

# TMP04CH00FXXX (JTMP04CH00XXS)

CMOS 4 bit LL Microcontroller

(LL: Low power consumption & Low voltage operation)

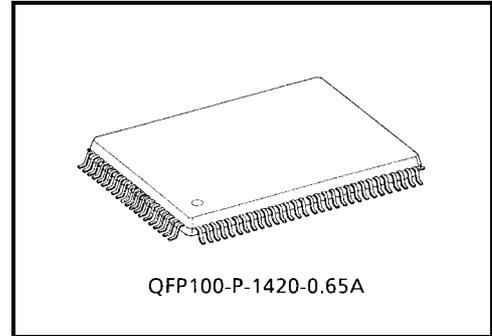
The TMP04CH00FXXX is a high-performance microcontroller designed to be in a variety of low-voltage products.

It is a 4 bit CMOS LL microcontroller with integrated a 4 bit high-performance CPU, memory (static work RAM, data RAM and program ROM). LCD display LL controller driver, and a multi-function timer into a single chip.

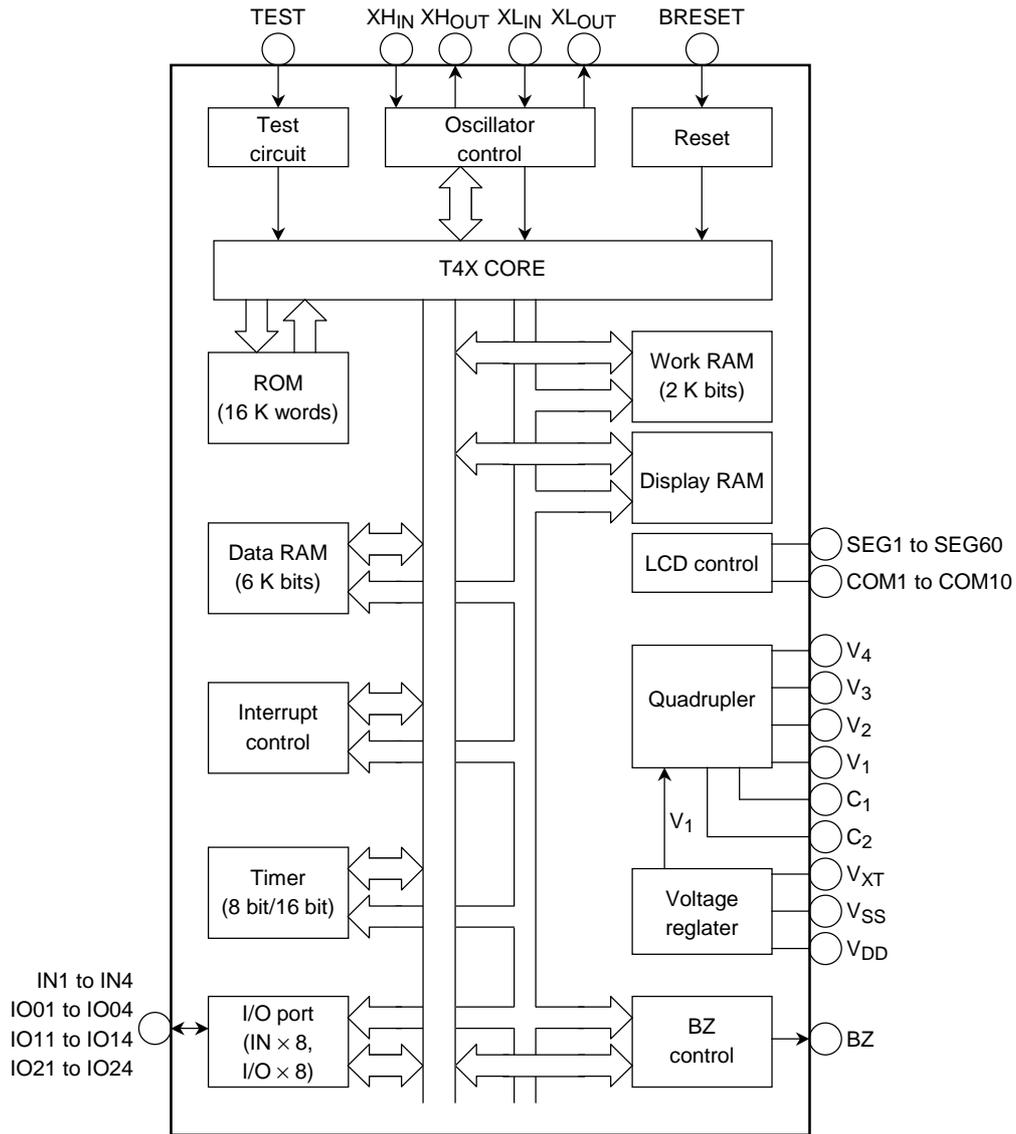
The basic features are as follows.

## Features

- Number of instructions: 56
- Minimum instruction execution time: 61  $\mu$ s (at 32.768 kHz)  
1  $\mu$ s (at 2 MHz/3.0 V)
- Oscillating circuit : low speed-crystal oscillator (32.768 kHz)/internal CR (33 kHz at 1.5 V)  
high speed-crystal oscillator (2 MHz at 3.0 V)/external CR (200 kHz at 1.5 V)
- Built-in ROM size : 16 K words (1 word = 16 bits)
- Built-in RAM size :
  - Work RAM : 512  $\times$  4 bits
  - Data RAM : 6 K bits
- Input pins : 8 pins (with interrupts)
- I/O pins : 8 pins
- Output pins : 1 pin (Buzzer)
- Interruption : 2 external system (input pins, general purpose I/O pin)  
2 internal system (timer/counter, timings)
- Timer : 8 bits  $\times$  2 ch or 16 bits  $\times$  1 ch (software-selectable)
- LCD display driver controller: 60 seg  $\times$  8 com Mask option  
58 seg  $\times$  10 com Mask option
- Built-in LCD driver power circuit
- Watchdog timer : Timer/Counter can be used as Watch Dog Timer
- Supply voltage : 1.5/3.0 V (typ.) Mask option



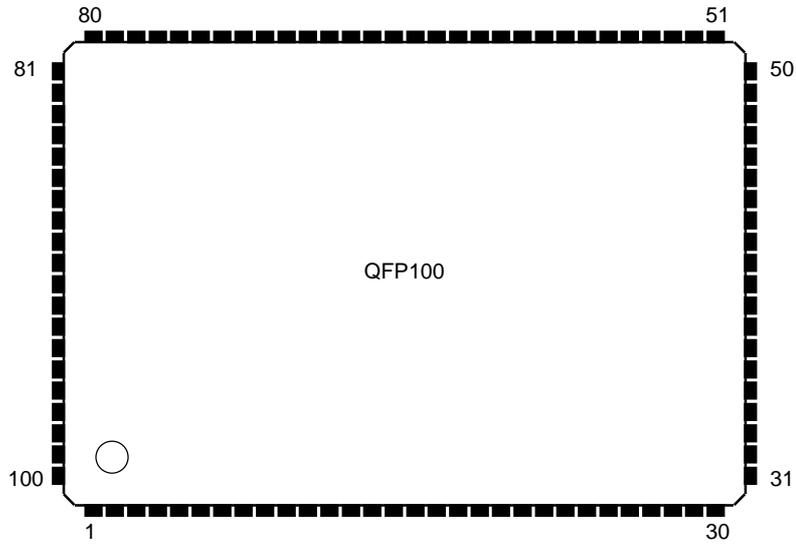
Weight: 1.65 g (typ.)



**Figure 1 Block diagram**

## Pin Configuration

### 1. Pin Assignment



Pin No.	Pin Name
1	V <sub>1</sub>
2	C <sub>1</sub>
3	C <sub>2</sub>
4	V <sub>SS</sub>
5	V <sub>XT</sub>
6	BRESET
7	XL <sub>IN</sub>
8	XL <sub>OUT</sub>
9	V <sub>DD</sub>
10	XH <sub>IN</sub>
11	XH <sub>OUT</sub>
12	TEST
13	BZ
14	IN1
15	IN2
16	IN3
17	IN4
18	IO01
19	IO02
20	IO03
21	IO04
22	IO11
23	IO12
24	IO13
25	IO14

Pin No.	Pin Name
26	IO21
27	IO22
28	IO23
29	IO24
30	S <sub>1</sub>
31	S <sub>2</sub>
32	S <sub>3</sub>
33	S <sub>4</sub>
34	S <sub>5</sub>
35	S <sub>6</sub>
36	S <sub>7</sub>
37	S <sub>8</sub>
38	S <sub>9</sub>
39	S <sub>10</sub>
40	S <sub>11</sub>
41	S <sub>12</sub>
42	S <sub>13</sub>
43	S <sub>14</sub>
44	S <sub>15</sub>
45	S <sub>16</sub>
46	S <sub>17</sub>
47	S <sub>18</sub>
48	S <sub>19</sub>
49	S <sub>20</sub>
50	S <sub>21</sub>

Pin No.	Pin Name
51	S <sub>22</sub>
52	S <sub>23</sub>
53	S <sub>24</sub>
54	S <sub>25</sub>
55	S <sub>26</sub>
56	S <sub>27</sub>
57	S <sub>28</sub>
58	S <sub>29</sub>
59	S <sub>30</sub>
60	S <sub>31</sub>
61	S <sub>32</sub>
62	S <sub>33</sub>
63	S <sub>34</sub>
64	S <sub>35</sub>
65	S <sub>36</sub>
66	S <sub>37</sub>
67	S <sub>38</sub>
68	S <sub>39</sub>
69	S <sub>40</sub>
70	S <sub>41</sub>
71	S <sub>42</sub>
72	S <sub>43</sub>
73	S <sub>44</sub>
74	S <sub>45</sub>
75	S <sub>46</sub>

Pin No.	Pin Name
76	S <sub>47</sub>
77	S <sub>48</sub>
78	S <sub>49</sub>
79	S <sub>50</sub>
80	S <sub>51</sub>
81	S <sub>52</sub>
82	S <sub>53</sub>
83	S <sub>54</sub>
84	S <sub>55</sub>
85	S <sub>56</sub>
86	S <sub>57</sub>
87	S <sub>58</sub>
88	S <sub>59</sub> /COM10
89	S <sub>60</sub> /COM9
90	COM8
91	COM7
92	COM6
93	COM5
94	COM4
95	COM3
96	COM2
97	COM1
98	V <sub>4</sub>
99	V <sub>3</sub>
100	V <sub>2</sub>

**2. Pin Description**

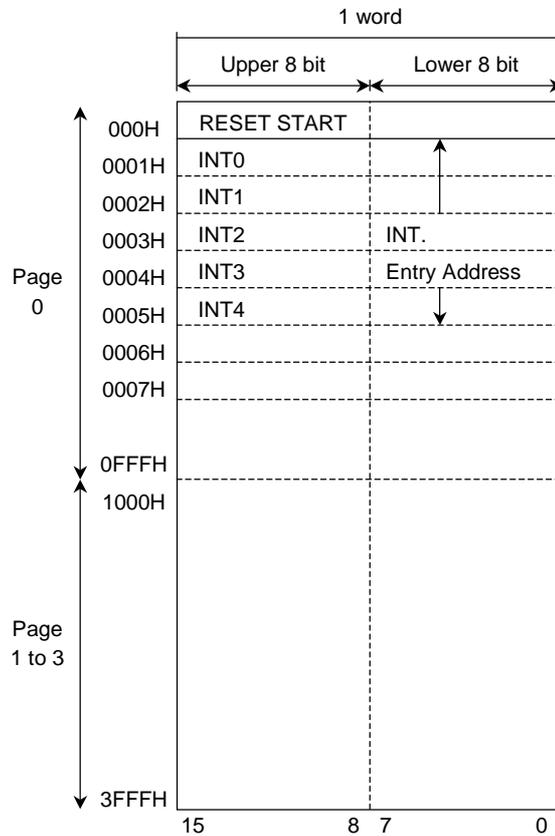
Pin Name	Function
V <sub>DD</sub>	Power supply (+)
V <sub>SS</sub>	Power supply (-)
V <sub>XT</sub>	Voltage regulator1 output (output for only the mask option 3.0 V type)
V <sub>1</sub>	Voltage regulator2 output
V <sub>2</sub> to V <sub>4</sub>	Boosted voltage output
C <sub>1</sub> , C <sub>2</sub>	Capacitor pin for LCD booster
XH <sub>IN</sub> , XH <sub>OUT</sub>	Crystal/resister connection pin for high speed oscillator
XL <sub>IN</sub> , XL <sub>OUT</sub>	Crystal connection pin for low speed oscillator
IN1 to IN4	Input port (with interruption)
IO01 to IO04	Input port (with interruption)
IO11 to IO14	I/O port
IO21 to IO24	I/O port
SEG1 to SEG60	LCD segment output
COM1 to COM10	LCD common output
BZ	Buzzer output
BRESET	Reset input (low active)
TEST	Test input

## Memory Map

### 1. Program ROM

Program ROM consists of 16 bits 1 word. Op-code and operand are executed in one word units. Program ROM consists of 4 K words per page. The internal program ROM area is 4 pages (16 K words).

This program ROM area can be used for constant data ROM. In this case, it can be used in byte units (1 byte = 8 bits).



**Figure 2 Program memory map**

Note: Use the CALL instruction to write the interrupt entry address. Write NOP for unused interrupts.

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Example:      CALL A   ; INT0
              NOP     ; INT1
              CALL B   ; INT2
              NOP     ; INT3
              NOP     ; INT4
              NOP     ; INT5
              NOP     ; INT6
    
