reset
CRCD	$03BD_{16}$ to $03BC_{16}$	Indeterminate

Function	Setting range	RW
When data is written to the CRCIN register after setting the initial value in the CRCD register, the CRC code can be read out from the CRCD register.	0000_{16} to $FFFF_{16}$	RW

CRC input register

Symbol	Address	After reset
CRCIN	$03BE_{16}$	Indeterminate

Function	Setting range	RW
Data input	00_{16} to FF_{16}	RW

Figure 13.2 CRCD Register and CRCIN Register

Setup procedure and CRC operation when generating CRC code “80C4$_{16}$”

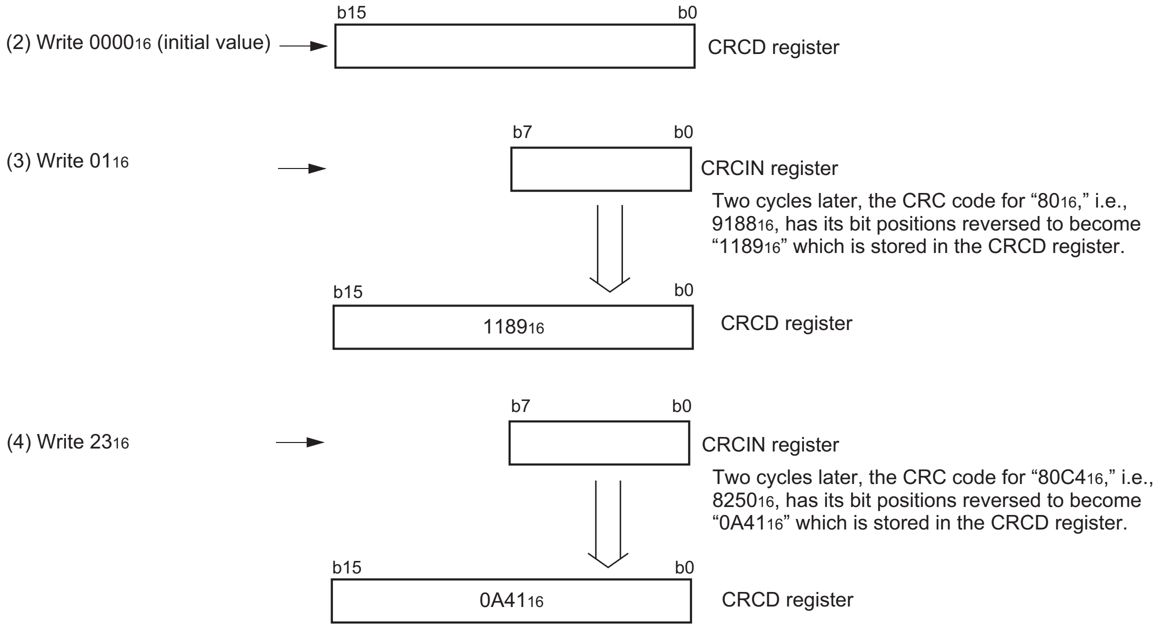
(a) CRC operation performed by the M16C

CRC code: Remainder of a division in which the value written to the CRCIN register with its bit positions reversed is divided by the generator polynomial

Generator polynomial: $X^{16} + X^{12} + X^{5} + 1$ (1 0001 0000 0010 0001$_2$)

(b) Setting procedure

(1) Reverse the bit positions of the value “80C4$_{16}$” bytewise in a program.
“80$_{16}$” → “01$_{16}$”, “C4$_{16}$” → “23$_{16}$”

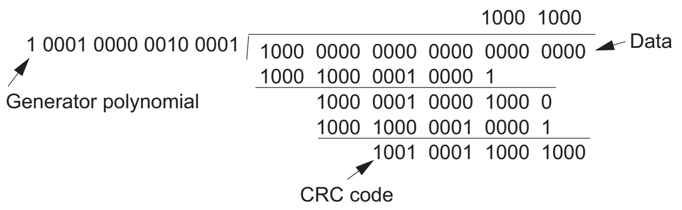


Two cycles later, the CRC code for “80$_{16}$,” i.e., 9188$_{16}$, has its bit positions reversed to become “1189$_{16}$” which is stored in the CRCD register.

Two cycles later, the CRC code for “80C4$_{16}$,” i.e., 8250$_{16}$, has its bit positions reversed to become “0A41$_{16}$” which is stored in the CRCD register.

(c) Details of CRC operation

In the case of (3) above, the value written to the CRCIN register “01$_{16}$ (00000001$_2$)” has its bit positions reversed to become “10000000$_2$.” The value “1000 0000 0000 0000 0000 0000$_2$” derived from that by adding 16 digits and the CRCD register’s initial value “0000$_{16}$” are added, the result of which is divided by the generator polynomial using modulo-2 arithmetic.



Modulo-2 operation is operation that complies with the law given below.

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0
-1 = 1

The value “0001 0001 1000 1001$_2$ (1189$_{16}$)” derived from the remainder “1001 0001 1000 1000$_2$ (9188$_{16}$)” by reversing its bit positions may be read from the CRCD register.

If operation (4) above is performed subsequently, the value written to the CRCIN register “23$_{16}$ (00100011$_2$)” has its bit positions reversed to become “11000100$_2$. The value “1100 0100 0000 0000 0000 0000$_2$” derived from that by adding 16 digits and the remainder in (3) “1001 0001 1000 1000$_2$” which is left in the CRCD register are added, the result of which is divided by the generator polynomial using modulo-2 arithmetic.
The value “0000 1010 0100 0001$_2$ (0A41$_{16}$)” derived from the remainder by reversing its bit positions may be read from the CRCD register.

Figure 13.3 CRC Calculation

14. Expansion Function

14.1 Expansion function description

Expansion function consists of CRC operation function, data slice function and humming decoder function. Each function is controlled by expansion memories.

1. CRC operation function

   It performs error detection of a code, and error correction.
2. Data slice function

   It performs data acquisition to get such format data as below.
   Hardware : TELETEXT, PDC, VPS, VBI and EPG-J
   Software : WSS, CC, CC2X and ID-1
3. Humming decoder function

   It performs 8/4 humming and 24/18 humming

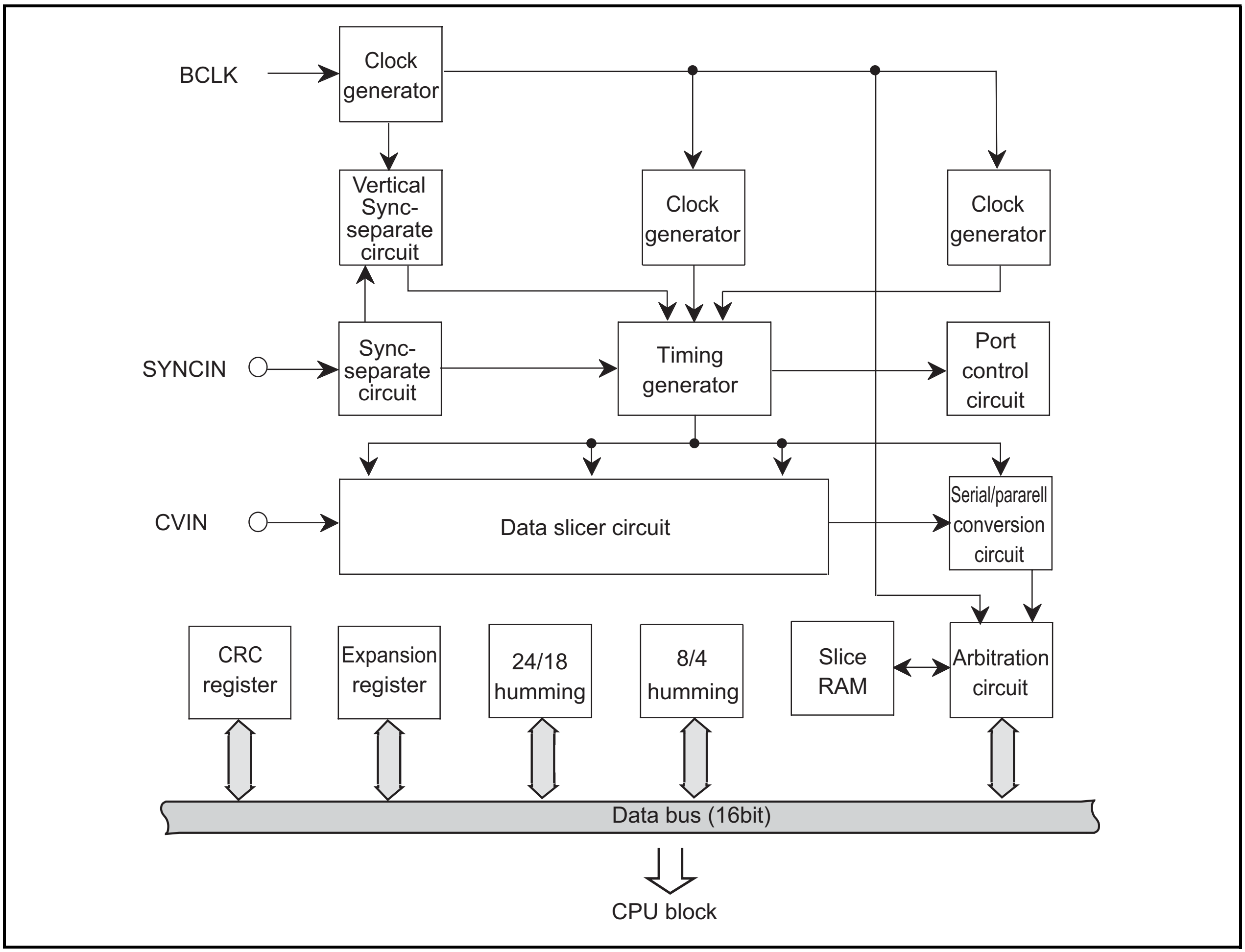


Figure 14.1 Block diagram of expansion function

14.2 Expansion memory

Expansion function memory is divided by 3 patterns ; Slice RAM, CRC registers and expansion registers (Humming decoder operates by the register placed on SFR). Data writing and read out to the Slice RAM, CRC registers and the expansion registers are carried out per 16 bit unit by the data setting register (addresses $020E_{16}$, 0210_{16}, 0212_{16}, 0214_{16}, 0216_{16} and 0218_{16}) placed on SFR.

Contents of each memory and data setting register are shown in Table 14.1.

Table 14.1 Expansion memory composition

Expansion memory	Contents	Data setting register
Slice RAM	This register holds acquired data.	Slice RAM address control register ($020E_{16}$) Slice RAM data control register (0210_{16})
CRC register	This register controls a set up generation polynomial and code data.	CRC register address control register (0212_{16}) CRC register data control register (0214_{16})
Expansion register	This register performs data slicer control and VBI encoder control.	Expansion register address control register (0216_{16}) Expansion register data control register (0218_{16})

14.3 Slice RAM

Slice RAM stores 18-line slice data. There are several types of Slice data : PDC, VPS, VBI, XDS, WSS, etc. All data are stored to addresses which corresponds to slice line (ex. 22 line' data is stored to addresses 200$_{16}$ to 217$_{16}$). 24 addresses (SR00x to SR17x) are prepared for 1 line, slice data is stored in order from LSB side. Then, slice data type and field information are stored to the top address of each line.

Slice RAM composition is shown in Table 14.2.

Table 14.2 Slice RAM composition

Slice RAM addresses (SA9 to SA0)	SD15	SD14	SD13	SD12	SD11	SD10	SD9	SD8	SD7	SD6	SD5	SD4	SD3	SD2	SD1	SD0	Remarks (Note1)
000$_{16}$ 001$_{16}$ to 016$_{16}$ 017$_{16}$	SR00F SR01F to SR16F SR17F	SR00E SR01E to SR16E SR17E	SR00D SR01D to SR16D SR17D	SR00C SR01C to SR16C SR17C	SR00B SR01B to SR16B SR17B	SR00A SR01A to SR16A SR17A	SR009 SR019 to SR169 SR179	SR008 SR018 to SR168 SR178	SR007 SR017 to SR167 SR177	SR006 SR016 to SR166 SR176	SR005 SR015 to SR165 SR175	SR004 SR014 to SR164 SR174	SR003 SR013 to SR163 SR173	SR002 SR012 to SR162 SR172	SR001 SR011 to SR161 SR171	SR000 SR010 to SR160 SR170	6th line or 318th line slice data
018$_{16}$ to 01F$_{16}$	Unused area																
020$_{16}$ to 037$_{16}$	SR00F to SR17F	SR00E to SR17E	SR00D to SR17D	SR00C to SR17C	SR00B to SR17B	SR00A to SR17A	SR009 to SR179	SR008 to SR178	SR007 to SR177	SR006 to SR176	SR005 to SR175	SR004 to SR174	SR003 to SR173	SR002 to SR172	SR001 to SR171	SR000 to SR170	7th line or 319th line slice data
040$_{16}$ to 1F7$_{16}$	⋮																8th line to 21th line or 320th line to 333 line slice data
200$_{16}$ to 217$_{16}$	SR00F to SR17F	SR00E to SR17E	SR00D to SR17D	SR00C to SR17C	SR00B to SR17B	SR00A to SR17A	SR009 to SR179	SR008 to SR178	SR007 to SR177	SR006 to SR176	SR005 to SR175	SR004 to SR174	SR003 to SR173	SR002 to SR172	SR001 to SR171	SR000 to SR170	22th line or 334th line slice data
220$_{16}$ to 237$_{16}$	SR00F to SR17F	SR00E to SR17E	SR00D to SR17D	SR00C to SR17C	SR00B to SR17B	SR00A to SR17A	SR009 to SR179	SR008 to SR178	SR007 to SR177	SR006 to SR176	SR005 to SR175	SR004 to SR174	SR003 to SR173	SR002 to SR172	SR001 to SR171	SR000 to SR170	23th line or 335th line slice data

Note 1. This is the line to support when the PAL video signal is sliced and setting the expansion registers to VPS_VP8 to VPS_VP0 (bits 8 to 0 in address 29$_{16}$) = "4$_{16}$".

For accessing to Slice RAM data, set accessing address (SA9 to SA0) (shown in Table 14.2) to Slice RAM address control register (address 020E$_{16}$). Then read out data from Slice RAM data control register (address 0210$_{16}$). When end the data reading, Slice RAM address control register increments address automatically. Then, next address data reading is possible. Do not access to unused area of each character codes. Must set address to each line because unused area has no address' automatically increment.

Slice RAM bit composition is shown in Figure 14.2, Slice RAM access registers are shown in Figure14.3 and Slice RAM access block diagram is shown in Figure 14.4

Slice RAM bit composition

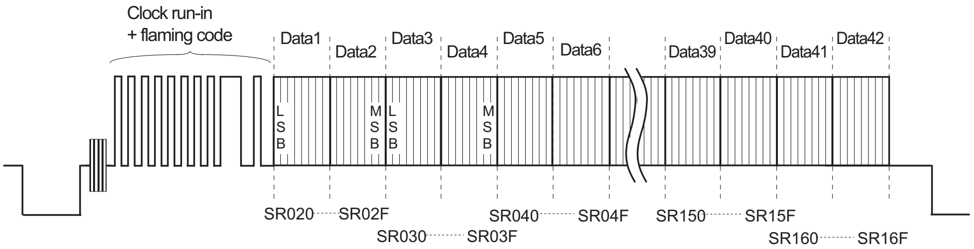
The each head address of the address is corresponded to slice line following slice information.

	SR00F to SR004	SR003	SR002	SR001	SR000
Line register 3	0	field*	0	1	1
Line register 2	0	field*	0	1	0
Line register 1	0	field*	0	0	1
Other	0	field*	0	0	0

* field
* the first field : 1
the second field : 0

(1) PDC

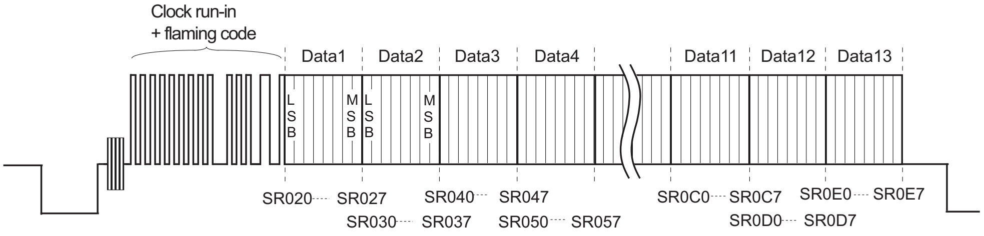
In case of the PDC data, 16 bits (2 data) are stored for the 1 address from the LSB side.



Note. The expansion register is the slice data storing pattern when setting the START (bit 1 in address 28_{16} bit) to "1". SR17x is the unused area.

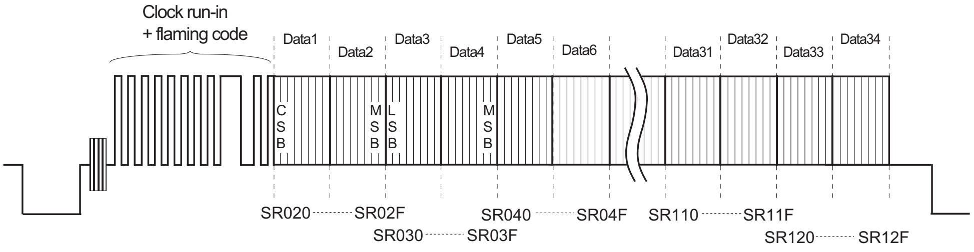
(2) VPS

In case of the VPS data or the VBI data, 8 bits (a data) are stored for an address from the LSB side.
Low-order 8 bits hold the slice data. And, high-order 8 bits hold warning bit, when the send data is not recognized as bi-phase type.
The case of bi-phase data ="1,0" or "0,1" (the bi-phase type) becomes "0" for this warning bit, and it becomes "1" in bi-phase data="0,0" or "1,1" (it is not the bi-phase type).
(For example, bi-phase data of SR011 is "0,0" or "1,1", "1" is set to SR019.)



Note. The expansion register is the slice data storing pattern when setting the START (bit 1 in address 28_{16} bit) to "1". From SR0Fx to SR17x are the unused area.

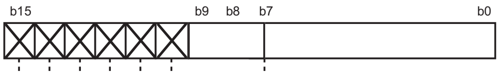
(3) EPG-J



Note. The expansion register is the slice data storing pattern when setting the START (bit 1 in address 28_{16} bit) to "1". From SR13x to SR17x are the unused area.

Figure 14.2 Slice RAM bit composition

Slice RAM address control register



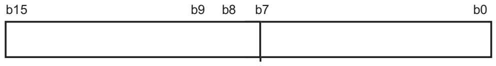
Symbol	Address	When reset
SA	020E16	000016

Function	Setting possible value	R	W
Specify accessing Slice RAM address	00016 to 23716	×	○
Nothing is assigned. When write, set to "0." When read, its content is indeterminate.		–	–

Note 1 : When access to Slice RAM, Slice RAM address control register (020E16) should be set at first.
Slice RAM address control register increments by accessing Slice RAM data control register. So, it is not neccesary to setting the next Slice RAM address.

Note 2 : When read Slice RAM data by software during slicer operation, access to Slice RAM after 1 horizontal synchronous period from the completion of a SLICEON (refer to 14.6 Expansion Register Construction Composition for a SLICEON period).

Slice RAM data control register



Symbol	Address	When reset
SD	021016	000016

Function	R	W
Read out the data of Slice RAM. Read out data of Slice RAM which is specified by Slice RAM address control register (address 020E16) by reading this register.	○	×

Note : Data access must be 16-bit unit. 8-bit unit access is disable.

Figure 14.3 Slice RAM access registers.

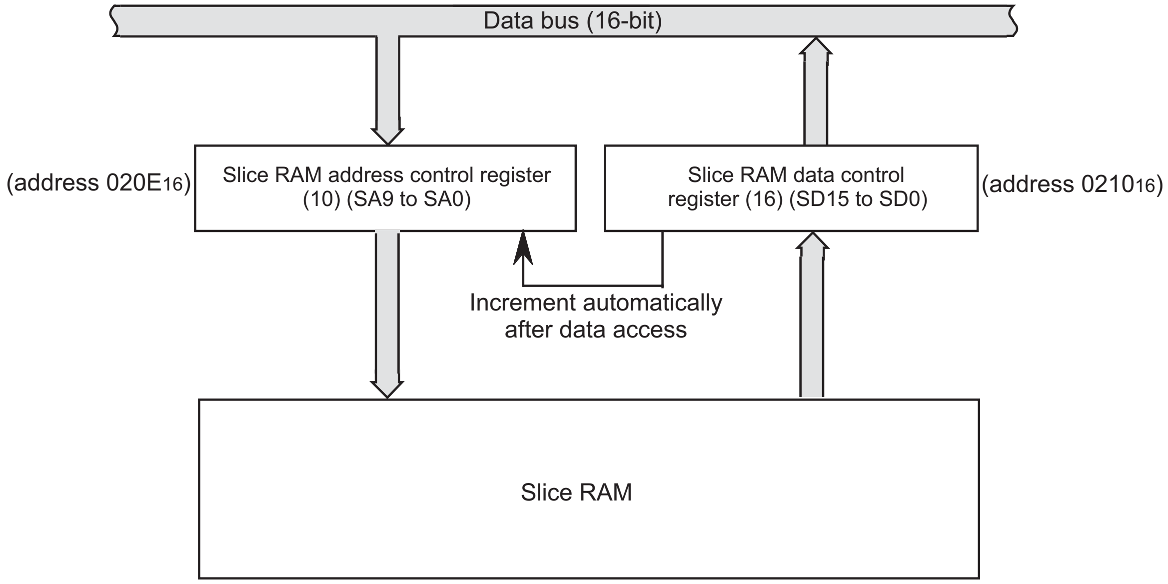


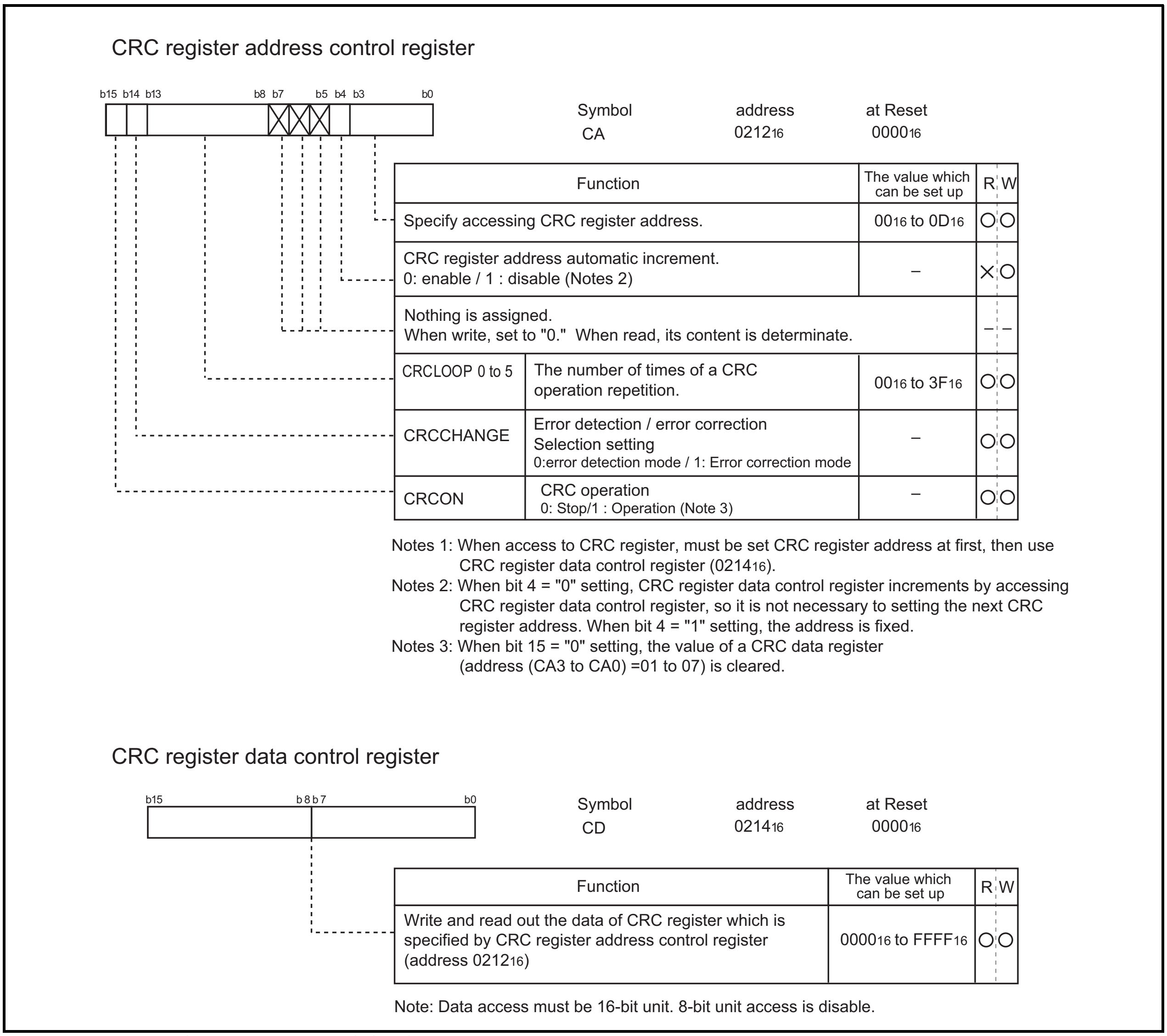
Figure 14.4 Slice RAM access block diagram

14.4 CRC Operation Circuit (EPG-J)

CRC operation circuit (EPG-J) is a circuit for performing error detection and error correction by the 272-190 shortening difference set cyclic code which is a coding system in a data multiplex broadcast.
CRC register consists of registers shown in Figure 14.5. CRC register can perform error detection and error correction by majority logic by setting up a generator polynomial, code data, etc. CRC register composition is shown in Table 14.3.

Table 14.3 CRC register composition

CA3 to CA0	CD15	CD14	CD13	CD12	CD11	CD10	CD9	CD8	CD7	CD6	CD5	CD4	CD3	CD2	CD1	CD0	Remarks
00_{16}	DAOUT15	DAOUT14	DAOUT13	DAOUT12	DAOUT11	DAOUT10	DAOUT9	DAOUT8	DAOUT7	DAOUT6	DAOUT5	DAOUT4	DAOUT3	DAOUT2	DAOUT1	DAOUT0	
01_{16}	–	–	–	–	–	CRC_ERR10	CRC_ERR09	CRC_ERR08	CRC_ERR07	CRC_ERR06	CRC_ERR05	CRC_ERR04	CRC_ERR03	CRC_ERR02	CRC_ERR01	CRC_ERR00	
02_{16}	CRC_66	CRC_67	CRC_68	CRC_69	CRC_70	CRC_71	CRC_72	CRC_73	CRC_74	CRC_75	CRC_76	CRC_77	CRC_78	CRC_79	CRC_80	CRC_81	
03_{16}	CRC_50	CRC_51	CRC_52	CRC_53	CRC_54	CRC_55	CRC_56	CRC_57	CRC_58	CRC_59	CRC_60	CRC_61	CRC_62	CRC_63	CRC_64	CRC_65	
04_{16}	CRC_34	CRC_35	CRC_36	CRC_37	CRC_38	CRC_39	CRC_40	CRC_41	CRC_42	CRC_43	CRC_44	CRC_45	CRC_46	CRC_47	CRC_48	CRC_49	
05_{16}	CRC_18	CRC_19	CRC_20	CRC_21	CRC_22	CRC_23	CRC_24	CRC_25	CRC_26	CRC_27	CRC_28	CRC_29	CRC_30	CRC_31	CRC_32	CRC_33	
06_{16}	CRC_02	CRC_03	CRC_04	CRC_05	CRC_06	CRC_07	CRC_08	CRC_09	CRC_10	CRC_11	CRC_12	CRC_13	CRC_14	CRC_15	CRC_16	CRC_17	
07_{16}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	CRC_00	CRC_01	
08_{16}	REG_C81	REG_C80	REG_C79	REG_C78	REG_C77	REG_C76	REG_C75	REG_C74	REG_C73	REG_C72	REG_C71	REG_C70	REG_C69	REG_C68	REG_C67	REG_C66	
09_{16}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
$0A_{16}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
$0B_{16}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
$0C_{16}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
$0D_{16}$	–	–	–	–	–	–	–	–	–	–	–	CRC16SEL	–	–	–	–	



CRC register address control register

Symbol	address	at Reset
CA	0212_{16}	0000_{16}

Function		The value which can be set up	R	W
Specify accessing CRC register address.		00_{16} to $0D_{16}$	○	○
CRC register address automatic increment. 0: enable / 1 : disable (Notes 2)		–	×	○
Nothing is assigned. When write, set to "0." When read, its content is determinate.			–	–
CRCLOOP 0 to 5	The number of times of a CRC operation repetition.	00_{16} to $3F_{16}$	○	○
CRCCHANGE	Error detection / error correction Selection setting 0:error detection mode / 1: Error correction mode	–	○	○
CRCON	CRC operation 0: Stop/1 : Operation (Note 3)	–	○	○

Notes 1: When access to CRC register, must be set CRC register address at first, then use CRC register data control register (0214_{16}).
Notes 2: When bit 4 = "0" setting, CRC register data control register increments by accessing CRC register data control register, so it is not necessary to setting the next CRC register address. When bit 4 = "1" setting, the address is fixed.
Notes 3: When bit 15 = "0" setting, the value of a CRC data register (address (CA3 to CA0) =01 to 07) is cleared.

CRC register data control register

Symbol	address	at Reset
CD	0214_{16}	0000_{16}

Function	The value which can be set up	R	W
Write and read out the data of CRC register which is specified by CRC register address control register (address 0212_{16})	0000_{16} to $FFFF_{16}$	○	○

Note: Data access must be 16-bit unit. 8-bit unit access is disable.

Figure 14.5 Composition of CRC register access related register

For accessing to CRC register data, set accessing address (CA3 to CA0) (shown in Table 14.3) to CRC register address control register (address 0212_{16}). Then write data (CD15 to CD0) by CRC register data control register (address 0214_{16}). When end the data accessing, CRC register address control register increments address automatically. Then, next address data writing is possible.
CRC register access registers are shown in Figure 14.5, CRC register access block diagram is shown in Figure 14.6. The operation example of CRC operation circuit is shown in Figure 14.7. The example of program is shown in Figure 14.8, and CRC register bit compositions are shown in p191 to p199.

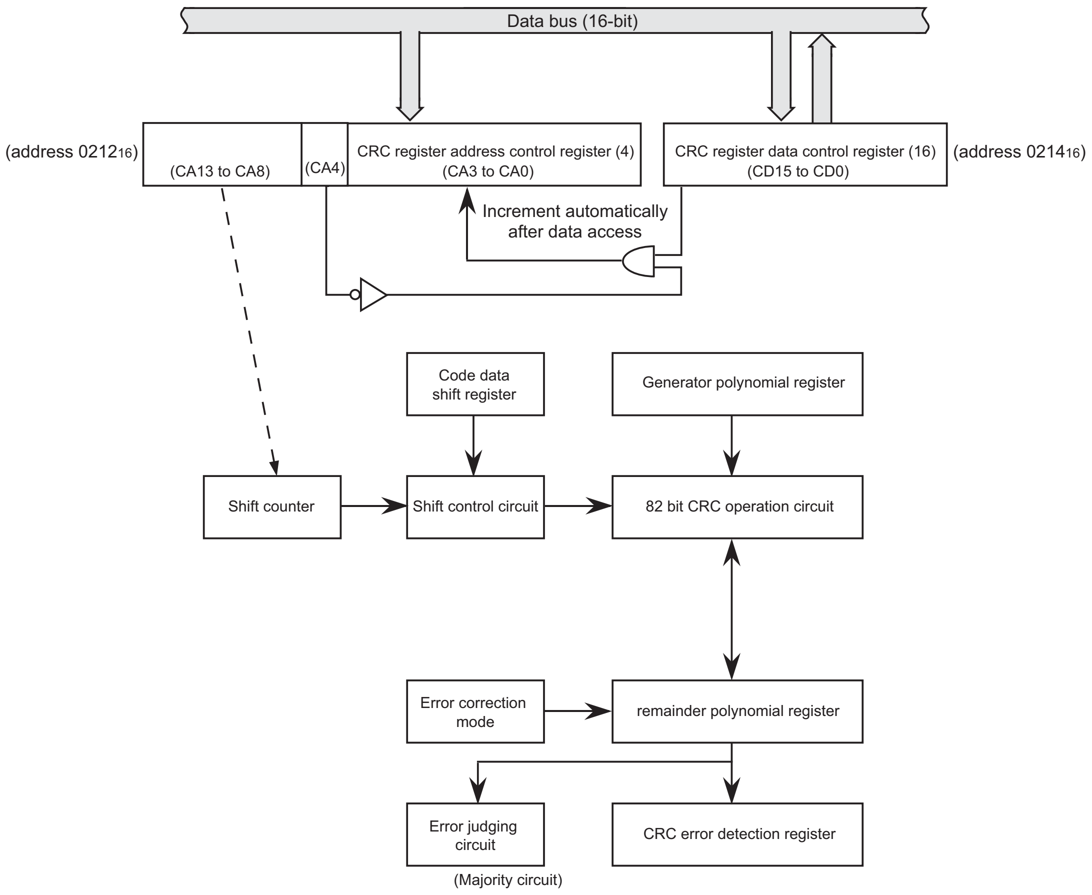
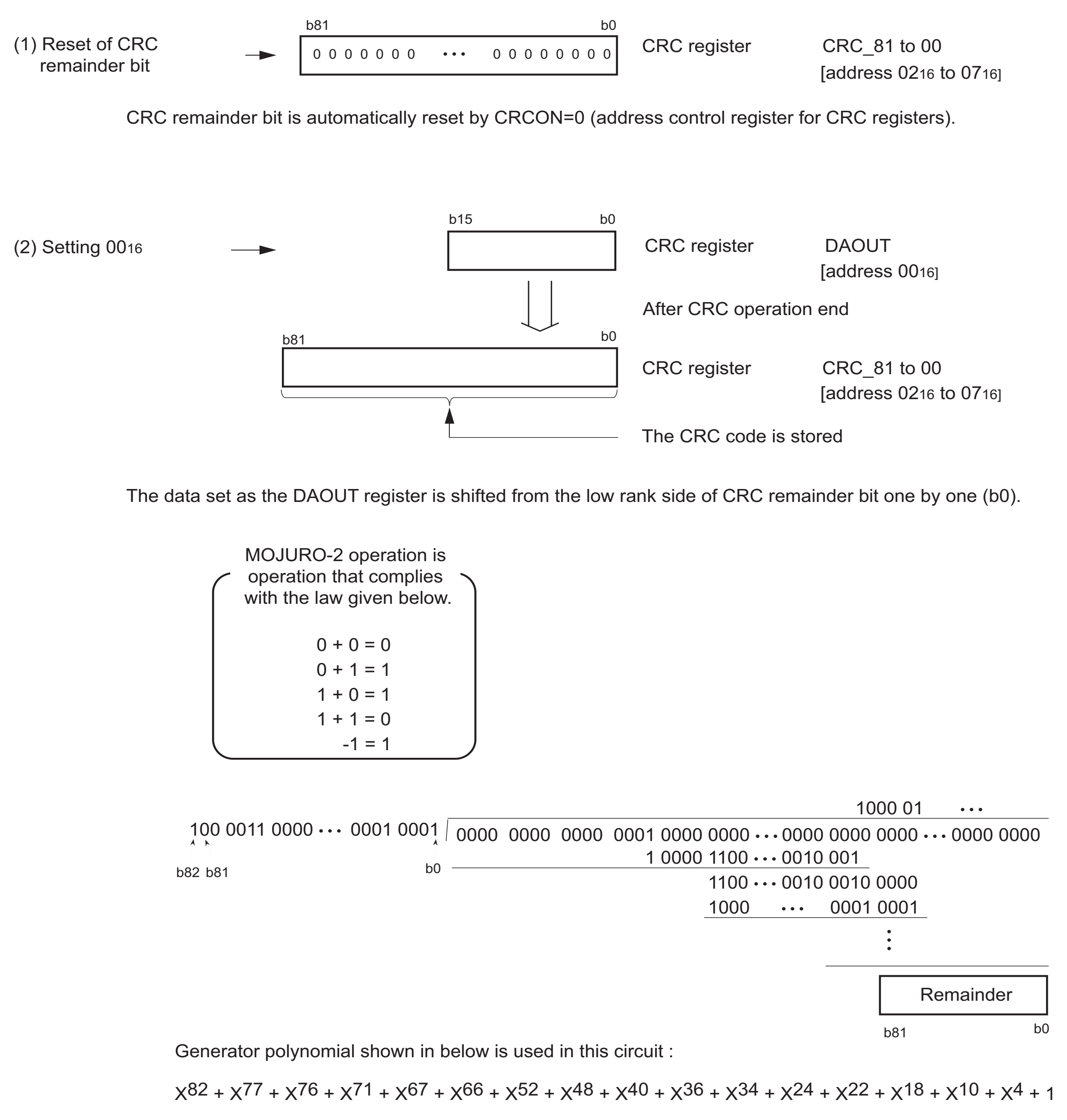


Figure 14.6 Access block diagram for CRC registers



CRC remainder bit is automatically reset by CRCON=0 (address control register for CRC registers).

The data set as the DAOUT register is shifted from the low rank side of CRC remainder bit one by one (b0).

MOJURO-2 operation is operation that complies with the law given below.

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0
-1 = 1

Generator polynomial shown in below is used in this circuit :

$$X^{82} + X^{77} + X^{76} + X^{71} + X^{67} + X^{66} + X^{52} + X^{48} + X^{40} + X^{36} + X^{34} + X^{24} + X^{22} + X^{18} + X^{10} + X^{4} + 1$$

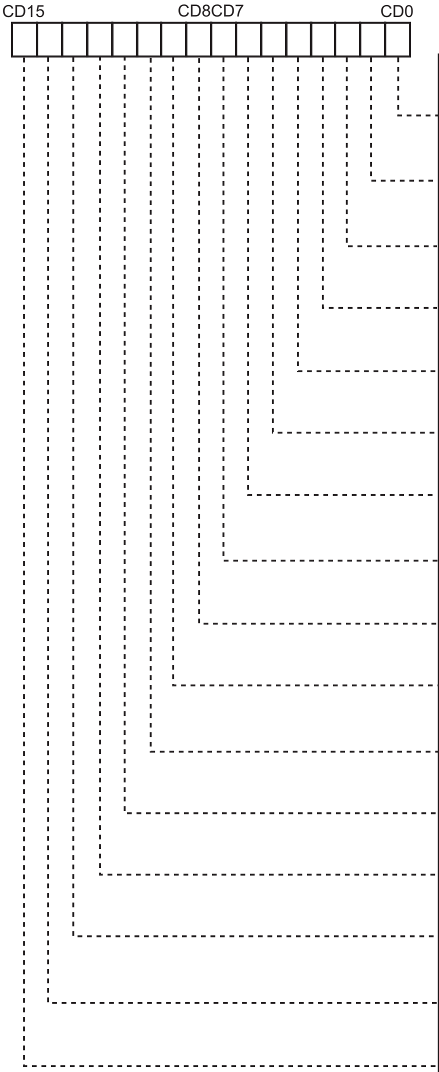
Figure 14.7 Example of operation of CRC operation circuit

```
;=====================================================================================
;        Equations (Constant definition)
;=====================================================================================
_CRC_ADRS               .equ        00212h                      ; SFR address of CRC register address control register
_CRC_DATA               .equ        00214h                      ; SFR address of CRC register data control register
SLICE_WORD_NUM          .equ        17                          ; Code data length (in nuits of word)

;=====================================================================================
;        Macro definition
;=====================================================================================
_wait    .macro
         nop
         nop
         nop
.endm

;=====================================================================================
;        CRC operation routine
;=====================================================================================

;--------- Setting of generator polynomial   ------------------------------------------------------------------------------------------------
         mov.w   #0008H                  , _CRC_ADRS            ; Set the head address of the generator polynomial register
         _wait                                                  ; Wait
         mov.w   0000110000100011B       , _CRC_DATA            ; Coefficient of generator polynomial 82nd to 66th ( x^77 +x~76 +x^71 +x^67 +x^66)

;------ Writing of code data  ----------------------------------------------------------------------------------------------------------------
         mov.w   #0000H                  , _CRC_ADRS            ; Initialization of CRC register address control register
         mov.w   #9010H                  , _CRC_ADRS            ; Set up of CRCON=1, CRCCHANGE=0, CRCLOOP=10H, Increment=ON, and CRC address=00H.
         mov.w   #0000H                  , A0                   ; Initialization of a loop variable (A0)

L18:                                                            ; Branch label
         cmp.w   #SLICE_WORD_NUM*2       , A0                   ; Comparison of the loop variable
         jgeu    L20                                            ; Go to L20 if writing code data is finished.
         lde.w   _CrcCodeData[A0]        , _CRC_DATA            ; Writing code data to the code data shift register.
         add.w   #0002H                  ,A0                    ; Increment of the address storing code data.
         jmp     L18                                            ; Return to the head of this loop.
L20:                                                            ; Branch label
;--------- Dummy shift  ----------------------------------------------------------------------------------------------------------------------
         ; After finishing writing 272-bit code data,
         ; shift a bit for dummy surely in error correction mode.
         ; Specifying 1-bit  is set up by CRCLOOP=01H.
         mov.w   #8100H                  , _CRC_ADRS            ; Set up of CRCON=1, CRCCHANGE=0, CRCLOOP=10H, Increment=OFF, and CRC address=00H.
         _wait                                                  ; Wait
         mov.w   #0000H                  , _CRC_DATA            ; Writing data to the code data shift register for dummy shift.

;--------- Error detection -------------------------------------------------------------------------------------------------------------------
; Since the address automatic increment in dummy shift (Increment=OFF), set CRC address=01H here.
; When accessing other CRC registers, the processing shown in the following two lines is necessary.
;        mov.w   #9001H     , _CRC_ADRS                         ; Set up of CRCON=1, CRCCHANGE=0, CRCLOOP=10H, Incremet=OFF and CRC address=01H.
;        _wait                                                  ; Wait

         mov.w   _CRC_DATA               , R0                   ; Read of CRC error detection register.
         cmp.w   #0000H                  , R0                   ; Judgement of CRC error.
         jeq              L16                                   ; In the case of R0=0, branch to L16 since CRC error has not occurred (CRC error correction is skipped).

;--------- Error correction  -----------------------------------------------------------------------------------------------------------------
         mov.w   #0D010H                 , _CRC_ADRS            ; Set up of CRCON=1, CRCCHANGE=1, CRCLOOP=10H, Increment=ON and CRC address=00H.
         _wait                                                  ; Wait
         mov.w   #0000H                  , A0                   ; Initialization of a loop variable (A0)
L22:                                                            ; Branch label
         cmp.w   #SLICE_WORD_NUB         , A0                   ; Comparison of the loop variable
         jgeu    L24                                            ; Go to L24 if correction of error data is finished.
         lde.w   _CrcCodeData[A0]        , _CRC_DATA            ; Writing code data to the code data shift register.
         jsr     _waitlong                                      ; Wait for finish of error correction.
         mov.w   _CRC_DATA               , _CrcCodeData[A0]     ; Read of error correction data in the address storing code data.
         add.w   #0002H                  , A0                   ; Increment of the address storing code data.
         jmp     L22                                            ; Return to the head of this loop.
L24:                                                            ; Branch label

;------- The check of error correction data--------------------------------------------------------------------------------------------------
         mov.w   #8111H                  , _CRC_ADRS            ; Set up of CRCON=1, CRCCHANGE=0, CRCLOOP=10H, Increment=ON and CRC address=00H
         _wait                                                  ; Wait
         mov.w   _CRC_DATA               , R0                   ; Error check after error correction. R0=000H if correction is performed.
L16:

;=====================================================================================
; The function sample for weight for error correction
;=====================================================================================
         .align
         .glb    _waitlong
_waitlong:                                                      ; Function label
         rts
```

Figure 14.8 Example of program

1.Bit composition of a CRC register

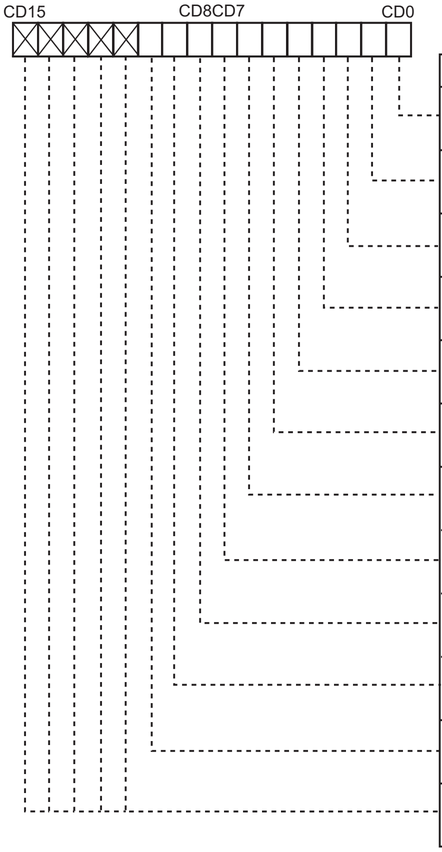
1. Address 00_{16} (=CA3 to 0)



Bit symbol	Bit name	Function	R	W
DAOUT0	The code data shift register write-in bit 0	When write, data is written to "code data shift register" (Note). When read, data differs between in error detection mode and in error correction mode. • In error detection mode (CRCCHANGE=0) 0000_{16} is read after shift end. When read during shift operation, its content is indeterminate. • In error correction mode (CRCCHANGE=1) Corrected data is read after the original data is written in and some interval of data shift.	○	○
DAOUT1	The code data shift register write-in bit 1		○	○
DAOUT2	The code data shift register write-in bit 2		○	○
DAOUT3	The code data shift register write-in bit 3		○	○
DAOUT4	The code data shift register write-in bit 4		○	○
DAOUT5	The code data shift register write-in bit 5		○	○
DAOUT6	The code data shift register write-in bit 6		○	○
DAOUT7	The code data shift register write-in bit 7		○	○
DAOUT8	The code data shift register write-in bit 8		○	○
DAOUT9	The code data shift register write-in bit 9		○	○
DAOUT10	The code data shift register write-in bit 10		○	○
DAOUT11	The code data shift register write-in bit 11		○	○
DAOUT12	The code data shift register write-in bit 12		○	○
DAOUT13	The code data shift register write-in bit 13		○	○
DAOUT14	The code data shift register write-in bit 14		○	○
DAOUT15	The code data shift register write-in bit 15		○	○

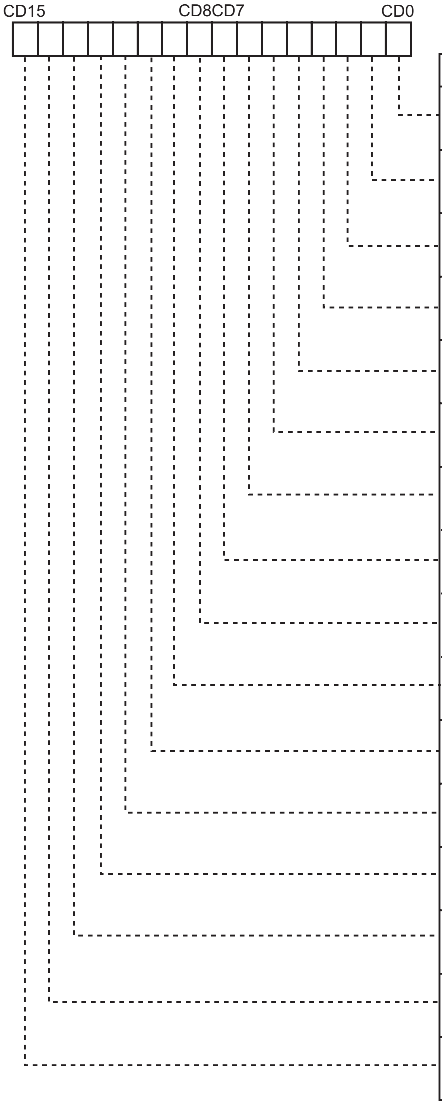
Note: Refer to Figure 14.16 Access block diagram for CRC registers.

