RL78/L23

24-Hour Clock Displayed on an LCD

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Introduction

This application note explains how to control an LCD panel using the LCD controller/driver integrated in the RL78/L23, as well as the operation of the provided sample code.

The sample code displays a 24-hour format clock on the LCD panel. The time display is updated every minute, and time adjustment is possible via switch input.

Target Device

RL78/L23

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Specifications

A 24-hour format clock is displayed on the LCD panel using the LCD controller/driver integrated in the RL78/L23. The realtime clock (RTC) is used for timekeeping. By pressing and holding the switch, the system cycles through the following three modes in sequence:

- Clock Display Mode
- Hour Adjustment Mode
- Minute Adjustment Mode

- Clock Display Mode

In this mode, the RTC time data is read using a periodic interrupt that occurs every minute, and the display on the LCD panel is updated accordingly. Additionally, the colon blinks at 0.5-second intervals.

- Hour Adjustment Mode

In this mode, the “hour” digits on the LCD panel blink. Each short press of the switch increments the hour value by one and updates the display.

- Minute Adjustment Mode

In this mode, the “minute” digits on the LCD panel blink. Each short press of the switch increments the minute value by one and updates the display.

Table 1.1 lists the peripheral function to be used and Its use, and Figure 1.1 shows an overview of the operation.

Table 1.1 Peripheral Function to be Used and Its Use

Peripheral Function	Use
LCD Controller/Driver	Display control of the LCD panel
RTC	Counts the time
8-bit Interval Timer 00 (8-bit IT00)	Measure how long the switch is pressed in 10ms units
8-bit Interval Timer 01 (8-bit IT01)	Generate timing for blinking the selected digit at 250ms intervals during time adjustment
External interrupt INTP0	Detect switch press

The LCD controller/driver allows selection from the following three methods for generating the drive voltage:

- External resistance division method
- Internal voltage boosting method
- Capacitor split method

For details on each of these methods, refer to Section 3.3: Drive Voltage Generation Circuit.

In this sample code, the internal voltage boosting method is used for generating the LCD drive voltage.

