MF1215-01

EPSON

CMOS 8-BIT SINGLE CHIP MICROCOMPUTER

E0C88832/88862 TECHNICAL MANUAL

E0C88832/88862 Technical Hardware

ENERGY SAVING EPSON

SEIKO EPSON CORPORATION

Contents

1 INTRODUCTION

The E0C88832/88862 microcomputer features the E0C88 (Model 3) CMOS 8-bit core CPU along with ROM, RAM, three different timers and a serial interface with optional asynchronization or clock synchronization.

The E0C88832/88862 fully operable over a wide range of voltages, and can perform high speed operations even at low voltage. Like all the equipment in the E0C Family, these microcomputers have low power consumption.

1.1 Configuration

In this manual, the E0C88832/88862 is associated with E0C88832 and E0C88862. In these models, there are differences in built-in ROM capacity, number of output ports and number of LCD drive segments, but the other peripheral circuits are made with the same configuration.

Table 1.1.1 Configuration

Model	Internal ROM	Output port	LCD segment *1
E0C88832	32K bytes	5 bits	1,632 (Max.)
E0C88862	60K bytes	4 bits	1,312 (Max.)

*1: Maximum number of drive segments when the 32 common is selected.

1.2 Features

Table 1.2.1 lists the features of the E0C88832/88862.

Table 1.2.1 Main features

Model		E0C88832	E0C88862
Core CPU		E0C88 (MODEL3) CMOS 8-bit core CPU	
OSC1 Oscillation circuit		Crystal oscillation circuit/CR oscillation circuit/external clock input 32.768 kHz (Typ.)	
OSC3 Oscillation circuit		Crystal oscillation circuit/ceramic oscillation circuit/CR oscillation circuit/external clock input 8.2 MHz (Max.)	
Instruction set		608 types (usable for multiplication and division instructions)	
Min. instruction execution time		0.244 μsec/8.2 MHz (2 clock)	
Internal ROM capacity		32K bytes	60K bytes
Internal RAM capacity		1.5K bytes/RAM, 3,216 bits/display memory	1.5K bytes/RAM, 2,736 bits/display memory
Input port		9 bits (1 bit can be set for event counter external clock input)	
Output port		5 bits (can be set for buzzer output, TOUT signal and FOUT output)	4 bits (can be set for buzzer output and TOUT signal output)
I/O port		8 bits (4 bits can be set for serial interface input/output)	
Serial interface		1ch (Optional clock synchronous system or asynchronous system)	
Timer		Programmable timer (8 bits): 2ch (1ch can be set as a an event counter or 2ch as a 16 bits programmable timer for 1ch) Clock timer (8 bits): 1ch Stopwatch timer (8 bits): 1ch	
Power supply circuit to drive liquid crystals		Built-in (booster type, 5 potentials/4 potentials)	
LCD driver		Dot matrix type (compatible with 5 × 8 or 5 × 5 fonts)	
		51 segments × 32 common	41 segments × 32 common
		67 segments × 16 common	57 segments × 16 common
		67 segments × 8 common	57 segments × 8 common
Sound generator		Envelope function, equipped with volume control	
Watchdog timer		Built-in	
Supply voltage detection (SVD) circuit		Can detect up to 16 different voltage levels	
Interrupt		External interrupt: Input interrupt 2 systems (3 types) Internal interrupt: Timer interrupt 3 systems (9 types) Serial interface interrupt 1 system (3 types)	
Supply voltage		Normal mode: 2.4 V–5.5 V (Max. 4.2 MHz) Low power mode: 1.8 V–3.5 V (Max. 80 kHz) High speed mode: 3.5 V–5.5 V (Max. 8.2 MHz)	
Consumed current	SLEEP	0.3 μA (Typ./normal mode)	
	HALT (32.768 kHz)	1.5 μA (Typ./normal mode)	
	In operation (32.768 kHz)	9 μA (Typ./normal mode)	
	In operation (4 MHz)	1.1 mA (Typ./normal mode)	
Supply form		QFP8-128pin, QFP15-128pin or chip	

1.3 Block Diagram

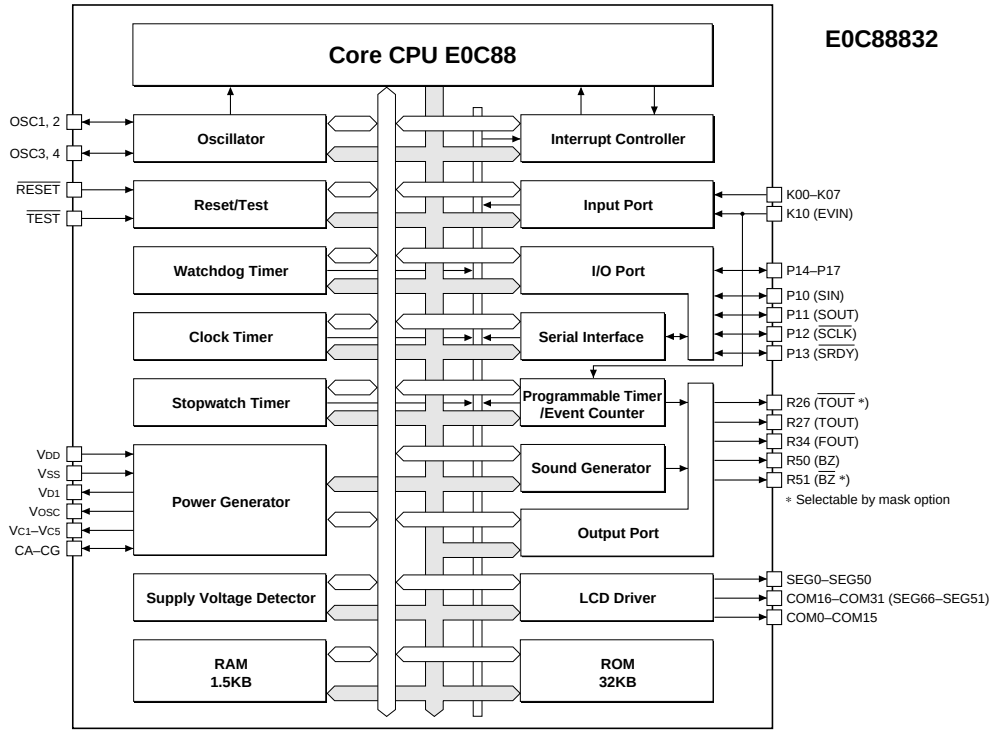


Fig. 1.3.1 E0C88832 block diagram

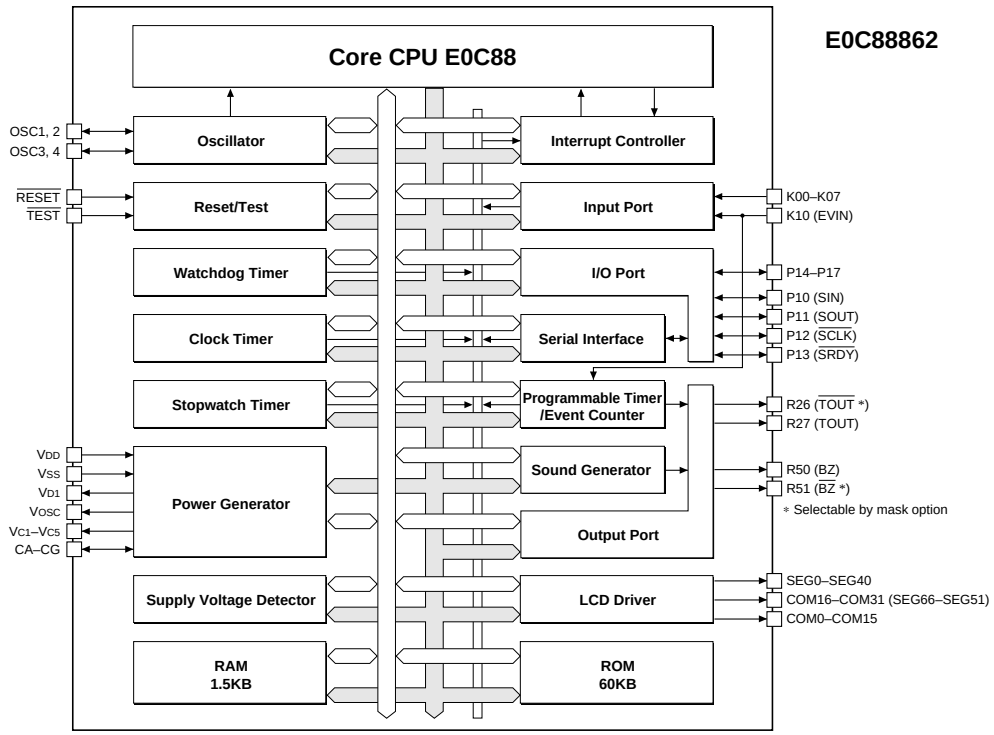
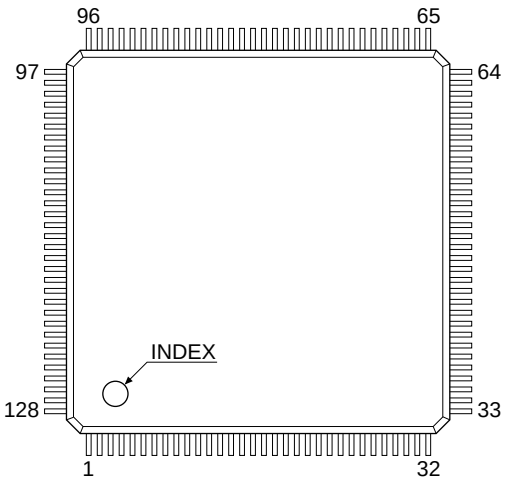


Fig. 1.3.2 E0C88862 block diagram

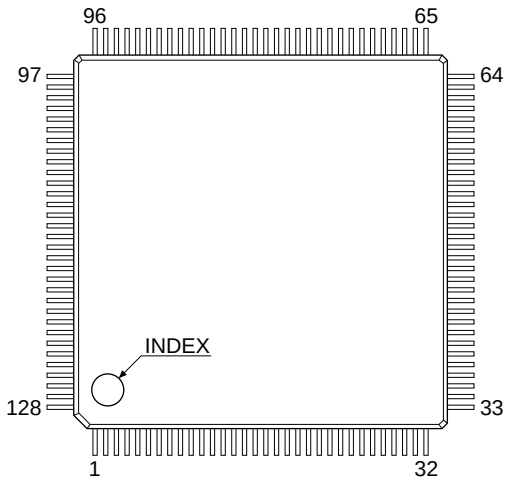
1.4 Pin Layout Diagram

E0C88832

QFP8-128pin



QFP15-128pin



Pin No.	Pin name	Pin No.	Pin name	Pin No.	Pin name	Pin No.	Pin name
1	COM19/SEG63	33	OSC3	65	N.C.	97	SEG31
2	COM18/SEG64	34	OSC4	66	SEG0	98	SEG32
3	COM17/SEG65	35	V_{OSC}	67	SEG1	99	SEG33
4	COM16/SEG66	36	V_{D1}	68	SEG2	100	SEG34
5	COM15	37	V_{DD}	69	SEG3	101	SEG35
6	COM14	38	V_{SS}	70	SEG4	102	SEG36
7	COM13	39	OSC1	71	SEG5	103	SEG37
8	COM12	40	OSC2	72	SEG6	104	SEG38
9	COM11	41	$\overline{TEST}$	73	SEG7	105	SEG39
10	COM10	42	$\overline{RESET}$	74	SEG8	106	SEG40
11	COM9	43	K10/EVIN	75	SEG9	107	SEG41
12	COM8	44	K07	76	SEG10	108	SEG42
13	COM7	45	K06	77	SEG11	109	SEG43
14	COM6	46	K05	78	SEG12	110	SEG44
15	COM5	47	K04	79	SEG13	111	SEG45
16	COM4	48	K03	80	SEG14	112	SEG46
17	COM3	49	K02	81	SEG15	113	SEG47
18	COM2	50	K01	82	SEG16	114	SEG48
19	COM1	51	K00	83	SEG17	115	SEG49
20	COM0	52	P17	84	SEG18	116	SEG50
21	CG	53	P16	85	SEG19	117	COM31/SEG51
22	CF	54	P15	86	SEG20	118	COM30/SEG52
23	CE	55	P14	87	SEG21	119	COM29/SEG53
24	CD	56	P13/$\overline{SRDY}$	88	SEG22	120	COM28/SEG54
25	CC	57	P12/$\overline{SCLK}$	89	SEG23	121	COM27/SEG55
26	CB	58	P11/SOUT	90	SEG24	122	COM26/SEG56
27	CA	59	P10/SIN	91	SEG25	123	COM25/SEG57
28	V_{C5}	60	R26/$\overline{TOUT}$	92	SEG26	124	COM24/SEG58
29	V_{C4}	61	R27/TOUT	93	SEG27	125	COM23/SEG59
30	V_{C3}	62	R34/FOUT	94	SEG28	126	COM22/SEG60
31	V_{C2}	63	R50/$\overline{BZ}$	95	SEG29	127	COM21/SEG61
32	V_{C1}	64	R51/$\overline{BZ}$	96	SEG30	128	COM20/SEG62

N.C.: No Connection

Fig. 1.4.1 E0C88832 pin layout

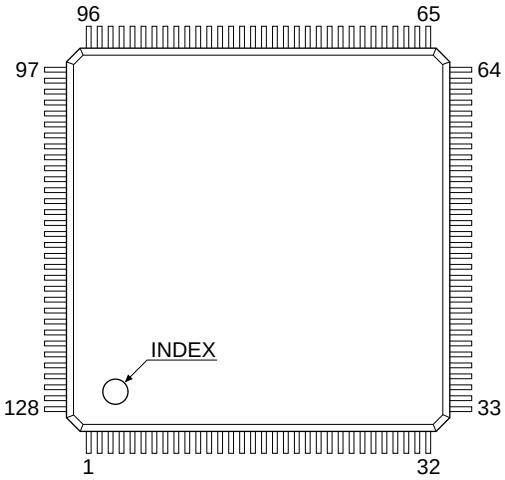
Table 1.4.1 E0C88832 pin description

Pin name	Pin No.	In/out	Function
V_{DD}	37	–	Power supply (+) terminal
V_{SS}	38	–	Power supply (GND) terminal
V_{D1}	36	–	Regulated voltage for internal circuit
V_{OSC}	35	–	Regulated voltage for OSC1 oscillation circuit
V_{C1}–V_{C5}	32–28	O	LCD drive voltage output terminals
CA–CG	27–21	–	Voltage boost/reduce-capacitor connection terminals for LCD
OSC1	39	I	OSC1 oscillation input terminal (select crystal oscillation/CR oscillation/external clock input with mask option)
OSC2	40	O	OSC1 oscillation output terminal
OSC3	33	I	OSC3 oscillation input terminal (select crystal/ceramic/CR oscillation/external clock input with mask option)
OSC4	34	O	OSC3 oscillation output terminal
K00–K07	51–44	I	Input terminals (K00–K07)
K10/EVIN	43	I	Input terminal (K10) or event counter external clock input terminal (EVIN)
R26/$\overline{\text{TOUT}}$	60	O	Output terminal (R26) or programmable timer underflow signal inverted output terminal ($\overline{\text{TOUT}}$) (selectable by mask option)
R27/TOUT	61	O	Output terminal (R27) or programmable timer underflow signal output terminal (TOUT)
R34/FOUT	62	O	Output terminal (R34) or clock output terminal (FOUT)
R50/BZ	63	O	Output terminal (R50) or buzzer output terminal (BZ)
R51/$\overline{\text{BZ}}$	64	O	Output terminal (R51) or buzzer inverted output terminal ($\overline{\text{BZ}}$) (selectable by mask option)
P10/SIN	59	I/O	I/O terminal (P10) or serial I/F data input terminal (SIN)
P11/SOUT	58	I/O	I/O terminal (P11) or serial I/F data output terminal (SOUT)
P12/$\overline{\text{SCLK}}$	57	I/O	I/O terminal (P12) or serial I/F clock I/O terminal ($\overline{\text{SCLK}}$)
P13/$\overline{\text{SRDY}}$	56	I/O	I/O terminal (P13) or serial I/F ready signal output terminal ($\overline{\text{SRDY}}$)
P14–P17	55–52	I/O	I/O terminals (P14–P17)
COM0–COM15	20–5	O	LCD common output terminals
COM16–COM31 /SEG66–SEG51	4–1, 128–117	O	LCD common output terminals (when 1/32 duty is selected) or LCD segment output terminal (when 1/16 or 1/8 duty is selected)
SEG0–SEG50	66–116	O	LCD segment output terminals
$\overline{\text{RESET}}$	42	I	Initial reset input terminal
$\overline{\text{TEST}}$ *1	41	I	Test input terminal

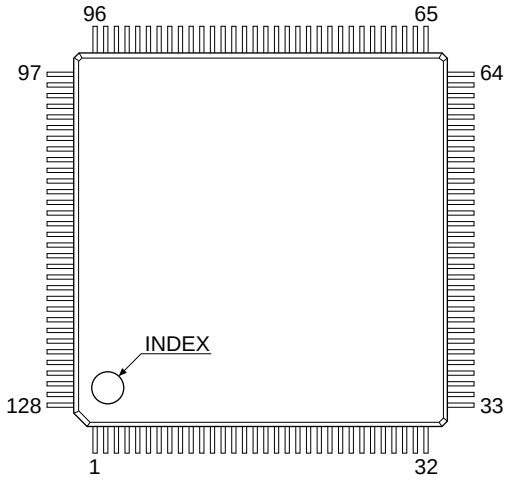
*1 $\overline{\text{TEST}}$ is the terminal used for shipping inspection of the IC. For normal operation be sure it is connected to V_{DD}.

E0C88862

QFP8-128pin



QFP15-128pin



Pin No.	Pin name	Pin No.	Pin name	Pin No.	Pin name	Pin No.	Pin name
1	N.C.	33	N.C.	65	N.C.	97	N.C.
2	N.C.	34	COM15	66	V_{OSC}	98	N.C.
3	N.C.	35	COM14	67	V_{D1}	99	N.C.
4	SEG28	36	COM13	68	V_{DD}	100	N.C.
5	SEG29	37	COM12	69	V_{SS}	101	SEG0
6	SEG30	38	COM11	70	OSC1	102	SEG1
7	SEG31	39	COM10	71	OSC2	103	SEG2
8	SEG32	40	COM9	72	$\overline{TEST}$	104	SEG3
9	SEG33	41	COM8	73	$\overline{RESET}$	105	SEG4
10	SEG34	42	COM7	74	K10/EVIN	106	SEG5
11	SEG35	43	COM6	75	K07	107	SEG6
12	SEG36	44	COM5	76	K06	108	SEG7
13	SEG37	45	COM4	77	K05	109	SEG8
14	SEG38	46	COM3	78	K04	110	SEG9
15	SEG39	47	COM2	79	K03	111	SEG10
16	SEG40	48	COM1	80	K02	112	SEG11
17	COM31/SEG51	49	COM0	81	K01	113	SEG12
18	COM30/SEG52	50	CG	82	K00	114	SEG13
19	COM29/SEG53	51	CF	83	P17	115	SEG14
20	COM28/SEG54	52	CE	84	P16	116	SEG15
21	COM27/SEG55	53	CD	85	P15	117	SEG16
22	COM26/SEG56	54	CC	86	P14	118	SEG17
23	COM25/SEG57	55	CB	87	P13/$\overline{SRDY}$	119	SEG18
24	COM24/SEG58	56	CA	88	P12/$\overline{SCLK}$	120	SEG19
25	COM23/SEG59	57	V_{C5}	89	P11/SOUT	121	SEG20
26	COM22/SEG60	58	V_{C4}	90	P10/SIN	122	SEG21
27	COM21/SEG61	59	V_{C3}	91	R26/$\overline{TOUT}$	123	SEG22
28	COM20/SEG62	60	V_{C2}	92	R27/TOUT	124	SEG23
29	COM19/SEG63	61	V_{C1}	93	R50/BZ	125	SEG24
30	COM18/SEG64	62	OSC3	94	R51/$\overline{BZ}$	126	SEG25
31	COM17/SEG65	63	OSC4	95	N.C.	127	SEG26
32	COM16/SEG66	64	N.C.	96	N.C.	128	SEG27

Fig. 1.4.2 E0C88862 pin layout

N.C.: No Connection

Table 1.4.2 E0C88862 pin description

Pin name	Pin No.	In/out	Function
V_{DD}	68	–	Power supply (+) terminal
V_{SS}	69	–	Power supply (GND) terminal
V_{D1}	67	–	Regulated voltage for internal circuit
V_{OSC}	66	–	Regulated voltage for OSC1 oscillation circuit
V_{C1}–V_{C5}	61–57	O	LCD drive voltage output terminals
CA–CG	56–50	–	Voltage boost/reduce-capacitor connection terminals for LCD
OSC1	70	I	OSC1 oscillation input terminal (select crystal oscillation/CR oscillation/external clock input with mask option)
OSC2	71	O	OSC1 oscillation output terminal
OSC3	62	I	OSC3 oscillation input terminal (select crystal/ceramic/CR oscillation/external clock input with mask option)
OSC4	63	O	OSC3 oscillation output terminal
K00–K07	82–75	I	Input terminals (K00–K07)
K10/EVIN	74	I	Input terminal (K10) or event counter external clock input terminal (EVIN)
R26/$\overline{\text{TOUT}}$	91	O	Output terminal (R26) or programmable timer underflow signal inverted output terminal ($\overline{\text{TOUT}}$) (selectable by mask option)
R27/TOUT	92	O	Output terminal (R27) or programmable timer underflow signal output terminal (TOUT)
R50/BZ	93	O	Output terminal (R50) or buzzer output terminal (BZ)
R51/$\overline{\text{BZ}}$	94	O	Output terminal (R51) or buzzer inverted output terminal ($\overline{\text{BZ}}$) (selectable by mask option)
P10/SIN	90	I/O	I/O terminal (P10) or serial I/F data input terminal (SIN)
P11/SOUT	89	I/O	I/O terminal (P11) or serial I/F data output terminal (SOUT)
P12/$\overline{\text{SCLK}}$	88	I/O	I/O terminal (P12) or serial I/F clock I/O terminal ($\overline{\text{SCLK}}$)
P13/$\overline{\text{SRDY}}$	87	I/O	I/O terminal (P13) or serial I/F ready signal output terminal ($\overline{\text{SRDY}}$)
P14–P17	86–83	I/O	I/O terminals (P14–P17)
COM0–COM15	49–34	O	LCD common output terminals
COM16–COM31 /SEG66–SEG51	32–17	O	LCD common output terminals (when 1/32 duty is selected) or LCD segment output terminal (when 1/16 or 1/8 duty is selected)
SEG0–SEG40	101–128, 4–16	O	LCD segment output terminals
$\overline{\text{RESET}}$	73	I	Initial reset input terminal
$\overline{\text{TEST}}$ *1	72	I	Test input terminal

*1 $\overline{\text{TEST}}$ is the terminal used for shipping inspection of the IC. For normal operation be sure it is connected to V_{DD}.

1.5 Mask Option

Mask options shown below are provided for the E0C88832/88862. Several hardware specifications are prepared in each mask option, and one of them can be selected according to the application. The function option generator WINFOG, that has been prepared as the development software tool of the E0C88832/88862, is used for this selection. Mask pattern of the IC is finally generated based on the data created by the WINFOG. Refer to the "E0C88 Family Development Tool Manual" for details on the WINFOG.

Functions selectable with E0C88832/88862 mask options

(1) $\overline{\text{RESET}}$ terminal pull-up resistor

This mask option can select whether the pull-up resistor for the $\overline{\text{RESET}}$ terminal is used or not.

(2) External reset by simultaneous LOW input to the input port (K00–K03)

This function resets the IC when several keys are pressed simultaneously. The mask option is used to select whether this function is used or not. Further when the function is used, a combination of the input ports (K00–K03), which are connected to the keys to be pressed simultaneously, can be selected. Refer to Section 4.1.2, "Simultaneous LOW level input at input port terminals K00–K03", for details.

(3) OSC1 oscillation circuit

The specification of the OSC1 oscillation circuit can be selected from among four types: "Crystal oscillation", "CR oscillation", "Crystal oscillation (gate capacitor built-in)" and "External clock input". Refer to Section 5.3.3, "OSC1 oscillation circuit", for details.

(4) OSC3 oscillation circuit

The specification of the OSC3 oscillation circuit can be selected from among four types: "Crystal oscillation", "Ceramic oscillation", "CR oscillation" and "External clock input". Refer to Section 5.3.4, "OSC3 oscillation circuit", for details.

(5) Input port pull-up resistor

This mask option can select whether the pull-up resistor for the input port terminal is used or not. It is possible to select for each bit of the input ports. Refer to Section 5.4, "Input Ports (K ports)", for details.

(6) R26, R51 output port specifications

The R26 port can be configured as a general-purpose output port or as the $\overline{\text{TOUT}}$ output port (TOUT inverted output).
The R51 port can be configured as a general-purpose output port or as the $\overline{\text{BZ}}$ output port (BZ inverted output). Refer to Section 5.5, "Output Ports (R ports)", for details.

(7) I/O port pull-up resistor

This mask option can select whether the pull-up resistor for the I/O port terminal (it works during input mode) is used or not. It is possible to select for each bit of the I/O ports. Refer to Section 5.6, "I/O Ports (P ports)", for details.

Since P10 to P13 are shared with the serial interface I/O terminals, the selected P10 and P12 terminal configuration is applied to the serial input (SIN) terminal and serial clock input terminal ($\overline{\text{SCLK}}$ in clock synchronous mode) when the serial interface is used. Refer to Section 5.7, "Serial Interface", for details.

(8) LCD drive duty

The drive duty for the built-in LCD driver can be selected whether it will be 1/32 and 1/16 software-switched or fixed at 1/8. Refer to Section 5.11, "LCD Controller", for details.

(9) LCD power supply

Either the internal power supply or an external power supply can be selected as the LCD system power source. Furthermore, when using the internal power supply, the LCD drive voltage can be set for a 4.5 V panel or a 5.5 V panel and the drive bias to 1/5 or 1/4. Refer to Section 5.11, "LCD Controller", for details.

(10) Initial reset by SVD circuit

The SVD circuit has a function that generates an initial reset signal when the supply voltage drops to level 0 or less. The mask option is used to select whether this function is used or not. Refer to Section 5.13, "Supply Voltage Detection (SVD) Circuit", for details.

Option list

The following options can be set for the E0C88832/88862. Multiple specifications are available in each option item as indicated in the Option List. Select the specifications that meet the target system and check the appropriate box.
The option selection is done interactively on the screen during WINFOG execution, using this option list as reference.

E0C88832/88862 mask option list (1/2)

1 OSC1 SYSTEM CLOCK

☐ 1. Crystal
☐ 2. External Clock
☐ 3. CR
☐ 4. Crystal (with Gate Capacity)

2 OSC3 SYSTEM CLOCK

☐ 1. Crystal
☐ 2. Ceramic
☐ 3. CR
☐ 4. External Clock

3 MULTIPLE KEY ENTRY RESET

• Combination ... ☐ 1. Not Use
☐ 2. Use K00, K01
☐ 3. Use K00, K01, K02
☐ 4. Use K00, K01, K02, K03

4 SVD RESET

☐ 1. Not Use
☐ 2. Use

5 INPUT PORT PULL UP RESISTOR

• K00	☐ 1. With Resistor	☐ 2. Gate Direct
• K01	☐ 1. With Resistor	☐ 2. Gate Direct
• K02	☐ 1. With Resistor	☐ 2. Gate Direct
• K03	☐ 1. With Resistor	☐ 2. Gate Direct
• K04	☐ 1. With Resistor	☐ 2. Gate Direct
• K05	☐ 1. With Resistor	☐ 2. Gate Direct
• K06	☐ 1. With Resistor	☐ 2. Gate Direct
• K07	☐ 1. With Resistor	☐ 2. Gate Direct
• K10	☐ 1. With Resistor	☐ 2. Gate Direct
• $\overline{\text{RESET}}$	☐ 1. With Resistor	☐ 2. Gate Direct

6 I/O PORT PULL UP RESISTOR

• P10	☐ 1. With Resistor	☐ 2. Gate Direct
• P11	☐ 1. With Resistor	☐ 2. Gate Direct
• P12	☐ 1. With Resistor	☐ 2. Gate Direct
• P13	☐ 1. With Resistor	☐ 2. Gate Direct
• P14	☐ 1. With Resistor	☐ 2. Gate Direct
• P15	☐ 1. With Resistor	☐ 2. Gate Direct
• P16	☐ 1. With Resistor	☐ 2. Gate Direct
• P17	☐ 1. With Resistor	☐ 2. Gate Direct

E0C88832/88862 mask option list (2/2)

7 LCD DRIVE DUTY

☐ 1. 1/32 & 1/16 Duty
☐ 2. 1/8 Duty

8 LCD POWER SUPPLY

☐ 1. Internal TYPE A (V_{C2} Standard, 1/5 Bias, 4.5 V)
☐ 2. External
☐ 3. Internal TYPE B (V_{C2} Standard, 1/5 Bias, 5.5 V)
☐ 4. Internal TYPE C (V_{C2} Standard, 1/4 Bias, 4.5 V)
☐ 5. Internal TYPE D (V_{C1} Standard, 1/4 Bias, 4.5 V)

9 R51 OUTPUT PORT SPECIFICATION

☐ 1. With $\overline{BZ}$ (Use)
☐ 2. Without $\overline{BZ}$ (Not Use)

10 R26 OUTPUT PORT SPECIFICATION

☐ 1. With $\overline{TOUT}$ (Use)
☐ 2. Without $\overline{TOUT}$ (Not Use)

2 POWER SUPPLY

In this section, we will explain the operating voltage and the configuration of the internal power supply circuit of the E0C88832/88862.

2.1 Operating Voltage

The E0C88832/88862 operating power voltage is as follows:

Normal mode:	2.4 V to 5.5 V
Low power mode:	1.8 V to 3.5 V
High speed mode:	3.5 V to 5.5 V

If supply voltage drops below level 0 (see Chapter 7, "ELECTRICAL CHARACTERISTICS"), the system is automatically reset by a supply voltage detection (SVD) circuit described in the latter. This function can be selected by mask option.

2.2 Internal Power Supply Circuit

The E0C88832/88862 incorporates the power supply circuit shown in Figure 2.2.1. When voltage within the range described above is supplied to V_{DD} (+) and V_{SS} (GND), all the voltages needed for the internal circuit are generated internally in the IC.

Roughly speaking, the power supply circuit is divided into three sections.

The internal logic voltage regulator generates the operating voltage <V_{D1}> for driving the internal logic circuits and the OSC3 oscillation circuit. The V_{D1} voltage can be selected from the following three types: 1.3 V for low-power mode, 2.2 V for normal mode and 3.3 V for high-speed mode. It should be selected by a program to switch according to the supply voltage and oscillation frequency.
See Section 5.3, "Oscillation Circuits and Operating Mode", for the switching of operating mode.

The oscillation system voltage regulator generates the operating voltage <VOSC> for the OSC1 oscillation circuit.

The LCD system power supply circuit generates the LCD drive voltages <V_{C1}> to <V_{C5}>. In 1/5 bias mode, V_{C1} is generated by halving V_{C2} output from the LCD system voltage regulator and V_{C3} to V_{C5} are generated by boosting V_{C2}. These five voltages can be supplied from outside the IC by mask option. Furthermore, 1/4 bias drive can be selected by mask option. In this case, the V_{C2} voltage level becomes equal to the V_{C3} voltage level. When using with 1/4 bias configuration, the mask option also allows selection of V_{C1} standard mode that generates V_{C2} to V_{C5} by boosting V_{C1}.
See Chapter 7, "ELECTRICAL CHARACTERISTICS" for the voltage values.
In the E0C88832/88862, the LCD drive voltage is supplied to the built-in LCD driver which drives the LCD panel connected to the SEG and COM terminals.

Note: Do not use the V_{C1}–V_{C5} outputs for driving external circuits.

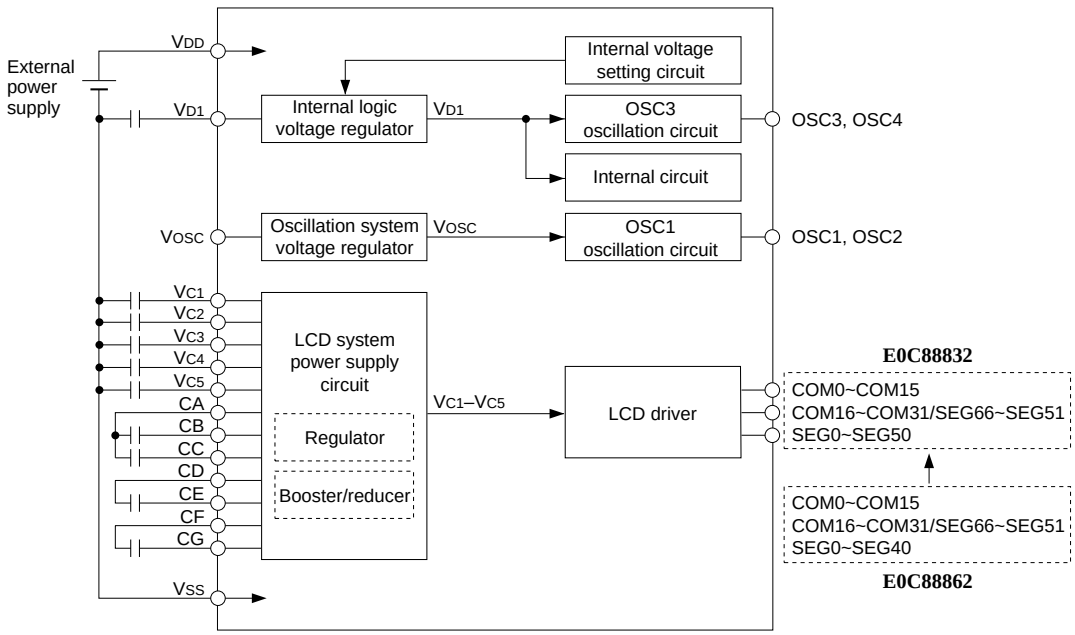


Fig. 2.2.1 Configuration of power supply circuit

2.3 Heavy Load Protection Mode

The E0C88832/88862 has a heavy load protection function for stable operation even when the supply voltage fluctuates by driving a heavy load. The heavy load protection mode becomes valid when the peripheral circuits are in the following status:

(1) The OSC3 oscillation circuit is switched ON (OSCC = "1" and not in SLEEP)

(2) The buzzer output is switched ON (BZON = "1" or BZSHT = "1")

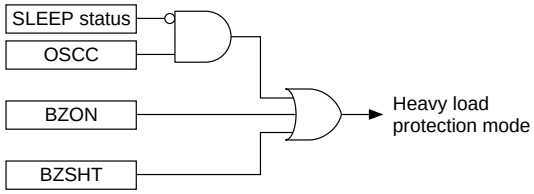


Fig. 2.3.1 Configuration of heavy load protection mode control circuit

For details of the OSC3 oscillation circuit and buzzer output, see "5.3 Oscillation Circuits and Operating Mode" and "5.12 Sound Generator", respectively.

3 CPU AND MEMORY CONFIGURATION

In this section, we will explain the CPU and memory configuration.

3.1 CPU

The E0C88832/88862 utilize the E0C88 8-bit core CPU whose resistor configuration, command set, etc. are virtually identical to other units in the family of processors incorporating the E0C88.

See the "E0C88 Core CPU Manual" for the E0C88.

The E0C88832/88862 supports Model 3/minimum mode of the E0C88 CPU which allows accessing of the internal memory mapped within the physical space from 000000H to 00FFFFH.

3.2 Internal Memory

The E0C88832/88862 is equipped with internal ROM and RAM as shown in Figure 3.2.1.

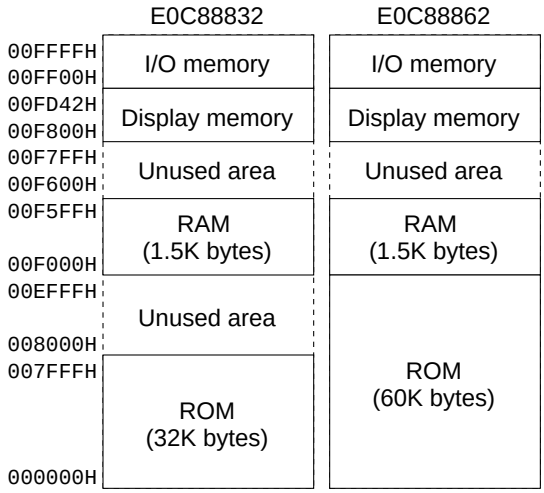


Fig. 3.2.1 Internal memory map

3.2.1 ROM

The internal ROM capacity is shown in Table 3.2.1.1.

Table 3.2.1.1 Internal ROM capacity

Model	ROM capacity	Address
E0C88832	32K bytes	000000H–007FFFH
E0C88862	60K bytes	000000H–00EFFFH

3.2.2 RAM

The internal ROM capacity is shown in Table 3.2.2.1.

Table 3.2.2.1 Internal ROM capacity

Model	RAM capacity	Address
E0C88832	1.5K bytes	00F000H–00F5FFH
E0C88862	1.5K bytes	00F000H–00F5FFH

3.2.3 I/O memory

A memory mapped I/O method is employed in the E0C88832/88862 for interfacing with internal peripheral circuit. Peripheral circuit control bits and data register are arranged in data memory space. Control and data exchange are conducted via normal memory access. The I/O memory is arranged from address 00FF00H to address 00FFFFH. See Section 5.1, "I/O Memory Map", for details of the I/O memory.

3.2.4 Display memory

The E0C88832/88862 is equipped with an internal display memory which stores a display data for LCD driver.
The display memory is arranged from address 00F800H to address 00FD42H (including the unused area). See Section 5.11, "LCD Controller", for details of the display memory.

3.3 Exception Processing Vectors

Address 000000H to address 000023H in the program area of the E0C88832/88862 is assigned as exception processing vectors. Furthermore, from address 000026H to address 0000FFH, software interrupt vectors are assignable to any two bytes which begin with an even address.
Table 3.3.1 lists the vector addresses and the exception processing factors to which they correspond.

Table 3.3.1 Vector addresses and exception processing factors

Vector address	Exception processing factor	Priority
000000H	Reset	High ↑
000002H	Zero division	
000004H	Watchdog timer ($\overline{NMI}$)	
000006H	Programmable timer 1 interrupt	
000008H	Programmable timer 0 interrupt	
00000AH	K10 input interrupt	
00000CH	K04–K07 input interrupt	
00000EH	K00–K03 input interrupt	
000010H	Serial I/F error interrupt	
000012H	Serial I/F receiving complete interrupt	
000014H	Serial I/F transmitting complete interrupt	
000016H	Stopwatch timer 100 Hz interrupt	
000018H	Stopwatch timer 10 Hz interrupt	
00001AH	Stopwatch timer 1 Hz interrupt	
00001CH	Clock timer 32 Hz interrupt	
00001EH	Clock timer 8 Hz interrupt	
000020H	Clock timer 2 Hz interrupt	↓
000022H	Clock timer 1 Hz interrupt	Low
000024H	System reserved (cannot be used)	No priority rating
000026H : 0000FEH	Software interrupt	

For each vector address and the address after it, the start address of the exception processing routine is written into the subordinate and super ordinate sequence. When an exception processing factor is generated, the exception processing routine is executed starting from the recorded address.

When multiple exception processing factors are generated at the same time, execution starts with the highest priority item.
The priority sequence shown in Table 3.3.1 assumes that the interrupt priority levels are all the same. The interrupt priority levels can be set by software in each system. (See Section 5.14 "Interrupt and Standby Status".)

Note: For exception processing other than reset, SC (system condition flag) and PC (program counter) are evacuated to the stack and branches to the exception processing routines. Consequently, when returning to the main routine from exception processing routines, please use the RETE instruction.

See the "E0C88 Core CPU Manual" for information on CPU operations when an exception processing factor is generated.

3.4 CC (Customized Condition Flag)

The E0C88832/88862 does not use the customized condition flag (CC) in the core CPU. Accordingly, it cannot be used as a branching condition for the conditional branching instruction (JRS, CARS).

4 INITIAL RESET

Initial reset in the E0C88832/88862 is required in order to initialize circuits. This chapter describes initial reset factors and the initial settings for internal registers.

4.1 Initial Reset Factors

There are three initial reset factors for the E0C88832/88862 as shown below.

(1) $\overline{\text{RESET}}$ terminal
(2) Simultaneous LOW level input at input port terminals K00–K03.
(3) Supply voltage detection (SVD) circuit

Figure 4.1.1 shows the configuration of the initial reset circuit.

The CPU and peripheral circuits are initialized by means of initial reset factors. When the factor is canceled, the CPU commences reset exception processing. (See "E0C88 Core CPU Manual".)

When this occurs, reset exception processing vectors, Bank 0, 000000H–000001H from program memory are read out and the program (initialization routine) which begins at the readout address is executed.

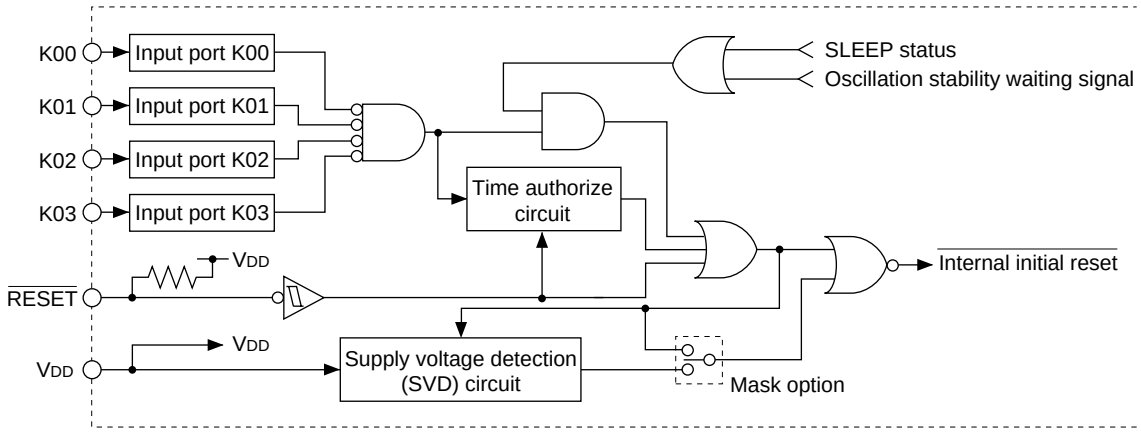


Fig. 4.1.1 Configuration of initial reset circuit

4.1.1 $\overline{\text{RESET}}$ terminal

Initial reset can be done by executed externally inputting a LOW level to the $\overline{\text{RESET}}$ terminal.
Be sure to maintain the $\overline{\text{RESET}}$ terminal at LOW level for the regulation time after the power on to assure the initial reset.
In addition, be sure to use the $\overline{\text{RESET}}$ terminal for the first initial reset after the power is turned on.
The $\overline{\text{RESET}}$ terminal is equipped with a pull-up resistor. You can select whether or not to use by mask option.

4.1.2 Simultaneous LOW level input at input port terminals K00–K03

Another way of executing initial reset externally is to input a LOW level simultaneously to the input ports (K00–K03) selected by mask option.
Since there is a built-in time authorize circuit, be sure to maintain the designated input port terminal at LOW level for two seconds (when the oscillation frequency f_{OSC1} = 32.768 kHz) or more to perform the initial reset by means of this function.

However, the time authorize circuit is bypassed during the SLEEP (standby) status and oscillation stabilization waiting period, and initial reset is executed immediately after the simultaneous LOW level input to the designated input ports.
The combination of input ports (K00–K03) that can be selected by mask option are as follows:
(1) Not use
(2) K00 & K01
(3) K00 & K01 & K02
(4) K00 & K01 & K02 & K03

For instance, if mask option (4) "K00 & K01 & K02 & K03" is selected, initial reset will take place when the input level at input ports K00–K03 is simultaneously LOW.

When using this function, make sure that the designated input ports do not simultaneously switch to LOW level while the system is in normal operation.

4.1.3 Supply voltage detection (SVD) circuit

When the SVD circuit detects that supply voltage has dropped below level 0 four successive times (see Chapter 7, "ELECTRICAL CHARACTERISTICS"), it outputs an initial reset signal until the supply voltage has been restored to level 2.
You can select whether or not to use the initial reset according to the SVD circuit by mask option. If you use it, the supply voltage must be at least level 2 for the first sampling of the SVD circuit, when the power is turned on. At this time, if the power voltage level is less than level 2, the initial reset status will not be canceled and instead the SVD circuit will continue sampling until the supply voltage reaches level 2 or more.
For more information, see "5.13 Supply Voltage Detection (SVD) Circuit" in this Manual.

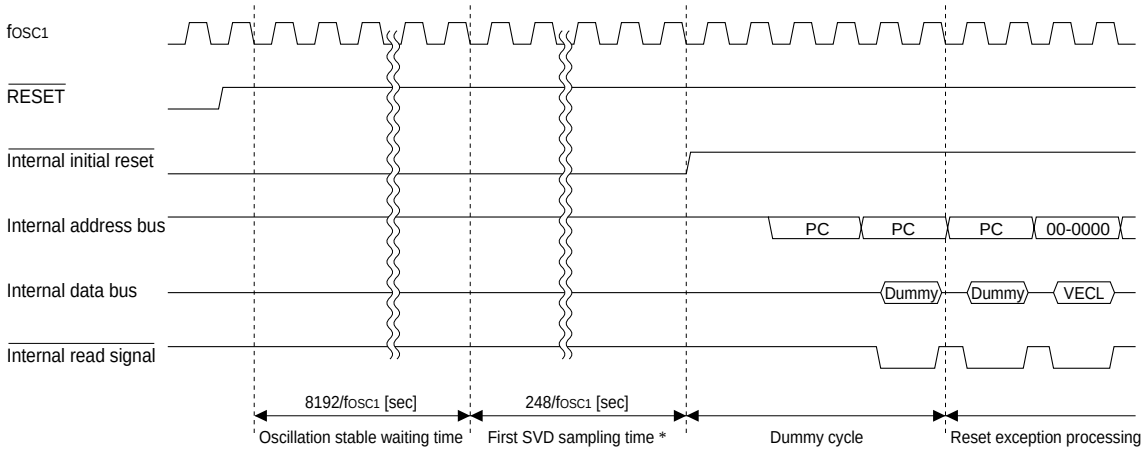
4.1.4 Initial reset sequence

After cancellation of the LOW level input to the $\overline{\text{RESET}}$ terminal, when the power is turned on, the start-up of the CPU is held back until the oscillation stabilization waiting time (8,192/f_{OSC1} sec.) has elapsed. When the initial reset by the SVD circuit has been used, an initial sampling time (248/f_{OSC1} sec.) is added as additional waiting time.
Figure 4.1.4.1 shows the operating sequence following initial reset release.

Also, when using the initial reset by simultaneous LOW level input into the input port, you should be careful of the following points.

(1) During SLEEP status, since the time authorization circuit is bypassed, an initial reset is triggered immediately after a LOW level simultaneous input value. In this case, the CPU starts after waiting the oscillation stabilization time and the SVD circuit initial sampling time (when used with the mask option), following cancellation of the LOW level simultaneous input.

(2) Other than during SLEEP status, an initial reset will be triggered 1–2 seconds after a LOW level simultaneous input. In this case, since a reset differential pulse (64/f_{OSC1} sec.) is generated within the E0C88832/88862, the CPU will start even if the LOW level simultaneous input status is not canceled.



** When the initial reset by the SVD circuit with the mask option has been used, this cycle is inserted as the waiting time.*

Fig. 4.1.4.1 Initial reset sequence

4.2 Initial Settings After Initial Reset

The CPU internal registers are initialized as follows during initial reset.

Table 4.2.1 Initial settings

Register name	Code	Bit length	Setting value
Data register A	A	8	Undefined
Data register B	B	8	Undefined
Index (data) register L	L	8	Undefined
Index (data) register H	H	8	Undefined
Index register IX	IX	16	Undefined
Index register IY	IY	16	Undefined
Program counter	PC	16	Undefined*
Stack pointer	SP	16	Undefined
Base register	BR	8	Undefined
Zero flag	Z	1	0
Carry flag	C	1	0
Overflow flag	V	1	0
Negative flag	N	1	0
Decimal flag	D	1	0
Unpack flag	U	1	0
Interrupt flag 0	I0	1	1
Interrupt flag 1	I1	1	1
New code bank register	NB	8	01H
Code bank register	CB	8	Undefined*
Expand page register	EP	8	00H
Expand page register for IX	XP	8	00H
Expand page register for IY	YP	8	00H

* Reset exception processing loads the preset values stored in 0 bank, 000000H–000001H into the PC. At the same time, 01H of the NB initial value is loaded into CB.

Initialize the registers which are not initialized at initial reset using software.

Since the internal RAM and display memory are not initialized at initial reset, be sure to initialize using software.

The respectively stipulated initializations are done for internal peripheral circuits. If necessary, the initialization should be done using software.
For initial value at initial reset, see the sections on the I/O memory map and peripheral circuit descriptions in the following chapter of this Manual.

5 PERIPHERAL CIRCUITS AND THEIR OPERATION

The peripheral circuits of the E0C88832/88862 is interfaced with the CPU by means of the memory mapped I/O method. For this reason, just as with other memory access operations, peripheral circuits can be controlled by manipulating I/O memory. Below is a description of the operation and control method for each individual peripheral circuit.

5.1 I/O Memory Map

Table 5.1.1(a) I/O Memory map (00FF00H–00FF10H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF00	D7	BSMD1	General-purpose register	1	0	0	R/W	Reserved register (Note)
	D6	BSMD0	General-purpose register			0	R/W	
	D5	CEMD1	General-purpose register			1	R/W	
	D4	CEMD0	General-purpose register			1	R/W	
	D3	CE3	General-purpose register			0	R/W	
	D2	CE2	General-purpose register			0	R/W	
	D1	CE1	General-purpose register			0	R/W	
	D0	CE0	General-purpose register			0	R/W	
00FF01	D7	SPP7	General-purpose register	1	0	0	R/W	Reserved register (Note)
	D6	SPP6	General-purpose register			0	R/W	
	D5	SPP5	General-purpose register			0	R/W	
	D4	SPP4	General-purpose register			0	R/W	
	D3	SPP3	General-purpose register			0	R/W	
	D2	SPP2	General-purpose register			0	R/W	
	D1	SPP1	General-purpose register			0	R/W	
	D0	SPP0	General-purpose register			0	R/W	
00FF02	D7	EBR	General-purpose register	1	0	0	R/W	Reserved register
	D6	WT2	General-purpose register			0	R/W	
	D5	WT1	General-purpose register			0	R/W	
	D4	WT0	General-purpose register			0	R/W	
	D3	CLKCHG	CPU operating clock switch	OSC3	OSC1	0	R/W	
	D2	OSCC	OSC3 oscillation On/Off control	On	Off	0	R/W	
	D1	VDC1	Operating mode selection VDC1 VDC0 Operating mode 1 × High speed (V_{D1}=3.3V) 0 1 Low power (V_{D1}=1.3V) 0 0 Normal (V_{D1}=2.2V)			0	R/W	
	D0	VDC0				0	R/W	
00FF10	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	LCCLK	General-purpose register	1	0	0	R/W	Reserved register
	D3	LCFRM	General-purpose register			0	R/W	
	D2	DTFNT	LCD dot font selection	5 x 5 dots	5 x 8 dots	0	R/W	
	D1	LDUTY	LCD drive duty selection	1/16 duty	1/32 duty	0	R/W	*1
	D0	SGOUT	General-purpose register	1	0	0	R/W	Reserved register

*1 When 1/8 duty has been selected by mask option, setting of this register becomes invalid.

Note) When debugging using the E0C88 Family debugging tools ICE88R (ICE88) and PRC88348, all the interrupts including $\overline{\text{NMI}}$ are disabled until values are written to addresses "00FF00H" and "00FF01H".

Table 5.1.1(b) I/O Memory map (00FF11H–00FF22H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF11	D7	–	–	–	–	–		"0" when being read
	D6	DSPAR	LCD display memory area selection	Display area 1	Display area 0	0	R/W	
	D5	LCDC1	LCD display control LCDC1 LCDC0 LCD display 1 1 All LCDs lit 1 0 All LCDs out 0 1 Normal display 0 0 Drive off			0	R/W	These bits are reset to (0, 0) when SLP instruction is executed.
	D4	LCDC0				0	R/W	
	D3	LC3	LCD contrast adjustment LC3 LC2 LC1 LC0 Contrast 1 1 1 1 Dark 1 1 1 0 : : : : : : 0 0 0 0 Light			0	R/W	
	D2	LC2				0	R/W	
	D1	LC1				0	R/W	
	D0	LC0				0	R/W	
00FF12	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	SVDSP	SVD auto-sampling control	On	Off	0	R/W	These registers are reset to "0" when SLP instruction is executed.
	D4	SVDON	SVD continuous sampling control/status R	Busy	Ready	1→0*1	R/W	
			W	On	Off	0		
	D3	SVD3	SVD detection level SVD3 SVD2 SVD1 SVD0 Detection level 1 1 1 1 Level 15 1 1 1 0 Level 14 : : : : : 0 0 0 0 Level 0			X	R	*2
	D2	SVD2				X	R	
	D1	SVD1				X	R	
	D0	SVD0				X	R	
00FF20	D7	PK01	K00–K07 interrupt priority register	PK01 PK00 PSIF1 PSIF0 PSW1 PSW0 PTM1 PTM0 Priority level 1 1 Level 3 1 0 Level 2 0 1 Level 1 0 0 Level 0		0	R/W	
	D6	PK00				0	R/W	
	D5	PSIF1	Serial interface interrupt priority register			0	R/W	
	D4	PSIF0				0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register			0	R/W	
	D2	PSW0				0	R/W	
	D1	PTM1	Clock timer interrupt priority register			0	R/W	
	D0	PTM0				0	R/W	
00FF21	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	PPT1	Programmable timer interrupt priority register	PPT1 PPT0 PK11 PK10 Priority level 1 1 Level 3 1 0 Level 2 0 1 Level 1 0 0 Level 0		0	R/W	
	D2	PPT0				0	R/W	
	D1	PK11	K10 interrupt priority register			0	R/W	
	D0	PK10				0	R/W	
00FF22	D7	–	–	–	–	–		"0" when being read
	D6	ESW100	Stopwatch timer 100 Hz interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D5	ESW10	Stopwatch timer 10 Hz interrupt enable register			0	R/W	
	D4	ESW1	Stopwatch timer 1 Hz interrupt enable register			0	R/W	
	D3	ETM32	Clock timer 32 Hz interrupt enable register			0	R/W	
	D2	ETM8	Clock timer 8 Hz interrupt enable register			0	R/W	
	D1	ETM2	Clock timer 2 Hz interrupt enable register			0	R/W	
	D0	ETM1	Clock timer 1 Hz interrupt enable register			0	R/W	

*1 After initial reset, this status is set "1" until conclusion of hardware first sampling.

*2 Initial values are set according to the supply voltage detected at first sampling by hardware.
Until conclusion of first sampling, SVD0–SVD3 data are undefined.

Table 5.1.1(c) I/O Memory map (00FF23H–00FF31H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF23	D7	EPT1	Programmable timer 1 interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D6	EPT0	Programmable timer 0 interrupt enable register			0	R/W	
	D5	EK1	K10 interrupt enable register			0	R/W	
	D4	EK0H	K04–K07 interrupt enable register			0	R/W	
	D3	EK0L	K00–K03 interrupt enable register			0	R/W	
	D2	ESERR	Serial I/F (error) interrupt enable register			0	R/W	
	D1	ESREC	Serial I/F (receiving) interrupt enable register			0	R/W	
	D0	ESTRA	Serial I/F (transmitting) interrupt enable register			0	R/W	
00FF24	D7	–	–	–	–	–		"0" when being read
	D6	FSW100	Stopwatch timer 100 Hz interrupt factor flag	(R) Interrupt factor is generated (W) Reset	(R) No interrupt factor is generated (W) No operation	0	R/W	
	D5	FSW10	Stopwatch timer 10 Hz interrupt factor flag			0	R/W	
	D4	FSW1	Stopwatch timer 1 Hz interrupt factor flag			0	R/W	
	D3	FTM32	Clock timer 32 Hz interrupt factor flag			0	R/W	
	D2	FTM8	Clock timer 8 Hz interrupt factor flag			0	R/W	
	D1	FTM2	Clock timer 2 Hz interrupt factor flag			0	R/W	
	D0	FTM1	Clock timer 1 Hz interrupt factor flag			0	R/W	
00FF25	D7	FPT1	Programmable timer 1 interrupt factor flag	(R) Interrupt factor is generated (W) Reset	(R) No interrupt factor is generated (W) No operation	0	R/W	
	D6	FPT0	Programmable timer 0 interrupt factor flag			0	R/W	
	D5	FK1	K10 interrupt factor flag			0	R/W	
	D4	FK0H	K04–K07 interrupt factor flag			0	R/W	
	D3	FK0L	K00–K03 interrupt factor flag			0	R/W	
	D2	FSERR	Serial I/F (error) interrupt factor flag			0	R/W	
	D1	FSREC	Serial I/F (receiving) interrupt factor flag			0	R/W	
	D0	FSTRA	Serial I/F (transmitting) interrupt factor flag			0	R/W	
00FF30	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	MODE16	8/16-bit mode selection	16-bit x 1	8-bit x 2	0	R/W	
	D3	CHSEL	TOUT output channel selection	Timer 1	Timer 0	0	R/W	
	D2	PTOUT	TOUT output control	On	Off	0	R/W	
	D1	CKSEL1	Prescaler 1 source clock selection	f_{OSC3}	f_{OSC1}	0	R/W	
	D0	CKSEL0	Prescaler 0 source clock selection	f_{OSC3}	f_{OSC1}	0	R/W	
00FF31	D7	EVCNT	Timer 0 counter mode selection	Event counter	Timer	0	R/W	
	D6	FCSEL	Timer 0 function selection: In timer mode	Pulse width measurement	Normal mode	0	R/W	
			Timer 0 function selection: In event counter mode	With noise rejector	Without noise rejector			
	D5	PLPOL	Timer 0 pulse polarity selection: Down count timing in event counter mode	Rising edge of K10 input	Falling edge of K10 input	0	R/W	
			Timer 0 pulse polarity selection: In pulse width measurement mode	High level measurement for K10 input	Low level measurement for K10 input			
	D4	PSC01	Timer 0 prescaler dividing ratio selection			0	R/W	
	D3	PSC00	PSC01 = 1, PSC00 = 1: Source clock / 64 PSC01 = 1, PSC00 = 0: Source clock / 16 PSC01 = 0, PSC00 = 1: Source clock / 4 PSC01 = 0, PSC00 = 0: Source clock / 1			0	R/W	
	D2	CONT0	Timer 0 continuous/one-shot mode selection	Continuous	One-shot	0	R/W	
	D1	PSET0	Timer 0 preset	Preset	No operation	–	W	"0" when being read
	D0	PRUN0	Timer 0 Run/Stop control	Run	Stop	0	R/W	

Table 5.1.1(d) I/O Memory map (00FF32H–00FF36H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF32	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	PSC11	Timer 1 prescaler dividing ratio selection PSC11 PSC10 Prescaler dividing ratio 1 1 Source clock / 64			0	R/W	
	D3	PSC10	1 0 Source clock / 16 0 1 Source clock / 4 0 0 Source clock / 1			0	R/W	
	D2	CONT1	Timer 1 continuous/one-shot mode selection	Continuous	One-shot	0	R/W	
	D1	PSET1	Timer 1 preset	Preset	No operation	–	W	"0" when being read
	D0	PRUN1	Timer 1 Run/Stop control	Run	Stop	0	R/W	
00FF33	D7	RLD07	Timer 0 reload data D7 (MSB)	High	Low	1	R/W	
	D6	RLD06	Timer 0 reload data D6			1	R/W	
	D5	RLD05	Timer 0 reload data D5			1	R/W	
	D4	RLD04	Timer 0 reload data D4			1	R/W	
	D3	RLD03	Timer 0 reload data D3			1	R/W	
	D2	RLD02	Timer 0 reload data D2			1	R/W	
	D1	RLD01	Timer 0 reload data D1			1	R/W	
	D0	RLD00	Timer 0 reload data D0 (LSB)			1	R/W	
00FF34	D7	RLD17	Timer 1 reload data D7 (MSB)	High	Low	1	R/W	
	D6	RLD16	Timer 1 reload data D6			1	R/W	
	D5	RLD15	Timer 1 reload data D5			1	R/W	
	D4	RLD14	Timer 1 reload data D4			1	R/W	
	D3	RLD13	Timer 1 reload data D3			1	R/W	
	D2	RLD12	Timer 1 reload data D2			1	R/W	
	D1	RLD11	Timer 1 reload data D1			1	R/W	
	D0	RLD10	Timer 1 reload data D0 (LSB)			1	R/W	
00FF35	D7	PTD07	Timer 0 counter data D7 (MSB)	High	Low	1	R	
	D6	PTD06	Timer 0 counter data D6			1	R	
	D5	PTD05	Timer 0 counter data D5			1	R	
	D4	PTD04	Timer 0 counter data D4			1	R	
	D3	PTD03	Timer 0 counter data D3			1	R	
	D2	PTD02	Timer 0 counter data D2			1	R	
	D1	PTD01	Timer 0 counter data D1			1	R	
	D0	PTD00	Timer 0 counter data D0 (LSB)			1	R	
00FF36	D7	PTD17	Timer 1 counter data D7 (MSB)	High	Low	1	R	
	D6	PTD16	Timer 1 counter data D6			1	R	
	D5	PTD15	Timer 1 counter data D5			1	R	
	D4	PTD14	Timer 1 counter data D4			1	R	
	D3	PTD13	Timer 1 counter data D3			1	R	
	D2	PTD12	Timer 1 counter data D2			1	R	
	D1	PTD11	Timer 1 counter data D1			1	R	
	D0	PTD10	Timer 1 counter data D0 (LSB)			1	R	

Table 5.1.1(e) I/O Memory map (00FF40H–00FF44H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF40	D7	–	–	–	–	–		"0" when being read
	D6	FOUT2	FOUT frequency selection FOUT2 FOUT1 FOUT0 Frequency 0 0 0 fOSC1 / 1 0 0 1 fOSC1 / 2 0 1 0 fOSC1 / 4 0 1 1 fOSC1 / 8 1 0 0 fOSC3 / 1 1 0 1 fOSC3 / 2 1 1 0 fOSC3 / 4 1 1 1 fOSC3 / 8			0	R/W	This is just R/W register on E0C88862.
	D5	FOUT1				0	R/W	
	D4	FOUT0				0	R/W	
	D3	FOUTON	FOUT output control	On	Off	0	R/W	
	D2	WDRST	Watchdog timer reset	Reset	No operation	–	W	Constantly "0" when being read
	D1	TMRST	Clock timer reset	Reset	No operation	–	W	
	D0	TMRUN	Clock timer Run/Stop control	Run	Stop	0	R/W	
00FF41	D7	TMD7	Clock timer data 1 Hz	High	Low	0	R	
	D6	TMD6	Clock timer data 2 Hz			0	R	
	D5	TMD5	Clock timer data 4 Hz			0	R	
	D4	TMD4	Clock timer data 8 Hz			0	R	
	D3	TMD3	Clock timer data 16 Hz			0	R	
	D2	TMD2	Clock timer data 32 Hz			0	R	
	D1	TMD1	Clock timer data 64 Hz			0	R	
	D0	TMD0	Clock timer data 128 Hz			0	R	
00FF42	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	SWRST	Stopwatch timer reset	Reset	No operation	–	W	
	D0	SWRUN	Stopwatch timer Run/Stop control	Run	Stop	0	R/W	
00FF43	D7	SWD7	Stopwatch timer data BCD (1/10 sec)			0	R	
	D6	SWD6				0	R	
	D5	SWD5				0	R	
	D4	SWD4				0	R	
	D3	SWD3	Stopwatch timer data BCD (1/100 sec)			0	R	
	D2	SWD2				0	R	
	D1	SWD1				0	R	
	D0	SWD0				0	R	
00FF44	D7	–	–	–	–	–		Constantry "0" when being read
	D6	BZSTP	One-shot buzzer forcibly stop	Forcibly stop	No operation	–	W	
	D5	BZSHT	One-shot buzzer trigger/status R	Busy	Ready	0	R/W	
			W	Trigger	No operation			
	D4	SHTPW	One-shot buzzer duration width selection	125 msec	31.25 msec	0	R/W	
	D3	ENRTM	Envelope attenuation time	1 sec	0.5 sec	0	R/W	
	D2	ENRST	Envelope reset	Reset	No operation	–	W	"0" when being read
	D1	ENON	Envelope On/Off control	On	Off	0	R/W	*1
	D0	BZON	Buzzer output control	On	Off	0	R/W	

*1 Reset to "0" during one-shot output.