```

2. Work RAM

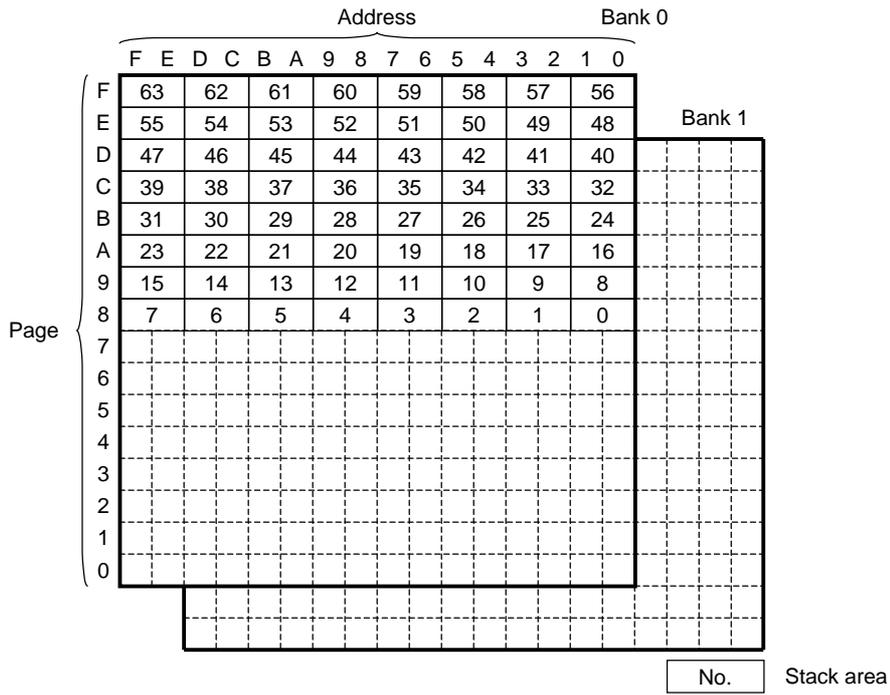
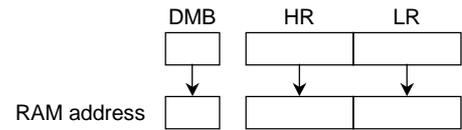


Figure 3 Work RAM

Work RAM consists of  $512 \times 4$  bits.

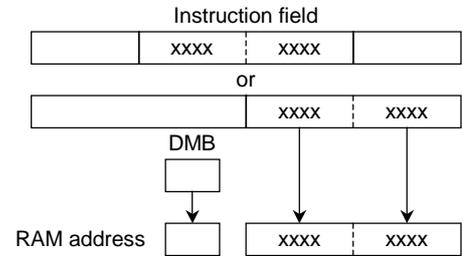
R/W is performed at the address specified by bellows.

- (1) Indirectly addressing mode (Figure 4 (a))  
 DMB in F-reg, H, L-reg specify the Work RAM address. (DMB: bank, H-reg : page, L-reg: address)  
 LD A, M:  $A \leftarrow \text{RAM}(\text{HL})$



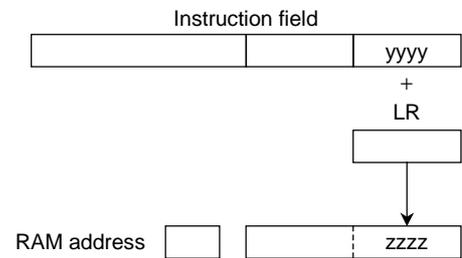
(a) Indirectly addressing

- (2) Directly addressing mode (Figure 4 (b))  
 Immediate data (8 bits) in instruction specify the Work RAM page and address.  
 Bank is specified by DMB in F-reg.  
 LDI 2CH, 0AH:  $\text{RAM}(2\text{CH}) \leftarrow \text{AH}$



(b) Directly addressing

- (3) Index addressing mode (Figure 4 (c))  
 Address (L-reg) is specified by the immediate data (4 bits) in instruction, and the other immediate data specify page.  
 LDRI 4H, 3H:  $\text{RAM}(\text{HL} + 4\text{H}) \leftarrow \text{RAM}(3\text{H}, \text{L})$   
 $\text{L} \leftarrow \text{L} + 1, \text{A} \leftarrow \text{A} - 1$



(c) Index addressing

**Figure 4 Addressing mode**

BANK0, PAGE8 to F area can be used as Stack area.

When using the "CALL/CALLS" instruction or start the interruption routine, the data of program counter and Program memory bank are stored in Stack area.

Then, using "RET" instruction, program return according to those data.

And, using "PUSH" instruction, 8 bits data in a pair register can be stored in Stack area.

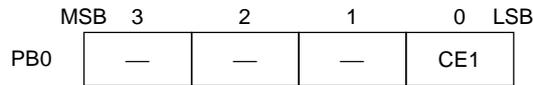
Then, using "POP" instruction, those data are returned to the register.

Maximum Stack area is 64 (0 to 63), and each Stack area consist of 8 bits.

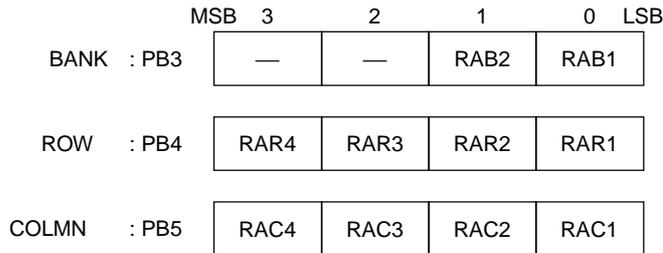
### 3. Data RAM

TMP04CH00FXXX has 6 K bits Data RAM (256AD × 3 bank × 8 bit), and addressing and data read/write is done by Register file, as follows.

When the data is read from Data RAM/written in Data RAM, CE1 (PB0) is needed to set 1.  
(PB0: Register file Page 3, AD0)

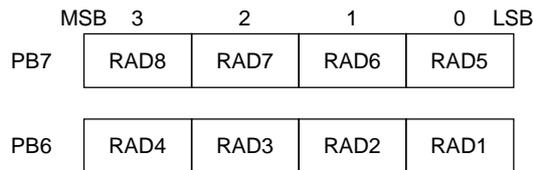


Addressing is decided by RAB1 to RAB2 (PB3), RAC1 to RAC4 (PB5), RAR1 to RAR4 (PB4)



Data is read/written by 8 bits which is set in RAD1 to RAD8 (PB6, PB7).

To read from/written into Data RAM, only 8 bits transference instruction can be used.

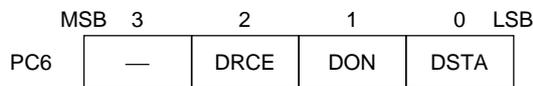


**CAUTION:** When "HALT" instruction is executed for the next instruction of transference the data to Data RAM, the data of Data RAM is broken. Also, data may be destroyed if the HALT instruction is executed while CE1 is set to 1. Therefore, be sure to set CE1 to CE0 before executing the HALT instruction. RAD1 to RAD8 (PB6, PB7) are valid for only 8-bit transfer instructions. Do not use the 4-bit transfer instructions.

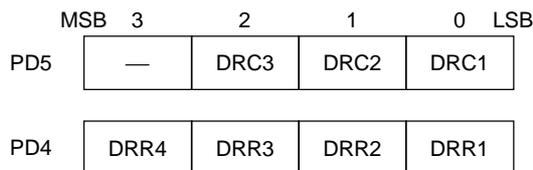
### 4. Display RAM

TMP04CH00FXXX has 600 bits Display RAM (60 seg × 8 com/58 seg × 10 com), and addressing and data read/write is decided by Register file, as follows.

When the data is read from/written into Display RAM, DRCE (PC6-bit2) is needed to be 1.



Addressing is decided by DRR1 to DRR4 (PD4), DRC1 to DRC3 (PD5) (LSB is DRR1, and MSB is DRC3)



Data is read/written by 8 bits which is set in DRD1 to DRD 8 (PD6, PD7).

To read from/written into DISPLAY, only 8 bits transference instruction can be used.

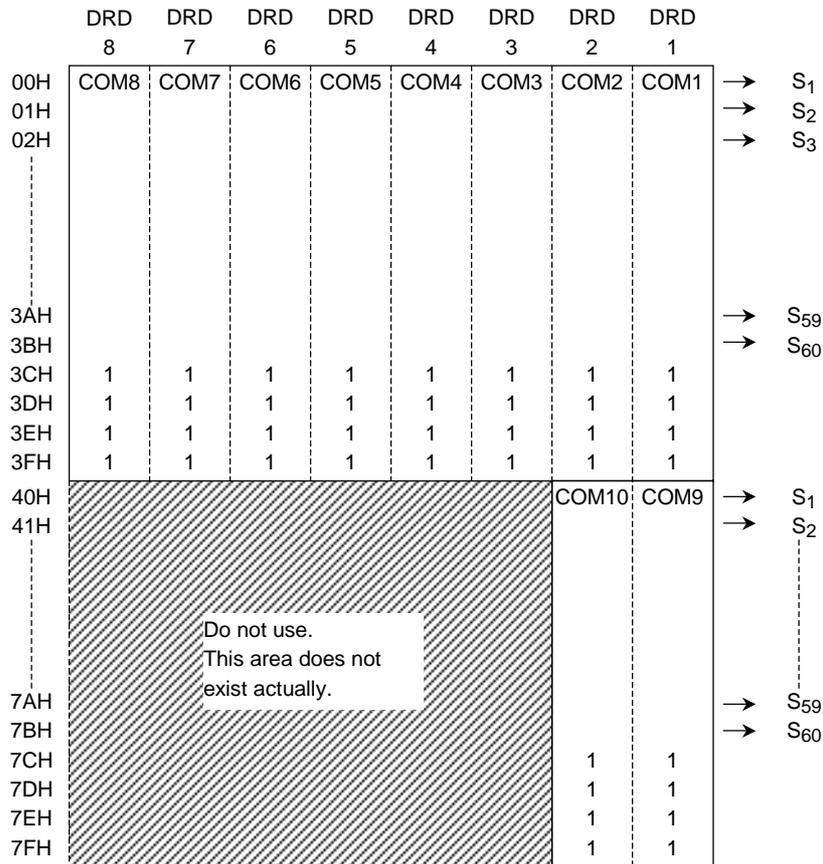


When the display duty is selected 1/8, S1 to S60 are used as segment output and display data is read from/written into Display RAM which address is 00H to 03BH.

Also, when using with a 1/10 duty cycle, segments are used from S1 up to S58 and the data COM9 and COM10 are written to and read from addresses beginning with 40H via DRD1 and DRD2.

**CAUTION:**

1. When "HALT" instruction is executed for the next instruction of the transference the data to Display RAM, the data of Display RAM is broken.
2. When "HALT" instruction is executed during DRCE is 1, the data of Display RAM is broken. Therefore, be sure to set DRCE to 0 before executing the HALT instruction. DRD1 to DRD8 (PD6, PD7) are valid for only 8-bit transfer instructions. Do not use the 4-bit transfer instructions.



**Figure 5 Display RAM**

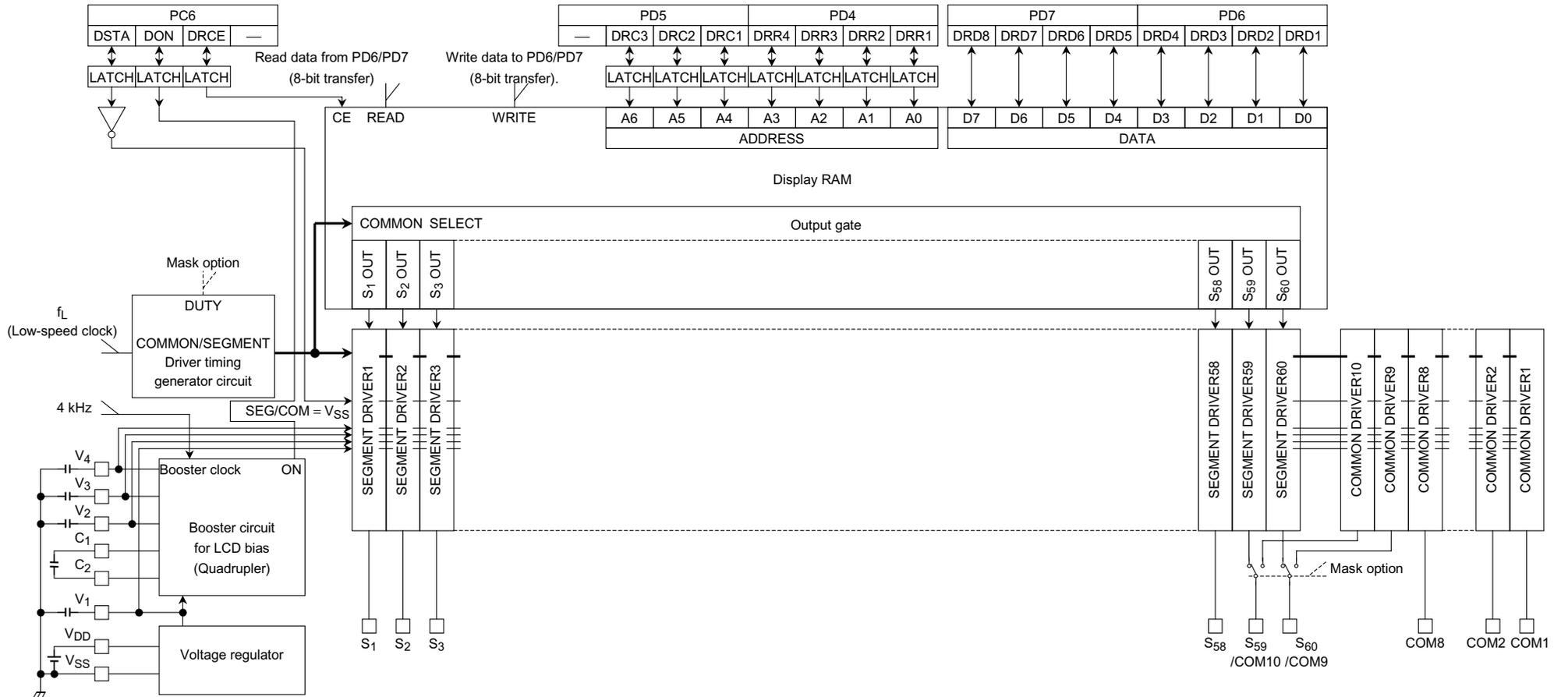


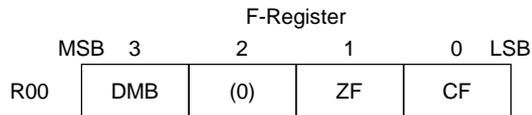
Figure 6 LCD driver

## Register File

Register files consist of (1) general-purpose registers, (2) system registers, and (3) peripheral I/O registers. Figure 6 shows the overall configuration of register files.

### 1. General Register

1. Flag Register: F-Register (PAGE/AD = 0/0)



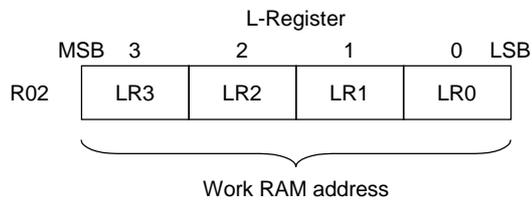
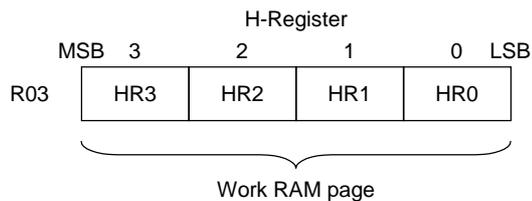
CF : Carry Flag

ZF : Zero Flag

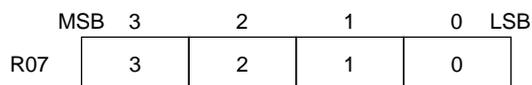
(0) : Not use

DMB : Work RAM Bank

2. Accumulator Register: A-Register (PAGE/AD = 0/1)  
Accumulator for arithmetic operations.  
When consecutive instructions are executed, used as a counter register.
3. H.L Register (PAGE/AD = 0/3 to 2)  
H.L Register are used for Work RAM address setting with DMB.



4. Bank Register (PAGE/AD = 0/7): B-Register  
B-Register is used for ROM page.



0000 = Page 0

0001 = Page 1

0010 = Page 2

0011 = Page 3

5. E-Register, D-Register, P-Register (B-Register) (PAGE/AD = 0/4, 0/5, 0/6, 0/7)  
General purpose register.  
When using ROM as Data Table Function, B, P, D, E-Register are used for ROM address setting.  
(Data table function: user can use ROM area for store the constant, and can access those constant by LDBL and LDBH instruction.)

## 2. System Registers

### 1. Stack pointer (PAGE/AD = 1/0, 1/1)

The stack pointer shows the location (63 to 0) in the stack area in work RAM.

	MSB	3	2	1	0
R10		SP4	SP2	SP1	—

	MSB	3	2	1	0
R11		—	SP32	SP16	SP8

### 2. Interrupt Enable/Disable Registers (PAGE/AD = 1/2, 1/3)

Enable/disable interrupts. There are five interrupt vectors (INT0 to INT4). Writing data in the bit corresponding to an interrupt enables/disables the interrupt. The details are described in the section on peripheral circuits.

	MSB	3	2	1	0
R12		INT2	INT1	INT0	(0)

	MSB	3	2	1	0
R13		—	—	INT4	INT3

### 3. Input/Output Registers (PAGE/AD = 1/4, 1/5)

Used for the input/output pins (IO11 to IO14, IO21 to IO24). Using the bit that corresponds to a pin, output data can be set or input data can be read. The details are described in the section on peripheral circuits.

	MSB	3	2	1	0
R14		IO14	IO13	IO12	IO11

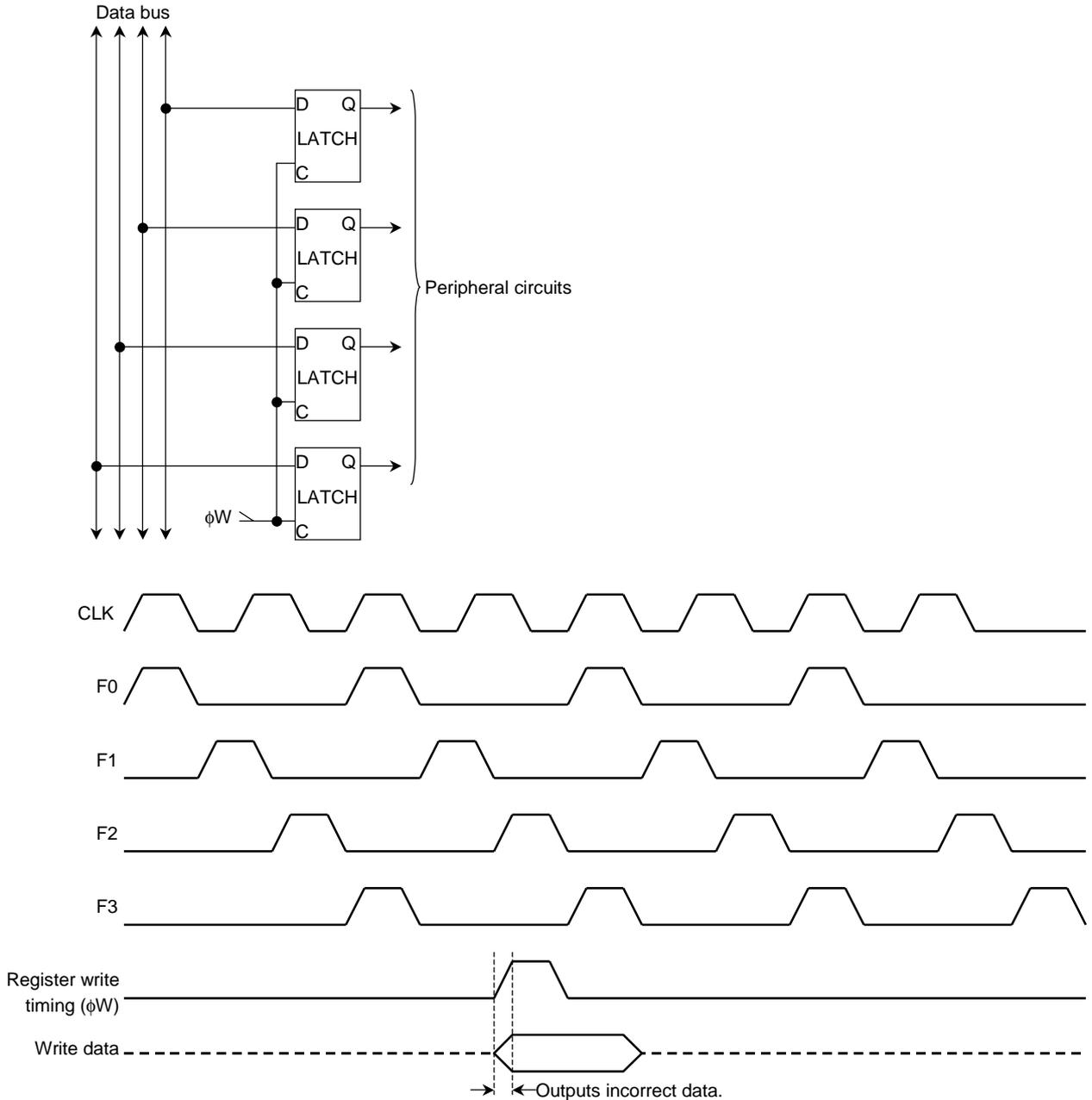
	MSB	3	2	1	0
R15		IO24	IO23	IO22	IO21

**3. Peripheral I/O Registers**

Registers used to control peripheral circuits specific to the product are allocated to pages 2 to 7. The details are described in the section on peripheral circuits.

Note: A precaution relating to Writes to System Registers/Peripheral I/O Registers.

Writing to System Register and I/O Registers is performed in synchronization with  $\phi W$ . Because rising edges of  $\phi W$  coincides with the timing at which Write data is output on the data bus, it is possible that incorrect data is output to the peripheral circuits for a very short period of time. Please take this into account when programming.



Page (RFB)		Address		0		1		2		3		4		5		6		7	