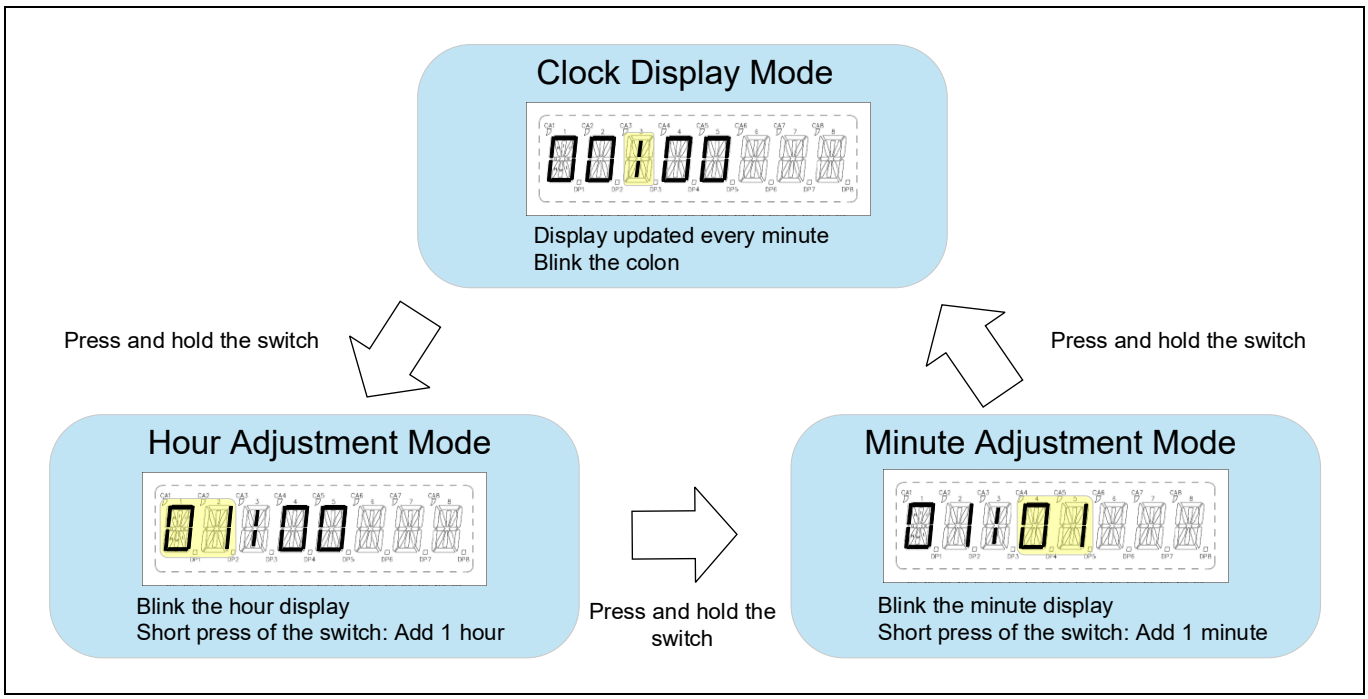

Figure 1.1 Operation Overview Diagram

1.1 Detailed Specifications

This section describes the initial settings and processing of the sample code.

(1) Initialize External Interrupt 0

<Setting conditions>

- Set INTP0 to trigger on the falling edge.

(2) Initialize 8-bit Interval Timers

<Setting conditions>

- Set the interval time of 8-bit IT00 to 10ms.
- Set the interval time of 8-bit IT01 to 250ms.

(3) Initialize the RTC

<Setting conditions>

- Set the time format to 24-hour mode.
- Set the periodic interrupt interval to once per minute.
- Set the second counter register (SEC) to 0.
- Set the minute counter register (MIN) to 0.
- Set the hour counter register (HOUR) to 0.

(4) Initialize the LCD Controller/Driver

<Setting conditions>

- Set the waveform type to Type A.
- Set the drive voltage generation method to VL1 reference internal boost.
- Set the display data area to use both A-pattern and B-pattern areas.
- Set the switching interval between display data areas to 0.5 seconds.
- Set the VLCD voltage (VL1) to 1.01 V.
- Set the frame frequency to 85.333 Hz.

(5) After initializing the peripheral functions, display the time “00:00” on the LCD panel and set the mode to “Clock Display Mode.”

(6) Enter STOP mode and wait for an interrupt request.

(7) When STOP mode is released, processing is performed according to the current mode as described below:

- Clock Display Mode
  - When an RTC periodic interrupt occurs (every 1 minute)

    The time data is read from the RTC registers, and the LCD panel display is updated.
  - When an external interrupt occurs (switch press)

    The 8-bit IT00 is enabled to begin determining whether the switch was short-pressed or long-pressed.
  - When an 8-bit IT00 interrupt occurs (every 10 ms)

    A counter used for distinguishing between short and long presses is incremented by 1.
    If the counter reaches 1 second, the press is judged as a long press, and the mode switches to Hour Adjustment Mode.

- Hour Adjustment Mode
  - Immediately after switching to this mode

    To make the “hour” digits on the LCD panel blink, the 8-bit IT01 is enabled.
    The time data is read from the RTC registers, and the LCD panel display is updated.
  - When an external interrupt occurs (switch press)

    The 8-bit IT00 is enabled to begin determining whether the switch was short-pressed or long-pressed.
  - When an 8-bit IT00 interrupt occurs (every 10ms)

    The press-detection counter is incremented by 1.
    If the counter remains below 1 second, it is judged as a short press: 1 is added to the RTC HOUR register, and the LCD display is updated.
    If the counter reaches 1 second, it is judged as a long press, and the mode switches to Minute Adjustment Mode.
  - When an 8-bit IT01 interrupt occurs (every 250ms)

    The blinking state of the “hour” digits on the LCD panel is toggled (on/off).