Table 5.1.1(f) I/O Memory map (00FF45H–00FF49H)

Address	Bit	Name	Function		1	0	SR	R/W	Comment
00FF45	D7	–	–		–	–	–		"0" when being read
	D6	DUTY2	Buzzer signal duty ratio selection				0	R/W	
	D5	DUTY1					0	R/W	
	D4	DUTY0					0	R/W	
	D3	–	–		–	–	–		"0" when being read
	D2	BZFQ2	Buzzer frequency selection				0	R/W	
	D1	BZFQ1					0	R/W	
	D0	BZFQ0					0	R/W	
00FF48	D7	–	–		–	–	–		"0" when being read
	D6	EPR	Parity enable register		With parity	Non parity	0	R/W	Only for asynchronous mode
	D5	PMD	Parity mode selection		Odd	Even	0	R/W	
	D4	SCS1	Clock source selection				0	R/W	In the clock synchronous slave mode, external clock is selected.
	D3	SCS0					0	R/W	
	D2	SMD1	Serial I/F mode selection				0	R/W	
	D1	SMD0					0	R/W	
	D0	ESIF	Serial I/F enable register		Serial I/F	I/O port	0	R/W	
00FF49	D7	–	–		–	–	–		"0" when being read
	D6	FER	Framing error flag	R	Error	No error	0	R/W	Only for asynchronous mode
				W	Reset (0)	No operation			
	D5	PER	Parity error flag	R	Error	No error	0	R/W	
				W	Reset (0)	No operation			
	D4	OER	Overrun error flag	R	Error	No error	0	R/W	
				W	Reset (0)	No operation			
	D3	RXTRG	Receive trigger/status	R	Run	Stop	0	R/W	
				W	Trigger	No operation			
	D2	RXEN	Receive enable		Enable	Disable	0	R/W	
	D1	TXTRG	Transmit trigger/status	R	Run	Stop	0	R/W	
				W	Trigger	No operation			
	D0	TXEN	Transmit enable		Enable	Disable	0	R/W	

DUTY2–1 / Buzzer frequency (Hz)

2	1	0	4096.0 2048.0	3276.8 1638.4	2730.7 1365.3	2340.6 1170.3
0	0	0	8/16	8/20	12/24	12/28
0	0	1	7/16	7/20	11/24	11/28
0	1	0	6/16	6/20	10/24	10/28
0	1	1	5/16	5/20	9/24	9/28
1	0	0	4/16	4/20	8/24	8/28
1	0	1	3/16	3/20	7/24	7/28
1	1	0	2/16	2/20	6/24	6/28
1	1	1	1/16	1/20	5/24	5/28

BZFQ2	BZFQ1	BZFQ0	Frequency (Hz)
0	0	0	4096.0
0	0	1	3276.8
0	1	0	2730.7
0	1	1	2340.6
1	0	0	2048.0
1	0	1	1638.4
1	1	0	1365.3
1	1	1	1170.3

SCS1	SCS0	Clock source
1	1	Programmable timer
1	0	f_{OSC3} / 4
0	1	f_{OSC3} / 8
0	0	f_{OSC3} / 16

SMD1	SMD0	Mode
1	1	Asynchronous 8-bit
1	0	Asynchronous 7-bit
0	1	Clock synchronous slave
0	0	Clock synchronous master

Table 5.1.1(g) I/O Memory map (00FF4AH–00FF54H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF4A	D7	TRXD7	Transmit/Receive data D7 (MSB)	High	Low	X	R/W	
	D6	TRXD6	Transmit/Receive data D6			X	R/W	
	D5	TRXD5	Transmit/Receive data D5			X	R/W	
	D4	TRXD4	Transmit/Receive data D4			X	R/W	
	D3	TRXD3	Transmit/Receive data D3			X	R/W	
	D2	TRXD2	Transmit/Receive data D2			X	R/W	
	D1	TRXD1	Transmit/Receive data D1			X	R/W	
	D0	TRXD0	Transmit/Receive data D0 (LSB)			X	R/W	
00FF50	D7	SIK07	K07 interrupt selection register	Interrupt enable	Interrupt disable	0	R/W	
	D6	SIK06	K06 interrupt selection register			0	R/W	
	D5	SIK05	K05 interrupt selection register			0	R/W	
	D4	SIK04	K04 interrupt selection register			0	R/W	
	D3	SIK03	K03 interrupt selection register			0	R/W	
	D2	SIK02	K02 interrupt selection register			0	R/W	
	D1	SIK01	K01 interrupt selection register			0	R/W	
	D0	SIK00	K00 interrupt selection register			0	R/W	
00FF51	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	SIK11	General-purpose register	1	0	0	R/W	Reserved register
	D0	SIK10	K10 interrupt selection register	Enable	Disable	0	R/W	
00FF52	D7	KCP07	K07 input comparison register	Interrupt generated at falling edge	Interrupt generated at rising edge	1	R/W	
	D6	KCP06	K06 input comparison register			1	R/W	
	D5	KCP05	K05 input comparison register			1	R/W	
	D4	KCP04	K04 input comparison register			1	R/W	
	D3	KCP03	K03 input comparison register			1	R/W	
	D2	KCP02	K02 input comparison register			1	R/W	
	D1	KCP01	K01 input comparison register			1	R/W	
	D0	KCP00	K00 input comparison register			1	R/W	
00FF53	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	KCP11	General-purpose register	1	0	1	R/W	Reserved register
	D0	KCP10	K10 input comparison register	Falling edge	Rising edge	1	R/W	
00FF54	D7	K07D	K07 input port data	High level input	Low level input	–	R	
	D6	K06D	K06 input port data			–	R	
	D5	K05D	K05 input port data			–	R	
	D4	K04D	K04 input port data			–	R	
	D3	K03D	K03 input port data			–	R	
	D2	K02D	K02 input port data			–	R	
	D1	K01D	K01 input port data			–	R	
	D0	K00D	K00 input port data			–	R	

Table 5.1.1(h) I/O Memory map (00FF55H–00FF72H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF55	D7	–	–	–	–	–		
	D6	–	–	–	–	–		
	D5	–	–	–	–	_		Constantly "0" when
	D4	–	–	–	–	_		being read
	D3	–	–	–	–	_		
	D2	–	–	–	–	_		
	D1	–	–	–	–	–		"1" when being read
	D0	K10D	K10 input port data	High level	Low level	–	R	
00FF61	D7	IOC17	P17 I/O control register	Output	Input	0	R/W	
	D6	IOC16	P16 I/O control register			0	R/W	
	D5	IOC15	P15 I/O control register			0	R/W	
	D4	IOC14	P14 I/O control register			0	R/W	
	D3	IOC13	P13 I/O control register			0	R/W	
	D2	IOC12	P12 I/O control register			0	R/W	
	D1	IOC11	P11 I/O control register			0	R/W	
	D0	IOC10	P10 I/O control register			0	R/W	
00FF63	D7	P17D	P17 I/O port data	High	Low	1	R/W	
	D6	P16D	P16 I/O port data			1	R/W	
	D5	P15D	P15 I/O port data			1	R/W	
	D4	P14D	P14 I/O port data			1	R/W	
	D3	P13D	P13 I/O port data			1	R/W	
	D2	P12D	P12 I/O port data			1	R/W	
	D1	P11D	P11 I/O port data			1	R/W	
	D0	P10D	P10 I/O port data			1	R/W	
00FF70	D7	HZR51	R51 high impedance control	Hi-Z	Output	0	R/W	
	D6	HZR50	R50 high impedance control			0	R/W	
	D5	HZR4H	General-purpose register	1	0	0	R/W	Reserved register
	D4	HZR4L	General-purpose register			0	R/W	
	D3	HZR1H	General-purpose register			0	R/W	
	D2	HZR1L	General-purpose register			0	R/W	
	D1	HZR0H	General-purpose register			0	R/W	
	D0	HZR0L	General-purpose register			0	R/W	
00FF71	D7	HZR27	R27 high impedance control	Hi-Z	Output	0	R/W	
	D6	HZR26	R26 high impedance control			0	R/W	
	D5	HZR25	General-purpose register	1	0	0	R/W	Reserved register
	D4	HZR24	General-purpose register			0	R/W	
	D3	HZR23	General-purpose register			0	R/W	
	D2	HZR22	General-purpose register			0	R/W	
	D1	HZR21	General-purpose register			0	R/W	
	D0	HZR20	General-purpose register			0	R/W	
00FF72 *1	D7	HZR37	General-purpose register	1	0	0	R/W	Reserved register
	D6	HZR36	General-purpose register			0	R/W	
	D5	HZR35	General-purpose register			0	R/W	
	D4	HZR34	R34 high impedance control	Hi-Z	Output	0	R/W	
	D3	HZR33	General-purpose register	1	0	0	R/W	Reserved register
	D2	HZR32	General-purpose register			0	R/W	
	D1	HZR31	General-purpose register			0	R/W	
	D0	HZR30	General-purpose register			0	R/W	

*1 This address is unavailable in the E0C88862.

Table 5.1.1(i) I/O Memory map (00FF75H–00FF78H)

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF75	D7	R27D	R27 output port data	High	Low	1	R/W	
	D6	R26D	R26 output port data			1 *1	R/W	
	D5	R25D	General-purpose register	1	0	1	R/W	Reserved register
	D4	R24D	General-purpose register			1	R/W	
	D3	R23D	General-purpose register			1	R/W	
	D2	R22D	General-purpose register			1	R/W	
	D1	R21D	General-purpose register			1	R/W	
	D0	R20D	General-purpose register			1	R/W	
00FF76 *2	D7	R37D	General-purpose register	1	0	1	R/W	Reserved register
	D6	R36D	General-purpose register			1	R/W	
	D5	R35D	General-purpose register			1	R/W	
	D4	R34D	R34 output port data	High	Low	1	R/W	
	D3	R33D	General-purpose register	1	0	1	R/W	Reserved register
	D2	R32D	General-purpose register			1	R/W	
	D1	R31D	General-purpose register			1	R/W	
	D0	R30D	General-purpose register			1	R/W	
00FF78	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	R51D	R51 output port data	High	Low	1	R/W	
	D0	R50D	R50 output port data			0	R/W	

*1 "0" when $\overline{\text{TOUT}}$ output is selected by mask option.
*2 This address is unavailable in the E0C88862.

5.2 Watchdog Timer

5.2.1 Configuration of watchdog timer

The E0C88832/88862 is equipped with a watchdog timer driven by OSC1 as source oscillation. The watchdog timer must be reset periodically in software, and if reset of more than 3–4 seconds (when f_{OSC1} = 32.768 kHz) does not take place, a non-maskable interrupt signal is generated and output to the CPU.

Figure 5.2.1.1 is a block diagram of the watchdog timer.

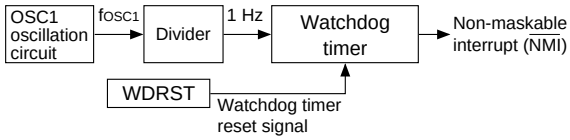


Fig. 5.2.1.1 Block diagram of watchdog timer

By running watchdog timer reset during the main routine of the program, it is possible to detect program runaway as if watchdog timer processing had not been applied. Normally, this routine is integrated at points that are regularly being processed.

The watchdog timer continues to operate during HALT and when a HALT state is continuous for longer than 3–4 seconds, the CPU shifts to exception processing.
During SLEEP, the watchdog timer is stopped.

5.2.2 Interrupt function

In cases where the watchdog timer is not periodically reset in software, the watchdog timer outputs an interrupt signal to the CPU's $\overline{NMI}$ (level 4) input. Unmaskable and taking priority over other interrupts, this interrupt triggers the generation of exception processing. See the "E0C88 Core CPU Manual" for more details on $\overline{NMI}$ exception processing.
This exception processing vector is set at 000004H.

5.2.3 Control of watchdog timer

Table 5.2.3.1 shows the control bits for the watchdog timer.

WDRST: 00FF40H•D2

Resets the watchdog timer.

When "1" is written: Watchdog timer is reset
When "0" is written: No operation
Reading: Constantly "0"

By writing "1" to WDRST, the watchdog timer is reset, after which it is immediately restarted.
Writing "0" will mean no operation.
Since WDRST is for writing only, it is constantly set to "0" during readout.

5.2.4 Programming notes

(1) The watchdog timer must reset within 3-second cycles by software.

(2) Do not execute the SLP instruction for 2 msec after a $\overline{NMI}$ interrupt has occurred (when f_{OSC1} is 32.768 kHz).

Table 5.2.3.1 Watchdog timer control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF40	D7	–	–	–	–	–		"0" when being read
	D6	FOUT2	FOUT frequency selection			0	R/W	
	D5	FOUT1				0	R/W	This is just R/W register on E0C88862.
	D4	FOUT0				0	R/W	
	D3	FOUTON	FOUT output control	On	Off	0	R/W	
	D2	WDRST	Watchdog timer reset	Reset	No operation	–	W	Constantly "0" when being read
	D1	TMRST	Clock timer reset	Reset	No operation	–	W	
	D0	TMRUN	Clock timer Run/Stop control	Run	Stop	0	R/W	

FOUT2	FOUT1	FOUT0	Frequency
0	0	0	f_{OSC1} / 1
0	0	1	f_{OSC1} / 2
0	1	0	f_{OSC1} / 4
0	1	1	f_{OSC1} / 8
1	0	0	f_{OSC3} / 1
1	0	1	f_{OSC3} / 2
1	1	0	f_{OSC3} / 4
1	1	1	f_{OSC3} / 8

5.3 Oscillation Circuits and Operating Mode

5.3.1 Configuration of oscillation circuits

The E0C88832/88862 is twin clock system with two internal oscillation circuits (OSC1 and OSC3). OSC1 oscillation circuit generates the 32.768 kHz (Typ.) main clock and OSC3 oscillation circuit the sub-clock when the CPU and some peripheral circuits (output port, serial interface and programmable timer) are in high speed operation.
Figure 5.3.1.1 shows the configuration of the oscillation circuit.

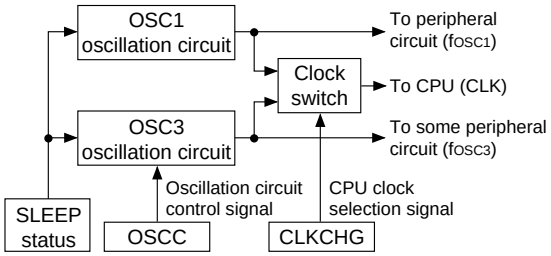


Fig. 5.3.1.1 Configuration of oscillation circuits

At initial reset, OSC1 oscillation circuit is selected for the CPU operating clock and OSC3 oscillation circuit is in a stopped state. ON/OFF switching of the OSC3 oscillation circuit and switching of the system clock between OSC1 and OSC3 are controlled in software. OSC3 circuit is utilized when high speed operation of the CPU and some peripheral circuits become necessary. Otherwise, OSC1 should be used to generate the operating clock and OSC3 circuit placed in a stopped state in order to reduce current consumption.

5.3.2 Mask option

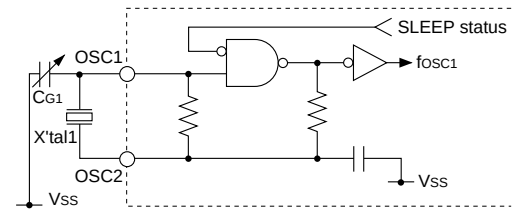
OSC1 oscillation circuit
- ☐ Crystal oscillation circuit
- ☐ External clock input
- ☐ CR oscillation circuit
- ☐ Crystal oscillation circuit (gate capacitor built-in)

OSC3 oscillation circuit
- ☐ Crystal oscillation circuit
- ☐ Ceramic oscillation circuit
- ☐ CR oscillation circuit
- ☐ External clock input

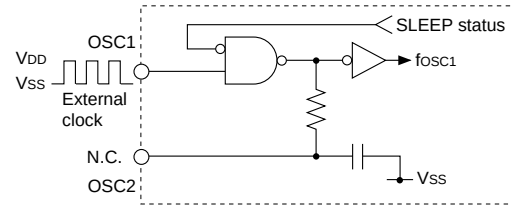
In terms of the oscillation circuit types for OSC1, either crystal oscillation, CR oscillation, crystal oscillation (gate capacitor built-in) or external clock input can be selected with the mask option.
In terms of oscillation circuit types for OSC3, either crystal oscillation, ceramic oscillation, CR oscillation or external clock input can be selected with the mask option, in the same way as OSC1.

5.3.3 OSC1 oscillation circuit

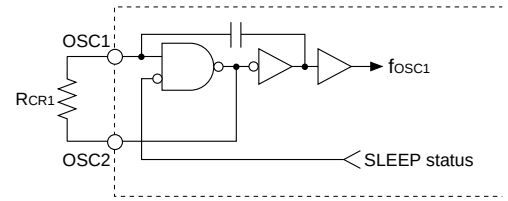
The OSC1 oscillation circuit generates the 32.768 kHz (Typ.) system clock which is utilized during low speed operation (low power mode) of the CPU and peripheral circuits. Furthermore, even when OSC3 is utilized as the system clock, OSC1 continues to generate the source clock for the clock timer and stopwatch timer.
This oscillation circuit stops when the SLP instruction is executed. However, in case the SVD circuit is executing an SLP instruction, oscillation is stopped in synchronization with the completion of sampling.
In terms of the oscillation circuit types, either crystal oscillation, CR oscillation, crystal oscillation (gate capacitor built-in) or external clock input can be selected with the mask option.
Figure 5.3.3.1 shows the configuration of the OSC1 oscillation circuit.



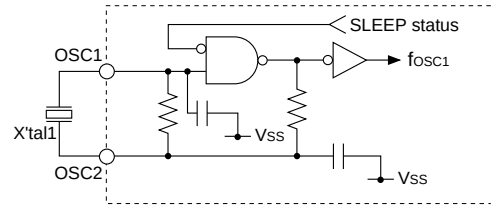
(1) Crystal oscillation circuit



(2) External clock input



(3) CR oscillation circuit



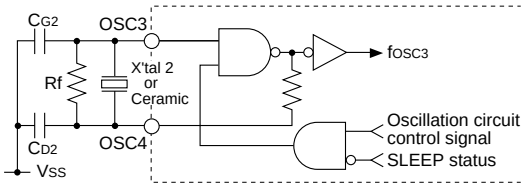
(4) Crystal oscillation circuit (gate capacitor built-in)

Fig. 5.3.3.1 OSC1 oscillation circuit

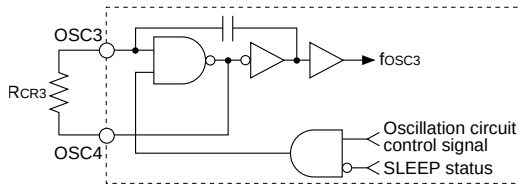
When crystal oscillation is selected, a crystal oscillation circuit can be easily formed by connecting a crystal oscillator X'tal1 (Typ. 32.768 kHz) between the OSC1 and OSC2 terminals along with a trimmer capacitor C_{G1} (5–25 pF) between the OSC1 terminal and V_{SS}.
In addition, the gate capacitor C_{G1} (15 pF) can be built into the circuit by the mask option.
When CR oscillation is selected, connect a resistor (R_{CR1}) between the OSC1 and OSC2 terminals.
When external input is selected, release the OSC2 terminal and input the rectangular wave clock into the OSC1 terminal.

5.3.4 OSC3 oscillation circuit

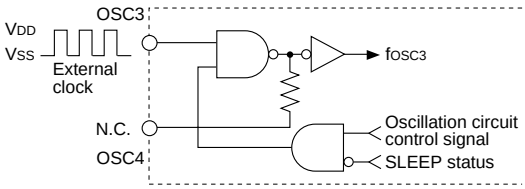
The OSC3 oscillation circuit generates the system clock when the CPU and some peripheral circuits (output port, serial interface and programmable timer) are in high speed operation.
This oscillation circuit stops when the SLP instruction is executed, or the OSCC register is set to "0".
In terms of oscillation circuit types, any one of crystal oscillation, ceramic oscillation, CR oscillation or external clock input can be selected with the mask option.
Figure 5.3.4.1 shows the configuration of the OSC3 oscillation circuit.



(1) Crystal/Ceramic oscillation circuit



(2) CR oscillation circuit



(3) External clock input

Fig. 5.3.4.1 OSC3 oscillation circuit

When crystal or ceramic oscillation circuit is selected, the crystal or ceramic oscillation circuit are formed by connecting either a crystal oscillator (X'tal2) or a combination of ceramic oscillator (Ceramic) and feedback resistor (Rf) between OSC3 and OSC4 terminals and connecting two capacitors (C_{G2}, C_{D2}) between the OSC3 terminal and V_{SS}, and between the OSC4 terminal and V_{SS}, respectively.
When CR oscillation is selected, the CR oscillation circuit is formed merely by connecting a resistor (R_{CR3}) between OSC3 and OSC4 terminals.
When external input is selected, release the OSC4 terminal and input the rectangular wave clock into the OSC3 terminal.

5.3.5 Operating mode

You can select three types of operating modes using software, to obtain a stable operation and good characteristics (operating frequency and current consumption) over a broad operation voltage. Here below are indicated the features of the respective modes.

- **Normal mode (V_{DD} = 2.4 V–5.5 V)**
  This mode is set following the initial reset. It permits the OSC3 oscillation circuit (Max. 4.2 MHz) to be used and also permits relative low power operation.
- **Low power mode (V_{DD} = 1.8 V–3.5 V)**
  This is a lower power mode than the normal mode. It makes ultra-low power consumption possible by operation on the OSC1 oscillation circuit, although the OSC3 circuit cannot be used.
- **High speed mode (V_{DD} = 3.5 V–5.5 V)**
  This mode permits higher speed operation than the normal mode. Since the OSC3 oscillation circuit (Max. 8.2 MHz) can be used, you should use this mode, when you require operation at 4.2 MHz or more. However, the current consumption will increase relative to the normal mode.

Using software to switch over among the above three modes to meet your actual usage circumstances will make possible a low power system. For example, you will be able to reduce current consumption by switching over to the normal mode when using the OSC3 as the CPU clock and, conversely, changing over to the low power mode when using the OSC1 as the CPU clock (OSC3 oscillation circuit is OFF).

Note: Do not turn the OSC3 oscillation circuit ON in the low power mode. Do not switch over the operating mode (normal mode ´ high speed mode) in the OSC3 oscillation circuit ON status, as this will cause faulty operation. You can not use two modes, the low power mode and the high speed mode on one application, with respect to the operating voltages.

5.3.6 Switching the CPU clocks

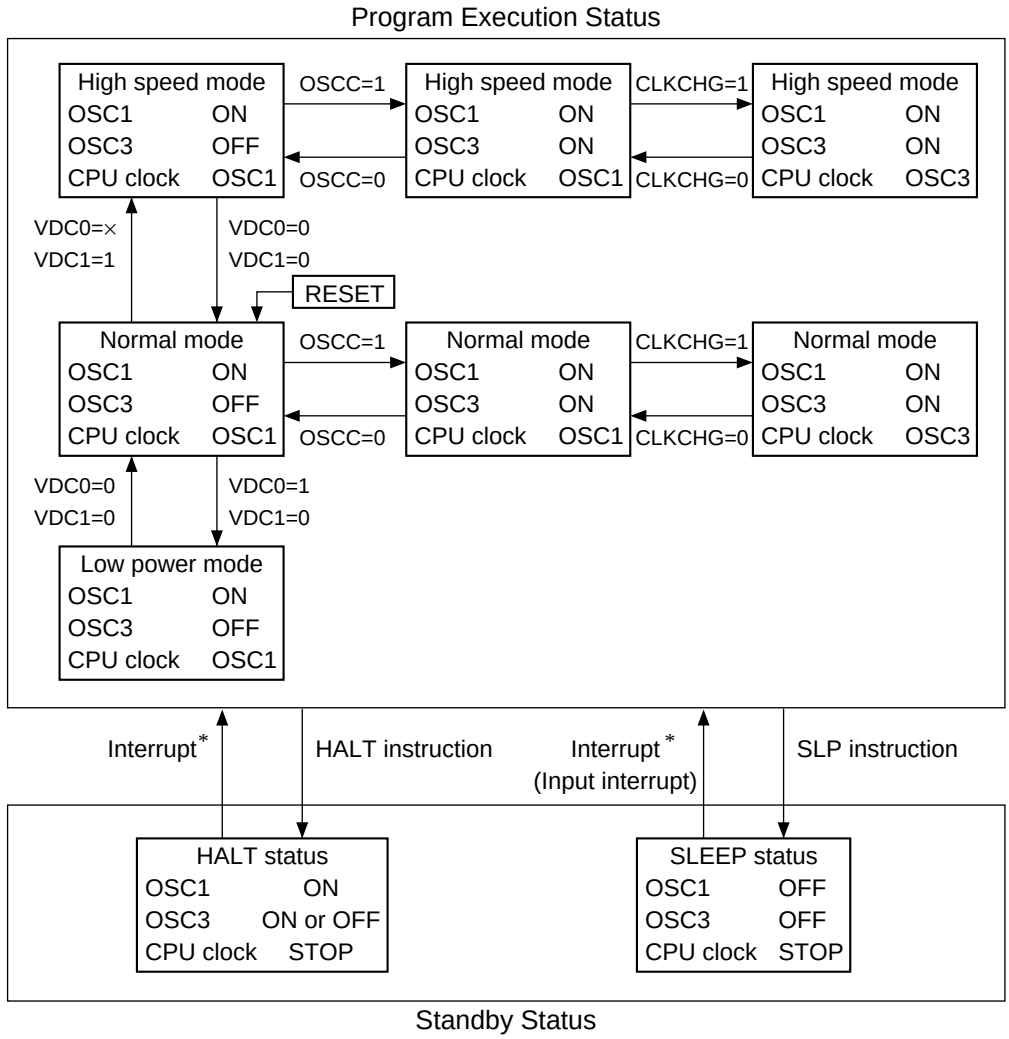
You can use either OSC1 or OSC3 as the system clock for the CPU and you can switch over by means of software.
You can save power by turning the OSC3 oscillation circuit off while the CPU is operating in OSC1. When you must operate on OSC3, you can change to high speed operation by turning the OSC3 oscillation circuit ON and switching over the system clock. In this case, since several 100 µsec to several 10 msec are necessary for the oscillation to stabilize after turning the OSC3 oscillation circuit ON, you should switch over the clock after stabilization time has elapsed. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)

When switching over from the OSC3 to the OSC1, turn the OSC3 oscillation circuit OFF immediately following the clock changeover.

The basic clock switching procedure is as described above, however, you must also combine it with the changeover of the operating mode to permit low current consumption and high speed operation.

Figure 5.3.6.1 indicates the status transition diagram for the operation mode and clock changeover.

Note: When turning ON the OSC3 oscillation circuit after switching the operating mode, you should allow a minimum waiting time of 5 msec.



* The return destination from the standby status becomes the program execution status prior to shifting to the standby status

Fig. 5.3.6.1 Status transition diagram for the operation mode and clock changeover

5.3.7 Control of oscillation circuit and operating mode

Table 5.3.7.1 shows the control bits for the oscillation circuits and operating modes.

Table 5.3.7.1 Oscillation circuit and operating mode control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF02	D7	EBR	General-purpose register	1	0	0	R/W	Reserved register
	D6	WT2	General-purpose register			0	R/W	
	D5	WT1	General-purpose register			0	R/W	
	D4	WT0	General-purpose register			0	R/W	
	D3	CLKCHG	CPU operating clock switch	OSC3	OSC1	0	R/W	
	D2	OSCC	OSC3 oscillation On/Off control	On	Off	0	R/W	
	D1	VDC1	Operating mode selection VDC1 VDC0 Operating mode 1 × High speed (V_{D1}=3.3V) 0 1 Low power (V_{D1}=1.3V) 0 0 Normal (V_{D1}=2.2V)			0	R/W	
	D0	VDC0				0	R/W	

VDC1, VDC0: 00FF02H•D1, D0

Selects the operating mode according to supply voltage and operating frequency.
Table 5.3.7.2 shows the correspondence between register preset values and operating modes.

Table 5.3.7.2 Correspondence between register preset values and operating modes

Operating mode	VDC1	VDC0	V_{D1}	Power voltage	Operating frequency
Normal mode	0	0	2.2 V	2.4–5.5 V	4.2 MHz (Max.)
Low power mode	0	1	1.3 V	1.8–3.5 V	80 kHz (Max.)
High speed mode	1	×	3.3 V	3.5–5.5 V	8.2 MHz (Max.)

* The V_{D1} voltage is the value where V_{SS} has been made the standard (GND).

At initial reset, this register is set to "0" (normal mode).

OSCC: 00FF02H•D2

Controls the ON and OFF settings of the OSC3 oscillation circuit.

When "1" is written: OSC3 oscillation ON
When "0" is written: OSC3 oscillation OFF
Reading: Valid

When the CPU and some peripheral circuits (output port, serial interface and programmable timer) are to be operated at high speed, OSCC is to be set to "1". At all other times, it should be set to "0" in order to reduce current consumption.
At initial reset, OSCC is set to "0" (OSC3 oscillation OFF).

CLKCHG: 00FF02H•D3

Selects the operating clock for the CPU.

When "1" is written: OSC3 clock
When "0" is written: OSC1 clock
Reading: Valid

When the operating clock for the CPU is switched to OSC3, CLKCHG should be set to "1" and when the clock is switched to OSC1, CLKCHG should be set to "0".
At initial reset, CLKCHG is set to "0" (OSC1 clock).

5.3.8 Programming notes

(1) When the high speed CPU operation is not necessary, you should operate the peripheral circuits according to the setting outline indicate below.

- CPU operating clock
  OSC1
- OSC3 oscillation circuit
  OFF (When the OSC3 clock is not necessary for some peripheral circuits.)
- Operating mode
  Low power mode (When V_{DD}–V_{SS} is 3.5 V or less)
  or Normal mode (When V_{DD}–V_{SS} is 3.5 V or more)

(2) Do not turn the OSC3 oscillation circuit ON in the low power mode.
Do not switch over the operating mode (normal mode ↔ high speed mode) in the OSC3 oscillation circuit ON status, as this will cause faulty operation.

(3) When turning ON the OSC3 oscillation circuit after switching the operating mode, you should allow a minimum waiting time of 5 msec.

(4) Since several 100 µsec to several 10 msec are necessary for the oscillation to stabilize after turning the OSC3 oscillation circuit ON. Consequently, you should switch the CPU operating clock (OSC1 → OSC3) after allowing for a sufficient waiting time once the OSC3 oscillation goes ON. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)

(5) When switching the clock from OSC3 to OSC1, be sure to switch OSC3 oscillation OFF with separate instructions. Using a single instruction to process simultaneously can cause a malfunction of the CPU.

5.4 Input Ports (K ports)

5.4.1 Configuration of input ports

The E0C88832/88862 is equipped with 9 input port bits (K00–K07 and K10) which are usable as general purpose input port terminals with interrupt function.

K10 terminal doubles as the external clock (EVIN) input terminal of the programmable timer (event counter) with input port functions sharing the input signal as is. (See "5.10 Programmable Timer")

Each input port is equipped with a pull-up resistor. The mask option can be used to select either "With resistor" or "Gate direct" for each input port.
Figure 5.4.1.1 shows the structure of the input port.

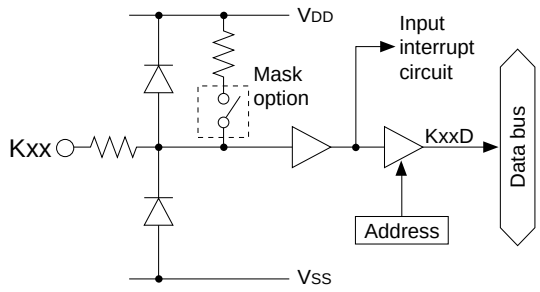


Fig. 5.4.1.1 Structure of input port

Each input port terminal is directly connected via a three-state buffer to the data bus. Furthermore, the input signal state at the instant of input port readout is read in that form as data.

5.4.2 Mask option

Input port pull-up resistors
K00 .... ☐ With resistor ☐ Gate direct
K01 .... ☐ With resistor ☐ Gate direct
K02 .... ☐ With resistor ☐ Gate direct
K03 .... ☐ With resistor ☐ Gate direct
K04 .... ☐ With resistor ☐ Gate direct
K05 .... ☐ With resistor ☐ Gate direct
K06 .... ☐ With resistor ☐ Gate direct
K07 .... ☐ With resistor ☐ Gate direct

K10 .... ☐ With resistor ☐ Gate direct

Input ports K00–K07 and K10 are all equipped with pull-up resistors. The mask option can be used to select 'With resistor' or 'Gate direct' for each port (bit).

The 'With resistor' option is rendered suitable for purposes such as push switch or key matrix input. When changing the input terminal from LOW level to HIGH with the built-in pull-up resistor, a delay in the waveform rise time will occur depending on the time constant of the pull-up resistor and the load capacitance of the terminal. It is necessary to set an appropriate wait time for introduction of an input port. In particular, special attention should be paid to key scan for key matrix formation. Make this wait time the amount of time or more calculated by the following expression.

Wait time = R_{IN} x (C_{IN} + load capacitance on the board) x 1.6 [sec]

R_{IN}: Pull up resistance Max. value
C_{IN}: Terminal capacitance Max. value

When 'Gate direct' is selected, the pull-up resistor is detached and the port is rendered suitable for purposes such as slide switch input and interfacing with other LSIs.
In this case, take care that a floating state does not occur in input.

For unused input ports, select the default setting of "With resistor".

5.4.3 Interrupt function and input comparison register

Input port K00–K07 and K10 are all equipped with an interrupt function. These input ports are divided into three groupings: K00–K03 (K0L), K04–K07 (K0H) and K10 (K1). Furthermore, the interrupt generation condition for each series of terminals can be set by software.
When the interrupt generation condition set for each series of terminals is met, the interrupt factor flag FK0L, FK0H or FK1 corresponding to the applicable series is set at "1" and an interrupt is generated.
Interrupt can be prohibited by setting the interrupt enable registers EK0L, EK0H and EK1 for the corresponding interrupt factor flags.
Furthermore, the priority level for input interrupt can be set at the desired level (0–3) using the interrupt priority registers PK00–PK01 and PK10–PK11 corresponding to each of two groups K0x (K00–K07) and K10.
For details on the interrupt control registers for the above and on operations subsequent to interrupt generation, see "5.14 Interrupt and Standby Status".

The exception processing vectors for each interrupt factor are set as follows:

K10 input interrupt:	00000AH
K04–K07 input interrupt:	00000CH
K00–K03 input interrupt:	00000EH

Figure 5.4.3.1 shows the configuration of the input interrupt circuit.

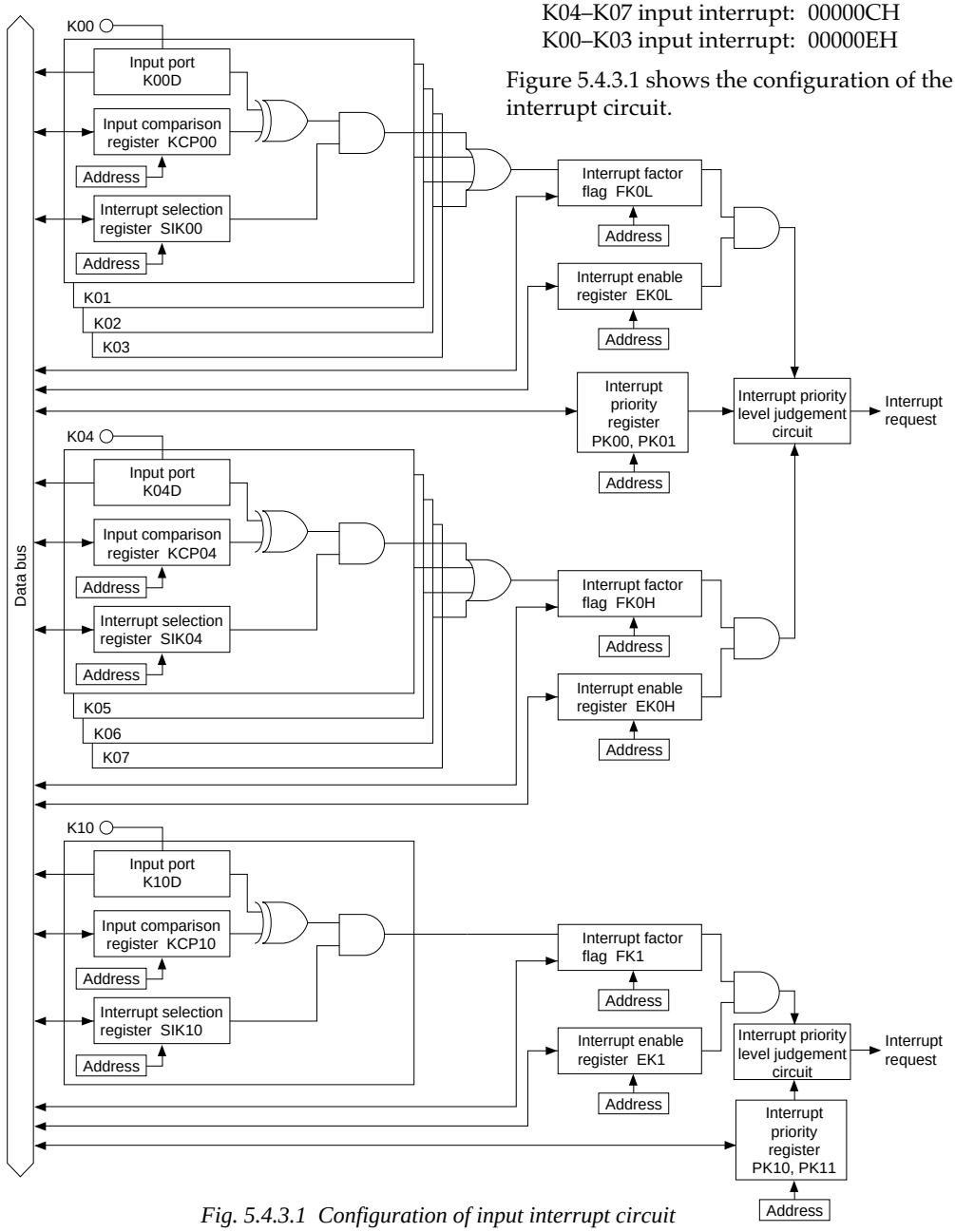


Fig. 5.4.3.1 Configuration of input interrupt circuit

The interrupt selection registers SIK00–SIK03, SIK04–SIK07 and SIK10 and input comparison registers KCP00–KCP03, KCP04–KCP07 and KCP10 for each port are used to set the interrupt generation condition described above.

Input port interrupt can be permitted or prohibited by the setting of the interrupt selection register SIK. In contrast to the interrupt enable register EK which masks the interrupt factor for each series of terminals, the interrupt selection register SIK is masks the bit units.

The input comparison register KCP selects whether the interrupt for each input port will be generated on the rising edge or the falling edge of input.

When the data content of the input terminals in which interrupt has been permitted by the interrupt selection register SIK and the data content of the input comparison register KCP change from a conformity state to a non-conformity state, the interrupt factor flag FK should be set to "1" and an interrupt is generated.

Figure 5.4.3.2 shows an example of interrupt generation in the series of terminals K0L (K00–K03).

Because interrupt has been prohibited for K00 by the interrupt selection register SIK00, with the settings as shown in (2), an interrupt will not be generated.
Since K03 is "0" in the next settings (3) in the figure, the non-conformity between the input terminal data K01–K03 where interrupt is permitted and the data from the input comparison registers KCP01–KCP03 generates an interrupt.
In line with the explanation above, since the change in the contents of input data and input comparison registers KCP from a conformity state to a non-conformity state introduces an interrupt generation condition, switching from one non-conformity state to another, as is the case in (4) in the figure, will not generate an interrupt. Consequently, in order to be able to generate a second interrupt, either the input terminal must be returned to a state where its content is once again in conformity with that of the input comparison register KCP, or the input comparison register KCP must be reset.
Input terminals for which interrupt is prohibited will not influence an interrupt generation condition.

Interrupt is generated in exactly the same way in the other two series of terminals K0H (K04–K07) and K1 (K10).

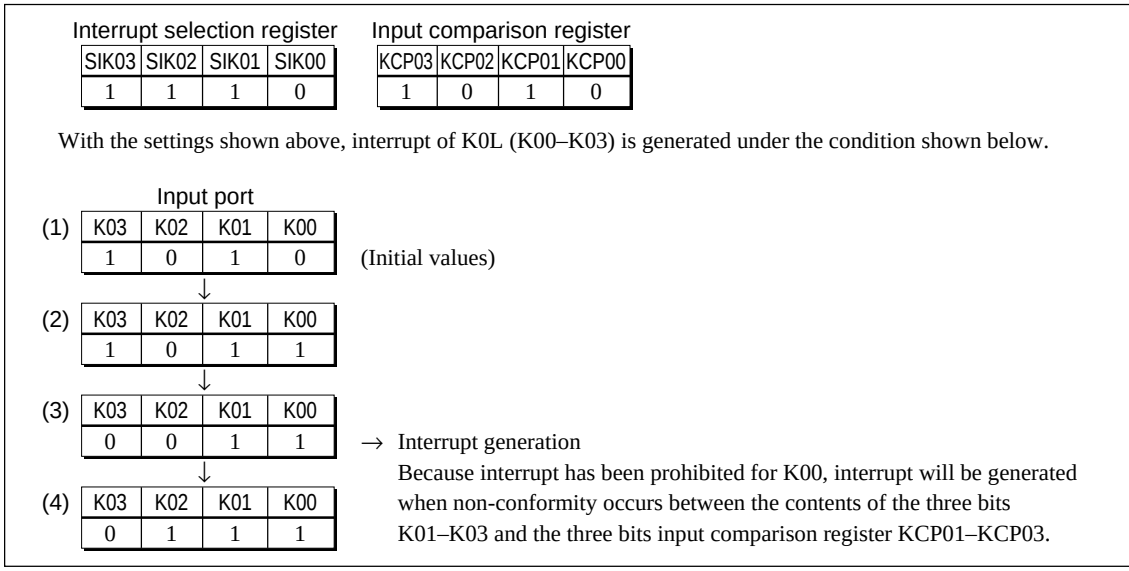


Fig. 5.4.3.2 Interrupt generation example in K0L (K00–K03)

5.4.4 Control of input ports

Table 5.4.4.1 shows the input port control bits.

Table 5.4.4.1(a) Input port control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF50	D7	SIK07	K07 interrupt selection register	Interrupt enable	Interrupt disable	0	R/W	
	D6	SIK06	K06 interrupt selection register			0	R/W	
	D5	SIK05	K05 interrupt selection register			0	R/W	
	D4	SIK04	K04 interrupt selection register			0	R/W	
	D3	SIK03	K03 interrupt selection register			0	R/W	
	D2	SIK02	K02 interrupt selection register			0	R/W	
	D1	SIK01	K01 interrupt selection register			0	R/W	
	D0	SIK00	K00 interrupt selection register			0	R/W	
00FF51	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	SIK11	General-purpose register	1	0	0	R/W	Reserved register
	D0	SIK10	K10 interrupt selection register	Enable	Disable	0	R/W	
00FF52	D7	KCP07	K07 input comparison register	Interrupt generated at falling edge	Interrupt generated at rising edge	1	R/W	
	D6	KCP06	K06 input comparison register			1	R/W	
	D5	KCP05	K05 input comparison register			1	R/W	
	D4	KCP04	K04 input comparison register			1	R/W	
	D3	KCP03	K03 input comparison register			1	R/W	
	D2	KCP02	K02 input comparison register			1	R/W	
	D1	KCP01	K01 input comparison register			1	R/W	
	D0	KCP00	K00 input comparison register			1	R/W	
00FF53	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	KCP11	General-purpose register	1	0	1	R/W	Reserved register
	D0	KCP10	K10 input comparison register	Falling edge	Rising edge	1	R/W	
00FF54	D7	K07D	K07 input port data	High level input	Low level input	–	R	
	D6	K06D	K06 input port data			–	R	
	D5	K05D	K05 input port data			–	R	
	D4	K04D	K04 input port data			–	R	
	D3	K03D	K03 input port data			–	R	
	D2	K02D	K02 input port data			–	R	
	D1	K01D	K01 input port data			–	R	
	D0	K00D	K00 input port data			–	R	
00FF55	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	_		
	D4	–	–	–	–	_		
	D3	–	–	–	–	_		
	D2	–	–	–	–	_		
	D1	–	–	–	–	–		"1" when being read
	D0	K10D	K10 input port data	High level	Low level	–	R	

Table 5.4.4.1(b) Input port control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF20	D7	PK01	K00–K07 interrupt priority register	PK01 PK00 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D6	PK00				0	R/W	
	D5	PSIF1	Serial interface interrupt priority register	PSIF1 PSIF0 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D4	PSIF0				0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register	PSW1 PSW0 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D2	PSW0				0	R/W	
	D1	PTM1	Clock timer interrupt priority register	PTM1 PTM0 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D0	PTM0				0	R/W	
00FF21	D7	–	–	–	–	–		
	D6	–	–	–	–	–		Constantly "0" when being read
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	PPT1	Programmable timer interrupt priority register	PPT1 PPT0 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D2	PPT0				0	R/W	
	D1	PK11	K10 interrupt priority register	PK11 PK10 = 1 1: Level 3; 1 0: Level 2; 0 1: Level 1; 0 0: Level 0		0	R/W	
	D0	PK10				0	R/W	
00FF23	D7	EPT1	Programmable timer 1 interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D6	EPT0	Programmable timer 0 interrupt enable register			0	R/W	
	D5	EK1	K10 interrupt enable register			0	R/W	
	D4	EK0H	K04–K07 interrupt enable register			0	R/W	
	D3	EK0L	K00–K03 interrupt enable register			0	R/W	
	D2	ESERR	Serial I/F (error) interrupt enable register			0	R/W	
	D1	ESREC	Serial I/F (receiving) interrupt enable register			0	R/W	
	D0	ESTRA	Serial I/F (transmitting) interrupt enable register			0	R/W	
00FF25	D7	FPT1	Programmable timer 1 interrupt factor flag	(R) Interrupt factor is generated	(R) No interrupt factor is generated	0	R/W	
	D6	FPT0	Programmable timer 0 interrupt factor flag			0	R/W	
	D5	FK1	K10 interrupt factor flag			0	R/W	
	D4	FK0H	K04–K07 interrupt factor flag			0	R/W	
	D3	FK0L	K00–K03 interrupt factor flag			0	R/W	
	D2	FSERR	Serial I/F (error) interrupt factor flag	(W) Reset	(W) No operation	0	R/W	
	D1	FSREC	Serial I/F (receiving) interrupt factor flag			0	R/W	
	D0	FSTRA	Serial I/F (transmitting) interrupt factor flag			0	R/W	

K00D–K07D: 00FF54H
K10D: 00FF55H•D0

Input data of input port terminal Kxx can be read out.

When "1" is read: HIGH level
When "0" is read: LOW level
Writing: Invalid

The terminal voltage of each of the input port K00–K07 and K10 can be directly read out as either a "1" for HIGH (V_{DD}) level or a "0" for LOW (V_{SS}) level. This bit is exclusively for readout and are not usable for write operations.

SIK00–SIK07: 00FF50H
SIK10: 00FF51H•D0

Sets the interrupt generation condition (interrupt permission/prohibition) for input port terminals K00–K07 and K10.

When "1" is written: Interrupt permitted
When "0" is written: Interrupt prohibited
Reading: Valid

SIKxx is the interrupt selection register which correspond to the input port Kxx. A "1" setting permits interrupt in that input port and a "0" prohibits it. Changes of state in an input terminal in which interrupt is prohibited, will not influence interrupt generation.
At initial reset, this register is set to "0" (interrupt prohibited).

KCP00–KCP07: 00FF52H
KCP10: 00FF53H•D0

Sets the interrupt generation condition (interrupt generation timing) for input port terminals K00–K07 and K10.

When "1" is written: Falling edge
When "0" is written: Rising edge
Reading: Valid

KCPxx is the input comparison register which correspond to the input port Kxx. Interrupt in those ports which have been set to "1" is generated on the falling edge of the input and in those set to "0" on the rising edge.
At initial reset, this register is set to "1" (falling edge).

PK00, PK01: 00FF20H•D6, D7
PK10, PK11: 00FF21H•D0, D1

Sets the input interrupt priority level. The two bits PK00 and PK01 are the interrupt priority registers corresponding to the interrupts for K00–K07 (K0L and K0H). Corresponding to K10 (K1), the two bits PK10 and PK11 perform the same function.
Table 5.4.4.2 shows the interrupt priority level which can be set by this register.

Table 5.4.4.2 Interrupt priority level settings

PK11 PK01	PK10 PK00	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (None)

At initial reset, this register is set to "0" (level 0).

EK0L, EK0H, EK1: 00FF23H•D3, D4, D5

How interrupt generation to the CPU is permitted or prohibited.

When "1" is written: Interrupt permitted
When "0" is written: Interrupt prohibited
Reading: Valid

The interrupt enable register EK0L corresponds to K00–K03, EK0H to K04–K07, and EK1 to K10. Interrupt is permitted in those series of terminals set to "1" and prohibited in those set to "0".
At initial reset, this register is set to "0" (interrupt prohibited).

FK0L, FK0H, FK1: 00FF25H•D3, D4, D5

Indicates the generation state for an input interrupt.

When "1" is read: Interrupt factor present
When "0" is read: Interrupt factor not present

When "1" is written: Reset factor flag
When "0" is written: Invalid

The interrupt factor flag FK0L corresponds to K00–K03, FK0H to K04–K07, and FK1 to K10 and they are set to "1" by the occurrence of an interrupt generation condition.
When set in this manner, if the corresponding interrupt enable register is set to "1" and the corresponding interrupt priority register is set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU. Regardless of the interrupt enable register and interrupt priority register settings, the interrupt factor flag will be set to "1" by the occurrence of an interrupt generation condition.
To accept the subsequent interrupt after interrupt generation, re-setting of the interrupt flags (set interrupt flag to lower level than the level indicated by the interrupt priority registers, or execute the RETE instruction) and interrupt factor flag reset are necessary. The interrupt factor flag is reset to "0" by writing "1".
At initial reset, this flag is all reset to "0".

5.4.5 Programming note

When changing the input terminal from LOW level to HIGH with the built-in pull-up resistor, a delay in the waveform rise time will occur depending on the time constant of the pull-up resistor and the load capacitance of the terminal. It is necessary to set an appropriate wait time for introduction of an input port. In particular, special attention should be paid to key scan for key matrix formation. Make this wait time the amount of time or more calculated by the following expression.

Wait time = R_{IN} x (C_{IN} + load capacitance on the board) x 1.6 [sec]

R_{IN}: Pull up resistance Max. value
C_{IN}: Terminal capacitance Max. value

5.5 Output Ports (R ports)

5.5.1 Configuration of output ports

The E0C88832 is equipped with 5 bits of output ports (R26, R27, R34, R50 and R51) and the E0C88862 is equipped with 4 bits of output ports (R26, R27, R50 and R51).

Figure 5.5.1.1 shows the basic structure (excluding special output circuits) of the output ports.
The output specification of each port is fixed at complementary output.

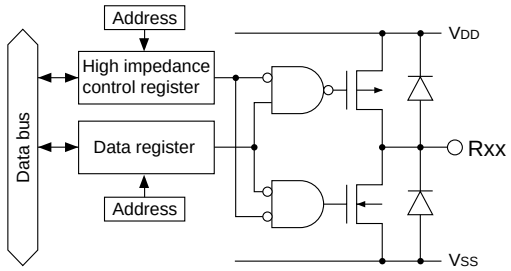


Fig. 5.5.1.1 Structure of output ports

Each output port can be set into high impedance state by software.

Besides normal DC output, the output ports have special output functions. The R27, R34 (E0C88832 only) and R50 functions can be selected by software and the R26 and R51 functions can be selected by mask option.

5.5.2 Mask option

R26 and R51 output port specifications
R26 ..... ☐ DC output ☐ $\overline{\text{TOUT}}$ output
R51 ..... ☐ DC output ☐ $\overline{\text{BZ}}$ output

The mask option allows selection of special outputs for the R26 and R51 output ports as well as the DC output. The R26 port can be set as the $\overline{\text{TOUT}}$ output port (TOUT signal inverted output) and the R51 port can be set as the $\overline{\text{BZ}}$ output port (buzzer signal inverted output).

5.5.3 High impedance control

The output port can be high impedance controlled in software.

A high impedance control register is set for each output port terminal as shown below. Either complementary output and high impedance state can be selected with this register.

HZR26: R26 high impedance control register
HZR27: R27 high impedance control register
HZR34: R34 high impedance control register *
HZR50: R50 high impedance control register
HZR51: R51 high impedance control register

* Available only in the E0C88832.

When a high impedance control register HZRxx is set to "1", the corresponding output port terminal becomes high impedance state and when set to "0", it becomes complementary output.

5.5.4 DC output

As Figure 5.5.1.1 shows, when "1" is written to the output port data register, the output terminal switches to HIGH (V_{DD}) level and when "0" is written it switches to LOW (V_{SS}) level. When output is in a high impedance state, the data written to the data register is output from the terminal at the instant when output is switched to complementary.

5.5.5 Special output

Besides normal DC output, each output port can also be assigned special output function in software (R27, R34*, R50) or mask option (R26, R51) as shown in Table 5.5.5.1.

Table 5.5.5.1 Special output ports

Output port	Special output
R26	$\overline{\text{TOUT}}$ output (mask option)
R27	TOUT output (software selection)
R34*	FOUT output (software selection)
R50	BZ output (software selection)
R51	$\overline{\text{BZ}}$ output (mask option)

* R34 (FOUT) is available only in the E0C88832.

■ TOUT output (R27), $\overline{\text{TOUT}}$ output (R26)

In order for the E0C88832/88862 to provide clock signal to an external device, the R27 output port terminal can be used to output a TOUT signal (clock output by the programmable timer). Furthermore, the R26 output port terminal can be used to output a $\overline{\text{TOUT}}$ signal (TOUT inverted signal). The configuration of the output ports R26 and R27 is shown in Figure 5.5.5.1.

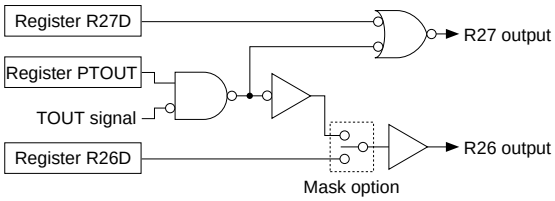


Fig. 5.5.5.1 Configuration of R26 and R27

The output control for the TOUT ($\overline{\text{TOUT}}$) signals is done by the register PTOUT. When you set "1" for the PTOUT, the TOUT ($\overline{\text{TOUT}}$) signal is output from the R27 (R26) output port terminal. When "0" is set, the R27 goes HIGH (V_{DD}) and the R26 goes LOW (V_{SS}).
To output the TOUT signal, "1" must always be set for the data register R27D.
The data register R26D does not affect the $\overline{\text{TOUT}}$ output.

The TOUT signal is generated from the programmable timer underflow signal by halving the frequency.
With respect to frequency control, see "5.10 Programmable Timer".
Since the TOUT ($\overline{\text{TOUT}}$) signal is generated asynchronously from the register PTOUT, when the signal is turned ON or OFF by setting the register, a hazard of a 1/2 cycle or less is generated.
Figure 5.5.5.2 shows the output waveform of the TOUT ($\overline{\text{TOUT}}$) signal.

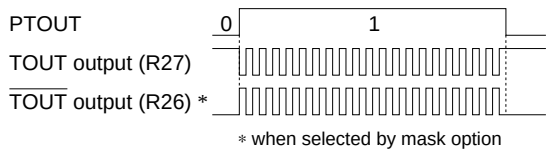


Fig. 5.5.5.2 TOUT ($\overline{\text{TOUT}}$) output waveform

■ FOUT output (R34)...E0C88832 only

In order for the E0C88832 to provide clock signal to an external device, a FOUT signal (divided clock of oscillation clock f_{OSC1} or f_{OSC3}) can be output from the output port terminal R34.
Figure 5.5.5.3 shows the configuration of output port R34.

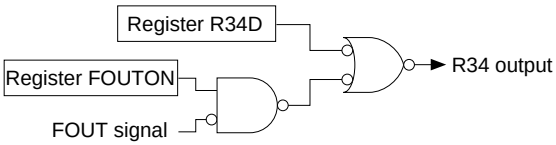


Fig. 5.5.5.3 Configuration of R34

The output control for the FOUT signal is done by the register FOUTON. When you set "1" for the FOUTON, the FOUT signal is output from the output port terminal R34, when "0" is set, the HIGH (V_{DD}) level is output. At this time, "1" must always be set for the data register R34D.
The frequency of the FOUT signal can be selected in software by setting the registers FOUT0–FOUT2. The frequency is selected any one from among eight settings as shown in Table 5.5.5.2.