		8 bit Address		0				2				4				6			
		R/W		LOWER4BIT		UPPER4BIT		L4BIT		H4BIT		L4BIT		H4BIT		L4BIT		H4BIT	
		Read	Write	Read	Write	Read	Write	Read	Write	Read	Write	Read	Write	Read	Write	Read	Write	Read	Write
0	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	F REGISTER		A REGISTER		L REGISTER		H REGISTER		E REGISTER		D REGISTER		P REGISTER		B REGISTER		
1 (R1x)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	0		STACK POINTER (SP)		INT2 INT1 INT0		INT4 INT3		IOD14 IOD13 IOD12 IOD11		IOO14 IOO13 IOO12 IOO11		IOD24 IOD23 IOD22 IOD21		IOO24 IOO23 IOO22 IOO21		
2 (PAx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	IND4 IND3 IND2 IND1	IOD04 IOD03 IOD02 IOD01											LOWCP CPMODE2 CPMODE1		RST4 RST3 RST2 RST1		
3 (PBx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	CE1						RAB2 RAB1		RAR4 RAR3 RAR2 RAR1		RAC4 RAC3 RAC2 RAC1		RAD4 RAD3 RAD2 RAD1		RAD8 RAD7 RAD6 RAD5		
4 (PCx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	ESELT ESELIO ESELI	IIN4 IIN3 IIN2 IIN1	IIE4 IIE3 IIE2 IIE1		IOIE0								DRCE DON DSTA		P2 P1		
5 (PDx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	TI4 TI3 TI2 TI1	1/2 4/8 16/32 128/256		TIR4 TIR3 TIR2 TIR1		TIE4 TIE3 TIE2 TIE1		DRR4 DRR3 DRR2 DRR1		DRC3 DRC2 DRC1		DRD4 DRD3 DRD2 DRD1		DRD8 DRD7 DRD6 DRD5			
6 (PEx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	TCR14 TCR13 TCR12 TCR11	SET14 SET13 SET12 SET11	TCR18 TCR17 TCR16 TCR15	SET18 SET17 SET16 SET15	CKS13 CKS12 CKS11	TC1EN CMPEN1 WDT1	TC1R TC1E TC1R							2/4 K BZ3 BZ2 BZ1			
7 (PFx)	MSB ↑ ↓ LSB	BIT 3 BIT 2 BIT 1 BIT 0	TCR24 TCR23 TCR22 TCR21	SET24 SET23 SET22 SET21	TCR28 TCR27 TCR26 TCR25	SET28 SET27 SET26 SET25	CKS23 CKS22 CKS21	TC2EN CMPEN2	TC2R TCI2E TCI2R										

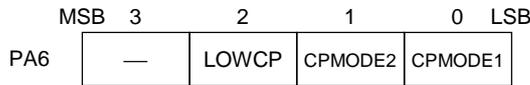
**Figure 7 Register file**

Note: Blank columns are indeterminate.

**Peripheral Circuit**

Each peripheral circuits can be accessed (Read/Write/Circuit setting) by Register files.

**1. Oscillator Block**



The CPU clock is generated by the asynchronous oscillator switching circuit which has low-speed and high-speed clock oscillator circuit.

This block also provides the clock for the timer circuit, LCD driver, Quadrupler.

Oscillation mode is controlled by Register files “CPMODE1” and “CPMODE2” (PAGE/AD = 2/6), as follows.

CPMODE 1	CPMODE 2	Low- speed OSC	High- speed OSC	System CP	Mode Name
0	0	OFF	OFF	OFF	(CPM0)
1	0	ON	OFF	Low-speed	(CPM1)
0	1	OFF	ON	High-speed	(CPM2)
1	1	ON	ON	High-speed	(CPM3)

CPMODE 1, 2 are initially 1 (CPM3).

“LOWCP” is the display clock control bit. When “LOWCP” is set to 1, Low OSC clock is supplied to LCD circuit. “LOWCP” is initially “0”. Even if LOWCP is set to 1, clock cannot be occupied to display circuit during Low-speed OSC stopped, and display cannot be shown.

Low-speed OSC circuit can select X’tal or internal CR oscillation by Mask option.

High-speed OSC circuit can select X’tal or external CR oscillation by Mask option.

Setting a register to CPM1 and executing a HALT instruction sets the mode to Halt (system CP off, high-speed oscillator off, low-speed oscillator on). Setting a register to CPM0 and executing a HALT instruction sets the mode to Stop (system CP off, high-speed oscillator and low-speed oscillators off). Even if, mode is changed to MODE 0 from MODE 1/2/3, there are no changing until use “HALT” instruction.

The High/Low-speed OSC circuit has WARM UP function.

The warm-up function disables the crystal oscillator as the system clock from when the crystal oscillator starts oscillation to when the frequency stabilizes. The warm-up circuit in the high-speed crystal oscillator circuit consists of a 15-stage binary counter. The warm-up time is 16,384 pulses of the high-speed clock.

The warm-up circuit in the low-speed crystal oscillator circuit consists of a 9-stage binary counter.

The warm-up time is 256 pulses of the high-speed clock.

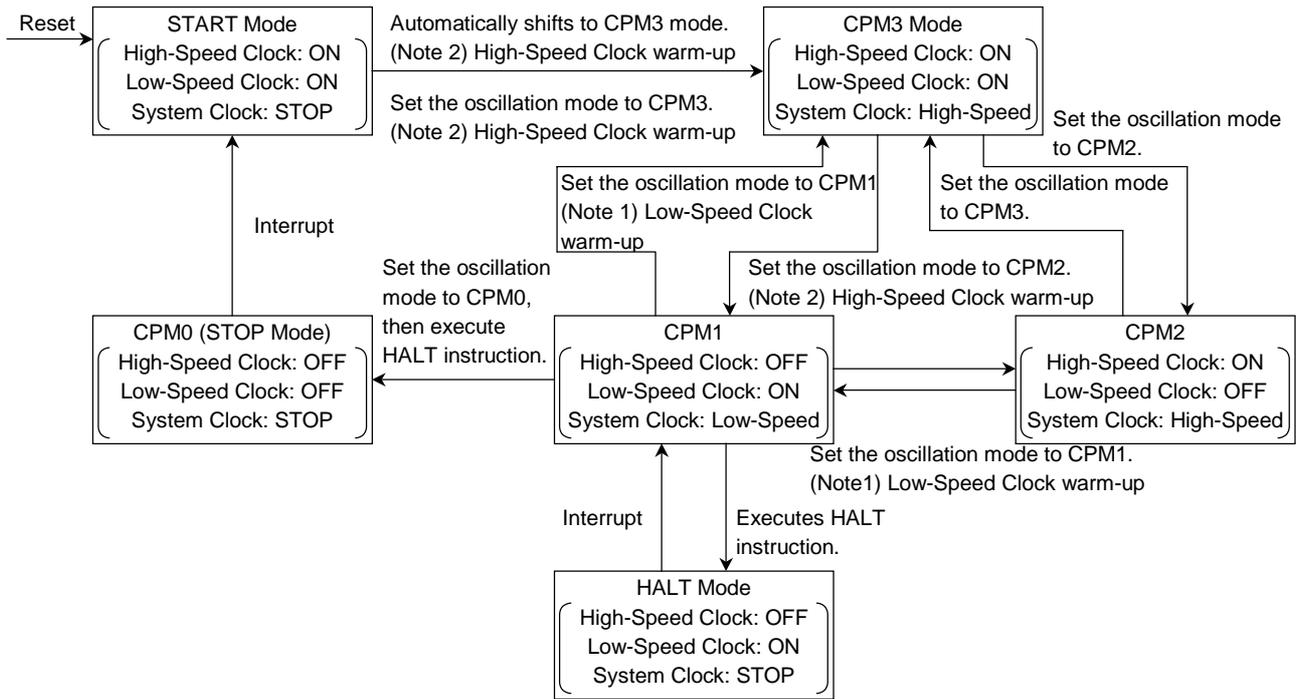
The low-speed oscillation does not have enough warm-up time, therefore, when the oscillation is started, software need to make warming up time enoughly.

Set the warm-up time by software to approx. 500 ms as standard.

When the System CP is changed between Low and High (CPM1 CPM2/3 or CPM2 CPM1), changing System CP waits to finish the warming up time.

Also that until the system CP is changed, instructions are executed with the previous system CP.

If the CR oscillator is selected as the high- or low-speed oscillator circuit, the warm-up function is disabled.



Note 1: Low-Speed Clock warm-up

If X'tal oscillation circuit is selected for low-speed oscillation, it takes some time before low-speed oscillation is used for system clock.

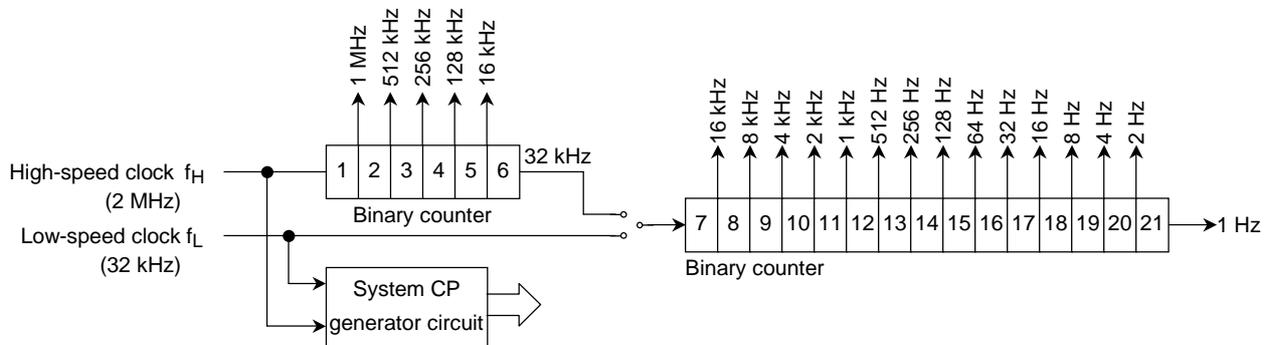
Note 2: High-Speed Clock warm-up

If X'tal oscillation circuit is selected for high-speed oscillation, it takes some time before high-speed oscillation is used for system clock.

**Figure 8 Mode transition**

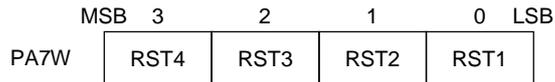
TMP04CH00FXXX has 21 bits Divider.

The divider circuit of bits 1 to 6 generates a clock from 1 MHz to 32 kHz by dividing the high-speed clock (2 MHz). The divider circuit of bits 7 to 21 generates a clock from 16 kHz to 1 Hz by dividing the 32 kHz clock. When the low-speed oscillator circuit is on (CPM1/CPM3), a low-speed clock (32 MHz) is supplied to the divider circuit of bits 7 to 21. When the low-speed oscillator circuit is off (CPM2), output from bit 6 is supplied.



**Figure 9 Divider circuit**

The reset for this Divider circuit is done by Register file RST1 to RST4 (PA7W).



RST1: Binary counter	1 to 6	(2 M to 32 kHz)	reset
RST2: Binary counter	7 to 12	(16 k to 512 Hz)	reset
RST3: Binary counter	13 to 17	(256Hz to 16 Hz)	reset
RST4: Binary counter	18 to 21	(8Hz to 1 Hz)	reset

(when using 2 MHz, 32 kHz crystal)

**CAUTION:**

1. Do not set System CP to low speed when the Low-speed OSC is not in operation or before stable.
2. Do not set System CP to high speed when the High-speed OSC is not in operation or before stable.
3. And, when Low-speed OSC is on, low-speed frequency is supplied from 7th bit Divider circuit (when use 2 MHz crystal for High-speed OSC and 32 kHz crystal for Low-speed OSC and the mode is CPM3, 1 MHz to 32 kHz are made by 2 MHz crystal, 16 kHz to 1 Hz are made by 32 kHz crystal. And when the mode is CPM2, all frequency are made by 2 MHz crystal. Therefore if the mode change between CPM1 and CPM2 or CPM2 and CPM3, the frequency which is supplied by Binary counter 7 to 21 shift the timing).
4. When operated with a 1.5 V power supply, the oscillation frequency on the high-speed side is 200 kHz (max), so that the output of binary counter 6 is 3.125 kHz (max). Consequently, if the mode is changed from CPM1 or CPM3 to CPM2 or from CPM2 to CPM1 or CPM3, the generated timing changes greatly.
5. When the crystal oscillator circuit is used for low-speed oscillation, a long time is required from oscillation stop to oscillation start. The LCD circuit operates using a low-speed clock. LCD cannot be performed until oscillation starts. After power on, operate the low-speed oscillator circuit at all times and do not change to STOP mode.

**Example 1**