- Minute Adjustment Mode
  - Immediately after switching to this mode

    The time data is read from the RTC registers, and the LCD panel display is updated.
  - When an external interrupt occurs (switch press)

    The 8-bit IT00 is enabled to begin determining whether the switch was short-pressed or long-pressed.
  - When an 8-bit IT00 interrupt occurs (every 10ms)

    The press-detection counter is incremented by 1.
    If the counter remains below 1 second, it is judged as a short press: 1 is added to the RTC MIN register, and the LCD display is updated.
    If the counter reaches 1 second, it is judged as a long press, and the mode switches to Clock Display Mode.
  - When an 8-bit IT01 interrupt occurs (every 250ms)

    The blinking state of the “minute” digits on the LCD panel is toggled (on/off).

2. Operation Check Conditions

The sample code contained in this application note has been checked under the conditions listed in the table below.

Table 2.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/L23（R7F100LPL）
Operating frequency	● High-speed on-chip oscillator (HOCO) clock: 32 MHz ● CPU/peripheral hardware clock: 32MHz ● RTC/LCD operation clock (f_{SUB}) : 32.768kHz
Operating voltage	● 3.3V ● LVD0 operations (V_{LVD0}): Reset mode Rising edge TYP. 1.90V Falling edge TYP. 1.86V
Integrated development environment (CS+)	CS + V8.13.00 from Renesas Electronics Corporation
C compiler (CS+)	CC-RL V1.15.00 from Renesas Electronics Corporation
Integrated development environment (e2 studio)	e2 studio V2025-04.1 (25.4.1) from Renesas Electronics Corporation
C compiler (e2 studio)	CC-RL V1.15.00 from Renesas Electronics Corporation
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V5.20.1 from IAR Systems
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V5.20.1.2826 from IAR Systems
Board used	RL78/L23 Fast Prototyping Board (RTK7RLL230S00WS1BJ)
LCD panel	VIM-878-DP-FC-S-LV from Varitronix The LCD panel is a standard component included on the RL78/L23 fast prototyping board.

3. Peripheral Function

This chapter describes the LCD controller/driver.

3.1 Basic Features of RL78/L23 LCD Controller/Driver

RL78/L23 LCD controller/driver includes the following features:

- Waveform A or B selectable
- LCD driver voltage generator can be switched between internal voltage boosting, capacitor split, or external resistance division
- Segment and common signals can be output automatically by reading the LCD display data register automatically
- Reference voltage generated when the voltage boost circuit is operating can be selected from 23 levels (contrast adjustment)
- Alternation of the image on the LCD is available. The time for switching in alternation of the display is selectable.

3.2 LCD Controller/Driver Display Mode

LCD controller/driver display modes are combinations of the LCD drive waveform and LCD voltage generator. Table 3.1 lists the maximum number of pixels in each display mode.

Table 3.1 Maximum Number of Pixels for an 100-pin Package (1/2)

Drive Waveform for LCD Driver	LCD Driver Voltage Generator		Bias Mode	Number of Time Slices	Maximum Number of Pixels
waveform A	External resistance division		-	Static	56 (56 segment signals, 1 common signal)
			1/2	2	112 (56 segment signals, 2 common signals)
				3	168 (56 segment signals, 3 common signals)
			1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	8	416 (52 segment signals, 8 common signals)
	Internal voltage boosting	V_{L1} reference V_{L2} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
		V_{L2} reference V_{DD} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)

Table 3.2 Maximum Number of Pixels for an 100-pin Package (2/2)

Drive Waveform for LCD Driver	LCD Driver Voltage Generator		Bias Mode	Number of Time Slices	Maximum Number of Pixels
waveform A	Internal voltage boosting	V_{DD} reference V_{L4} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
		V_{L4} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
waveform B	External resistance division		1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	8	416 (52 segment signals, 8 common signals)
	Internal voltage boosting	V_{L1} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	8	416 (52 segment signals, 8 common signals)
		V_{L2} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
	Capacitor split	V_{DD} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)
			1/4	8	416 (52 segment signals, 8 common signals)
		V_{L4} reference	1/3	3	168 (56 segment signals, 3 common signals)
				4	224 (56 segment signals, 4 common signals)
				6	324 (54 segment signals, 6 common signals)
				8	416 (52 segment signals, 8 common signals)

3.3 LCD Drive Voltage Generator

The RI78/L23 LCD controller/driver can use external resistance division, internal voltage boosting, or capacitor split to generate LCD drive voltage. This chapter covers the features of each method.