Table 5.5.5.2 FOUT frequency setting

FOUT2	FOUT1	FOUT0	FOUT frequency
0	0	0	f_{OSC1} / 1
0	0	1	f_{OSC1} / 2
0	1	0	f_{OSC1} / 4
0	1	1	f_{OSC1} / 8
1	0	0	f_{OSC3} / 1
1	0	1	f_{OSC3} / 2
1	1	0	f_{OSC3} / 4
1	1	1	f_{OSC3} / 8

f_{OSC1}: OSC1 oscillation frequency
f_{OSC3}: OSC3 oscillation frequency

When the FOUT frequency is made "f_{OSC3}/n", you must turn on the OSC3 oscillation circuit before outputting FOUT. A time interval of several 100 µsec to several 10 msec, from the turning ON of the OSC3 oscillation circuit to until the oscillation stabilizes, is necessary, due to the oscillation element that is used. Consequently, if an abnormality occurs as the result of an unstable FOUT signal being output externally, you should allow an adequate waiting time after turning ON of the OSC3 oscillation, before turning outputting FOUT. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, OSC3 oscillation circuit is set to OFF state.

Since the FOUT signal is generated asynchronously from the register FOUTON, when the signal is turned ON or OFF by the register settings, a hazard of a 1/2 cycle or less is generated.
Figure 5.5.5.4 shows the output waveform of the FOUT signal.

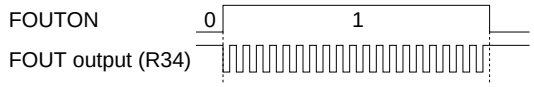


Fig. 5.5.5.4 Output waveform of FOUT signal

■ BZ output (R50), $\overline{BZ}$ output (R51)

In order for the E0C88832/88862 to drive an external buzzer, a BZ signal (sound generator output) can be output from the output port terminal R50. Furthermore, the R51 output port terminal can be used to output a $\overline{BZ}$ signal (BZ inverted signal).
The configuration of the output ports R50 and R51 is shown in Figure 5.5.5.5.

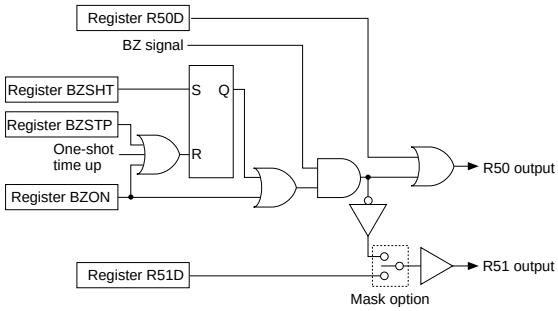


Fig. 5.5.5.5 Configuration of R50 and R51

The output control for the BZ ($\overline{BZ}$) signal is done by the registers BZON, BZSHT and BZSTP. When you set "1" for the BZON or BZSHT, the BZ ($\overline{BZ}$) signal is output from the output port terminal R50 (R51). When "0" is set for the BZON or "1" is set for the BZSTP, the R50 goes LOW (V_{SS}) and the R51 goes HIGH (V_{DD}).
To output the BZ signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.

The BZ ($\overline{BZ}$) signal is generated by the sound generator. With respect to control of frequency and envelope, see "5.12 Sound Generator".

Since the BZ ($\overline{BZ}$) signal is generated asynchronously from the registers BZON, BZSHT and BZSTP, when the signal is turned ON or OFF by setting the registers, a hazard of a 1/2 cycle or less is generated.
Figure 5.5.5.6 shows the output waveform of the BZ ($\overline{BZ}$) signal.

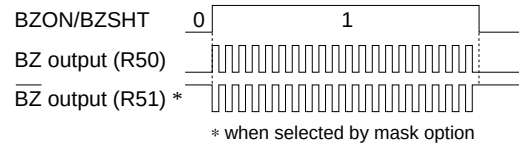


Fig. 5.5.5.6 BZ ($\overline{BZ}$) output waveform

5.5.6 Control of output ports

Table 5.5.6.1 shows the output port control bits.

Table 5.5.6.1(a) Output port control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF70	D7	HZR51	R51 high impedance control	Hi-Z	Output	0	R/W	
	D6	HZR50	R50 high impedance control			0	R/W	
	D5	HZR4H	General-purpose register	1	0	0	R/W	Reserved register
	D4	HZR4L	General-purpose register			0	R/W	
	D3	HZR1H	General-purpose register			0	R/W	
	D2	HZR1L	General-purpose register			0	R/W	
	D1	HZR0H	General-purpose register			0	R/W	
	D0	HZR0L	General-purpose register			0	R/W	
00FF71	D7	HZR27	R27 high impedance control	Hi-Z	Output	0	R/W	
	D6	HZR26	R26 high impedance control			0	R/W	
	D5	HZR25	General-purpose register	1	0	0	R/W	Reserved register
	D4	HZR24	General-purpose register			0	R/W	
	D3	HZR23	General-purpose register			0	R/W	
	D2	HZR22	General-purpose register			0	R/W	
	D1	HZR21	General-purpose register			0	R/W	
	D0	HZR20	General-purpose register			0	R/W	
00FF72 *2	D7	HZR37	General-purpose register	1	0	0	R/W	Reserved register
	D6	HZR36	General-purpose register			0	R/W	
	D5	HZR35	General-purpose register			0	R/W	
	D4	HZR34	R34 high impedance control	Hi-Z	Output	0	R/W	
	D3	HZR33	General-purpose register	1	0	0	R/W	Reserved register
	D2	HZR32	General-purpose register			0	R/W	
	D1	HZR31	General-purpose register			0	R/W	
	D0	HZR30	General-purpose register			0	R/W	
00FF75	D7	R27D	R27 output port data	High	Low	1	R/W	
	D6	R26D	R26 output port data			1 *1	R/W	
	D5	R25D	General-purpose register	1	0	1	R/W	Reserved register
	D4	R24D	General-purpose register			1	R/W	
	D3	R23D	General-purpose register			1	R/W	
	D2	R22D	General-purpose register			1	R/W	
	D1	R21D	General-purpose register			1	R/W	
	D0	R20D	General-purpose register			1	R/W	
00FF76 *2	D7	R37D	General-purpose register	1	0	1	R/W	Reserved register
	D6	R36D	General-purpose register			1	R/W	
	D5	R35D	General-purpose register			1	R/W	
	D4	R34D	R34 output port data	High	Low	1	R/W	
	D3	R33D	General-purpose register	1	0	1	R/W	Reserved register
	D2	R32D	General-purpose register			1	R/W	
	D1	R31D	General-purpose register			1	R/W	
	D0	R30D	General-purpose register			1	R/W	
00FF78	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	R51D	R51 output port data	High	Low	1	R/W	
	D0	R50D	R50 output port data			0	R/W	

*1 "0" when $\overline{\text{TOUT}}$ output is selected by mask option.
*2 These addresses are unavailable in the E0C88862.

Table 5.5.6.1(b) Output port control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF30	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	MODE16	8/16-bit mode selection	16-bit x 1	8-bit x 2	0	R/W	
	D3	CHSEL	TOUT output channel selection	Timer 1	Timer 0	0	R/W	
	D2	PTOUT	TOUT output control	On	Off	0	R/W	
	D1	CKSEL1	Prescaler 1 source clock selection	fOSC3	fOSC1	0	R/W	
	D0	CKSEL0	Prescaler 0 source clock selection	fOSC3	fOSC1	0	R/W	
00FF40	D7	–	–	–	–	–		"0" when being read
	D6	FOUT2	FOUT frequency selection FOUT2 FOUT1 FOUT0 Frequency 0 0 0 fOSC1 / 1 0 0 1 fOSC1 / 2 0 1 0 fOSC1 / 4 0 1 1 fOSC1 / 8 1 0 0 fOSC3 / 1 1 0 1 fOSC3 / 2 1 1 0 fOSC3 / 4 1 1 1 fOSC3 / 8			0	R/W	This is just R/W register on E0C88862.
	D5	FOUT1				0	R/W	
	D4	FOUT0				0	R/W	
	D3	FOUTON	FOUT output control	On	Off	0	R/W	
	D2	WDRST	Watchdog timer reset	Reset	No operation	–	W	Constantly "0" when being read
	D1	TMRST	Clock timer reset	Reset	No operation	–	W	
	D0	TMRUN	Clock timer Run/Stop control	Run	Stop	0	R/W	
00FF44	D7	–	–	–	–	–		Constantry "0" when being read
	D6	BZSTP	One-shot buzzer forcibly stop	Forcibly stop	No operation	–	W	
	D5	BZSHT	One-shot buzzer trigger/status R	Busy	Ready	0	R/W	
			W	Trigger	No operation			
	D4	SHTPW	One-shot buzzer duration width selection	125 msec	31.25 msec	0	R/W	
	D3	ENRTM	Envelope attenuation time	1 sec	0.5 sec	0	R/W	
	D2	ENRST	Envelope reset	Reset	No operation	–	W	"0" when being read
	D1	ENON	Envelope On/Off control	On	Off	0	R/W	*1
	D0	BZON	Buzzer output control	On	Off	0	R/W	

*1 Reset to "0" during one-shot output.

■ High impedance control

HZR26: 00FF71H•D6
HZR27: 00FF71H•D7
HZR34: 00FF72H•D4 *
HZR50: 00FF70H•D6
HZR51: 00FF70H•D7

Sets the output terminals to a high impedance state.

When "1" is written: High impedance
When "0" is written: Complementary
Reading: Valid

HZRxx is the high impedance control register which correspond to the Rxx output port terminal. When "1" is set to the HZRxx register, the corresponding output port terminal becomes high impedance state and when "0" is set, it becomes complementary output.
This control is effective even if the port is set as a special output port.
At initial reset, this register is set to "0" (complimentary).

* HZR34 is unavailable in the E0C88862.

■ DC output control

R26D: 00FF75H•D6
R27D: 00FF75H•D7
R34D: 00FF76H•D4 *
R50D: 00FF78H•D0
R51D: 00FF78H•D1

Sets the data output from the output port terminal Rxx.

When "1" is written: HIGH level output
When "0" is written: LOW level output
Reading: Valid

RxxD is the data register for the Rxx output port. When "1" is set to the register, the corresponding output port terminal goes HIGH (V_{DD}), and when "0" is set, it goes LOW (V_{SS}).
At initial reset, R50D is set to "0" (LOW level output). The other registers are set to "1" (HIGH level output).
When R26 and/or R51 are set to the special outputs by mask option, R26D and/or R51D can be used as general-purpose registers that do not affect the output status.

* R34D is unavailable in the E0C88862.

■ Special output control

PTOUT: 00FF30H•D2

Controls the TOUT (programmable timer output clock) signal output.

When "1" is written: TOUT signal output ON
When "0" is written: TOUT signal output OFF
Reading: Valid

PTOUT is the output control register for TOUT signal. When "1" is set to the register, the TOUT ($\overline{TOUT}$) signal is output from the output port terminal R27 (R26). When "0" is set, the R27 goes HIGH (V_{DD}) and the R26 goes LOW (V_{SS}).
To output the TOUT signal, "1" must always be set for the data register R27D. The data register R26D does not affect the $\overline{TOUT}$ output.
At initial reset, PTOUT is set to "0" (output OFF).
The $\overline{TOUT}$ signal can be output from R26 only when the function is selected by mask option.

FOUTON: 00FF40H•D3 *

Controls the FOUT (f_{OSC1}/f_{OSC3} dividing clock) signal output.

When "1" is written: FOUT signal output
When "0" is written: HIGH level (DC) output
Reading: Valid

FOUTON is the output control register for FOUT signal. When "1" is set, the FOUT signal is output from the output port terminal R34 and when "0" is set, HIGH (V_{DD}) level is output. At this time, "1" must always be set for the data register R34D.
At initial reset, FOUTON is set to "0" (HIGH level output).

* In the E0C88862, FOUTON is a general purpose register with read/write capabilities.

FOUT0, FOUT1, FOUT2: 00FF40H•D4, D5, D6 *

FOUT signal frequency is set as shown in Table 5.5.6.2.

Table 5.5.6.2 FOUT frequency settings

FOUT2	FOUT1	FOUT0	FOUT frequency
0	0	0	f_{OSC1} / 1
0	0	1	f_{OSC1} / 2
0	1	0	f_{OSC1} / 4
0	1	1	f_{OSC1} / 8
1	0	0	f_{OSC3} / 1
1	0	1	f_{OSC3} / 2
1	1	0	f_{OSC3} / 4
1	1	1	f_{OSC3} / 8

f_{OSC1}: OSC1 oscillation frequency
f_{OSC3}: OSC3 oscillation frequency

At initial reset, this register is set to "0" (f_{OSC1}/1).

* In the E0C88862, FOUT0, FOUT1 and FOUT2 are general purpose registers with read/write capabilities.

BZON: 00FF44H•D0

Controls the buzzer (BZ and $\overline{BZ}$) signal output.

When "1" is written: Buzzer signal output ON
When "0" is written: Buzzer signal output OFF
Reading: Valid

BZON is the output control register for buzzer signal. When "1" is set to the register, the BZ ($\overline{BZ}$) signal is output from the output port terminal R50 (R51). When "0" is set, the R50 goes LOW (V_{SS}) and the R51 goes HIGH (V_{DD}).
To output the BZ signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.
At initial reset, BZON is set to "0" (output OFF).
The $\overline{BZ}$ signal can be output from R51 only when the function is selected by mask option.

BZSHT: 00FF44H•D5

Controls the one-shot buzzer output.

When "1" is written: Trigger
When "0" is written: No operation

When "1" is read: Busy
When "0" is read: Ready

Writing "1" into BZSHT causes the one-shot output circuit to operate. The BZ ($\overline{BZ}$) signal is output from the R50 (R51) terminal. The buzzer output is automatically turned OFF after the time set by SHTPW has elapsed.
To output the BZ signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.
The one-shot output is only valid when the normal buzzer output is OFF (BZON = "0") state. The trigger is invalid during ON (BZON = "1") state.
When a re-trigger is assigned during a one-shot output, the one-shot output time set with SHTPW is measured again from that point. (time extension)
The operation status of the one-shot output circuit can be confirmed by reading BZSHT, when the one-shot output is ON, "1" is read from BZSHTand when the output is OFF, "0" is read.
At initial reset, BZSHT is set to "0" (ready).
The $\overline{BZ}$ signal can be output from R51 only when the function is selected by mask option.

BZSTP: 00FF44H•D6

Forcibly stops the one-shot buzzer output.

When "1" is written: Forcibly stop
When "0" is written: No operation
Reading: Constantly "0"

By writing "1" into BZSTP, the one-shot buzzer output can be stopped prior to the elapsing of the time set with SHTPW.
Writing "0" is invalid and writing "1" except during one-shot output is also invalid.
When "1" is written to BZSHT and BZSTP simultaneously, BZSTP takes precedence and one-shot output becomes stop status.
Since BZSTP is for writing only, during readout it is constantly set to "0".

5.5.7 Programming notes

(1) Since the special output signals (TOUT/$\overline{TOUT}$, FOUT, BZ/$\overline{BZ}$) are generated asynchronously from the output control registers (PTOUT, FOUTON, BZON, BZSHT and BZSTP), when the signals is turned ON or OFF by the output control register settings, a hazard of a 1/2 cycle or less is generated.

(2) The SLP instruction has executed when the special output signals (TOUT,/$\overline{TOUT}$, FOUT, BZ/$\overline{BZ}$) are in the enable status, an unstable clock is output for the special output at the time of return from the SLEEP state. Consequently, when shifting to the SLEEP state, you should set the special output signal to the disable status prior to executing the SLP instruction.

(3) When the FOUT frequency is made "f_{OSC3}/n", you must turn on the OSC3 oscillation circuit before outputting FOUT. A time interval of several 100 µsec to several 10 msec, from the turning ON of the OSC3 oscillation circuit to until the oscillation stabilizes, is necessary, due to the oscillation element that is used. Consequently, if an abnormality occurs as the result of an unstable FOUT signal being output externally, you should allow an adequate waiting time after turning ON of the OSC3 oscillation, before turning outputting FOUT. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, OSC3 oscillation circuit is set to OFF state.

* FOUT output is available only in the E0C88832.

5.6 I/O Ports (P ports)

5.6.1 Configuration of I/O ports

The E0C88832/88862 is equipped with 8 bits of I/O ports (P10–P17).
Figure 5.6.1.1 shows the structure of an I/O port.

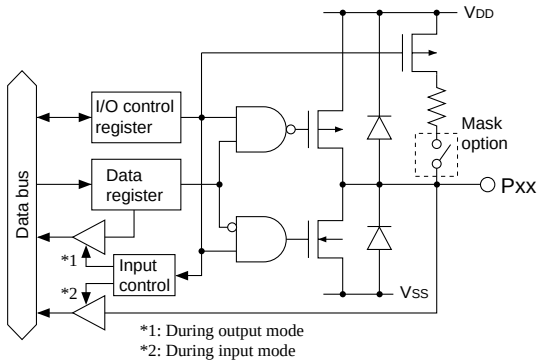


Fig. 5.6.1.1 Structure of I/O port

I/O port can be set for input or output mode in one bit unit. These settings are performed by writing data to the I/O control registers.
I/O port terminals P10–P13 are shared with serial interface input/output terminals. The function of the terminals is switchable in software. With respect to the serial interface, see "5.7 Serial Interface".
The data registers and I/O control registers of the I/O ports set as serial interface outputs are usable as general purpose registers with read/write capabilities which do not affect I/O activities of the terminal.
The same as above, I/O control registers of the I/O ports set as serial interface inputs are usable as general purpose register.

5.6.2 Mask option

I/O port pull-up resistors		
P10	☐ With resistor	☐ Gate direct
P11	☐ With resistor	☐ Gate direct
P12	☐ With resistor	☐ Gate direct
P13	☐ With resistor	☐ Gate direct
P14	☐ With resistor	☐ Gate direct
P15	☐ With resistor	☐ Gate direct
P16	☐ With resistor	☐ Gate direct
P17	☐ With resistor	☐ Gate direct

I/O ports P10–P17 are equipped with a pull-up resistor which goes ON in the input mode. Whether this resistor is used or not can be selected for each port (one bit unit).
In cases where the 'With resistor' option is selected, the pull-up resistor goes ON when the port is in input mode.
When changing the port terminal from LOW level to HIGH with the built-in pull-up resistor, a delay in the waveform rise time will occur depending on the time constant of the pull-up resistor and the load capacitance of the terminal. It is necessary to set an appropriate wait time for introduction of an I/O port. Make this wait time the amount of time or more calculated by the following expression.

Wait time = R_{IN} x (C_{IN} + load capacitance on the board) x 1.6 [sec]

R_{IN}: Pull up resistance Max. value
C_{IN}: Terminal capacitance Max. value

For unused I/O ports, select the default setting of "With resistor".

5.6.3 I/O control registers and I/O mode

I/O ports P10–P17 are set either to input or output modes by writing data to the I/O control registers IOC10–IOC17 which correspond to each bit.
To set an I/O port to input mode, write "0" to the I/O control register.
An I/O port which is set to input mode will shift to a high impedance state and functions as an input port. Readout in input mode consists simply of a direct readout of the input terminal state: the data being "1" when the input terminal is at HIGH (V_{DD}) level and "0" when it is at LOW (V_{SS}) level.
When the "With resistor" option is selected using the mask option, the resistor is pulled up onto the port terminal in input mode.
Even in input mode, data can be written to the data registers without affecting the terminal state.
To set an I/O port to output mode, write "1" to the I/O control register. An I/O port which is set to output mode functions as an output port.
When port output data is "1", a HIGH (V_{DD}) level is output and when it is "0", a LOW (V_{SS}) level is output. Readout in output mode consists of the contents of the data register.
At initial reset, I/O control registers are set to "0" (I/O ports are set to input mode).

5.6.4 Control of I/O ports

Table 5.6.4.1 shows the I/O port control bits.

Table 5.6.4.1 I/O port control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF61	D7	IOC17	P17 I/O control register	Output	Input	0	R/W	
	D6	IOC16	P16 I/O control register			0	R/W	
	D5	IOC15	P15 I/O control register			0	R/W	
	D4	IOC14	P14 I/O control register			0	R/W	
	D3	IOC13	P13 I/O control register			0	R/W	
	D2	IOC12	P12 I/O control register			0	R/W	
	D1	IOC11	P11 I/O control register			0	R/W	
	D0	IOC10	P10 I/O control register			0	R/W	
00FF63	D7	P17D	P17 I/O port data	High	Low	1	R/W	
	D6	P16D	P16 I/O port data			1	R/W	
	D5	P15D	P15 I/O port data			1	R/W	
	D4	P14D	P14 I/O port data			1	R/W	
	D3	P13D	P13 I/O port data			1	R/W	
	D2	P12D	P12 I/O port data			1	R/W	
	D1	P11D	P11 I/O port data			1	R/W	
	D0	P10D	P10 I/O port data			1	R/W	

P10D–P17D: 00FF63H

How I/O port terminal P1x data readout and output data settings are performed.

When writing data:

When "1" is written: HIGH level
When "0" is written: LOW level

When the I/O port is set to output mode, the data written is output as is to the I/O port terminal. In terms of port data, when "1" is written, the port terminal goes to HIGH (V_{DD}) level and when "0" is written to a LOW (V_{SS}) level.
Even when the port is in input mode, data can still be written in.

When reading out data:

When "1" is read: HIGH level ("1")
When "0" is read: LOW level ("0")

When an I/O port is in input mode, the voltage level being input to the port terminal is read out. When terminal voltage is HIGH (V_{DD}), it is read as a "1", and when it is LOW (V_{SS}), it is read as a "0". Furthermore, in output mode, the contents of the data register are read out.
At initial reset, this register is set to "1" (HIGH level).

The data registers of I/O ports set for the output terminal of serial interface can be used as general purpose registers with read/write capabilities which do not affect I/O activities of the terminals.

IOC10–IOC17: 00FF61H

Sets the I/O ports to input or output mode.

When "1" is written: Output mode
When "0" is written: Input mode
Reading: Valid

IOC1x is the I/O control register which correspond to each I/O port in a bit unit.
Writing "1" to the IOC1x register will switch the corresponding I/O port P1x to output mode, and writing "0" will switch it to input mode.
At initial reset, this register is set to "0" (input mode).

The data registers of I/O ports set for the input terminal of serial interface can be used as general purpose registers with read/write capabilities which do not affect I/O activities of the terminals.

5.6.5 Programming note

When changing the port terminal from LOW level to HIGH with the built-in pull-up resistor, a delay in the waveform rise time will occur depending on the time constant of the pull-up resistor and the load capacitance of the terminal. It is necessary to set an appropriate wait time for introduction of an I/O port. Make this wait time the amount of time or more calculated by the following expression.

Wait time = R_{IN} x (C_{IN} + load capacitance on the board) x 1.6 [sec]

R_{IN}: Pull up resistance Max. value
C_{IN}: Terminal capacitance Max. value

5.7 Serial Interface

5.7.1 Configuration of serial interface

The E0C88832/88862 incorporates a full duplex serial interface (when asynchronous system is selected) that allows the user to select either clock synchronous system or asynchronous system.
The data transfer method can be selected in software.
When the clock synchronous system is selected, 8-bit data transfer is possible.
When the asynchronous system is selected, either 7-bit or 8-bit data transfer is possible, and a parity check of received data and the addition of a parity bit for transmitting data can automatically be done by selecting in software.
Figure 5.7.1.1 shows the configuration of the serial interface.

Serial interface input/output terminals, SIN, SOUT, $\overline{\text{SCLK}}$ and $\overline{\text{SRDY}}$ are shared with I/O ports P10–P13. In order to utilize these terminals for the serial interface input/output terminals, proper settings have to be made with registers ESIF, SMD0 and SMD1. (At initial reset, these terminals are set as I/O port terminals.)
The direction of I/O port terminals set for serial interface input/output terminals are determined by the signal and transfer mode for each terminal. Furthermore, the settings for the corresponding I/O control registers for the I/O ports become invalid.

Table 5.7.1.1 Configuration of input/output terminals

Terminal	When serial interface is selected
P10	SIN
P11	SOUT
P12	$\overline{\text{SCLK}}$
P13	$\overline{\text{SRDY}}$

* The terminals used may vary depending on the transfer mode.

SIN and SOUT are serial data input and output terminals which function identically in clock synchronous system and asynchronous system.
$\overline{\text{SCLK}}$ is exclusively for use with clock synchronous system and functions as a synchronous clock input/output terminal. $\overline{\text{SRDY}}$ is exclusively for use in clock synchronous slave mode and functions as a send-receive ready signal output terminal.
When asynchronous system is selected, since $\overline{\text{SCLK}}$ and $\overline{\text{SRDY}}$ are superfluous, the I/O port terminals P12 and P13 can be used as I/O ports.
In the same way, when clock synchronous master mode is selected, since $\overline{\text{SRDY}}$ is superfluous, the I/O port terminal P13 can be used as I/O port.

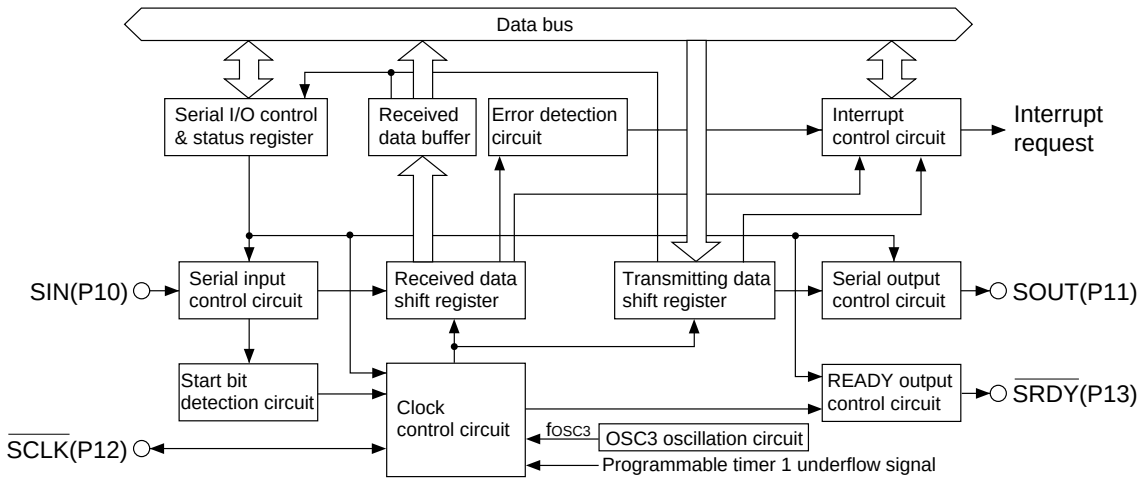


Fig. 5.7.1.1 Configuration of serial interface

5.7.2 Mask option

Since serial interface input/output terminals are shared with the I/O ports, serial interface terminal specifications have necessarily been selected with the mask option for I/O ports.

I/O port pull-up resistors
P10 (SIN) ..... ☐ With resistor ☐ Gate direct
P12 ($\overline{SCLK}$) .... ☐ With resistor ☐ Gate direct

Each I/O port terminal is equipped with a pull-up resistor which goes ON in input mode. A selection can be made for each port (one bit unit) as to whether or not the resistor will be used. Specifications (whether the pull-up will be used or not) of P10 (SIN) and P12 ($\overline{SCLK}$) which will become input terminals when using the serial interface are decided by settings the options for the I/O port.

When "Gate direct" is selected in the serial I/F mode, be sure that the input terminals do not go into a floating state.

5.7.3 Transfer modes

There are four transfer modes for the serial interface and mode selection is made by setting the two bits of the mode selection registers SMD0 and SMD1 as shown in the table below.

Table 5.7.3.1 Transfer modes

SMD1	SMD0	Mode
1	1	Asynchronous 8-bit
1	0	Asynchronous 7-bit
0	1	Clock synchronous slave
0	0	Clock synchronous master

Table 5.7.3.2 Terminal settings corresponding to each transfer mode

Mode	SIN	SOUT	$\overline{SCLK}$	$\overline{SRDY}$
Asynchronous 8-bit	Input	Output	P12	P13
Asynchronous 7-bit	Input	Output	P12	P13
Clock synchronous slave	Input	Output	Input	Output
Clock synchronous master	Input	Output	Output	P13

At initial reset, transfer mode is set to clock synchronous master mode.

■ Clock synchronous master mode

In this mode, the internal clock is utilized as a synchronous clock for the built-in shift registers, and clock synchronous 8-bit serial transfers can be performed with this serial interface as the master.
The synchronous clock is also output from the $\overline{SCLK}$ terminal which enables control of the external (slave side) serial I/O device. Since the $\overline{SRDY}$ terminal is not utilized in this mode, it can be used as an I/O port.
Figure 5.7.3.1(a) shows the connection example of input/output terminals in the clock synchronous master mode.

■ Clock synchronous slave mode

In this mode, a synchronous clock from the external (master side) serial input/output device is utilized and clock synchronous 8-bit serial transfers can be performed with this serial interface as the slave.
The synchronous clock is input to the $\overline{SCLK}$ terminal and is utilized by this interface as the synchronous clock.
Furthermore, the $\overline{SRDY}$ signal indicating the transmit-receive ready status is output from the $\overline{SRDY}$ terminal in accordance with the serial interface operating status.
In the slave mode, the settings for registers SCS0 and SCS1 used to select the clock source are invalid.
Figure 5.7.3.1(b) shows the connection example of input/output terminals in the clock synchronous slave mode.

■ Asynchronous 7-bit mode

In this mode, asynchronous 7-bit transfer can be performed. Parity check during data reception and addition of parity bit (odd/even/none) during transmitting can be specified and data processed in 7 bits with or without parity. Since this mode employs the internal clock, the $\overline{SCLK}$ terminal is not used. Furthermore, since the $\overline{SRDY}$ terminal is not utilized either, both of these terminals can be used as I/O ports.
Figure 5.7.3.1(c) shows the connection example of input/output terminals in the asynchronous mode.

■ Asynchronous 8-bit mode

In this mode, asynchronous 8-bit transfer can be performed. Parity check during data reception and addition of parity bit (odd/even/none) during transmitting can be specified and data processed in 8 bits with or without parity. Since this mode employs the internal clock, the $\overline{SCLK}$ terminal is not used. Furthermore, since the $\overline{SRDY}$ terminal is not utilized either, both of these terminals can be used as I/O ports.
Figure 5.7.3.1(c) shows the connection example of input/output terminals in the asynchronous mode.

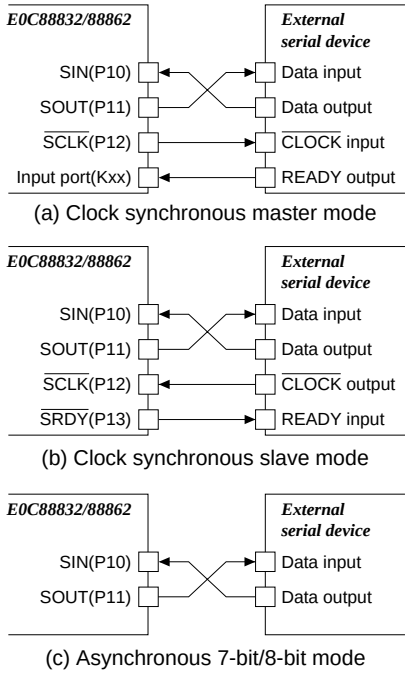


Fig. 5.7.3.1 Connection examples of serial interface I/O terminals

5.7.4 Clock source

There are four clock sources and selection is made by setting the two bits of the clock source selection register SCS0 and SCS1 as shown in table below.

Table 5.7.4.1 Clock source

SCS1	SCS0	Clock source
1	1	Programmable timer
1	0	fOSC3 / 4
0	1	fOSC3 / 8
0	0	fOSC3 / 16

This register setting is invalid in clock synchronous slave mode and the external clock input from the SCLK terminal is used.
When the "programmable timer" is selected, the programmable timer 1 underflow signal is divided by 1/2 and this signal used as the clock source. With respect to the transfer rate setting, see "5.10 Programmable Timer".
At initial reset, the synchronous clock is set to "fOSC3/16".
Whichever clock is selected, the signal is further divided by 1/16 and then used as the synchronous clock.
Furthermore, external clock input is used as is for SCLK in clock synchronous slave mode.
Table 5.7.4.2 shows an examples of transfer rates and OSC3 oscillation frequencies when the clock source is set to programmable timer.
When the demultiplied signal of the OSC3 oscillation circuit is made the clock source, it is necessary to turn the OSC3 oscillation ON, prior to using the serial interface.
A time interval of several 100 µsec to several 10 msec, from the turning ON of the OSC3 oscillation circuit to until the oscillation stabilizes, is necessary, due to the oscillation element that is used. Consequently, you should allow an adequate waiting time after turning ON of the OSC3 oscillation, before starting transmitting/receiving of serial interface. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, the OSC3 oscillation circuit is set to OFF status.

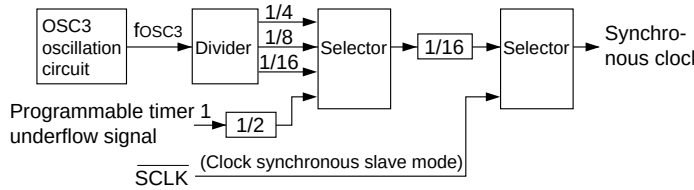


Fig. 5.7.4.1 Division of the synchronous clock

Table 5.7.4.2 OSC3 oscillation frequencies and transfer rates

Transfer rate (bps)	OSC3 oscillation frequency / Programmable timer settings					
	fOSC3 = 3.072 MHz		fOSC3 = 4.608 MHz		fOSC3 = 4.9152 MHz	
	PSC1X	RLD1X	PSC1X	RLD1X	PSC1X	RLD1X
9,600	0 (1/1)	09H	0 (1/1)	0EH	0 (1/1)	0FH
4,800	0 (1/1)	13H	0 (1/1)	1DH	0 (1/1)	1FH
2,400	0 (1/1)	27H	0 (1/1)	3BH	0 (1/1)	3FH
1,200	0 (1/1)	4FH	0 (1/1)	77H	0 (1/1)	7FH
600	0 (1/1)	9FH	0 (1/1)	EFH	0 (1/1)	FFH
300	1 (1/4)	4FH	1 (1/4)	77H	1 (1/4)	7FH
150	1 (1/4)	9FH	1 (1/4)	EFH	1 (1/4)	FFH

5.7.5 Transmit-receive control

Below is a description of the registers which handle transmit-receive control. With respect to transmit-receive control procedures and operations, please refer to the following sections in which these are discussed on a mode by mode basis.

■ Shift register and received data buffer

Exclusive shift registers for transmitting and receiving are installed in this serial interface. Consequently, duplex communication simultaneous transmit and receive is possible when the asynchronous system is selected.

Data being transmitted are written to TRXD0–TRXD7 and converted to serial through the shift register and is output from the SOUT terminal.

In the reception section, a received data buffer is installed separate from the shift register.
Data being received are input to the SIN terminal and is converted to parallel through the shift register and written to the received data buffer. Since the received data buffer can be read even during serial input operation, the continuous data is received efficiently.
However, since buffer functions are not used in clock synchronous mode, be sure to read out data before the next data reception begins.

■ Transmit enable register and transmit control bit

For transmitting control, use the transmit enable register TXEN and transmit control bit TXTRG.

The transmit enable register TXEN is used to set the transmitting enable/disable status. When "1" is written to this register to set the transmitting enable status, clock input to the shift register is enabled and the system is ready to transmit data. In the clock synchronous mode, synchronous clock input/output from the $\overline{SCLK}$ terminal is also enabled.

The transmit control bit TXTRG is used as the trigger to start transmitting data.
Data to be transmitted is written to the transmit data shift register, and when transmitting preparations a recomplete, "1" is written to TXTRG whereupon data transmitting begins.
When interrupt has been enabled, an interrupt is generated when the transmission is completed. If there is subsequent data to be transmitted it can be sent using this interrupt.
In addition, TXTRG can be read as the status. When set to "1", it indicates transmitting operation, and "0" indicates transmitting stop.
For details on timing, see the timing chart which gives the timing for each mode.

When not transmitting, set TXEN to "0" to disable transmitting status.

■ Receive enable register, receive control bit

For receiving control, use the receive enable register RXEN and receive control bit RXTRG.
Receive enable register RXEN is used to set receiving enable/disable status. When "1" is written into this register to set the receiving enable status, clock input to the shift register is enabled and the system is ready to receive data. In the clock synchronous mode, synchronous clock input/output from the $\overline{SCLK}$ terminal is also enabled.
With the above setting, receiving begins and serial data input from the SIN terminal goes to the shift register.
The operation of the receive control bit RXTRG is slightly different depending on whether a clock synchronous system or an asynchronous system is being used.
In the clock synchronous system, the receive control bit TXTRG is used as the trigger to start receiving data.
When received data has been read and the preparation for next data receiving is completed, write "1" into RXTRG to start receiving. (When "1" is written to RXTRG in slave mode, $\overline{SRDY}$ switches to "0".)
In an asynchronous system, RXTRG is used to prepare for next data receiving. After reading the received data from the received data buffer, write "1" into RXTRG to signify that the received data buffer is empty. If "1" is not written into RXTRG, the overrun error flag OER will be set to "1" when the next receiving operation is completed. (An overrun error will be generated when receiving is completed between reading the received data and the writing of "1" to RXTRG.)
In addition, RXTRG can be read as the status. In either clock synchronous mode or asynchronous mode, when RXTRG is set to "1", it indicates receiving operation and when set to "0", it indicates that receiving has stopped.
For details on timing, see the timing chart which gives the timing for each mode.

When you do not receive, set RXEN to "0" to disable receiving status.

5.7.6 Operation of clock synchronous transfer

Clock synchronous transfer involves the transfer of 8-bit data by synchronizing it to eight clocks. The same synchronous clock is used by both the transmitting and receiving sides.
When the serial interface is used in the master mode, the clock signal selected using SCS0 and SCS1 is further divided by 1/16 and employed as the synchronous clock. This signal is then sent via the $\overline{\text{SCLK}}$ terminal to the slave side (external serial I/O device).
When used in the slave mode, the clock input to the $\overline{\text{SCLK}}$ terminal from the master side (external serial input/output device) is used as the synchronous clock.

In the clock synchronous mode, since one clock line ($\overline{\text{SCLK}}$) is shared for both transmitting and receiving, transmitting and receiving cannot be performed simultaneously. (Half duplex only is possible in clock synchronous mode.)

Transfer data is fixed at 8 bits and both transmitting and receiving are conducted with the LSB (bit 0) coming first.

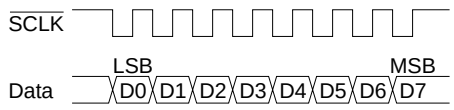


Fig. 5.7.6.1 Transfer data configuration using clock synchronous mode

Below is a description of initialization when performing clock synchronous transfer, transmit-receive control procedures and operations.
With respect to serial interface interrupt, see "5.7.8 Interrupt function".

■ Initialization of serial interface

When performing clock synchronous transfer, the following initial settings must be made.

(1) Setting of transmitting/receiving disable
To set the serial interface into a status in which both transmitting and receiving are disabled, "0" must be written to both the transmit enable register TXEN and the receive enable register RXEN. Fix these two registers to a disable status until data transfer actually begins.

(2) Port selection
Because serial interface input/output ports SIN, SOUT, $\overline{\text{SCLK}}$ and $\overline{\text{SRDY}}$ are set as I/O port terminals P10–P13 at initial reset, "1" must be written to the serial interface enable register ESIF in order to set these terminals for serial interface use.

(3) Setting of transfer mode
Select the clock synchronous mode by writing the data as indicated below to the two bits of the mode selection registers SMD0 and SMD1.

Master mode: SMD0 = "0", SMD1 = "0"
Slave mode: SMD0 = "1", SMD1 = "0"

(4) Clock source selection
In the master mode, select the synchronous clock source by writing data to the two bits of the clock source selection registers SCS0 and SCS1. (See Table 5.7.4.1.)
This selection is not necessary in the slave mode.

Since all the registers mentioned in (2)–(4) are assigned to the same address, it's possible to set them all with one instruction. The parity enable register EPR is also assigned to this address, however, since parity is not necessary in the clock synchronous mode, parity check will not take place regardless of how they are set.

(5) Clock source control
When the master mode is selected and programmable timer for the clock source is selected, set transfer rate on the programmable timer side. (See "5.10 Programmable Timer".)
When the divided signal of OSC3 oscillation circuit is selected for the clock source, be sure that the OSC3 oscillation circuit is turned ON prior to commencing data transfer. (See "5.3 Oscillation Circuits and Operating Mode".)

■ Data transmit procedure

The control procedure and operation during transmitting is as follows.

(1) Write "0" in the transmit enable register TXEN and the receive enable register RXEN to reset the serial interface.

(2) Write "1" in the transmit enable register TXEN to set into the transmitting enable status.

(3) Write the transmitting data into TRXD0–TRXD7.

(4) In case of the master mode, confirm the receive ready status on the slave side (external serial input/output device), if necessary. Wait until it reaches the receive ready status.

(5) Write "1" in the transmit control bit TXTRG and start transmitting.

In the master mode, this control causes the synchronous clock to change to enable and to be provided to the shift register for transmitting and output from the $\overline{SCLK}$ terminal.
In the slave mode, it waits for the synchronous clock to be input from the $\overline{SCLK}$ terminal.
The transmitting data of the shift register shifts one bit at a time at each falling edge of the synchronous clock and is output from the SOUT terminal. When the final bit (MSB) is output, the SOUT terminal is maintained at that level, until the next transmitting begins.

The transmitting complete interrupt factor flag FSTRA is set to "1" at the point where the data transmitting of the shift register is completed. When interrupt has been enabled, a transmitting complete interrupt is generated at this point.
Set the following transmitting data using this interrupt.

(6) Repeat steps (3) to (5) for the number of bytes of transmitting data, and then set the transmit disable status by writing "0" to the transmit enable register TXEN, when the transmitting is completed.

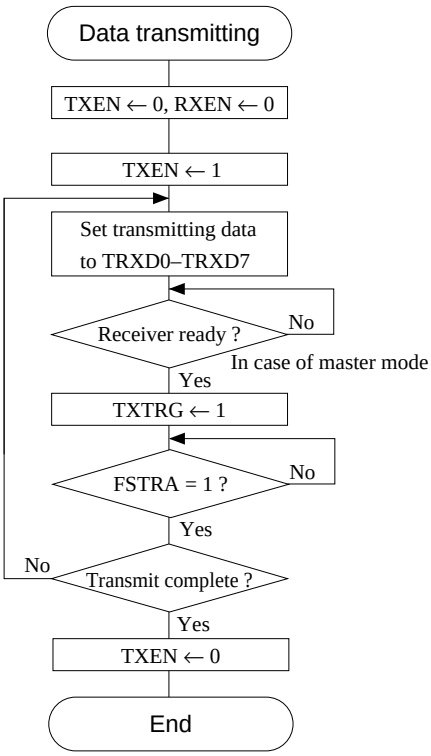


Fig. 5.7.6.2 Transmit procedure in clock synchronous mode

■ Data receive procedure

The control procedure and operation during receiving is as follows.

(1) Write "0" in the receive enable register RXEN and transmit enable register TXEN to reset the serial interface.

(2) Write "1" in the receive enable register RXEN to set into the receiving enable status.

(3) In case of the master mode, confirm the transmit ready status on the slave side (external serial input/output device), if necessary. Wait until it reaches the transmit ready status.

(4) Write "1" in the receive control bit RXTRG and start receiving.

In the master mode, this control causes the synchronous clock to change to enable and is provided to the shift register for receiving and output from the $\overline{SCLK}$ terminal.
In the slave mode, it waits for the synchronous clock to be input from the $\overline{SCLK}$ terminal. The received data input from the SIN terminal is successively incorporated into the shift register in synchronization with the rising edge of the synchronous clock.
At the point where the data of the 8th bit has been incorporated at the final (8th) rising edge of the synchronous clock, the content of the shift register is sent to the received data buffer and the receiving complete interrupt factor flag FSREC is set to "1". When interrupt has been enabled, a receiving complete interrupt is generated at this point.

(5) Read the received data from TRXD0–TRXD7 using receiving complete interrupt.

(6) Repeat steps (3) to (5) for the number of bytes of receiving data, and then set the receive disable status by writing "0" to the receive enable register RXEN, when the receiving is completed.

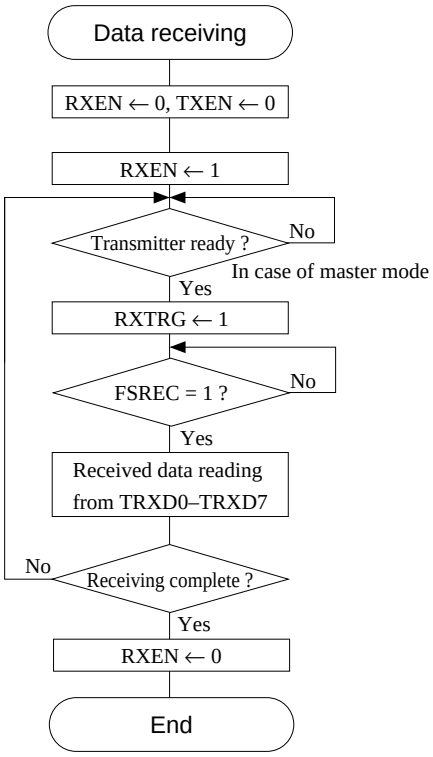


Fig. 5.7.6.3 Receiving procedure in clock synchronous mode

■ Transmit/receive ready ($\overline{\text{SRDY}}$) signal

When this serial interface is used in the clock synchronous slave mode (external clock input), an $\overline{\text{SRDY}}$ signal is output to indicate whether or not this serial interface can transmit/receive to the master side (external serial input/output device). This signal is output from the $\overline{\text{SRDY}}$ terminal and when this interface enters the transmit or receive enable (READY) status, it becomes "0" (LOW level) and becomes "1" (HIGH level) when there is a BUSY status, such as during transmit/receive operation.

The $\overline{\text{SRDY}}$ signal changes the "1" to "0," immediately after writing "1" into the transmit control bit TXTRG or the receive control bit RXTRG and returns from "0" to "1", at the point where the first synchronous clock has been input (falling edge). When you have set in the master mode, control the transfer by inputting the same signal from the slave side using the input port or I/O port. At this time, since the $\overline{\text{SRDY}}$ terminal is not set and instead P13 functions as the I/O port, you can apply this port for said control.

■ Timing chart

The timing chart for the clock synchronous system transmission is shown in Figure 5.7.6.4.

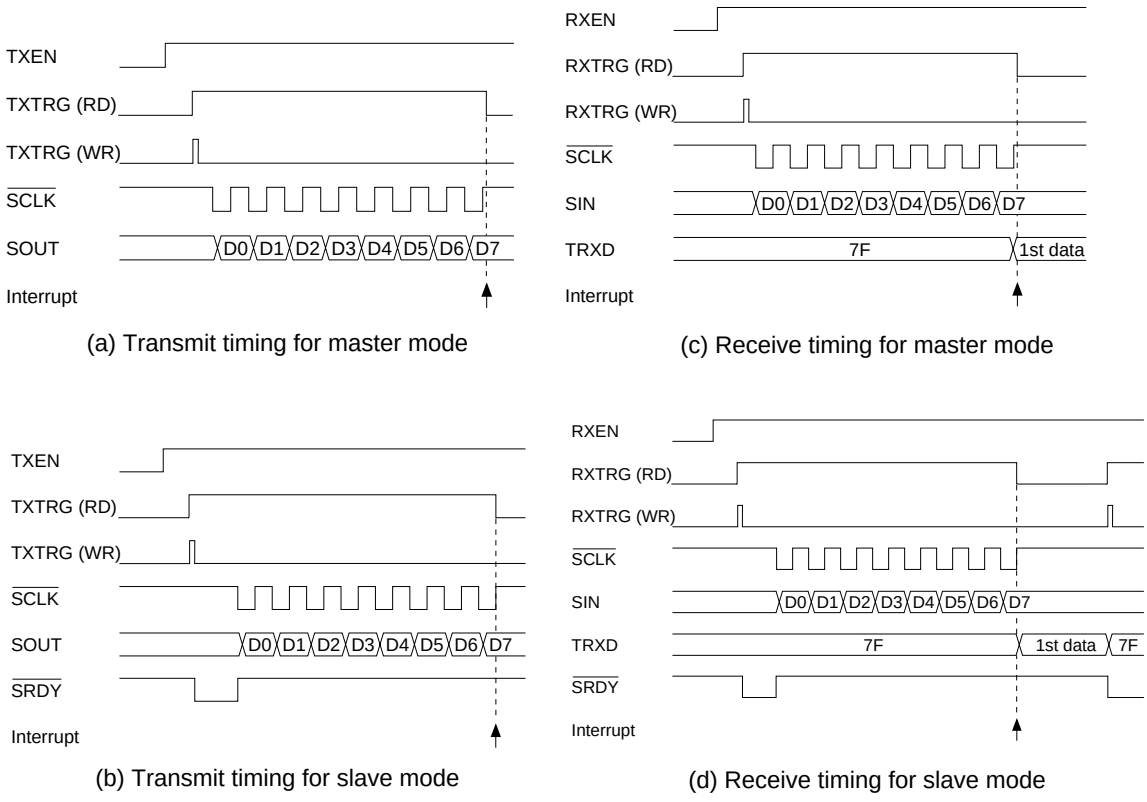
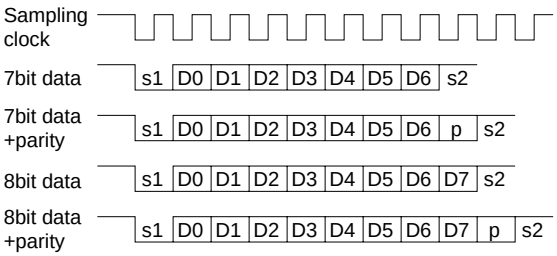


Fig. 5.7.6.4 Timing chart (clock synchronous system transmission)

5.7.7 Operation of asynchronous transfer

Asynchronous transfer is a mode that transfers by adding a start bit and a stop bit to the front and the back of each piece of serial converted data. In this mode, there is no need to use a clock that is fully synchronized clock on the transmit side and the receive side, but rather transmission is done while adopting the synchronization at the start/stop bits that have attached before and after each piece of data. The RS-232C interface functions can be easily realized by selecting this transfer mode.
This interface has separate transmit and receive shift registers and is designed to permit full duplex transmission to be done simultaneously for transmitting and receiving.

For transfer data in the asynchronous 7-bit mode, either 7 bits data (no parity) or 7 bits data + parity bit can be selected. In the asynchronous 8-bit mode, either 8 bits data (no parity) or 8 bits data + parity bit can be selected.
Parity can be even or odd, and parity checking of received data and adding a party bit to transmitting data will be done automatically. Thereafter, it is not necessary to be conscious of parity itself in the program.
The start bit and stop bit are respectively fixed at one bit and data is transmitted and received by placing the LSB (bit 0) at the front.



s1 : Start bit (Low level, 1 bit)
s2 : Stop bit (High level, 1 bit)
p : Parity bit

Fig. 5.7.7.1 Transfer data configuration for asynchronous system

Here following, we will explain the control sequence and operation for initialization and transmitting /receiving in case of asynchronous data transfer. See "5.7.8 Interrupt function" for the serial interface interrupts.

■ Initialization of serial interface

The below initialization must be done in cases of asynchronous system transfer.

(1) Setting of transmitting/receiving disable
To set the serial interface into a status in which both transmitting and receiving are disabled, "0" must be written to both the transmit enable register TXEN and the receive enable register RXEN. Fix these two registers to a disable status until data transfer actually begins.

(2) Port selection
Because serial interface input/output terminals SIN and SOUT are set as I/O port terminals P10 and P11 at initial reset, "1" must be written to the serial interface enable register ESIF in order to set these terminals for serial interface use. $\overline{\text{SCLK}}$ and $\overline{\text{SRDY}}$ terminals set in the clock synchronous mode are not used in the asynchronous mode. These terminals function as I/O port terminals P12 and P13.

(3) Setting of transfer mode
Select the asynchronous mode by writing the data as indicated below to the two bits of the mode selection registers SMD0 and SMD1.

7-bit mode: SMD0 = "0", SMD1 = "1"
8-bit mode: SMD0 = "1", SMD1 = "1"

(4) Parity bit selection
When checking and adding parity bits, write "1" into the parity enable register EPR to set to "with parity check". As a result of this setting, in the asynchronous 7-bit mode, it has a 7 bits data + parity bit configuration and in the asynchronous 8-bit mode it has an 8 bits data + parity bit configuration.In this case, parity checking for receiving and adding a party bit for transmitting is done automatically in hardware. Moreover, when "with parity check" has been selected, "odd" or "even" parity must be further selected in the parity mode selection register PMD.
When "0" is written to the PMD register to select "without parity check" in the asynchronous 7-bit mode, data configuration is set to 7 bits data (no parity) and in the asynchronous 8-bit mode (no parity) it is set to 8 bits data (no parity) and parity checking and parity bit adding will not be done.

(5) Clock source selection
Select the clock source by writing data to the two bits of the clock source selection registers SCS0 and SCS1. (See Table 5.7.4.1.)
Since all the registers mentioned in (2)–(5) are assigned to the same address, it's possible to set them all with one instruction.

(6) Clock source control
When the programmable timer is selected for the clock source, set transfer rate on the programmable timer side. (See "5.10 Programmable Timer".)
When the divided signal of OSC3 oscillation circuit is selected for the clock source, be sure that the OSC3 oscillation circuit is turned ON prior to commencing data transfer. (See "5.3 Oscillation Circuits and Operating Mode".)

■ Data transmit procedure

The control procedure and operation during transmitting is as follows.

(1) Write "0" in the transmit enable register TXEN to reset the serial interface.

(2) Write "1" in the transmit enable register TXEN to set into the transmitting enable status.

(3) Write the transmitting data into TRXD0–TRXD7. Also, when 7-bit data is selected, the TRXD7 data becomes invalid.

(4) Write "1" in the transmit control bit TXTRG and start transmitting.
This control causes the shift clock to change to enable and a start bit (LOW) is output to the SOUT terminal in synchronize to its rising edge. The transmitting data set to the shift register is shifted one bit at a time at each rising edge of the clock thereafter and is output from the SOUT terminal. After the data output, it outputs a stop bit (HIGH) and HIGH level is maintained until the next start bit is output.

The transmitting complete interrupt factor flag FSTRA is set to "1" at the point where the data transmitting is completed. When interrupt has been enabled, a transmitting complete interrupt is generated at this point.
Set the following transmitting data using this interrupt.

(5) Repeat steps (3) to (4) for the number of bytes of transmitting data, and then set the transmit disable status by writing "0" to the transmit enable register TXEN, when the transmitting is completed.

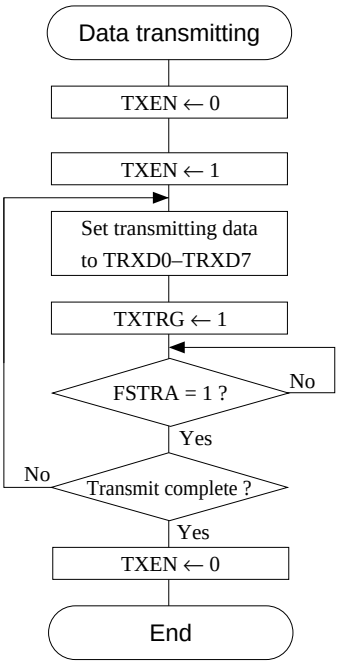


Fig. 5.7.7.2 Transmit procedure in asynchronous mode

■ Data receive procedure

The control procedure and operation during receiving is as follows.

(1) Write "0" in the receive enable register RXEN to set the receiving disable status and to reset the respective PER, OER, FER flags that indicate parity, overrun and framing errors.

(2) Write "1" in the receive enable register RXEN to set into the receiving enable status.

(3) The shift clock will change to enable from the point where the start bit (LOW) has been input from the SIN terminal and the receive data will be synchronized to the rising edge following the second clock, and will thus be successively incorporated into the shift register.
After data bits have been incorporated, the stop bit is checked and, if it is not HIGH, it becomes a framing error and the error interrupt factor flag FSERR is set to "1". When interrupt has been enabled, an error interrupt is generated at this point.
When receiving is completed, data in the shift register is transferred to the received data buffer and the receiving complete interrupt flag FSREC is set to "1". When interrupt has been enabled, a receiving complete interrupt is generated at this point. (When an overrun error is generated, the interrupt factor flag FSREC is not set to "1" and a receiving complete interrupt is not generated.)
If "with parity check" has been selected, a parity check is executed when data is transferred into the received data buffer from the shift register and if a parity error is detected, the error interrupt factor flag is set to "1". When the interrupt has been enabled, an error interrupt is generated at this point just as in the framing error mentioned above.

(4) Read the received data from TRXD0–TRXD7 using receiving complete interrupt.

(5) Write "1" to the receive control bit RXTRG to inform that the receive data has been read out. When the following data is received prior to writing "1" to RXTRG, it is recognized as an overrun error and the error interrupt factor flag is set to "1". When the interrupt has been enabled, an error interrupt is generated at this point just as in the framing error and parity error mentioned above.

(6) Repeat steps (3) to (5) for the number of bytes of receiving data, and then set the receive disable status by writing "0" to the receive enable register RXEN, when the receiving is completed.

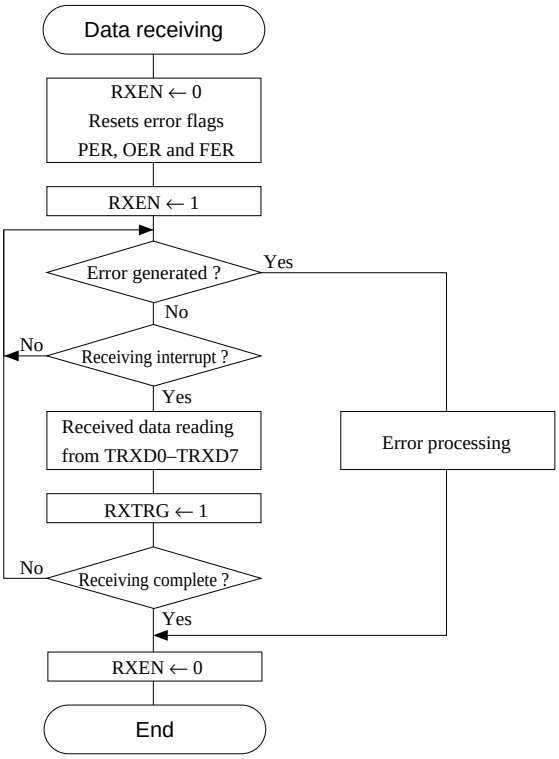


Fig. 5.7.7.3 Receiving procedure in asynchronous mode

■ Receive error

During receiving the following three types of errors can be detected by an interrupt.

(1) Parity error

When writing "1" to the EPR register to select "with parity check", a parity check (vertical parity check) is executed during receiving. After each data bit is sent a parity check bit is sent. The parity check bit is a "0" or a "1". Even parity checking will cause the sum of the parity bit and the other bits to be even. Odd parity causes the sum to be odd. This is checked on the receiving side.

The parity check is performed when data received in the shift register is transferred to the received data buffer. It checks whether the parity check bit is a "1" or a "0" (the sum of the bits including the parity bit) and the parity set in the PMD register match. When it does not match, it is recognized as an parity error and the parity error flag PER and the error interrupt factor flag FSERR is set to "1".

When interrupt has been enabled, an error interrupt is generated at this point.

The PER flag is reset to "0" by writing "1".

Even when this error has been generated, the received data corresponding to the error is transferred in the received data buffer and the receive operation also continues.

The received data at this point cannot assured because of the parity error.

(2) Framing error

In asynchronous transfer, synchronization is adopted for each character at the start bit ("0") and the stop bit ("1"). When receiving has been done with the stop bit set at "0", the serial interface judges the synchronization to be off and a framing error is generated. When this error is generated, the framing error flag FER and the error interrupt factor flag FSERR are set to "1". When interrupt has been enabled, an error interrupt is generated at this point.

The FER flag is reset to "0" by writing "1".

Even when this error has been generated, the received data for it is loaded into the receive data buffer and the receive operation also continues. However, even when it does not become a framing error with the following data receipt, such data cannot be assured.

Even when this error has been generated, the received data corresponding to the error is transferred in the received data buffer and the receive operation also continues. However, even when it does not become a framing error with the following data receiving, such data cannot be assured.

(3) Overrun error

When the next data is received before "1" is written to RXTRG, an overrun error will be generated, because the previous receive data will be overwritten. When this error is generated, the overrun error flag OER and the error interrupt factor flag FSERR are set to "1". When interrupt has been enabled, an error interrupt is generated at this point. The OER flag is reset to "0" by writing "1" into it.

Even when this error has been generated, the received data corresponding to the error is transferred in the received data buffer and the receive operation also continues.

Furthermore, when the timing for writing "1" to RXTRG and the timing for the received data transfer to the received data buffer overlap, it will be recognized as an overrun error.

■ Timing chart

Figure 5.7.7.4 show the asynchronous transfer timing chart.

