M37274EFSP

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER with CLOSED CAPTION DECODER and ON-SCREEN DISPLAY CONTROLLER

DESCRIPTION

The M3727EFSP is a single-chip microcomputer designed with CMOS silicon gate technology. It is housed in a 52-pin shrink plastic molded DIP.

In addition to their simple instruction sets, the ROM, RAM and I/O addresses are placed on the same memory map to enable easy programming.

The M3727EFSP has a OSD function and a data slicer function, so it is useful for a channel selection system for TV with a closed caption decoder.

FEATURES

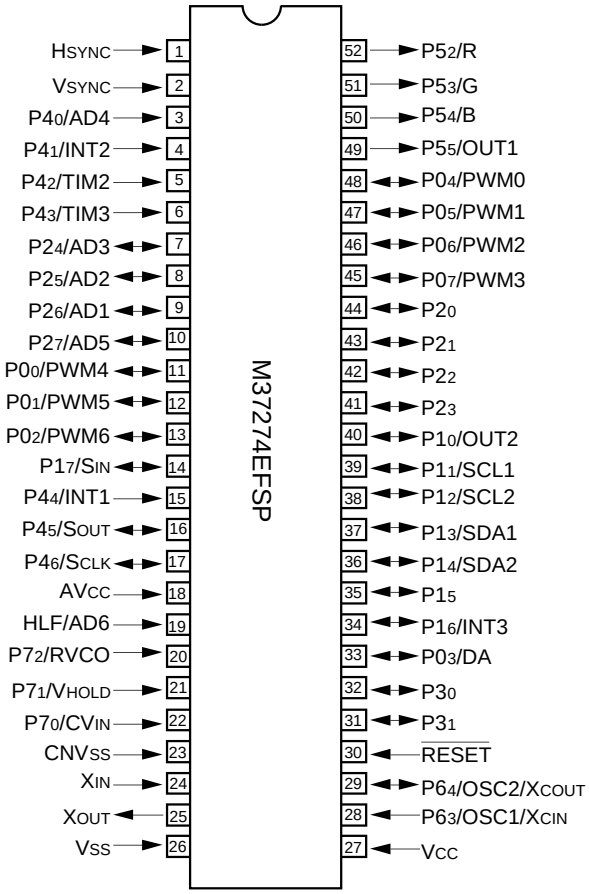
- Number of basic instructions 71
- Memory size
  - ROM ..... 60 K bytes
  - RAM ..... 1024 bytes
  - ROM correction memory ..... 64 bytes
  - ROM for OSD ..... 11072 bytes
  - RAM for OSD ..... 1920 bytes
- Minimum instruction execution time
  ..... 0.5 μs (at 8 MHz oscillation frequency)
- Power source voltage ..... 5 V ± 10 %
- Subroutine nesting ..... 128 levels (Max.)
- Interrupts ..... 18 types, 16 vectors
- 8-bit timers 6
- Programmable I/O ports (Ports P0, P1, P2, $P3_0$, $P3_1$) 26
- Input ports (Ports $P4_0$–$P4_6$, $P6_3$, $P6_4$, $P7_0$–$P7_2$) 12
- Output ports (Ports $P5_2$–$P5_5$) 4
- 12 V withstand ports 7
- LED drive ports 2
- Serial I/O ..... 8-bit × 1 channel
- Multi-master I^2C-BUS interface ..... 1 (2 systems)
- A-D converter (8-bit resolution) ..... 6 channels
- PWM output circuit ..... 14-bit × 1, 8-bit × 7
- Power dissipation
  - In high-speed mode 165mW
    (at V_{CC} = 5.5V, 8MHz oscillation frequency, CRT on, and Data slicer on)
  - In low-speed mode 0.33mW
    (at V_{CC} = 5.5V, 32kHz oscillation frequency)
- Data slicer
- ROM correction function
- OSD function
  - Display characters ..... 40 characters × 16 lines
  - Kinds of characters ..... 256 kinds
    (In EXOSD mode, they can be combined with 16 kinds of extra fonts)
  - Character display area ..... CC mode : 16 × 26 dots
    OSD mode : 16 × 20 dots
    EXOSD mode : 16 × 26 dots
  - Kinds of character sizes ..... CC mode : 2 types
    OSD mode : 14 types
    EXOSD mode : 6 types
  - Kinds of character background colors
    CC mode : 7 kinds (a character unit)
    OSD mode : 7 kinds (a character unit)
    EXOSD mode : 5 kinds (a character unit)
    It can be specified by a screen unit (maximum 7 kinds).
    Extra font coloring, raster coloring, border coloring
  - Kinds of character colors ..... CC mode : 7 kinds (R, G, B)
    OSD mode : 7 kinds (R, G, B)
    EXOSD mode : 5 kinds (R, G, B)
  - Display position
    - Horizontal ..... 256 levels
    - Vertical ..... 1024 levels
  - Attribute ..... CC mode : smooth italic, underline, flash
    OSD mode : border
    EXOSD mode : border, extra font (16 kinds)
  - Automatic solid space function
  - Window function
  - Dual layer OSD function

APPLICATION

TV with a closed caption decoder

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER with CLOSED CAPTION DECODER and ON-SCREEN DISPLAY CONTROLLER

PIN CONFIGURATION (TOP VIEW)

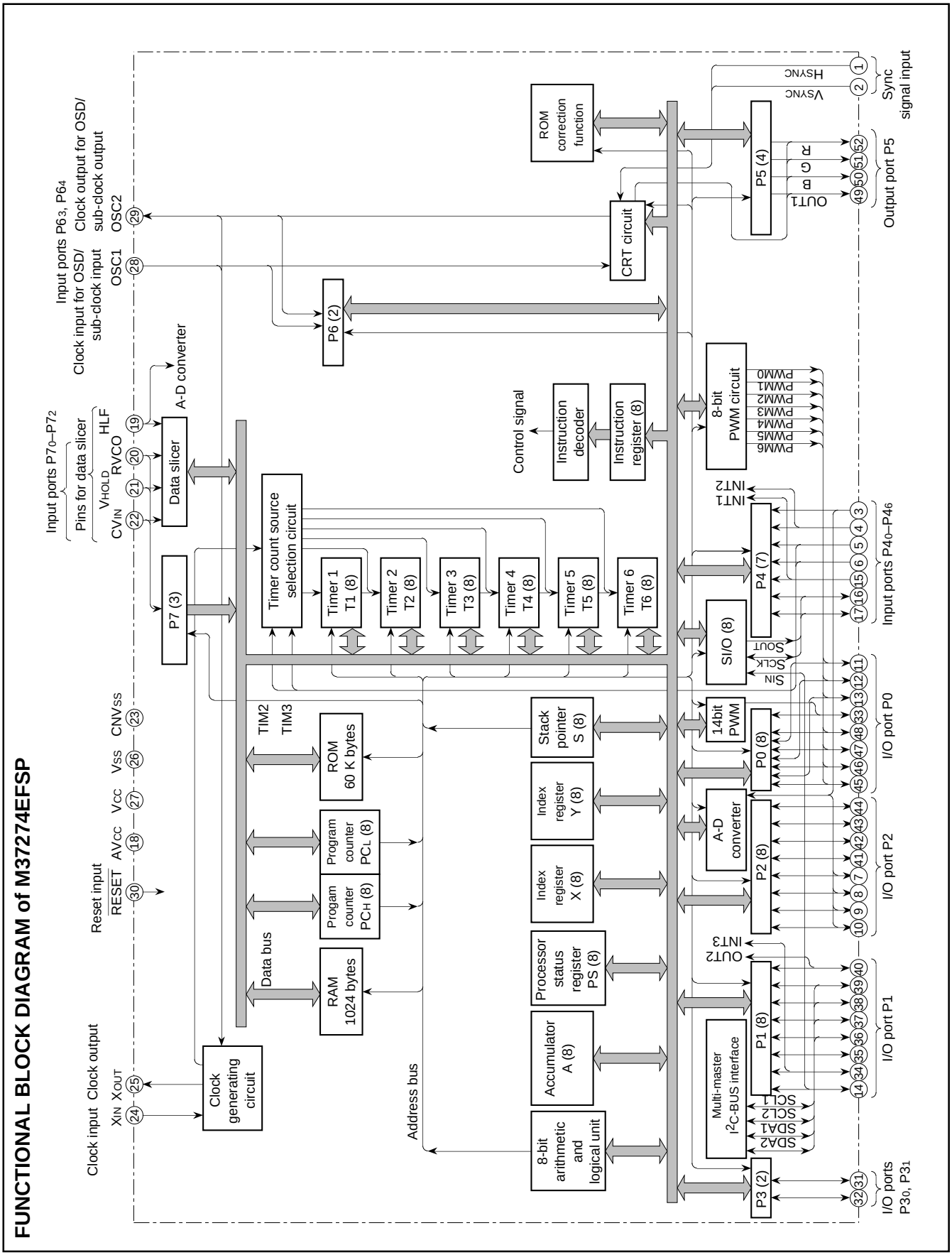


Outline 52P4B

MITSUBISHI ELECTRIC

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER with CLOSED CAPTION DECODER
and ON-SCREEN DISPLAY CONTROLLER

FUNCTIONAL BLOCK DIAGRAM of M37274EFSP



FUNCTIONS

Parameter			Functions
Number of basic instructions			71
Instruction execution time			0.5 μs (the minimum instruction execution time, at 8 MHz oscillation frequency)
Clock frequency			8 MHz (maximum)
Memory size	ROM		60 K bytes
	RAM		1024 bytes
	ROM correction memory		64 bytes
	OSD ROM		11072 bytes
	OSD RAM		1920 bytes
Input/Output ports	$P0_0$–$P0_2$, $P0_4$–$P0_7$	I/O	7-bit × 1 (N-channel open-drain output structure, can be used as 8-bit PWM output pins)
	$P0_3$	I/O	1-bit × 1 (CMOS input/output structure, can be used as 14-bit PWM output pin)
	$P1_0$, $P1_5$–$P1_7$	I/O	4-bit × 1 (CMOS input/output structure, can be used as OSD output pin, INT input pin, serial input pin)
	$P1_1$–$P1_4$	I/O	4-bit × 1 (N-channel open-drain output structure, can be used as multi-master I^2C-BUS interface)
	$P2$	I/O	8-bit × 1 (CMOS input/output structure, can be used as A-D input pins)
	$P3_0$, $P3_1$	I/O	2-bit × 1 (CMOS input/output structure)
	$P4_0$–$P4_4$	Input	5-bit × 1 (can be used as A-D input pins, INT input pins, external clock input pins)
	$P4_5$, $P4_6$	Input	2-bit × 1 (N-channel open-drain output structure when serial I/O is used, can be used as serial I/O pins)
	$P5_2$–$P5_5$	Output	4-bit × 1 (CMOS output structure, can be used as OSD output)
	$P6_3$	Input	1-bit × 1 (can be used as sub-clock input pin, OSD clock input pin)
	$P6_4$	Input	1-bit × 1 (CMOS output structure when LC is oscillating, can be used as sub-clock output pin, OSD clock output pin)
	$P7_0$–$P7_2$	Input	3-bit × 1 (can be used as data slicer input/output)
Serial I/O			8-bit × 1
Multi-master I^2C-BUS interface			1
A-D converter			6 channels (8-bit resolution)
PWM output circuit			14-bit × 1, 8-bit × 7
Timers			8-bit timer × 6
Subroutine nesting			128 levels (maximum)
Interrupt			External interrupt × 3, Internal timer interrupt × 6, Serial I/O interrupt × 1, OSD interrupt × 1, Multi-master I^2C-BUS interface interrupt × 1, Data slicer interrupt × 1, f(X_{IN})/4092 interrupt × 1, V_{SYNC} interrupt × 1, A-D conversion interrupt × 1, BRK instruction interrupt × 1
Clock generating circuit			2 built-in circuits (externally connected to a ceramic resonator or a quartz-crystal oscillator)
Data slicer			Built in

FUNCTIONS (continued)

Parameter				Functions
OSD function	Number of display characters			40 characters × 16 lines
	Character display area			CC mode: 16 × 26 dots (dot structure: 16 × 20 dots) OSD mode: 16 × 20 dots EXOSD mode: 16 × 26 dots
	Kinds of characters			256 kinds (In EXOSDmode, they can be combined with 16 kinds of extra fonts)
	Kinds of character sizes			CC mode: 2 kinds OSD mode: 14 kinds EXOSD mode: 6 kinds
	Kinds of character colors			CC mode: 7 kinds (R, G, B) OSD mode: 7 kinds (R, G, B) EXOSD mode: 5 kinds (R, G, B)
	Display position (horizontal, vertical)			256 levels (horizontal) × 1024 levels (vertical)
Power source voltage				5 V ± 10 %
Power dissipation	In high-speed mode	OSD ON	Data slicer ON	165 mW typ. (at oscillation frequency f(X_{IN}) = 8 MHz, f_{OSC} = 13 MHz)
		OSD OFF	Data slicer OFF	82.5 mW typ. (at oscillation frequency f(X_{IN}) = 8 MHz)
	In low-speed mode	OSD OFF	Data slicer OFF	0.33mW typ. (at oscillation frequency f(X_{CIN}) = 32 kHz, f(X_{IN}) = stopped)
	In stop mode			0.055 mW (maximum)
Operating temperature range				–10 °C to 70 °C
Device structure				CMOS silicon gate process
Package				52-pin shrink plastic molded DIP

PIN DESCRIPTION

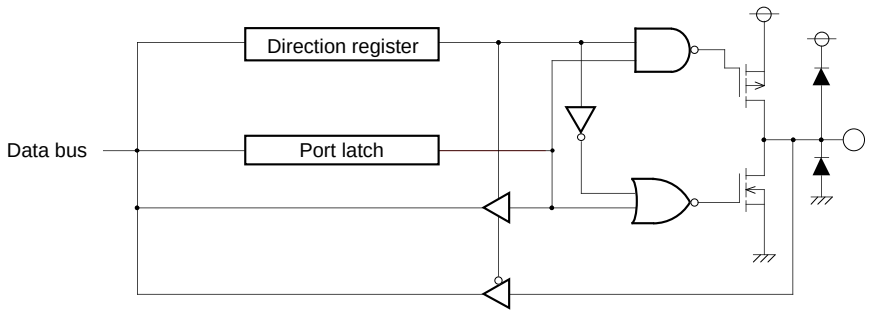
Pin	Name	Input/ Output	Functions
V_{CC}, AV_{CC}, V_{SS}	Power source		Apply voltage of 5 V ± 10 % (typical) to V_{CC} and AV_{CC}, and 0 V to V_{SS}.
CNV_{SS}	CNV_{SS}		Connected to V_{SS}.
$\overline{RESET}$	Reset input	Input	To enter the reset state, the reset input pin must be kept at a "L" for 2 μs or more (under normal V_{CC} conditions). If more time is needed for the quartz-crystal oscillator to stabilize, this "L" condition should be maintained for the required time.
X_{IN}	Clock input	Input	This chip has an internal clock generating circuit. To control generating frequency, an external ceramic resonator or a quartz-crystal oscillator is connected between pins X_{IN} and X_{OUT}. If an external clock is used, the clock source should be connected to the X_{IN} pin and the X_{OUT} pin should be left open.
X_{OUT}	Clock output	Output	
$P0_0$/PWM4–$P0_2$/PWM6, $P0_3$/DA, $P0_4$/PWM0–$P0_7$/PWM3	I/O port P0	I/O	Port P0 is an 8-bit I/O port with direction register allowing each I/O bit to be individually programmed as input or output. At reset, this port is set to input mode. The output structure of $P0_3$ is CMOS output, that of $P0_0$–$P0_2$ and $P0_4$–$P0_7$ are N-channel open-drain output. See notes at end of Table for full details of port P0 functions.
	DA output	Output	Pin $P0_3$ is also used as 14-bit PWM output pin DA. The output structure is CMOS output.
	8-bit PWM output	Output	Pins $P0_0$–$P0_2$ and $P0_4$–$P0_7$ are also used as PWM output pins PWM4–PWM6 and PWM0–PWM3 respectively. The output structure is N-channel open-drain output.
$P1_0$/OUT2, $P1_1$/SCL1, $P1_2$/SCL2, $P1_3$/SDA1, $P1_4$/SDA2, $P1_5$, $P1_6$/INT3, $P1_7$/S_{IN}	I/O port P1	I/O	Port P1 is an 8-bit I/O port and has basically the same functions as port P0. The output structure of $P1_0$ and $P1_5$–$P1_7$ is CMOS output, that of $P1_1$–$P1_4$ is N-channel open-drain output.
	OSD output	Output	Pin $P1_0$ is also used as OSD output pin OUT2. The output structure is CMOS output.
	Multi-master I^2C-BUS interface	Output	Pin $P1_1$ is used as SCL1, SCL2, SDA1 and SDA2 respectively, when multi-master I^2C-BUS interface is used. The output structure is N-channel open-drain output.
	External interrupt input	Input	Pin $P1_6$ is also used as external interrupt input pin INT3.
	Serial I/O data input	Input	Pin $P1_7$ is also used as serial I/O data input pin S_{IN}.
$P2_0$–$P2_3$ $P2_4$/AD3–$P2_6$/AD_1, $P2_7$/AD5	I/O port P2	I/O	Port P2 is an 8-bit I/O port and has basically the same functions as port P0. The output structure is CMOS output.
	Analog input	Input	Pins $P2_4$–$P2_6$, $P2_7$ are also used as analog input pins AD3–AD1, AD5 respectively.
$P3_0$, $P3_1$	I/O port P3	I/O	Ports $P3_0$ and $P3_1$ are 2-bit I/O ports and have basically the same functions as port P0. The output structure is CMOS output.
$P4_0$/AD4, $P4_1$/INT2, $P4_2$/TIM2, $P4_3$/TIM3, $P4_4$/INT1, $P4_5$/S_{OUT}, $P4_6$/S_{CLK}	Input port P4	Input	Ports $P4_0$–$P4_6$ are a 7-bit input port.
	Analog input	Input	Pin $P4_0$ is also used as analog input pin AD4.
	External interrupt input	Input	Pins $P4_1$, $P4_4$ are also used as external interrupt input pins INT2, INT1.
	External clock input	Input	Pins $P4_2$ and $P4_3$ are also used as external clock input pins TIM2, TIM3 respectively.
	Serial I/O data output	Output	Pin $P4_5$ is used as serial I/O data output pin S_{OUT}. The output structure is N-channel open-drain output.
	Serial I/O synchronous clock input/output	I/O	Pin $P4_6$ is used as serial I/O synchronous clock input/output pin S_{CLK}. The output structure is N-channel open-drain output.
$P5_2$/R,$P5_3$/G, $P5_4$/B, $P5_5$/OUT1	Output port P5	Output	Ports $P5_2$–$P5_5$ are 4-bit output ports. The output structure is CMOS output.
	OSD output	Output	Pins $P5_2$–$P5_5$ are also used as OSD output pins R, G, B, OUT1 respectively.

PIN DESCRIPTION (continued)

Pin	Name	Input/ Output	Functions
P6$_3$/OSC1/ XCIN, P6$_4$/OSC2/ XCOUT	Input port	Input	Ports P6$_3$ and P6$_4$ are 2-bit input port.
	Clock input for OSD	Input	Pin P6$_3$ is also used as OSD clock input pin OSC1.
	Clock output for OSD	Output	Pin P6$_4$ is also used as OSD clock output pin OSC2. The output structure is CMOS output.
	Sub-clock output	Output	Pin P6$_4$ is also used as sub-clock output pin XCOUT. The output structure is CMOS output.
	Sub-clock input	Input	Pin P6$_3$ is also used as sub-clock input pin XCIN.
P7$_0$/CVIN, P7$_1$/VHOLD, P7$_2$/RVCO	Input port P7	Input	Ports P7$_0$–P7$_2$ are 3-bit input port.
	Input for data slicer	Input	Pins P7$_0$, P7$_1$ are also used as data slicer input pins CVIN, VHOLD respectively. When using data slicer, input composite video signal through a capacitor. Connect a capacitor between VHOLD and VSS.
	Input/output for data slicer	I/O	Pins P7$_2$ pin is also used as input/output pin for data slicer RVCO. When using data slicer, connect a resistor between RVCO and VSS.
HLF/AD$_6$			When using data slicer, connect a filter using of a capacitor and a resistor between HLF and VSS.
	Analog input	Input	This is an analog input pin AD6.
HSYNC	HSYNC input	Input	This is a horizontal synchronous signal input for OSD.
VSYNC	VSYNC input	Input	This is a vertical synchronous signal input for OSD.

Note : As shown in the memory map (Figure 5), port P0 is accessed as a memory at address 00C0$_{16}$ of zero page. Port P0 has the port P0 direction register (address 00C1$_{16}$ of zero page) which can be used to program each bit as an input (“0”) or an output (“1”). The pins programmed as “1” in the direction register are output pins. When pins are programmed as “0,” they are input pins. When pins are programmed as output pins, the output data are written into the port latch and then output. When data is read from the output pins, the output pin level is not read but the data of the port latch is read. This allows a previously-output value to be read correctly even if the output “L” voltage has risen, for example, because a light emitting diode was directly driven. The input pins float, so the values of the pins can be read. When data is written into the input pin, it is written only into the port latch, while the pin remains in the floating state.

Ports $P0_3$, $P1_0$, $P1_5$–$P1_7$, P2, $P3_0$, $P3_1$

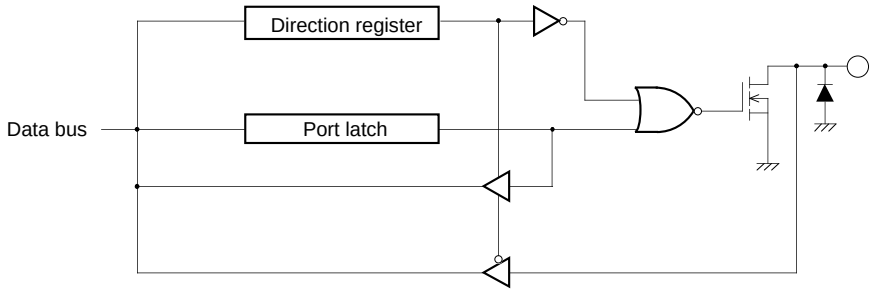


CMOS output

Ports $P0_3$, $P1_0$, $P1_5$–$P1_7$,
P2, $P3_0$, $P3_1$

Note : Each port is also used as follows :
$P0_3$/DA
$P1_0$: OUT2
$P1_6$: INT3
$P1_7$: S_{IN}
$P2_4$–$P2_6$: AD3–AD1
$P2_7$: AD5

Ports $P0_0$–$P0_2$, $P0_4$–$P0_7$

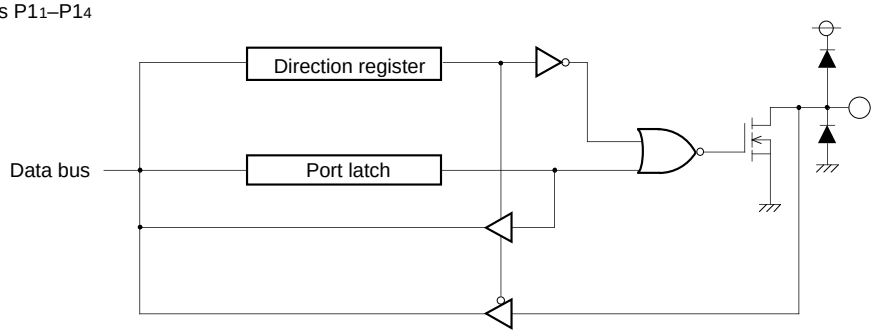


N-channel open-drain output

Ports $P0_0$–$P0_2$, $P0_4$–$P0_7$

Note : Each port is also used as follows :
$P0_0$–$P0_2$: PWM4–PWM6
$P0_4$–$P0_7$: PWM0–PWM3

Ports $P1_1$–$P1_4$



N-channel open-drain output

Port $P1_1$-$P1_4$

Note : Each port is also used as follows :
$P1_1$: SCL1
$P1_2$: SCL2
$P1_3$: SDA1
$P1_4$: SDA2

Fig. 1. I/O Pin Block Diagram (1)

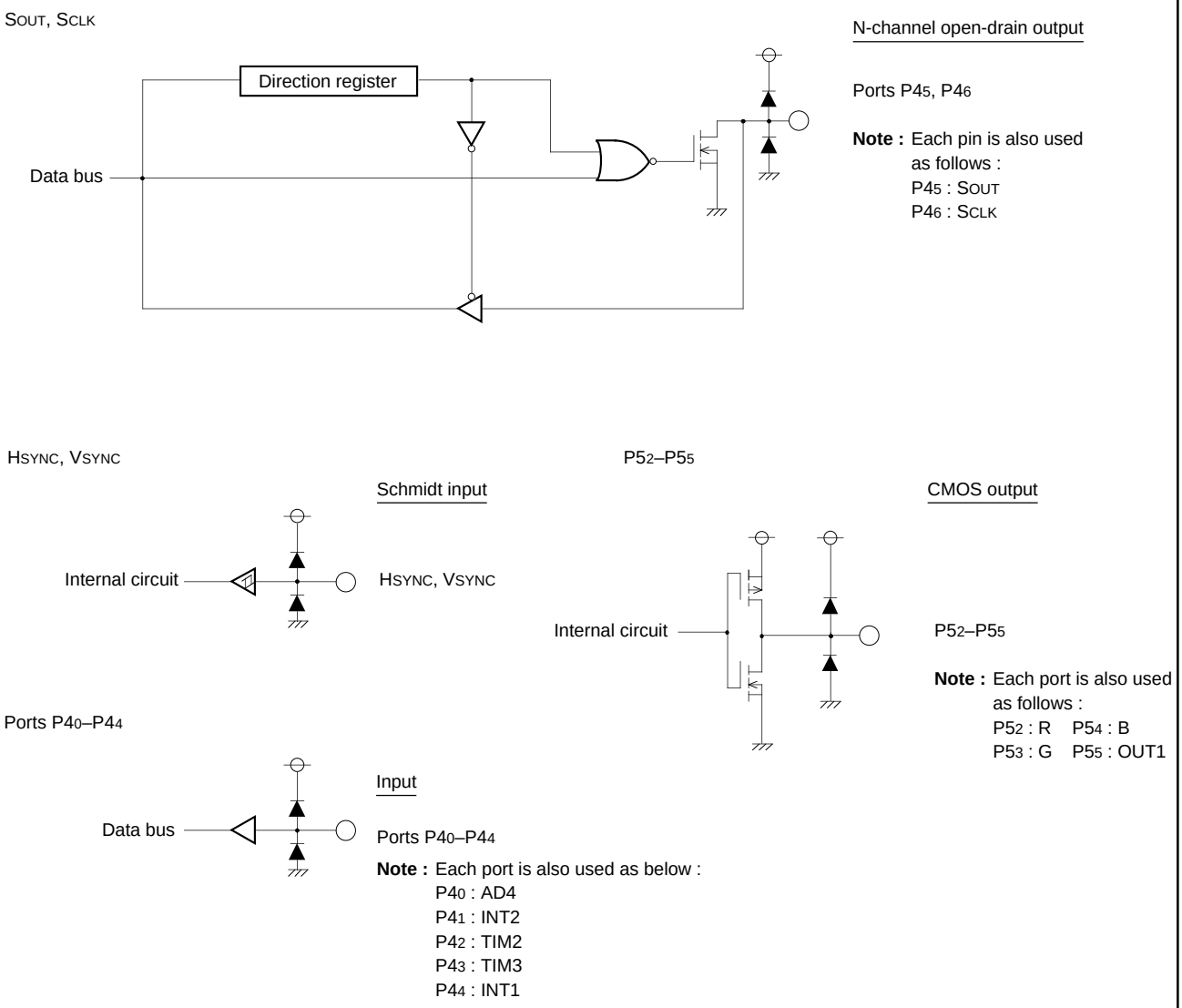


Fig. 2. I/O Pin Block Diagram (2)

FUNCTIONAL DESCRIPTION

Central Processing Unit (CPU)

The M37274EFSP uses the standard 740 Family instruction set. Refer to the table of 740 Family addressing modes and machine instructions or the SERIES 740 <Software> User's Manual for details on the instruction set.

Machine-resident 740 Family instructions are as follows:

The FST, SLW instruction cannot be used.

The MUL, DIV, WIT and STP instructions can be used.

CPU Mode Register

The CPU mode register contains the stack page selection bit and internal system clock selection bit. The CPU mode register is allocated at address 00FB16.

CPU Mode Register

b7 b6 b5 b4 b3 b2 b1 b0

			1	1		0	0

CPU mode register (CPUM) (CM) [Address FB16]

B	Name	Functions	After reset	R	W
0, 1	Processor mode bits (CM0, CM1)	b1 b0 0 0: Single-chip mode 0 1: 1 0: 1 1: } Not available	0	R	W
2	Stack page selection bit (CM2) (See note)	0: 0 page 1: 1 page	1	R	W
3, 4	Fix these bits to "1."		1	R	W
5	XCOUT drivability selection bit (CM5)	0: LOW drive 1: HIGH drive	1	R	W
6	Main Clock (XIN–XOUT) stop bit (CM6)	0: Oscillating 1: Stopped	0	R	W
7	Internal system clock selection bit (CM7)	0: XIN–XOUT selected (high-speed mode) 1: XCIN–XCOUT selected (high-speed mode)	0	R	W

Note: This bit is set to "1" after the reset release.

Fig. 3. CPU Mode Register

MEMORY

Special Function Register (SFR) Area
The special function register (SFR) area in the zero page contains control registers such as I/O ports and timers.

RAM
RAM is used for data storage and for stack area of subroutine calls and interrupts.

ROM
ROM is used for storing user programs as well as the interrupt vector area.

RAM for OSD
RAM for display is used for specifying the character codes and colors to display.

ROM for OSD
ROM for display is used for storing character data.

Interrupt Vector Area
The interrupt vector area contains reset and interrupt vectors.

Zero Page
The 256 bytes from addresses 0000_{16} to $00FF_{16}$ are called the zero page area. The internal RAM and the special function registers (SFR) are allocated to this area.
The zero page addressing mode can be used to specify memory and register addresses in the zero page area. Access to this area with only 2 bytes is possible in the zero page addressing mode.

Special Page
The 256 bytes from addresses $FF00_{16}$ to $FFFF_{16}$ are called the special page area. The special page addressing mode can be used to specify memory addresses in the special page area. Access to this area with only 2 bytes is possible in the special page addressing mode.

ROM Correction Memory (RAM)
This is used as the program area for ROM correction.

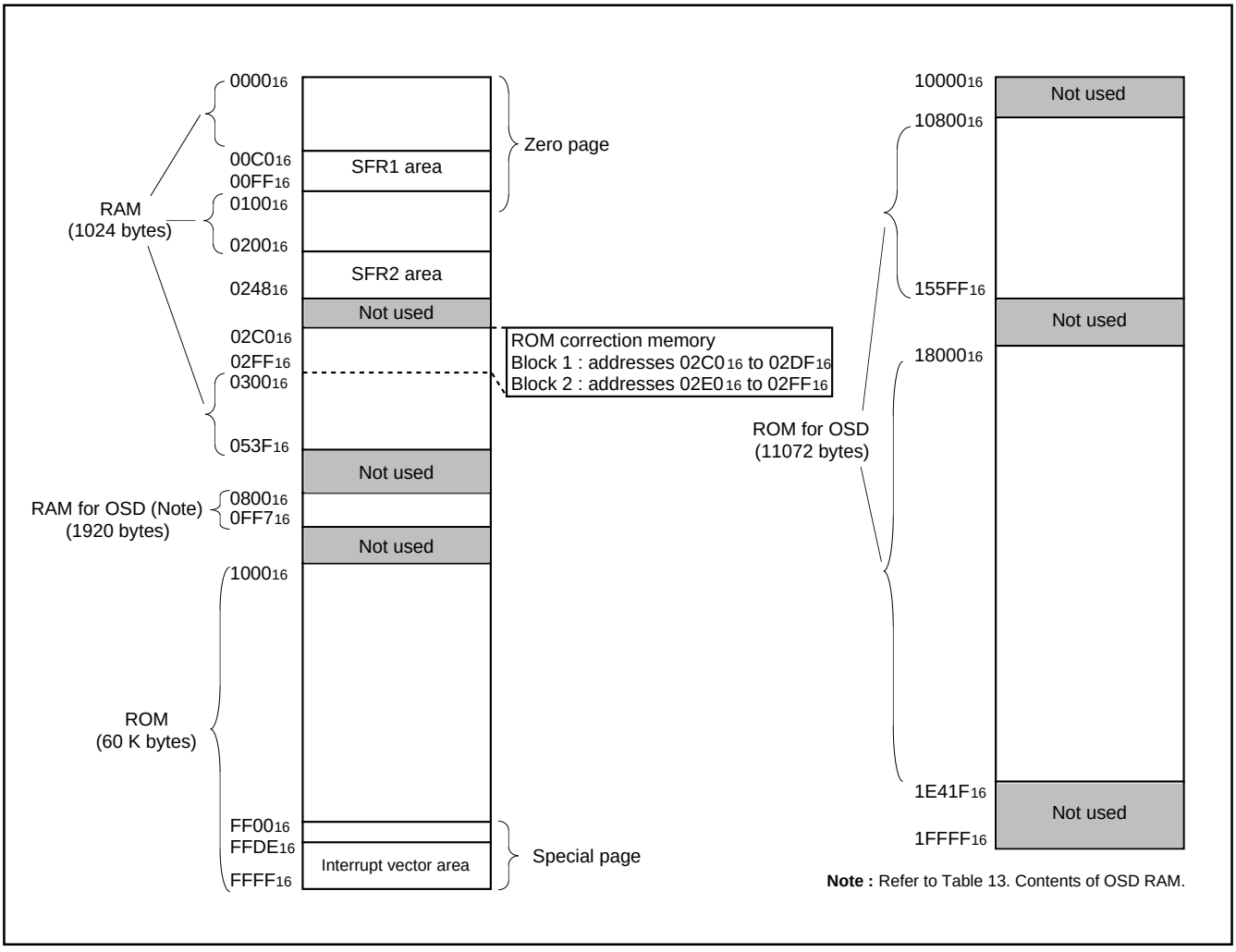


Fig. 4. Memory map

■ SFR1 area (addresses $C0_{16}$ to DF_{16})

<Bit allocation>

: } Function bit
Name :

: No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
$C0_{16}$	Port P0 (P0)									?							
$C1_{16}$	Port P0 direction register (D0)									00_{16}							
$C2_{16}$	Port P1 (P1)									?							
$C3_{16}$	Port P1 direction register (D1)									00_{16}							
$C4_{16}$	Port P2 (P2)									?							
$C5_{16}$	Port P2 direction register (D2)									00_{16}							
$C6_{16}$	Port P3 (P3)									?							
$C7_{16}$	Port P3 direction register (D3)	P6IM	T3SC							00_{16}							
$C8_{16}$	Port P4 (P4)									?							
$C9_{16}$	Port P4 direction register (D4)		P46D	P45D					0	00_{16}							
CA_{16}	Port P5 (P5)									?							
CB_{16}	OSD port control register (PF)	0	OUT2	OUT1	B	G	R	0	0	00_{16}							
CC_{16}	Port P6 (P6)									?							
CD_{16}	Port P7 (P7)									0	0	0	0	0	?	?	?
CE_{16}	OSD control register (OC)	OC7	OC6	OC5	OC4	OC3	OC2	OC1	OC0	00_{16}							
CF_{16}	Horizontal position register (HP)	HP7	HP6	HP5	HP4	HP3	HP2	HP1	HP0	00_{16}							
$D0_{16}$	Block control register 1 (BC_1)	BC_17	BC_16	BC_15	BC_14	BC_13	BC_12	BC_11	BC_10	?							
$D1_{16}$	Block control register 2 (BC_2)	BC_27	BC_26	BC_25	BC_24	BC_23	BC_22	BC_21	BC_20	?							
$D2_{16}$	Block control register 3 (BC_3)	BC_37	BC_36	BC_35	BC_34	BC_33	BC_32	BC_31	BC_30	?							
$D3_{16}$	Block control register 4 (BC_4)	BC_47	BC_46	BC_45	BC_44	BC_43	BC_42	BC_41	BC_40	?							
$D4_{16}$	Block control register 5 (BC_5)	BC_57	BC_56	BC_55	BC_54	BC_53	BC_52	BC_51	BC_50	?							
$D5_{16}$	Block control register 6 (BC_6)	BC_67	BC_66	BC_65	BC_64	BC_63	BC_62	BC_61	BC_60	?							
$D6_{16}$	Block control register 7 (BC_7)	BC_77	BC_76	BC_75	BC_74	BC_73	BC_72	BC_71	BC_70	?							
$D7_{16}$	Block control register 8 (BC_8)	BC_87	BC_86	BC_85	BC_84	BC_83	BC_82	BC_81	BC_80	?							
$D8_{16}$	Block control register 9 (BC_9)	BC_97	BC_96	BC_95	BC_94	BC_93	BC_92	BC_91	BC_90	?							
$D9_{16}$	Block control register 10 (BC_{10})	$BC_{10}7$	$BC_{10}6$	$BC_{10}5$	$BC_{10}4$	$BC_{10}3$	$BC_{10}2$	$BC_{10}1$	$BC_{10}0$	?							
DA_{16}	Block control register 11 (BC_{11})	$BC_{11}7$	$BC_{11}6$	$BC_{11}5$	$BC_{11}4$	$BC_{11}3$	$BC_{11}2$	$BC_{11}1$	$BC_{11}0$	?							
DB_{16}	Block control register 12 (BC_{12})	$BC_{12}7$	$BC_{12}6$	$BC_{12}5$	$BC_{12}4$	$BC_{12}3$	$BC_{12}2$	$BC_{12}1$	$BC_{12}0$	?							
DC_{16}	Block control register 13 (BC_{13})	$BC_{13}7$	$BC_{13}6$	$BC_{13}5$	$BC_{13}4$	$BC_{13}3$	$BC_{13}2$	$BC_{13}1$	$BC_{13}0$	?							
DD_{16}	Block control register 14 (BC_{14})	$BC_{14}7$	$BC_{14}6$	$BC_{14}5$	$BC_{14}4$	$BC_{14}3$	$BC_{14}2$	$BC_{14}1$	$BC_{14}0$	?							
DE_{16}	Block control register 15 (BC_{15})	$BC_{15}7$	$BC_{15}6$	$BC_{15}5$	$BC_{15}4$	$BC_{15}3$	$BC_{15}2$	$BC_{15}1$	$BC_{15}0$	?							
DF_{16}	Block control register 16 (BC_{16})	$BC_{16}7$	$BC_{16}6$	$BC_{16}5$	$BC_{16}4$	$BC_{16}3$	$BC_{16}2$	$BC_{16}1$	$BC_{16}0$	?							

Fig. 5. Memory Map of Special Function Register 1 (SFR1) (1)

MITSUBISHI ELECTRIC

■ SFR1 area (addresses $E0_{16}$ to FF_{16})

<Bit allocation>

□ : } Function bit
Name : }

▨ : No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
$E0_{16}$	Caption position register (CP)	1	0	0	CP4	CP3	CP2	CP1	CP0	00_{16}							
$E1_{16}$	Start bit position register (SP)	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	00_{16}							
$E2_{16}$	Window register (WN)	0	0	WN5	WN4	WN3	WN2	WN1	WN0	00_{16}							
$E3_{16}$	Sync slice register (SSL)	SSL7	0	0	0	0	1	0	1	00_{16}							
$E4_{16}$	Caption data register 1 (CD1)									00_{16}							
$E5_{16}$	Caption data register 2 (CD2)									00_{16}							
$E6_{16}$	Clock run-in register 1 (CR1)	0	1	0	1	CR13	CR12	CR11	CR10	00_{16}							
$E7_{16}$	Clock run-in register 2 (CR2)	1	0	0	1	1	1	CR21	1	00_{16}							
$E8_{16}$	Clock run-in detect register 1 (CRD1)	CRD17	CRD15	CRD15	CRD15	CRD15				00_{16}							
$E9_{16}$	Clock run-in detect register 2 (CRD2)	CRD27	CRD25	CRD25	CRD25	CRD25	CRD22	CRD21	CRD20	00_{16}							
EA_{16}	Data slicer control register 1 (DSC1)	DSC17	0	DSC15	0	0	DSC12	DSC11	DSC10	?	0	?	0	0	0	0	0
EB_{16}	Data slicer control register 2 (DSC2)	DSC27	0	DSC25	0	0	DSC22	DSC21	DSC20	?	0	?	0	0	?	0	0
EC_{16}	Caption data register 3 (CD3)									00_{16}							
ED_{16}	Caption data register 4 (CD4)									00_{16}							
EE_{16}	A-D conversion register (AD)									?							
EF_{16}	A-D control register (ADCON)	0		0	ADVREF	ADSTR	ADIN2	ADIN1	ADIN0	0	?	0	0	1	0	0	0
$F0_{16}$	Timer 1 (TM1)									FF_{16}							
$F1_{16}$	Timer 2 (TM2)									07_{16}							
$F2_{16}$	Timer 3 (TM3)									FF_{16}							
$F3_{16}$	Timer 4 (TM4)									07_{16}							
$F4_{16}$	Timer mode register 1 (TM1)	TM17	TM16	TM15	TM14	TM13	TM12	TM11	TM10	00_{16}							
$F5_{16}$	Timer mode register 2 (TM2)	TM27	TM26	TM25	TM24	TM23	TM22	TM21	TM20	00_{16}							
$F6_{16}$	I^2C data shift register (S0)	D7	D6	D5	D4	D3	D2	D1	D0	?							
$F7_{16}$	I^2C address register (S0D)	SAD6	SAD5	SAD4	SAD3	SAD2	SAD1	SAD0	RBW	00_{16}							
$F8_{16}$	I^2C status register (S1)	MST	TRX	BB	PIN	AL	AAS	AD0	LRB	0	0	0	1	0	0	0	?
$F9_{16}$	I^2C control register (S1D)	BSEL1	BSEL0	10 BIT SAD	ALS	ES0	BC2	BC1	BC0	00_{16}							
FA_{16}	I^2C clock control register (S2)	ACK	ACK BIT	FAST MODE	CCR4	CCR3	CCR2	CCR1	CCR0	00_{16}							
FB_{16}	CPU mode register (CPUM)	CM7	CM6	CM5	1	1	CM2	0	0	0	0	1	1	1	1	0	0
FC_{16}	Interrupt request register 1 (IREQ1)		ADR	VSCR	CRTR	TM4R	TM3R	TM2R	TM1R	00_{16}							
FD_{16}	Interrupt request register 2 (IREQ2)	0	T56R	IICR	INT2R	1MSR	SIOR	DSR	INT1R	00_{16}							
FE_{16}	Interrupt control register 1 (ICON1)		ADE	VSCE	CRTE	TM4E	TM3E	TM2E	TM1E	00_{16}							
FF_{16}	Interrupt control register 2 (ICON2)	T56S	T56E	IICE	INT2E	1MSE	SIOE	DSE	INT1E	00_{16}							

Fig. 6. Memory Map of Special Function Register 1 (SFR2) (2)

■ SFR2 area (addresses 200_{16} to $21F_{16}$)

<Bit allocation>

: } Function bit
Name :

: No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
200_{16}	PWM0 register (PWM0)									?							
201_{16}	PWM1 register (PWM1)									?							
202_{16}	PWM2 register (PWM2)									?							
203_{16}	PWM3 register (PWM3)									?							
204_{16}	PWM4 register (PWM4)									?							
205_{16}	PWM5 register (PWM5)									?							
206_{16}	PWM6 register (PWM6)									?							
207_{16}										?							
208_{16}	Clock run-in detect register 3 (CRD3)	CRD35	CRD34	CRD33	CRD32	CRD31				00_{16}							
209_{16}	Clock run-in register (CR3)		CR36	CR35	CR34	CR33	CR32	CR31	CR30	?							
$20A_{16}$	PWM mode register 1 (PN)					PN3	PN2	PN1	PN0	?	?	?	?	0	0	0	0
$20B_{16}$	PWM mode register 2 (PW)	0	PW6	PW5	PW4	PW3	PW2	PW1	PW0	00_{16}							
$20C_{16}$	Timer 5 (TM5)									07_{16}							
$20D_{16}$	Timer 6 (TM6)									FF_{16}							
$20E_{16}$		00_{16}								00_{16}							
$20F_{16}$	Sync pulse counter register (SYC)			SYC5	SYC4	SYC3	SYC2	SYC1	SYC0	00_{16}							
210_{16}	Data slicer control register 3 (DSC3)	DSC37	DSC36	DSC35	DSC34	DSC33	DSC32	DSC31	DSC30	00_{16}							
211_{16}										?							
212_{16}	Interrupt input polarity register (IP)	AD/INT3 SEL	INT3 POL	0	INT2 POL	INT1 POL	0	0	0	00_{16}							
213_{16}	Serial I/O mode register (SM)	0	0	SM5	SM4	SM3	SM2	SM1	SM0	00_{16}							
214_{16}	Serial I/O register (SIO)									?							
215_{16}										?							
216_{16}	Clock source control register (CS)	0	CS6	CS5	CS4	CS3	CS2	CS1	CS0	00_{16}							
217_{16}	I/O polarity control register (PC)	PC7	PC6	PC5	PC4	0	PC2	PC1	PC0	1	0	0	0	0	0	0	0
218_{16}	Raster color register (RC)	RC7	RC6	RC5	0	0	RC2	RC1	RC0	00_{16}							
219_{16}	Extra font color register (EC)				0	0	EC2	EC1	EC0	00_{16}							
$21A_{16}$					0	0	0	0	0	00_{16}							
$21B_{16}$	Border color register (FC)				0	0	FC2	FC1	FC0	00_{16}							
$21C_{16}$	Window H register 1 (WH1)	WH17	WH16	WH15	WH14	WH13	WH12	WH11	WH10	?							
$21D_{16}$	Window L register 1 (WL1)	WL17	WL16	WL15	WL14	WL13	WL12	WL21	WL20	?							
$21E_{16}$	Window H register 2 (WH2)							WH21	WH20	?							
$21F_{16}$	Window L register 2 (WL2)							WL21	WL20	?							

Fig. 7. Memory Map of Special Function Register 2 (SFR2) (1)

■ SFR2 area (addresses 220_{16} to 248_{16})

<Bit allocation>

: } Function bit (Name)

: No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

< State immediately after reset >

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
220_{16}	Vertical position register 1_1 ($VP1_1$)	$VP1_17$	$VP1_16$	$VP1_15$	$VP1_14$	$VP1_13$	$VP1_12$	$VP1_11$	$VP1_10$	?							
221_{16}	Vertical position register 1_2 ($VP1_2$)	$VP1_27$	$VP1_26$	$VP1_25$	$VP1_24$	$VP1_23$	$VP1_22$	$VP1_21$	$VP1_20$	?							
222_{16}	Vertical position register 1_3 ($VP1_3$)	$VP1_37$	$VP1_36$	$VP1_35$	$VP1_34$	$VP1_33$	$VP1_32$	$VP1_31$	$VP1_30$	?							
223_{16}	Vertical position register 1_4 ($VP1_4$)	$VP1_47$	$VP1_46$	$VP1_45$	$VP1_44$	$VP1_43$	$VP1_42$	$VP1_41$	$VP1_40$	?							
224_{16}	Vertical position register 1_5 ($VP1_5$)	$VP1_57$	$VP1_56$	$VP1_55$	$VP1_54$	$VP1_53$	$VP1_52$	$VP1_51$	$VP1_50$	?							
225_{16}	Vertical position register 1_6 ($VP1_6$)	$VP1_67$	$VP1_66$	$VP1_65$	$VP1_64$	$VP1_63$	$VP1_62$	$VP1_61$	$VP1_60$	?							
226_{16}	Vertical position register 1_7 ($VP1_7$)	$VP1_77$	$VP1_76$	$VP1_75$	$VP1_74$	$VP1_73$	$VP1_72$	$VP1_71$	$VP1_70$	?							
227_{16}	Vertical position register 1_8 ($VP1_8$)	$VP1_87$	$VP1_86$	$VP1_85$	$VP1_84$	$VP1_83$	$VP1_82$	$VP1_81$	$VP1_80$	?							
228_{16}	Vertical position register 1_9 ($VP1_9$)	$VP1_97$	$VP1_96$	$VP1_95$	$VP1_94$	$VP1_93$	$VP1_92$	$VP1_91$	$VP1_90$	?							
229_{16}	Vertical position register 1_{10} ($VP1_{10}$)	$VP1_{10}7$	$VP1_{10}6$	$VP1_{10}5$	$VP1_{10}4$	$VP1_{10}3$	$VP1_{10}2$	$VP1_{10}1$	$VP1_{10}0$	?							
$22A_{16}$	Vertical position register 1_{11} ($VP1_{11}$)	$VP1_{11}7$	$VP1_{11}6$	$VP1_{11}5$	$VP1_{11}4$	$VP1_{11}3$	$VP1_{11}2$	$VP1_{11}1$	$VP1_{11}0$	?							
$22B_{16}$	Vertical position register 1_{12} ($VP1_{12}$)	$VP1_{12}7$	$VP1_{12}6$	$VP1_{12}5$	$VP1_{12}4$	$VP1_{12}3$	$VP1_{12}2$	$VP1_{12}1$	$VP1_{12}0$	?							
$22C_{16}$	Vertical position register 1_{13} ($VP1_{13}$)	$VP1_{13}7$	$VP1_{13}6$	$VP1_{13}5$	$VP1_{13}4$	$VP1_{13}3$	$VP1_{13}2$	$VP1_{13}1$	$VP1_{13}0$	?							
$22D_{16}$	Vertical position register 1_{14} ($VP1_{14}$)	$VP1_{14}7$	$VP1_{14}6$	$VP1_{14}5$	$VP1_{14}4$	$VP1_{14}3$	$VP1_{14}2$	$VP1_{14}1$	$VP1_{14}0$	?							
$22E_{16}$	Vertical position register 1_{15} ($VP1_{15}$)	$VP1_{15}7$	$VP1_{15}6$	$VP1_{15}5$	$VP1_{15}4$	$VP1_{15}3$	$VP1_{15}2$	$VP1_{15}1$	$VP1_{15}0$	?							
$22F_{16}$	Vertical position register 1_{16} ($VP1_{16}$)	$VP1_{16}7$	$VP1_{16}6$	$VP1_{16}5$	$VP1_{16}4$	$VP1_{16}3$	$VP1_{16}2$	$VP1_{16}1$	$VP1_{16}0$	?							
230_{16}	Vertical position register 2_1 ($VP2_1$)							$VP2_11$	$VP2_10$	?							
231_{16}	Vertical position register 2_2 ($VP2_2$)							$VP2_21$	$VP2_20$	?							
232_{16}	Vertical position register 2_3 ($VP2_3$)							$VP2_31$	$VP2_30$	?							
233_{16}	Vertical position register 2_4 ($VP2_4$)							$VP2_41$	$VP2_40$	?							
234_{16}	Vertical position register 2_5 ($VP2_5$)							$VP2_51$	$VP2_50$	?							
235_{16}	Vertical position register 2_6 ($VP2_6$)							$VP2_61$	$VP2_60$	?							
236_{16}	Vertical position register 2_7 ($VP2_7$)							$VP2_71$	$VP2_70$	?							
237_{16}	Vertical position register 2_8 ($VP2_8$)							$VP2_81$	$VP2_80$	?							
238_{16}	Vertical position register 2_9 ($VP2_9$)							$VP2_91$	$VP2_90$	?							
239_{16}	Vertical position register 2_{10} ($VP2_{10}$)							$VP2_{10}1$	$VP2_{10}0$	?							
$23A_{16}$	Vertical position register 2_{11} ($VP2_{11}$)							$VP2_{11}1$	$VP2_{11}0$	?							
$23B_{16}$	Vertical position register 2_{12} ($VP2_{12}$)							$VP2_{12}1$	$VP2_{12}0$	?							
$23C_{16}$	Vertical position register 2_{13} ($VP2_{13}$)							$VP2_{13}1$	$VP2_{13}0$	?							
$23D_{16}$	Vertical position register 2_{14} ($VP2_{14}$)							$VP2_{14}1$	$VP2_{14}0$	?							
$23E_{16}$	Vertical position register 2_{15} ($VP2_{15}$)							$VP2_{15}1$	$VP2_{15}0$	?							
$23F_{16}$	Vertical position register 2_{16} ($VP2_{16}$)							$VP2_{16}1$	$VP2_{16}0$	?							
240_{16}	DA-H register (DA-H)									?							
241_{16}	DA-L register (DA-L)									0	0	?	?	?	?	?	?
242_{16}	ROM correction address 1 (high-order)									00_{16}							
243_{16}	ROM correction address 1 (low-order)									00_{16}							
244_{16}	ROM correction address 2 (high-order)									00_{16}							
245_{16}	ROM correction address 2 (low-order)									00_{16}							
246_{16}	ROM correction enable register (RCR)					0	0	RCR1	RCR0	00_{16}							
247_{16}		00_{16}								00_{16}							
248_{16}							0	0	0	00_{16}							

Fig. 8. Memory Map of Special Function Register 2 (SFR2) (2)

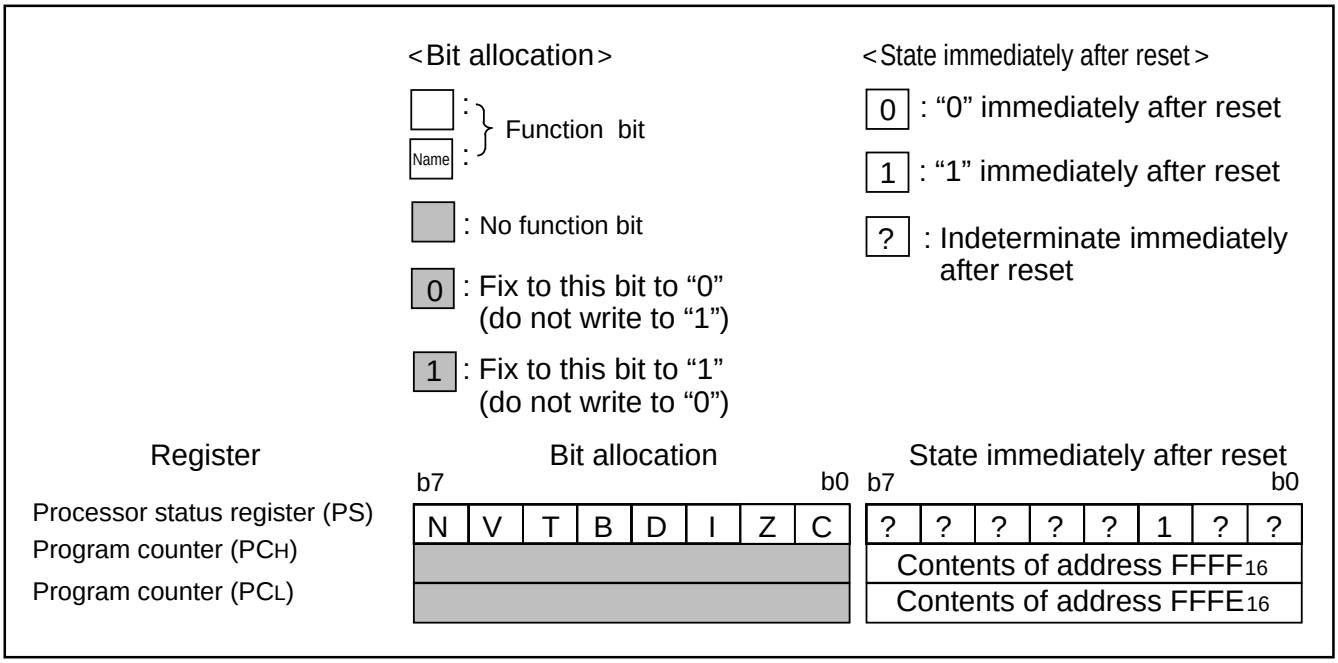


Fig. 9. Internal State of Processor Status Register and Program Counter at Reset

INTERRUPTS

Interrupts can be caused by 18 different sources consisting of 4 external, 12 internal, 1 software, and reset. Interrupts are vectored interrupts with priorities as shown in Table 1. Reset is also included in the table because its operation is similar to an interrupt.