Table 3.1 LCD Drive Method and Its Application

LCD Drive Method	Feature/Usage			Application
	Drive capacity	Operating current	Drive voltage	
External resistance division	High Supports large LCDs	Standard	V_{DD}-dependent LCD display becomes dim with the supply voltage decreased	**Suitable for large format LCDs or AC power supply sets** The LCD drive capacity is high and the drive voltage is generated by a resistor divider, which contributes to cost reduction. This method generates the LVD drive voltage by an external resistor divider. As the voltage is applied externally, the operating current and drive capacity can be adjusted by an external resistor.
Internal voltage boosting	Standard	Small	Constant As the drive voltage is constant, the LCD display does not change with the battery voltage decreased	**Suitable for battery sets** The operating current is small and the LCD display does not become dim as the drive voltage is constant even when the battery voltage is reduced. This method generates the reference voltage internally and boosts it by an external capacitor. As the reference voltage is adjusted by software, the LCD contrast can be adjusted from 23 levels in RL78/L23.
Capacitor split	Standard	Much smaller	V_{DD}-dependent LCD display becomes dim with the supply voltage decreased	**Suitable for battery sets** This method has the smallest operating current among three LCD drive modes, and thus the LCD display becomes dim with decreasing the supply voltage. Use this method to allow the screen to be dim according to the battery level. If you do not want the screen to be dim when the battery voltage is decreased, change the LCD drive method to internal voltage boosting. It works in an external circuit of the capacitor split method.

3.3.1 External Resistance Division Method

This is suitable for large format LCDs or AC power sets. As it has a large drive capacity and generates the drive voltage by a resistor divider, which contributes to cost reduction.

To be more specific, this method generates an LCD drive voltage using an external resistor divider. As the voltage is applied externally, the operating current or the drive capacity can be adjusted by the external resistor.

Figure 3.1 and Figure 3.2 show connection examples of external resistance division method.