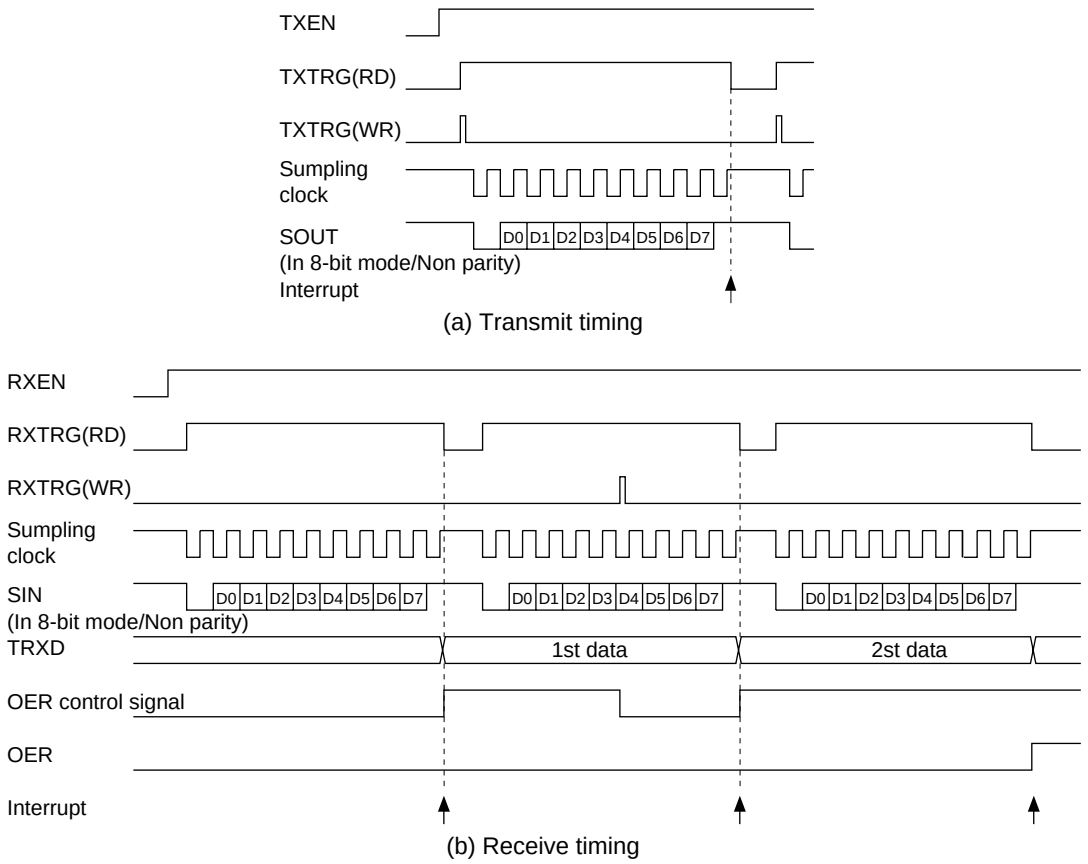


Fig. 5.7.7.4 Timing chart (asynchronous transfer)

5.7.8 Interrupt function

This serial interface includes a function that generates the below indicated three types of interrupts.

- **Transmitting complete interrupt**
- **Receiving complete interrupt**
- **Error interrupt**

The interrupt factor flag FSxxx and the interrupt enable register ESxxx for the respective interrupt factors are provided and then the interrupt enable/disable can be selected by the software. In addition, a priority level of the serial interface interrupt for the CPU can be optionally set at levels 0 to 3 by the interrupt priority registers PSIF0 and PSIF1.
For details on the above mentioned interrupt control register and the operation following generation of an interrupt, see "5.14 Interrupt and Standby Status".
Figure 5.7.8.1 shows the configuration of the serial interface interrupt circuit.

■ Transmitting complete interrupt

This interrupt factor is generated at the point where the sending of the data written into the shift register has been completed and sets the interrupt factor flag FSTRA to "1". When set in this manner, if the corresponding interrupt enable register ESTRA is set to "1" and the corresponding interrupt priority registers PSIF0 and PSIF1 are set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
When "0" has been written into the interrupt enable register ESTRA and interrupt has been disabled, an interrupt is not generated to the CPU. Even in this case, the interrupt factor flag FSTRA is set to "1".
The interrupt factor flag FSTRA is reset to "0" by writing "1".
The following transmitting data can be set and the transmitting start (writing "1" to TXTRG) can be controlled by generation of this interrupt factor.
The exception processing vector address for this interrupt factor is set at 000014H.

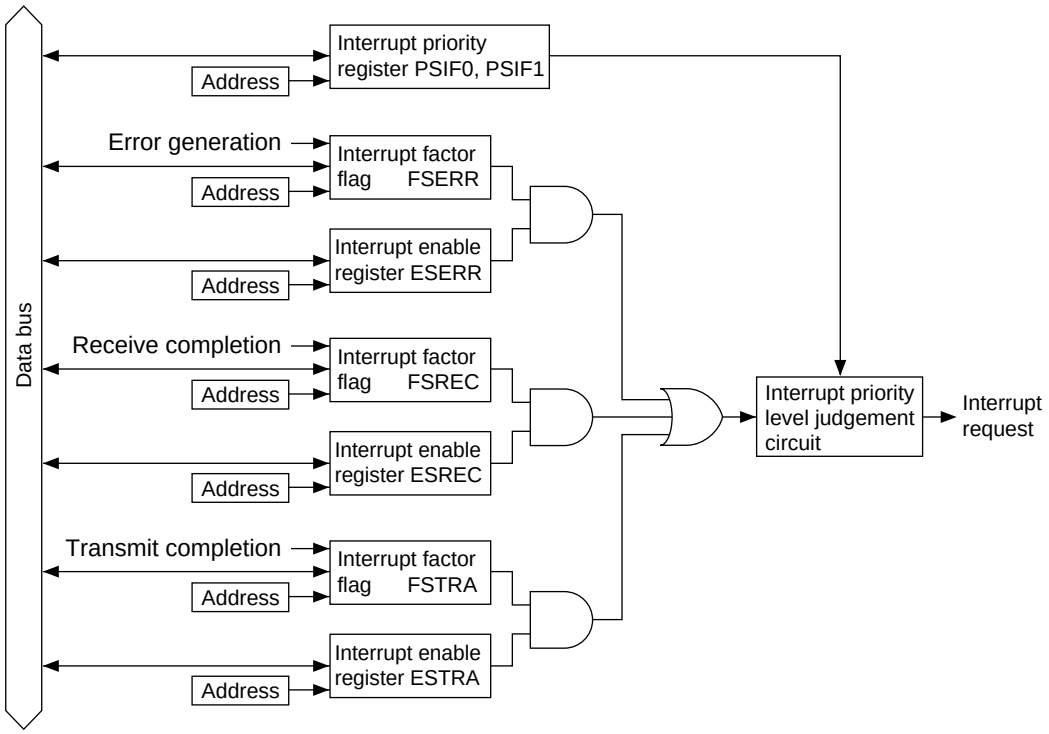


Fig. 5.7.8.1 Configuration of serial interface interrupt circuit

■ Receiving complete interrupt

This interrupt factor is generated at the point where receiving has been completed and the receive data incorporated into the shift register has been transferred into the received data buffer and it sets the interrupt factor flag FSREC to "1". When set in this manner, if the corresponding interrupt enable register ESREC is set to "1" and the corresponding interrupt priority registers PSIF0 and PSIF1 are set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
When "0" has been written into the interrupt enable register ESREC and interrupt has been disabled, an interrupt is not generated to the CPU. Even in this case, the interrupt factor flag FSREC is set to "1". The interrupt factor flag FSREC is reset to "0" by writing "1".

The generation of this interrupt factor permits the received data to be read.

Also, the interrupt factor flag is set to "1" when a parity error or framing error is generated.

The exception processing vector address for this interrupt factor is set at 000012H.

■ Error interrupt

This interrupt factor is generated at the point where a parity error, framing error or overrun error is detected during receiving and it sets the interrupt factor flag FSERR to "1". When set in this manner, if the corresponding interrupt enable register ESERR is set to "1" and the corresponding interrupt priority registers PSIF0 and PSIF1 are set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
When "0" has been written in the interrupt enable register ESERR and interrupt has been disabled, an interrupt is not generated to the CPU. Even in this case, the interrupt factor flag FSERR is set to "1". The interrupt factor flag FSERR is reset to "0" by writing "1".

Since all three types of errors result in the same interrupt factor, you should identify the error that has been generated by the error flags PER (parity error), OER (overrun error) and FER (framing error).

The exception processing vector address for this interrupt factor is set at 000010H.

5.7.9 Control of serial interface

Table 5.7.9.1 show the serial interface control bits.

Table 5.7.9.1(a) Serial interface control bits

Address	Bit	Name	Function		1	0	SR	R/W	Comment
00FF48	D7	–	–		–	–	–		"0" when being read
	D6	EPR	Parity enable register		With parity	Non parity	0	R/W	Only for
	D5	PMD	Parity mode selection		Odd	Even	0	R/W	asynchronous mode
	D4	SCS1	Clock source selection				0	R/W	In the clock synchro-
			SCS1 SCS0 Clock source						nous slave mode,
			1 1 Programmable timer						external clock is
	D3	SCS0	1 0 fOSC3 / 4				0	R/W	selected.
			0 1 fOSC3 / 8						
			0 0 fOSC3 / 16						
	D2	SMD1	Serial I/F mode selection				0	R/W	
			SMD1 SMD0 Mode						
			1 1 Asynchronous 8-bit						
	D1	SMD0	1 0 Asynchronous 7-bit				0	R/W	
			0 1 Clock synchronous slave						
			0 0 Clock synchronous master						
	D0	ESIF	Serial I/F enable register		Serial I/F	I/O port	0	R/W	
00FF49	D7	–	–		–	–	–		"0" when being read
	D6	FER	Framing error flag	R	Error	No error	0	R/W	Only for
				W	Reset (0)	No operation			asynchronous mode
	D5	PER	Parity error flag	R	Error	No error	0	R/W	
				W	Reset (0)	No operation			
	D4	OER	Overrun error flag	R	Error	No error	0	R/W	
				W	Reset (0)	No operation			
	D3	RXTRG	Receive trigger/status	R	Run	Stop	0	R/W	
				W	Trigger	No operation			
	D2	RXEN	Receive enable		Enable	Disable	0	R/W	
	D1	TXTRG	Transmit trigger/status	R	Run	Stop	0	R/W	
				W	Trigger	No operation			
	D0	TXEN	Transmit enable		Enable	Disable	0	R/W	
00FF4A	D7	TRXD7	Transmit/Receive data D7 (MSB)		High	Low	X	R/W	
	D6	TRXD6	Transmit/Receive data D6				X	R/W	
	D5	TRXD5	Transmit/Receive data D5				X	R/W	
	D4	TRXD4	Transmit/Receive data D4				X	R/W	
	D3	TRXD3	Transmit/Receive data D3				X	R/W	
	D2	TRXD2	Transmit/Receive data D2				X	R/W	
	D1	TRXD1	Transmit/Receive data D1				X	R/W	
	D0	TRXD0	Transmit/Receive data D0 (LSB)				X	R/W	
00FF20	D7	PK01	K00–K07 interrupt priority register				0	R/W	
	D6	PK00					0	R/W	
	D5	PSIF1	Serial interface interrupt priority register				0	R/W	
	D4	PSIF0					0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register				0	R/W	
	D2	PSW0					0	R/W	
	D1	PTM1	Clock timer interrupt priority register				0	R/W	
	D0	PTM0					0	R/W	

PK01	PK00	
PSIF1	PSIF0	
PSW1	PSW0	Priority
PTM1	PTM0	level
1	1	Level 3
1	0	Level 2
0	1	Level 1
0	0	Level 0

Table 5.7.9.1(b) Serial interface control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF23	D7	EPT1	Programmable timer 1 interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D6	EPT0	Programmable timer 0 interrupt enable register			0	R/W	
	D5	EK1	K10 interrupt enable register			0	R/W	
	D4	EK0H	K04–K07 interrupt enable register			0	R/W	
	D3	EK0L	K00–K03 interrupt enable register			0	R/W	
	D2	ESERR	Serial I/F (error) interrupt enable register			0	R/W	
	D1	ESREC	Serial I/F (receiving) interrupt enable register			0	R/W	
	D0	ESTRA	Serial I/F (transmitting) interrupt enable register			0	R/W	
00FF25	D7	FPT1	Programmable timer 1 interrupt factor flag	(R) Interrupt factor is generated	(R) No interrupt factor is generated	0	R/W	
	D6	FPT0	Programmable timer 0 interrupt factor flag			0	R/W	
	D5	FK1	K10 interrupt factor flag			0	R/W	
	D4	FK0H	K04–K07 interrupt factor flag			0	R/W	
	D3	FK0L	K00–K03 interrupt factor flag			0	R/W	
	D2	FSERR	Serial I/F (error) interrupt factor flag	(W) Reset	(W) No operation	0	R/W	
	D1	FSREC	Serial I/F (receiving) interrupt factor flag			0	R/W	
	D0	FSTRA	Serial I/F (transmitting) interrupt factor flag			0	R/W	

ESIF: 00FF48H•D0

Sets the serial interface terminals (P10–P13).

When "1" is written: Serial input/output terminal
When "0" is written: I/O port terminal
Reading: Valid

The ESIF is the serial interface enable register and P10–P13 terminals become serial input/output terminals (SIN, SOUT, $\overline{SCLK}$, $\overline{SRDY}$) when "1" is written, and they become I/O port terminals when "0" is written.
Also, see Table 5.7.3.2 for the terminal settings according to the transfer modes.
At initial reset, ESIF is set to "0" (I/O port).

SMD0, SMD1: 00FF48H•D1, D2

Set the transfer modes according to Table 5.7.9.2.

Table 5.7.9.2 Transfer mode settings

SMD1	SMD0	Mode
1	1	Asynchronous system 8-bit
1	0	Asynchronous system 7-bit
0	1	Clock synchronous system slave
0	0	Clock synchronous system master

SMD0 and SMD1 can also read out.
At initial reset, this register is set to "0" (clock synchronous master mode).

SCS0, SCS1: 00FF48H•D3, D4

Select the clock source according to Table 5.7.9.3.

Table 5.7.9.3 Clock source selection

SCS1	SCS0	Clock source
1	1	Programmable timer
1	0	f_{OSC3} / 4
0	1	f_{OSC3} / 8
0	0	f_{OSC3} / 16

SCS0 and SCS1 can also be read out.
In the clock synchronous slave mode, setting of this register is invalid.
At initial reset, this register is set to "0" (f_{OSC3}/16).

EPR: 00FF48H•D6

Selects the parity function.

When "1" is written: With parity
When "0" is written: Non parity
Reading: Valid

Selects whether or not to check parity of the received data and to add a parity bit to the transmitting data. When "1" is written to EPR, the most significant bit of the received data is considered to be the parity bit and a parity check is executed. A parity bit is added to the transmitting data. When "0" is written, neither checking is done nor is a parity bit added.
Parity is valid only in asynchronous mode and the EPR setting becomes invalid in the clock synchronous mode.
At initial reset, EPR is set to "0" (non parity).

PMD: 00FF48H•D5

Selects odd parity/even parity.

When "1" is written:	Odd parity
When "0" is written:	Even parity
Reading:	Valid

When "1" is written to PMD, odd parity is selected and even parity is selected when "0" is written. The parity check and addition of a parity bit is only valid when "1" has been written to EPR. When "0" has been written to EPR, the parity setting by PMD becomes invalid.
At initial reset, PMD is set to "0" (even parity).

TXEN: 00FF49H•D0

Sets the serial interface to the transmitting enable status.

When "1" is written:	Transmitting enable
When "0" is written:	Transmitting disable
Reading:	Valid

When "1" is written to TXEN, the serial interface shifts to the transmitting enable status and shifts to the transmitting disable status when "0" is written.
Set TXEN to "0" when making the initial settings of the serial interface and similar operations.
At initial reset, TXEN is set to "0" (transmitting disable).

TXTRG: 00FF49H•D1

Functions as the transmitting start trigger and the operation status indicator (transmitting/stop status).

When "1" is read:	During transmitting
When "0" is read:	During stop
When "1" is written:	Transmitting start
When "0" is written:	Invalid

Starts the transmitting when "1" is written to TXTRG after writing the transmitting data.
TXTRG can be read as the status. When set to "1", it indicates transmitting operation, and "0" indicates transmitting stop.
At initial reset, TXTRG is set to "0" (during stop).

RXEN: 00FF49H•D2

Sets the serial interface to the receiving enable status.

When "1" is written:	Receiving enable
When "0" is written:	Receiving disable
Reading:	Valid

When "1" is written to RXEN, the serial interface shifts to the receiving enable status and shifts to the receiving disable status when "0" is written.
Set RXEN to "0" when making the initial settings of the serial interface and similar operations.
At initial reset, RXEN is set to "0" (receiving disable).

RXTRG: 00FF49H•D3

Functions as the receiving start trigger or preparation for the following data receiving and the operation status indicator (during receiving/during stop).

When "1" is read:	During receiving
When "0" is read:	During stop
When "1" is written:	Receiving start/following data receiving preparation
When "0" is written:	Invalid

RXTRG has a slightly different operation in the clock synchronous system and the asynchronous system.

The RXTRG in the clock synchronous system, is used as the trigger for the receiving start.
Writes "1" into RXTRG to start receiving at the point where the receive data has been read and the following receive preparation has been done. (In the slave mode, $\overline{\text{SRDY}}$ becomes "0" at the point where "1" has been written into into the RXTRG.)

RSTRG is used in the asynchronous system for preparation of the following data receiving. Reads the received data located in the received data buffer and writes "1" into RXTRG to inform that the received data buffer has shifted to empty. When "1" has not been written to RXTRG, the overrun error flag OER is set to "1" at the point where the following receiving has been completed. (When the receiving has been completed between the operation to read the received data and the operation to write "1" into RXTRG, an overrun error occurs.)

In addition, RXTRG can be read as the status. In either clock synchronous mode or asynchronous mode, when RXTRG is set to "1", it indicates receiving operation and when set to "0", it indicates that receiving has stopped.
At initial reset, RXTRG is set to "0" (during stop).

TRXD0–TRXD7: 00FF4AH

During transmitting

Write the transmitting data into the transmit shift register.

When "1" is written: HIGH level
When "0" is written: LOW level

Write the transmitting data prior to starting transmitting.
In the case of continuous transmitting, wait for the transmitting complete interrupt, then write the data.
The TRXD7 becomes invalid for the asynchronous 7-bit mode.
Converted serial data for which the bits set at "1" as HIGH (V_{DD}) level and for which the bits set at "0" as LOW (V_{SS}) level are output from the SOUT terminal.

During receiving

Read the received data.

When "1" is read: HIGH level
When "0" is read: LOW level

The data from the received data buffer can be read out. Since the sift register is provided separately from this buffer, reading can be done during the receive operation in the asynchronous mode. (The buffer function is not used in the clock synchronous mode.)
Read the data after waiting for the receiving complete interrupt.
When performing parity check in the asynchronous 7-bit mode, "0" is loaded into the 8th bit (TRXD7) that corresponds to the parity bit.
The serial data input from the SIN terminal is level converted, making the HIGH (V_{DD}) level bit "1" and the LOW (V_{SS}) level bit "0" and is then loaded into this buffer.
At initial reset, the buffer content is undefined.

OER: 00FF49H•D4

Indicates the generation of an overrun error.

When "1" is read: Error
When "0" is read: No error

When "1" is written: Reset to "0"
When "0" is written: Invalid

OER is an error flag that indicates the generation of an overrun error and becomes "1" when an error has been generated.
An overrun error is generated when the receiving of data has been completed prior to the writing of "1" to RXTRG in the asynchronous mode.
OER is reset to "0" by writing "1".
At initial reset and when RXEN is "0", OER is set to "0" (no error).

PER: 00FF49H•D5

Indicates the generation of a parity error.

When "1" is read: Error
When "0" is read: No error

When "1" is written: Reset to "0"
When "0" is written: Invalid

PER is an error flag that indicates the generation of a parity error and becomes "1" when an error has been generated.
When a parity check is performed in the asynchronous mode, if data that does not match the parity is received, a parity error is generated.
PER is reset to "0" by writing "1".
At initial reset and when RXEN is "0", PER is set to "0" (no error).

FER: 00FF49H•D6

Indicates the generation of a framing error.

When "1" is read: Error
When "0" is read: No error

When "1" is written: Reset to "0"
When "0" is written: Invalid

FER is an error flag that indicates the generation of a framing error and becomes "1" when an error has been generated.
When the stop bit for the receiving of the asynchronous mode has become "0", a framing error is generated.
FER is reset to "0" by writing "1".
At initial reset and when RXEN is "0", FER is set to "0" (no error).

PSIF0, PSIF1: 00FF20H•D4, D5

Sets the priority level of the serial interface interrupt. The two bits PSIF0 and PSIF1 are the interrupt priority register corresponding to the serial interface interrupt. Table 5.7.9.4 shows the interrupt priority level which can be set by this register.

Table 5.7.9.4 Interrupt priority level settings

PSIF1	PSIF0	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (None)

At initial reset, this register is set to "0" (level 0).

ESTRA, ESREC, ESERR: 00FF23H•D0, D1, D2

Enables or disables the generation of an interrupt for the CPU.

When "1" is written: Interrupt enabled
When "0" is written: Interrupt disabled
Reading: Valid

ESTRA, ESREC and ESERR are interrupt enable registers that respectively correspond to the interrupt factors for transmitting complete, receiving complete and receiving error. Interrupts set to "1" are enabled and interrupts set to "0" are disabled.
At initial reset, this register is set to "0" (interrupt disabled).

FSTRA, FSREC, FSERR: 00FF25H•D0, D1, D2

Indicates the serial interface interrupt generation status.

When "1" is read: Interrupt factor present
When "0" is read: Interrupt factor not present

When "1" is written: Resets factor flag
When "0" is written: Invalid

FSTRA, FSREC and FSERR are interrupt factor flags that respectively correspond to the interrupts for transmitting complete, receiving complete and receiving error and are set to "1" by generation of each factor.
Transmitting complete interrupt factor is generated at the point where the data transmitting of the shift register has been completed.
Receiving complete interrupt factor is generated at the point where the received data has been transferred into the received data buffer.
Receive error interrupt factor is generated when a parity error, framing error or overrun error has been detected during data receiving.
When set in this manner, if the corresponding interrupt enable register is set to "1" and the corresponding interrupt priority register is set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
Regardless of the interrupt enable register and interrupt priority register settings, the interrupt factor flag will be set to "1" by the occurrence of an interrupt generation condition.
To accept the subsequent interrupt after interrupt generation, re-setting of the interrupt flags (set interrupt flag to lower level than the level indicated by the interrupt priority registers, or execute the RETE instruction) and interrupt factor flag reset are necessary. The interrupt factor flag is reset to "0" by writing "1".
At initial reset, this flag is reset to "0".

5.7.10 Programming notes

(1) Be sure to initialize the serial interface mode in the transmitting/receiving disable status (TXEN = RXEN = "0").

(2) Do not perform double trigger (writing "1") to TXTRG (RXTRG) when the serial interface is in the transmitting (receiving) operation. Furthermore, do not execute the SLP instruction. (When executing the SLP instruction, set TXEN = RXEN = "0".)

(3) In the clock synchronous mode, since one clock line ($\overline{SCLK}$) is shared for both transmitting and receiving, transmitting and receiving cannot be performed simultaneously. (Half duplex only is possible in clock synchronous mode.)
Consequently, be sure not to write "1" to RXTRG (TXTRG) when TXTRG (RXTRG) is "1".

(4) When a parity error or flaming error is generated during receiving in the asynchronous mode, the receiving error interrupt factor flag FSERR is set to "1" prior to the receiving complete interrupt factor flag FSREC for the time indicated in Table 5.7.10.1. Consequently, when an error is generated, you should reset the receiving complete interrupt factor flag FSREC to "0" by providing a wait time in error processing routines and similar routines.
When an overrun error is generated, the receiving complete interrupt factor flag FSREC is not set to "1" and a receiving complete interrupt is not generated.

Table 5.7.10.1 Time difference between FSERR and FSREC on error generation

Clock source	Time difference
f_{OSC3} / n	1/2 cycles of f_{OSC3} / n
Programmable timer	1 cycle of timer 1 underflow

(5) When the demultiplied signal of the OSC3 oscillation circuit is made the clock source, it is necessary to turn the OSC3 oscillation ON, prior to using the serial interface.
A time interval of several 100 µsec to several 10 msec, from the turning ON of the OSC3 oscillation circuit to until the oscillation stabilizes, is necessary, due to the oscillation element that is used. Consequently, you should allow an adequate waiting time after turning ON of the OSC3 oscillation, before starting transmitting/receiving of serial interface. (The oscillation start time will vary somewhat depending on the oscillator and on the externally attached parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, the OSC3 oscillation circuit is set to OFF status.

5.8 Clock Timer

5.8.1 Configuration of clock timer

The E0C88832/88862 has built in a clock timer that uses the OSC1 oscillation circuit as clock source.
The clock timer is composed of an 8-bit binary counter that uses the 256 Hz signal dividing f_{OSC1} as its input clock and can read the data of each bit (128–1 Hz) by software.
Normally, this clock timer is used for various timing functions such as clocks.
The configuration of the clock timer is shown in Figure 5.8.1.1.

5.8.2 Interrupt function

The clock timer can generate an interrupt by each of the 32 Hz, 8 Hz, 2 Hz and 1 Hz signals.
The configuration of the clock timer interrupt circuit is shown in Figure 5.8.2.1.

Interrupts are generated by respectively setting the corresponding interrupt factor flags FTM32, FTM8, FTM2 and FTM1 at the falling edge of the 32 Hz, 8 Hz, 2 Hz and 1 Hz signals to "1". Interrupt can be prohibited by the setting the interrupt enable registers ETM32, ETM8, ETM2 and ETM1 corresponding to each interrupt factor flag.
In addition, a priority level of the clock timer interrupt for the CPU can be optionally set at levels 0 to 3 by the interrupt priority registers PTM0 and PTM1.
For details on the above mentioned interrupt control register and the operation following generation of an interrupt, see "5.14 Interrupt and Standby Status".

The exception processing vector addresses for each interrupt factor are respectively set as shown below.

32 Hz interrupt:	00001CH
8 Hz interrupt:	00001EH
2 Hz interrupt:	000020H
1 Hz interrupt:	000022H

Figure 5.8.2.2 shows the timing chart for the clock timer.

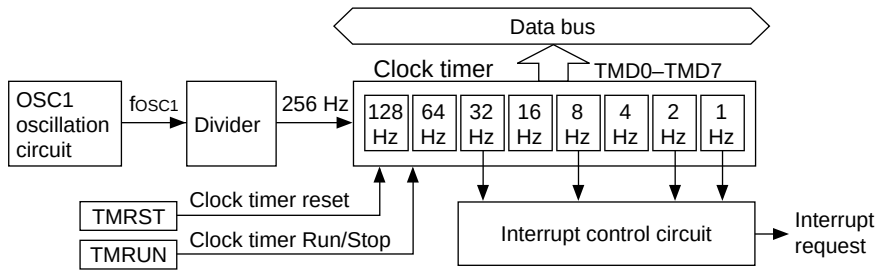


Fig. 5.8.1.1 Configuration of clock timer

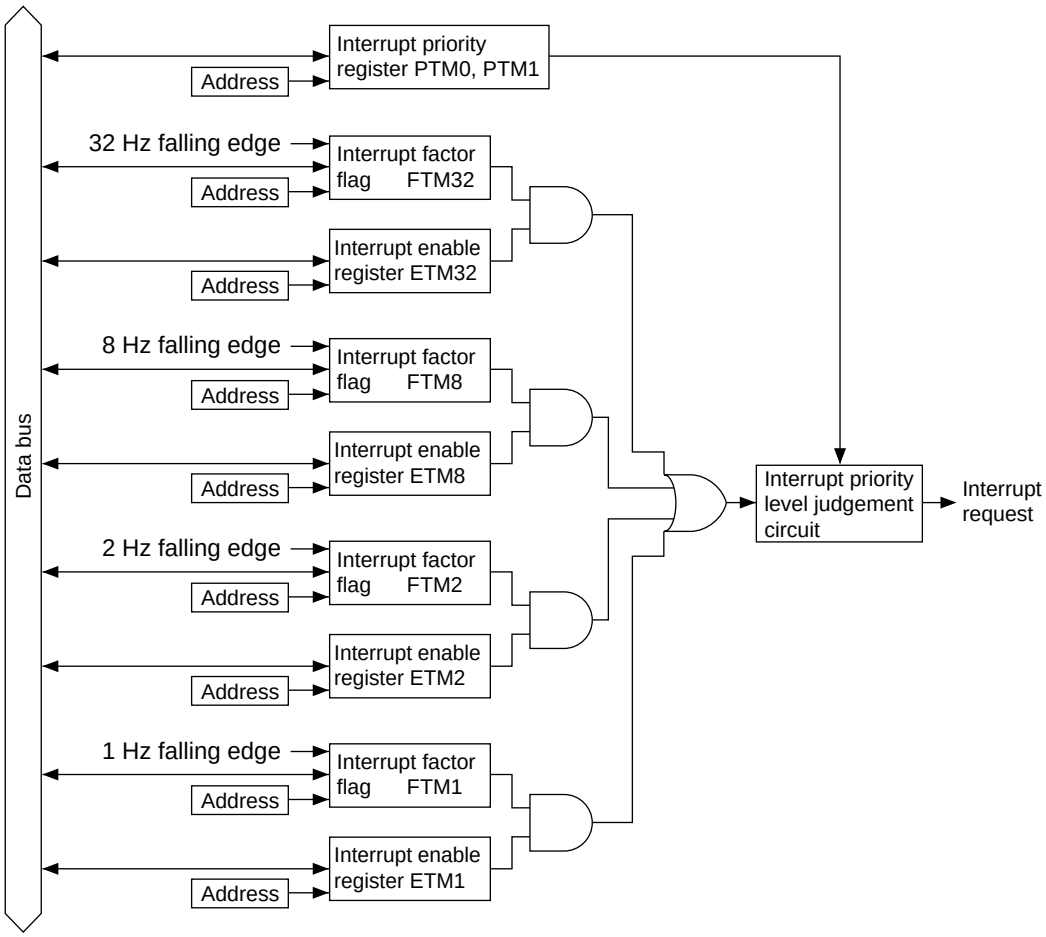


Fig. 5.8.2.1 Configuration of clock timer interrupt circuit

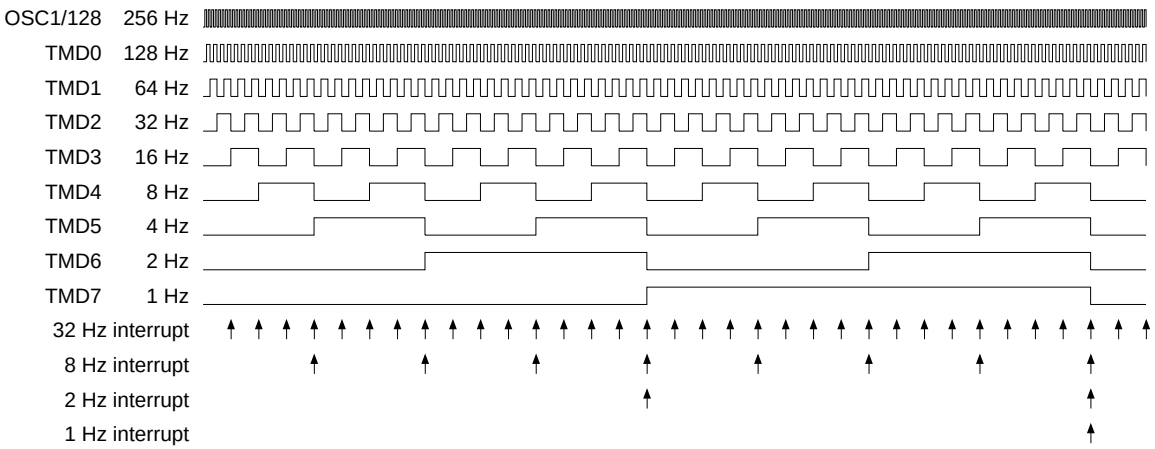


Fig. 5.8.2.2 Timing chart of clock timer

5.8.3 Control of clock timer

Table 5.8.3.1 shows the clock timer control bits.

Table 5.8.3.1 Clock timer control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF40	D7	–	–	–	–	–		"0" when being read
	D6	FOUT2	FOUT frequency selection FOUT2 FOUT1 FOUT0 Frequency 0 0 0 fOSC1 / 1 0 0 1 fOSC1 / 2 0 1 0 fOSC1 / 4 0 1 1 fOSC1 / 8 1 0 0 fOSC3 / 1 1 0 1 fOSC3 / 2 1 1 0 fOSC3 / 4 1 1 1 fOSC3 / 8			0	R/W	This is just R/W register on E0C88862.
	D5	FOUT1				0	R/W	
	D4	FOUT0				0	R/W	
	D3	FOUTON	FOUT output control	On	Off	0	R/W	
	D2	WDRST	Watchdog timer reset	Reset	No operation	–	W	Constantly "0" when being read
	D1	TMRST	Clock timer reset	Reset	No operation	–	W	
	D0	TMRUN	Clock timer Run/Stop control	Run	Stop	0	R/W	
00FF41	D7	TMD7	Clock timer data 1 Hz	High	Low	0	R	
	D6	TMD6	Clock timer data 2 Hz			0	R	
	D5	TMD5	Clock timer data 4 Hz			0	R	
	D4	TMD4	Clock timer data 8 Hz			0	R	
	D3	TMD3	Clock timer data 16 Hz			0	R	
	D2	TMD2	Clock timer data 32 Hz			0	R	
	D1	TMD1	Clock timer data 64 Hz			0	R	
	D0	TMD0	Clock timer data 128 Hz			0	R	
00FF20	D7	PK01	K00–K07 interrupt priority register	PK01 PK00 PSIF1 PSIF0 PSW1 PSW0 PTM1 PTM0 Priority level 1 1 Level 3 1 0 Level 2 0 1 Level 1 0 0 Level 0		0	R/W	
	D6	PK00				0	R/W	
	D5	PSIF1	Serial interface interrupt priority register			0	R/W	
	D4	PSIF0				0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register			0	R/W	
	D2	PSW0				0	R/W	
	D1	PTM1	Clock timer interrupt priority register			0	R/W	
	D0	PTM0				0	R/W	
00FF22	D7	–	–	–	–	–		"0" when being read
	D6	ESW100	Stopwatch timer 100 Hz interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D5	ESW10	Stopwatch timer 10 Hz interrupt enable register			0	R/W	
	D4	ESW1	Stopwatch timer 1 Hz interrupt enable register			0	R/W	
	D3	ETM32	Clock timer 32 Hz interrupt enable register			0	R/W	
	D2	ETM8	Clock timer 8 Hz interrupt enable register			0	R/W	
	D1	ETM2	Clock timer 2 Hz interrupt enable register			0	R/W	
	D0	ETM1	Clock timer 1 Hz interrupt enable register			0	R/W	
00FF24	D7	–	–	–	–	–		"0" when being read
	D6	FSW100	Stopwatch timer 100 Hz interrupt factor flag	(R) Interrupt factor is generated (W) Reset	(R) No interrupt factor is generated (W) No operation	0	R/W	
	D5	FSW10	Stopwatch timer 10 Hz interrupt factor flag			0	R/W	
	D4	FSW1	Stopwatch timer 1 Hz interrupt factor flag			0	R/W	
	D3	FTM32	Clock timer 32 Hz interrupt factor flag			0	R/W	
	D2	FTM8	Clock timer 8 Hz interrupt factor flag			0	R/W	
	D1	FTM2	Clock timer 2 Hz interrupt factor flag			0	R/W	
	D0	FTM1	Clock timer 1 Hz interrupt factor flag			0	R/W	

TMD0–TMD7: 00FF41H

The clock timer data can be read out.
Each bit of TMD0–TMD7 and frequency correspondence are as follows:

TMD0:	128Hz	TMD4:	8Hz
TMD1:	64Hz	TMD5:	4Hz
TMD2:	32Hz	TMD6:	2Hz
TMD3:	16Hz	TMD7:	1Hz

Since the TMD0–TMD7 is exclusively for reading, the write operation is invalid.
At initial reset, the timer data is set to "00H".

TMRST: 00FF40H•D1

Resets the clock timer.

When "1" is written:	Clock timer reset
When "0" is written:	No operation
Reading:	Always "0"

The clock timer is reset by writing "1" to the TMRST.
When the clock timer is reset in the RUN status, it restarts immediately after resetting. In the case of the STOP status, the reset data "00H" is maintained.
No operation results when "0" is written to the TMRST.
Since the TMRST is exclusively for writing, it always becomes "0" during reading.

TMRUN: 00FF40H•D0

Controls RUN/STOP of the clock timer.

When "1" is written:	RUN
When "0" is written:	STOP
Reading:	Valid

The clock timer starts up-counting by writing "1" to the TMRUN and stops by writing "0".
In the STOP status, the count data is maintained until it is reset or set in the next RUN status. Also, when the STOP status changes to the RUN status, the data that was maintained can be used for resuming the count.
At initial reset, the TMRUN is set to "0" (STOP).

PTM0, PTM1: 00FF20H•D0, D1

Sets the priority level of the clock timer interrupt. The two bits PTM0 and PTM1 are the interrupt priority register corresponding to the clock timer interrupt. Table 5.8.3.2 shows the interrupt priority level which can be set by this register.

Table 5.8.3.2 Interrupt priority level settings

PTM1	PTM0	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (None)

At initial reset, this register is set to "0" (level 0).

ETM1, ETM2, ETM8, ETM32: 00FF22H•D0–D3

Enables or disables the generation of an interrupt for the CPU.

When "1" is written:	Interrupt enabled
When "0" is written:	Interrupt disabled
Reading:	Valid

The ETM1, ETM2, ETM8 and ETM32 are interrupt enable registers that respectively correspond to the interrupt factors for 1 Hz, 2 Hz, 8 Hz and 32 Hz. Interrupts set to "1" are enabled and interrupts set to "0" are disabled.
At initial reset, this register is set to "0" (interrupt disabled).

FTM1, FTM2, FTM8, FTM32: 00FF24H•D0–D3

Indicates the clock timer interrupt generation status.

When "1" is read:	Interrupt factor present
When "0" is read:	Interrupt factor not present
When "1" is written:	Resets factor flag
When "0" is written:	Invalid

The FTM1, FTM2, FTM8 and FTM32 are interrupt factor flags that respectively correspond to the interrupts for 1 Hz, 2 Hz, 8 Hz and 32 Hz and are set to "1" at the falling edge of each signal.
When set in this manner, if the corresponding interrupt enable register is set to "1" and the corresponding interrupt priority register is set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
Regardless of the interrupt enable register and interrupt priority register settings, the interrupt factor flag will be set to "1" by the occurrence of an interrupt generation condition.
To accept the subsequent interrupt after interrupt generation, re-setting of the interrupt flags (set interrupt flag to lower level than the level indicated by the interrupt priority registers, or execute the RETE instruction) and interrupt factor flag reset are necessary. The interrupt factor flag is reset to "0" by writing "1".
At initial reset, this flag is reset to "0".

5.8.4 Programming notes

(1) The clock timer is actually made to RUN/STOP in synchronization with the falling edge of the 256 Hz signal after writing to the TMRUN register. Consequently, when "0" is written to the TMRUN, the timer shifts to STOP status when the counter is incremented "1". The TMRUN maintains "1" for reading until the timer actually shifts to STOP status.
Figure 5.8.4.1 shows the timing chart of the RUN/STOP control.

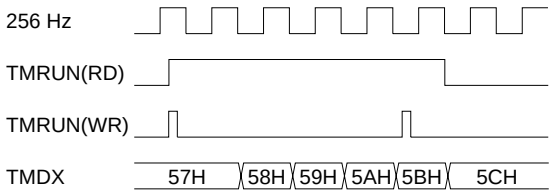


Fig. 5.8.4.1 Timing chart of RUN/STOP control

(2) The SLP instruction is executed when the clock timer is in the RUN status (TMRUN = "1"). The clock timer operation will become unstable when returning from SLEEP status. Therefore, when shifting to SLEEP status, set the clock timer to STOP status (TMRUN = "0") prior to executing the SLP instruction.

5.9 Stopwatch Timer

5.9.1 Configuration of stopwatch timer

The E0C88832/88862 has a built-in 1/100 sec and 1/10 sec stopwatch timer. The stopwatch timer is composed of a 4-bit 2 stage BCD counter (1/100 sec units and 1/10 sec units) that makes the 256 Hz signal that divides the fOSC1 the input clock and it can read the count data by software.
Figure 5.9.1.1 shows the configuration of the stopwatch timer.
The stopwatch timer can be used as a timer different from the clock timer and can easily realize stopwatch and other such functions by software.

5.9.2 Count up pattern

The stopwatch timer is respectively composed of the 4-bit BCD counters SWD0–SWD3 and SWD4–SWD7.

Figure 5.9.2.1 shows the count up pattern of the stopwatch timer.

The feedback dividing circuit generates an approximate 100 Hz signal at 2/256 sec and 3/256 sec intervals from a 256 Hz signal divided from fOSC1.

The 1/100 sec counter (SWD0–SWD3) generates an approximate 10 Hz signal at 25/256 sec and 26/256 sec intervals by counting the approximate 100 Hz signal generated by the feedback dividing circuit in 2/256 sec and 3/256 sec intervals. The count-up is made approximately 1/100 sec counting by the 2/256 sec and 3/256 sec intervals.

The 1/10 sec counter (SWD4–SWD7) generates a 1 Hz signal by counting the approximate 10 Hz signal generated by the 1/100 sec counter at 25/256 sec and 26/256 sec intervals in 4:6 ratios.

The count-up is made approximately 1/10 sec counting by 25/256 sec and 26/256 sec intervals.

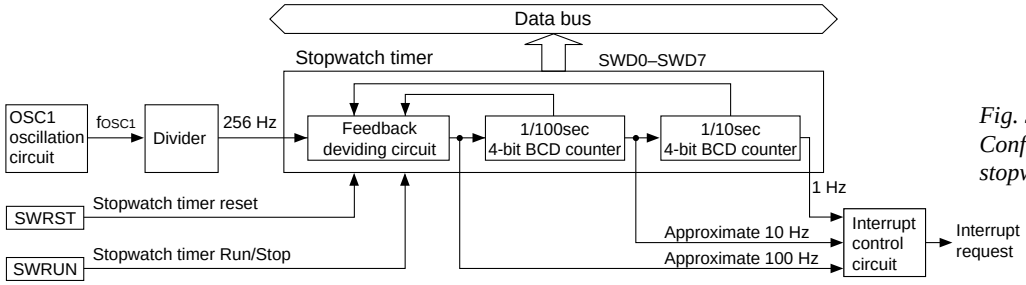


Fig. 5.9.1.1 Configuration of stopwatch timer

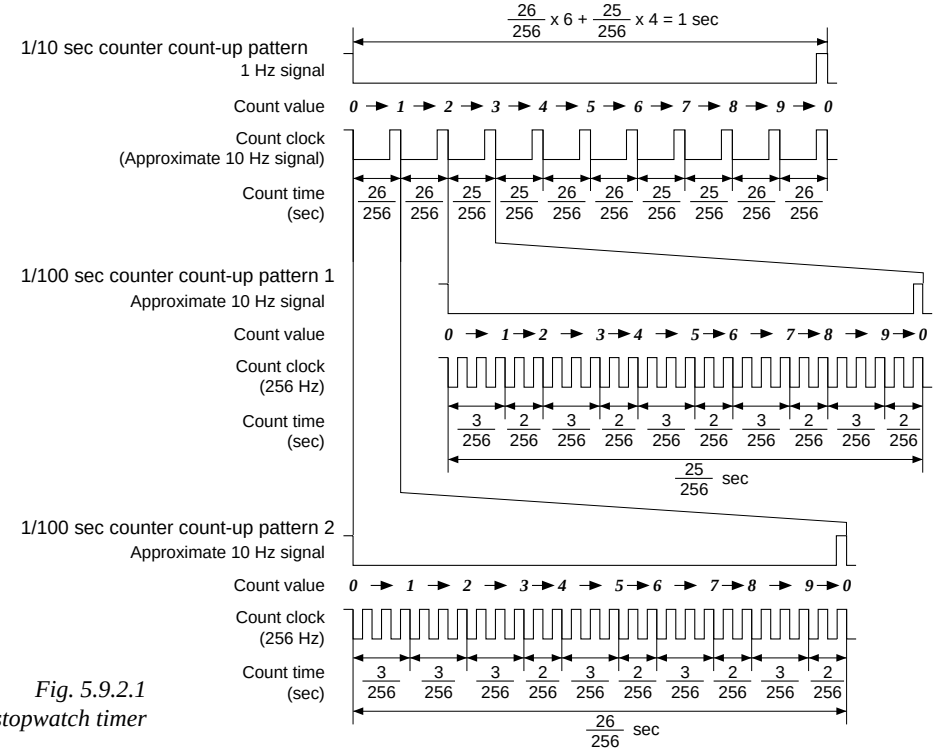


Fig. 5.9.2.1 Count-up pattern of stopwatch timer

5.9.3 Interrupt function

The stopwatch timer can generate an interrupt by each of the 100 Hz (approximately 100 Hz), 10 Hz (approximately 10 Hz) and 1 Hz signals.
Figure 5.9.3.1 shows the configuration of the stopwatch timer interrupt circuit

The corresponding factor flags FSW100, FSW10 and FSW1 are respectively set to "1" at the falling edge of the 100 Hz, 10Hz and 1Hz signal and an interrupt is generated. Interrupt can be prohibited by the setting of the interrupt enable registers ESW100, ESW10 and ESW1 corresponding to each interrupt factor flag.

In addition, a priority level of the stopwatch timer interrupt for the CPU can be optionally set at levels 0 to 3 by the interrupt priority registers PSW0 and PSW1.
For details on the above mentioned interrupt control registers and the operation following generation of an interrupt, see "5.14 Interrupt and Standby Status".
The exception processing vector addresses of each interrupt factor are respectively set as shown below.

100 Hz interrupt:	000016H
10 Hz interrupt:	000018H
1 Hz interrupt:	00001AH

Figure 5.9.3.2 shows the timing chart for the stopwatch timer.

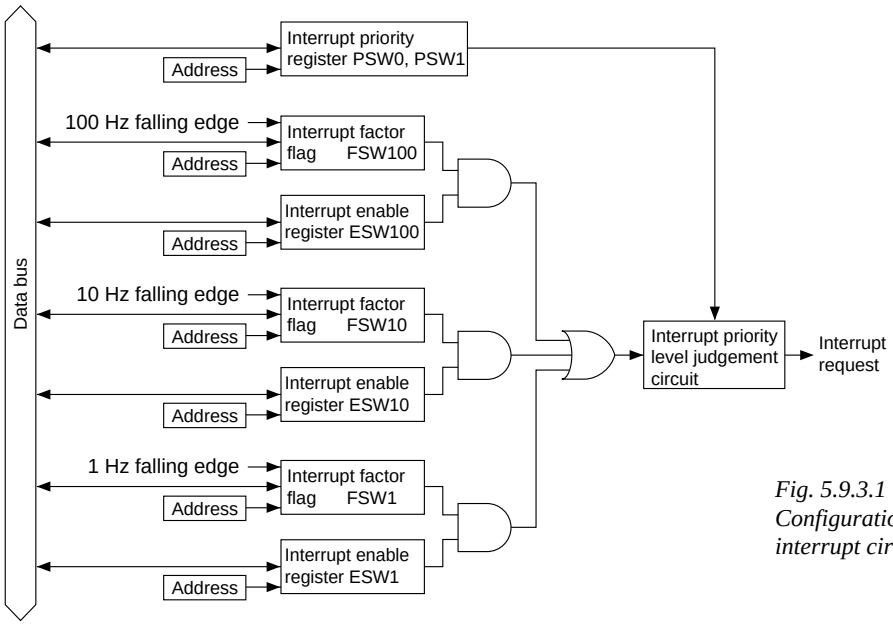


Fig. 5.9.3.1
Configuration of the stopwatch timer interrupt circuit

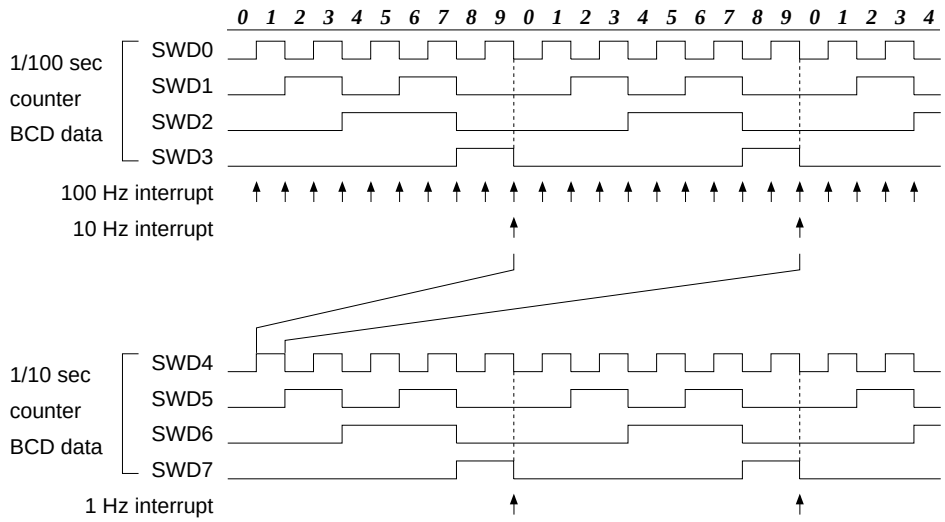


Fig. 5.9.3.2
Stopwatch timer timing chart

5.9.4 Control of stopwatch timer

Table 5.9.4.1 shows the stopwatch timer control bits.

Table 5.9.4.1 Stopwatch timer control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF42	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	–	–	–	–	–		
	D2	–	–	–	–	–		
	D1	SWRST	Stopwatch timer reset	Reset	No operation	–	W	
	D0	SWRUN	Stopwatch timer Run/Stop control	Run	Stop	0	R/W	
00FF43	D7	SWD7	Stopwatch timer data			0	R	
	D6	SWD6				0	R	
	D5	SWD5	BCD (1/10 sec)			0	R	
	D4	SWD4				0	R	
	D3	SWD3	Stopwatch timer data			0	R	
	D2	SWD2				0	R	
	D1	SWD1	BCD (1/100 sec)			0	R	
	D0	SWD0				0	R	
00FF20	D7	PK01	K00–K07 interrupt priority register	PK01 PK00 / PSIF1 PSIF0 / PSW1 PSW0 / PTM1 PTM0 / Priority level: 1 1 Level 3; 1 0 Level 2; 0 1 Level 1; 0 0 Level 0		0	R/W	
	D6	PK00				0	R/W	
	D5	PSIF1	Serial interface interrupt priority register			0	R/W	
	D4	PSIF0				0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register			0	R/W	
	D2	PSW0				0	R/W	
	D1	PTM1	Clock timer interrupt priority register			0	R/W	
	D0	PTM0				0	R/W	
00FF22	D7	–	–	–	–	–		"0" when being read
	D6	ESW100	Stopwatch timer 100 Hz interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D5	ESW10	Stopwatch timer 10 Hz interrupt enable register			0	R/W	
	D4	ESW1	Stopwatch timer 1 Hz interrupt enable register			0	R/W	
	D3	ETM32	Clock timer 32 Hz interrupt enable register			0	R/W	
	D2	ETM8	Clock timer 8 Hz interrupt enable register			0	R/W	
	D1	ETM2	Clock timer 2 Hz interrupt enable register			0	R/W	
	D0	ETM1	Clock timer 1 Hz interrupt enable register			0	R/W	
00FF24	D7	–	–	–	–	–		"0" when being read
	D6	FSW100	Stopwatch timer 100 Hz interrupt factor flag	(R) Interrupt factor is generated / (W) Reset	(R) No interrupt factor is generated / (W) No operation	0	R/W	
	D5	FSW10	Stopwatch timer 10 Hz interrupt factor flag			0	R/W	
	D4	FSW1	Stopwatch timer 1 Hz interrupt factor flag			0	R/W	
	D3	FTM32	Clock timer 32 Hz interrupt factor flag			0	R/W	
	D2	FTM8	Clock timer 8 Hz interrupt factor flag			0	R/W	
	D1	FTM2	Clock timer 2 Hz interrupt factor flag			0	R/W	
	D0	FTM1	Clock timer 1 Hz interrupt factor flag			0	R/W	

SWD0–SWD7: 00FF43H

The stopwatch timer data can be read out.
Higher and lower nibbles and BCD digit correspondence are as follows:

SWD0–SWD3: BCD (1/100sec)
SWD4–SWD7: BCD (1/10sec)

Since SWD0–SWD7 are exclusively for reading, the write operation is invalid.
At initial reset, the timer data is set to "00H".

SWRST: 00FF42H•D1

Resets the stopwatch timer.

When "1" is written: Stopwatch timer reset
When "0" is written: No operation
Reading: Always "0"

The stopwatch timer is reset by writing "1" to the SWRST. When the stopwatch timer is reset in the RUN status, it restarts immediately after resetting. In the case of the STOP status, the reset data "00H" is maintained.
No operation results when "0" is written to the SWRST.
Since the SWRST is exclusively for writing, it always becomes "0" during reading.

SWRUN: 00FF42H•D0

Controls RUN/STOP of the stopwatch timer.

When "1" is written: RUN
When "0" is written: STOP
Reading: Valid

The stopwatch timer starts up-counting by writing "1" to the SWRUN and stops by writing "0".
In the STOP status, the timer data is maintained until it is reset or set in the next RUN status. Also, when the STOP status changes to the RUN status, the data that was maintained can be used for resuming the count.
At initial reset, the SWRUN is set at "0" (STOP).

PSW0, PSW1: 00FF20H•D2, D3

Sets the priority level of the stopwatch timer interrupt.
The two bits PSW0 and PSW1 are the interrupt priority register corresponding to the stopwatch timer interrupt. Table 5.9.4.2 shows the interrupt priority level which can be set by this register.

Table 5.9.4.2 Interrupt priority level settings

PSW1	PSW0	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (None)

At initial reset, this register is set to "0" (level 0).

ESW1, ESW10, ESW100: 00FF22H•D4, D5, D6

Enables or disables the generation of an interrupt for the CPU.

When "1" is written: Interrupt enabled
When "0" is written: Interrupt disabled
Reading: Valid

The ESW1, ESW10 and ESW100 are interrupt enable registers that respectively correspond to the interrupt factors for 1 Hz, 10 Hz and 100 Hz. Interrupts set to "1" are enabled and interrupts set to "0" are disabled.
At initial reset, this register is set to "0" (interrupt disabled).

FSW1, FSW10, FSW100: 00FF24H•D4, D5, D6

Indicates the stopwatch timer interrupt generation status.

When "1" is read: Interrupt factor present
When "0" is read: Interrupt factor not present

When "1" is written: Resets factor flag
When "0" is written: Invalid

The FSW1, FSW10 and FSW100 are interrupt factor flags that respectively correspond to the interrupts for 1 Hz, 10 Hz and 100 Hz and are set to "1" in synchronization with the falling edge of each signal. When set in this manner, if the corresponding interrupt enable register is set to "1" and the corresponding interrupt priority register is set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU. Regardless of the interrupt enable register and interrupt priority register settings, the interrupt factor flag will be set to "1" by the occurrence of an interrupt generation condition.
To accept the subsequent interrupt after interrupt generation, re-setting of the interrupt flags (set interrupt flag to lower level than the level indicated by the interrupt priority registers, or execute the RETE instruction) and interrupt factor flag reset are necessary. The interrupt factor flag is reset to "0" by writing "1".
At initial reset, this flag is reset to "0".

5.9.5 Programming notes

(1) The stopwatch timer is actually made to RUN/STOP in synchronization with the falling edge of the 256 Hz signal after writing to the SWRUN register. Consequently, when "0" is written to the SWRUN, the timer shifts to STOP status when the counter is incremented "1". The SWRUN maintains "1" for reading until the timer actually shifts to STOP status.
Figure 5.9.5.1 shows the timing chart of the RUN/STOP control.

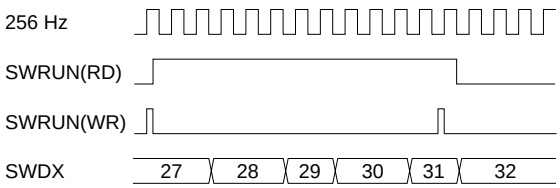


Fig. 5.9.5.1 Timing chart of RUN/STOP control

(2) The SLP instruction is executed when the stopwatch timer is in the RUN status (SWRUN = "1"). The stopwatch timer operation will become unstable when returning from SLEEP status. Therefore, when shifting to SLEEP status, set the clock timer to STOP status (SWRUN = "0") prior to executing the SLP instruction.

5.10 Programmable Timer

5.10.1 Configuration of programmable timer

The E0C88832/88862 has two built-in 8-bit programmable timer systems (timer 0 and timer 1). Timer 0 and timer 1 are composed of 8-bit presettable down counters and they can be used as 8-bit × 2 channels or 16-bit × 1 channel programmable timer. They also have an event counter function and a pulse width measurement function using the K10 input port terminal.
Figure 5.10.1.1 shows the configuration of the programmable timer.

Programmable setting of the transfer rate is possible, due to the fact that the programmable timer underflow signal can be used as a synchronous clock for the serial interface.
Furthermore, this halved underflow signal (TOUT) can also be output externally from the R27 output port terminal. Furthermore, the R26 output port terminal can be used to output the $\overline{\text{TOUT}}$ signal (TOUT inverted signal) by mask option.

5.10.2 Count operation and setting basic mode

Here we will explain the basic operation and setting of the programmable timer.

■ Setting of initial value and counting down

The timers 0 and 1 each have a down counter and reload data register.

The reload data registers RLD00–RLD07 (timer 0) and RLD10–RLD17 (timer 1) are registers that set the initial value of the counter.
By writing "1" to the preset control bit PSET0 (timer 0) or PSET1 (timer 1), the down counter loads the initial value set in the reload register RLD.
Therefore, down-counting is executed from the stored initial value according to the input clock.

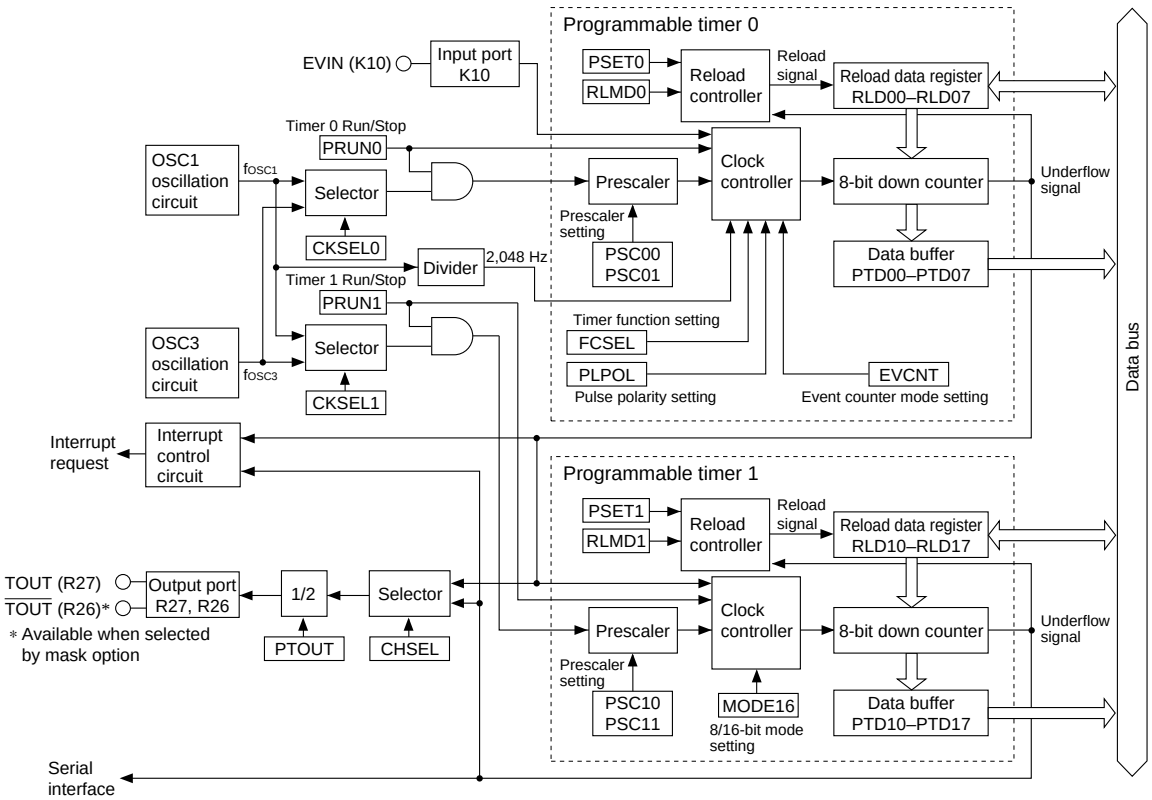


Fig. 5.10.1.1 Configuration of programmable timer

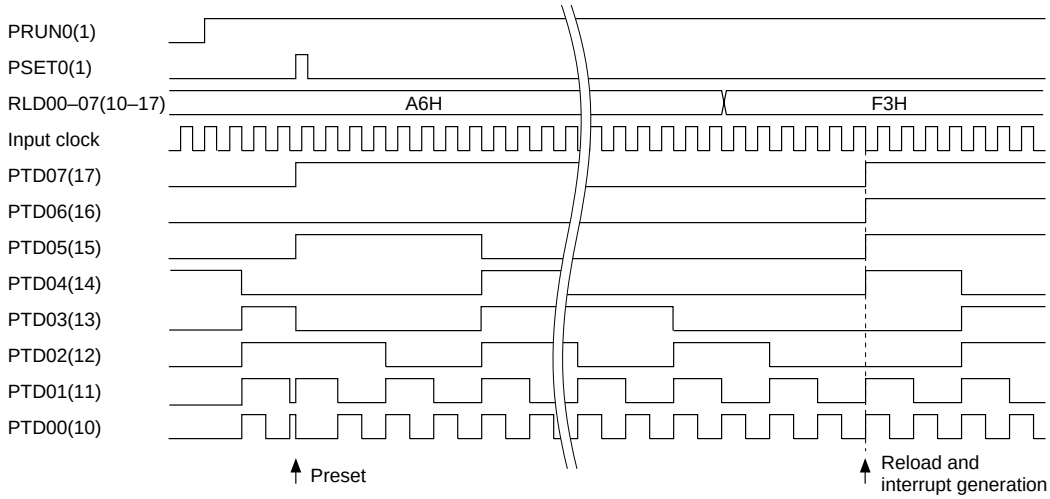


Fig. 5.10.2.1 Basic operation timing of the counter

The registers PRUN0 (timer 0) and PRUN1 (timer 1) are provided to control the RUN/STOP for timers 0 and 1.
After the reload data has been preset into the counter, down-counting is begun by writing "1" to this register. When "0" is written, the clock input is prohibited and the count stops.
The control of this RUN/STOP has no affect on the counter data. The counter data is maintained even during the stoppage of the counter and it can start the count, continuing from that data.