When an interrupt is accepted,

(1) The contents of the program counter and processor status register are automatically stored into the stack.
(2) The interrupt disable flag I is set to "1" and the corresponding interrupt request bit is set to "0."
(3) The jump destination address stored in the vector address enters the program counter.

Other interrupts are disabled when the interrupt disable flag is set to "1."

All interrupts except the BRK instruction interrupt have an interrupt request bit and an interrupt enable bit. The interrupt request bits are in interrupt request registers 1 and 2 and the interrupt enable bits are in interrupt control registers 1 and 2. Figures 11 to 15 show the interrupt-related registers.

Interrupts other than the BRK instruction interrupt and reset are accepted when the interrupt enable bit is "1," interrupt request bit is "1," and the interrupt disable flag is "0." The interrupt request bit can be set to "0" by a program, but not set to "1." The interrupt enable bit can be set to "0" and "1" by a program.

Reset is treated as a non-maskable interrupt with the highest priority. Figure 10 shows interrupt control.

Interrupt Causes

(1) VSYNC and OSD interrupts
The VSYNC interrupt is an interrupt request synchronized with the vertical sync signal.
The OSD interrupt occurs after character block display to the CRT is completed.

(2) INT1, INT2, INT3 interrupts
With an external interrupt input, the system detects that the level of a pin changes from "L" to "H" or from "H" to "L," and generates an interrupt request. The input active edge can be selected by bits 3, 4 and 6 of the interrupt input polarity register (address 0212_{16}) : when this bit is "0," a change from "L" to "H" is detected; when it is "1," a change from "H" to "L" is detected. Note that all bits are cleared to "0" at reset.

(3) Timer 1, 2, 3 and 4 interrupts
An interrupt is generated by an overflow of timer 1, 2, 3 or 4.

(4) Serial I/O interrupt
This is an interrupt request from the clock synchronous serial I/O function.

(5) f(XIN)/4096 interrupt
This interrupt occurs regularly with a f(XIN)/4096 period. Set bit 0 of the PWM mode register 1 to "0."

(6) Data slicer interrupt
An interrupt occurs when slicing data is completed.

(7) Multi-master I^2C-BUS interface interrupt
This is an interrupt request related to the multi-master I^2C-BUS interface.

(8) A-D conversion interrupt
An interrupt occurs at the completion of A-D conversion. Since A-D conversion interrupt and the INT3 interrupt share the same vector, an interrupt source is selected by bit 7 of the interrupt interval determination control register (address 0212_{16}).

Table 1. Interrupt Vector Addresses and Priority

Interrupt Source	Priority	Vector Addresses	Remarks
Reset	1	$FFFF_{16}$, $FFFE_{16}$	Non-maskable
OSD interrupt	2	$FFFD_{16}$, $FFFC_{16}$	
INT1 interrupt	3	$FFFB_{16}$, $FFFA_{16}$	Active edge selectable
Data slicer interrupt	4	$FFF9_{16}$, $FFF8_{16}$	
Serial I/O interrupt	5	$FFF7_{16}$, $FFF6_{16}$	
Timer 4 interrupt	6	$FFF5_{16}$, $FFF4_{16}$	
f(XIN)/4096 interrupt	7	$FFF3_{16}$, $FFF2_{16}$	
VSYNC interrupt	8	$FFF1_{16}$, $FFF0_{16}$	Active edge selectable
Timer 3 interrupt	9	$FFEF_{16}$, $FFEE_{16}$	
Timer 2 interrupt	10	$FFED_{16}$, $FFEC_{16}$	
Timer 1 interrupt	11	$FFEB_{16}$, $FFEA_{16}$	
A-D convertion · INT3 interrupt	12	$FFE9_{16}$, $FFE8_{16}$	Software switch by software (See note)/ When selecting INT3 interrupt, active edge selectable.
INT2 interrupt	13	$FFE7_{16}$, $FFE6_{16}$	Active edge selectable
Multi-master I^2C-BUS interface interrupt	14	$FFE5_{16}$, $FFE4_{16}$	
Timer 5 · 6 interrupt	15	$FFE3_{16}$, $FFE2_{16}$	Software switch by software (See note)
BRK instruction interrupt	16	$FFDF_{16}$, $FFDE_{16}$	Non-maskable (software interrupt)

Note : Switching a source during a program causes an unnecessary interrupt occurs. Accordingly, set a source at initializing of program.

(9)Timer 5 · 6 interrupt

An interrupt is generated by an overflow of timer 5 or 6. Their priorities are same, and can be switched by software.

(10)BRK instruction interrupt

This software interrupt has the least significant priority. It does not have a corresponding interrupt enable bit, and it is not affected by the interrupt disable flag I (non-maskable).

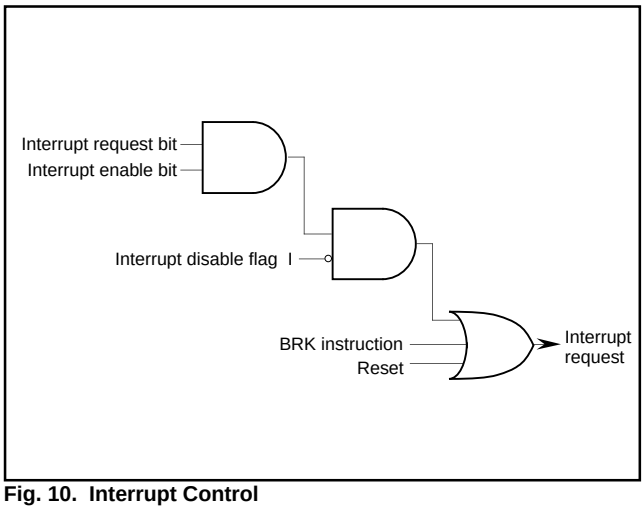
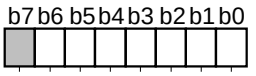


Fig. 10. Interrupt Control

Interrupt Request Register 1



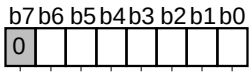
Interrupt request register 1 (IREQ1) [Address 00FC16]

B	Name	Functions	After reset	R	W
0	Timer 1 interrupt request bit (TM1R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
1	Timer 2 interrupt request bit (TM2R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
2	Timer 3 interrupt request bit (TM3R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
3	Timer 4 interrupt request bit (TM4R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
4	OSD interrupt request bit (CRTR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
5	VSYNC interrupt request bit (VSCR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
6	A-D conversion • INT3 interrupt request bit (ADR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is “0.”		0	R	—

✻: “0” can be set by software, but “1” cannot be set.

Fig. 11. Interrupt Request Register 1

Interrupt Request Register 2



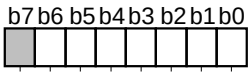
Interrupt request register 2 (IREQ2) [Address 00FD16]

B	Name	Functions	After reset	R	W
0	INT1 interrupt request bit (INT1R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
1	Data slicer interrupt request bit (DSR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
2	Serial I/O interrupt request bit (SIOR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
3	f(XIN)/4096 interrupt request bit (1MSR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
4	INT2 interrupt request bit (INT2R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
5	Multi-master I2C-BUS interrupt request bit (IICR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
6	Timer 5 • 6 interrupt request bit (T56R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
7	Fix this bit to “0.”		0	R	W

✻: “0” can be set by software, but “1” cannot be set.

Fig. 12. Interrupt Request Register 2

Interrupt Control Register 1

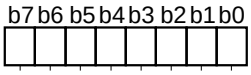


Interrupt control register 1 (ICON1) [Address 00FE16]

B	Name	Functions	After reset	R	W
0	Timer 1 interrupt enable bit (TM1E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
1	Timer 2 interrupt enable bit (TM2E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
2	Timer 3 interrupt enable bit (TM3E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
3	Timer 4 interrupt enable bit (TM4E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
4	OSD interrupt enable bit (CRTE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
5	VSYNC interrupt enable bit (VSCR)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
6	A-D conversion • INT3 interrupt enable bit (ADE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is “0.”		0	R	—

Fig. 13. Interrupt Control Register 1

Interrupt Control Register 2

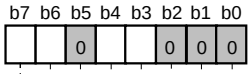


Interrupt control register 2 (ICON2) [Address 00FF16]

B	Name	Functions	After reset	R	W
0	INT1 interrupt enable bit (INT1E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
1	Data slicer interrupt enable bit (DSR)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
2	Serial I/O interrupt enable bit (SIOE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
3	f(XIN)/4096 interrupt enable bit (1MSE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
4	INT2 interrupt enable bit (INT2E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
5	Multi-master I2C-BUS interface interrupt enable bit (IICE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
6	Timer 5 • 6 interrupt enable bit (T56E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
7	Timer 5 • 6 interrupt switch bit (TM56S)	0 : Timer 5 1 : Timer 6	0	R	W

Fig. 14. Interrupt Control Register 2

Interrupt Input Polarity Register



Interrupt input polarity register (IP) [Address 0212_{16}]

B	Name	Functions	After reset	R	W
0 to 2, 5	Fix these bits to "0."		0	R	W
3	INT1 polarity switch bit (INT1POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
4	INT2 polarity switch bit (INT2POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
6	INT3 polarity switch bit (INT3POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
7	A-D conversion • INT3 interrupt source selection bit (RE7)	0 : Positive polarity 1 : Negative polarity	0	R	W

Fig. 15. Interrupt Input Polarity Register

TIMERS

The M37271MF-XXXSP has 6 timers: timer 1, timer 2, timer 3, timer 4, timer 5, and timer 6. All timers are 8-bit timers with the 8-bit timer latch. The timer block diagram is shown in Figure 18.

All of the timers count down and their divide ratio is 1/(n+1), where n is the value of timer latch. By writing a count value to the corresponding timer latch (addresses $00F0_{16}$ to $00F3_{16}$: timers 1 to 4, addresses $020C_{16}$ and $020D_{16}$: timers 5 and 6), the value is also set to a timer, simultaneously.

The count value is decremented by 1. The timer interrupt request bit is set to "1" by a timer overflow at the next count pulse, after the count value reaches "00_{16}".

(1) Timer 1

Timer 1 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- f(XIN)/4096 or f(XCIN)/4096
- External clock from the $P4_2$ TIM2 pin

The count source of timer 1 is selected by setting bits 5 and 0 of timer mode register 1 (address $00F4_{16}$). Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register.

Timer 1 interrupt request occurs at timer 1 overflow.

(2) Timer 2

Timer 2 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- Timer 1 overflow signal
- External clock from the TIM2 pin

The count source of timer 2 is selected by setting bits 4 and 1 of timer mode register 1 (address $00F4_{16}$). Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register. When timer 1 overflow signal is a count source for the timer 2, the timer 1 functions as an 8-bit prescaler.

Timer 2 interrupt request occurs at timer 2 overflow.

(3) Timer 3

Timer 3 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- f(XCIN)
- External clock from the TIM3 pin

The count source of timer 3 is selected by setting bit 0 of timer mode register 2 (address $00F5_{16}$) and bit 6 at address $00C7_{16}$. Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register.

Timer 3 interrupt request occurs at timer 3 overflow.

(4) Timer 4

Timer 4 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- f(XIN)/2 or f(XCIN)/2
- f(XCIN)

The count source of timer 3 is selected by setting bits 1 and 4 of timer mode register 2 (address $00F5_{16}$). Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register. When timer 3 overflow signal is a count source for the timer 4, the timer 3 functions as an 8-bit prescaler.

Timer 4 interrupt request occurs at timer 4 overflow.

(5) Timer 5

Timer 5 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- Timer 2 overflow signal
- Timer 4 overflow signal

The count source of timer 3 is selected by setting bit 6 of timer mode register 1 (address $00F4_{16}$) and bit 7 of timer mode register 2 (address $00F5_{16}$). When overflow of timer 2 or 4 is a count source for timer 5, either timer 2 or 4 functions as an 8-bit prescaler. Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register.

Timer 5 interrupt request occurs at timer 5 overflow.

(6) Timer 6

Timer 6 can select one of the following count sources:

- f(XIN)/16 or f(XCIN)/16
- Timer 5 overflow signal

The count source of timer 6 is selected by setting bit 7 of timer mode register 1 (address $00F4_{16}$). Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register. When timer 5 overflow signal is a count source for timer 6, timer 5 functions as an 8-bit prescaler.

Timer 6 interrupt request occurs at timer 6 overflow.

At reset, timers 3 and 4 are connected by hardware and "FF_{16}" is automatically set in timer 3; "07_{16}" in timer 4. The f(XIN) * /16 is selected as the timer 3 count source. The internal reset is released by timer 4 overflow in this state and the internal clock is connected.

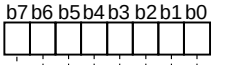
At execution of the STP instruction, timers 3 and 4 are connected by hardware and "FF_{16}" is automatically set in timer 3; "07_{16}" in timer 4. However, the f(XIN) * /16 is not selected as the timer 3 count source. So set both bit 0 of timer mode register 2 (address $00F5_{16}$) and bit 6 at address $00C7_{16}$ to "0" before execution of the STP instruction (f(XIN) * /16 is selected as the timer 3 count source). The internal STP state is released by timer 4 overflow in this state and the internal clock is connected.

As a result of the above procedure, the program can start under a stable clock.

* : When bit 7 of the CPU mode register (CM_7) is "1," f(XIN) becomes f(XCIN).

The structure of timer-related registers is shown in Figure 16 and 17.

Timer Mode Register 1



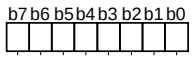
Timer mode register 1 (TM1) [Address $00F4_{16}$]

B	Name	Functions	After reset	R	W
0	Timer 1 count source selection bit 1 (TM10)	0: $f(X_{IN})/16$ or $f(X_{CIN})/16$ (Note) 1: Count source selected by bit 5 of TM1	0	R	W
1	Timer 2 count source selection bit 1 (TM11)	0: Count source selected by bit 4 of TM1 1: External clock from TIM2 pin	0	R	W
2	Timer 1 count stop bit (TM12)	0: Count start 1: Count stop	0	R	W
3	Timer 2 count stop bit (TM13)	0: Count start 1: Count stop	0	R	W
4	Timer 2 count source selection bit 2 (TM14)	0: $f(X_{IN})/16$ or $f(X_{CIN})/16$ (See note) 1: Timer 1 overflow	0	R	W
5	Timer 1 count source selection bit 2 (TM15)	0: $f(X_{IN})/4096$ or $f(X_{CIN})/4096$ (See note) 1: External clock from TIM2 pin	0	R	W
6	Timer 5 count source selection bit 2 (TM16)	0: Timer 2 overflow 1: Timer 4 overflow	0	R	W
7	Timer 6 internal count source selection bit (TM17)	0: $f(X_{IN})/16$ or $f(X_{CIN})/16$ (See note) 1: Timer 5 overflow	0	R	W

Note: Either $f(X_{IN})$ or $f(X_{CIN})$ is selected by bit 7 of the CPU mode register.

Fig. 16. Timer Mode Register 1

Timer Mode Register 2

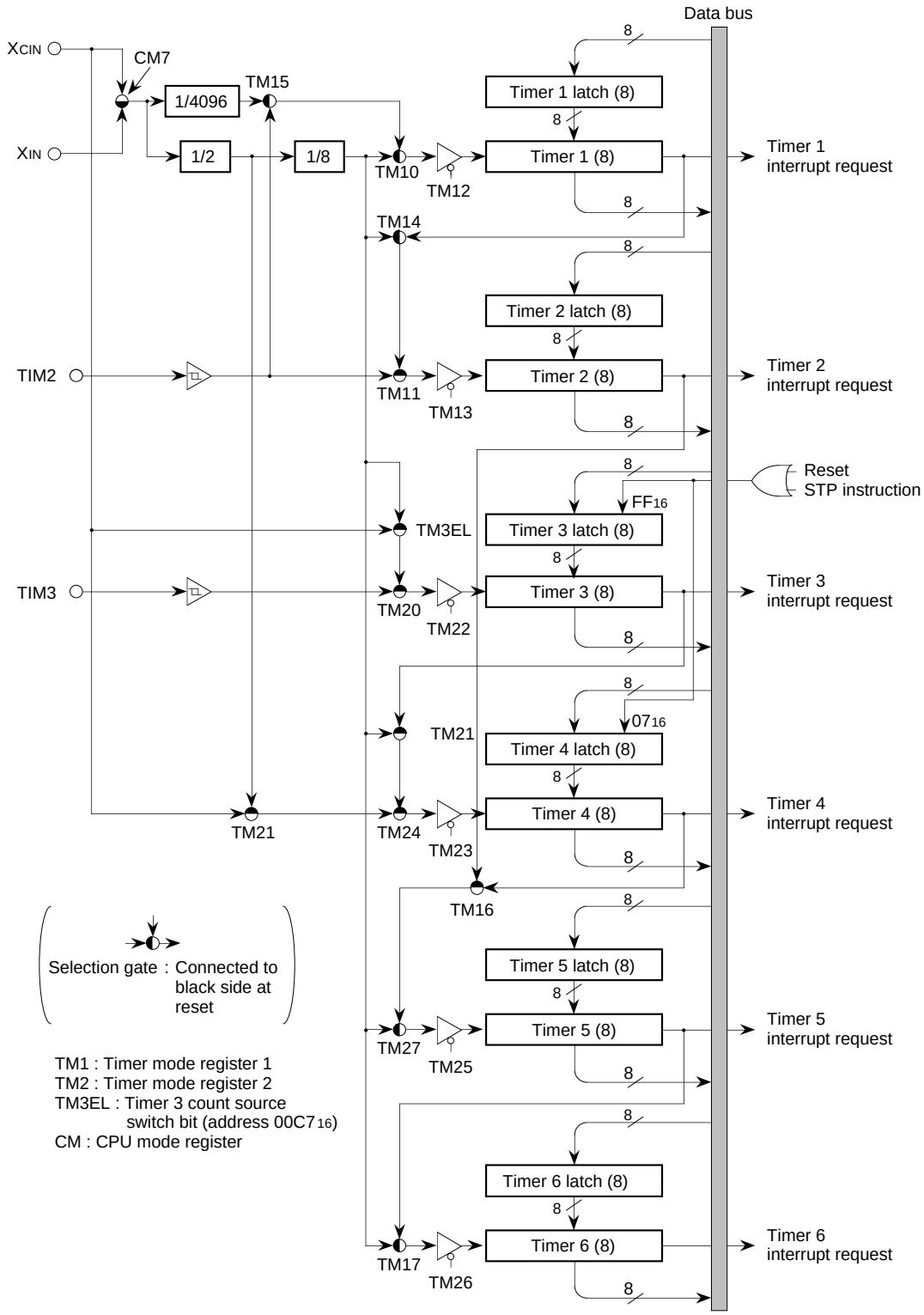


Timer mode register 2 (TM2) [Address $00F5_{16}$]

B	Name	Functions	After reset	R	W
0	Timer 3 count source selection bit (TM20)	(b6 at address $00C7_{16}$) b0 0 0 : $f(X_{IN})/16$ or $f(X_{CIN})/16$ (See note) 0 1 : $f(X_{CIN})$ 1 0 : 1 1 : } External clock from TIM3 pin	0	R	W
1, 4	Timer 4 count source selection bits (TM21, TM24)	b4 b1 0 0 : Timer 3 overflow signal 0 1 : $f(X_{IN})/16$ or $f(X_{CIN})/16$ (See note) 1 0 : $f(X_{IN})/2$ or $f(X_{CIN})/2$ (See note) 1 1 : $f(X_{CIN})$	0	R	W
2	Timer 3 count stop bit (TM22)	0: Count start 1: Count stop	0	R	W
3	Timer 4 count stop bit (TM23)	0: Count start 1: Count stop	0	R	W
5	Timer 5 count stop bit (TM25)	0: Count start 1: Count stop	0	R	W
6	Timer 6 count stop bit (TM26)	0: Count start 1: Count stop	0	R	W
7	Timer 5 count source selection bit 1 (TM27)	0: $f(X_{IN})/16$ or $f(X_{CIN})/16$ (See note) 1: Count source selected by bit 6 of TM1	0	R	W

Note: Either $f(X_{IN})$ or $f(X_{CIN})$ is selected by bit 7 of the CPU mode register.

Fig. 17. Timer Mode Register 2



Notes 1: HIGH pulse width of external clock inputs TIM2 and TIM3 needs 4 machine cycles or more.
2: When the external clock source is selected, timers 1, 2, and 3 are counted at a rising edge of input signal.
3: In the stop mode or the wait mode, external clock inputs TIM2 and TIM3 cannot be used.

Fig. 18. Timer Block Diagram

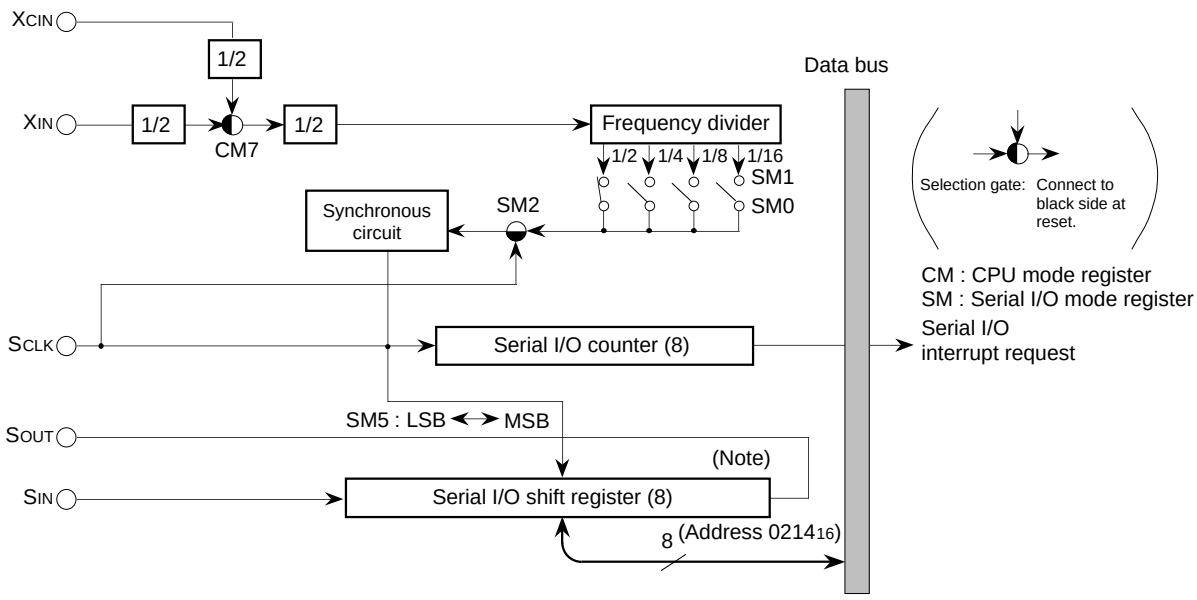
SERIAL I/O

The M37274EFSP has a built-in serial I/O which can either transmit or receive 8-bit data serially in the clock synchronous mode.

The serial I/O block diagram is shown in Figure 19. The synchronous clock I/O pin (SCLK), and data output pin (SOUT) also function as port P4, data input pin (SIN) also functions as port P1.

Bit 2 of the serial I/O mode register (address 0213_{16}) selects whether the synchronous clock is supplied internally or externally (from the P46/SCLK pin). When an internal clock is selected, bits 1 and 0 select whether f(XIN) or f(XCIN) is divided by 8, 16, 32, or 64. To use SOUT and P46/SCLK pins for serial I/O, set the corresponding bits of the port P4 direction register (address $00C9_{16}$) to "0." To use SIN pin for serial I/O, set the corresponding bit of the port P1 direction register (address $00C3_{16}$) to "0."

The operation of the serial I/O is described below. The operation of the serial I/O differs depending on the clock source; external clock or internal clock.



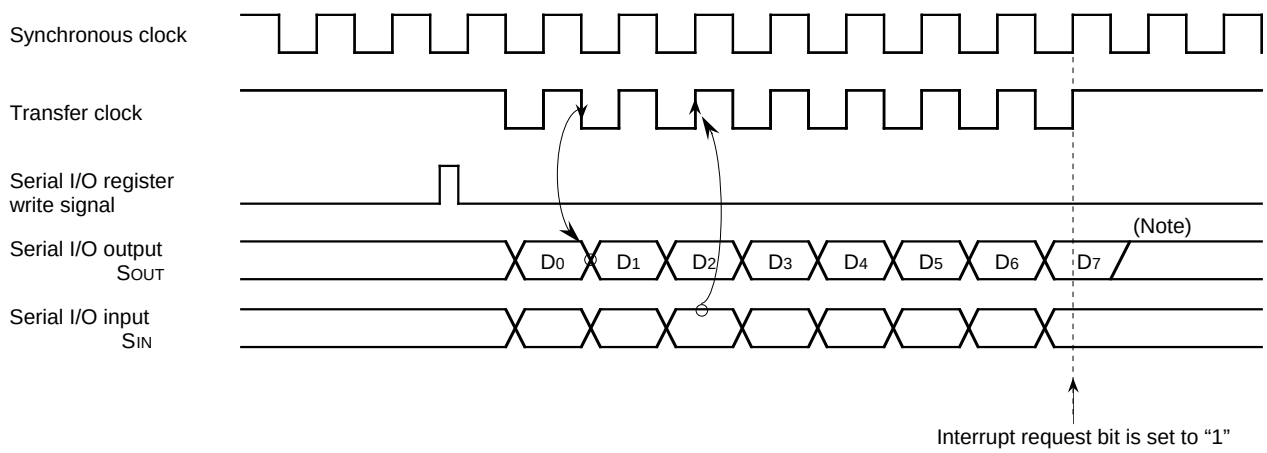
Note : When the data is set in the serial I/O register (address 0214 16), the register functions as the serial I/O shift register.

Fig. 19. Serial I/O Block Diagram

Internal clock : The serial I/O counter is set to "7" during the write cycle into the serial I/O register (address 0214_{16}), and the transfer clock goes "H" forcibly. At each falling edge of the transfer clock after the write cycle, serial data is output from the SOUT pin. Transfer direction can be selected by bit 5 of the serial I/O mode register. At each rising edge of the transfer clock, data is input from the SIN pin and data in the serial I/O register is shifted 1 bit.
After the transfer clock has counted 8 times, the serial I/O counter becomes "0" and the transfer clock stops at HIGH. At this time the interrupt request bit is set to "1."

External clock : The an external clock is selected as the clock source, the interrupt request is set to "1" after the transfer clock has been counted 8 counts. However, transfer operation does not stop, so the clock should be controlled externally. Use the external clock of 500kHz or less with a duty cycle of 50%.
The serial I/O timing is shown in Figure 20. When using an external clock for transfer, the external clock must be held at HIGH for initializing the serial I/O counter. When switching between an internal clock and an external clock, do not switch during transfer. Also, be sure to initialize the serial I/O counter after switching.

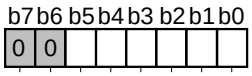
Notes 1: On programming, note that the serial I/O counter is set by writing to the serial I/O register with the bit managing instructions, such as SEB and CLB.
2: When an external clock is used as the synchronous clock, write transmit data to the serial I/O register when the transfer clock input level is HIGH.



Note : When an internal clock is selected, the SOUT pin is at high-impedance after transfer is completed.

Fig. 20. Serial I/O Timing (for LSB first)

Serial I/O Mode Register



Serial I/O mode register (SM) [Address 0213_{16}]

B	Name	Functions	After reset	R	W
0, 1	Internal synchronous clock selection bits (SM0, SM1)	b1 b0 0 0: f(X_{IN})/4 or f(X_{CIN})/4 0 1: f(X_{IN})/16 or f(X_{CIN})/16 1 0: f(X_{IN})/32 or f(X_{CIN})/32 1 1: f(X_{IN})/64 or f(X_{CIN})/64	0	R	W
2	Synchronous clock selection bit (SM2)	0: External clock 1: Internal clock	0	R	W
3	Port function selection bit (SM3)	0: $P1_1$, $P1_3$ 1: SCL1, SDA1	0	R	W
4	Port function selection bit (SM4)	0: $P1_2$, $P1_4$ 1: SCL2, SDA2	0	R	W
5	Transfer direction selection bit (SM5)	0: LSB first 1: MSB first	0	R	W
6, 7	Fix these bits to “0.”		0	R	W

Fig. 21. Serial I/O Mode Register

PWM OUTPUT FUNCTION

The M37274EFSP is equipped with a 14-bit PWM (DA) seven 8-bit PWMs (PWM0–PWM6). DA has a 14-bit resolution with the minimum resolution bit width of 0.25 μs and a repeat period of 4096 μs (for f(X_{IN}) = 8 MHz). PWM0–PWM6 have the same circuit structure and an 8-bit resolution with minimum resolution bit width of 4 μs and repeat period of 1024 μs (for f(X_{IN}) = 8 MHz) .

Figure 22 shows the PWM block diagram. The PWM timing generating circuit applies individual control signals to PWM0–PWM6 using f(X_{IN}) divided by 2 as a reference signal.

(1) Data Setting

When outputting DA, first set the high-order 8 bits to the DA-H register (address 0240_{16}), then the low-order 6 bits to the DA-L register (address 0241_{16}). When outputting PWM0–PWM6, set 8-bit output data to the PWMi register (i means 0 to 6; addresses 0200_{16} to 0206_{16}).

(2) Transmitting Data from Register to PWM circuit

Data transfer from the 8-bit PWM register to the 8-bit PWM circuit is executed at writing data to the register.

The signal output from the 8-bit PWM output pin corresponds to the contents of this register.

Also, data transfer from the DA register (addresses 0240_{16} and 0241_{16}) to the 14-bit PWM circuit is executed at writing data to the DA-L register (address 0241_{16}). Reading from the DA-H register (address 0240_{16}) means reading this transferred data. Accordingly, it is possible to confirm the data being output from the D-A output pin by reading the DA register.

(3) Operating of 8-bit PWM

The following explains PWM operation.

First, set the bit 0 of PWM mode register 1 (address $020A_{16}$) to “0” (at reset, bit 0 is already set to “0” automatically), so that the PWM count source is supplied.

PWM0–PWM3 are also used as pins $P0_4$–$P0_7$, PWM4–PWM6 are also used as pins $P0_0$–$P0_2$, respectively. Set the corresponding bits of the port P0 direction register to “1” (output mode). And select each output polarity by bit 3 of PWM mode register 1 (address $020A_{16}$). Then, set bits 7 to 0 of PWM mode register 2 to “1” (PWM output).

The PWM waveform is output from the PWM output pins by setting these registers.

Figure 23 shows the 8-bit PWM timing. One cycle (T) is composed of 256 (2^8) segments. The 8 kinds of pulses, relative to the weight of each bit (bits 0 to 7), are output inside the circuit during 1 cycle. Refer to Figure 20 (a). The 8-bit PWM outputs waveform which is the logical sum (OR) of pulses corresponding to the contents of bits 0 to 7 of the 8-bit PWM register. Several examples are shown in Figure 23 (b). 256 kinds of output (HIGH area: 0/256 to 255/256) are selected by changing the contents of the PWM register. A length of entirely HIGH cannot be output, i.e. 256/256.

(4) Operating of 14-bit PWM

As with 8-bit PWM, set the bit 0 of the PWM mode register 1 (address $020A_{16}$) to “0” (at reset, bit 0 is already set to “0” automatically), so that the PWM count source is supplied. Pin DA is also used as port $P0_3$. Select output mode by setting bit 3 of the port P0 direction register. Next, select the output polarity by bit 3 of the PWM mode register 1. Then, the 14-bit PWM outputs from the D-A output pin by setting bit 1 of the PWM mode register 1 to “0” (at reset, this bit already set to “0” automatically) to select the DA output.

The output example of the 14-bit PWM is shown in Figure 23.

The 14-bit PWM divides the data of the DA latch into the low-order 6 bits and the high-order 8 bits.

The fundamental waveform is determined with the high-order 8-bit data “D_H.” A “H” level area with a length $\tau \times D_H$(“H” level area of fundamental waveform) is output every short area of “t” = 256τ = 64 μs (τ is the minimum resolution bit width of 0.25 μs). The “H” level area increase interval (t_m) is determined with the low-order 6-bit data “D_L.” The “H” level are of smaller intervals “t_m” shown in Table 6 is longer by τ than that of other smaller intervals in PWM repeat period “T” = 64t. Thus, a rectangular waveform with the different “H” width is output from the D-A pin. Accordingly, the PWM output changes by τ unit pulse width by changing the contents of the DA-H and DA-L registers. A length of entirely “H” output cannot be output, i. e. 256/256.

(5) Output after Reset

At reset, the output of ports $P0_0$–$P0_2$ and $P0_4$–$P0_7$ is in the high-impedance state and the contents of the PWM register and the PWM circuit are undefined. Note that after reset, the PWM output is undefined until setting the PWM register.

Table 2. Relation Between Low-order 6-bit Data and High-level Area Increase Interval

Low-order 6 bits of Data	Area Longer by τ Than That of Other t_m (m = 0 to 63)
0 0 0 0 0 0 (LSB)	Nothing
0 0 0 0 0 1	m = 32
0 0 0 0 1 0	m = 16, 48
0 0 0 1 0 0	m = 8, 24, 40, 56
0 0 1 0 0 0	m = 4, 12, 20, 28, 36, 44, 52, 60
0 1 0 0 0 0	m = 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62
1 0 0 0 0 0	m = 1, 3, 5, 7, ... 57, 59, 61, 63

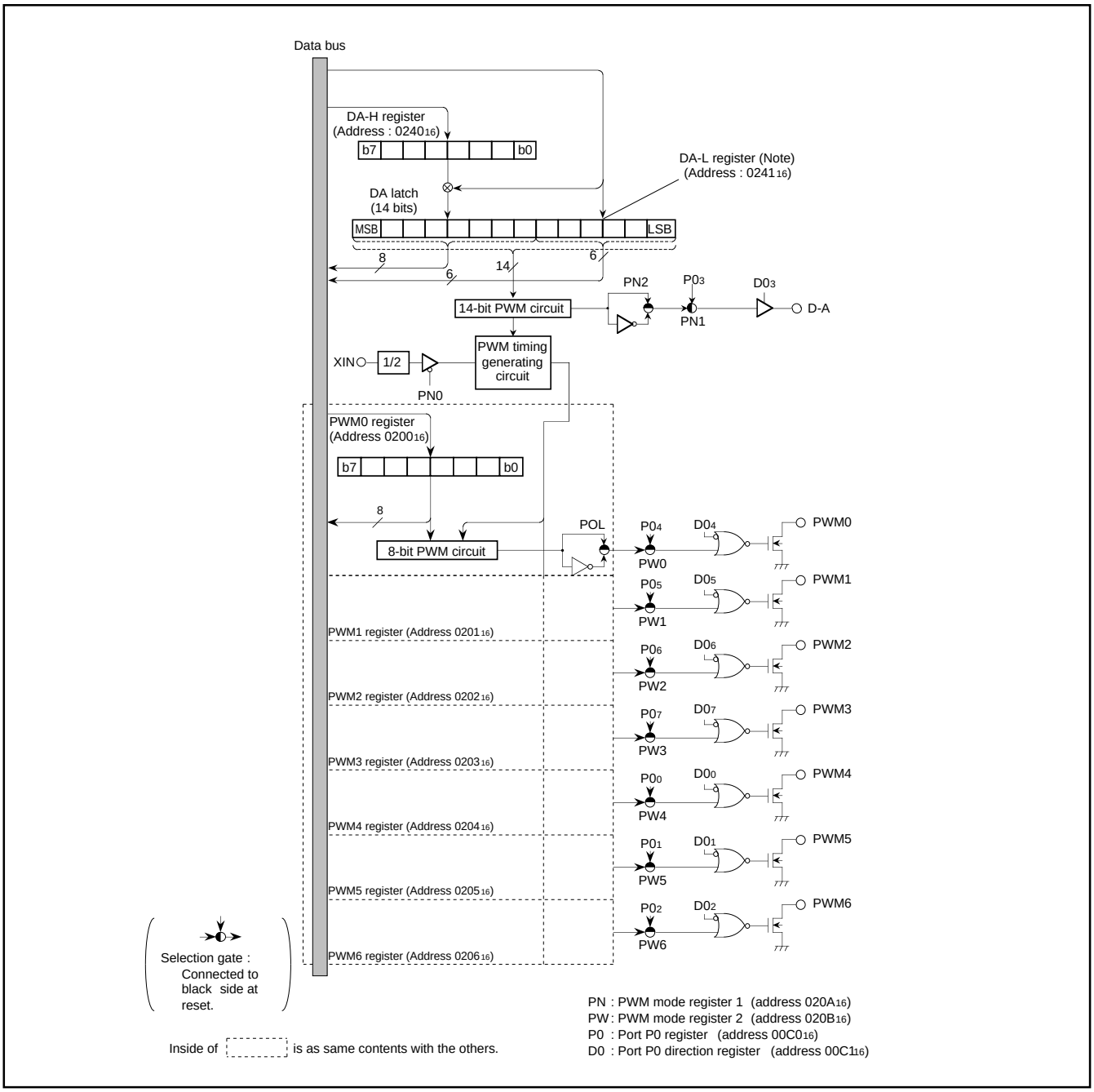


Fig. 22. PWM Block Diagram

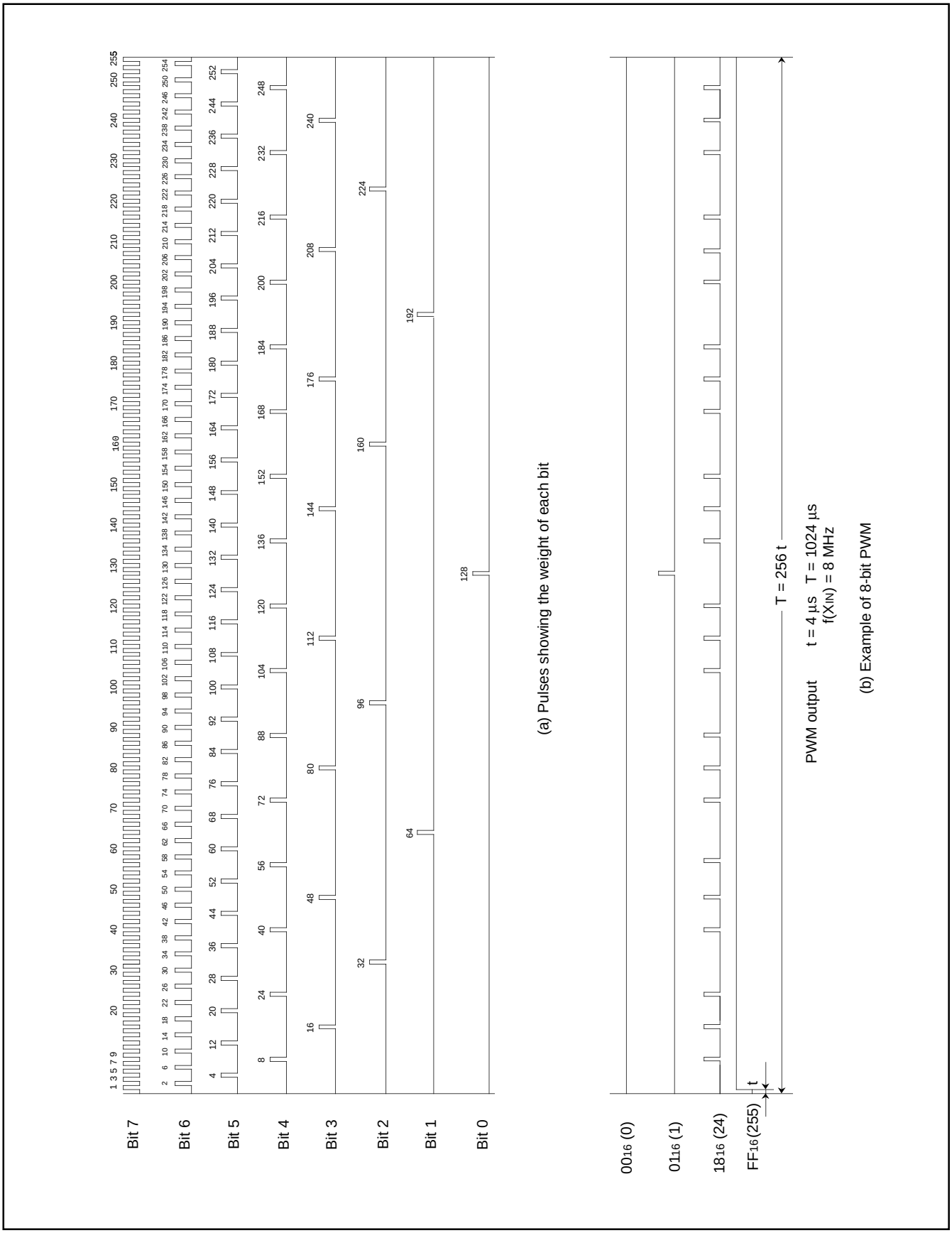


Fig. 23. 8-bit PWM Timing

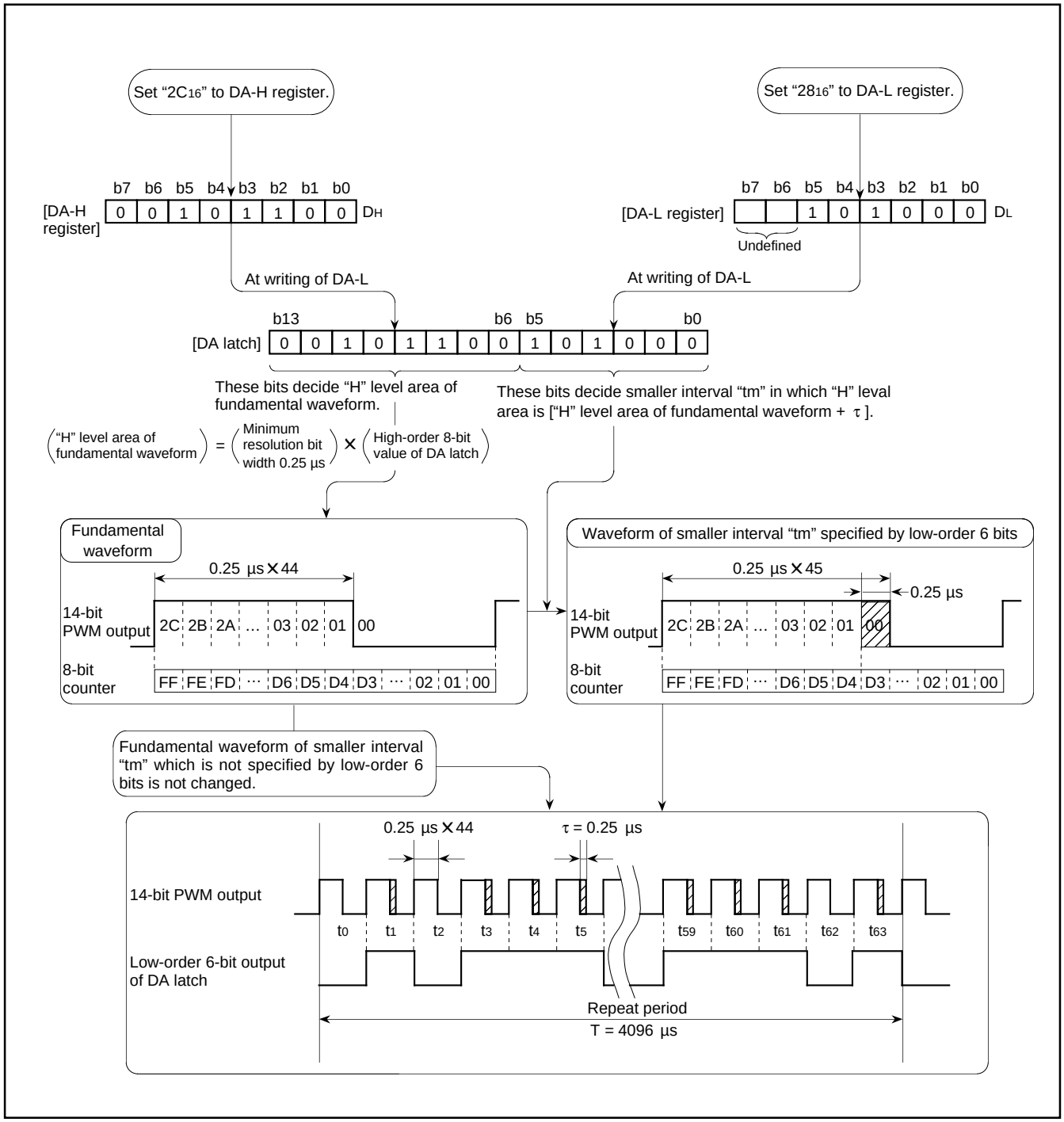
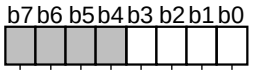


Fig. 24. 14-bit PWM Output Example (f(XIN) = 8MHz)

PWM Mode Register 1

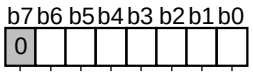


PWM mode register 1 (PN) [Address $020A_{16}$]

B	Name	Functions	After reset	R	W
0	PWM counts source selection bit (PN0)	0 : Count source supply 1 : Count source stop	0	R	W
1	DA/$P0_3$ output selection bit (PN1)	0 : $P0_3$ output 1 : DA output	0	R	W
2	DA output polarity selection bit (PN2)	0 : Positive polarity 1 : Negative polarity	0	R	W
3	PWM output polarity selection bit (PN3)	0 : Positive polarity 1 : Negative polarity	0	R	W
4 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		Indeterminate	R	—

Fig. 25. PWM Mode Register 1

PWM Mode Register 2



PWM mode register 2 (PW) [Address $020B_{16}$]

B	Name	Functions	After reset	R	W
0	$P0_4$/PWM0 output selection bit (PW0)	0 : $P0_4$ output 1 : PWM0 output	0	R	W
1	$P0_5$/PWM1 output selection bit (PW1)	0 : $P0_5$ output 1 : PWM1 output	0	R	W
2	$P0_6$/PWM2 output selection bit (PW2)	0 : $P0_6$ output 1 : PWM2 output	0	R	W
3	$P0_7$/PWM3 output selection bit (PW3)	0 : $P0_7$ output 1 : PWM3 output	0	R	W
4	$P0_0$/PWM4 output selection bit (PW4)	0 : $P0_0$ output 1 : PWM4 output	0	R	W
5	$P0_1$/PWM5 output selection bit (PW5)	0: $P0_1$ output 1: PWM5 output	0	R	W
6	$P0_2$/PWM6 output selection bit (PW6)	0: $P0_2$ output 1: PWM6 output	0	R	W
7	Fix this bit to “0.”		0	R	W

Fig. 26. PWM Mode Register 2

A-D CONVERTER

(1)A-D Conversion Register (AD)

A-D conversion reigister is a read-only register that stores the result of an A-D conversion. This register should not be read during A-D conversion.

(2)A-D Control Register (ADCON)

The A-D control register controls A-D conversion. Bits 1 and 0 of this register select analog input pins. When these pins are not used as anlog input pins, they are used as ordinary I/O pins. Bit 3 is the A-D conversion completion bit, A-D conversion is started by writing "0" to this bit. The value of this bit remains at "0" during an A-D conversion, then changes to "1" when the A-D conversion is completed.

Bit 4 controls connection between the resistor ladder and V_{CC}. When not using the A-D converter, the resistor ladder can be cut off from the internal V_{CC} by setting this bit to "0," accordingly providing low-power dissipation.

(3)Comparison Voltage Generator (Resistor Ladder)

The voltage generator divides the voltage between V_{SS} and V_{CC} by 256, and outputs the divided voltages to the comparator as the reference voltage V_{ref}.

(4)Channel Selector

The channel selector connects an analog input pin, selected by bits 1 and 0 of the A-D control register, to the comparator.

(5)Comparator and Control Circuit

The conversion result of the analog input voltage and the reference voltage "V_{ref}" is stored in the A-D conversion register. The A-D conversion completion bit and A-D conversion interrupt request bit are set to "1" at the completion of A-D conversion.