```

START mode (After warming up, program start at address 0000.)
  ↓
CPM3 (High/Low speed ON, SYSCP = High, LOWCP OFF)
  ↓   LD 26O, 7H
CPM3 (High/Low speed ON, SYSCP = High, LOWCP ON)
  ↓   LD 26O, 4H
CPM0 (High/Low speed ON, SYSCP = High, LOWCP ON)
  ↓   HALT
STOP mode (High/Low-speed OSC, STOP, SYSCP OFF, LOWCP OFF)
  
```

When an interruption occurs, the mode is changed to START mode and program start at the address which is decided by each interruption (refer to Figure 2).

**Example 2**

```

START mode (After warming up, program start at address 0000.)
  ↓
CPM3 (High/Low speed ON, SYSCP = High, LOWCP OFF)
  ↓   LD 26O, 5H
CPM1 (Low speed ON, SYSCP = low, LOWCP ON)
  ↓   HALT
HALT mode (High speed OSC OFF, Low-speed OSC ON, SYSCP OFF, LOWCP ON)
  
```

When an interruption occurs, the mode is changed to slow mode (CPM1) and program start at the address which is decided by each interruption.

### Example 3

START mode (After warming up, program start at address 0000.)

↓

CPM3 (High/Low speed ON, SYSCP = High, LOWCP OFF)

↓ LD 260, 7H

CPM3 (High/Low speed ON, SYSCP = High, LOWCP ON)

↓ LD 260, 4H

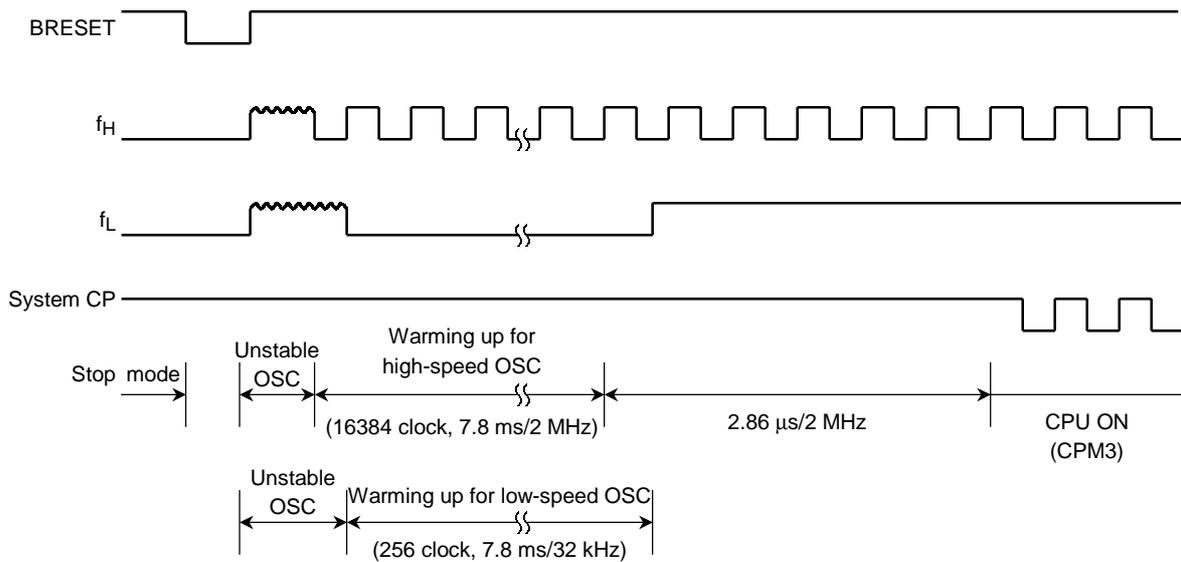
CPM0 (High/Low speed ON, SYSCP = High, LOWCP ON)

(There are no change after shift to CPM0.)

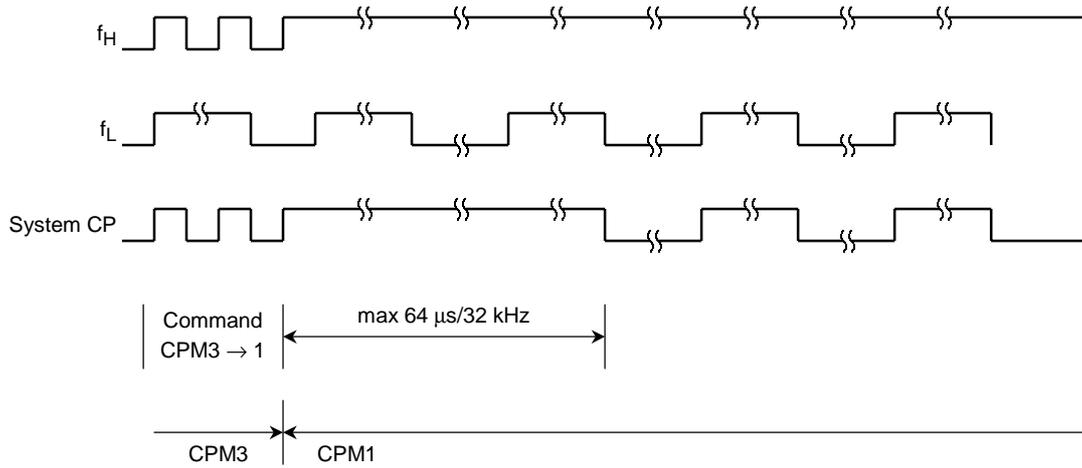
↓ LD 260, 7H

CPM3 (High/Low speed ON, SYSCP = High, LOWCP ON)

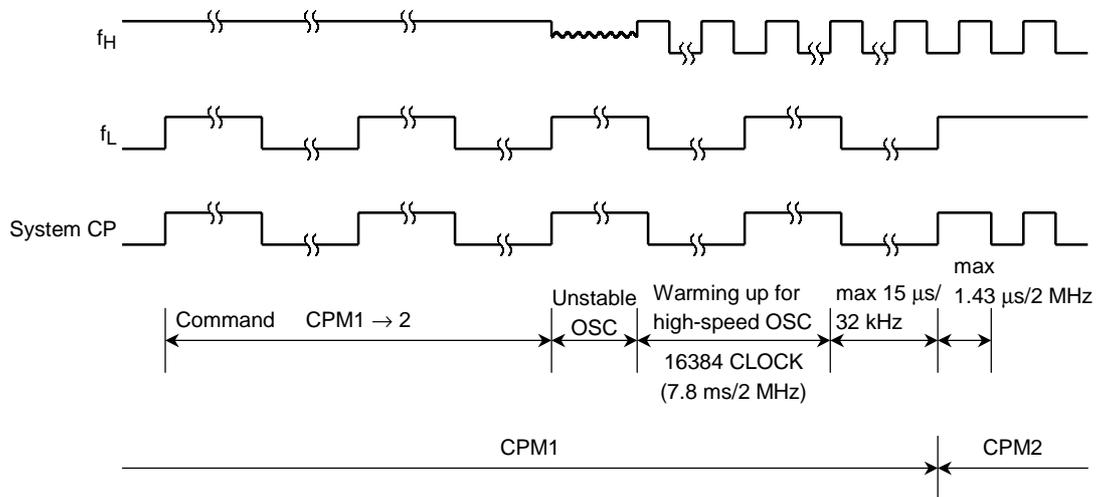
### Example 4 (After reset)



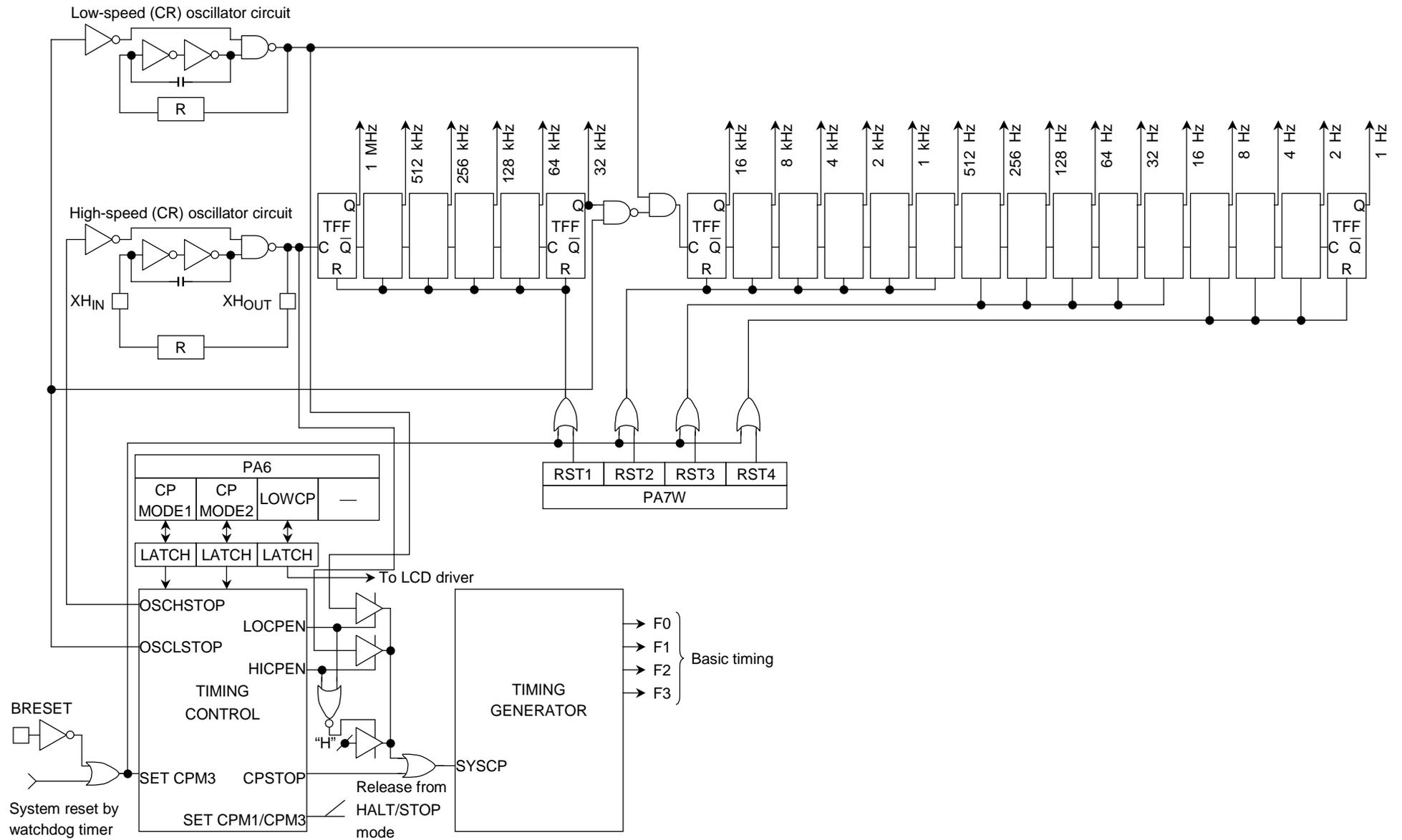
Example 5 (CPM3 → 1)



Example 6 (CPM1 → 2)



Note: No warm-up is provided for high-speed and low-speed RC oscillations by mask options.



**Figure 10 Oscillator circuit/Divider circuit**

**2. Interruption Block**

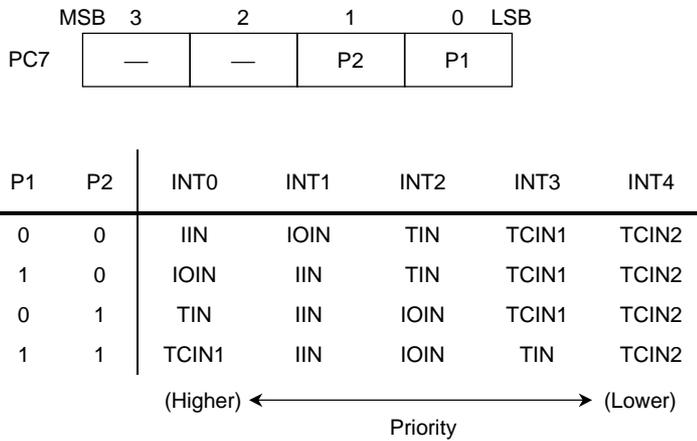
Interruption is supplied by IN1 to IN4, IO01 to IO04, Timer/Counter1 to Counter2, Timing.

(Interruption priority)

Interruption priority can be selected by Register file P1 and P2.

Interrupt priority is valid only when multiple interrupts occur simultaneously.

P1 and P2 are initially 0.



IIN: IN1 to IN4, IOIN: IO01 to IO04, TIN: TIMING, TCIN1/2: TIMER/COUNTER1/2

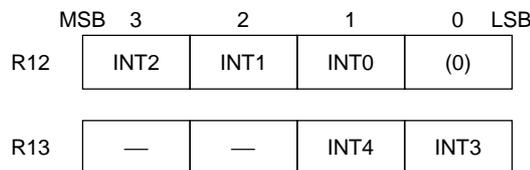
(Interruption enable/disable)

Each interruption (IIN, IOIN, TIN, TCIN1, TCIN2) is decided enable/disable as follows.

- IIN : IIE1 to IIE4 (R42-BIT 0 to 3)
- IOIN : IOIE0 (R43-BIT 0)
- TIN : TIE1 to TIE4 (R53-BIT 0 to 3)
- TCIN1 : TCI1E (R64-BIT 1)
- TCIN2 : TCI2E (R74-BIT 1)

After deciding priority by P1, P2 each interruption is decided enable/disable by INT0 to INT4. Disable the unnecessary interrupts in your application by initial settings of IIE1-4, IOIE, TIE1-4, and TCI1E/2E.

INT0 to INT4 are initially 0 (disable)



INT0 to INT4 = 0    INT0 to INT4 disable  
 = 1    INT0 to INT4 enable

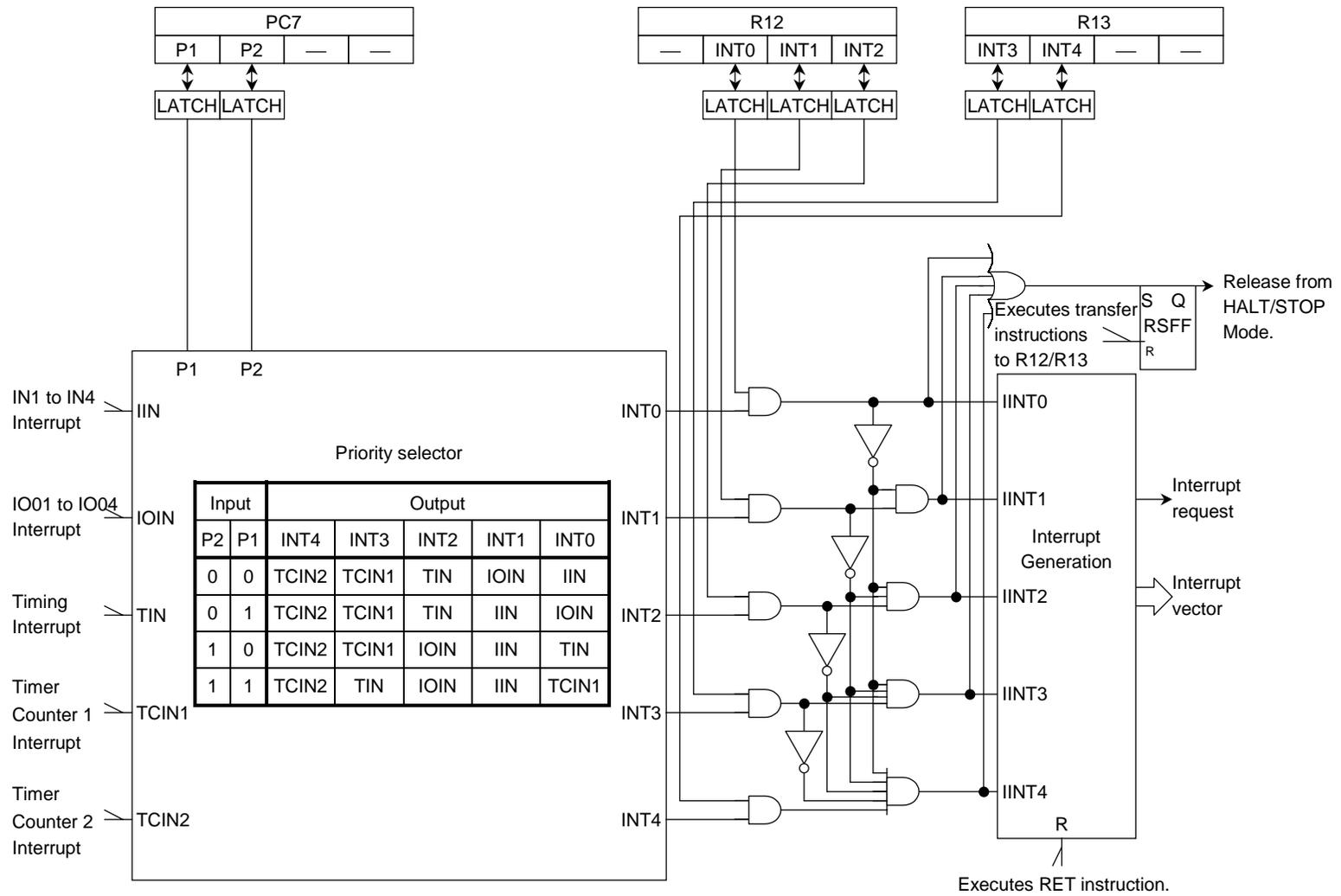
(Interrupt reset)

After an interrupt occurs, reset the interrupt following the procedures described below.

First, reset IN1 to IN4 interrupt/IO01 to IO04 Interrupt/Timing Interrupt/Timer Counter 1 Interrupt/Timer Counter 2 Interrupt.

Then reset the signal "Release from HALT/STOP Mode" by executing a transfer instruction to R12 or R13. (Re-enable interrupts by executing a transfer instruction to R12 or R13, as you need.)

How to deactivate respective interrupts will be explained in the sections which describe each of the interrupts.



**Figure 11 Interruption circuit block**

## 2-1. Input or I/O Interruption

(Interruption enable/disable)

	MSB	3	2	1	0	LSB
PC2		IIE4	IIE3	IIE2	IIE1	

IIE1 = 0 IN1 Interruption disable  
 1 IN1 Interruption enable  
 IIE2 = 0 IN2 Interruption disable  
 1 IN2 Interruption enable  
 IIE3 = 0 IN3 Interruption disable  
 1 IN3 Interruption enable  
 IIE4 = 0 IN4 Interruption disable  
 1 IN4 Interruption enable

IIE1 to IIE4 are initially 0 (IN1 to IN4 interruption disable).

	MSB	3	2	1	0	LSB
PC3		—	—	—	IOIE0	

IOIE0 = 0 IO01 to IO04 Interruption disable  
 1 IO01 to IO04 Interruption enable

IOIE0 is initially 0 (disable).

Interruption enable/disable bit can use as interruption reset.

When the interruption occurs and after recognizing the interruption, it can be reset by setting IIE1 to IIE4 or IOIE0.

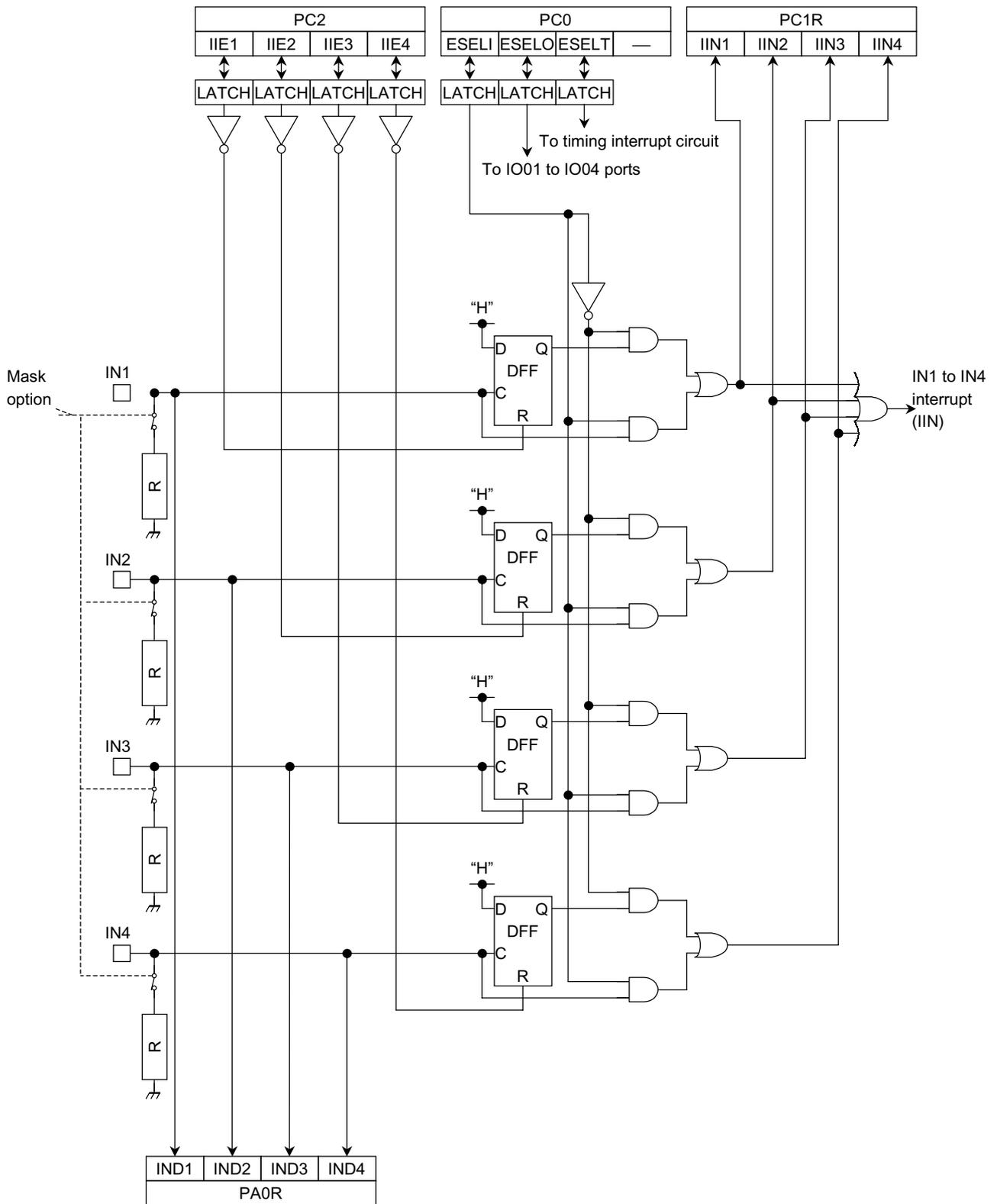
(Interruption data read)

Interruption Data of IN1 to IN4 can be read by Register file IIN1 to IIN4.

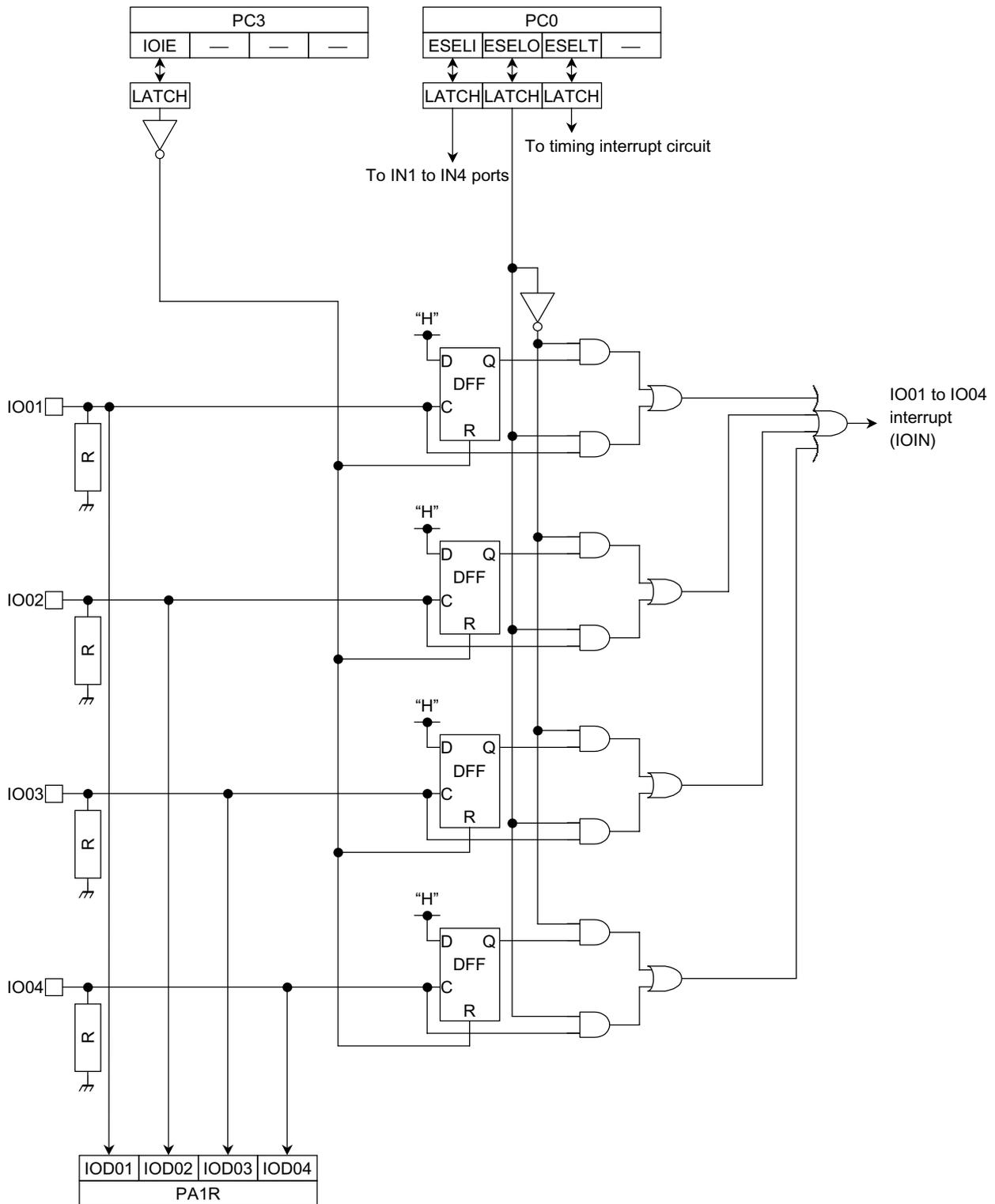
	MSB	3	2	1	0	LSB
PC1R		IIN4	IIN3	IIN2	IIN1	

### Example