The reading of the counter data can be done through the data buffers PTD00–PTD07 (timer 0) and PTD10–PTD17 (timer 1) with optional timing.
When the down-counting has progressed and an underflow is generated, the counter reloads the initial value set in the reload data register.
This underflow signal controls an interrupt generation, pulse (TOUT signal) output and serial interface clocking, in addition to reloading the counter.

■ Continuous/one-shot mode setting

By writing "1" to the continuous/one-shot mode selection registers CONT0 (timer 0) and CONT1 (timer 1), the programmable timer is set to the continuous mode. In the continuous mode, the initial counter value is automatically loaded when an underflow is generated, and counting is continued. This mode is suitable when programmable intervals are necessary (such as an interrupt and a synchronous clock for the serial interface).
On the other hand, when writing "0" to the registers CONT0 (timer 0) and CONT1 (timer 1), the programmable timer is set to the one-shot mode. The counter loads an initial value and stops when an underflow is generated. At this time, the RUN/STOP control register PRUN0 (timer 0) and PRUN1 (timer 1) are automatically reset to "0". After the counter stops, a one-shot count can be performed once again by writing "1" to registers PRUN0 (timer 0) and PRUN1 (timer 1). This mode is suitable for single time measurement, for example.

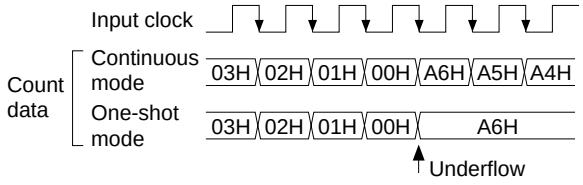


Fig. 5.10.2.2 Continuous mode and one-shot mode

■ 8/16-bit mode setting

By writing "0" to the 8/16-bit mode selection register MODE16, timer 0 and timer 1 are set as independent timers in 8-bit × 2 channels. In this mode, timer 0 and timer 1 can be controlled individually and each of them operates independently.
On the other hand, when writing "1" to the register MODE16, timer 0 and timer1 are set as 1 channel 16-bit timer. This is done by setting timer 0 to the lower 8 bits, and timer 1 to the upper 8 bits. The timer is controlled by timer 0's registers. In this case, the control registers for timer 1 are invalid. (PRUN1 is fixed at "0".)

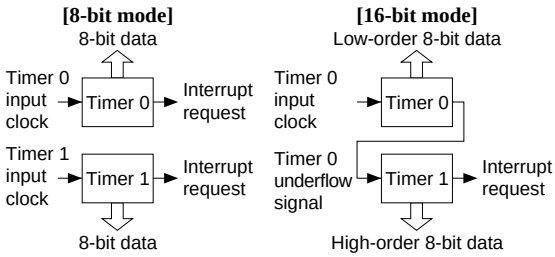


Fig. 5.10.2.3 8/16-bit mode setting and counter configuration

5.10.3 Setting of input clock

Prescalers have been provided for timers 0 and 1. The prescalers generate the input clock for each by dividing the source clock signal from the OSC1 or OSC3 oscillation circuit.
The source clock and the dividing ratio of the prescaler can be selected individually for timer 0 and timer 1 in software.

The input clocks are set by the below sequence.

(1) Selection of source clock

Select the source clock (OSC1 or OSC3) for each prescaler. This is done with the source clock selection registers CKSEL0 (timer 0) and CKSEL1 (timer 1): when "0" is written, OSC1 is selected and when "1" is written, OSC3 is selected. When the 16-bit mode is selected, the source clock is selected by register CKSEL0, and the register CKSEL1 setting becomes invalid.
When the OSC3 oscillation circuit is made the clock source, it is necessary to turn the OSC3 oscillation ON, prior to using the programmable timer.
From the time the OSC3 oscillation circuit is turning ON until oscillation stabilizes, an interval of several 100 μsec to several 10 msec is necessary. Consequently, you should allow an adequate waiting time after turning the OSC3 oscillation circuit ON before starting the count of the programmable timer. (The oscillation start time will vary somewhat depending on the oscillator and on external parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, OSC3 oscillation circuit is set to OFF status.

(2) Selection of prescaler dividing ratio

Select the dividing ratio of each prescaler from among 4 types. This selection is done by the prescaler dividing ratio selection registers PSC00/PSC01 (timer 0) and PSC10/PSC11 (timer 1). Setting value and dividing ratio correspondence are shown in Table 5.10.3.1.

Table 5.10.3.1 Selection of prescaler dividing ratio

PSC11 PSC01	PSC10 PSC00	Prescaler dividing ratio
1	1	Source clock / 64
1	0	Source clock / 16
0	1	Source clock / 4
0	0	Source clock / 1

By writing "1" to the register PRUN0 (timer 0) and PRUN1 (timer 1), the source clock is input to the prescaler. Therefore, the clock with selected dividing ratio is input to the timer and the timer starts counting down.
When the 16-bit mode has been selected, the dividing ratio for the source clock is selected by register PSC00/PSC01 and the setting of register PSC10/PSC11 becomes invalid.

5.10.4 Timer mode

The timer mode counts down using the prescaler output as an input clock. In this mode, the programmable timer operates as a timer that obtains fixed cycles using the OSC1 or OSC3 oscillation circuit as a clock source.
See "5.10.2 Count operation and basic mode setting" for basic operation and control, and "5.10.3 Setting input clock" for the clock source and setting of the prescaler.

5.10.5 Event counter mode

Timer 0 includes an even counter function that counts by inputting an external clock (EVIN) to input port K10. This function is selected by writing "1" to the timer 0 counter mode selection register EVCNT.
When the event counter mode is selected, timer 0 operates as an event counter and timer 1 operates as a normal timer in 8-bit mode. In the 16-bit mode, timer 0 and timer 1 operate as 1 channel 16-bit event counter. In the event counter mode, since the timer 0 is clocked externally, the settings of registers PSC00/PSC01 become invalid.
Count down timing can be controlled by either the falling edge or rising edge selected by the timer 0 pulse polarity selection register PLPOL. When "0" is written to the register PLPOL, the falling edge is selected, and when "1" is written, the rising edge is selected. The timing is shown in Figure 5.10.5.1.

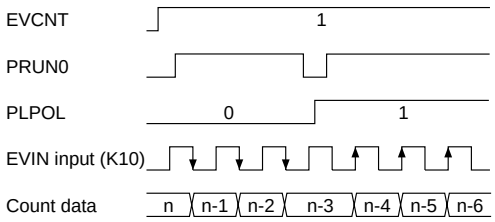


Fig. 5.10.5.1 Timing chart for event counter mode

The event counter also includes a noise rejecter to eliminate noise such as chattering for the external clock (EVIN). This function is selected by writing "1" to the timer 0 function selection register FCSEL.
For a reliable count when "with noise rejecter" is selected, you must allow 0.98 msec or more pulse width for both LOW and HIGH levels. (The noise rejecter allows clocking counter at the second falling edge of the internal 2,048 Hz signal after changing the input level of the K10 input port terminal. Consequently, the pulse width that can reliably be rejected is 0.48 msec.)
Figure 5.10.5.2 shows the count down timing with the noise rejecter selected.

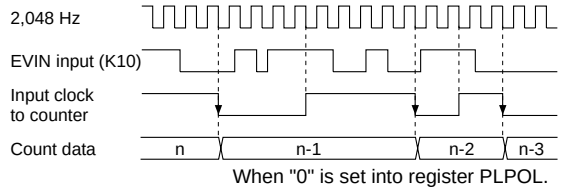


Fig. 5.10.5.2 Count down timing with noise rejecter

The event counter mode is the same as the timer mode except that the clock is external (EVIN).
See "5.10.2 Count operation and setting basic mode" for the basic operation and control.

5.10.6 Pulse width measurement timer mode

Timer 0 includes a pulse width measurement function that measures the width of the input signal to the K10 input port terminal. This function is selected by writing "1" to the timer function selection register FCSEL when in the timer mode (EVCNT = "0").
When the pulse width measurement mode is selected, timer 0 operates as an pulse width measurement and timer 1 operates as a normal timer in 8-bit mode. In the 16-bit mode, timer 0 and timer 1 operate as 1 channel 16-bit pulse width measurement.
The level of the input signal (EVIN) for measurement can be changed either a LOW or HIGH level by the timer 0 pulse polarity selection register PLPOL. When "0" is written to register PLPOL, a LOW level width is measured and when "1" is written, a HIGH level width is measured. The timing is shown in Figure 5.10.6.1.

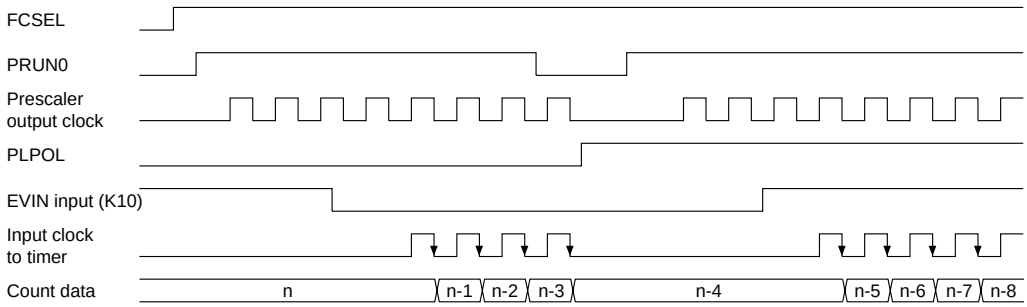


Fig. 5.10.6.1 Timing chart for pulse width measurement timer mode

The pulse width measurement timer mode is the same as the timer mode except that the input clock is controlled by the level of the signal (EVIN) input to the K10 input port terminal.
See "5.10.2 Count operation and setting basic mode" for the basic operation and control.

5.10.7 Interrupt function

The programmable timer can generate an interrupt due to an underflow signal of timer 0 and timer 1. Figure 5.10.7.1 shows the configuration of the programmable timer interrupt circuit.

The respectively corresponding interrupt factor flags FPT0 and FPT1 are set to "1" and an interrupt is generated by an underflow signal of timers 1 and 0. Interrupt can also be prohibited by the setting of the interrupt enable registers EPT0 and EPT1 corresponding to each interrupt flag.

In addition, a priority level of the programmable timer interrupt for the CPU can be optionally set at levels 0 to 3 by the interrupt priority registers PPT0 and PPT1.
For details on the above mentioned interrupt control registers and the operation following generation of an interrupt, see "5.14 Interrupt and Standby Status".

The exception processing vector addresses of each interrupt factor are respectively set as shown below.

Programmable timer 1 interrupt:	000006H
Programmable timer 0 interrupt:	000008H

When the 16-bit mode is selected, the interrupt factor flag FPT0 is not set to "1" and a timer 0 interrupt cannot be generated. (In the 16-bit mode, the interrupt factor flag FPT1 is set to "1" by an underflow of the 16-bit counter.

5.10.8 Setting of TOUT output

The programmable timer can generate the TOUT signal due to an underflow of timer 0 or timer 1. The TOUT signal is generated from the above mentioned underflow signal by halving the frequency. The timer underflow which is to be used can be selected by the TOUT output channel selection register CHSEL. When writing "0" to register CHSEL, timer 0 is selected and when "1" is written, timer 1 is selected. However, in the 16-bit mode, it is fixed in timer 1 (underflow of the 16-bit timer) and the setting of register CHSEL becomes invalid.
Figure 5.10.8.1 shows the TOUT signal waveform when channel switching.

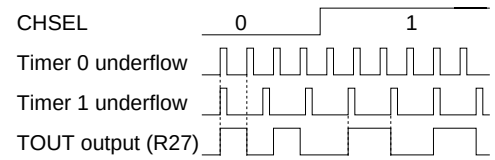


Fig. 5.10.8.1 TOUT signal waveform at channel change

The TOUT signal can be output from the R27 output port terminal, and the programmable clock can be supplied to an external device.
Furthermore, the R26 output port terminal can be used to output the $\overline{\text{TOUT}}$ signal (TOUT inverted signal) by mask option.
The configuration of the output ports R27 and R26 is shown in Figure 5.10.8.2.

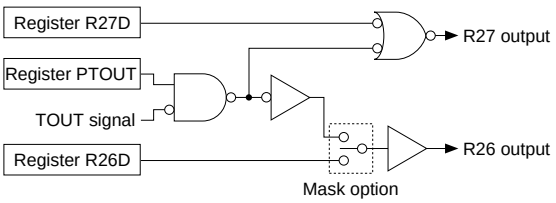


Fig. 5.10.8.2 Configuration of R27 and R26

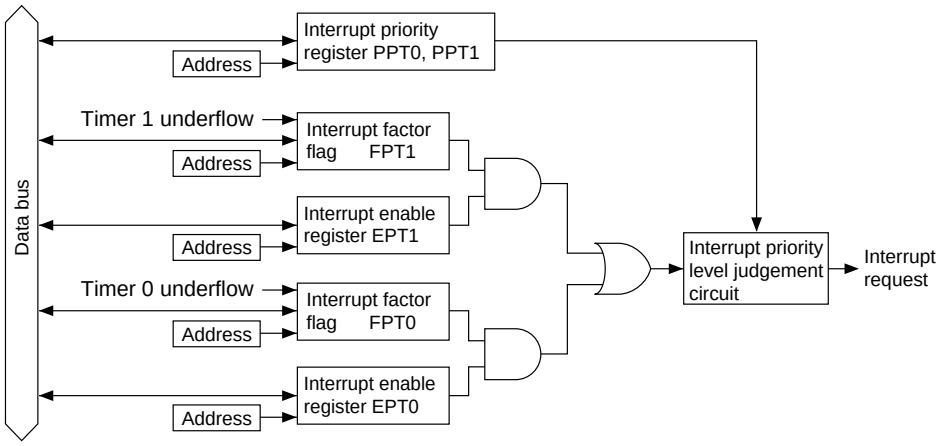


Fig. 5.10.7.1 Configuration of programmable timer interrupt circuit

The output control for the TOUT ($\overline{TOUT}$) signal is done by the register PTOUT. When you set "1" for the PTOUT, the TOUT ($\overline{TOUT}$) signal is output from the R27 (R26) output port terminal. When "0" is set, the R27 goes HIGH (V_{DD}) and the R26 goes LOW (V_{SS}).
To output the TOUT signal, "1" must always be set for the data register R27D. The data register R26D does not affect the $\overline{TOUT}$ output.

Since the TOUT signal is generated asynchronously from the register PTOUT, when the signal is turned ON or OFF by the register setting, a hazard of a 1/2 cycle or less is generated.
Figure 5.10.8.3 shows the output waveform of TOUT signal.

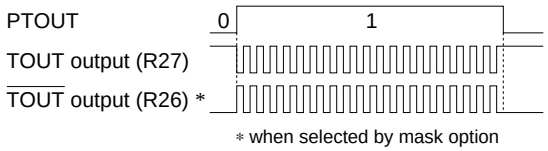


Fig. 5.10.8.3 TOUT output waveform

5.10.9 Transmission rate setting of serial interface

The underflow signal of the timer 1 can be used to clock the serial interface.
The transmission rate setting in this case is made in registers PSC1X and PLD1X, and is used to set the count mode to the reload count mode (RLMD1 = "1").
Since the underflow signal of the timer 1 is divided by 1/32 in the serial interface, the value set in register RLD1X which corresponds to the transmission rate is shown in the following expression:

$$\mathbf{RLD1X = fosc / (32*bps*4^{PSC1X}) - 1}$$

fosc: Oscillation frequency (OSC1/OSC3)
bps: Transmission rate
PSC1X: Setting value to the register PSC1X (0–3)

(00H can be set to RLD1X)

Table 5.10.9.1 shows an example of the transmission rate setting when the OSC3 oscillation circuit is used as a clock source.

Table 5.10.9.1 Example of transmission rate setting

Transfer rate (bps)	OSC3 oscillation frequency / Programmable timer settings					
	f_{OSC3} = 3.072 MHz		f_{OSC3} = 4.608 MHz		f_{OSC3} = 4.9152 MHz	
	PSC1X	RLD1X	PSC1X	RLD1X	PSC1X	RLD1X
9,600	0 (1/1)	09H	0 (1/1)	0EH	0 (1/1)	0FH
4,800	0 (1/1)	13H	0 (1/1)	1DH	0 (1/1)	1FH
2,400	0 (1/1)	27H	0 (1/1)	3BH	0 (1/1)	3FH
1,200	0 (1/1)	4FH	0 (1/1)	77H	0 (1/1)	7FH
600	0 (1/1)	9FH	0 (1/1)	EFH	0 (1/1)	FFH
300	1 (1/4)	4FH	1 (1/4)	77H	1 (1/4)	7FH
150	1 (1/4)	9FH	1 (1/4)	EFH	1 (1/4)	FFH

5.10.10 Control of programmable timer

Table 5.10.10.1 shows the programmable timer control bits.

Table 5.10.10.1(a) Programmable timer control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF30	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	MODE16	8/16-bit mode selection	16-bit x 1	8-bit x 2	0	R/W	
	D3	CHSEL	TOUT output channel selection	Timer 1	Timer 0	0	R/W	
	D2	PTOUT	TOUT output control	On	Off	0	R/W	
	D1	CKSEL1	Prescaler 1 source clock selection	f_{OSC3}	f_{OSC1}	0	R/W	
	D0	CKSEL0	Prescaler 0 source clock selection	f_{OSC3}	f_{OSC1}	0	R/W	
00FF31	D7	EVCNT	Timer 0 counter mode selection	Event counter	Timer	0	R/W	
	D6	FCSEL	Timer 0 function selection: In timer mode	Pulse width measurement	Normal mode	0	R/W	
			Timer 0 function selection: In event counter mode	With noise rejector	Without noise rejector			
	D5	PLPOL	Timer 0 pulse polarity selection: Down count timing in event counter mode	Rising edge of K10 input	Falling edge of K10 input	0	R/W	
			Timer 0 pulse polarity selection: In pulse width measurement mode	High level measurement for K10 input	Low level measurement for K10 input			
	D4	PSC01	Timer 0 prescaler dividing ratio selection			0	R/W	
	D3	PSC00	PSC01 PSC00 Prescaler dividing ratio 1 1 Source clock / 64 1 0 Source clock / 16 0 1 Source clock / 4 0 0 Source clock / 1			0	R/W	
	D2	CONT0	Timer 0 continuous/one-shot mode selection	Continuous	One-shot	0	R/W	
	D1	PSET0	Timer 0 preset	Preset	No operation	–	W	"0" when being read
	D0	PRUN0	Timer 0 Run/Stop control	Run	Stop	0	R/W	
00FF32	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	PSC11	Timer 1 prescaler dividing ratio selection			0	R/W	
	D3	PSC10	PSC11 PSC10 Prescaler dividing ratio 1 1 Source clock / 64 1 0 Source clock / 16 0 1 Source clock / 4 0 0 Source clock / 1			0	R/W	
	D2	CONT1	Timer 1 continuous/one-shot mode selection	Continuous	One-shot	0	R/W	
	D1	PSET1	Timer 1 preset	Preset	No operation	–	W	"0" when being read
	D0	PRUN1	Timer 1 Run/Stop control	Run	Stop	0	R/W	
00FF33	D7	RLD07	Timer 0 reload data D7 (MSB)	High	Low	1	R/W	
	D6	RLD06	Timer 0 reload data D6			1	R/W	
	D5	RLD05	Timer 0 reload data D5			1	R/W	
	D4	RLD04	Timer 0 reload data D4			1	R/W	
	D3	RLD03	Timer 0 reload data D3			1	R/W	
	D2	RLD02	Timer 0 reload data D2			1	R/W	
	D1	RLD01	Timer 0 reload data D1			1	R/W	
	D0	RLD00	Timer 0 reload data D0 (LSB)			1	R/W	

Table 5.10.10.1(b) Programmable timer control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF34	D7	RLD17	Timer 1 reload data D7 (MSB)	High	Low	1	R/W	
	D6	RLD16	Timer 1 reload data D6			1	R/W	
	D5	RLD15	Timer 1 reload data D5			1	R/W	
	D4	RLD14	Timer 1 reload data D4			1	R/W	
	D3	RLD13	Timer 1 reload data D3			1	R/W	
	D2	RLD12	Timer 1 reload data D2			1	R/W	
	D1	RLD11	Timer 1 reload data D1			1	R/W	
	D0	RLD10	Timer 1 reload data D0 (LSB)			1	R/W	
00FF35	D7	PTD07	Timer 0 counter data D7 (MSB)	High	Low	1	R	
	D6	PTD06	Timer 0 counter data D6			1	R	
	D5	PTD05	Timer 0 counter data D5			1	R	
	D4	PTD04	Timer 0 counter data D4			1	R	
	D3	PTD03	Timer 0 counter data D3			1	R	
	D2	PTD02	Timer 0 counter data D2			1	R	
	D1	PTD01	Timer 0 counter data D1			1	R	
	D0	PTD00	Timer 0 counter data D0 (LSB)			1	R	
00FF36	D7	PTD17	Timer 1 counter data D7 (MSB)	High	Low	1	R	
	D6	PTD16	Timer 1 counter data D6			1	R	
	D5	PTD15	Timer 1 counter data D5			1	R	
	D4	PTD14	Timer 1 counter data D4			1	R	
	D3	PTD13	Timer 1 counter data D3			1	R	
	D2	PTD12	Timer 1 counter data D2			1	R	
	D1	PTD11	Timer 1 counter data D1			1	R	
	D0	PTD10	Timer 1 counter data D0 (LSB)			1	R	
00FF21	D7	–	–	–	–	–		Constantly "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	PPT1	Programmable timer interrupt priority register	PPT1 PK11 / PPT0 PK10 / Priority level: 1 1 Level 3; 1 0 Level 2; 0 1 Level 1; 0 0 Level 0		0	R/W	
	D2	PPT0				0	R/W	
	D1	PK11	K10 interrupt priority register			0	R/W	
	D0	PK10				0	R/W	
00FF23	D7	EPT1	Programmable timer 1 interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D6	EPT0	Programmable timer 0 interrupt enable register			0	R/W	
	D5	EK1	K10 interrupt enable register			0	R/W	
	D4	EK0H	K04–K07 interrupt enable register			0	R/W	
	D3	EK0L	K00–K03 interrupt enable register			0	R/W	
	D2	ESERR	Serial I/F (error) interrupt enable register			0	R/W	
	D1	ESREC	Serial I/F (receiving) interrupt enable register			0	R/W	
	D0	ESTRA	Serial I/F (transmitting) interrupt enable register			0	R/W	
00FF25	D7	FPT1	Programmable timer 1 interrupt factor flag	(R) Interrupt factor is generated / (W) Reset	(R) No interrupt factor is generated / (W) No operation	0	R/W	
	D6	FPT0	Programmable timer 0 interrupt factor flag			0	R/W	
	D5	FK1	K10 interrupt factor flag			0	R/W	
	D4	FK0H	K04–K07 interrupt factor flag			0	R/W	
	D3	FK0L	K00–K03 interrupt factor flag			0	R/W	
	D2	FSERR	Serial I/F (error) interrupt factor flag			0	R/W	
	D1	FSREC	Serial I/F (receiving) interrupt factor flag			0	R/W	
	D0	FSTRA	Serial I/F (transmitting) interrupt factor flag			0	R/W	

MODE16: 00FF30H•D4

Selects the 8/16-bit mode.

When "1" is written: 16 bits × 1 channel
When "0" is written: 8 bits × 2 channels
Reading: Valid

Select whether timer 0 and timer 1 will be used as 2 channel independent 8-bit timers or as a 1 channel combined 16-bit timer. When "0" is written to MODE16, 8-bit × 2 channels is selected and when "1" is written, 16-bit × 1 channel is selected.
At initial reset, MODE16 is set to "0" (8-bit × 2 channels).

CKSEL0, CKSEL1: 00FF30H•D0, D1

Select the source clock of the prescaler.

When "1" is written: OSC3 clock
When "0" is written: OSC1 clock
Reading: Valid

Select whether the source clock of prescaler 0 will be set to OSC1 or OSC3. When "0" is written to CKSEL0, OSC1 is selected and when "1" is written, OSC3 is selected.
In the same way, the source clock of prescaler 1 is selected by CKSEL1.
When event counter mode has been selected, the setting of the CKSEL0 becomes invalid. In the same way, the CKSEL1 setting becomes invalid when 16-bit mode has been selected.
At initial reset, this register is set to "0" (OSC1 clock).

PSC00, PSC01: 00FF31H•D3, D4
PSC10, PSC11: 00FF32H•D3, D4

Select the dividing ratio of the prescaler.
Two-bit PSC00 and PSC01 is the prescaler dividing ratio selection registers for timer 0, and the two-bit PSC10 and PSC11 correspond to timer 1. The prescaler dividing ratios that can be set by these registers are shown in Table 5.10.10.2.

Table 5.10.10.2 Selection of prescaler dividing ratio

PSC11 PSC01	PSC10 PSC00	Prescaler dividing ratio
1	1	Input clock / 64
1	0	Input clock / 16
0	1	Input clock / 4
0	0	Input clock / 1

When event counter mode has been selected, the setting of the PSC00 and PSC01 becomes invalid. In the same way, the PSC10 and PSC11 setting becomes invalid when 16-bit mode has been selected.
At initial reset, this register is set to "0" (input clock/1).

EVCNT: 00FF31H•D7

Selects the counter mode for the timer 0.

When "1" is written: Event counter mode
When "0" is written: Timer mode
Reading: Valid

Select whether timer 0 will be used as an event counter or a timer. When "1" is written to EVCNT, the event counter mode is selected and when "0" is written, the timer mode is selected.
At initial reset, EVCNT is set to "0" (timer mode).

FCSEL: 00FF31H•D6

Selects the function for each counter mode of timer 0.

• In timer mode

When "1" is written: Pulse width measurement timer mode
When "0" is written: Normal mode
Reading: Valid

In the timer mode, select whether timer 0 will be used as a pulse width measurement timer or a normal timer. When "1" is written to FCSEL, the pulse width measurement mode is selected and the counting is done according to the level of the signal (EVIN) input to the K10 input port terminal. When "0" is written to FCSEL, the normal mode is selected and the counting is not affected by the K10 input port terminal.

• In event counter mode

When "1" is written: With noise rejecter
When "0" is written: Without noise rejecter
Reading: Valid

In the event counter mode, select whether the noise rejecter for the K10 input port terminal will be selected or not.
When "1" is written to FCSEL, the noise rejecter is selected and counting is done by an external clock (EVIN) with 0.98 msec or more pulse width. (The noise rejecter allows clocking counter at the second falling edge of the internal 2,048 Hz signal after changing the input level of the K10 input port terminal. Consequently, the pulse width that can reliably be rejected is 0.48 msec.)
When "0" is written to FCSEL, the noise rejector is not selected and the counting is done directly by an external clock (EVIN) input to the K10 input port terminal.
At initial reset, FCSEL is set to "0".

PLPOL: 00FF31H•D5

Selects the pulse polarity for the K10 input port terminal.

• In event counter mode

When "1" is written: Rising edge
When "0" is written: Falling edge
Reading: Valid

In the event counter mode, select whether the count timing will be set at the falling edge of the external clock (EVIN) input to the K10 input port terminal or at the rising edge. When "0" is written to PLPOL, the falling edge is selected and when "1" is written, the rising edge is selected.

• In pulse width measurement mode

When "1" is written: High level pulse width measurement
When "0" is written: LOW level pulse width measurement
Reading: Valid

In the pulse width measurement mode, select whether the LOW level width of the signal (EVIN) input to the K10 input port terminal will be measured or the HIGH level will be measured. When "0" is written to PLPOL, the LOW level width measurement is selected and when "1" is written, the HIGH level width measurement is selected.
In the normal mode (EVCNT = FCSEL = "0"), the setting of PLPOL becomes invalid.
At initial reset, PLPOL is set to "0".

CONT0, CONT1: 00FF31H•D2, 00FF32H•D2

Select the continuous/one-shot mode.

When "1" is written: Continuous mode
When "0" is written: One-shot mode
Reading: Valid

Select whether timer 0 will be used in the continuous mode or in the one-shot mode.
By writing "1" to CONT0, the programmable timer is set to the continuous mode. In the continuous mode, the initial counter value is automatically loaded when an underflow is generated, and counting is continued. On the other hand, when writing "0" to CONT0, the programmable timer is set to the one-shot mode. The counter loads an initial value and stops when an underflow is generated. At this time, PRUN0 is automatically reset to "0".
In the same way, the continuous/one-shot mode for timer 1 is selected by CONT1. (In the one-shot mode for timer 1, PRUN1 is automatically reset to "0" when the counter underflow is generated.)
At initial reset, this register is set to "0" (one-shot mode).

RLD00–RLD07: 00FF33H
RLD10–RLD17: 00FF34H

Sets the initial value for the counter.

RLD00–RLD07: Reload data for Timer 0
RLD10–RLD17: Reload data for Timer 1

The reload data set in this register is loaded into the respective counters and is counted down with that as the initial value.
Reload data is loaded to the counter under two conditions, when "1" is written to PSET0 or PSET1 and when the counter underflow automatically loads.
At initial reset, this register is set to "FFH".

PTD00–PTD07: 00FF35H
PTD10–PTD17: 00FF36H

Data of the programmable timer can be read out.

PTD00–PTD07: Timer 0 counter data
PTD10–PTD17: Timer 1 counter data

These bits act as a buffer to maintain the counter data during readout, and the data can be read as optional timing. However, in the 16-bit mode, to avoid a read error, (data error when a borrow from timer 0 to timer 1 is generated in the middle of reading PTD00–PTD07 and PTD10–PTD17), PTD10–PTD17 latches the timer 1 counter data according to the reading of PTD00–PTD07.
The latched status of PTD10–PTD17 is canceled according to the readout of PTD10–PTD17 or when 0.73–1.22 msec (depends on the readout timing) has elapsed. Therefore, in 16-bit mode, be sure to read the counter data of PTD00–PTD07 and PTD10–PTD17 in order.
Since these bits are exclusively for reading, the write operation is invalid.
At initial reset, these bits are set to "FFH".

PSET0, PSET1: 00FF31H•D1, 00FF32H•D1

Presets the reload data to the counter.

When "1" is written: Preset
When "0" is written: No operation
Reading: Always "0"

By writing "1" to PSET0, the reload data in PLD00–PLD07 is preset to the counter of timer 0. When the counter of timer 0 is preset in the RUN status, it restarts immediately after presetting.
In the case of STOP status, the reload data that has been preset is maintained.
No operation results when "0" is written.
In the same way, the reload data in PLD10–PLD17 is preset to the counter of timer 1 by PSET1.
When the 16-bit mode is selected, writing "1" to PSET1 is invalid.
This bit is exclusively for writing, it always becomes "0" during reading.

PRUN0, PRUN1: 00FF31H•D0, 00FF32H•D0

Controls the RUN/STOP of the counter.

When "1" is written: RUN
When "0" is written: STOP
Reading: Valid

The counter of timer 0 starts down-counting by writing "1" to PRUN0 and stops by writing "0". In the STOP status, the counter data is maintained until it is preset or set in the next RUN status. Also, when the STOP status changes to the RUN status, the data that was maintained can be used for resuming the count.
In the same way, the RUN/STOP of the timer 1 counter is controlled by PRUN1.
When the 16-bit mode is selected, PRUN1 is fixed at "0".
At initial reset and when an underflow is generated in the one-shot mode, this register is set to "0" (STOP).

CHSEL: 00FF30H•D3

Selects a channel for generating the TOUT signal.

When "1" is written: Timer 0 underflow
When "0" is written: Timer 1 underflow
Reading: Valid

Select whether the timer 0 underflow will be used for the TOUT signal or the timer 1 underflow will be used. When "0" is written to CHSEL, timer 0 is selected and when "1" is written, timer 1 is selected.When the 16-bit mode has been selected, it is fixed to timer 1 (underflow of the 16-bit timer), and setting of CHSEL becomes invalid.
At initial reset, CHSEL is set to "0" (timer 1 underflow).

PTOUT: 00FF30H•D2

Controls the TOUT (programmable timer output clock) signal output.

When "1" is written: TOUT signal output ON
When "0" is written: TOUT signal output OFF
Reading: Valid

PTOUT is the output control register for TOUT ($\overline{TOUT}$) signal. When "1" is set to the register, the TOUT signal is output from the output port terminal R27 (R26). When "0" is set, the R27 goes HIGH (V_{DD}) and the R26 goes LOW (V_{SS}).
To output the TOUT signal, "1" must always be set for the data register R27D. The data register R26D does not affect the $\overline{TOUT}$ output.
At initial reset, PTOUT is set to "0" (DC output).
The $\overline{TOUT}$ signal can be output from R26 only when the function is selected by mask option.

PPT0, PPT1: 00FF21H•D2, D3

Sets the priority level of the programmable timer interrupt.
The two bits PPT0 and PPT1 are the interrupt priority register corresponding to the programmable timer interrupt. Table 5.10.10.3 shows the interrupt priority level which can be set by this register.

Table 5.10.10.3 Interrupt priority level settings

PPT1	PPT0	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (None)

At initial reset, this register is set to "0" (level 0).

EPT0, EPT1: 00FF23H•D6, D7

Enables or disables the generation of an interrupt for the CPU.

When "1" is written: Interrupt enabled
When "0" is written: Interrupt disabled
Reading: Valid

The EPT0 and EPT1 are interrupt enable registers that respectively correspond to the interrupt factors for timer 0 and timer 1. Interrupts set to "1" are enabled and interrupts set to "0" are disabled.
When the 16-bit mode is selected, setting of EPT0 becomes invalid.
At initial reset, this register is set to "0" (interrupt disabled).

FPT0, FPT1: 00FF25H•D6, D7

Indicates the programmable timer interrupt generation status.

When "1" is read: Interrupt factor present
When "0" is read: Interrupt factor not present

When "1" is written: Resets factor flag
When "0" is written: Invalid

The FPT0 and FPT1 are interrupt factor flags that respectively correspond to the interrupts for timer 0 and timer 1 and are set to "1" in synchronization with the underflow of each counter.
When set in this manner, if the corresponding interrupt enable register is set to "1" and the corresponding interrupt priority register is set to a higher level than the setting of interrupt flags (I0 and I1), an interrupt will be generated to the CPU.
Regardless of the interrupt enable register and interrupt priority register settings, the interrupt factor flag will be set to "1" by the occurrence of an interrupt generation condition.

To accept the subsequent interrupt after interrupt generation, re-setting of the interrupt flags (set interrupt flag to lower level than the level indicated by the interrupt priority registers, or execute the RETE instruction) and interrupt factor flag reset are necessary. The interrupt factor flag is reset to "0" by writing "1".
When the 16-bit mode is selected, the interrupt factor flag FPT0 is not set to "1" and a timer 0 interrupt cannot be generated. (In the 16-bit mode, the interrupt factor flag FPT1 is set to "1" by an underflow of the 16-bit counter.)
At initial reset, this flag is reset to "0".

5.10.11 Programming notes

(1) The programmable timer is actually made to RUN/STOP in synchronization with the falling edge of the input clock after writing to the PRUN0(1) register. Consequently, when "0" is written to the PRUN0(1), the timer shifts to STOP status when the counter is decremented "1". The PRUN0(1) maintains "1" for reading until the timer actually shifts to STOP status. Figure 5.10.11.1 shows the timing chart of the RUN/STOP control.

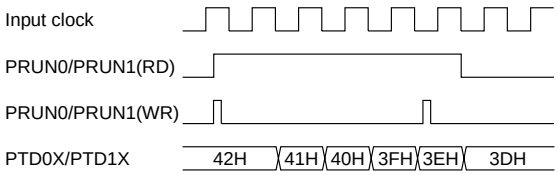


Fig. 5.10.11.1 Timing chart of RUN/STOP control

The event counter mode is excluded from the above note.

(2) The SLP instruction is executed when the programmable timer is in the RUN status (PRUN0(1) = "1"). The programmable timer operation will become unstable when returning from SLEEP status. Therefore, when shifting to SLEEP status, set the clock timer to STOP status (PRUN0(1) = "0") prior to executing the SLP instruction.
In the same way, disable the TOUT signal output (PTOUT = "0") to avoid an unstable clock output to the R27 output port terminal.

(3) Since the TOUT signal is generated asynchronously from the register PTOUT, when the signal is turned ON or OFF by the register setting, a hazard of a 1/2 cycle or less is generated.

(4) When the OSC3 oscillation circuit is made the clock source, it is necessary to turn the OSC3 oscillation ON, prior to using the programmable timer.
From the time the OSC3 oscillation circuit is turning ON until oscillation stabilizes, an interval of several 100 μsec to several 10 msec is necessary. Consequently, you should allow an adequate waiting time after turning the OSC3 oscillation circuit ON before starting the count of the programmable timer. (The oscillation start time will vary somewhat depending on the oscillator and on external parts. Refer to the oscillation start time example indicated in Chapter 7, "ELECTRICAL CHARACTERISTICS".)
At initial reset, OSC3 oscillation circuit is set to OFF status.

(5) When the 16-bit mode has been selected, be sure to read the counter data in the order of PTD00–PTD07 and PTD10–PTD17. Moreover, the time interval between reading PTD00–PTD07 and PTD10–PTD17 should be 0.73 msec or less.

5.11 LCD Controller

5.11.1 Configuration of LCD controller

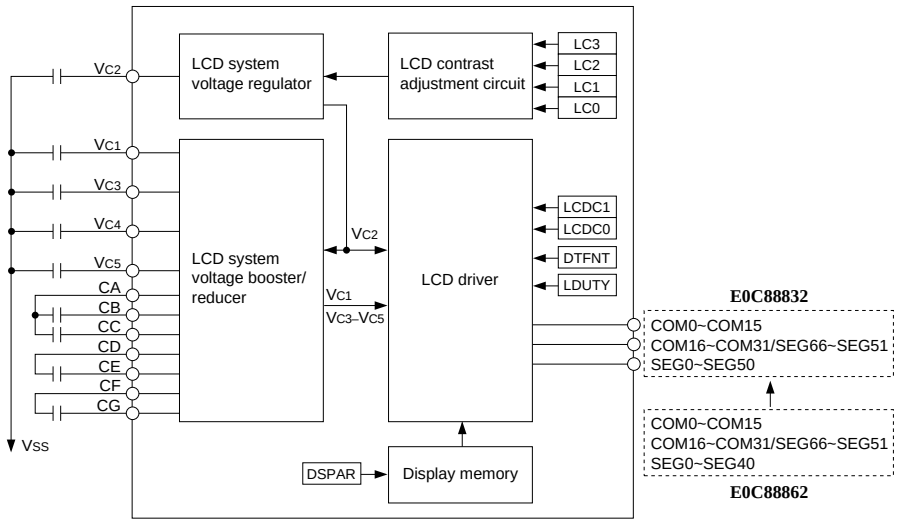
The E0C88832/88862 has a built-in dot matrix LCD driver. The E0C88832 allows an LCD panel with a maximum of 1,632 dots (51 segments × 32 commons). In the E0C88862 a maximum of 1,312 dots (41 segments × 32 commons) are permitted. Figure 5.11.1.1 shows the configuration of the LCD controller and the drive power supply.

5.11.2 Mask option

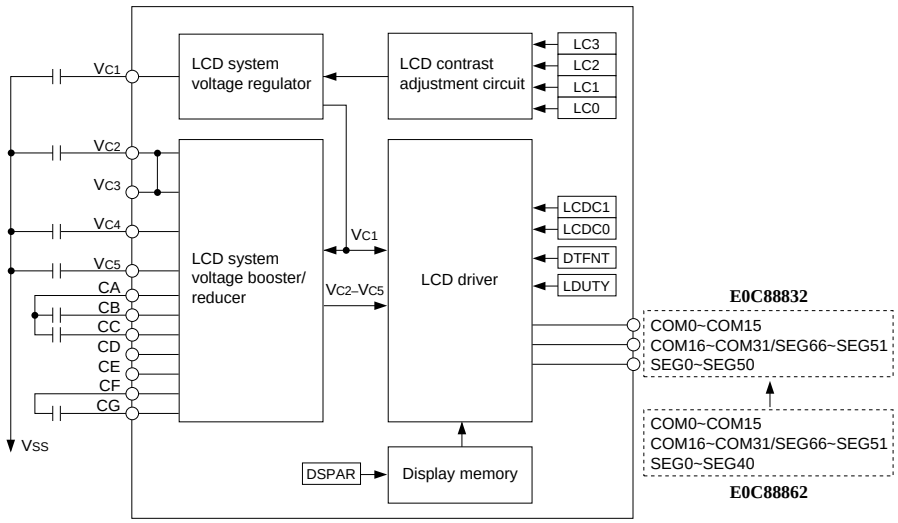
The drive duty for the built-in LCD driver can be selected whether it will be 1/32 and 1/16 software-switched or fixed at 1/8 by the mask option.

LCD drive duty
- ☐ 1/32 & 1/16 duty
- ☐ 1/8 duty

When "1/32 & 1/16 duty" is selected, the drive duty can be selected by software. When "0" is written to the drive duty selection register LDUTY, 1/32 duty is selected and when "1" is written, 1/16 duty is selected.
When "1/8 duty" is selected, the drive duty is fixed at 1/8 and setting of LDUTY becomes invalid.
When the built-in LCD driver is not used, select the default setting of "1/32 & 1/16 duty".



(a) V_{C2} standard



(b) V_{C1} standard

Note: V_{C1} standard can be selected only for 1/4 bias drive.

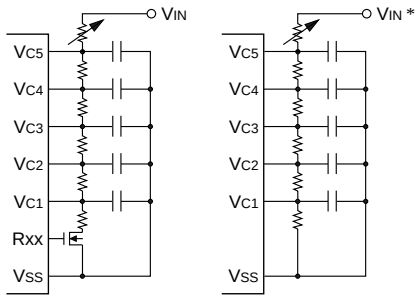
Fig. 5.11.1.1 Configuration of LCD controller and drive power supply

5.11.3 LCD power supply

Either the internal power supply (built-in LCD system voltage regulator and voltage booster/reducer) or an external power supply can be selected by mask option to generate the LCD system drive voltages V_{C1}–V_{C5}.
Furthermore, the internal power supply can be selected from among four types, TYPE A to TYPE D, according to the LCD panel characteristics.

LCD power supply
☐ Internal power supply TYPE A (V_{C2} standard, 1/5 bias, 4.5 V)
☐ Internal power supply TYPE B (V_{C2} standard, 1/5 bias, 5.5 V)
☐ Internal power supply TYPE C (V_{C2} standard, 1/4 bias, 4.5 V)
☐ Internal power supply TYPE D (V_{C1} standard, 1/4 bias, 4.5 V)
☐ External power supply

The internal power supply is designed for a small scale LCD panel and is not suitable for driving a panel that has large size pixels or for driving a large capacity panel using an external expanded LCD driver. In this case, select external power supply and input the regulated voltage from outside the IC.
Note that the LCD must be driven with 1/5 bias when external power supply is selected.
Figure 5.11.3.1 shows the circuit examples when using an external power supply.



* V_{SS} level or high impedance when LCD is not driven.

Fig. 5.11.3.1 Circuit examples when using an external power supply

5.11.4 LCD driver

The maximum number of dots changes according to the drive duty selection.
When 1/32 duty is selected, the combined common/segment output terminal is switched to the common terminal. An LCD panel with 51 segments × 32 commons (maximum 1,632 dots) in the E0C88832 and 41 segments × 32 commons (maximum 1,312 dots) in the E0C88862 can be driven.
When 1/16 duty is selected, the combined common/segment output terminal is switched to the segment terminal. An LCD panel with 67 segments × 16 commons (maximum 1,072 dots) in the E0C88832 and 57 segments × 16 commons (maximum 912 dots) in the E0C88862 can be driven.
When 1/8 duty is selected, the combined common/segment output terminal is switched to the segment terminal as when 1/16 duty is selected. An LCD panel with 67 segments × 8 commons (maximum 536 dots) in the E0C88832 and 57 segments × 8 commons (maximum 456 dots) in the E0C88862 can be driven. Furthermore, when 1/8 duty is selected, terminals COM8–COM15 become invalid, in that they always output an OFF signal.
Table 5.11.4.1 shows the correspondence between the drive duty and the maximum number of displaying dots.

Figures 5.11.4.1 to 5.11.4.3 show the 1/5 bias drive waveforms.
When driving with 1/4 bias, the V_{C2} voltage level is the same as V_{C3}.

Table 5.11.4.1 Correspondence between drive duty and maximum number of displaying dots

Model	Mask option	LDUTY	Duty	Common terminal	Segment terminal	Maximum number of display dots
E0C88832	1/32 & 1/16 duty	0	1/32	COM0–COM31	SEG0–SEG50	1,632 dots
		1	1/16	COM0–COM15	SEG0–SEG66	1,072 dots
	1/8 duty	×	1/8	COM0–COM7		536 dots
E0C88862	1/32 & 1/16 duty	0	1/32	COM0–COM31	SEG0–SEG40	1,312 dots
		1	1/16	COM0–COM15	SEG0–SEG40	912 dots
	1/8 duty	×	1/8	COM0–COM7	SEG51–SEG66	456 dots

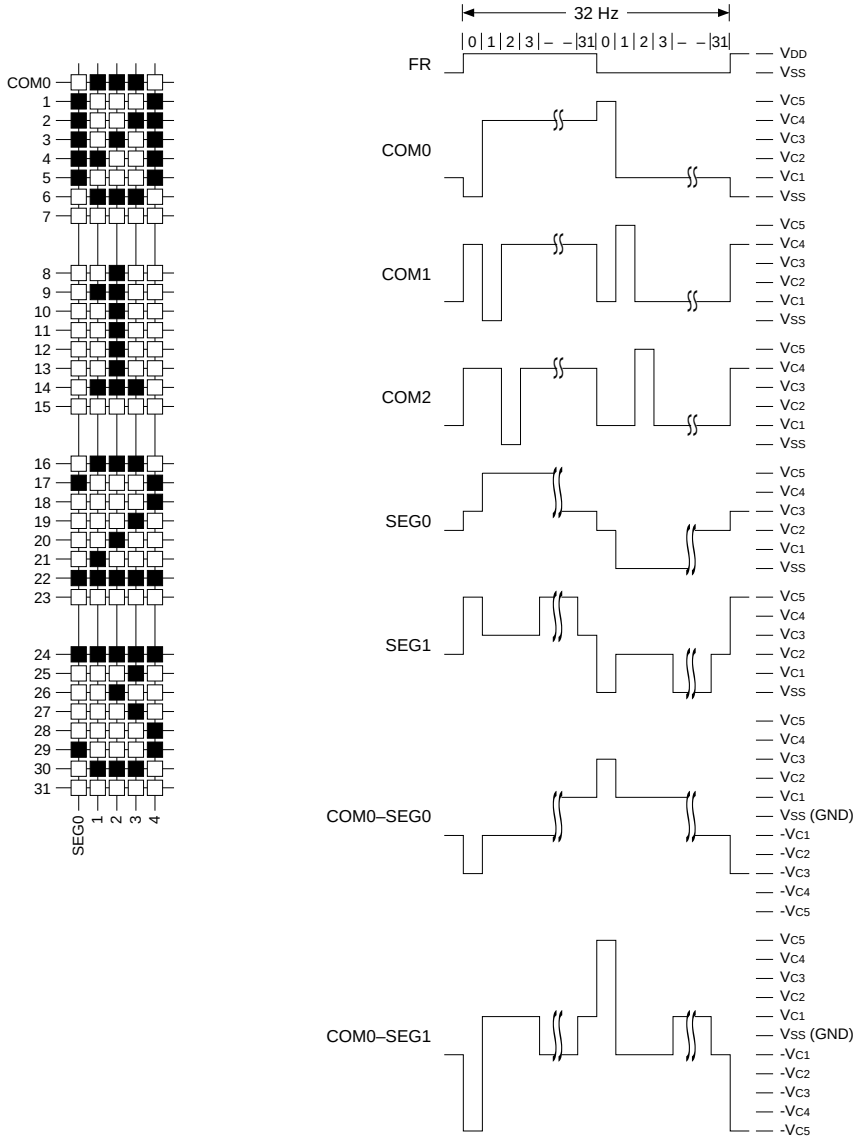


Fig. 5.11.4.1 Drive waveform for 1/32 duty

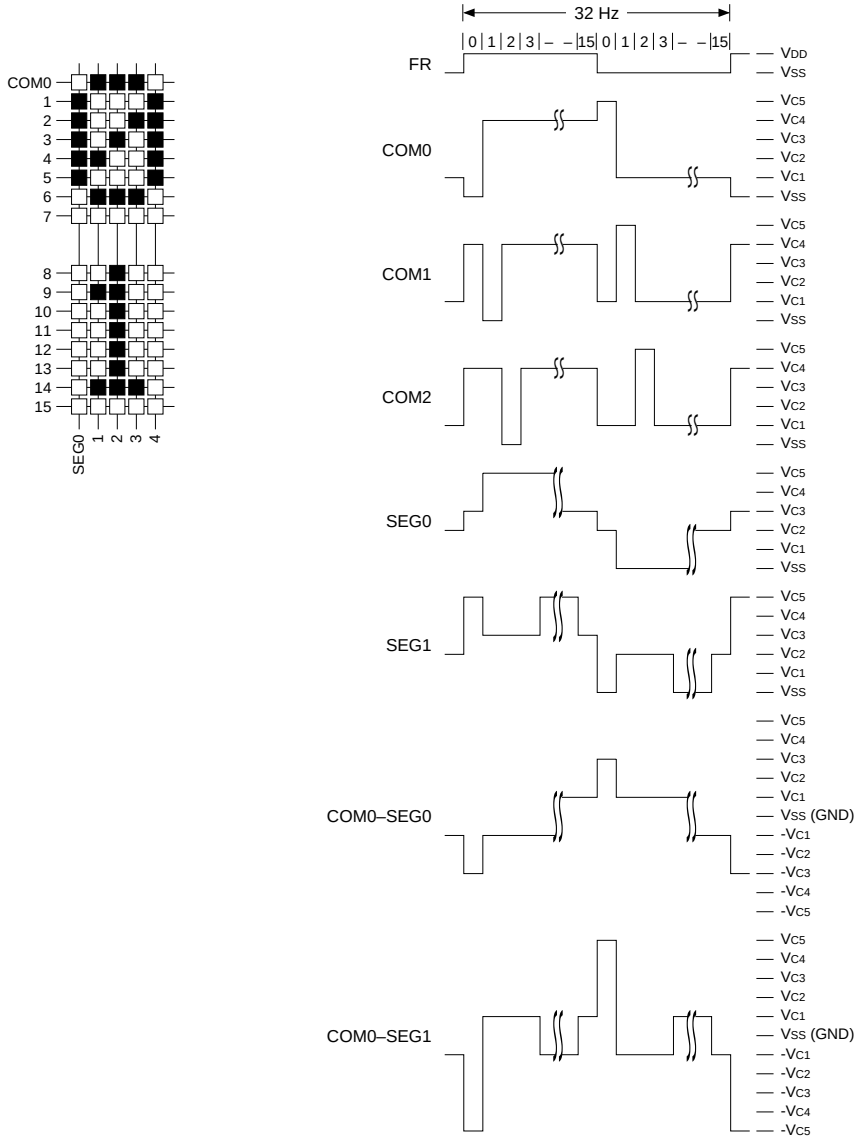


Fig. 5.11.4.2 Drive waveform for 1/16 duty

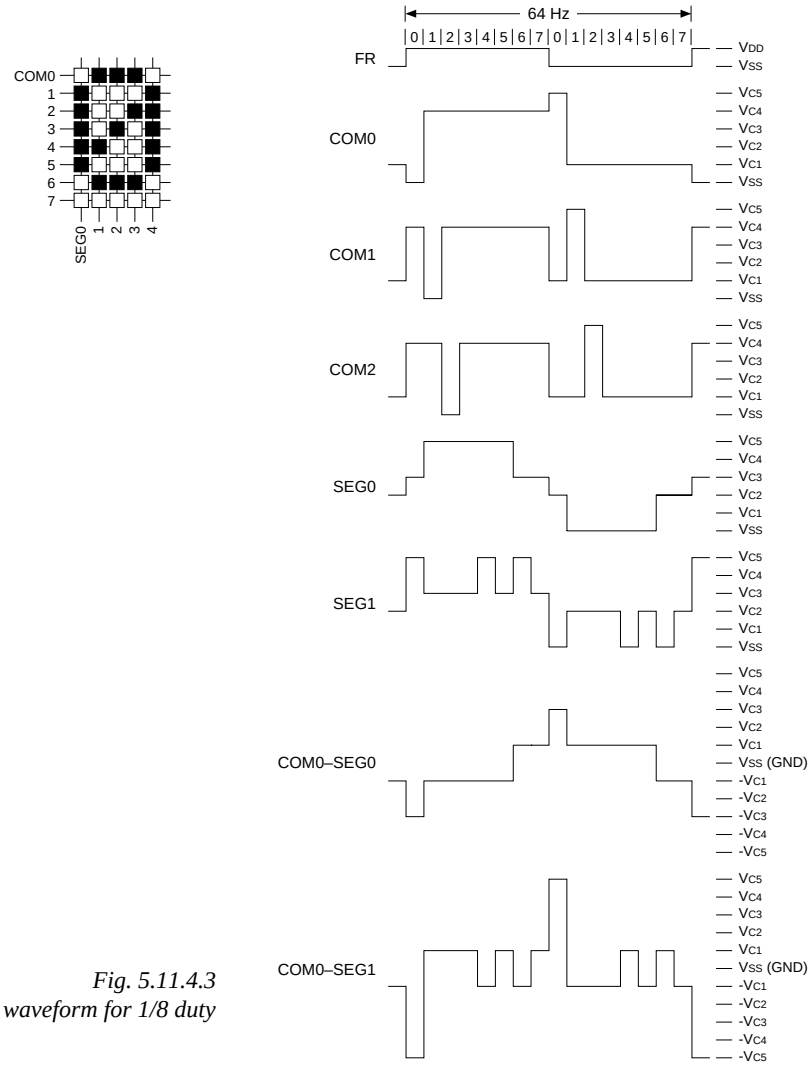


Fig. 5.11.4.3
Drive waveform for 1/8 duty

5.11.5 Display memory

The E0C88832 has a built-in 402-byte display memory. The E0C88862 has a built-in 342-byte display memory. The display memory is allocated to address F800H–FD42H (including unavailable areas) and the correspondence between the memory bits and common/segment terminal is changed according to the selection status of the following items.

(1) Drive duty (1/32, 1/16 or 1/8 duty)
(2) Dot font (5 × 8 or 5 × 5 dots)

When 1/16 or 1/8 duty is selected for drive duty, two-screen memory can be secured, and the two screens can be switched by the display memory area selection register DSPAR. When "0" is written to DSPAR, display area 0 is selected and when "1" is written, display area 1 is selected.
Furthermore, memory allocation for 5 × 8 dots and 5 × 5 dots can be selected in order to easily display 5 × 5-dot font characters on the LCD panel. This selection can be done by the dot font selection register DTFNT: when "0" is written to DTFNT, 5 × 8 dots is selected and when "1" is written, 5 × 5 dots is selected.
The correspondence between the display memory bits set according to the drive duty and font size, and the common/segment terminals are shown in Figures 5.11.5.1–5.11.5.6.
When "1" is written to the display memory bit corresponding to the dot on the LCD panel, the dot goes ON and when "0" is written, it goes OFF. Since display memory is designed to permit reading/writing, it can be controlled in bit units by logical operation instructions and other means (read, modify and write instruction)s.
The display memory bits that have not been assigned can be used as general purpose RAM with read/write capabilities. Even when external memory has expanded into the display memory area, this area is not released to external memory. Access to this area is always via display memory.

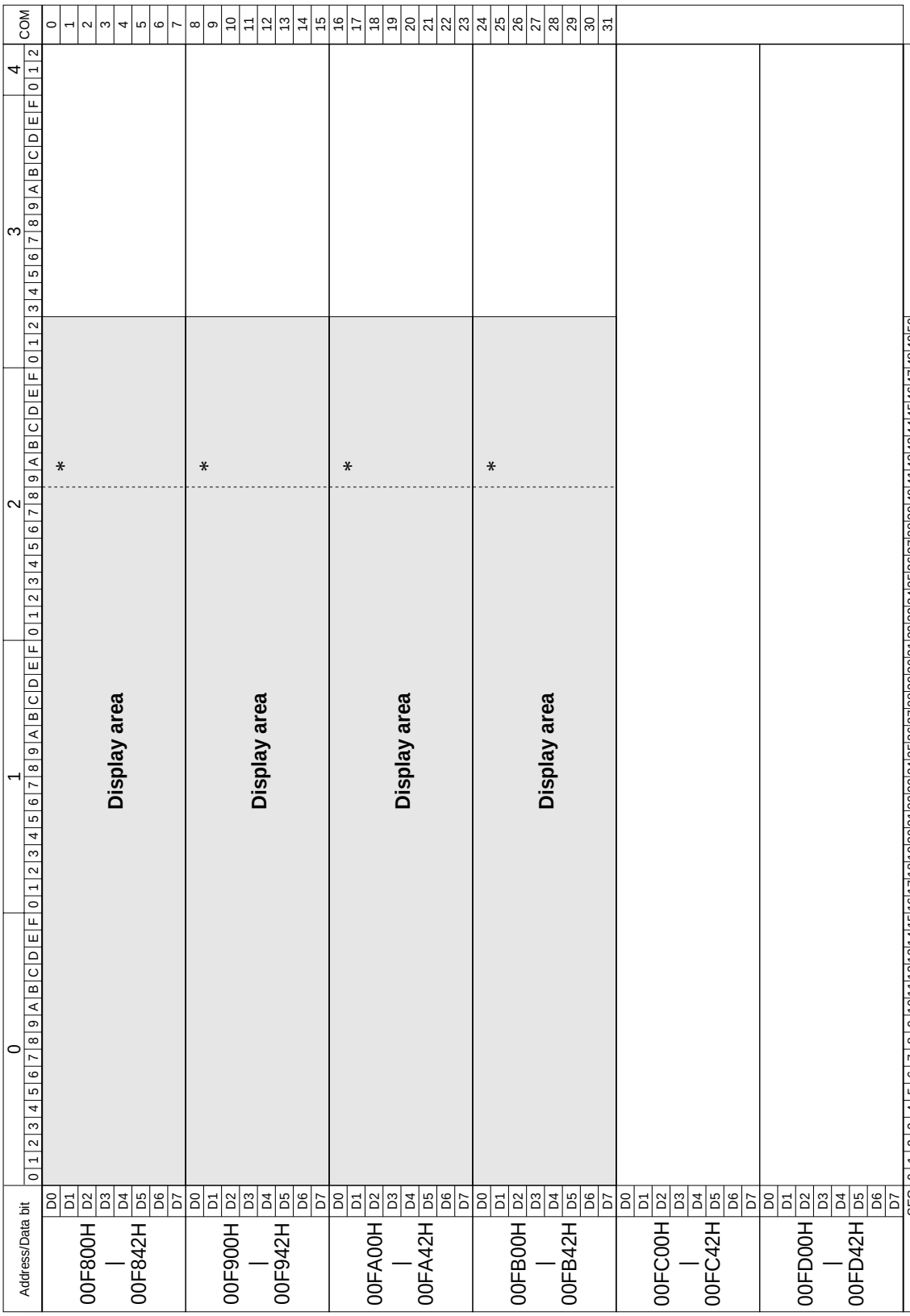


Fig. 5.11.5.1 1/32 duty and 5 × 8 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8–BH).