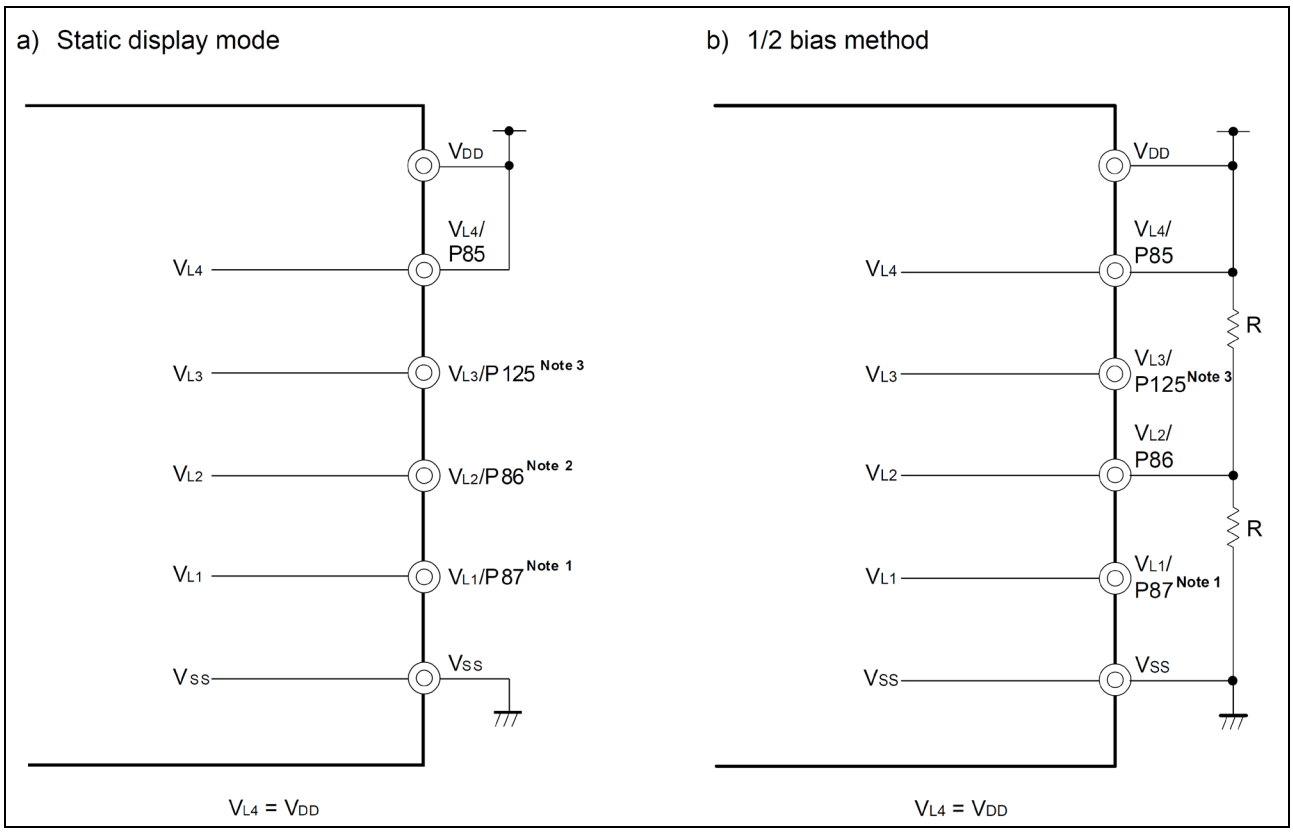

Figure 3.1 Connection Example of External Resistance Division Method (1/2)

Note 1. V_{L1} can be used as port-pin P87.

Note 2. V_{L2} can be used as port-pin P86.

Note 3. V_{L3} can be used as port-pin P125.

Caution CAPL can be used as port-pin P126 and CAPH can be used as port-pin P127.