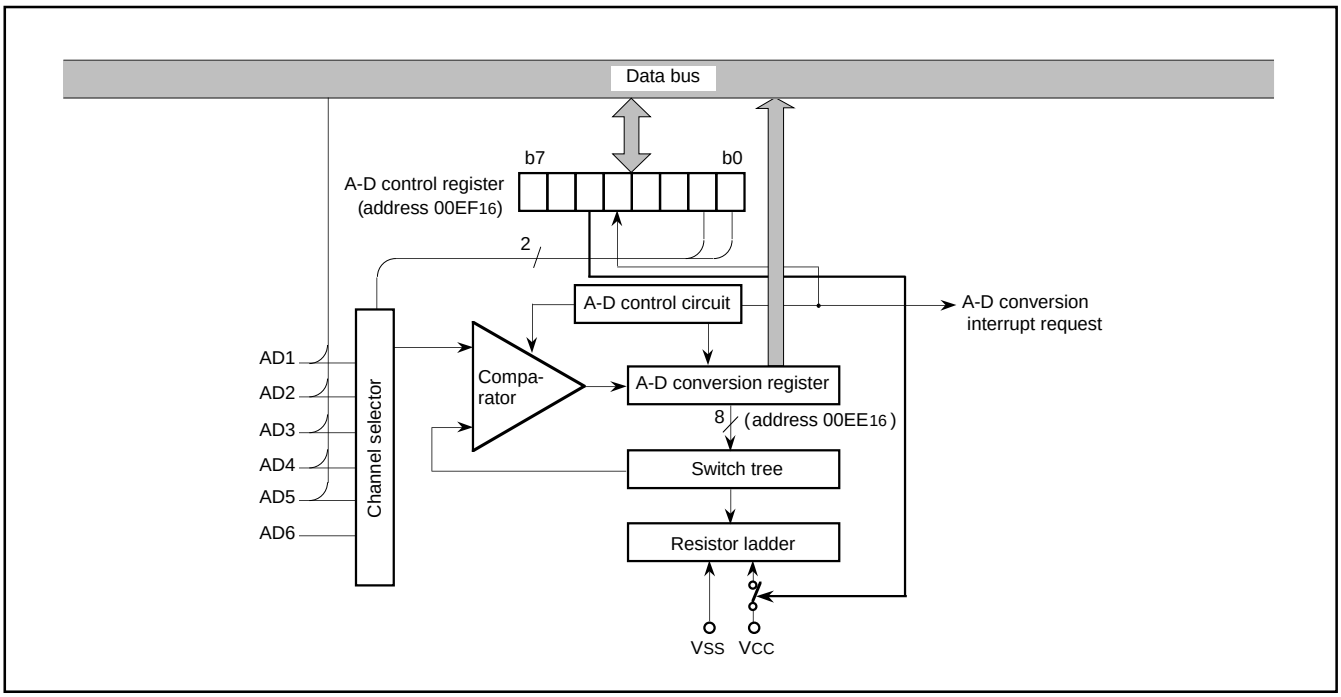
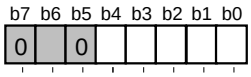


Fig. 27. A-D Comparator Block Diagram

A-D Control Register



A-D control register (ADCON) [Address 00EF16]

B	Name	Functions	After reset	R	W
0 to 2	Analog input pin selection bits (ADIN0 to ADIN2)	b2 b1 b0 0 0 0 : AD1 0 0 1 : AD2 0 1 0 : AD3 0 1 1 : AD4 1 0 0 : AD5 1 0 1 : AD6 1 1 0 : } Do not set. 1 1 1 : }	0	R	W
3	A-D conversion completion bit (ADSTR)	0: Conversion in progress 1: Convertion completed	Indeterminate	R	W
4	VCC connection selection bit (ADVREF)	0: OFF 1: ON	Indeterminate	R	W
6	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is indeterminate.		Indeterminate	R	—
5, 7	Fix these bits to “0.”		0	R	—

Fig. 28. A-D Control Register

(6) Conversion Method

①Set bit 7 of the interrupt input polarity register (address 0212_{16}) to "1" to generate an interrupt request at completion of A-D conversion.
②Set the A-D conversion • INT3 interrupt request bit to "0" (even when A-D conversion is started, the A-D conversion • INT3 interrupt reguest bit is not set to "0" automatically).
③When using A-D conversion interrupt, enable interrupts by setting A-D conversion • INT3 interrupt request bit to "1" and setting the interrupt disable flag to "0."
④Set the V_{CC} connection selection bit to "1" to connect V_{CC} to the resistor ladder.
⑤Select analog input pins by the analog input selection bit of the A-D control register.
⑥Set the A-D conversion completion bit to "0." This write operation starts the A-D conversion. Do not read the A-D conversion register during the A-D conversion.
⑦Verify the completion of the conversion by the state ("1") of the A-D conversion completion bit, the state ("1") of A-D conversion • INT3 interrupt reguest bit, or the occurrence of an A-D conversion interrupt.
⑧Read the A-D conversion register to obtain the conversion results.

Note : When the ladder resistor is disconnect from V_{CC}, set the V_{CC} connection selection bit to "0" between steps ⑦and ⑧.

(7) Internal Operation

When the A-D conversion starts, the following operations are automatically performed.
①The A-D conversion register is set to "00_{16}."
②The most significant bit of the A-D conversion register becomes "1, " and the comparison voltage "V_{ref}" is input to the comparator. At this point, V_{ref} is compared with the analog input voltage "V_{IN} ."
③Bit 7 is determined by the comparison results as follows.
When $V_{ref} < V_{IN}$: bit 7 holds "1"
When $V_{ref} > V_{IN}$: bit 7 becomes "0"
With the above operations, the analog value is converted into a digital value. The A-D conversion terminates in a maximum of 50 machine cycles (12.5 µs at $f(X_{IN})$ = 8 MHz) after it starts, and the conversion result is stored in the A-D conversion register.
An A-D conversion interrupt request occurs at the same time as A-D conversion completion, the A-D conversion • INT3 interrupt request bit becomes "1." The A-D conversion completion bit also becomes "1."

Table 3. Expression for V_{ref} and V_{REF}

A-D conversion register contents "n" (decimal notation)	V_{ref} (V)
0	0
1 to 255	$\frac{V_{REF}}{256} \times (n - 0.5)$

Note: V_{REF} indicates the voltage of internal V_{CC}.

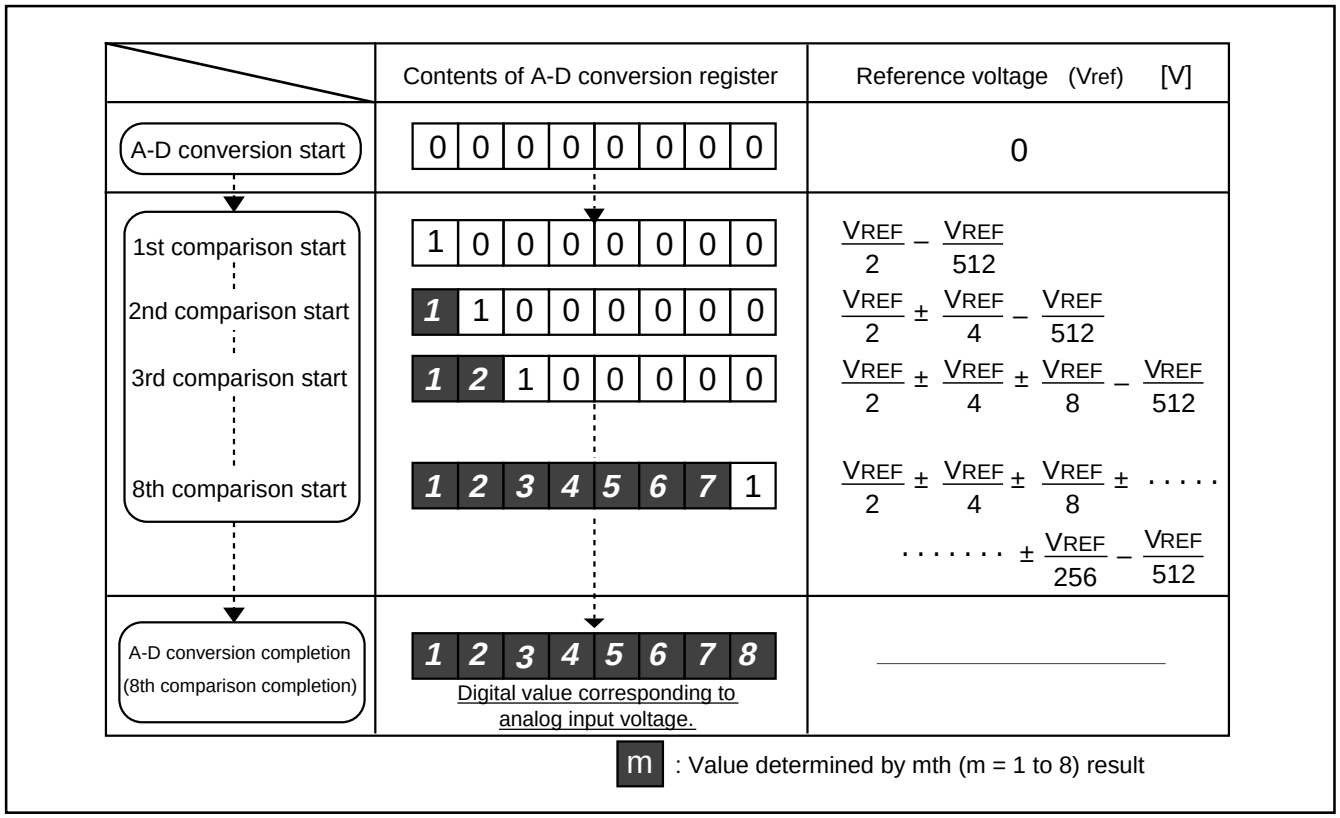


Fig. 29. Changes in A-D Conversion Register and Comparison Voltage during A-D Conversion

(8) Definition of A-D Conversion Accuracy

The definition of A-D conversion accuracy is described below.

① Relative accuracy

• **Zero transition error (V_{0T})**

The deviation of the input voltage at which A-D conversion output data changes from "0" to "1," from the corresponding ideal A-D conversion characteristics between 0 and V_{REF}.

$$V_{0T} = \frac{(V_0 - 1/2 \times V_{REF}/256)}{1LSB} \quad [LSB]$$

• **Full-scale transition error (V_{FST})**

The deviation of the input voltage at which A-D conversion output data changes from "255" to "254," from the corresponding ideal A-D conversion characteristics between 0 and V_{REF}.

$$V_{FST} = \frac{(V_{REF} - 3/2 \times V_{REF}/256) - V_{254}}{1LSB} \quad [LSB]$$

• **Non-linearity error**

The deviation of the actual A-D conversion characteristics, from the ideal A-D conversion characteristics between V_0 and V_{254}.

$$\text{Non-linearity error} = \frac{V_n - (1LSB \times n + V_0)}{1LSB} \quad [LSB]$$

• **Differential non-linearity error**

The deviation of the input voltage required to change output data by "1," from the corresponding ideal A-D conversion characteristics between 0 and V_{REF}.

$$\text{Differential non-linearity error} = \frac{(V_{n+1} - V_n) - 1LSB}{1LSB} [LSB]$$

②Absolute accuracy

• **Absolute accuracy error**

The deviation of the actual A-D conversion characteristics, from the ideal A-D conversion characteristics between 0 and V_{REF}.

$$\text{Absolute accuracy error} = \frac{V_n - 1LSB_A \times (n + 1/2)}{1LSB_A} \quad [LSB]$$

Note: The analog input voltage "Vn" at which A-D conversion output data changes from "n" to "n + 1" (n ; 0 to 254) is as follows (refer to Figure 30) :

$$1LSB \text{ with respect to relative accuracy} = \frac{V_{254} - V_0}{254} \quad [V]$$

$$1LSB_A \text{ with respect to absolute accuracy} = \frac{V_{REF}}{256} \quad [V]$$

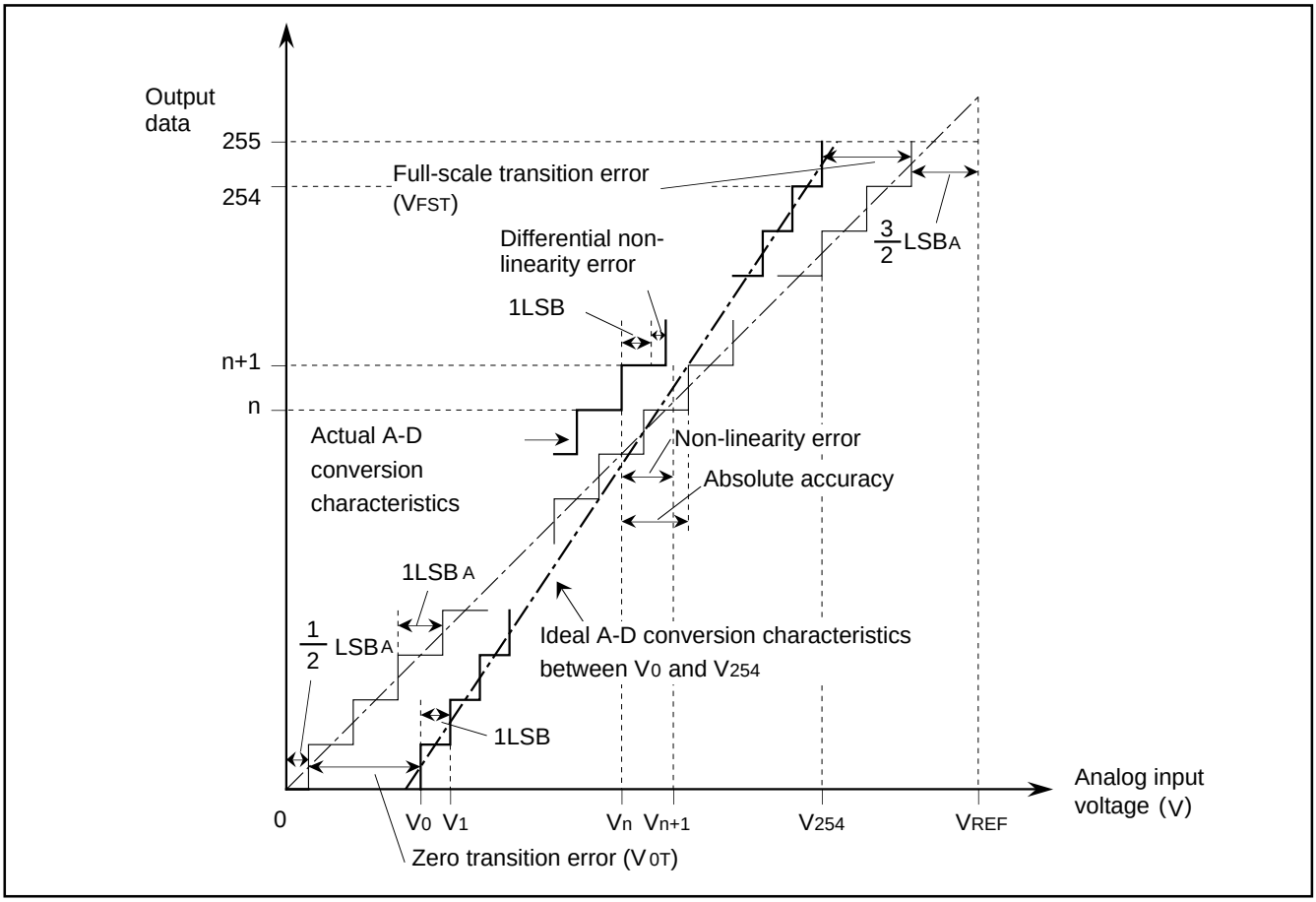
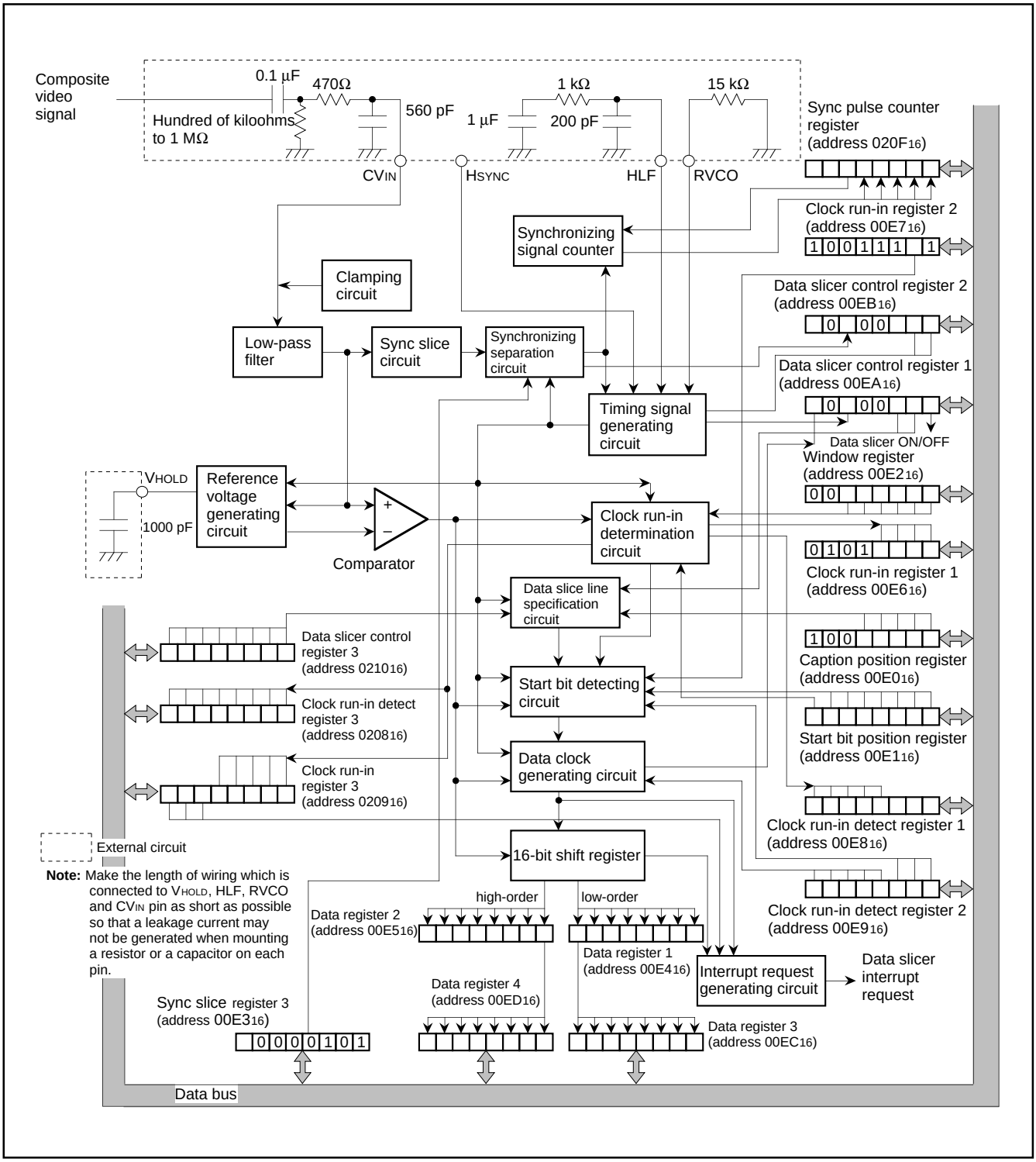


Fig. 30. Definition of A-D Conversion Accuracy

DATA SLICER

The M37274EFSP includes the data slicer function for the closed caption decoder (referred to as the CCD). This function takes out the caption data superimposed in the vertical blanking interval of a composite video signal. A composite video signal which makes the sync chip's polarity negative is input to the CV_{IN} pin.

When the data slicer function is not used, the data slicer circuit can be cut off by setting bit 0 of data slicer control register 1 (address $00EA_{16}$) to "0." Also, the timing signal generating circuit can be cut off by setting bit 0 of data slicer control register 2 (address $00EB_{16}$) to "0." These settings can realize the low-power dissipation.



Note: Make the length of wiring which is connected to V_{HOLD}, HLF, RVCO and CV_{IN} pin as short as possible so that a leakage current may not be generated when mounting a resistor or a capacitor on each pin.

Fig. 31. Data Slicer Block Diagram

Figures 32 to 34 show the data slicer control registers.

Data Slicer Control Register 1

b7 b6 b5 b4 b3 b2 b1 b0

	0		0	0			

Data slicer control register 1(DSC1) [Address $00EA_{16}$]

B	Bit	Functions	After reset	R	W
0	Data slicer control bit (DSC10)	0: Data slicer stopped 1: Data slicer operating	0	R	W
1, 2	Field to be sliced data selection bit (DSC11, DSC12)	b2 b1 — Field of main data slice line — Field for setting refernce voltage 0 0 — F2 — F2 0 1 — F1 — F1 1 0 — F1 and F2 — F2 1 1 — F1 and F2 — F1	0	R	W
3, 4, 6	Fix these bits to "0."		0	R	W
5	Field determination flag (DSC15)	0 : Hsep, Vsep 1 : Hsep, Vsep	Indeterminate	R	—
7	Data latch completion flag for caption data in main data slice line (DSC17)	0: Data is not yet latched 1: Data is latched	Indeterminate	R	W

Definition of fields 1 (F1) and 2 (F2)

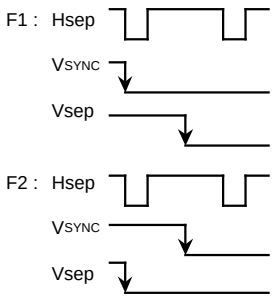


Fig. 32. Data Slicer Control Register 1

Data slicer Control Register 2

b7	b6	b5	b4	b3	b2	b1	b0
	0		0	0			

Data slicer Control register 2 (DSC2) [Address 00EB16]

B	Name	Functions	After reset	R	W
0	Timing signal generating circuit control bit (DSC20)	0: Stopped 1: Operating	0	R	W
1	Reference clock source selection bit (DSC21)	0: Video signal 1: HSYNC signal	0	R	W
2, 7	Test bit	Read-only	Indeterminate	R	—
3, 4, 6	Fix these bits to "0."		0	R	W
5	V-pulse shape determination flag (DSC25)	0: Match 1: Mis match	Indeterminate	R	—

Fig. 33. Data Slicer Control Register 2

Data Slicer Control Register 3

b7	b6	b5	b4	b3	b2	b1	b0

Data slicer control register 3 (DSC3) [Address 021016]

B	Bit	Functions	After reset	R	W
0	Line selection bit for slice voltage (DSC30)	0: Main data slice line 1: Sub-data slice line	0	R	W
1, 2	Field to be sliced data selection bit (DSC31, DSC32)	b2 b1: Field of sub-data slice line / Field for setting refernce voltage 0 0: F2 / F2 0 1: F1 / F1 1 0: F1 and F2 / F2 1 1: F1 and F2 / F1	0	R	W
3 to 7	Setting bit of sub-data slice line (DSC33 to DSC37)		0	R	W

Definition of fields 1 (F1) and 2 (F2)

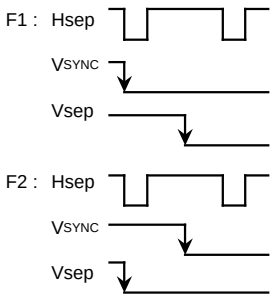


Fig. 34. Data Slicer Control Register 3

(1) Clamping Circuit and Low-pass Filter

This filter attenuates the noise of the composite video signal input from the CV_{IN} pin. The CV_{IN} pin to which composite video signal is input requires a capacitor (0.1 μF) coupling outside. Pull down the CV_{IN} pin with a resistor of hundreds of kiloohms to 1 M . In addition, we recommend to install externally a simple low-pass filter using a resistor and a capacitor at the CV_{IN} pin (refer to Figure 25).

(2) Sync Slice Circuit

This circuit takes out a composite sync signal from the output signal of the low-pass filter. Figure 25 shows the structure of the sync slice register.

Sync Slice Register

	b7	b6	b5	b4	b3	b2	b1	b0
		0	0	0	0	1	0	1

Sync slice register (SSL) [Address $00E3_{16}$]

B	Name	Functions	After reset	R	W
0, 2	Fix these bits to “1.”		0	R	W
1, 3 to 6	Fix these bits to “0.”		0	R	W
7	Vertical synchronous signal (V_{sep}) generating method selection bit (SSL7)	0: Method 1 1: Method 2	0	R	W

Fig. 35. Sync Slice Register

(3) Synchronous Signal Separation Circuit

This circuit separates a horizontal synchronous signal and a vertical synchronous signal from the composite sync signal taken out in the sync slice circuit.

①Horizontal synchronous signal (H_{sep})

A one-shot horizontal synchronous signal Hsep is generated at the falling edge of the composite sync signal.

②Vertical synchronous signal (V_{sep})

As a V_{sep} signal generating method, it is possible to select one of the following 2 methods by using bit 7 of the sync slice register (address $00E3_{16}$).

- •Method 1 The "L" level width of the composite sync signal is measured. If this width exceeds a certain time, a V_{sep} signal is generated in synchronization with the rising of the timing signal immediately after this "L" level.
- •Method 2 The "L" level width of the composite sync signal is measured. If this width exceeds a certain time, it is detected whether a falling of the composite sync signal exits or not in the "L" level period of the timing signal immediately after this "L" level. If a falling exists, a V_{sep} signal is generated in synchronization with the rising of the timing signal (refer to Figure 36).

Figure 36 shows a V_{sep} generating timing. The timing signal shown in the figure is generated from the reference clock which the timing generating circuit outputs.

Reading bit 5 of data slicer control register 2 permits determinating the shape of the V-pulse portion of the composite sync signal. As shown in Figure 38, when the A level matches the B level, this bit is "0." In the case of a mismatch, the bit is "1."

For the pins RVCO and the HLF, connect a resistor and a capacitor as shown in Figure 31. Make the length of wiring which is connected to these pins as short as possible so that a leakage current may not be generated.

Note: It takes a few tens of milliseconds until the reference clock becomes stable after the data slicer and the timing signal generating circuit are started. In this period, various timing signals, H_{sep} signals and V_{sep} signals become unstable. For this reason, take stabilization time into consideration when programming.

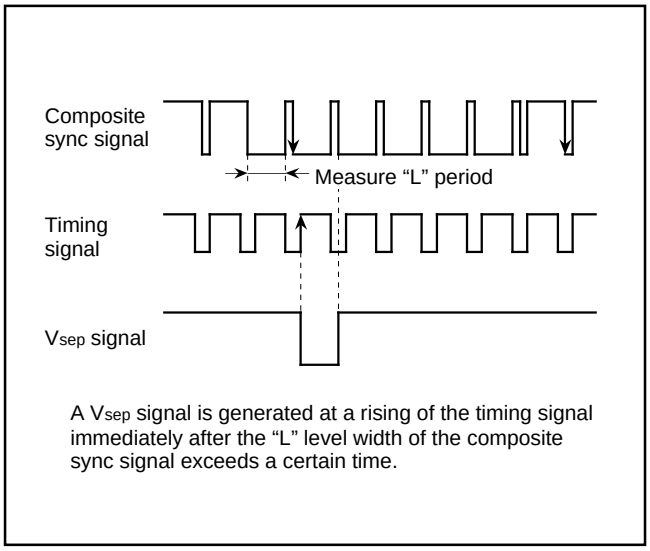


Fig. 36. Vsep Generating Timing (method 2)

(4) Timing Signal Generating Circuit

This circuit generates a reference clock which is 832 times as large as the horizontal synchronous signal frequency. It also generates various timing signals on the basis of the reference clock, horizontal synchronous signal and vertical synchronizing signal. The circuit operates by setting bit 0 of data slicer control register 2 (address $00EB_{16}$) to "1."

The reference clock can be used as a display clock for OSD function in addition to the data slicer. The HSYNC signal can be used as a count source instead of the composite sync signal. However, when the HSYNC signal is selected, the data slicer cannot be used. A count source of the reference clock can be selected by bit 1 of data slicer control register 2 (address $00EB_{16}$).

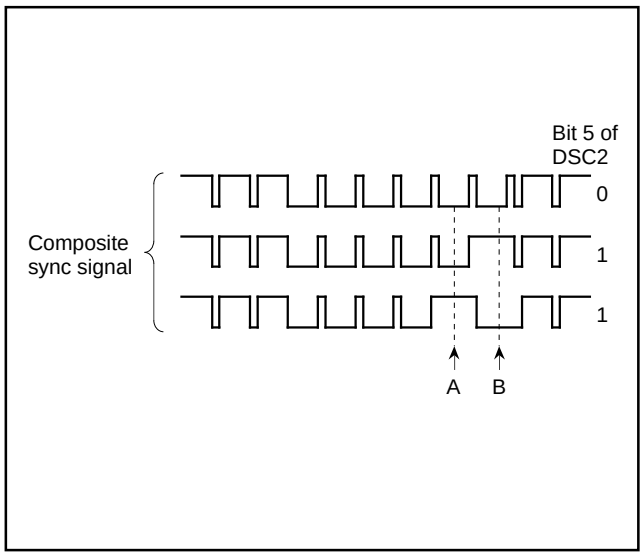


Fig. 37. Determination of V-pulse Waveform

(5) Data Slice Line Specification Circuit

①Specification of data slice line

M37274MA-XXXSP has 2 data slice line specification circuits for slicing arbitrary 2 H_{sep} in 1 field. The following 2 data slice lines are specified .

<Main data slice line>

This line is specified by the caption position register (address $00E0_{16}$).

<Sub-data slice line>

This line is specified by the data slicer control register 3 (address $00EB_{16}$).

The counter is reset at the falling edge of V_{sep} and is incremented by 1 every H_{sep} pulse. When the counter value matched the value specified by bits 4 to 0 of the caption position register (in case of the sub-data slice line, by bits 3 to 7 of the data slicer control register 3), this H_{sep} is sliced.

The values of "00_{16}" to "$1F_{16}$" can be set in the caption position register. Bit 7 to bit 5 are used for testing. Set "100_2." Figure 38 shows the signals in the vertical blanking interval. Figure 39 shows the structure of the caption position register.

②Selection of field to be sliced data

In the case of the main data slice line, the field to be sliced data is selected by bits 2 and 1 of the data slicer control register 1 (address $00EA_{16}$). In the case of the sub-data slice line, the field is selected by bits 2 and 1 of the data slicer control register 3. When bit 2 of the data slicer control register 1 is set to "1," it is possible to slice data of both fields (refer to Figures 32 to 34).

③Specification of line to set slice voltage

The reference voltage for slicing (slice voltage) is generated by integrating the amplitude of the clock run-in pulse in the particular line (refer to Table 4).

④Field determination

The field determination flag can be read out by bit 5 of the data slicer control register 1. This flag charge at the falling edge of V_{sep}.

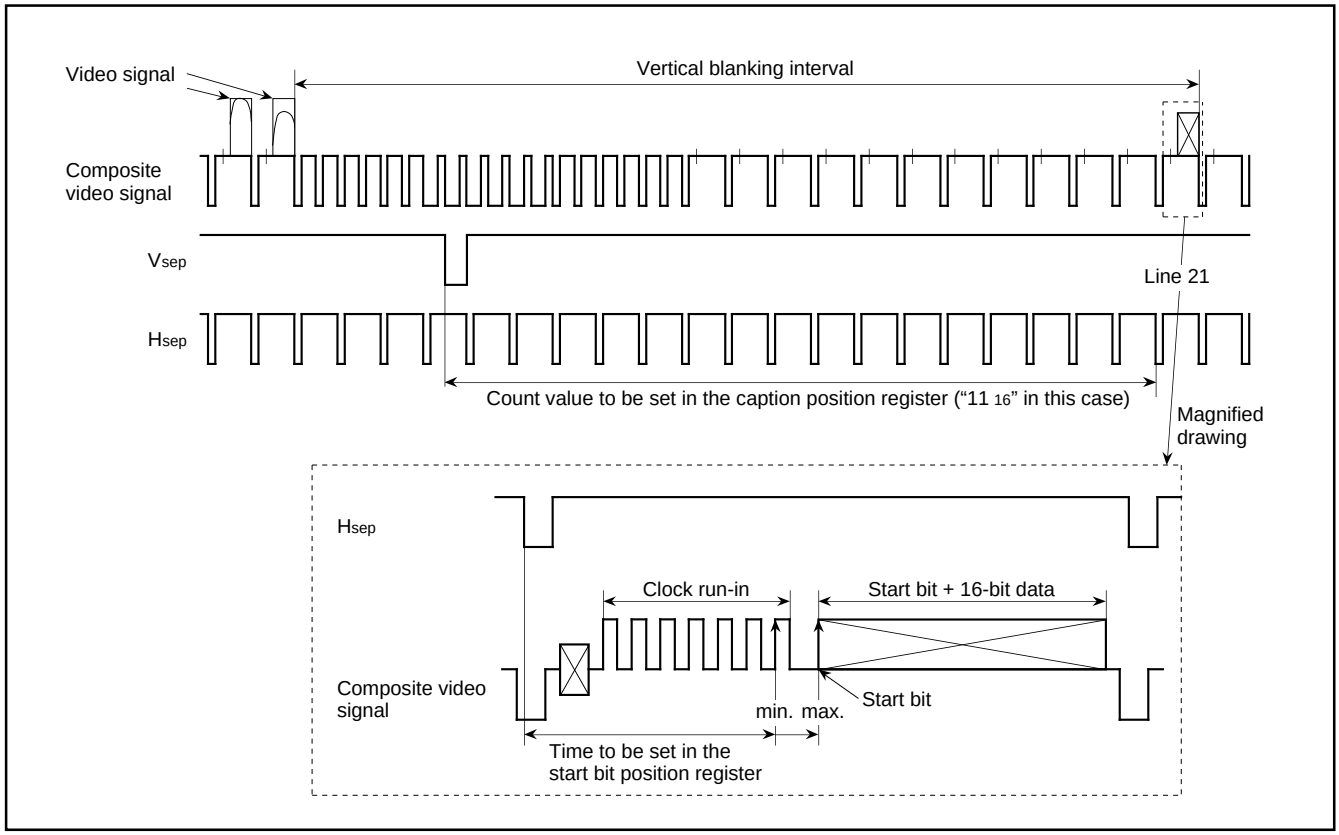


Fig. 38. Signals in Vertical Blanking Interval

Table 4. Specifying of Field Whose Sets Reference Voltage

Bit 0 of DSC3	Field	Line
0	Field specified by bit 1 of DSC1 0: F2 1: F1	Line specified by bits 4 to 0 of CP (Main data slice line)
1	Field specified by bit 1 of DSC3 0: F2 1: F1	Line specified by bits 7 to 3 of DSC3 (Sub-data slice line)

DSC1 : Data slice control register 1
DSC3 : Data slice control register 3
CP : Caption position register

(6) Reference Voltage Generating Circuit and Comparator

The composite video signal clamped by the clamping circuit is input to the reference voltage generating circuit and the comparator.

① Reference voltage generating circuit

This circuit generates a reference voltage (slice voltage) by using the amplitude of the clock run-in pulse in line specified by the data slice line specification circuit. Connect a capacitor between the V_{HOLD} pin and the V_{SS} pin, and make the length of wiring as short as possible so that a leakage current may not be generated.

② Comparator

The comparator compares the voltage of the composite video signal with the voltage (reference voltage) generated in the reference voltage generating circuit, and converts the composite video signal into a digital value.

Caption Position Register

b7	b6	b5	b4	b3	b2	b1	b0
1	0	0					

Caption Position Register (CP) [Address $00E0_{16}$]

B	Name	Functions	After reset	R	W
0 to 4	Specification main data slice line (CP0 to CP4)		0	R	W
5, 6	Fix these bits to “0.”		0	R	W
7	Fix this bit to “0.”		0	R	W

Fig. 39. Caption Position Register

(7) Start Bit Detecting Circuit

This circuit detects a start bit at line decided in the data slice line specification circuit. For start bit detection, it is possible to select one of the following two types by using bit 1 of clock run-in register 2 (address $00E7_{16}$).

①After the lapse of the time corresponding to the set value of the start bit position register (address $00E1_{16}$), the first rising of the composite video signal is detected as a start bit.

The time is set in bits 0 to 6 of the start bit position register (address $00E1_{16}$) (refer to Figure 40). Set a value fit for the following conditions.

Figure 40 shows the structure of the start bit position register.

[Time from the falling of the horizontal synchronizing signal to the last rising of the clock run-in] < [4 × set value of the start bit position register × reference clock period] < [Time from the faling of the horizontal synchronous signal to occurrence of the start bit]

Start Bit Position Register

b7 b6 b5 b4 b3 b2 b1 b0

Start bit position register (SP) [Address $00E1_{16}$]

B	Name	Functions	After reset	R	W
0 to 6	Start bit generating time (SP0 to SP6)	Time from a falling of the horizontal synchronous signal to occurrence of a start bit = 4 × set value ("00_{16}" to "$7F_{16}$") × reference clock period	0	R	W
7	DSC1 bit 7 control bit (SP7)	0 : Generation of 16 pulses 1 : Generation of 16 pulses and detection of clock run-in pulse (4 to 6 pulses)	0	R	W

Fig. 40. Start Bit Position Register

②After a falling of the clock run-in pulse set in bits 2 to 0 of clock run-in detect register 2 (address 00E9$_{16}$) is detected, a start bit is detected by sampling a comparator output. A sampling clock for sampling is obtained by dividing the reference clock generated in the timing signal generating circuit by 13.

Figure 42 shows the structure of clock run-in detect register 2. The contents of bits 2 to 0 of clock run-in detect register 2 and bit 1 of clock run-in register 2 are written at a falling of the horizontal synchronous signal. For this reason, even if an instruction for setting is executed, the contents of the register cannot be rewritten until a falling of the horizontal synchronous signal.

Clock Run-in Register 2

b7	b6	b5	b4	b3	b2	b1	b0
1	0	0	1	1	1		1

Clock run-in register 2 (CR2) [Address 00E7$_{16}$]

B	Name	Functions	After reset	R	W
0, 2 to 4, 7	Fix these bits to "1."		0	R	W
1	Start bit detecting method selection bit (CR21)	0: Method 1 1: Method 2	0	R	W
5, 6	Fix these bits to "0."		0	R	W

Fig. 41. Clock Run-in Register 2

Clock Run-in Detect Register 2

b7	b6	b5	b4	b3	b2	b1	b0

Clock run-in detect register 2 (CRD2) [Address 00E9$_{16}$]

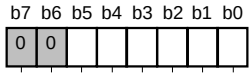
B	Name	Functions	After reset	R	W
0 to 2	Clock run-in pulses for sampling (CRD20 to CRD22)	b2 b1 b0 0 0 0 : Not available 0 0 1 : 1st pulse 0 1 0 : 2nd pulse 0 1 1 : 3rd pulse 1 0 0 : 4th pulse 1 0 1 : 5th pulse 1 1 0 : 6th pulse 1 1 1 : 7th pulse	0	R	W
3 to 7	Data clock generating time (CRD23 to CRD27)	Time from detection of a start bit to occurrence of a data clock = (13 + set value) × reference clock period	0	R	W

Fig. 42. Clock Run-in Detect Register 2

(8) Clock run-in determination circuit

This circuit sets a window in the clock run-in portion in the composite video signal, and then determinates clock run-in by counting the number of pulses in this window. Set the time from a falling of the horizontal synchronizing signal to a start of the window by bits 0 to 5 of the window register (address $00E2_{16}$; refer to Figure 43). The window ends according to the contents of the setting of the start bit position register (refer to Figure 40).

Window Register



Window register (WN) [Address $00E2_{16}$]

B	Name	Functions	After reset	R	W
0 to 5	Window start time (WN0 to WN5)	Time from a falling of the horizontal synchronous signal to start of the window = 4 × set value ("00_{16}" to "$3F_{16}$") × reference clock period	0	R	W
6, 7	Fix these bits to "0."		0	R	W

Fig. 43. Window Register

For the main data slice line, the count value of pulses in the window is stored in clock run-in register 1 (address $00E6_{16}$; refer to Figure 44). For the sub-data slice line, the count value of pulses in the window is stored in clock run-in register (address 0209_{16}; refer to Figure 45). When this count value is 4 to 6, it is determined as a clock run-in. Accordingly, set the count value so that the window may start after the first pulse of the clock run-in (refer to Figure 46).
The contents to be set in the window register are written at a falling of the horizontal synchronous signal. For this reason, even if an instruction for setting is executed, the contents of the register cannot be rewritten until a falling of the horizontal synchronous signal.

For the main data slice line, reference clock is counted in the period from a falling of the clock pulse set in bits 0 to 2 of clock run-in detect register 2 (address $00E9_{16}$) to the next falling. The count value is stored in bits 3 to 7 of clock run-in detect register 1 (address $00E8_{16}$) (When the count value exceeds "$1F_{16}$," "$1F_{16}$" is held). For the sub-data slice line, the count value is stored in bits 3 to 7 of clock run-in detect register 3 (address 0208_{16}). Read out these bits after the occurence of a data slicer interrupt (refer to (11) Interrupt Request Generating Circuit).
Figure 48 shows the structure of clock run-in detect registers 1 and 3.

Clock Run-in Register 1

b7	b6	b5	b4	b3	b2	b1	b0
0	1	0	1				

Clock run-in register 1 (CR1) [Address $00E6_{16}$]

B	Name	Functions	After reset	R	W
0 to 3	Clock run-in count value of main-data slice line (CR10 to CR13)		0	R	W
4, 6	Fix these bits to "1."		0	R	W
5, 7	Fix these bits to "0."		0	R	W

Fig. 44. Clock Run-in Register 1

Clock Run-in Register 3

b7 b6 b5 b4 b3 b2 b1 b0

Clock run-in register 3 (CR3) [Address 0209_{16}]

B	Name	Functions	After reset	R	W
0 to 3	Clock run-in count value of sub-data slice line (CR30 to CR33)		0	R	W
4	Data latch completion flag for caption data in sub-data slice line (CR34)	0: Data is not latched yet 1: Data is latched	Indeterminate	R	W
5	Data slice line selection bit for interrupt request (CR35)	0: Main data slice line 1: Sub- data slice line	Indeterminate	R	W
6	Interrupt mode selection bit (CR36)	0: Interrupt occurs at end of data slice line 1: Interrupt occurs at completion of caption data latch	Indeterminate	R	W
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is "0."		Indeterminate	R	—

Fig. 45. Clock Run-in Register 3

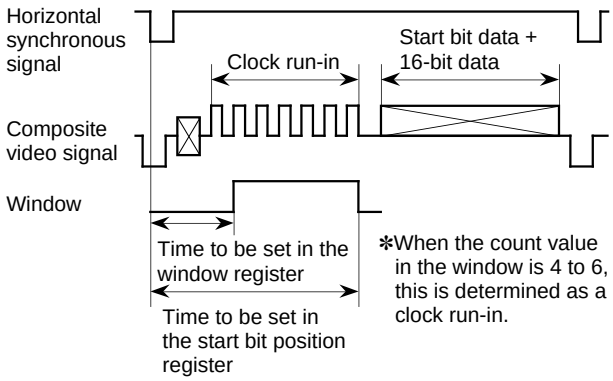


Fig. 46. Window Setting

Clock Run-in Detect Register i

b7 b6 b5 b4 b3 b2 b1 b0

Clock run-in detect register i (CRDi) (i=1, 3) [Addresses $00E8_{16}$, 0208_{16}]

B	Name	Functions	After reset	R	W
0 to 2	Test bits	Read-only	0	R	W
3 to 7	Clock run-in detection bits (CRDi3 to CRDi7)	Number of reference clock s to be counted one clock run-in pulse period	0	R	—

Fig. 47. Clock Run-in Detect Registers 1 and 3

(9) Data clock generating circuit

This circuit generates a data clock synchronized with the start bit detected in the start bit detecting circuit.
Set the time from detection of the start bit to occurrence of the data clock in bits 3 to 7 of clock run-in detect register 2 (address $00E9_{16}$). The time to be set is represented by the following expression:

Time = (13 + set value) × reference clock period

For a data clock, 16 pulses are generated. When just 16 pulses have been generated, bit 7 of the data slicer control register is set to "1" (refer to Figure 32 to 34). When method 1 is already selected as a start bit detecting method, this bit becomes a logical product (AND) value with a clock run-in determination result by setting bit 7 of the start bit position register to "1."
When method 2 is already selected as a start bit detecting method and 16 pulses are generated of a data clock regardless of bit 7 of the start bit position register, this bit is set to "1." The contents of this bit are reset at a falling of the vertical synchronizing signal (V_{sep}).

Table 5. Setting Conditions for Caption Data Latch Completion Flag

Bit 7 of SP	Conditions for Setting Bit 7 of DSC1 to "1"	Conditions for Setting Bit 4 of DSC3 to "1"
0	Data clock of 16 pulses has occured in main data slaice line	Data clock of 16 pulses has occured in sub-data slaice line
1	Data clock of 16 pulses has occured in main data slaice line AND Clock run-in pulse are detected 4 to 6 times	Data clock of 16 pulses has occured in sub-data slaice line AND Clock run-in pulse are detected 4 to 6 times

(10) 16-bit Shift Register

The caption data converted into a digital value by the comparator is stored into the 16-bit shift register in synchronization with the data clock. For the main data slice line, the contents of the high-order 8 bits of the stored caption data and the contents of the low-order 8 bits of the same data can be obtained by reading out data register 2 (address $00E5_{16}$) and data register 1 (address $00E4_{16}$), respectively. For the sub-data slice line, the contents of the high-order 8 bits and the contents of the low-order 8 bits can be obtained by reading out the data register 4 (address $00ED_{16}$) and data register 3 (address $00EC_{16}$), respectively. These registers are reset to "0" at a falling of V_{sep}. Read out data registers 1 and 2 after the occurence of a data slicer interrupt (refer to (11) Interrupt Request Generating Circuit).

(11) Interrupt Request Generating Circuit

The interrupt requests as shown in Table 6 are generated by combination of the following bits; bits 5 and 6 of the clock run-in register 3 (address 0209_{16}), bit 1 of the clock run-in register 2 (address $00E7_{16}$). Read out the contents of data registers 1 to 4 and the contents of bits 3 to 7 of clock run-in detect registers 1 and 3 after the occurence of a data slicer interrupt request.

Table 6. Occurence Sources of Interrupt Request

CR3		CR2	Occurence Souces of Interrupt Request	
b5	b6	b1	Slice line	Sources
0	0	0	Main data slice line	At end of data slice line
		1		
	1	0		Data clock of 16 pulses has occured AND Clock run-in pulse are detected 4 to 6 times
		1		Data clock of 16 pulses has occured
1	0	0	Sub-data slice line	At end of data slice line
		1		
	1	0		Data clock of 16 pulses has occured AND Clock run-in pulse are detected 4 to 6 times
		1		Data clock of 16 pulses has occured

(12) Synchronous Signal Counter

The synchronous signal counter counts the composite sync signal taken out from a video signal in the data slicer circuit or the vertical synchronous signal V_{sep} as a count source.

The count value in a certain time (T time) generated by $f(X_{IN})/2^{13}$ or $f(X_{IN})/2^{13}$ is stored into the 5-bit latch. Accordingly, the latch value changes in the cycle of T time. When the count value exceeds "$1F_{16}$," "$1F_{16}$" is stored into the latch.

The latch value can be obtained by reading out the sync pulse counter register (address $020F_{16}$). A count source is selected by bit 5 of the sync pulse counter register.

The synchronous signal counter is used when bit 0 of PWM mode register 1 (address $02EA_{16}$).

Figure 48 shows the structure of the sync pulse counter and Figure 49 shows the synchronous signal counter block diagram.

Sync Pulse Counter Register

b7 b6 b5 b4 b3 b2 b1 b0

Sync pulse counter register (SYC) [Address $020F_{16}$]

B	Name	Functions	After reset	R	W
0 to 4	Count value (SYC0 to SYC4)		0	R	—
5	Count source (SYC5)	0: H_{SYNC} signal 1: Composite sync signal	0	R	W
6, 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are "0."		0	R	—

Fig. 48. Sync Pulse Counter Register

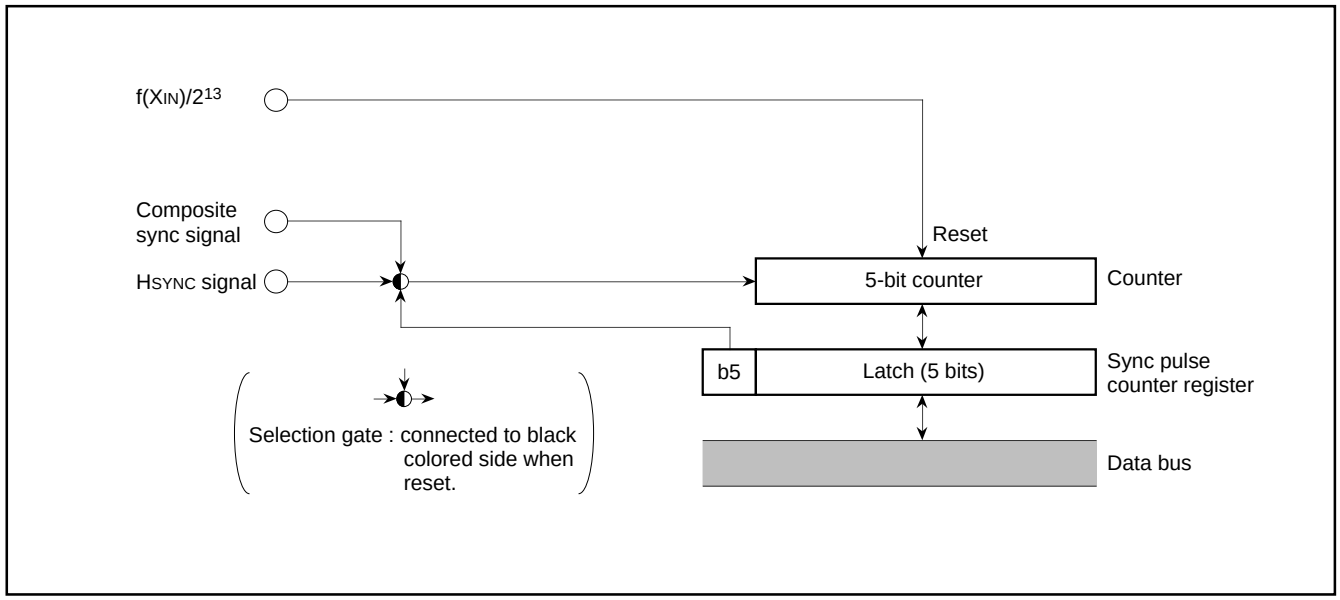


Fig. 49. Synchronous Signal Counter Block Diagram

MULTI-MASTER I²C-BUS INTERFACE

The multi-master I²C-BUS interface is a serial communications circuit, conforming to the Philips I²C-BUS data transfer format. This interface, offering both arbitration lost detection and a synchronous functions, is useful for the multi-master serial communications.
Figure 50 shows a block diagram of the multi-master I²C-BUS interface and Table 7 shows multi-master I²C-BUS interface functions.
This multi-master I²C-BUS interface consists of the I²C address register, the I²C data shift register, the I²C clock control register, the I²C control register, the I²C status register and other control circuits.

Table 7. Multi-master I²C-BUS Interface Functions

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 (at ϕ = 4 MHz)

ϕ : System clock = f(XIN)/2

Note: We are not responsible for any third party's infringement of patent rights or other rights attributable to the use of the control function (bits 6 and 7 of the I²C control register at address 00F9₁₆) for connections between the I²C-BUS interface and ports (SCL1, SCL2, SDA1, SDA2).