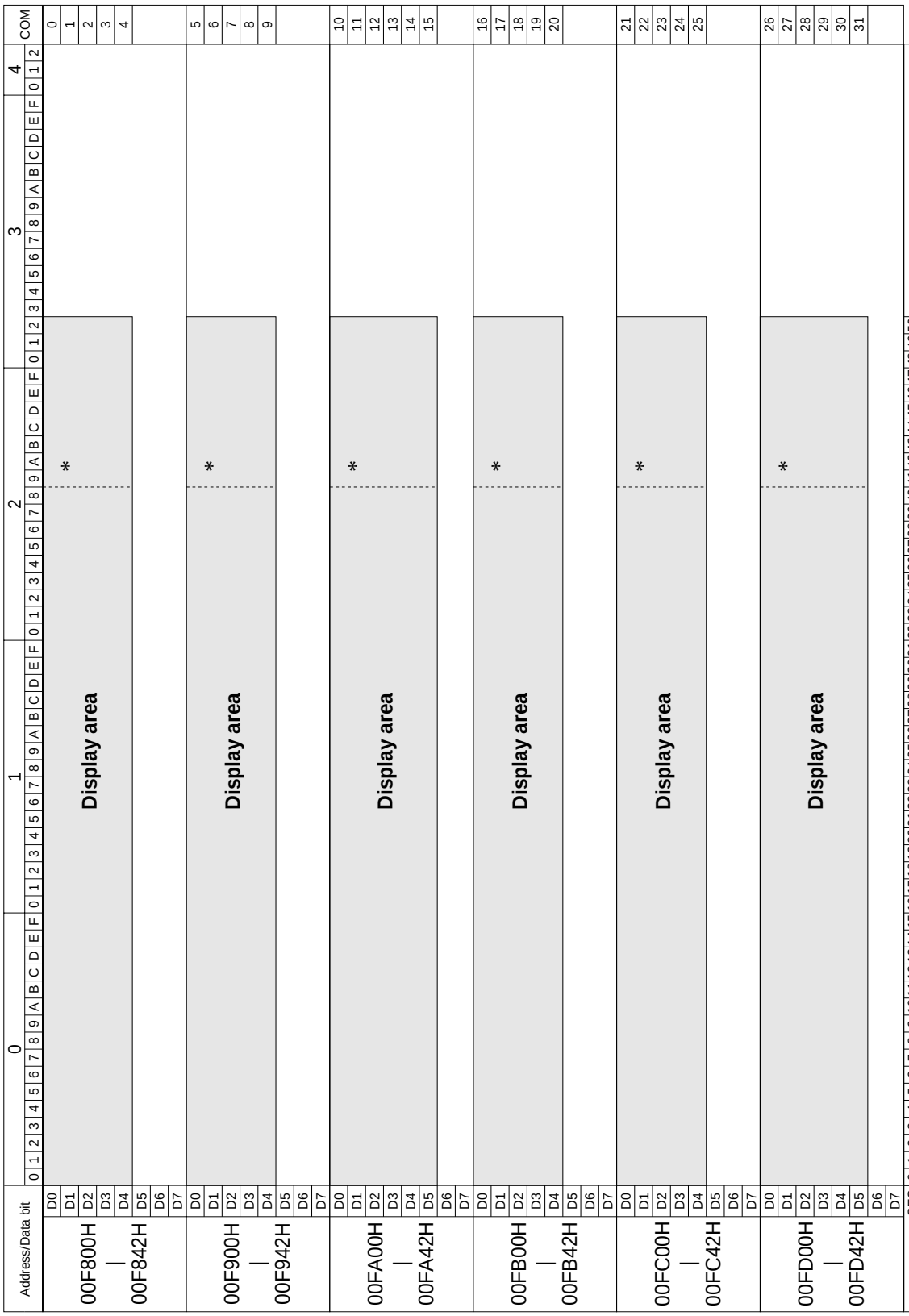


Fig. 5.11.5.2 1/32 duty and 5 ×5 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8–DH).

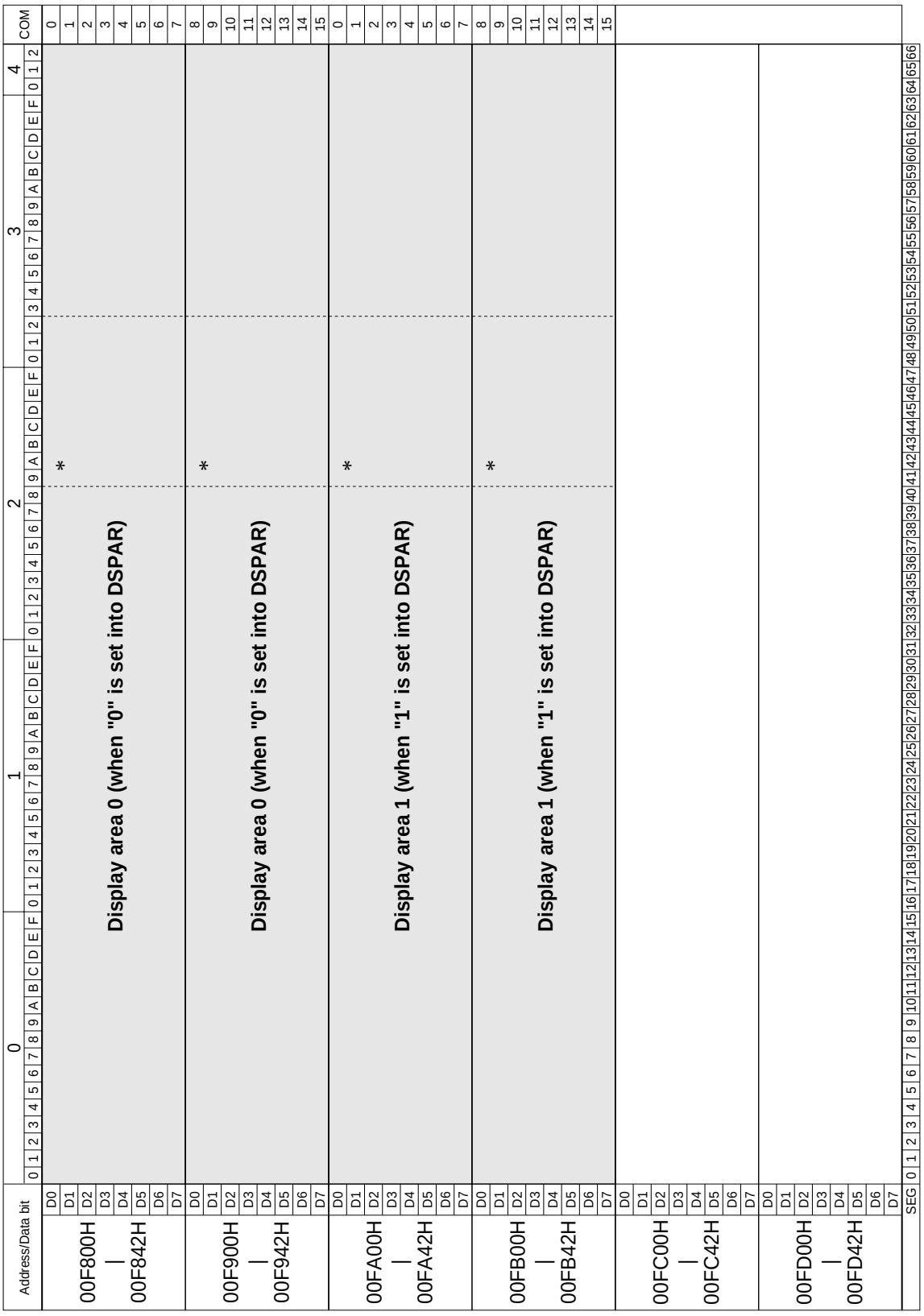


Fig. 5.11.5.3 1/16 duty and 5 × 8 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8–BH).

Fig. 5.11.5.4 1/16 duty and 5 ×5 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8–DH).

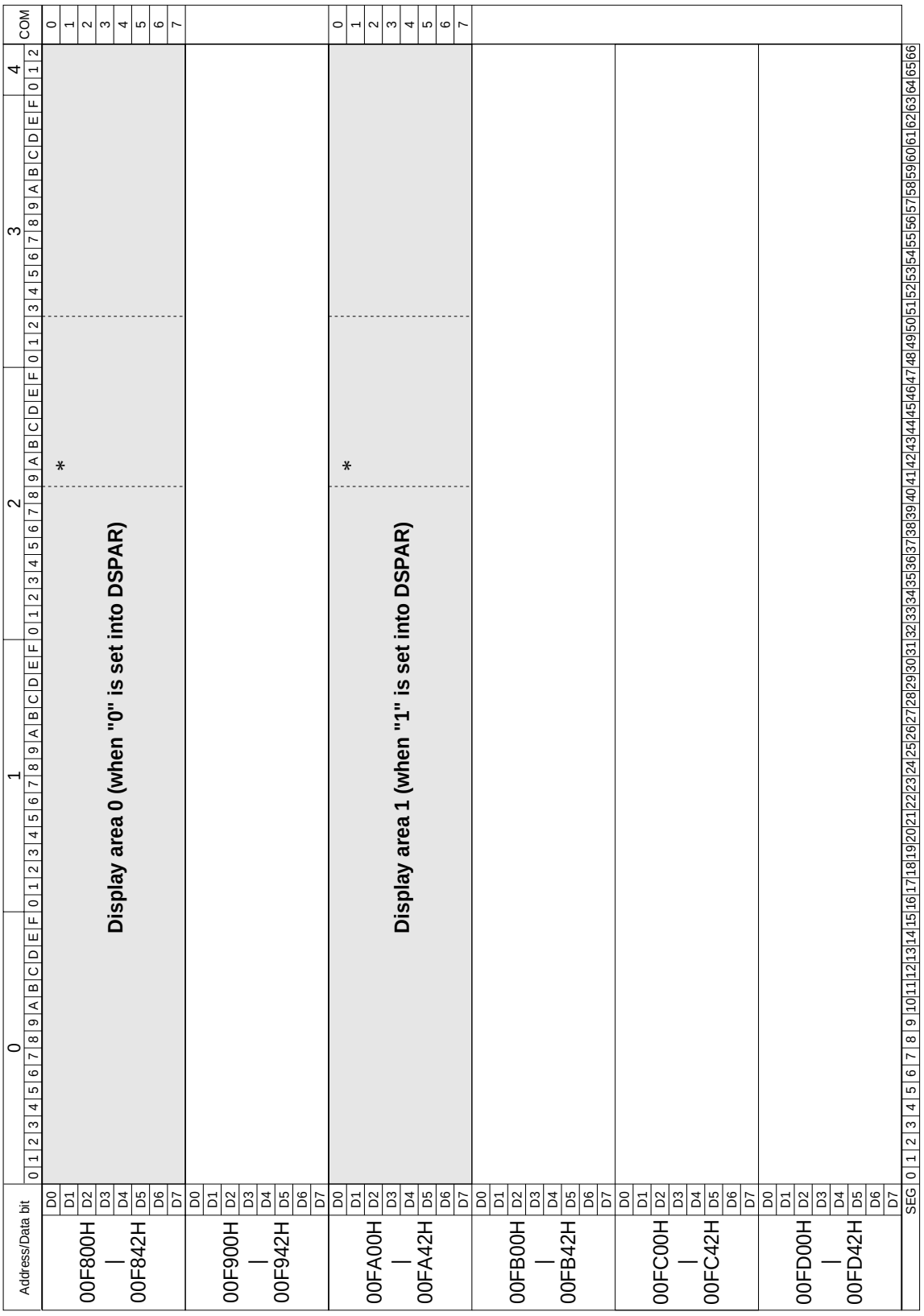


Fig. 5.11.5.5 1/8 duty and 5 × 8 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8, AH).

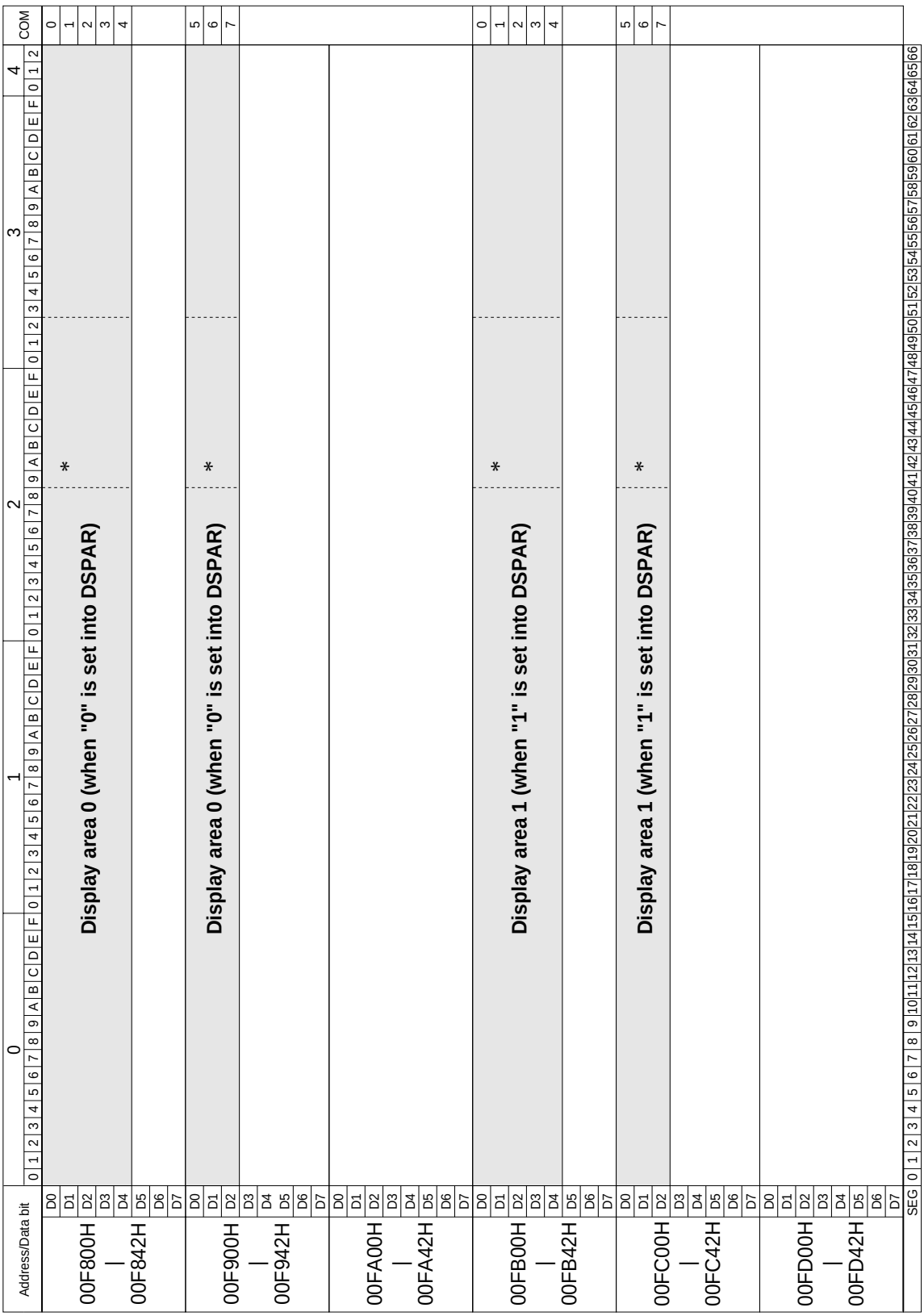


Fig. 5.11.5.6 1/8 duty and 5 × 5 dots display memory map

* In the E0C88862, no memory is allocated to the area from 00Fx29H to 00Fx32H (x = 8, 9, BH, CH).

5.11.6 Display control

The display status of the built-in LCD driver and the contrast adjustment can be controlled with the built-in LCD controller. The LCD display status can be selected by display control registers LCDC0 and LCDC1. Setting the value and display status are shown in Table 5.11.6.1.

Table 5.11.6.1 LCD display control

LCDC1	LCDC0	LCD display
1	1	All LCDs lit (Static)
1	0	All LCDs out (Dynamic)
0	1	Normal display
0	0	Drive OFF

All the dots in the LCD display can be turned on or off directly by the drive waveform output from the LCD driver, and data in the display memory is not changed. Also, since the common terminal at this time is set to static drive when all the dots are on and is set to dynamic drive when they are off, this function can be used as follows:

(1) Since all dots on is binary output (V_{C5} and V_{SS}) with static drive, the common/segment terminal can be used as a monitor terminal for the OSC1 oscillation frequency adjustment.

(2) Since all dots off is dynamic drive, you can brink the entire LCD display without changing display memory data.

Selecting LCD drive OFF turns the LCD drive power circuit OFF and all the V_{C1}–V_{C5} terminals go to V_{SS} level. However, if external power supply has been selected by the mask option, the V_{C1}–V_{C5} shift to floating status when drive is turned OFF. Furthermore, when the SLP instruction is executed, registers LCDC0 and LCDC1 are automatically reset to "0" (set to drive off) by hardware.

The LCD contrast can be adjusted in 16 stages. This adjustment is done by the contrast adjustment register LC0–LC3, and the setting values correspond to the contrast as shown in Table 5.11.6.2. However, if external power supply has been selected by the mask option, the contrast adjustment register LC0–LC3 is ineffective and contrast adjustment cannot be done.

Table 5.11.6.2 LCD contrast adjustment

LC3	LC2	LC1	LC0	Contrast
1	1	1	1	Dark
1	1	1	0	↑
1	1	0	1	
:	:	:	:	
0	0	1	0	
0	0	0	1	↓
0	0	0	0	Light

Note: Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.

5.11.7 Control of LCD controller

Table 5.11.7.1 shows the LCD controller control bits.

Table 5.11.7.1 LCD controller control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF10	D7	–	–	–	–	–		Constantry "0" when being read
	D6	–	–	–	–	–		
	D5	–	–	–	–	–		
	D4	LCCLK	General-purpose register	1	0	0	R/W	Reserved register
	D3	LCFRM	General-purpose register			0	R/W	
	D2	DTFNT	LCD dot font selection	5 x 5 dots	5 x 8 dots	0	R/W	
	D1	LDUTY	LCD drive duty selection	1/16 duty	1/32 duty	0	R/W	*1
	D0	SGOUT	General-purpose register	1	0	0	R/W	Reserved register
00FF11	D7	–	–	–	–	–		"0" when being read
	D6	DSPAR	LCD display memory area selection	Display area 1	Display area 0	0	R/W	
	D5	LCDC1	LCD display control LCDC1 LCDC0 LCD display 1 1 All LCDs lit 1 0 All LCDs out 0 1 Normal display 0 0 Drive off			0	R/W	These bits are reset to (0, 0) when SLP instruction is executed.
	D4	LCDC0				0	R/W	
	D3	LC3	LCD contrast adjustment LC3 LC2 LC1 LC0 Contrast 1 1 1 1 Dark 1 1 1 0 : : : : : : 0 0 0 0 Light			0	R/W	
	D2	LC2				0	R/W	
	D1	LC1				0	R/W	
	D0	LC0				0	R/W	

*1 When 1/8 duty has been selected by mask option, setting of this register becomes invalid.

LDUTY: 00FF10H•D1

Selects the drive duty.

When "1" is written: 1/16 duty
When "0" is written: 1/32 duty
Reading: Valid

When "1/32 & 1/16 duty" is selected by the mask option, select whether the drive duty will be 1/32 or 1/16.
When "0" is written to LDUTY, 1/32 duty is selected and the combined common/segment output terminal is switched to the common terminal.
When "1" is written to LDUTY, 1/16 duty is selected and the combined common/segment output terminal is switched to the segment terminal.
When "1/8 duty" is selected by the mask option, the combined common/segment terminals are fixed to the segment terminals and the setting of LDUTY becomes invalid.
The correspondence between the display memory bits set according to the drive duty, and the common/segment terminals are shown in Figures 5.11.5.1–5.11.5.6.
At initial reset, LDUTY is set to "0" (1/32 duty).

DTFNT: 00FF10H•D2

Selects the dot font.

When "1" is written: 5 × 5 dots
When "0" is written: 5 × 8 dots
Reading: Valid

Select 5 × 8 dots or 5 × 5 dots type for the display memory area.
When "0" is written to DTFNT, 5 × 8 dots is selected and when "1" is written, 5 × 5 dots is selected.
The correspondence between the display memory bits set according to the dot font, and the common/segment terminals are shown in Figures 5.11.5.1–5.11.5.6.
At initial reset, DTFNT is set to "0" (5 × 8 dots).

DSPAR: 00FF11H•D6

Selects the display area.

When "1" is written: Display area 1
When "0" is written: Display area 0
Reading: Valid

Selects which display area is secured for two screens in the display memory, will be displayed when 1/16 or 1/8 duty is selected.
When "0" is written to DSPAR, display area 0 is selected and when "1" is written, display area 1 is selected.

When 1/32 duty is selected, since the display area is only for one screen, the setting of DSPAR becomes invalid.
The correspondence between the display memory bits set according to the display area, and the common/segment terminals are shown in Figures 5.11.5.1–5.11.5.6.
At initial reset, DSPAR is set to "0" (display area 0).

LCDC0, LCDC1: 00FF11H•D4, D5

Controls the LCD display.

Table 5.11.7.2 LCD display control

LCDC1	LCDC0	LCD display
1	1	All LCDs lit (Static)
1	0	All LCDs out (Dynamic)
0	1	Normal display
0	0	Drive OFF

The four settings mentioned above can be made without changing the display memory data.
At initial reset and in the SLEEP status, this register is set to "0" (drive off).

LC0–LC3: 00FF11H•D0–D3

Adjusts the LCD contrast.

Table 5.11.7.3 LCD contract adjustment

LC3	LC2	LC1	LC0	Contrast
1	1	1	1	Dark
1	1	1	0	↑
1	1	0	1	
1	1	0	0	
1	0	1	1	
1	0	1	0	
1	0	0	1	
1	0	0	0	
0	1	1	1	
0	1	1	0	
0	1	0	1	
0	1	0	0	
0	0	1	1	
0	0	1	0	
0	0	0	1	↓
0	0	0	0	Light

The contrast can be adjusted in 16 stages as mentioned above. This adjustment changes the drive voltage on terminals V_{C1}–V_{C5}.
At initial reset, this register is set to "0".

Notes:
- *If external power supply has been selected by the mask option, the contrast adjustment register LC0–LC3 is ineffective.*
- *Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.*

5.11.8 Programming note

When the SLP instruction is executed, display control registers LCDC0 and LCDC1 are automatically reset to "0" by hardware.

5.12 Sound Generator

5.12.1 Configuration of sound generator

The E0C88832/88862 has a built-in sound generator for generating the buzzer (BZ and $\overline{BZ}$) signal.
The BZ signal generated from the sound generator can be output from the R50 output port terminal. Furthermore, the R51 terminal can be set as the $\overline{BZ}$ signal (BZ inverted signal) output by mask option.
Aside permitting the respective setting of the buzzer signal frequency and sound level (duty adjustment) to 8 stages, it permits the adding of a digital envelope by means of duty ratio control. It also has a one-shot output function for outputting key operated sounds.
Figure 5.12.1.1 shows the configuration of the sound generator.

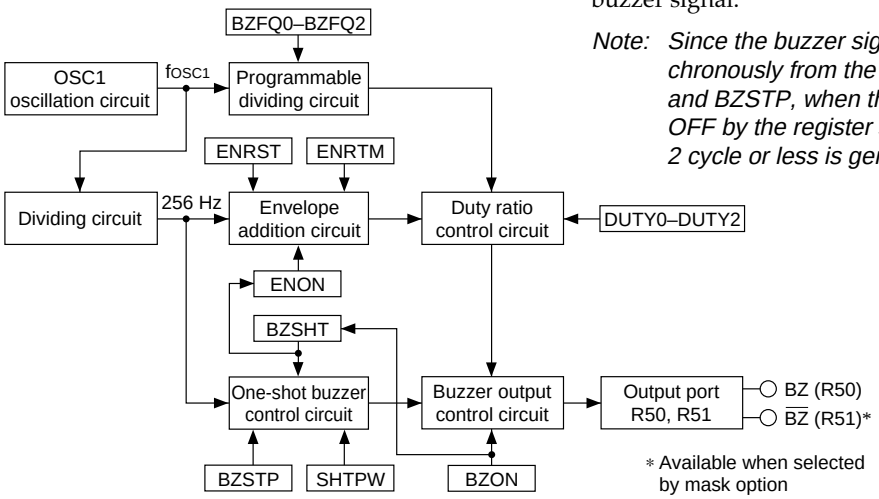


Fig. 5.12.1.1 Configuration of sound generator

5.12.2 Control of buzzer output

The BZ signal can be output from the R50 output port terminal. Furthermore, the R51 output port terminal can be used to output the $\overline{BZ}$ signal (BZ inverted signal) by mask option.
The configuration of the output ports R50 and R51 is shown in Figure 5.12.2.1.

The output control for the buzzer signal generated by the sound generator is done by the buzzer output control register BZON, one-shot buzzer trigger bit BZSHT and one-shot buzzer forced stop bit BZSTP. When "1" is set to BZON or BZSTP, the R50 goes LOW (V_{SS}) and the R51 goes HIGH (V_{DD}).
To output the buzzer signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.
Figure 5.12.2.2 shows the output waveform of the buzzer signal.

Note: Since the buzzer signal is generated asynchronously from the registers BZON, BZSHT and BZSTP, when the signal is turned ON or OFF by the register settings, a hazard of a 1/2 cycle or less is generated.

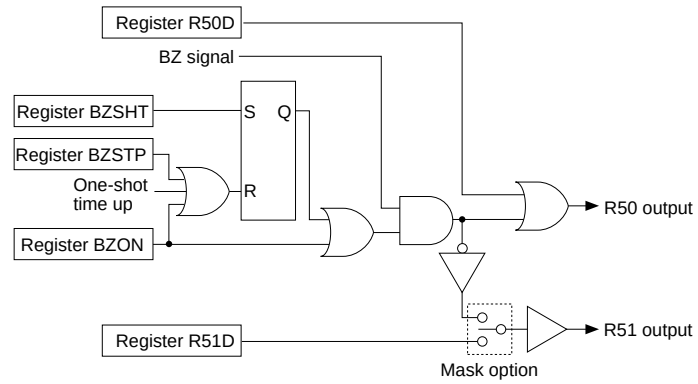


Fig. 5.12.2.1 Configuration of R50 and R51

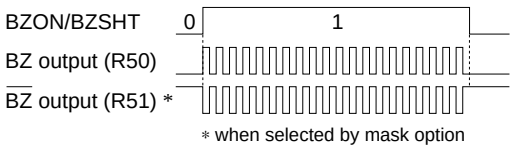


Fig. 5.12.2.2 Buzzer output waveform

5.12.3 Setting of buzzer frequency and sound level

The buzzer signal is divided signal using the OSC1 oscillation circuit (32.768 kHz) as the clock source and 8 frequencies can be selected. This selection is done by the buzzer frequency selection register BZFQ0–BZFQ2. The setting value and buzzer frequency correspondence is shown in Table 5.12.3.1.

By selecting the duty ratio of the buzzer signal from among 8 types, the buzzer sound level can be adjusted. This selection is made in the duty ratio selection register DUTY0–DUTY2. The setting value and duty ratio correspondence is shown in Table 5.12.3.2.

Table 5.12.3.1 Buzzer signal frequency settings

BZFQ2	BZFQ1	BZFQ0	Buzzer frequency (Hz)
0	0	0	4096.0
0	0	1	3276.8
0	1	0	2730.7
0	1	1	2340.6
1	0	0	2048.0
1	0	1	1638.4
1	1	0	1365.3
1	1	1	1170.3

Table 5.12.3.2 Duty ratio settings

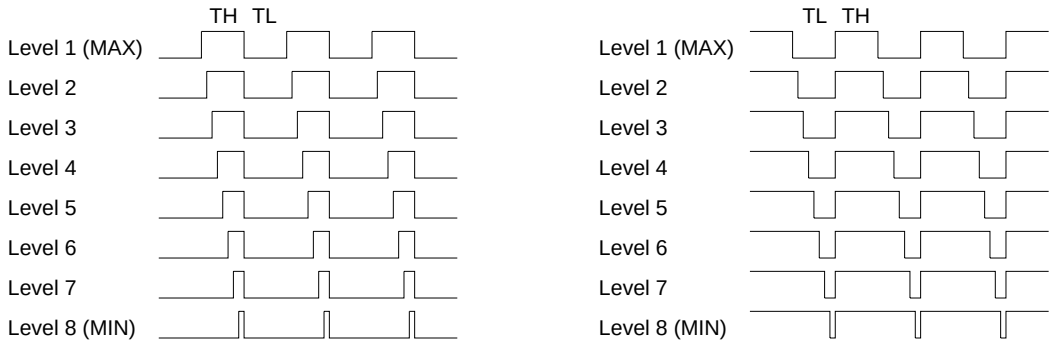
Level	DUTY2	DUTY1	DUTY0	Duty ratio by buzzer frequencies (Hz)			
				4096.0	3276.8	2730.7	2340.6
				2048.0	1638.4	1365.3	1170.3
Level 1 (Max)	0	0	0	8/16	8/20	12/24	12/28
Level 2	0	0	1	7/16	7/20	11/24	11/28
Level 3	0	1	0	6/16	6/20	10/24	10/28
Level 4	0	1	1	5/16	5/20	9/24	9/28
Level 5	1	0	0	4/16	4/20	8/24	8/28
Level 6	1	0	1	3/16	3/20	7/24	7/28
Level 7	1	1	0	2/16	2/20	6/24	6/28
Level 8 (Min)	1	1	1	1/16	1/20	5/24	5/28

Duty ratio refers to the ratio of pulse width to the pulse cycle; given that HIGH level output time is TH, and low level output time is TL the BZ signal duty ratio becomes TH/(TH+TL) and the $\overline{BZ}$ signal duty ratio becomes TL/(TH+TL).
When DUTY0–DUTY2 have all been set to "0", the duty ratio becomes maximum and the sound level also becomes maximum.

Conversely, when DUTY0–DUTY2 have all been set to "1", the duty ratio becomes minimum and the sound level also becomes minimum.

Note that the duty ratio setting differ depending on frequency. See Table 5.12.3.2.

Note: When using the digital envelope, the DUTY0–DUTY2 setting becomes invalid.



(a) BZ signal *(b) $\overline{BZ}$ signal*

Fig. 5.12.3.1 Duty ratio of buzzer signal waveform

5.12.4 Digital envelope

A digital envelope with duty control can be added to the buzzer signal.
The envelope can be realized by staged changing of the same duty ratio as detailed in Table 5.12.3.2 in the preceding section from level 1 (maximum) to level 8 (minimum).
The addition of an envelope to the buzzer signal can be done by writing "1" to the envelope control register ENON. When "0" is written, the duty ratio is set at the level selected in DUTY0–DUTY2.

By writing "1" to ENON to turn the buzzer output ON (writing "1" to BZON), the buzzer signal with a level 1 duty ratio is output, and then the duty ratio can be attenuated in stages to level 8. The attenuated envelope can be returned to level 1 by writing "1" to the envelope reset bit ENRST. When attenuated to level 8, the duty level remains at level 8 until the buzzer output is turned OFF (writing "0" to BZON) or writing "1" to ENRST.
The stage changing time for the envelope level can be selected either 125 msec or 62.5 msec by the envelope attenuation time selection register ENRTM.
Figure 5.12.4.1 shows the timing chart of the digital envelope.

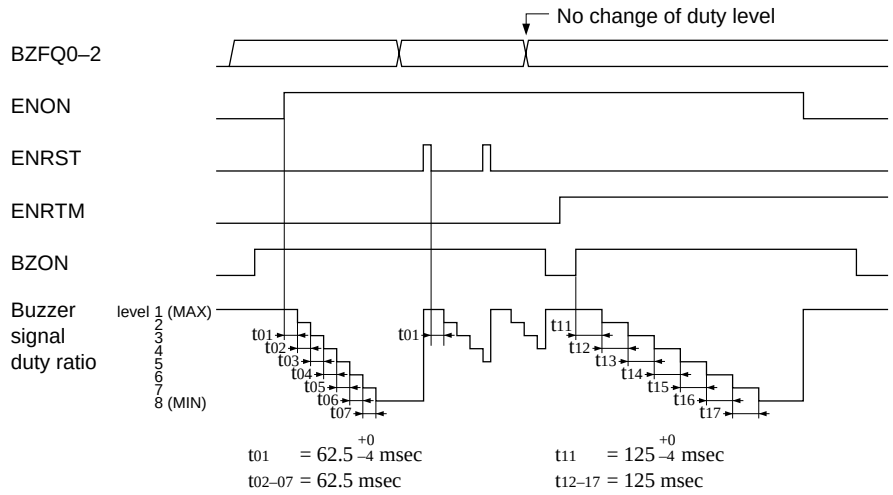


Fig. 5.12.4.1 Timing chart of digital envelope

5.12.5 One-shot output

The sound generator has a built-in one-shot output function for outputting a short duration buzzer signal for key operation sounds and similar effects. Either 125 msec or 31.25 msec can be selected by the one-shot buzzer duration selection register SHTPW for buzzer signal output time.
The output control of the one-shot buzzer is done by writing "1" to the one-shot buzzer trigger BZSHT, then the buzzer signal is output in synchronization with the internal 256 Hz signal from the output port terminal. Thereafter, when the set time has elapsed, the buzzer signal in synchronization with the 256 Hz signal automatically goes OFF in the same manner.
The BZSHT can be read to determine status. When BZSHT is "1", it indicates a BUSY status (during one-shot output) and when BZSHT is "0", it indicates a READY status (during stop).
When you want to turn the buzzer signal OFF prior to the elapse of the set time, the buzzer signal can be immediately stopped (goes OFF in asynchonization with 256 Hz signal) by writing "1" to the one-shot forced stop bit BZSTP.

Since the one-shot output has a short duration, an envelope cannot be added. (When "1" is written to BZSHT, ENON is automatically reset to "0".) Consequently, only the frequency and sound level can be set for one-shot output.

The control for the one-shot output is invalid during normal buzzer output.

Figure 5.12.5.1 shows the timing chart of the one-shot output.

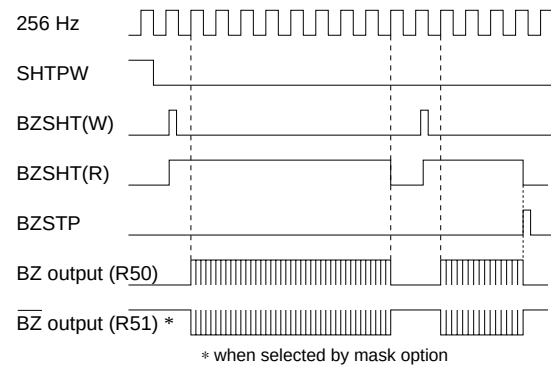


Fig. 5.12.5.1 Timing chart of one-shot output

5.12.6 Control of sound generator

Table 5.12.6.1 shows the sound generator control bits.

Table 5.12.6.1 Sound generator control bits

Address	Bit	Name	Function		1	0	SR	R/W	Comment
00FF44	D7	–	–		–	–	–		Constantry "0" when
	D6	BZSTP	One-shot buzzer forcibly stop		Forcibly stop	No operation	–	W	being read
	D5	BZSHT	One-shot buzzer trigger/status	R	Busy	Ready	0	R/W	
				W	Trigger	No operation			
	D4	SHTPW	One-shot buzzer duration width selection		125 msec	31.25 msec	0	R/W	
	D3	ENRTM	Envelope attenuation time		1 sec	0.5 sec	0	R/W	
	D2	ENRST	Envelope reset		Reset	No operation	–	W	"0" when being read
	D1	ENON	Envelope On/Off control		On	Off	0	R/W	*1
	D0	BZON	Buzzer output control		On	Off	0	R/W	
00FF45	D7	–	–		–	–	–		"0" when being read
	D6	DUTY2	Buzzer signal duty ratio selection				0	R/W	
	D5	DUTY1					0	R/W	
	D4	DUTY0					0	R/W	
	D3	–	–		–	–	–		"0" when being read
	D2	BZFQ2	Buzzer frequency selection				0	R/W	
	D1	BZFQ1					0	R/W	
	D0	BZFQ0					0	R/W	

Buzzer signal duty ratio selection

DUTY2–1			Buzzer frequency (Hz)			
2	1	0	4096.0 2048.0	3276.8 1638.4	2730.7 1365.3	2340.6 1170.3
0	0	0	8/16	8/20	12/24	12/28
0	0	1	7/16	7/20	11/24	11/28
0	1	0	6/16	6/20	10/24	10/28
0	1	1	5/16	5/20	9/24	9/28
1	0	0	4/16	4/20	8/24	8/28
1	0	1	3/16	3/20	7/24	7/28
1	1	0	2/16	2/20	6/24	6/28
1	1	1	1/16	1/20	5/24	5/28

Buzzer frequency selection

BZFQ2	BZFQ1	BZFQ0	Frequency (Hz)
0	0	0	4096.0
0	0	1	3276.8
0	1	0	2730.7
0	1	1	2340.6
1	0	0	2048.0
1	0	1	1638.4
1	1	0	1365.3
1	1	1	1170.3

*1 Reset to "0" during one-shot output.

BZON: 00FF44H•D0

Controls the buzzer (BZ and $\overline{BZ}$) signal output.

When "1" is written: Buzzer signal output ON
When "0" is written: Buzzer signal output OFF
Reading: Valid

BZON is the output control register for buzzer signal. When "1" is set to the register, the BZ ($\overline{BZ}$) signal is output from the output port terminal R50 (R51). When "0" is set, the R50 goes LOW (V_{SS}) and the R51 goes HIGH (V_{DD}).
To output the BZ signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.
At initial reset, BZON is set to "0" (output OFF).
The $\overline{BZ}$ signal can be output from R51 only when the function is selected by mask option.

BZFQ0–BZFQ2: 00FF45H•D0–D2

Selects the buzzer signal frequency.

Table 5.12.6.2 Buzzer frequency settings

BZFQ2	BZFQ1	BZFQ0	Buzzer frequency (Hz)
0	0	0	4096.0
0	0	1	3276.8
0	1	0	2730.7
0	1	1	2340.6
1	0	0	2048.0
1	0	1	1638.4
1	1	0	1365.3
1	1	1	1170.3

The buzzer frequency can be selected from among the above 8 types that have divided the OSC1 clock.
At initial reset, this register is set at "0" (4096.0 Hz).

DUTY0–DUTY2: 00FF45H•D4–D6

Selects the duty ratio of the buzzer signal.

Table 5.12.6.3 Duty ratio settings

Level	DUTY2	DUTY1	DUTY0	Duty ratio by buzzer frequencies (Hz)			
				4096.0 2048.0	3276.8 1638.4	2730.7 1365.3	2340.6 1170.3
Level 1 (Max)	0	0	0	8/16	8/20	12/24	12/28
Level 2	0	0	1	7/16	7/20	11/24	11/28
Level 3	0	1	0	6/16	6/20	10/24	10/28
Level 4	0	1	1	5/16	5/20	9/24	9/28
Level 5	1	0	0	4/16	4/20	8/24	8/28
Level 6	1	0	1	3/16	3/20	7/24	7/28
Level 7	1	1	0	2/16	2/20	6/24	6/28
Level 8 (Min)	1	1	1	1/16	1/20	5/24	5/28

The buzzer sound level can be adjusted by selecting the duty ratio from among the above 8 types. However, when the envelope has been set to ON (ENON = "1"), this setting becomes invalid.
At initial reset, this register is set to "0" (level 1).

ENRST: 00FF44H•D2

Resets the envelope.

When "1" is written: Reset
When "0" is written: No operation
Reading: Always "0"

The envelope is reset by writing "1" to ENRST and the duty ratio returns to level 1 (maximum). Writing "0" to ENRST and writing "1" when an envelope has not been added become invalid. Since ENRST is exclusively for writing, it always becomes "0" during reading.

ENON: 00FF44H•D1

Controls the addition of an envelope to the buzzer signal.

When "1" is written: ON
When "0" is written: OFF
Reading: Valid

By writing "1" to ENON, an envelope can be added to buzzer signal output. When "0" is written, an envelope is not added and the buzzer signal is fixed at the duty ratio selected in DUTY0–DUTY2.
At initial reset and when "1" is written to BZSHT, ENON is set to "0" (OFF).

ENRTM: 00FF44H•D3

Selects the envelope attenuation time that is added to the buzzer signal.

When "1" is written: 1.0 sec
(125 msec × 7 = 875 msec)
When "0" is written: 0.5 sec
(62.5 msec × 7 = 437.5 msec)
Reading: Valid

The attenuation time of the digital envelope is determined by the time for changing the duty ratio. The duty ratio is changed in 125 msec (8 Hz) units when "1" is written to ENRTM and in 62.5 msec (16 Hz) units, when "0" is written.
This setting becomes invalid when an envelope has been set to OFF (ENON = "0").
At initial reset, ENRTM is set to "0" (0.5 sec).

SHTPW: 00FF44H•D4

Selects the output duration width of the one-shot buzzer.

When "1" is written: 125 msec
When "0" is written: 31.25 msec
Reading: Valid

The one-shot buzzer output duration width is set to 125 msec when "1" is written to SHTPW and 62.5 msec, when "0" is written.
At initial reset, SHTPW is set to "0" (31.25 msec).

BZSHT: 00FF44H•D5

Controls the one-shot buzzer output.

When "1" is written: Trigger
When "0" is written: No operation

When "1" is read: Busy
When "0" is read: Ready

Writing "1" into BZSHT causes the one-shot output circuit to operate. The BZ ($\overline{BZ}$) signal is output from the R50 (R51) terminal. The buzzer output is automatically turned OFF after the time set by SHTPW has elapsed.
To output the BZ signal, "0" must always be set for the data register R50D. The data register R51D does not affect the $\overline{BZ}$ output.
The one-shot output is only valid when the normal buzzer output is OFF (BZON = "0") state. The trigger is invalid during ON (BZON = "1") state.
When a re-trigger is assigned during a one-shot output, the one-shot output time set with SHTPW is measured again from that point. (time extension)
The operation status of the one-shot output circuit can be confirmed by reading BZSHT, when the one-shot output is ON, "1" is read from BZSHTand when the output is OFF, "0" is read.
At initial reset, BZSHT is set to "0" (ready).
The $\overline{BZ}$ signal can be output from R51 only when the function is selected by mask option.

BZSTP: 00FF44H•D6

Forcibly stops the one-shot buzzer output.

When "1" is written: Forcibly stop
When "0" is written: No operation
Reading: Constantly "0"

By writing "1" into BZSTP, the one-shot buzzer output can be stopped prior to the elapsing of the time set with SHTPW.
Writing "0" is invalid and writing "1" except during one-shot output is also invalid.
When "1" is written to BZSHT and BZSTP simultaneously, BZSTP takes precedence and one-shot output becomes stop status.
Since BZSTP is for writing only, during readout it is constantly set to "0".

5.12.7 Programming notes

(1) Since the buzzer signal is generated asynchronously from the register BZON, when the signal is turned ON or OFF by the register setting, a hazard of a 1/2 cycle or less is generated.

(2) The SLP instruction has executed when the buzzer signal output is in the enable status (BZON = "1" or BZSHT = "1"), unstable clock is output from the output terminal at the time of return from the SLEEP status. Consequently, when shifting to the SLEEP status, you should set the buzzer signal output to the disable status (BZON = BZSHT = "0") prior to executing the SLP instruction.

(3) The one-shot output is only valid when the normal buzzer output is OFF (BZON = "0") status. The trigger is invalid during ON (BZON = "1") status.

5.13 Supply Voltage Detection (SVD) Circuit

5.13.1 Configuration of SVD circuit

The E0C88832/88862 has a built-in supply voltage detection (SVD) circuit configured with a 4-bit successive approximation A/D converter.
The SVD circuit has 16 sampling levels (level 0–level 15) for supply voltage, and this can be controlled by software.
In addition, an initial reset signal can be generated when the supply voltage drops to level 0 or less. This is selected by the mask option.
Figure 5.13.1.1 shows the configuration of the SVD circuit.

5.13.2 Operation of SVD circuit

■ Sampling control of the SVD circuit

The SVD circuit has two operation modes: continuous sampling and 1/4 Hz auto-sampling mode. Operation mode selection is done by the SVD control registers SVDON and SVDSP as shown in Table 5.13.2.1. When both bits of SVDON and SVDSP are set to "1", continuous sampling is selected.

Table 5.13.2.1 Correspondence between control register and operation mode

SVDON	SVDSP	Operating mode
0	0	SVD circuit OFF
0	1	1/4 Hz auto-sampling ON
1	×	Continuous sampling ON

In both operation modes, reading SVDON can confirm whether the SVD circuit is operating (BUSY) or on standby (READY); "1" indicates BUSY and "0" indicates READY.
When executing an SLP instruction while the SVD circuit is operating, the stop operation of the OSC1 oscillation circuit is kept waiting until the sampling is completed. The two bits of SVDON and SVDSP are automatically reset to "0" by hardware while waiting for completion of sampling.
To reduce current consumption, turn the SVD circuit OFF when it is not necessary.

■ Detection result

The SVD circuit A/D converts the supply voltage (V_{DD}–V_{SS}) by 4-bit resolution and sets the result thereof into the SVD0–SVD3 register.
The data in SVD0–SVD3 correspond to the detection levels as shown in Table 5.13.2.2 and the detection data is maintained until the next sampling.

For the correspondence between the detection level and the supply voltage, see "7 ELECTRICAL CHARACTERISTICS".
An interval of 7.8 msec (f_{OSC1} = 32.768 kHz) is required from the start of supply voltage sampling by the SVD circuit to completion by writing the result into SVD0–SVD3. Therefore, when reading SVD0–SVD3 before sampling is finished, the previous result will be read.

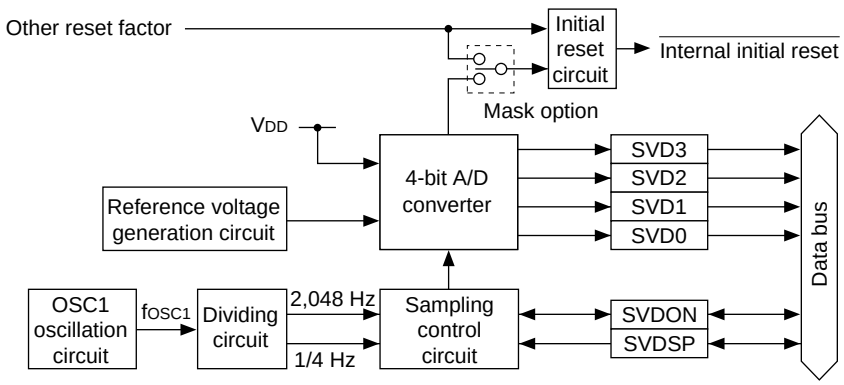


Fig. 5.13.1.1 Configuration of SVD circuit

Table 5.13.2.2 Supply voltage detection results

SVD3	SVD2	SVD1	SVD0	Detection level
1	1	1	1	Level 15
1	1	1	0	Level 14
1	1	0	1	Level 13
1	1	0	0	Level 12
1	0	1	1	Level 11
1	0	1	0	Level 10
1	0	0	1	Level 9
1	0	0	0	Level 8
0	1	1	1	Level 7
0	1	1	0	Level 6
0	1	0	1	Level 5
0	1	0	0	Level 4
0	0	1	1	Level 3
0	0	1	0	Level 2
0	0	0	1	Level 1
0	0	0	0	Level 0

■ Timing of sampling

Next, we will explain the timing for two operation modes.

(1) Continuous sampling mode

This mode is selected when "1" is written to SVDON and sampling of the supply voltage is done continuously in 7.8 msec cycles.

The SVD circuit starts operation in synchronization with the internal 2,048 Hz signal and performs one sampling in 16 clock cycles. The sampling is done continuously without setting the standby time and the result is latched to SVD0–SVD3 in every 16 clock cycles. Cancellation of continuous sampling is done by writing "0" to SVDON. The SVD circuit maintains ON status until completion of sampling and then goes OFF.
After writing "0" to SVDON, SVDON reads "1" until the SVD circuit actually goes OFF.
Figure 5.13.2.1 shows the timing chart of the continuous sampling.

(2) 1/4 Hz auto-sampling mode

This mode is selected when "0" is written to SVDON and "1" is written to SVDSP. In this case, supply voltage sampling is done in every 4 seconds.
The sampling time is 7.8 msec as in continuous sampling, and the result in SVD0–SVD3 is updated every 4 seconds.
Cancellation of 1/4 Hz auto-sampling is done by writing "0" to SVDSP. If the SVD circuit is sampling, SVD circuit waits until completion and then turns OFF. In addition, "1" is read from SVDON while the SVD circuit is sampling.
Figure 5.13.2.2 shows the timing chart of the 1/4 Hz auto-sampling.

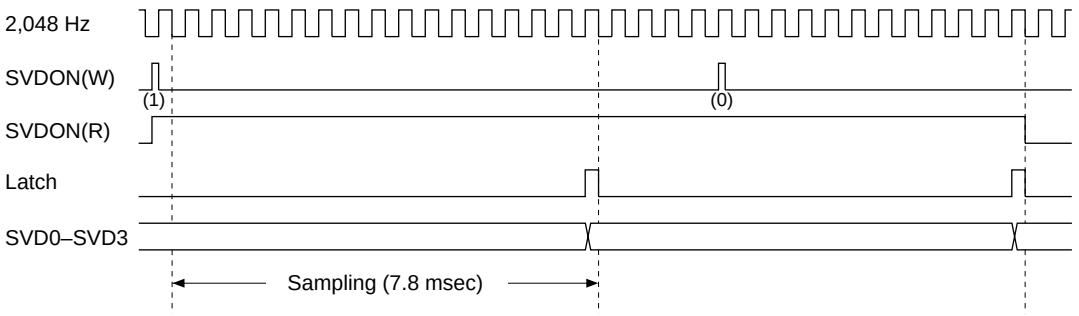


Fig. 5.13.2.1 Timing chart of continuous sampling

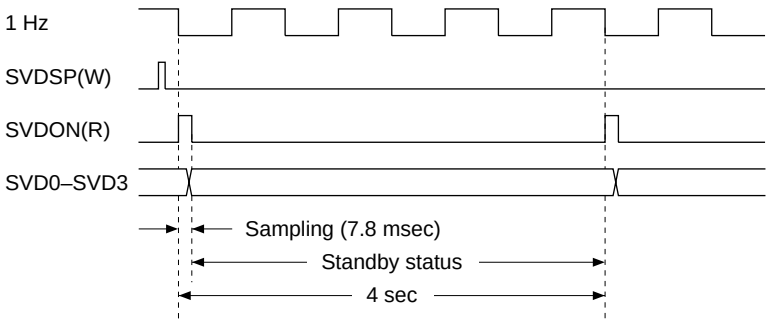


Fig. 5.13.2.2 Timing chart of 1/4 Hz auto-sampling

■ Reset function at low voltage detection

To avoid CPU runaway due to a supply voltage drop, an initial reset function when the supply voltage drops to level 0 or less can be selected by the mask option.
The SVD circuit shifts to continuous sampling status when it detects level 0 (SVD3–SVD0 = 0000B) four successive times. At this time, the internal initial reset signal is generated. The reset status continues until the supply voltage returns to level 2 (SVD3–SVD0 = 0010B) or higher.
When the reset status is canceled by the restoration of the supply voltage, the SVD circuit returns to its previous status. Continuous sampling status continues in case of the previous status was continuous sampling. Then CPU starts the reset exception processing.
Figure 5.13.2.3 shows the timing chart of the initial reset signal generation. (Example when using 1/4 Hz auto-sampling.)

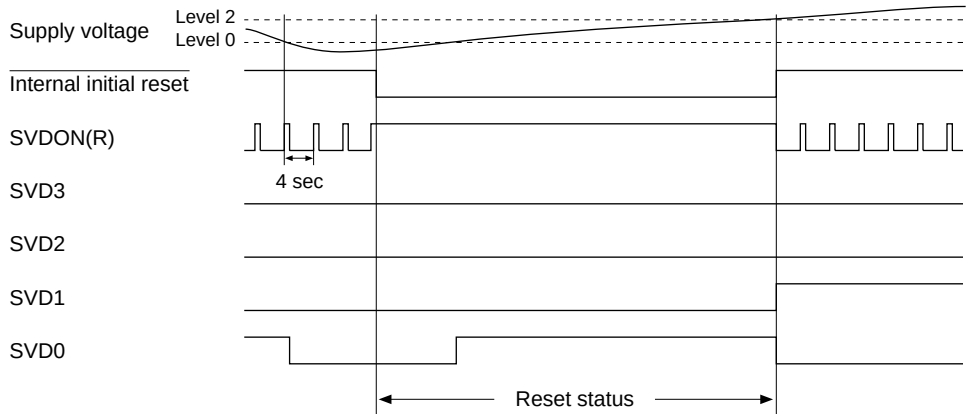


Fig. 5.13.2.3 Timing chart of the initial reset signal generation

5.13.3 Control of SVD circuit

Table 5.13.3.1 shows the SVD circuit control bits.

Table 5.13.3.1 SVD circuit control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF12	D7	–	–	–	–	–		Constantry "0" when
	D6	–	–	–	–	–		being read
	D5	SVDSP	SVD auto-sampling control	On	Off	0	R/W	These registers are reset to "0" when
	D4	SVDON	SVD continuous sampling control/status R	Busy	Ready	1→0*1	R/W	SLP instruction
			W	On	Off	0		is executed.
	D3	SVD3	SVD detection level			X	R	*2
	D2	SVD2	SVD3 SVD2 SVD1 SVD0 Detection level			X	R	
	D1	SVD1	1 1 1 1 Level 15			X	R	
	D0	SVD0	1 1 1 0 Level 14			X	R	
			: : : : :					
			0 0 0 0 Level 0			X	R	

*1 After initial reset, this status is set "1" until conclusion of hardware first sampling.
*2 Initial values are set according to the supply voltage detected at first sampling by hardware.
Until conclusion of first sampling, SVD0–SVD3 data are undefined.

SVDON: 00FF12H•D4

Controls the turning ON/OFF of the continuous sampling mode.

When "1" is written: Continuous sampling ON
When "0" is written: Continuous sampling OFF

When "1" is read: BUSY
When "0" is read: READY

The continuous sampling mode goes ON when "1" is written to SVDON and goes OFF, when "0" is written.
In the ON status, sampling of the supply voltage is done continuously in 7.8 msec cycles and the detection result is latched to SVD0–SVD3.
SVDON can be read, and "1" indicates SVD circuit operation (BUSY) and "0" indicates standby (READY).
At initial reset and in the SLEEP status, SVDON is set to "0" (continuous sampling OFF/READY).

SVDSP: 00FF12H•D5

Controls the turning ON/OFF of the 1/4 Hz auto-sampling mode.

When "1" is written: Auto-sampling ON
When "0" is written: Auto-sampling OFF
Reading: Valid

The 1/4 Hz auto-sampling mode goes ON when "1" is written to SVDSP and goes OFF, when "0" is written.
In the ON status, sampling is done in every 4 seconds and "1" is read from SVDON during the actual sampling period (7.8 msec).
At initial reset and in the SLEEP status, SVDSP is set to "0" (auto-sampling OFF).

SVD0–SVD3: 00FF12H•D0–D3

The detection result of the SVD is set.
The reading data correspond to the detection levels as shown in Table 5.13.3.2 and the data is maintained until the next sampling.

Table 5.13.3.2 Supply voltage detection results

SVD3	SVD2	SVD1	SVD0	Detection level
1	1	1	1	Level 15
1	1	1	0	Level 14
1	1	0	1	Level 13
1	1	0	0	Level 12
1	0	1	1	Level 11
1	0	1	0	Level 10
1	0	0	1	Level 9
1	0	0	0	Level 8
0	1	1	1	Level 7
0	1	1	0	Level 6
0	1	0	1	Level 5
0	1	0	0	Level 4
0	0	1	1	Level 3
0	0	1	0	Level 2
0	0	0	1	Level 1
0	0	0	0	Level 0

For the correspondence between the detection level and the supply voltage, see "7 ELECTRICAL CHARACTERISTICS".
The initial value at initial reset is set according to the supply voltage detected at first sampling by hardware. Data of this bit is undefined until this sampling is completed.

5.13.4 Programming notes

(1) To reduce current consumption, turn the SVD circuit OFF (SVDON = SVDSP = "0") when it is not necessary.

(2) When executing an SLP instruction while the SVD circuit is operating, the stop operation of the OSC1 oscillation circuit is kept waiting until the sampling is completed. The two bits of SVDON and SVDSP are automatically reset to "0" by hardware while waiting for completion of sampling.

5.14 Interrupt and Standby Status

■ Types of interrupts

Six systems and 15 types of interrupts have been provided for the E0C88832/88862.

External interrupt
- K00–K07 input interrupt (2 types)
- K10 input interrupt (1 type)

Internal interrupt
- Clock timer interrupt (4 types)
- Stopwatch interrupt (3 types)
- Programmable timer interrupt (2 types)
- Serial interface interrupt (3 types)

An interrupt factor flag that indicates the generation of an interrupt factor and an interrupt enable register that sets enable/disable for interrupt requests have been provided for each interrupt and interrupt generation can be optionally set for each factor.
In addition, an interrupt priority register has been provided for each system of interrupts and the priority of interrupt processing can be set to 3 levels in each system.
Figure 5.14.1 shows the configuration of the interrupt circuit.

Refer to the explanations of the respective peripheral circuits for details on each interrupt.

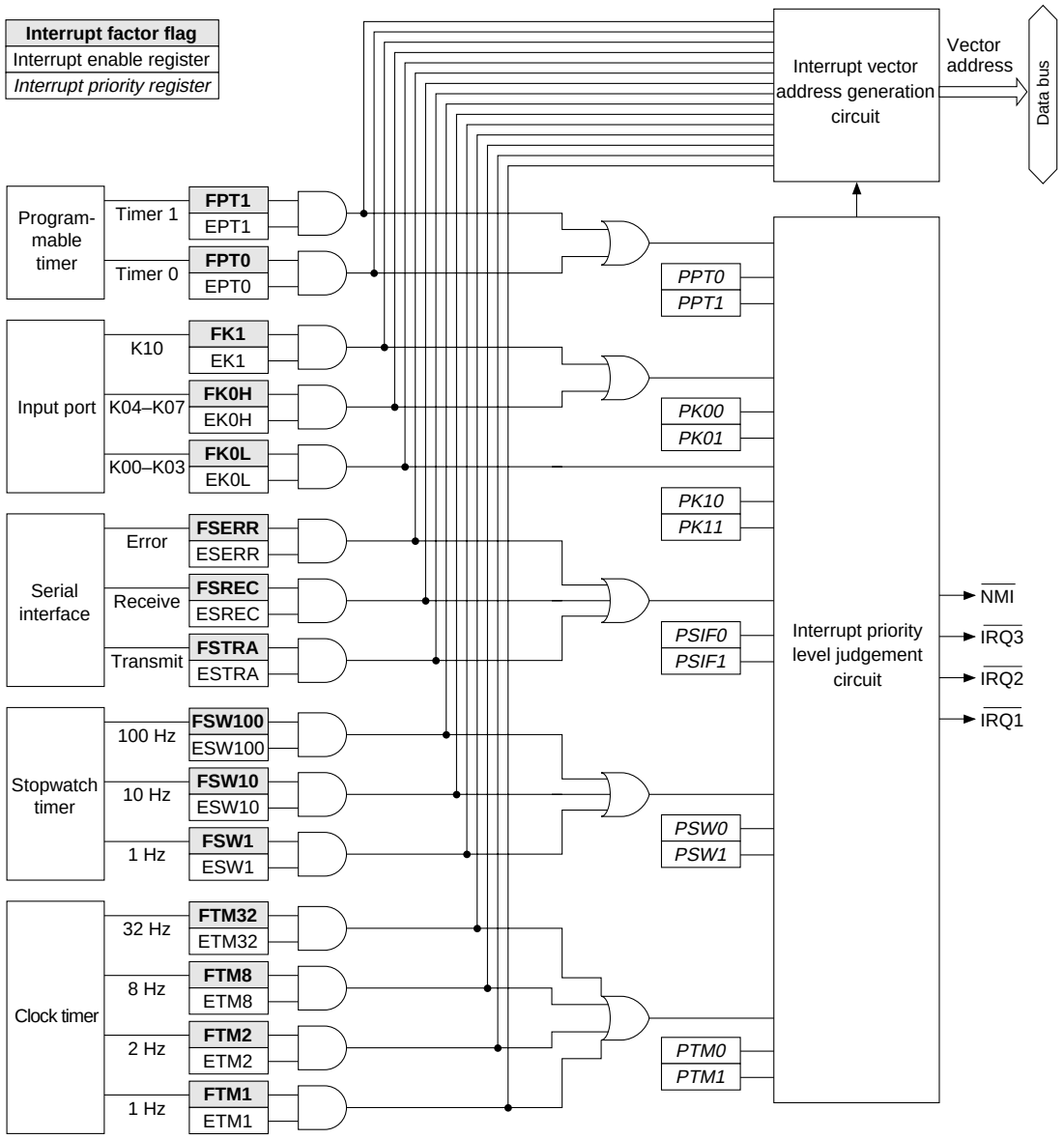


Fig. 5.14.1 Configuration of interrupt circuit

■ HALT status

By executing the program's HALT instruction, the E0C88832/88862 shifts to the HALT status.
Since CPU operation stops in the HALT status, power consumption can be reduced with only peripheral circuit operation.
Cancellation of the HALT status is done by initial reset or an optional interrupt request, and the CPU restarts program execution from an exception processing routine.
See the "E0C88 Core CPU Manual" for the HALT status and reactivation sequence.