2. Address 01$_{16}$ (=CA3 to 0)



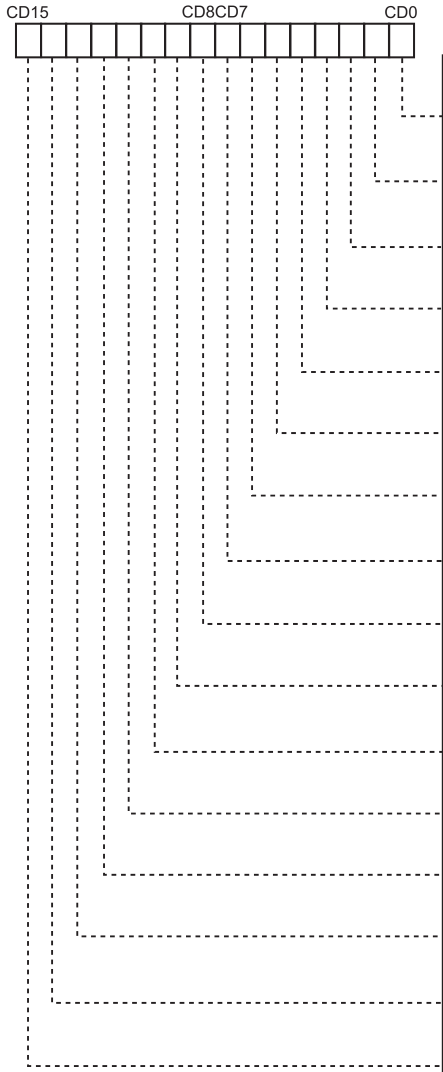
Bit symbol	Bit name	Function	R	W
CRC_ERR00	The CRC bit 81 to 74 error detection bit	Logical OR of the CRC remainder bits 81 to 74 (address 02$_{16}$)	○	×
CRC_ERR01	The CRC bit 73 to 66 error detection bit	Logical OR of the CRC remainder bits 73 to 66 (address 02$_{16}$)	○	×
CRC_ ERR02	The CRC bit 65 to 58 error detection bit	Logical OR of the CRC remainder bits 65 to 58 (address 03$_{16}$)	○	×
CRC_ERR03	The CRC bit 57 to 50 error detection bit	Logical OR of the CRC remainder bits 57 to 50 (address 03$_{16}$)	○	×
CRC_ERR04	The CRC bit 49 to 42 error detection bit	Logical OR of the CRC remainder bits 49 to 42 (address 04$_{16}$)	○	×
CRC_ERR05	The CRC bit 41 to 34 error detection bit	Logical OR of the CRC remainder bits 41 to 34 (address 04$_{16}$)	○	×
CRC_ERR06	The CRC bit 33 to 26 error detection bit	Logical OR of the CRC remainder bits 33 to 26 (address 05$_{16}$)	○	×
CRC_ERR07	The CRC bit 25 to 18 error detection bit	Logical OR of the CRC remainder bits 25 to 18 (address 05$_{16}$)	○	×
CRC_ERR08	The CRC bit 17 to 10 error detection bit	Logical OR of the CRC remainder bits 17 to 10 (address 06$_{16}$)	○	×
CRC_ERR09	The CRC bit 09 to 02 error detection bit	Logical OR of the CRC remainder bits 09 to 02 (address 06$_{16}$)	○	×
CRC_ERR10	The CRC bit 01 to 00 error detection bit	Logical OR of the CRC remainder bits 01 to 00 (address 07$_{16}$)	○	×
Nothing is assigned. The value is "0" when it reads.			×	×

3. Address 02_{16} (=CA3 to 0)



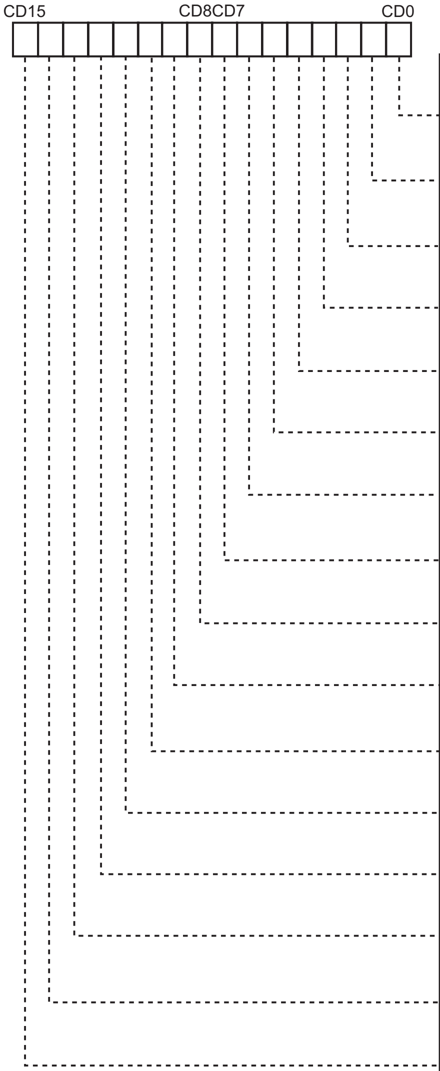
Bit symbol	Bit name	Function	R	W
CRC_81	81th remainder polynomial coefficient bit	The coefficient of each degree of a remainder polynomial is set up. It is shown in below when a remainder polynomial is made into CRC_MOD. $CRC\_MOD = \sum_{n=0}^{81} CRC\_n \cdot X^{n}$	○	×
CRC_80	80th remainder polynomial coefficient bit		○	×
CRC_79	79th remainder polynomial coefficient bit		○	×
CRC_78	78th remainder polynomial coefficient bit		○	×
CRC_77	77th remainder polynomial coefficient bit		○	×
CRC_76	76th remainder polynomial coefficient bit		○	×
CRC_75	75th remainder polynomial coefficient bit		○	×
CRC_74	74th remainder polynomial coefficient bit		○	×
CRC_73	73th remainder polynomial coefficient bit		○	×
CRC_72	72th remainder polynomial coefficient bit		○	×
CRC_71	71th remainder polynomial coefficient bit		○	×
CRC_70	70th remainder polynomial coefficient bit		○	×
CRC_69	69th remainder polynomial coefficient bit		○	×
CRC_68	68th remainder polynomial coefficient bit		○	×
CRC_67	67th remainder polynomial coefficient bit		○	×
CRC_66	66th remainder polynomial coefficient bit		○	×

4. Address 03$_{16}$ (=CA3 to 0)



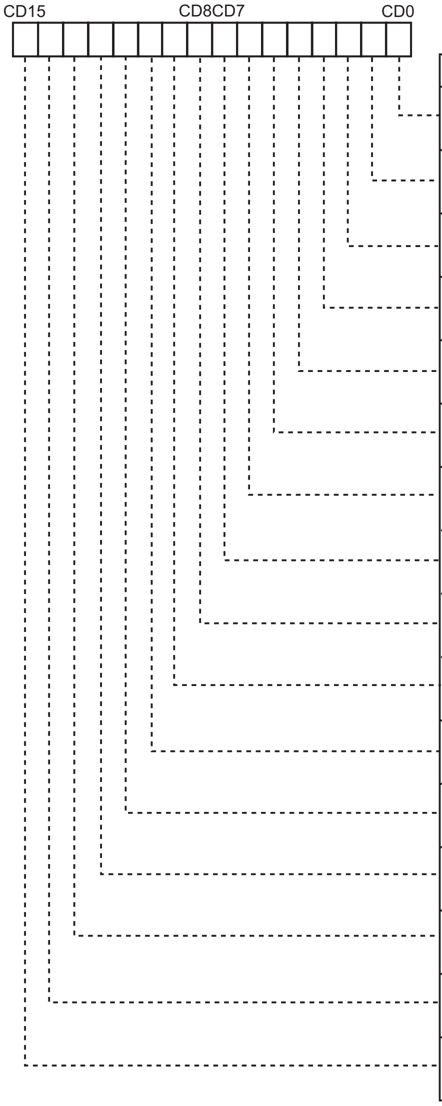
Bit symbol	Bit name	Function	R	W
CRC_65	65th remainder polynomial coefficient bit	Refer to CRC_81 to 66 (address 02$_{16}$).	○	×
CRC_64	64th remainder polynomial coefficient bit		○	×
CRC_63	63th remainder polynomial coefficient bit		○	×
CRC_62	62th remainder polynomial coefficient bit		○	×
CRC_61	61th remainder polynomial coefficient bit		○	×
CRC_60	60th remainder polynomial coefficient bit		○	×
CRC_59	59th remainder polynomial coefficient bit		○	×
CRC_58	58th remainder polynomial coefficient bit		○	×
CRC_57	57th remainder polynomial coefficient bit		○	×
CRC_56	56th remainder polynomial coefficient bit		○	×
CRC_55	55th remainder polynomial coefficient bit		○	×
CRC_54	54th remainder polynomial coefficient bit		○	×
CRC_53	53th remainder polynomial coefficient bit		○	×
CRC_52	52th remainder polynomial coefficient bit		○	×
CRC_51	51th remainder polynomial coefficient bit		○	×
CRC_50	50th remainder polynomial coefficient bit		○	×

5. Address 04_{16} (=CA3 to 0)



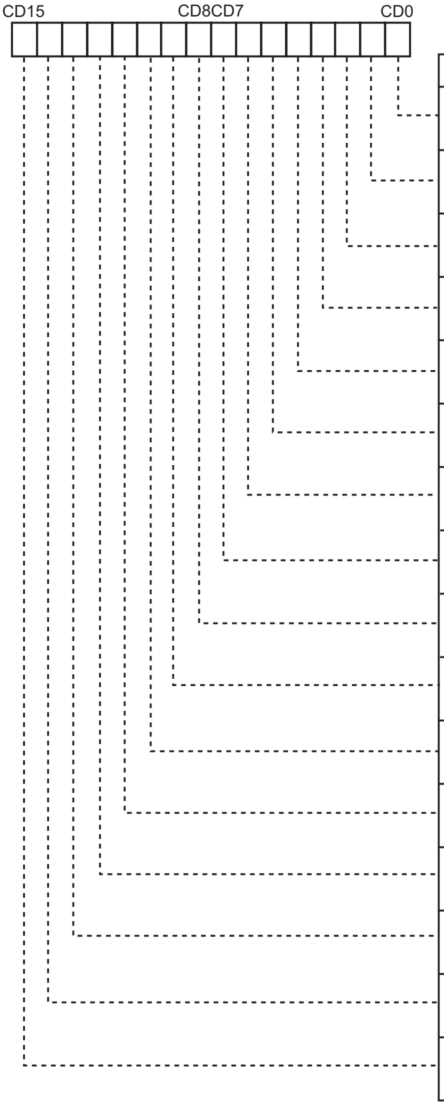
Bit symbol	Bit name	Function	R	W
CRC_49	49th remainder polynomial coefficient bit	Refer to CRC_81 to 66 (address 02_{16}).	○	×
CRC_48	48th remainder polynomial coefficient bit		○	×
CRC_47	47th remainder polynomial coefficient bit		○	×
CRC_46	46th remainder polynomial coefficient bit		○	×
CRC_45	45th remainder polynomial coefficient bit		○	×
CRC_44	44th remainder polynomial coefficient bit		○	×
CRC_43	43th remainder polynomial coefficient bit		○	×
CRC_42	42th remainder polynomial coefficient bit		○	×
CRC_41	41th remainder polynomial coefficient bit		○	×
CRC_40	40th remainder polynomial coefficient bit		○	×
CRC_39	39th remainder polynomial coefficient bit		○	×
CRC_38	38th remainder polynomial coefficient bit		○	×
CRC_37	37th remainder polynomial coefficient bit		○	×
CRC_36	36th remainder polynomial coefficient bit		○	×
CRC_35	35th remainder polynomial coefficient bit		○	×
CRC_34	34th remainder polynomial coefficient bit		○	×

6. Address 05_{16} (=CA3 to 0)



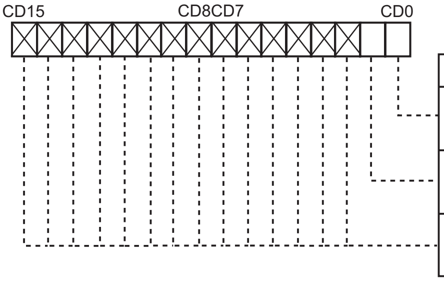
Bit symbol	Bit name	Function	R	W
CRC_33	33th remainder polynomial coefficient bit	Refer to CRC_81 to 66 (address 02_{16}).	○	×
CRC_32	32th remainder polynomial coefficient bit		○	×
CRC_31	31th remainder polynomial coefficient bit		○	×
CRC_30	30th remainder polynomial coefficient bit		○	×
CRC_29	29th remainder polynomial coefficient bit		○	×
CRC_28	28th remainder polynomial coefficient bit		○	×
CRC_27	27th remainder polynomial coefficient bit		○	×
CRC_26	26th remainder polynomial coefficient bit		○	×
CRC_25	25th remainder polynomial coefficient bit		○	×
CRC_24	24th remainder polynomial coefficient bit		○	×
CRC_23	23th remainder polynomial coefficient bit		○	×
CRC_22	22th remainder polynomial coefficient bit		○	×
CRC_21	21th remainder polynomial coefficient bit		○	×
CRC_20	20th remainder polynomial coefficient bit		○	×
CRC_19	19th remainder polynomial coefficient bit		○	×
CRC_18	18th remainder polynomial coefficient bit		○	×

7. Address 06_{16} (=CA3 to 0)



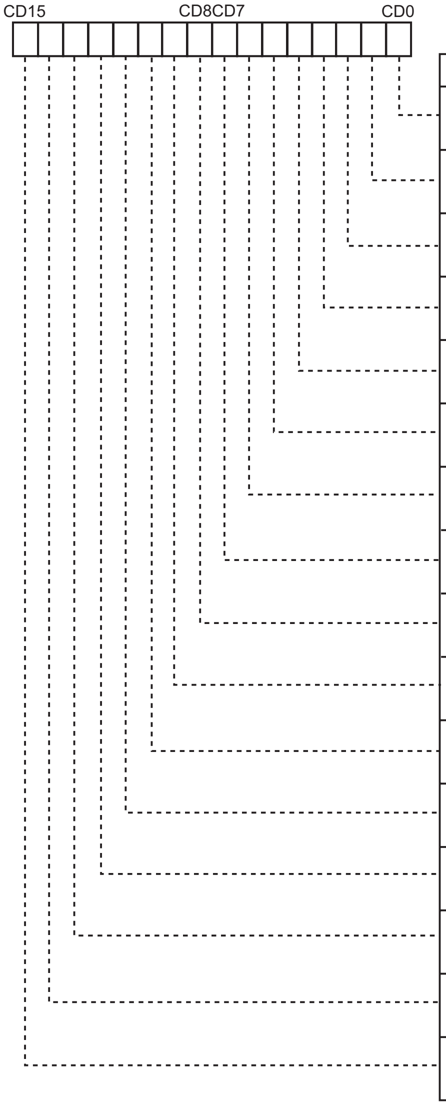
Bit symbol	Bit name	Function	R	W
CRC_17	17th remainder polynomial coefficient bit	Refer to CRC_81 to 66 (address 02_{16}).	○	×
CRC_16	16th remainder polynomial coefficient bit		○	×
CRC_15	15th remainder polynomial coefficient bit		○	×
CRC_14	14th remainder polynomial coefficient bit		○	×
CRC_13	13th remainder polynomial coefficient bit		○	×
CRC_12	12th remainder polynomial coefficient bit		○	×
CRC_11	11th remainder polynomial coefficient bit		○	×
CRC_10	10th remainder polynomial coefficient bit		○	×
CRC_09	09th remainder polynomial coefficient bit		○	×
CRC_08	08th remainder polynomial coefficient bit		○	×
CRC_07	07th remainder polynomial coefficient bit		○	×
CRC_06	06th remainder polynomial coefficient bit		○	×
CRC_05	05th remainder polynomial coefficient bit		○	×
CRC_04	04th remainder polynomial coefficient bit		○	×
CRC_03	03rd remainder polynomial coefficient bit		○	×
CRC_02	02nd remainder polynomial coefficient bit		○	×

8. Address 07_{16} (=CA3 to 0)



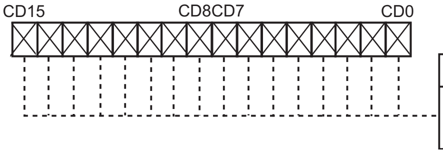
Bit symbol	Bit name	Function	R	W
CRC_01	01st remainder polynomial coefficient bit	Refer to CRC_81 to 66 (address 02_{16}).	○	×
CRC_00	00th remainder polynomial coefficient bit		○	×
Nothing is assigned. The value is "0" when it reads.			×	×

9. Address 08_{16} (=CA3 to 0)



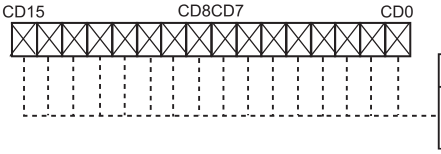
Bit symbol	Bit name	Function	R	W
REG_C0	Coefficient bit of the 66/0th generation polynomials	The coefficient of each degree of the generation polynomial is set. The coefficient from 81 to the 66th is set for 82 bit CRC mode. The 15th in case of 16 bit CRC mode. The 0th coefficients are set. When generation polynomial to be CRC_GP, $CRC\_GP = X^{82}$ $\sum_{n=0}^{15} REG\_Cn \cdot X^{n+66}$ $+ X^{56} + X^{52} + X^{48} + X^{40}$ $+ X^{36} + X^{34} + X^{24} + X^{22}$ $+ X^{18} + X^{10} + X^{4} + 1$ (For 82 bit CRC mode) $CRC\_GP = X^{16} + \sum_{n=0}^{15} RE6\_Cn \cdot X^{n}$ (For 16 bit CRC mode)	○	○
REG_C1	Coefficient bit of the 67/1th generation polynomials		○	○
REG_C2	Coefficient bit of the 68/2th generation polynomials		○	○
REG_C3	Coefficient bit of the 69/3th generation polynomials		○	○
REG_C4	Coefficient bit of the 70/4th generation polynomials		○	○
REG_C5	Coefficient bit of the 71/5th generation polynomials		○	○
REG_C6	Coefficient bit of the 72/6th generation polynomials		○	○
REG_C7	Coefficient bit of the 73/7th generation polynomials		○	○
REG_C8	Coefficient bit of the 74/8th generation polynomials		○	○
REG_C9	Coefficient bit of the 75/9th generation polynomials		○	○
REG_C10	Coefficient bit of the 76/10th generation polynomials		○	○
REG_C11	Coefficient bit of the 77/11th generation polynomials		○	○
REG_C12	Coefficient bit of the 78/12th generation polynomials		○	○
REG_C13	Coefficient bit of the 79/13th generation polynomials		○	○
REG_C14	Coefficient bit of the 80/14th generation polynomials		○	○
REG_C15	Coefficient bit of the 81/15th generation polynomials		○	○

10. Address 09_{16} (=CA3 to 0)



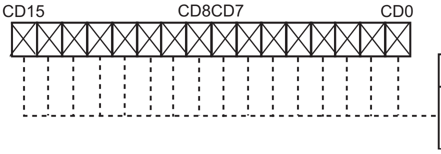
Bit symbol	Bit name	Function	R	W
Nothing is assigned. The value is unfixed when it reads.			×	×

11. Address 0A16 (=CA3 to 0)



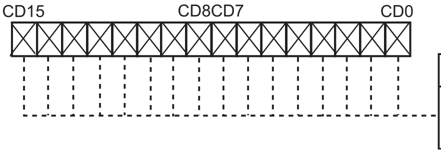
Bit symbol	Bit name	Function	R	W
Nothing is assigned. The value is unfixed when it reads.			×	×

12. Address 0B16 (=CA3 to 0)



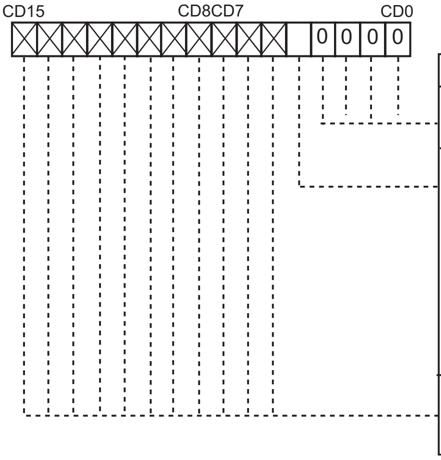
Bit symbol	Bit name	Function	R	W
Nothing is assigned. The value is unfixed when it reads.			×	×

13. Address 0C16 (=CA3 to 0)



Bit symbol	Bit name	Function	R	W
Nothing is assigned. The value is unfixed when it reads.			×	×

14. Address 0D16 (=CA3 to 0)



<table>
<tr><th>Bit symbol</th><th>Bit name</th><th>Function</th><th>R</th><th>W</th></tr>
<tr><td colspan="2">Reserved bit</td><td>Must set to "0."</td><td>○</td><td>○</td></tr>
<tr><td>CRC16SEL</td><td>CRC mode select bit</td><td>Selects 82 bit CRC/16 bit CRC mode<table><tr><th>CRC16SEL</th><th>CRC mode</th></tr><tr><td>0</td><td>82 bit CRC</td></tr><tr><td>1</td><td>16 bit CRC</td></tr></table></td><td>○</td><td>○</td></tr>
<tr><td colspan="3">Nothing is assigned Indeterminate at reading</td><td>×</td><td>×</td></tr>
</table>

14.5 Expansion Register

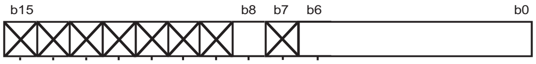
Control Data slice function. Expansion register composition is shown in Table 14.4.

Table 14.4 Expansion register composition

DA5 to DA0	DD15	DD14	DD13	DD12	DD11	DD10	DD9	DD8	DD7	DD6	DD5	DD4	DD3	DD2	DD1	DD0	Remarks
00_{16}	LN15_EV0	LN14_EV0	LN13_EV0	LN12_EV0	LN11_EV0	LN10_EV0	LN9_EV0	LN8_EV0	LN7_EV0	LN6_EV0	LN5_EV0	LN4_EV0	LN3_EV0	LN2_EV0	LN1_EV0	LN0_EV0	Line register
01_{16}	LN15_EV1	LN14_EV1	LN13_EV1	LN12_EV1	LN11_EV1	LN10_EV1	LN9_EV1	LN8_EV1	LN7_EV1	LN6_EV1	LN5_EV1	LN4_EV1	LN3_EV1	LN2_EV1	LN1_EV1	LN0_EV1	
02_{16}	LN17_EV0	LN16_EV0	_	_	_	_	_	_	LN17_OD0	LN16_OD0	_	_	_	_	_	_	
03_{16}	LN17_EV1	LN16_EV1	_	_	_	_	_	_	LN17_OD1	LN16_OD1	_	_	_	_	_	_	
04_{16}	LN15_OD0	LN14_OD0	LN13_OD0	LN12_OD0	LN11_OD0	LN10_OD0	LN9_OD0	LN8_OD0	LN7_OD0	LN6_OD0	LN5_OD0	LN4_OD0	LN3_OD0	LN2_OD0	LN1_OD0	LN0_OD0	
05_{16}	LN15_OD1	LN14_OD1	LN13_OD1	LN12_OD1	LN11_OD1	LN10_OD1	LN9_OD1	LN8_OD1	LN7_OD1	LN6_OD1	LN5_OD1	LN4_OD1	LN3_OD1	LN2_OD1	LN1_OD1	LN0_OD1	
06_{16}	DIVS1	DIVS0	SELVCO	_	_	_	_	_	_	_	_	_	_	_	_	_	Status register 1
07_{16}	FLC15	FLC14	FLC13	FLC12	FLC11	FLC10	FLC9	FLC8	FLC7	FLC6	FLC5	FLC4	FLC3	FLC2	FLC1	FLC0	
08_{16}	CHK_FLC15	CHK_FLC14	CHK_FLC13	CHK_FLC12	CHK_FLC11	CHK_FLC10	CHK_FLC9	CHK_FLC8	CHK_FLC7	CHK_FLC6	CHK_FLC5	CHK_FLC4	CHK_FLC3	CHK_FLC2	CHK_FLC1	CHK_FLC0	
09_{16}	_	_	_	_	BIFON	SLSLVL1	SLSLVL0	_	SEKI7	SEKI6	SEKI5	SEKI4	SEKI3	SEKI2	SEKI1	SEKI0	
$0A_{16}$	GETPEEK3	GETPEEK2	GETPEEK1	GETPEEK0	_	_	GET_HP1	GET_HP0	SLS_HP7	SLS_HP6	SLS_HP5	SLS_HP4	SLS_HP3	SLS_HP2	SLS_HP1	SLS_HP0	
$0B_{16}$	_	FRAM	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
$0C_{16}$	_	GSTTIM	SELSTART	_	_	_	_	_	SLS7	SLS6	SLS5	SLS4	SLS3	SLS2	SLS1	SLS0	
$0D_{16}$	DIVS1	DIVS0	SELVCO	_	_	_	_	_	_	_	_	_	_	_	_	_	Status register 2
$0E_{16}$	FLC15	FLC14	FLC13	FLC12	FLC11	FLC10	FLC9	FLC8	FLC7	FLC6	FLC5	FLC4	FLC3	FLC2	FLC1	FLC0	
$0F_{16}$	CHK_FLC15	CHK_FLC14	CHK_FLC13	CHK_FLC12	CHK_FLC11	CHK_FLC10	CHK_FLC9	CHK_FLC8	CHK_FLC7	CHK_FLC6	CHK_FLC5	CHK_FLC4	CHK_FLC3	CHK_FLC2	CHK_FLC1	CHK_FLC0	
10_{16}	_	_	_	_	BIFON	SLSLVL1	SLSLVL0	_	SEKI7	SEKI6	SEKI5	SEKI4	SEKI3	SEKI2	SEKI1	SEKI0	
11_{16}	GETPEEK3	GETPEEK2	GETPEEK1	GETPEEK0	_	_	GET_HP1	GET_HP0	SLS_HP7	SLS_HP6	SLS_HP5	SLS_HP4	SLS_HP3	SLS_HP2	SLS_HP1	SLS_HP0	
12_{16}	_	FRAM	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
13_{16}	_	GSTTIM	SELSTART	_	_	_	_	_	SLS7	SLS6	SLS5	SLS4	SLS3	SLS2	SLS1	SLS0	
14_{16}	DIVS1	DIVS0	SELVCO	_	_	_	_	_	_	_	_	_	_	_	_	_	Status register 3
15_{16}	FLC15	FLC14	FLC13	FLC12	FLC11	FLC10	FLC9	FLC8	FLC7	FLC6	FLC5	FLC4	FLC3	FLC2	FLC1	FLC0	
16_{16}	CHK_FLC15	CHK_FLC14	CHK_FLC13	CHK_FLC12	CHK_FLC11	CHK_FLC10	CHK_FLC9	CHK_FLC8	CHK_FLC7	CHK_FLC6	CHK_FLC5	CHK_FLC4	CHK_FLC3	CHK_FLC2	CHK_FLC1	CHK_FLC0	
17_{16}	_	_	_	_	BIFON	SLSLVL1	SLSLVL0	_	SEKI7	SEKI6	SEKI5	SEKI4	SEKI3	SEKI2	SEKI1	SEKI0	
18_{16}	GETPEEK3	GETPEEK2	GETPEEK1	GETPEEK0	_	_	GET_HP1	GET_HP0	SLS_HP7	SLS_HP6	SLS_HP5	SLS_HP4	SLS_HP3	SLS_HP2	SLS_HP1	SLS_HP0	
19_{16}	_	FRAM	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
$1A_{16}$	_	GSTTIM	SELSTART	_	_	_	_	_	SLS7	SLS6	SLS5	SLS4	SLS3	SLS2	SLS1	SLS0	
$1B_{16}$	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
$1C_{16}$	ADSTART	_	EXT_PDC2	_	_	_	_	_	_	_	_	_	_	_	_	_	
$1D_{16}$	_	_	_	_	_	_	VPS_VCO_ON	PDC_VCO_R1	PDC_VCO_R0	PDC_VCO_ON	_	_	_	_	_	_	
$1E_{16}$	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	for read
$1F_{16}$	_	_	_	_	_	_	_	_	MACRO_ON	_	_	FLD1V	_	_	_	_	for read
20_{16}	_	MPAL	NXP	_	_	_	LEVELA	NORMAL	_	SEPV0	_	_	_	_	_	_	
21_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
22_{16}	HM84SEL	_	_	_	DIV_PDC8	DIV_PDC7	DIV_PDC6	DIV_PDC5	DIV_PDC4	DIV_PDC3	DIV_PDC2	DIV_PDC1	DIV_PDC0	DIV_PDCS2	DIV_PDCS1	DIV_PDCS0	
23_{16}	_	_	_	HORAX_ON	DIV_VPS8	DIV_VPS7	DIV_VPS6	DIV_VPS5	DIV_VPS4	DIV_VPS3	DIV_VPS2	DIV_VPS1	DIV_VPS0	DIV_VPSS2	DIV_VPSS1	DIV_VPSS0	
24_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
25_{16}	_	_	_	_	_	_	_	_	_	_	_	SLION_TIM	_	_	ADON_TIM	ADSEL	
26_{16}	DIVV_CK7	DIVV_CK6	DIVV_CK5	DIVV_CK4	DIVV_CK3	DIVV_CK2	DIVV_CK1	DIVV_CK0	DIVP_CK7	DIVP_CK6	DIVP_CK5	DIVP_CK4	DIVP_CK3	DIVP_CK2	DIVP_CK1	DIVP_CK0	
27_{16}	_	_	_	WEIGHT4	WEIGHT3	WEIGHT2	WEIGHT1	WEIGHT0	DLYSEL7	DLYSEL6	DLYSEL5	DLYSEL4	DLYSEL3	DLYSEL2	DLYSEL1	DLYSEL0	
28_{16}	_	_	_	_	_	INTDA	INTAD	ADON	SYNLVL2	SYNLVL1	SYNLVL0	_	6BITOFF	_	START	ADLAT	
29_{16}	_	_	_	_	STBSYNCSEP	SYNCSEP_ON0	SLI_GO	VPS_VP8	VPS_VP7	VPS_VP6	VPS_VP5	VPS_VP4	VPS_VP3	VPS_VP2	VPS_VP1	VPS_VP0	
$2A_{16}$	_	_	_	_	_	_	_	_	MASK7	MASK6	MASK5	MASK4	MASK3	MASK2	MASK1	MASK0	
$2B_{16}$	SEL_PDEC	_	SEL_VPSH	SEL_PDCH	_	_	_	_	_	_	_	_	_	_	_	_	
$2C_{16}$	_	_	_	_	_	_	_	PLSPOS8	PLSPOS7	PLSPOS6	PLSPOS5	PLSPOS4	PLSPOS3	PLSPOS2	PLSPOS1	PLSPOS0	
$2D_{16}$	_	_	_	_	_	_	_	PLSNEG8	PLSNEG7	PLSNEG6	PLSNEG5	PLSNEG4	PLSNEG3	PLSNEG2	PLSNEG1	PLSNEG0	
$2E_{16}$	HCOUNT15	HCOUNT14	HCOUNT13	HCOUNT12	HCOUNT11	HCOUNT10	HCOUNT9	HCOUNT8	HCOUNT7	HCOUNT6	HCOUNT5	HCOUNT4	HCOUNT3	HCOUNT2	HCOUNT1	HCOUNT0	for read
$2F_{16}$	STB_RES	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
30_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
31_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
32_{16}	RMTSEL	_	_	_	JSTCKON	JSTCKDIV1	JSTCKDIV0	RMTHD0(8)	RMTHD0(7)	RMTHD0(6)	RMTHD0(5)	RMTHD0(4)	RMTHD0(3)	RMTHD0(2)	RMTHD0(1)	RMTHD0(0)	
33_{16}	FILDIV1(1)	FILDIV1(0)	_	VERTX	FILDIV0	_	FILDIV0	RMTHD1(8)	RMTHD1(7)	RMTHD1(6)	RMTHD1(5)	RMTHD1(4)	RMTHD1(3)	RMTHD1(2)	RMTHD1(1)	RMTHD1(0)	
34_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
35_{16}	EXAOFF	_	_	_	_	PTD8	PTC8	HINT_LINE8	HINT_LINE7	HINT_LINE6	HINT_LINE5	HINT_LINE4	HINT_LINE3	HINT_LINE2	HINT_LINE1	HINT_LINE0	
36_{16}	SECINT3	SECINT2	SECINT1	SECINT0	HINT3	HINT2	HINT1	HINT0	INTRMT3	INTRMT2	INTRMT1	INTRMT0	VINT3	VINT2	VINT1	VINT0	
37_{16}	_	_	YUKOU1(5)	YUKOU1(4)	YUKOU1(3)	YUKOU1(2)	YUKOU1(1)	YUKOU1(0)	_	_	YUKOU0(5)	YUKOU0(4)	YUKOU0(3)	YUKOU0(2)	YUKOU0(1)	YUKOU0(0)	
38_{16}	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	
39_{16}	SECJUST	_	_	_	_	_	_	RTCON	_	_	SECOUT5	SECOUT4	SECOUT3	SECOUT2	SECOUT1	SECOUT0	
$3A_{16}$	_	_	_	_	_	MINOUT10	MINOUT9	MINOUT8	MINOUT7	MINOUT6	MINOUT5	MINOUT4	MINOUT3	MINOUT2	MINOUT1	MINOUT0	
$3B_{16}$	DAYCUONT15	DAYCUONT14	DAYCUONT13	DAYCUONT12	DAYCUONT11	DAYCUONT10	DAYCUONT9	DAYCUONT8	DAYCUONT7	DAYCUONT6	DAYCUONT5	DAYCUONT4	DAYCUONT3	DAYCUONT2	DAYCUONT1	DAYCUONT0	
$3C_{16}$	RMT_TM(7)	RMT_TM(6)	RMT_TM(5)	RMT_TM(4)	RMT_TM(3)	RMT_TM(2)	RMT_TM(1)	RMT_TM(0)	RMTDIV(1)	RMTDIV(0)	RMCDIV(1)	RMCDIV(0)	IRPOL(2)	IRPOL(1)	IRPOL(0)	RMTSTART	
$3D_{16}$	RMT_TMH(7)	RMT_TMH(6)	RMT_TMH(5)	RMT_TMH(4)	RMT_TMH(3)	RMT_TMH(2)	RMT_TMH(1)	RMT_TMH(0)	RMT_TML(7)	RMT_TML(6)	RMT_TML(5)	RMT_TML(4)	RMT_TML(3)	RMT_TML(2)	RMT_TML(1)	RMT_TML(0)	
$3E_{16}$	_	IROUT_SLICEON	_	_	_	_	_	_	_	_	_	_	RMTTXINT(3)	RMTTXINT(2)	RMTTXINT(1)	RMTTXINT(0)	
$3F_{16}$	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	

For accessing to expansion register data, set accessing address (DA5 to DA0) (shown in Table 14.4) to expansion register address control register (address 0216_{16}). Then write data (DD15 to DD0) to expansion register data control register (address 0218_{16}). When end the data accessing, expansion register address control register increments address automatically. Then, next address data writing is possible. After reset, the value of expansion register become “0” all, except for the clock timer.
Expansion register access registers are shown in Figure 14.9, expansion register access block diagram is shown in Figure 14.10, and expansion register bit compositions are shown in p202 to p239.

Expansion register address control register

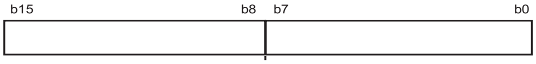


Symbol	Address	When reset
DA	0216_{16}	0000_{16}

Function	Setting possible value	R	W
Specify accessing expansion register address	00_{16} to 45_{16}	○	○
Nothing is assigned. When write, set to “0”. When read, its content is indeterminate.		—	—
Expansion register address automatic increment 0:enable / 1:disable (Note2)	—	×	○
Nothing is assigned. In an attempt to write to these bits, write “0”. The value, if read, turns out to be indeterminated.		—	—

Note1 : When access to expansion register, must be set expansion register address at first, then use expansion register data control register (0218_{16}).
Note2 : When bit 8 = “0” setting, expansion register data control register increments by accessing expansion register data control register, so it is not necessary to setting the next expansion register address. When bit 8 = “1” setting, the address is fixed.

Expansion register data control register



Symbol	Address	When reset
DD	0218_{16}	0000_{16}

Function	Setting possible value	R	W
Write and read out the data of expansion register which is specified by expansion register address control register (address 0216_{16})	0000_{16} to $FFFF_{16}$	○	○

Note : Data access must be 16-bit unit. 8-bit unit access is disable.

Figure 14.9 Expansion register access registers composition

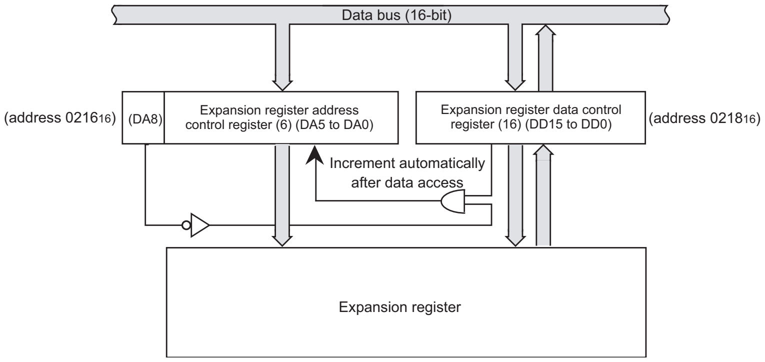
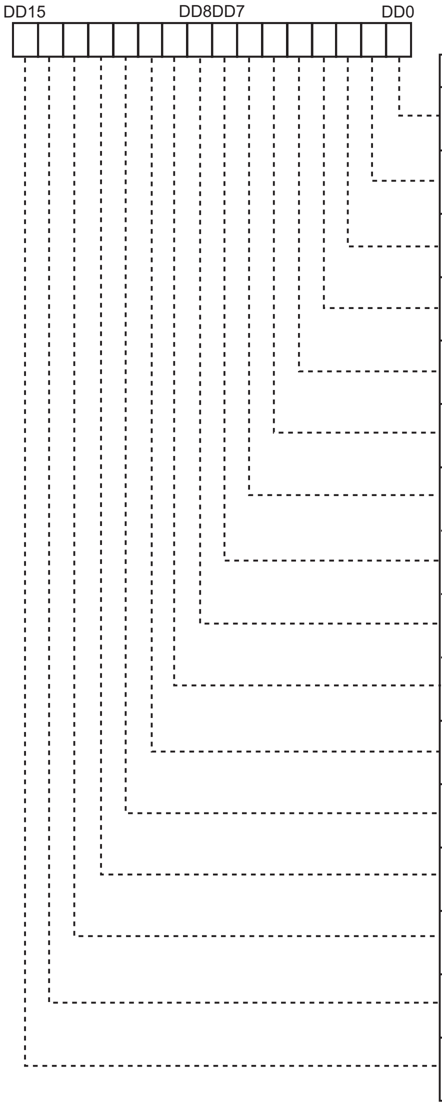


Figure 14.10 Expansion register access block diagram

Bit composition of an expansion register

1. Address 00_{16} (=DA5 to 0)



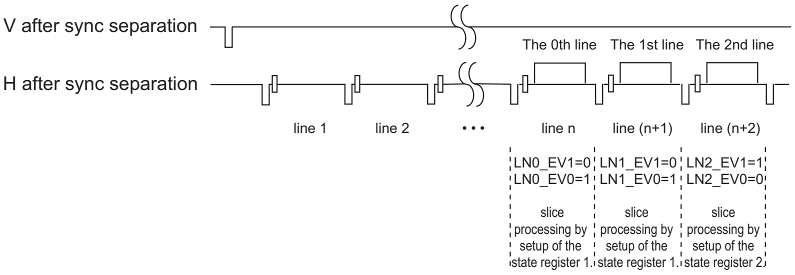
Bit symbol	Bit name	Function	R	W
LN0_EV0	The 0th line state register selection bit	As for the slicing method of the n-th line (Notes 1), it is chosen which set of the state register settings of the three sets (Notes 2) is used with the combination of LNn_EV0 (address 00_{16} and 02_{16}, n = 0 to 17) and LNn_EV1 (address 01_{16} and 03_{16}, n= 0 to 17.) Four kinds of following state registers can be chosen for every line (Notes 3.)	○	○
LN1_EV0	The 1st line state register selection bit		○	○
LN2_EV0	The 2nd line state register selection bit		○	○
LN3_EV0	The 3rd line state register selection bit		○	○
LN4_EV0	The 4th line state register selection bit		○	○
LN5_EV0	The 5th line state register selection bit		○	○
LN6_EV0	The 6th line state register selection bit		○	○
LN7_EV0	The 7th line state register selection bit		○	○
LN8_EV0	The 8th line state register selection bit		○	○
LN9_EV0	The 9th line state register selection bit		○	○
LN10_EV0	The 10th line state register selection bit		○	○
LN11_EV0	The 11th line state register selection bit		○	○
LN12_EV0	The 12th line state register selection bit		○	○
LN13_EV0	The 13th line state register selection bit		○	○
LN14_EV0	The 14th line state register selection bit		○	○
LN15_EV0	The 15th line state register selection bit		○	○

LNn_EV1	LNn_EV0	State register(Notes 2)
0	0	Do not set up
0	1	State register 1
1	0	State register 2
1	1	State register 3

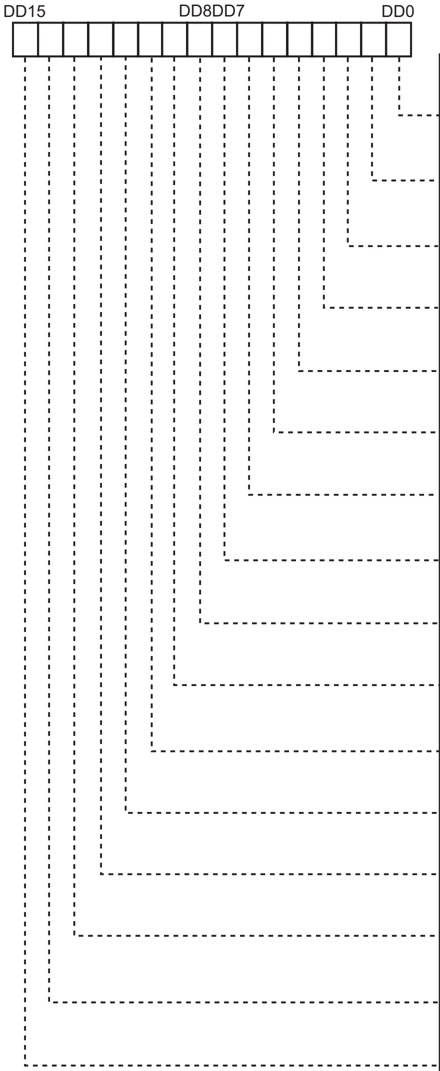
Notes 1. The n-th line: The number of lines after a slice start.
Please refer to the supplement (3) of 15.6 expansion register composition (P229) for details.

Notes 2. 06h to 0Ch address: State register 1
0Dh to 13h address: State register 2
14h to 1Ah address: State register 3

Notes 3. The example of a setting.

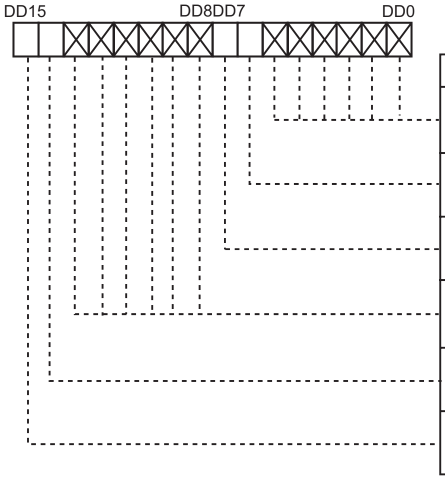


2. Address 01_{16} (=DA5 to 0)



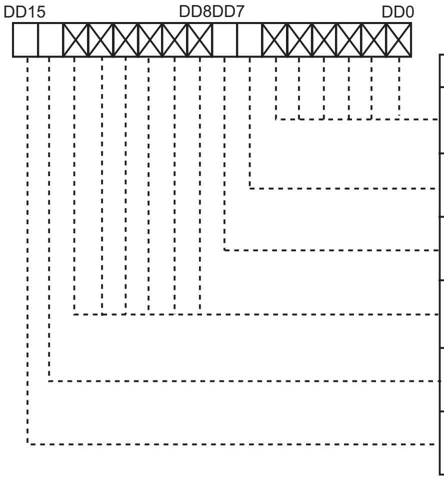
Bit symbol	Bit name	Function	R	W
LN0_EV1	The 0th line state register selection bit	Refer to LNn_EV0 (address 00_{16})	○	○
LN1_EV1	The 1st line state register selection bit		○	○
LN2_EV1	The 2nd line state register selection bit		○	○
LN3_EV1	The 3rd line state register selection bit		○	○
LN4_EV1	The 4th line state register selection bit		○	○
LN5_EV1	The 5th line state register selection bit		○	○
LN6_EV1	The 6th line state register selection bit		○	○
LN7_EV1	The 7th line state register selection bit		○	○
LN8_EV1	The 8th line state register selection bit		○	○
LN9_EV1	The 9th line state register selection bit		○	○
LN10_EV1	The 10th line state register selection bit		○	○
LN11_EV1	The 11th line state register selection bit		○	○
LN12_EV1	The 12th line state register selection bit		○	○
LN13_EV1	The 13th line state register selection bit		○	○
LN14_EV1	The 14th line state register selection bit		○	○
LN15_EV1	The 15th line state register selection bit		○	○

3. Address 02$_{16}$ (=DA5 to 0)



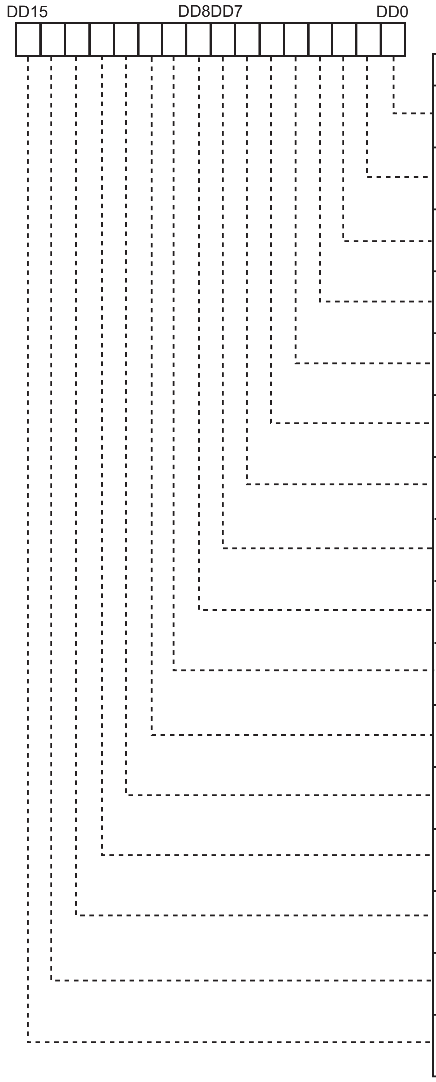
Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
LN16_OD0	The 16th line state register selection bit	Refer to LNn_OD0 (address 04$_{16}$)	○	○
LN17_OD0	The 17th line state register selection bit		○	○
Nothing is assigned.			×	×
LN16_EV0	The 16th line state register selection bit	Refer to LNn_EV0 (address 00$_{16}$)	○	○
LN17_EV0	The 17th line state register selection bit		○	○

4. Address 03$_{16}$ (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
LN16_OD1	The 16th line state register selection bit	Refer to LNn_OD0 (address 04$_{16}$)	○	○
LN17_OD1	The 17th line state register selection bit		○	○
Nothing is assigned.			×	×
LN16_EV1	The 16th line state register selection bit	Refer to LNn_EV0 (address 00$_{16}$)	○	○
LN17_EV1	The 17th line state register selection bit		○	○

5. Address 04_{16} (=DA5 to 0)



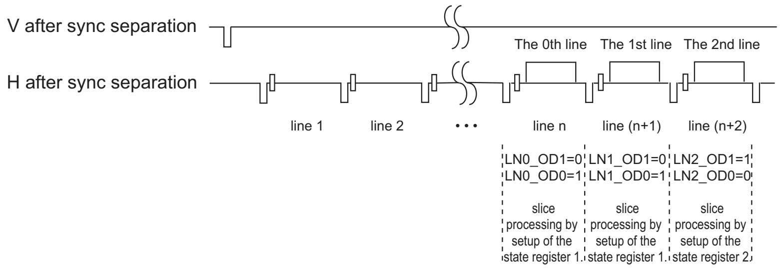
Bit symbol	Bit name	Function	R	W
LN0_OD0	The 0th line state register selection bit	As for the slicing method of the n-th line (Notes 1), it is chosen which set of the state register settings of the three sets (Notes 2) is used with the combination of LNn_OD0 (address 04_{16} and 02_{16}, n = 0 to 17) and LNn_OD1 (address 05_{16} and 03_{16}, n= 0 to 17.) Four kinds of following state registers can be chosen for every line. (Notes 3)	○	○
LN1_OD0	The 1st line state register selection bit		○	○
LN2_OD0	The 2nd line state register selection bit		○	○
LN3_OD0	The 3rd line state register selection bit		○	○
LN4_OD0	The 4th line state register selection bit		○	○
LN5_OD0	The 5th line state register selection bit		○	○
LN6_OD0	The 6th line state register selection bit		○	○
LN7_OD0	The 7th line state register selection bit		○	○
LN8_OD0	The 8th line state register selection bit		○	○
LN9_OD0	The 9th line state register selection bit		○	○
LN10_OD0	The 10th line state register selection bit		○	○
LN11_OD0	The 11th line state register selection bit		○	○
LN12_OD0	The 12th line state register selection bit		○	○
LN13_OD0	The 13th line state register selection bit		○	○
LN14_OD0	The 14th line state register selection bit		○	○
LN15_OD0	The 15th line state register selection bit		○	○

LNn_EV1	LNn_EV0	State register(Notes 2)
0	0	Do not set up
0	1	State register 1
1	0	State register 2
1	1	State register 3

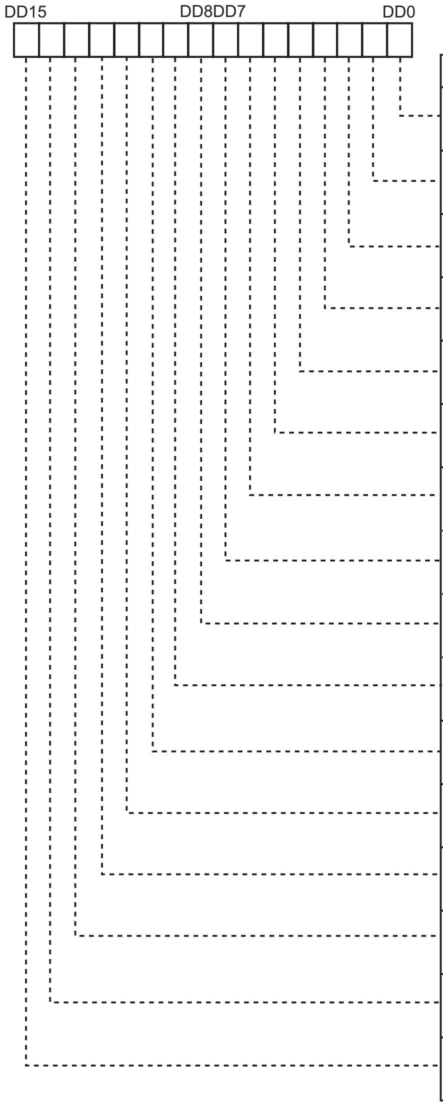
Notes 1. The n-th line: The number of lines after a slice start.
Please refer to the supplement (3) of 14.6 expansion register composition for details.

Notes 2. 06h to 0Ch address: State register 1
0Dh to 13h address: State register 2
14h to 1Ah address: State register 3

Notes 3. The example of a setting.



6. Address 05$_{16}$ (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
LN0_OD1	The 0th line state register selection bit	Refer to LNn_OD0 (address 04$_{16}$)	○	○
LN1_OD1	The 1st line state register selection bit		○	○
LN2_OD1	The 2nd line state register selection bit		○	○
LN3_OD1	The 3rd line state register selection bit		○	○
LN4_OD1	The 4th line state register selection bit		○	○
LN5_OD1	The 5th line state register selection bit		○	○
LN6_OD1	The 6th line state register selection bit		○	○
LN7_OD1	The 7th line state register selection bit		○	○
LN8_OD1	The 8th line state register selection bit		○	○
LN9_OD1	The 9th line state register selection bit		○	○
LN10_OD1	The 10th line state register selection bit		○	○
LN11_OD1	The 11th line state register selection bit		○	○
LN12_OD1	The 12th line state register selection bit		○	○
LN13_OD1	The 13th line state register selection bit		○	○
LN14_OD1	The 14th line state register selection bit		○	○
LN15_OD1	The 15th line state register selection bit		○	○

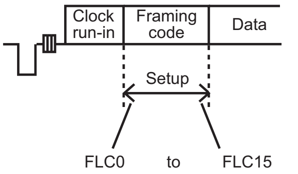
7. Address 06_{16}, $0D_{16}$, 14_{16} (=DA5 to 0)

DD15							DD8	DD7							DD0
			☒	☒	☒	1	1	0	0	0	0	0	0	0	0

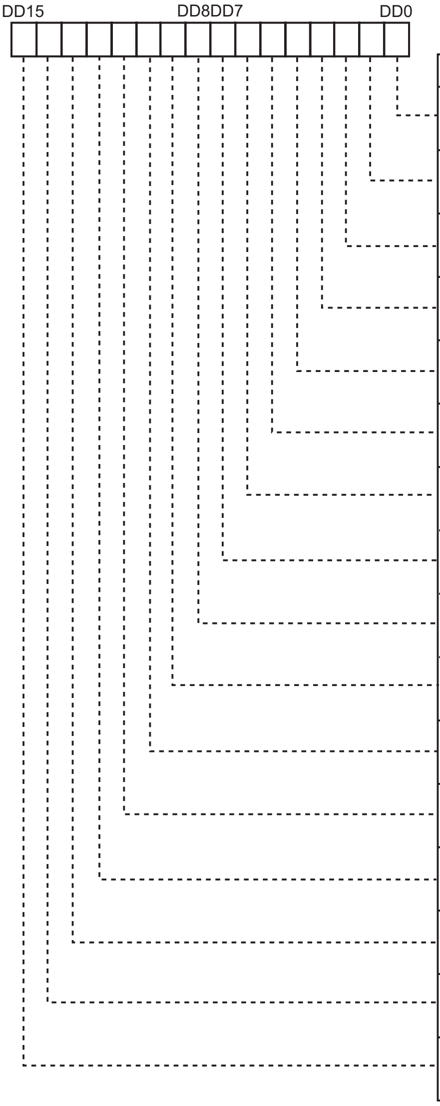
Bit symbol	Bit name	Function	R	W
	Reserved bits	Must set to "0."	×	○
	Reserved bits	Must set to "1."	×	○
Nothing is assigned.			×	×
SELVCO	The PLL selection bit for slice	0 PDC 1 VPS	○	○
DIVS0	The clock division bit for slice	DIVS1 / DIVS0 / divided value 0 / 0 / no division 0 / 1 / divided by 2 1 / 0 / divided by 3 1 / 1 / divided by 5	○	○
DIVS1			○	○

8. Address 07_{16}, $0E_{16}$, 15_{16} (=DA5 to 0)

DD15							DD8	DD7							DD0

Bit symbol	Bit name	Function	R	W
FLC0	Framing code selection bit	Framing code is set up  16 bits are checked at maximum. However, the bit of CHK_FLCn (addresses 08_{16}, $0F_{16}$ and 16_{16}) = "1" is not checked.	○	○
FLC1			○	○
FLC2			○	○
FLC3			○	○
FLC4			○	○
FLC5			○	○
FLC6			○	○
FLC7			○	○
FLC8			○	○
FLC9			○	○
FLC10			○	○
FLC11			○	○
FLC12			○	○
FLC13			○	○
FLC14			○	○
FLC15			○	○

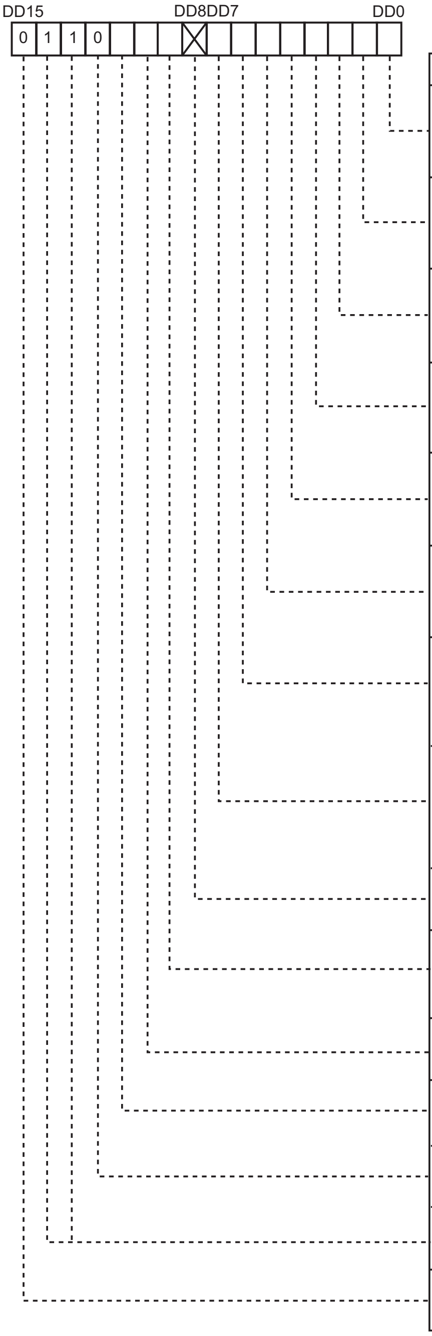
9. Address 08$_{16}$, 0F$_{16}$, 16$_{16}$ (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
CHK_FLC0	Framing code check selection bit	When acquiring data, it sets up whether framing code set up by FLC 0 to 15 (addresses 07$_{16}$, 0E$_{16}$, and 15$_{16}$) is checked or not per bit. Data will be acquired if the n-th bit which is set as check is in agreement.	○	○
CHK_FLC1			○	○
CHK_FLC2			○	○
CHK_FLC3			○	○
CHK_FLC4			○	○
CHK_FLC5			○	○
CHK_FLC6			○	○
CHK_FLC7			○	○
CHK_FLC8			○	○
CHK_FLC9			○	○
CHK_FLC10			○	○
CHK_FLC11			○	○
CHK_FLC12			○	○
CHK_FLC13			○	○
CHK_FLC14			○	○
CHK_FLC15			○	○

CHK_FLCn	n-th bit
0	check
1	No check

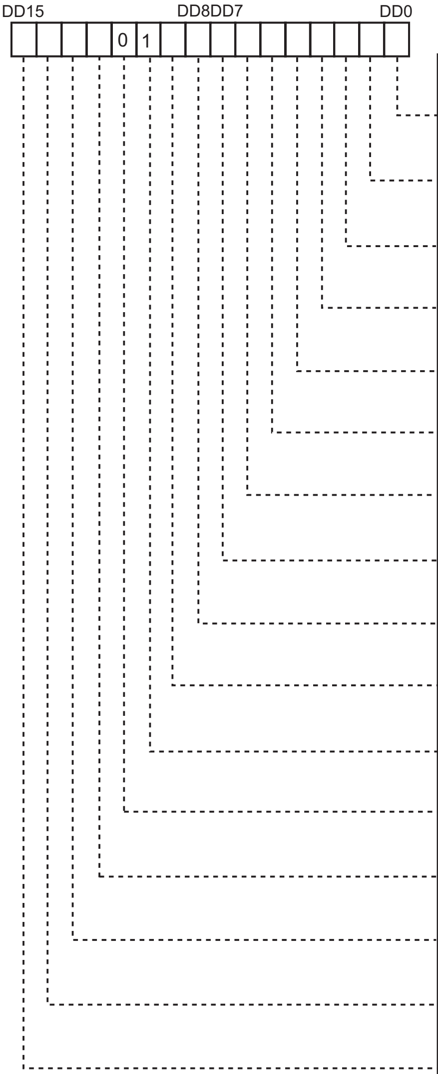
10. Address 09$_{16}$, 10$_{16}$, 17$_{16}$ (=DA5 to 0)

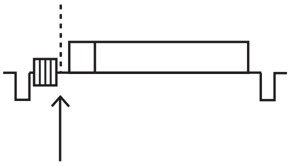


Bit symbol	Bit name	Function	R	W
SEKI0	Data slicer control bit 1	SEKI1 / SEKI0 / N 0 / 0 / 5 (Note1) 0 / 1 / 4 (Note2) 1 / 0 / 6 (Note3) 1 / 1 / 8 (Note4) N-times the digital value after SEKI7.6.	○	○
SEKI1			○	○
SEKI2	Data slicer control bit 2	SEKI3 / SEKI2 / N 0 / 0 / 4 0 / 1 / 3 1 / 0 / 1 1 / 1 / No differentiation It differentiates from the digitized data in front of N/8 cycles (clock run-in cycle) to the digital value after SEKI0 and 1.	○	○
SEKI3			○	○
SEKI4	Data slicer control bit 3	SEKI5 / SEKI4 / N 0 / 0 / 4 0 / 1 / 3 1 / 0 / 1 1 / 1 / No differentiation It differentiates from the digitized data in after N/8 cycles (clock run-in cycle) to the digital value after SEKI3 and 2.	○	○
SEKI5			○	○
SEKI6	Data slicer control bit 4	SEKI6 / Leveling existence of the following A-D convert value 0 / Average for four clocks 1 / It doesn't level	○	○
SEKI7	Data slicer control bit 5	0 / The differentiation by SEKI2, 3, SEKI4, and 5 is differentiated by one time the value. 1 / The differentiation by SEKI2, 3, SEKI4, and 5 is differentiated by twice the value.	○	○
Nothing is assigned.			×	×
SISLVL0	Slice level control bit	0 / The clock line average level is used 1 / The slice level selection bit (0C16,1316, 1A16, and house number SLS7?0) is used.	○	○
SISLVL1	Slice level measurement period selection bit	0 / 2 cycles of Clock run-in 1 / 4 cycles of Clock run-in	○	○
BIFON	Data format selection bit	0 / Non Return Zero 1 / Bi-phase type	○	○
Reserved bit		Must set to "0."	×	○
Reserved bits		Must set to "1."	×	○
Reserved bit		Must set to "0."	×	○

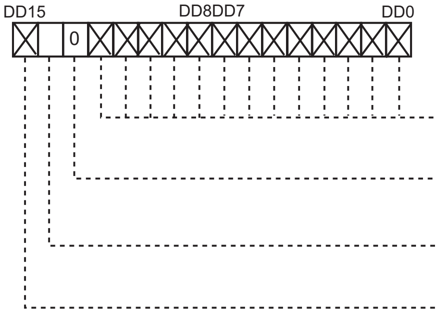
Note 1. When selecting 5 times with SEKI0, 1 and twice with SEKI7, select "none" for any one of SEKI2, 3 or SEKI4, 5.
Note 2. When selecting 8 times for SEKI0, 1, select "none" for both SEKI2, 3 and SEKI4, 5.
Note 3. When selecting 6 times for SEKI0, 1 and twice for SEKI7, select "none" for any one of SEKI2, 3 or SEKI4, 5.
Note 4. When selecting "none" for both SEKI2, 3 and SEKI4, 5, do not select 4 times, and select 8 times for SEKI0, 1.