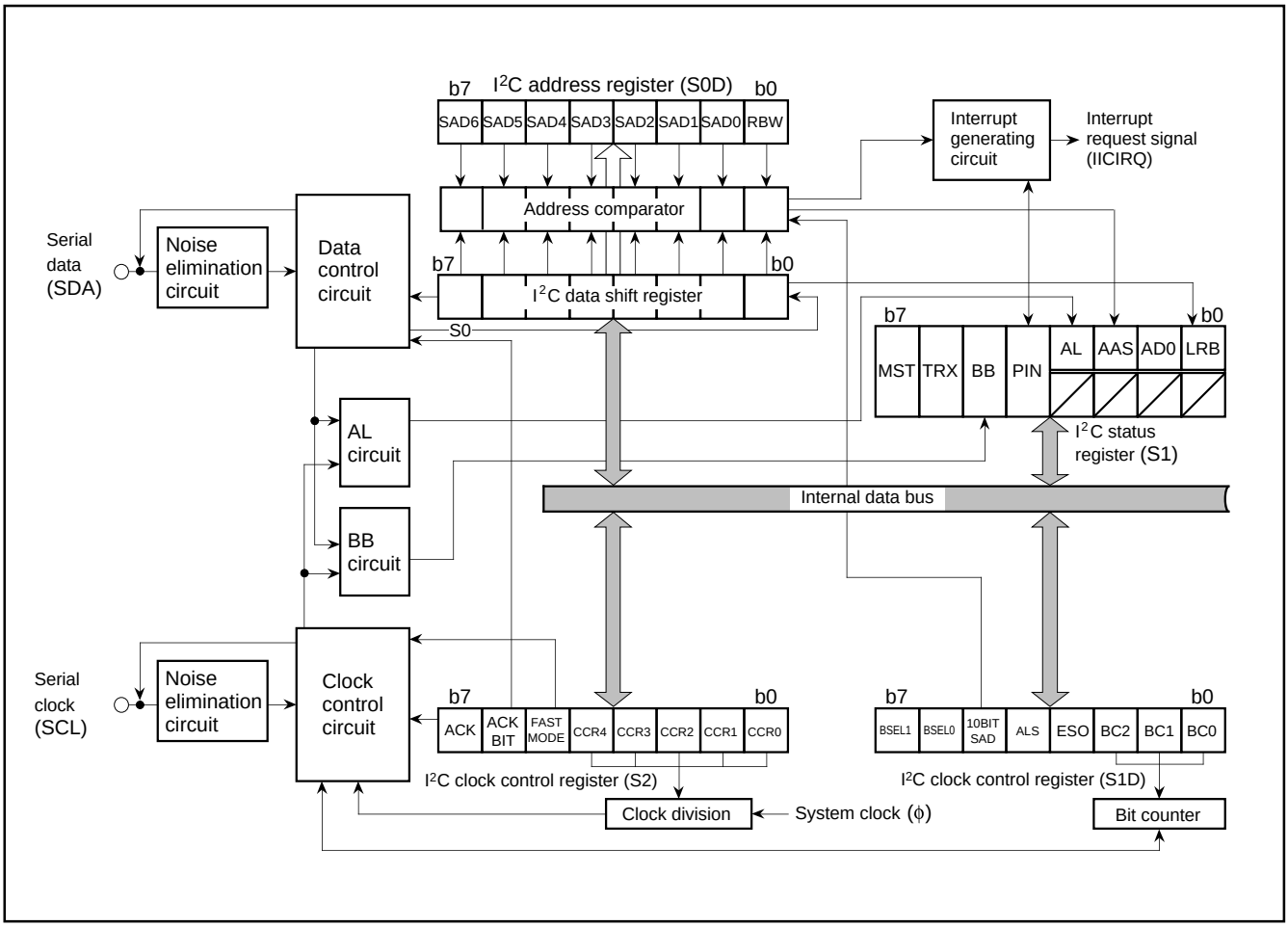
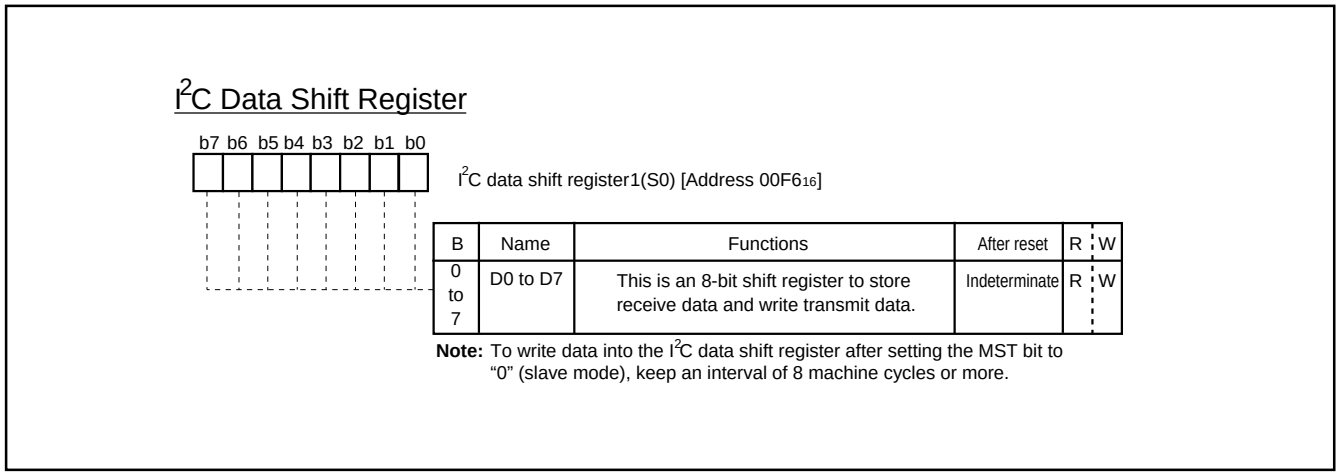


Fig. 50. Block Diagram of Multi-master I²C-BUS Interface

(1) I²C Data Shift Register

The I²C data shift register (S0 : address 00F6₁₆) 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 (address 00F9₁₆) 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 (address 00F8₁₆) 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.

Note: To write data into the I²C data shift register after setting the MST bit to "0" (slave mode), keep an interval of 8 machine cycles or more.



B	Name	Functions	After reset	R	W
0 to 7	D0 to D7	This is an 8-bit shift register to store receive data and write transmit data.	Indeterminate	R	W

Note: To write data into the I²C data shift register after setting the MST bit to "0" (slave mode), keep an interval of 8 machine cycles or more.

Fig. 51. I²C Address Register

(2) I²C Address Register

The I²C address register (address 00F7₁₆) consists of a 7-bit slave address and a 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: 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 I²C address register.

The RBW bit is cleared to "0" automatically when the stop condition is detected.

■ Bits 1 to 7: Slave Address (SAD0–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.

I²C Address Register

b7 b6 b5 b4 b3 b2 b1 b0

I²C address register (S0D) [Address 00F7₁₆]

B	Name	Functions	After reset	R	W
0	Read/write bit (RBW)	0: Read 1: Write	0	R	—
1 to 7	Slave address (SAD0 to SAD6)	The address data transmitted from the master is compared with the contents of these bits.	0	R	W

Fig. 52. I²C Address Register

(3) I²C Clock Control Register

The I²C clock control register (address 00FA16) 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. Refer to Table 7.

■ 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.

I²C Clock Control Register

b7 b6 b5 b4 b3 b2 b1 b0

I²C clock control register (S2 : address 00FA16)

B	Name	Functions			After reset	R	W
0 to 4	SCL frequency control bits (CCR0 to CCR4)	Setup value of CCR4–CCR0	Standard clock mode	High speed clock mode	0	R	W
		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 ϕ = 4 MHz, unit : kHz)					
5	SCL mode specification bit (FAST MODE)	0 : Standard clock mode 1 : High-speed clock mode			0	R	W
6	ACK bit (ACK BIT)	0 : ACK is returned. 1 : ACK is not returned.			0	R	W
7	ACK clock bit (ACK)	0 : No ACK clock 1 : ACK clock			0	R	W

Note: At 4000kHz 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

Fig. 53. I²C Address Register

(4) I²C Control Register

The I²C control register (address 00F9₁₆) 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 "000₂" and the address data is always transmitted and received in 8 bits.

■ Bit 3: I²C Interface Use Enable Bit (ESO)

This bit enables usage of the multimaster I²C BUS interface. 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 at address 00F8₁₆).
- Writing data to the I²C data shift register (address 00F6₁₆) is disabled.

■ Bit 4: Data Format Selection Bit (ALS)

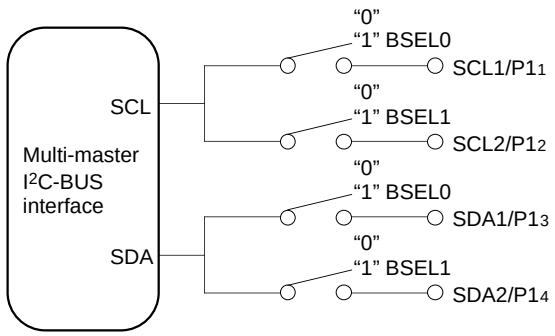
This bit decides whether or not to recognize slave addresses. When this bit is set to "0," the addressing format is selected, so that address data is recognized. When a match is found between a slave address and address data as a result of comparison or when a general call (refer to "(5) I²C Status Register," 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 (address 00F7₁₆) 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.

■ Bits 6 and 7: Connection Control Bits between I²C-BUS Interface and Ports (BSEL0, BSEL1)

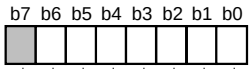
These bits controls the connection between SCL and ports or SDA and ports (refer to Figure 55).



Note: When using multi-master I²C-BUS interface, set bits 3 and 4 of the serial I/O mode register (address 0213₁₆) to "1." Moreover, set the corresponding direction register to "1" to use the port as multi-master I²C-BUS interface.

Fig. 54. Connection Port Control by BSEL0 and BSEL1

I²C Control Register



I²C control register (S1D : address 00F9 16)

B	Name	Functions	After reset	R	W
0 to 2	Bit counter (Number of transmit/recieve bits) (BC0 to BC2)	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	0	R	W
3	I²C-BUS interface use enable bit (ESO)	0 : Disabled 1 : Enabled	0	R	W
4	Data format selection bit (ALS)	0 : Addressing mode 1 : Free data format	0	R	W
5	Addressing format selection bit (10BIT SAD)	0 : 7-bit addressing format 1 : 10-bit addressing format	0	R	W
6, 7	Connection control bits between I²C-BUS interface and ports	b7 b6 Connection port (See note) 0 0 : None 0 1 : SCL1, SDA1 1 0 : SCL2, SDA2 1 1 : SCL1, SDA1 SCL2, SDA2	0	R	W

Note: When using ports P1₁-P1₄ as I²C-BUS interface, the output structure changes automatically from CMOS output to N-channel open-drain output.

Fig. 55. I²C Control Register

(5) I²C Status Register

The I²C status register (address 00F8₁₆) controls the I²C-BUS interface status. The low-order 4 bits are read-only bits and the high-order 4 bits 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 (address 00F6₁₆).

■ 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 "0" by detecting the STOP condition or START condition.

✻General call: The master transmits the general call address "00₁₆" to all slaves.

■ Bit 2: Slave Address Comparison Flag (AAS)

This flag indicates a comparison result of address data.

① 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 (address 00F7₁₆).
- A general call is received.

② 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.

③ The state of this bit is changed from "1" to "0" by executing a write instruction to the I²C data shift register (address 00F6₁₆). ■ 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.

✻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 the PIN bit is "0," the SCL is kept in the "0" state and clock generation is disabled. Figure 57 shows an interrupt request signal generating timing chart.

The PIN bit is set to "1" in any one of the following conditions.
- Executing a write instruction to the I²C data shift register (address 00F6₁₆).
- When the ESO bit is "0"
- At reset

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 (Note).

This flag can be written by software only in the master transmission mode. 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 (address 00F9₁₆) 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 I^2C control register (address $00F9_{16}$) is "0" in the slave reception mode is selected, the TRX bit is set to "1" (transmit) if the least significant bit (R/$\overline{W}$ bit) of the address data transmitted by the master is "1." When the ALS bit is "0" and the R/$\overline{W}$ 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 occurence 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)

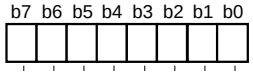
This bit is used for master/slave specification for data communication. When this bit is "0," the slave is specified, so that a START condition and a STOP condition generated by the master are received, and data communication is performed in synchronization with the clock generated by the master. When 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 (Note).
- At reset

Note: The START condition duplication prevention function disables the START condition generation, reset of bit counter reset, and SCL output, when the following condition is satisfied:
• a START condition is set by another master device.

I^2C Status Register



I^2C status register (S1) [Address $00F8_{16}$]

B	Name	Functions	After reset	R	W
0	Last receive bit (LRB) (See note)	0 : Last bit = "0 " 1 : Last bit = "1 "	Indeterminate	R	—
1	General call detecting flag (AD0) (See note)	0 : No general call detected 1 : General call detected	0	R	—
2	Slave address comparison flag (AAS) (See note)	0 : Address mismatch 1 : Address match	0	R	—
3	Arbitration lost detecting flag (AL) (See note)	0 : Not detected 1 : Detected	0	R	—
4	I^2C-BUS interface interrupt request bit (PIN)	0 : Interrupt request issued 1 : No interrupt request issued	0	R	—
5	Bus busy flag (BB)	0 : Bus free 1 : Bus busy	0	R	W
6, 7	Communication mode specification bits (TRX, MST)	b7 b6 0 0 : Slave recieve mode 0 1 : Slave transmit mode 1 0 : Master recieve mode 1 1 : Master transmit mode	0	R	W

Note : These bits and flags can be read out, but cannnot be written.

Fig. 56. I^2C Status Register

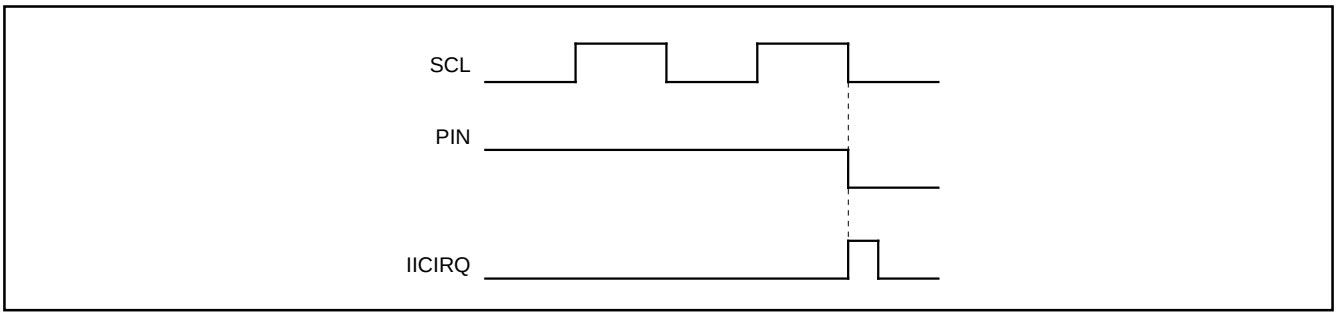


Fig. 57. Interrupt Request Signal Generation Timing

(6) START Condition Generation Method

When the ESO bit of the I^2C control register (address $00F9_{16}$) is "1," execute a write instruction to the I^2C status register (address $00F8_{16}$) 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 58 for the START condition generation timing diagram, and Table 8 for the START condition/STOP condition generation timing table.

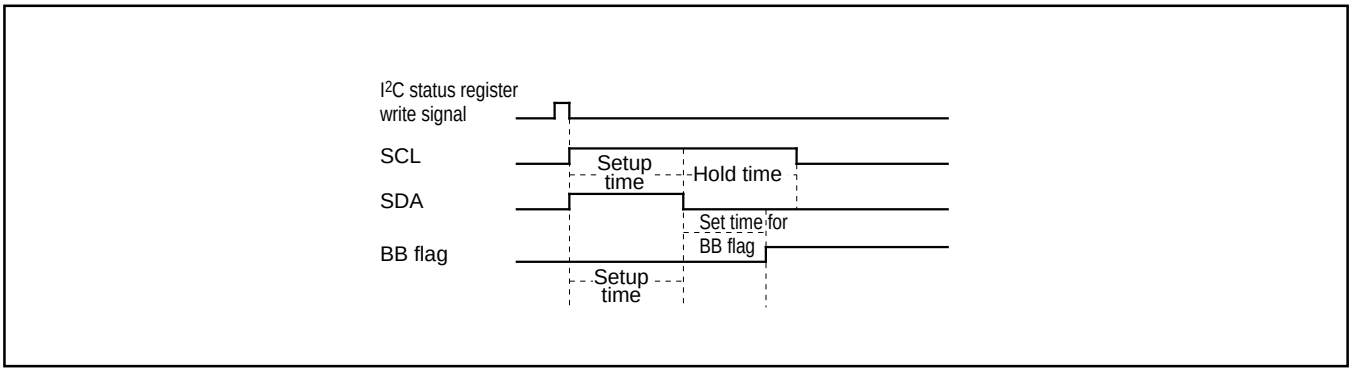


Fig. 58. START Condition Generation Timing Diagram

(7) RESTART Condition Generation Method

To generate the RESTART condition, take the following sequence:

①Set "20_{16}" to the I^2C status register (S1).

②Write a transmit data to the I^2C data shift register.

③Set "$F0_{16}$" to the I^2C status register (S1) again.

<Example of Setting of RESTART Condition>

I^2C status register ; S1 = 20_{16}
I^2C data shift register ; S0 = transmit data after restart
I^2C status register ; S1 = $F0_{16}$

(8) STOP Condition Generation Method

When the ES0 bit of the I^2C control register (address $00F9_{16}$) is "1," execute a write instruction to the I^2C status register (address $00F8_{16}$) 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 51 for the STOP condition generation timing diagram, and Table 8 for the START condition/STOP condition generation timing table.

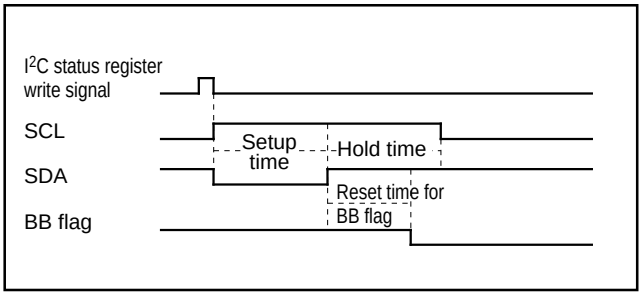


Fig. 59. STOP Condition Generation Timing Diagram

(9) START/STOP Condition Detect Conditions

The START/STOP condition detect conditions are shown in Figure 52 and Table 9. Only when the 3 conditions of Table 9 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 "IICIRQ" is generated to the CPU.

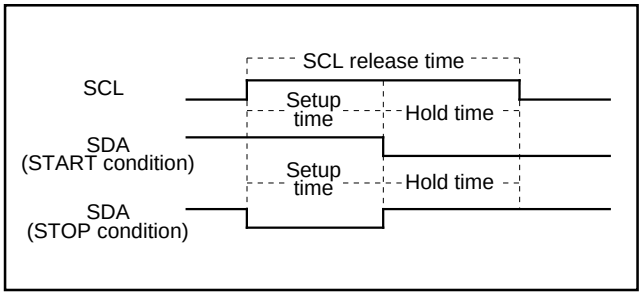


Fig. 60. START Condition/STOP Condition Detect Timing Diagram

Table 8. START Condition/STOP Condition Generation Timing Table

Item	Standard Clock Mode	High-speed Clock Mode
Setup time	5.0 μs (20 cycles)	2.5 μs (10 cycles)
Hold time	5.0 μs (20 cycles)	2.5 μs (10 cycles)
Set/reset time for BB flag	3.0 μs (12 cycles)	1.5 μs (6 cycles)

Note: Absolute time at ϕ = 4 MHz. The value in parentheses denotes the number of ϕ cycles.

Table 9. START Condition/STOP Condition Detect Conditions

Standard Clock Mode	High-speed Clock Mode
6.5 μs (26 cycles) < SCL release time	1.0 μs (4 cycles) < SCL release time
3.25 μs (13 cycles) < Setup time	0.5 μs (2 cycles) < Setup time
3.25 μs (13 cycles) < Hold time	0.5 μs (2 cycles) < Hold time

Note: Absolute time at ϕ = 4 MHz. The value in parentheses denotes the number of ϕ cycles.

(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.

① 7-bit addressing format

To meet the 7-bit addressing format, set the 10BIT SAD bit of the I^2C control register (address $00F9_{16}$) 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^2C address register (address $00F7_{16}$). At the time of this comparison, address comparison of the RBW bit of the I^2C address register (address $00F7_{16}$) is not made. For the data transmission format when the 7-bit addressing format is selected, refer to Figure 61, (1) and (2).

② 10-bit addressing format

To meet the 10-bit addressing format, set the 10BIT SAD bit of the I^2C control register (address $00F9_{16}$) 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^2C address register (address $00F7_{16}$). At the time of this comparison, an address comparison between the RBW bit of the I^2C address register (address $00F7_{16}$) 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^2C status register (address $00F8_{16}$) is set to "1." After the second-byte address data is stored into the I^2C data shift register (address $00F6_{16}$), 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^2C address register (address $00F7_{16}$) 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^2C address register (address $00F7_{16}$). For the data transmission format when the 10-bit addressing format is selected, refer to Figure 61, (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 I^2C address register (address $00F7_{16}$) and "0" in the RBW bit.
② Set the ACK return mode and SCL = 100 kHz by setting "85_{16}" in the I^2C clock control register (address $00FA_{16}$).
③ Set "10_{16}" in the I^2C status register (address $00F8_{16}$) and hold the SCL at the HIGH.
④ Set a communication enable status by setting "48_{16}" in the I^2C control register (address $00F9_{16}$).
⑤ Set the address data of the destination of transmission in the high-order 7 bits of the I^2C data shift register (address $00F6_{16}$) and set "0" in the least significant bit.
⑥ Set "$F0_{16}$" in the I^2C status register (address $00F8_{16}$) 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 I^2C data shift register (address $00F6_{16}$). 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 I^2C status register (address $00F8_{16}$). 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 I^2C address register (address $00F7_{16}$) and "0" in the RBW bit.
② Set the no ACK clock mode and SCL = 400 kHz by setting "25_{16}" in the I^2C clock control register (address $00FA_{16}$).
③ Set "10_{16}" in the I^2C status register (address $00F8_{16}$) and hold the SCL at the HIGH.
④ Set a communication enable status by setting "48_{16}" in the I^2C control register (address $00F9_{16}$).
⑤ When a START condition is received, an address comparison is made.
⑥ •When all transmitted addresses are "0" (general call) :
AD0 of the I^2C status register (address $00F8_{16}$) is set to "1" and an interrupt request signal occurs.
•When the transmitted addresses match the address set in ①:
AAS of the I^2C status register (address $00F8_{16}$) is set to "1" and an interrupt request signal occurs.
•In the cases other than the above :
AD0 and AAS of the I^2C status register (address $00F8_{16}$) are set to "0" and no interrupt request signal occurs.
⑦ Set dummy data in the I^2C data shift register (address $00F6_{16}$).
⑧ When receiving control data of more than 1 byte, repeat step ⑦.
⑨ When a STOP condition is detected, the communication ends.

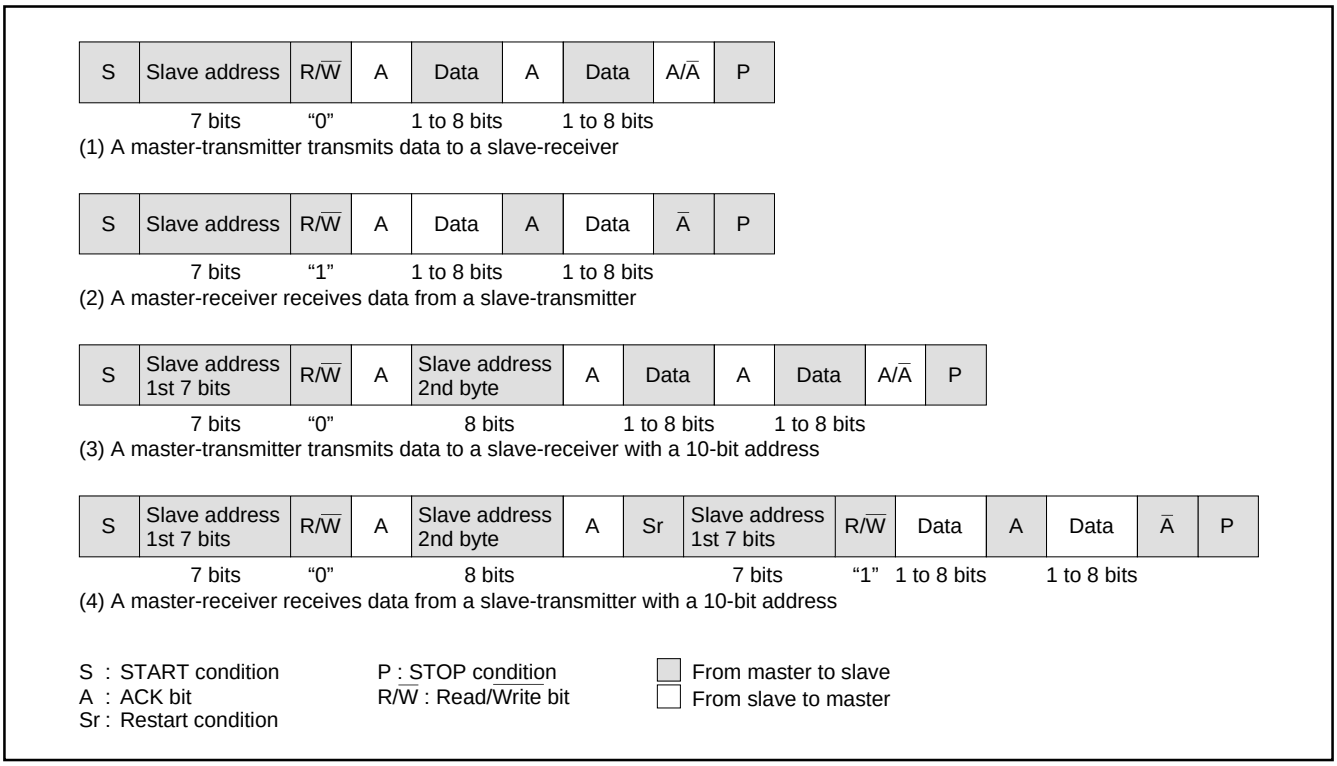


Fig. 61. Address Data Communication Format

OSD FUNCTIONS

Table 10 outlines the OSD functions of the M37274EFSP.
The M37274EFSP incorporates an OSD circuit of 40 characters × 16 lines. OSD is controlled by the OSD control register. There are 3 display modes and they are selected by a block unit. The display modes are selected by block control register i (i = 1 to 16).
The features of each mode are described below.

Note : Note that MASK version has 36 characters × 12 lines when programming.

Table 10. Features of Each Display Mode

Parameter		Display Mode		
		CC Mode (Closed caption mode)	OSD Mode (On-screen display mode)	EXOSD Mode (Extra on-screen display mode)
Number of display characters		40 characters × 16 lines		
Character display area		16 × 26 dots (character dot structure : 20 × 16 dots)	16 × 20 dots	16 × 26 dots
Kinds of characters		256 kinds (In EXOSD mode, they can be combined with 16 kinds of extra fonts)		
Kinds of character sizes		2 kinds	14 kinds	6 kinds
	Pre-divide ratio (Note)	× 1, × 2	× 1, × 2, × 3	× 1, × 2, × 3
	Dot size	1Tc × 1/2H	1Tc × 1/2H, 1Tc × 1H, 1.5Tc × 1/2H, 1.5Tc × 1H, 2Tc × 2H, 3Tc × 3H	1Tc × 1/2H, 1Tc × 1H
Attribute		Smooth italic, under line, flash	Border	Border, extra font (16 kinds)
Character font coloring		1 screen : 7 kinds, Max. 7 kinds (a character unit)	1 screen : 7 kinds, Max. 7 kinds (a character unit)	1 screen : 5 kinds, Max. 5 kinds (a character unit)
Raster coloring		Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)	Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)	Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)
Character background coloring		Possible (a character unit, 1 screen : 7 kinds, max. 7 kinds)	Possible (a character unit, 1 screen : 7 kinds, max. 7 kinds)	Possible (a character unit, 1 screen : 7 kinds, max. 5 kinds)
Border coloring		———	Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)	Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)
Extra font coloring		———	———	Possible (a screen unit, 1 screen : 7 kinds, max. 7 kinds)
OSD output		R, G, B, OUT1, OUT2	R, G, B, OUT1, OUT2	R, G, B, OUT1, OUT2
Function		Auto solid space function Window function Dual layer OSD function (layer 1)	Dual layer OSD function (layer 2)	———
Display expansion (multiline display)		Possible	Possible	Possible

Notes 1: The divide ratio of the frequency divider (the pre-divide circuit) is referred as “pre-divide ratio” hereafter.
2: The character size is specified with dot size and pre-divide ratio (refer to (3) Dote size).

The OSD circuit has an extended display mode. This mode allows multiple lines (16 lines or more) to be displayed on the screen by interrupting the display each time one line is displayed and rewriting data in the block for which display is terminated by software.
Figure 62 shows the configuration of OSD character. Figure 63 shows the block diagram of the OSD circuit. Figure 64 shows the structure of the OSD control register. Figure 65 shows the structure of the block control register i.

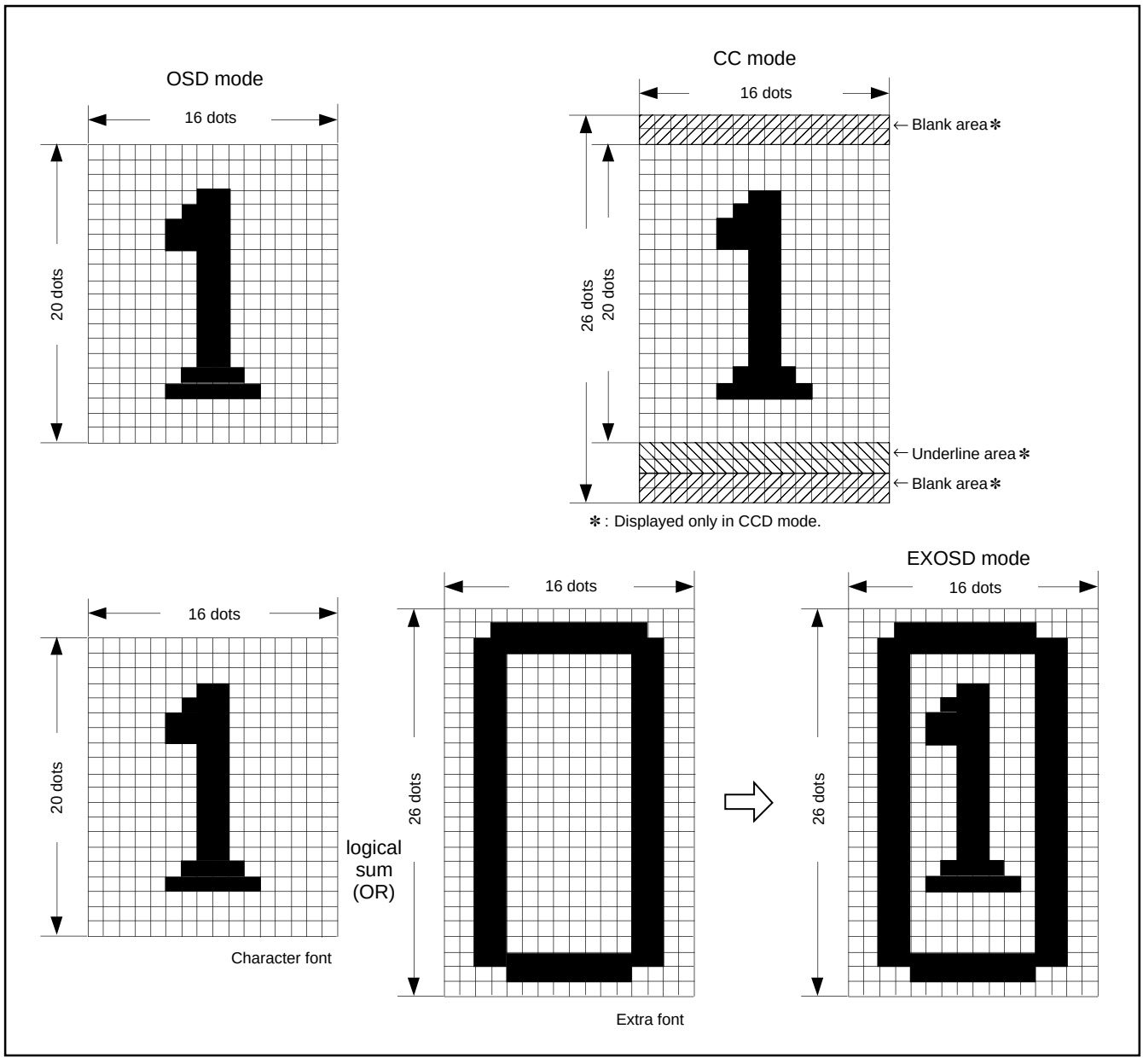


Fig. 62. Configuration of OSD Character Display Area

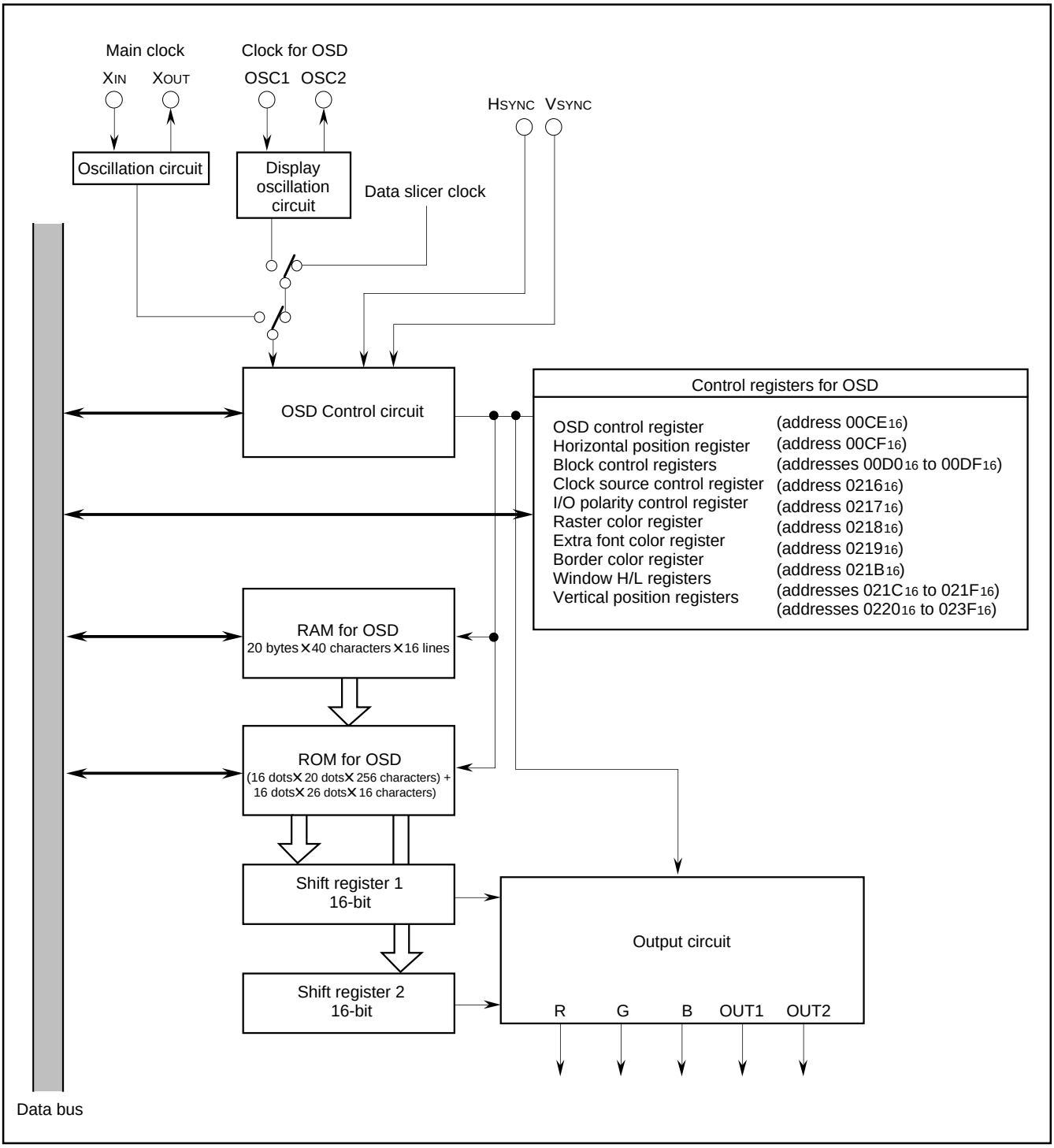


Fig. 63. Block Diagram of OSD Circuit

OSD Control Register

b7 b6 b5 b4 b3 b2 b1 b0

OSD control register (OC) [Address 00CE16]

B	Name	Functions	After reset	R	W
0	OSD control bit (OC0) (See note 1)	0 : All-blocks display off 1 : All-blocks display on	0	R	W
1	Scan mode selection bit (OC1)	0 : Normal scnan mode 1 : Bi-scan mode	0	R	W
2	Border type selection bit (OC2)	0 : All bordered 1 : Shadow bordered (See note 2)	0	R	W
3	Flash mode selection bit (OC3)	0 : Color signal of character background part does not flash 1 : Color signal of character background part flashes	0	R	W
4	Automatic solid space control bit (OC4)	0 : OFF 1 : ON	0	R	W
5	Window control bit (OC5)	0 : OFF 1 : ON	0	R	W
6, 7	Layer mixing control bits (OC6, OC7) (See note 3)	b7 b6 0 0: Logic sum (OR) of layer 1's color and layer 2's color 0 1: Layer 1's color has priority 1 0: Layer 2's color has priority 1 1: Do not set.	0	R	W

Notes 1 : Even this bit is switched during display, the display screen remains unchanged until a rising (falling) of the next V SYNC.
2 : Shadow border is output at right and bottom side of the font.
3 : Set "00" during displaying extra fonts.

Fig. 64. OSD Control Register

Block Control register i

b7 b6 b5 b4 b3 b2 b1 b0

Block control register i (BCi) (i=1 to 16) [Addresses 00D016 to 00DF16](See note 1)

B	Name	Functions	After reset	R	W
0, 1	Display mode selection bits (BCi0, BCi1)	b1 b0 0 0: Display OFF 0 1: OSD mode 1 0: CC mode 1 1: EXOSD mode	Indeterminate	R	W
2	Border control bit (BCi2)	0: Border OFF 1: Border ON	Indeterminate	R	W
3, 4	Dot size selection bits (BCi3, BCi4)	b6 b5 b4 b3 CS6 Pre-divide ratio Dot size Display layer 0 0 0 0 — ×1 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H 0 0 0 1 — ×1 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H 0 0 1 0 — ×1 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H 0 0 1 1 — ×1 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H 0 1 0 0 — ×2 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 0 1 0 1 — ×2 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 0 1 1 0 — ×2 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 0 1 1 1 — ×2 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 1 0 0 0 — ×3 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 1 0 0 1 — ×3 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 1 0 1 0 — ×3 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 1 0 1 1 — ×3 1Tc × 1/2H, 1Tc × 1H, 2Tc × 2H, 3Tc × 3H Layer1 1 1 — 0 0 ×1 1Tc × 1/2H, 1Tc × 1H Layer2 1 1 — 1 0 ×1 1Tc × 1/2H, 1Tc × 1H Layer2 1 1 0 0 1 ×2 1Tc × 1/2H, 1Tc × 1H, 1.5Tc × 1/2H, 1.5Tc × 1H Layer2 1 1 0 1 1 ×2 1Tc × 1/2H, 1Tc × 1H, 1.5Tc × 1/2H, 1.5Tc × 1H Layer2 1 1 1 0 1 ×2 1Tc × 1/2H, 1Tc × 1H, 1.5Tc × 1/2H, 1.5Tc × 1H Layer2 1 1 1 1 1 ×2 1Tc × 1/2H, 1Tc × 1H, 1.5Tc × 1/2H, 1.5Tc × 1H Layer2	Indeterminate	R	W
5, 6	Pre-divide ratio • layer selection bit (BCi5, BCi6)		Indeterminate	R	W
7	OUT2 output control bit (BCi7) (See note 2)	BC17: Window top boundary BC27: Window bottom boundary	Indeterminate	R	W

Notes 1: Note that MASK version the block control registers at addresses 00D0 16 to 00DB16 when programming.
2: Bit 4 of the color code 1 controls OUT1 output when bit 7 is "0".
Bit 4 of the color code 1 controls OUT2 output when bit 7 is "1".
3: CS6 : Bit 6 of the clock control register (address 0216 16)
4: Tc : Pre-devided clock period for OSD
5: H : Hsync

Fig. 65. Block Control Registers

(1) Dual Layer OSD

M37274MA-XXXSP has 2 layers; layer 1 and layer 2. These layers display the OSD for controlling TV and the closed caption display at the same time and overlayed on each other.

Each block can be assigned to either layer by bits 6 and 5 of the block control register (refer to Figure 65). For example, only when both bits 5 and 6 are "1," the block is assigned to layer 2. Other bit combinations assign the block to layer 1.

When a block of layer 1 is overlapped with that of layer 2, a screen is combined (refer to Figure 67) by bits 7 and 6 of the OSD control register (refer to Figure 64).

Note: When using the dual layer OSD, note Table 11.

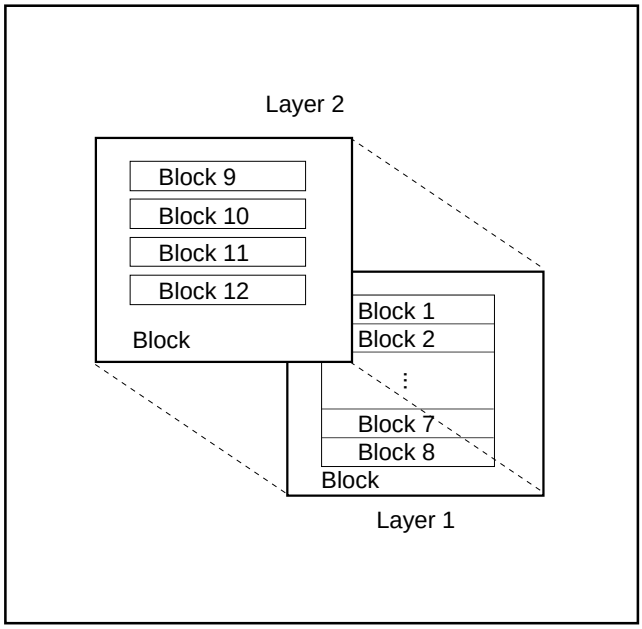


Fig. 66. Image of Dual Layer OSD

Table 11. Conditions of Dual Layer

Parameter \ Block	Block in Layer 1	Block in Layer 2	
Display mode	CC mode	OSD mode	
OSD Clock source	Data slicer clock or OSC1 or main clock	Same as layer 1	
Pre-divide ratio	× 1 or × 2 (all blocks)	Same as layer 1 (Note)	
Dot size	1Tc × 1/2H	Pre-divide ratio = 1	Pre-divide ratio = 2
		1Tc × 1/2H	1Tc × 1/2H, 1.5Tc × 1/2H
		1Tc × 1H	1Tc × 1H, 1.5Tc × 1H
Horizontal display start position	Arbitrary	Same position as layer 1	

Note: For the pre-divide ratio of the layer 2, select the same as the layer 1's ratio by bit 6 of the clock control register.

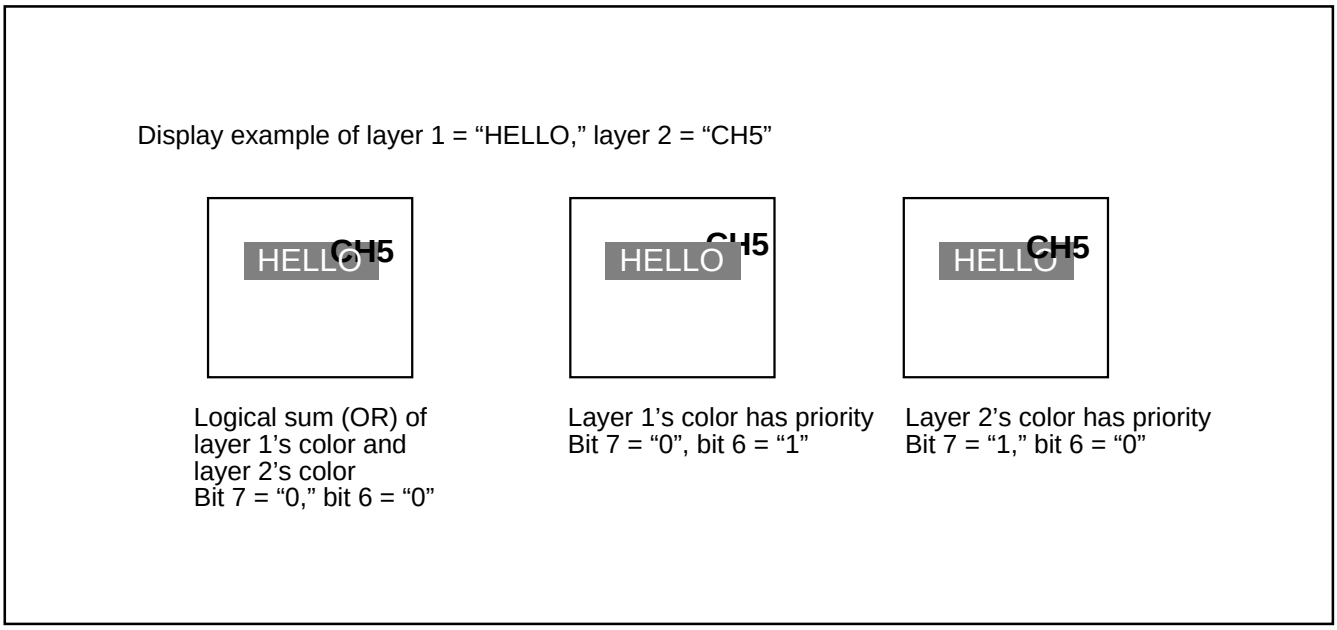


Fig. 67. Display Example of Dual Layer OSD

(2) Display Position

The display positions of characters are specified by a block. There are 16 blocks, blocks 1 to 16. Up to 40 characters can be displayed in each block (refer to (6) Memory for OSD).

The display position of each block can be set in both horizontal and vertical directions by software.

The display position in the horizontal direction can be selected for all blocks in common from 256-step display positions in units of 4 T_{OSC} (T_{OSC} = OSD oscillation cycle).

The display position in the vertical direction for each block can be selected from 1024-step display positions in units of 1 T_H (T_H = H_{SYNC} cycle).

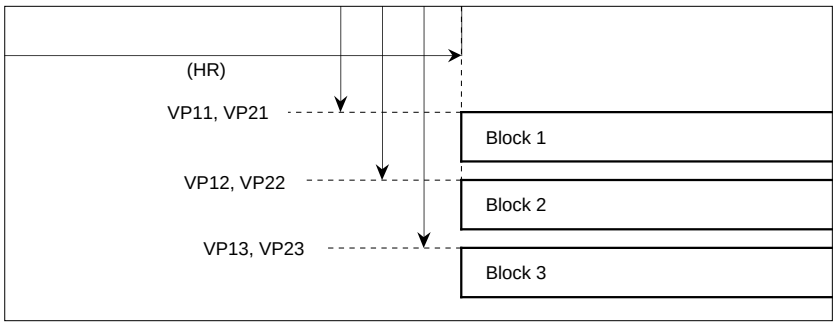
Blocks are displayed in conformance with the following rules:

① When the display position is overlapped with another block (Figure 68, (b)), a lower block number (1 to 16) is displayed on the front.

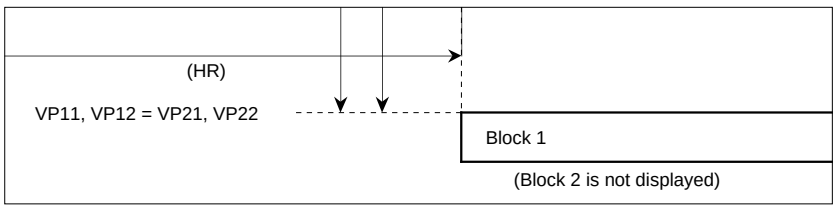
② When another block display position appears while one block is displayed (Figure 68 (c)), the block with a larger set value as the vertical display start position is displayed. However, do not display block with the dot size of 2Tc × 2H or 3Tc × 3H during display period (✻) of another block.

✻ In the case of OSD mode block: 20 dots in vertical from the vertical display start position.

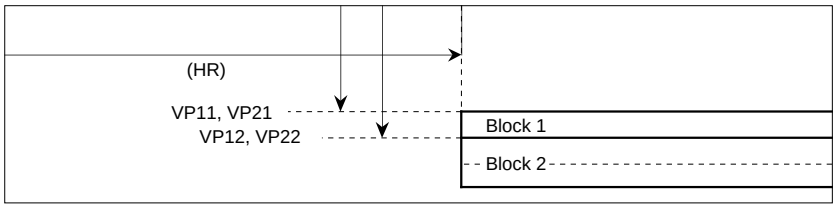
✻ In the case of CC or EXOSD mode block: 26 dots in vertical from the vertical display start position.



(a) Example when each block is separated



(b) Example when block 2 overlaps with block 1

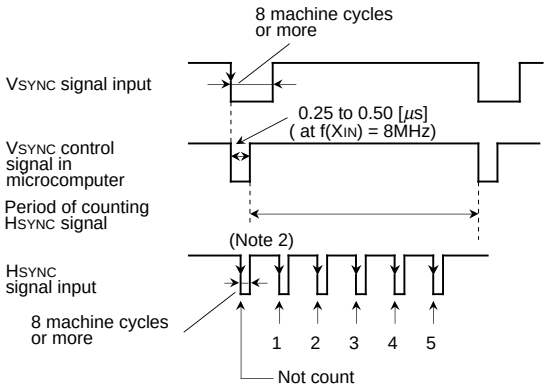


(c) Example when block 2 overlaps in process of block 1

Note: VP1i or VP2i (i : 1 to 16) indicates the vertical display start position of display block i.

Fig. 68. Display Position

The display position in the vertical direction is determined by counting the horizontal sync signal (HSYNC). At this time, when VSYNC and HSYNC are positive polarity (negative polarity), it starts to count the rising edge (falling edge) of HSYNC signal from after fixed cycle of rising edge (falling edge) of VSYNC signal. So interval from rising edge (falling edge) of VSYNC signal to rising edge (falling edge) of HSYNC signal needs enough time (2 machine cycles or more) for avoiding jitter. The polarity of HSYNC and VSYNC signals can select with the I/O polarity control register (address 0217_{16}).



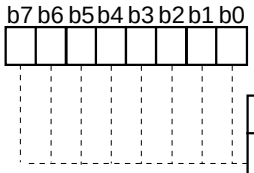
When bits 0 and 1 of the I/O polarity control register (address 0217_{16}) are set to "1" (negative polarity)

Notes 1 : The vertical position is determined by counting falling edge of HSYNC signal after rising edge of VSYNC control signal in the microcomputer.
2 : Do not generate falling edge of HSYNC signal near rising edge of VSYNC control signal in microcomputer to avoid jitter.
3 : The pulse width of VSYNC and HSYNC needs 8 machine cycles or more.

Fig. 69. Supplement Explanation for Display Position

The vertical position for each block can be set in 1024 steps (where each step is 1TH (TH: HSYNC cycle)) as values "00$_{16}$" to "FF$_{16}$" in vertical position register 1i (i = 1 to 12) (addresses 0220$_{16}$ to 022B$_{16}$) and values "00$_{16}$" to "03$_{16}$" in vertical position register 2i (i = 1 to 12) (addresses 0230$_{16}$ to 023B$_{16}$). The structure of the vertical position registers is shown in Figure 70 and 71.

Vertical Position Register 1i



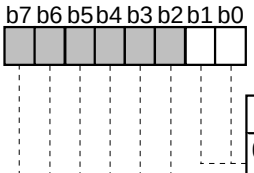
Vertical position register 1i (VP1i) (i = 1 to 16) [Addresses 0220$_{16}$ to 022F$_{16}$]

B	Name	Functions	After reset	R	W
0 to 7	Control bits of vertical display start positions (VP1i0 to VP1i7) (See note 1)	Vertical display start positions (low-order 8 bits) TH × (setting value of low-order 2 bits of VP2i × 16^2 + setting value of low-order 4 bits of VP1i × 16^1 + setting value of low-order 4 bits of VP1i × 16^0)	Indeterminate	R	W

Notes 1: Set values except "00$_{16}$" "01$_{16}$" to VP1i when VP2i is "00$_{16}$."
2: TH is cycle of HSYNC.