■ SLEEP status

By executing the program's SLP instruction, the E0C88832/88862 shifts to the SLEEP status.
Since the operation of the CPU and peripheral circuits stop completely in the SLEEP status, power consumption can be reduced even more than in the HALT status.
Cancellation of the SLEEP status is done by initial reset or an input interrupt from the input port. The CPU reactivates after waiting 8,192/f_{OSC1} seconds of oscillation stabilization time. At this time, the CPU restarts program execution from an exception processing routine (input interrupt routine).

Note: Since oscillation is unstable for a short time after reactivation from the SLEEP status, the wait time is not always 250 msec even when using the 32.768 kHz crystal oscillator for the OSC1 oscillation circuit.

5.14.1 Interrupt generation conditions

The interrupt factor flags that indicate the generation of their respective interrupt factors are provided for the previously indicated 6 systems and 15 types of interrupts and they will be set to "1" by the generation of a factor.

In addition, interrupt enable registers with a 1 to 1 correspondence to each of the interrupt factor flags are provided. An interrupt is enabled when "1" is written and interrupt is disabled when "0" is written.

The CPU manages the enable/disable of interrupt requests at the interrupt priority level. An interrupt priority register that sets the priority level is provided for each of the interrupts of the 6 systems and the CPU accepts only interrupts above the level that has been indicated with the interrupt flags (I0 and I1).
Consequently, the following three conditions are necessary for the CPU to accept the interrupt.

(1) The interrupt factor flag has been set to "1" by generation of an interrupt factor.
(2) The interrupt enable register corresponding to the above has been set to "1".
(3) The interrupt priority register corresponding to the above has been set to a priority level higher than the interrupt flag (I0 and I1) setting.

The CPU initially samples the interrupt for the first op-code fetch cycle of each instruction. Thereupon, the CPU shifts to the exception processing when the above mentioned conditions have been established.
See the "E0C88 Core CPU Manual" for the exception processing sequence.

5.14.2 Interrupt factor flag

Table 5.14.2.1 shows the correspondence between the factors generating an interrupt and the interrupt factor flags.
The corresponding interrupt factor flags are set to "1" by generation of the respective interrupt factors.
The corresponding interrupt factor can be confirmed by reading the flags through software.

Table 5.14.2.1 Interrupt factors

Interrupt factor	Interrupt factor flag	
Programmable timer 1 underflow	FPT1	(00FF25 D7)
Programmable timer 0 underflow	FPT0	(00FF25 D6)
Non matching of the K10 input and the input comparison register KCP10	FK1	(00FF25 D5)
Non matching of the K04–K07 inputs and the input comparison registers KCP04–KCP07	FK0H	(00FF25 D4)
Non matching of the K00–K03 inputs and the input comparison registers KCP00–KCP03	FK0L	(00FF25 D3)
Serial interface receiving error (in asynchronous mode)	FSERR	(00FF25 D2)
Serial interface receiving completion	FSREC	(00FF25 D1)
Serial interface transmitting completion	FSTRA	(00FF25 D0)
Falling edge of the stopwatch timer 100 Hz signal	FSW100	(00FF24 D6)
Falling edge of the stopwatch timer 10 Hz signal	FSW10	(00FF24 D5)
Falling edge of the stopwatch timer 1 Hz signal	FSW1	(00FF24 D4)
Rising edge of the clock timer 32 Hz signal	FTM32	(00FF24 D3)
Rising edge of the clock timer 8 Hz signal	FTM8	(00FF24 D2)
Rising edge of the clock timer 2 Hz signal	FTM2	(00FF24 D1)
Rising edge of the clock timer 1 Hz signal	FTM1	(00FF24 D0)

Interrupt factor flag that has been set to "1" is reset to "0" by writing "1".
At initial reset, the interrupt factor flags are reset to "0".

Note: When executing the RETE instruction without resetting the interrupt factor flag after an interrupt has been generated, the same interrupt will be generated. Consequently, the interrupt factor flag corresponding to that routine must be reset (writing "1") in the interrupt processing routine.

5.14.3 Interrupt enable register

The interrupt enable register has a 1 to 1 correspondence with each interrupt factor flag and enable/disable of interrupt requests can be set.

When "1" is written to the interrupt enable register, an interrupt request is enabled, and is disabled when "0" is written. This register also permits reading, thus making it possible to confirm that a status has been set.
At initial reset, the interrupt enable registers are set to "0" and shifts to the interrupt disable status.
Table 5.14.3.1 shows the correspondence between the interrupt enable registers and the interrupt factor flags.

5.14.4 Interrupt priority register and interrupt priority level

The interrupt priority registers shown in Table 5.14.4.1 are set to each system of interrupts and the interrupt priority levels for the CPU can be set to the optional priority level (0–3). As a result, it is possible to have multiple interrupts that match the system's interrupt processing priority levels.

The interrupt priority level between each system can optionally be set to three levels by the interrupt priority register. However, when more than one system is set to the same priority level, they are processed according to the default priority level.

Table 5.14.4.2 Setting of interrupt priority level

P*1	P*0	Interrupt priority level
1	1	Level 3 ($\overline{IRQ3}$)
1	0	Level 2 ($\overline{IRQ2}$)
0	1	Level 1 ($\overline{IRQ1}$)
0	0	Level 0 (non)

Table 5.14.3.1 Interrupt enable registers and interrupt factor flags

Interrupt	Interrupt factor flag		Interrupt enable register	
Programmable timer 1	FPT1	(00FF25 D7)	EPT1	(00FF23 D7)
Programmable timer 0	FPT0	(00FF25 D6)	EPT0	(00FF23 D6)
K10 input	FK1	(00FF25 D5)	EK1	(00FF23 D5)
K04–K07 input	FK0H	(00FF25 D4)	EK0H	(00FF23 D4)
K00–K03 input	FK0L	(00FF25 D3)	EK0L	(00FF23 D3)
Serial interface receiving error	FSERR	(00FF25 D2)	ESERR	(00FF23 D2)
Serial interface receiving completion	FSREC	(00FF25 D1)	ESREC	(00FF23 D1)
Serial interface transmitting completion	FSTRA	(00FF25 D0)	ESTRA	(00FF23 D0)
Stopwatch timer 100 Hz	FSW100	(00FF24 D6)	ESW100	(00FF22 D6)
Stopwatch timer 10 Hz	FSW10	(00FF24 D5)	ESW10	(00FF22 D5)
Stopwatch timer 1 Hz	FSW1	(00FF24 D4)	ESW1	(00FF22 D4)
Clock timer 32 Hz	FTM32	(00FF24 D3)	ETM32	(00FF22 D3)
Clock timer 8 Hz	FTM8	(00FF24 D2)	ETM8	(00FF22 D2)
Clock timer 2 Hz	FTM2	(00FF24 D1)	ETM2	(00FF22 D1)
Clock timer 1 Hz	FTM1	(00FF24 D0)	ETM1	(00FF22 D0)

Table 5.14.4.1 Interrupt priority register

Interrupt	Interrupt priority register	
Programmable timer interrupt	PPT0, PPT1	(00FF21 D2, D3)
K10 input interrupt	PK10, PK11	(00FF21 D0, D1)
K00–K07 input interrupt	PK00, PK01	(00FF20 D6, D7)
Serial interface interrupt	PSIF0, PSIF1	(00FF20 D4, D5)
Stopwatch timer interrupt	PSW0, PSW1	(00FF20 D2, D3)
Clock timer interrupt	PTM0, PTM1	(00FF20 D0, D1)

At initial reset, the interrupt priority registers are all set to "0" and each interrupt is set to level 0. Furthermore, the priority levels in each system have been previously decided and they cannot be changed.
The CPU can mask each interrupt by setting the interrupt flags (I0 and I1). The relation between the interrupt priority level of each system and interrupt flags is shown in Table 5.14.4.3, and the CPU accepts only interrupts above the level indicated by the interrupt flags.
The $\overline{NMI}$ (watchdog timer) that has level 4 priority, is always accepted regardless of the setting of the interrupt flags.

Table 5.14.4.3 Interrupt mask setting of CPU

I1	I0	Acceptable interrupt
1	1	Level 4 ($\overline{NMI}$)
1	0	Level 4, Level 3 ($\overline{IRQ3}$)
0	1	Level 4, Level 3, Level 2 ($\overline{IRQ2}$)
0	0	Level 4, Level 3, Level 2, Level 1 ($\overline{IRQ1}$)

After an interrupt has been accepted, the interrupt flags are written to the level of that interrupt. However, interrupt flags after an $\overline{NMI}$ has been accepted are written to level 3 (I0 = I1 = "1").

Table 5.14.4.4 Interrupt flags after acceptance of interrupt

Accepted interrupt priority level		I1	I0
Level 4	($\overline{NMI}$)	1	1
Level 3	($\overline{IRQ3}$)	1	1
Level 2	($\overline{IRQ2}$)	1	0
Level 1	($\overline{IRQ1}$)	0	1

The set interrupt flags are reset to their original value on return from the interrupt processing routine. Consequently, multiple interrupts up to 3 levels can be controlled by the initial settings of the interrupt priority registers alone. Additional multiplexing can be realized by rewriting the interrupt flags and interrupt enable register in the interrupt processing routine.

Note: Beware. If the interrupt flags have been rewritten (set to lower priority) prior to resetting an interrupt factor flag after an interrupt has been generated, the same interrupt will be generated again.

5.14.5 Exception processing vectors

When the CPU accepts an interrupt request, it starts exception processing following completion of the instruction being executed. In exception processing, the following operations branch the program.

(1) In the minimum mode, the program counter (PC) and system condition flag (SC) are moved to stack and in the maximum mode, the code bank register (CB), PC and SC are moved.

(2) The branch destination address is read from the exception processing vector corresponding to each exception processing (interrupt) factor and is placed in the PC.

An exception vector is 2 bytes of data in which the top address of each exception (interrupt) processing routine has been stored and the vector addresses correspond to the exception processing factors as shown in Table 5.14.5.1.

Table 5.14.5.1 Vector address and exception processing correspondence

Vector address	Exception processing factor	Priority
000000H	Reset	High
000002H	Zero division	↑
000004H	Watchdog timer ($\overline{NMI}$)	
000006H	Programmable timer 1 interrupt	
000008H	Programmable timer 0 interrupt	
00000AH	K10 input interrupt	
00000CH	K04–K07 input interrupt	
00000EH	K00–K03 input interrupt	
000010H	Serial I/F error interrupt	
000012H	Serial I/F receiving complete interrupt	
000014H	Serial I/F transmitting complete interrupt	
000016H	Stopwatch timer 100 Hz interrupt	
000018H	Stopwatch timer 10 Hz interrupt	
00001AH	Stopwatch timer 1 Hz interrupt	
00001CH	Clock timer 32 Hz interrupt	
00001EH	Clock timer 8 Hz interrupt	
000020H	Clock timer 2 Hz interrupt	↓
000022H	Clock timer 1 Hz interrupt	Low
000024H	System reserved (cannot be used)	No priority rating
000026H : 0000FEH	Software interrupt	

Note: An exception processing vector is fixed at 2 bytes, so it cannot specify a branch destination bank address. Consequently, to branch from multiple banks to a common exception processing routine, the top portion of an exception processing routine must be described within the common area (000000H–007FFFH).

5.14.6 Control of interrupt

Table 5.14.6.1 shows the interrupt control bits.

Table 5.14.6.1 Interrupt control bits

Address	Bit	Name	Function	1	0	SR	R/W	Comment
00FF20	D7	PK01	K00–K07 interrupt priority register	PK01 PK00 / PSIF1 PSIF0 / PSW1 PSW0 / PTM1 PTM0 / Priority level: 1 1 / Level 3; 1 0 / Level 2; 0 1 / Level 1; 0 0 / Level 0		0	R/W	
	D6	PK00				0	R/W	
	D5	PSIF1	Serial interface interrupt priority register			0	R/W	
	D4	PSIF0				0	R/W	
	D3	PSW1	Stopwatch timer interrupt priority register			0	R/W	
	D2	PSW0				0	R/W	
	D1	PTM1	Clock timer interrupt priority register			0	R/W	
	D0	PTM0				0	R/W	
00FF21	D7	–	–	–	–	–		
	D6	–	–	–	–	–		Constantly "0" when being read
	D5	–	–	–	–	–		
	D4	–	–	–	–	–		
	D3	PPT1	Programmable timer interrupt priority register	PPT1 PPT0 / PK11 PK10 / Priority level: 1 1 / Level 3; 1 0 / Level 2; 0 1 / Level 1; 0 0 / Level 0		0	R/W	
	D2	PPT0				0	R/W	
	D1	PK11	K10 interrupt priority register			0	R/W	
	D0	PK10				0	R/W	
00FF22	D7	–	–	–	–	–		"0" when being read
	D6	ESW100	Stopwatch timer 100 Hz interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D5	ESW10	Stopwatch timer 10 Hz interrupt enable register			0	R/W	
	D4	ESW1	Stopwatch timer 1 Hz interrupt enable register			0	R/W	
	D3	ETM32	Clock timer 32 Hz interrupt enable register			0	R/W	
	D2	ETM8	Clock timer 8 Hz interrupt enable register			0	R/W	
	D1	ETM2	Clock timer 2 Hz interrupt enable register			0	R/W	
	D0	ETM1	Clock timer 1 Hz interrupt enable register			0	R/W	
00FF23	D7	EPT1	Programmable timer 1 interrupt enable register	Interrupt enable	Interrupt disable	0	R/W	
	D6	EPT0	Programmable timer 0 interrupt enable register			0	R/W	
	D5	EK1	K10 interrupt enable register			0	R/W	
	D4	EK0H	K04–K07 interrupt enable register			0	R/W	
	D3	EK0L	K00–K03 interrupt enable register			0	R/W	
	D2	ESERR	Serial I/F (error) interrupt enable register			0	R/W	
	D1	ESREC	Serial I/F (receiving) interrupt enable register			0	R/W	
	D0	ESTRA	Serial I/F (transmitting) interrupt enable register			0	R/W	
00FF24	D7	–	–	–	–	–		"0" when being read
	D6	FSW100	Stopwatch timer 100 Hz interrupt factor flag	(R) Interrupt factor is generated / (W) Reset	(R) No interrupt factor is generated / (W) No operation	0	R/W	
	D5	FSW10	Stopwatch timer 10 Hz interrupt factor flag			0	R/W	
	D4	FSW1	Stopwatch timer 1 Hz interrupt factor flag			0	R/W	
	D3	FTM32	Clock timer 32 Hz interrupt factor flag			0	R/W	
	D2	FTM8	Clock timer 8 Hz interrupt factor flag			0	R/W	
	D1	FTM2	Clock timer 2 Hz interrupt factor flag			0	R/W	
	D0	FTM1	Clock timer 1 Hz interrupt factor flag			0	R/W	
00FF25	D7	FPT1	Programmable timer 1 interrupt factor flag	(R) Interrupt factor is generated / (W) Reset	(R) No interrupt factor is generated / (W) No operation	0	R/W	
	D6	FPT0	Programmable timer 0 interrupt factor flag			0	R/W	
	D5	FK1	K10 interrupt factor flag			0	R/W	
	D4	FK0H	K04–K07 interrupt factor flag			0	R/W	
	D3	FK0L	K00–K03 interrupt factor flag			0	R/W	
	D2	FSERR	Serial I/F (error) interrupt factor flag			0	R/W	
	D1	FSREC	Serial I/F (receiving) interrupt factor flag			0	R/W	
	D0	FSTRA	Serial I/F (transmitting) interrupt factor flag			0	R/W	

Refer to the explanations on the respective peripheral circuits for the setting content and control method for each bit.

5.14.7 Programming notes

(1) When executing the RETE instruction without resetting the interrupt factor flag after an interrupt has been generated, the same interrupt will be generated. Consequently, the interrupt factor flag corresponding to that routine must be reset (writing "1") in the interrupt processing routine.

(2) Beware. If the interrupt flags (I0 and I1) have been rewritten (set to lower priority) prior to resetting an interrupt factor flag after an interrupt has been generated, the same interrupt will be generated again.

(3) An exception processing vector is fixed at 2 bytes, so it cannot specify a branch destination bank address. Consequently, to branch from multiple banks to a common exception processing routine, the front portion of an exception processing routine must be described within the common area (000000H–007FFFH).

(4) Do not execute the SLP instruction for 2 msec after a $\overline{\text{NMI}}$ interrupt has occurred (when f_{OSC1} is 32.768 kHz).

5.15 Notes for Low Current Consumption

The E0C88832/88862 can turn circuits, which consume a large amount of power, ON or OFF by control registers.
You can reduce power consumption by creating a program that operates the minimum necessary circuits using these control registers.

Next, which circuit systems' operation can be controlled and their control registers (instructions) are explained. You should refer to these when programming.

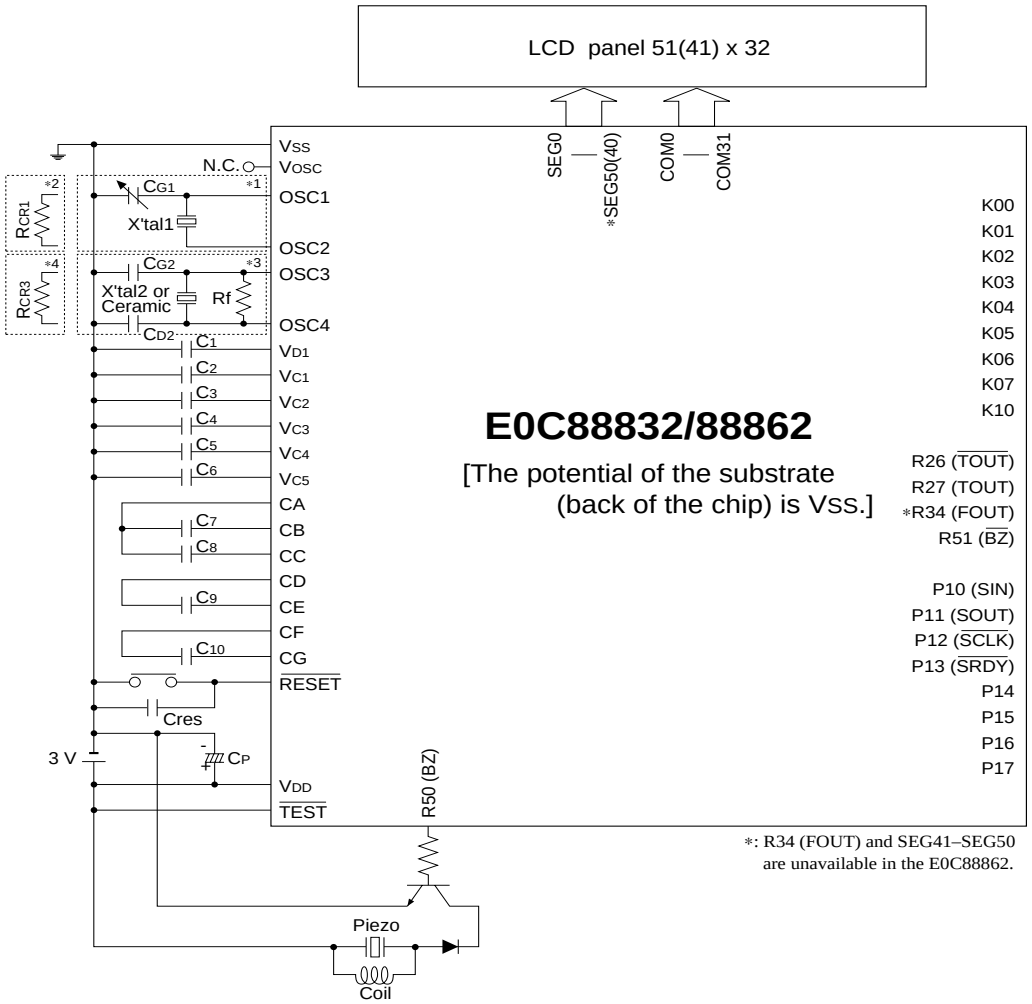
See Chapter 7, "ELECTRICAL CHARACTERISTICS" for the current consumption.

Table 5.15.1 Circuit systems and control registers

Circuit type	Control register (Instruction)	Status at time of initial resetting
CPU	HALT and SLP instructions	Operation status
Oscillation circuit	CLKCHG, OSCC	OSC1 clock (CLKCHG = "0") OSC3 oscillation OFF (OSCC = "0")
Operating mode	VDC0, VDC1	Normal mode (VDC0 = VDC1 = "0")
LCD controller	LCDC0, LCDC1	Drive OFF (LCDC0 = LCDC1 = "0")
SVD circuit	SVDON, SVDSP	OFF status (SVDON = SVDSP = "0")

6 BASIC EXTERNAL WIRING DIAGRAM

● **When the piezoelectric buzzer is driven single terminal and LCD panel is used by 1/5 bias**



*: R34 (FOUT) and SEG41–SEG50 are unavailable in the E0C88862.

Recommended values for external parts

Symbol	Name	Recommended value
X'tal1	Crystal oscillator	32.768 kHz, CI(Max.)=35 kΩ
C_{G1}	Trimmer capacitor	5–25 pF
R_{CR1}	Resistor for CR oscillation	800 kΩ
X'tal2	Crystal oscillator	4.9152 MHz
Ceramic	Ceramic oscillator	4 MHz
Rf	Feedback resistor	1 MΩ
C_{G2}	Gate capacitor	15 pF (Crystal oscillator) 30 pF (Ceramic oscillator)
C_{D2}	Drain capacitor	15 pF (Crystal oscillator) 30 pF (Ceramic oscillator)
R_{CR3}	Resistor for CR oscillation	20 kΩ

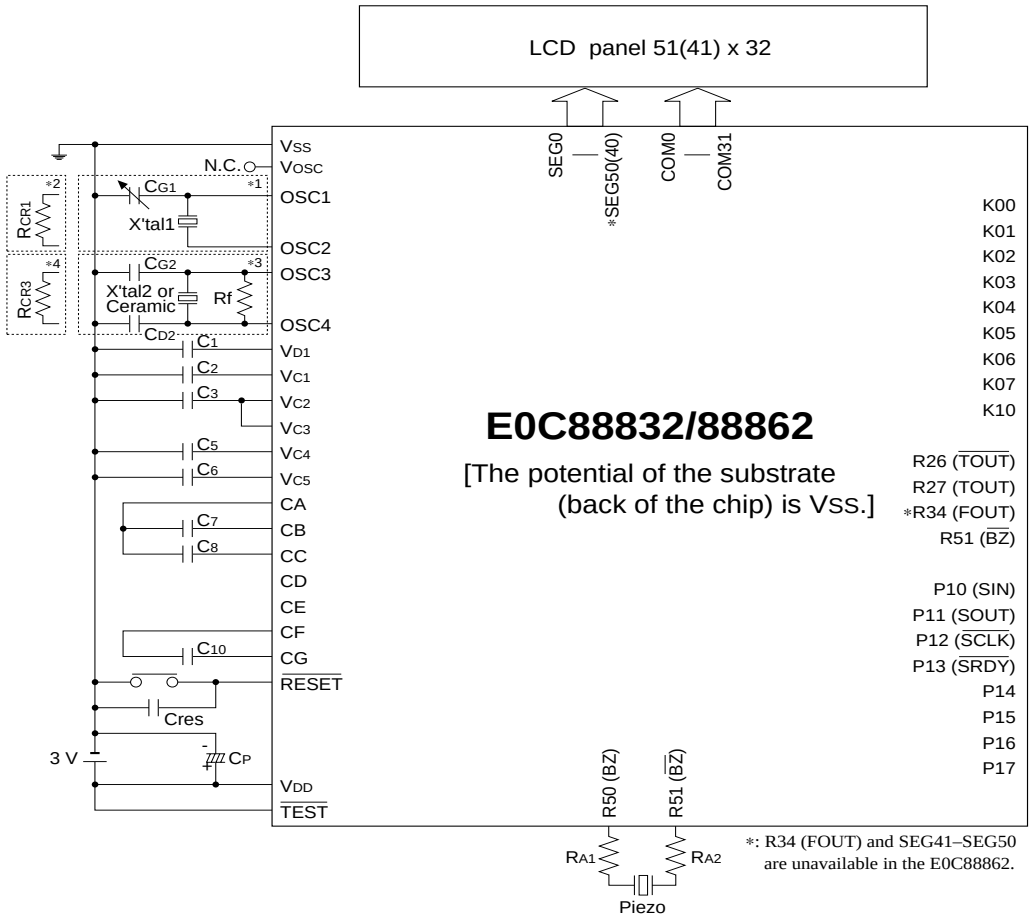
Symbol	Name	Recommended value
C_1	Capacitor between V_{SS} and V_{D1}	0.1 µF
C_2	Capacitor between V_{SS} and V_{C1}	0.1 µF
C_3	Capacitor between V_{SS} and V_{C2}	0.1 µF
C_4	Capacitor between V_{SS} and V_{C3}	0.1 µF
C_5	Capacitor between V_{SS} and V_{C4}	0.1 µF
C_6	Capacitor between V_{SS} and V_{C5}	0.1 µF
C_7–C_{10}	Booster/reducer capacitors	0.1 µF
C_P	Capacitor for power supply	3.3 µF
Cres	Capacitor for $\overline{RESET}$ terminal	0.47 µF

* The connection diagram shown above is an example of when mask option settings are as follows:
LCD power source: Internal power supply (1/5 bias), $\overline{RESET}$ terminal: With pull-up resistor,
R51 specification: General-purpose output port

*1 OSC1 = Crystal oscillation, *2 OSC1 = CR oscillation, *3 OSC3 = Crystal/Ceramic oscillation, *4 OSC3 = CR oscillation

Note: The above table is simply an example. Refer to Chapter 7, "ELECTRICAL CHARACTERISTICS", for detailed characteristics.

● When the piezoelectric buzzer is driven directl and LCD panel is used by 1/4 bias



Recommended values for external parts

Symbol	Name	Recommended value
X'tal1	Crystal oscillator	32.768 kHz, CI(Max.)=35 kΩ
C_{G1}	Trimmer capacitor	5–25 pF
R_{CR1}	Resistor for CR oscillation	800 kΩ
X'tal2	Crystal oscillator	4.9152 MHz
Ceramic	Ceramic oscillator	4 MHz
Rf	Feedback resistor	1 MΩ
C_{G2}	Gate capacitor	15 pF (Crystal oscillator)
		30 pF (Ceramic oscillator)
C_{D2}	Drain capacitor	15 pF (Crystal oscillator)
		30 pF (Ceramic oscillator)
R_{CR3}	Resistor for CR oscillation	20 kΩ

Symbol	Name	Recommended value
C_1	Capacitor between V_{SS} and V_{D1}	0.1 µF
C_2	Capacitor between V_{SS} and V_{C1}	0.1 µF
C_3	Capacitor between V_{SS} and V_{C2}	0.1 µF
C_5	Capacitor between V_{SS} and V_{C4}	0.1 µF
C_6	Capacitor between V_{SS} and V_{C5}	0.1 µF
C_7	Booster/reducer capacitors	0.1 µF
C_8	Booster/reducer capacitors	0.1 µF
C_{10}	Booster/reducer capacitors	0.1 µF
C_P	Capacitor for power supply	3.3 µF
Cres	Capacitor for $\overline{RESET}$ terminal	0.47 µF
R_{A1}, R_{A2}	Protection resistance	100 Ω

* The connection diagram shown above is an example of when mask option settings are as follows:
LCD power source: Internal power supply (1/4 bias), $\overline{RESET}$ terminal: With pull-up resistor,
R51 specification: $\overline{BZ}$ output port

*1 OSC1 = Crystal oscillation, *2 OSC1 = CR oscillation, *3 OSC3 = Crystal/Ceramic oscillation, *4 OSC3 = CR oscillation

Note: The above table is simply an example. Refer to Chapter 7, "ELECTRICAL CHARACTERISTICS", for detailed characteristics.

7 ELECTRICAL CHARACTERISTICS

7.1 Absolute Maximum Rating

(V_{SS} = 0 V)

Item	Symbol	Condition	Rated value	Unit	Note
Power voltage	V_{DD}		-0.3 to +7.0	V	
Liquid crystal power voltage	V_{C5}		-0.3 to +7.0	V	
Input voltage	V_I		-0.3 to V_{DD} + 0.3	V	
Output voltage	V_O		-0.3 to V_{DD} + 0.3	V	1
High level output current	I_{OH}	1 terminal	-5	mA	
		Total of all terminals	-20	mA	
Low level output current	I_{OL}	1 terminal	5	mA	
		Total of all terminals	20	mA	
Permitted loss	P_D		200	mW	2
Operating temperature	Topr		-40 to +85	°C	
Storage temperature	Tstg		-65 to +150	°C	
Soldering temperature / time	Tsol		260°C, 10sec (lead section)	–	

Note) 1 Case that to Nch open drain output by the mask option is included.
2 In case of plastic package.

7.2 Recommended Operating Conditions

(V_{SS} = 0 V, Ta = -40 to 85°C)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Operating power voltage (Normal mode)	V_{DD}		2.4		5.5	V	
Operating power voltage (Low power mode)	V_{DD}		1.8		3.5	V	
Operating power voltage (High speed mode)	V_{DD}		3.5		5.5	V	
Operating frequency (Normal mode)	f_{OSC1}	V_{DD} = 2.4 to 5.5 V	30.000	32.768	80.000	kHz	1
	f_{OSC3}		0.03		4.2	MHz	1
Operating frequency (Low power mode)	f_{OSC1}	V_{DD} = 1.8 to 3.5 V	30.000	32.768	80.000	kHz	1
Operating frequency (High speed mode)	f_{OSC1}	V_{DD} = 3.5 to 5.5 V	30.000	32.768	80.000	kHz	1
	f_{OSC3}		0.03		8.2	MHz	1
Liquid crystal power voltage	V_{C5}	$V_{C5} \geq V_{C4} \geq V_{C3} \geq V_{C2} \geq V_{C1} \geq V_{SS}$			6.0	V	2
Capacitor between V_{D1} and V_{SS}	C_1			0.1		µF	
Capacitor between V_{C1} and V_{SS}	C_2			0.1		µF	3
Capacitor between V_{C2} and V_{SS}	C_3			0.1		µF	3
Capacitor between V_{C3} and V_{SS}	C_4			0.1		µF	3, 4
Capacitor between V_{C4} and V_{SS}	C_5			0.1		µF	3
Capacitor between V_{C5} and V_{SS}	C_6			0.1		µF	3
Capacitor between CA and CB	C_7			0.1		µF	3
Capacitor between CA and CC	C_8			0.1		µF	3
Capacitor between CD and CE	C_9			0.1		µF	3, 4
Capacitor between CF and CG	C_{10}			0.1		µF	3

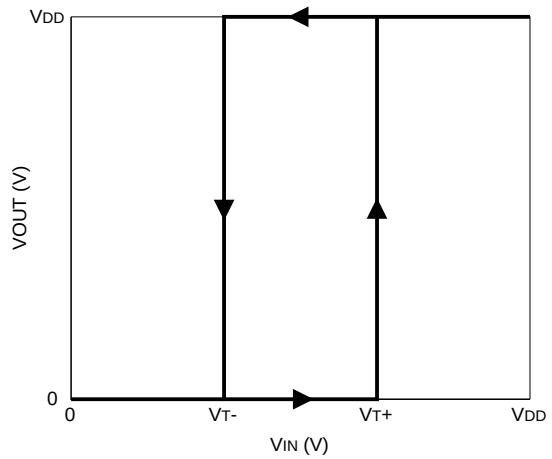
Note) 1 When an external clock is input from the OSC1 terminal by the mask option, leave the OSC2 terminal open, and when an external clock is input from the OSC3 terminal, leave the OSC4 terminal open.
2 When external power supply is selected by the mask option.
3 When LCD drive power is not used, the capacitor is not necessary.
In this case, leave the V_{C1} to V_{C5} and CA to CG terminals open.
4 When LCD drive power is used by 1/4 bias, the C_4 and C_9 capacitors are not necessary.

7.3 DC Characteristics

Unless otherwise specified: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
High level input voltage (1)	V_{IH1}	Kxx, Pxx	0.8V_{DD}		V_{DD}	V	
Low level input voltage (1)	V_{IL1}	Kxx, Pxx,	0		0.2V_{DD}	V	
High level input voltage (2) (Normal mode)	V_{IH2}	OSC3	1.6		V_{DD}	V	1
High level input voltage (2) (Low power mode)	V_{IH2}	OSC1	1.0		V_{DD}	V	1
High level input voltage (2) (High speed mode)	V_{IH2}	OSC3	2.4		V_{DD}	V	1
Low level input voltage (2) (Normal mode)	V_{IL2}	OSC3	0		0.6	V	1
Low level input voltage (2) (Low power mode)	V_{IL2}	OSC1	0		0.3	V	1
Low level input voltage (2) (High speed mode)	V_{IL2}	OSC3	0		0.9	V	1
High level schmitt input voltage	V_{T+}	$\overline{RESET}$	0.5V_{DD}		0.9V_{DD}	V	
Low level schmitt input voltage	V_{T-}	$\overline{RESET}$	0.1V_{DD}		0.5V_{DD}	V	
High level output current	I_{OH}	Pxx, Rxx, V_{OH} = 0.9 V_{DD}			0.5	mA	
Low level output current	I_{OL}	Pxx, Rxx, V_{OL} = 0.1 V_{DD}	0.5			mA	
Input leak current	I_{LI}	Kxx, Pxx, $\overline{RESET}$	-1		1	µA	
Output leak current	I_{LO}	Pxx, Rxx	-1		1	µA	
Input pull-up resistance	R_{IN}	Kxx, Pxx, $\overline{RESET}$	100	300	500	kΩ	2
Input terminal capacitance	C_{IN}	Kxx, Pxx V_{IN} = 0 V, f = 1 MHz, Ta = 25°C		7	15	pF	
Segment/Common output current	I_{SEGH}	SEGxx, COMxx, V_{SEGH} = V_{C5}-0.1 V			-5	µA	
	I_{SEGL}	SEGxx, COMxx, V_{SEGL} = 0.1 V	5			µA	

Note) 1 When external clock is selected by mask option.
2 When pull-up resistor is added by mask option.



7.4 Analog Circuit Characteristics

■ LCD drive circuit

The Typ. values of the LCD drive voltage shown in the following table shift in difference of panel load (panel size, drive duty, display segment number, display pattern). Therefore, these should be evaluated by connecting to the actual panel to be used. See "7.8 Characteristics Curves" for the load characteristics.

• TYPE A

Unless otherwise specified: V_{DD} = V_{C2} (LCX = FH) + 0.1 to 5.5 V, V_{SS} = 0 V, Ta = 25°C, C_1–C_{10} = 0.1 µF

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Note
LCD drive voltage	V_{C2}	When 1 MΩ load resistor is connected between V_{SS} and V_{C2} (no panel load)			0.412V_{C5}		V	
	V_{C5} TYPE A	When 1 MΩ load resistor is connected between V_{SS} and V_{C5} (no panel load)	LCX = 0H	Typ×0.94	3.61	Typ×1.06	V	1
			LCX = 1H		3.76		V	
			LCX = 2H		3.88		V	
			LCX = 3H		4.00		V	
			LCX = 4H		4.12		V	
			LCX = 5H		4.27		V	
			LCX = 6H		4.39		V	
			LCX = 7H		4.51		V	
			LCX = 8H		4.63		V	
			LCX = 9H		4.75		V	
			LCX = AH		4.90		V	
			LCX = BH		5.02		V	
			LCX = CH		5.14		V	
			LCX = DH		5.26		V	
			LCX = EH		5.38		V	
			LCX = FH		5.53		V	

Note) 1 Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.

• TYPE B

Unless otherwise specified: V_{DD} = V_{C2} (LCX = FH) + 0.1 to 5.5 V, V_{SS} = 0 V, Ta = 25°C, C_1–C_{10} = 0.1 µF

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Note
LCD drive voltage	V_{C2}	When 1 MΩ load resistor is connected between V_{SS} and V_{C2} (no panel load)			0.412V_{C5}		V	
	V_{C5} TYPE B	When 1 MΩ load resistor is connected between V_{SS} and V_{C5} (no panel load)	LCX = 0H	Typ×0.94	4.20	Typ×1.06	V	1
			LCX = 1H		4.34		V	
			LCX = 2H		4.49		V	
			LCX = 3H		4.63		V	
			LCX = 4H		4.78		V	
			LCX = 5H		4.92		V	
			LCX = 6H		5.07		V	
			LCX = 7H		5.21		V	
			LCX = 8H		5.36		V	
			LCX = 9H		5.50		V	
			LCX = AH		5.65		V	
			LCX = BH		5.80		V	
			LCX = CH		5.94		V	
			LCX = DH		6.09		V	
			LCX = EH		6.23		V	
			LCX = FH		6.38		V	

Note) 1 Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.

• TYPE C

Unless otherwise specified: V_{DD} = V_{C2} (LCX = FH) + 0.1 to 5.5 V, V_{SS} = 0 V, Ta = 25°C, C_1–C_3, C_5–C_8, C_{10} = 0.1 µF

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Note
LCD drive voltage	V_{C2}	When 1 MΩ load resistor is connected between V_{SS} and V_{C2} (no panel load)			0.505V_{C5}		V	
	V_{C5} TYPE C	When 1 MΩ load resistor is connected between V_{SS} and V_{C5} (no panel load)	LCX = 0H	Typ×0.94	3.43	Typ×1.06	V	1
			LCX = 1H		3.54		V	
			LCX = 2H		3.66		V	
			LCX = 3H		3.78		V	
			LCX = 4H		3.90		V	
			LCX = 5H		4.02		V	
			LCX = 6H		4.14		V	
			LCX = 7H		4.26		V	
			LCX = 8H		4.38		V	
			LCX = 9H		4.49		V	
			LCX = AH		4.61		V	
			LCX = BH		4.73		V	
			LCX = CH		4.85		V	
			LCX = DH		4.97		V	
			LCX = EH		5.09		V	
			LCX = FH		5.21		V	

Note) 1 Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.

• TYPE D

Unless otherwise specified: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = 25°C, C_1–C_3, C_5–C_8, C_{10} = 0.1 µF

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Note
LCD drive voltage	V_{C1}	When 1 MΩ load resistor is connected between V_{SS} and V_{C1} (no panel load)			0.260V_{C5}		V	
	V_{C5} TYPE D	When 1 MΩ load resistor is connected between V_{SS} and V_{C5} (no panel load)	LCX = 0H	Typ×0.94	3.80	Typ×1.06	V	1
			LCX = 1H		3.88		V	
			LCX = 2H		3.96		V	
			LCX = 3H		4.03		V	
			LCX = 4H		4.15		V	
			LCX = 5H		4.22		V	
			LCX = 6H		4.30		V	
			LCX = 7H		4.38		V	
			LCX = 8H		4.45		V	
			LCX = 9H		4.53		V	
			LCX = AH		4.65		V	
			LCX = BH		4.72		V	
			LCX = CH		4.80		V	
			LCX = DH		4.88		V	
			LCX = EH		4.95		V	
			LCX = FH		5.07		V	

Note) 1 Fixing the LCD contrast is not recommended. A contrast adjustment function should be included in the software.

■ SVD circuit

Unless otherwise specified: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = 25°C

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
SVD voltage	V_{SVD}	Level 1 → Level 0	Typ×0.92	1.82	Typ×1.08	V	1
		Level 2 → Level 1		2.00		V	1
		Level 3 → Level 2		2.18		V	1
		Level 4 → Level 3		2.36		V	2
		Level 5 → Level 4		2.54		V	2
		Level 6 → Level 5		2.72		V	2
		Level 7 → Level 6		2.90		V	3
		Level 8 → Level 7		3.08		V	3
		Level 9 → Level 8		3.26		V	3
		Level 10 → Level 9	Typ×0.88	3.45	Typ×1.12	V	4
		Level 11 → Level 10		3.65		V	4
		Level 12 → Level 11		3.85		V	4
		Level 13 → Level 12		4.05		V	4
		Level 14 → Level 13		4.25		V	4
		Level 15 → Level 14		4.50		V	4

$V_{SVD\ (Level\ 0)} < V_{SVD\ (Level\ 1)} < V_{SVD\ (Level\ 2)} < V_{SVD\ (Level\ 3)} < V_{SVD\ (Level\ 4)} < V_{SVD\ (Level\ 5)} < V_{SVD\ (Level\ 6)} < V_{SVD\ (Level\ 7)}$
$< V_{SVD\ (Level\ 8)} < V_{SVD\ (Level\ 9)} < V_{SVD\ (Level\ 10)} < V_{SVD\ (Level\ 11)} < V_{SVD\ (Level\ 12)} < V_{SVD\ (Level\ 13)} < V_{SVD\ (Level\ 14)} < V_{SVD\ (Level\ 15)}$

Note) 1 Low power operating mode only
2 Low power operating mode or Normal operating mode only
3 Normal operating mode only
4 Normal operating mode or High speed operating mode only

7.5 Power Current Consumption

Unless otherwise specified: V_{DD} = Within the operating voltage in each operating mode, V_{SS} = 0 V, Ta = 25°C, OSC1 = 32.768 kHz crystal oscillation, C_G = 25 pF, OSC3 = crystal/ceramic oscillation, Non heavy load protection mode, C_1–C_{10} = 0.1 µF, No panel load

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Power current (Normal mode)	I_{DD1}	In SLEEP status *1		0.3	1	µA	
	I_{DD2}	In HALT status *2		1.5	4	µA	
	I_{DD3}	CPU is in operating (32.768 kHz) *3		9	15	µA	
	I_{DD4}	CPU is in operating (4 MHz) *4		1.1	1.5	mA	
Power current (Low power mode)	I_{DD1}	In SLEEP status *1		0.2	1	µA	
	I_{DD2}	In HALT status *2		1	3	µA	
	I_{DD3}	CPU is in operating (32.768 kHz) *3		5	8	µA	
Power current (High speed mode)	I_{DD1}	In SLEEP status *1		1	3	µA	
	I_{DD2}	In HALT status *2		2	6	µA	
	I_{DD3}	CPU is in operating (32.768 kHz) *3		13	22	µA	
	I_{DD4}	CPU is in operating (8 MHz) *5		3.7	4.9	mA	
LCD drive circuit current	I_{LCDN}			2.5	5	µA	1
	I_{LCDH}	In heavy load protection mode		23	30	µA	2
SVD circuit current	I_{SVDN}	V_{DD} = 3.0 V		30	60	µA	3
OSC1 CR oscillation current	I_{CR1}	R_{CR1} = 800 kΩ		3	20	µA	4

*1 OSC1: Stop, OSC3 = Stop, CPU, ROM, RAM: SLEEP status, Clock timer: Stop, Others: Stop status

*2 OSC1: Oscillating, OSC3 = Stop, CPU, ROM, RAM: HALT status, Clock timer: Operating, Others: Stop status

*3 OSC1: Oscillating, OSC3 = Stop, CPU, ROM, RAM: Operating in 32.768 kHz, Clock timer: Operating, Others: Stop status

*4 OSC1: Oscillating, OSC3 = Oscillating, CPU, ROM, RAM: Operating in 4 MHz, Clock timer: Operating, Others: Stop status
See "7.8 Characteristics Curves" for current consumption with an operating frequency other than 4 MHz.

*5 OSC1: Oscillating, OSC3 = Oscillating, CPU, ROM, RAM: Operating in 8 MHz, Clock timer: Operating, Others: Stop status
See "7.8 Characteristics Curves" for current consumption with an operating frequency other than 8 MHz.

Note) 1 The LCD drive circuit current varies according to the display patterns.

2 It is the value of current which flows in the heavy load protection circuit when in the heavy load protection mode (OSC3 ON or buzzer ON).

3 The value in ***x*** V can be found by the following expression: I_{SVDN} (V_{DD} = ***x*** V) = (***x*** × 20) - 30 (Typ. value), I_{SVDN} (V_{DD} = ***x*** V) = (***x*** × 30) - 30 (Max. value)

4 When OSC1 CR oscillation circuit is selected by the mask option.

7.6 AC Characteristics

■ External memory access

Condition: V_{DD} = Within the operating voltage in each operating mode, V_{SS} = 0 V, Ta = -40 to 85°C

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Operating frequency (Normal mode)	f_{OSC1}	V_{DD} = 2.4 to 5.5 V	30.000	32.768	80.000	kHz	
	f_{OSC3}		0.03		4.2	MHz	
Operating frequency (Low power mode)	f_{OSC1}	V_{DD} = 1.8 to 3.5 V	30.000	32.768	80.000	kHz	
Operating frequency (High speed mode)	f_{OSC1}	V_{DD} = 3.5 to 5.5 V	30.000	32.768	80.000	kHz	
	f_{OSC3}		0.03		8.2	MHz	
Instruction execution time (during operation with OSC1 clock)	tcy	1-cycle instruction	25	61	67	µS	
		2-cycle instruction	50	122	133	µS	
		3-cycle instruction	75	183	200	µS	
		4-cycle instruction	100	244	267	µS	
		5-cycle instruction	125	305	333	µS	
		6-cycle instruction	150	366	400	µS	
Instruction execution time Normal mode (during operation with OSC3 clock)	tcy	1-cycle instruction	0.5		66.7	µS	
		2-cycle instruction	1.0		133.3	µS	
		3-cycle instruction	1.4		200.0	µS	
		4-cycle instruction	1.9		266.7	µS	
		5-cycle instruction	2.4		333.3	µS	
		6-cycle instruction	2.9		400.0	µS	
Instruction execution time High speed mode (during operation with OSC3 clock)	tcy	1-cycle instruction	0.2		66.7	µS	
		2-cycle instruction	0.5		133.3	µS	
		3-cycle instruction	0.7		200.0	µS	
		4-cycle instruction	1.0		266.7	µS	
		5-cycle instruction	1.2		333.3	µS	
		6-cycle instruction	1.5		400.0	µS	

■ Serial interface

• Clock synchronous master mode (Normal operating mode)

Condition: V_{DD} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tsmd			200	nS	
Receiving data input set-up time	tsms	500			nS	
Receiving data input hold time	tsmh	200			nS	

• Clock synchronous master mode (High speed operating mode)

Condition: V_{DD} = 3.5 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tsmd			100	nS	
Receiving data input set-up time	tsms	250			nS	
Receiving data input hold time	tsmh	100			nS	

• Clock synchronous master mode (Low power operating mode)

Condition: V_{DD} = 1.8 to 3.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tsmd			5	µS	
Receiving data input set-up time	tsms	10			µS	
Receiving data input hold time	tsmh	5			µS	

• Clock synchronous slave mode (Normal operating mode)

Condition: V_{DD} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tssd			500	nS	
Receiving data input set-up time	tsss	200			nS	
Receiving data input hold time	tssh	200			nS	

• Clock synchronous slave mode (High speed operating mode)

Condition: V_{DD} = 3.5 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tssd			250	nS	
Receiving data input set-up time	tsss	100			nS	
Receiving data input hold time	tssh	100			nS	

• Clock synchronous slave mode (Low power operating mode)

Condition: V_{DD} = 1.8 to 3.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}, V_{OH} = 0.8V_{DD}, V_{OL} = 0.2V_{DD}

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Transmitting data output delay time	tssd			10	µS	
Receiving data input set-up time	tsss	5			µS	
Receiving data input hold time	tssh	5			µS	

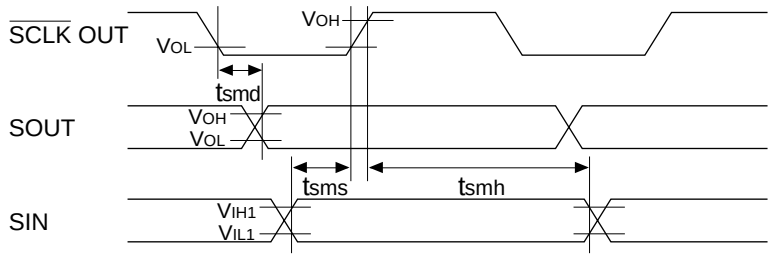
• Asynchronous system (All operating mode)

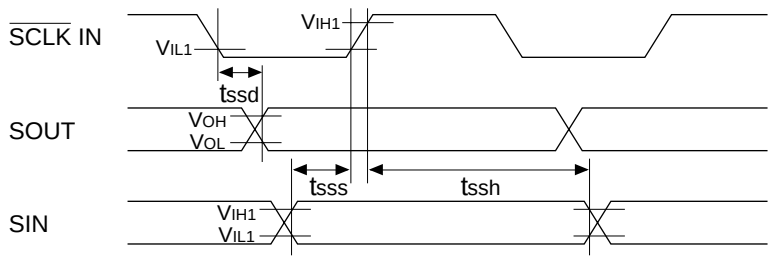
Condition: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C

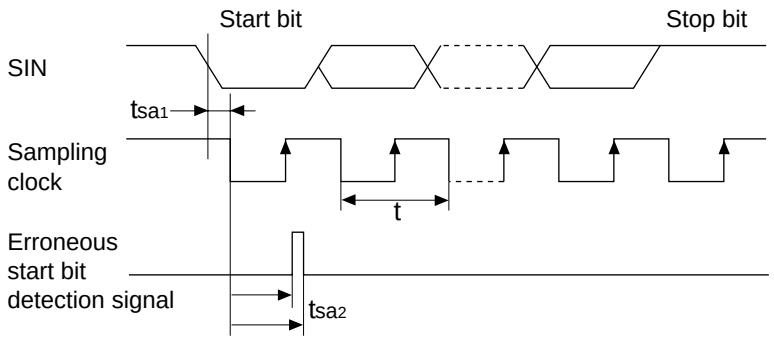
Item	Symbol	Min.	Typ.	Max.	Unit	Note
Start bit detection error time	t_{sa1}	0		t/16	S	1
Erroneous start bit detection range time	t_{sa2}	9t/16		10t/16	S	2

Note) 1 Start bit detection error time is a logical delay time from inputting the start bit until internal sampling begins operating. (Time as far as AC is excluded.)

2 Erroneous start bit detection range time is a logical range to detect whether a LOW level (start bit) has been input again after a start bit has been detected and the internal sampling clock has started.
When a HIGH level is detected, the start bit detection circuit is reset and goes into a wait status until the next start bit. (Time as far as AC is excluded.)







■ Input clock

• OSC3 external clock (Normal operating mode)

Condition: V_{DD} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH2} = 1.6 V, V_{IL2} = 0.6 V

Item		Symbol	Min.	Typ.	Max.	Unit	Note
OSC3 input clock time	Cycle time	t_{o3cy}	250		32,000	nS	
	"H" pulse width	t_{o3h}	125		16,000	nS	
	"L" pulse width	t_{o3l}	125		16,000	nS	
Input clock rising time		t_{osr}			25	nS	
Input clock falling time		t_{osf}			25	nS	

• OSC3 external clock (High speed operating mode)

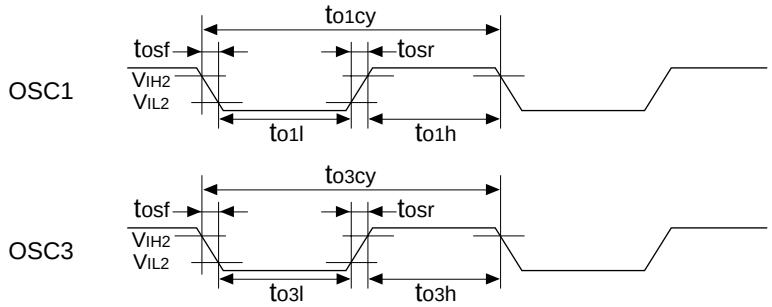
Condition: V_{DD} = 3.5 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH2} = 2.4 V, V_{IL2} = 0.9 V

Item		Symbol	Min.	Typ.	Max.	Unit	Note
OSC3 input clock time	Cycle time	t_{o3cy}	125		32,000	nS	
	"H" pulse width	t_{o3h}	62.5		16,000	nS	
	"L" pulse width	t_{o3l}	62.5		16,000	nS	
Input clock rising time		t_{osr}			25	nS	
Input clock falling time		t_{osf}			25	nS	

• OSC1 external clock (Low power operating mode)

Condition: V_{DD} = 1.8 to 3.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH2} = 1.0 V, V_{IL2} = 0.3 V

Item		Symbol	Min.	Typ.	Max.	Unit	Note
OSC1 input clock time	Cycle time	t_{o1cy}	12		32	µS	
	"H" pulse width	t_{o1h}	6		16	µS	
	"L" pulse width	t_{o1l}	6		16	µS	
Input clock rising time		t_{osr}			25	nS	
Input clock falling time		t_{osf}			25	nS	



• $\overline{\text{SCLK}}$, EVIN input clock (Normal operating mode)

Condition: V_{DD} = 2.4 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}

Item		System	Min.	Typ.	Max.	Unit	Note
$\overline{\text{SCLK}}$ input clock time	Cycle time	tsccy	4			µS	
	"H" pulse width	tsch	2			µS	
	"L" pulse width	tscl	2			µS	
EVIN input clock time (With noise rejector)	Cycle time	tevcy	64 / f_{OSC1}			S	
	"H" pulse width	tevh	32 / f_{OSC1}			S	
	"L" pulse width	tevl	32 / f_{OSC1}			S	
EVIN input clock time (Without noise rejector)	Cycle time	tevcy	4			µS	
	"H" pulse width	tevh	2			µS	
	"L" pulse width	tevl	2			µS	
Input clock rising time		tckr			25	nS	
Input clock falling time		tckf			25	nS	

• $\overline{\text{SCLK}}$, EVIN input clock (High speed operating mode)

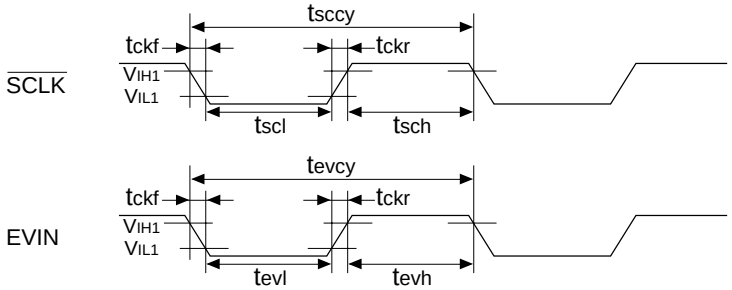
Condition: V_{DD} = 3.5 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}

Item		System	Min.	Typ.	Max.	Unit	Note
$\overline{\text{SCLK}}$ input clock time	Cycle time	tsccy	2			µS	
	"H" pulse width	tsch	1			µS	
	"L" pulse width	tscl	1			µS	
EVIN input clock time (With noise rejector)	Cycle time	tevcy	64 / f_{OSC1}			S	
	"H" pulse width	tevh	32 / f_{OSC1}			S	
	"L" pulse width	tevl	32 / f_{OSC1}			S	
EVIN input clock time (Without noise rejector)	Cycle time	tevcy	2			µS	
	"H" pulse width	tevh	1			µS	
	"L" pulse width	tevl	1			µS	
Input clock rising time		tckr			25	nS	
Input clock falling time		tckf			25	nS	

• $\overline{\text{SCLK}}$, EVIN input clock (Low power operating mode)

Condition: V_{DD} = 1.8 to 3.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH1} = 0.8V_{DD}, V_{IL1} = 0.2V_{DD}

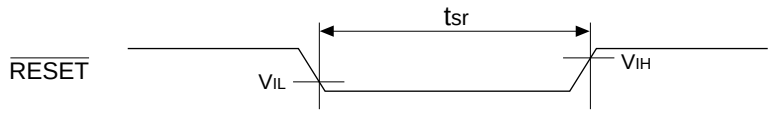
Item		System	Min.	Typ.	Max.	Unit	Note
$\overline{\text{SCLK}}$ input clock time	Cycle time	tsccy	100			µS	
	"H" pulse width	tsch	50			µS	
	"L" pulse width	tscl	50			µS	
EVIN input clock time (With noise rejector)	Cycle time	tevcy	64 / f_{OSC1}			S	
	"H" pulse width	tevh	32 / f_{OSC1}			S	
	"L" pulse width	tevl	32 / f_{OSC1}			S	
EVIN input clock time (Without noise rejector)	Cycle time	tevcy	100			µS	
	"H" pulse width	tevh	50			µS	
	"L" pulse width	tevl	50			µS	
Input clock rising time		tckr			25	nS	
Input clock falling time		tckf			25	nS	



• $\overline{\text{RESET}}$ input clock (All operating mode)

Condition: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C, V_{IH} = 0.5V_{DD}, V_{IL} = 0.1V_{DD}

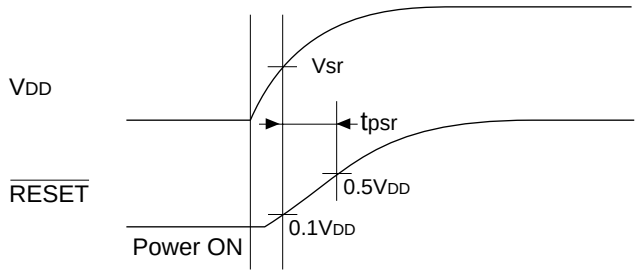
Item	Symbol	Min.	Typ.	Max.	Unit	Note
$\overline{\text{RESET}}$ input time	tsr	100			µS	

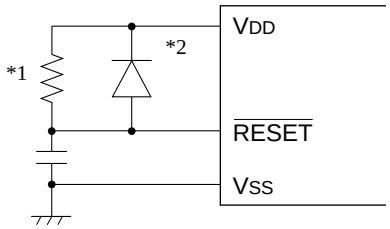


■ Power ON reset

Condition: V_{SS} = 0 V, Ta = -40 to 85°C

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Operating power voltage	Vsr	2.4			V	
$\overline{\text{RESET}}$ input time	tpsr	10			mS	





*1 When the built-in pull up resistor is not used.

*2 Because the potential of the $\overline{\text{RESET}}$ terminal not reached V_{DD} level or higher.

■ Operating mode switching

Condition: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Stabilization time	tvdc	5			mS	1

Note) 1 Stabilization time is the time from switching on the operating mode until operating mode is stabilized. For example, when turning the OSC3 oscillation circuit on, stabilization time is needed after the operating mode is switched on.

7.7 Oscillation Characteristics

Oscillation characteristics change depending on conditions (board pattern, components used, etc.). Use the following characteristics as reference values. In particular, when a ceramic oscillator is used for OSC3, use the oscillator manufacturer's recommended values for constants such as capacitance and resistance. The oscillation start time is important because it becomes the wait time when OSC3 clock is used. (If OSC3 is used as CPU clock before oscillation stabilizes, the CPU may malfunction.)

■ OSC1 (Crystal)

Unless otherwise specified: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = 25°C, Crystal oscillator = C2-TYPE*, C_{G1} = 25 pF (external), C_{D1} = Built-in

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Oscillation start time	tsta				3	S	
External gate capacitance	C_{G1}	Including board capacitance	5		25	pF	1
Built-in gate capacitance	C_{G1}	In case of the chip		12		pF	2
Built-in drain capacitance	C_{D1}	In case of the chip		12		pF	
Frequency/IC deviation	∂f/∂IC	V_{DD} = constant	-10		10	ppm	
Frequency/power voltage deviation	∂f/∂V				1	ppm/V	
Frequency adjustment range	∂f/∂C_G	V_{DD} = constant, C_G = 5 to 25 pF	25			ppm	

* C2-TYPE Made by Seiko Epson corporation

Note) 1 When crystal oscillation is selected by the mask option.