11. Address $0A_{16}$, 11_{16}, 18_{16} (=DA5 to 0)



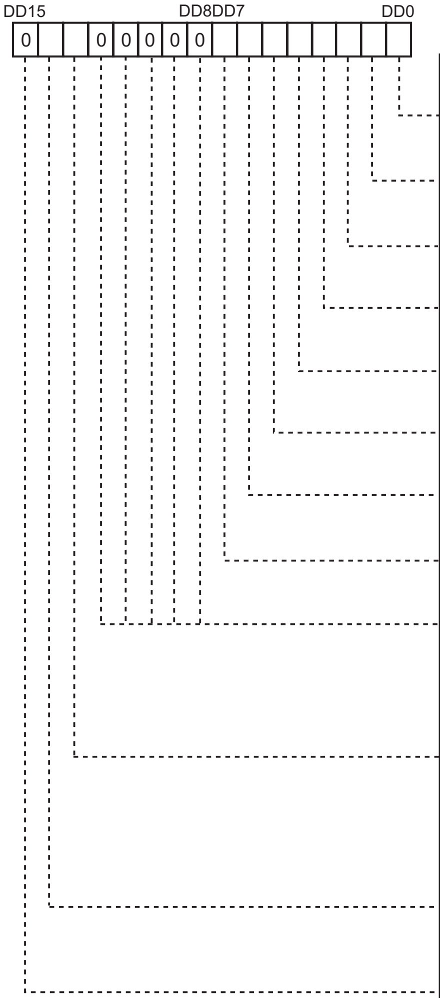
Bit symbol	Bit name	Function	R	W
SLS_HP0	Slice check start position selection bit	It will become below if data slice start position is made into SLS_HS. $SLS\_HS = T2 \times \sum_{n=0}^{7} 2^{n}\ SLS\_HPn$ T2 : Clock run-in cycle /2  The position where framing code begins to be checked is set up. Setup in a 1-bit unit is possible.	○	○
SLS_HP1			○	○
SLS_HP2			○	○
SLS_HP3			○	○
SLS_HP4			○	○
SLS_HP5			○	○
SLS_HP6			○	○
SLS_HP7			○	○
GET_HP0	Phase fine-tuning bit	Slice data 0/1 judging clock is tuned finely.	○	○
GET_HP1			○	○
Reserved bit		Must set to "1."	5	○
Reserved bit		Must set to "0."	5	○
GETPEEK0	Peak detection period selection bit 0	GETPEEK1 GETPEEK0 Clock run-in period 0 0 2 0 1 4 1 0 5 1 1 6	○	○
GETPEEK1	Peak detection period selection bit 1		○	○
GETPEEK2	Peak detection period selection bit 2	0 With clock compensation 1 With no clock compensation	○	○
GETPEEK3	Peak detection period selection bit 3	0 Only a mountain is detected. 1 A mountain and a valley are detected.	○	○

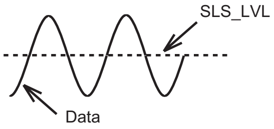
12. Address $0B_{16}$, 12_{16}, 19_{16} (=DA5 to 0)



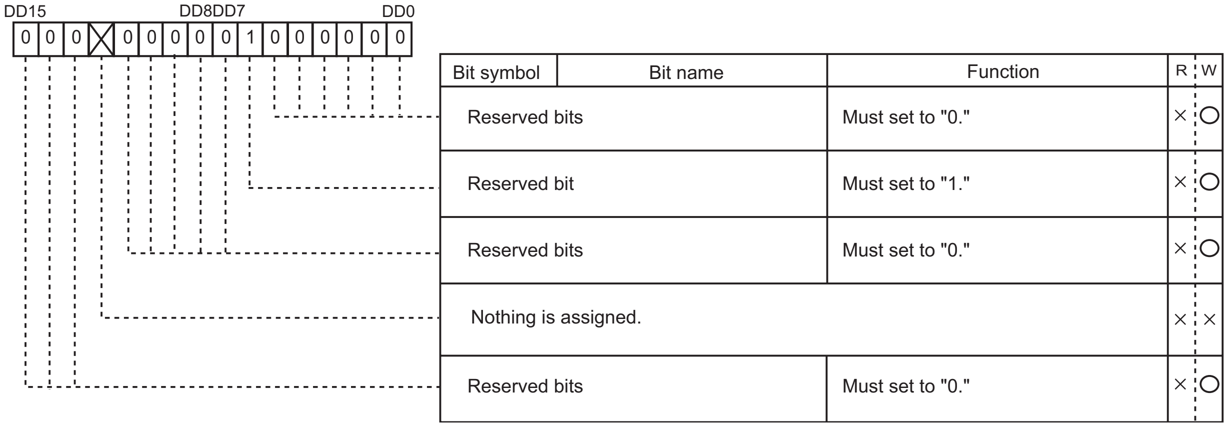
Bit symbol	Bit name	Function	R	W
Nothing is assigned.			X	X
Reserved bit		Must set to "0."	X	○
FRAM	The number selection bit of framing code check bits	0 15-bit check 1 16-bit check	○	○
Nothing is assigned.			X	X

13. Address $0C_{16}$, 13_{16}, $1A_{16}$ (=DA5 to 0)



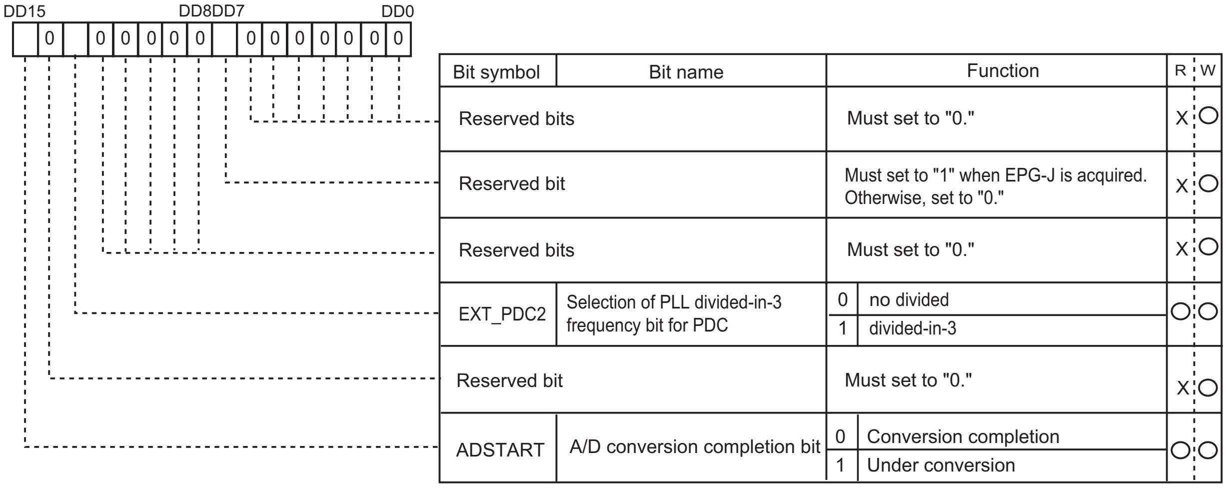
Bit symbol	Bit name	Function	R	W
SLS0	Slice level selection bit	It will become below if a slice level is made into SLS_LVL.  At the time of SLS7 = "H" $SLS\_LVL = \sum_{n=0}^{6} 2^n SLSn - 128$ At the time of SLS7 = "L" $SLS\_LVL = \sum_{n=0}^{6} 2^n SLSn$	○	○
SLS1			○	○
SLS2			○	○
SLS3			○	○
SLS4			○	○
SLS5			○	○
SLS6			○	○
SLS7			○	○
Reserved bits		Must set to "0."	×	○
SELSTART	Slice start condition selection bit	0 Slice beginning after slice check period (SLS_HP7 to 0 of addresses 0A,11 and 18) passes 1 Slice beginning after standing up of clock run-in after slice check period (SLS_HP7 to 0 of addresses 0A,11 and 18) passes	○	○
GSTTIM	Ghost correct control bit	0 Ghost correct OFF 1 Ghost correct ON	○	○
Reserved bit		Must set to "0."	×	○

14. Address $1B_{16}$ (=DA5 to 0)



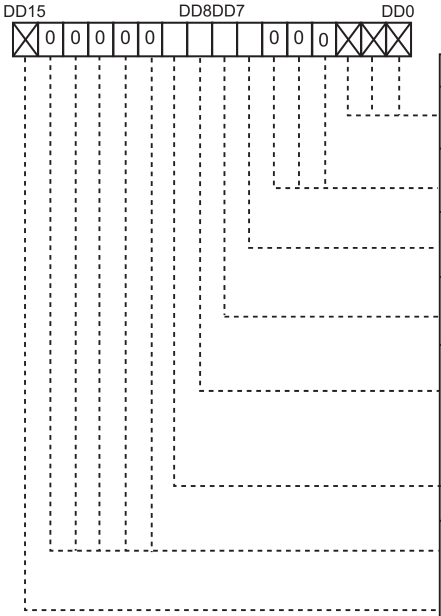
Bit symbol	Bit name	Function	R	W
Reserved bits		Must set to "0."	×	○
Reserved bit		Must set to "1."	×	○
Reserved bits		Must set to "0."	×	○
Nothing is assigned.			×	×
Reserved bits		Must set to "0."	×	○

15. Address $1C_{16}$ (=DA5 to 0)



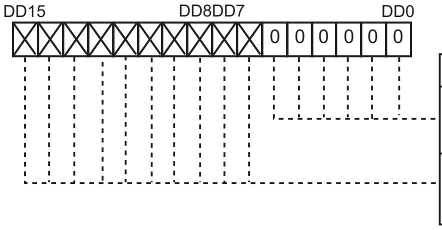
Bit symbol	Bit name	Function	R	W
Reserved bits		Must set to "0."	X	○
Reserved bit		Must set to "1" when EPG-J is acquired. Otherwise, set to "0."	X	○
Reserved bits		Must set to "0."	X	○
EXT_PDC2	Selection of PLL divided-in-3 frequency bit for PDC	0 no divided 1 divided-in-3	○	○
Reserved bit		Must set to "0."	X	○
ADSTART	A/D conversion completion bit	0 Conversion completion 1 Under conversion	○	○

16. Address $1D_{16}$ (=DA5 to 0)



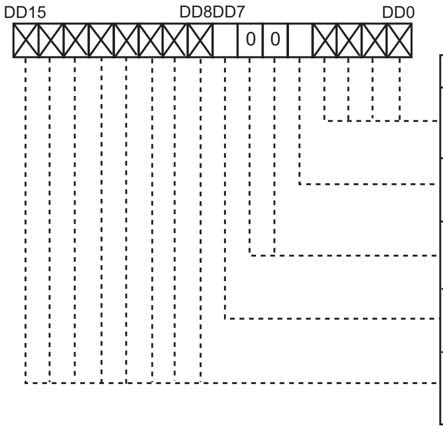
Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
Reserved bits		Must set to "0."	×	○
PDC_VCO_ON	PDC clock oscillation selection bit	0 PDC clock stop 1 PDC clock oscillation	○	○
PDC_VCO_R0 PDC_VCO_R1	PDC clock oscillation change bit	PDC_VCO_R1 PDC_VCO_R0 0 0 Select PDC clock 1 0 Select EPG-J clock 0 1 Do not set up 1 1 Do not set up	×	○
VPS_VCO_ON	VPS clock oscillation selection bit	0 VPS clock stop 1 VPS clock oscillation	○	○
Reserved bits		Must set to "0."	×	○
Nothing is assigned.			×	×

17. Address $1E_{16}$ (=DA5 to 0)



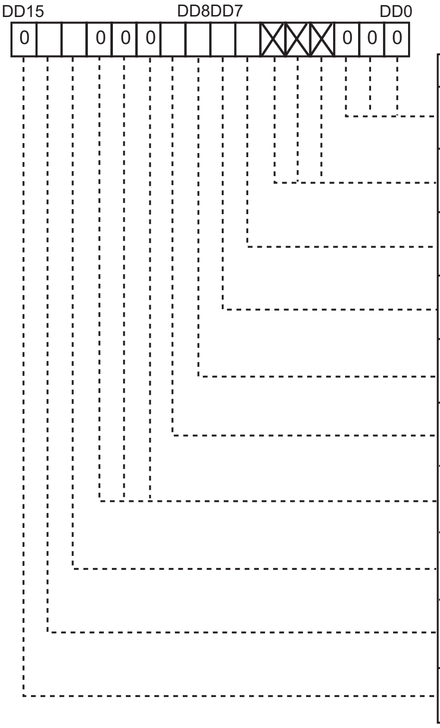
Bit symbol	Bit name	Function	R	W
Reserved bits		Must set to "0."	×	○
Nothing is assigned.			×	×

18. Address $1F_{16}$ (=DA5 to 0)



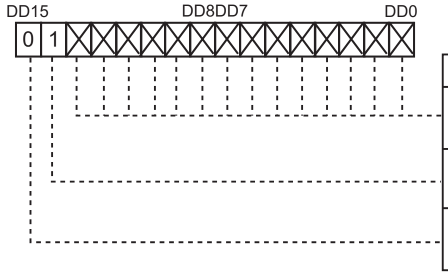
Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
FLD1V	Field state flag	0 Even field 1 Odd field	○	×
Reserved bits		Must set to "0."	×	○
MACRO_ON	Synchronized signal search flag	0 normal 1 unusual	○	×
Nothing is assigned.			×	×

19. Address 20_{16} (=DA5 to 0)



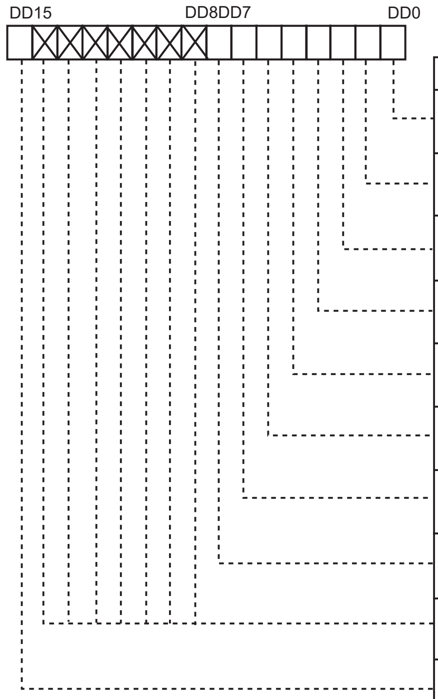
Bit symbol	Bit name	Function	R	W
	Reserved bits	Must set to "0."	×	○
	Nothing is assigned.		×	×
SEPV0	Vertical synchronous separation standard selection bit	0 Detected in L period of 15ms/22ms. 1 Detected in L period of 22ms.	○	○
	Reserved bit	Must set to "0."	×	○
NORMAL	Framing code check control bit	0 Check (Data is acquired if Framing code is in agreement). 1 No check (All data is acquired).	○	○
LEVELA	Synchronous signal slice potential generating control bit	0 Synchronous signal slice potential generating circuit OFF 1 Synchronous signal slice potential generating circuit ON	○	○
	Reserved bits	Must set to "0."	×	○
NXP	Broadcast method selection bit	NXP MPAL Broadcast method 0 0 NTSC 0 1 M-PAL 1 0 PAL 1 1 Do not set up	○	○
MPAL			○	○
	Reserved bit	Must set to "0."	×	○

20. Address 21_{16} (=DA5 to 0)



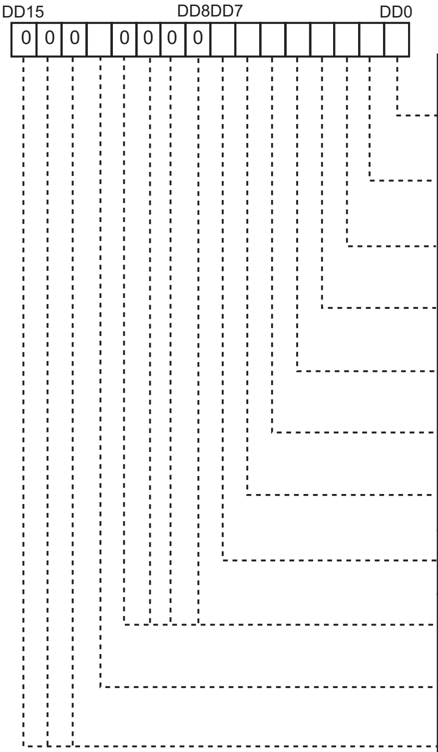
Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
	Reserved bit	Must set to "1."	×	○
	Reserved bit	Must set to "0."	×	○

21. Address 22_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
DIV_PDCS0	The PLL fine-tuning bit for PDC	Slice clock frequency f_{PDC} for PDC is adjusted. $f_{PDC} = f_{DIVP} \times \left(\sum_{n=0}^{8} 2^{n}\,\mathrm{DIV\_PDCn} + \sum_{m=0}^{2} 2^{m-3}\,\mathrm{DIV\_PDCSm+2} \right)$ f_{DIVP} : Horizontal synchronized signal frequency • When teletext (PDC) data is acquired (DIV_PDC4 to 0, DIV_PDCS2 to 0 = $(00100011)_2$) • When EPG-J is acquired (DIV_PDC4 to 0, DIV_PDCS2 to 0 = $(00010011)_2$)	○	○
DIV_PDCS1			○	○
DIV_PDCS2			○	○
DIV_PDC0	The divided value selection bit of PLL for PDC		○	○
DIV_PDC1			○	○
DIV_PDC2			○	○
DIV_PDC3			○	○
DIV_PDC4			○	○
Nothing is assigned.			×	×
HM84SEL	8/4 humming polarity selection bit	0 Normal 1 The 4-bit data of 8/4 humming is reversal-outputted.	○	○

22. Address 23_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	Ω
DIV_VPSS0	The PLL fine-tuning bit for VPS	Slice clock frequency f_{PDC} for VPS is adjusted. $f\ VPS = f_{DIVV} \times \left(\sum_{n=0}^{8} 2^{n}\ DIV\_VPSn + \sum_{m=0}^{2} 2^{m-3} DIV\_VPSSm + 2 \right)$ f_{DIVV} : Horizontal synchronized signal frequency When VPS is acquired (DIV_VPS4 to 0, DIV_VPSS2 to 0 = $(00100110)_2$) When CC, CC2X and ID-1 are acquired (DIV_VPS4 to 0, DIV_VPSS2 to 0 = $(11010100)_2$)	○	○
DIV_VPSS1			○	○
DIV_VPSS2			○	○
DIV_VPS0	The divided value selection bit of PLL for VPS		○	○
DIV_VPS1			○	○
DIV_VPS2			○	○
DIV_VPS3			○	○
DIV_VPS4			○	○
Reserved bits		Must set to "0."	×	○
HORAX_ON	Horizontal synchronized signal selection bit	0 Analog input 1 The digital input of HOR	○	○
Reserved bits		Must set to "0."	×	○

23. Address 24_{16} (=DA5 to 0)

DD15							DD8	DD7							DD0

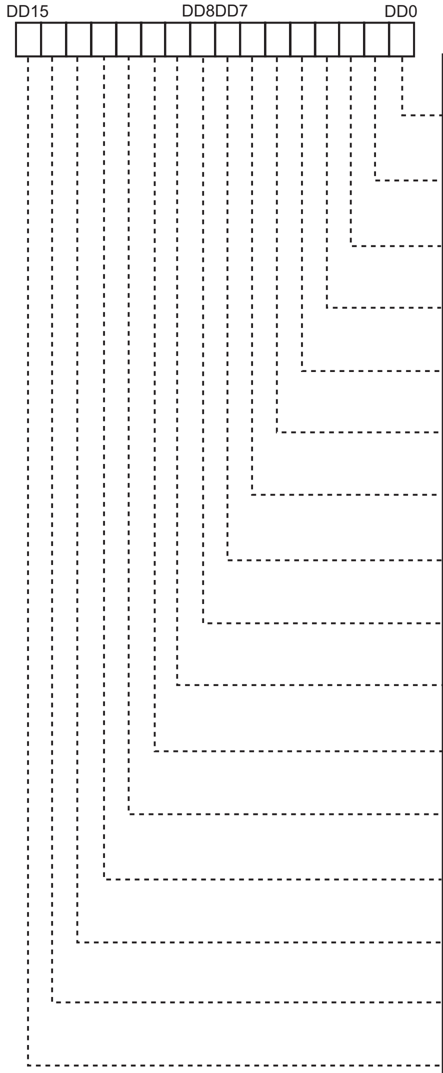
Bit symbol	Bit name	Function	R	W
	Reserved bits	Must set to "8808_{16}" when EPG-J is acquired. Otherwise, set to "0000_{16}."	×	○

24. Address 25_{16} (=DA5 to 0)

DD15							DD8	DD7							DD0
0	0	0	1	0	0	1	1	0	0	0		0	0		

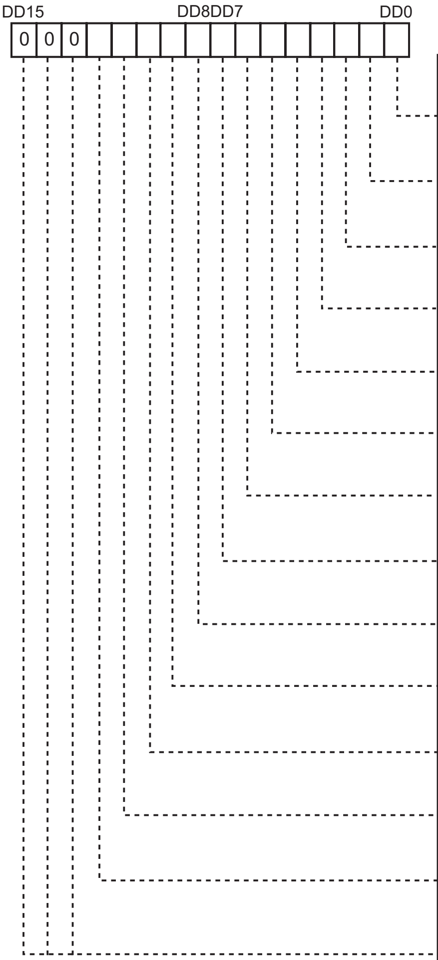
Bit symbol	Bit name	Function		R	W
ADSEL	A/D conversion slice bit	0	Normal	○	○
		1	The digital value after A/D conversion is given from outside (with register).		
ADON_TIM	A/D operation control bit	0	Programmable	○	○
		1	Slice period		
	Reserved bits	Must set to "0."		○	○
SLICEON_TIM	Slice selection bit	0	Every line (CHECK_START)	○	○
		1	Programmable (PRE_START)		
	Reserved bits	Must set to "0."		×	○
	Reserved bits	Must set to "1."		×	○
	Reserved bits	Must set to "0."		×	○
	Reserved bit	Must set to "1."		×	○
	Reserved bits	Must set to "0."		×	○

25. Address 26_{16} (=DA5 to 0)



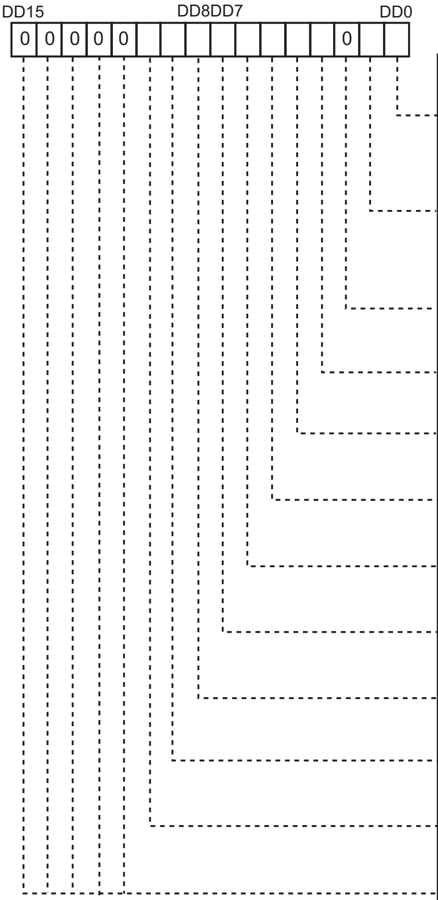
Bit symbol	Bit name	Function	R	W
DIVP_CK0	The clock division value selection bit for phase comparison with a PDC clock	The divided clock used for the phase comparison with a PDC clock is set up. $f_{FSC} = f_{DIVP} \times \left(\sum_{n=0}^{7} 2^n \text{DIVS\_CKn} + 2 \right)$ f_{DIVP}: The slice clock frequency for PDC (please refer to DIV_PDCS0 to 2 and DIV_PDC0 to 4 (address 22_{16}).) When teletext (PDC) data is acquired DIVP_CK7 to 0 = $(00001110)_2$ When EPG-J is acquired DIVP_CK7 to 0 = $(00001001)_2$	○	○
DIVP_CK1			○	○
DIVP_CK2			○	○
DIVP_CK3			○	○
DIVP_CK4			○	○
DIVP_CK5			○	○
DIVP_CK6			○	○
DIVP_CK7			○	○
DIVV_CK0	The clock division value selection bit for phase comparison with a VPS clock	The divided clock used for the phase comparison with a VPS clock is set up. $f_{FSC} = f_{DIVV} \times \left(\sum_{n=0}^{7} 2^n \text{DIVV\_CKn} + 2 \right)$ f_{DIVV} : The slice clock frequency for VPS (refer to DIV_VPSS0 to 2 and DIV_VPS0 to 4 (address 23_{16}).) When VPS is acquired DIVV_CK7 to 0 = $(00001110)_2$ When CC, CC2X and ID-1 are acquired DIVV_CK7 to 0 = $(01010011)_2$	○	○
DIVV_CK1			○	○
DIVV_CK2			○	○
DIVV_CK3			○	○
DIVV_CK4			○	○
DIVV_CK5			○	○
DIVV_CK6			○	○
DIVV_CK7			○	○

26. Address 27_{16} (=DA5 to 0)



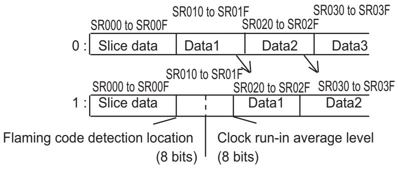
Bit symbol	Bit name	Function	R	W
DLYSEL0	Data slicer control bit5	These are the control bits of the ghost correction circuit.	○	○
DLYSEL1			○	○
DLYSEL2			○	○
DLYSEL3			○	○
DLYSEL4			○	○
DLYSEL5			○	○
DLYSEL6			○	○
DLYSEL7			○	○
WEIGHT0	Data slicer control bit6	These are the control bits of the ghost correction circuit.	○	○
WEIGHT1			○	○
WEIGHT2			○	○
WEIGHT3			○	○
WEIGHT4			○	○
Reserved bits		Must set to "0."	×	○

27. Address 28$_{16}$ (=DA5 to 0)

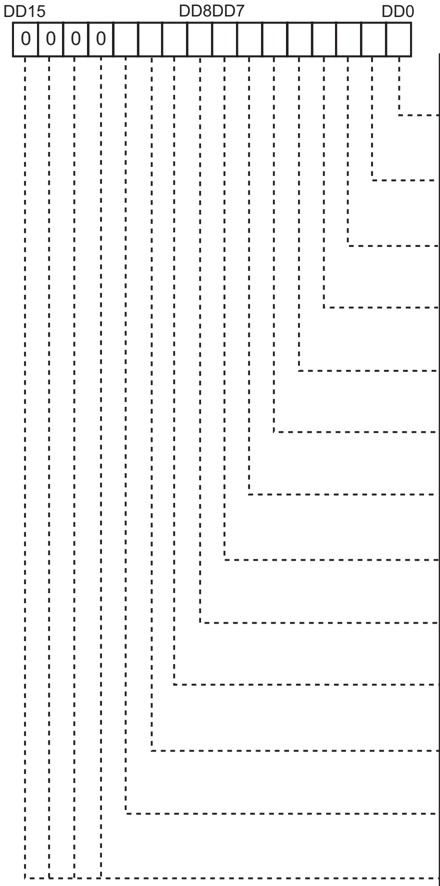


Bit symbol	Bit name	Function	R	W
ADLAT	Data acquisition selection bit	0: Acquisition of slice data 1: Acquisition of A/D data	○	○
START	Slice data selection bit	Turning on the output after slice RAM of Flaming code detection position (8 bits) and the average of the clock run-in level (8 bits)and turning off are set (note.)	○	○
Reserved bit		Must set to "0."	×	○
6BITOFF	A/D lower bit selection bit	0: Normal 1: Stop by 6th bit of A/D	○	○
Reserved bit		Must set to "1" when EPG-J is acquired. Otherwise, set to "0."	×	○
SYNLVL0	Synchronous signal slice level control bit	SYNLVL2 SYNLVL1 SYNLVL0: Slice level 0 0 0: approx.1.10V±0.10V 0 0 1: approx.1.15V±0.10V 0 1 0: approx.1.20V±0.10V 0 1 1: approx.1.25V±0.10V 1 0 0: approx.1.30V±0.10V 1 0 1: approx.1.35V±0.10V 1 1 0: approx.1.40V±0.10V 1 1 1: approx.1.45V±0.10V	○	○
SYNLVL1				
SYNLVL2				
ADON	Data slicer control bit	0: Data slicer OFF. (The amplifier for slicer is also turned off). 1: Data slicer ON (see INTAD and the INTDA about the amplifier for slicer)	○	○
INTAD	The amplifier control bit for data slicers	0: Always data slicer ON. 1: On 3 to 23 lines and 315 to 335 line amplifier ON. On other line amplifier OFF	○	○
INTDA	The rudder resistance control bit for data slicers	0: Always ladder resistance for data slicer ON. 1: On 3 to 23 lines and 315 to 335 line Ladder resistance ON. On other line Ladder resistance OFF	○	○
Reserved bits		Must set to "0."	×	○

Note. Slice RAM: Refer to Figure "Slice RAM bit construction"



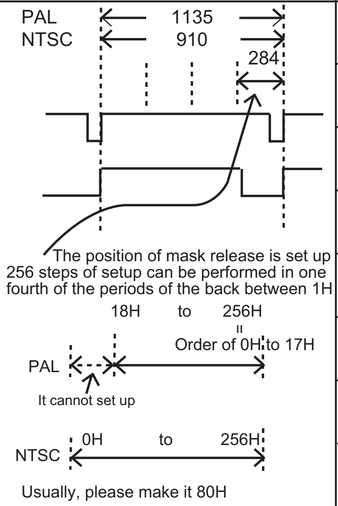
28. Address 29_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
VPS_VP0	Setup of a slice start line (Shared by the first field and the second field)	If a slice start line is made into SLI_VS At PAL <The first field> $SLI\_VS = \sum_{n=0}^{8} 2^n VPS\_VPn + 2$ <the second field> $SLI\_VS = \sum_{n=0}^{8} 2^n VPS\_VPn + 315$ At NTSC <The first field> $SLI\_VS = \sum_{n=0}^{8} 2^n VPS\_VPn + 5$ <the second field> $SLI\_VS = \sum_{n=0}^{8} 2^n VPS\_VPn + 268$ The data for 18 lines is stored in Slice RAM from the line set up by this register.	○	○
VPS_VP1			○	○
VPS_VP2			○	○
VPS_VP3			○	○
VPS_VP4			○	○
VPS_VP5			○	○
VPS_VP6			○	○
VPS_VP7			○	○
VPS_VP8			○	○
SLI_GO	Slice ON/OFF control bit	0 Slice OFF 1 Slice ON	○	○
SYNCSEP_ON0	Synchronous separate selection bit	0 Synchronous separate circuit OFF 1 Synchronous separate circuit ON	○	○
STBSYNCSEP	Synchronous separate input control bit	0 SYNCIN analog input 1 SYNCIN digital input	○	○
Reserved bits		Must set to "0."	×	○

29. Address $2A_{16}$ (=DA5 to 0)

DD15							DD8	DD7							DD0
1	0	0	0	0	0	0	0								

Bit symbol	Bit name	Function	R	W
MASK0	Mask width for time bases selection bit.		○	○
MASK1			○	○
MASK2			○	○
MASK3			○	○
MASK4			○	○
MASK5			○	○
MASK6			○	○
MASK7			○	○
Reserved bits		Must set to "0."	×	○
Reserved bit		Must set to "1."	×	○

The position of mask release is set up 256 steps of setup can be performed in one fourth of the periods of the back between 1H

Usually, please make it 80H

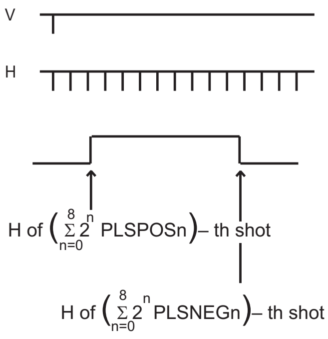
30. Address $2B_{16}$ (=DA5 to 0)

DD15							DD8	DD7							DD0
	0			0	0	0	0	☒	0	0	0	0	0	0	0

Bit symbol	Bit name	Function	R	W
Reserved bits		Must set to "0."	×	○
Nothing is assigned.			×	×
Reserved bits		Must set to "0."	×	○
SEL_PDCH	The internal H selection bit for data slicers	SEL_PDCH SEL_VPSH 0 0 External Hsync 0 1 From PLL for VPS 1 0 From PLL for PDC 1 1 VPS or PDC	○	○
SEL_VPSH			○	○
Reserved bit		Must set to "0."	×	○
SEL_PDEC	The clock selection bit for a PLL lock	0 VPS and a PLL lock from Hsync. 1 VPS and a PLL lock from a X'tal system.	○	○

31. Address $2C_{16}$ (=DA5 to 0)

DD15							DD8	DD7							DD0
1	0	0	0	0	0	0									

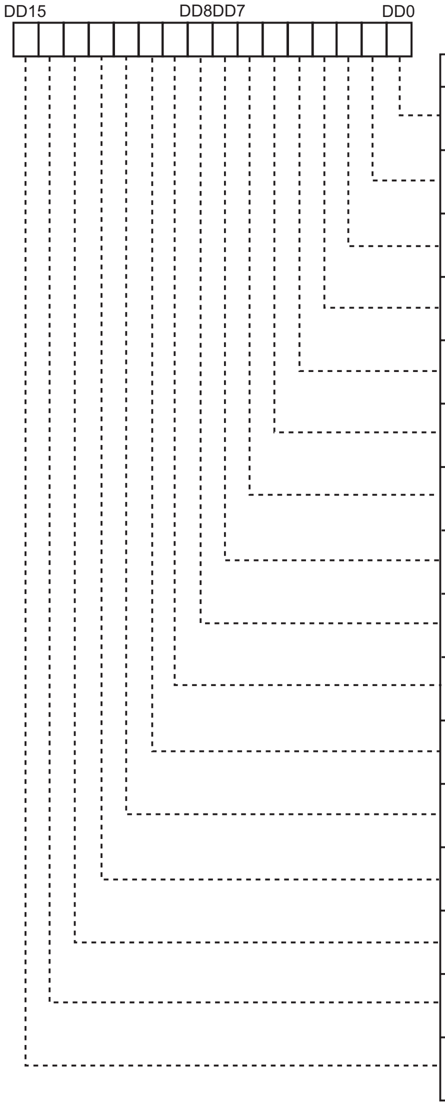
Bit symbol	Bit name	Function	R	W
PLSPOS0	Slice A/D ON period selection bit	Slice A/D ON period is counted. 	○	○
PLSPOS1			○	○
PLSPOS2			○	○
PLSPOS3			○	○
PLSPOS4			○	○
PLSPOS5			○	○
PLSPOS6			○	○
PLSPOS7			○	○
PLSPOS8			○	○
Reserved bits		Must set to "0."	×	○
Reserved bit		Must set to "1."	×	○

32. Address $2D_{16}$ (=DA5 to 0)

DD15							DD8	DD7							DD0
0	0		0	0	0	0									

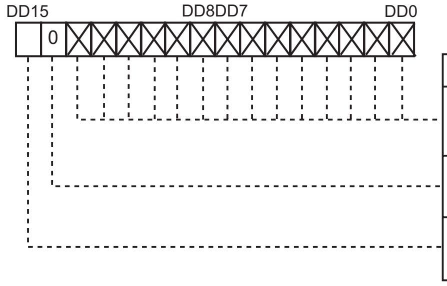
Bit symbol	Bit name	Function	R	W
PLSNEG0	Slice-ON period selection bit	Refer to PLSPOS0 to 8 (Address $2C_{16}$)	○	○
PLSNEG1			○	○
PLSNEG2			○	○
PLSNEG3			○	○
PLSNEG4			○	○
PLSNEG5			○	○
PLSNEG6			○	○
PLSNEG7			○	○
PLSNEG8			○	○
Reserved bits		Must set to "0."	×	○
Reserved bit		Must set to "1" when teletext (PDC) data is acquired.	×	○
Reserved bits		Must set to "0."	×	○

33. Address $2E_{16}$ (=DA5 to 0)



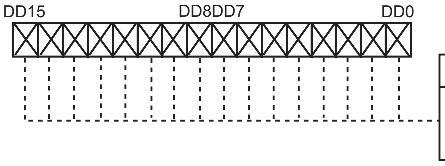
Bit symbol	Bit name	Function	R	W
HCOUNT0	Synchronous detection bit	A horizontal synchronized signal is counted. These bits are reset by set the VERTX bit (address 33_{16}) to "0."	○	×
HCOUNT1			○	×
HCOUNT2			○	×
HCOUNT3			○	×
HCOUNT4			○	×
HCOUNT5			○	×
HCOUNT6			○	×
HCOUNT7			○	×
HCOUNT8			○	×
HCOUNT9			○	×
HCOUNT10			○	×
HCOUNT11			○	×
HCOUNT12			○	×
HCOUNT13			○	×
HCOUNT14			○	×
HCOUNT15			○	×

34. Address $2F_{16}$ (=DA5 to 0)



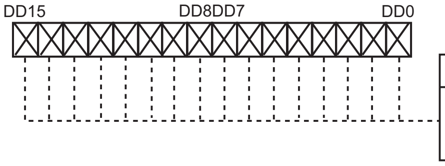
Bit symbol	Bit name	Function	R	W
Nothing is assigned			×	×
	Reserved bit	Set to "0" usually	×	○
STB_RES	Extended register all reset bit	0: Normal 1: It resets to address 00_{16} to the address $2E_{16}$ extended register.	○	○

35. Address 30_{16} (=DA5 to 0)



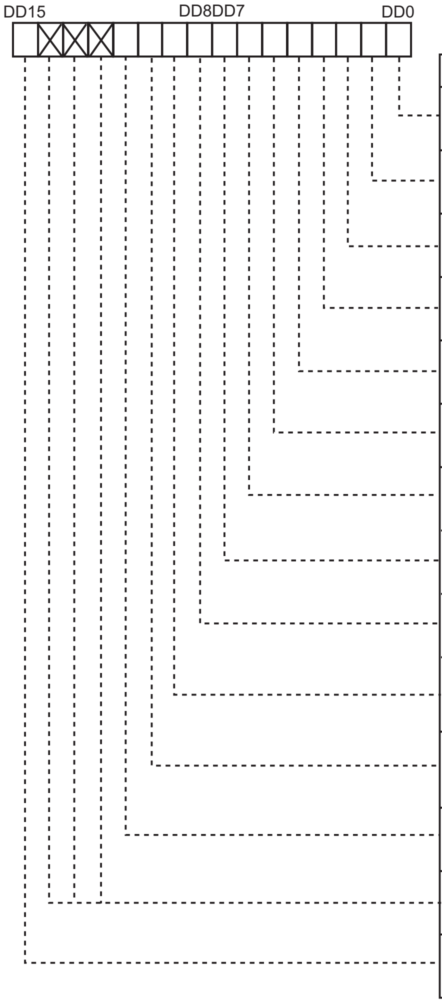
Bit symbol	Bit name	Function	R	W
Nothing is assigned			×	×

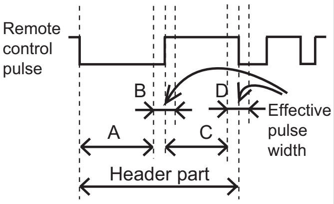
36. Address 31_{16} (=DA5 to 0)



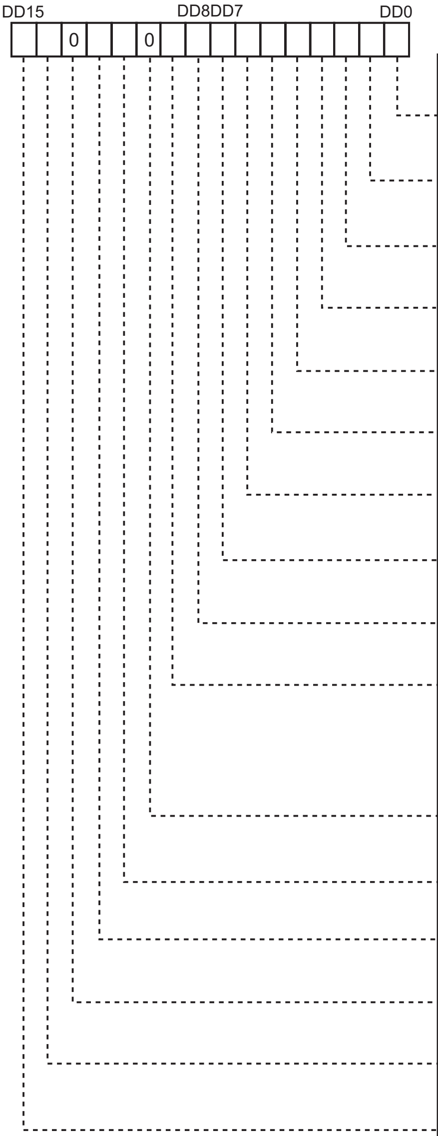
Bit symbol	Bit name	Function	R	W
Nothing is assigned			×	×

37. Address 32_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
RMHTD0(0)	Remote control header length selection bit	In order to detect a remote control pulse in standby mode, the header length to the oscillation for clocks (address 32_{16}) is chosen.  $A = \mathrm{TXCIN} \times \sum_{n=0}^{8} 2^{n}$ RMHTD0(n) $C = \mathrm{TXCIN} \times \sum_{n=0}^{8} 2^{n}$ RMHTD1(n) $B = \mathrm{TXCIN} \times \mathrm{FILDIV0} \times \sum_{n=0}^{5}$ YUKOU0(n) $D = \mathrm{TXCIN} \times \mathrm{FILDIV0} \times \sum_{n=0}^{5}$ YUKOU1(n) TXCIN : XCIN pin input cycle Division value set by FILDIV0 (bit 9 of address 33_{16})	○	○
RMHTD0(1)			○	○
RMHTD0(2)			○	○
RMHTD0(3)			○	○
RMHTD0(4)			○	○
RMHTD0(5)			○	○
RMHTD0(6)			○	○
RMHTD0(7)			○	○
RMHTD0(8)			○	○
JSTCKDIV0	Clock division value of JUST CLOCK filter selection bit.	JSTCKDIV1 / JSTCKDIV0 / Main clock divided value 0 / 0 / 32 divided 0 / 1 / 64 divided 1 / 0 / 128 divided 1 / 1 / 256 divided	○	○
JSTCKDIV1			○	○
JSTCKON	ON/OFF of JUST CLOCK filter selection bit.	0 Filter OFF 1 Filter ON	○	○
Nothing is assigned.			×	×
RMTSEL	Remote control header polarity selection bit	0 No reverse 1 reverse	○	○

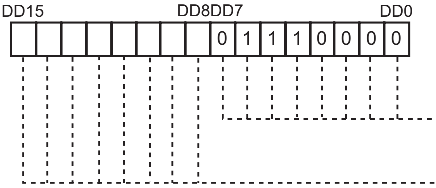
38. Address 33_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
RMHTD1(0)	Remote control header length selection bit	Refer to RMHTD0 (0) to (8) (address 32_{16}).	○	○
RMHTD1(1)			○	○
RMHTD1(2)			○	○
RMHTD1(3)			○	○
RMHTD1(4)			○	○
RMHTD1(5)			○	○
RMHTD1(6)			○	○
RMHTD1(7)			○	○
RMHTD1(8)			○	○
FILDIV0	Clock division value of remote control pulse selection bit	Clock division value for Remote control tolerance period measurement is selected. (Note 1) FILDIV0 : Sub clock divided value 0 : No divided 1 : 2	○	○
Reserved bit		Must set to "0. "	○	○
FILON	Filter ON/OFF of remote control pulse selection bit (Notes 2, 3)	0 OFF 1 ON	○	○
VERTX	Synchronous detection reset bit	0 Reset 1 Horizontal synchronized signal count	○	○
Reserved bit		Must set to "0. "	○	○
FILDIV1(0)	Filter of remote control clock divide value selection bit	FILDIV1(1) / FILDIV1(0) / Sub clock divided value 0 / 0 / 2 0 / 1 / 4 1 / 0 / 8 1 / 1 / 16	○	○
FILDIV1(1)			○	○

Notes 1. Refer to RMHTD0 (0) to (8) (address 32_{16})
Notes 2. Change these bits at initialization and do not rewrite during remote control receive.
Notes 3. The remote control pulse filter is only for the sub clock. Set it to OFF when the sub clock is not mounted.

39. Address 34_{16} (=DA5 to 0)

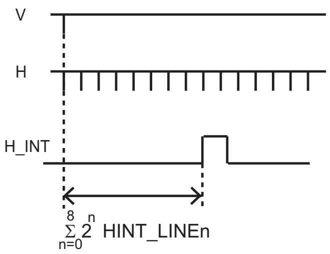


Bit symbol	Bit name	Function	R	W
Reserved bits		Must set to "70_{16}."	×	○
Reserved bits		Must set to "DD_{16}" when EPG-J is acquired. Otherwise, set to "00_{16}."	×	○

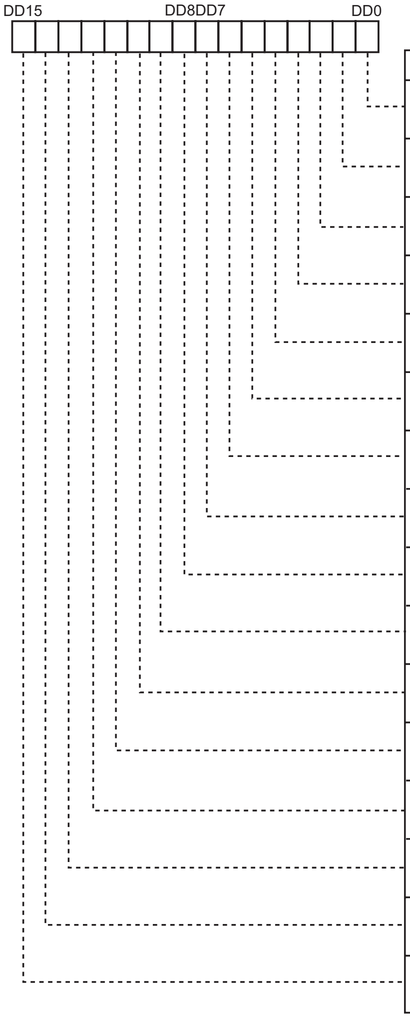
40. Address 35_{16} (=DA5 to 0)

DD15							DD8	DD7							DD0
0	0	0	0	0	0	1	1								

Bit symbol	Bit name	Function	R	W
HINT_LINE0	H_INT interruption position selection bit	A period after V is inputted until H_INT rises is counted.	○	○
HINT_LINE1			○	○
HINT_LINE2			○	○
HINT_LINE3			○	○
HINT_LINE4			○	○
HINT_LINE5			○	○
HINT_LINE6			○	○
HINT_LINE7			○	○
HINT_LINE8			○	○
Reserved bits		Must set to "1."	○	○
Reserved bits		Must set to "0."	×	○
Reserved bit		Must set to "0."	○	○



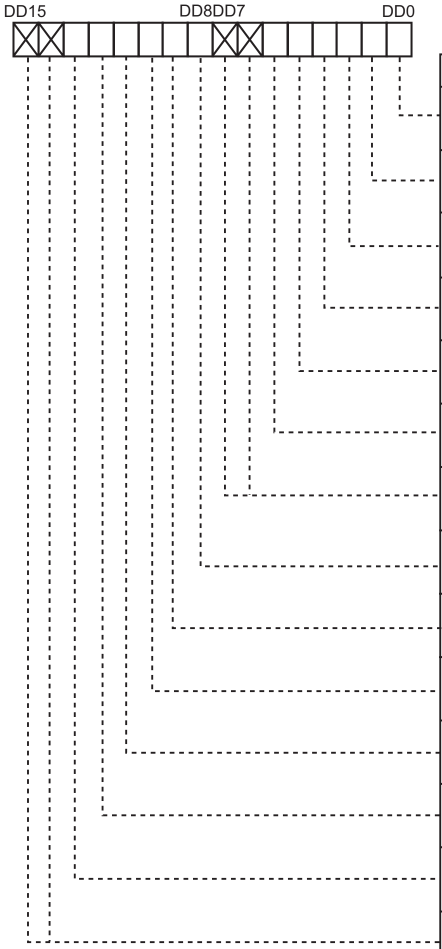
41. Address 36_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
VINT0	SLICEON interruption control test bit	0000 : Interrupt disabled (Note 3) 1011 : Interrupt enabled Others : Do not set up When the period of data acquisition expires, the interrupt occurs by setting these bits to 1011. Set up the TB5IC register (Note 4) when use by “Interrupt enabled.”	○	○
VINT1			○	○
VINT2			○	○
VINT3			○	○
INTRMT0	Remote control interruption control bit (Note 1)	0000 : Interrupt disabled (Note 3) 1010 : Interrupt enabled Others : Do not set up Set up the TB4IC register (Note 4) when use by “Interrupt enabled.”	○	○
INTRMT1			○	○
INTRMT2			○	○
INTRMT3			○	○
HINT0	HINT interruption control test bit (Note 2)	0000 : Interrupt disabled (Note 3) 1001 : Interrupt enabled Others : Do not set up Set up the TB3IC register (Note 4) when use by “Interrupt enabled.”	○	○
HINT1			○	○
HINT2			○	○
HINT3			○	○
SECINT0	Clock timer interruption control bit	0000 : Interrupt disabled (Note 3) 1000 : Interrupt enabled (Note 5) Others : Do not set up Set up the TB2IC register (Note 4) when use by “Interrupt enabled.”	○	○
SECINT1			○	○
SECINT2			○	○
SECINT3			○	○

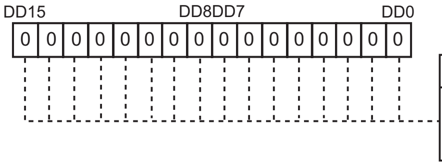
Notes 1. Refer to 15.6 Expansion Register Construction Composition.
Notes 2. Refer to the function of HINT_LINEn (Address 35_{16}.)
Notes 3. Set these bits to 0000 when use the interrupt of Timer B2, Timer B3, Timer B4, or Timer B5.
Notes 4. Refer to Figure 6.3 Interrupt Control Registers.
Notes 5. When the second counter (Address 39_{16}) is changed, an interrupt is generated every 1 second.
Notes 6. Please do not change data after setting initial data to address 36_{16} corresponding interrupt control bit VINTi, INTRMTi, HINTi, and SECINTi (i = 0 to 3) when you use the SLICEON, remote control, HINT, and the clock timer interrupt.