Fig. 70. Vertical Position Register 1

Vertical Position Register 2i



Vertical position register 2i (VP2i) (i = 1 to 16) [Addresses 0230$_{16}$ to 023F$_{16}$]

B	Name	Functions	After reset	R	W
0, 1	Control bits of vertical display start positions (VP1i0, VP1i1) (See note 1)	Vertical display start positions (high-order 2 bits) TH × (setting value of low-order 2 bits of VP2i × 16^2 + setting value of low-order 4 bits of VP1i × 16^1 + setting value of low-order 4 bits of VP1i × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values except "00$_{16}$" "01$_{16}$" to VP1i when VP2i is "00$_{16}$."
2: TH is cycle of HSYNC.

Fig. 71. Vertical Position Register 2

The horizontal position is common to all blocks, and can be set in 256 steps (where 1 step is 4TOSC, TOSC being the oscillating cycle for display) as values "00_{16}" to "FF_{16}" in bits 0 to 7 of the horizontal position register (address $00CF_{16}$). The structure of the horizontal position register is shown in Figure 72.

Horizontal Position Register

b7 b6 b5 b4 b3 b2 b1 b0

Horizontal position register (HP) [Address $00CF_{16}$]

B	Name	Functions	After reset	R	W
0 to 7	Control bits of horizontal display start positions (HP0 to HP7)	Horizontal display start positions 4TOSC × (setting value of high-order 4 bits × 16^1 + setting value of low-order 4 bits × 16^0)	0	R	W

Notes 1. The setting value synchronizes with the V SYNC.
2. TOSC = OSD oscillation period.

Fig. 72. Horizontal Position Register

Notes 1 : 1Tc (Tc : OSD clock cycle divided by prescaler) gap occurs between the horizontal display start position set by the horizontal position register and the most left dot of the 1st block. Accordingly, when 2 blocks have different pre-divide ratios, their horizontal display start position will not match.
Ordinaly, this gap is 1Tc regardless of character sizes, however, the gap is 1.5Tc only when the character size is 1.5Tc.

2 : The horizontal start position is based on the OSD clock source cycle selected for each block. Accordingly, when 2 blocks have different OSD clock source cycles, their horizontal display start position will not match.

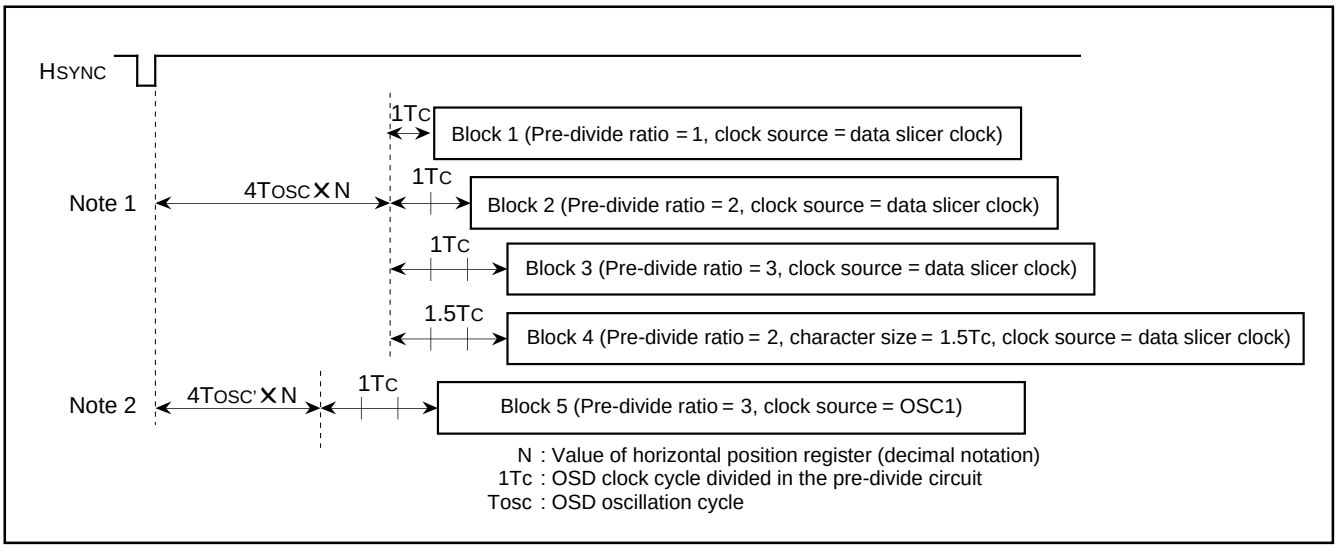


Fig. 73. Notes on Horizontal Display Start Position

(3) Dot Size

The dot size can be selected by a block unit. The dot size in vertical direction is determined by dividing HSYNC in the vertical dot size control circuit. The dot size in horizontal is determined by dividing the following clock in the horizontal dot size control circuit : the clock gained by dividing the OSD clock source (data slicer clock, OSC1, main clock) in the pre-divide circuit. The clock cycle divided in the pre-divide circuit is defined as 1TC.

The dot size of the layer 1 is specified by bits 6 to 3 of the block control register.

The dot size of the layer 2 is specified by the following bits : bits 3 and 4 of the block control register, bit 6 of the clock source control register. Refer to Figure 65 (the structure of the block control register), refer to Figure 76 (the structure of the clock source control register).

The block diagram of dot size control circuit is shown in Figure 75.

Notes 1 : The pre-divide ratio = 3 cannot be used in the CC mode.

2 : The pre-divide ratio of the OSD mode block on the layer 2 must be same as that of the CC mode block on the layer 1 by bit 6 of the clock source control register.

3 : In the bi-scan mode, the dot size in the vertical direction is 2 times as compared with the normal mode. Refer to "(13) Scan Mode" about the scan mode.

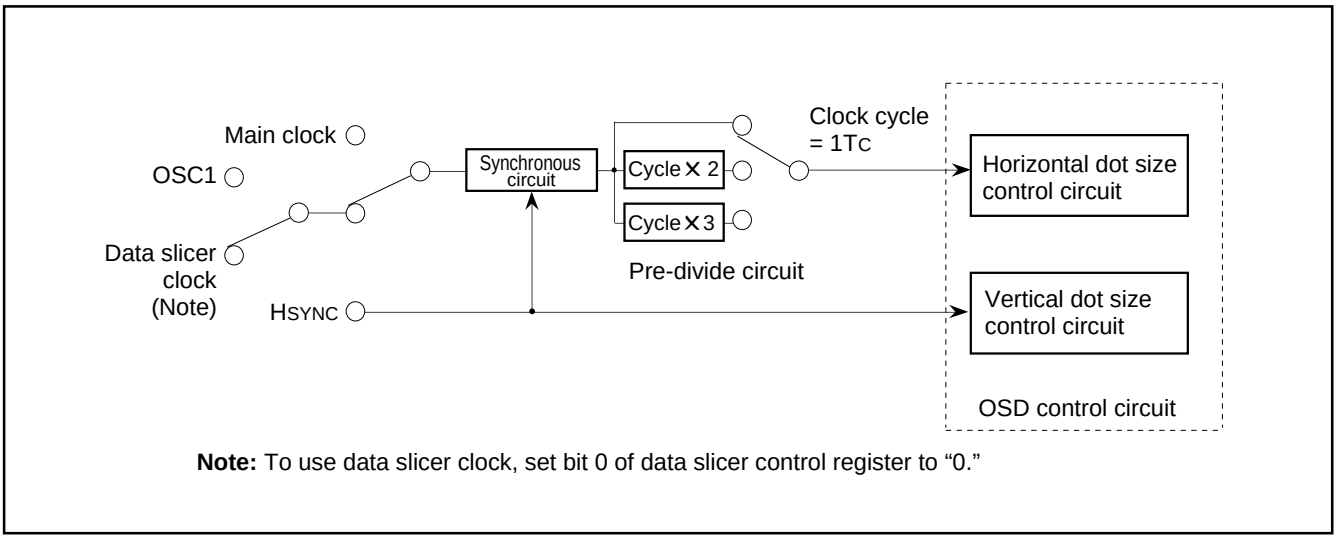


Fig. 74. Block Diagram of Dot Size Control Circuit

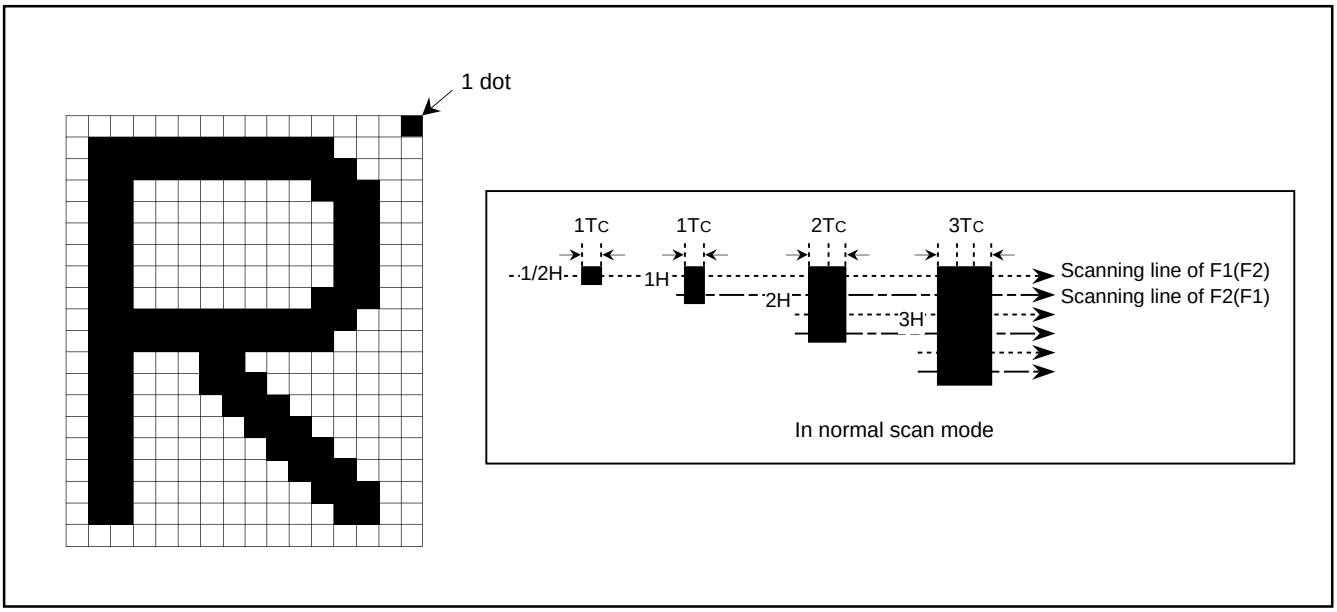


Fig. 75. Definition of Dot Sizes

(4) Clock for OSD

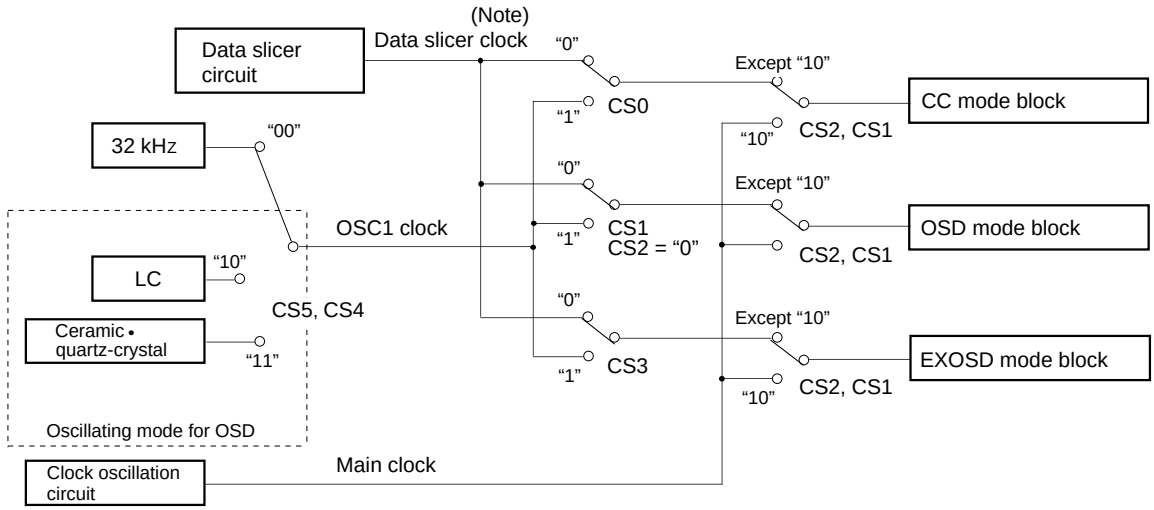
As a clock for display to be used for OSD, it is possible to select one of the following 4 types.

- Main clock (8 MHz)
- Data slicer clock output from the data slicer (approximately 26 MHz)
- Clock from the LC oscillator supplied from the pins OSC1 and OSC2
- Clock from the ceramic resonator or the quartz-crystal oscillator from the pins OSC1 and OSC2

This OSD clock for each block can be selected by the following bits : bit 7 of the port P3 direction register, bits 5 and 4 of the clock source control register (addresses 0216_{16}). A variety of character sizes can be obtained by combining dot sizes with OSD clocks. When not using the pins OSC1 and OSC2 for the OSD clock I/O pins, the pins can be used as sub-clock I/O pins or port P6.

Table 12. Setting for $P6_3$/OSC1/X_{CIN}, $P6_4$/OSC2/X_{COUT}

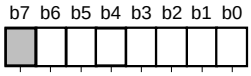
Register \ Function		OSD Clock I/O Pin		Sub-clock I/O Pin	Input Port
b7 of port P3 direction register		0		0	1
Clock source control register	b5	1	1	0	0
	b4	0	1	0	1



Note : To use data slicer clock, set bit 0 of data slicer control register to "1."

Fig. 76. Block Diagram of OSD Selection Circuit

Clock Source Control Register



Clock source control register (CS) [Address 0216_{16}]

B	Name	Functions	After reset	R	W
0	CC mode clock selection bit (CS0)	0: Data slicer clock 1: OSC1 clock	0	R	W
1, 2	OSD mode clock selection bits (CS1, CS2)	b2 b1 0 0: Data slicer clock 0 1: OSC1 clock 1 0: Main clock (See note 1) 1 1: Do not set	0	R	W
3	EXOSD mode clock selection bit (CS3)	0: Data slicer clock 1: OSC1 clock	0	R	W
4, 5	OSD oscillating mode selection bits (CS4, CS5)	b5 b4 0 0: 32 kHz oscillating mode 0 1: Input ports $P6_3$, $P6_4$ (See note 2) 1 0: LC oscillating mode 1 1: Ceramic • quartz-crystal oscillating mode	0	R	W
6	Pre-divide ratio of layer 2 selection bit (CS6)	0: × 1 1: × 2	0	R	W
7	Test bit (See note 3)		0	R	W

Notes 1: When setting "10_2," main clock is set as a clock in the CC mode and EXOSD mode regardless of bits 0, 3.
2: When selecting input ports $P6_3$ and $P6_4$, set bit 7 at address $00C7_{16}$ to "0."
3: Be sure to set bit 7 to "0" for program of the mask and the EPROM versions. For the emulator MCU version (M37274ERSS), be sure to set bit 7 to "1" when using the data slicer clock for software debugging.

Fig. 77. Clock Control Register

(5) Field Determination Display

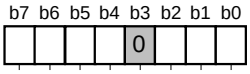
To display the block with vertical dot size of 1/2H, whether an even field or an odd field is determined through differences in a synchronizing signal waveform of interlacing system. The dot line 0 or 1 (refer to Figure 79) corresponding to the field is displayed alternately.

In the following, the field determination standard for the case where both the horizontal sync signal and the vertical sync signal are negative-polarity inputs will be explained. A field determination is determined by detecting the time from a falling edge of the horizontal sync signal until a falling edge of the VSYNC control signal (refer to Figure 69) in the microcomputer and then comparing this time with the time of the previous field. When the time is longer than the comparing time, it is regarded as even field. When the time is shorter, it is regarded as odd field

The contents of this field can be read out by the field determination flag (bit 7 of the I/O polarity control register at address 0217_{16}). A dot line is specified by bit 6 of the I/O polarity control register (refer to Figure 79).

However, the field determination flag read out from the CPU is fixed to “0” at even field or “1” at odd field, regardless of bit 6.

I/O Polarity Control Register



I/O polarity control register (PC) [Address 0217_{16}]

B	Name	Functions	After reset	R	W
0	HSYNC input polarity switch bit (PC0)	0 : Positive polarity input 1 : Negative polarity input	0	R	W
1	VSYNC input polarity switch bit (PC1)	0 : Positive polarity input 1 : Negative polarity input	0	R	W
2	R, G, B output polarity switch bit (PC2)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
3	Fix this bit to "0".		0	R	—
4	OUT1 output polarity switch bit (PC4)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
5	OUT2 output polarity switch bit (PC5)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
6	Display dot line selection bit (PC6) (See note)	0 : “□” at even field “▨” at odd field 1 : “▨” at even field “□” at odd field	0	R	W
7	Field determination flag (PC7)	0 : Even field 1 : Odd field	1	R	—

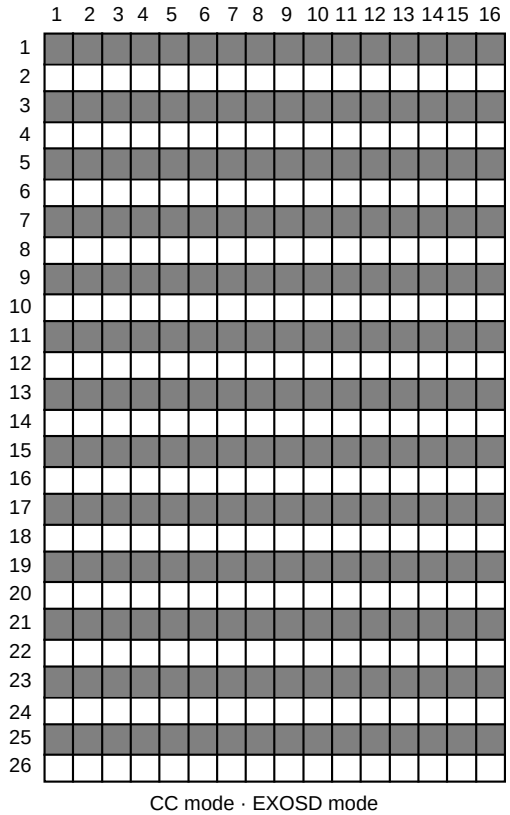
Note: Refer to Figure 79.

Fig. 78. I/O Polarity Control Register

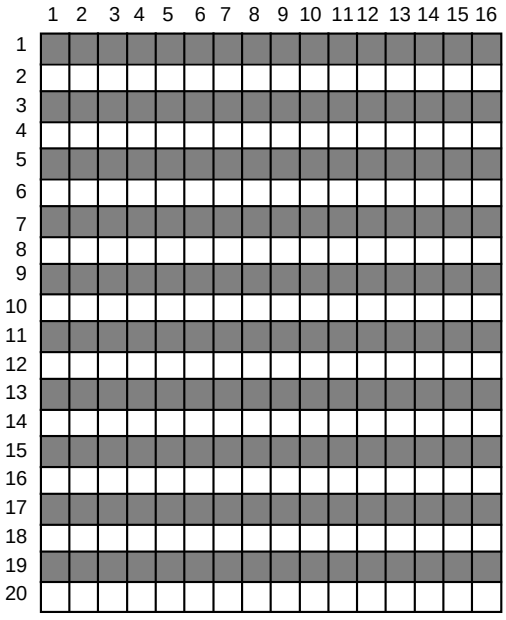
Both HSYNC signal and VSYNC signal are negative-polarity input

HSYNC		Field	Field determination flag(Note)	Display dot line selection bit	Display dot line
VSYNC and VSYNC control signal in microcomputer Upper : VSYNC signal Lower : VSYNC control signal in microcomputer	(n – 1) field (Odd-numbered) T1 0.25 to 0.50[μs] at f(XIN) = 8 MHz	Odd			
	(n) field (Even-numbered) T2	Even	0 (T2 > T1)	0	Dot line 1 □
				1	Dot line 0 ■
	(n + 1) field (Odd-numbered) T3	Odd	1 (T3 < T2)	0	Dot line 0 ■
				1	Dot line 1 □

When using the field determination flag, be sure to set bit 0 of the PWM mode register 1 (address 020A 16) to “0.”



CC mode · EXOSD mode



OSD mode

When the display dot line selection bit is “0,” the “ □ ” font is displayed at even field, the “ ■ ” font is displayed at odd field. Bit 7 of the I/O polarity control register can be read as the field determination flag : “1” is read at odd field, “0” is read at even field.

OSD ROM font configuration diagram

Note : The field determination flag changes at a rising edge of the V SYNC control signal (negative-polarity input) in the microcomputer.

Fig. 79. Relation between Field Determination Flag and Display Font

(6) Memory for OSD

There are 2 types of memory for OSD : ROM for OSD (addresses 10800_{16} to $155FF_{16}$, 18000_{16} to $1E41F_{16}$) used to store character dot data (masked) and RAM for OSD (addresses 0800_{16} to $0DF3_{16}$) used to specify the characters and colors to be displayed. The following describes each type of memory.

① ROM for OSD (addresses 10800_{16} to $155FF_{16}$, 18000_{16} to $1E43F_{16}$)

The ROM for OSD contains dot pattern data for characters to be displayed. To actually display the character code and the extra code stored in this ROM, it is necessary to specify them by writing the character code inherent to each character (code determined based on the addresses in the ROM for OSD) into the RAM for OSD.

The OSD ROM of the character font has a capacity of 11072 bytes. Since 40 bytes are required for 1 character data, the ROM can stores up to 256 kinds of characters. The OSD ROM of the extra font has a capacity of 832 bytes. Since 52 bytes are required for 1 character data, the ROM can stores up to 16 kinds of characters.

Data of the character font and extra font is specified shown in Figure 80.

OSD ROM address of character font data

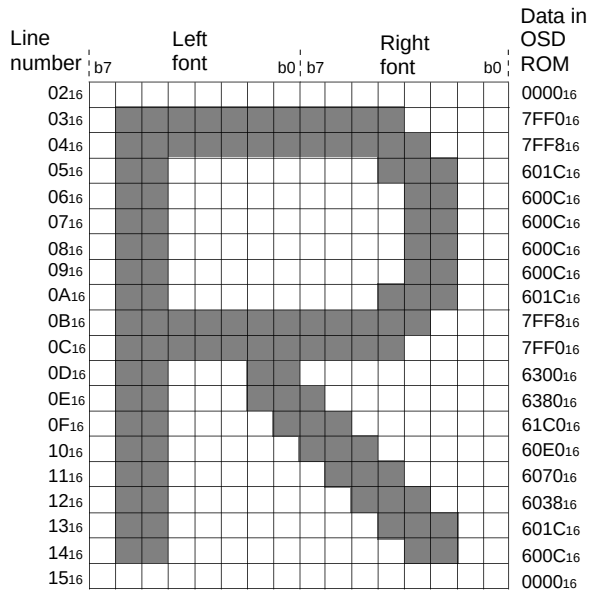
OSD ROM address bit	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
Line number/character code/font bit	1	0	Line number					0	Character code								Font bit

Line number = "02_{16}" to "15_{16}"
Character code = "00_{16}" to "FFF_{16}"
Font bit = 0 : left font 1 : right font

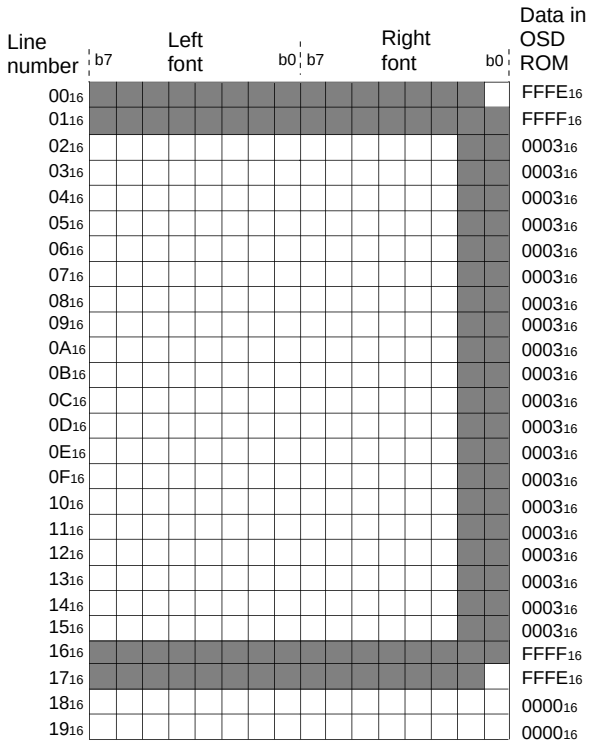
OSD ROM address of extra font data

OSD ROM address bit	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
Line number/extra code /font bit	1	1	Line number					0	0	0	0	0	Extra code				Font bit

Line number = "00_{16}" to "19_{16}"
Extra code = "00_{16}" to "$0F_{16}$"
Font bit = 0 : left font 1 : right font



Character font



Extra font

Fig. 80. OSD Character Data Storing Form

② RAM for OSD (addresses 0800_{16} to $0FF7_{16}$)

The RAM for OSD is allocated at addresses 0800_{16} to $0FF7_{16}$, and is divided into a display character code specification part, color code 1 specification part, and color code 2 specification part for each block. Table 13 shows the contents of the RAM for OSD.

For example, to display 1 character position (the left edge) in block 1, write the character code in address 0800_{16}, write color code 1 at 0840_{16}, and write color code 2 at 0828_{16}.

The structure of the RAM for OSD is shown in Figure 82.

Note: For the OSD mode block with dot size of 1.5Tc × 1/2H and 1.5Tc × 1H, the 3nth (n = 1 to 13) character is skipped as compared with ordinary block*. Accordingly, maximum 27 characters (the right 1/3 part of the 27th's character area is not displayed) are only displayed in 1 block. The RAM data for the 3nth character does not effect the display. Any character data can be stored here (refer to Figure 81).

Mask version has maximum 24 characters in 1 block when programming.

✻ Blocks with dot size of 1Tc × 1/2H and 1Tc × 1H, or blocks on the layer 1

Table 13. Contents of OSD RAM

Block	Display Position (from left)	Character Code Specification	Color Code 1 Specification	Color Code 2 Specification
Block 1	1st character	0800_{16}	0840_{16}	0828_{16}
	2nd character : 24th character	0801_{16} : 0817_{16}	0841_{16} : 0857_{16}	0829_{16} : $083F_{16}$
	25th character : 39th character	0818_{16} : 0826_{16}	0858_{16} : 0866_{16}	0868_{16} : 0876_{16}
	40th character	0827_{16}	0867_{16}	0877_{16}
Block 2	1st character	0880_{16}	$08C0_{16}$	$08A8_{16}$
	2nd character : 24th character	0881_{16} : 0897_{16}	$08C1_{16}$: $08D7_{16}$	$08A9_{16}$: $08BF_{16}$
	25th character : 39th character	$0E98_{16}$: $08A6_{16}$	$08D8_{16}$: $08E6_{16}$	$08E8_{16}$: $08F6_{16}$
	40th character	$08A7_{16}$	$08E7_{16}$	$08F7_{16}$
Block 3	1st character	0900_{16}	0940_{16}	0928_{16}
	2nd character : 24th character	0901_{16} : 0917_{16}	0941_{16} : 0957_{16}	0929_{16} : $093F_{16}$
	25th character : 39th character	0918_{16} : 0926_{16}	0958_{16} : 0966_{16}	0968_{16} : 0976_{16}
	40th character	0927_{16}	0967_{16}	0977_{16}
Block 4	1st character	0980_{16}	$09C0_{16}$	$09A8_{16}$
	2nd character : 24th character	0981_{16} : 0997_{16}	$09C1_{16}$: $09D7_{16}$	$09A9_{16}$: $09BF_{16}$
	25th character : 39th character	0998_{16} : $09A6_{16}$	$08D8_{16}$: $09E6_{16}$	$09E8_{16}$: $09F6_{16}$
	40th character	$09A7_{16}$	$09E7_{16}$	$09F7_{16}$
Block 5	1st character	$0A00_{16}$	$0A40_{16}$	$0A28_{16}$
	2nd character : 24th character	$0A01_{16}$: $0A17_{16}$	$0A41_{16}$: $0A57_{16}$	$0A29_{16}$: $0A3F_{16}$
	25th character : 39th character	$0A18_{16}$: $0A26_{16}$	$0A58_{16}$: $0A66_{16}$	$0A68_{16}$: $0A76_{16}$
	40th character	$0A27_{16}$	$0A67_{16}$	$0A77_{16}$

Table 13. Contents of OSD RAM (continued)

Block	Display Position (from left)	Character Code Specification	Color Code 1 Specification	Color Code 2 Specification
Block 6	1st character	$0A80_{16}$	$0AC0_{16}$	$0AA8_{16}$
	2nd character : 24th character	$0A81_{16}$: $0A97_{16}$	$0AC1_{16}$: $0AD7_{16}$	$0AA9_{16}$: $0ABF_{16}$
	25th character : 39th character	$0A98_{16}$: $0AA6_{16}$	$0AD8_{16}$: $0AE6_{16}$	$0AE8_{16}$: $0AF6_{16}$
	40th character	$0AA7_{16}$	$0AE7_{16}$	$0AF7_{16}$
Block 7	1st character	$0B00_{16}$	$0B40_{16}$	$0B28_{16}$
	2nd character : 24th character	$0B01_{16}$: $0B17_{16}$	$0B41_{16}$: $0B57_{16}$	$0B29_{16}$: $0B3F_{16}$
	25th character : 39th character	$0B18_{16}$: $0B26_{16}$	$0B58_{16}$: $0B66_{16}$	$0B68_{16}$: $0B76_{16}$
	40th character	$0B27_{16}$	$0B67_{16}$	$0B77_{16}$
Block 8	1st character	$0B80_{16}$	$0BC0_{16}$	$0BA8_{16}$
	2nd character : 24th character	$0B81_{16}$: $0B97_{16}$	$0BC1_{16}$: $0BD7_{16}$	$0BA9_{16}$: $0BBF_{16}$
	25th character : 39th character	$0B98_{16}$: $0BA6_{16}$	$0BD8_{16}$: $0BE6_{16}$	$0BE8_{16}$: $0BF6_{16}$
	40th character	$0BA7_{16}$	$0BE7_{16}$	$0BF7_{16}$
Block 9	1st character	$0C00_{16}$	$0C40_{16}$	$0C28_{16}$
	2nd character : 24th character	$0C01_{16}$: $0C17_{16}$	$0C41_{16}$: $0C57_{16}$	$0C29_{16}$: $0C3F_{16}$
	25th character : 39th character	$0C18_{16}$: $0C26_{16}$	$0C58_{16}$: $0C66_{16}$	$0C68_{16}$: $0C76_{16}$
	40th character	$0C27_{16}$	$0C67_{16}$	$0C77_{16}$
Block 10	1st character	$0C80_{16}$	$0CC0_{16}$	$0CA8_{16}$
	2nd character : 24th character	$0C81_{16}$: $0C97_{16}$	$0CC1_{16}$: $0CD7_{16}$	$0CA9_{16}$: $0CBF_{16}$
	25th character : 39th character	$0C98_{16}$: $0CA6_{16}$	$0CD8_{16}$: $0CE6_{16}$	$0CE8_{16}$: $0CF6_{16}$
	40th character	$0CA7_{16}$	$0CE7_{16}$	$0CF7_{16}$
Block 11	1st character	$0D00_{16}$	$0D40_{16}$	$0D28_{16}$
	2nd character : 24th character	$0D01_{16}$: $0D17_{16}$	$0D41_{16}$: $0D57_{16}$	$0D29_{16}$: $0D3F_{16}$
	25th character : 39th character	$0D18_{16}$: $0D26_{16}$	$0D58_{16}$: $0D66_{16}$	$0D68_{16}$: $0D76_{16}$
	40th character	$0D27_{16}$	$0D67_{16}$	$0D77_{16}$
Block 12	1st character	$0D80_{16}$	$0DC0_{16}$	$0DA8_{16}$
	2nd character : 24th character	$0D81_{16}$: $0D97_{16}$	$0DC1_{16}$: $0DD7_{16}$	$0DA9_{16}$: $0DBF_{16}$
	25th character : 39th character	$0D98_{16}$: $0DA6_{16}$	$0DD8_{16}$: $0DE6_{16}$	$0DE8_{16}$: $0DF6_{16}$
	40th character	$0DA7_{16}$	$0DE7_{16}$	$0DF7_{16}$

Table 13. Contents of OSD RAM (continued)

Block	Display Position (from left)	Character Code Specification	Color Code 1 Specification	Color Code 2 Specification
Block 13	1st character	$0E00_{16}$	$0E40_{16}$	$0E28_{16}$
	2nd character : 24th character	$0E01_{16}$: $0E17_{16}$	$0E41_{16}$: $0E57_{16}$	$0E29_{16}$: $0E3F_{16}$
	25th character : 39th character	$0E18_{16}$: $0E26_{16}$	$0E58_{16}$: $0E66_{16}$	$0E68_{16}$: $0E76_{16}$
	40th character	$0E27_{16}$	$0E67_{16}$	$0E77_{16}$
Block 14	1st character	$0E80_{16}$	$0EC0_{16}$	$0EA8_{16}$
	2nd character : 24th character	$0E81_{16}$: $0E97_{16}$	$0EC1_{16}$: $0ED7_{16}$	$0EA9_{16}$: $0EBF_{16}$
	25th character : 39th character	$0E98_{16}$: $0FA6_{16}$	$0ED8_{16}$: $0EE6_{16}$	$0EE8_{16}$: $0EE6_{16}$
	40th character	$0FA7_{16}$	$0EE7_{16}$	$0EF7_{16}$
Block 15	1st character	$0F00_{16}$	$0F40_{16}$	$0F28_{16}$
	2nd character : 24th character	$0F01_{16}$: $0F17_{16}$	$0F41_{16}$: $0F57_{16}$	$0F29_{16}$: $0F3F_{16}$
	25th character : 39th character	$0F18_{16}$: $0F26_{16}$	$0F58_{16}$: $0F66_{16}$	$0F68_{16}$: $0F76_{16}$
	40th character	$0F27_{16}$	$0F67_{16}$	$0F77_{16}$
Block 16	1st character	$0F80_{16}$	$0FC0_{16}$	$0FA8_{16}$
	2nd character : 24th character	$0F81_{16}$: $0F97_{16}$	$0FC1_{16}$: $0FD7_{16}$	$0FA9_{16}$: $0FBF_{16}$
	25th character : 39th character	$0F98_{16}$: $0FA6_{16}$	$0FD8_{16}$: $0FE6_{16}$	$0FE8_{16}$: $0FF6_{16}$
	40th character	$0FA7_{16}$	$0FE7_{16}$	$0FF7_{16}$

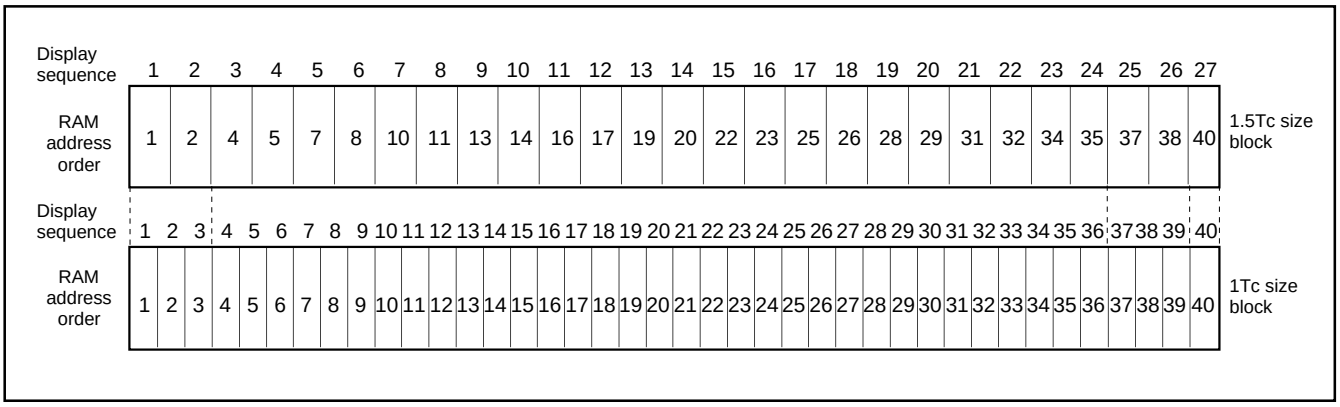


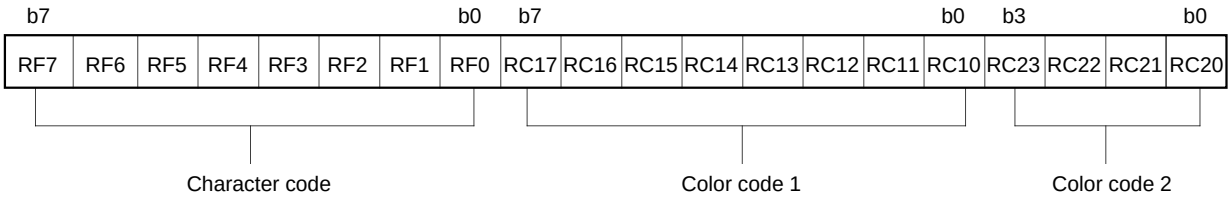
Fig. 81. RAM Data for 3nth Character

Note: Do not read from and write to addresses shown in Table 14.

Table 14. List of Access Disable Addresses

0878$_{16}$	0879$_{16}$	087A$_{16}$
08F8$_{16}$	08F9$_{16}$	08FA$_{16}$
0978$_{16}$	0979$_{16}$	097A$_{16}$
09F8$_{16}$	09F9$_{16}$	09FA$_{16}$
0A78$_{16}$	0A79$_{16}$	0A7A$_{16}$
0AF8$_{16}$	0AF9$_{16}$	0AFA$_{16}$
0B78$_{16}$	0B79$_{16}$	0B7A$_{16}$
0BF8$_{16}$	0BF9$_{16}$	0BFA$_{16}$
0C78$_{16}$	0C79$_{16}$	0C7A$_{16}$
0CF8$_{16}$	0CF9$_{16}$	0CFA$_{16}$
0D78$_{16}$	0D79$_{16}$	0D7A$_{16}$
0DF8$_{16}$	0DF9$_{16}$	0DFA$_{16}$
0E78$_{16}$	0E79$_{16}$	0E7A$_{16}$
0EF8$_{16}$	0EF9$_{16}$	0EFA$_{16}$
0F78$_{16}$	0F79$_{16}$	0F7A$_{16}$
0FF8$_{16}$	0FF9$_{16}$	0FFA$_{16}$

Blocks 1 to16



Bit	CC mode		OSD mode		EXOSD mode	
	Bit name	Function	Bit name	Function	Bit name	Function
RF0 RF1 RF2 RF3 RF4 RF5 RF6 RF7	Character code (Low-order 8 bits)	Specification of character code in OSD ROM	Character code (Low-order 8 bits)	Specification of character code in OSD ROM	Character code (Low-order 8 bits)	Specification of character code in OSD ROM
RC10	0	———	0	———	0	———
RC11 RC12 RC13	Control of character color R Control of character color G Control of character color B	0: Color signal output OFF 1: Color signal output ON	Control of character color R Control of character color G Control of character color B	0: Color signal output OFF 1: Color signal output ON	Character color code 0 (CC0) Character color code 1 (CC1) Character color code 2 (CC2)	Specification of character color
RC14	OUT1 control	0: Character output 1: Background output	OUT1 control	0: Character output 1: Background output	OUT1 control	0: Character output 1: Background output
RC15	Flash control	0: Flash OFF 1: Flash ON	Not used	———	Extra code 0 (EX0)	Specification of extra code in OSD ROM
RC16	Underline control	0: Underline OFF 1: Underline ON			Extra code 1 (EX1)	
RC17	Italic control	0: Italic OFF 1: Italic ON			Extra code 2 (EX2)	
RC20 RC21 RC22	Control of background color R Control of background color G Control of background color B	0: Color signal output OFF 1: Color signal output ON	Control of background color R Control of background color G Control of background color B	0: Color signal output OFF 1: Color signal output ON	Background color code 0 (BCC0) Background color code 1 (BCC1) Background color code 2 (BCC2)	Specification of background color
RC23	Not used	———	Not used	———	Extra code 3 (EX3)	Specification of extra code in OSD ROM

Notes 1: Read value of bits 4 to 7 of the color code 2 is undefined.
2: For “not used” bits, the write value is read.
3: Set “0” to RC10.

Fig. 82. Structure of OSD RAM

(7) Character color

The color for each character is displayed by the color code 1. The kinds and specification method of character color are different depending on each mode.

- CC mode ..... 7 kinds
  Specified by bits 1 (R), 2 (G), and 3 (B) of color code 1
- OSD mode ..... 7 kinds
  Specified by bits 1 (R), 2 (G) and 3 (B)of color code 1
- EXOSD mode ..... 5 kinds
  Specified by bits 1 (CC0), 2 (CC1), and 3 (CC2) of color code 1

The correspondence Table of color code 1 and color signal output in the EXOSD mode is shown in Table 15.

(8) Character background color

The character background color can be displayed in the character display area. The character background color for each character is specified by color code 2. The kinds and specification method of character background color are different depending on each mode.

- CC mode ..... 7 kinds
  Specified by bits 0 (R), 1 (G), and 2 (B) of color code 2
- OSD mode ..... 7 kinds
  Specified by bits 0 (R), 1 (G), and 2 (B) of color code 2
- EXOSD mode ..... 5 kinds
  Specified by bits 0 (BCC0), 1 (BCC1), and 2 (BCC2) of color code 2

The correspondence table of the color code 2 and color signal output in the EXOSD mode is shown in Table 16.

Note : The character background color is displayed in the following part :
(character display area)–(character font)–(border)–(extra font).
Accordingly, the character background color does not mix with these color signal.

Table 15. Correspondence Table of Color Code 1 and Color Signal Output in EXOSD Mode

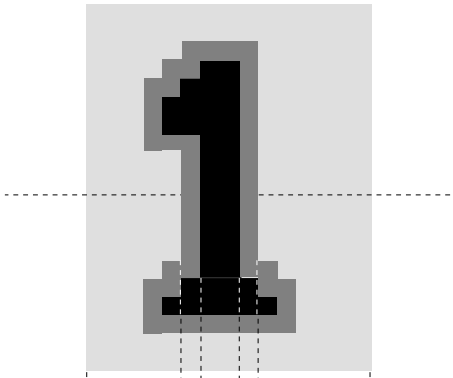
Color Code 1			Color Signal Output		
Bit 3 CC2	Bit 2 CC1	Bit 1 CC0	R	G	B
0	0	0	0	0	0
0	0	1	1	0	0
0	1	0	0	1	0
0	1	1	1	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	0	1	1
1	1	1	1	1	1

Table 16. Correspondence Table of Color Code 2 and Color Signal Output in EXOSD Mode

Color Code 2			Color Signal Output		
Bit 2 BCC2	Bit 1 BCC1	Bit 0 BCC0	R	G	B
0	0	0	0	0	0
0	0	1	1	0	0
0	1	0	0	1	0
0	1	1	1	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	0	1	1
1	1	1	1	1	1

(9) OUT1, OUT2 signals

The OUT1, OUT2 signals are used to control the luminance of the video signal. The output waveform of the OUT1, OUT2 signals is controlled by bit 4 of color code 1 (refer to Figure 82), bits 2 and 7 of the block control register i (refer to Figure 65). The setting values for controlling OUT1, OUT2 and the corresponding output waveform is shown in Figure 83.



Block control register i		OUT1 control (b4 of color code 1)	Output waveform
OUT2 output control bit (b7)	Border output control bit (b2)		
0	0	0	OUT1 / OUT2
		1	OUT1 / OUT2
	1	0	OUT1 / OUT2
		1	OUT1 / OUT2
1	0	0	OUT1 / OUT2
		1	OUT1 / OUT2
	1	0	OUT1 / OUT2
		1	OUT1 / OUT2

Fig. 83. Setting Value for Controlling OUT1, OUT2 and Corresponding Output Waveform

(10) Attribute

The attributes (flash, underline, italic) are controlled to the character font. The attributes for each character are specified by the color codes 1 and 2 (refer to Figure 71). The attributes to be controlled are different depending on each mode.

CC mode ..... Flash, underline, italic
OSD mode ..... Border (all bordered, shadow bordered can be selected)
EXOSD mode ..... Border (all bordered, shadow bordered can be selected) , extra font (16 kinds)

①Under line

The underline is output at the 23th and 24th dots in vertical direction only in the CC mode. The underline is controlled by bit 6 of color code 1. The color of underline is the same color as that of the character font.

②Flash

The parts of the character font, the underline, and the character background are flashed only in the CC mode. The color signals (R, G, B, OUT1) of the character font and the underline are controlled by bit 5 of color code 1. All of the color signals for the character font flash. However, the color signal for the character background can be controlled by bit 3 of the OSD control register (refer to Figure 64). The flash cycle bases on the VSYNC count.

· VSYNC cycle 5 48 ; 800 ms (at flash ON)
· VSYNC cycle 5 16 ; 267 ms (at flash OFF)

③Italic

The italic is made by slanting the font stored in OSD ROM to the right only in the CC mode. The italic is controlled by bit 7 of color code 1.

The display example of the italic and underline is shown in Figure 85. In this case, “R” is displayed.

Notes 1: When setting both the italic and the flash, the italic character flashes.
2: When the pre-divide ratio = 1, the italic character with slant of 1 dot 5 5 steps is displayed (refer to Figure 84 (c)). When the pre-divide ratio = 2, the italic character with slant of 1/2 dot 5 10 steps is displayed (refer to Figure 84 (d)).
3: The boundary of character color is displayed in italic. However, the boundary of character background color is not affected by the italic (refer to Figure 85).
4: The adjacent character (one side or both side) to an italic character is displayed in italic even when the character is not specified to display in italic (refer to Figure 85).
5: When displaying the italic character in the block with the pre-divide ratio = 1, set the OSD clock frequency to 11 MHz to 14 MHz.

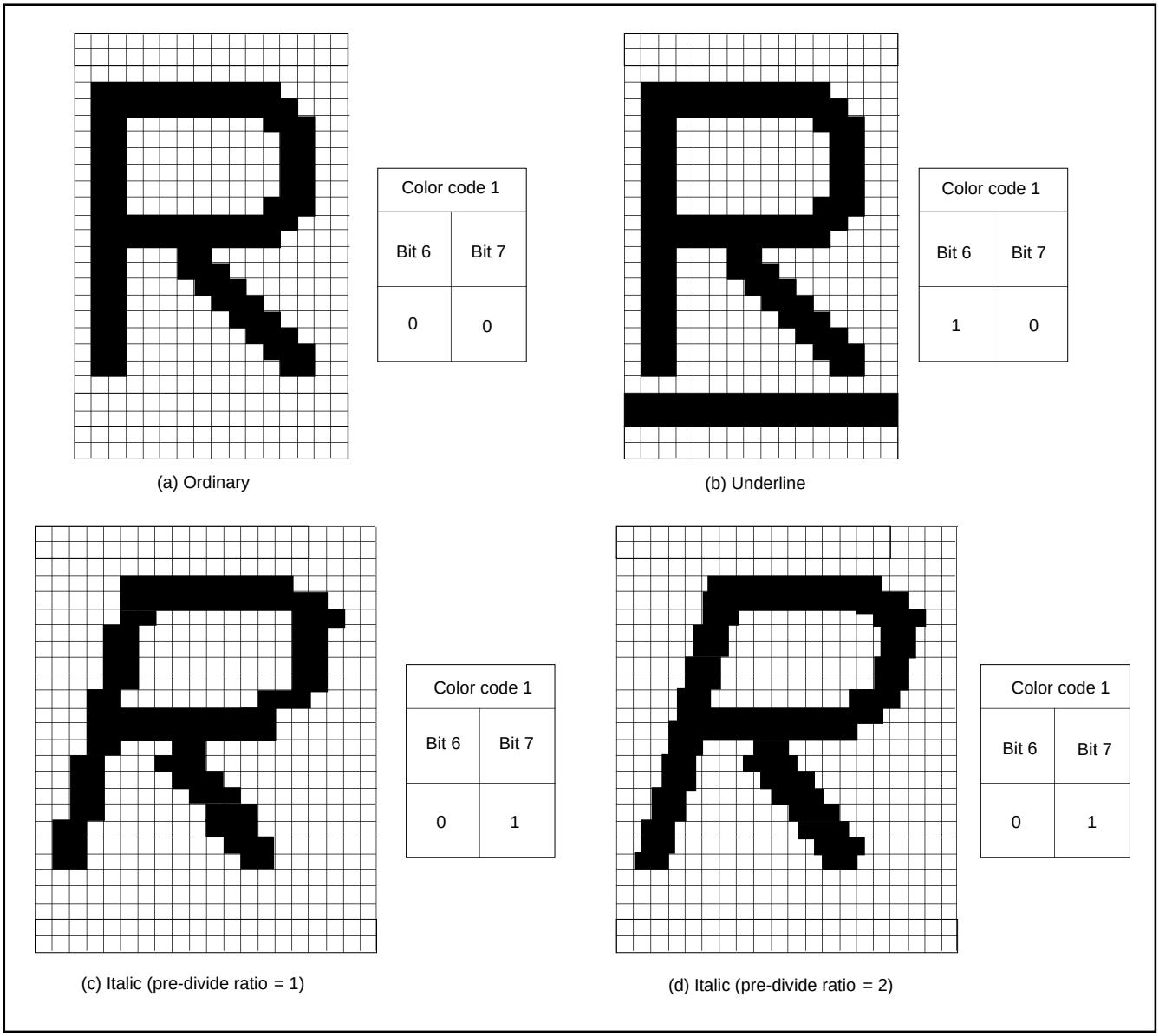


Fig. 84. Example of Attribute Display (in CC mode)

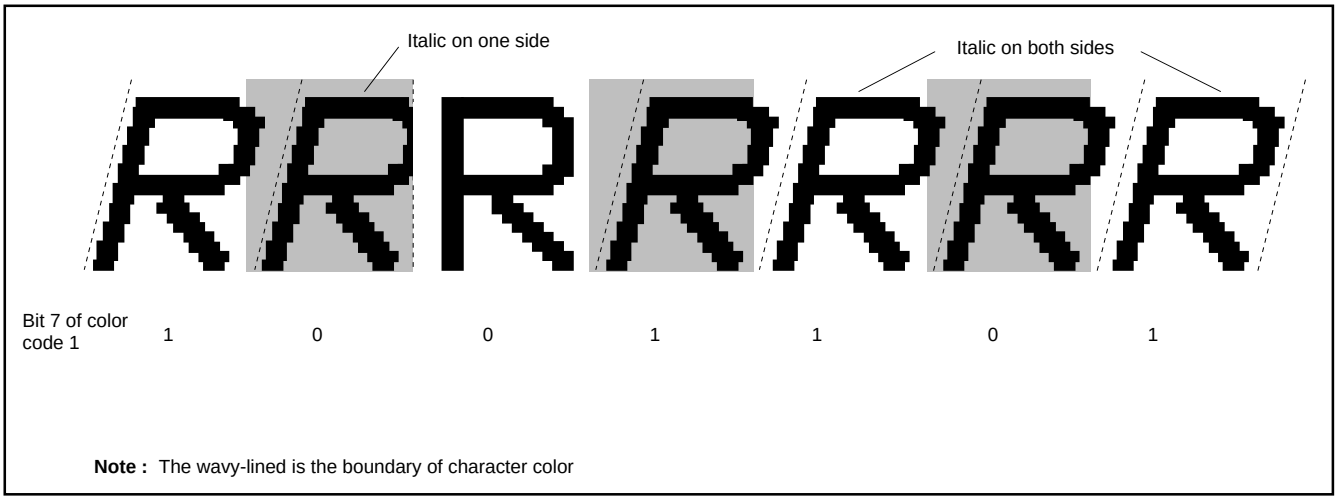


Fig. 85. Example of Italic Display

④ **Extra font**

There are 16 kinds of the extra fonts configured with 16 × 26 dots in OSD ROM. This 16 kinds fonts can be displayed by ORed with the character font by a character unit (refer to Figure 62). In only the EXOSD mode, the extra font is controlled the following : bits 7 to 5 of the color code 1 and bit 3 of the color code 2.