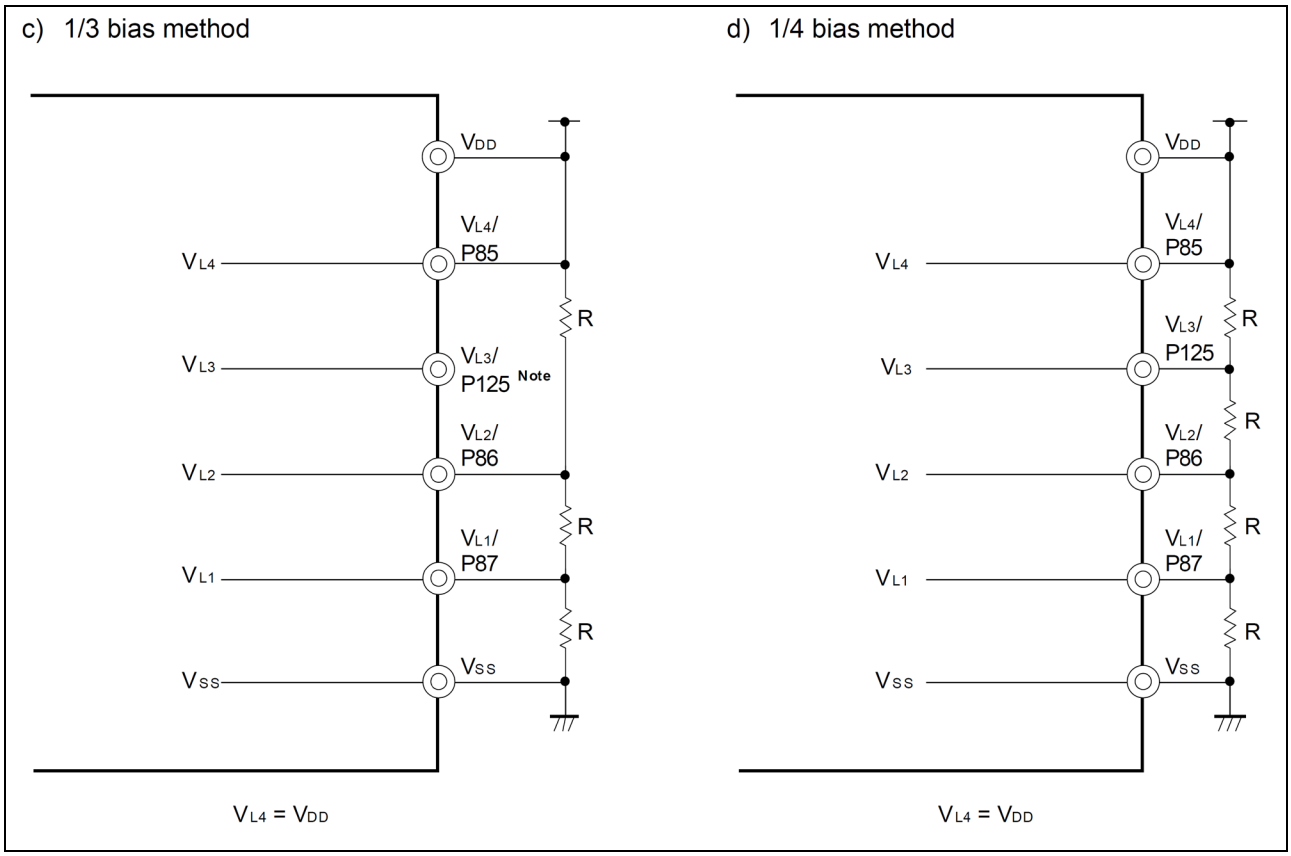

Figure 3.2 Connection Example of External Resistance Division Method (2/2)

Note V_{L3} can be used as port-pin P125.

Caution 1. CAPL can be used as port-pin P126 and CAPH can be used as port-pin P127.

Caution 2. The reference resistance “R” value for external resistance division is 10kΩ to 1 MΩ. In addition, to stabilize the potential of the V_{L1} to V_{L4} pins, connect a capacitor between each of pins V_{L1} to V_{L4} and the GND pin as needed.

The reference capacitance is about 0.47μF but it depends on the LCD panel used, the number of segment pins, the number of common pins, the frame frequency, and the operating environment. Thoroughly evaluate these values in accordance with your system and adjust and determine the capacitance.

3.3.2 Internal Voltage Boosting Method

This is suitable for a battery set.

The operating current is small and the LCD display does not become dim as the drive voltage is constant even when the battery voltage is reduced.

This method generates the reference voltage internally and boosts it by an external capacitor. As the reference voltage is adjusted by software (the LCD boost level control register, VLCD), the LCD contrast can be adjusted from 16 levels in RL78/L23.

Figure 3.3 shows a connection example of internal voltage boosting method.