```
LD 420, 0FH    (set enable to IN1 to IN4)
↓
IN1 interruption occurs.
Program goes to the address which is decided by each interruption.
LD M, 410      (read IN1 to IN4 interruption)
↓
recognize which interruption is occurred.
(recognize IN1 interruption is occurred.)
LD 420, 0EH    (reset IN1 interruption)
↓
LD 120, 0FH    (set enable to INT0 to INT2)
↓
LD 130, 0FH    (set enable to INT3 to INT4)
↓
LD 420, 0FH    (set enable to IN1 to IN4 interruption)
```



**Figure 12 IN1 to IN4 interrupts**



**Figure 13 IO01 to IO04 interrupts**

Note: Disabling input or input/output interrupts using PC2 or PC3 is valid only when a rising edge interrupt (see 4, Input/Output ports) is selected. If a level interrupt is selected, disabling interrupts using PC2 or PC3 is invalid.

## 2-2. Timing Interruption

(Timing Interruption selecting)

Timing Interruptions are selectable by Register file (PD1) 128/256, 16/32, 4/8, 1/2. 128/256, 16/32, 4/8 and 1/2 are initially 0 (1 Hz, 4 Hz, 16 Hz, 128 Hz is selected).

	MSB	3	2	1	0	LSB
PD1		1/2	4/8	16/32	128/256	

128/256	= 0	128 Hz	INT. select
	1	256 Hz	INT. select
16/32	= 0	16 Hz	INT. select
	1	32 Hz	INT. select
4/8	= 0	4 Hz	INT. select
	1	8 Hz	INT. select
1/2	= 0	1 Hz	INT. select
	1	2 Hz	INT. select

(Timing Interruption enable/disable)

Selected Timing Interruption can be controlled enable/disable by Register file TIE1 to TIE4 (PD3).

TIE1 to TIE4 are initially 0 (disable).

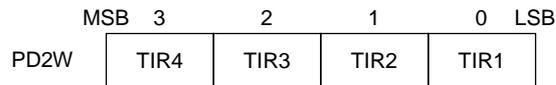
	MSB	3	2	1	0	LSB
PD3		TIE4	TIE3	TIE2	TIE1	

TIE1	= 0	1 Hz	or 2 Hz	INT. disable
	1	1 Hz	or 2 Hz	INT. enable
TIE2	= 0	4 Hz	or 8 Hz	INT. disable
	1	4 Hz	or 8 Hz	INT. enable
TIE3	= 0	16 Hz	or 32 Hz	INT. disable
	1	16 Hz	or 32 Hz	INT. enable
TIE4	= 0	128 Hz	or 256 Hz	INT. disable
	1	128 Hz	or 256 Hz	INT. enable

### (Timing Interruption Reset)

The timing interruption for the selected timing interruption is reset by register files TIR1 to TIR4 (PD2W).

TIR1 to TIR4 are initially 0 (disable).



TIR1 = 1 1 Hz or 2 Hz Interruption reset

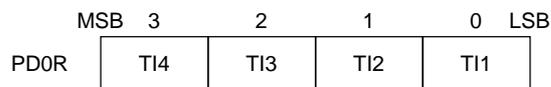
TIR2 = 1 4 Hz or 8 Hz Interruption reset

TIR3 = 1 16 Hz or 32 Hz Interruption reset

TIR4 = 1 128 Hz or 256 Hz Interruption reset

### (Timing Interruption Read)

Selected Timing Interruption can be read by Register file TI1 to TI4 (PD0R).



TI1: Interruption data of 1 Hz or 2 Hz

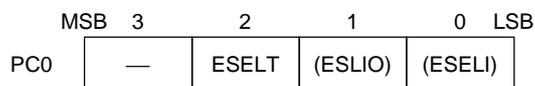
TI2: Interruption data of 4 Hz or 8 Hz

TI3: Interruption data of 16 Hz or 32 Hz

TI4: Interruption data of 128 Hz or 256 Hz

### (Interruption Edge Selection)

TIN Interruption can be selected the reading point ( $\uparrow$  or  $\downarrow$ ) by Register file ESELT. ESTLT is initially 0 (rising edge).



ESELT = 0: Interruption at rising Edge of Timing INT.

1: Interruption at down Edge of Timing INT.

### Example

LD 510, 01H (256 Hz, 16 Hz, 4 Hz, 1 Hz select)

↓

LD 530, 07H (256 Hz disable, 16 Hz, 4 Hz, 1 Hz enable)

↓

When the 1Hz interruption occurs.

LD M, 500 (read timing interruption)

↓

Recognize 1Hz interruption.

LD 520, 01H (reset 1Hz interruption)

Note: Since a mode transition from CPM1 or CPM3 to CPM2 or from CPM2 to CPM1 or CPM3 causes the timing of the binary counters 7-21 to change, timing interrupts also have their timings changed.

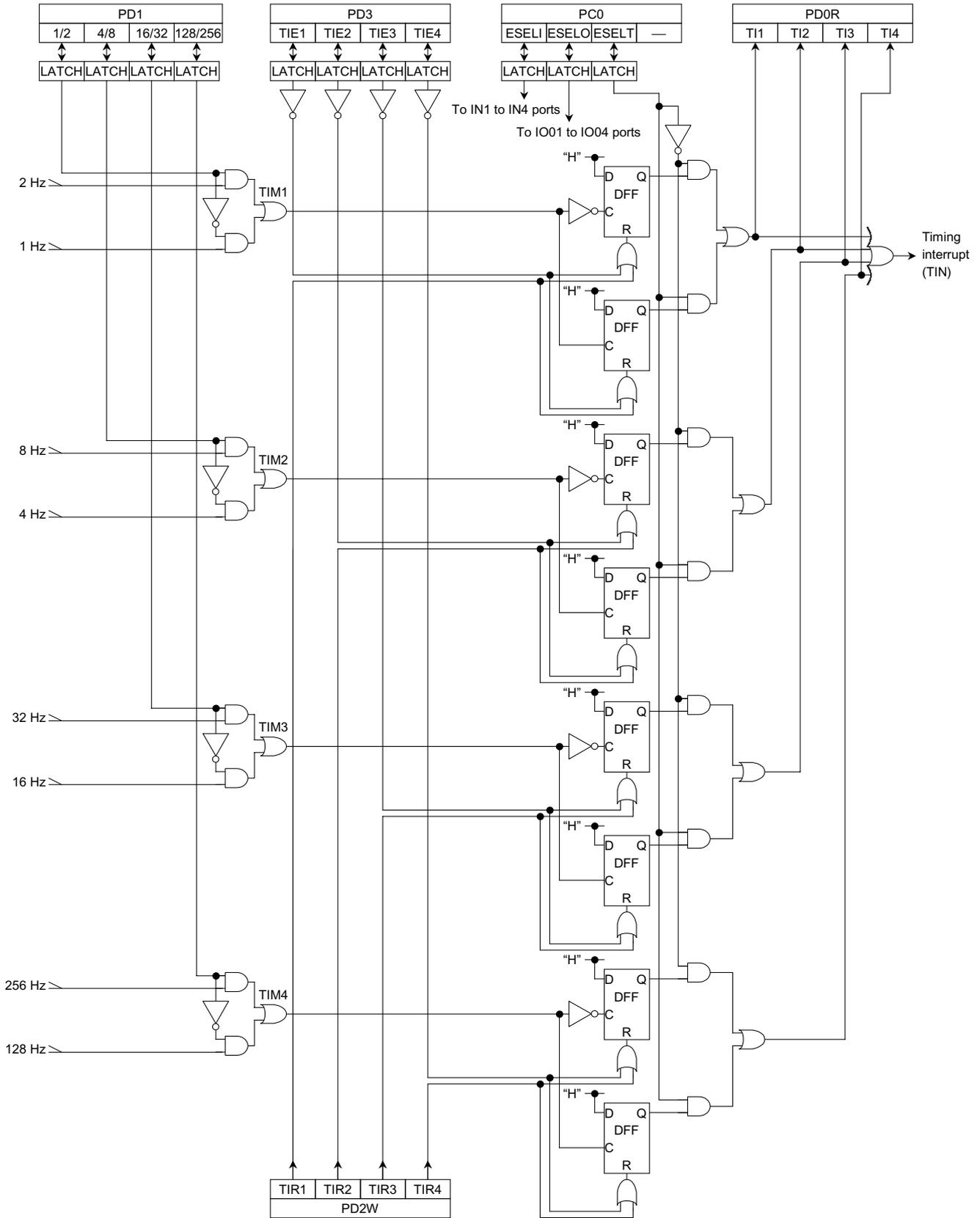
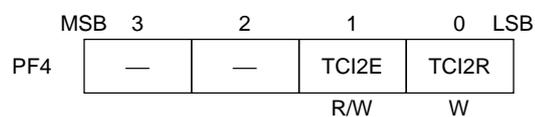
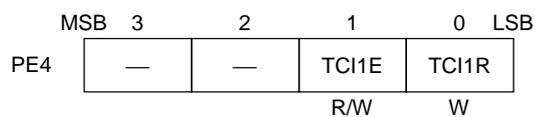


Figure 14 Timing interrupt circuit

## 2-3. 8 bits/16 bits Timer Counter Interruption

When Timer/Counter1, 2 overflow or coincide with setting Time/Count, each Interruption occurs.



TCI1E/TCI2E = 1 Timer/Counter1, 2 Interruption enable  
 = 0 Timer/Counter1, 2 Interruption disable

TCI1R/TCI2R = 1 Timer/Counter1, 2 Interruption reset

TCI1E, TCI2E and TCI2R are initially 0 (DISABLE).

### 3. Timer/Counter

The Timer/Counter circuit can use as 8 bit × 2ch or 16 bit × 1ch Timer/Counter.

And there Time/Counter can be use as general Timer/Counter, Watch Dog Timer, or Multi Interruption Timer.

8 bits/16 bits can be switched by Register file TCPS. And input frequency also can be changed by Register CKS11 to CKS13 and CKS21 to CKS23, as follows.

	MSB	3	2	1	0	LSB
PE2		—	CKS13	CKS12	CKS11	

	MSB	3	2	1	0	LSB
PF2		TCPS	CKS23	CKS22	CKS21	

CKS 11	CKS 12	CKS 13	Input Frequency for Timer Counter1 ( $f_H = 2 \text{ MHz}$ , $f_L = 32 \text{ kHz}$ )	
0	0	0	$f_H/2^{21}$ ( $f_L/2^{15}$ )	1 Hz (1.0 s)
1	0	0	$f_H/2^{12}$ ( $f_L/2^6$ )	512 Hz (19.5 ms)
0	1	0	$f_H/2^8$ ( $f_L/2^2$ )	$2^{13}$ Hz (122 μs)
1	1	0	$f_H/2^3$	$2^{18}$ Hz (3.81 μs)
—	—	1	OFF	

CKS 21	CKS 22	CKS 23	Input Frequency for Timer Counter2 ( $f_H = 2 \text{ MHz}$ , $f_L = 32 \text{ kHz}$ )	
0	0	0	$f_H/2^{15}$ ( $f_L/2^9$ )	64 Hz (15.6 ms)
1	0	0	$f_H/2^9$ ( $f_L/2^3$ )	$2^{12}$ Hz (244 μs)
0	1	0	$f_H/2^5$	$2^{16}$ Hz (15.2 μs)
1	1	0	$f_H/2^2$	$2^{19}$ Hz (1.90 μs)
—	—	1	OFF	

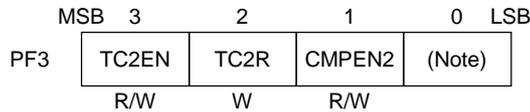
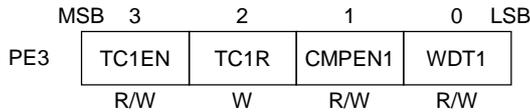
TCPS = 0 8 bit × 2 ch Timer/Counter  
 = 1 16 bit × 1 ch Timer/Counter

( When Timer/Counter is used as 16 bits timer, TIMER2 is used as lower bits.  
 And CKS11 to CKS13 are ignored. Input Frequency is decided by CKS21 to CKS23. )

CKS11 to CKS13, CKS21 to CKS23, TCPS are initially 0.  
 (Timer/Counter1 : 1Hz, Timer/Counter2: 64 Hz, 8 bit × 2 ch)

CAUTION: 256 kHz of Timer/Counter1, 512 kHz, 64 kHz of Timer/Counter2 can be used when High-speed OSC is on.

Timer function can be selected by Register file/WDT1 and CMPEN1, 2.  
 Timer/Counter1 can be used as Watch Dog Timer.  
 And Input Frequency can be controlled by Register file TC1EN and TC2EN.  
 Timer/Counter is resetted by Register file TC1R, TC2R.



Note: Writing 1 invalidates TC2 interrupts.

Timer/Counter1 setting is made in PE3.  
 Timer/Counter2 setting is made in PF3.

All the bits of PE3 and PF3 are initially 0.

PE3 WDT1 = 0: Used as 8-bit Timer/Counter.  
 = 1: Used as Watchdog Timer.

CMPEN1 = 0: An interrupt is generated if Timer/Counter1 overflows.  
 (The entire system is reset if WDT1 = 1.)  
 = 1: An interrupt is generated if Timer/Counter1 values match Time/Count set values  
 (The entire system is reset if WDT1 = 1.)

TC1R = 1: Timer/Counter1 is reset (cleared).  
 Timer/Counter1 resumes counting up after reset. (Refer to the timing chart below.)

TC1EN = 0: Reference clock input on Timer/Counter1 is stopped.  
 = 1: Reference clock input on Timer/Counter1 is started.

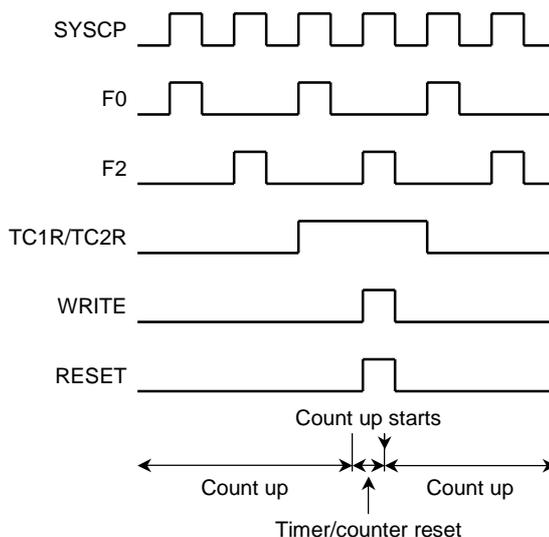
PF3 BIT 0 = 1: Timer/Counter2 cannot be used as 8-bit Timer/Counter.  
 = 0: Timer/Counter2 is used as 8-bit Timer/Counter.

CMPEN2 = 0: An interrupt occurs if Timer/Counter2 overflows.  
 = 1: An interrupt occurs if Timer/Counter2 values match Time/Count set values.

TC2R = 1: Timer/Counter2 is reset (cleared).  
 Timer/Counter2 resumes counting up after reset. (Refer to the timing chart below.)

TC2EN = 0: Reference clock input on Timer/Counter2 is stopped.  
 = 1: Reference clock input on Timer/Counter2 is started.

Timing chart for timer/counter 1/2 reset



Timer/Counter1,2 data can read from Register file TCR11 to TCR18 and TCR21 to TCR28.

	MSB	3	2	1	0	LSB
PE0R	TCR14	TCR13	TCR12	TCR11		
PE1R	TCR18	TCR17	TCR16	TCR15		
PF0R	TCR24	TCR23	TCR22	TCR21		
PF1R	TCR28	TCR27	TCR26	TCR25		

Timer/Counter1, 2 Comparison data is set by Register file SET11 to SET18 and SET21 to SET28.

	MSB	3	2	1	0	LSB
PE0W	SET14	SET13	SET12	SET11		
PE1W	SET18	SET17	SET16	SET15		
PF0W	SET24	SET23	SET22	SET21		
PF1W	SET28	SET27	SET26	SET25		

SET11 to SET18 and SET21 to SET28 are initially 0.

**CAUTION:**

1. When generating an interrupt for the timer/counter by comparing it with the setup value (SET11 to SET18, SET21 to SET28) or resetting the system, set the setup values in register files SET11 to SET18 and SET21 to SET28 before enabling CMPEN1 and CMPEN2.
2. When generating an interrupt by a 16-bit timer by comparing it with the setup value, enable all of CMPEN1, CMPEN2, TC1EN, and TC2EN using instructions.
3. Since the setup values and timer/counter values both are 0 after initialization, an interrupt is generated or the system is reset immediately when CMPEN1 is enabled.