The extra font color for each screen is specified by the extra color register. When the character font overlaps with the extra font, the color of the area becomes the ORed color of both fonts.

Notes 1 : When using the extra font, set bits 7 and 6 of the OSD control register to "0" (refer to Figure 64).

2 : Extra fonts are always displayed by ORed with the character font. Accordingly, when displaying only a extra font, set a blank for a character font and OR with it.

Extra Font Color Register

b7 b6 b5 b4 b3 b2 b1 b0
0 0

Extra font color register (EC) [Address 0219_{16}]

B	Name	Functions	After reset	R	W
0	Extra font color R control bit (EC0)	0 : No output 1 : Output	0	R	W
1	Extra font color G control bit (EC1)	0 : No output 1 : Output	0	R	W
2	Extra font color B control bit (EC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to "0."		0	R	W
5 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are "0."		0	R	—

Fig. 86. Extra Font Color Register

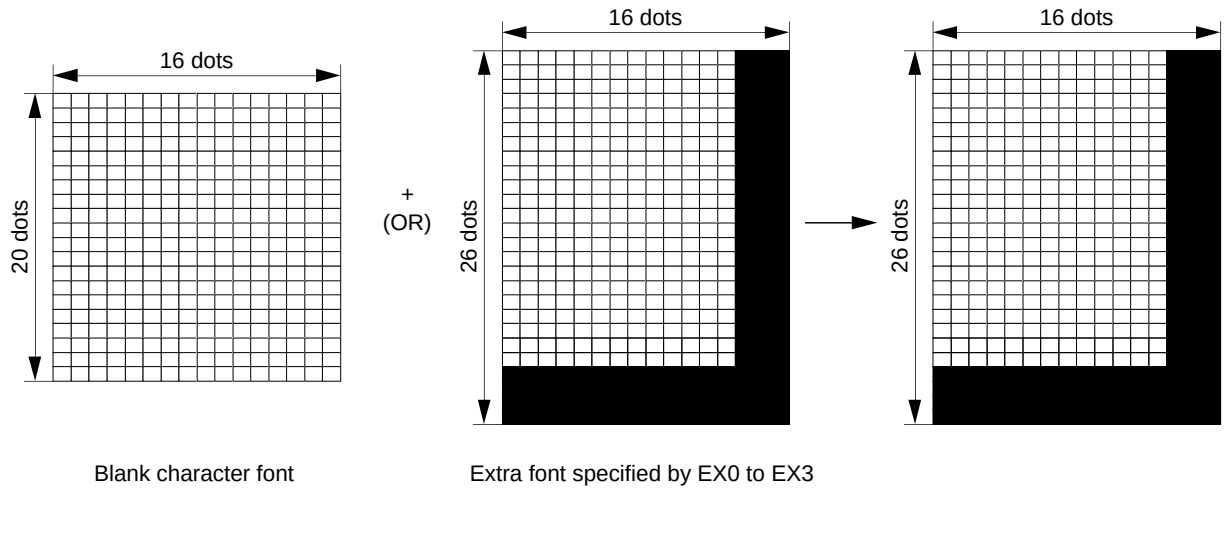


Fig. 87. Display Example of Only Extra Font

⑤Border

The border is output in the OSD mode and the EXOSD mode. The all bordered (bordering around of character font) and the shadow bordered (bordering right and bottom sides of character font) are selected (refer to Figure 88) by bit 2 of the OSD control register (refer to Figure 64). The border ON/OFF is controlled by bit 2 of the block control register (refer to Figure 65).

The OUT1 signal is used for border output. The border color for each screen is specified by the border color register.

The horizontal size (x) of border is 1Tc (OSD clock cycle divided in the pre-divide circuit) regardless of the character font dot size. However, only when the pre-divide ratio = 2 and character size = 1.5Tc, the horizontal size is 1.5Tc. The vertical size (y) different depending on the screen scan mode and the vertical dot size of character font.

Notes 1 : There is no border for the extra font.

2 : The border dot area is the shaded area as shown in Figure 90. In the EXOSD mode, top and bottom of character font display area is not bordered.

3 : When the border dot overlaps on the next character font, the character font has priority (refer to Figure 91 A). When the border dot overlaps on the next character back ground, the border has priority (refer to Figure 91 B).

4 : The border is not displayed at right side of the most right dot in the display area of the 40th character (the character located at the most right of the block).
However, note that MASK version cannot display the border for the right edge dots of the 36th's character area.

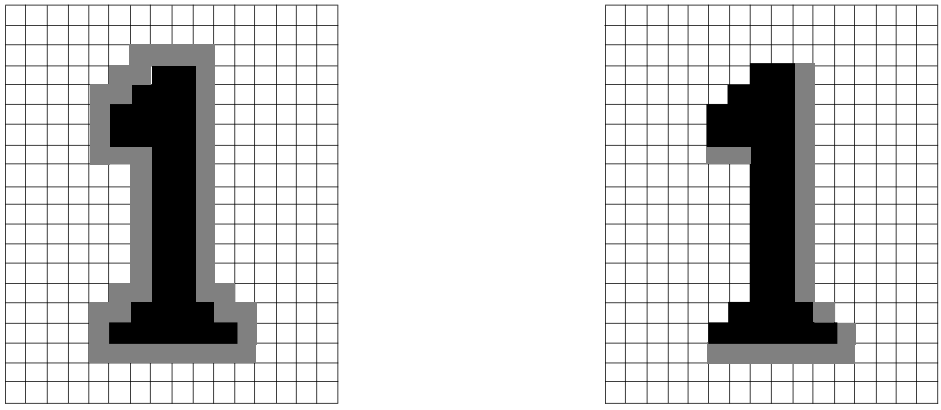
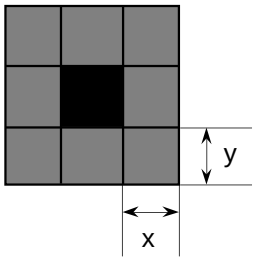


Fig. 88. Example of Border Display



Scan mode / Vertical dot size of character font	Normal scan mode		Bi-scan mode
Border dot size	1/2H	1H, 2H, 3H	1/2H, 1H, 2H, 3H
Horizontal size (x)	1Tc (OSD clock cycle divided in pre-divide circuit) 1.5Tc when selecting 1.5Tc for character size.		
Vertical size (y)	1/2H	1H	1H

Fig. 89. Horizontal and Vertical Size of Border

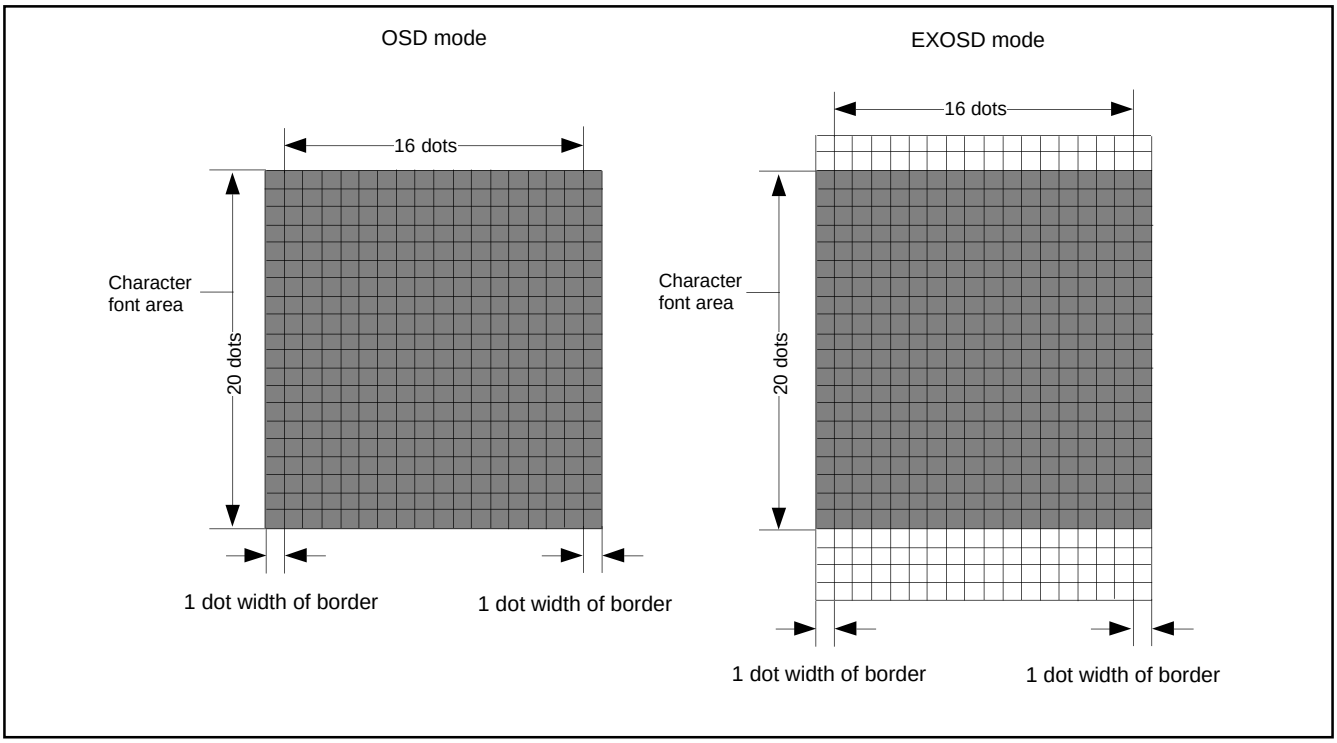


Fig. 90. Border Area

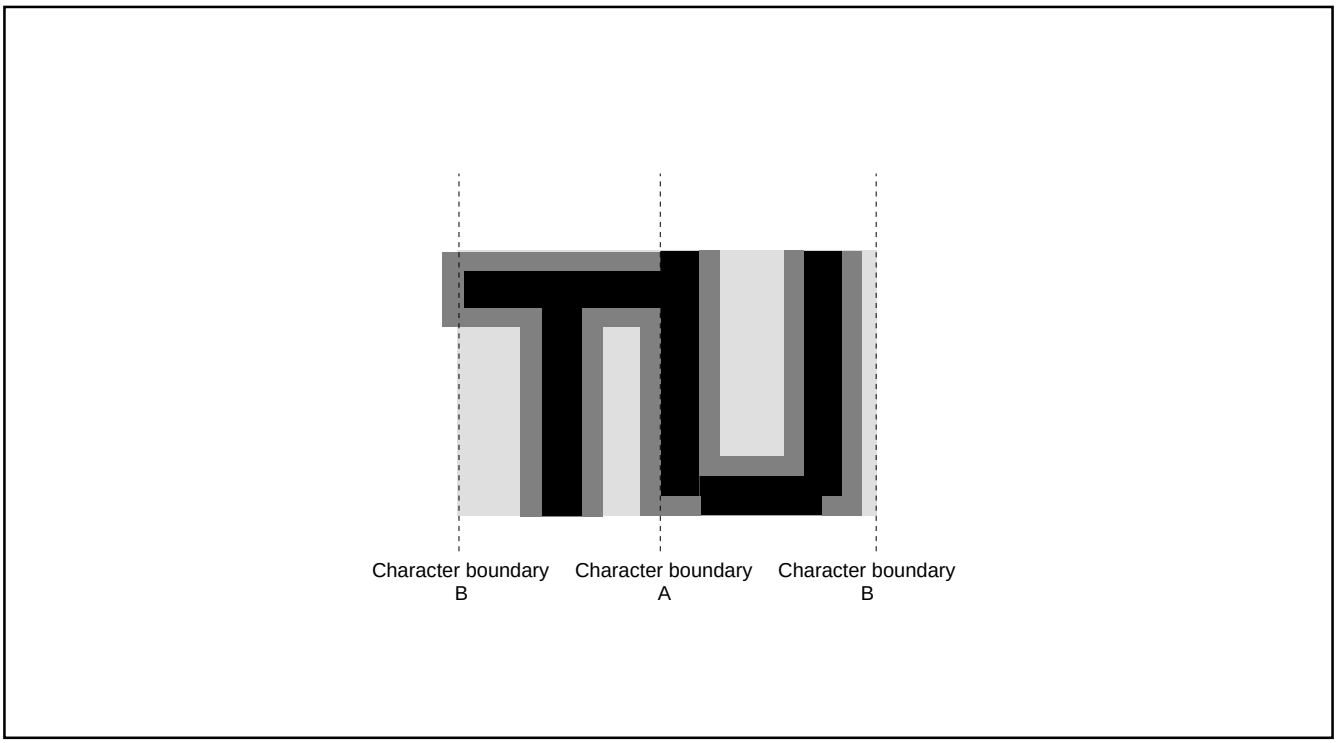
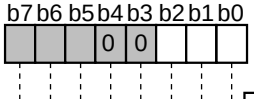


Fig. 91. Border Priority

Border Color Register



Border color register (FC) [Address $021B_{16}$]

B	Name	Functions	After reset	R	W
0	Border color R control bit (FC0)	0 : No output 1 : Output	0	R	W
1	Border color G control bit (FC1)	0 : No output 1 : Output	0	R	W
2	Border color B control bit (FC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to “0.”		0	R	W
5 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		0	R	—

Fig. 92. Border Color Register

(11) Multiline Display

The M37274EFSP can ordinarily display 16 lines on the CRT screen by displaying 16 blocks at different vertical positions. In addition, it can display up to 16 lines by using OSD interrupts.

An OSD interrupt request occurs at the point at which display of each block has been completed. In other words, when a scanning line reaches the point of the display position (specified by the vertical position registers) of a certain block, the character display of that block starts, and an interrupt occurs at the point at which the scanning line exceeds the block. The mode in which an OSD interrupt occurs is different depending on the setting of the raster color register (refer to Figure 99).

- When bit 7 of the raster color register is "0"
  An OSD interrupt occurs at the end of block display in the OSD and the EXOSD mode.
- When bit 7 of the raster color register is "1"
  An OSD interrupt occurs at the end of block display in the CC mode.

Notes 1: An OSD interrupt does not occur at the end of display when the block is not displayed. In other words, if a block is set to off display by the display control bit of the block control register (addresses $00D0_{16}$ to $00DB_{16}$), an OSD interrupt request does not occur (refer to Figure 93 (A)).

2: When another block display appeares while one block is displayed, an OSD interrupt request occurs only once at the end of the another block display (refer to Figure 93 (B)).

3: On the screen setting window, an OSD interrupt occurs even at the end of the CC mode block (off display) out of window (refer to Figure 93 (C)).

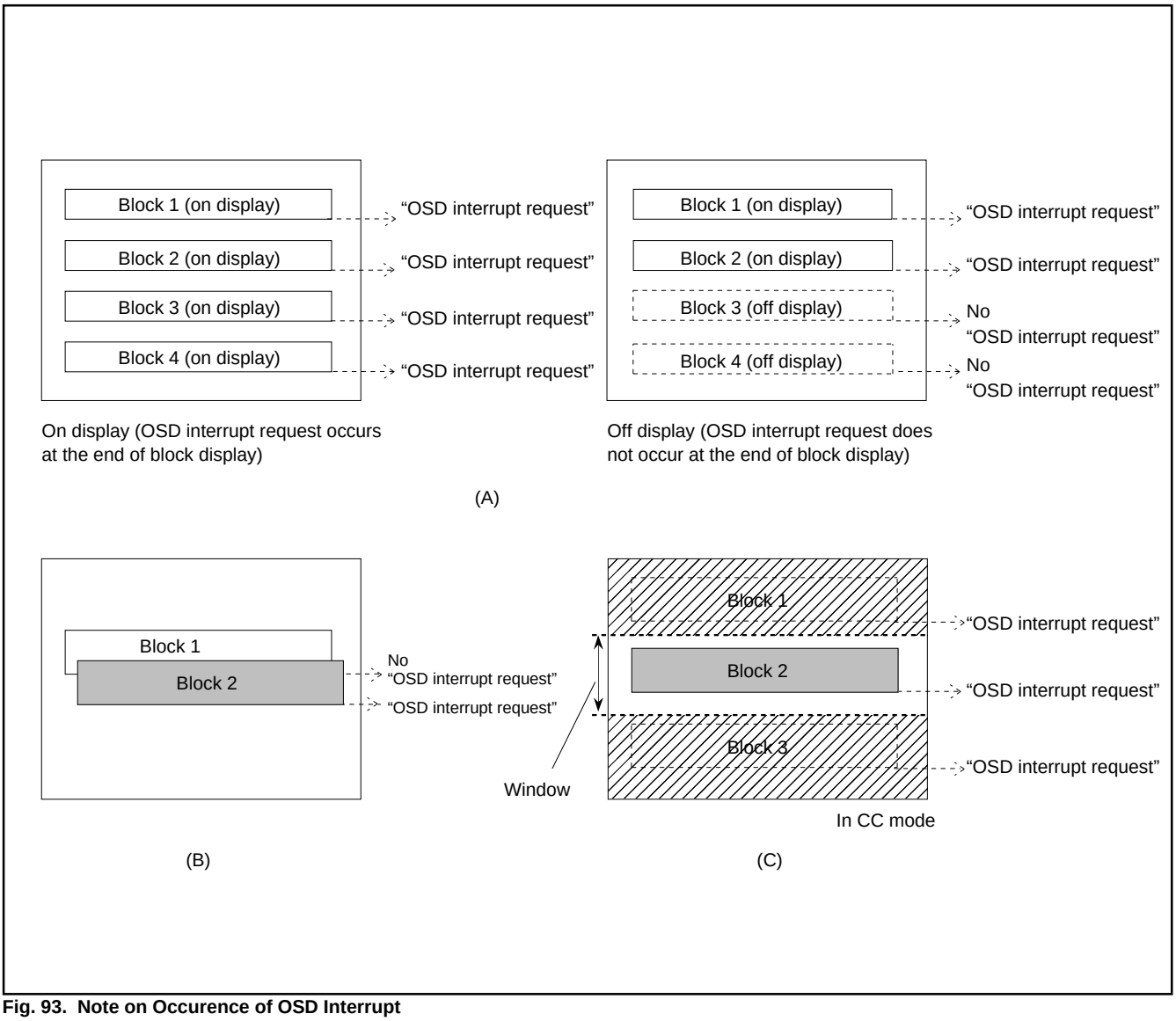


Fig. 93. Note on Occurence of OSD Interrupt

(12) Automatic Solid Space Function

This function generates automatically the solid space (OUT1 or OUT2 blank output) of the character area in the CC mode.
The solid space is output in the following area :
· the character area except character code "09_{16} "
· the character area on the left and right sides
This function is turned on and off by bit 4 of the OSD control register (refer to Figure 64).

Note : When using this function, set "09_{16}" to the character below :
· The 1st character
· The 34th character and the following character.

Table 17. Setting for Automatic Solid Space

Bit 4 of OSD control register	0				1			
Bit 7 of block control register	0		1		0		1	
Bit 4 of color code 1	0	1	0	1	0	1	0	1
OUT1 output signal	Character font part	Character display area	Character font part		Solid space		Character font part	
OUT2 output signal	OFF		OFF	Character display area	OFF		Solid space	

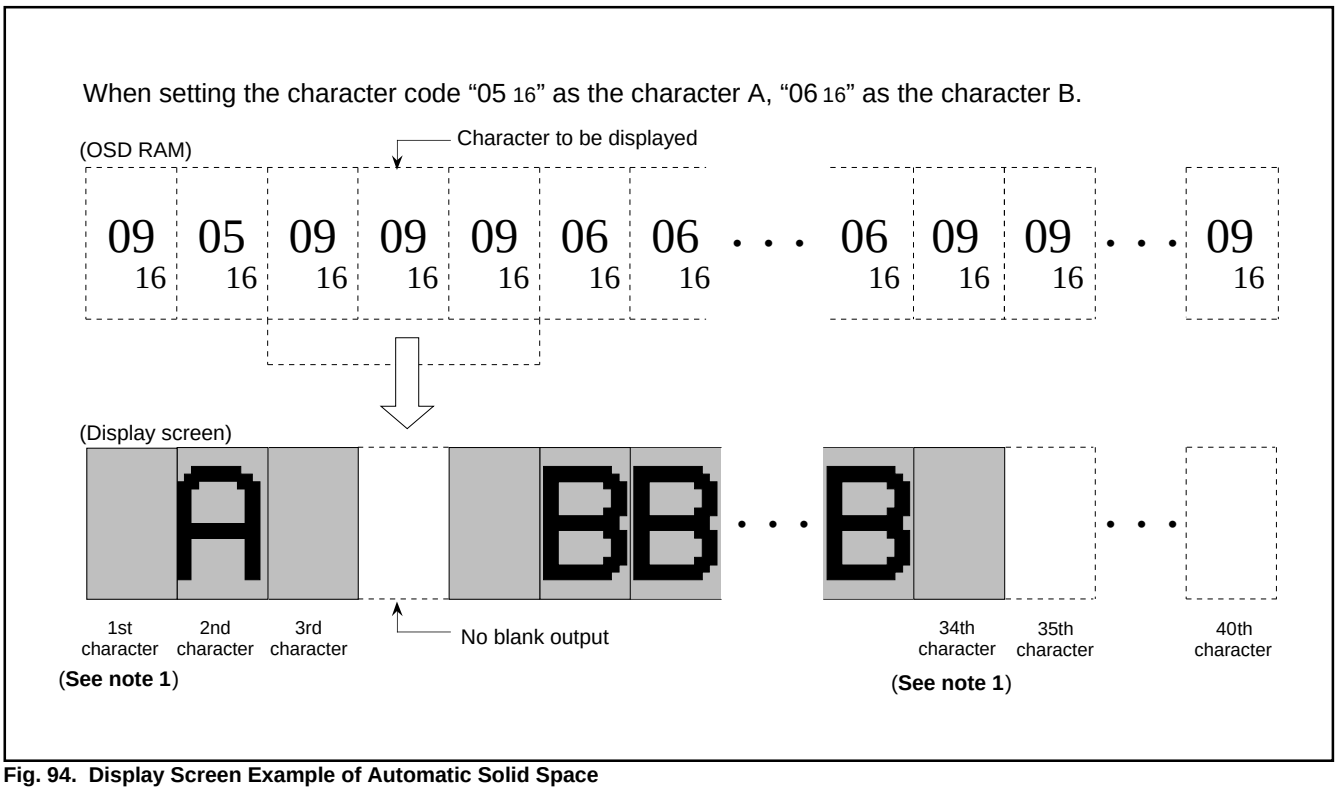


Fig. 94. Display Screen Example of Automatic Solid Space

(13) Scan Mode

M37274EFSP has the bi-scan mode for corresponding to HSYNC of double speed frequency. In the bi-scan mode, the vertical start display position and the vertical size is two times as compared with the normal scan mode. The scan mode is selected by bit 1 of the OSD control register (refer to Figure 64).

Table 18. Setting for Scan Mode

Parameter \ Scan Mode	Normal Scan	Bi-Scan
Bit 1 of OSD control register	0	1
Vertical display start position	Value of vertical position register × 1H	Value of vertical position register × 2H
Vertical dot size	1Tc × 1/2H	1Tc × 1H
	1Tc × 1H	1Tc × 2H
	2Tc × 2H	2Tc × 4H
	3Tc × 3H	3Tc × 6H

(14) Window Function

This function sets the top and bottom boundary of display limit on a screen. The window function is valid only in the CC mode. The top boundary is set by window H registers 1 and 2. The bottom boundary is set by window L registers 1 and 2. This function is turned on and off by bit 5 of the OSD control register (refer to Figure 64).
The window H registers 1 and 2 is shown in Figures 96 and 97, of window L registers 1 and 2 is shown in Figures 98 and 99.

Notes 1: Set values except "00_{16}" and "01_{16}" to the window H register 1 when the window H register 2 is "00_{16}."
2: Set the register value fit for the following condition :
(WH1 + WH2) < (WL1 + WL2)

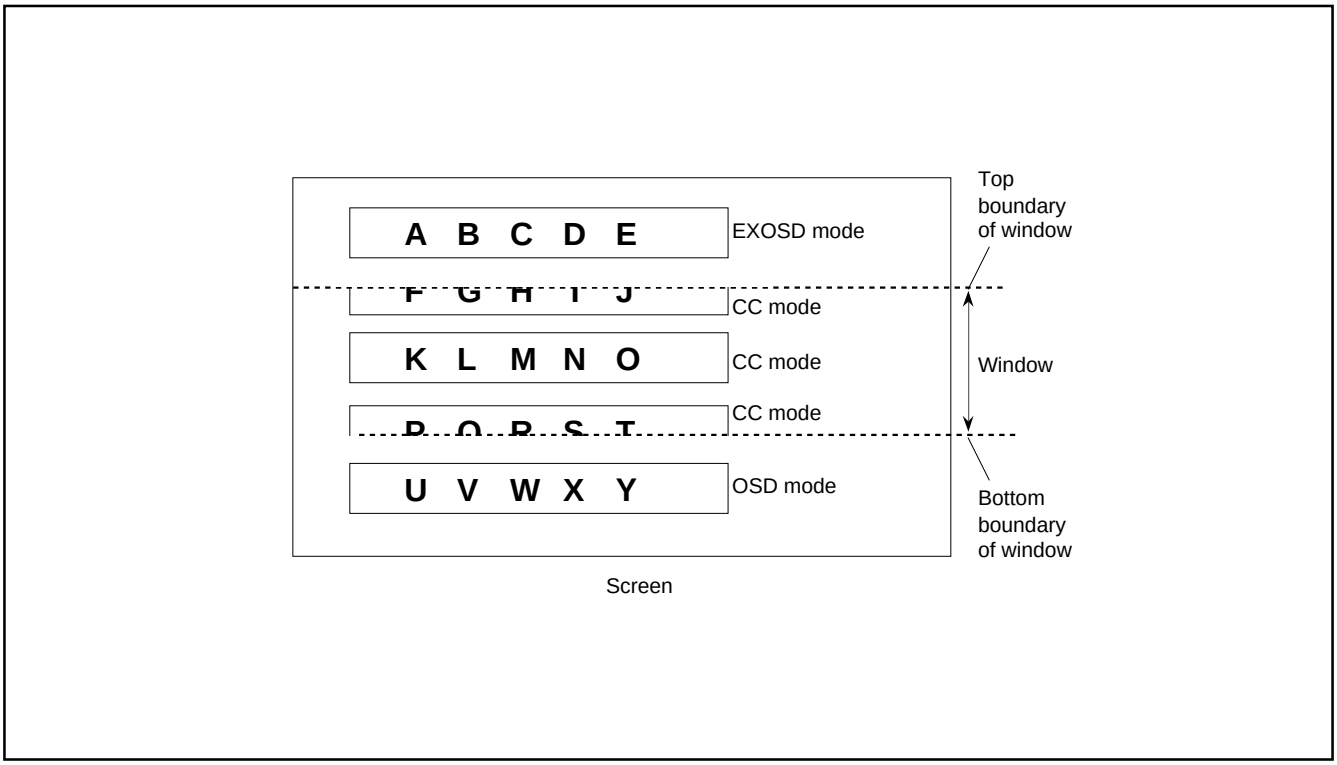
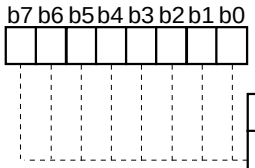


Fig. 95. Example of Window Function

Window H Register 1



Window H register 1 (WH1) [Address 021C16]

B	Name	Functions	After reset	R	W
0 to 7	Control bits of window top boundary (WN10 to WN17) (See note 1)	Top boundary position (low-order 8 bits) TH × (setting value of low-order 2 bits of WH2 × 16^2 + setting value of high-order 4 bits of WH1 × 16^1 + setting value of low-order 4 bits of WH1 × 16^0)	Indeterminate	R	W

Notes 1: Set values except "00 16" to the WH1 when WH2 is "00 16."
2: TH is cycle of HSYNC.
3: WH2: Window H register 2

Fig. 96. Window H Register 1

Window H Register 2

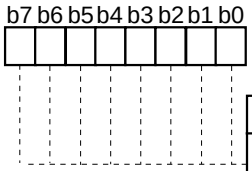
Window H register 2 (WH2) [Address 021E16]

B	Name	Functions	After reset	R	W
0, 1	Control bits of window top boundary (WN20 ,WN21) (See note 1)	Top boundary position (high-order 2 bits) TH × (setting value of low-order 2 bits of WH2 × 16^2 + setting value of high-order 4 bits of WH1 × 16^1 + setting value of low-order 4 bits of WH1 × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values except "00 16" to the WH1 when WH2 is "00 16."
2: TH is cycle of HSYNC.
3: WH1: Window H register 1

Fig. 97. Window H Register 2

Window L Register 1



Window L register 1 (WL1) [Address 021D16]

B	Name	Functions	After reset	R	W
0 to 7	Control bits of window top boundary (WL10 to WL17) (See note 1)	Top boundary position (low-order 8 bits) TH × (setting value of low-order 2 bits of WL2 × 16^2 + setting value of high-order 4 bits of WL1 × 16^1 + setting value of low-order 4 bits of WL1 × 16^0)	Indeterminate	R	W

Notes 1: Set values fit for the following condition: (WH1+WH2 ×16^2)<(WL1+WL2×16^2)
2: TH is cycle of HSYNC.
3: WL2: Window L register 2

Fig. 98. Window L Register 1

Window L Register 2

Window L register 2 (WL2) [Address 021F16]

B	Name	Functions	After reset	R	W
0, 1	Control bits of window top boundary (WL20, WL21) (See note 1)	Top boundary position (high-order 2 bits) TH × (setting value of low-order 2 bits of WL2 × 16^2 + setting value of high-order 4 bits of WL1 × 16^1 + setting value of low-order 4 bits of WL1 × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values fit for the following condition: (WH1+WH2 ×16^2)<(WL1+WL2×16^2)
2: TH is cycle of HSYNC.
3: WL1: Window L register 1

Fig. 99. Window L Register 2

(15) OSD Output Pin Control

The OSD output pins R, G, B, and OUT1 can also function as ports $P5_2$, $P5_3$, $P5_4$ and $P5_5$. Set the corresponding bit of the OSD port control register (address $00CB_{16}$) to "0" to specify these pins as OSD output pins, or set it to "1" to specify it as a general-purpose port P5 pins. The OUT2 can also function as port $P1_0$. Set the corresponding bit of the port P1 direction register (address $00C3_{16}$) to "1" (output mode). After that, switch between the OSD output function and the port function by the OSD port control register. Set the corresponding bit to "1" to specify the pin as OSD output pin, or set it to "0" to specify as port P1 pin.

The input polarity of the HSYNC, VSYNC and output polarity of signals R, G, B, OUT1 and OUT2 can be specified with the I/O polarity control register (address 0217_{16}) . Set a bit to "0" to specify positive polarity; set it to "1" to specify negative polarity (refer to Figure 78).

The OSD port control register is shown in Figure 100.

OSD Port Control Register

b7	b6	b5	b4	b3	b2	b1	b0
0						0	0

OSD port control register (PF) [Address $00CB_{16}$]

B	Name	Functions	After reset	R	W
0, 1, 7	Fix these bits to "0."		0	R	W
2	Port $P5_2$ output signal selection bit (R)	0 : R signal output 1 : Port $P5_2$ output	0	R	W
3	Port $P5_3$ output signal selection bit (G)	0 : G signal output 1 : Port $P5_3$ output	0	R	W
4	Port $P5_4$ output signal selection bit (B)	0 : B signal output 1 : Port $P5_4$ output	0	R	W
5	Port $P5_5$ output signal selection bit (OUT1)	0 : OUT1 signal output 1 : Port $P5_5$ output	0	R	W
6	Port $P1_0$ output signal selection bit (OUT2)	0 : Port $P1_0$ output 1 : OUT2 signal output (**Note**)	0	R	W

Note. Set bit 0 of Port P1 direction register (address $00C3_{16}$) to "1" (output mode).

Fig. 100. OSD Port Control Register

(16) Raster Coloring Function

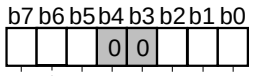
An entire screen (raster) can be colored by setting the bits 6 to 0 of the raster color register. Since each of the R, G, B, OUT1, and OUT2 pins can be switched to raster coloring output, 7 raster colors can be obtained.

If the OUT1 pin has been set to raster coloring output, a raster coloring signal is always output during 1 horizontal scanning period. This setting is necessary for erasing a background TV image.

If the R, G, and B pins have been set to output, a raster coloring signal is output in the part except a no-raster colored character (in Figure 102, a character “1”) and the character background output during 1 horizontal scanning period. This ensures that the character color/the character background color is not mixed with the raster color.

The structure of the raster color register is shown in Figure 101, the example of raster coloring is shown in Figure 102.

Raster Color Register



Raster color register (RC) [Address 0218_{16}]

B	Name	Functions	After reset	R	W
0	Raster color R control bit (RC0)	0 : No output 1 : Output	0	R	W
1	Raster color G control bit (RC1)	0 : No output 1 : Output	0	R	W
2	Raster color B control bit (RC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to “0.”		0	R	—
5	Raster color OUT1 control bit (RC5)	0 : No output 1 : Output	0	R	W
6	Raster color OUT2 control bit (RC6)	0 : No output 1 : Output	0	R	W
7	OSD interrupt source selection bit (RC7)	0 : Interrupt occurs at end of OSD or EXOSD block display 1 : Interrupt occurs at end of CC mode block display	0	R	W

Fig. 101. Raster Color Register

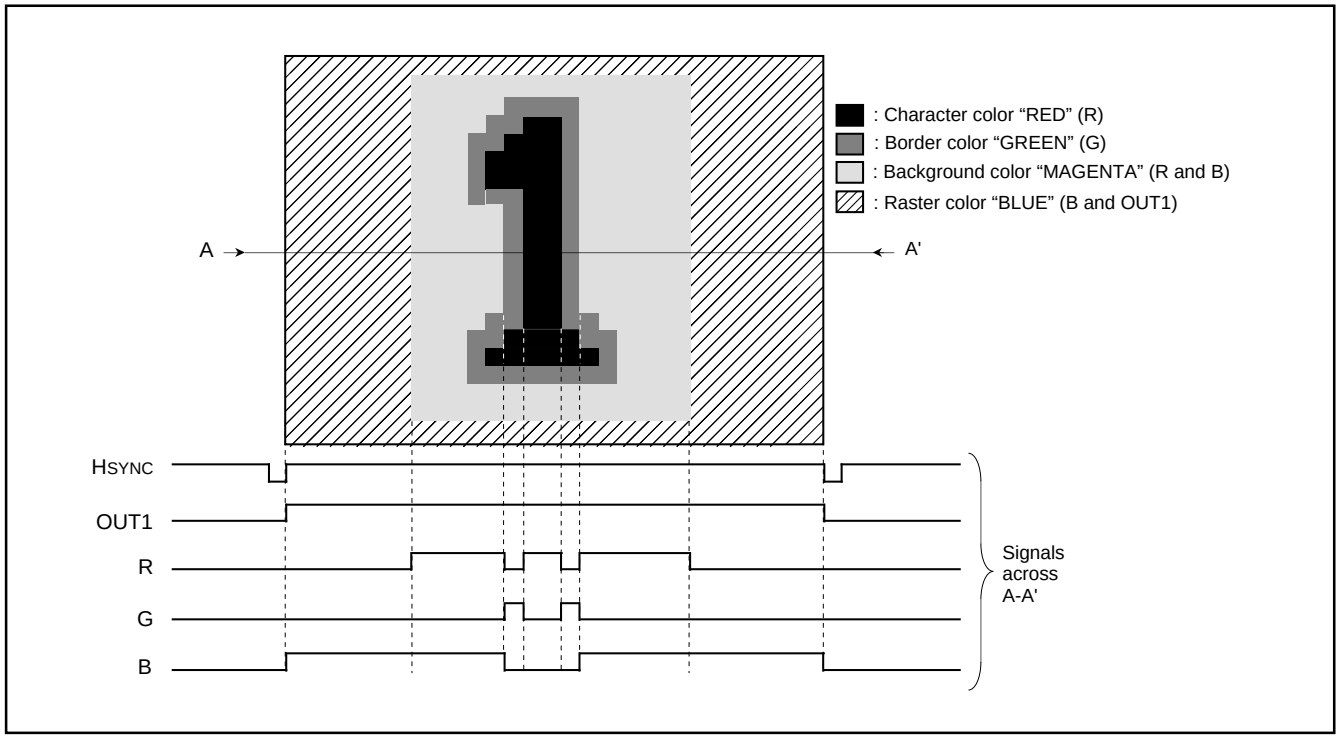


Fig. 102. Example of Raster Coloring

ROM CORRECTION FUNCTION

This can correct program data in ROM. Up to 2 addresses (2 blocks) can be corrected, a program for correction is stored in the ROM correction memory in RAM. The ROM memory for correction is 32 bytes × 2 blocks.

Block 1 : addresses $02C0_{16}$ to $02DF_{16}$
Block 2 : addresses $02E0_{16}$ to $02FF_{16}$

Set the address of the ROM data to be corrected into the ROM correction address register. When the value of the counter matches the ROM data address in the ROM correction address, the main program branches to the correction program stored in the ROM memory for correction. To return from the correction program to the main program, the op code and operand of the JMP instruction (total of 3 bytes) are necessary at the end of the correction program. When the blocks 1 and 2 are used in series, the above instruction is not needed at the end of the block 1.

The ROM correction function is controlled by the ROM correction enable register.

Notes 1 : Specify the first address (op code address) of each instruction as the ROM correction address.
2 : Use the JMP instruction (total of 3 bytes) to return from the main program to the correction program.
3 : Do not set the same ROM correction address to blocks 1 and 2.

ROM correction address 1 (high-order)	0242_{16}
ROM correction address 1 (low-order)	0243_{16}
ROM correction address 2 (high-order)	0244_{16}
ROM correction address 2 (low-order)	0245_{16}

Fig. 103. ROM Correction Address Registers

ROM Correction Enable Register

b7 b6 b5 b4 b3 b2 b1 b0
0 0

ROM correction enable register (RCR) [Address 0246_{16}]

B	Name	Functions	After reset	R	W
0	Block 1 enable bit (RC0)	0: Disabled 1: Enabled	0	R	W
1	Block 2 enable bit (RC1)	0: Disabled 1: Enabled	0	R	W
2, 3	Fix these bits to “0.”		0	R	W
4 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		0	R	—

Fig. 104. ROM Correction Enable Register

RESET CIRCUIT

When the oscillation of a quartz-crystal oscillator or a ceramic resonator is stable and the power source voltage is 5 V ± 10 %, hold the $\overline{\text{RESET}}$ pin at LOW for 2 μs or more, then return is to HIGH. Then, as shown in Figure 106, reset is released and the program starts form the address formed by using the content of address FFFF16 as the high-order address and the content of the address FFFE16 as the low-order address. The internal state of microcomputer at reset are shown in Figures 5 to 9.

An example of the reset circuit is shown in Figure 105.

The reset input voltage must be kept 0.9 V or less until the power source voltage surpasses 4.5 V.

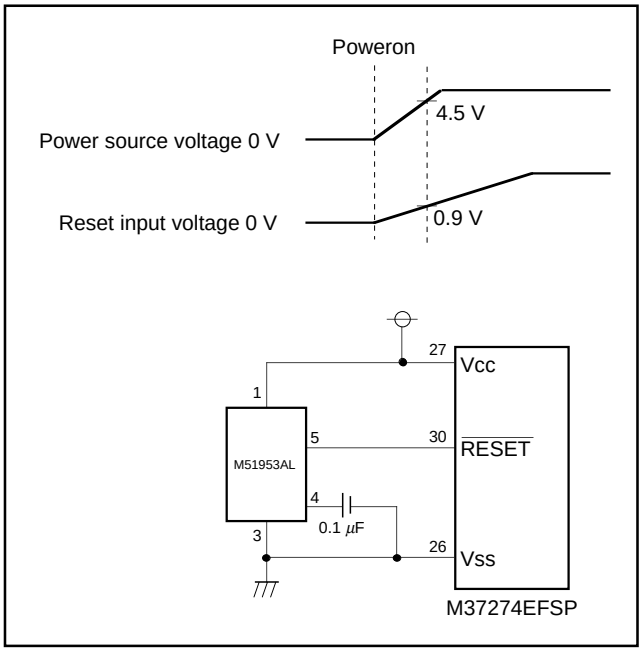
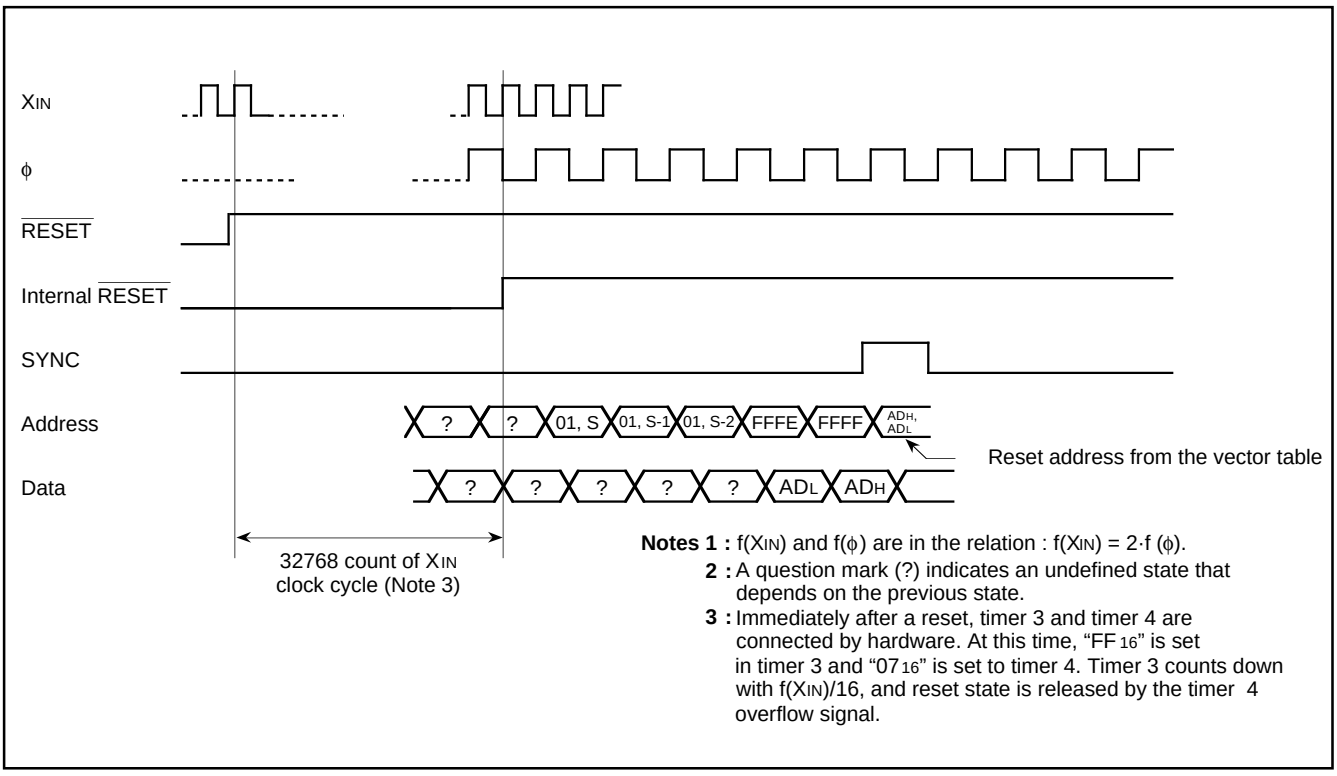


Fig. 105. Example of Reset Circuit



Notes 1 : f(XIN) and f(ϕ) are in the relation : f(XIN) = 2·f (ϕ).
2 : A question mark (?) indicates an undefined state that depends on the previous state.
3 : Immediately after a reset, timer 3 and timer 4 are connected by hardware. At this time, "FF16" is set in timer 3 and "0716" is set to timer 4. Timer 3 counts down with f(XIN)/16, and reset state is released by the timer 4 overflow signal.

Fig. 106. Reset Sequence

CLOCK GENERATING CIRCUIT

The M37274EFSP has 2 built-in oscillation circuits. An oscillation circuit can be formed by connecting a resonator between XIN and XOUT (XCIN and XCOUT). Use the circuit constants in accordance with the resonator manufacturer's recommended values. No external resistor is needed between XIN and XOUT since a feed-back resistor exists on-chip. However, an external feed-back resistor is needed between XCIN and XCOUT. When using XCIN-XCOUT as sub-clock, clear bits 5 and 4 of the clock source control register to "0." To supply a clock signal externally, input it to the XIN (XCIN) pin and make the XOUT (XCOUT) pin open. When not using XCIN clock, connect the XCIN to VSS and make the XCOUT pin open.

After reset has completed, the internal clock ϕ is half the frequency of XIN. Immediately after poweron, both the XIN and XCIN clock start oscillating. To set the internal clock ϕ to low-speed operation mode, set bit 7 of the CPU mode register (address $00FB_{16}$) to "1."

Oscillation Control

(1) Stop mode

The built-in clock generating circuit is shown in Figure 95. When the STP instruction is executed, the internal clock ϕ stops at HIGH. At the same time, timers 3 and 4 are connected by hardware and "FF_{16}" is set in timer 3 and "07_{16}" is set in timer 4. Select f(XIN)/16 or f(XCIN)/16 as the timer 3 count source (set both bit 0 of the timer mode register 2 and bit 6 at address $00C7_{16}$ to "0" before the execution of the STP instruction). Moreover, set the timer 3 and timer 4 interrupt enable bits to disabled ("0") before execution of the STP instruction. The oscillator restarts when external interrupt is accepted. However, the internal clock ϕ keeps its "H" level until timer 4 overflows, allowing time for oscillation stabilization when a ceramic resonator or a quartz-crystal oscillator is used.

(2) Wait mode

When the WIT instruction is executed, the internal clock ϕ stops in the "H" level but the oscillator continues running. This wait state is released at reset or when an interrupt is accepted (Note). Since the oscillator does not stop, the next instruction can be executed at once.

Note: In the wait mode, the following interrupts are invalid.

(1) VSYNC interrupt
(2) OSD interrupt
(3) Timers 1 and 2 interrupts using TIM2 pin input as count source
(4) Timer 3 interrupt using TIM3 pin input as count source
(5) Data slicer interrupt
(6) Multi-master I^2C-BUS interface interrupt
(7) f(XIN)/4096 interrupt
(8) All timer interrupts using f(XIN)/2 or f(XCIN)/2 as count source
(9) All timer interrupts using f(XIN)/4096 or f(XCIN)/4096 as count source
(10) A-D conversion interrupt

(3) Low-Speed Mode

If the internal clock is generated from the sub-clock (XCIN), a low power consumption operation can be realized by stopping only the main clock XIN. To stop the main clock, set bit 6 (CM_6) of the CPU mode register ($00FB_{16}$) to "1." When the main clock XIN is restarted, the program must allow enough time to for oscillation to stabilize.

Note that in low-power-consumption mode the XCIN-XCOUT drivability can be reduced, allowing even lower power consumption. To reduce the XCIN-XCOUT drivability, clear bit 5 (CM_5) of the CPU mode register ($00FB_{16}$) to "0." At reset, this bit is set to "1" and strong drivability is selected to help the oscillation to start. When an STP instruction is executed, set this bit to "1" by software before executing.