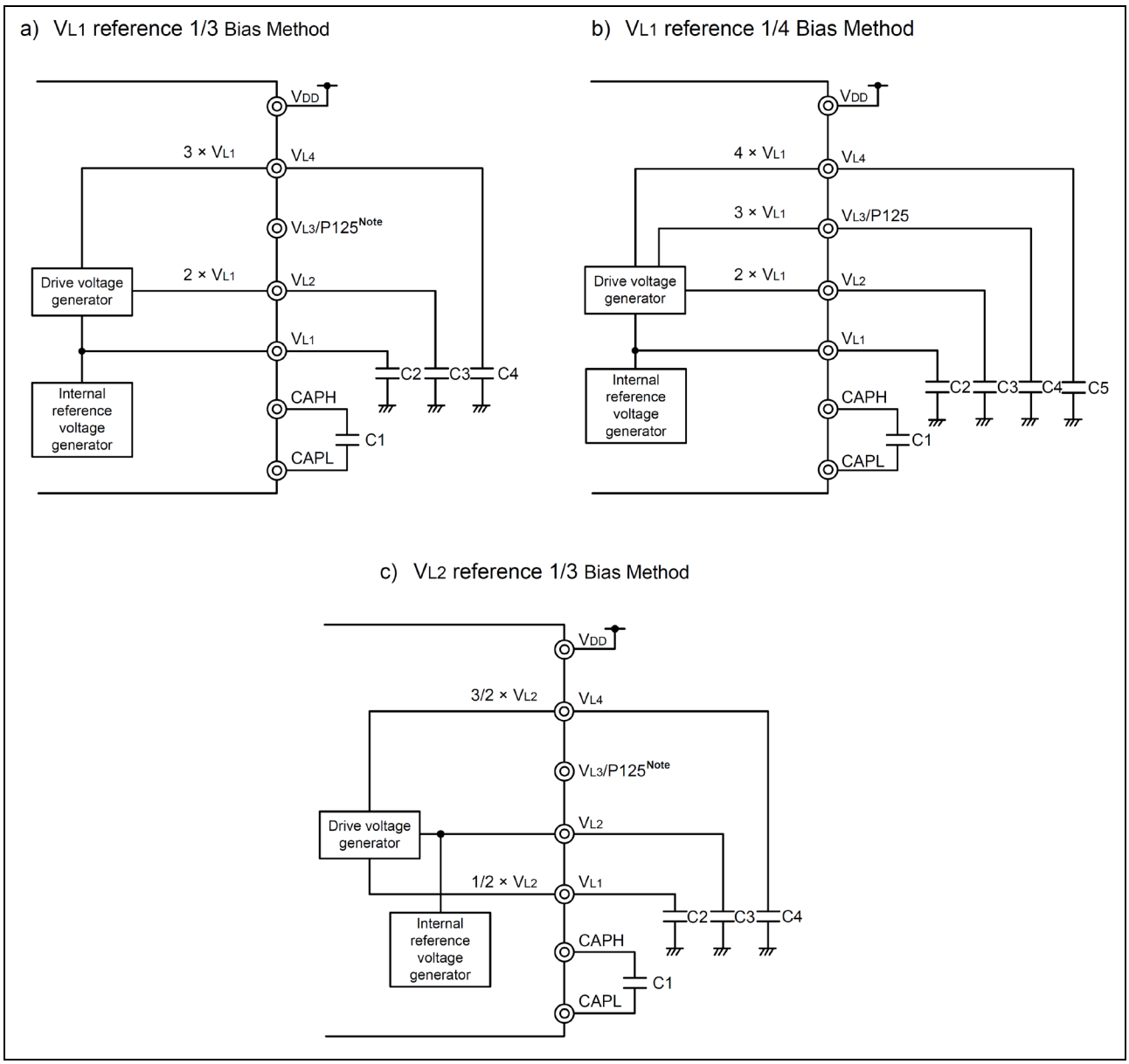

Figure 3.3 Connection Example of Internal Voltage Boosting Method

Note V_{L3} can be used as port-pin P125.

Remark Use a capacitor with as little leakage as possible.
In addition, make C1 a nonpolar capacitor.

3.3.3 Capacitor Split Method

This is also suitable for a battery set.

This method has the smallest operating current among three LCD drive modes, and thus the LCD display becomes dim with the supply voltage decreased.

If you do not want the screen to be dim when the battery voltage is decreased, change the LCD drive method to internal voltage boosting method. The method works in an external circuit of the capacitor split method.

Figure 3.4 shows a connection example of capacitor split method.