42. Address 37_{16} (=DA5 to 0)



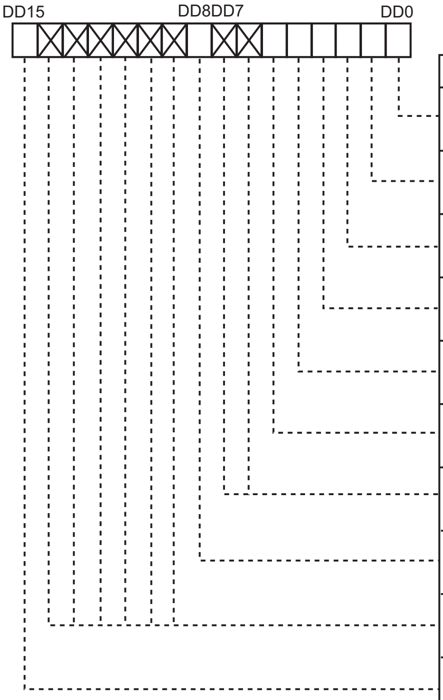
Bit symbol	Bit name	Function	R	W
YUKOU0(0)	Remote control header judging pulse length selection bit 0	Refer to RMTHD0(0) to (8) (Address 32_{16})	○	○
YUKOU0(1)			○	○
YUKOU0(2)			○	○
YUKOU0(3)			○	○
YUKOU0(4)			○	○
YUKOU0(5)			○	○
Nothing is assigned.			×	×
YUKOU1(0)	Remote control header judging pulse length selection bit 1	Refer to RMTHD0(0) to (8) (Address 32_{16})	○	○
YUKOU1(1)			○	○
YUKOU1(2)			○	○
YUKOU1(3)			○	○
YUKOU1(4)			○	○
YUKOU1(5)			○	○
Nothing is assigned.			×	×

43. Address 38_{16} (=DA5 to 0)\



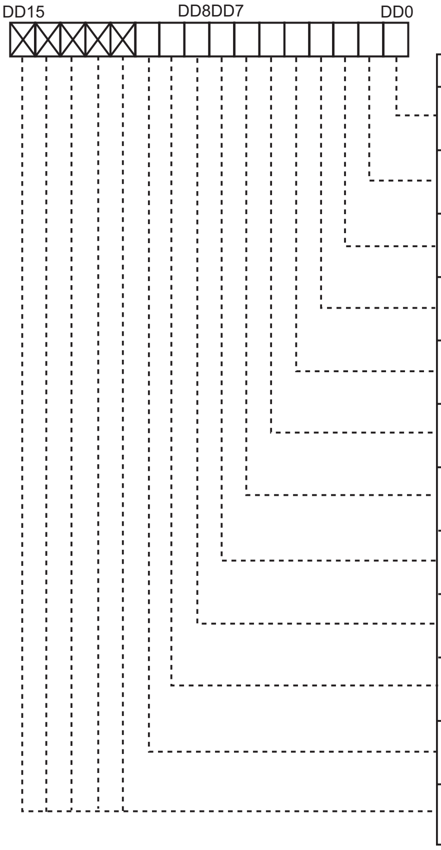
Bit symbol	Bit name	Function	R	W
Reserved bit		Must set to "0."	○	○

44. Address 39_{16} (=DA5 to 0)



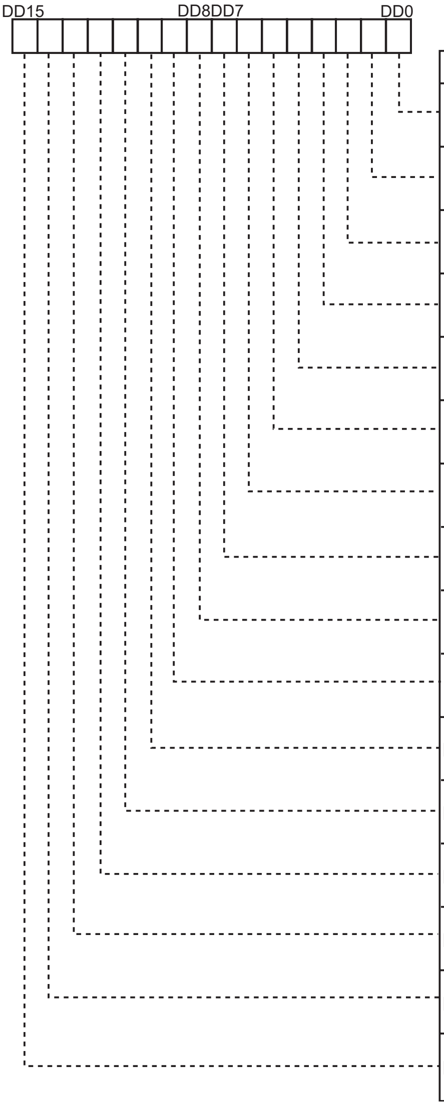
Bit symbol	Bit name	Function	R	W
SECOUT0	Clock Timer Second Setting Bit	Set seconds (0 to 59 seconds) of clock timer. The settable values are 0 to 59.	○	○
SECOUT1			○	○
SECOUT2			○	○
SECOUT3			○	○
SECOUT4			○	○
SECOUT5			○	○
Nothing is assigned.			×	×
RTCON	Clock Timer Operation Selection Bit	0 Clock timer stops 1 Clock timer operates	○	○
Nothing is assigned.			×	×
SECJUST	Second Just Setting Bit	When writing "1", less than second of the clock timer is reset. When reading, the value is "0".	×	○

45. Address $3A_{16}$ (=DA5 to 0)



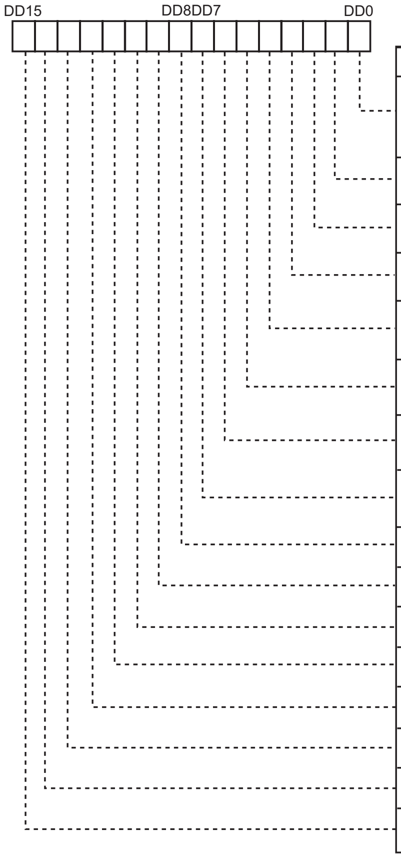
Bit symbol	Bit name	Function	R	W
MINOUT0	Clock Timer Minute Setting Bit	Set hours and minutes of the clock timer by the minute. The settable values are 0 to 1439 (00:00 to 23:59)	○	○
MINOUT1			○	○
MINOUT2			○	○
MINOUT3			○	○
MINOUT4			○	○
MINOUT5			○	○
MINOUT6			○	○
MINOUT7			○	○
MINOUT8			○	○
MINOUT9			○	○
MINOUT10			○	○
Nothing is assigned.			×	×

46. Address $3B_{16}$ (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
DAYCUONT0	Clock Timer Day Setting Bit	Set days of the clock timer. The settable value are 0 to 65535.	○	○
DAYCUONT1			○	○
DAYCUONT2			○	○
DAYCUONT3			○	○
DAYCUONT4			○	○
DAYCUONT5			○	○
DAYCUONT6			○	○
DAYCUONT7			○	○
DAYCUONT8			○	○
DAYCUONT9			○	○
DAYCUONT10			○	○
DAYCUONT11			○	○
DAYCUONT12			○	○
DAYCUONT13			○	○
DAYCUONT14			○	○
DAYCUONT15			○	○

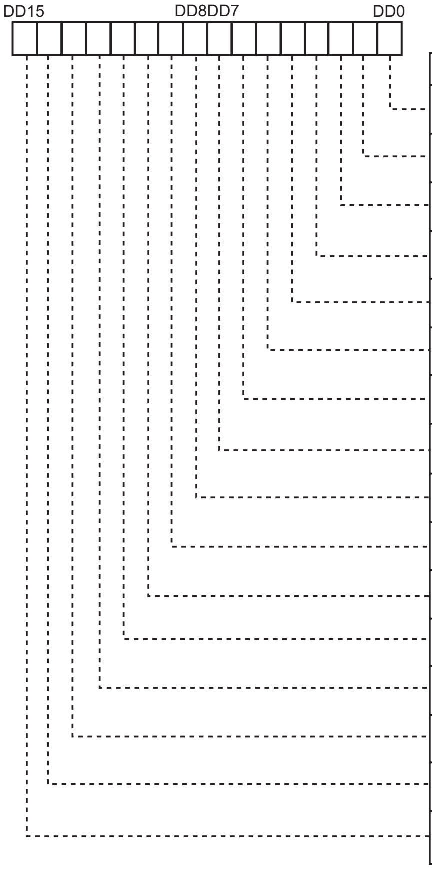
47. Address $3C_{16}$ (=DA5 to 0) (Note 1)



Bit symbol	Bit name	Function	R	W
RMTSTART	Remote control transmission start bit	Start and the stop of wave form output is selected. 0: Stop 1: Start	○	○
IRPOL(0)	Carrier selection bit	The output mode of remote control transmission wave form is selected. 000: External wave, Carrier and AND output. 010: External wave, Carrier and OR output. 101: Only external wave is output (carrier none.) Additionally: Setting prohibition.	○	○
IRPOL(1)				
IRPOL(2)				
RMCDIV(0)	Carrier clock source selection bit	Carrier's clock source is selected. 00: The main clock (There is not dividing frequency.) 01: 2.5 dividing of the main clock. 10: 8 dividing of the main clock. 11: Setting prohibition.	○	○
RMCDIV(1)				
RMTDIV(0)	External wave clock source selection bit	The clock source of external wave is selected. 00: The main clock (There is not dividing frequency.) 01: 8 dividing of the main clock. 10: 64 dividing of the main clock. 11: 256 dividing of the main clock.	○	○
RMTDIV(1)				
RMT_TM(0)	External wave clock dividing frequency value setting bit	Dividing frequency value which is selected by RMTDIV(1, 0) Set RMT_TM. RMT_TM = $\sum_{n=0}^{7} 2^n \cdot$ RMT_TM0(n)	○	○
RMT_TM(1)				
RMT_TM(2)				
RMT_TM(3)				
RMT_TM(4)				
RMT_TM(5)				
RMT_TM(6)				
RMT_TM(7)				

Note 1. Refer to 14.6 "(6) Remote control transmission function."

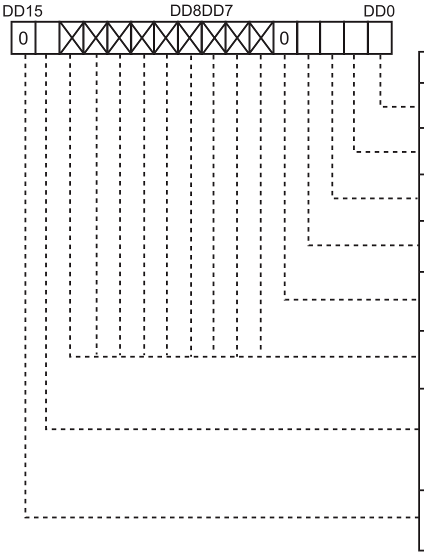
48. Address $3D_{16}$ (=DA5 to 0) (Note 1)



Bit symbol	Bit name	Function	R	W
RMT_TML(0)	Carrier L period setting bit	Carrier's L period is set. RMT_TML = $\sum_{n=0}^{7} 2^n \cdot$ RMT_TML(n)	○	○
RMT_TML(1)				
RMT_TML(2)				
RMT_TML(3)				
RMT_TML(4)				
RMT_TML(5)				
RMT_TML(6)				
RMT_TML(7)				
RMT_TMH(0)	Carrier H period setting bit	Carrier's H period is set. RMT_TMH = $\sum_{n=0}^{7} 2^n \cdot$ RMT_TMH(n)	○	○
RMT_TMH(1)				
RMT_TMH(2)				
RMT_TMH(3)				
RMT_TMH(4)				
RMT_TMH(5)				
RMT_TMH(6)				
RMT_TMH(7)				

Note 1. Refer to 14.6 "(6) Remote control transmission function."

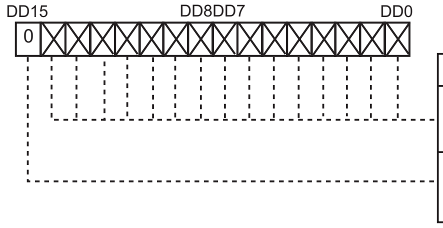
49. Address $3E_{16}$ (=DA5 to 0) (Note 1)



Bit symbol	Bit name	Function	R	W
RMTTXINT(0)	Remote control transmission interrupt control (Note 1, Note 4)	0000: Interrupt prohibition (Note 2) 0001: Interrupt permission Additionally: Setting prohibition Please set INT2IC register when using it by "Interrupt permission."	○	○
RMTTXINT(1)				
RMTTXINT(2)				
RMTTXINT(3)				
Reserved bit		Must set to "0."	×	○
Nothing is assigned.			×	×
IROUT_SLICEON	P8$_4$ output signal selection bit 2 (Note 3)	0: Normal setting (When use P8$_4$ I/O port or INT2 interrupt.) 1: Remote control transmission pulse output	○	○
Reserved bit		Must set to "0."	×	○

Notes 1. Refer to 14.6 "(6) Remote control transmission function."
Notes 2. Set and use 0000_2 when use INT2 interrupt.
Notes 3. Set "1" to bit b4 of port P8 direction register when use the remote control transmission function.
Notes 4. Please do not change data after setting the initialization data to remote control transmission interrupt control bit RMTTXINT(i) (i = 0 to 3) when you use the remote control transmission interrupt.

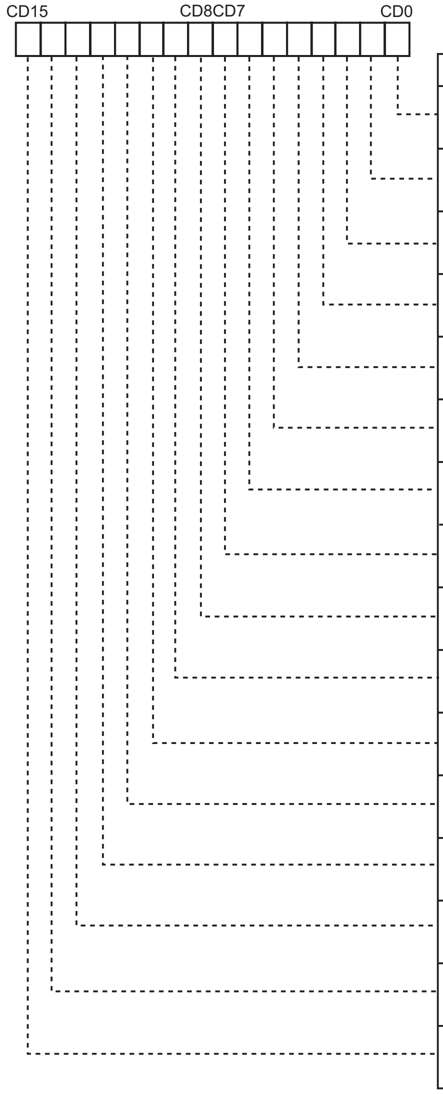
50. Address 3F$_{16}$ (=DA5 to 0) (Note 1)



Bit symbol	Bit name	Function	R	W
Nothing is assigned.			×	×
Reserved bit		Must set to "0."	×	○

Note 1. Refer to 14.6 "(6) Remote control transmission function."

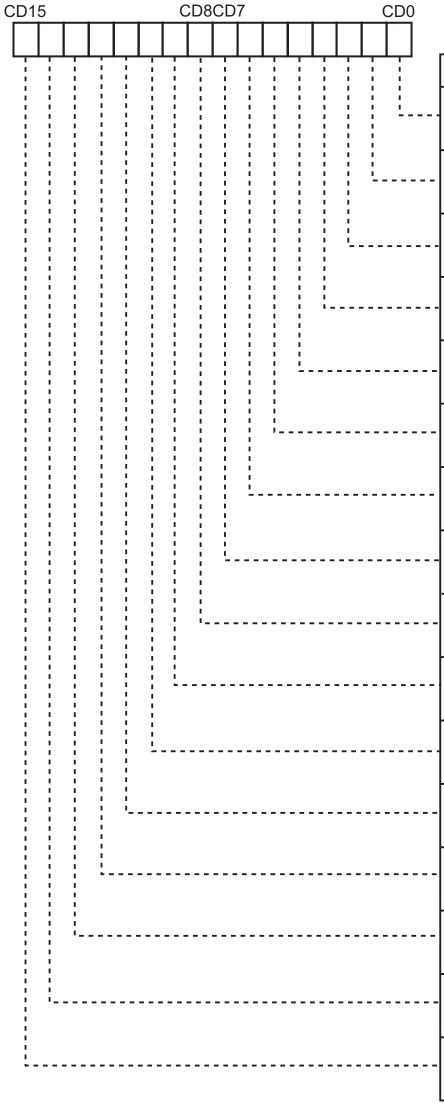
51. Address 40$_{16}$ (=DA5 to 0)



Bit symbol	Bit mane	Function	R	W
FPLS_MIN0	Fixed length pulse lower bound value setting bit	The fixed length pulse lower bound value is set. (note 1)	○	○
FPLS_MIN1			○	○
FPLS_MIN2			○	○
FPLS_MIN3			○	○
FPLS_MIN4			○	○
FPLS_MIN5			○	○
FPLS_MIN6			○	○
FPLS_MIN7			○	○
FPLS_MAX0	Fixed length pulse upper bound value setting bit	The fixed length pulse upper bound value is set. (note 1)	○	○
FPLS_MAX1			○	○
FPLS_MAX2			○	○
FPLS_MAX3			○	○
FPLS_MAX4			○	○
FPLS_MAX5			○	○
FPLS_MAX6			○	○
FPLS_MAX7			○	○

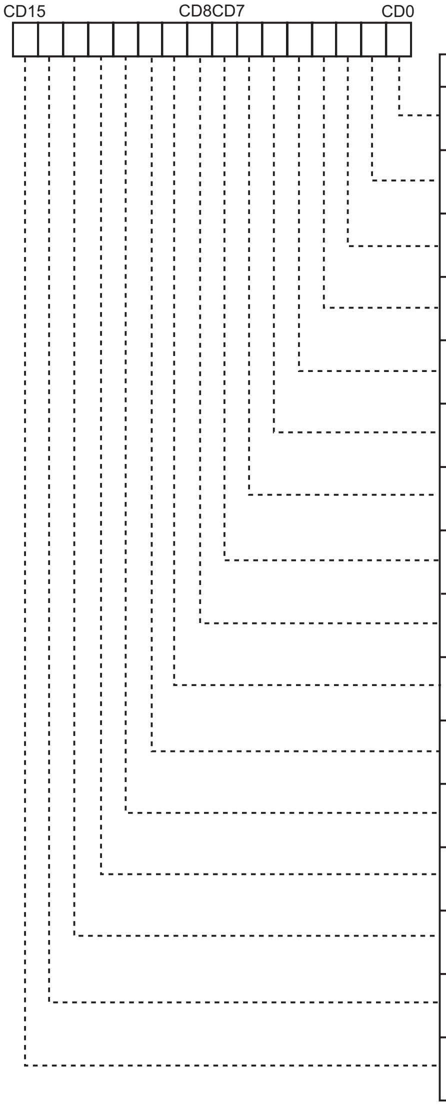
*Note 1: The fixed value pulse is a pulse ("H" or "L" part) where 0/1 is not judged. It does according to enhancing register VBITPOL (Address 43$_{16}$ and bit 13) at H period of 0/1 judgments or it does at L period or it selects it.

52. Address 41_{16} (=DA5 to 0)



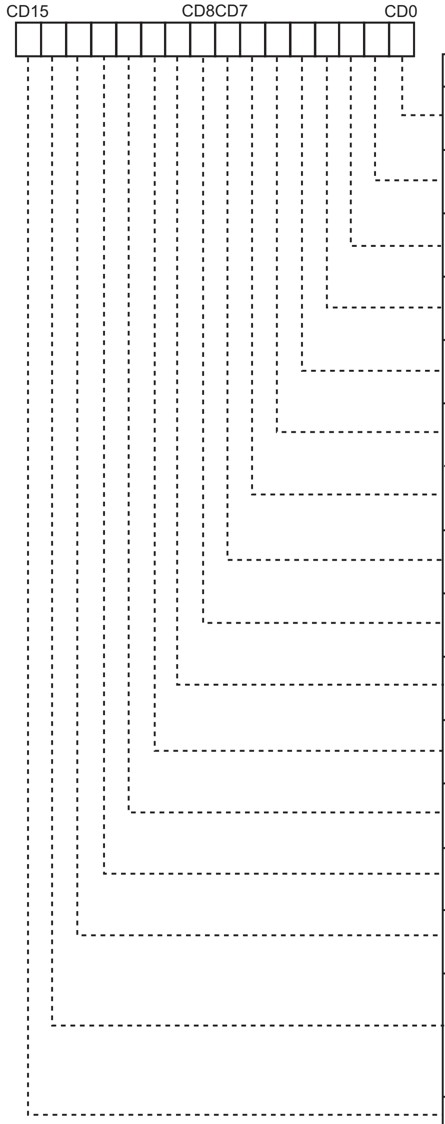
Bit symbol	Bit name	Function	R	W
DT0_MIN0	"0" data pulse length lower bound value setting bit	"0" data pulse length lower bound value is set.	○	○
DT0_MIN1			○	○
DT0_MIN2			○	○
DT0_MIN3			○	○
DT0_MIN4			○	○
DT0_MIN5			○	○
DT0_MIN6			○	○
DT0_MIN7			○	○
DT0_MAX0	"0" data pulse elder limit value setting bit	"0" data pulse elder limit value is set	○	○
DT0_MAX1			○	○
DT0_MAX2			○	○
DT0_MAX3			○	○
DT0_MAX4			○	○
DT0_MAX5			○	○
DT0_MAX6			○	○
DT0_MAX7			○	○

53. Address 42_{16} (=DA5 to 0)



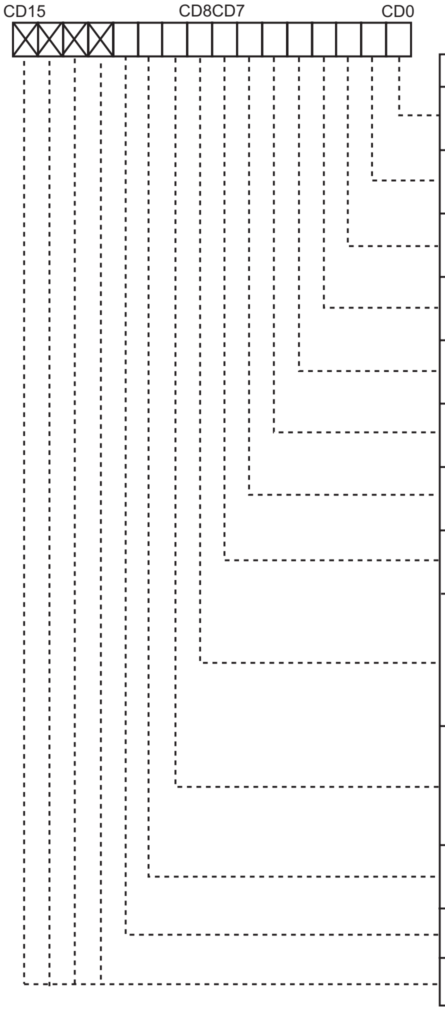
Bit symbol	Bit name	Function	R	W
DT1_MIN0	"1" data pulse length lower bound value setting bit	"1" data pulse length lower bound value is set.	○	○
DT1_MIN1			○	○
DT1_MIN2			○	○
DT1_MIN3			○	○
DT1_MIN4			○	○
DT1_MIN5			○	○
DT1_MIN6			○	○
DT1_MIN7			○	○
DT1_MAX0	"1" data pulse elder limit value setting bit	"1" data pulse elder limit value is set.	○	○
DT1_MAX1			○	○
DT1_MAX2			○	○
DT1_MAX3			○	○
DT1_MAX4			○	○
DT1_MAX5			○	○
DT1_MAX6			○	○
DT1_MAX7			○	○

54. Address 43_{16} (=DA5 to 0)



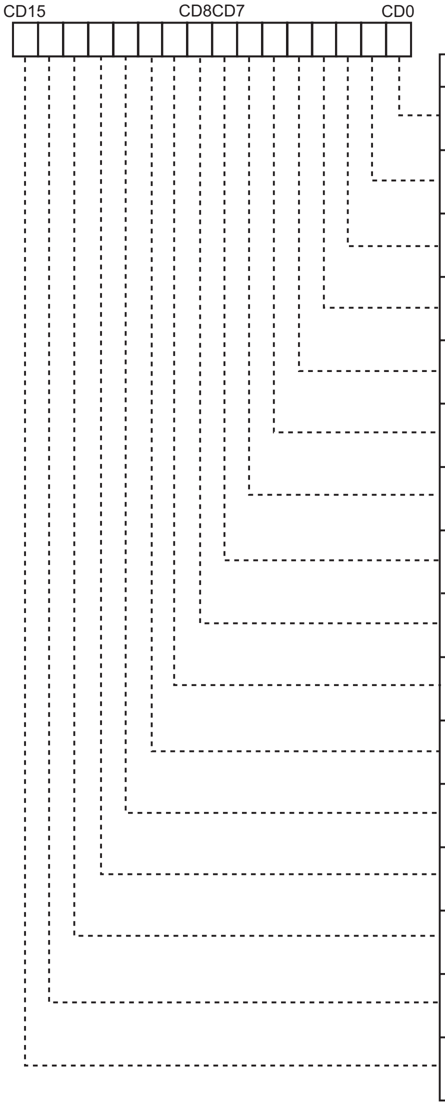
Bit symbol	Bit name	Function	R	W
MAXBIT0	The maximum reception bit number setting bit	The number of maximum reception bits is set.	○	○
MAXBIT1			○	○
MAXBIT2			○	○
MAXBIT3			○	○
MAXBIT4			○	○
MAXBIT5			○	○
MINBIT0	Minimum reception bit number setting bit	The number of minimum reception bits is set.	○	○
MINBIT1			○	○
MINBIT2			○	○
MINBIT3			○	○
MINBIT4			○	○
MINBIT5			○	○
RMTLSB	LSB/MSB reception selection bit	0:It receives it with MSB. 1:It receives it with LSB.	○	○
VBITPOL	0/1 judgment level selection bit	0:0/1 is judged at L period. 1:0/1 is judged at H period.	○	○
INTSEL	Interrupt selection bit	0:After it matches it, interrupt is generated. 1:When a reception of the data of the 16th bit and the maximum data are received, interrupt is generated	○	○
GET_DATA	Bit that takes data	1:When "1" is written from the reception buffer in the reception register, the data of the reception buffer is written in the reception register. (The value when reading it is 0.)	×	○

55. Address 44_{16} (=DA5 to 0)



Bit symbol	Bit name	Function	R	W
DATAOL0 DATAOL1 DATAOL2 DATAOL3 DATAOL4 DATAOL5	Number of receive data bits	The number of bits of received data is displayed.	○	×
NU0 NU1	Number of receive data words	16 piece nbit data was received. (n=0,1,2)	○	×
INTRMTFL0	One word reception completion flag	The reception completion of 0/1 data for one word (16 bits) is shown. 0:The data of the 16th bit is not received. 1:The data of the 16th bit was received	○	×
INTRMTFL1	Flag that received data of number of maximum bits	0:The data of the number of maximum bits was not received. 1:The data of the number of maximum bits was received	○	×
INTRMTFL2	Flag that received the data everything	0:Everything did not receive the data. 1:Everything received the data.	○	×
NG	NG flag bit of reception	1:There was NG while receiving it.	○	×
Nothing is assigned.			×	×

56. Address 45$_{16}$ (=DA5 to 0)

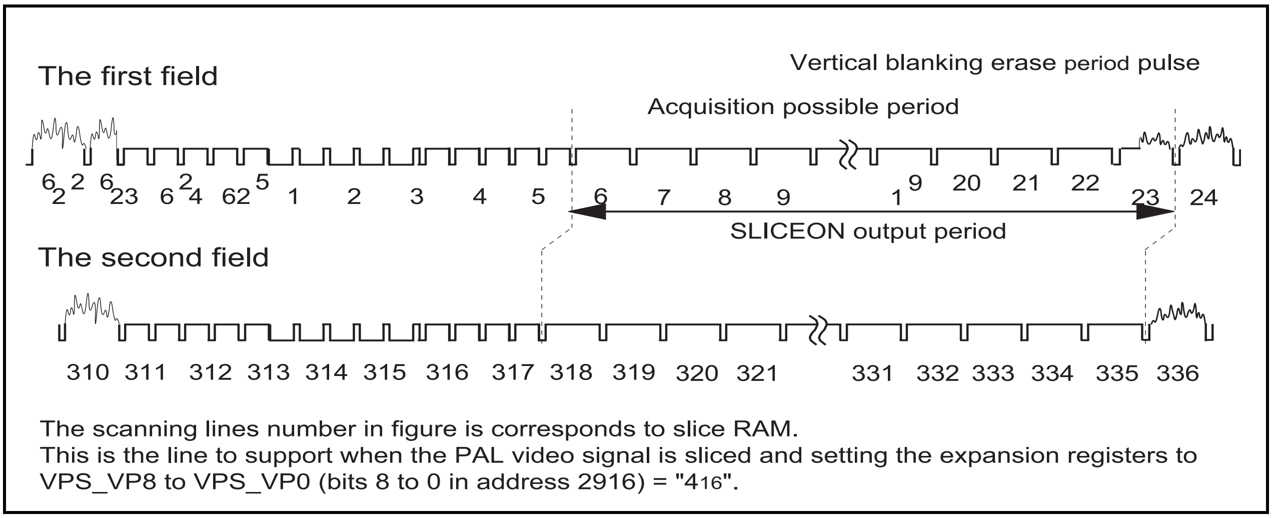


Bit symbol	Bit name	Function	R	W
RMTDA0	Reception register	The received data ("H" data 0/1 judgments by the period of "L") is stored.	○	×
RMTDA1			○	×
RMTDA2			○	×
RMTDA3			○	×
RMTDA4			○	×
RMTDA5			○	×
RMTDA6			○	×
RMTDA7			○	×
RMTDA8			○	×
RMTDA9			○	×
RMTDA10			○	×
RMTDA11			○	×
RMTDA12			○	×
RMTDA13			○	×
RMTDA14			○	×
RMTDA15			○	×

14.6 Expansion Register Construction Composition

(1) Acquisition timing

The SLICEON signal is output in the acquisition possible period.

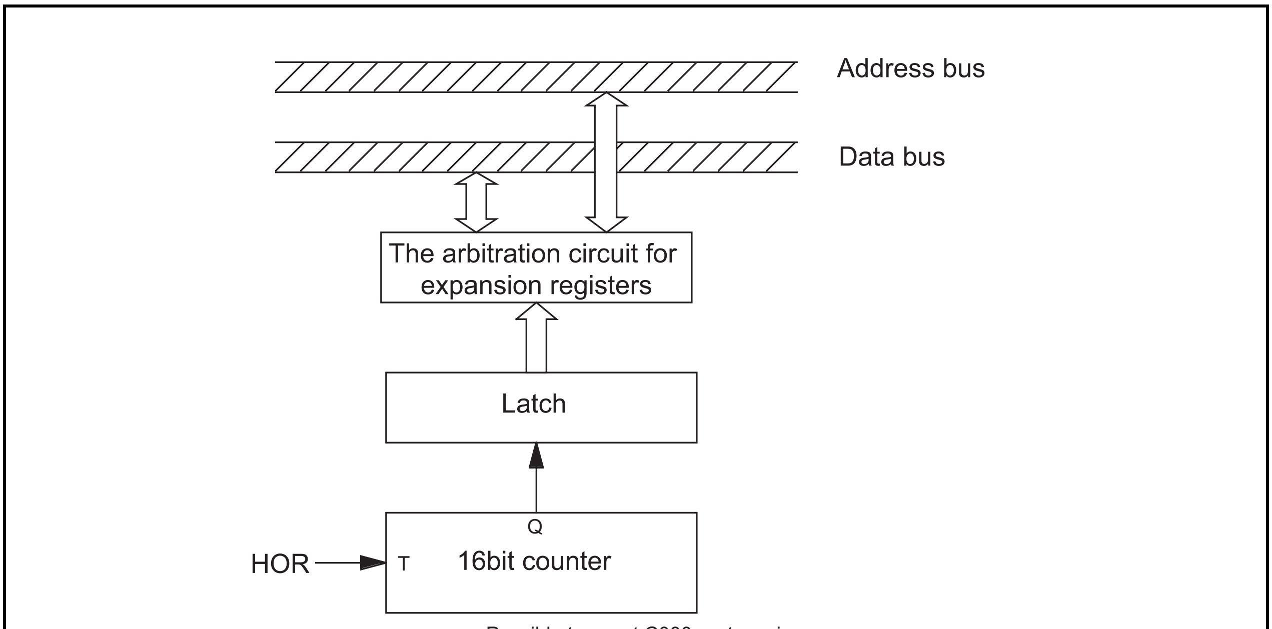


The scanning lines number in figure is corresponds to slice RAM.
This is the line to support when the PAL video signal is sliced and setting the expansion registers to VPS_VP8 to VPS_VP0 (bits 8 to 0 in address 29_{16}) = "4_{16}".

Figure 14.11 Expansion register access registers composition

(2) Synchronized signal detection circuit

The number of pulses of the horizontal synchronized signal of a compound video signal is counted during a fixed period. The horizontal synchronous number of pulses can always be read from an expansion register.
A block diagram is shown in Figure. 14.12.



Possible to count $C000_{16}$ at maximum.

Figure 14.12 Block diagram of Synchronized detection circuit

(3) Register related to Slicer

The relation between V, H signal, and the register related to slicer is shown in Figure. 14.13 and Figure. 14.14.

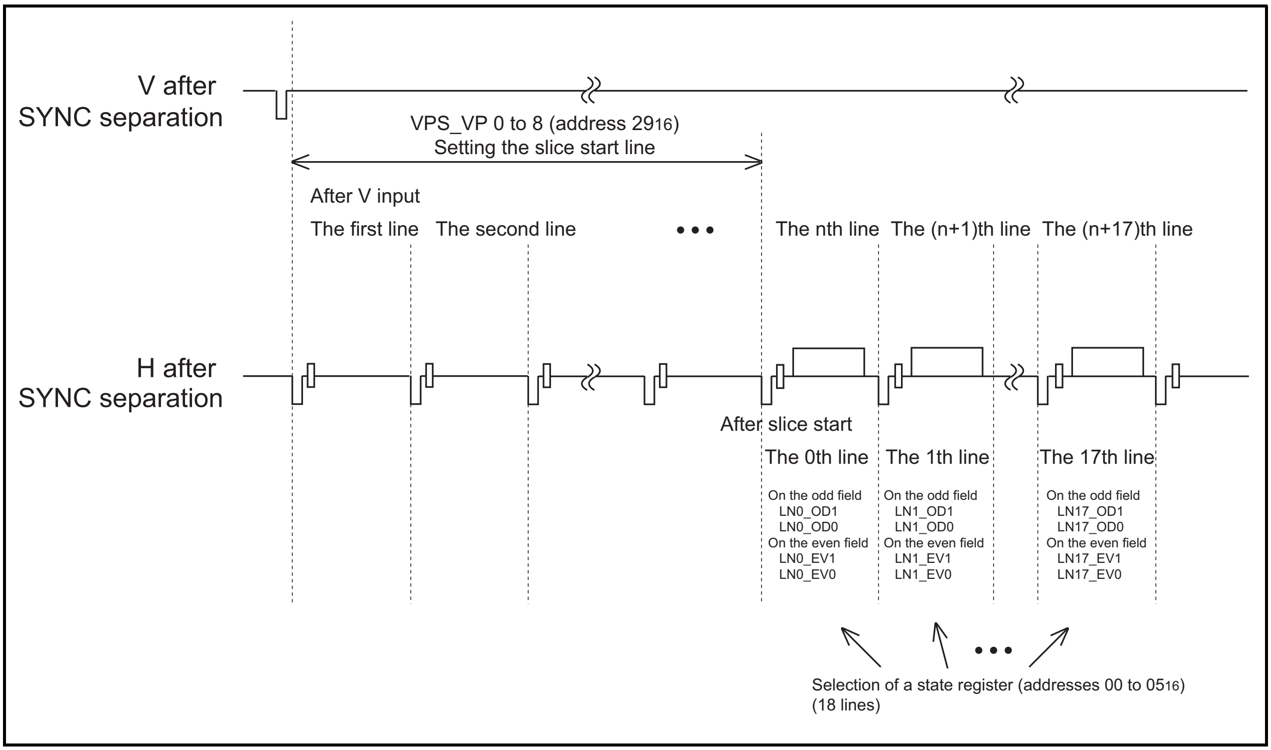


Figure 14.13 Register related to slicer (1)

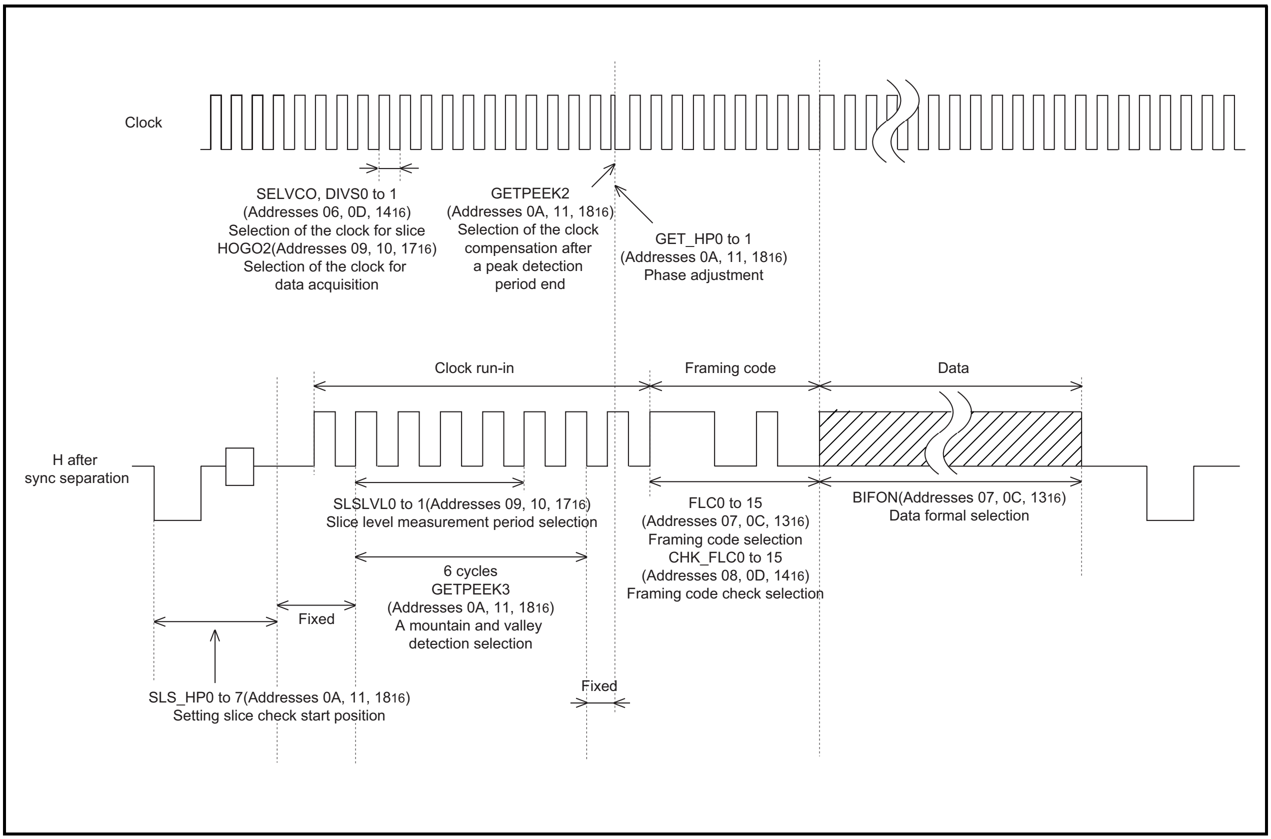


Figure 14.14 Register related to slicer (2)

(4) Remote control pattern recognition

Pattern matching of remote control is performed using a sub clock oscillation. Remote control input is input from RMTIN terminal. Interruption is generated when pattern matching is in agreement.

4 times match noise filter is being included, in front of the pattern matching circuit. A block diagram is shown in Figure 14.15.

The example of a waveform of pattern matching is shown in Figure.14.16. The flow of pattern matching is shown in Figure.14.17.

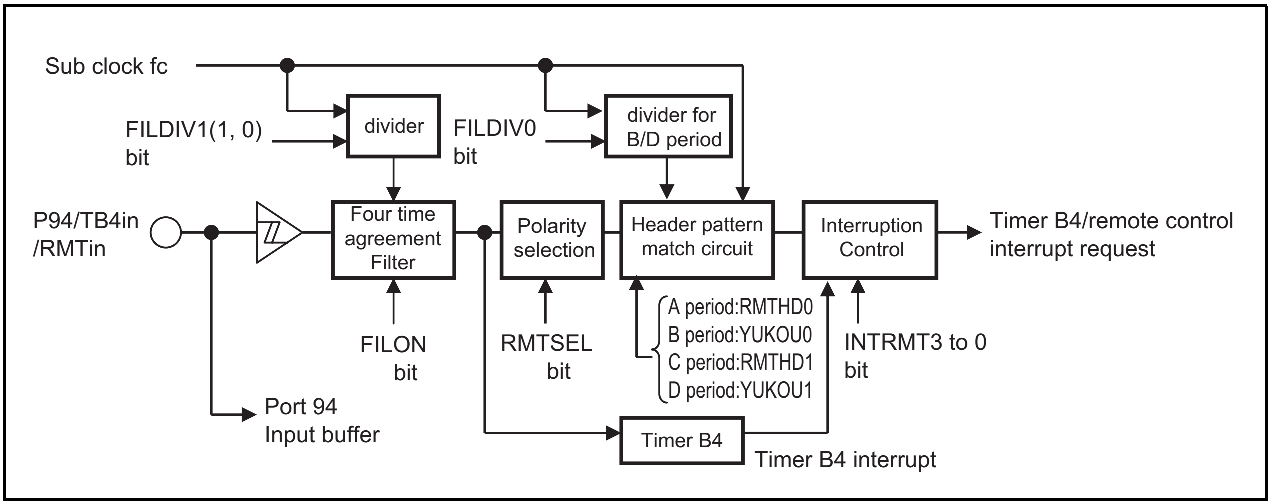
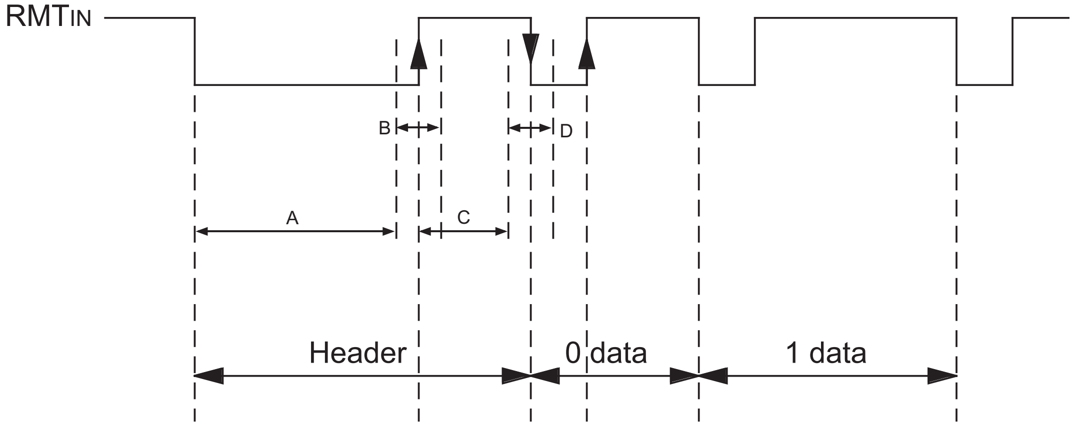


Figure 14.15 Remote control pattern recognition block diagram



		The number of registers	At maximum check time
A	"L" check programmable	9 bit	15.6 ms
B	Check of a rising edge	6 bit	3.8 ms (Note 2)
C	"H" check programmable	9 bit	15.6 ms
D	Check of a falling edge	6 bit	3.8 ms (Note 2)

Note 1. 1bit unit 32.768kHz (a part for one clock)
Note 2. The maximum check period of B and D is the values when enhancing register FILDIV0 (Address 33_{16}) is set to "1".

Figure 14.16 Example of waveform of pattern matching

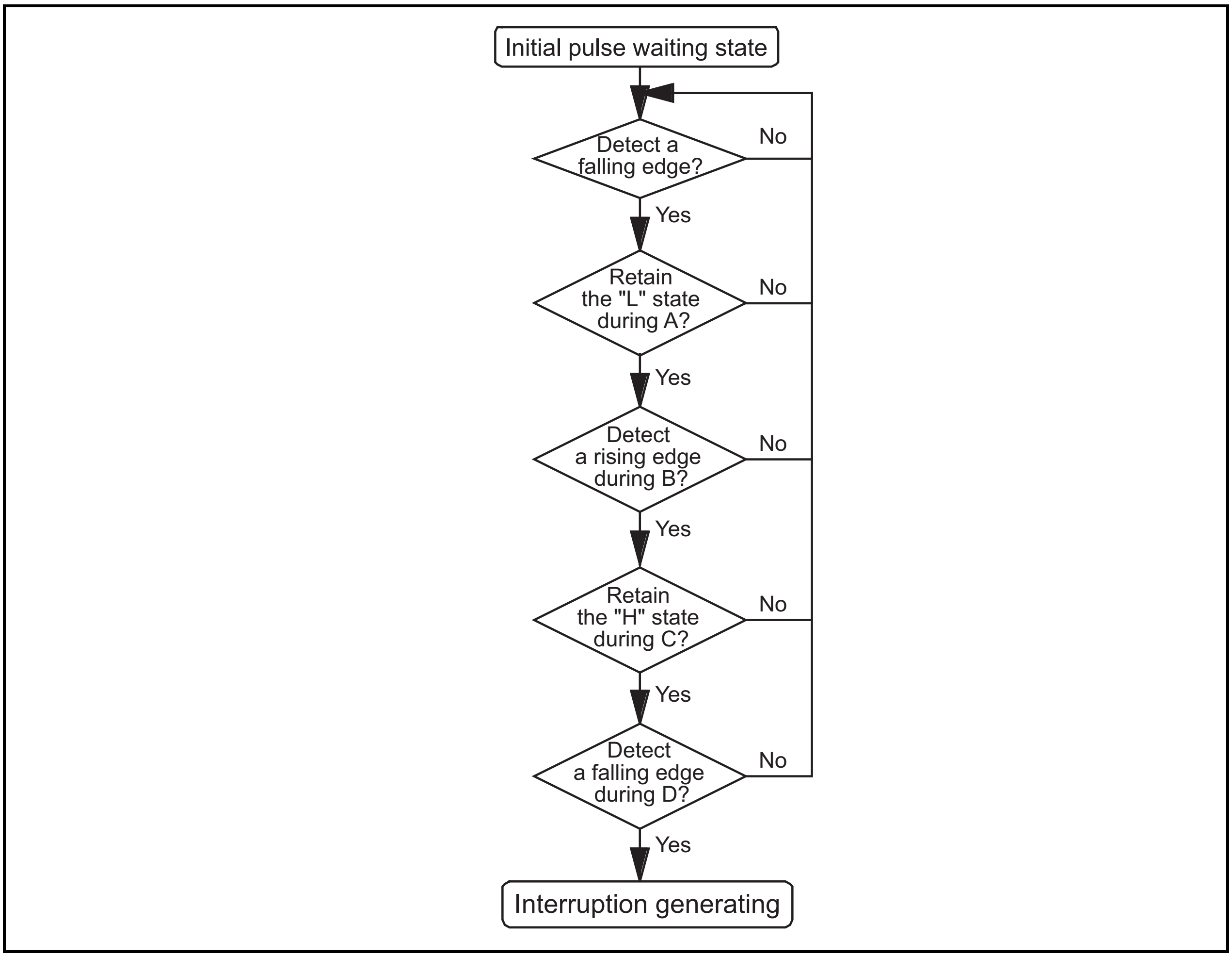


Figure 14.17 Flow of pattern matching

4 times match process operation

This is a 4 times match digital filter using the sub clock oscillation. The input signal of the RMTin pin is sampled 4 times and the output level will change only when the level matches 4 times. When using this filter, set the FILON bit (bit11) in the expansion register 33H to "1". The signal after passing 4 times match filter is applied to the header pattern matching circuit and timer B4 at filter ON. The sampling rate can be changed by the FILDIV1 (1, 0) bit in the expansion register 33H. Refer to the FILDIV1 bit of the expansion register 33H function description for details. The input signal is through supplied to the latter circuit at filter OFF. (no clock delay).Since this filter operates only with the sub clock and cannot be used for the main clock, set the filter to OFF (FILON bit ="0") when the sub clock is not mounted.

(5) Clock timer function

The sub clock is selected as the count source and the clock timer can set and read the count value every day, minute and second. It has the following functions.

Clock function

1.This timer is dedicated clock function which is independent from timer A and timer B.
2.The settable ranges of day, minute and second are 0 to 65535 days, 0 to 1439 minutes and 0 to 59 seconds.
3.Second just setting is available (reset the count value of less than second).

1 second interrupt

1.The interrupt request is generated when second of the clock timer is incremented.
(The interrupt request is not generated at the second just setting.)

(6) Remote control transmission function

The career is synthesized to two kinds of pulses of external wave, and the remote control transmission circuit is output from the microcomputer pin.

The specification of the remote control transmitter is shown in Table 14.5, The remote control transmission circuit output wave form is shown in Figure 14.18, and The remote control transmission circuit block chart is shown in Figure 14.19.

The feature is shown below.

- Career is a continuous pulse of the arbitrary width obtained by dividing the main clock (Figure 14.18 Wave forms 2 and 3.)
- External wave is a shape of waves generated from the transmission data buffer with reading pin output value ("H"/"L") and the pulse width one by one (Figure 14.18 Wave form 4.)
- The shape of waves that can synthesize the career to external wave is output from the pin (Figure 14.18 Wave form 5.)

Table 14.5 Specification of remote control transmission function

Item	Specifications
Count source	Carrier: Selection from f1 (There is not XIN dividing frequency), f2.5 (XIN 2.5 dividing frequency), and f8 (XIN 8 dividing frequency.) External wave: Selection from f1 (There is not XIN dividing frequency), f8 (XIN 8 dividing frequency), f64 (XIN 64 dividing frequency), and f256 (XIN 256 dividing frequency.)
Count operation (carrier)	● Down count ● The register for “H” width setting is read by standing up about the pulse, and it continues the count. ● The register for “L” width setting is read by standing up about the pulse, and it continues the count.
Comparing of dividing frequency (carrier)	● “H” period and “L” period are 1 to 256.
Count operation (external wave)	● Down count ● Wave form output value (“H”/“L”) and the count value are read from the remote control transmission data buffer with stand up/fall down of the pulse, and the port output and the count are continued.
Comparing of dividing frequency (external wave)	1 to 16384 (14bit)
Start of counting condition	The remote control transmission start bit is set to “1.”
Count stop condition	● The remote control transmission start bit is set to “0.” ● After the untransmission data number reference bit is empty and the count value is underflow
Interrupt generation timing	● When external wave stand up/fall down (When the value of the interrupt setting bit read from the remote control transmission data buffer is only 1.)
Remote control transmission mode	● OR output of career and external wave ● Only external wave is output (carrier none.)