4. Since a mode transition from CPM1 or CPM3 to CPM2 or from CPM2 to CPM1 or CPM3 causes the timing of the binary counters 7-21 to change, the timer/counters also have their timings changed.
5. Do not change the timer/counter from 8 bits to 16 bits in the middle of operation after the timer/counter has started counting, because such a change could cause the data to be destroyed.

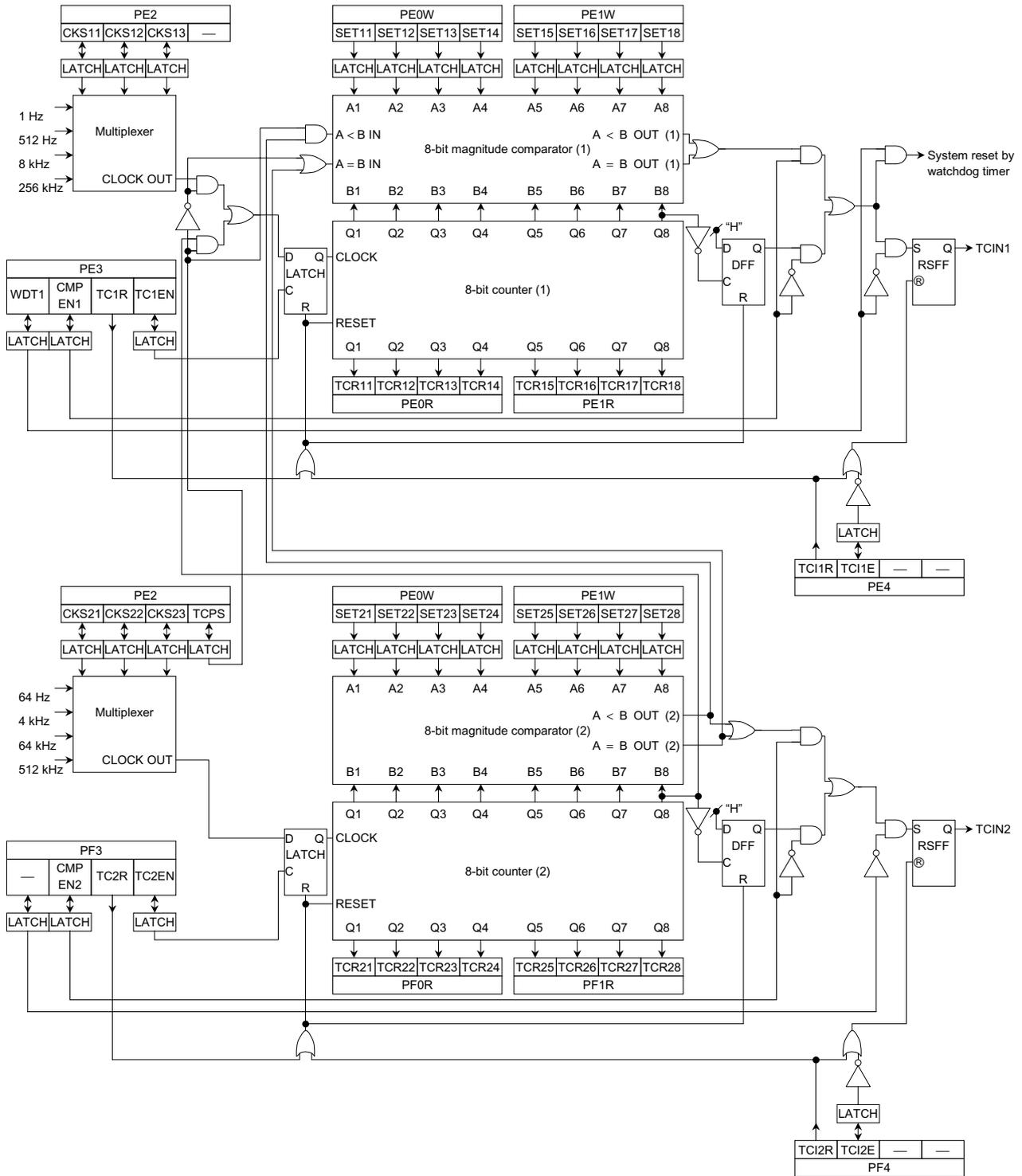


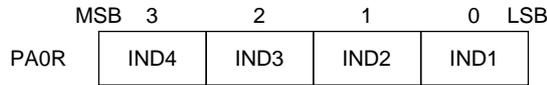
Figure 15 Timer/Counter

**4. Input/IO Ports (Refer to Figure 18)**

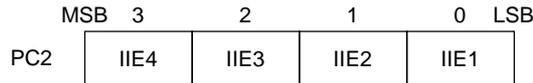
TMP04CH00FXXX has 8 inputs and 8 I/O ports.  
8 input ports have Interruption.

**4-1. Input (IN1 to IN4, IO01 to IO04)**

Each input data can be read by Register file IND1 to IND4.



Each input Interruption function can be set enable/disable by Register file IIE1 to IIE4.

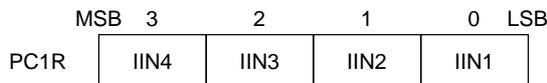


IIE1 to IIE 4 = 0 IN1 to IN4 each Interruption disable  
= 1 IN1 to IN4 each Interruption enable

Note 1: IIE1 to IIE4 interrupt disable/enables are register files that are effective when rising-edge interrupts are selected.

When level interrupts are selected, interrupts are disabled/enabled by the data input from ports. In this case, therefore, interrupts cannot be disabled/enabled by the register files. After the level-triggered interrupt is selected, do not apply 61-μs or less pulse (low speed, two cycles) to the IN pin. Malfunction may occur.

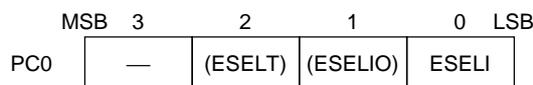
4 inputs (IN1 to IN4) Interruption data can be read by Register file IIN1 to IIN4.



Note 2: Interrupt data IO01 to IO04 cannot be read out. Only the data input from ports can be read out. (Refer to Figure 13.)

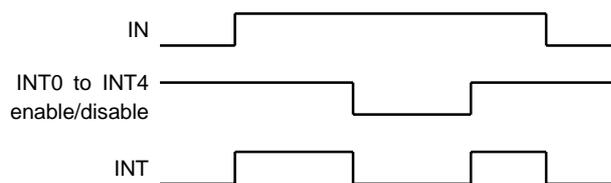
Interrupt timings (rising edge/evel) can be selected using register file ESELI.

Each input Interruption recognized timing (rising edge/High level) can be selected by Register file ESELI (R40 bit1).



ESELI = 0 IN1 to IN4: Interruption at rising edge of input INT.  
1 IN1 to IN4: High level of input INT.

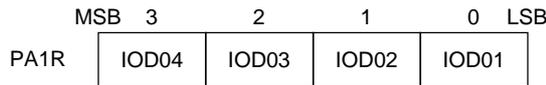
Input level-triggered interrupts are possible when ESELI = 1. In this case, if interrupts have been enabled by register files INT0-4, the interrupt remain asserted while the input level is high.



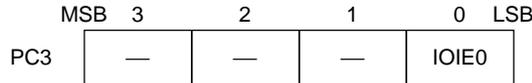
**Figure 16 Interruption by high level-read**

Input ports (IO01 to IO04)

The input data can be read out via register files IOD01 to IOD04.



IOD01 to IOD04 have an interrupt facility, so that interrupts can be disabled/enabled by register file IOIE0. (Four interrupt sources are collectively disabled/enabled by IOIE0.)



IOIE0 = 0 IO01 to IO04 are disabled.

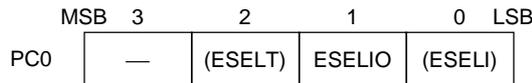
1 IO01 to IO04 are enabled.

Note: The IO01 to IO04 interrupt disable/enables are the register files that are effective when rising-edge interrupts are selected.

When level interrupts are selected, interrupts are disabled/enabled by the data input from ports. In this case, therefore, interrupts cannot be disabled/enabled by the register files.

After the level-triggered interrupt is selected, do not apply 61- $\mu$ s or less pulse (low speed, two cycles) to the IO0 pin. Malfunction may occur.

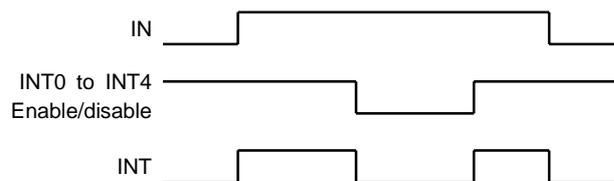
Interrupt timings of IO01 to IO04 (rising edge/level) can be selected using register file ESELIO.



ESELIO = 0 Interrupts IO01 to IO04 are rising edge-triggered.

1 Interrupts IO01 to IO04 level-triggered.

Input level-triggered interrupts are possible when ESELIO = 1. In this case, if interrupts have been enabled by register files INT0 to INT4, the interrupt remain asserted while the input level is high.



**Figure 17 Level-triggered interrupts**

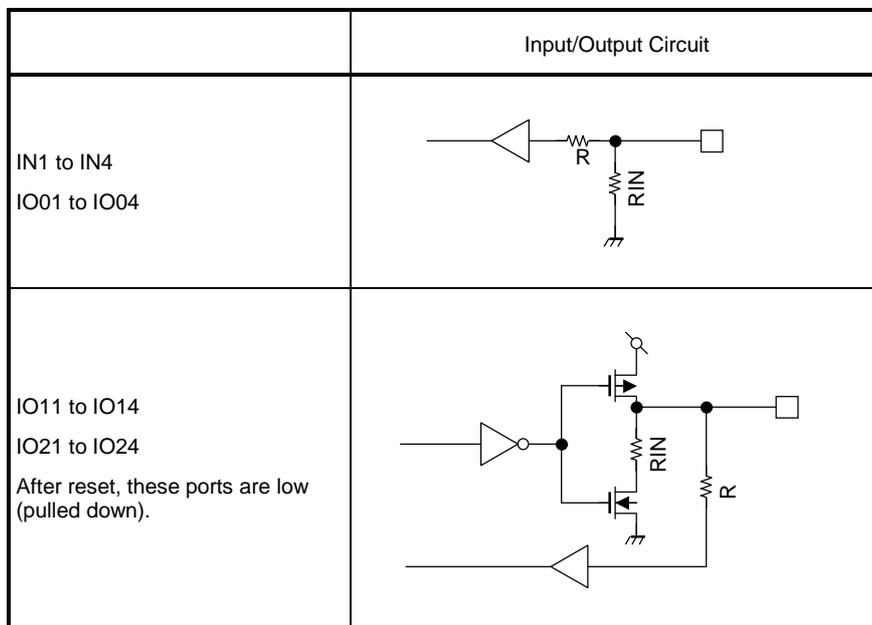
### 4-2. I/O ports (IO11 to IO14, IO21 to IO24)

Each input data can be read by following Register file, when using input port.

	MSB	3	2	1	0	LSB
R14R		IOD14	IOD13	IOD12	IOD11	
R15R		IOD24	IOD23	IOD22	IOD21	

When using each input/output port for output, the output data can be set using the register file shown below.

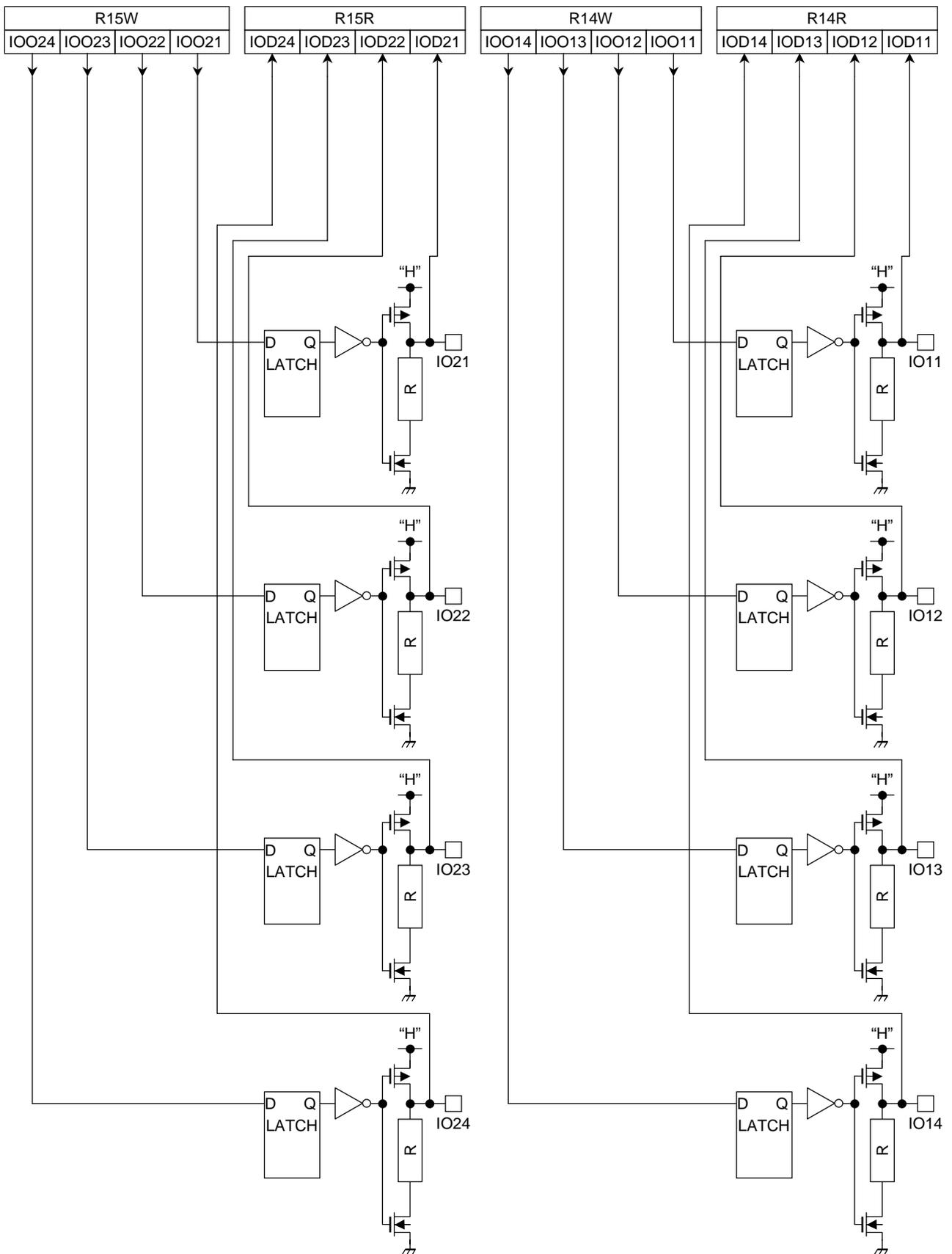
	MSB	3	2	1	0	LSB
R14W		IOO14	IOO13	IOO12	IOO11	
R15W		IOO24	IOO23	IOO22	IOO21	



**Figure 18 Structure of input/output port**

RIN: Internal pull-down resistor, 400 kΩ (typ.)

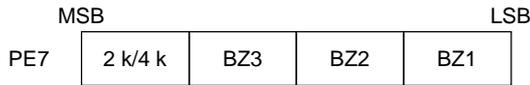
R : Input protective resistor, 100 Ω (typ.)



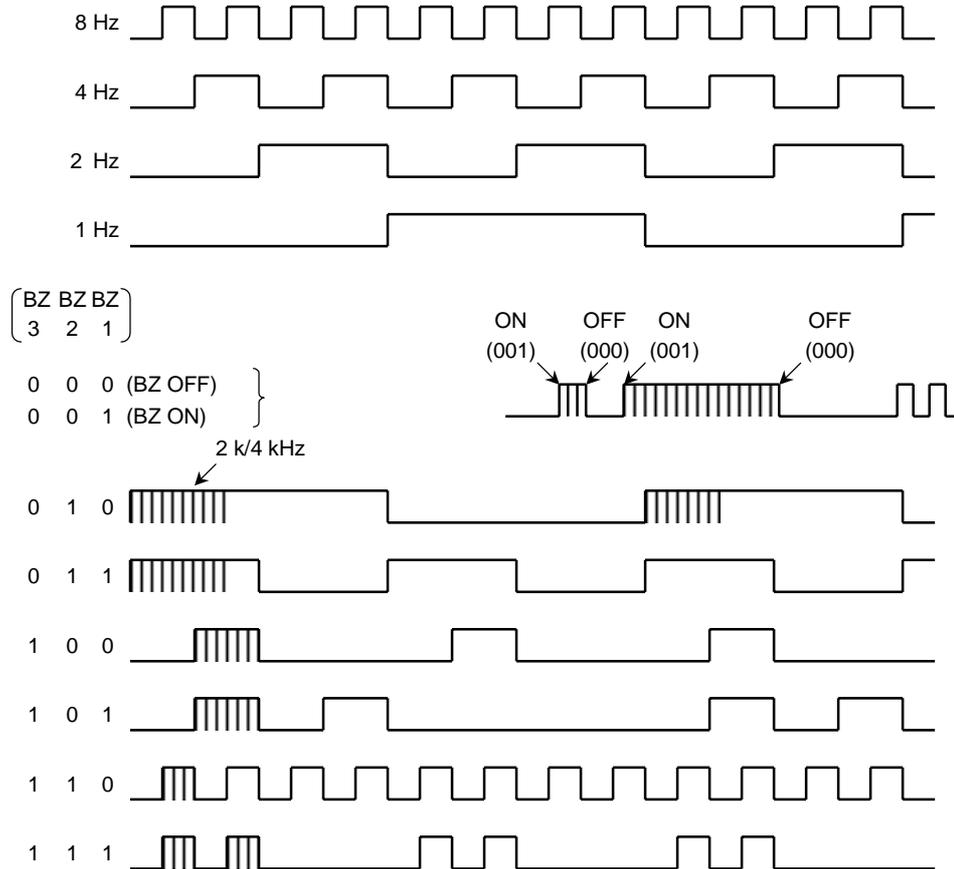
**Figure 19 IO11 to IO14, IO21 to IO24**

**5. Buzzer Circuit**

Buzzer sound can be selected by Register file BZ1, BZ2, BZ3 and 2k/4k.



2 k/4 k = 0 Basic frequency 2 kHz  
 = 1 Basic frequency 4 kHz

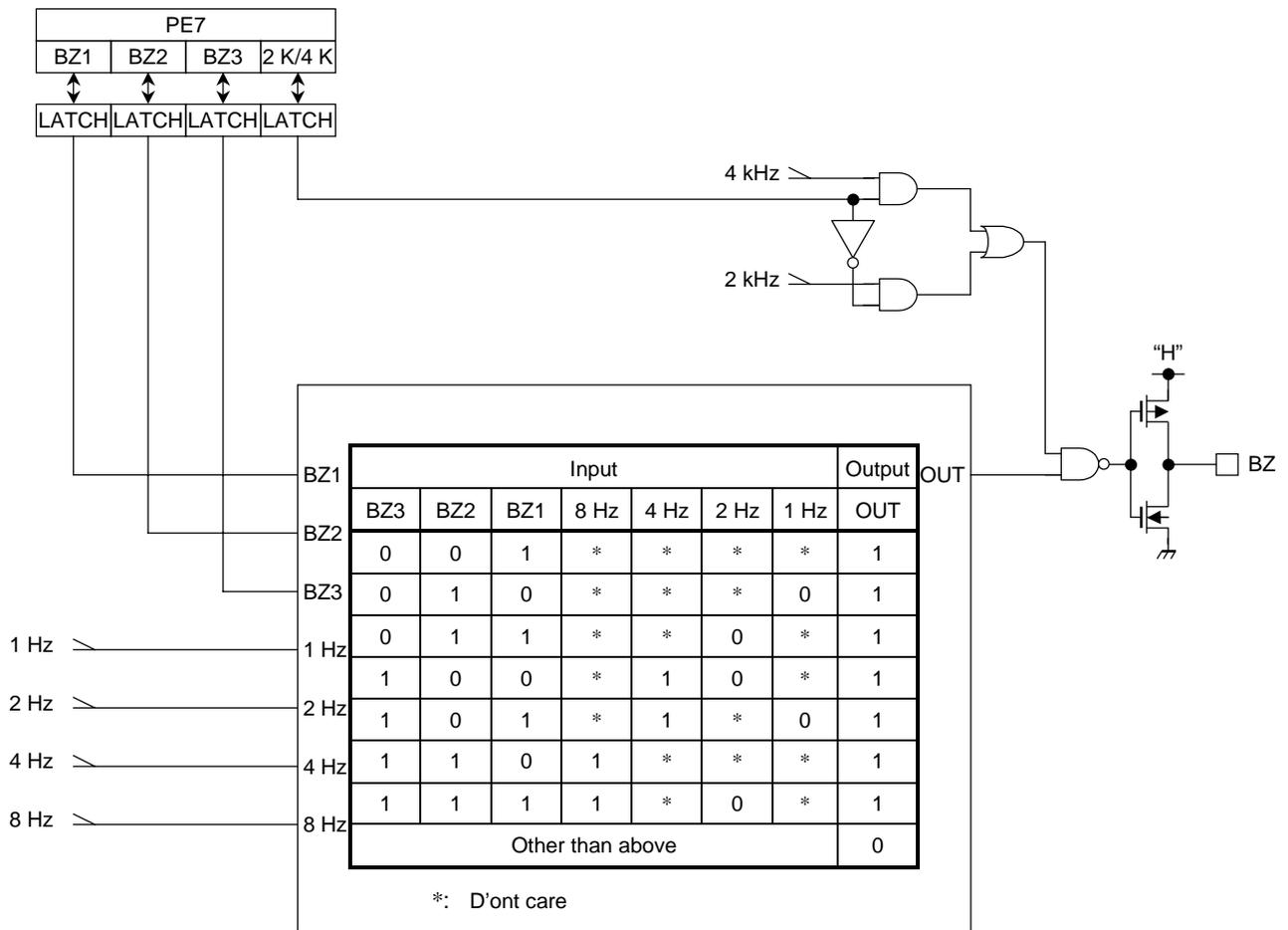


**Figure 20 Buzzer sound**

BZ sound can be made by software using (000), (001) setting, as above.

When the Register file R67 is set the above ((BZ3, BZ2, BZ1) = (010) to (111)), each BZ sound is continuously released setting (BZ3, BZ2, BZ1) to (000).

Note: The above buzzer sounds are shown with respect to timings in the CPM2 mode where the high-speed oscillation frequency is 2 MHz, the CPM1/3 mode where the low-speed oscillation frequency is 32 kHz, and in the HALT mode.



**Figure 21 Buzzer circuit**

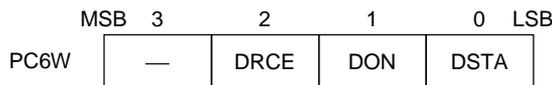
**6. LCD Circuit**

The LCD driver circuit has common signals and segment signals to drive 4.5 V, 1/8 or 1/10 duty, 1/4 bias LCD.

Duty can be selected by Mask option either 1/8 or 1/10.

Duty	Frame Frequency	Common	Segment
1/8	97.5 Hz	COM1 to COM8	S <sub>1</sub> to S <sub>60</sub>
1/10	117.0 Hz	COM1 to COM10	S <sub>1</sub> to S <sub>58</sub>

The LCD driver circuit is controlled by Register file both DSTA and DON, and Display RAM is enable on DRCE = 1

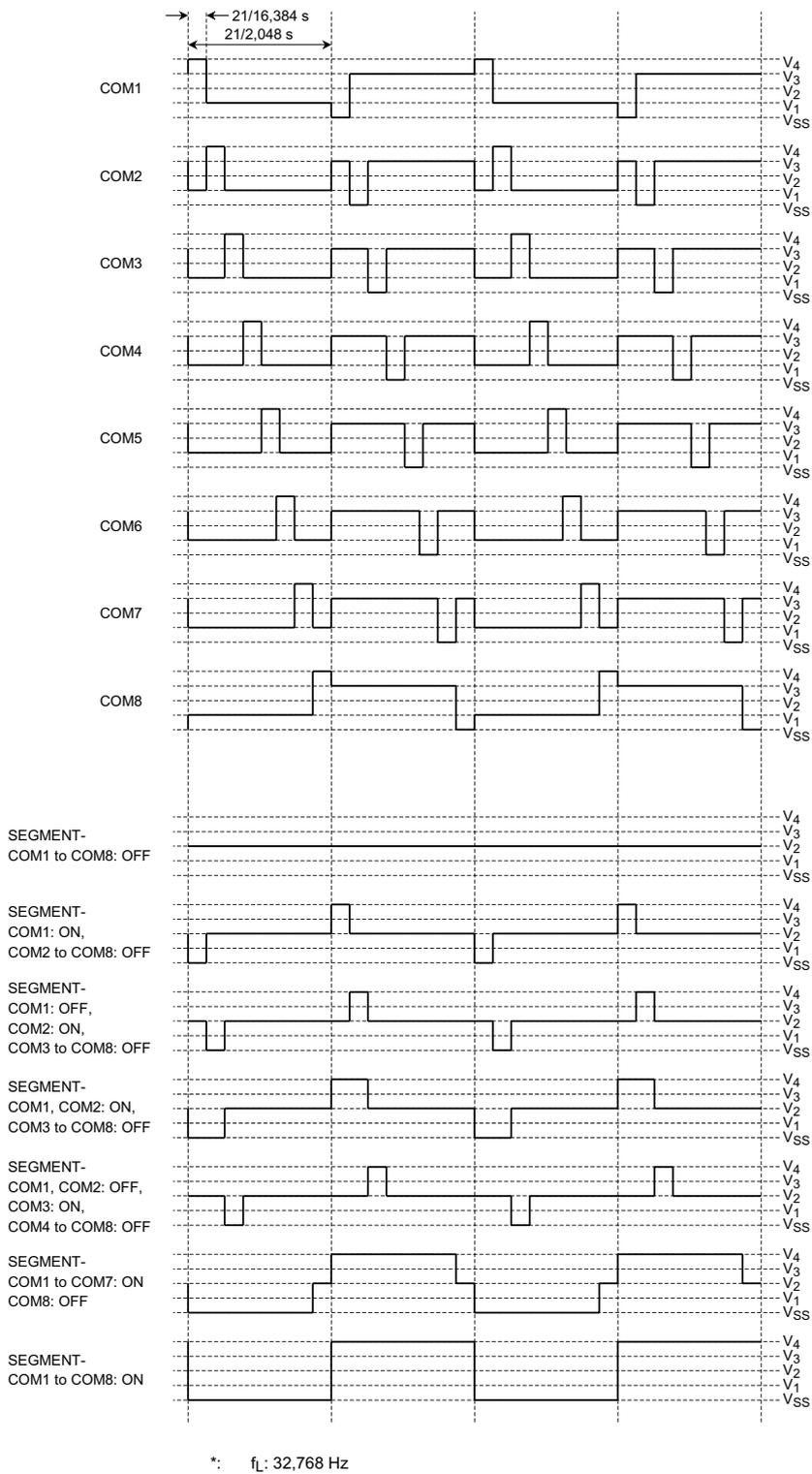


- DSTA = 0 com/seg = V<sub>SS</sub>
- = 1 enable normal Display
- DON = 0 Booster circuit (Quadrupler) OFF
- = 1 Booster circuit (Quadrupler) ON
- DRCE = 0 disable Display RAM
- = 1 enable Display RAM

**CAUTION:**

1. Display signals from segment and common are made by the clock which come from low- speed oscillation. Even though the high-speed oscillator may be operating no display is output unless the low-speed oscillator is operating.
2. Register file DON and DSTA are read to Display Driver circuit by the clock which is made by LOWCP. When the LOWCP is needed OFF it is needs max. 103 ms after changing the data of DON and DSTA.

LCD drive waveform  
(1) 1/8 duty



**Figure 22 LCD drive waveform (1/8 duty)**

(2) 1/10 duty

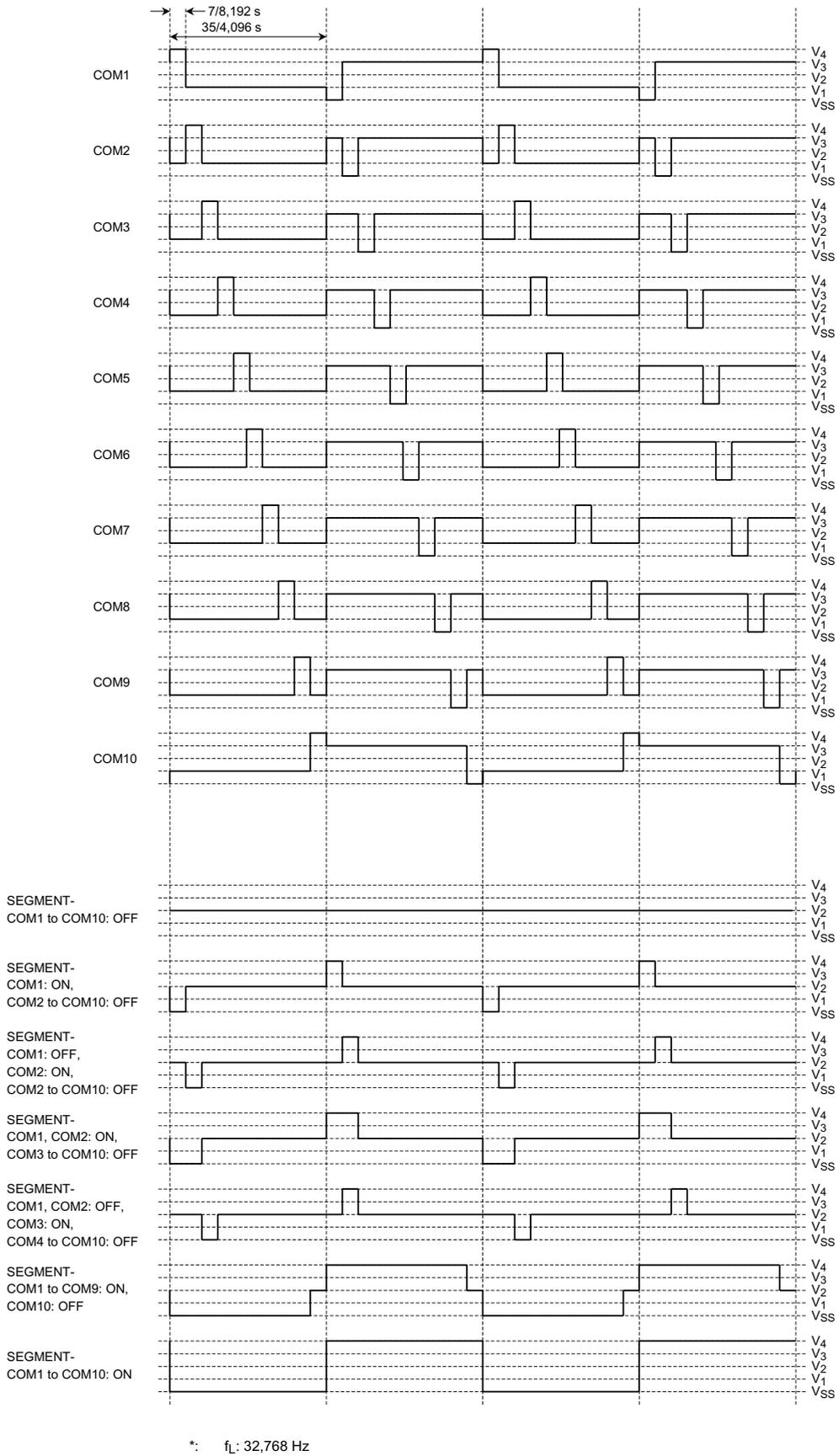


Figure 23 LCD drive waveform (1/10 duty)

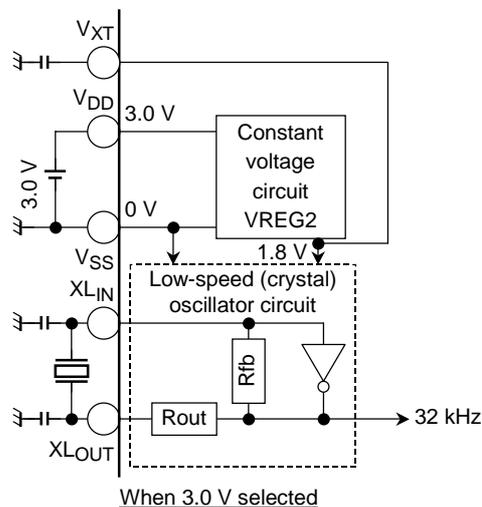
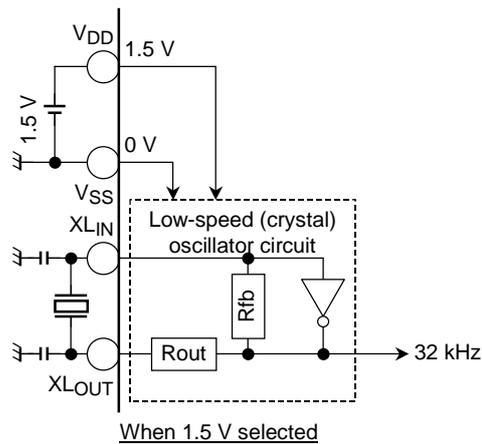
## 7. Mask option

TMP04CH00FXXX has 12 Mask option.

Mask code	Battery	Duty	Segment	High-speed OSC	Low-speed OSC	IN1 to IN4 Pull-down Resister
A1081	1.5 V	1/8	60	CR	X'tal	Incorporated
A1083	1.5 V	1/8	60	CR	CR	Incorporated
A10A1	1.5 V	1/10	58	CR	X'tal	Incorporated
A10A3	1.5 V	1/10	58	CR	CR	Incorporated
A3080	3.0 V	1/8	60	X'tal	X'tal	Incorporated
A3081	3.0 V	1/8	60	CR	X'tal	Incorporated
A3083	3.0 V	1/8	60	CR	CR	Incorporated
A30A0	3.0 V	1/10	58	X'tal	X'tal	Incorporated
A30A1	3.0 V	1/10	58	CR	X'tal	Incorporated
A30A3	3.0 V	1/10	58	CR	CR	Incorporated
A3480	3.0 V	1/8	60	X'tal	X'tal	Not Incorporated
A34A0	3.0 V	1/10	58	X'tal	X'tal	Not Incorporated

### (1) Supply voltage

Either 1.5 V or 3.0 V can be selected as the supply voltage. When 3.0 V is used, the low-speed oscillator circuit is driven by output from the internal constant voltage circuit (VREG2) thus reducing current dissipation.



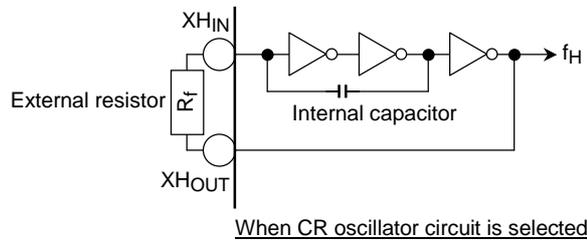
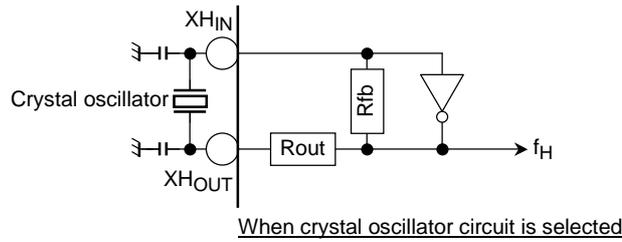
(2) LCD duties/number of segments

Either 1/8 or 1/10 can be selected as the LCD duty. When 1/8 is selected, the number of segment pins is 60. When 1/10 is selected, the number of segment pins is 58. Among LCD drive pins, the functions (segment/common) of S59/COM10 and S60/COM9 are switched depending on the duty selected.

(3) High-speed oscillator circuit

Either the crystal or the CR oscillator circuit can be selected as the high-speed oscillator circuit.

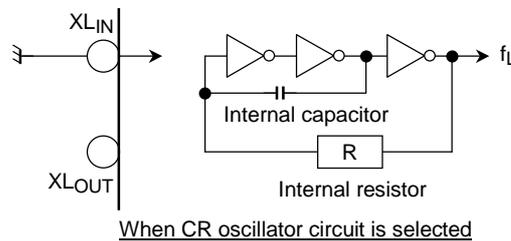
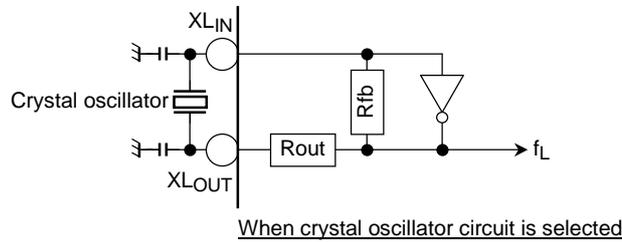