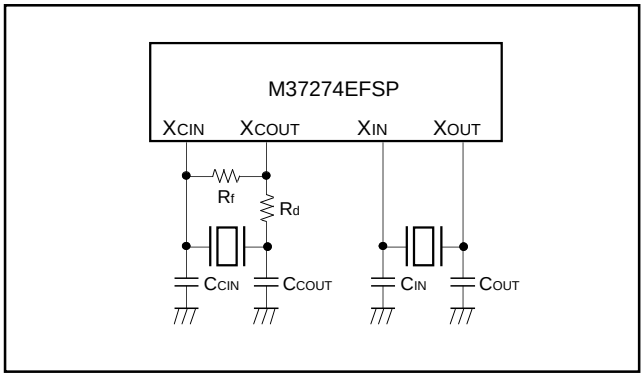


Fig. 107. Ceramic Resonator Circuit Example

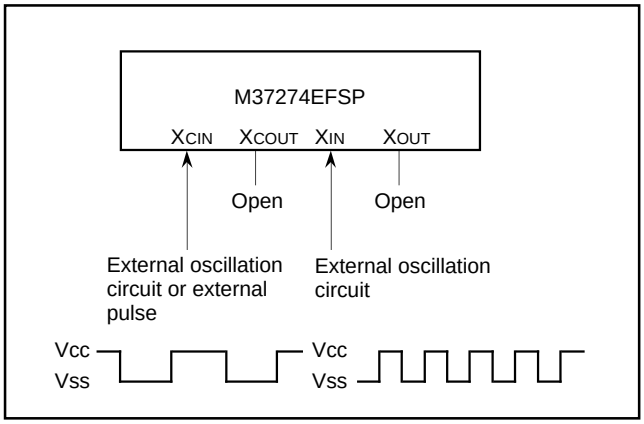
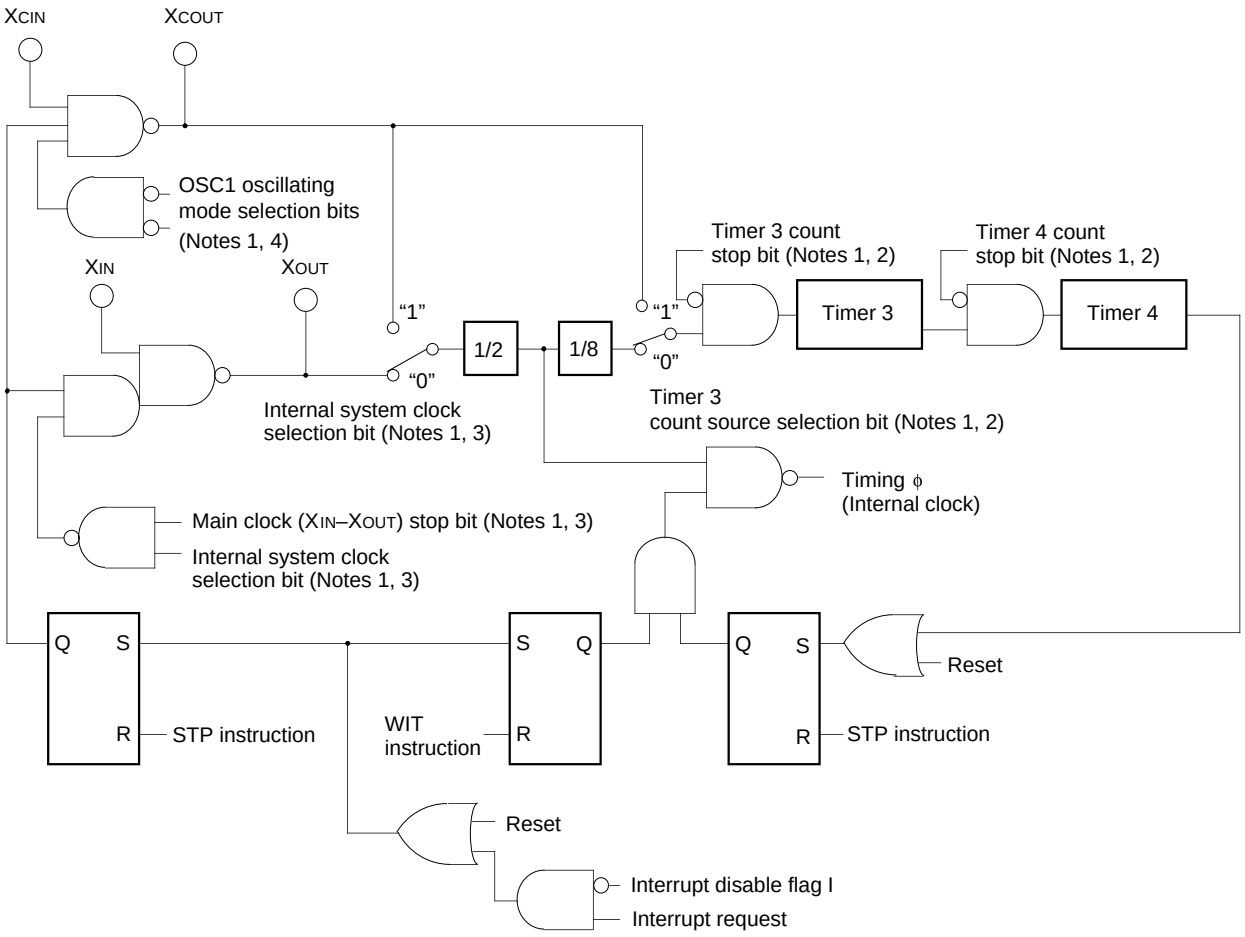
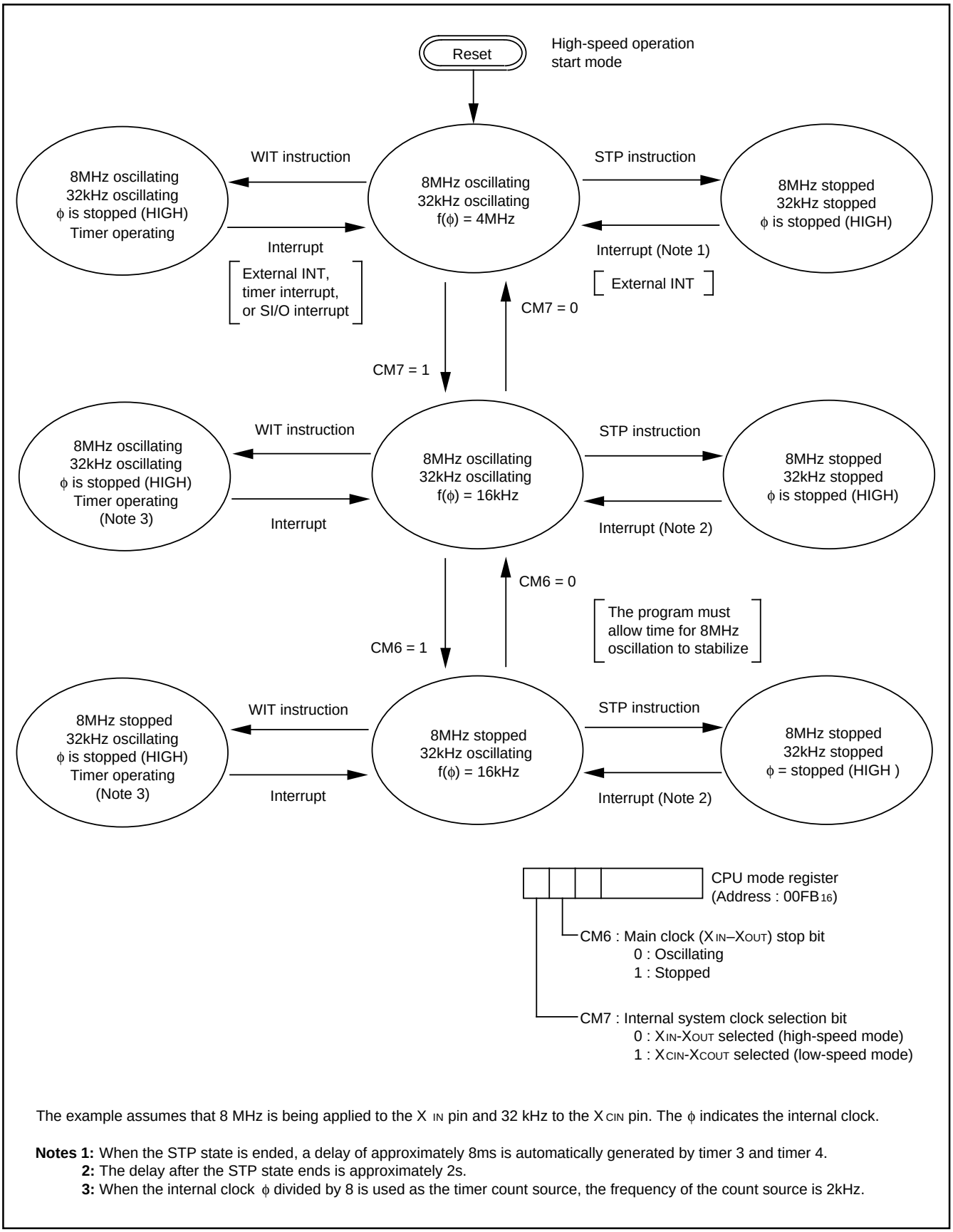


Fig. 108. External Clock Input Circuit Example



Notes 1 : The value at reset is "0."
2 : Refer to the structure of timer mode register 2.
3 : Refer to the structure of CPU mode register (next page).
4 : Refer to the structure of clock source control register.

Fig. 109. Clock Generating Circuit Block Diagram



The example assumes that 8 MHz is being applied to the X_{IN} pin and 32 kHz to the X_{CIN} pin. The ϕ indicates the internal clock.

Notes 1: When the STP state is ended, a delay of approximately 8ms is automatically generated by timer 3 and timer 4.
2: The delay after the STP state ends is approximately 2s.
3: When the internal clock ϕ divided by 8 is used as the timer count source, the frequency of the count source is 2kHz.

Fig. 110. State Transitions of System Clock

DISPLAY OSCILLATION CIRCUIT

The OSD oscillation circuit has a built-in clock oscillation circuits, so that a clock for OSD can be obtained simply by connecting an LC, a ceramic resonator, or a quartz-crystal oscillator across the pins OSC1 and OSC2. Which of the sub-clock or the OSD oscillation circuit is selected by setting bits 5 and 4 of the clock source control register (address 0216_{16}).

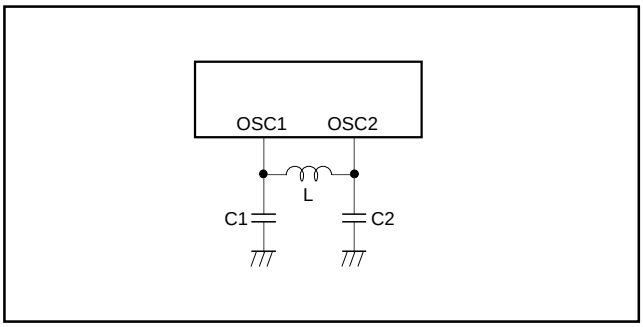
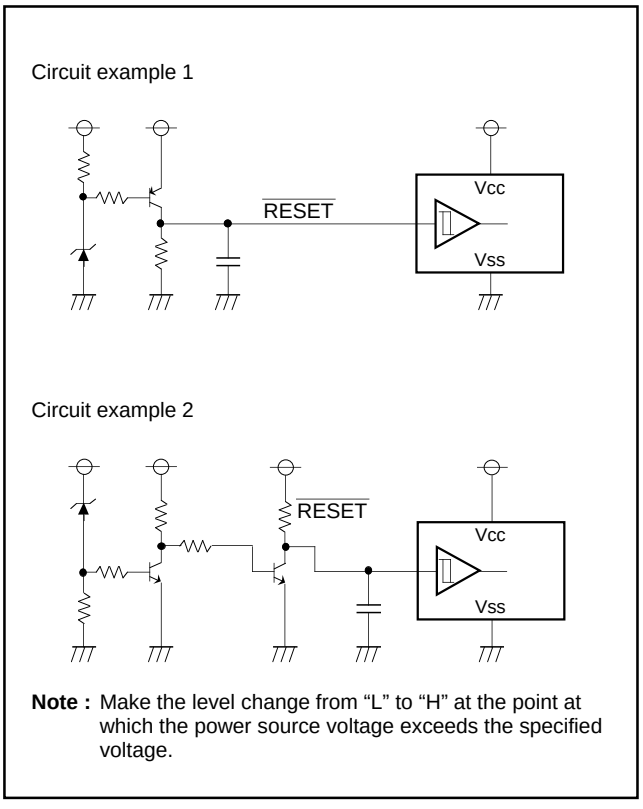


Fig. 111. Display Oscillation Circuit

AUTO-CLEAR CIRCUIT

When a power source is supplied, the auto-clear function will operate by connecting the following circuit to the $\overline{\text{RESET}}$ pin.



Note : Make the level change from "L" to "H" at the point at which the power source voltage exceeds the specified voltage.

Fig. 112. Auto-clear Circuit Example

ADDRESSING MODE

The memory access is reinforced with 17 kinds of addressing modes. Refer to SERIES 740 <Software> User's Manual for details.

MACHINE INSTRUCTIONS

There are 71 machine instructions. Refer to SERIES 740 <Soft- ware> User's Manual for details.

PROGRAMMING NOTES

(1) The divide ratio of the timer is 1/(n+1).

(2) Even though the BBC and BBS instructions are executed immediately after the interrupt request bits are modified (by the program), those instructions are only valid for the contents before the modification. At least one instruction cycle is needed (such as an NOP) between the modification of the interrupt request bits and the execution of the BBC and BBS instructions.

(3) After the ADC and SBC instructions are executed (in the decimal mode), one instruction cycle (such as an NOP) is needed before the SEC, CLC, or CLD instruction is executed.

(4) An NOP instruction is needed immediately after the execution of a PLP instruction.

(5) In order to avoid noise and latch-up, connect a bypass capacitor ($\approx 0.1\ \mu$F) directly between the V_{CC} pin–V_{SS} pin, AV_{CC} pin–V_{SS} pin, and the V_{CC} pin–CNV_{SS} pin, using a thick wire.

PROM Programming Method

The built-in PROM of the One Time PROM version (blank) and the built-in EPROM version can be read or programmed with a general-purpose PROM programmer using a special programming adapter.

Product	Name of Programming Adapter
M37274EFSP	PCA7400

The PROM of the One Time PROM version (blank) is not tested or screened in the assembly process nor any following processes. To ensure proper operation after programming, the procedure shown in Figure 97 is recommended to verify programming.

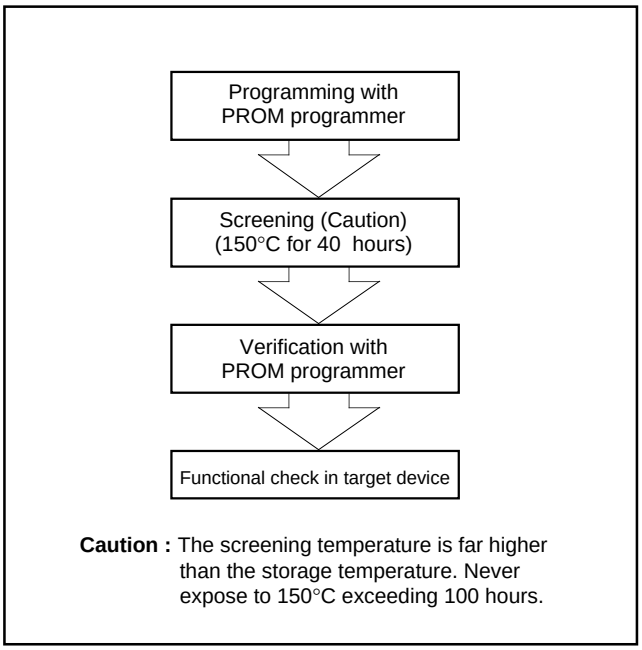


Fig. 113. Programming and testing of One Time PROM version

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Conditions	Ratings	Unit
V_{CC}, AV_{CC}	Power source voltage	V_{CC}, AV_{CC}	All voltages are based on V_{SS}. Output transistors are cut off.	–0.3 to 6	V
V_I	Input voltage	CNV$_{SS}$		–0.3 to 6	V
V_I	Input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P4_0$–$P4_6$, $P6_4$, $P6_3$, $\overline{P7_0}$–$\overline{P7_2}$, X_{IN}, H_{SYNC}, V_{SYNC}, $\overline{RESET}$		–0.3 to V_{CC} + 0.3	V
V_O	Output voltage	$P0_3$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P5_2$–$P5_5$, S_{OUT}, S_{CLK}, X_{OUT}, OSC2		–0.3 to V_{CC} + 0.3	V
V_O	Output voltage	$P0_0$–$P0_2$, $P0_4$–$P0_7$		–0.3 to 13	V
I_{OH}	Circuit current	$P5_2$–$P5_5$, $P1_0$, $P0_3$, $P1_5$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$		0 to 1 (Note 1)	mA
I_{OL1}	Circuit current	$P5_2$–$P5_5$, $P1_0$, , $P0_3$, $P1_5$–$P1_7$, $P2_0$–$P2_7$, S_{OUT}, S_{CLK}		0 to 2 (Note 2)	mA
I_{OL2}	Circuit current	$P1_1$–$P1_4$		0 to 6 (Note 2)	mA
I_{OL3}	Circuit current	$P0_0$–$P0_2$, $P0_4$–$P0_7$		0 to 1 (Note 2)	mA
I_{OL4}	Circuit current	$P3_0$, $P3_1$		0 to 10 (Note 3)	mA
P_d	Power dissipation		T_a = 25 °C	550	mW
T_{opr}	Operating temperature			–10 to 70	°C
T_{stg}	Storage temperature			–40 to 125	°C

RECOMMENDED OPERATING CONDITIONS (T_a = –10 °C to 70 °C, V_{CC} = 5 V ± 10 %, unless otherwise noted)

Symbol	Parameter			Limits			Unit
				Min.	Typ.	Max.	
V_{CC}, AV_{CC}	Power source voltage (Note 4), During CPU, OSD, data slicer operation			4.5	5.0	5.5	V
V_{CC}, AV_{CC}	RAM hold voltage (when clock is stopped)			2.0		5.5	V
V_{SS}	Power source voltage			0	0	0	V
V_{IH1}	HIGH input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P4_0$–$P4_6$, $P6_4$, $P7_0$–$P7_2$, H_{SYNC}, V_{SYNC}, $\overline{RESET}$, X_{IN}, $P6_3$		0.8V_{CC}		V_{CC}	V
V_{IH2}	HIGH input voltage	SCL1, SCL2, SDA1, SDA2		0.7V_{CC}		V_{CC}	V
V_{IL1}	LOW input voltage	$P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P4_0$–$P4_6$, $P6_3$, $P6_4$, $P7_0$–$P7_2$		0		0.4 V_{CC}	V
V_{IL2}	LOW input voltage	SCL1, SCL2, SDA1, SDA2		0		0.3 V_{CC}	V
V_{IL3}	LOW input voltage (Note 6)	$\overline{RESET}$, X_{IN}, OSC1, H_{SYNC}, V_{SYNC}, INT1, INT2, INT3, TIM2, TIM3, S_{CLK}, S_{IN}		0		0.2 V_{CC}	V
I_{OH}	HIGH average output current (Note 1)	$P5_2$–$P5_5$, $P1_0$, $P0_3$, $P1_5$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$				1	mA
I_{OL1}	LOW average output current (Note 2)	$P5_2$–$P5_5$, $P1_0$, $P0_3$, $P1_5$–$P1_7$, $P2_0$–$P2_7$, S_{OUT}, S_{CLK}				2	mA
I_{OL2}	LOW average output current (Note 2)	$P1_1$–$P1_4$				6	mA
I_{OL3}	LOW average output current (Note 2)	$P0_0$–$P0_2$, $P0_4$–$P0_7$				1	mA
I_{OL4}	LOW average output current (Note 3)	$P3_0$, $P3_1$				10	mA
f(X_{IN})	Oscillation frequency (for CPU operation) (Note 5)	X_{IN}		7.9	8.0	8.1	MHz
f(X_{CIN})	Oscillation frequency (for sub-clock operation)	X_{CIN}		29	32	35	kHz
f_{OSC}	Oscillation frequency (for OSD)	OSC1	LC oscillating mode	11.0		27.0	MHz
			Ceramic oscillating mode	26.5	27.0	27.5	
f_{hs1}	Input frequency	TIM2, TIM3, INT1, INT2, INT3				100	kHz
f_{hs2}	Input frequency	S_{CLK}				1	MHz
f_{hs3}	Input frequency	SCL1, SCL2				400	kHz
f_{hs4}	Input frequency	Horizontal sync. signal of video signal		15.262	15.734	16.206	kHz
V_I	Input amplitude video signal	CV_{IN}		1.5	2.0	2.5	V

ELECTRIC CHARACTERISTICS (V_{CC} = 5 V ± 10 %, V_{SS} = 0 V, f(X_{IN}) = 8 MHz, T_a = –10 °C to 70 °C, unless otherwise noted)

Symbol	Parameter		Test conditions		Limits			Unit
					Min.	Typ.	Max.	
I_{CC}	Power source current	System operation	V_{CC} = 5.5 V, f(X_{IN}) = 8 MHz	CRT OFF Data slicer OFF		15	30	mA
				CRT ON Data slicer ON		30	50	
			V_{CC} = 5.5 V, f(X_{IN}) = 0, f(X_{CIN}) = 32kHz, OSD OFF, Data slicer OFF, Low-power dissipation mode set (CM_5 = "0", CM_6 = "1")			60	200	μA
		Wait mode	V_{CC} = 5.5 V, f(X_{IN}) = 8 MHz			2	4	mA
			V_{CC} = 5.5 V, f(X_{IN}) = 0, f(X_{CIN}) = 32kHz, Low-power dissipation mode set (CM_5 = "0", CM_6 = "1")			25	100	μA
		Stop mode	V_{CC} = 5.5 V, f(X_{IN}) = 0, f(X_{CIN}) = 0			1	10	
V_{OH}	HIGH output voltage	$P5_2$–$P5_5$, $P1_0$, $P0_3$, $P1_5$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$	V_{CC} = 4.5 V, I_{OH} = –0.5 mA		2.4			V
V_{OL}	LOW output voltage	$P5_2$–$P5_5$, $P1_0$, SOUT, SCLK, $P0_0$–$P0_7$, $P1_5$–$P1_7$, $P2_0$–$P2_7$	V_{CC} = 4.5 V, I_{OL} = 0.5 mA				0.4	V
	LOW output voltage	$P3_0$, $P3_1$	V_{CC} = 4.5 V, I_{OL} = 10.0 mA				3.0	
	LOW output voltage	$P1_1$–$P1_4$	V_{CC} = 4.5 V	I_{OL} = 3 mA			0.4	
				I_{OL} = 6 mA			0.6	
V_{T+}–V_{T-}	Hysteresis (Note 6)	$\overline{RESET}$, HSYNC, VSYNC, INT1, INT2, INT3, TIM2, TIM3, SIN, SCLK, SCL1, SCL2, SDA1, SDA2	V_{CC} = 5.0 V			0.5	1.3	V
I_{IZH}	HIGH input leak current	$\overline{RESET}$, $P0_3$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P4_0$–$P4_6$, $P6_3$, $P6_4$, $P7_0$–$P7_2$, HSYNC, VSYNC	V_{CC} = 5.5 V, V_I = 5.5 V				5	μA
	HIGH input leak current	$P0_0$–$P0_2$, $P0_4$–$P0_7$	V_{CC} = 5.5 V, V_I = 12 V				10	
I_{IZL}	LOW input leak current	$\overline{RESET}$, $P0_0$–$P0_7$, $P1_0$–$P1_7$, $P2_0$–$P2_7$, $P3_0$, $P3_1$, $P4_0$–$P4_6$, $P6_3$, $P6_4$, $P7_0$–$P7_2$, HSYNC, VSYNC	V_{CC} = 5.5 V, V_I = 0 V				5	μA
R_{BS}	I^2C-BUS·BUS switch connection resistor (between SCL1 and SCL2, SDA1 and SDA2)		V_{CC} = 4.5 V				130	Ω

Notes 1: The total current that flows out of the IC must be 20 or less.

2: The total input current to IC (I_{OL1} + I_{OL2} + I_{OL3}) must be 20 mA or less.

3: The total average input current for ports $P3_0$, $P3_1$ to IC must be 10 mA or less.

4: Connect 0.1 μF or more capacitor externally between the power source pins V_{CC}–V_{SS} and AV_{CC}–V_{SS} so as to reduce power source noise.
Also connect 0.1 μF or more capacitor externally between the pins V_{CC}–CNV_{SS}.

5: Use a quartz-crystal oscillator or a ceramic resonator for the CPU oscillation circuit. When using the data slicer, use 8 MHz.

6: $P1_6$, $P4_1$–$P4_4$ have the hysteresis when these pins are used as interrupt input pins or timer input pins. $P1_1$–$P1_4$ have the hysteresis when these pins are used as multi-master I^2C-BUS interface ports. $P1_7$ and $P4_6$ have the hysteresis when these pins are used as serial I/O pins.

7: When using the sub-clock, set f_{CLK} < f_{CPU}/3.

8: Pin names in each parameter is described as below.
(1) Dedicated pins: dedicated pin names.
(2) Duble-/triple-function ports
• When the same limits: I/O port name.
• When the limits of functins except ports are different from I/O port limits: function pin name.

A-D CONVERTER CHARACTERISTICS

(V_{CC} = 5 V ± 10 %, V_{SS} = 0 V, f(X_{IN}) = 8 MHz, T_a = –10 °C to 70 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min.	Typ.	Max.	
—	Resolution				8	bits
—	Non-linearity error		0		±2	LSB
—	Differential non-linearity error		0		±0.9	LSB
V_{OT}	Zero transition error	V_{CC} = 5.12V I_{OL} (SUM) = 0mA	0		2	LSB
V_{FST}	Full-scale transition error	V_{CC} = 5.12V	0		4	LSB
T_{CONV}	Conversion time		12.25		12.5	μs
V_{REF}	Reference voltage				V_{CC}	V
R_{LADDER}	Ladder resistor			25		kΩ
V_{IA}	Analog input current		0		V_{REF}	V

MULTI-MASTER I²C-BUS BUS LINE CHARACTERISTICS

Symbol	Parameter	Standard clock mode		High-speed clock mode		Unit
		Min.	Max.	Min.	Max.	
t_{BUF}	Bus free time	4.7		1.3		μs
$t_{HD:STA}$	Hold time for START condition	4.0		0.6		μs
t_{LOW}	LOW period of SCL clock	4.7		1.3		μs
t_R	Rising time of both SCL and SDA signals		1000	20+0.1C_b	300	ns
$t_{HD:DAT}$	Data hold time	0		0	0.9	μs
t_{HIGH}	HIGH period of SCL clock	4.0		0.6		μs
t_F	Falling time of both SCL and SDA signals		300	20+0.1C_b	300	ns
$t_{SU:DAT}$	Data set-up time	250		100		ns
$t_{SU:STA}$	Set-up time for repeated START condition	4.7		0.6		μs
$t_{SU:STO}$	Set-up time for STOP condition	4.0		0.6		μs

Note: C_b = total capacitance of 1 bus line

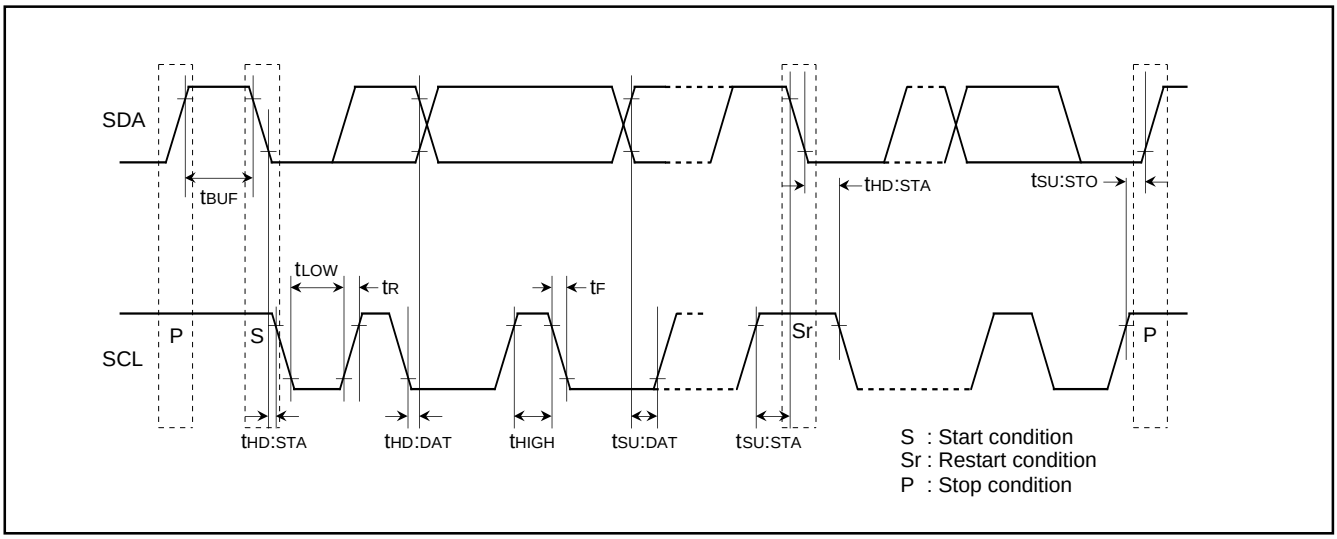


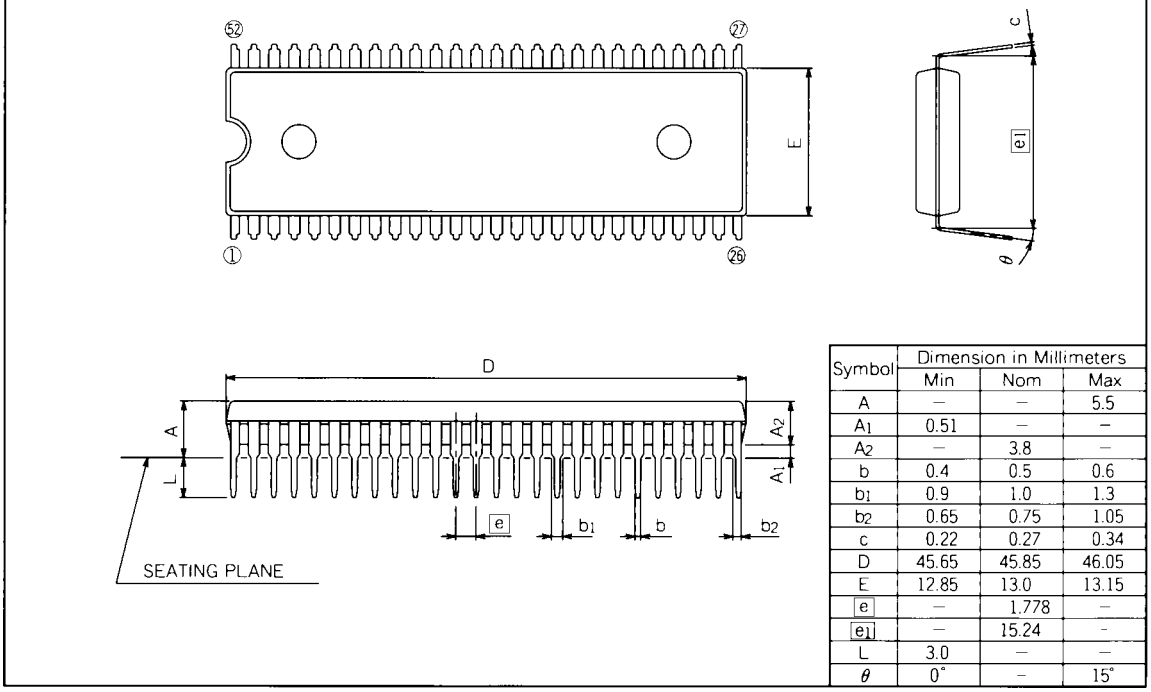
Fig. 114. Definition Diagram of Timing on Multi-master I²C-BUS

PACKAGE OUTLINE

52P4B — Plastic 52pin 600mil SDIP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
SDIP52-P-600-1.78	–	5.1	Alloy 42/Cu Alloy

Scale : 1.5/1



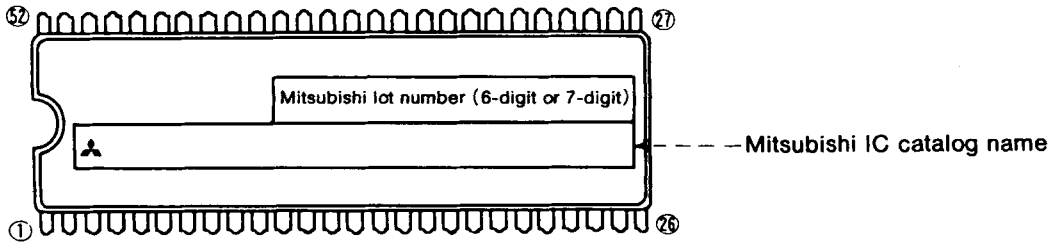
Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	5.5
A_1	0.51	–	–
A_2	–	3.8	–
b	0.4	0.5	0.6
b_1	0.9	1.0	1.3
b_2	0.65	0.75	1.05
c	0.22	0.27	0.34
D	45.65	45.85	46.05
E	12.85	13.0	13.15
e	–	1.778	–
e_1	–	15.24	–
L	3.0	–	–
θ	0°	–	15°

52P4B (52-PIN SHRINK DIP) MARK SPECIFICATION FORM

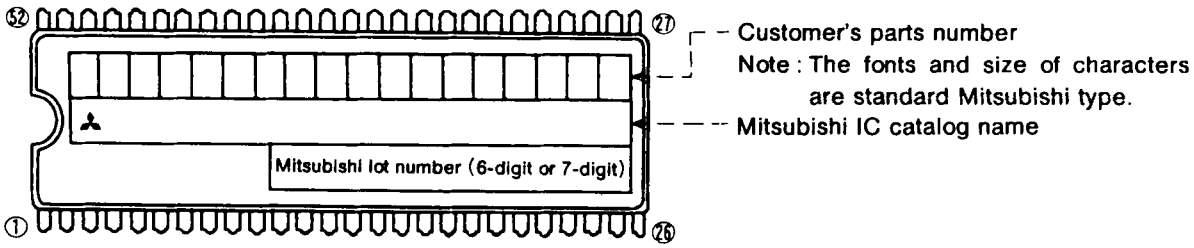
Mitsubishi IC catalog name ☐

Please choose one of the marking types below (A, B, C), and enter the Mitsubishi IC catalog name and the special mark (if needed).

A. Standard Mitsubishi Mark

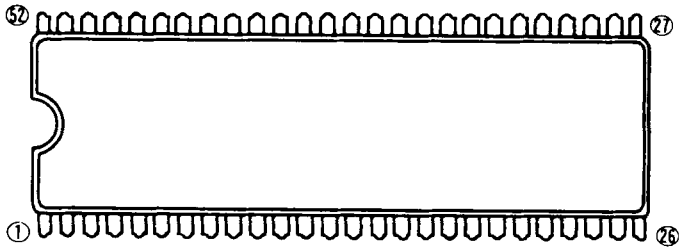


B. Customer's Parts Number + Mitsubishi Catalog Name



Note1 : The mark field should be written right aligned.
2 : The fonts and size of characters are standard Mitsubishi type.
3 : Customer's parts number can be up to 18 characters :
Only 0~9, A~Z, +, −, /, (,), &, ©, . (period), and , (comma) are usable.
4 : If the Mitsubishi logo ⅄ is not required, check the box on the right. ⅄Mitsubishi logo is not required ☐

C. Special Mark Required

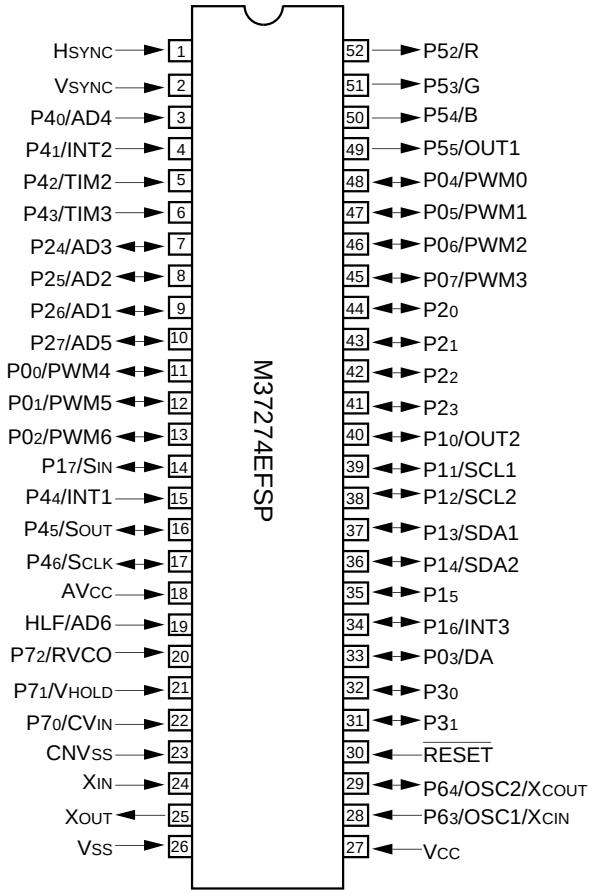


Note1 : If the special mark is to be printed, indicate the desired layout of the mark in the upper figure. The layout will be duplicated as close as possible. Mitsubishi lot number (6-digit or 7-digit) and mask ROM number (3-digit) are always marked.
2 : If the customer's trade mark logo must be used in the special mark, check the box below. Please submit a clean original of the logo.
For the new special character fonts a clean font original (ideally logo drawing) must be submitted.
Special logo required ☐

The standard Mitsubishi font is used for all characters except for a logo.

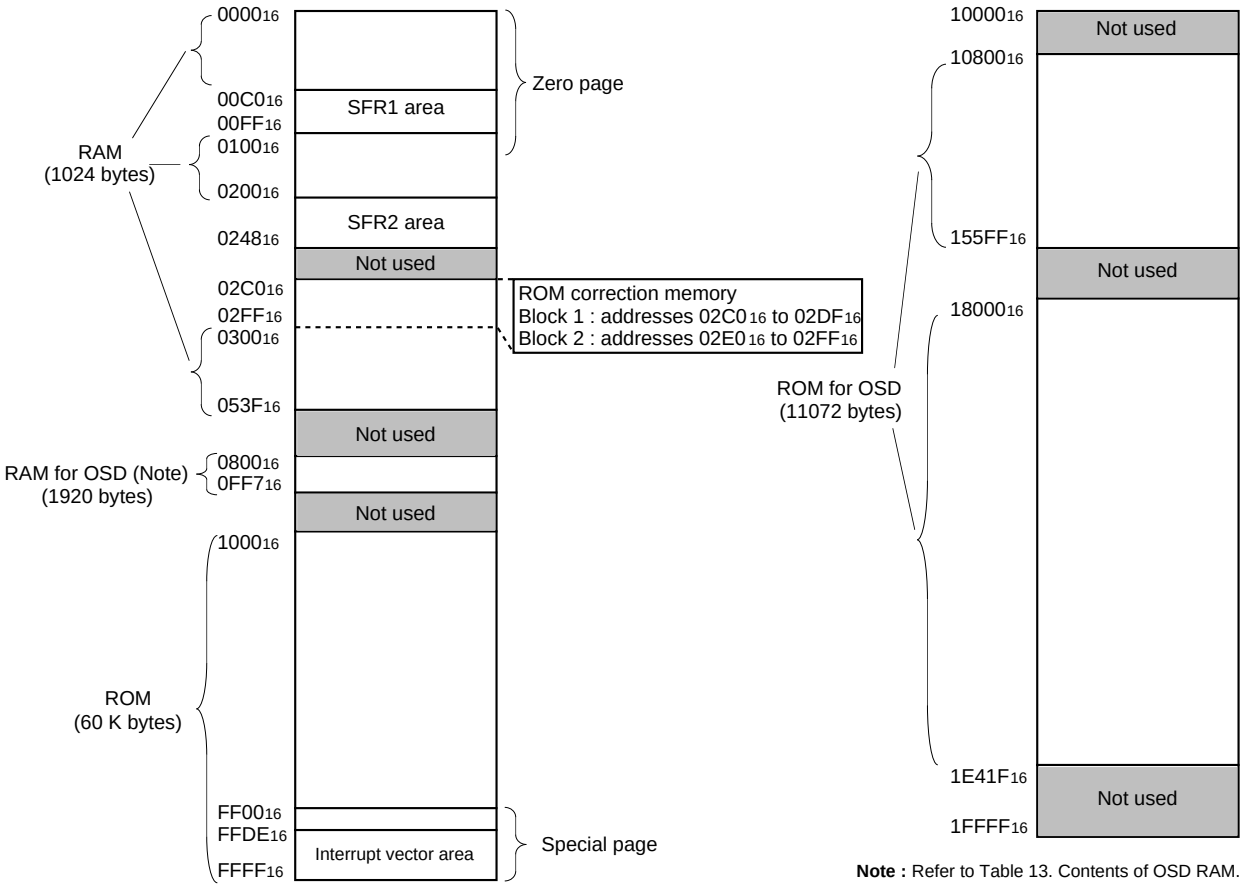
APPENDIX

Pin Configuration (TOP VIEW)



Outline 52P4B

Memory Map



Note : Refer to Table 13. Contents of OSD RAM.

Memory Map of Special Function Register (SFR)

■SFR1 area (addresses $C0_{16}$ to DF_{16})

<Bit allocation>

: } Function bit
Name : }

: No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
$C0_{16}$	Port P0 (P0)									?							
$C1_{16}$	Port P0 direction register (D0)									00_{16}							
$C2_{16}$	Port P1 (P1)									?							
$C3_{16}$	Port P1 direction register (D1)									00_{16}							
$C4_{16}$	Port P2 (P2)									?							
$C5_{16}$	Port P2 direction register (D2)									00_{16}							
$C6_{16}$	Port P3 (P3)									?							
$C7_{16}$	Port P3 direction register (D3)	P6IM	T3SC							00_{16}							
$C8_{16}$	Port P4 (P4)									?							
$C9_{16}$	Port P4 direction register (D4)		P46D	P45D					0	00_{16}							
CA_{16}	Port P5 (P5)									?							
CB_{16}	OSD port control register (PF)	0	OUT2	OUT1	B	G	R	0	0	00_{16}							
CC_{16}	Port P6 (P6)									?							
CD_{16}	Port P7 (P7)									0	0	0	0	0	?	?	?
CE_{16}	OSD control register (OC)	OC7	OC6	OC5	OC4	OC3	OC2	OC1	OC0	00_{16}							
CF_{16}	Horizontal position register (HP)	HP7	HP6	HP5	HP4	HP3	HP2	HP1	HP0	00_{16}							
$D0_{16}$	Block control register 1 (BC_1)	BC_17	BC_16	BC_15	BC_14	BC_13	BC_12	BC_11	BC_10	?							
$D1_{16}$	Block control register 2 (BC_2)	BC_27	BC_26	BC_25	BC_24	BC_23	BC_22	BC_21	BC_20	?							
$D2_{16}$	Block control register 3 (BC_3)	BC_37	BC_36	BC_35	BC_34	BC_33	BC_32	BC_31	BC_30	?							
$D3_{16}$	Block control register 4 (BC_4)	BC_47	BC_46	BC_45	BC_44	BC_43	BC_42	BC_41	BC_40	?							
$D4_{16}$	Block control register 5 (BC_5)	BC_57	BC_56	BC_55	BC_54	BC_53	BC_52	BC_51	BC_50	?							
$D5_{16}$	Block control register 6 (BC_6)	BC_67	BC_66	BC_65	BC_64	BC_63	BC_62	BC_61	BC_60	?							
$D6_{16}$	Block control register 7 (BC_7)	BC_77	BC_76	BC_75	BC_74	BC_73	BC_72	BC_71	BC_70	?							
$D7_{16}$	Block control register 8 (BC_8)	BC_87	BC_86	BC_85	BC_84	BC_83	BC_82	BC_81	BC_80	?							
$D8_{16}$	Block control register 9 (BC_9)	BC_97	BC_96	BC_95	BC_94	BC_93	BC_92	BC_91	BC_90	?							
$D9_{16}$	Block control register 10 (BC_{10})	$BC_{10}7$	$BC_{10}6$	$BC_{10}5$	$BC_{10}4$	$BC_{10}3$	$BC_{10}2$	$BC_{10}1$	$BC_{10}0$	?							
DA_{16}	Block control register 11 (BC_{11})	$BC_{11}7$	$BC_{11}6$	$BC_{11}5$	$BC_{11}4$	$BC_{11}3$	$BC_{11}2$	$BC_{11}1$	$BC_{11}0$	?							
DB_{16}	Block control register 12 (BC_{12})	$BC_{12}7$	$BC_{12}6$	$BC_{12}5$	$BC_{12}4$	$BC_{12}3$	$BC_{12}2$	$BC_{12}1$	$BC_{12}0$	?							
DC_{16}	Block control register 13 (BC_{13})	$BC_{13}7$	$BC_{13}6$	$BC_{13}5$	$BC_{13}4$	$BC_{13}3$	$BC_{13}2$	$BC_{13}1$	$BC_{13}0$	?							
DD_{16}	Block control register 14 (BC_{14})	$BC_{14}7$	$BC_{14}6$	$BC_{14}5$	$BC_{14}4$	$BC_{14}3$	$BC_{14}2$	$BC_{14}1$	$BC_{14}0$	?							
DE_{16}	Block control register 15 (BC_{15})	$BC_{15}7$	$BC_{15}6$	$BC_{15}5$	$BC_{15}4$	$BC_{15}3$	$BC_{15}2$	$BC_{15}1$	$BC_{15}0$	?							
DF_{16}	Block control register 16 (BC_{16})	$BC_{16}7$	$BC_{16}6$	$BC_{16}5$	$BC_{16}4$	$BC_{16}3$	$BC_{16}2$	$BC_{16}1$	$BC_{16}0$	?							

■SFR1 area (addresses $E0_{16}$ to FF_{16})

<Bit allocation>

□ : } Function bit
Name : }

▨ : No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
$E0_{16}$	Caption position register (CP)	1	0	0	CP4	CP3	CP2	CP1	CP0	00_{16}							
$E1_{16}$	Start bit position register (SP)	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	00_{16}							
$E2_{16}$	Window register (WN)	0	0	WN5	WN4	WN3	WN2	WN1	WN0	00_{16}							
$E3_{16}$	Sync slice register (SSL)	SSL7	0	0	0	0	1	0	1	00_{16}							
$E4_{16}$	Caption data register 1 (CD1)									00_{16}							
$E5_{16}$	Caption data register 2 (CD2)									00_{16}							
$E6_{16}$	Clock run-in register 1 (CR1)	0	1	0	1	CR13	CR12	CR11	CR10	00_{16}							
$E7_{16}$	Clock run-in register 2 (CR2)	1	0	0	1	1	1	CR21	1	00_{16}							
$E8_{16}$	Clock run-in detect register 1 (CRD1)	CRD17	CRD15	CRD15	CRD15	CRD15				00_{16}							
$E9_{16}$	Clock run-in detect register 2 (CRD2)	CRD27	CRD25	CRD25	CRD25	CRD25	CRD22	CRD21	CRD20	00_{16}							
EA_{16}	Data slicer control register 1 (DSC1)	DSC17	0	DSC15	0	0	DSC12	DSC11	DSC10	?	0	?	0	0	0	0	0
EB_{16}	Data slicer control register 2 (DSC2)	DSC27	0	DSC25	0	0	DSC22	DSC21	DSC20	?	0	?	0	0	?	0	0
EC_{16}	Caption data register 3 (CD3)									00_{16}							
ED_{16}	Caption data register 4 (CD4)									00_{16}							
EE_{16}	A-D conversion register (AD)									?							
EF_{16}	A-D control register (ADCON)	0		0	ADVREF	ADSTR	ADIN2	ADIN1	ADIN0	0	?	0	0	1	0	0	0
$F0_{16}$	Timer 1 (TM1)									FF_{16}							
$F1_{16}$	Timer 2 (TM2)									07_{16}							
$F2_{16}$	Timer 3 (TM3)									FF_{16}							
$F3_{16}$	Timer 4 (TM4)									07_{16}							
$F4_{16}$	Timer mode register 1 (TM1)	TM17	TM16	TM15	TM14	TM13	TM12	TM11	TM10	00_{16}							
$F5_{16}$	Timer mode register 2 (TM2)	TM27	TM26	TM25	TM24	TM23	TM22	TM21	TM20	00_{16}							
$F6_{16}$	I^2C data shift register (S0)	D7	D6	D5	D4	D3	D2	D1	D0	?							
$F7_{16}$	I^2C address register (S0D)	SAD6	SAD5	SAD4	SAD3	SAD2	SAD1	SAD0	RBW	00_{16}							
$F8_{16}$	I^2C status register (S1)	MST	TRX	BB	PIN	AL	AAS	AD0	LRB	0	0	0	1	0	0	0	?
$F9_{16}$	I^2C control register (S1D)	BSEL1	BSEL0	10 BIT SAD	ALS	ES0	BC2	BC1	BC0	00_{16}							
FA_{16}	I^2C clock control register (S2)	ACK	ACK BIT	FAST MODE	CCR4	CCR3	CCR2	CCR1	CCR0	00_{16}							
FB_{16}	CPU mode register (CPUM)	CM7	CM6	CM5	1	1	CM2	0	0	0	0	1	1	1	1	0	0
FC_{16}	Interrupt request register 1 (IREQ1)		ADR	VSCR	CRTR	TM4R	TM3R	TM2R	TM1R	00_{16}							
FD_{16}	Interrupt request register 2 (IREQ2)	0	T56R	IICR	INT2R	1MSR	SIOR	DSR	INT1R	00_{16}							
FE_{16}	Interrupt control register 1 (ICON1)		ADE	VSCE	CRTE	TM4E	TM3E	TM2E	TM1E	00_{16}							
FF_{16}	Interrupt control register 2 (ICON2)	T56S	T56E	IICE	INT2E	1MSE	SIOE	DSE	INT1E	00_{16}							

■SFR2 area (addresses 200_{16} to $21F_{16}$)

<Bit allocation>

: } Function bit
Name : }

: No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

<State immediately after reset>

0 : "0" immediately after reset

1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7							b0	State immediately after reset b7							b0
200_{16}	PWM0 register (PWM0)									?							
201_{16}	PWM1 register (PWM1)									?							
202_{16}	PWM2 register (PWM2)									?							
203_{16}	PWM3 register (PWM3)									?							
204_{16}	PWM4 register (PWM4)									?							
205_{16}	PWM5 register (PWM5)									?							
206_{16}	PWM6 register (PWM6)									?							
207_{16}										?							
208_{16}	Clock run-in detect register 3 (CRD3)	CRD35	CRD34	CRD33	CRD32	CRD31				00_{16}							
209_{16}	Clock run-in register (CR3)		CR36	CR35	CR34	CR33	CR32	CR31	CR30	?							
$20A_{16}$	PWM mode register 1 (PN)					PN3	PN2	PN1	PN0	?	?	?	?	0	0	0	0
$20B_{16}$	PWM mode register 2 (PW)	0	PW6	PW5	PW4	PW3	PW2	PW1	PW0	00_{16}							
$20C_{16}$	Timer 5 (TM5)									07_{16}							
$20D_{16}$	Timer 6 (TM6)									FF_{16}							
$20E_{16}$		00_{16}								00_{16}							
$20F_{16}$	Sync pulse counter register (SYC)			SYC5	SYC4	SYC3	SYC2	SYC1	SYC0	00_{16}							
210_{16}	Data slicer control register 3 (DSC3)	DSC37	DSC36	DSC35	DSC34	DSC33	DSC32	DSC31	DSC30	00_{16}							
211_{16}										?							
212_{16}	Interrupt input polarity register (IP)	AD/INT3 SEL	INT3 POL	0	INT2 POL	INT1 POL	0	0	0	00_{16}							
213_{16}	Serial I/O mode register (SM)	0	0	SM5	SM4	SM3	SM2	SM1	SM0	00_{16}							
214_{16}	Serial I/O register (SIO)									?							
215_{16}										?							
216_{16}	Clock source control register (CS)	0	CS6	CS5	CS4	CS3	CS2	CS1	CS0	00_{16}							
217_{16}	I/O polarity control register (PC)	PC7	PC6	PC5	PC4	0	PC2	PC1	PC0	1	0	0	0	0	0	0	0
218_{16}	Raster color register (RC)	RC7	RC6	RC5	0	0	RC2	RC1	RC0	00_{16}							
219_{16}	Extra font color register (EC)				0	0	EC2	EC1	EC0	00_{16}							
$21A_{16}$					0	0	0	0	0	00_{16}							
$21B_{16}$	Border color register (FC)				0	0	FC2	FC1	FC0	00_{16}							
$21C_{16}$	Window H register 1 (WH1)	WH17	WH16	WH15	WH14	WH13	WH12	WH11	WH10	?							
$21D_{16}$	Window L register 1 (WL1)	WL17	WL16	WL15	WL14	WL13	WL12	WL21	WL20	?							
$21E_{16}$	Window H register 2 (WH2)							WH21	WH20	?							
$21F_{16}$	Window L register 2 (WL2)							WL21	WL20	?							