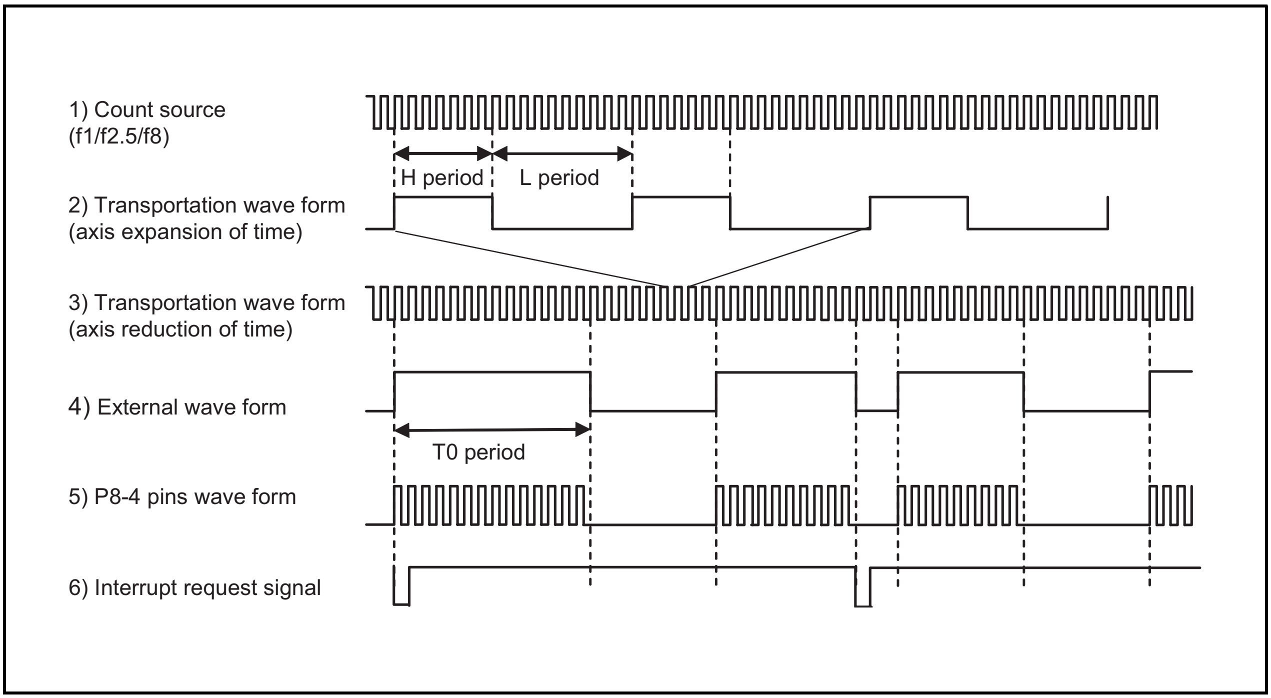


Figure 14.18 Remote control transmission circuit output wave form

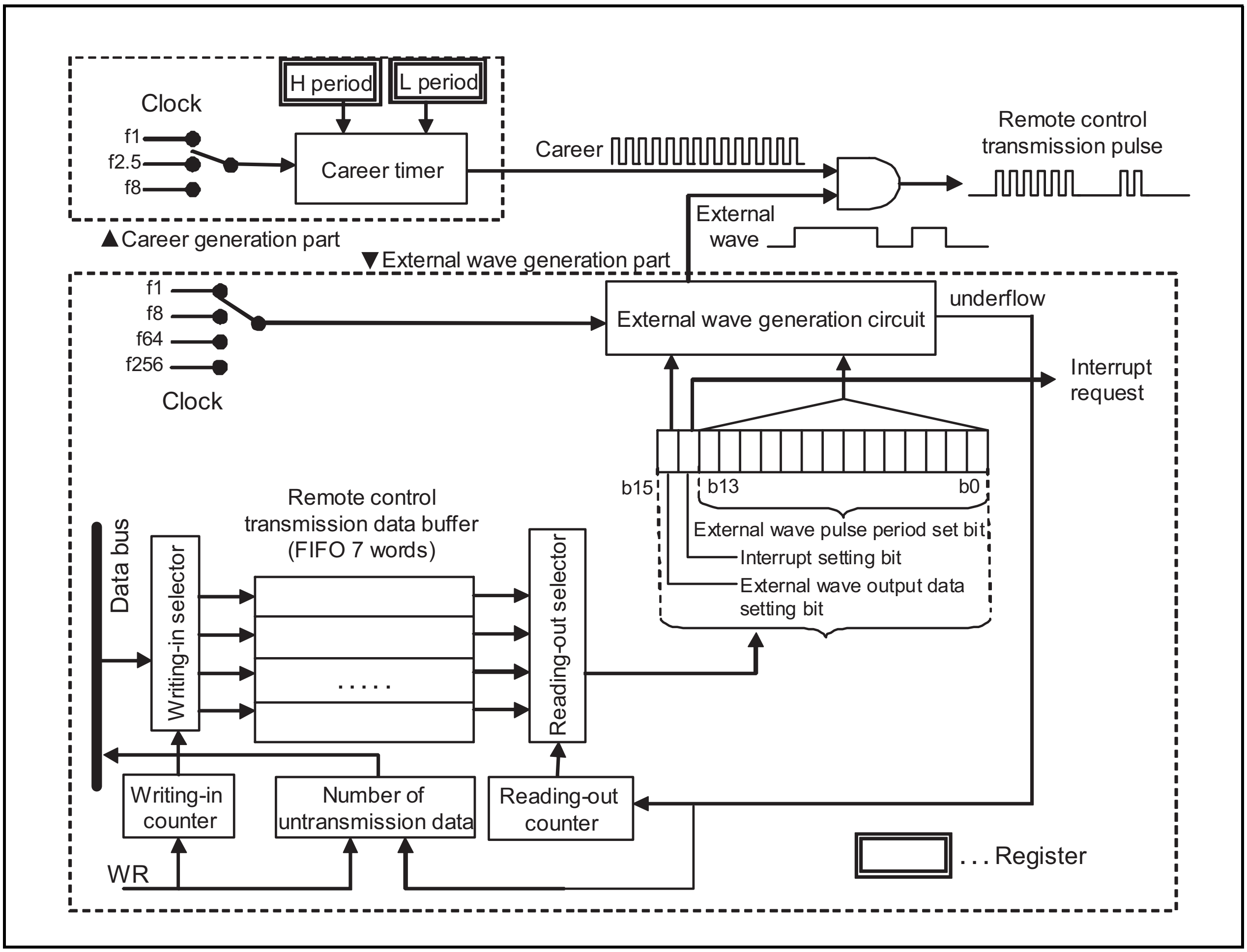
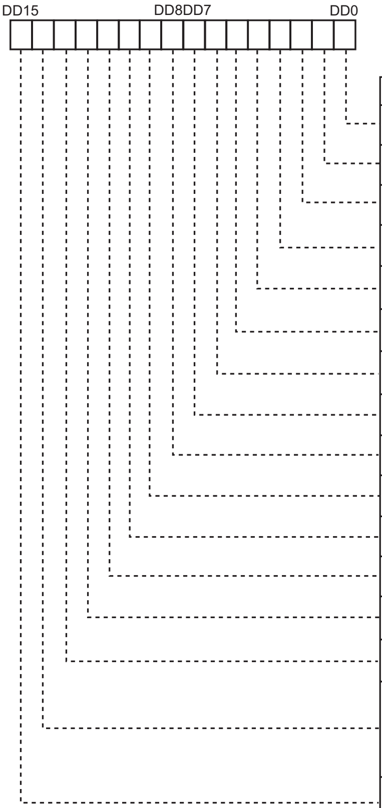


Figure 14.19 Remote control transmission circuit block chart

Remote control transmission data buffer register



Symbol	Address	When reset
RMT_TMHL	200_{16}	0000_{16}

Bit symbol	Bit name	Function	R	W
RMT_TMHL (0)	External wave pulse period setting/Untransmission data number reference bit	When writing in: Set one pulse period of the remote control transmission external wave. When reading out: The number of data (number of untransmission data) that remains in the remote control transmission data buffer is read out.	○	○
RMT_TMHL (1)				
RMT_TMHL (2)				
RMT_TMHL (3)				
RMT_TMHL (4)				
RMT_TMHL (5)				
RMT_TMHL (6)				
RMT_TMHL (7)				
RMT_TMHL (8)				
RMT_TMHL (9)				
RMT_TMHL (10)				
RMT_TMHL (11)				
RMT_TMHL (12)				
RMT_TMHL (13)				
RMT_TMHL (14)	Interrupt setting bit	The presence of the interrupt generation is specified at the change of the external wave output. 0:The interrupt request signal is not generated. 1:The interrupt request signal is generated.	○	○
RMT_TMHL (15)	External wave output data setting bit	The remote control transmission external wave data is set.	○	○

Figure 14.20 **Setting of enhancing register (Only the part related to the remote control transmission.)**

14.7 8/4 Humming Decoder

8/4 humming decoder operates only by written the data which is 8/4 humming- encoded to 8/4 humming register (address 021A16). 8/4 humming register consists of 16 bits, can decode two data at once. Can obtain the decoded result by reading 8/4 humming register, and the decoded value and error information are output. Corrects and outputs the decoded value for single error, and outputs only error information for double error. Decoded result is shown in Figure 14.21 and humming 8/4 register composition is shown in Figure 14.22.

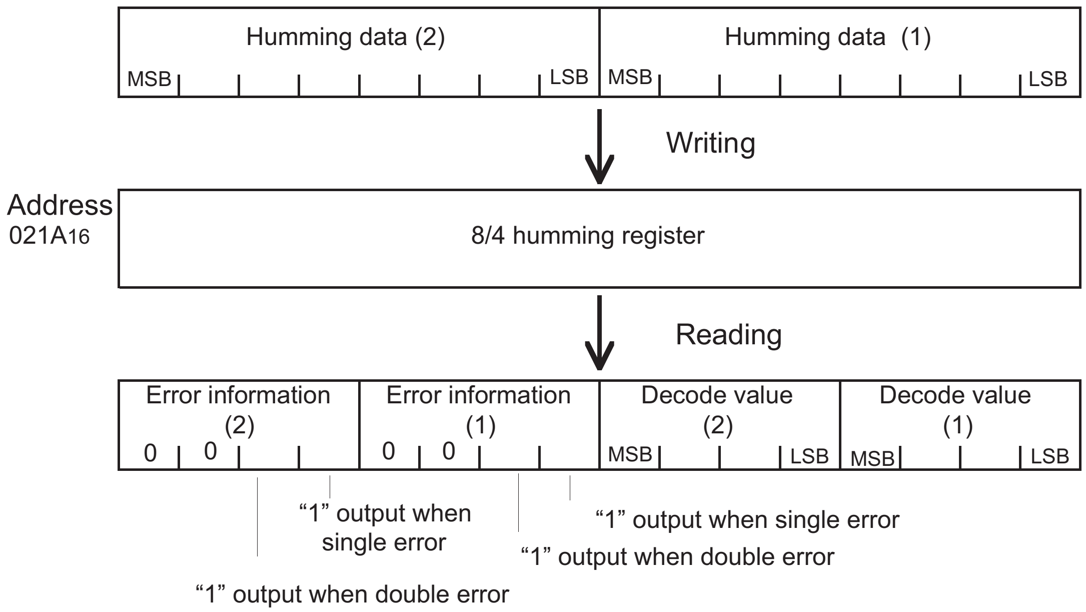
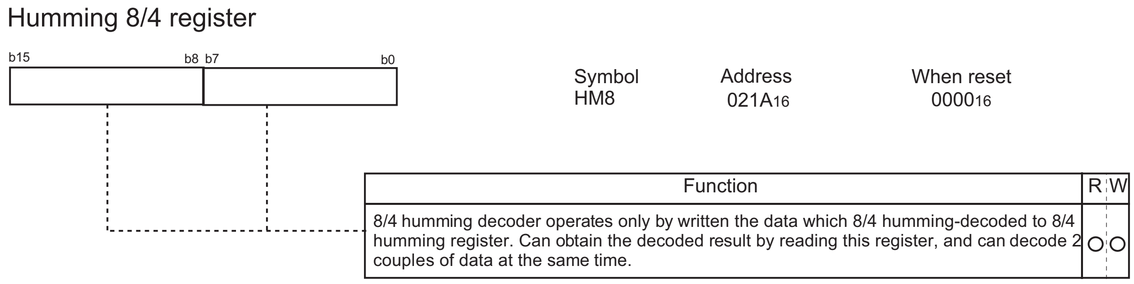


Figure 14.21 Decoded result



Symbol	Address	When reset
HM8	021A16	000016

Function	R	W
8/4 humming decoder operates only by written the data which 8/4 humming-decoded to 8/4 humming register. Can obtain the decoded result by reading this register, and can decode 2 couples of data at the same time.	○	○

Figure 14.22 Humming 8/4 register composition

14.8 24/18 Humming Decoder

24/18 humming decoder operates only by written the data which is 24/18 humming-encoded to 24/18 humming register 0 (address 021C16) and 1 (address 021E16). Can obtain the decoded result by reading the same 24/18 humming register, and the decoded value and error information are output.

Decoded result is shown in Figure 14.23 and humming 24/18 register composition is shown in Figure 14.24.

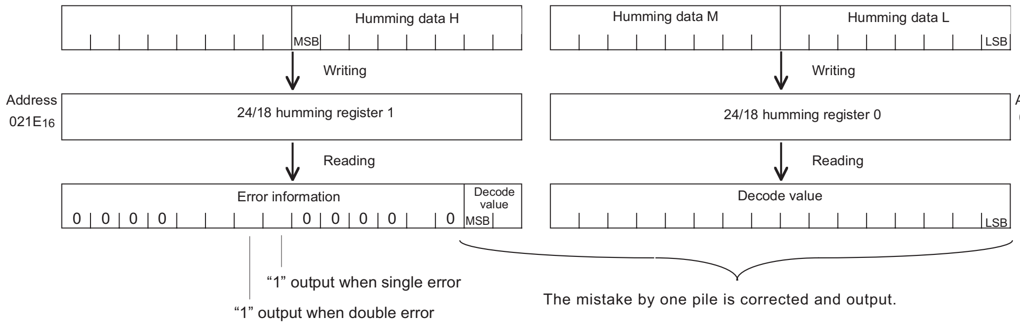
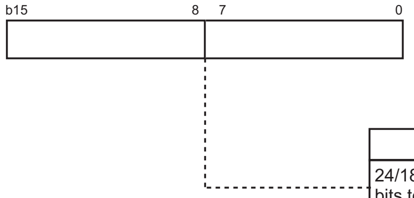


Figure 14.23 Decoded result

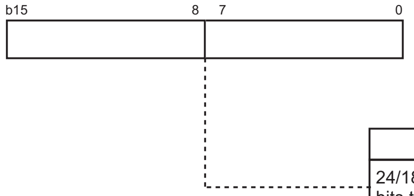
Humming 24/18 register 0



Symbol	Address	When reset
HM0	021C16	000016

Function	R	W
24/18 humming decoder operates by two ways : writing data low-order and middle-order 16 bits to this register and writing data high-order 8 bits to humming 24/18 register 1 (021E16). Can obtain the decoded result by reading this register and humming 24/18 register 1.	○	○

Humming 24/18 register 1



Symbol	Address	When reset
HM1	021E16	000016

Function	R	W
24/18 humming decoder operates by two ways : writing data low-order and middle-order 16 bits to humming 24/18 register 0 (021C16) to this register and writing data high-order 8 bits to this register. Can obtain the decoded result by reading this register and humming 24/18 register 0.	○	○

Figure 14.24 Humming 24/18 register composition

Continuous error correction

When uses humming 8/4 (address $021A_{16}$) at the same time as humming 24/18, can do the continuous error correction.

Continuous error correction sequence is shown in Figure 14.25.

A	Humming data (1) M	Humming data (1) L
B	Humming data (2) L	Humming data (1) H
C	Humming data (2) H	Humming data (2) M
D	Humming data (3) M	Humming data (3) L
E	Humming data (4) L	Humming data (3) H
F	Humming data (4) H	Humming data (4) M

1. Writes data A to address $021C_{16}$ and writes data B to address $021E_{16}$. (Setting the humming data (1) and L of humming data (2).)
2. Reads addresses $021C_{16}$ and $021E_{16}$ data (Obtains the decoded value and error information on the humming data (1)).
3. Writes data C to address $021A_{16}$ (Setting H and M of the humming data (2)).
4. Reads addresses $021C_{16}$ and $021E_{16}$ data (Obtains the decoded value and error information on the humming data (2)).
5. Writes data D to address $021C_{16}$ and writes data E to $021E_{16}$ (Setting the humming data (3) and L of humming data (4).)
6. Reads addresses $021C_{16}$ and $021E_{16}$ data (Obtains the decoded value and error information on the humming data (3)).
7. Writes data F to address $021A_{16}$ (Setting H and M of the humming data (4)).
8. Reads addresses $021C_{16}$ and $021E_{16}$ data (Obtains the decoded value and error information on the humming data (4)).

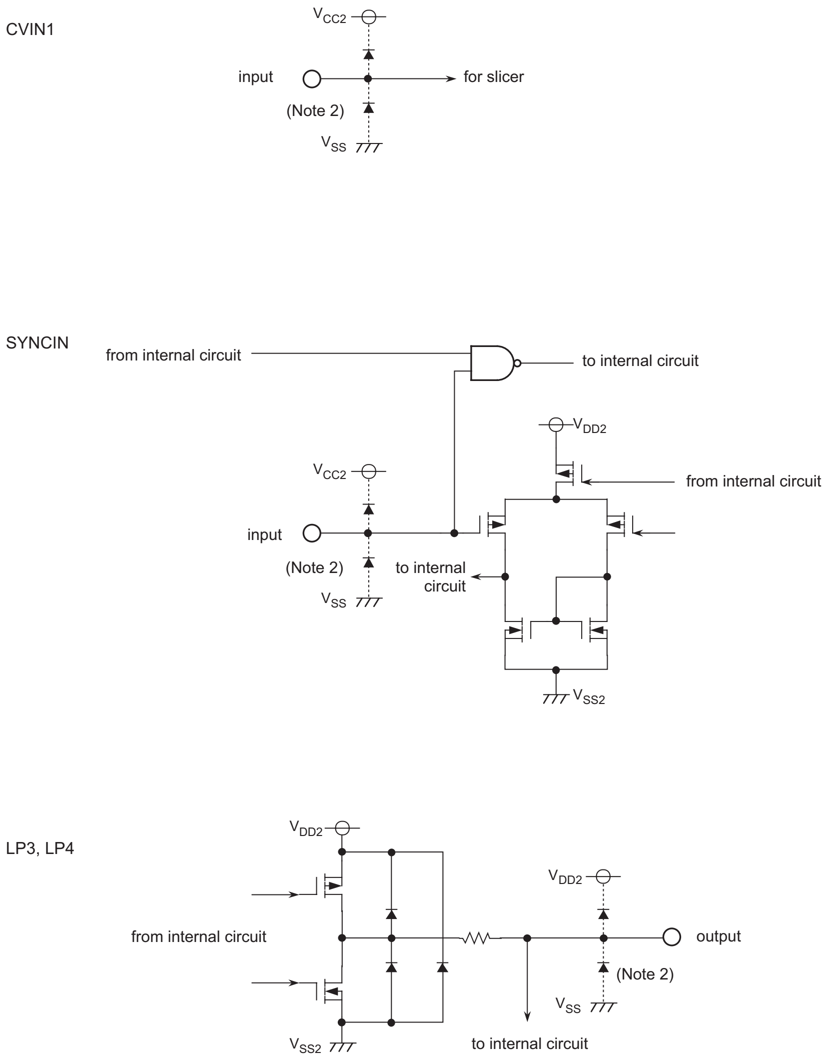
Figure 14.25 Continuous error correction sequence

Then, because using a part of circuit of humming 8/4 about this operation, cannot use this operation at the same time.

When using the humming circuit, do the decoded result reading operation at once after the setting data of humming. And do not access other memories (Including the humming circuit) before reading of the decoded result.

14.9 I/O Composition of pins for Expansion Function

Figure 14.26 and figure 14.27 show pins for expansion function.

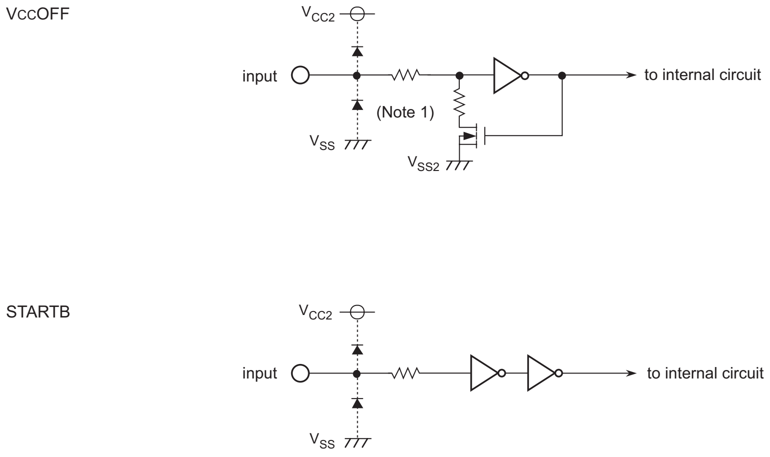


Notes 1. Refer to expansion register composition (Address 35$_{16}$.)

Notes 2. ·····◄|····· This is a parasitic diode.

The applied voltage to each port should hot exceed V_{CC}.
(V_{CC}: V_{CC2} for CVIN1 and SYNCIN, and V_{DD2} for LP3 and LP4.)

Figure 14.26 Pins for expansion function (1)



Note 1. This is a parasitic diode.
The applied voltage to each port should hot exceed VCC.
(VCC=VCC2)

Figure 14.27 Pins for expansion function (2)

15. Programmable I/O Ports

The programmable input/output ports (hereafter referred to simply as “I/O ports”) consist of 79 lines P0 toP9 (except P85). Each port can be set for input or output every line by using a direction register, and can also be chosen to be or not be pulled high every 4 lines. P85 is an input-only port and does not have a pull-up resistor. Port P85 shares the pin with $\overline{\text{NMI}}$, so that the $\overline{\text{NMI}}$ input level can be read from the P8 register P8_5 bit.
Figures 15.1 to 15.5 show the I/O ports. Figure 15.6 shows the I/O pins.
Each pin functions as an I/O port, a peripheral function input/output.
For details on how to set peripheral functions, refer to each functional description in this manual. If any pin is used as a peripheral function input, set the direction bit for that pin to “0” (input mode). Any pin used as an output pin for peripheral functions is directed for output no matter how the corresponding direction bit is set.

15.1 Port Pi Direction Register (PDi Register, i = 0 to 9)

Figure 15.7 shows the direction registers.
This register selects whether the I/O port is to be used for input or output. The bits in this register correspond one for one to each port.
No direction register bit for P85 is available.

15.2 Port Pi Register (Pi Register, i = 0 to 9)

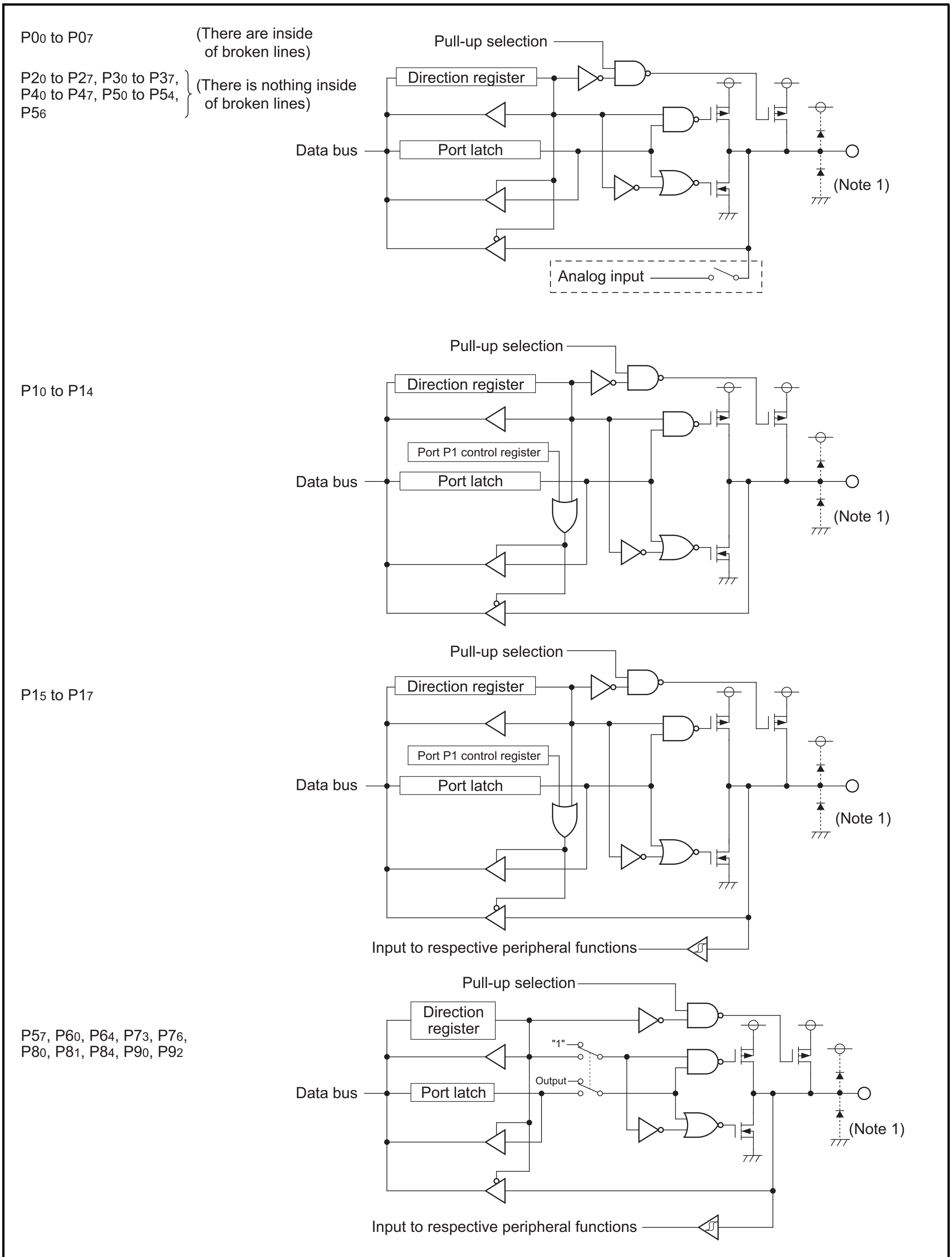
Figure 15.8 show the Pi registers.
Data input/output to and from external devices are accomplished by reading and writing to the Pi register. The Pi register consists of a port latch to hold the output data and a circuit to read the pin status. For ports set for input mode, the input level of the pin can be read by reading the corresponding Pi register, and data can be written to the port latch by writing to the Pi register.
For ports set for output mode, the port latch can be read by reading the corresponding Pi register, and data can be written to the port latch by writing to the Pi register. The data written to the port latch is output from the pin. The bits in the Pi register correspond one for one to each port.

15.3 Pull-up Control Register 0 to Pull-up Control Register 2 (PUR0 to PUR2 Registers)

Figure 15.9 shows the PUR0 to PUR2 registers.
The PUR0 to PUR2 register bits can be used to select whether or not to pull the corresponding port high in 4 bit units. The port chosen to be pulled high has a pull-up resistor connected to it when the direction bit is set for input mode.

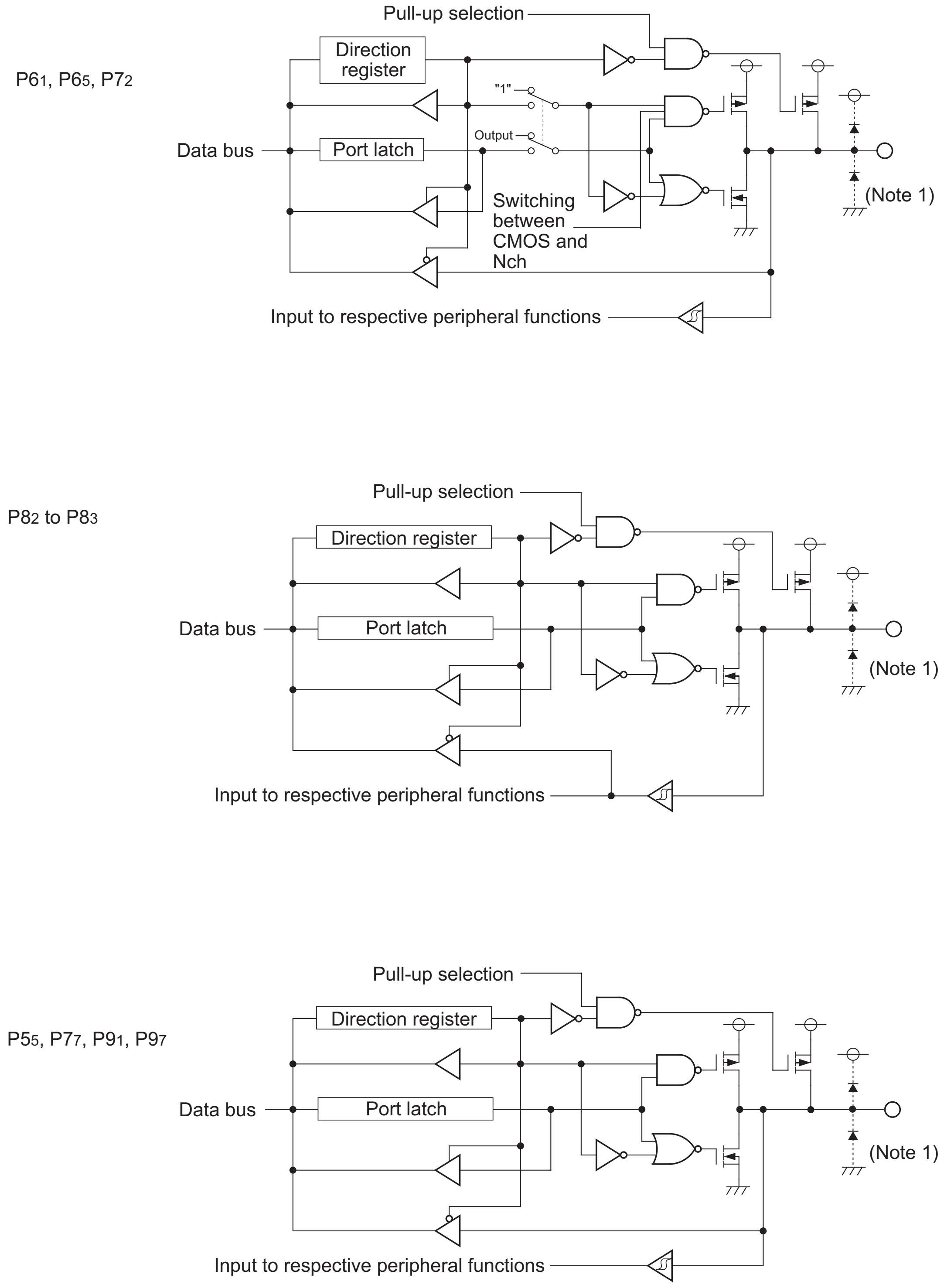
15.4 Port Control Register

Figure 15.10 shows the port control register.
When the P1 register is read after setting the PCR register’s PCR0 bit to “1”, the corresponding port latch can be read no matter how the PD1 register is set.



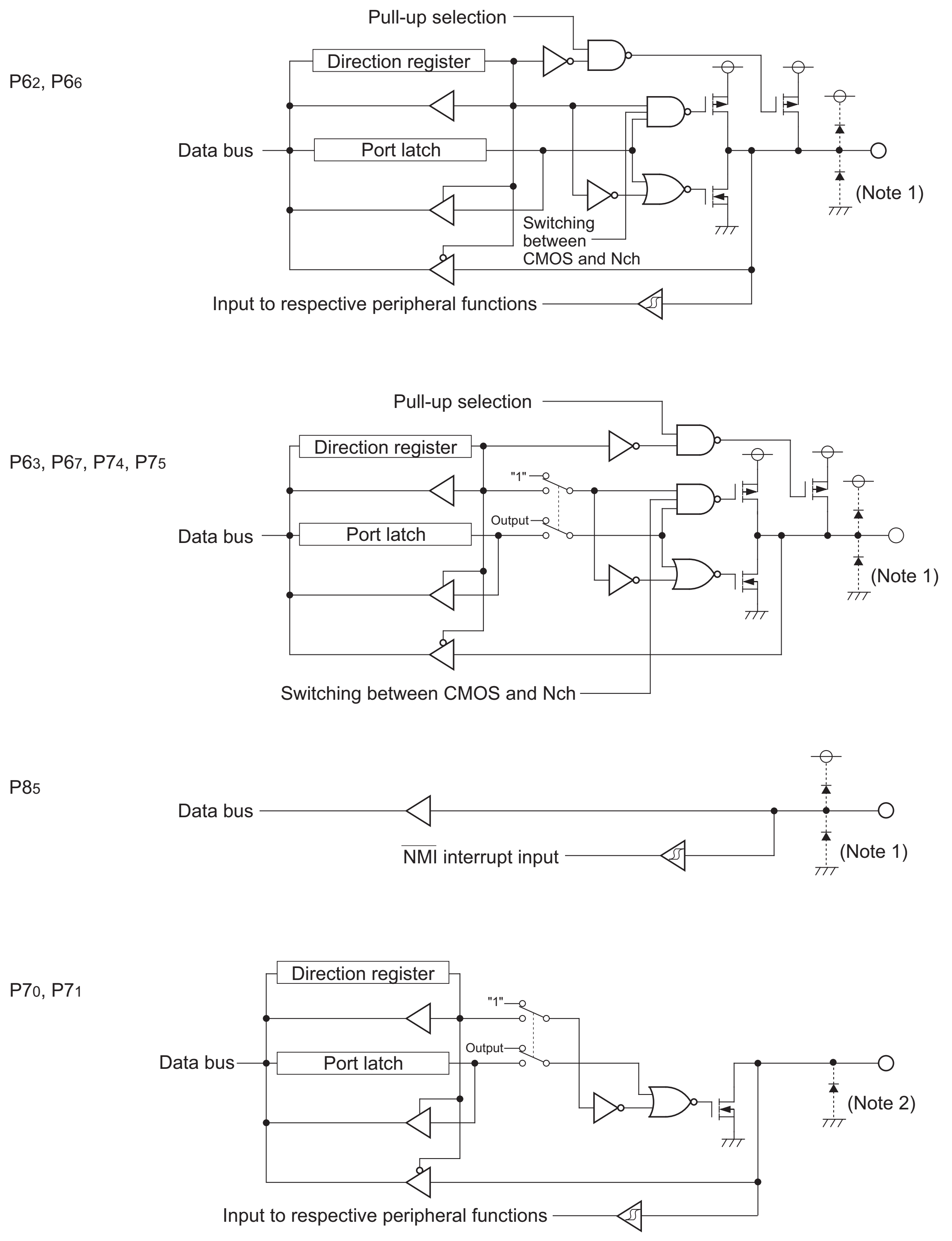
Note 1: ·····▸|····· symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed VCC.
(VCC: VCC1 for the port P6 to P7 and P8$_0$ to P8$_4$, and VCC2 for the port P0 to P5, P8$_5$ to P8$_7$ and P9.)

Figure 15.1 I/O Ports (1)



Note 1: ····◄|····· symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed V_{CC}.
(V_{CC}: V_{CC1} for the port P6 to P7 and P8$_0$ to P8$_4$, and V_{CC2} for the port P0 to P5, P8$_5$ to P8$_7$ and P9.)

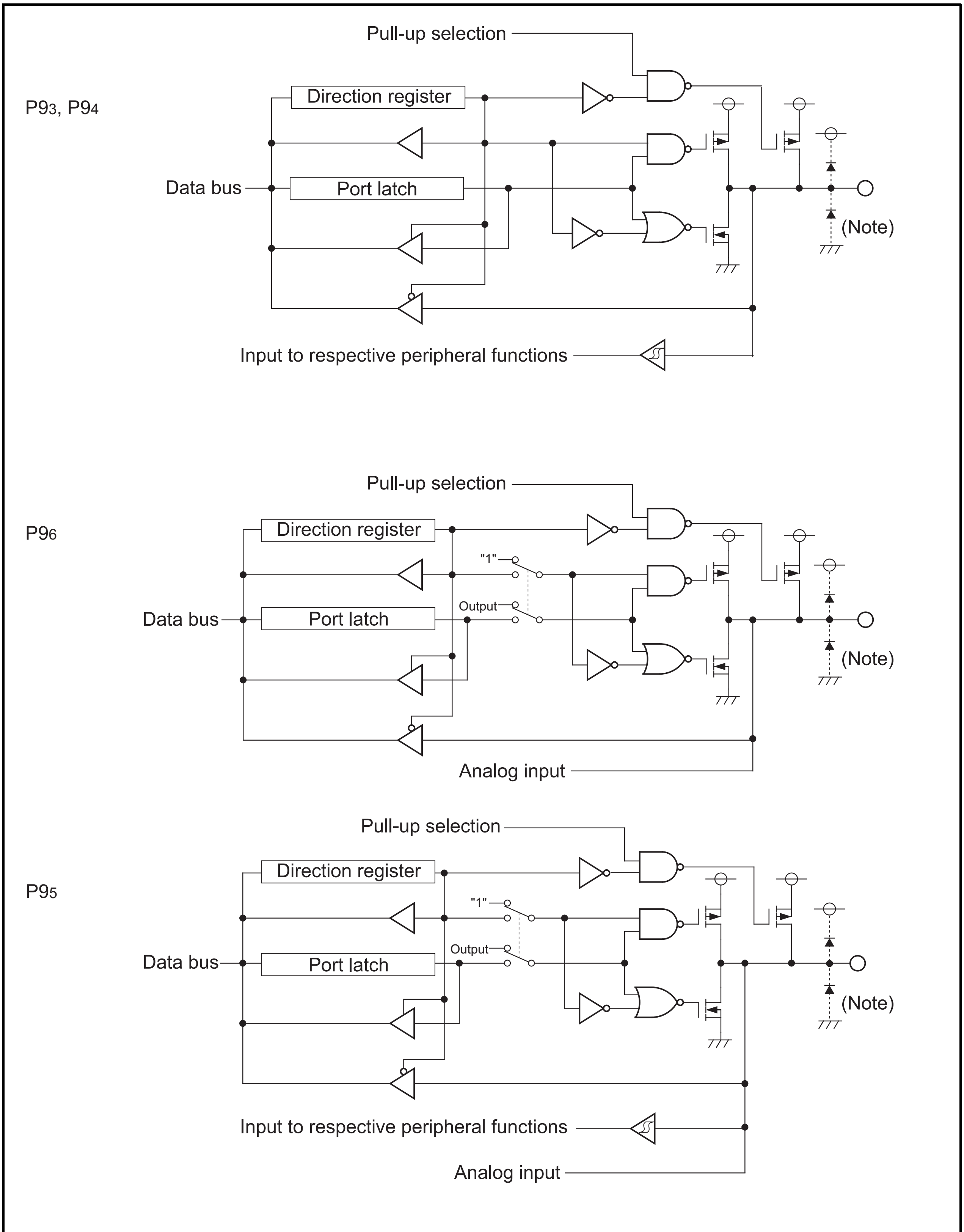
Figure 15.2 I/O Ports (2)



Note 1: ·····◄|····· symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed VCC.
(VCC: VCC1 for the port P6 to P7 and P80 to P84, and VCC2 for the port P0 to P5, P85 to P87 and P9.)

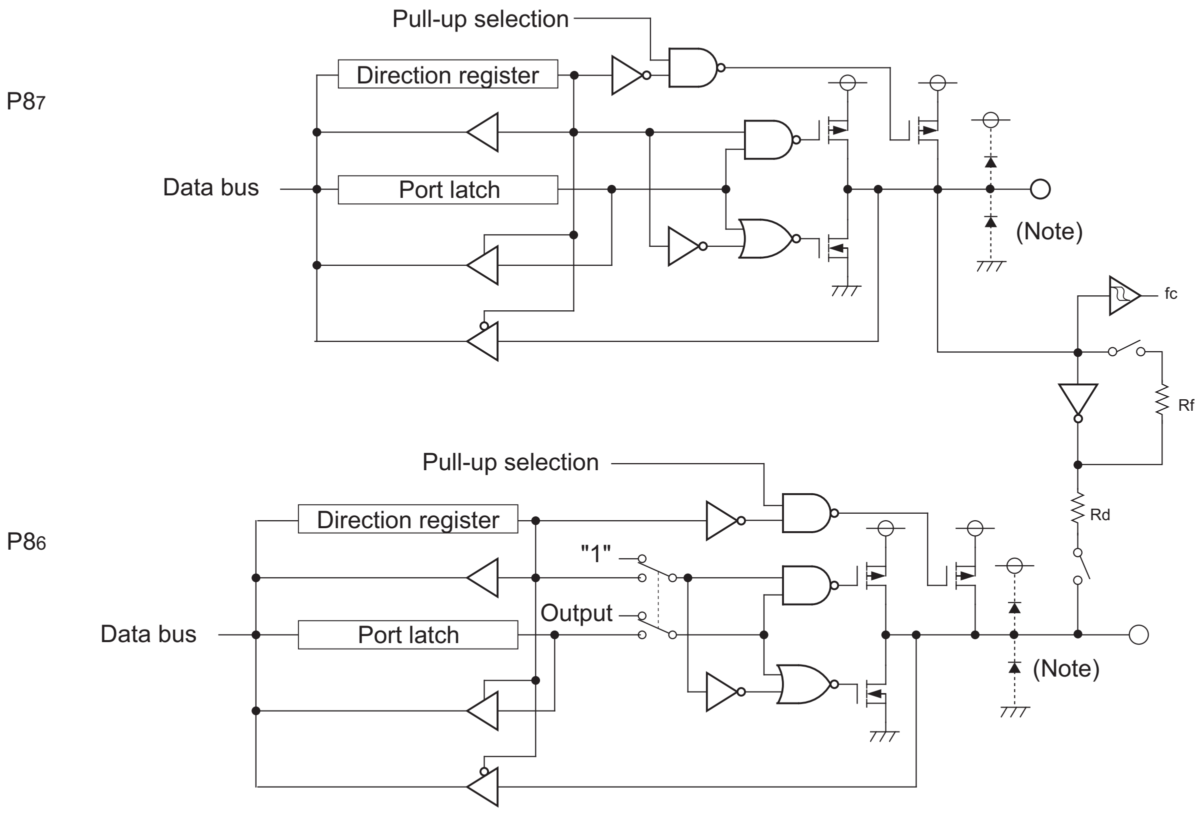
Note 2: ·····◄|····· symbolizes a parasitic diode.

Figure 15.3 I/O Ports (3)



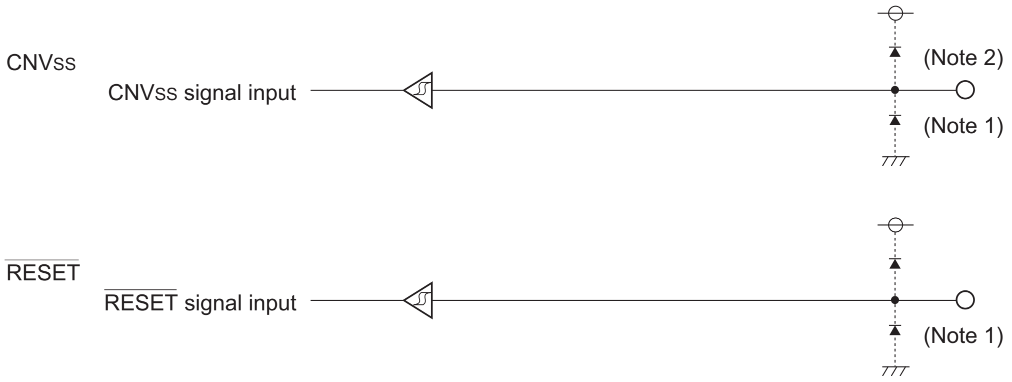
Note: ·····◄······ symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed VCC.
(VCC=VCC2)

Figure 15.4 I/O Ports (4)



Note: ----◄---- symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed VCC.
(VCC=VCC2)

Figure 15.5 I/O Ports (5)

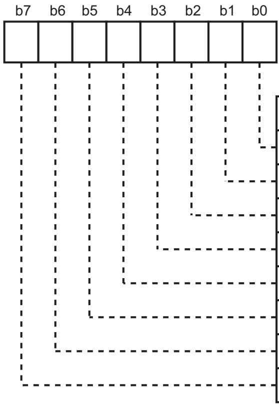


Note 1: ----◄---- symbolizes a parasitic diode.
Make sure the input voltage on each port will not exceed Vcc.
Note 2: A parasitic diode on the Vcc side is added to the mask ROM version.
Make sure the input voltage on each port will not exceed Vcc.
(Vcc=Vcc2)

Figure 15.6 I/O Pins

Port Pi direction register (i=0 to 7 and 9) (Note 1, 2)

Symbol	Address	After reset
PD0 to PD3	$03E2_{16}$, $03E3_{16}$, $03E6_{16}$, $03E7_{16}$	00_{16}
PD4 to PD7	$03EA_{16}$, $03EB_{16}$, $03EE_{16}$, $03EF_{16}$	00_{16}
PD9	$03F3_{16}$	00_{16}

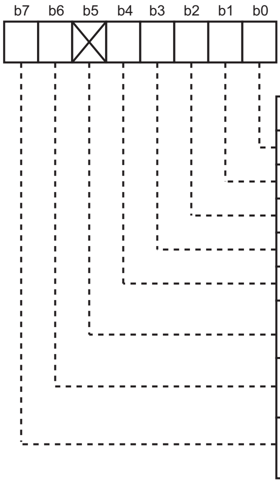


Bit symbol	Bit name	Function	RW
PDi_0	Port Pi_0 direction bit	0 : Input mode (Functions as an input port) 1 : Output mode (Functions as an output port) (i = 0 to 7 and 9)	RW
PDi_1	Port Pi_1 direction bit		RW
PDi_2	Port Pi_2 direction bit		RW
PDi_3	Port Pi_3 direction bit		RW
PDi_4	Port Pi_4 direction bit		RW
PDi_5	Port Pi_5 direction bit		RW
PDi_6	Port Pi_6 direction bit		RW
PDi_7	Port Pi_7 direction bit		RW

Note 1: Make sure the PD9 register is written to by the next instruction after setting the PRCR register’s PRC2 bit to “1” (write enabled).

Port P8 direction register

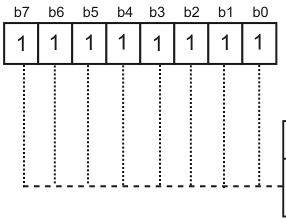
Symbol	Address	After reset
PD8	$03F2_{16}$	$00X00000_2$



Bit symbol	Bit name	Function	RW
PD8_0	Port $P8_0$ direction bit	0 : Input mode (Functions as an input port) 1 : Output mode (Functions as an output port)	RW
PD8_1	Port $P8_1$ direction bit		RW
PD8_2	Port $P8_2$ direction bit		RW
PD8_3	Port $P8_3$ direction bit		RW
PD8_4	Port $P8_4$ direction bit		RW
— (b5)	Nothing is assigned. In an attempt to write to this bit, write “0”. The value, if read, turns out to be indeterminate.		—
PD8_6	Port $P8_6$ direction bit	0 : Input mode (Functions as an input port) 1 : Output mode (Functions as an output port)	RW
PD8_7	Port $P8_7$ direction bit		RW

Reserved register

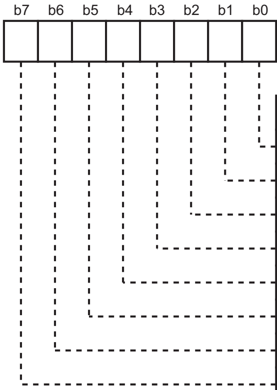
Symbol	Address	After reset
RSV03F6	$03F6_{16}$	00_{16}



Bit symbol	Bit name	Function	RW
— (b7-b0)	Reserved bits	Must set to "1."	RW

Figure 15.7 PD0 to PD9 Registers

Port Pi register (i=0 to 7 and 9) (Note 1)

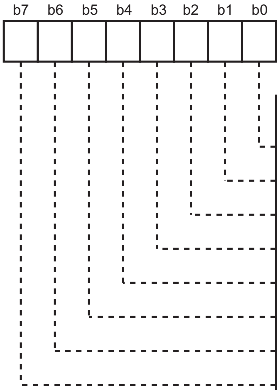


Symbol	Address	After reset
P0 to P3	$03E0_{16}$, $03E1_{16}$, $03E4_{16}$, $03E5_{16}$	Indeterminate
P4 to P7	$03E8_{16}$, $03E9_{16}$, $03EC_{16}$, $03ED_{16}$	Indeterminate
P9	$03F1_{16}$	Indeterminate

Bit symbol	Bit name	Function	RW
Pi_0	Port Pi$_0$ bit	The pin level on any I/O port which is set for input mode can be read by reading the corresponding bit in this register. The pin level on any I/O port which is set for output mode can be controlled by writing to the corresponding bit in this register 0 : “L” level 1 : “H” level (Note 1) (i = 0 to 7 and 9)	RW
Pi_1	Port Pi$_1$ bit		RW
Pi_2	Port Pi$_2$ bit		RW
Pi_3	Port Pi$_3$ bit		RW
Pi_4	Port Pi$_4$ bit		RW
Pi_5	Port Pi$_5$ bit		RW
Pi_6	Port Pi$_6$ bit		RW
Pi_7	Port Pi$_7$ bit		RW

Note 1: Since P7$_0$ and P7$_1$ are N-channel open drain ports, the data is high-impedance.

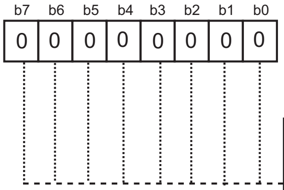
Port P8 register



Symbol	Address	After reset
P8	$03F0_{16}$	Indeterminate

Bit symbol	Bit name	Function	RW
P8_0	Port P8$_0$ bit	The pin level on any I/O port which is set for input mode can be read by reading the corresponding bit in this register. The pin level on any I/O port which is set for output mode can be controlled by writing to the corresponding bit in this register (except for P8$_5$) 0 : “L” level 1 : “H” level	RW
P8_1	Port P8$_1$ bit		RW
P8_2	Port P8$_2$ bit		RW
P8_3	Port P8$_3$ bit		RW
P8_4	Port P8$_4$ bit		RW
P8_5	Port P8$_5$ bit		RO
P8_6	Port P8$_6$ bit		RW
P8_7	Port P8$_7$ bit		RW

Reserved register



Symbol	Address	After reset
RSV03F4	$03F4_{16}$	Indeterminate

Bit symbol	Bit name	Function	RW
— (b7-b0)	Reserved bits	Must set to "0."	RW

Figure 15.8 P0 to P9 Registers

Pull-up control register 0 (Note 1)

b7	b6	b5	b4	b3	b2	b1	b0

Symbol	Address	After reset
PUR0	03FC$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
PU00	P0$_0$ to P0$_3$ pull-up	0 : Not pulled high 1 : Pulled high (Note 1)	RW
PU01	P0$_4$ to P0$_7$ pull-up		RW
PU02	P1$_0$ to P1$_3$ pull-up		RW
PU03	P1$_4$ to P1$_7$ pull-up		RW
PU04	P2$_0$ to P2$_3$ pull-up		RW
PU05	P2$_4$ to P2$_7$ pull-up		RW
PU06	P3$_0$ to P3$_3$ pull-up		RW
PU07	P3$_4$ to P3$_7$ pull-up		RW

Note 1: The pin for which this bit is "1" (pulled high) and the direction bit is "0" (input mode) is pulled high.

Pull-up control register 1

b7	b6	b5	b4	b3	b2	b1	b0

Symbol	Address	After reset (Note 3)
PUR1	03FD$_{16}$	00000000$_2$

Bit symbol	Bit name	Function	RW
PU10	P4$_0$ to P4$_3$ pull-up	0 : Not pulled high 1 : Pulled high (Note 2)	RW
PU11	P4$_4$ to P4$_7$ pull-up		RW
PU12	P5$_0$ to P5$_3$ pull-up		RW
PU13	P5$_4$ to P5$_7$ pull-up		RW
PU14	P6$_0$ to P6$_3$ pull-up		RW
PU15	P6$_4$ to P6$_7$ pull-up		RW
PU16	P7$_2$ to P7$_3$ pull-up (Note 1)		RW
PU17	P7$_4$ to P7$_7$ pull-up		RW

Note 1: The P7$_0$ and P7$_1$ pins do not have pull-ups.
Note 2: The pin for which this bit is "1" (pulled high) and the direction bit is "0" (input mode) is pulled high.
Note 3: The values after hardware reset are as follows:

- 00000000$_2$ when input on CNVss pin is "L"

The values after software reset and watchdog timer reset are as follows:

- 00000000$_2$ when PM 01 to PM00 bits of PM0 register are "00$_2$" (single-chip mode)

Pull-up control register 2

b7	b6	b5	b4	b3	b2	b1	b0
☒	☒	0	0				

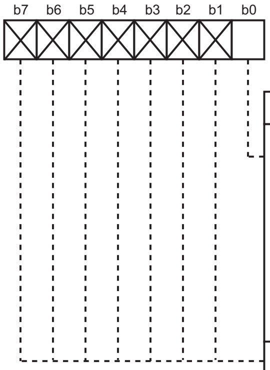
Symbol	Address	After reset
PUR2	03FE$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
PU20	P8$_0$ to P8$_3$ pull-up	0 : Not pulled high 1 : Pulled high (Note 1)	RW
PU21	P8$_4$ to P8$_7$ pull-up (Note 2)		RW
PU22	P9$_0$ to P9$_3$ pull-up		RW
PU23	P9$_4$ to P9$_7$ pull-up		RW
(b5-b4)	Must set to "0"		RW
— (b7-b6)	Nothing is assigned. In an attempt to write to these bits, write "0". The value, if read, turns out to be "0".		—

Note 1: The pin for which this bit is "1" (pulled high) and the direction bit is "0" (input mode) is pulled high.
Note 2: The P8$_5$ pin does not have pull-up.

Figure 15.9 PUR0 to PUR2 Registers

Port control register



Symbpl	Address	After reset
PCR	03FF$_{16}$	00$_{16}$

Bit symbol	Bit name	Function	RW
PCR0	Port P1 control bit	Operation performed when the P1 register is read 0: When the port is set for input, the input levels of P10 to P17 pins are read. When set for output, the port latch is read. 1: The port latch is read regardless of whether the port is set for input or output.	RW
—— (b7-b1)	Nothing is assigned. In an attempt to write to these bits, write “0”. The value, if read, turns out to be “0”.		—

Figure 15.10 PCR Register

Table 15.1 Unassigned Pin Handling in Single-chip Mode

Pin name	Connection
Ports P0 to P7, P80 to P84, P86 to P87, P9	After setting for input mode, connect every pin to VSS via a resistor(pull-down); or after setting for output mode, leave these pins open. (Note 1, 2 ,3)
XOUT (Note 4)	Open
$\overline{\text{NMI}}$ (P85)	Connect via resistor to VCC (pull-up)
AVCC	Connect to VCC
AVSS	Connect to VSS

Note 1: When setting the port for output mode and leave it open, be aware that the port remains in input mode until it is switched to output mode in a program after reset. For this reason, the voltage level on the pin becomes indeterminate, causing the power supply current to increase while the port remains in input mode. Furthermore, by considering a possibility that the contents of the direction registers could be changed by noise or noise-induced runaway, it is recommended that the contents of the direction registers be periodically reset in software, for the increased reliability of the program.

Note 2: Make sure the unused pins are processed with the shortest possible wiring from the microcomputer pins (within 2 cm).