Note: After a reset, the CPU starts operating using the high-speed clock as the system clock. Therefore, even if only a low-speed clock is used for the following processes, the high-speed oscillator circuit must operate normally at startup. Select either the crystal or the CR oscillator circuit and correctly connect the external component (crystal oscillator or resistor) to the XH<sub>IN</sub>/XH<sub>OUT</sub> pin.



(4) Low-speed oscillator circuit

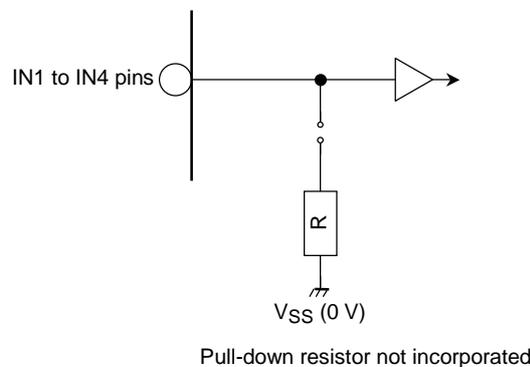
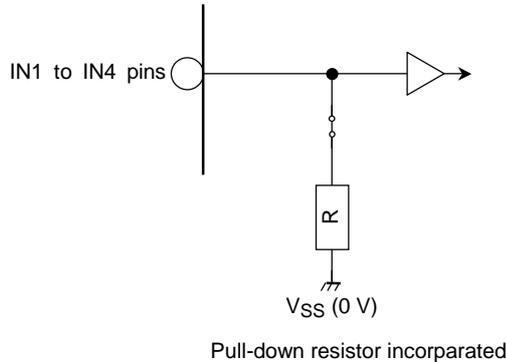
Either the crystal or the CR oscillator circuit can be selected as the low-speed oscillator circuit.

Note: A low-speed clock is used in the LCD driver circuit. To display the LCD, the low-speed oscillator circuit must be operated. When the CR oscillator circuit is selected, because both resistor and capacitor are built in, an external component is not required. Connect the XL<sub>IN</sub> pin to V<sub>SS</sub>. If the pin is left open, the internal circuit gates become unstable, possibly allowing surge current to flow.



(5) IN1 to IN4 pull-down resistor

Pull-down resistor for IN1 to IN4 pins can be chosen to be incorporated or not incorporated.



## Electrical Characteristics

### Absolute Maximum Ratings (V<sub>SS</sub> = 0 V)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>DD</sub>	-0.3 to 6.0	V
Input voltage	V <sub>IN</sub>	-0.3 to V <sub>DD</sub> + 0.3	V
Power dissipation (T <sub>opr</sub> = 80°C)	P <sub>D</sub>	350	mW
Solder temperature	T <sub>sol</sub>	260 (10 s)	°C
Storage temperature	T <sub>stg</sub>	-55 to 125	°C
Operating temperature	T <sub>opr</sub>	0 to 40	°C

### Recommended operating condition

#### 1.5V version (unless otherwise specified, V<sub>SS</sub> = 0 V, T<sub>opr</sub> = 0°C to 40°C)

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Power supply voltage		V <sub>DD</sub>	f <sub>XTH</sub> = 200 kHz	1.2	1.5	1.8	V
Oscillation frequency		f <sub>XTL1</sub>	V <sub>DD</sub> = 1.2 V to 1.8 V (Note 1)	—	32.768	—	kHz
		f <sub>XTL2</sub>	V <sub>DD</sub> = 1.5 V (Note 2)	20	33	55	
		f <sub>XTH1</sub>	V <sub>DD</sub> = 1.5 V (Note 3)	—	200	—	
Input voltage	"H" level	V <sub>IH</sub>	V <sub>DD</sub> = 1.3 V	V <sub>DD</sub> × 0.8	—	V <sub>DD</sub>	V
			V <sub>DD</sub> = 1.7 V	V <sub>DD</sub> × 0.7	—	V <sub>DD</sub>	
	"L" level	V <sub>IL</sub>	V <sub>DD</sub> = 1.3 V	0	—	V <sub>DD</sub> × 0.2	
			V <sub>DD</sub> = 1.7 V	0	—	V <sub>DD</sub> × 0.3	
Quadrupler capacitance		C <sub>1</sub> , C <sub>2</sub>	—	—	0.1	—	μF
Voltage capacitance		V <sub>1</sub>	—	—	0.1	—	μF
		V <sub>2</sub>	—	—	0.1	—	
		V <sub>3</sub>	—	—	0.1	—	
		V <sub>4</sub>	—	—	0.1	—	

Note 1: Crystal oscillation circuit is used for low-speed oscillator.

Note 2: Internal CR oscillator is used for low-speed oscillator.

Note 3: An CR oscillating circuit configured with an external R is used for the high-speed oscillator.

### Oscillation

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
OSC starting voltage	V <sub>STA</sub>	T <sub>STA</sub> = 10 s, T <sub>opr</sub> = 25°C (Note 4)	1.4	—	—	V
OSC holding voltage	V <sub>HOLD</sub>	(Note 4)	1.2	—	—	V
Frequency of internal CR OSC	f <sub>OSC1</sub>	V <sub>DD</sub> = 1.5 V (Note 5)	20	33	55	kHz
Frequency of High-speed OSC	f <sub>OSC2</sub>	V <sub>DD</sub> = 1.5 V R <sub>f</sub> = 150 kΩ (Note 6)	—	200	—	kHz

Note 4: Crystal oscillation circuit for low-speed oscillator. Input 1.4 V or more at power-on.

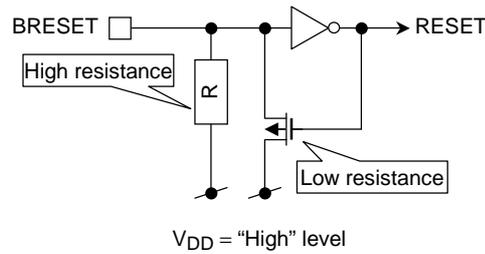
Note 5: Internal CR oscillator for low-speed oscillator.

Note 6: An CR oscillating circuit configured with an external R is used for the high-speed oscillator.

## DC Characteristics

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit	
Input current (1) (IN1 to IN4, IO01 to IO04, IO11 to IO14, IO21 to IO24)	$I_{IH1}$	$V_{DD} = 1.8 \text{ V}, V_{IN} = 0 \text{ V}$	-500	—	500	nA	
	$I_{IL1}$	$V_{DD} = 1.8 \text{ V}, V_{IN} = 1.8 \text{ V}$	3.21	4.5	7.5	$\mu\text{A}$	
Input current (2) (BRESET)	$I_{IH2L}$ (Note)	$V_{DD} = 1.8 \text{ V}, V_{IN} = 0 \text{ V},$ Low Resistor side	-60	-36	-25.7	$\mu\text{A}$	
	$I_{IH2H}$	$V_{DD} = 1.8 \text{ V}, V_{IN} = 0 \text{ V},$ High Resistor side	-6	-3.6	-2.57		
Input current (3) (TEST)	$I_{IL3}$	$V_{DD} = 1.8 \text{ V}, V_{IN} = 1.8 \text{ V}$	6.43	9.0	15.0	$\mu\text{A}$	
Output current (1) (IO11 to IO14, IO21 to IO24)	$I_{OH1}$	$V_{DD} = 1.2 \text{ V}, V_{OH} = 0.7 \text{ V}$	—	—	-150	$\mu\text{A}$	
	$I_{OL1}$	$V_{DD} = 1.2 \text{ V}, V_{OL} = 0.5 \text{ V}$	0.89	1.25	2.08		
Output current (2) (BZ)	$I_{OH2}$	$V_{DD} = 1.2 \text{ V}, V_{OH} = 0.7 \text{ V}$	—	—	-500	$\mu\text{A}$	
	$I_{OL2}$	$V_{DD} = 1.2 \text{ V}, V_{OL} = 0.5 \text{ V}$	500	—	—		
Output current (3) (SEGMENT)	$I_{OH3}$	$V_1 = 1.125 \text{ V},$ $V_2 = 2.25 \text{ V},$ $V_3 = 3.375 \text{ V},$ $V_4 = 4.5 \text{ V}$	$V_{OH} = V_4 - 0.5 \text{ V}$	—	—	-100	$\mu\text{A}$
	$I_{OL3}$		$V_{OL} = 0.5 \text{ V}$	100	—	—	
	$I_{OM3}$		$V_{OM} = V_2 - 0.5 \text{ V}$	—	—	-50	
Output current (4) (COMMON)	$I_{OH4}$	$V_1 = 1.125 \text{ V},$ $V_2 = 2.25 \text{ V},$ $V_3 = 3.375 \text{ V},$ $V_4 = 4.5 \text{ V}$	$V_{OH} = V_4 - 0.5 \text{ V}$	—	—	-100	$\mu\text{A}$
	$I_{OL4}$		$V_{OL} = 0.5 \text{ V}$	100	—	—	
	$I_{OM4}$		$V_{OM} = V_3 - 0.5 \text{ V}$	—	—	-50	
	$I_{OM4}$		$V_{OM} = V_1 + 0.5 \text{ V}$	50	—	—	
Quadrupler output voltage	$V_1$	$V_1 = 1.125 \text{ V}, T_a = 25^\circ\text{C}$	1.075	1.125	1.175	V	
	$V_2$		2.05	2.25	2.45		
	$V_3$		3.175	3.375	3.575		
	$V_4$		4.3	4.5	4.7		
Power supply voltage (1) (Low-speed crystal oscillation circuit)	$I_{DDOP}$	$V_{DD} = 1.5 \text{ V},$ $f_H = 200 \text{ kHz}$ $f_L = 32 \text{ kHz}$ At High-speed operation	Display ON	—	48	77	$\mu\text{A}$
			Display OFF	—	—	73	
	$I_{DDSLow}$	$V_{DD} = 1.5 \text{ V},$ $f_L = 32 \text{ kHz}$ At Low-speed operation	Display ON	—	9.5	12	
			Display OFF	—	—	11	
	$I_{DDHOLD}$	$V_{DD} = 1.5 \text{ V},$ $f_L = 32 \text{ kHz}$ In HOLD mode	Display ON	—	4	7	
			Display OFF	—	—	6	
	$I_{DDSTOP}$	$V_{DD} = 1.5 \text{ V},$ In STOP mode	—	0.4	1		
	Power supply current (2) (Low-speed CR oscillation circuit)	$I_{DDOP}$	$V_{DD} = 1.5 \text{ V}, f = 200 \text{ kHz}$ $f_L = \text{Internal}$ At High-speed operation	Display ON	—	50	
Display OFF				—	—	73	
$I_{DDSLow}$		$V_{DD} = 1.5 \text{ V}, f_L = \text{Internal}$ At Low-speed operation	Display ON	—	12	17	
			Display OFF	—	—	16	
$I_{DDHOLD}$		$V_{DD} = 1.5 \text{ V}, f_L = \text{Internal}$ In HOLD mode	Display ON	—	5	7.5	
			Display OFF	—	—	6.5	
$I_{DDSTOP}$		$V_{DD} = 1.5 \text{ V},$ In STOP mode	—	0.4	1		

Note: The BRESET pin is connected to  $V_{DD}$  (High level) via two resistors as shown below. To minimize the current that flows at reset, the low resistance consists of a P-channel FET. When the input level is  $V_{SS}$  (Low level), the FET is off. The resistance is  $\infty$ . The specified input current (2),  $I_{IH2L}$ , is the current that flows when the low resistance = P-channel FET is on. However, the low-resistance is off when  $V_{IN} = 0 \text{ V}$ , so actual measurement is impossible.



**Recommended operating condition**

**3.0 V version (unless otherwise specified, V<sub>SS</sub> = 0 V, T<sub>opr</sub> = 0 to 40°C)**

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Power supply voltage		V <sub>DD</sub>	f <sub>XTH</sub> = 2 MHz	2.4	3.0	3.6	V
Oscillation frequency		f <sub>XTL1</sub>	V <sub>DD</sub> = 2.4 V to 3.6 V (Note 1)	—	32.768	—	kHz
		f <sub>XTL2</sub>	V <sub>DD</sub> = 3.0 V (Note 2)	20	35	60	
		f <sub>XTH1</sub>	V <sub>DD</sub> = 2.4 V to 3.6 V (Note 3)	—	2.0	—	MHz
		f <sub>XTH2</sub>	V <sub>DD</sub> = 3.0 V (Note 4)	—	2.0	—	
Input voltage	"H" level	V <sub>IH</sub>	V <sub>DD</sub> = 2.4 V	V <sub>DD</sub> × 0.8	—	V <sub>DD</sub>	V
			V <sub>DD</sub> = 3.6 V	V <sub>DD</sub> × 0.7	—	V <sub>DD</sub>	
	"L" level	V <sub>IL</sub>	V <sub>DD</sub> = 2.4 V	0	—	V <sub>DD</sub> × 0.2	
			V <sub>DD</sub> = 3.6 V	0	—	V <sub>DD</sub> × 0.3	
Quadrupler capacitance		C <sub>1</sub> , C <sub>2</sub>	—	—	0.1	—	μF
Voltage capacitance		V <sub>1</sub>	—	—	0.1	—	μF
		V <sub>2</sub>	—	—	0.1	—	
		V <sub>3</sub>	—	—	0.1	—	
		V <sub>4</sub>	—	—	0.1	—	
		V <sub>XT</sub>	—	—	—	0.1	

Note 1: Crystal oscillation circuit is used for low-speed oscillator.