■SFR2 area (addresses 220_{16} to 248_{16})

< Bit allocation >

□ : } Function bit
Name : }

▨ : No function bit

0 : Fix to this bit to "0" (do not write to "1")

1 : Fix to this bit to "1" (do not write to "0")

< State immediately after reset >

0 : "0" immediately after reset

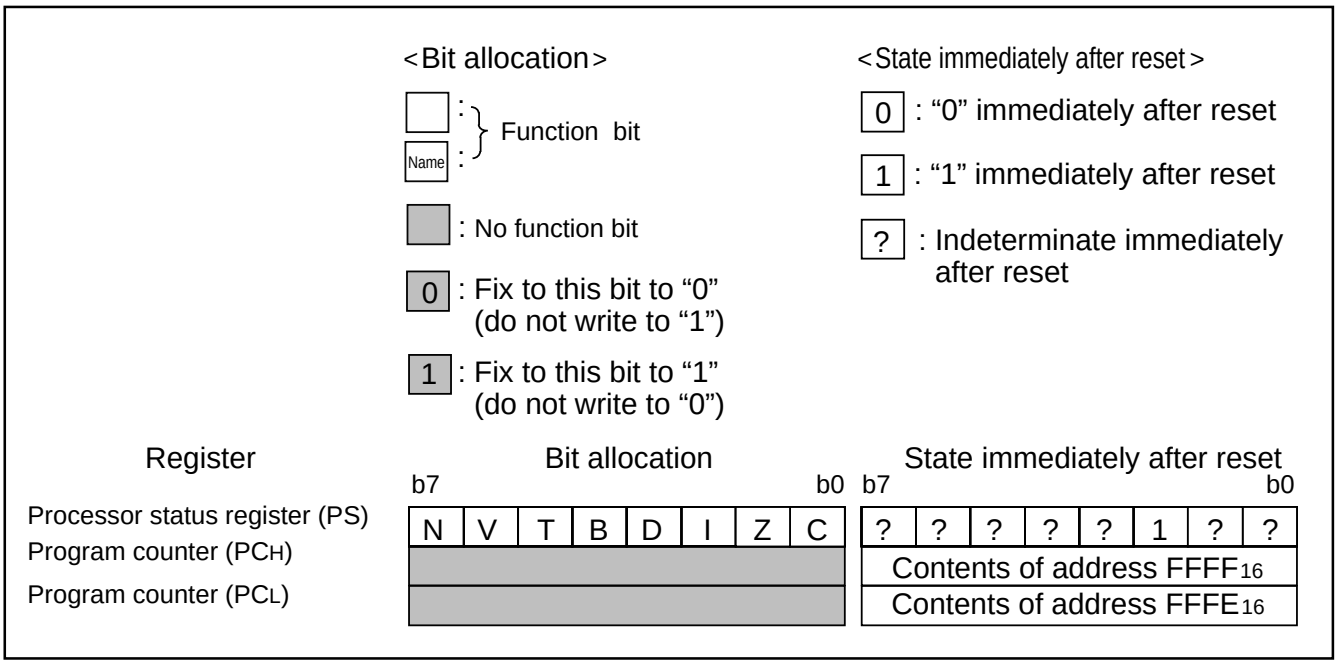
1 : "1" immediately after reset

? : Indeterminate immediately after reset

Address	Register	Bit allocation b7	b6	b5	b4	b3	b2	b1	b0	State immediately after reset b7	b6	b5	b4	b3	b2	b1	b0
220_{16}	Vertical position register 1_1 ($VP1_1$)	$VP1_1 7$	$VP1_1 6$	$VP1_1 5$	$VP1_1 4$	$VP1_1 3$	$VP1_1 2$	$VP1_1 1$	$VP1_1 0$	?							
221_{16}	Vertical position register 1_2 ($VP1_2$)	$VP1_2 7$	$VP1_2 6$	$VP1_2 5$	$VP1_2 4$	$VP1_2 3$	$VP1_2 2$	$VP1_2 1$	$VP1_2 0$	?							
222_{16}	Vertical position register 1_3 ($VP1_3$)	$VP1_3 7$	$VP1_3 6$	$VP1_3 5$	$VP1_3 4$	$VP1_3 3$	$VP1_3 2$	$VP1_3 1$	$VP1_3 0$	?							
223_{16}	Vertical position register 1_4 ($VP1_4$)	$VP1_4 7$	$VP1_4 6$	$VP1_4 5$	$VP1_4 4$	$VP1_4 3$	$VP1_4 2$	$VP1_4 1$	$VP1_4 0$	?							
224_{16}	Vertical position register 1_5 ($VP1_5$)	$VP1_5 7$	$VP1_5 6$	$VP1_5 5$	$VP1_5 4$	$VP1_5 3$	$VP1_5 2$	$VP1_5 1$	$VP1_5 0$	?							
225_{16}	Vertical position register 1_6 ($VP1_6$)	$VP1_6 7$	$VP1_6 6$	$VP1_6 5$	$VP1_6 4$	$VP1_6 3$	$VP1_6 2$	$VP1_6 1$	$VP1_6 0$	?							
226_{16}	Vertical position register 1_7 ($VP1_7$)	$VP1_7 7$	$VP1_7 6$	$VP1_7 5$	$VP1_7 4$	$VP1_7 3$	$VP1_7 2$	$VP1_7 1$	$VP1_7 0$	?							
227_{16}	Vertical position register 1_8 ($VP1_8$)	$VP1_8 7$	$VP1_8 6$	$VP1_8 5$	$VP1_8 4$	$VP1_8 3$	$VP1_8 2$	$VP1_8 1$	$VP1_8 0$	?							
228_{16}	Vertical position register 1_9 ($VP1_9$)	$VP1_9 7$	$VP1_9 6$	$VP1_9 5$	$VP1_9 4$	$VP1_9 3$	$VP1_9 2$	$VP1_9 1$	$VP1_9 0$	?							
229_{16}	Vertical position register 1_{10} ($VP1_{10}$)	$VP1_{10} 7$	$VP1_{10} 6$	$VP1_{10} 5$	$VP1_{10} 4$	$VP1_{10} 3$	$VP1_{10} 2$	$VP1_{10} 1$	$VP1_{10} 0$	?							
$22A_{16}$	Vertical position register 1_{11} ($VP1_{11}$)	$VP1_{11} 7$	$VP1_{11} 6$	$VP1_{11} 5$	$VP1_{11} 4$	$VP1_{11} 3$	$VP1_{11} 2$	$VP1_{11} 1$	$VP1_{11} 0$	?							
$22B_{16}$	Vertical position register 1_{12} ($VP1_{12}$)	$VP1_{12} 7$	$VP1_{12} 6$	$VP1_{12} 5$	$VP1_{12} 4$	$VP1_{12} 3$	$VP1_{12} 2$	$VP1_{12} 1$	$VP1_{12} 0$	?							
$22C_{16}$	Vertical position register 1_{13} ($VP1_{13}$)	$VP1_{13} 7$	$VP1_{13} 6$	$VP1_{13} 5$	$VP1_{13} 4$	$VP1_{13} 3$	$VP1_{13} 2$	$VP1_{13} 1$	$VP1_{13} 0$	?							
$22D_{16}$	Vertical position register 1_{14} ($VP1_{14}$)	$VP1_{14} 7$	$VP1_{14} 6$	$VP1_{14} 5$	$VP1_{14} 4$	$VP1_{14} 3$	$VP1_{14} 2$	$VP1_{14} 1$	$VP1_{14} 0$	?							
$22E_{16}$	Vertical position register 1_{15} ($VP1_{15}$)	$VP1_{15} 7$	$VP1_{15} 6$	$VP1_{15} 5$	$VP1_{15} 4$	$VP1_{15} 3$	$VP1_{15} 2$	$VP1_{15} 1$	$VP1_{15} 0$	?							
$22F_{16}$	Vertical position register 1_{16} ($VP1_{16}$)	$VP1_{16} 7$	$VP1_{16} 6$	$VP1_{16} 5$	$VP1_{16} 4$	$VP1_{16} 3$	$VP1_{16} 2$	$VP1_{16} 1$	$VP1_{16} 0$	?							
230_{16}	Vertical position register 2_1 ($VP2_1$)	▨	▨	▨	▨	▨	▨	$VP2_1 1$	$VP2_1 0$	?							
231_{16}	Vertical position register 2_2 ($VP2_2$)	▨	▨	▨	▨	▨	▨	$VP2_2 1$	$VP2_2 0$	?							
232_{16}	Vertical position register 2_3 ($VP2_3$)	▨	▨	▨	▨	▨	▨	$VP2_3 1$	$VP2_3 0$	?							
233_{16}	Vertical position register 2_4 ($VP2_4$)	▨	▨	▨	▨	▨	▨	$VP2_4 1$	$VP2_4 0$	?							
234_{16}	Vertical position register 2_5 ($VP2_5$)	▨	▨	▨	▨	▨	▨	$VP2_5 1$	$VP2_5 0$	?							
235_{16}	Vertical position register 2_6 ($VP2_6$)	▨	▨	▨	▨	▨	▨	$VP2_6 1$	$VP2_6 0$	?							
236_{16}	Vertical position register 2_7 ($VP2_7$)	▨	▨	▨	▨	▨	▨	$VP2_7 1$	$VP2_7 0$	?							
237_{16}	Vertical position register 2_8 ($VP2_8$)	▨	▨	▨	▨	▨	▨	$VP2_8 1$	$VP2_8 0$	?							
238_{16}	Vertical position register 2_9 ($VP2_9$)	▨	▨	▨	▨	▨	▨	$VP2_9 1$	$VP2_9 0$	?							
239_{16}	Vertical position register 2_{10} ($VP2_{10}$)	▨	▨	▨	▨	▨	▨	$VP2_{10} 1$	$VP2_{10} 0$	?							
$23A_{16}$	Vertical position register 2_{11} ($VP2_{11}$)	▨	▨	▨	▨	▨	▨	$VP2_{11} 1$	$VP2_{11} 0$	?							
$23B_{16}$	Vertical position register 2_{12} ($VP2_{12}$)	▨	▨	▨	▨	▨	▨	$VP2_{12} 1$	$VP2_{12} 0$	?							
$23C_{16}$	Vertical position register 2_{13} ($VP2_{13}$)	▨	▨	▨	▨	▨	▨	$VP2_{13} 1$	$VP2_{13} 0$	?							
$23D_{16}$	Vertical position register 2_{14} ($VP2_{14}$)	▨	▨	▨	▨	▨	▨	$VP2_{14} 1$	$VP2_{14} 0$	?							
$23E_{16}$	Vertical position register 2_{15} ($VP2_{15}$)	▨	▨	▨	▨	▨	▨	$VP2_{15} 1$	$VP2_{15} 0$	?							
$23F_{16}$	Vertical position register 2_{16} ($VP2_{16}$)	▨	▨	▨	▨	▨	▨	$VP2_{16} 1$	$VP2_{16} 0$	?							
240_{16}	DA-H register (DA-H)									?							
241_{16}	DA-L register (DA-L)	▨	▨							0	0	?	?	?	?	?	?
242_{16}	ROM correction address 1 (high-order)									00_{16}							
243_{16}	ROM correction address 1 (low-order)									00_{16}							
244_{16}	ROM correction address 2 (high-order)									00_{16}							
245_{16}	ROM correction address 2 (low-order)									00_{16}							
246_{16}	ROM correction enable register (RCR)	▨	▨	▨	▨	0	0	RCR1	RCR0	00_{16}							
247_{16}		00_{16}								00_{16}							
248_{16}		▨	▨	▨	▨	▨	0	0	0	00_{16}							

MITSUBISHI ELECTRIC

Internal State of Processor Status Register and Program Counter at Reset

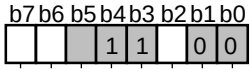


Structure of Register

The figure of each register structure describes its functions, contents at reset, and attributes as follows:

Note : The following registers are the EPROM version's registers. They are different from the MASK version's.

CPU Mode Register



Bits **Bit attributes** (Note 2)
Values immediately after reset release (Note 1)

CPU mode register (CPUM) (CM) [Address FB 16]

B	Name	Functions	After reset	R	W
0, 1	Processor mode bits (CM0, CM1)	b1 b0 0 0: Single-chip mode 0 1: } Not available 1 0: } 1 1: }	0	R	W
2	Stack page selection bit (Note) (CM2)	0: 0 page 1: 1 page	0	R	W
3, 4	Fix these bits to "1."		1	R	W
5	Nothing is assigned. This bit is write disable bit. When this bit is read out, the value is "0."			R	W
6, 7	Clock switch bits (CM6, CM7)	b7 b6 0 0: f(XIN) = 8 MHz 0 1: f(XIN) = 12 MHz 1 0: f(XIN) = 16 MHz 1 1: Do not set	0	R	W

: Bit in which nothing is assigned

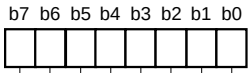
Notes 1: Values immediately after reset release
0••••••"0" after reset release
1••••••"1" after reset release
?••••••Indeterminate after reset release

2: Bit attributes••••••The attributes of control register bits are classified into 3 types : read-only, write-only and read and write. In the figure, these attributes are represented as follows :

R••••••Read
○••••••Read enabled
×••••••Read disabled

W••••••Write
○••••••Write enabled
×••••••Write disabled
✻••••••"0" can be set by software, but "1" cannot be set.

Port Pi Direction Register



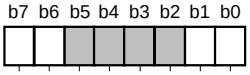
Port Pi direction register (Di) (i=0,1,2) [Addresses $00C1_{16}$, $00C3_{16}$, $00C5_{16}$]

B	Name	Functions	After reset	R	W
0	Port Pi direction register	0 : Port Pi_0 input mode 1 : Port Pi_0 output mode	0	R	W
1		0 : Port Pi_1 input mode 1 : Port Pi_1 output mode	0	R	W
2		0 : Port Pi_2 input mode 1 : Port Pi_2 output mode	0	R	W
3		0 : Port Pi_3 input mode 1 : Port Pi_3 output mode	0	R	W
4		0 : Port Pi_4 input mode 1 : Port Pi_4 output mode	0	R	W
5		0 : Port Pi_5 input mode 1 : Port Pi_5 output mode	0	R	W
6		0 : Port Pi_6 input mode 1 : Port Pi_6 output mode	0	R	W
7		0 : Port Pi_7 input mode 1 : Port Pi_7 output mode	0	R	W

Port Pi Direction Register

Addresses $00C1_{16}$, $00C3_{16}$, $00C5_{16}$

Port P3 Direction Register



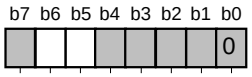
Port P3 direction register (D3) [Address $00C7_{16}$]

B	Name	Functions	After reset	R	W
0	Port P3 direction register	0 : Port $P3_0$ input mode 1 : Port $P3_0$ output mode	0	R	W
1		0 : Port $P3_1$ input mode 1 : Port $P3_1$ output mode	0	R	W
2 to 5	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are "0."		0	R	—
6	Timer 3 count source selection bit (T3SC)	Refer to Timer mode register 2 (address $00F5_{16}$).	0	R	W
7	Ports $P6_3$, $P6_4$ selection bit (P6IM)	Refer to clock source control register (address 0216_{16}).	0	R	W

Port P3 Direction Register

Address $00C7_{16}$

Port P4 Direction Register



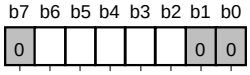
Port P4 direction register (D4) [Address 00C9 16]

B	Name	Functions	After reset	R	W
0	Fix this bit to "0."		0	R	W
1 to 4, 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are "0."		0	R	—
5	Port $P4_5$ selection bit	0: S_{OUT} pin 1: Input port $P4_5$	0	R	W
6	Port $P4_6$ selection bit	0: S_{CLK} pin 1: Input port $P4_6$	0	R	W

Port P4 Direction Register

Address $00C9_{16}$

OSD Port Control Register



OSD port control register (PF) [Address $00CB_{16}$]

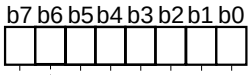
B	Name	Functions	After reset	R	W
0, 1, 7	Fix these bits to "0."		0	R	W
2	Port $P5_2$ output signal selection bit (R)	0 : R signal output 1 : Port $P5_2$ output	0	R	W
3	Port $P5_3$ output signal selection bit (G)	0 : G signal output 1 : Port $P5_3$ output	0	R	W
4	Port $P5_4$ output signal selection bit (B)	0 : B signal output 1 : Port $P5_4$ output	0	R	W
5	Port $P5_5$ output signal selection bit (OUT1)	0 : OUT1 signal output 1 : Port $P5_5$ output	0	R	W
6	Port $P1_0$ output signal selection bit (OUT2)	0 : Port $P1_0$ output 1 : OUT2 signal output (**Note**)	0	R	W

Note. Set bit 0 of Port P1 direction register (address 00C3 16) to "1" (output mode).

OSD Port Control Register

Address $00CB_{16}$

OSD Control Register



OSD control register (OC) [Address 00CE16]

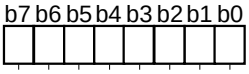
B	Name	Functions	After reset	R	W
0	OSD control bit (OC0) (See note 1)	0 : All-blocks display off 1 : All-blocks display on	0	R	W
1	Scan mode selection bit (OC1)	0 : Normal scnan mode 1 : Bi-scan mode	0	R	W
2	Border type selection bit (OC2)	0 : All bordered 1 : Shadow bordered (See note 2)	0	R	W
3	Flash mode selection bit (OC3)	0 : Color signal of character background part does not flash 1 : Color signal of character background part flashes	0	R	W
4	Automatic solid space control bit (OC4)	0 : OFF 1 : ON	0	R	W
5	Window control bit (OC5)	0 : OFF 1 : ON	0	R	W
6, 7	Layer mixing control bits (OC6, OC7) (See note 3)	b7 b6 0 0: Logic sum (OR) of layer 1's color and layer 2's color 0 1: Layer 1's color has priority 1 0: Layer 2's color has priority 1 1: Do not set.	0	R	W

Notes 1 : Even this bit is switched during display, the display screen remains unchanged until a rising (falling) of the next V SYNC.
2 : Shadow border is output at right and bottom side of the font.
3 : Set "00" during displaying extra fonts.

OSD Control Register

Address 00CE16

Horizontal Position Register



Horizontal position register (HP) [Address 00CF16]

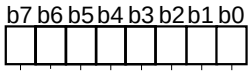
B	Name	Functions	After reset	R	W
0 to 7	Control bits of horizontal display start positions (HP0 to HP7)	Horizontal display start positions 4TOSC × (setting value of high-order 4 bits × 16^1 + setting value of low-order 4 bits × 16^0)	0	R	W

Notes 1. The setting value synchronizes with the V SYNC.
2. TOSC = OSD oscillation period.

Horizontal Position Register

Address 00CF16

Block Control register i



Block control register i (BCi) (i=1 to 16) [Addresses 00D0$_{16}$ to 00DF$_{16}$](See note 1)

B	Name	Functions	After reset	R	W
0, 1	Display mode selection bits (BCi0, BCi1)	b1 b0 0 0: Display OFF 0 1: OSD mode 1 0: CC mode 1 1: EXOSD mode	Indeterminate	R	W
2	Border control bit (BCi2)	0: Border OFF 1: Border ON	Indeterminate	R	W
3, 4	Dot size selection bits (BCi3, BCi4)	See table below	Indeterminate	R	W
5, 6	Pre-divide ratio • layer selection bit (BCi5, BCi6)	See table below	Indeterminate	R	W
7	OUT2 output control bit (BCi7) (See note 2)	BC17: Window top boundary BC27: Window bottom boundary	Indeterminate	R	W

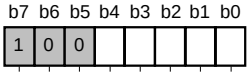
b6	b5	b4	b3	CS6	Pre-divide ratio	Dot size	Display layer
0	0	0	0	—	× 1	1Tc × 1/2H	Layer1
		0	1			1Tc × 1H	
		1	0			2Tc × 2H	
		1	1			3Tc × 3H	
0	1	0	0	—	× 2	1Tc × 1/2H	
		0	1			1Tc × 1H	
		1	0			2Tc × 2H	
		1	1			3Tc × 3H	
1	0	0	0	—	× 3	1Tc × 1/2H	
		0	1			1Tc × 1H	
		1	0			2Tc × 2H	
		1	1			3Tc × 3H	
1	1	—	0	0	× 1	1Tc × 1/2H	Layer2
		—	1			1Tc × 1H	
1	1	0	0	1	× 2	1Tc × 1/2H	
		0	1			1Tc × 1H	
		1	0			1.5Tc × 1/2H	
		1	1			1.5Tc × 1H	

Notes 1: Note that MASK version the block control registers at addresses 00D0$_{16}$ to 00DB$_{16}$ when programming.
2: Bit 4 of the color code 1 controls OUT1 output when bit 7 is "0".
Bit 4 of the color code 1 controls OUT2 output when bit 7 is "1".
3: CS6 : Bit 6 of the clock control register (address 0216 $_{16}$)
4: Tc : Pre-devided clock period for OSD
5: H : Hsync

Block Control Register i

Addresses 00D0$_{16}$ to 00DB$_{16}$

Caption Position Register



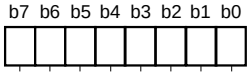
Caption Position Register (CP) [Address 00E0 16]

B	Name	Functions	After reset	R	W
0 to 4	Specification main data slice line (CP0 to CP4)		0	R	W
5, 6	Fix these bits to "0."		0	R	W
7	Fix this bit to "0."		0	R	W

Caption Position Register

Address 00E0$_{16}$

Start Bit Position Register



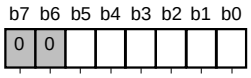
Start bit position register (SP) [Address 00E1$_{16}$]

B	Name	Functions	After reset	R	W
0 to 6	Start bit generating time (SP0 to SP6)	Time from a falling of the horizontal synchronous signal to occurrence of a start bit = 4 × set value ("00$_{16}$" to "7F$_{16}$") × reference clock period	0	R	W
7	DSC1 bit 7 control bit (SP7)	0 : Generation of 16 pulses 1 : Generation of 16 pulses and detection of clock run-in pulse (4 to 6 pulses)	0	R	W

Start Bit Position Register

Address 00E1$_{16}$

Window Register



Window register (WN) [Address 00E2 16]

B	Name	Functions	After reset	R	W
0 to 5	Window start time (WN0 to WN5)	Time from a falling of the horizontal synchronous signal to start of the window = 4 × set value ("00$_{16}$" to "3F$_{16}$") × reference clock period	0	R	W
6, 7	Fix these bits to "0."		0	R	W

Window Register

Address 00E2$_{16}$

Sync Slice Register

b7 b6 b5 b4 b3 b2 b1 b0

	0	0	0	0	1	0	1

Sync slice register (SSL) [Address $00E3_{16}$]

B	Name	Functions	After reset	R	W
0, 2	Fix these bits to "1."		0	R	W
1, 3 to 6	Fix these bits to "0."		0	R	W
7	Vertical synchronous signal (V_{sep}) generating method selection bit (SSL7)	0: Method 1 1: Method 2	0	R	W

Sync Slice Register

Address $00E3_{16}$

Clock Run-in Register 1

b7 b6 b5 b4 b3 b2 b1 b0

0	1	0	1				

Clock run-in register 1 (CR1) [Address $00E6_{16}$]

B	Name	Functions	After reset	R	W
0 to 3	Clock run-in count value of main-data slice line (CR10 to CR13)		0	R	W
4, 6	Fix these bits to "1."		0	R	W
5, 7	Fix these bits to "0."		0	R	W

Clock Run-in Register 1

Address $00E6_{16}$

Clock Run-in Register 2

b7 b6 b5 b4 b3 b2 b1 b0

1	0	0	1	1	1		1

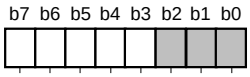
Clock run-in register 2 (CR2) [Address $00E7_{16}$]

B	Name	Functions	After reset	R	W
0, 2 to 4, 7	Fix these bits to "1."		0	R	W
1	Start bit detecting method selection bit (CR21)	0: Method 1 1: Method 2	0	R	W
5, 6	Fix these bits to "0."		0	R	W

Clock Run-in Register 2

Address $00E7_{16}$

Clock Run-in Detect Register i



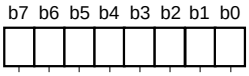
Clock run-in detect register i (CRDi) (i=1, 3) [Addresses $00E8_{16}$, 0208_{16}]

B	Name	Functions	After reset	R	W
0 to 2	Test bits	Read-only	0	R	W
3 to 7	Clock run-in detection bits (CRDi3 to CRDi7)	Number of reference clock s to be counted one clock run-in pulse period	0	R	—

Clock Run-in detect Register i

Addresses $00E8_{16}$, 0208_{16}

Clock Run-in Detect Register 2



Clock run-in detect register 2 (CRD2) [Address $00E9_{16}$]

B	Name	Functions	After reset	R	W
0 to 2	Clock run-in pulses for sampling (CRD20 to CRD22)	b2 b1 b0 0 0 0 : Not available 0 0 1 : 1st pulse 0 1 0 : 2nd pulse 0 1 1 : 3rd pulse 1 0 0 : 4th pulse 1 0 1 : 5th pulse 1 1 0 : 6th pulse 1 1 1 : 7th pulse	0	R	W
3 to 7	Data clock generating time (CRD23 to CRD27)	Time from detection of a start bit to occurrence of a data clock = (13 + set value) × reference clock period	0	R	W

Clock Run-in detect Register 2

Address $00E9_{16}$

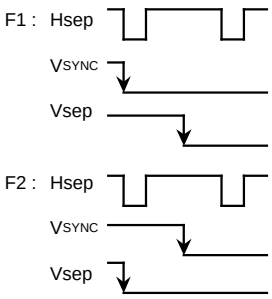
Data Slicer Control Register 1

b7	b6	b5	b4	b3	b2	b1	b0
	0		0	0			

Data slicer control register 1(DSC1) [Address 00EA16]

B	Bit	Functions	After reset	R	W
0	Data slicer control bit (DSC10)	0: Data slicer stopped 1: Data slicer operating	0	R	W
1, 2	Field to be sliced data selection bit (DSC11, DSC12)	b2 b1 — Field of main data slice line — Field for setting refernce voltage 0 0 — F2 — F2 0 1 — F1 — F1 1 0 — F1 and F2 — F2 1 1 — F1 and F2 — F1	0	R	W
3, 4, 6	Fix these bits to "0."		0	R	W
5	Field determination flag (DSC15)	0 : Hsep, Vsep 1 : Hsep, Vsep	Indeterminate	R	—
7	Data latch completion flag for caption data in main data slice line (DSC17)	0: Data is not yet latched 1: Data is latched	Indeterminate	R	W

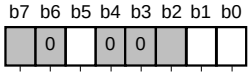
Definition of fields 1 (F1) and 2 (F2)



Data Slicer Control Register 1

Address 00EA16

Data slicer Control Register 2



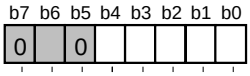
Data slicer Control register 2 (DSC2) [Address $00EB_{16}$]

B	Name	Functions	After reset	R	W
0	Timing signal generating circuit control bit (DSC20)	0: Stopped 1: Operating	0	R	W
1	Reference clock source selection bit (DSC21)	0: Video signal 1: H_{SYNC} signal	0	R	W
2, 7	Test bit	Read-only	Indeterminate	R	—
3, 4, 6	Fix these bits to "0."		0	R	W
5	V-pulse shape determination flag (DSC25)	0: Match 1: Mis match	Indeterminate	R	—

Data Slicer Control Register 2

Address $00EB_{16}$

A-D Control Register



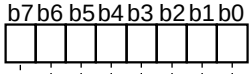
A-D control register (ADCON) [Address $00EF_{16}$]

B	Name	Functions	After reset	R	W
0 to 2	Analog input pin selection bits (ADIN0 to ADIN2)	b2 b1 b0 0 0 0 : AD1 0 0 1 : AD2 0 1 0 : AD3 0 1 1 : AD4 1 0 0 : AD5 1 0 1 : AD6 1 1 0 : } Do not set. 1 1 1 : }	0	R	W
3	A-D conversion completion bit (ADSTR)	0: Conversion in progress 1: Convertion completed	Indeterminate	R	W
4	V_{CC} connection selection bit (ADVREF)	0: OFF 1: ON	Indeterminate	R	W
6	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is indeterminate.		Indeterminate	R	—
5, 7	Fix these bits to "0."		0	R	—

A-D Control Register

Address $00EF_{16}$

Timer Mode Register 1



Timer mode register 1 (TM1) [Address 00F4$_{16}$]

B	Name	Functions	After reset	R	W
0	Timer 1 count source selection bit 1 (TM10)	0: f(XIN)/16 or f(XCIN)/16 (Note) 1: Count source selected by bit 5 of TM1	0	R	W
1	Timer 2 count source selection bit 1 (TM11)	0: Count source selected by bit 4 of TM1 1: External clock from TIM2 pin	0	R	W
2	Timer 1 count stop bit (TM12)	0: Count start 1: Count stop	0	R	W
3	Timer 2 count stop bit (TM13)	0: Count start 1: Count stop	0	R	W
4	Timer 2 count source selection bit 2 (TM14)	0: f(XIN)/16 or f(XCIN)/16 (See note) 1: Timer 1 overflow	0	R	W
5	Timer 1 count source selection bit 2 (TM15)	0: f(XIN)/4096 or f(XCIN)/4096 (See note) 1: External clock from TIM2 pin	0	R	W
6	Timer 5 count source selection bit 2 (TM16)	0: Timer 2 overflow 1: Timer 4 overflow	0	R	W
7	Timer 6 internal count source selection bit (TM17)	0: f(XIN)/16 or f(XCIN)/16 (See note) 1: Timer 5 overflow	0	R	W

Note: Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register.

Timer Mode Register 1

Address 00F4$_{16}$

Timer Mode Register 2

b7 b6 b5 b4 b3 b2 b1 b0

Timer mode register 2 (TM2) [Address 00F5$_{16}$]

B	Name	Functions	After reset	R	W
0	Timer 3 count source selection bit (TM20)	(b6 at address 00C7$_{16}$) b0 0 0 : f(XIN)/16 or f(XCIN)/16 (See note) 0 1 : f(XCIN) 1 0 : 1 1 : } External clock from TIM3 pin	0	R	W
1, 4	Timer 4 count source selection bits (TM21, TM24)	b4 b1 0 0 : Timer 3 overflow signal 0 1 : f(XIN)/16 or f(XCIN)/16 (See note) 1 0 : f(XIN)/2 or f(XCIN)/2 (See note) 1 1 : f(XCIN)	0	R	W
2	Timer 3 count stop bit (TM22)	0: Count start 1: Count stop	0	R	W
3	Timer 4 count stop bit (TM23)	0: Count start 1: Count stop	0	R	W
5	Timer 5 count stop bit (TM25)	0: Count start 1: Count stop	0	R	W
6	Timer 6 count stop bit (TM26)	0: Count start 1: Count stop	0	R	W
7	Timer 5 count source selection bit 1 (TM27)	0: f(XIN)/16 or f(XCIN)/16 (See note) 1: Count source selected by bit 6 of TM1	0	R	W

Note: Either f(XIN) or f(XCIN) is selected by bit 7 of the CPU mode register.

Timer Mode Register 2

Address 00F5$_{16}$

I^{2}C Data Shift Register

b7 b6 b5 b4 b3 b2 b1 b0

I^{2}C data shift register1(S0) [Address 00F6$_{16}$]

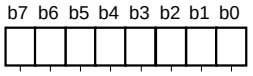
B	Name	Functions	After reset	R	W
0 to 7	D0 to D7	This is an 8-bit shift register to store receive data and write transmit data.	Indeterminate	R	W

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.

I^{2}C Data Shift Register

Address 00F6$_{16}$

I²C Address Register



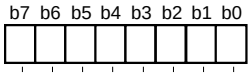
I²C address register (S0D) [Address 00F7₁₆]

B	Name	Functions	After reset	R	W
0	Read/write bit (RBW)	0: Read 1: Write	0	R	—
1 to 7	Slave address (SAD0 to SAD6)	The address data transmitted from the master is compared with the contents of these bits.	0	R	W

I²C Address Register

Address 00F7₁₆

I²C Status Register



I²C status register (S1) [Address 00F8₁₆]

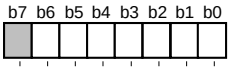
B	Name	Functions	After reset	R	W
0	Last receive bit (LRB) (See note)	0 : Last bit = “0 ” 1 : Last bit = “1 ”	Indeterminate	R	—
1	General call detecting flag (AD0) (See note)	0 : No general call detected 1 : General call detected	0	R	—
2	Slave address comparison flag (AAS) (See note)	0 : Address mismatch 1 : Address match	0	R	—
3	Arbitration lost detecting flag (AL) (See note)	0 : Not detected 1 : Detected	0	R	—
4	I²C-BUS interface interrupt request bit (PIN)	0 : Interrupt request issued 1 : No interrupt request issued	0	R	—
5	Bus busy flag (BB)	0 : Bus free 1 : Bus busy	0	R	W
6, 7	Communication mode specification bits (TRX, MST)	b7 b6 0 0 : Slave recieve mode 0 1 : Slave transmit mode 1 0 : Master recieve mode 1 1 : Master transmit mode	0	R	W

Note : These bits and flags can be read out, but cannnot be written.

I²C Status Register

Address 00F8₁₆

I²C Control Register



I²C control register (S1D : address 00F9 16)

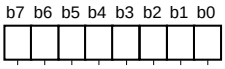
B	Name	Functions	After reset	R	W
0 to 2	Bit counter (Number of transmit/recieve bits) (BC0 to BC2)	b2 b1 b0 0 0 0 : 8 0 0 1 : 7 0 1 0 : 6 0 1 1 : 5 1 0 0 : 4 1 0 1 : 3 1 1 0 : 2 1 1 1 : 1	0	R	W
3	I²C-BUS interface use enable bit (ESO)	0 : Disabled 1 : Enabled	0	R	W
4	Data format selection bit (ALS)	0 : Addressing mode 1 : Free data format	0	R	W
5	Addressing format selection bit (10BIT SAD)	0 : 7-bit addressing format 1 : 10-bit addressing format	0	R	W
6, 7	Connection control bits between I²C-BUS interface and ports	b7 b6 Connection port (See note) 0 0 : None 0 1 : SCL1, SDA1 1 0 : SCL2, SDA2 1 1 : SCL1, SDA1 SCL2, SDA2	0	R	W

Note: When using ports P1₁-P1₄ as I²C-BUS interface, the output structure changes automatically from CMOS output to N-channel open-drain output.

I²C Control Register

Address 00F9₁₆

I²C Clock Control Register



I²C clock control register (S2 : address 00FA 16)

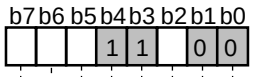
B	Name	Functions			After reset	R	W
0 to 4	SCL frequency control bits (CCR0 to CCR4)	Setup value of CCR4–CCR0	Standard clock mode	High speed clock mode	0	R	W
		00 to 02	Setup disabled	Setup disabled			
		03	Setup disabled	333			
		04	Setup disabled	250			
		05	100	400 (See note)			
		06	83.3	166			
		⋮	500/CCR value	1000/CCR value			
		1D	17.2	34.5			
		1E	16.6	33.3			
		1F	16.1	32.3			
		(at ϕ = 4 MHz, unit : kHz)					
5	SCL mode specification bit (FAST MODE)	0 : Standard clock mode 1 : High-speed clock mode			0	R	W
6	ACK bit (ACK BIT)	0 : ACK is returned. 1 : ACK is not returned.			0	R	W
7	ACK clock bit (ACK)	0 : No ACK clock 1 : ACK clock			0	R	W

Note: At 4000kHz 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

I²C Clock Control Register

Address 00FA₁₆

CPU Mode Register



CPU mode register (CPUM) (CM) [Address FB16]

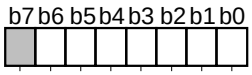
B	Name	Functions	After reset	R	W
0, 1	Processor mode bits (CM0, CM1)	b1 b0 0 0: Single-chip mode 0 1: 1 0: 1 1: } Not available	0	R	W
2	Stack page selection bit (CM2) (See note)	0: 0 page 1: 1 page	1	R	W
3, 4	Fix these bits to "1."		1	R	W
5	XCOUT drivability selection bit (CM5)	0: LOW drive 1: HIGH drive	1	R	W
6	Main Clock (XIN–XOUT) stop bit (CM6)	0: Oscillating 1: Stopped	0	R	W
7	Internal system clock selection bit (CM7)	0: XIN–XOUT selected (high-speed mode) 1: XCIN–XCOUT selected (high-speed mode)	0	R	W

Note: This bit is set to "1" after the reset release.

CPU Mode Register

Address 00FB16

Interrupt Request Register 1



Interrupt request register 1 (IREQ1) [Address 00FC16]

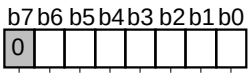
B	Name	Functions	After reset	R	W
0	Timer 1 interrupt request bit (TM1R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
1	Timer 2 interrupt request bit (TM2R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
2	Timer 3 interrupt request bit (TM3R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
3	Timer 4 interrupt request bit (TM4R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
4	OSD interrupt request bit (CRTR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
5	VSYNC interrupt request bit (VSCR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
6	A-D conversion • INT3 interrupt request bit (ADR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is "0."		0	R	—

✻: "0" can be set by software, but "1" cannot be set.

Interrupt Request Register 1

Address 00FC16

Interrupt Request Register 2



Interrupt request register 2 (IREQ2) [Address 00FD16]

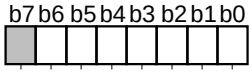
B	Name	Functions	After reset	R	W
0	INT1 interrupt request bit (INT1R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
1	Data slicer interrupt request bit (DSR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
2	Serial I/O interrupt request bit (SIOR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
3	f(XIN)/4096 interrupt request bit (1MSR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
4	INT2 interrupt request bit (INT2R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
5	Multi-master I2C-BUS interrupt request bit (IICR)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
6	Timer 5 • 6 interrupt request bit (T56R)	0 : No interrupt request issued 1 : Interrupt request issued	0	R	✻
7	Fix this bit to “0.”		0	R	W

✻: “0” can be set by software, but “1” cannot be set.

Interrupt Request Register 2

Address 00FD16

Interrupt Control Register 1



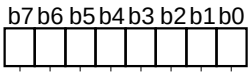
Interrupt control register 1 (ICON1) [Address 00FE16]

B	Name	Functions	After reset	R	W
0	Timer 1 interrupt enable bit (TM1E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
1	Timer 2 interrupt enable bit (TM2E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
2	Timer 3 interrupt enable bit (TM3E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
3	Timer 4 interrupt enable bit (TM4E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
4	OSD interrupt enable bit (CRTE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
5	VSYNC interrupt enable bit (VSCR)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
6	A-D conversion • INT3 interrupt enable bit (ADE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is “0.”		0	R	—

Interrupt Control Register 1

Address 00FE16

Interrupt Control Register 2



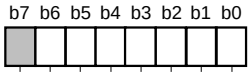
Interrupt control register 2 (ICON2) [Address 00FF16]

B	Name	Functions	After reset	R	W
0	INT1 interrupt enable bit (INT1E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
1	Data slicer interrupt enable bit (DSR)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
2	Serial I/O interrupt enable bit (SIOE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
3	f(XIN)/4096 interrupt enable bit (1MSE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
4	INT2 interrupt enable bit (INT2E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
5	Multi-master I2C-BUS interface interrupt enable bit (IICE)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
6	Timer 5 • 6 interrupt enable bit (T56E)	0 : Interrupt disabled 1 : Interrupt enabled	0	R	W
7	Timer 5 • 6 interrupt switch bit (TM56S)	0 : Timer 5 1 : Timer 6	0	R	W

Interrupt Control Register 2

Address 00FF16

Clock Run-in Register 3



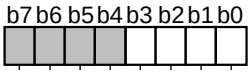
Clock run-in register 3 (CR3) [Address 0209₁₆]

B	Name	Functions	After reset	R	W
0 to 3	Clock run-in count value of sub-data slice line (CR30 to CR33)		0	R	W
4	Data latch completion flag for caption data in sub-data slice line (CR34)	0: Data is not latched yet 1: Data is latched	Indeterminate	R	W
5	Data slice line selection bit for interrupt request (CR35)	0: Main data slice line 1: Sub- data slice line	Indeterminate	R	W
6	Interrupt mode selection bit (CR36)	0: Interrupt occurs at end of data slice line 1: Interrupt occurs at completion of caption data latch	Indeterminate	R	W
7	Nothing is assigned. This bit is a write disable bit. When this bit is read out, the value is “0.”		Indeterminate	R	—

Clock Run-in Register 3

Address 0209₁₆

PWM Mode Register 1



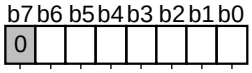
PWM mode register 1 (PN) [Address 020A16]

B	Name	Functions	After reset	R	W
0	PWM counts source selection bit (PN0)	0 : Count source supply 1 : Count source stop	0	R	W
1	DA/P03 output selection bit (PN1)	0 : P03 output 1 : DA output	0	R	W
2	DA output polarity selection bit (PN2)	0 : Positive polarity 1 : Negative polarity	0	R	W
3	PWM output polarity selection bit (PN3)	0 : Positive polarity 1 : Negative polarity	0	R	W
4 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		Indeterminate	R	—

PWM Mode Register 1

Address 020A16

PWM Mode Register 2



PWM mode register 2 (PW) [Address 020B16]

B	Name	Functions	After reset	R	W
0	P04/PWM0 output selection bit (PW0)	0 : P04 output 1 : PWM0 output	0	R	W
1	P05/PWM1 output selection bit (PW1)	0 : P05 output 1 : PWM1 output	0	R	W
2	P06/PWM2 output selection bit (PW2)	0 : P06 output 1 : PWM2 output	0	R	W
3	P07/PWM3 output selection bit (PW3)	0 : P07 output 1 : PWM3 output	0	R	W
4	P00/PWM4 output selection bit (PW4)	0 : P00 output 1 : PWM4 output	0	R	W
5	P01/PWM5 output selection bit (PW5)	0: P01 output 1: PWM5 output	0	R	W
6	P02/PWM6 output selection bit (PW6)	0: P02 output 1: PWM6 output	0	R	W
7	Fix this bit to “0.”		0	R	W

PWM Mode Register 2

Address 020B16

Sync Pulse Counter Register

b7 b6 b5 b4 b3 b2 b1 b0

Sync pulse counter register (SYC) [Address 020F16]

B	Name	Functions	After reset	R	W
0 to 4	Count value (SYC0 to SYC4)		0	R	—
5	Count source (SYC5)	0: HSYNC signal 1: Composite sync signal	0	R	W
6, 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are "0."		0	R	—

Sync Pulse Counter Register

Address 020F16

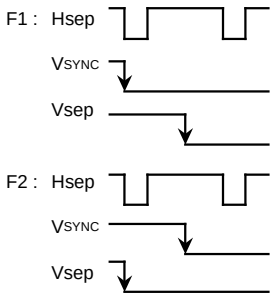
Data Slicer Control Register 3

b7 b6 b5 b4 b3 b2 b1 b0

Data slicer control register 3 (DSC3) [Address 021016]

B	Bit	Functions	After reset	R	W
0	Line selection bit for slice voltage (DSC30)	0: Main data slice line 1: Sub-data slice line	0	R	W
1, 2	Field to be sliced data selection bit (DSC31, DSC32)	b2 b1 — Field of sub-data slice line — Field for setting refernce voltage 0 0 — F2 — F2 0 1 — F1 — F1 1 0 — F1 and F2 — F2 1 1 — F1 and F2 — F1	0	R	W
3 to 7	Setting bit of sub-data slice line (DSC33 to DSC37)		0	R	W

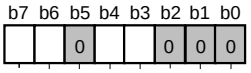
Definition of fields 1 (F1) and 2 (F2)



Data Slicer Control Register 3

Address 021016

Interrupt Input Polarity Register



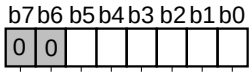
Interrupt input polarity register (IP) [Address 0212_{16}]

B	Name	Functions	After reset	R	W
0 to 2, 5	Fix these bits to "0."		0	R	W
3	INT1 polarity switch bit (INT1POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
4	INT2 polarity switch bit (INT2POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
6	INT3 polarity switch bit (INT3POL)	0 : Positive polarity 1 : Negative polarity	0	R	W
7	A-D conversion • INT3 interrupt source selection bit (RE7)	0 : Positive polarity 1 : Negative polarity	0	R	W

Interrupt Input Polarity Register

Address 0212_{16}

Serial I/O Mode Register



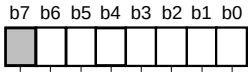
Serial I/O mode register (SM) [Address 0213_{16}]

B	Name	Functions	After reset	R	W
0, 1	Internal synchronous clock selection bits (SM0, SM1)	b1 b0 0 0: f(X_{IN})/4 or f(X_{CIN})/4 0 1: f(X_{IN})/16 or f(X_{CIN})/16 1 0: f(X_{IN})/32 or f(X_{CIN})/32 1 1: f(X_{IN})/64 or f(X_{CIN})/64	0	R	W
2	Synchronous clock selection bit (SM2)	0: External clock 1: Internal clock	0	R	W
3	Port function selection bit (SM3)	0: $P1_1$, $P1_3$ 1: SCL1, SDA1	0	R	W
4	Port function selection bit (SM4)	0: $P1_2$, $P1_4$ 1: SCL2, SDA2	0	R	W
5	Transfer direction selection bit (SM5)	0: LSB first 1: MSB first	0	R	W
6, 7	Fix these bits to "0."		0	R	W

Serial I/O Mode Register

Address 0213_{16}

Clock Source Control Register



Clock source control register (CS) [Address 0216_{16}]

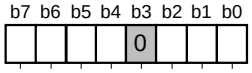
B	Name	Functions	After reset	R	W
0	CC mode clock selection bit (CS0)	0: Data slicer clock 1: OSC1 clock	0	R	W
1, 2	OSD mode clock selection bits (CS1, CS2)	b2 b1 0 0: Data slicer clock 0 1: OSC1 clock 1 0: Main clock (See note 1) 1 1: Do not set	0	R	W
3	EXOSD mode clock selection bit (CS3)	0: Data slicer clock 1: OSC1 clock	0	R	W
4, 5	OSD oscillating mode selection bits (CS4, CS5)	b5 b4 0 0: 32 kHz oscillating mode 0 1: Input ports $P6_3$, $P6_4$ (See note 2) 1 0: LC oscillating mode 1 1: Ceramic • quartz-crystal oscillating mode	0	R	W
6	Pre-divide ratio of layer 2 selection bit (CS6)	0: × 1 1: × 2	0	R	W
7	Test bit (See note 3)		0	R	W

Notes 1: When setting "10_2," main clock is set as a clock in the CC mode and EXOSD mode regardless of bits 0, 3.
2: When selecting input ports $P6_3$ and $P6_4$, set bit 7 at address $00C7_{16}$ to "0."
3: Be sure to set bit 7 to "0" for program of the mask and the EPROM versions. For the emulator MCU version (M37274ERSS), be sure to set bit 7 to "1" when using the data slicer clock for software debugging.

Clock Source Control Register

Address 0216_{16}

I/O Polarity Control Register



I/O polarity control register (PC) [Address 0217_{16}]

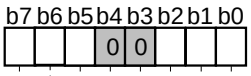
B	Name	Functions	After reset	R	W
0	HSYNC input polarity switch bit (PC0)	0 : Positive polarity input 1 : Negative polarity input	0	R	W
1	VSYNC input polarity switch bit (PC1)	0 : Positive polarity input 1 : Negative polarity input	0	R	W
2	R, G, B output polarity switch bit (PC2)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
3	Fix this bit to "0".		0	R	—
4	OUT1 output polarity switch bit (PC4)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
5	OUT2 output polarity switch bit (PC5)	0 : Positive polarity output 1 : Negative polarity output	0	R	W
6	Display dot line selection bit (PC6) (See note)	0 : "□" at even field "▨" at odd field 1 : "▨" at even field "□" at odd field	0	R	W
7	Field determination flag (PC7)	0 : Even field 1 : Odd field	1	R	—

Note: Refer to Figure 79.

I/O Polarity Control Register

Address 0217_{16}

Raster Color Register



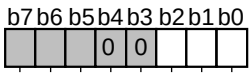
Raster color register (RC) [Address 0218_{16}]

B	Name	Functions	After reset	R	W
0	Raster color R control bit (RC0)	0 : No output 1 : Output	0	R	W
1	Raster color G control bit (RC1)	0 : No output 1 : Output	0	R	W
2	Raster color B control bit (RC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to "0."		0	R	—
5	Raster color OUT1 control bit (RC5)	0 : No output 1 : Output	0	R	W
6	Raster color OUT2 control bit (RC6)	0 : No output 1 : Output	0	R	W
7	OSD interrupt source selection bit (RC7)	0 : Interrupt occurs at end of OSD or EXOSD block display 1 : Interrupt occurs at end of CC mode block display	0	R	W

Raster Color Register

Address 0218_{16}

Extra Font Color Register

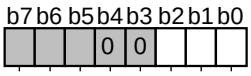


Extra font color register (EC) [Address 0219_{16}]

B	Name	Functions	After reset	R	W
0	Extra font color R control bit (EC0)	0 : No output 1 : Output	0	R	W
1	Extra font color G control bit (EC1)	0 : No output 1 : Output	0	R	W
2	Extra font color B control bit (EC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to “0.”		0	R	W
5 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		0	R	—

Extra Font Color Register **Address 0219_{16}**

Border Color Register

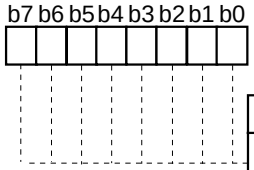


Border color register (FC) [Address $021B_{16}$]

B	Name	Functions	After reset	R	W
0	Border color R control bit (FC0)	0 : No output 1 : Output	0	R	W
1	Border color G control bit (FC1)	0 : No output 1 : Output	0	R	W
2	Border color B control bit (FC2)	0 : No output 1 : Output	0	R	W
3, 4	Fix these bits to “0.”		0	R	W
5 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		0	R	—

Border Color Register **Address $021B_{16}$**

Window H Register 1



Window H register 1 (WH1) [Address 021C16]

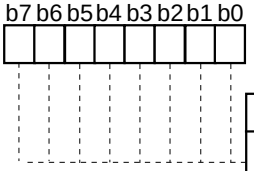
B	Name	Functions	After reset	R	W
0 to 7	Control bits of window top boundary (WN10 to WN17) (See note 1)	Top boundary position (low-order 8 bits) TH × (setting value of low-order 2 bits of WH2 × 16^2 + setting value of high-order 4 bits of WH1 × 16^1 + setting value of low-order 4 bits of WH1 × 16^0)	Indeterminate	R	W

Notes 1: Set values except "00 16" to the WH1 when WH2 is "00 16."
2: TH is cycle of HSYNC.
3: WH2: Window H register 2

Window H Register 1

Address 021C16

Window L Register 1



Window L register 1 (WL1) [Address 021D16]

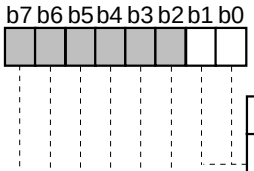
B	Name	Functions	After reset	R	W
0 to 7	Control bits of window top boundary (WL10 to WL17) (See note 1)	Top boundary position (low-order 8 bits) TH × (setting value of low-order 2 bits of WL2 × 16^2 + setting value of high-order 4 bits of WL1 × 16^1 + setting value of low-order 4 bits of WL1 × 16^0)	Indeterminate	R	W

Notes 1: Set values fit for the following condition: (WH1+WH2 ×16^2)<(WL1+WL2× 16^2)
2: TH is cycle of HSYNC.
3: WL2: Window L register 2

Window L Register 1

Address 021D16

Window H Register 2



Window H register 2 (WH2) [Address 021E16]

B	Name	Functions	After reset	R	W
0, 1	Control bits of window top boundary (WN20 ,WN21) (See note 1)	Top boundary position (high-order 2 bits) TH × (setting value of low-order 2 bits of WH2 × 16^2 + setting value of high-order 4 bits of WH1 × 16^1 + setting value of low-order 4 bits of WH1 × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values except "00 16" to the WH1 when WH2 is "00 16."
2: TH is cycle of HSYNC.
3: WH1: Window H register 1

Window H Register 2

Address 021E16

Window L Register 2

Window L register 2 (WL2) [Address 021F16]

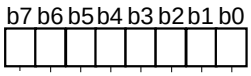
B	Name	Functions	After reset	R	W
0, 1	Control bits of window top boundary (WL20, WL21) (See note 1)	Top boundary position (high-order 2 bits) TH × (setting value of low-order 2 bits of WL2 × 16^2 + setting value of high-order 4 bits of WL1 × 16^1 + setting value of low-order 4 bits of WL1 × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values fit for the following condition: (WH1+WH2 ×16^2)<(WL1+WL2×16^2)
2: TH is cycle of HSYNC.
3: WL1: Window L register 1

Window L Register 2

Address 021F16

Vertical Position Register 1i



Vertical position register 1i (VP1i) (i = 1 to 16) [Addresses 022016 to 022F16]

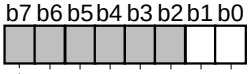
B	Name	Functions	After reset	R	W
0 to 7	Control bits of vertical display start positions (VP1i0 to VP1i7) (See note 1)	Vertical display start positions (low-order 8 bits) TH × (setting value of low-order 2 bits of VP2i × 16^2 + setting value of low-order 4 bits of VP1i × 16^1 + setting value of low-order 4 bits of VP1i × 16^0)	Indeterminate	R	W

Notes 1: Set values except "00 16" "01 16" to VP1i when VP2i is "00 16."
2: TH is cycle of HSYNC.

Vertical Position Register 1i

Addresses 022016 to 022B16

Vertical Position Register 2i



Vertical position register 2i (VP2i) (i = 1 to 16) [Addresses 023016 to 023F16]

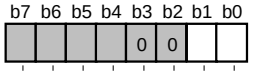
B	Name	Functions	After reset	R	W
0, 1	Control bits of vertical display start positions (VP1i0, VP1i1) (See note 1)	Vertical display start positions (high-order 2 bits) TH × (setting value of low-order 2 bits of VP2i × 16^2 + setting value of low-order 4 bits of VP1i × 16^1 + setting value of low-order 4 bits of VP1i × 16^0)	Indeterminate	R	W
2 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are indeterminate.		Indeterminate	R	—

Notes 1: Set values except "00 16" "01 16" to VP1i when VP2i is "00 16."
2: TH is cycle of HSYNC.

Vertical Position Register 2i

Addresses 023016 to 023B16

ROM Correction Enable Register



ROM correction enable register (RCR) [Address 0246$_{16}$]

B	Name	Functions	After reset	R	W
0	Block 1 enable bit (RC0)	0: Disabled 1: Enabled	0	R	W
1	Block 2 enable bit (RC1)	0: Disabled 1: Enabled	0	R	W
2, 3	Fix these bits to “0.”		0	R	W
4 to 7	Nothing is assigned. These bits are write disable bits. When these bits are read out, the values are “0.”		0	R	—

ROM Correction Enable Register

Address 0246$_{16}$

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