Note 3: When the ports P70 and P71 are set for output mode, make sure a low-level signal is output from the pins. The ports P70 and P71 are N-channel open-drain outputs.

Note 4: With external clock input to XIN pin.

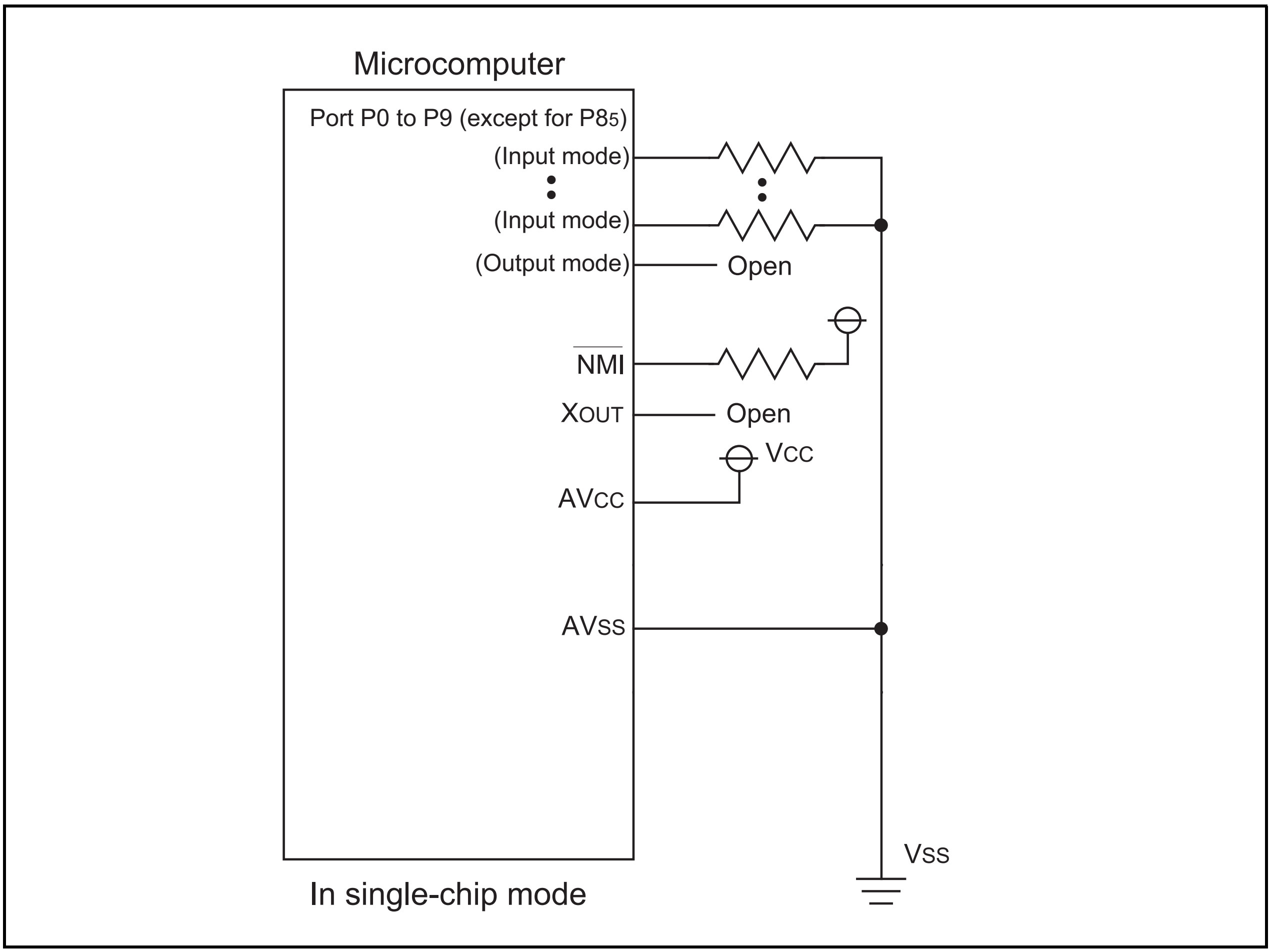


Figure 15.11 Unassigned Pins Handling

16. Electrical Characteristics

Table 16.1 Absolute Maximum Ratings

Symbol	Parameter		Condition	Rated value	Unit
V_{CC1}, V_{CC2}	Supply voltage		V_{CC2}=AVcc	-0.3 to 6.0	V
V_{CC1}	Supply voltage		V_{CC1}	-0.3 to V_{CC2}	V
AV_{CC}	Analog supply voltage		V_{CC2}=AVcc	-0.3 to 6.0	V
V_{DD2}	Analog supply voltage		V_{CC2}=V_{DD2}	-0.3 to 6.0	V
V_I	Input voltage	$\overline{RESET}$, CNV_{SS} $P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_5$ to $P8_7$, $P9_0$ to $P9_7$, X_{IN}, M1, STARTB		-0.3 to V_{CC2} + 0.3	V
		$P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$		-0.3 to V_{CC1} + 0.3	V
		$P7_0$, $P7_1$		-0.3 to 6.0	V
V_O	Output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$, X_{OUT}		-0.3 to V_{CC2} + 0.3	V
		$P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$		-0.3 to V_{CC1} + 0.3	V
		$P7_0$, $P7_1$		-0.3 to 6.0	V
P_d	Power dissipation		Topr=25 °C	550	mW
T_{opr}	Operating ambient temperature			-20 to 70	°C
T_{stg}	Storage temperature			-20 to 125	°C

Note: Following setting is required: $V_{CC1} \leq V_{CC2}$

Table 16.2 Recommended Operating Conditions (Note 1)

Symbol	Parameter		Standard			Unit
			Min.	Typ.	Max.	
V_{CC1}, V_{CC2}	Supply voltage ($V_{CC1} \leq V_{CC2}$)		2.0	5.0	5.5	V
AVcc	Analog supply voltage			V_{CC2}		V
V_{DD2}	Analog supply voltage			V_{CC2}		V
Vss	Supply voltage			0		V
AVss	Analog supply voltage			0		V
V_{IH}	HIGH input voltage	$P3_1$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$	$0.8V_{CC2}$		V_{CC2}	V
		$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$	$0.8V_{CC2}$		V_{CC2}	V
		$P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$	$0.8V_{CC1}$		V_{CC1}	V
		$P8_5$ to $P8_7$, $P9_0$ to $P9_7$ X_{IN}, $\overline{RESET}$, CNV_{SS}, M1, STARTB	$0.8V_{CC2}$		V_{CC2}	V
		$P7_0$, $P7_1$	$0.8V_{CC1}$		5.75	V
V_{IL}	LOW input voltage	$P3_1$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$	0		$0.2V_{CC2}$	V
		$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$	0		$0.2V_{CC2}$	V
		$P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$	0		$0.2V_{CC1}$	V
		$P8_5$ to $P8_7$, $P9_0$ to $P9_7$, X_{IN}, $\overline{RESET}$, CNV_{SS}, M1, STARTB	0		$0.2V_{CC2}$	V
V_{CVIN}	Composite video input voltage	CVIN, SYNCIN		$2V_{P-P}$		V
$I_{OH\ (peak)}$	HIGH peak output current (Note2, Note3)	$P0_0$ to $P0_7$,$P1_0$ to $P1_7$, $P2_0$ to $P2_7$,$P3_0$ to $P3_7$, $P4_0$ to $P4_7$,$P5_0$ to $P5_7$, $P6_0$ to $P6_7$,$P7_2$ to $P7_7$, $P8_0$ to $P8_4$,$P8_6$,$P8_7$,$P9_0$ to $P9_7$			- 10.0	mA
$I_{OH\ (avg)}$	HIGH average output current	$P0_0$ to $P0_7$,$P1_0$ to $P1_7$, $P2_0$ to $P2_7$,$P3_0$ to $P3_7$, $P4_0$ to $P4_7$,$P5_0$ to $P5_7$, $P6_0$ to $P6_7$,$P7_2$ to $P7_7$, $P8_0$ to $P8_4$,$P8_6$,$P8_7$,$P9_0$ to $P9_7$			- 5.0	mA
$I_{OL\ (peak)}$	LOW peak output current	$P0_0$ to $P0_7$,$P1_0$ to $P1_7$, $P2_0$ to $P2_7$,$P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$,$P7_0$ to $P7_7$, $P8_0$ to $P8_4$,$P8_6$,$P8_7$,$P9_0$ to $P9_7$			10.0	mA
$I_{OL\ (avg)}$	LOW average output current	$P0_0$ to $P0_7$,$P1_0$ to $P1_7$, $P2_0$ to $P2_7$,$P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$,$P7_0$ to $P7_7$, $P8_0$ to $P8_4$,$P8_6$,$P8_7$,$P9_0$ to $P9_7$			5.0	mA
f (X_{IN})	Main clock input oscillation frequency (Note 4)	V_{CC2}=2.9 to 5.5V	0		16	MHz
f (X_{CIN})	Sub-clock oscillation frequency	V_{CC2}=2.0 to 5.5V(Note 5)		32.768	50	kHz
f (BCLK)	CPU operation clock		0		16	MHz

Note 1: Referenced to V_{CC} = V_{CC1} = V_{CC2} = 2.0 to 5.5V at Topr = -20 to 70 ˚C unless otherwise specified.

Note 2: The mean output current is the mean value within 100ms.

Note 3: The total I_{OL} (peak) for ports P0, P1, P2, P3, P4, P5,$P8_6$, $P8_7$, P9 must be 80mA max. The total I_{OL} (peak) for ports P6, P7andP8$_0$ to P8$_4$ must be 80mA max. The total I_{OH} (peak) for ports P0, P1, and P2 must be -40mA max. The total I_{OH} (peak) for ports P3, P4andP5 must be -40mA max.

Note 4: Use the V_{CC1} and V_{CC2} power supply voltage on the following conditions.
- V_{CC1} = 3.00V to V_{CC2}, V_{CC2} = 4.00V to 5.5V (at f(X_{IN}) = 16MHz)
- V_{CC1} = 2.90V to V_{CC2}, V_{CC2} = 2.90V to 5.5V (at f(X_{IN}) = 16MHz, at divide-by-8 or 16)

Note 5: Use in low power dissipation mode. When operating on low voltage (V_{CC} = 3.0V), only single-chip mode can be used. If the V_{CC2} supply voltage is less than 2.6 V, be aware that only the CPU, RAM, clock timer, interrupt, and Input/Output ports can be used. Other control circuits (e.g., timers A and B, serial I/O, UART) cannot be used.

Table 16.3 A/D Conversion Characteristics (Note 1)

Symbol	Parameter	Measuring condition		Standard			Unit
				Min.	Typ.	Max.	
–	Resolution	V_{REF} =V_{CC}				8	Bits
–	Absolute accuracy	V_{REF}= V_{CC} = 5V	AN_0 to AN_7 input			±3	LSB
			ANEX0, ANEX1 input External operation amp			±4	LSB
t_{CONV}	Conversion time(8bit), Sample & hold function available	V_{REF} =V_{CC}=5V, $ø_{AD}$=10MHz		2.8			µs
t_{SAMP}	Sampling time			0.3			µs
V_{REF}	Reference voltage			4.5		V_{CC}	V
V_{IA}	Analog input voltage			0		V_{REF}	V

Note 1: Referenced to V_{CC2}=AV_{CC}=V_{REF}=4.5 to 5.5V, V_{SS}=AV_{SS}=0V at Topr = -20 to 70 ˚C unless otherwise specified.
Note 2: AD operation clock frequency ($Ø_{AD}$ frequency) must be 10 MHz or less.
Note 3: A case without sample & hold function turn $Ø_{AD}$ frequency into 250 kHz or more.
A case with sample & hold function turn $Ø_{AD}$ frequency into 1 MHz or more.

Table 16.4 Flash Memory Version Electrical Characteristics (Note 1)

Symbol	Parameter	Measuring condition	Standard			Unit
			Min.	Typ.	Max	
—	Word program time			30	200	µs
—	Block erase time			1	4	s
—	Lock bit program time			30	200	µs
tps	Flash memory circuit stabilization wait time				15	µs

Note 1: Referenced to V_{CC2}=4.75 to 5.25V at Topr = 0 to 60 ˚C unless otherwise specified.

Table 16.5 Flash Memory Version Program/Erase Voltage and Read Operation Voltage Characteristics (Topr = 0 to 60°C

Flash program, erase voltage	Flash read operation voltage
V_{CC2} = 5.0 ± 0.25 V	V_{CC2} = 2.0 to 5.5 V

Table 16.6 Power Supply Circuit Timing Characteristics

Symbol	Parameter	Measuring condition	Standard			Unit
			Min.	Typ.	ax.	
td(P-R)	Time for internal power supply stabilization during powering-on	VCC=5.0V			2	ms
td(R-S)	STOP release time				150	µs
td(W-S)	Low power dissipation mode wait mode release time				150	µs

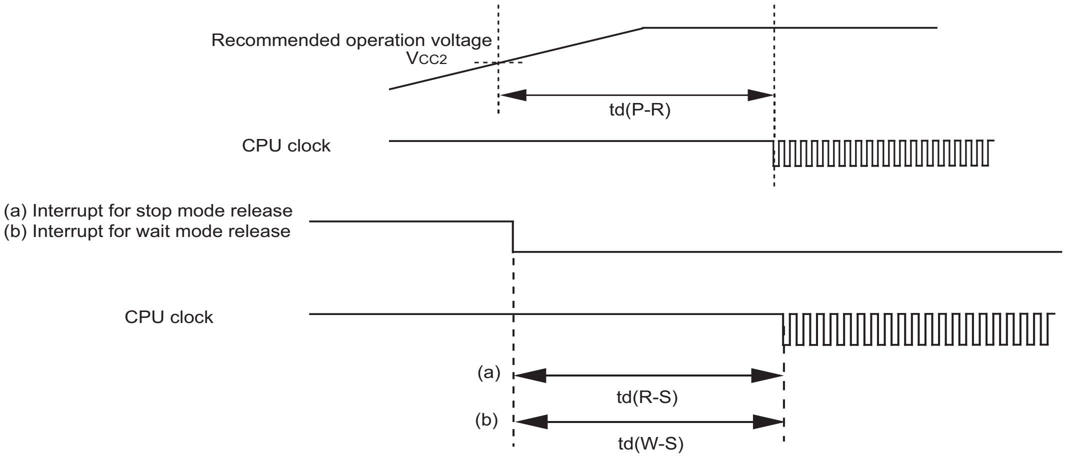


Table 16.7 Electrical Characteristics (1) (Note 1)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter			Measuring condition	Standard			Unit
					Min	Typ.	Max.	
V_{OH}	HIGH output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OH}=-5mA	V_{CC2}-2.0		V_{CC2}	V
		$P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$		I_{OH}=-5mA	V_{CC1}-2.0		V_{CC1}	V
V_{OH}	HIGH output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OH}=-200µA	V_{CC2}-0.3		V_{CC2}	V
		$P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$		I_{OH}=-200µA	V_{CC1}-0.3		V_{CC1}	V
V_{OH}	HIGH output voltage	LP3 , LP4		V_{CC}=4.5V, I_{OH}=-0.05mA	3.75			V
V_{OH}	HIGH output voltage	X_{OUT}	HIGHPOWER	I_{OH}=-1mA	V_{CC2}-2.0		V_{CC2}	V
			LOWPOWER	I_{OH}=-0.5mA	V_{CC2}-2.0		V_{CC2}	
	HIGH output voltage	X_{COUT}	HIGHPOWER	With no load applied		2.5		V
			LOWPOWER	With no load applied		1.6		
V_{OL}	LOW output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OL}=5mA			2.0	V
		$P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$		I_{OL}=5mA			2.0	V
V_{OL}	LOW output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OL}=200µA			0.45	V
		$P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$		I_{OL}=200µA			0.45	V
V_{OL}	LOW output voltage	LP3 to LP4		V_{CC}=4.5V, I_{OL}=0.05mA			0.4	V
V_{OL}	LOW output voltage	X_{OUT}	HIGHPOWER	I_{OL}=1mA			2.0	V
			LOWPOWER	I_{OL}=0.5mA			2.0	
	LOW output voltage	X_{COUT}	HIGHPOWER	With no load applied		0		V
			LOWPOWER	With no load applied		0		
V_{T+}-V_{T-}	Hysteresis	$TA0_{IN}$ to $TA4_{IN}$, $TB0_{IN}$ to $TB5_{IN}$, $\overline{INT_0}$ to $\overline{INT_5}$, $\overline{NMI}$, $\overline{AD_{TRG}}$, $\overline{CTS_0}$ to $\overline{CTS_2}$, SCL, SDA, CLK_0 to CLK_4, $TA2_{OUT}$ to $TA4_{OUT}$, RxD_0 to RxD_2, S_{IN3}, S_{IN4}			0.2		1.0	V
V_{T+}-V_{T-}	Hysteresis	$\overline{RESET}$			0.2		2.2	V
I_{IH}	HIGH input current	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$ X_{IN}, $\overline{RESET}$, CNVss, M1, STARTB		V_I=5V			5.0	µA
I_{IL}	LOW input current	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$ X_{IN}, $\overline{RESET}$, CNVss, M1, STARTB		V_I=0V			-5.0	µA
R_{PULLUP}	Pull-up resistance	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		V_I=0V	30	50	170	kΩ
R_{fXIN}	Feedback resistance	X_{IN}				1.5		MΩ
R_{fXCIN}	Feedback resistance	X_{CIN}				15		MΩ
V_{RAM}	RAM retention voltage			Stop mode	2.0			V
V_{SYNCIN}	Sync voltage amplitude				0.3	0.6	1.2	V
$V_{dat(text)}$	Teletext data voltage amplitude				0.6	0.9	1.4	V
f_H	Horizontal synchronous signal frequency				14.6	15.625	17.0	kHz

Note 1: Referenced to V_{CC}=V_{CC1}=V_{CC2}=4.50 to 5.50 V, V_{SS}=0V at Topr = -20 to 70 °C, f(BCLK)=16MHz unless otherwise specified.

Table 16.8 Electrical Characteristics (2) (Note)

$V_{CC1} = V_{CC2} = 3V$

Symbol	Parameter			Measuring condition	Standard			Unit
					Min.	Typ.	Max.	
V_{OH}	HIGH output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OH} = -1 mA	V_{CC2} - 0.5		V_{CC}	V
		$P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$		I_{OH} = -1 mA	V_{CC1} - 0.5		V_{CC}	V
V_{OH}	HIGH output voltage	X_{OUT}	HIGHPOWER	I_{OH} = -0.1 mA	V_{CC2} - 0.5		V_{CC2}	V
			LOWPOWER	I_{OH} = -50 µA	V_{CC2} - 0.5		V_{CC2}	
	HIGH output voltage	X_{COUT}	HIGHPOWER	With no load applied		2.5		V
			LOWPOWER	With no load applied		1.6		
V_{OL}	LOW output voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_4$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		I_{OL} = 1 mA			0.5	V
V_{OL}	LOW output voltage	X_{OUT}	HIGHPOWER	I_{OL} = 0.1 mA			0.5	V
			LOWPOWER	I_{OL} = 50 µA			0.5	
	LOW output voltage	X_{COUT}	HIGHPOWER	With no load applied		0		V
			LOWPOWER	With no load applied		0		
V_{T+}-V_{T-}	Hysteresis	$TA0_{IN}$ to $TA4_{IN}$, $TB0_{IN}$ to $TB5_{IN}$, $\overline{INT_0}$ to $\overline{INT_5}$ $TA2_{OUT}$ to $TA4_{OUT}$			0.2		0.8	V
V_{T+}-V_{T-}	Hysteresis	$\overline{RESET}$			0.2	(0.7)	1.8	V
I_{IH}	HIGH input voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$ X_{IN}, $\overline{RESET}$, CNVss, M1, STARTB		V_I = 3 V			4.0	µA
I_{IL}	HIGH input voltage	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$ X_{IN}, $\overline{RESET}$, CNVss, M1, STARTB		V_I = 0 V			-4.0	µA
R_{PULLUP}	Pull-up resistance	$P0_0$ to $P0_7$, $P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_7$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_2$ to $P7_7$, $P8_0$ to $P8_4$, $P8_6$, $P8_7$, $P9_0$ to $P9_7$		V_I = 0 V	50	100	500	kΩ
R_{fXCIN}	Feedback resistance	X_{IN}				3.0		MΩ
	Feedback resistance	X_{CIN}				25		MΩ

Note : Referenced to V_{CC} = V_{CC1} = V_{CC2} = 3.0 V, V_{SS} = 0 V at Topr = -20 to 70 °C, f (X_{CIN}) = 32kHz unless otherwise specified. Use in single-chip mode and low power dissipation mode.

Table 16.9 Electrical Characteristics (2) (Note 1)

Symbol	Parameter		Measuring condition		Standard			Unit
					Min.	Typ.	Max.	
I_{CC}	Power supply current	In single-chip mode, the output pins are open and other pins are V_{SS}	Mask ROM	f(BCLK)=16MHz, V_{CC}=5.0V		50	100	mA
			Flash memory	f(BCLK)=16MHz, V_{CC}=5.0V		50	100	mA
			Flash memory Program	f(BCLK)=16MHz, V_{CC}=5.0V		15		mA
			Flash memory Erase	f(BCLK)=16MHz, V_{CC}=5.0V		25		mA
			Mask ROM	f(X_{CIN})=32kHz, Low power dissipation mode, ROM(Note 3), (Note4) Vcc=5.0V		25		µA
			Flash memory	f(BCLK)=32kHz, Low power dissipation mode, RAM(Note 3), (Note4) Vcc=5.0V		25		µA
				f(BCLK)=32kHz Low power dissipation mode, Flash memory(Note 3), (Note4) Vcc=5.0V		420		µA
			Mask ROM Flash memory	f(BCLK)=32kHz, Wait mode (Note 2), (Note4) Oscillation capacity High		7.5		µA
				f(BCLK)=32kHz, Wait mode(Note 2), (Note4) Oscillation capacity Low Vcc=5.0V		5.0	10.0	µA
				f(BCLK)=32kHz, Wait mode (Note 2), (Note4) Oscillation capacity High Vcc=3.0V		6.0		µA
				f(BCLK)=32kHz, Wait mode(Note 2), (Note4) Oscillation capacity Low Vcc=3.0V		2.0	8.0	µA
				Stop mode, (Note4) T_{opr}=25˚C Vcc=5.0V		0.8	5.0	µA

Note 1: Referenced to V_{CC1}=V_{CC2}= 5V, V_{SS}=0V at Topr =25 ˚C, f(BCLK)=16MHz unless otherwise specified.
Note 2: With one timer operated using f_{C32}. (Slicer operation OFF)
Note 3: This indicates the memory in which the program to be executed exists.
Note 4:
- All of V_{DD2} is at the same potential level as V_{CC2}.
- Extension registers (addresses 00_{16} through $3F_{16}$) are set to the initial state.
- Inputs to the SYNCIN and CVIN pins are disabled.
- For current consumption reducing, set the level of V_{SS} or V_{CC} to the ports used in input mode.

Table 16.10 Video signal input conditions (Note 1)

Symbol	Parameter	Measuring condition	Standard			Unit
			Min	Typ.	Max.	
V_{IN-cu}	Composite video signal input clamp voltage	Sync-chip voltage		1.0		V

Note 1: Referenced to V_{CC2} = 5.0 V at Topr = -20 to 70 °C unless otherwise specified.

Timing Requirements

(V_{CC1} = V_{CC2} = 5V, V_{SS} = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.11 External Clock Input (X_{IN} input)

V_{CC1} = V_{CC2} = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
t_c	External clock input cycle time	62.5		ns
$t_{w(H)}$	External clock input HIGH pulse width	30		ns
$t_{w(L)}$	External clock input LOW pulse width	30		ns
t_r	External clock rise time		15	ns
t_f	External clock fall time		15	ns

Table 16.12 Remote Control Pulse Input

V_{CC1} = V_{CC2} = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$T_{w(RMTH)}$	RMT_{IN} input HIGH pulse width	61		µs
$T_{w(RMTL)}$	RMT_{IN} input LOW pulse width	61		µs

Table 16.13 JUST CLOCK Input

V_{CC1} = V_{CC2} = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$T_{w(JSTH)}$	JST_{IN} input HIGH pulse width	61		µs
$T_{w(JSTL)}$	JST_{IN} input LOW pulse width	61		µs

Timing Requirements

(V_{CC1} = V_{CC2} = 5V, V_{SS} = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.14 Timer A Input (Counter Input in Event Counter Mode)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi_{IN} input cycle time	100		ns
$t_{w(TAH)}$	TAi_{IN} input HIGH pulse width	40		ns
$t_{w(TAL)}$	TAi_{IN} input LOW pulse width	40		ns

Table 16.15 Timer A Input (Gating Input in Timer Mode)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi_{IN} input cycle time	400		ns
$t_{w(TAH)}$	TAi_{IN} input HIGH pulse width	200		ns
$t_{w(TAL)}$	TAi_{IN} input LOW pulse width	200		ns

Table 16.16 Timer A Input (External Trigger Input in One-shot Timer Mode)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi_{IN} input cycle time	200		ns
$t_{w(TAH)}$	TAi_{IN} input HIGH pulse width	100		ns
$t_{w(TAL)}$	TAi_{IN} input LOW pulse width	100		ns

Table 16.17 Timer A Input (External Trigger Input in Pulse Width Modulation Mode)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{w(TAH)}$	TAi_{IN} input HIGH pulse width	100		ns
$t_{w(TAL)}$	TAi_{IN} input LOW pulse width	100		ns

Table 16.18 Timer A Input (Counter Increment/decrement Input in Event Counter Mode)

$V_{CC1} = V_{CC2} = 5V$

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(UP)}$	TAi_{OUT} input cycle time	2000		ns
$t_{w(UPH)}$	TAi_{OUT} input HIGH pulse width	1000		ns
$t_{w(UPL)}$	TAi_{OUT} input LOW pulse width	1000		ns
$t_{su(UP-T_{IN})}$	TAi_{OUT} input setup time	400		ns
$t_{h(T_{IN}-UP)}$	TAi_{OUT} input hold time	400		ns

Timing Requirements

(VCC1 = VCC2 = 5V, VSS = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.19 Timer B Input (Counter Input in Event Counter Mode)

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBiIN input cycle time (counted on one edge)	100		ns
$t_{w(TBH)}$	TBiIN input HIGH pulse width (counted on one edge)	40		ns
$t_{w(TBL)}$	TBiIN input LOW pulse width (counted on one edge)	40		ns
$t_{c(TB)}$	TBiIN input HIGH pulse width (counted on both edges)	200		ns
$t_{w(TBH)}$	TBiIN input LOW pulse width (counted on both edges)	80		ns
$t_{w(TBL)}$	TBiIN input LOW pulse width (counted on both edges)	80		ns

Table 16.20 Timer B Input (Pulse Period Measurement Mode))

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBiIN input cycle time	400		ns
$t_{w(TBH)}$	TBiIN input HIGH pulse width	200		ns
$t_{w(TBL)}$	TBiIN input LOW pulse width	200		ns

Table 16.21 Timer B Input (Pulse Width Measurement Mode))

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBiIN input cycle time	400		ns
$t_{w(TBH)}$	TBiIN input HIGH pulse width	200		ns
$t_{w(TBL)}$	TBiIN input LOW pulse width	200		ns

Table 16.22 A/D Trigger Input

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(AD)}$	$\overline{\mathrm{ADTRG}}$ input cycle time (trigger able minimum)	1000		ns
$t_{w(ADL)}$	$\overline{\mathrm{ADTRG}}$ input LOW pulse width	125		ns

Table 16.23 Serial I/O

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(CK)}$	CLKi input cycle time	200		ns
$t_{w(CKH)}$	CLKi input HIGH pulse width	100		ns
$t_{w(CKL)}$	CLKi input LOW pulse width	100		ns
$t_{d(C-Q)}$	TxDi output delay time		80	ns
$t_{h(C-Q)}$	TxDi hold time	0		ns
$t_{su(D-C)}$	RxDi input setup time	30		ns
$t_{h(C-D)}$	RxDi input hold time	90		ns

Table 16.24 External Interrupt INTi Input

VCC1 = VCC2 = 5V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{w(INH)}$	$\overline{\mathrm{INTi}}$ input HIGH pulse width	250		ns
$t_{w(INL)}$	$\overline{\mathrm{INTi}}$ input LOW pulse width	250		ns

Timing Requirements

(V_{CC1} = V_{CC2} = 3V, V_{SS} = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.25 External Clock Input (X_{IN} Input)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
t_c	External clock input cycle time	100		ns
$t_{w(H)}$	External clock input HIGH pulse width	40		ns
$t_{w(L)}$	External clock input LOW pulse width	40		ns
t_r	External clock rise time		18	ns
t_f	External clock fall time		18	ns

Timing Requirements

(V_{CC1} = V_{CC2} = 3V, V_{SS} = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.26 Timer A Input (Counter Input in Event Counter Mode)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi$_{IN}$ input cycle time	150		ns
$t_{w(TAH)}$	TAi$_{IN}$ input HIGH pulse width	60		ns
$t_{w(TAL)}$	TAi$_{IN}$ input LOW pulse width	60		ns

Table 16.27 Timer A Input (Gating Input in Timer Mode)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi$_{IN}$ input cycle time	600		ns
$t_{w(TAH)}$	TAi$_{IN}$ input HIGH pulse width	300		ns
$t_{w(TAL)}$	TAi$_{IN}$ input LOW pulse width	300		ns

Table 16.28 Timer A Input (External Trigger Input in One-shot Timer Mode)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TA)}$	TAi$_{IN}$ input cycle time	300		ns
$t_{w(TAH)}$	TAi$_{IN}$ input HIGH pulse width	150		ns
$t_{w(TAL)}$	TAi$_{IN}$ input LOW pulse width	150		ns

Table 16.29 Timer A Input (External Trigger Input in Pulse Width Modulation Mode)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{w(TAH)}$	TAi$_{IN}$ input HIGH pulse width	150		ns
$t_{w(TAL)}$	TAi$_{IN}$ input LOW pulse width	150		ns

Table 16.30 Timer A Input (Counter Increment/decrement Input in Event Counter Mode)

V_{CC1} = V_{CC2} = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(UP)}$	TAi$_{OUT}$ input cycle time	3000		ns
$t_{w(UPH)}$	TAi$_{OUT}$ input HIGH pulse width	1500		ns
$t_{w(UPL)}$	TAi$_{OUT}$ input LOW pulse width	1500		ns
$t_{su(UP-TIN)}$	TAi$_{OUT}$ input setup time	600		ns
$t_{h(TIN-UP)}$	TAi$_{OUT}$ input hold time	600		ns

Timing Requirements

(VCC1 = VCC2 = 3V, VSS = 0V, at Topr = – 20 to 70°C unless otherwise specified)

Table 16.31 Timer B Input (Counter Input in Event Counter Mode)

VCC1 = VCC2 = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBi_{IN} input cycle time (counted on one edge)	150		ns
$t_{w(TBH)}$	TBi_{IN} input HIGH pulse width (counted on one edge)	60		ns
$t_{w(TBL)}$	TBi_{IN} input LOW pulse width (counted on one edge)	60		ns
$t_{c(TB)}$	TBi_{IN} input cycle time (counted on both edges)	300		ns
$t_{w(TBH)}$	TBi_{IN} input HIGH pulse width (counted on both edges)	120		ns
$t_{w(TBL)}$	TBi_{IN} input LOW pulse width (counted on both edges)	120		ns

Table 16.32 Timer B Input (Pulse Period Measurement Mode)

VCC1 = VCC2 = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBi_{IN} input cycle time	600		ns
$t_{w(TBH)}$	TBi_{IN} input HIGH pulse width	300		ns
$t_{w(TBL)}$	TBi_{IN} input LOW pulse width	300		ns

Table 16.33 Timer B Input (Pulse Period Measurement Mode)

VCC1 = VCC2 = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(TB)}$	TBi_{IN} input cycle time	600		ns
$t_{w(TBH)}$	TBi_{IN} input HIGH pulse width	300		ns
$t_{w(TBL)}$	TBi_{IN} input LOW pulse width	300		ns

Table 16.34 Serial I/O (Pulse Period Measurement Mode)

VCC1 = VCC2 = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{c(CK)}$	CLKi input cycle time	300		ns
$t_{w(CKH)}$	CLKi input HIGH pulse width	150		ns
$t_{w(CKL)}$	CLKi input LOW pulse width	150		ns
$t_{d(C-Q)}$	TxDi output delay time		160	ns
$t_{h(C-Q)}$	TxDi hold time	0		ns
$t_{su(D-C)}$	RxDi input setup time	70		ns
$t_{h(C-D)}$	RxDi input hold time	90		ns

Table 16.35 External Interrupt INTi Input (Pulse Period Measurement Mode)

VCC1 = VCC2 = 3V

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{w(INH)}$	$\overline{\text{INTi}}$ input HIGH pulse width	380		ns
$t_{w(INL)}$	$\overline{\text{INTi}}$ input LOW pulse width	380		ns

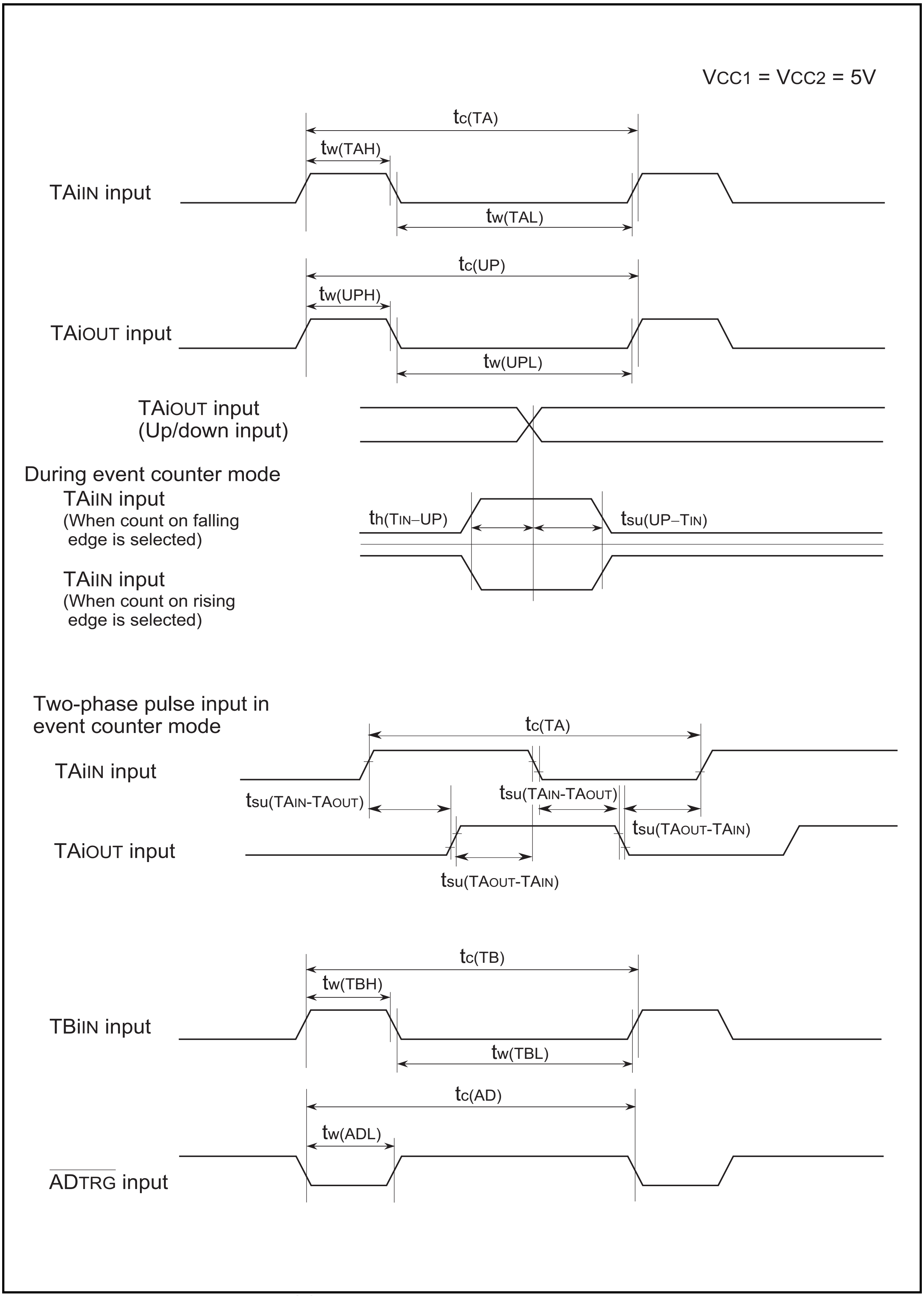


Figure 16.1 Timing Diagram (1)

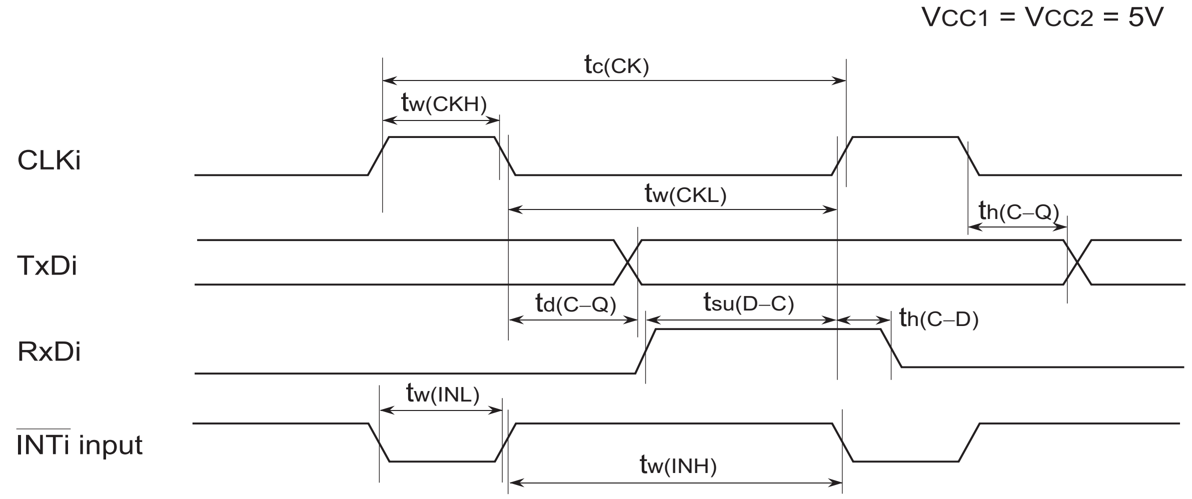


Figure 16.2 **Timing Diagram (2)**

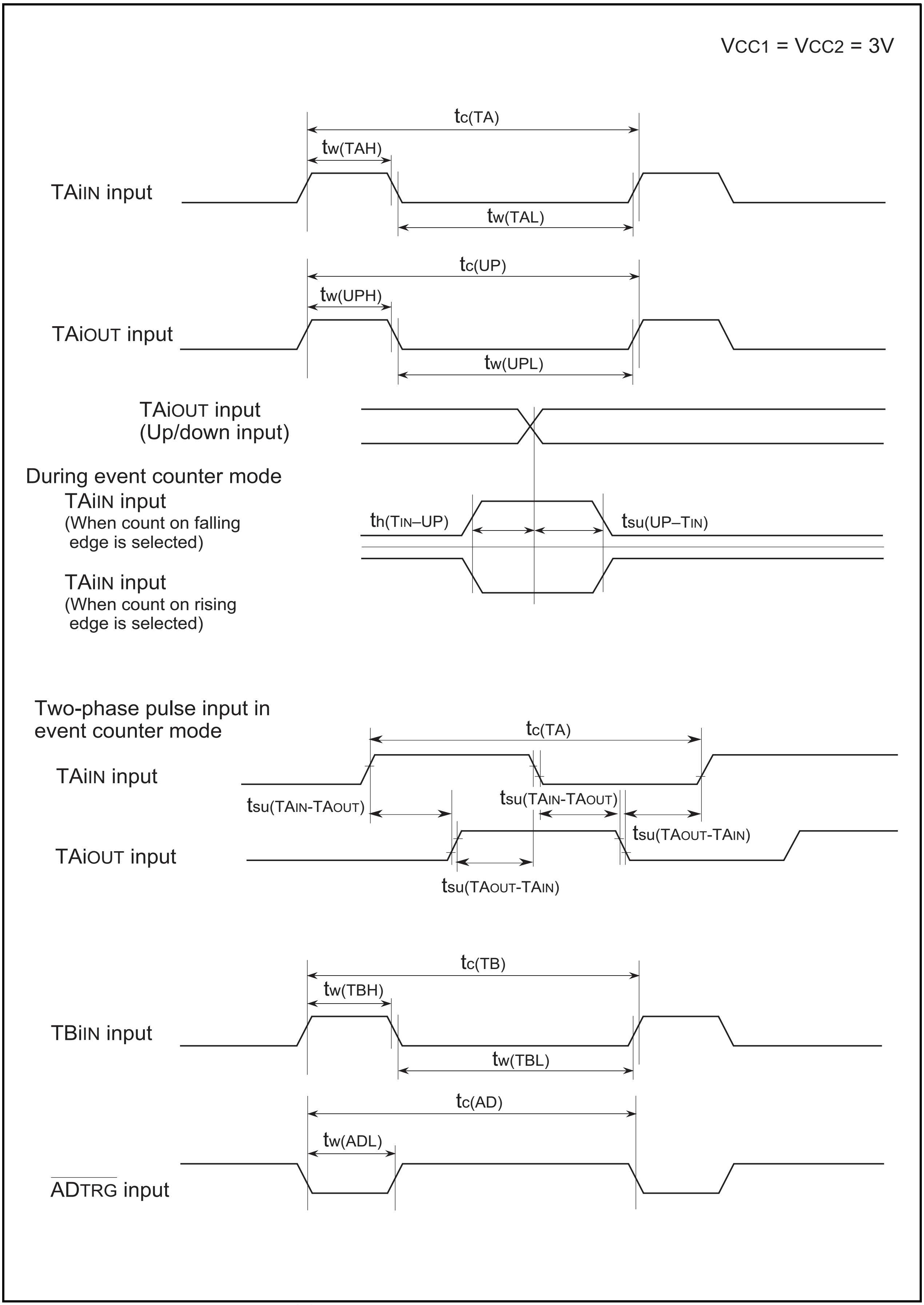


Figure 16.3 Timing Diagram (3)

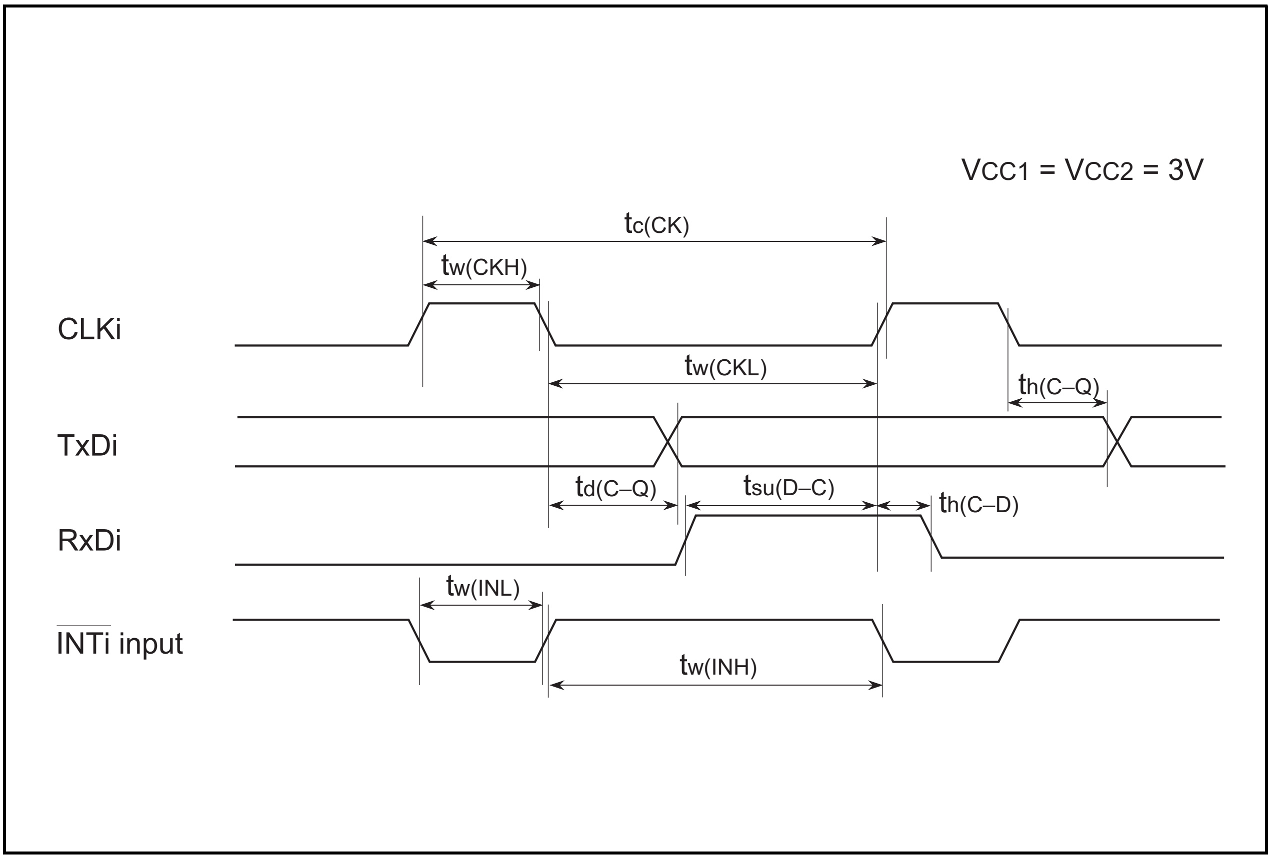


Figure 16.4 **Timing Diagram (4)**

17. Flash Memory Version

17.1 Flash Memory Performance

The flash memory version is functionally the same as the mask ROM version except that it internally contains flash memory.

The flash memory version has three modes–CPU rewrite, standard serial input/output, and parallel input/output modes–in which its internal flash memory can be operated on.

Table 17.1 shows the outline performance of flash memory version (see Table 1.1 for the items not listed in Table 17.1.).

Table 17.1 Flash Memory Version Specifications

Item		Specification
Flash memory operating mode		3 modes (CPU rewrite, standard serial I/O, parallel I/O)
Erase block	User ROM area	See Figure 17.1
	Boot ROM area	1 block (4 Kbytes) (Note 1)
Method for program		In units of word
Method for erasure		Block erase
Program, erase control method		Program and erase controlled by software command
Protect method		Protected for each block by lock bit
Number of commands		7 commands
Number of program and erasure		100 times
Data Retention		10 years
ROM code protection		Parallel I/O and standard serial I/O modes are supported.

Note 1: The boot ROM area contains a standard serial I/O mode rewrite control program which is stored in it when shipped from the factory. This area can only be rewritten in parallel input/output mode.

Table 17.2 **Flash Memory Rewrite Modes Overview**

Flash memory rewrite mode	CPU rewrite mode (Note 1)	Standard serial I/O mode	Parallel I/O mode
Function	The user ROM area is rewritten by executing software commands from the CPU. EW0 mode: Can be rewritten in any area other than the flash memory (Note 2) EW1 mode: Can be rewritten in the flash memory	The user ROM area is rewritten by using a dedicated serial programmer. Standard serial I/O mode 1: Clock sync serial I/O Standard serial I/O mode 2: UART	The boot ROM and user ROM areas are rewritten by using a dedicated parallel programmer.
Areas which can be rewritten	User ROM area	User ROM area	User ROM area Boot ROM area
Operation mode	Single chip mode Boot mode (EW0 mode)	Boot mode	Parallel I/O mode
ROM programmer	None	Serial programmer	Parallel programmer

Note 1: Bit 3 of processor mode register 1 remains set to "1" while the FMR0 register FMR01 bit = 1 (CPU rewrite mode enabled).

Bit 3 of processor mode register 1 is reverted to its original value by clearing the FMR01 bit to "0" (CPU rewrite mode disabled). However, if bit 3 of processor mode register 1 is changed during CPU rewrite mode, its changed value is not reflected until after the FMR01 bit is cleared to "0".

Note 2: When in CPU rewrite mode, bit 0 and bit 3 in the PM1 register are set to "1". The rewrite control program can only be executed in the internal RAM.

17.2 Memory Map

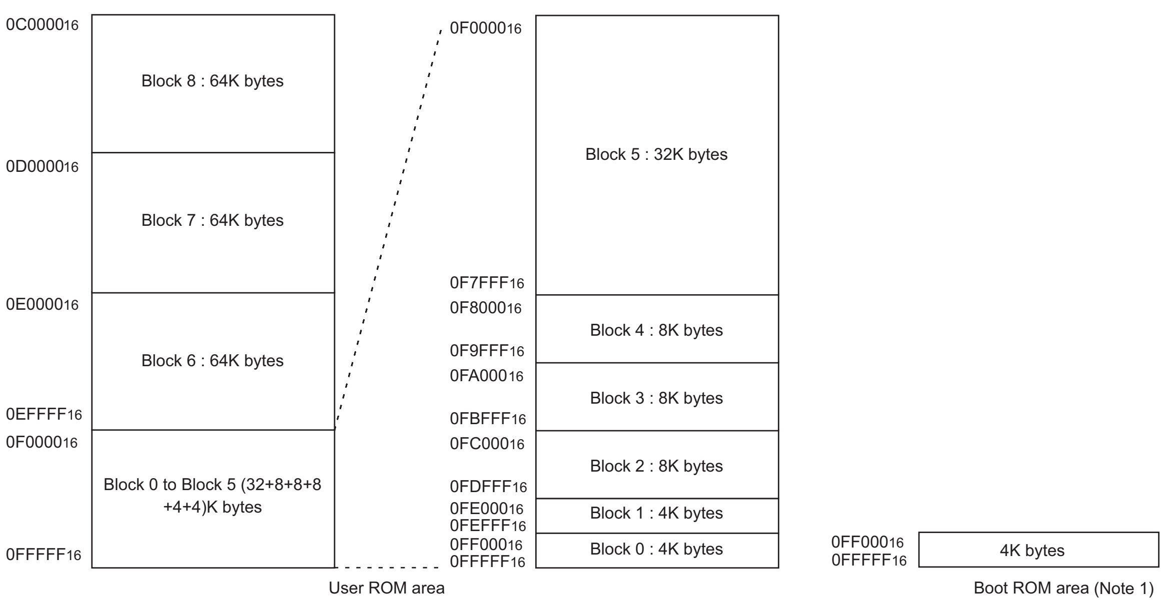
The ROM in the flash memory version is separated between a user ROM area and a boot ROM area.

Figure 17.1 shows the block diagram of flash momoery.

The user ROM area is divided into several blocks, each of which can individually be protected (locked) against programming or erasure. The user ROM area can be rewritten in all of CPU rewrite, standard serial input/output, and parallel input/output modes.

The boot ROM area is located at addresses that overlap the user ROM area, and can only be rewritten in parallel input/output mode. After a hardware reset that is performed by applying a high-level signal to the CNVSS and P50 pins and a low-level signal to the M1 pin, the program in the boot ROM area is executed.

After a hardware reset that is performed by applying a low-level signal to the CNVSS pin, the program in the user ROM area is executed (but the boot ROM area cannot be read).



Note 1: The boot ROM area can only be rewritten in parallel input/output mode.
Note 2: To specify a block, use an even address in that block.
Note 3: Shown here is a block diagram during single-chip mode.

Figure 17.1 Flash Memory Block Diagram

17.3 Boot Mode

After a hardware reset which is performed by applying a low-level signal to the M1 pin and a high-level signal to the CNV$_{SS}$ and $P5_0$ pins, the microcomputer is placed in boot mode, thereby executing the program in the boot ROM area.

During boot mode, the boot ROM and user ROM areas are switched over by the FMR05 bit in the FMR0 register.

The boot ROM area contains a standard serial input/output mode based rewrite control program which was stored in it when shipped from the factory.

The boot ROM area can be rewritten in parallel input/output mode. Prepare an EW0 mode based rewrite control program and write it in the boot ROM area, and the flash memory can be rewritten as suitable for the system.

17.4 Functions To Prevent Flash Memory from Rewriting

To prevent the flash memory from being read or rewritten easily, parallel input/output mode has a ROM code protect and standard serial input/output mode has an ID code check function.

17.4.1 ROM Code Protect Function

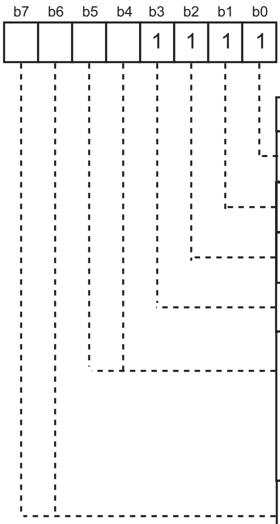
The ROM code protect function inhibits the flash memory from being read or rewritten during parallel input/output mode. Figure 17.2 shows the ROMCP register.

The ROMCP register is located in the user ROM area. The ROMCP1 bit consists of two bits. The ROM code protect function is enabled by clearing one or both of two ROMCP1 bits to “0” when the ROMCR bits are not ‘00_2,’ with the flash memory thereby protected against reading or rewriting. Conversely, when the ROMCR bits are ‘00_2’ (ROM code protect removed), the flash memory can be read or rewritten. Once the ROM code protect function is enabled, the ROMCR bits cannot be changed during parallel input/output mode. Therefore, use standard serial input/output or other modes to rewrite the flash memory.

17.4.2 ID Code Check Function

Use this function in standard serial input/output mode. Unless the flash memory is blank, the ID codes sent from the programmer and the ID codes written in the flash memory are compared to see if they match. If the ID codes do not match, the commands sent from the programmer are not accepted. The ID code consists of 8-bit data, the areas of which, beginning with the first byte, are 0FFFDF$_{16}$, 0FFFE3$_{16}$, 0FFFEB$_{16}$, 0FFFEF$_{16}$, 0FFFF3$_{16}$, 0FFFF7$_{16}$, and 0FFFFB$_{16}$. Prepare a program in which the ID codes are preset at these addresses and write it in the flash memory.