Note 2: Internal CR oscillator is used for low-speed oscillator.

Note 3: Crystal oscillation circuit is used for high-speed oscillator.

Note 4: An CR oscillating circuit configured with an external R is used for the high-speed oscillator.

**Oscillation**

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
OSC starting voltage (Low-speed)		V <sub>STA1</sub>	T <sub>STA</sub> = 10 s, T <sub>opr</sub> = 25°C	1.85	—	—	V
OSC starting voltage (High-speed)		V <sub>STA2</sub>	T <sub>STA</sub> = 8 ms	2.10	—	—	V
OSC holding voltage (Low-speed)		V <sub>HOLD1</sub>	—	1.65	—	—	V
OSC holding voltage (High-speed)		V <sub>HOLD2</sub>	—	1.90	—	—	V
Frequency of internal CR OSC		f <sub>OSC1</sub>	V <sub>DD</sub> = 3.0 V (Note 5)	20	35	60	kHz
Frequency of High-speed OSC		f <sub>OSC2</sub>	V <sub>DD</sub> = 3.0 V, R <sub>f</sub> = 13.0 kΩ (Note 6)	—	2.0	—	MHz

Note 5: Internal CR oscillator for low-speed oscillator.

Note 6: An CR oscillating circuit configured with an external R is used for the high-speed oscillator.

## DC Characteristics

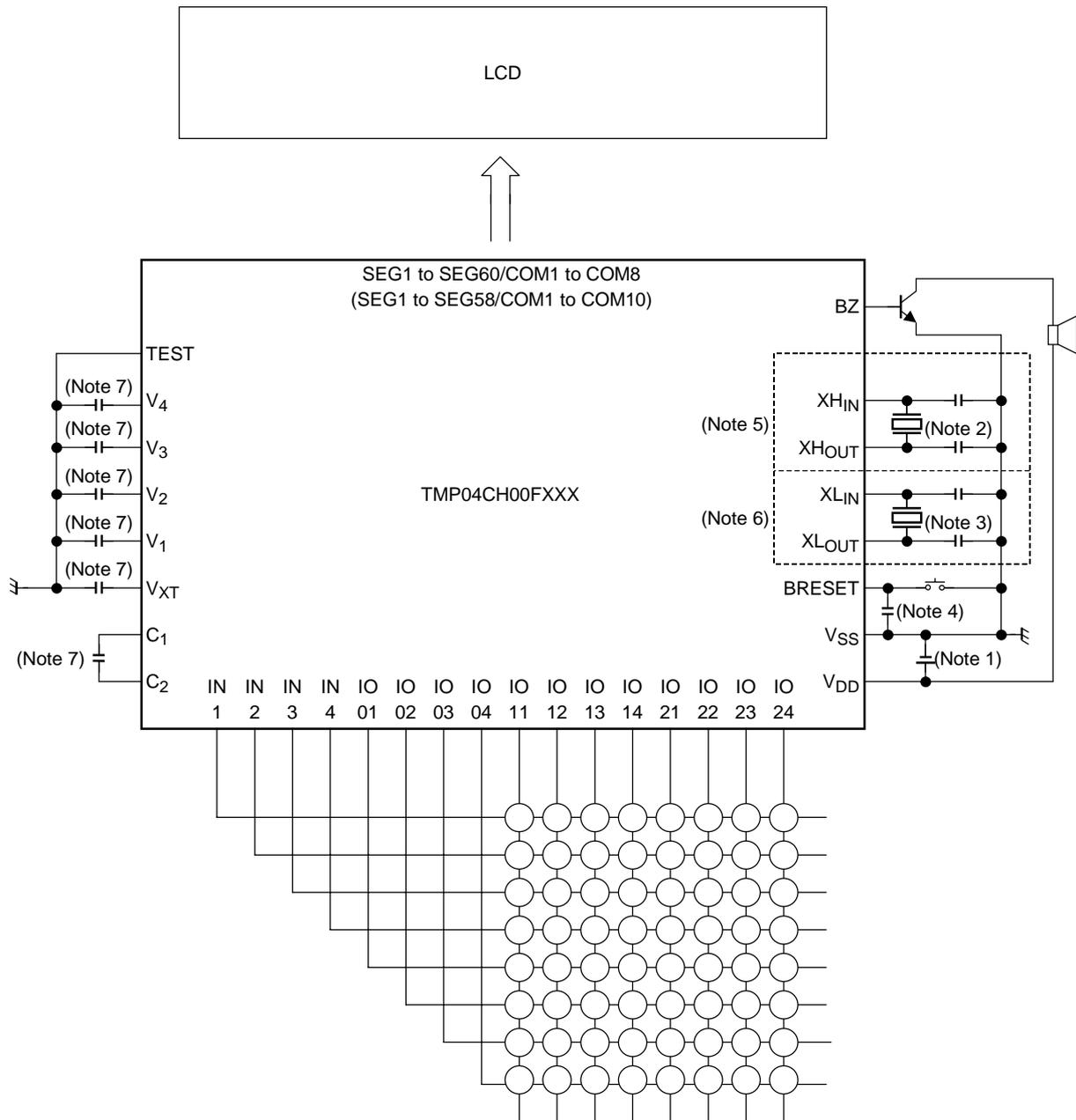
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit	
Input current (1) (IN1 to IN4, IO01 to IO04, IO11 to IO14, IO21 to IO24)	$I_{IH1}$	$V_{DD} = 3.6 \text{ V}, V_{IN} = 0 \text{ V}$	-500	—	500	nA	
	$I_{IL1}$	$V_{DD} = 3.6 \text{ V}, V_{IN} = 3.6 \text{ V}$	6.43	9.0	15.0	$\mu\text{A}$	
Input current (2) (BRESET)	$I_{IH2L}$	$V_{DD} = 3.6 \text{ V}, V_{IN} = 0 \text{ V},$ Low Resistor side	-120	-72	-51.4	$\mu\text{A}$	
	$I_{IH2H}$	$V_{DD} = 3.6 \text{ V}, V_{IN} = 0 \text{ V},$ High Resistor side	-12	-7.2	-5.14		
Input current (3) (TEST)	$I_{IL3}$	$V_{DD} = 3.6 \text{ V}, V_{IN} = 3.6 \text{ V}$	12.9	18.0	30.0	$\mu\text{A}$	
Output current (1) (IO11 to IO14, IO21 to IO24)	$I_{OH1}$	$V_{DD} = 2.4 \text{ V}, V_{OH} = 1.9 \text{ V}$	—	—	-1.5	$\mu\text{A}$	
	$I_{OL1}$	$V_{DD} = 2.4 \text{ V}, V_{OL} = 0.5 \text{ V}$	0.89	1.25	2.08		
Output current (2) (BZ)	$I_{OH2}$	$V_{DD} = 2.4 \text{ V}, V_{OH} = 1.9 \text{ V}$	—	—	-2.0	mA	
	$I_{OL2}$	$V_{DD} = 2.4 \text{ V}, V_{OL} = 0.5 \text{ V}$	2.0	—	—		
Output current (3) (SEGMENT)	$I_{OH3}$	$V_{DD} = 3.0 \text{ V},$ $V_{REG} = 1.125 \text{ V},$ $V_2 = 2.25 \text{ V},$ $V_3 = 3.375 \text{ V},$ $V_4 = 4.5 \text{ V}$	$V_{OH} =$ $V_4 - 0.5 \text{ V}$	—	—	-100	$\mu\text{A}$
	$I_{OL3}$		$V_{OL} = 0.5 \text{ V}$	100	—	—	
	$I_{OM3}$		$V_{OM} =$ $V_2 - 0.5 \text{ V}$	—	—	-50	
Output current (4) (COMMON)	$I_{OH4}$	$V_{DD} = 3.0 \text{ V},$ $V_{REG} = 1.125 \text{ V},$ $V_2 = 2.25 \text{ V},$ $V_3 = 3.375 \text{ V},$ $V_4 = 4.5 \text{ V}$	$V_{OH} =$ $V_4 - 0.5 \text{ V}$	—	—	-100	$\mu\text{A}$
	$I_{OL4}$		$V_{OL} = 0.5 \text{ V}$	100	—	—	
	$I_{OM4}$		$V_{OM} =$ $V_3 - 0.5 \text{ V}$	—	—	-50	
	$I_{OM4}$		$V_{OM} =$ $V_1 + 0.5 \text{ V}$	50	—	—	
Voltage regulator output	$V_{REG1}$	$V_{DD} = 3.0 \text{ V}$ (Note 1)	1.075	1.125	1.175	V	
	$V_{REG2}$	$V_{DD} = 3.0 \text{ V}$ (Note 2)	—	1.8	—		
Quadrupler output	$V_2$	$V_{DD} = 3.0 \text{ V}$ $V_{REG} = 1.125 \text{ V}, T_a = 25^\circ\text{C}$	2.05	2.25	2.45	V	
	$V_3$		3.175	3.375	3.575		
	$V_4$		4.3	4.5	4.7		

Note 1: Voltage regulator for quadrupler

Note 2: Voltage output regulator for low-speed oscillator

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit	
Power supply current (1) (High-speed crystal oscillation circuit) (Low-speed crystal oscillation circuit)	I <sub>DDOP</sub>	V <sub>DD</sub> = 3.0 V, f <sub>H</sub> = 2 MHz, f <sub>L</sub> = 32 kHz At High-speed operation	Display ON	—	0.85	1.2	mA
			Display OFF	—	—	1.2	
	I <sub>DDSLow</sub>	V <sub>DD</sub> = 3.0 V, f <sub>L</sub> = 32 kHz At Low-speed operation	Display ON	—	17.0	24.0	μA
			Display OFF	—	—	23.0	
	I <sub>DDHOLD</sub>	V <sub>DD</sub> = 3.0 V, f <sub>L</sub> = 32 kHz In HOLD mode	Display ON	—	5.5	11.0	
			Display OFF	—	—	10.0	
	I <sub>DDSTOP</sub>	V <sub>DD</sub> = 3.0 V In STOP mode	—	0.8	1.2		
	Power supply current (2) (High-speed CR oscillation circuit) (Low-speed CR oscillation circuit)	I <sub>DDOP</sub>	V <sub>DD</sub> = 3.0 V, f <sub>H</sub> = 2 MHz, f <sub>L</sub> = Internal At High-speed operation	Display ON	—	0.85	1.5
Display OFF				—	—	1.5	
I <sub>DDSLow</sub>		V <sub>DD</sub> = 3.0 V f <sub>L</sub> = Internal At Low-speed operation	Display ON	—	23.0	40.0	μA
			Display OFF	—	—	39.0	
I <sub>DDHOLD</sub>		V <sub>DD</sub> = 3.0 V, f <sub>L</sub> = Internal In HOLD mode	Display ON	—	6.5	14.0	
			Display OFF	—	—	12.0	
I <sub>DDSTOP</sub>		V <sub>DD</sub> = 3.0 V In STOP mode	—	0.8	1.4		

## Example of Application Circuit



Note 1: Either 1.5 V or 3 V can be selected as the supply voltage.

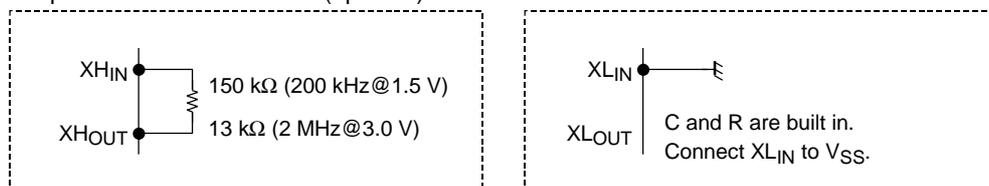
Note 2: Recommended high-speed oscillator circuit capacitor: 22 pF

Note 3: Recommended low-speed oscillator circuit capacitor: 15 pF

Note 4: Insert a 0.1  $\mu$ F capacitor between BRESET and V<sub>SS</sub>.

Note 5: High-speed CR oscillator circuit (optional)

Note 6: Low-speed CR oscillator circuit (optional)

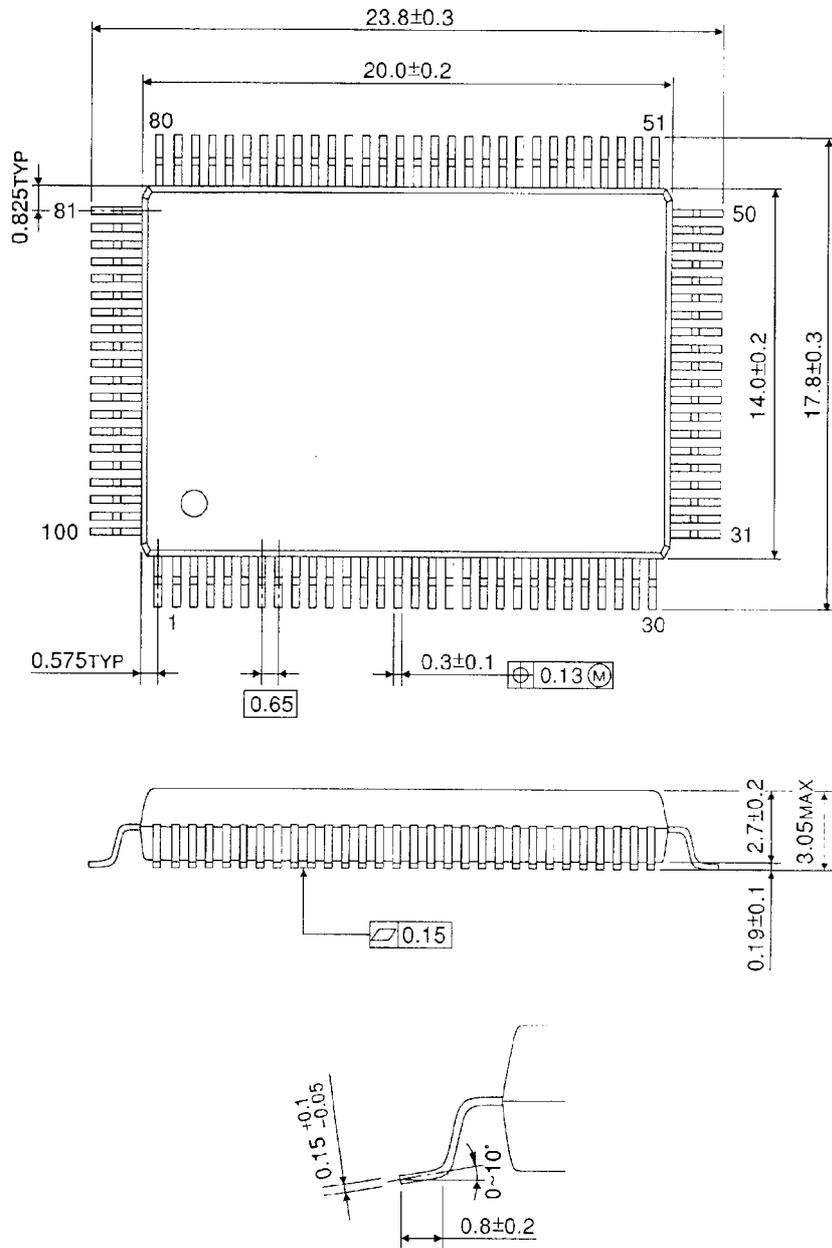


Note 7: Adjust between 0.1 to 1.0  $\mu$ F depending on the size of the LCD panel used.

**Package Dimensions**

QFP100-P-1420-0.65A

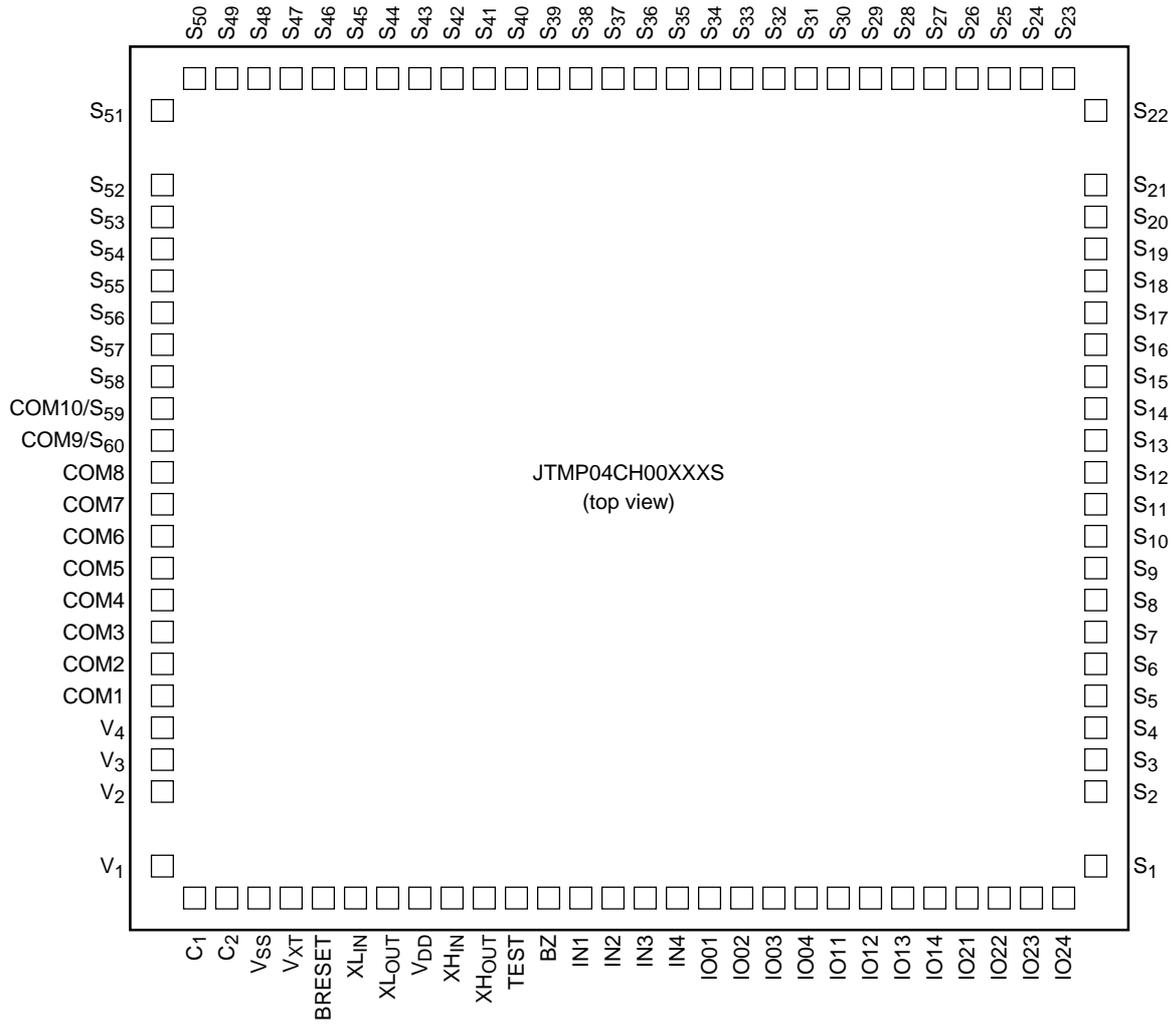
Unit: mm



Weight: 1.65 g (typ.)

Bare chip

1. Pad assignment



Chip size            5.87 × 5.39 (mm)

Chip thickness      450 ± 30 (μm)

Substrate voltage   V<sub>SS</sub>

## 2. Pad location table

( $\times 10^{-3}$ mm)

No.	PAD Name	X Point	Y Point
1	V <sub>1</sub>	-2695	-2031
100	V <sub>2</sub>	-2695	-1694
99	V <sub>3</sub>	-2695	-1514
98	V <sub>4</sub>	-2695	-1330
97	COM1	-2695	-1148
96	COM2	-2695	-968
95	COM3	-2695	-788
94	COM4	-2695	-608
93	COM5	-2695	-428
92	COM6	-2695	-248
91	COM7	-2695	-68
90	COM8	-2695	112
89	S <sub>60</sub> /COM9	-2695	292
88	S <sub>59</sub> /COM10	-2695	472
87	S <sub>58</sub>	-2695	652
86	S <sub>57</sub>	-2695	832
85	S <sub>56</sub>	-2695	1012
84	S <sub>55</sub>	-2695	1192
83	S <sub>54</sub>	-2695	1372
82	S <sub>53</sub>	-2695	1552
81	S <sub>52</sub>	-2695	1732
80	S <sub>51</sub>	-2695	2150
79	S <sub>50</sub>	-2428	2427
78	S <sub>49</sub>	-2248	2427
77	S <sub>48</sub>	-2068	2427
76	S <sub>47</sub>	-1888	2427
75	S <sub>46</sub>	-1708	2427
74	S <sub>45</sub>	-1528	2427
73	S <sub>44</sub>	-1348	2427
72	S <sub>43</sub>	-1168	2427
71	S <sub>42</sub>	-988	2427
70	S <sub>41</sub>	-808	2427
69	S <sub>40</sub>	-628	2427
68	S <sub>39</sub>	-448	2427
67	S <sub>38</sub>	-268	2427
66	S <sub>37</sub>	-88	2427

No.	PAD Name	X Point	Y Point
65	S <sub>36</sub>	92	2427
64	S <sub>35</sub>	272	2427
63	S <sub>34</sub>	452	2427
62	S <sub>33</sub>	632	2427
61	S <sub>32</sub>	812	2427
60	S <sub>31</sub>	992	2427
59	S <sub>30</sub>	1172	2427
58	S <sub>30</sub>	1352	2427
57	S <sub>28</sub>	1532	2427
56	S <sub>27</sub>	1712	2427
55	S <sub>26</sub>	1892	2427
54	S <sub>25</sub>	2072	2427
53	S <sub>24</sub>	2252	2427
52	S <sub>23</sub>	2432	2427
51	S <sub>22</sub>	2695	2150
50	S <sub>21</sub>	2695	1733
49	S <sub>20</sub>	2695	1553
48	S <sub>19</sub>	2695	1373
47	S <sub>18</sub>	2695	1193
46	S <sub>17</sub>	2695	1013
45	S <sub>16</sub>	2695	833
44	S <sub>15</sub>	2695	653
43	S <sub>14</sub>	2695	473
42	S <sub>13</sub>	2695	293
41	S <sub>12</sub>	2695	113
40	S <sub>11</sub>	2695	-67
39	S <sub>10</sub>	2695	-252
38	S <sub>9</sub>	2695	-432
37	S <sub>8</sub>	2695	-612
36	S <sub>7</sub>	2695	-792
35	S <sub>6</sub>	2695	-972
34	S <sub>5</sub>	2695	-1152
33	S <sub>4</sub>	2695	-1332
32	S <sub>3</sub>	2695	-1512
31	S <sub>2</sub>	2695	-1692
30	S <sub>1</sub>	2695	-2031

No.	PAD Name	X Point	Y Point
29	IO24	2444	-2427
28	IO23	2264	-2427
27	IO22	2084	-2427
26	IO21	1904	-2427
25	IO14	1724	-2427
24	IO13	1544	-2427
23	IO12	1364	-2427
22	IO11	1184	-2427
21	IO04	1004	-2427
20	IO03	824	-2427
19	IO02	644	-2427
18	IO01	464	-2427
17	IN4	272	-2427
16	IN3	92	-2427
15	IN2	-88	-2427
14	IN1	-268	-2427
13	BZ	-452	-2427
12	TEST	-633	-2427
11	XHOUT	-813	-2427
10	XHIN	-933	-2427
9	VDD	-1202	-2427
8	XLOUT	-1408	-2427
7	XLIN	-1588	-2427
6	BRESET	-1768	-2427
5	VXT	-1948	-2427
4	VSS	-2116	-2427
3	C <sub>2</sub>	-2281	-2427
2	C <sub>1</sub>	-2461	-2427

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000707EBA

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