2 When crystal oscillation (gate capacitor built-in) is selected by the mask option.

■ OSC1 (CR)

Unless otherwise specified: V_{DD} = 1.8 to 5.5 V, V_{SS} = 0 V, Ta = -40 to 85°C

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Oscillation start time	tsta				100	µS	
Frequency/IC deviation	∂f/∂IC	R_{CR} = constant	-25		25	%	

■ OSC3 (Crystal)

Unless otherwise specified: V_{DD} = Within the operating voltage in each operating mode, V_{SS} = 0 V, Ta = 25°C,
Crystal oscillator = CA-301 4MHz / CA-301 8MHz*, R_F = 1 MΩ, C_{G2} = C_{D2} = 15 pF

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Oscillation start time (Normal mode)	tsta	4.0 MHz crystal oscillator			10	mS	1
Oscillation start time (High speed mode)	tsta	8.0 MHz crystal oscillator			10	mS	1

* CA-301 4MHz / CA-301 8MHz Made by Seiko Epson corporation

Note) 1 The crystal oscillation start time changes by the crystal oscillator to be used, C_{G2} and C_{D2}.

■ OSC3 (Ceramic)

Unless otherwise specified: V_{DD} = Within the operating voltage in each operating mode, V_{SS} = 0 V, Ta = 25°C,
Ceramic oscillator = CSA4.00MG / CSA8.00MTZ*, R_F = 1 MΩ, C_{G2} = C_{D2} = 30 pF

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Oscillation start time (Normal mode)	tsta	4.0 MHz ceramic oscillator			1	mS	
Oscillation start time (High speed mode)	tsta	8.0 MHz ceramic oscillator			1	mS	

* CSA4.00MG / CSA8.00MTZ Made by Murata Mfg. corporation

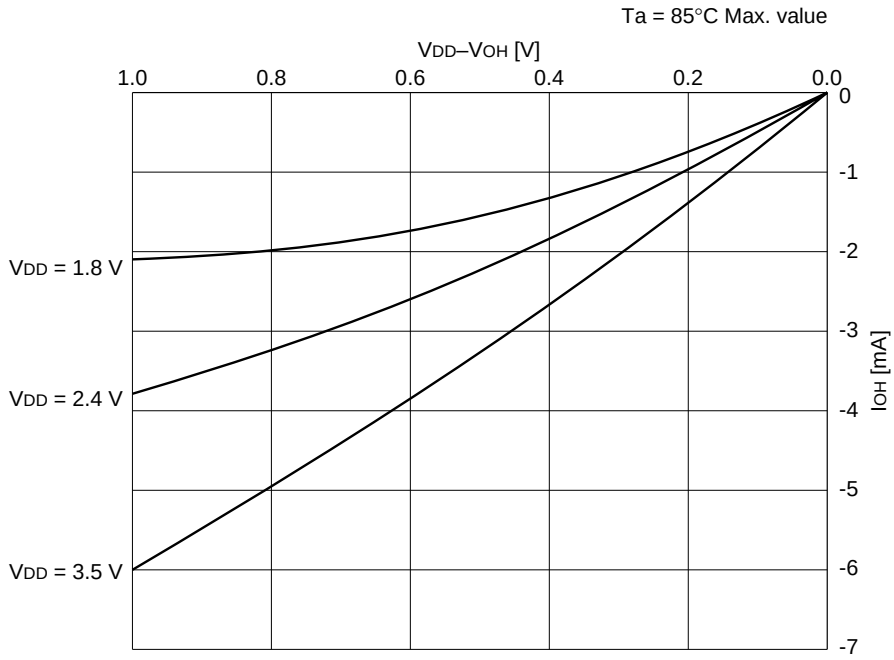
■ OSC3 (CR)

Unless otherwise specified: V_{DD} = Within the operating voltage in each operating mode, V_{SS} = 0 V, Ta = -40 to 85°C

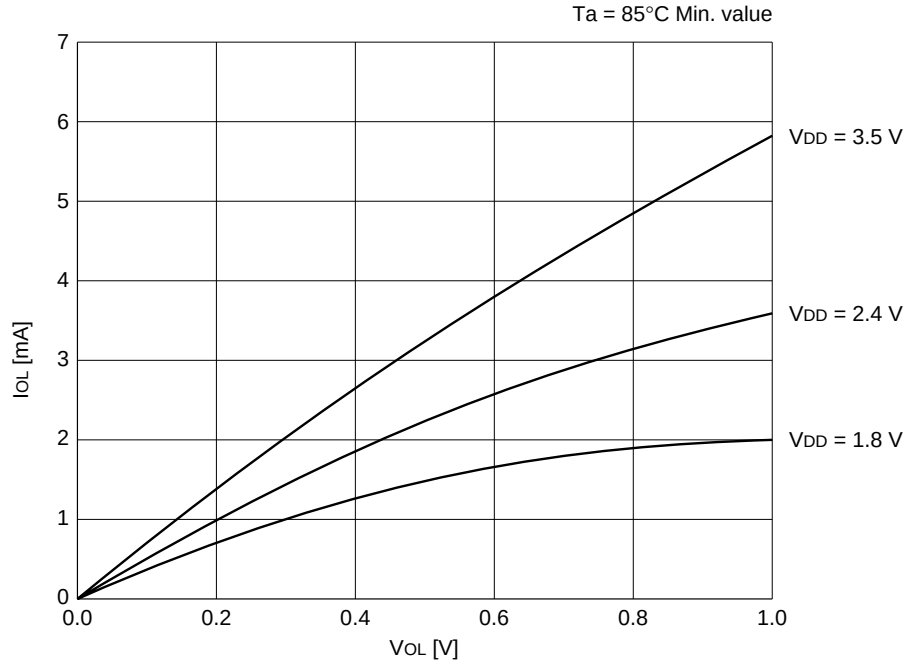
Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Oscillation start time (Normal mode)	tsta				100	µS	
Oscillation start time (High speed mode)	tsta				100	µS	
Frequency/IC deviation (Normal mode)	∂f/∂IC	R_{CR} = constant	-25		25	%	
Frequency/IC deviation (High speed mode)	∂f/∂IC	R_{CR} = constant	-25		25	%	

7.8 Characteristics Curves (reference value)

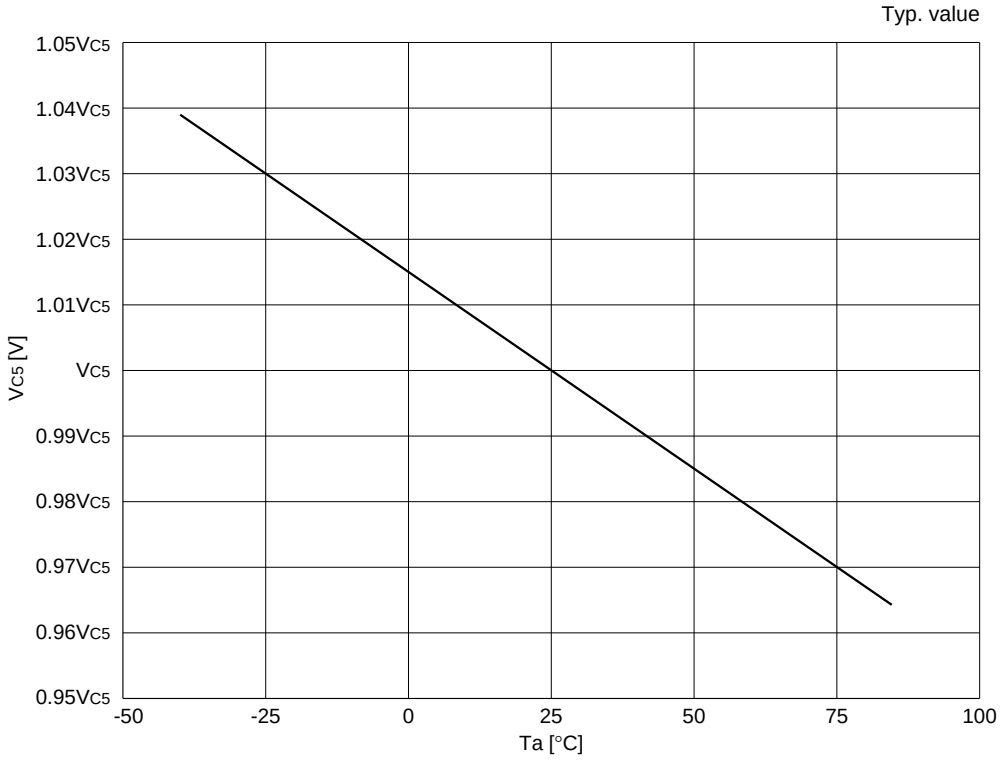
■ High level output current-voltage characteristic



■ Low level output current-voltage characteristic

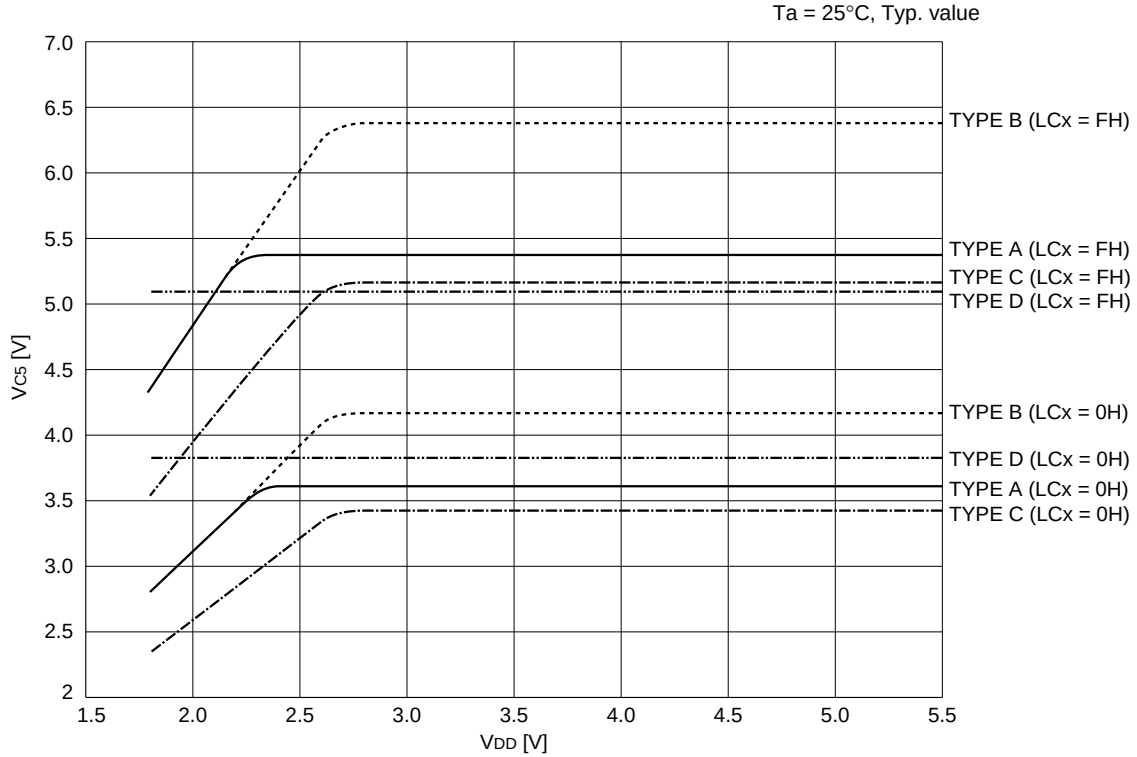


■ LCD drive voltage-ambient temperature characteristic

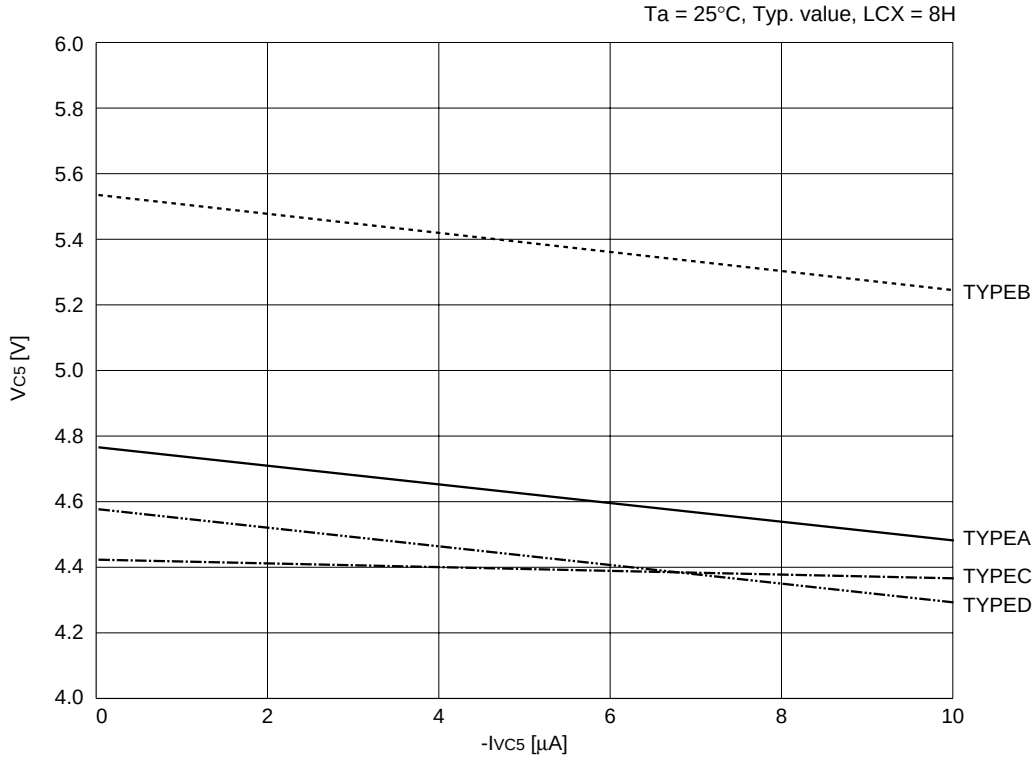


■ LCD drive voltage-supply voltage characteristic

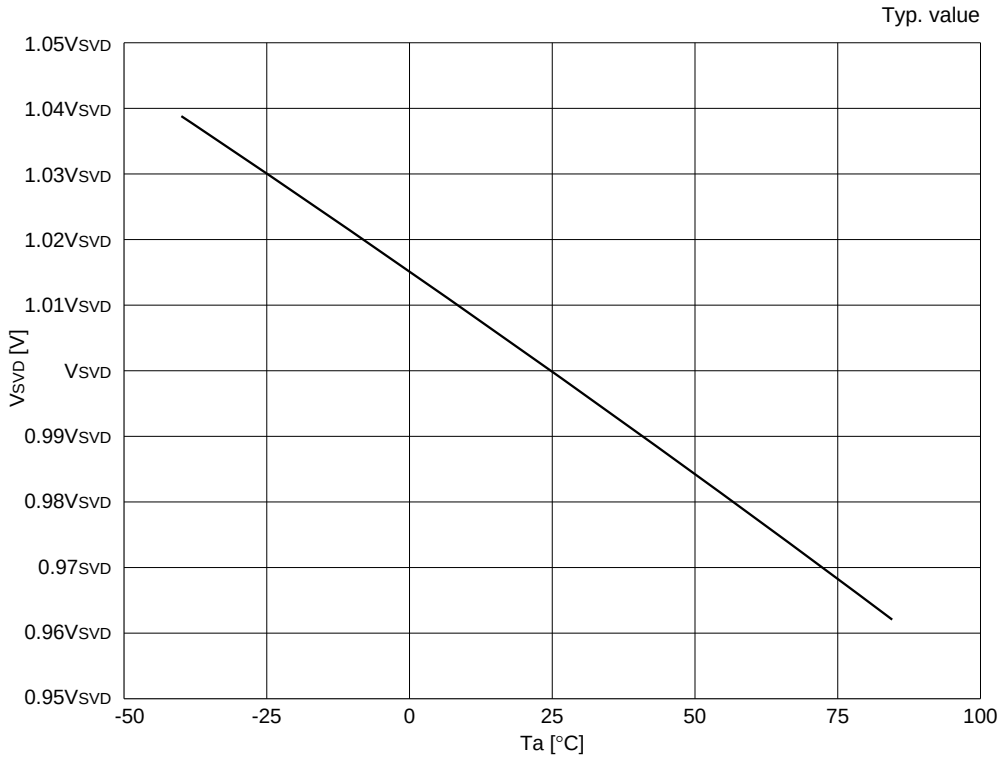
When 1 MΩ load resistor is connected between VSS and VC5 (no panel load)



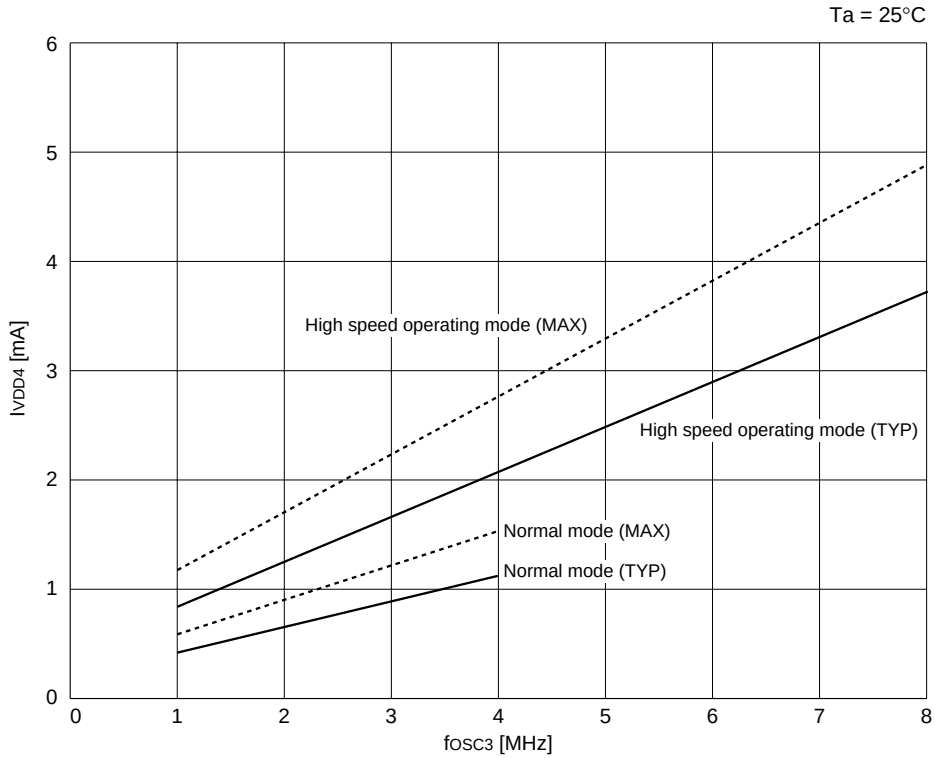
■ LCD drive voltage-load characteristic



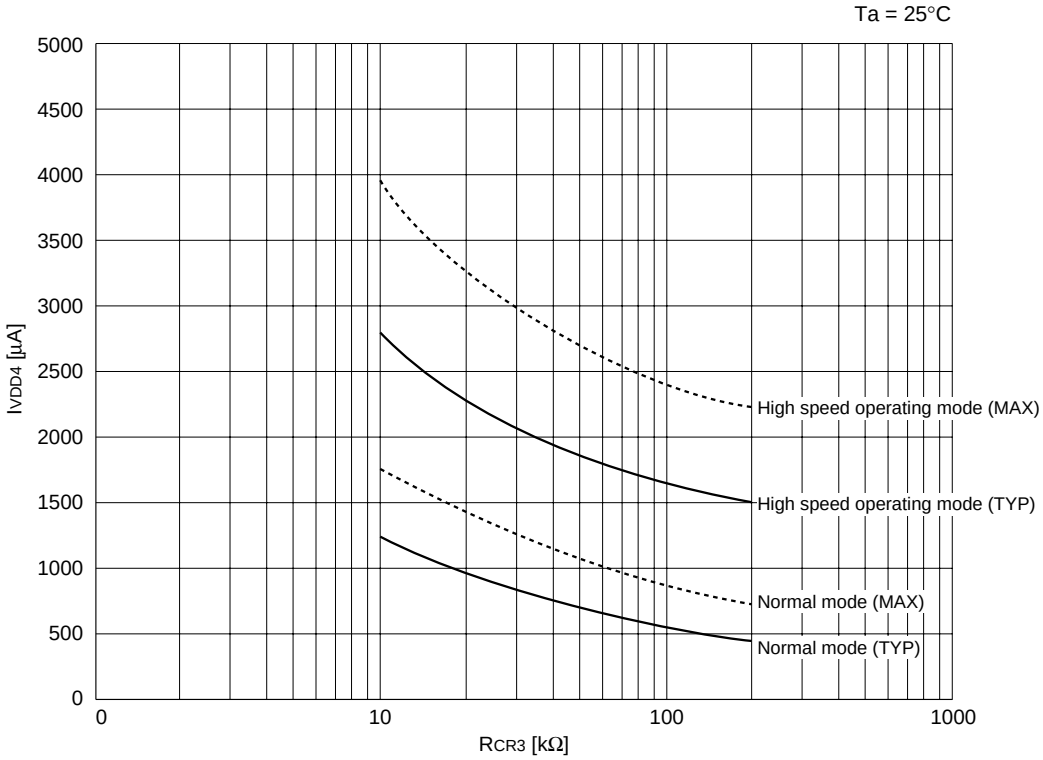
■ SVD voltage-ambient temperature characteristic



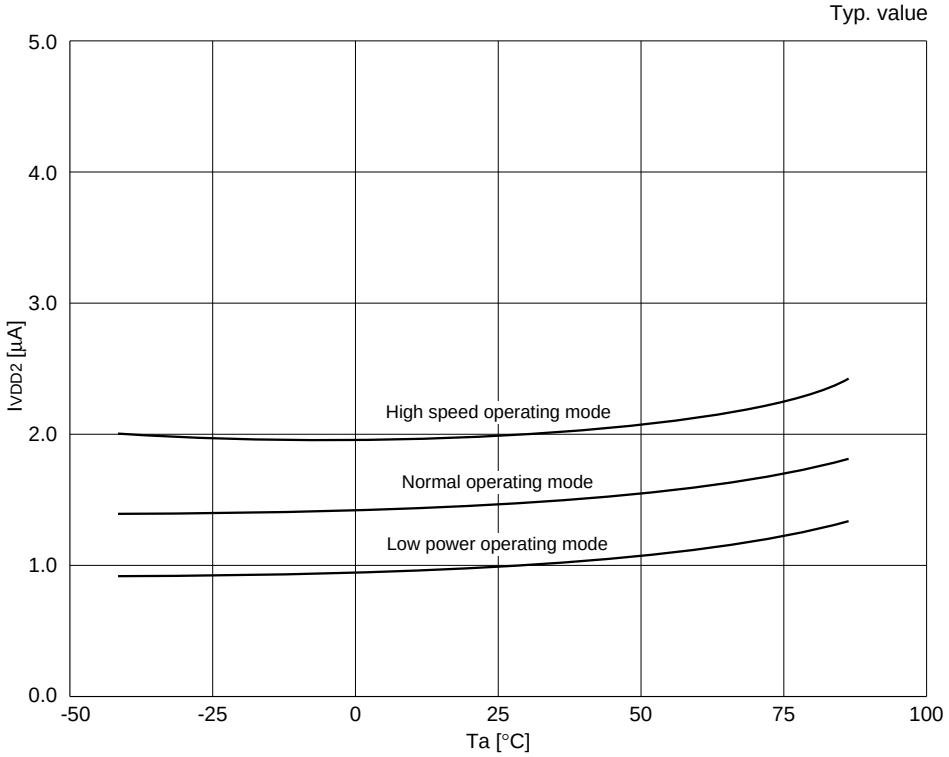
■ Power current (CPU is in operating) <OSC3 crystal/ceramic oscillation>



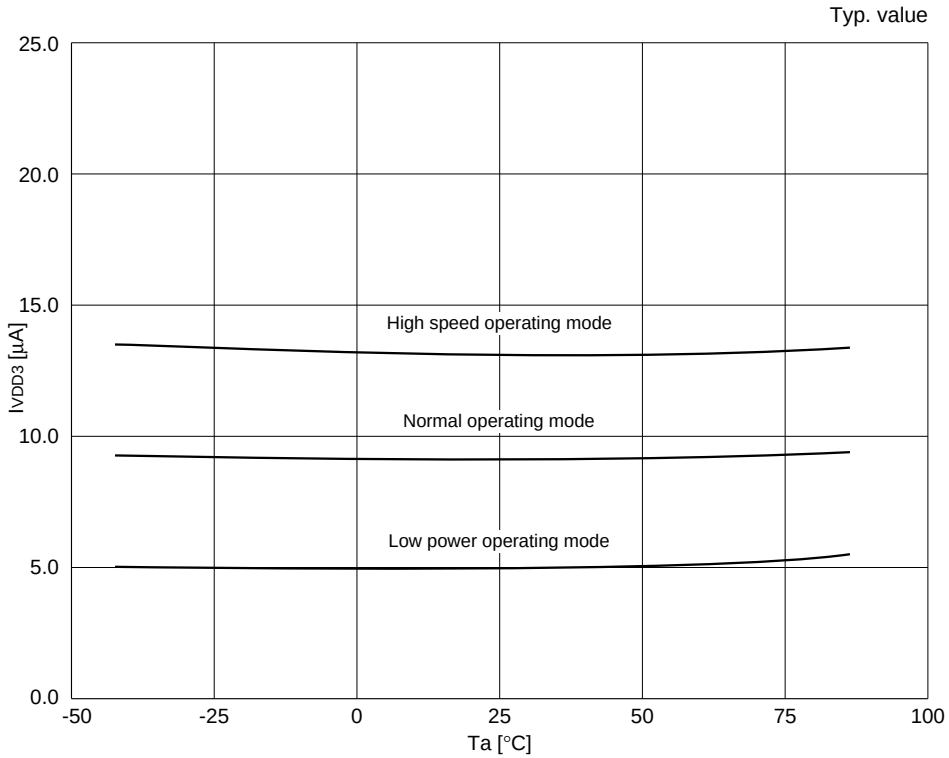
■ Power current (CPU is in operating) <OSC3 CR oscillation>



■ Power current-ambient temperature characteristic (In HALT status)



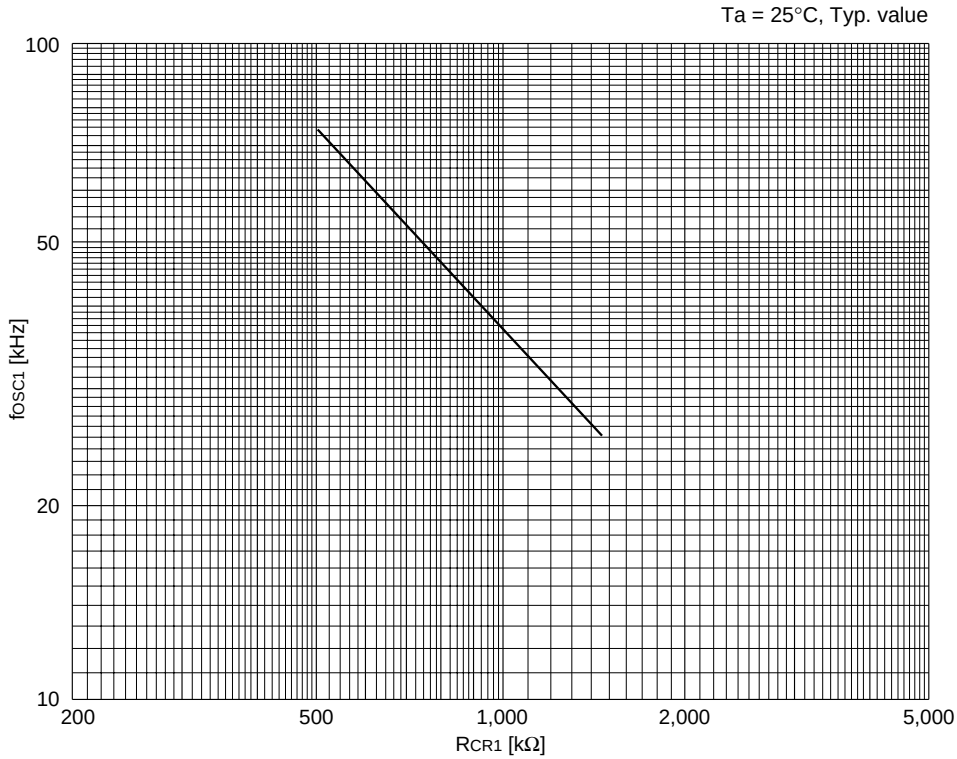
■ Power current-ambient temperature characteristic (CPU is under 32.768 kHz operation)



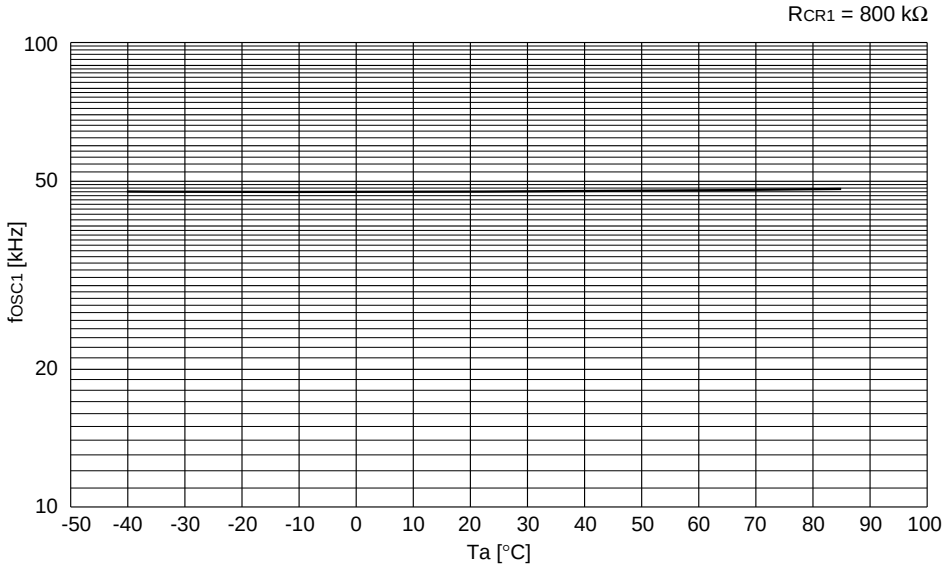
■ CR oscillation frequency characteristic

Note: Oscillation frequency changes depending on the conditions (components used, board pattern, etc.). In particular, the OSC3 oscillation frequency changes extensively depending on the product form (chip, plastic package or ceramic package) and board capacitance. Therefore, use the following charts for reference only and select the resistance value after evaluating the actual product. (The resistance value should be set to $R_{CR3} \geq 15$ kΩ.)

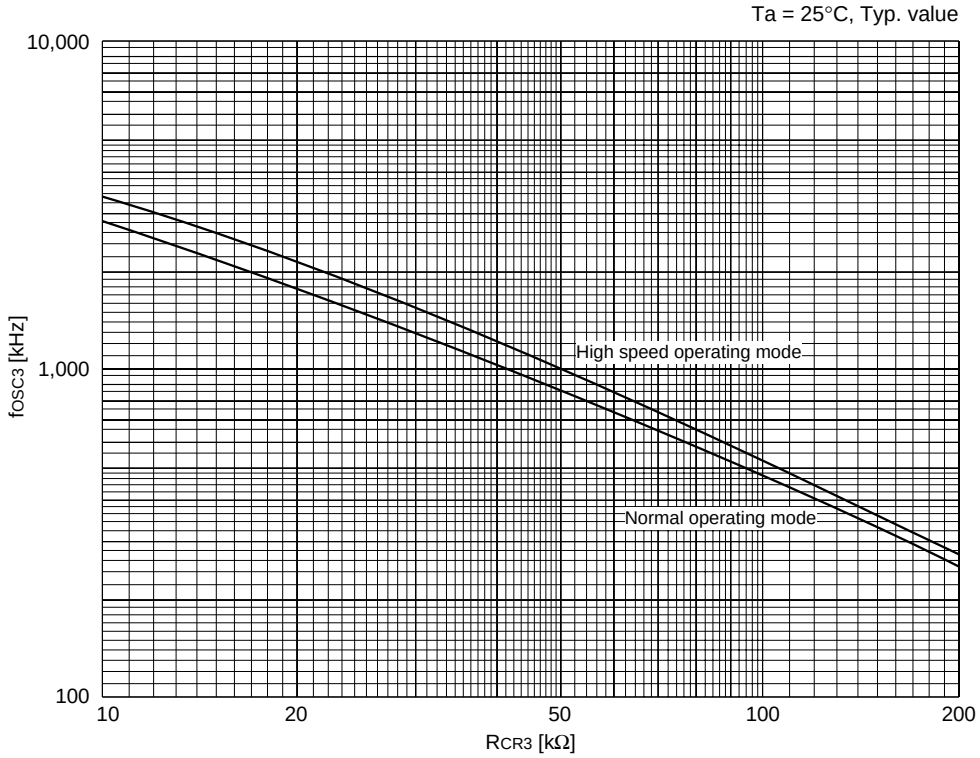
- **Oscillation frequency resistor characteristic (OSC1)**



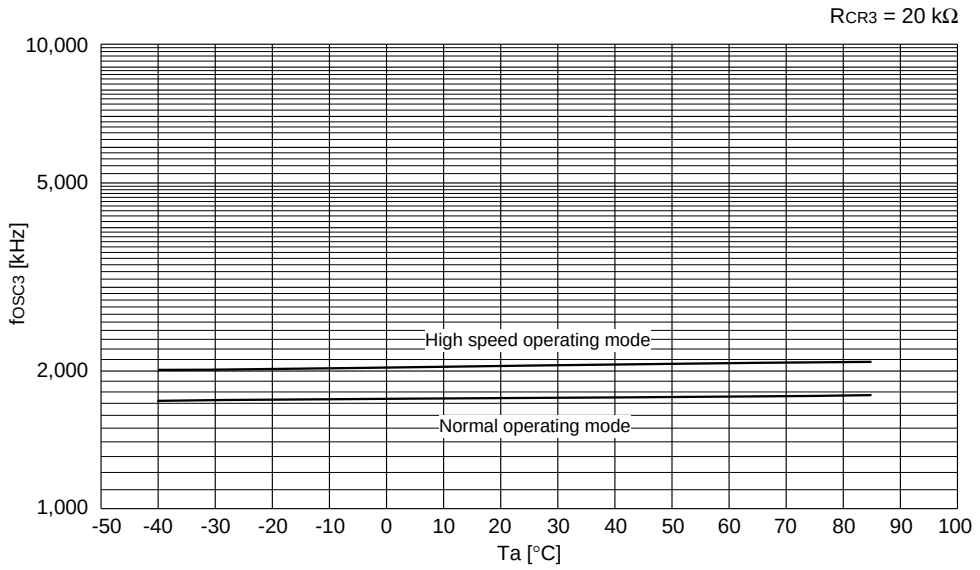
- **Oscillation frequency temperature characteristic (OSC1)**



- **Oscillation frequency resistor characteristic (OSC3)**



- **Oscillation frequency temperature characteristic (OSC3)**

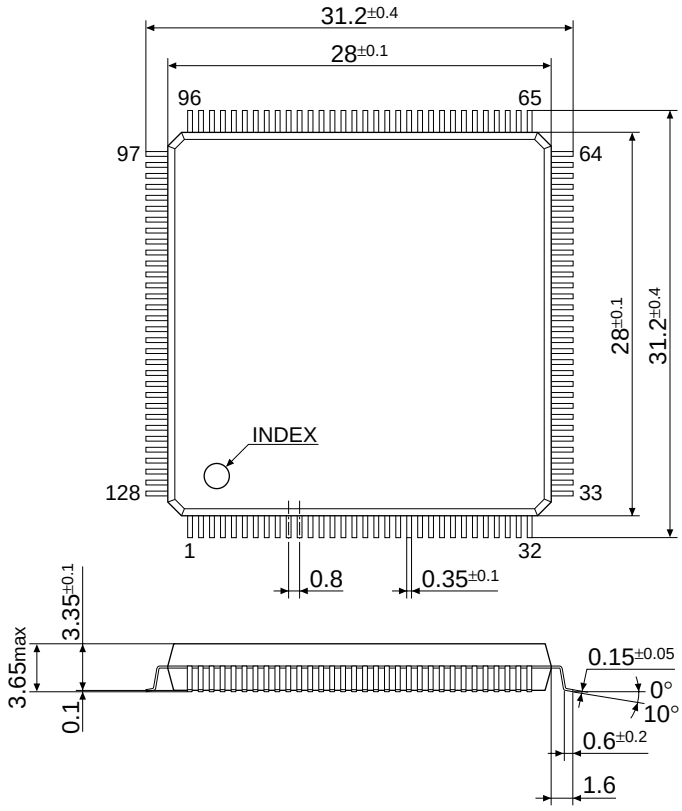


8 PACKAGE

8.1 Plastic Package

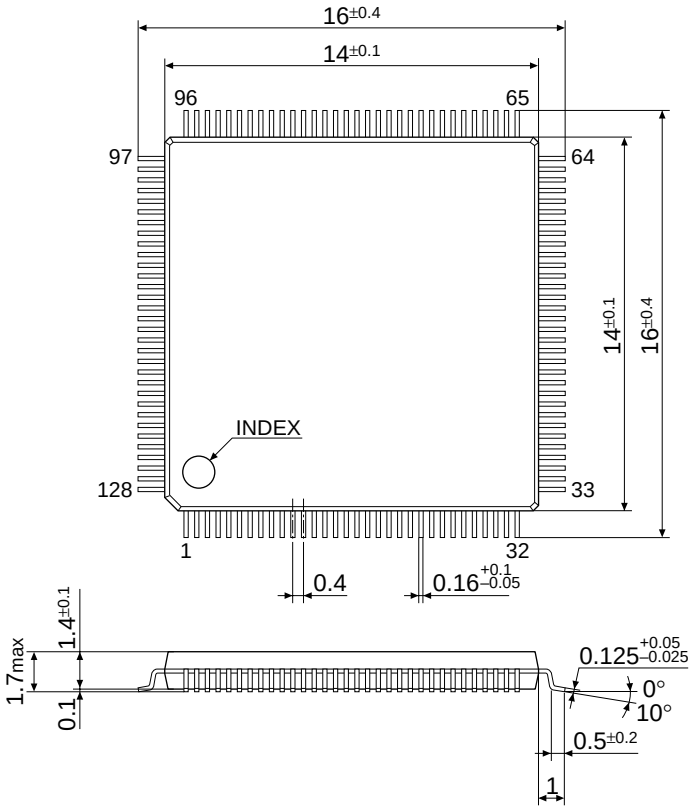
QFP8-128pin

(Unit: mm)



QFP15-128pin

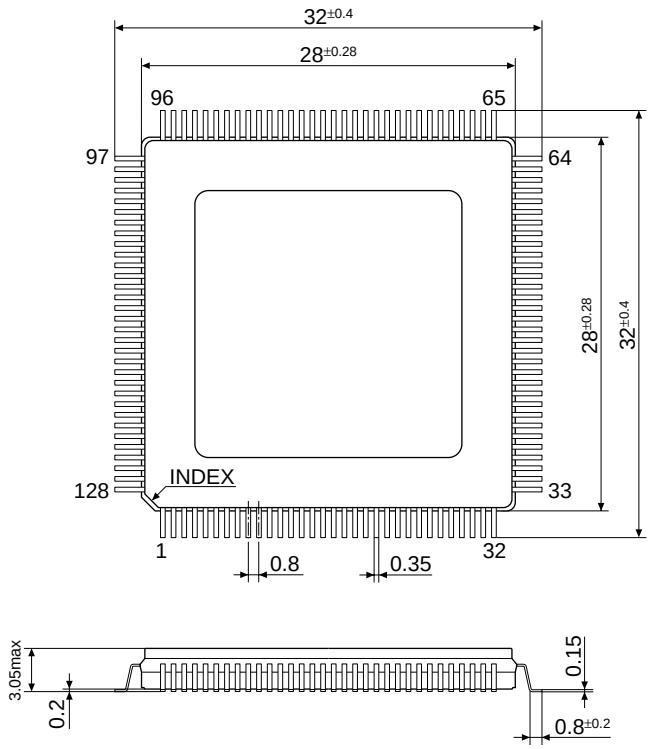
(Unit: mm)



8.2 Ceramic Package

QFP8-128pin

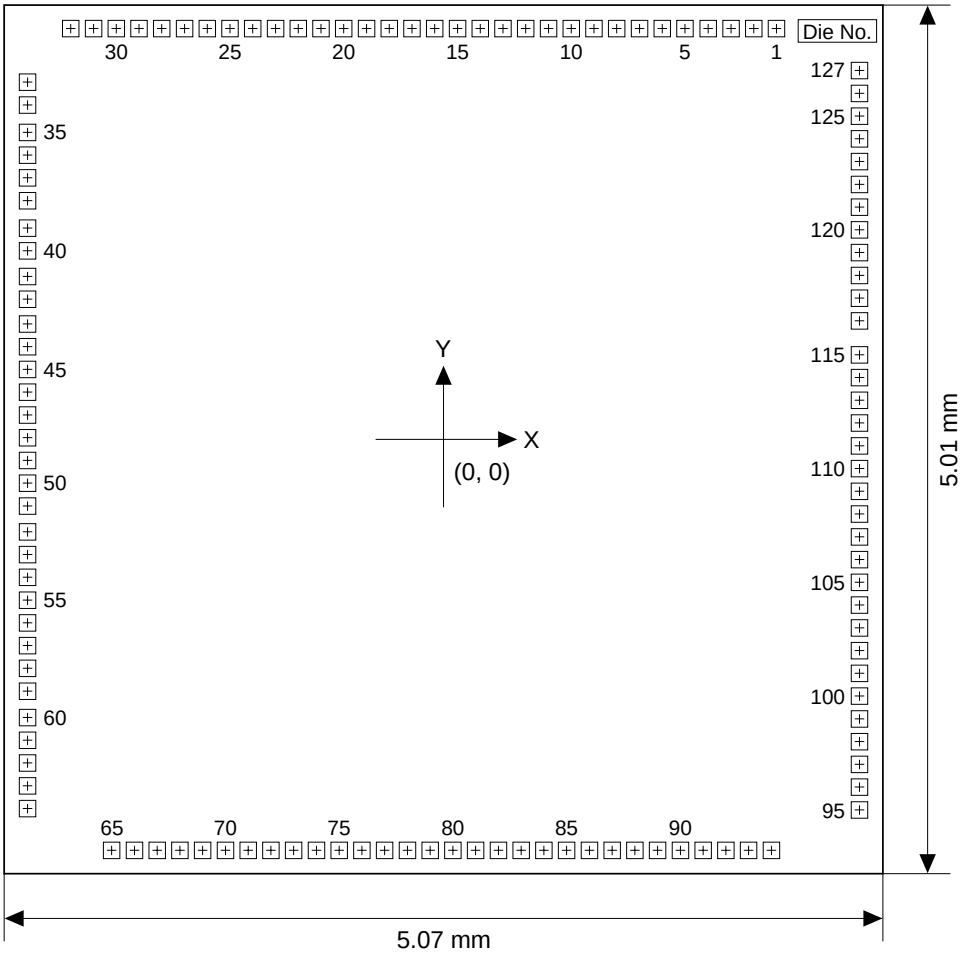
(Unit: mm)



9 PAD LAYOUT

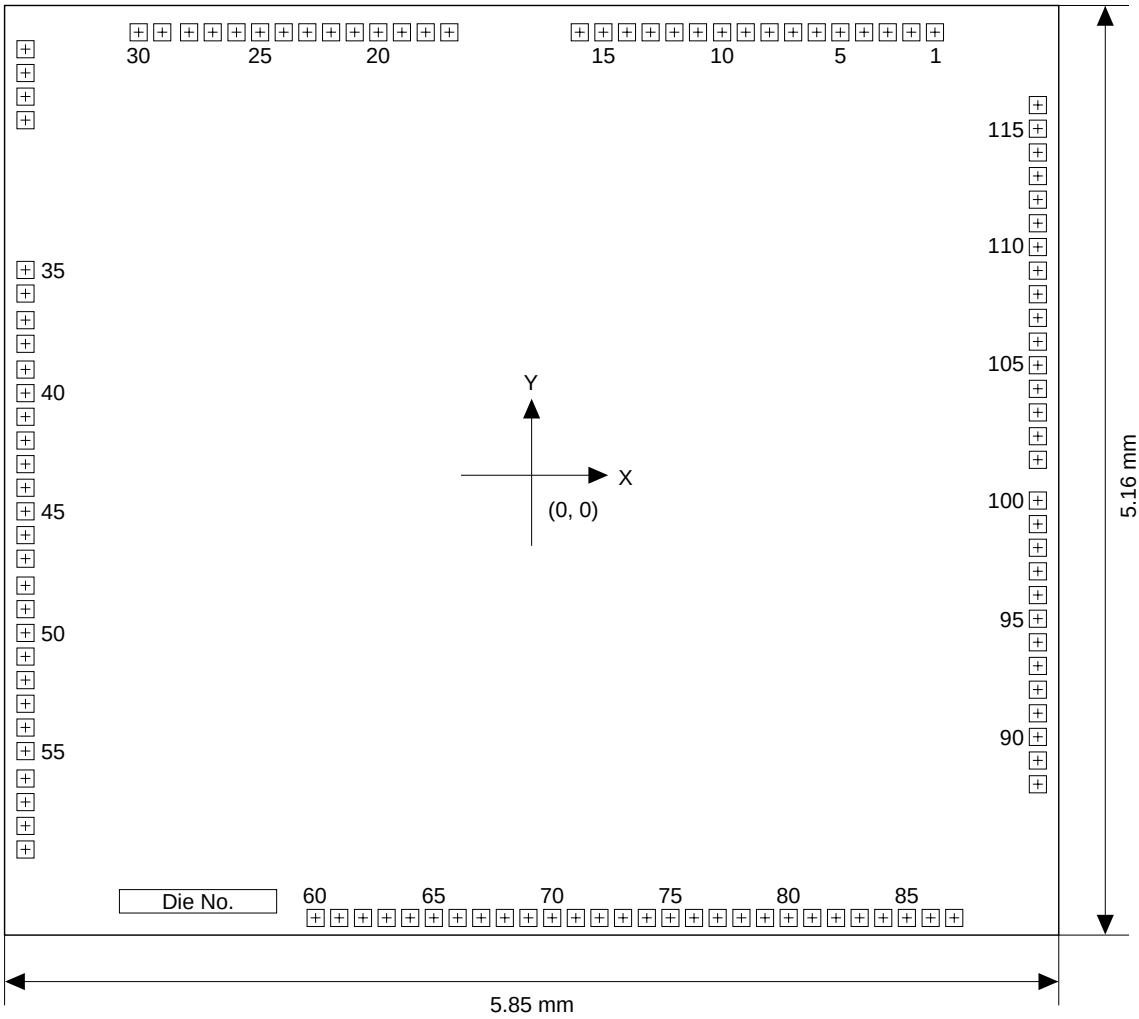
9.1 Diagram of Pad Layout

E0C88832



Chip thickness: 0.4 mm
Pad opening: 95 μm

E0C88862



Chip thickness: 0.4 mm
Pad opening: 100 μm

9.2 Pad Coordinates

Table 9.2.1 Pad coordinates (E0C88832) (Unit: µm)

No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y
1	COM19/SEG63	1,921	2,370	33	OSC3	-2,400	2,061	65	SEG0	-1,915	-2,370	97	SEG32	2,400	-1,874
2	COM18/SEG64	1,790	2,370	34	OSC4	-2,400	1,929	66	SEG1	-1,783	-2,370	98	SEG33	2,400	-1,743
3	COM17/SEG65	1,659	2,370	35	V_{OSC}	-2,400	1,771	67	SEG2	-1,652	-2,370	99	SEG34	2,400	-1,612
4	COM16/SEG66	1,527	2,370	36	V_{D1}	-2,400	1,640	68	SEG3	-1,521	-2,370	100	SEG35	2,400	-1,480
5	COM15	1,393	2,370	37	V_{DD}	-2,400	1,509	69	SEG4	-1,390	-2,370	101	SEG36	2,400	-1,349
6	COM14	1,262	2,370	38	V_{SS}	-2,400	1,377	70	SEG5	-1,258	-2,370	102	SEG37	2,400	-1,218
7	COM13	1,131	2,370	39	OSC1	-2,400	1,219	71	SEG6	-1,127	-2,370	103	SEG38	2,400	-1,087
8	COM12	999	2,370	40	OSC2	-2,400	1,088	72	SEG7	-996	-2,370	104	SEG39	2,400	-955
9	COM11	868	2,370	41	$\overline{\text{TEST}}$	-2,400	940	73	SEG8	-865	-2,370	105	SEG40	2,400	-824
10	COM10	737	2,370	42	$\overline{\text{RESET}}$	-2,400	809	74	SEG9	-733	-2,370	106	SEG41	2,400	-693
11	COM9	606	2,370	43	K10/EVIN	-2,400	666	75	SEG10	-602	-2,370	107	SEG42	2,400	-562
12	COM8	474	2,370	44	K07	-2,400	535	76	SEG11	-471	-2,370	108	SEG43	2,400	-430
13	COM7	343	2,370	45	K06	-2,400	404	77	SEG12	-340	-2,370	109	SEG44	2,400	-299
14	COM6	212	2,370	46	K05	-2,400	273	78	SEG13	-208	-2,370	110	SEG45	2,400	-168
15	COM5	81	2,370	47	K04	-2,400	141	79	SEG14	-77	-2,370	111	SEG46	2,400	-37
16	COM4	-51	2,370	48	K03	-2,400	10	80	SEG15	54	-2,370	112	SEG47	2,400	95
17	COM3	-182	2,370	49	K02	-2,400	-121	81	SEG16	185	-2,370	113	SEG48	2,400	226
18	COM2	-313	2,370	50	K01	-2,400	-252	82	SEG17	317	-2,370	114	SEG49	2,400	357
19	COM1	-444	2,370	51	K00	-2,400	-384	83	SEG18	448	-2,370	115	SEG50	2,400	488
20	COM0	-576	2,370	52	P17	-2,400	-533	84	SEG19	579	-2,370	116	COM31/SEG51	2,400	684
21	CG	-707	2,370	53	P16	-2,400	-664	85	SEG20	710	-2,370	117	COM30/SEG52	2,400	815
22	CF	-838	2,370	54	P15	-2,400	-795	86	SEG21	842	-2,370	118	COM29/SEG53	2,400	946
23	CE	-969	2,370	55	P14	-2,400	-927	87	SEG22	973	-2,370	119	COM28/SEG54	2,400	1,078
24	CD	-1,101	2,370	56	P13/$\overline{\text{SRDY}}$	-2,400	-1,058	88	SEG23	1,104	-2,370	120	COM27/SEG55	2,400	1,209
25	CC	-1,232	2,370	57	P12/$\overline{\text{SCLK}}$	-2,400	-1,189	89	SEG24	1,235	-2,370	121	COM26/SEG56	2,400	1,340
26	CB	-1,363	2,370	58	P11/SOUT	-2,400	-1,320	90	SEG25	1,367	-2,370	122	COM25/SEG57	2,400	1,471
27	CA	-1,494	2,370	59	P10/SIN	-2,400	-1,452	91	SEG26	1,498	-2,370	123	COM24/SEG58	2,400	1,603
28	V_{C5}	-1,626	2,370	60	R26/$\overline{\text{TOUT}}$	-2,400	-1,604	92	SEG27	1,629	-2,370	124	COM23/SEG59	2,400	1,734
29	V_{C4}	-1,757	2,370	61	R27/TOUT	-2,400	-1,735	93	SEG28	1,760	-2,370	125	COM22/SEG60	2,400	1,865
30	V_{C3}	-1,888	2,370	62	R34/FOUT	-2,400	-1,866	94	SEG29	1,892	-2,370	126	COM21/SEG61	2,400	1,996
31	V_{C2}	-2,019	2,370	63	R50/BZ	-2,400	-1,998	95	SEG30	2,400	-2,137	127	COM20/SEG62	2,400	2,128
32	V_{C1}	-2,151	2,370	64	R51/$\overline{\text{BZ}}$	-2,400	-2,129	96	SEG31	2,400	-2,005	–			

Table 9.2.2 Pad coordinates (E0C88862)

(Unit: μm)

No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y	No.	Name	X	Y
1	COM15	2,238	2,458	31	V_{OSC}	-2,809	2,364	60	SEG0	-1,199	-2,458	88	SEG28	2,809	-1,716
2	COM14	2,107	2,458	32	V_{D1}	-2,809	2,232	61	SEG1	-1,068	-2,458	89	SEG29	2,809	-1,584
3	COM13	1,976	2,458	33	V_{DD}	-2,809	2,101	62	SEG2	-936	-2,458	90	SEG30	2,809	-1,453
4	COM12	1,845	2,458	34	V_{SS}	-2,809	1,970	63	SEG3	-805	-2,458	91	SEG31	2,809	-1,322
5	COM11	1,713	2,458	35	OSC1	-2,809	1,139	64	SEG4	-674	-2,458	92	SEG32	2,809	-1,191
6	COM10	1,582	2,458	36	OSC2	-2,809	1,008	65	SEG5	-543	-2,458	93	SEG33	2,809	-1,059
7	COM9	1,451	2,458	37	$\overline{\text{TEST}}$	-2,809	860	66	SEG6	-411	-2,458	94	SEG34	2,809	-928
8	COM8	1,320	2,458	38	$\overline{\text{RESET}}$	-2,809	729	67	SEG7	-280	-2,458	95	SEG35	2,809	-797
9	COM7	1,188	2,458	39	K10/EVIN	-2,809	586	68	SEG8	-149	-2,458	96	SEG36	2,809	-666
10	COM6	1,057	2,458	40	K07	-2,809	455	69	SEG9	-18	-2,458	97	SEG37	2,809	-534
11	COM5	923	2,458	41	K06	-2,809	324	70	SEG10	114	-2,458	98	SEG38	2,809	-403
12	COM4	792	2,458	42	K05	-2,809	192	71	SEG11	245	-2,458	99	SEG39	2,809	-272
13	COM3	660	2,458	43	K04	-2,809	61	72	SEG12	376	-2,458	100	SEG40	2,809	-141
14	COM2	529	2,458	44	K03	-2,809	-70	73	SEG13	507	-2,458	101	COM31/SEG51	2,809	85
15	COM1	398	2,458	45	K02	-2,809	-201	74	SEG14	639	-2,458	102	COM30/SEG52	2,809	216
16	COM0	267	2,458	46	K01	-2,809	-333	75	SEG15	770	-2,458	103	COM29/SEG53	2,809	348
17	CG	-457	2,458	47	K00	-2,809	-464	76	SEG16	901	-2,458	104	COM28/SEG54	2,809	479
18	CF	-588	2,458	48	P17	-2,809	-613	77	SEG17	1,032	-2,458	105	COM27/SEG55	2,809	610
19	CE	-720	2,458	49	P16	-2,809	-744	78	SEG18	1,164	-2,458	106	COM26/SEG56	2,809	741
20	CD	-851	2,458	50	P15	-2,809	-876	79	SEG19	1,295	-2,458	107	COM25/SEG57	2,809	873
21	CC	-982	2,458	51	P14	-2,809	-1,007	80	SEG20	1,426	-2,458	108	COM24/SEG58	2,809	1,004
22	CB	-1,113	2,458	52	P13/$\overline{\text{SRDY}}$	-2,809	-1,138	81	SEG21	1,557	-2,458	109	COM23/SEG59	2,809	1,135
23	CA	-1,245	2,458	53	P12/$\overline{\text{SCLK}}$	-2,809	-1,269	82	SEG22	1,689	-2,458	110	COM22/SEG60	2,809	1,266
24	V_{C5}	-1,376	2,458	54	P11/SOUT	-2,809	-1,401	83	SEG23	1,820	-2,458	111	COM21/SEG61	2,809	1,398
25	V_{C4}	-1,507	2,458	55	P10/SIN	-2,809	-1,532	84	SEG24	1,951	-2,458	112	COM20/SEG62	2,809	1,529
26	V_{C3}	-1,638	2,458	56	R26/$\overline{\text{TOUT}}$	-2,809	-1,684	85	SEG25	2,082	-2,458	113	COM19/SEG63	2,809	1,660
27	V_{C2}	-1,770	2,458	57	R27/TOUT	-2,809	-1,815	86	SEG26	2,214	-2,458	114	COM18/SEG64	2,809	1,791
28	V_{C1}	-1,901	2,458	58	R50/BZ	-2,809	-1,947	87	SEG27	2,345	-2,458	115	COM17/SEG65	2,809	1,923
29	OSC3	-2,050	2,458	59	R51/$\overline{\text{BZ}}$	-2,809	-2,078	–				116	COM16/SEG66	2,809	2,054
30	OSC4	-2,181	2,458	–				–				–			

10 PRECAUTIONS ON MOUNTING

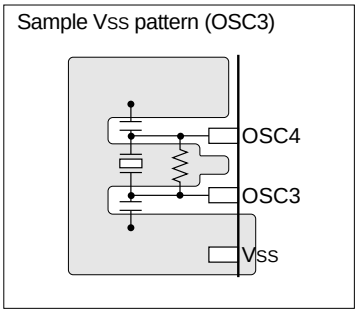
<Oscillation Circuit>

- Oscillation characteristics change depending on conditions (board pattern, components used, etc.).
  In particular, when a ceramic oscillator or crystal oscillator is used, use the oscillator manufacturer's recommended values for constants such as capacitance and resistance.

- Disturbances of the oscillation clock due to noise may cause a malfunction. Consider the following points to prevent this:

  (1) Components which are connected to the OSC1, OSC2, OSC3, OSC4 terminals, such as oscillators, resistors and capacitors, should be connected in the shortest line.

  (2) As shown in the right hand figure, make a V_{SS} pattern as large as possible at circumscription of the OSC1, OSC2, OSC3, OSC4 terminals and the components connected to these terminals.
  Furthermore, do not use this V_{SS} pattern for any purpose other than the oscillation system.



  (3) When supplying an external clock to the OSC1 (OSC3) terminal, the clock source should be connected to the OSC1 (OSC3) terminal in the shortest line.
  Furthermore, do not connect anything else to the OSC2 (OSC4) terminal.

- In order to prevent unstable operation of the oscillation circuit due to current leak between OSC1 (OSC3) and V_{DD}, please keep enough distance between OSC1 (OSC3) and V_{DD} or other signals on the board pattern.

<Reset Circuit>

- The power-on reset signal which is input to the $\overline{RESET}$ terminal changes depending on conditions (power rise time, components used, board pattern, etc.).
  Decide the time constant of the capacitor and resistor after enough tests have been completed with the application product.
  When the built-in pull-up resistor is added to the $\overline{RESET}$ terminal by mask option, take into consideration dispersion of the resistance for setting the constant.

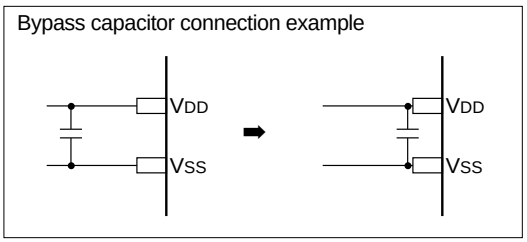
- In order to prevent any occurrences of unnecessary resetting caused by noise during operating, components such as capacitors and resistors should be connected to the $\overline{RESET}$ terminal in the shortest line.

<Power Supply Circuit>

- Sudden power supply variation due to noise may cause malfunction. Consider the following points to prevent this:

(1) The power supply should be connected to the V_{DD} and V_{SS} terminals with patterns as short and large as possible.

(2) When connecting between the V_{DD} and V_{SS} terminals with a bypass capacitor, the terminals should be connected as short as possible.



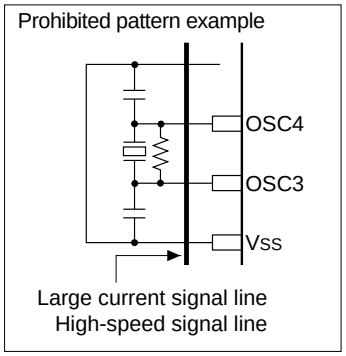
(3) Components which are connected to the V_{D1}, V_{C1}–V_{C5} and CA–CG terminals, such as capacitors, should be connected in the shortest line. In particular, the V_{C1}–V_{C5} voltages affect the display quality.

- Do not connect anything to the V_{C1}–V_{C5} and CA–CG terminals when the LCD driver is not used.

<Arrangement of Signal Lines>

- In order to prevent generation of electromagnetic induction noise caused by mutual inductance, do not arrange a large current signal line near the circuits that are sensitive to noise such as the oscillation unit.

- When a signal line is parallel with a high-speed line in long distance or intersects a high-speed line, noise may generated by mutual interference between the signals and it may cause a malfunction.
  Do not arrange a high-speed signal line especially near circuits that are sensitive to noise such as the oscillation unit.



<Precautions for Visible Radiation (when bare chip is mounted)>

- Visible radiation causes semiconductor devices to change the electrical characteristics. It may cause this IC to malfunction. When developing products which use this IC, consider the following precautions to prevent malfunctions caused by visible radiations.

(1) Design the product and implement the IC on the board so that it is shielded from visible radiation in actual use.

(2) The inspection process of the product needs an environment that shields the IC from visible radiation.

(3) As well as the face of the IC, shield the back and side too.

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