ROM code protect control address



Symbol	Address	Value when shipped
ROMCP	$0FFFFF_{16}$	FF_{16} (Note 4)

Bit symbol	Bit name	Function	RW
—	Reserved bit	Set this bit to "1"	RW
—	Reserved bit	Set this bit to "1"	RW
—	Reserved bit	Set this bit to "1"	RW
—	Reserved bit	Set this bit to "1"	RW
ROMCR	ROM code protect reset bit (Note 2, Note 4)	b5 b4 00: Removes protect 01: } Enables ROMCP1 bit 10: 11:	RW RW
ROMCP1	ROM code protect level 1 set bit (Note 1, Note 3, Note 4)	b7 b6 00: } Protect enabled 01: 10: 11: Protect disabled	RW RW

Note 1: If the ROMCR bits are set to other than "00_2"and the ROMCP1 bits are set to other than "11_2" (ROM code protect enabled), the flash memory is disabled against reading and rewriting in parallel input/output mode.

Note 2: If the ROMCR bits are set to "00_2," ROM code protect level 1 is removed. However, because the ROMCR bits cannot be modified during parallel input/output mode, they need to be modified in standard serial input/output or other modes.

Note 3: The ROMCP1 bits are effective when the ROMCR bits are "01_2," "10_2," or "11_2."

Note 4: Once any of these bits is cleared to "0", it cannot be set back to "1". If a memory block that contains the ROMCP register is erased, the ROMCP register is set to "FF_{16}."

Figure 17.2 ROMCP Register

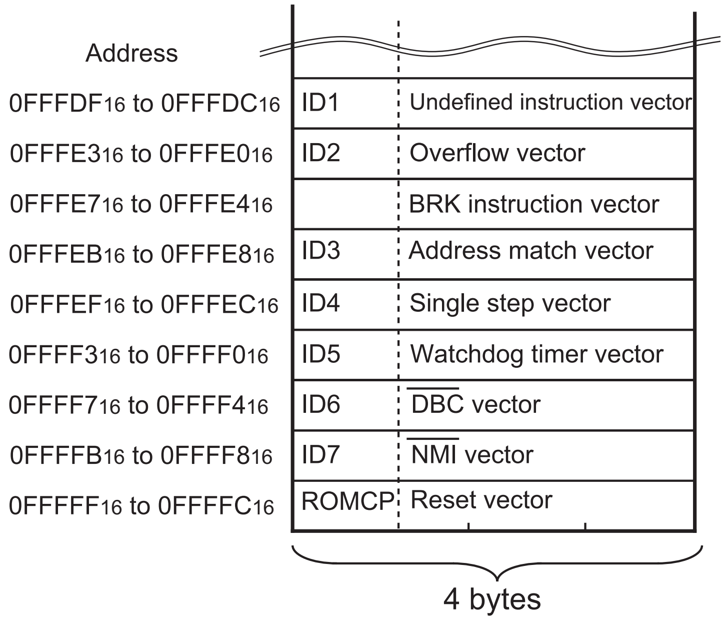


Figure 17.3 Address for ID Code Stored

17.5 CPU Rewrite Mode

In CPU rewrite mode, the user ROM area can be rewritten by executing software commands from the CPU. Therefore, the user ROM area can be rewritten directly while the microcomputer is mounted on-board without having to use a ROM programmer, etc.

In CPU rewrite mode, only the user ROM area shown in Figure 17.1 can be rewritten and the boot ROM area cannot be rewritten. Make sure the Program and the Block Erase commands are executed only on each block in the user ROM area.

During CPU rewrite mode, the user ROM area be operated on in either Erase Write 0 (EW0) mode or Erase Write 1 (EW1) mode. Table 17.3 lists the differences between Erase Write 0 (EW0) and Erase Write 1 (EW1) modes.

Table 17.3 EW0 Mode and EW1 Mode

Item	EW0 mode	EW1 mode
Operation mode	• Single chip mode • Boot mode	Single chip mode
Areas in which a rewrite control program can be located	• User ROM area • Boot ROM area	User ROM area
Areas in which a rewrite control program can be executed	Must be transferred to any area other than the flash memory (RAM) before being executed (Note 2)	Can be executed directly in the user ROM area
Areas which can be rewritten	User ROM area	User ROM area However, this does not include the area in which a rewrite control program exists
Software command limitations	None	• Program, Block Erase command Cannot be executed on any block in which a rewrite control program exists • Read Status Register command Cannot be executed
Modes after Program or Erase	Read Status Register mode	Read Array mode
CPU status during Auto Write and Auto Erase	Operating	Hold state (I/O ports retain the state in which they were before the command was executed)(Note 1)
Flash memory status detection	• Read the FMR0 register's FMR00, FMR06, and FMR07 bits in a program • Execute the Read Status Register command to read the status register's SR7, SR5, and SR4 flags.	Read the FMR0 register's FMR00, FMR06, and FMR07 bits in a program

Note 1: Make sure no interrupts (except $\overline{\text{NMI}}$ and watchdog timer interrupts) and DMA transfers will occur.

Note 2: When in CPU rewrite mode, bit 0 and bit 3 in the PM1 register are set to "1". The rewrite control program can only be executed in the internal RAM.

17.5.1 EW0 Mode

The microcomputer is placed in CPU rewrite mode by setting the FMR0 register's FMR01 bit to "1" (CPU rewrite mode enabled), ready to accept commands. In this case, because the FMR1 register's FMR11 bit = 0, EW0 mode is selected. The FMR01 bit can be set to "1" by writing "0" and then "1" in succession.
Use software commands to control program and erase operations. Read the FMR0 register or status register to check the status of program or erase operation at completion.

17.5.2 EW1 Mode

EW1 mode is selected by setting FMR11 bit to "1" (by writing "0" and then "1" in succession) after setting the FMR01 bit to "1" (by writing "0" and then "1" in succession).
Read the FMR0 register to check the status of program or erase operation at completion. The status register cannot be read during EW1 mode.
Figure 17.4 shows the FMR0 and FMR1 registers.
Registers FMR0 and FMR1 are shown in Figure 17.4.

FMR00 Bit

This bit indicates the operating status of the flash memory. The bit is “0” when the Program, Erase, or Lock Bit program is running; otherwise, the bit is “1”.

FMR01 Bit

The microcomputer is made ready to accept commands by setting the FMR01 bit to “1” (CPU rewrite mode). During boot mode, make sure the FMR05 bit also is “1” (user ROM area access).

FMR02 Bit

The lock bit set for each block can be disabled by setting the FMR02 bit to “1” (lock bit disabled). (Refer to the description of the data protect function.) The lock bits set are enabled by setting the FMR02 bit to “0”.
The FMR02 bit only disables the lock bit function and does not modify the lock bit data (lock bit status flag). However, if the Erase command is executed while the FMR02 bit is set to “1”, the lock bit data changes state from “0” (locked) to “1” (unlocked) after Erase is completed.

FMSTP Bit

This bit is provided for initializing the flash memory control circuits, as well as for reducing the amount of current consumed in the flash memory. The internal flash memory is disabled against access by setting the FMSTP bit to “1”. Therefore, make sure the FMSTP bit is modified in other than the flash memory.
In the following cases, set the FMSTP bit to “1”:

- . When flash memory access resulted in an error while erasing or programming in EW0 mode (FMR00 bit not reset to “1” (ready))
- . When entering low power mode

Figure 17.7 shows a flow chart to be followed before and after entering low power mode.
Note that when going to stop or wait mode, the FMR0 register does not need to be set because the power for the internal flash memory is automatically turned off and is turned back on again after returning from stop or wait mode.

FMR05 Bit

This bit switches between the boot ROM and user ROM areas during boot mode. Set this bit to “0” when accessing the boot ROM area (for read) or “1” (user ROM access) when accessing the user ROM area (for read, write, or erase).

FMR06 Bit

This is a read-only bit indicating the status of auto program operation. The bit is set to “1” when a program error occurs; otherwise, it is cleared to “0”. For details, refer to the description of the full status check.

FMR07 Bit

This is a read-only bit indicating the status of auto erase operation. The bit is set to “1” when an erase error occurs; otherwise, it is cleared to “0”. For details, refer to the description of the full status check.

Figure 17.5 and 17.6 show the setting and resetting of EW0 mode and EW1 mode, respectively.

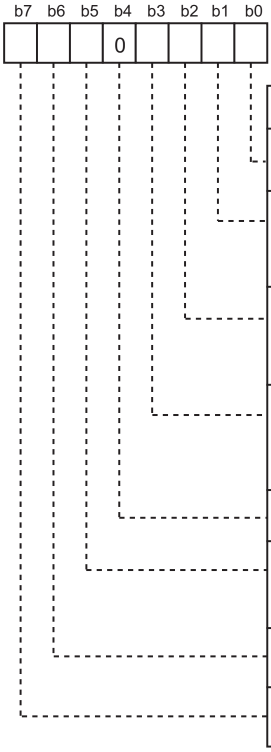
FMR11 Bit

Setting this bit to “1” places the microcomputer in EW1 mode.

FMR16 Bit

This is a read-only bit indicating the execution result of the Read Lock Bit Status command.

Flash memory control register 0



Symbol	Address	After reset
FMR0	$01B7_{16}$	$XX000001_2$

Bit symbol	Bit name	Function	RW
FMR00	RY/$\overline{BY}$ status flag	0: Busy (being written or erased) 1: Ready	RO
FMR01	CPU rewrite mode select bit (Note 1)	0: Disables CPU rewrite mode 1: Enables CPU rewrite mode	RW
FMR02	Lock bit disable select bit (Note 2)	0: Enables lock bit 1: Disables lock bit	RW
FMSTP	Flash memory stop bit (Note 3, Note 5))	0: Enables flash memory operation 1: Stops flash memory operation (placed in low power mode, flash memory initialized)	RW
(b4)	Reserved bit	Must always be set to “0”	RW
FMR05	User ROM area select bit (Note 3) (Effective in only boot mode)	0: Boot ROM area is accessed 1: User ROM area is accessed	RW
FMR06	Program status flag (Note 4)	0: Terminated normally 1: Terminated in error	RO
FMR07	Erase status flag (Note 4)	0: Terminated normally 1: Terminated in error	RO

Note 1: To set this bit to “1”, write “0” and then “1” in succession. Make sure no interrupts or DMA transfers will occur before writing “1” after writing “0”.
Write to this bit when the $\overline{NMI}$ pin is in the high state. Also, while in EW0 mode, modify this bit in other than the flash memory.

Note 2: To set this bit to “1”, write “0” and then “1” in succession when the FMR01 bit = 1. Make sure no interrupts or no DMA transfers will occur before writing “1” after writing “0”.

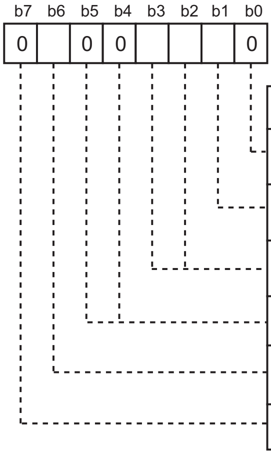
Note 3: modify this bit in other than the flash memory.

Note 4: This flag is cleared to “0” by executing the Clear Status command.

Note 5: Effective when the FMR01 bit = 1 (CPU rewrite mode). If the FMR01 bit = 0, although the FMSTP bit can be set to “1” by writing “1” in a program, the flash memory is neither placed in low power mode nor initialized.

Note 6: This status includes writing or reading with the Lock Bit Program or Read Lock Bit Status command.

Flash memory control register 1

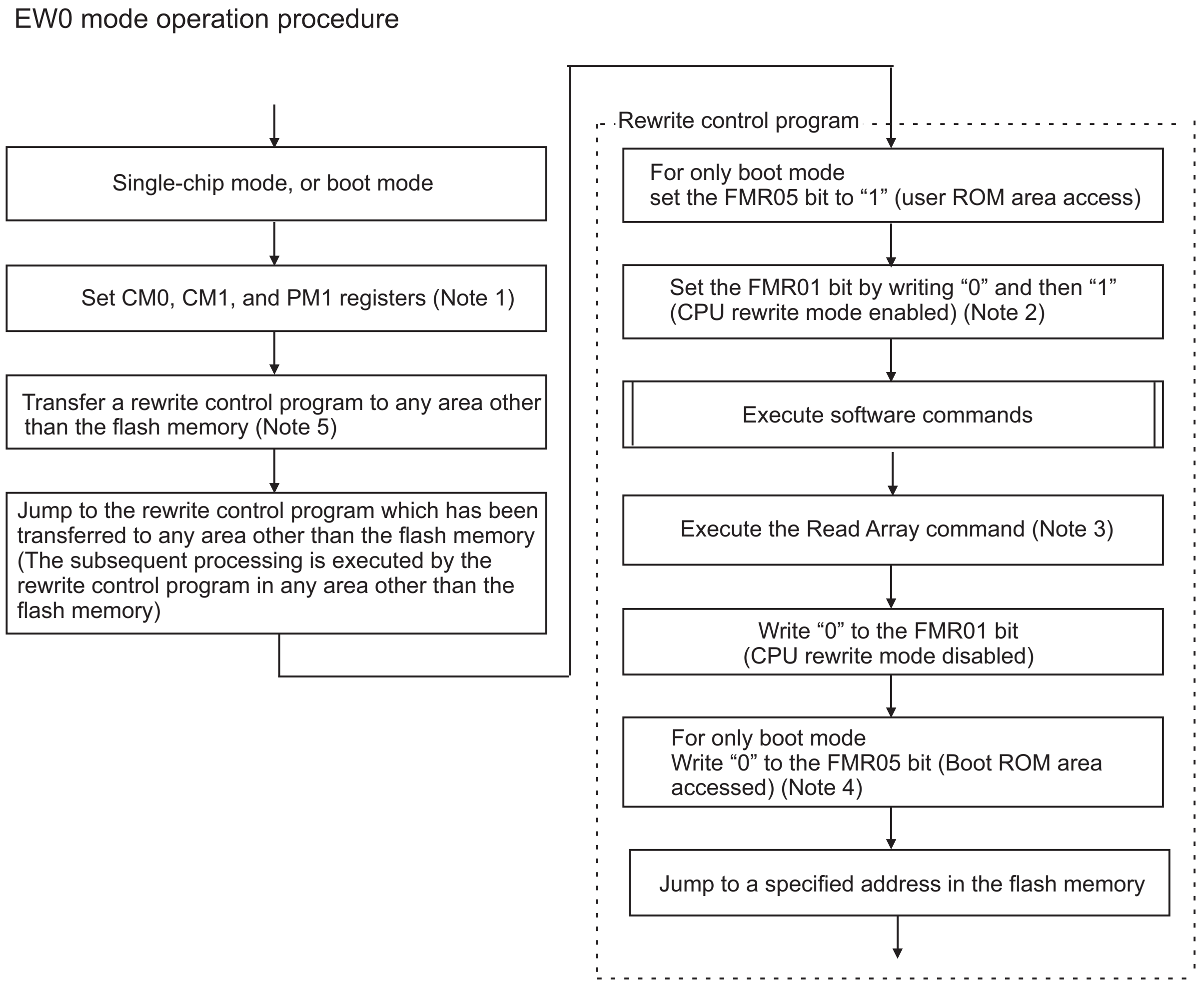


Symbol	Address	After reset
FMR1	$01B5_{16}$	$0X00XX0X_2$

Bit symbol	Bit name	Function	RW
(b0)	Reserved bit	The value in this bit when read is indeterminate.	RO
FMR11	EW1 mode select bit (Note)	0: EW0 mode 1: EW1 mode	RW
(b3-b2)	Reserved bit	The value in this bit when read is indeterminate.	RO
(b5-b4)	Reserved bit	Must always be set to “0”	RW
FMR16	Lock bit status flag	0: Lock 1: Unlock	RO
(b7)	Reserved bit	Must always be set to “0”	RW

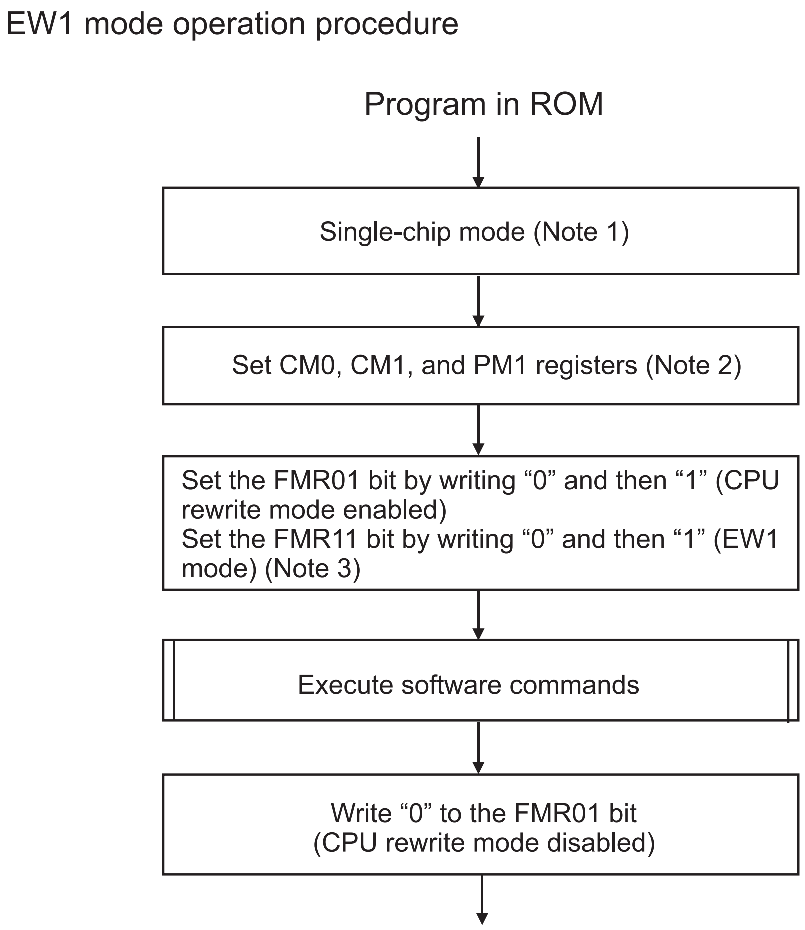
Note : To set this bit to “1”, write “0” and then “1” in succession when the FMR01 bit = 1. Make sure no interrupts or no DMA transfers will occur before writing “1” after writing “0”. Write this bit in the state the $\overline{NMI}$ pin = “H”. The FMR01 and FMR11 bits both are cleared to “0” by setting the FMR01 bit to “0”.

Figure 17.4 FMR0 and FMR1 Registers



Note 1: Select 10 MHz or less for CPU clock using the CM0 register’s CM06 bit and CM1 register’s CM17 to 6 bits. Also, set the PM1 register’s PM17 bit to “1” (with wait state).
Note 2: To set the FMR01 bit to “1”, write “0” and then “1” in succession. Make sure no interrupts or no DMA transfers will occur before writing “1” after writing “0”.
Write to the FMR01 bit from a program in other than the flash memory. Also write only when the $\overline{\text{NMI}}$ pin is “H” level.
Note 3: Disables the CPU rewrite mode after executing the Read Array command.
Note 4: User ROM area is accessed when the FMR05 bit is set to “1”.
Note 5: When in CPU rewrite mode, bit 0 and bit 3 in the PM1 register are set to “1”. The rewrite control program can only be executed in the internal RAM or in an external area that is enabled for use when the PM13 bit = 1.

Figure 17.5 Setting and Resetting of EW0 Mode

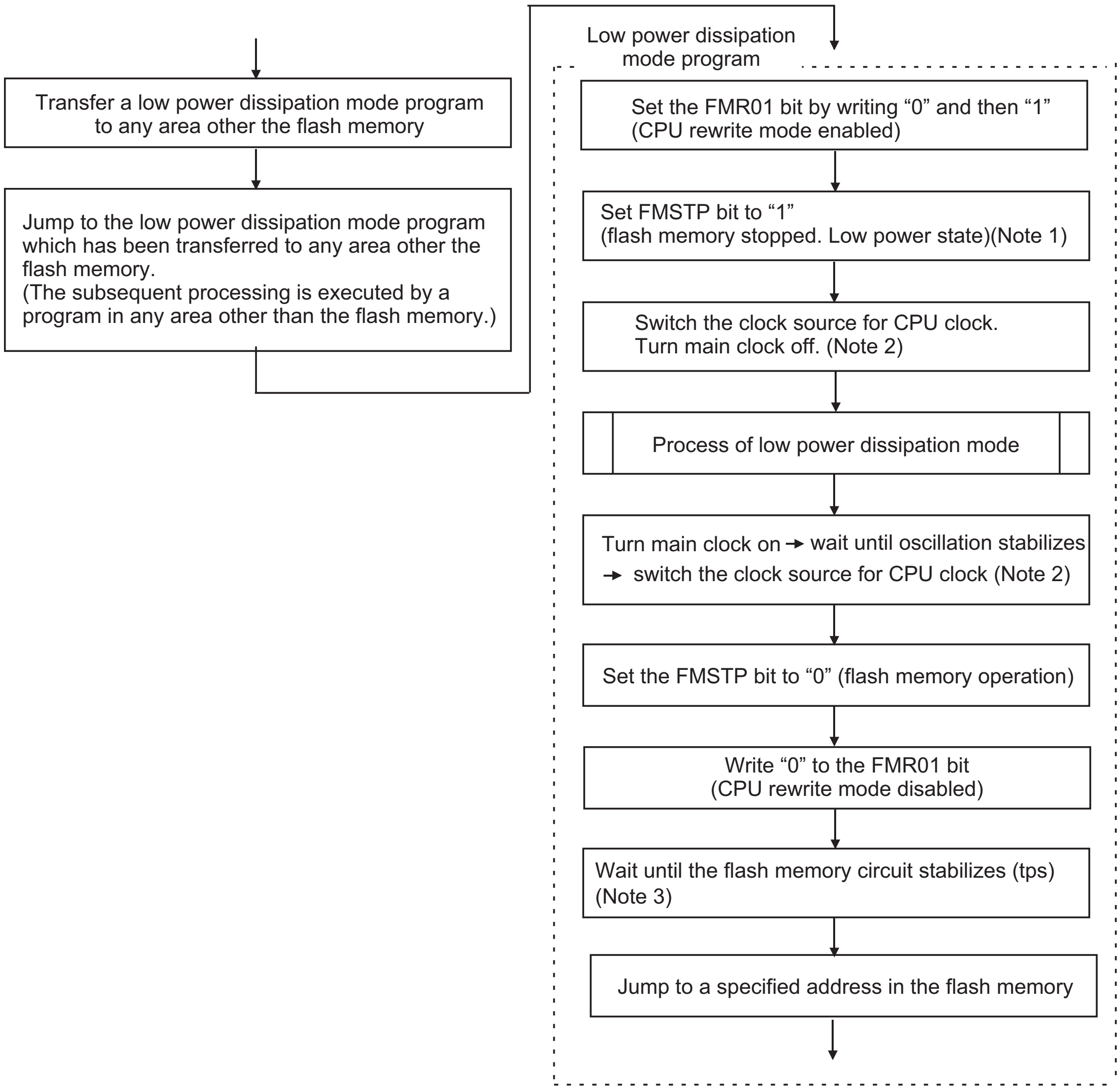


Note 1: In EW1 mode, do not set the microcomputer in boot mode.

Note 2: Select 10 MHz or less for CPU clock using the CM0 register’s CM06 bit and CM1 register’s CM17 to 6 bits. Also, set the PM1 register’s PM17 bit to “1” (with wait state).

Note 3: To set the FMR01 bit to “1”, write “0” and then “1” in succession. Make sure no interrupts or no DMA transfers will occur before writing “1” after writing “0”. Write to the FMR01 bit from a program in other than the flash memory. Also write only when the $\overline{NMI}$ pin is “H” level.

Figure 17.6 Setting and Resetting of EW1 Mode



Note 1: Set the FMSTP bit to 1 after setting the FMR01 bit to "1".
Note 2: Before the clock source for CPU clock can be changed to main clock or sub clock, the clock to which to be changed must be stable.
Note 3: Insert a tps wait time in a program. The flash memory cannot be accessed during this wait time.

Figure 17.7 Processing Before and After Low Power Dissipation Mode

17.5.3 Precautions on CPU Rewrite Mode

Described below are the precautions to be observed when rewriting the flash memory in CPU rewrite mode.

(1) Operation Speed

Before entering CPU rewrite mode (EW0 or EW1 mode), select 10 MHz or less for BCLK using the CM06 bit in the CM0 register and the CM17 to CM16 bits in the CM1 register. Also, set the PM17 bit in the PM1 register to “1” (with wait state).

(2) Instructions to Prevent from Using

The following instructions cannot be used in EW0 mode because the flash memory’s internal data is referenced: UND instruction, INTO instruction, JMPS instruction, JSRS instruction, and BRK instruction.

(3) Interrupts

EW0 Mode

- Any interrupt which has a vector in the variable vector table can be used providing that its vector is transferred into the RAM area.
- The $\overline{\text{NMI}}$ and watchdog timer interrupts can be used because the FMR0 register and FMR1 register are initialized when one of those interrupts occurs. The jump addresses for those interrupt service routines should be set in the fixed vector table.
  Because the rewrite operation is halted when a $\overline{\text{NMI}}$ or watchdog timer interrupt occurs, the rewrite program must be executed again after exiting the interrupt service routine.
- The address match interrupt cannot be used because the flash memory’s internal data is referenced.

EW1 Mode

- Make sure that any interrupt which has a vector in the variable vector table or address match interrupt will not be accepted during the auto program or auto erase period.
- Avoid using watchdog timer interrupts.
- The $\overline{\text{NMI}}$ interrupt can be used because the FMR0 register and FMR1 register are initialized when this interrupt occurs. The jump address for the interrupt service routine should be set in the fixed vector table.
  Because the rewrite operation is halted when a $\overline{\text{NMI}}$ interrupt occurs, the rewrite program must be executed again after exiting the interrupt service routine.

(4) How to Access

To set the FMR01, FMR02, or FMR11 bit to “1”, write “0” and then “1” in succession. This is necessary to ensure that no interrupts or DMA transfers will occur before writing “1” after writing “0”. Also only when $\overline{\text{NMI}}$ pin is “H” level.

(5) Writing in the User ROM Space

EW0 Mode

- If the power supply voltage drops while rewriting any block in which the rewrite control program is stored, a problem may occur that the rewrite control program is not correctly rewritten and, consequently, the flash memory becomes unable to be rewritten thereafter. In this case, standard serial I/O or parallel I/O mode should be used.

EW1 Mode

- Avoid rewriting any block in which the rewrite control program is stored.

(6) DMA Transfer

In EW1 mode, make sure that no DMA transfers will occur while the FMR0 registerÅfs FMR00 bit = 0 (during the auto program or auto erase period).

(7) Writing Command and Data

Write the command code and data at even addresses.

(8) Wait Mode

When shifting to wait mode, set the FMR01 bit to “0” (CPU rewrite mode disabled) before executing the WAIT instruction.

(9) Stop Mode

When shifting to stop mode, the following settings are required:

- •Set the FMR01 bit to “0” (CPU rewrite mode disabled) and disable DMA transfers before setting the CM10 bit to “1” (stop mode).
- •Execute the JMP.B instruction subsequent to the instruction which sets the CM10 bit to “1” (stop mode)

```
Example program      BSET      0, CM1      ; Stop mode
                     JMP.B     L1
                L1:
                     Program after returning from stop mode
```

(10) Low Power Dissipation Mode

If the CM05 bit is set to “1” (main clock stop), the following commands must not be executed.

- •Program
- •Block erase
- •Lock bit program

17.5.4 Software Commands

Software commands are described below. The command code and data must be read and written in 16-bit units, to and from even addresses in the user ROM area. When writing command code, the 8 high order bits (D_{1t}–D_8) are ignored.

Table 17.4 Software Commands

Command	First bus cycle			Second bus cycle		
	Mode	Address	Data (D_0 to D_{15})	Mode	Address	Data (D_0 to D_7)
Read array	Write	X	xxFF$_{16}$			
Read status register	Write	X	xx70$_{16}$	Read	X	SRD
Clear status register	Write	X	xx50$_{16}$			
Program	Write	WA	xx40$_{16}$	Write	WA	WD
Block erase	Write	X	xx20$_{16}$	Write	BA	xxD0$_{16}$
Lock bit program	Write	BA	xx77$_{16}$	Write	BA	xxD0$_{16}$
Read lock bit status	Write	X	xx71$_{16}$	Write	BA	xxD0$_{16}$

SRD: Status register data (D_7 to D_0)
WA: Write address (Make sure the address value specified in the the first bus cycle is the same even address as the write address specified in the second bus cycle.)
WD: Write data (16 bits)
BA: Uppermost block address (even address, however)
X: Any even address in the user ROM area
xx: High-order 8 bits of command code (ignored)

Read Array Command (FF$_{16}$)

This command reads the flash memory.
Writing 'exxFF$_{16}$' in the first bus cycle places the microcomputer in read array mode. Enter the read address in the next or subsequent bus cycles, and the content of the specified address can be read in 16-bit units.
Because the microcomputer remains in read array mode until another command is written, the contents of multiple addresses can be read in succession.

Read Status Register Command (70$_{16}$)

This command reads the status register.
Write 'exx70$_{16}$' in the first bus cycle, and the status register can be read in the second bus cycle. (Refer to "Status Register.") When reading the status register too, specify an even address in the user ROM area.
Do not execute this command in EW1 mode.

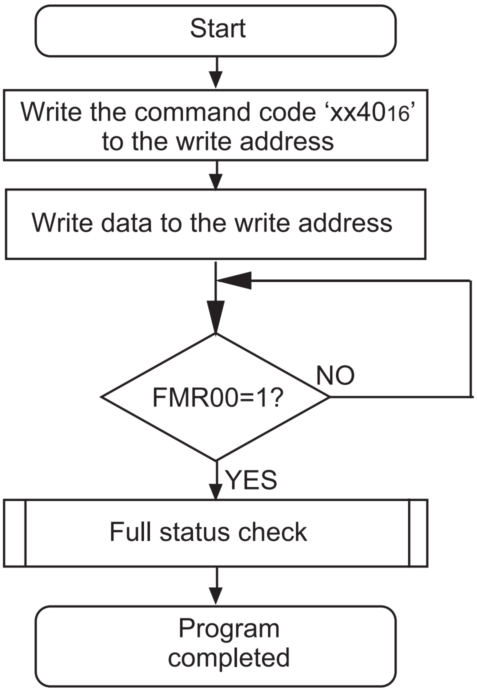
Clear Status Register Command

This command clears the status register to “0”.
Write ‘exx50$_{16}$’ in the first bus cycle, and the FMR06 to FMR07 bits in the FMR0 register and SR4 to SR5 in the status register will be cleared to “0”.

Program Command

This command writes data to the flash memory in 1 word (2 byte) units.
Write ‘exx40$_{16}$’ in the first bus cycle and write data to the write address in the second bus cycle, and an auto program operation (data program and verify) will start. Make sure the address value specified in the first bus cycle is the same even address as the write address specified in the second bus cycle.
Check the FMR00 bit in the FMR0 register to see if auto programming has finished. The FMR00 bit is “0” during auto programming and set to “1” when auto programming is completed.
Check the FMR06 bit in the FMR0 register after auto programming has finished, and the result of auto programming can be known. (Refer to “Full Status Check.”)
Each block can be protected against programming by a lock bit. (Refer to “Data Protect Function.”)
Be careful not to write over the already programmed addresses.

In EW1 mode, do not execute this command on any address at which the rewrite control program is located.
In EW0 mode, the microcomputer goes to read status register mode at the same time auto programming starts, making it possible to read the status register. The status register bit 7 (SR7) is cleared to “0” at the same time auto programming starts, and set back to “1” when auto programming finishes. In this case, the microcomputer remains in read status register mode until a read command is written next. The result of auto programming can be known by reading the status register after auto programming has finished.

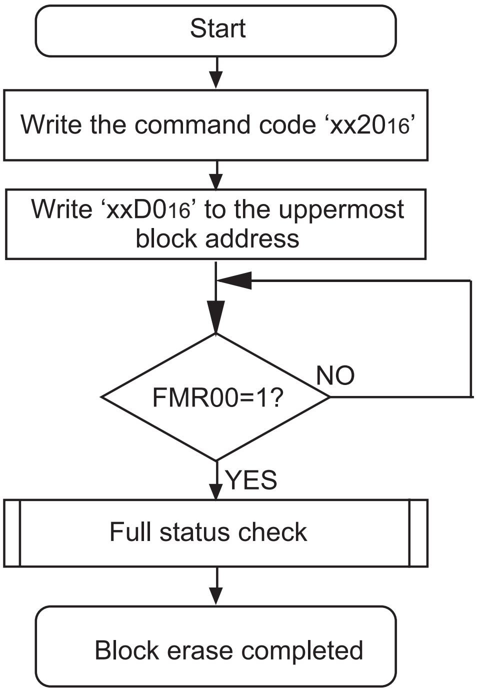


Note: Write the command code and data at even number.

Figure 17.8 Program Command

Block Erase

Write ‘exx20_{16}’ in the first bus cycle and write ‘exx$D0_{16}$’ to the uppermost address of a block (even address, however) in the second bus cycle, and an auto erase operation (erase and verify) will start.
Check the FMR0 register’s FMR00 bit to see if auto erasing has finished.
The FMR00 bit is “0” during auto erasing and set to “1” when auto erasing is completed.
Check the FMR0 register’s FMR07 bit after auto erasing has finished, and the result of auto erasing can be known. (Refer to “Full Status Check.”)
Figure 17.9 shows an example of a block erase flowchart.
Each block can be protected against erasing by a lock bit. (Refer to “Data Protect Function.”) In EW1 mode, do not execute this command on any address at which the rewrite control program is located.
In EW0 mode, the microcomputer goes to read status register mode at the same time auto erasing starts, making it possible to read the status register. The status register bit 7 (SR7) is cleared to “0” at the same time auto erasing starts, and set back to “1” when auto erasing finishes. In this case, the microcomputer remains in read status register mode until the Read Array or Read Lock Bit Status command is written next.

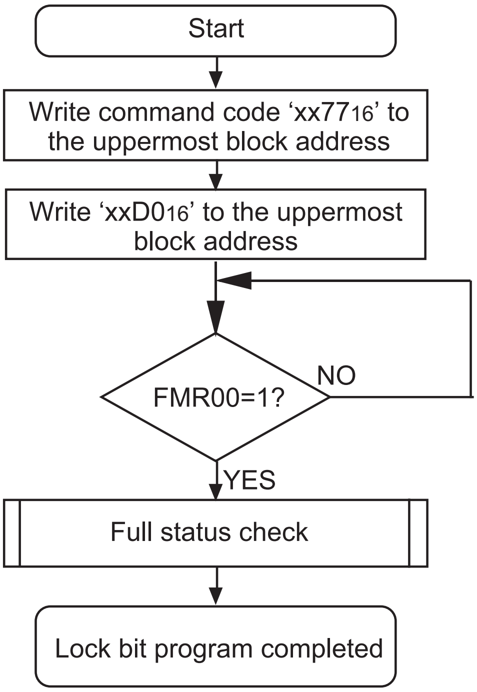


Note: Write the command code and data at even number.

Figure 17.9 Block Erase Command

Lock Bit Program Command

This command sets the lock bit for a specified block to “0” (locked).
Write ‘exx77$_{16}$’ in the first bus cycle and write ‘exxD0$_{16}$’ to the uppermost address of a block (even address, however) in the second bus cycle, and the lock bit for the specified block is cleared to “0”.
Make sure the address value specified in the first bus cycle is the same uppermost block address that is specified in the second bus cycle.
Figure 17.10 shows an example of a lock bit program flowchart. The lock bit status (lock bit data) can be read using the Read Lock Bit Status command.
Check the FMR0 register’s FMR00 bit to see if writing has finished.
For details about the lock bit function, and on how to set the lock bit to “1”, refer to “Data Protect Function.”

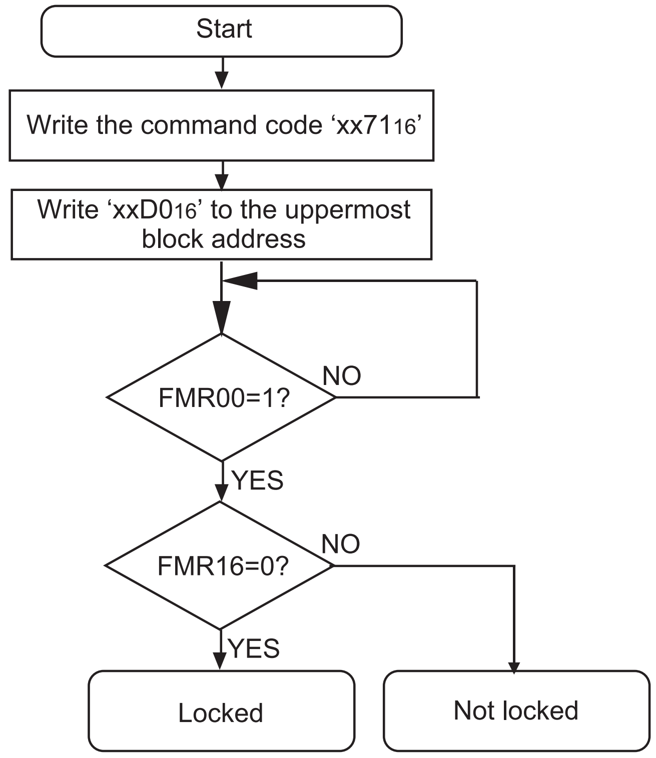


Note: Write the command code and data at even number.

Figure 17.10 Lock Bit Program Command

Read Lock Bit Status Command

This command reads the lock bit status of a specified block.
Write 'exx71_{16}' in the first bus cycle and write 'exx$D0_{16}$' to the uppermost address of a block (even address, however) in the second bus cycle, and the lock bit status of the specified block is stored in the FMR1 register's FMR16 bit. Read the FMR16 bit after the FMR0 register's FMR00 bit is set to "1" (ready).
Figure 17.11 shows an example of a read lock bit status flowchart.



Note: Write the command code and data at even number.

Figure 17.11 Read Lock Bit Status Command

17.6 Data Protect Function

Each block in the flash memory has a nonvolatile lock bit. The lock bit is effective when the FMR02 bit = 0 (lock bit enabled). The lock bit allows each block to be individually protected (locked) against programming and erasure. This helps to prevent data from inadvertently written to or erased from the flash memory. The following shows the relationship between the lock bit and the block status.

- When the lock bit = 0, the block is locked (protected against programming and erasure).
- When the lock bit = 1, the block is not locked (can be programmed or erased).

The lock bit is cleared to "0" (locked) by executing the Lock Bit Program command, and is set to "1" (unlocked) by erasing the block. The lock bit cannot be set to "1" by a command.
The lock bit status can be read using the Read Lock Bit Status command.

The lock bit function is disabled by setting the FMR02 bit to "1", with all blocks placed in an unlocked state. (The lock bit data itself does not change state.) Setting the FMR02 bit to "0" enables the lock bit function (lock bit data retained).
If the Block Erase command is executed while the FMR02 bit = 1, the target block or all blocks are erased irrespective of how the lock bit is set. The lock bit for each block is set to "1" after completion of erasure.
For details about the commands, refer to "Software Commands."

17.7 Status Register

The status register indicates the operating status of the flash memory and whether an erase or programming operation terminated normally or in error. The status of the status register can be known by reading the FMR0 register's FMR00, FMR06, and FMR07 bits.
Table 17.5 shows the status register.
In EW0 mode, the status register can be read in the following cases:

(1) When a given even address in the user ROM area is read after writing the Read Status Register command
(2) When a given even address in the user ROM area is read after executing the Program, Block Erase, or Lock Bit Program command but before executing the Read Array command.

Sequencer Status (SR7 and FMR00 Bits)

The sequence status indicates the operating status of the flash memory. SR7 = 0 (busy) during auto programming, auto erase, and lock bit write, and is set to "1" (ready) at the same time the operation finishes.

Erase Status (SR5 and FMR07 Bits)

Refer to "Full Status Check."

Program Status (SR4 and FMR06 Bits)

Refer to "Full Status Check."

Table 17.5 Status Register

Status register bit	FMR0 register bit	Status name	Contents		Value after reset
			"0"	"1"	
SR7 (D7)	FMR00	Sequencer status	Busy	Ready	1
SR6 (D6)	——	Reserved	-	-	——
SR5 (D5)	FMR07	Erase status	Terminated normally	Terminated in error	0
SR4 (D4)	FMR06	Program status	Terminated normally	Terminated in error	0
SR3 (D3)	——	Reserved	-	-	——
SR2 (D2)	——	Reserved	-	-	——
SR1 (D1)	——	Reserved	-	-	——
SR0 (D0)	——	Reserved	-	-	——

- D0 to D7: Indicates the data bus which is read out when the Read Status Register command is executed.
- The FMR07 bit (SR5) and FMR06 bit (SR4) are cleared to “0” by executing the Clear Status Register command.
- When the FMR07 bit (SR5) or FMR06 bit (SR4) = 1, the Program, Block Erase, and Lock Bit Program commands are not accepted.

17.8 Full Status Check

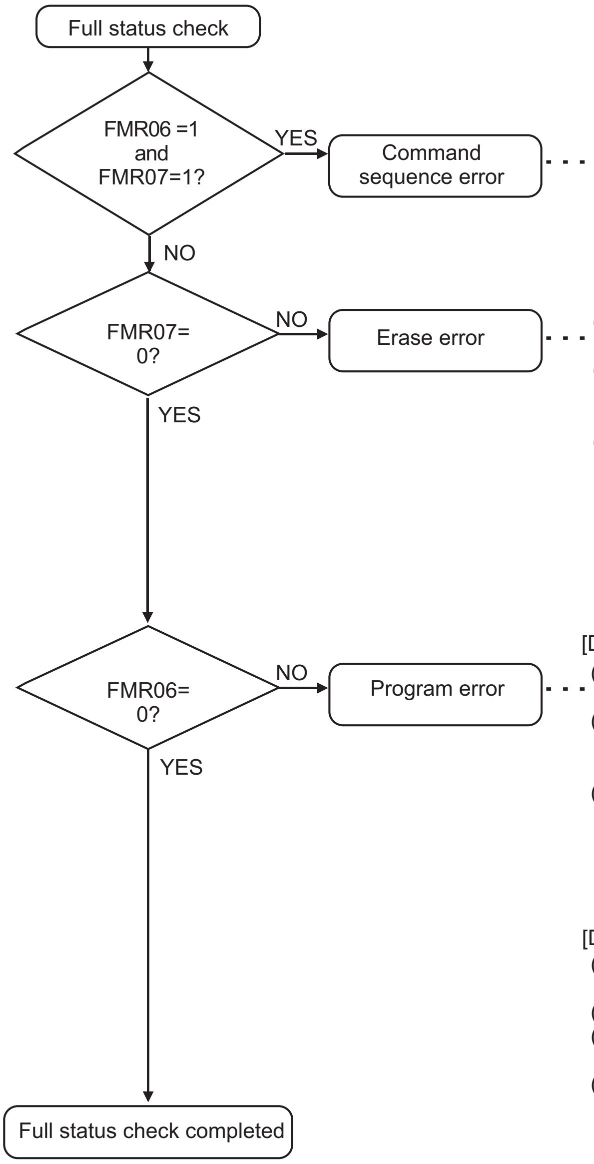
When an error occurs, the FMR0 register's FMR06 to FMR07 bits are set to "1", indicating occurrence of each specific error. Therefore, execution results can be verified by checking these status bits (full status check). Table 17.6 lists errors and FMR0 register status. Figure 17.12 shows a full status check flowchart and the action to be taken when each error occurs.

Table 17.6 Errors and FMR0 Register Status

FRM00 register (status register) status		Error	Error occurence condition
FMR07 (SR5)	FMR06 (SR4)		
1	1	Command sequence error	• When any command is not written correctly • When invalid data was written other than those that can be written in the second bus cycle of the Lock Bit Program or Block Erase command (i.e., other than '$xxD0_{16}$' or '$xxFF_{16}$') (Note 1)
1	0	Erase error	• When the Block Erase command was executed on locked blocks (Note 2) • When the Block Erase command was executed on unlocked blocks but the blocks were not automatically erased correctly
0	1	Program error	• When the Program command was executed on locked blocks (Note 2) • When the Program command was executed on unlocked blocks but the blocks were not automatically programmed correctly. • When the Lock Bit Program command was executed but not programmed correctly

Note 1: If "$xxFF_{16}$" is written by the 2nd bus cycle of these commands, it will become lead array mode and the command code written by the 1st bus cycle will become invalid simultaneously.

Note 2: When FMR02 bit is "1" (lock bit is invalid), an error is not generated on these conditions.



(1) Execute the Clear Status Register command to clear these status flags to “0”.
(2) Reexecute the command after checking that it is entered correctly.

(1) Execute the Clear Status Register command to clear the erase status flag to “0”.
(2) Execute the Read Lock Bit Status command to see if the lock bit for the block in error is “0”. If so, set the FMR0 register’s FMR02 bit to “1”.
(3) Reexecute the Block Erase command.

Note 1: If the error still occurs, the block in error cannot be used.
Furthermore, if the lock bit = 1 in (2) above, the block in error cannot be used either.

[During programming]
(1) Execute the Clear Status Register command to clear the program status flag to “0”.
(2) Execute the Read Lock Bit Status command to see if the lock bit for the block in error is “0”. If so, set the FMR0 register’s FMR02 bit to “1”.
(3) Reexecute the Program command.

Note 2: If the error still occurs, the block in error cannot be used.
Furthermore, if the lock bit = 1 in (2) above, the block in error cannot be used either.

[During lock bit programming]
(1) Execute the Clear Status Register command to clear the program status flag to “0”.
(2) Set the FMR0 register’s FMR02 bit to “1”.
(3) Execute the Block Erase command to erase the block in error.
(4) Reexecute the Lock Bit command.

Note 3: If the error still occurs, the block in error cannot be used.

Note 4: If FMR06 or FMR07 = 1, any of the Program, Block Erase, Lock Bit Program, or Read Lock Bit Status command is not accepted. Execute the Clear Status Register command before executing those commands.

Figure 17.12 Full Status Check and Handling Procedure for Each Error

17.9 Standard Serial I/O Mode

In standard serial input/output mode, the user ROM area can be rewritten while the microcomputer is mounted on-board by using a serial programmer suitable for M306H7FGFP. For more information about serial programmers, contact the manufacturer of your serial programmer. For details on how to use, refer to the user's manual included with your serial programmer.
Table 17.7 lists pin functions (flash memory standard serial input/output mode). Figures 17.13 show pin connections for serial input/output mode.

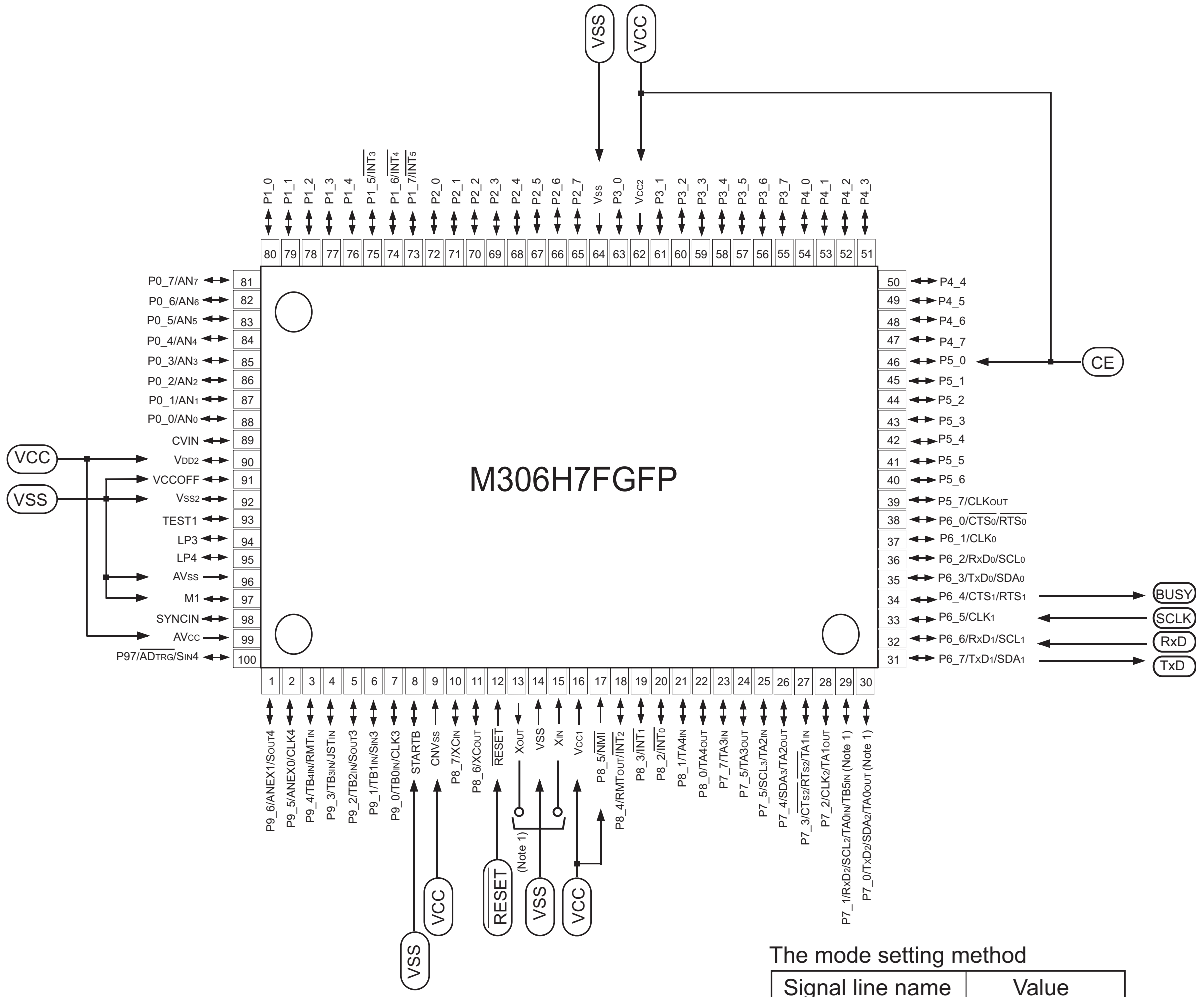
17.9.1 ID Code Check Function

This function determines whether the ID codes sent from the serial programmer and those written in the flash memory match. (Refer to the description of the functions to inhibit rewriting flash memory version.)

Table 17.7 Pin Functions (Flash Memory Standard Serial I/O Mode)

Pin		Name	I/O	Description
VCC1, VCC2, VSS		Power input		Input VCC1 to VCC1 pin. Input 4.75 to 5.25V to VCC2 pin. Input condition is VCC1 ≤ VCC2.
CNVSS		CNVSS	I	Connect to VCC2 pin.
$\overline{\text{RESET}}$		Reset input	I	Reset input pin. While $\overline{\text{RESET}}$ pin is "L" level, input a 20 cycle or longer clock to XIN pin.
M1		Mode select	I	Connect to VSS pin.
STARTB		Oscillation selection input	I	Connect to VSS pin.
XIN		Clock input	I	Connect a ceramic resonator or crystal oscillator between XIN and XOUT pins. To input an externally generated clock, input it to XIN pin and open XOUT pin.
XOUT		Clock output	O	
AVCC, AVSS		Analog power supply input		Connect AVss to Vss and AVcc to VCC2, respectively Apply VCC2 to AVcc pin and 0V to AVSS pin..
P00 to P07		Input port P0	I	Input "H" or "L" level signal or open.
P10 to P17		Input port P1	I	Input "H" or "L" level signal or open.
P20 to P27		Input port P2	I	Input "H" or "L" level signal or open.
P30 to P37		Input port P3	I	Input "H" or "L" level signal or open.
P40 to P47		Input port P4	I	Input "H" or "L" level signal or open.
P5	P51 to P57	Input port P5	I	Input "H" or "L" level signal or open.
	P50	$\overline{\text{CE}}$ input	I	Input "H" level signal.
P6	P60 to P63	Input port P6	I	Input "H" or "L" level signal or open.
	P64/$\overline{\text{RTS1}}$	BUSY output	O	Standard serial I/O mode 1: BUSY signal output pin Standard serial I/O mode 2: Monitors the boot program operation check signal output pin.
	P65/$\overline{\text{CLK1}}$	SCLK input	I	Standard serial I/O mode 1: Serial clock input pin Standard serial I/O mode 2: Input "L".
	P66/RXD1	RxD input	I	Serial data input pin
	P67/TXD1	TxD output	O	Serial data output pin (Note 1)
P70 to P77		Input port P7	I	Input "H" or "L" level signal or open.
P80 to P84, P86, P87		Input port P8	I	Input "H" or "L" level signal or open.
P85/$\overline{\text{NM1}}$		$\overline{\text{NMI}}$ input	I	Connect this pin to VCC2.
P90 to P97		Input port P9	I	Input "H" or "L" level signal or open.
VDD2, Vss2		Power input		Connect VDD2 pin to VCC2 and connect VSS2 pin to VSS. Apply VCC2 to VDD2 pin and 0V to VSS2 pin.
LP3, LP4		Filter output	O	Open
CVIN1, SYNCIN		Compound video input	I	Input "H" or "L" level signal or open.
VCCOFF		VCC1 faction power supply input switch	I	Input "L" level signal.

Note 1: When using standard serial input/output mode 1, the TxD pin must be held high while the $\overline{\text{RESET}}$ pin is pulled low. Therefore, connect this pin to VCC1 via a resistor. Because this pin is directed for data output after reset, adjust the pull-up resistance value in the system so that data transfers will not be affected.



Note 1. Connect an oscillation circuit.
Note 2. Figure is a use example for VCC1=VCC2.

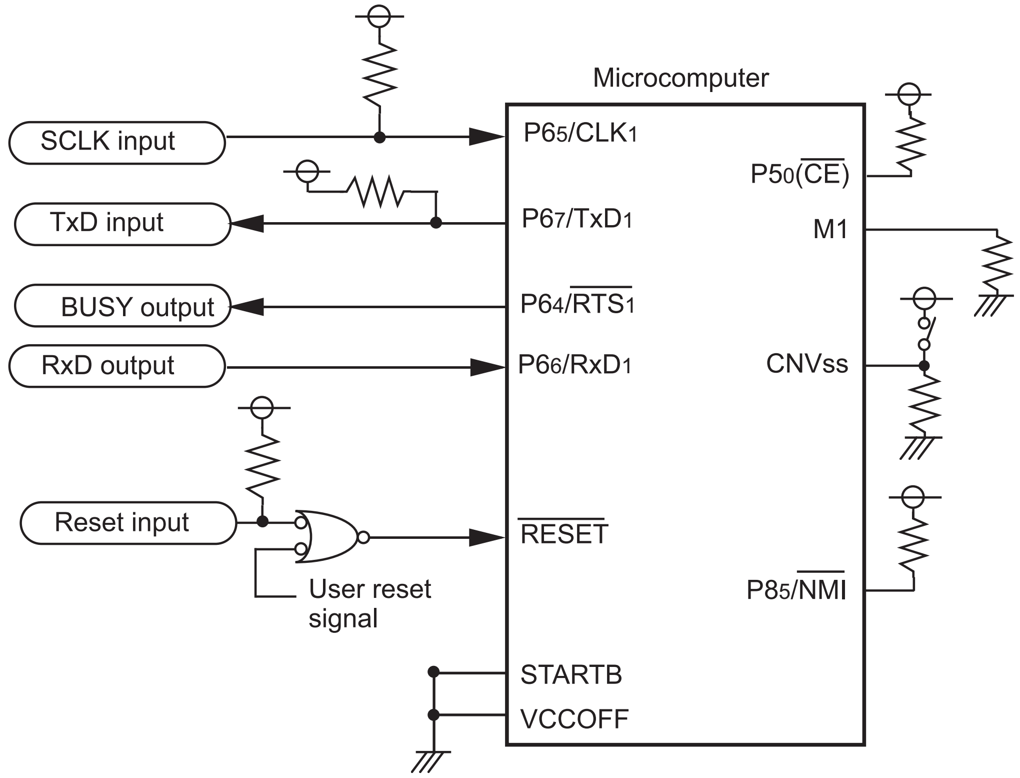
The mode setting method

Signal line name	Value
CNVss	Vcc
M1	Vss
RESET	Vss→Vcc
CE	Vcc

Figure 17.13 Pin Connections for Serial I/O Mode

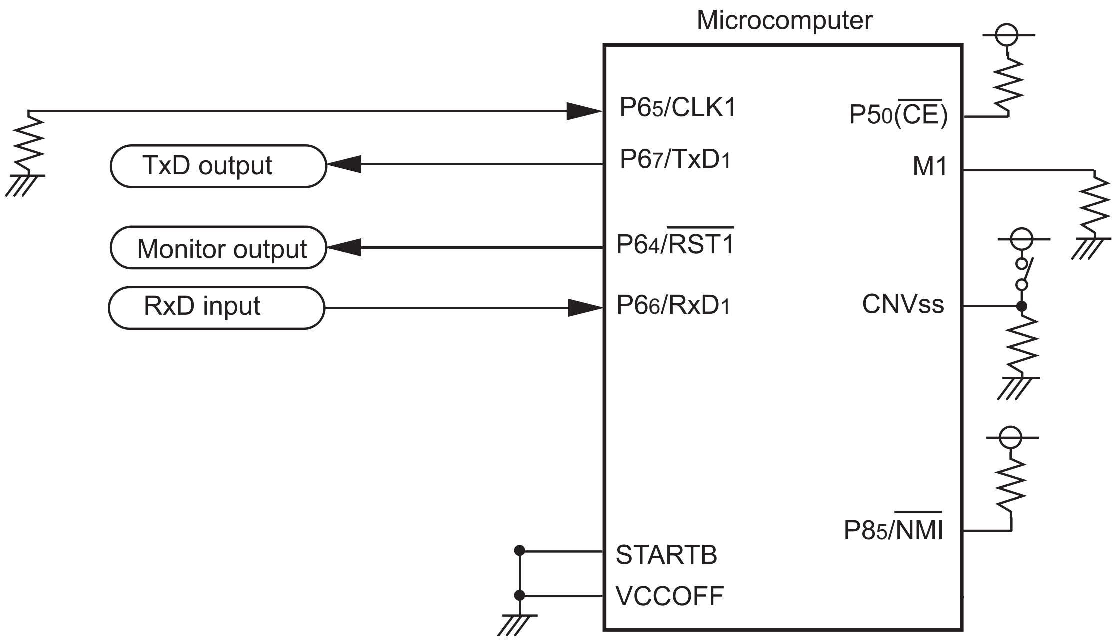
17.9.2 Example of Circuit Application in the Standard Serial I/O Mode

Figure 17.14 and 17.15 show example of circuit application in standard serial I/O mode 1 and mode 2, respectively. Refer to the user's manual for serial writer to handle pins controlled by a serial writer.



(1) Control pins and external circuitry will vary according to programmer. For more information, see the programmer manual.
(2) In this example, modes are switched between single-chip mode and standard serial input/output mode by controlling the CNVss input with a switch.
(3) If in standard serial input/output mode 1 there is a possibility that the user reset signal will go low during serial input/output mode, break the connection between the user reset signal and $\overline{\text{RESET}}$ pin by using, for example, a jumper switch.

Figure 17.14 Circuit Application in Standard Serial I/O Mode 1



(1) In this example, modes are switched between single-chip mode and standard serial input/output mode by controlling the CNVss input with a switch.

Figure 17.15 Circuit Application in Standard Serial I/o Mode 2

17.10 Parallel I/O Mode

In parallel input/output mode, the user ROM and boot ROM areas can be rewritten by using a parallel programmer suitable for M306H7FGFP. For more information about parallel programmers, contact the manufacturer of your parallel programmer. For details on how to use, refer to the user's manual included with your parallel programmer.

17.10.1 User ROM and Boot ROM Areas

In the boot ROM area, an erase block operation is applied to only one 4 Kbyte block. The boot ROM area contains a standard serial input/output mode based rewrite control program which was written in it when shipped from the factory. Therefore, when using a serial programmer, be careful not to rewrite the boot ROM area.

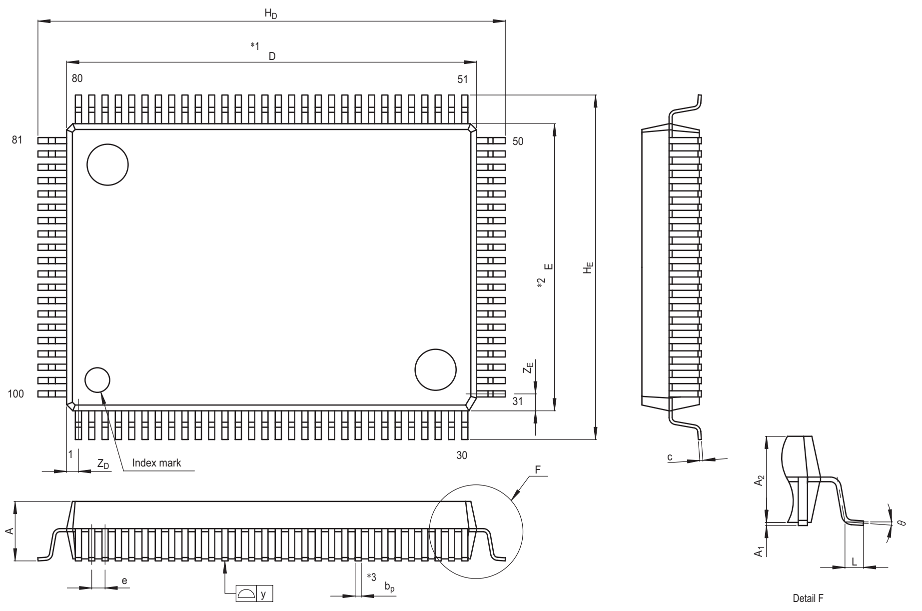
When in parallel output mode, the boot ROM area is located at addresses $0FF000_{16}$ to $0FFFFF_{16}$. When rewriting the boot ROM area, make sure that only this address range is rewritten. (Do not access other than the addresses $0FF000_{16}$ to $0FFFFF_{16}$.)

17.10.2 ROM Code Protect Function

The ROM code protect function inhibits the flash memory from being read or rewritten. (Refer to the description of the functions to inhibit rewriting flash memory version.)

18. Package Outline

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-QFP100-14x20-0.65	PRQP0100JB-A	100P6S-A	1.6g



NOTE)
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	19.8	20.0	20.2
E	13.8	14.0	14.2
A_2	——	2.8	——
H_D	22.5	22.8	23.1
H_E	16.5	16.8	17.1
A	——	——	3.05
A_1	0	0.1	0.2
b_p	0.25	0.3	0.4
c	0.13	0.15	0.2
θ	0°	——	10°
e	0.5	0.65	0.8
y	——	——	0.10
Z_D	——	0.575	——
Z_E	——	0.825	——
L	0.4	0.6	0.8

19. USEGE NOTES

19.1 Precautions for Power Control

(1) When exiting stop mode by hardware reset, set $\overline{\text{RESET}}$ pin to “L” until a main clock or sub clock oscillation is stabilized.

(2) Insert more than four NOP instructions after an WAIT instruction or a instruction to set the CM10 bit of CM1 register to “1”. When shifting to wait mode or stop mode, an instruction queue reads ahead to the next instruction to halt a program by an WAIT instruction and an instruction to set the CM10 bit to “1” (all clocks stopped). The next instruction may be executed before entering wait mode or stop mode, depending on a combination of instruction and an execution timing.

(3) Wait until the main clock oscillation stabilization time, before switching the clock source for CPU clock to the main clock.
Similarly, wait until the sub clock oscillates stably before switching the clock source for CPU clock to the sub clock.

(4) Suggestions to reduce power consumption

- Ports
  The processor retains the state of each I/O port even when it goes to wait mode or to stop mode. A current flows in active I/O ports. A pass current flows in input ports that high-impedance state. When entering wait mode or stop mode, set non-used ports to input and stabilize the potential.
- A/D converter
  When A/D conversion is not performed, set the VCUT bit of ADiCON1 register to “0” (no VREF connection). When A/D conversion is performed, start the A/D conversion at least 1 ƒÊs or longer after setting the VCUT bit to “1” (VREF connection).
- Stopping peripheral functions
  Use the CM0 register CM02 bit to stop the unnecessary peripheral functions during wait mode. However, because the peripheral function clock (fC32) generated from the sub-clock does not stop, this measure is not conducive to reducing the power consumption of the chip. If low speed mode or low power dissipation mode is to be changed to wait mode, set the CM02 bit to “0” (do not peripheral function clock stopped when in wait mode), before changing wait mode.
- Switching the oscillation-driving capacity
  Set the driving capacity to “LOW” when oscillation is stable.
- External clock
  When using an external clock input for the CPU clock, set the CM0 register CM05 bit to “1” (stop). Setting the CM05 bit to “1” disables the XOUT pin from functioning, which helps to reduce the amount of current drawn in the chip. (When using an external clock input, note that the clock remains fed into the chip regardless of how the CM05 bit is set.)

19.2 Precautions for Protect

Set the PRC2 bit to “1” (write enabled) and then write to any address, and the PRC2 bit will be cleared to “0” (write protected). The registers protected by the PRC2 bit should be changed in the next instruction after setting the PRC2 bit to “1”. Make sure no interrupts or DMA transfers will occur between the instruction in which the PRC2 bit is set to “1” and the next instruction.

19.3 Precautions for Interrupts

19.3.1 Reading address 00000_{16}

Do not read the address 00000_{16} in a program. When a maskable interrupt request is accepted, the CPU reads interrupt information (interrupt number and interrupt request priority level) from the address 00000_{16} during the interrupt sequence. At this time, the IR bit for the accepted interrupt is cleared to “0”.
If the address 00000_{16} is read in a program, the IR bit for the interrupt which has the highest priority among the enabled interrupts is cleared to “0”. This causes a problem that the interrupt is canceled, or an unexpected interrupt request is generated.

19.3.2 Setting the SP

Set any value in the SP (USP, ISP) before accepting an interrupt. The SP (USP, ISP) is cleared to ‘0000_{16}’ after reset. Therefore, if an interrupt is accepted before setting any value in the SP (USP, ISP), the program may go out of control.

Especially when using $\overline{\text{NMI}}$ interrupt, set a value in the ISP at the beginning of the program. For the first and only the first instruction after reset, all interrupts including $\overline{\text{NMI}}$ interrupt are disabled.

19.3.3 The $\overline{\text{NMI}}$ Interrupt

(1) The $\overline{\text{NMI}}$ interrupt cannot be disabled. If this interrupt is unused, connect the $\overline{\text{NMI}}$ pin to VCC via a resistor (pull-up).

(2) The input level of the $\overline{\text{NMI}}$ pin can be read by accessing the P8 register’s P8_5 bit. Note that the P8_5 bit can only be read when determining the pin level in $\overline{\text{NMI}}$ interrupt routine.

(3) Stop mode cannot be entered into while input on the $\overline{\text{NMI}}$ pin is low. This is because while input on the $\overline{\text{NMI}}$ pin is low the CM1 register’s CM10 bit is fixed to “0”.

(4) Do not go to wait mode while input on the $\overline{\text{NMI}}$ pin is low. This is because when input on the $\overline{\text{NMI}}$ pin goes low, the CPU stops but CPU clock remains active; therefore, the current consumption in the chip does not drop. In this case, normal condition is restored by an interrupt generated thereafter.

(5) The low and high level durations of the input signal to the $\overline{\text{NMI}}$ pin must each be 2 CPU clock cycles + 300 ns or more.

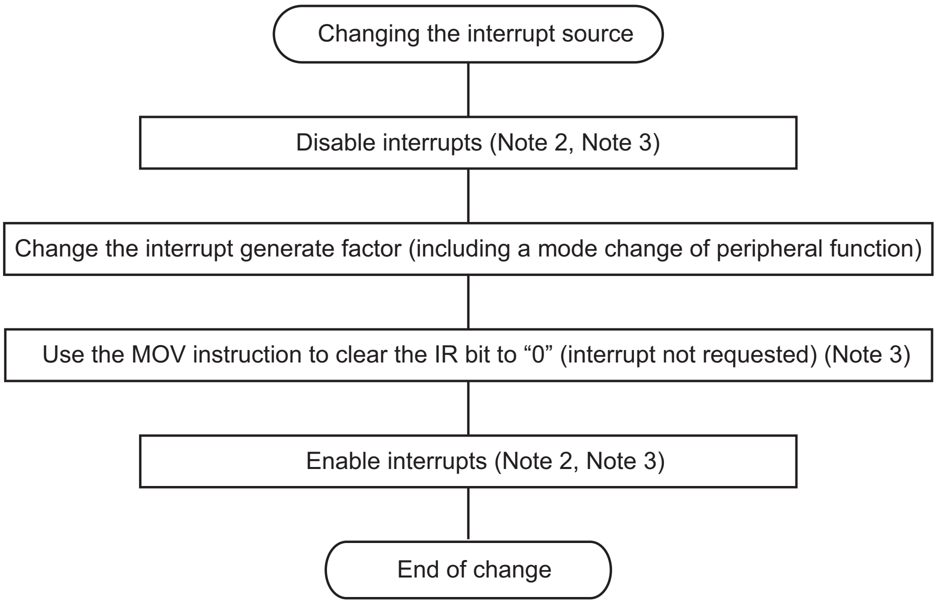
19.3.4 Changing the Interrupt Generate Factor

If the interrupt generate factor is changed, the IR bit in the interrupt control register for the changed interrupt may inadvertently be set to “1” (interrupt requested). If you changed the interrupt generate factor for an interrupt that needs to be used, be sure to clear the IR bit for that interrupt to “0” (interrupt not requested).

“Changing the interrupt generate factor” referred to here means any act of changing the source, polarity or timing of the interrupt assigned to each software interrupt number. Therefore, if a mode change of any peripheral function involves changing the generate factor, polarity or timing of an interrupt, be sure to clear the IR bit for that interrupt to “0” (interrupt not requested) after making such changes.

Refer to the description of each peripheral function for details about the interrupts from peripheral functions.

Figure 19.1 shows the procedure for changing the interrupt generate factor.



IR bit: A bit in the interrupt control register for the interrupt whose interrupt generate factor is to be changed

Note 1: The above settings must be executed individually. Do not execute two or more settings simultaneously (using one instruction).
Note 2: Use the I flag for the $\overline{\mathrm{INTi}}$ interrupt (i = 0 to 5).
For the interrupts from peripheral functions other than the $\overline{\mathrm{INTi}}$ interrupt, turn off the peripheral function that is the source of the interrupt in order not to generate an interrupt request before changing the interrupt generate factor. In this case, if the maskable interrupts can all be disabled without causing a problem, use the I flag. Otherwise, use the corresponding ILVL2 to ILVL0 bit for the interrupt whose interrupt generate factor is to be changed.
Note 3: Refer to Section “Rewrite the Interrupt Control Register” for details about the instructions to use and the notes to be taken for instruction execution.

Figure 19.1 Procedure for Changing the Interrupt Generate Factor

19.3.5 $\overline{\mathrm{INT}}$ Interrupt

(1) Either an “L” level of at least $t_{W(INL)}$ or an “H” level of at least $t_{W(INH)}$ width is necessary for the signal input to pins INT_0 through INT_5 regardless of the CPU operation clock.

(2) If the POL bit in the INT0IC to INT5IC registers or the IFSR7 to IFSR0 bits in the IFSR register are changed, the IR bit may inadvertently set to 1 (interrupt requested). Be sure to clear the IR bit to 0 (interrupt not requested) after changing any of those register bits.

19.3.6 Rewrite the Interrupt Control Register

(1) The interrupt control register for any interrupt should be modified in places where no requests for that interrupt may occur. Otherwise, disable the interrupt before rewriting the interrupt control register.

(2) To rewrite the interrupt control register for any interrupt after disabling that interrupt, be careful with the instruction to be used.

- Changing any bit other than the IR bit

If while executing an instruction, a request for an interrupt controlled by the register being modified occurs, the IR bit in the register may not be set to “1” (interrupt requested), with the result that the interrupt request is ignored. If such a situation presents a problem, use the instructions shown below to modify the register.
Usable instructions: AND, OR, BCLR, BSET

- Changing the IR bit

Depending on the instruction used, the IR bit may not always be cleared to “0” (interrupt not requested). Therefore, be sure to use the MOV instruction to clear the IR bit.

(3) When using the I flag to disable an interrupt, refer to the sample program fragments shown below as you set the I flag. (Refer to (2) for details about rewrite the interrupt control registers in the sample program fragments.)

Examples 1 through 3 show how to prevent the I flag from being set to “1” (interrupts enabled) before the interrupt control register is rewrited, owing to the effects of the internal bus and the instruction queue buffer.

Example 1: Using the NOP instruction to keep the program waiting until the interrupt control register is modified

```
INT_SWITCH1:
FCLR     I                     ; Disable interrupts.
AND.B    #00h, 0055h           ; Set the TA0IC register to “0016”.
NOP ;
NOP
FSET      I                     ; Enable interrupts.
```

The number of NOP instruction is as follows.
PM20=1(1 wait) : 2, PM20=0(2 wait) : 3, when using HOLD function : 4.

Example 2: Using the dummy read to keep the FSET instruction waiting

```
INT_SWITCH2:
FCLR     I                     ; Disable interrupts.
AND.B    #00h, 0055h           ; Set the TA0IC register to “0016”.
MOV.W    MEM, R0               ; Dummy read.
FSET      I                    ; Enable interrupts.
```

Example3: Using the POPC instruction to changing the I flag

```
INT_SWITCH3:
PUSHC    FLG
FCLR     I                     ; Disable interrupts.
AND.B    #00h, 0055h           ; Set the TA0IC register to “0016”.
POPC     FLG                   ; Enable interrupts.
```

- Watchdog Timer Interrupt

Initialize the watchdog timer after the watchdog timer interrupt occurs.

19.4 Precautions for DMAC

19.4.1 Write to DMAE Bit in DMiCON Register

When both of the conditions below are met, follow the steps below.

Conditions

- The DMAE bit is set to “1” again while it remains set (DMAi is in an active state).
- A DMA request may occur simultaneously when the DMAE bit is being written.

Step 1: Write “1” to the DMAE bit and DMAS bit in DMiCON register simultaneously (*1).
Step 2: Make sure that the DMAi is in an initial state (*2) in a program.
If the DMAi is not in an initial state, the above steps should be repeated.

Notes

*1 The DMAS bit remains unchanged even if “1” is written. However, if “0” is written to this bit, it is set to “0” (DMA not requested). In order to prevent the DMAS bit from being modified to “0”, “1” should be written to the DMAS bit when “1” is written to the DMAE bit. In this way the state of the DMAS bit immediately before being written can be maintained.
Similarly, when writing to the DMAE bit with a read-modify-write instruction, “1” should be written to the DMAS bit in order to maintain a DMA request which is generated during execution.

*2 Read the TCRi register to verify whether the DMAi is in an initial state. If the read value is equal to a value which was written to the TCRi register before DMA transfer start, the DMAi is in an initial state. (If a DMA request occurs after writing to the DMAE bit, the value written to the TCRi register 1.) If the read value is a value in the middle of transfer, the DMAi is not in an initial state.

19.5 Precautions for Timers

Precautions for Timer A

19.5.1 Timer A

(1) Timer A (Timer Mode)
The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TAiMR (i = 0 to 4) register and the TAi register before setting the TAiS bit in the TABSR register to “1” (count starts).
Always make sure the TAiMR register is modified while the TAiS bit remains “0” (count stops) regardless whether after reset or not.

(2) While counting is in progress, the counter value can be read out at any time by reading the TAi register. However, if the counter is read at the same time it is reloaded, the value “$FFFF_{16}$” is read.
Also, if the counter is read before it starts counting after a value is set in the TAi register while not counting, the set value is read.

19.5.2 Timer A (Event Counter Mode)

(1) The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TAiMR (i = 0 to 4) register, the TAi register, the UDF register, the ONSF register TAZIE, TA0TGL and TA0TGH bits and the TRGSR register before setting the TAiS bit in the TABSR register to “1” (count starts).
Always make sure the TAiMR register, the UDF register, the ONSF register TAZIE, TA0TGL and TA0TGH bits and the TRGSR register are modified while the TAiS bit remains “0” (count stops) regardless whether after reset or not.

(2) While counting is in progress, the counter value can be read out at any time by reading the TAi register. However, “$FFFF_{16}$” can be read in underflow, while reloading, and “0000_{16}” in overflow.
When setting TAi register to a value during a counter stop, the setting value can be read before a counter starts counting.

19.5.3 Timer A (One-shot Timer Mode)

(1) The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TAiMR (i = 0 to 4) register, the TAi register, the ONSF register TA0TGL and TA0TGH bits and the TRGSR register before setting the TAiS bit in the TABSR register to “1” (count starts).
Always make sure the TAiMR register, the ONSF register TA0TGL and TA0TGH bits and the TRGSR register are modified while the TAiS bit remains “0” (count stops) regardless whether after reset or not.

(2) When setting TAiS bit to “0” (count stop), the followings occur:
•A counter stops counting and a content of reload register is reloaded.
•TAi_{OUT} pin outputs “L”.
•After one cycle of the CPU clock, the IR bit of TAiIC register is set to “1” (interrupt request).

(3) Output in one-shot timer mode synchronizes with a count source internally generated. When an external trigger has been selected, one-cycle delay of a count source as maximum occurs between a trigger input to TAi_{IN} pin and output in one-shot timer mode.

(4) The IR bit is set to “1” when timer operation mode is set with any of the following procedures:
•Select one-shot timer mode after reset.
•Change an operation mode from timer mode to one-shot timer mode.
•Change an operation mode from event counter mode to one-shot timer mode.
To use the timer Ai interrupt (the IR bit), set the IR bit to “0” after the changes listed above have been made.

(5) When a trigger occurs, while counting, a counter reloads the reload register to continue counting after generating a re-trigger and counting down once. To generate a trigger while counting, generate a second trigger between occurring the previous trigger and operating longer than one cycle of a timer count source.

19.5.4 Timer A (Pulse Width Modulation Mode)

(1) The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TAiMR (i = 0 to 4) register, the TAi register, the ONSF register TA0TGL and TA0TGH bits and the TRGSR register before setting the TAiS bit in the TABSR register to “1” (count starts).
Always make sure the TAiMR register, the ONSF register TA0TGL and TA0TGH bits and the TRGSR register are modified while the TAiS bit remains “0” (count stops) regardless whether after reset or not.

(2) The IR bit is set to “1” when setting a timer operation mode with any of the following procedures:

•Select the PWM mode after reset.

•Change an operation mode from timer mode to PWM mode.

•Change an operation mode from event counter mode to PWM mode.
To use the timer Ai interrupt (interrupt request bit), set the IR bit to “0” by program after the above listed changes have been made.

(3) When setting TAiS register to “0” (count stop) during PWM pulse output, the following action occurs:

•Stop counting.

•When TAiOUT pin is output “H”, output level is set to “L” and the IR bit is set to “1”.

•When TAiOUT pin is output “L”, both output level and the IR bit remains unchanged.

Precautions for Timer B

19.5.5 Timer B (Timer Mode)

(1) The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TBiMR (i = 0 to 5) register and TBi register before setting the TBiS bit in the TABSR or the TBSR register to “1” (count starts).
Always make sure the TBiMR register is modified while the TBiS bit remains “0” (count stops) regardless whether after reset or not.

(2) A value of a counter, while counting, can be read in TBi register at any time. “$FFFF_{16}$” is read while reloading. Setting value is read between setting values in TBi register at count stop and starting a counter.

19.5.6 Timer B (Event Counter Mode)

(1) The timer remains idle after reset. Set the mode, count source, counter value, etc. using the TBiMR (i = 0 to 5) register and TBi register before setting the TBiS bit in the TABSR or the TBSR register to “1” (count starts).
Always make sure the TBiMR register is modified while the TBiS bit remains “0” (count stops) regardless whether after reset or not.

(2) The counter value can be read out on-the-fly at any time by reading the TBi register. However, if this register is read at the same time the counter is reloaded, the read value is always “$FFFF_{16}$.” If the TBi register is read after setting a value in it while not counting but before the counter starts counting, the read value is the one that has been set in the register.

19.5.7 Timer B (Pulse Period/pulse Width Measurement Mode)

(1) The timer remains idle after reset. Set the mode, count source, etc. using the TBiMR (i = 0 to 5) register before setting the TBiS bit in the TABSR or the TBSR register to “1” (count starts).
Always make sure the TBiMR register is modified while the TBiS bit remains “0” (count stops) regardless whether after reset or not. To clear the MR3 bit to “0” by writing to the TBiMR register while the TBiS bit = “1” (count starts), be sure to write the same value as previously written to the TM0D0, TM0D1, MR0, MR1, TCK0 and TCK1 bits and a 0 to the MR2 bit.

(2) The IR bit of TBiIC register (i=0 to 5) goes to “1” (interrupt request), when an effective edge of a measurement pulse is input or timer Bi is overflowed. The factor of interrupt request can be determined by use of the MR3 bit of TBiMR register within the interrupt routine.

(3) If the source of interrupt cannot be identified by the MR3 bit such as when the measurement pulse input and a timer overflow occur at the same time, use another timer to count the number of times timer B has overflowed.

(4) To set the MR3 bit to “0” (no overflow), set TBiMR register with setting the TBiS bit to “1” and counting the next count source after setting the MR3 bit to “1” (overflow).

(5) Use the IR bit of TBiIC register to detect only overflows. Use the MR3 bit only to determine the interrupt factor within the interrupt routine.

(6) When a count is started and the first effective edge is input, an indeterminate value is transferred to the reload register. At this time, timer Bi interrupt request is not generated.

(7) A value of the counter is indeterminate at the beginning of a count. MR3 may be set to “1” and timer Bi interrupt request may be generated between a count start and an effective edge input.

(8) For pulse width measurement, pulse widths are successively measured. Use program to check whether the measurement result is an “H” level width or an “L” level width.

19.6 Precautions for Serial I/O (Clock-synchronous Serial I/O)

19.6.1 Transmission/reception

With an external clock selected, and choosing the $\overline{\mathrm{RTS}}$ function, the output level of the $\overline{\mathrm{RTSi}}$ pin goes to “L” when the data-receivable status becomes ready, which informs the transmission side that the reception has become ready. The output level of the $\overline{\mathrm{RTSi}}$ pin goes to “H” when reception starts. So if the $\overline{\mathrm{RTSi}}$ pin is connected to the $\overline{\mathrm{CTSi}}$ pin on the transmission side, the circuit can transmission and reception data with consistent timing. With the internal clock, the RTS function has no effect.

19.6.2 Transmission

When an external clock is selected, the conditions must be met while if the UiC0 register’s CKPOL bit = “0” (transmit data output at the falling edge and the receive data taken in at the rising edge of the transfer clock), the external clock is in the high state; if the UiC0 register’s CKPOL bit = “1” (transmit data output at the rising edge and the receive data taken in at the falling edge of the transfer clock), the external clock is in the low state.

- The TE bit of UiC1 register= “1” (transmission enabled)
- The TI bit of UiC1 register = “0” (data present in UiTB register)
- If $\overline{\mathrm{CTS}}$ function is selected, input on the $\overline{\mathrm{CTSi}}$ pin = “L”

19.6.3 Reception

(1) In operating the clock-synchronous serial I/O, operating a transmitter generates a shift clock. Fix settings for transmission even when using the device only for reception. Dummy data is output to the outside from the TxDi pin when receiving data.

(2) When an internal clock is selected, set the UiC1 register (i = 0 to 2)’s TE bit to 1 (transmission enabled) and write dummy data to the UiTB register, and the shift clock will thereby be generated.
When an external clock is selected, set the UiC1 register (i = 0 to 2)’s TE bit to 1 and write dummy data to the UiTB register, and the shift clock will be generated when the external clock is fed to the CLKi input pin.

(3) When successively receiving data, if all bits of the next receive data are prepared in the UARTi receive register while the UiC1 register (i = 0 to 2)’s RE bit = “1” (data present in the UiRB register), an overrun error occurs and the UiRB register OER bit is set to “1” (overrun error occurred). In this case, because the content of the UiRB register is indeterminate, a corrective measure must be taken by programs on the transmit and receive sides so that the valid data before the overrun error occurred will be retransmitted. Note that when an overrun error occurred, the SiRIC register IR bit does not change state.

(4) To receive data in succession, set dummy data in the lower-order byte of the UiTB register every time reception is made.

(5) When an external clock is selected, the conditions must be met while if the CKPOL bit = “0”, the external clock is in the high state; if the CKPOL bit = “1”, the external clock is in the low state.

•. The RE bit of UiC1 register= “1” (reception enabled)
•. The TE bit of UiC1 register= “1” (transmission enabled)
•. The TI bit of UiC1 register= “0” (data present in the UiTB register)

19.7 Precautions for Serial I/O (UART Mode)

19.7.1 Special Mode 4 (SIM Mode)

A transmit interrupt request is generated by setting the U2C1 register U2IRS bit to “1” (transmission complete) and U2ERE bit to “1” (error signal output) after reset. Therefore, when using SIM mode, be sure to clear the IR bit to “0” (no interrupt request) after setting these bits.

19.8 Precautions for A/D Converter

(1) Set ADCON0 (except bit 6), ADCON1 and ADCON2 registers when A/D conversion is stopped (before a trigger occurs).

(2) When the VCUT bit of ADCON1 register is changed from “0” (Vref not connected) to “1” (Vref connected), start A/D conversion after passing 1 µs or longer.

(3) To prevent noise-induced device malfunction or latchup, as well as to reduce conversion errors, insert capacitors between the AVCC and analog input pins (ANi (i=0 to 7)) each and the AVSS pin. Similarly, insert a capacitor between the VCC pin and the VSS pin. Figure 19.2 is an example connection of each pin.

(4) Make sure the port direction bits for those pins that are used as analog inputs are set to “0” (input mode). Also, if the ADCON0 register’s TGR bit = 1 (external trigger), make sure the port direction bit for the $\overline{\text{ADTRG}}$ pin is set to “0” (input mode).

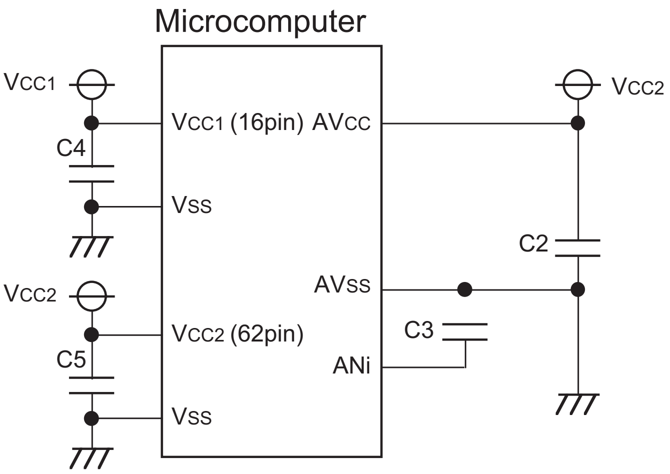
(5) The ϕAD frequency must be 10 MHz or less. Without sample-and-hold function, limit the ϕAD frequency to 250kHZ or more. With the sample and hold function, limit the ϕAD frequency to 1MHZ or more.

(6) When changing an A/D operation mode, select analog input pin again in the CH2 to CH0 bits of ADCON0 register and the SCAN1 to SCAN0 bits of ADCON1 register.

(7) If the CPU reads the ADi register (i = 0 to 7) at the same time the conversion result is stored in the ADi register after completion of A/D conversion, an incorrect value may be stored in the ADi register. This problem occurs when a divide-by-n clock derived from the main clock or a subclock is selected for CPU clock.

- When operating in one-shot or single-sweep mode
  Check to see that A/D conversion is completed before reading the target ADi register. (Check the ADIC register’s IR bit to see if A/D conversion is completed.)
- When operating in repeat mode or repeat sweep mode 0 or 1
  Use the main clock for CPU clock directly without dividing it.

(8) If A/D conversion is forcibly terminated while in progress by setting the ADCON0 register’s ADST bit to “0” (A/D conversion halted), the conversion result of the A/D converter is indeterminate. The contents of ADi registers irrelevant to A/D conversion may also become indeterminate. If while A/D conversion is underway the ADST bit is cleared to “0” in a program, ignore the values of all ADi registers.



ANi: ANi (i=0 to 7)

Note 1: C1≥0.47μF, C2≥0.47μF, C3≥100pF, C4≥0.1μF, C5≥0.1μF (reference)
Note 2: Use thick and shortest possible wiring to connect capacitors.

Figure 19.2 Use of capacitors to reduce noise

19.9 Precautions for Programmable I/O Ports

(1) Setting the SM32 bit in the S3C register to “1” causes the P9$_2$ pin to go to a high-impedance state. Similarly, setting the SM42 bit in the S4C register to “1” causes the P9$_6$ pin to go to a high-impedance state.

(2) The input threshold voltage of pins differs between programmable input/output ports and peripheral functions.
Therefore, if any pin is shared by a programmable input/output port and a peripheral function and the input level at this pin is outside the range of recommended operating conditions V$_{IH}$ and V$_{IL}$ (neither “high” nor “low”), the input level may be determined differently depending on which side–the programmable input/output port or the peripheral function–is currently selected.

19.10 Electric Characteristic Differences Between Mask ROM and Flash Memory Version Microcomputers

Flash memory version and mask ROM version may have different characteristics, operating margin,
noise tolerated dose, noise width dose in electrical characteristics due to internal ROM, different layout pattern, etc. When switching to the mask ROM version, conduct equivalent tests as system evaluation tests conducted in the flush memory version.

19.11 Precautions for Flash Memory Version

19.11.1 Precautions for Functions to Inhibit Rewriting Flash Memory Rewrite

ID codes are stored in addresses 0FFFDF$_{16}$, 0FFFE3$_{16}$, 0FFFEB$_{16}$, 0FFFEF$_{16}$, 0FFFF3$_{16}$, 0FFFF7$_{16}$, and 0FFFFB$_{16}$. If wrong data are written to theses addresses, the flash memory cannot be read or written in standard serial I/O mode.
The ROMCP register is mapped in address 0FFFFF$_{16}$. If wrong data is written to this address, the flash memory cannot be read or written in parallel I/O mode.
In the flash memory version of microcomputer, these addresses are allocated to the vector addresses (H) of fixed vectors.

19.11.2 Precautions for Stop mode

When shifting to stop mode, the following settings are required:

- Set the FMR01 bit to “0” (CPU rewrite mode disabled) and disable DMA transfers before setting the CM10 bit to “1” (stop mode).
- Execute the JMP.B instruction subsequent to the instruction which sets the CM10 bit to “1” (stop mode)

```
Example program      BSET      0, CM      1 ; Stop mode
                     JMP.B     L1
               L1:
                     Program after returning from stop mode
```

19.11.3 Precautions for Wait mode

When shifting to wait mode, set the FMR01 bit to “0” (CPU rewrite mode diabled) before executing the WAIT instruction.

19.11.4 Precautions for Low power dissipation mode

If the CM05 bit is set to “1” (main clock stop), the following commands must not be executed.

- Program
- Block erase
- Lock bit program

19.11.5 Writing command and data

Write the command code and data at even addresses.

19.11.6 Precautions for Program Command

Write ‘xx40$_{16}$’ in the first bus cycle and write data to the write address in the second bus cycle, and an auto program operation (data program and verify) will start. Make sure the address value specified in the first bus cycle is the same even address as the write address specified in the second bus cycle.

19.11.7 Precautions for Lock Bit Program Command

Write ‘xx77$_{16}$’ in the first bus cycle and write ‘xxD0$_{16}$’ to the uppermost address of a block (even address, however) in the second bus cycle, and the lock bit for the specified block is cleared to “0”.
Make sure the address value specified in the first bus cycle is the same uppermost block address that is specified in the second bus cycle.

19.11.8 Operation speed

Before entering CPU rewrite mode (EW0 or EW1 mode), select 10 MHz or less for CPU clock using the CM0 register’s CM06 bit and CM1 register’s CM17–6 bits. Also, set the PM1 register’s PM17 bit to 1 (with wait state).

19.11.9 Instructions inhibited against use

The following instructions cannot be used in EW0 mode because the flash memory’s internal data is referenced: UND instruction, INTO instruction, JMPS instruction, JSRS instruction, and BRK instruction

19.11.10 Interrupts

EW0 Mode

- Any interrupt which has a vector in the variable vector table can be used providing that its vector is transferred into the RAM area.
- The $\overline{\text{NMI}}$ and watchdog timer interrupts can be used because the FMR0 register and FMR1 register are initialized when one of those interrupts occurs. The jump addresses for those interrupt service routines should be set in the fixed vector table.
  Because the rewrite operation is halted when a $\overline{\text{NMI}}$ or watchdog timer interrupt occurs, the rewrite program must be executed again after exiting the interrupt service routine.
- The address match interrupt cannot be used because the flash memory’s internal data is referenced.

EW1 Mode

- Make sure that any interrupt which has a vector in the variable vector table or address match interrupt will not be accepted during the auto program or auto erase period.
- Avoid using watchdog timer interrupts.
- The $\overline{\text{NMI}}$ interrupt can be used because the FMR0 register and FMR1 register are initialized when this interrupt occurs. The jump address for the interrupt service routine should be set in the fixed vector table.
  Because the rewrite operation is halted when a $\overline{\text{NMI}}$ interrupt occurs, the rewrite program must be executed again after exiting the interrupt service routine.

19.11.11 How to access

To set the FMR01, FMR02, or FMR11 bit to “1”, write “0” and then “1” in succession. This is necessary to ensure that no interrupts or DMA transfers will occur before writing “1” after writing “0”. Also only when $\overline{\text{NMI}}$ pin is “H” level.

19.11.12 Writing in the user ROM area

EW0 Mode

- If the power supply voltage drops while rewriting any block in which the rewrite control program is stored, a problem may occur that the rewrite control program is not correctly rewritten and, consequently, the flash memory becomes unable to be rewritten thereafter. In this case, standard serial I/O or parallel I/O mode should be used.

EW1 Mode

- Avoid rewriting any block in which the rewrite control program is stored.

19.11.13 DMA transfer

In EW1 mode, make sure that no DMA transfers will occur while the FMR0 register’s FMR00 bit = 0 (during the auto program or auto erase period).

19.11.14 Regarding Programming/Erasure Times and Execution Time

As the number of programming/erasure times increases, so does the execution time for software commands (Program, Block Erase, and Lock Bit Program). Especially when the number of programming/erasure times exceeds 100, the software command execution time is noticeably extended.
Therefore, the software command wait time that is set must be greater than the maximum rated value of electrical characteristics.
The software commands are aborted by hardware reset 1, $\overline{\text{NMI}}$ interrupt, and watchdog timer interrupt. If a software command is aborted by such reset or interrupt, the block that was in process must be erased before reexecuting the aborted command.

19.12 Other Notes

19.12.1 When the power is being turned on or off

Start VCC1, VCC2, VDD2 and AVCC simultaneously.
While this device is operating, set these pins to the same electric potential.
Also, turn off VCC1, VCC2, VDD2 and AVCC simultaneously when the power supply is being turned off.
When using VCC1 < VCC2, ensure voltage of VCC1 will not exceed voltage of VCC2 while the power is being turned on or off.
Execute in the following procedure when VCC1 is turned off (VCC2 voltage is supplied).

19.12.2 Procedure of VCC1 OFF(Note 1)

(1) Disable an interrupt which uses pins related to VCC1.
(2) Stop peripheral functions related to VCC1 (Note 2).
(3) Set pins related to VCC1 to input mode.
(4) VCCOFF pin is switched from “L” to “H” .
(5) Turn off VCC1.

19.12.3 Procedure of VCC1 ON

(1) Turn on VCC1.
(2) VCCOFF pin (91-pin) is switched from “H” to “L” .
(3) Set pins VCC1, Peripheral function and Interrupt.

Note 1: Refer to the following “Additions” for details of procedures (1) to (4).
Note 2: Only when the input from pins related to VCC1 is used. Refer to the following “Additions” for details.

<Additions>

(1) Disable an affected interrupt by pins related to VCC1.

Disable an affected interrupt by pins related to VCC1 by setting the interrupt priority level selection and the interrupt request bits in the the following interrupt control register to “0”.
In the transitional state when changing the power supply voltage including being turned on or off, ensure each voltage of VCC1, VDD2, and VDD3 will not exceed voltage of VCC2.

TA0IC to TA4IC (timer A interrupt control register)
INT0 to INT2IC (external interrupt control register)
S0RIC to S2RIC (UART receive interrupt control register)

Even if other interrupts are disabled without any problem in software, clear the I flag and it is also possible to execute the above interrupt disable process after the procedure (4).

(2) Stop peripheral functions related to VCC1

Stop the function when pins related to VCC1 input affect.
When pins related to VCC1 input affect as follows:

- When operating in timer A (TA0 to TA4) and the event count mode
- When the gate input function is used in the event count mode, the one-shot timer, and PWM mode. (When the MR2 bit in the timer A mode registers TA0MR to TA4MR are set to “1”)
- When UART to UART2 reception are set

Set the following in these cases.

- Timer A
  Set the timer count start flags of timers A0 to A4 (TA0S to TA4S bits in the TABSR register) to “0”.
- UART reception
  Set the RE and TE bits in the U0C1 to U2C1 registers to “0”.

19.12.4 Precautions when sub clock starts

When a signal “H” is applied to the STARTB pin and a reset is deserted, a sub clock divided-by-8 becomes a CPU clock.
When using in this condition, set the CM07 bit in the CM0 register to “1” and switch the CPU clock to sub clock (no division).

19.12.5 Power supply noise and latch-up

In order to avoid power supply noise and latch-up, connect a bypass capacitor (more than 0.1μF) directly between the VCC pin and VSS pin, VDD2 pin and VSS2 pin, AVCC pin and AVSS pin using a heavy wire.
And, connect VSS (GND) to the TEST1 pin (93 pin) via the capacitor (more than 0.1μF).

19.12.6 When oscillation circuit stop for data slicer

Expansion register XTAL_VCO, PDC_VCO_ON,VPS_VCO_ON is set at “L”, when the data slicer is not used, and the oscillation is stopped. When starting oscillation again, set data at the folowing order.

(a) Set expansion register XTAL_VCO = “H.”
(b) Set expansion register PDC_VCO_ON, VPS_VCO_ON = “H.”
(c) 60 ms or more is a waiting state (stability period of internal oscillation circuit + data slice prepara tion).

* To operate slice RAM, set expansion register XTAL_VCO = “H.”
Access the memories after wating for 20 ms certainly when resuming synchronous oscillation from the off state.

19.12.7 When operation start from stand-by mode (clock is stopped)

Set up an extended register as follows in standby mode.

(a) Set extended register XTAL_VCO, PDC_VCO_ON, and VPS_VCO_ON as “L.”

When you return to an oscillation state from a clock oscillation stop, set up as the notes of the oscillation circuit stop for data slicers.

19.12.8 Notes concerning address 36_{16} expansion registers and address $3E_{16}$ data setting

Please do not change data after setting initial data to the corresponding addresses 36_{16} and $3E_{16}$ interrupt control bits when you use the interrupt of the expansion feature (SLICEON, remote control, HINT, clock timer, and remote control transmission interrupt).

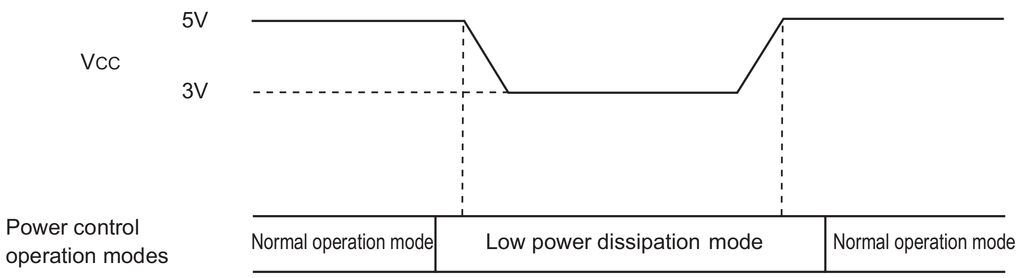
19.12.9 Notes on operating with a low supply voltage (VCC = 2.0 V to 5.5 V, f(XCIN) = 32 kHz)

When in single-chip mode, this product can operate with a low supply voltage only during low power dissipation mode. Before operating with a low supply voltage, always be sure to set the relevant register bits to select low power dissipation mode (BCLK : f(XCIN), main clock XIN : stop, subclock XCIN : oscillating). Then reduce the power supply voltage VCC to 3.0 V.

Also, when returning to normal operation, raise the power supply voltage to 5.0V while in low power consumption mode before entering normal operation mode.

When moving from any operation mode to another, make sure a state transition occurs according to the state transition diagram (Figure 4.9) in Section 4.4, "Power control."

The status of the power supply voltage VCC during operation mode transition is shown in Figure 19.3 below.



Note 1: Normal operation mode refers to the high-speed, medium-speed, and low-speed modes.

Note 2: When operating with a low supply voltage (2.6 V or more), be aware that only the CPU, ROM, RAM, input/output ports, timers (timers A and B), clock timer, and the interrupt control circuit can be used.
All other internal resources (e.g., data slicer, DMAC and A/D) cannot be used.

Note 3: When operating with a low supply voltage (less than 2.6 V), be aware that only the CPU, RAM, Input/Output ports, clock timer, and interrupt control circuit can be used.

Figure 19.3 Status of the power supply voltage VCC during operation mode transition

19.13 Serial I/O (RxDi input setup time)

For the RXDi input setup time, refer to the rated values shown below, as well as Electrical Characteristics Table 16.23, "Serial I/O."

Table 19.1 Serial I/O (Vcc=5V)

Symbol	Parameter	Standard		Unit
		Min.	Max.	
$t_{su(D-C)}$	RxDi input setup time	70		ns

Note: Refer to "Table 16.23. Serial I/O of the Electrical Characteristics.

19.14 Precautions for LP3 and LP4 pins

Cannect capacitors to LP3 and LP4 as shown in Figure 19.4.

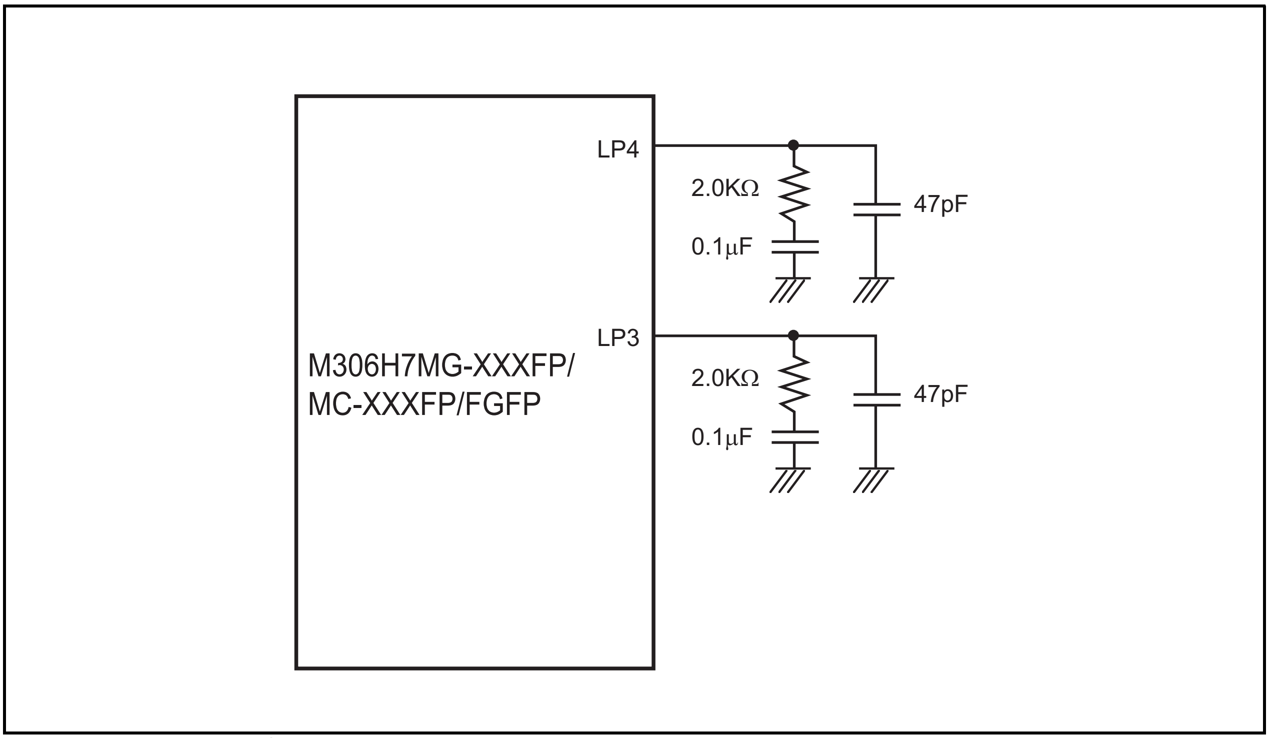


Figure 19.4 Use of capacitors to reduce noise

Notes on pins CVIN, SYNCIN, and SVREF

Please connect pins CVIN, SYNCIN, and SVREF with GND when you do not use the data slicer.

Rev.	Date	Description	
		Page	Summary
1.00	Sep 02, 2005	323	First Edition issued
1.01	Sep 15, 2005	9	DESCRIPTION Table 1.5 Pin Description (3) The polarity of STARTB was opposite --> it corrected.
1.02	Oct 27, 2005	162	I^{2}C0 Interrupt Control Register and Reserved Register are added.
2.00	Mar 31, 2006	162	Reserved Register is changed.
		211	Figure of 13. Address $0C_{16}$, 13_{16}, $1A_{16}$ is changed.
		212	Figure of 15. Address $1C_{16}$ is changed.
		215	Figure of 21. Address 22_{16} is changed.
		216	Figure of 22. Address 23_{16} is changed.
		217	Figure of 23. Address 24_{16} is changed.
		218	Figure of 25. Address 26_{16} is changed.
		220	Figure of 27. Address 28_{16} is changed.
		223	Figure of 32. Address $2D_{16}$ is changed.
		225	Figure of 35. Address 30_{16} is changed. Figure of 36. Address 31_{16} is changed.
		226	Figure of 39. Address 34_{16} is changed.
		227	Figure of 40. Address 35_{16} is changed.
		232 to 234	Figure of 47. Assress $3C_{16}$ to 50. Assress $3F_{16}$ are changed.
		241	F.14.14 is changed.
		244 to 246	14.6 (6) Remote control transmission function is added.
		277	Notes of T.17.2 are changed.
		281	Note 2 of T.17.3 is changed.
		285	Note 5 of T.17.5 is changed.
		300	T.17.7 is changed.
		301	F.17.13 is changed.
2.10	Oct 25, 2006	19	Table of register address is changed.
		23	F.3.4 is changed.
		36	T.4.2 is changed.
		38	T.4.4 is changed.
		47	T.6.2 is changed.
		53	F.6.6 is changed.
		56	F.6.9 is changed.
		57	L9 to L10 are added.
		64	Notes of F.8.2 is changed.
		65	Notes of F.8.3 is changed.
		143	T.11.1 is changed.
		162	Figure of I^{2}C0 Interrupt Control Register is changed.
		166	Notes of F.12.3 is changed.

REVISION HISTORY

M306H7MG-XXXFP/MC-XXXFP/FGFP Datasheet

Rev.	Date	Description	
		Page	Summary
2.10	Oct 25, 2006	182	F.14.1 is changed.
		200	T.14.4 is changed.
		211	Figure of 13. Address $0C_{16}$, 13_{16}, $1A_{16}$, is changed.
		218	Figure of 25. Address 26_{16} is changed.
		226	Figure of 38. Address 33_{16} is changed.
		228	Figure of 41. Address 36_{16} is changed.
		233	Figure of 49. Address $3E_{16}$ is changed.
		253	F.15.1 is changed.
		260	F.15.9 is changed.
		262	Note of F.15.11 is delated.
		267	T.16.8 is changed.
		293	T.17.4 is changed.
		303	T.17.7 is changed.
		304	F.17.13 is changed.
		305	F.17.14 is changed.
		306	F.17.15 is changed.
		324	19.12.8 Notes concerning address 36_{16} expansion registers and address $3E_{16}$ is added.

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