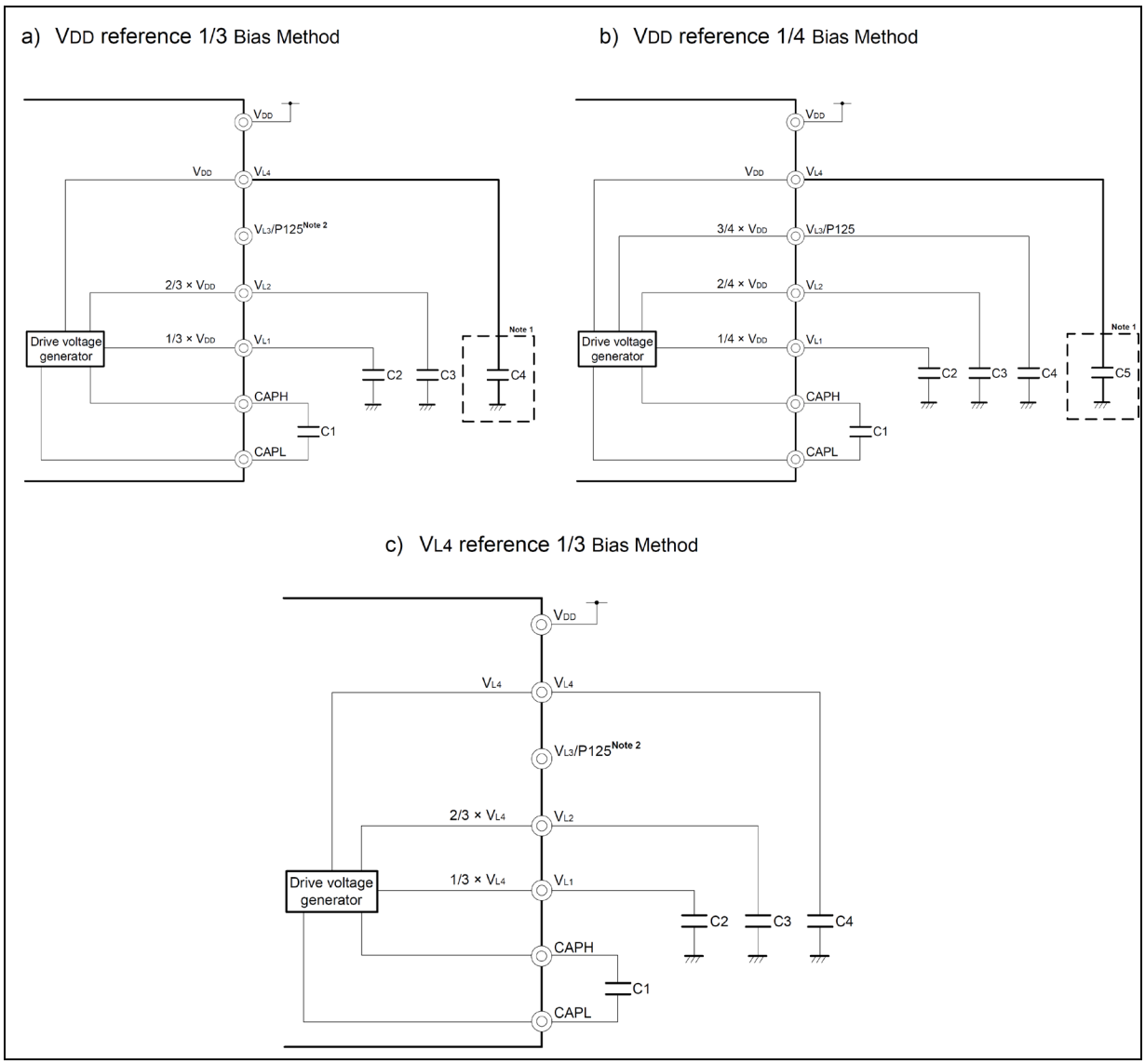

Figure 3.4 Connection Example of Capacitor Split Method

Note 1. As the V_{L4} pin is internally connected to the V_{DD} pin, the capacitor is not always essential. Note, however, that selection of the internal voltage boosting method requires connection of this capacitor. In addition, when only capacitor split method is in use, the capacitor can be connected as a means for stabilizing the voltage supplied to the LCD.

Note 2. V_{L3} can be used as port-pin P125.

Remark Use a capacitor with as little leakage as possible.

In addition, make C1 a nonpolar capacitor.

4. Hardware

4.1 Hardware Example

Figure 4.1 shows the hardware configuration used in this application note.

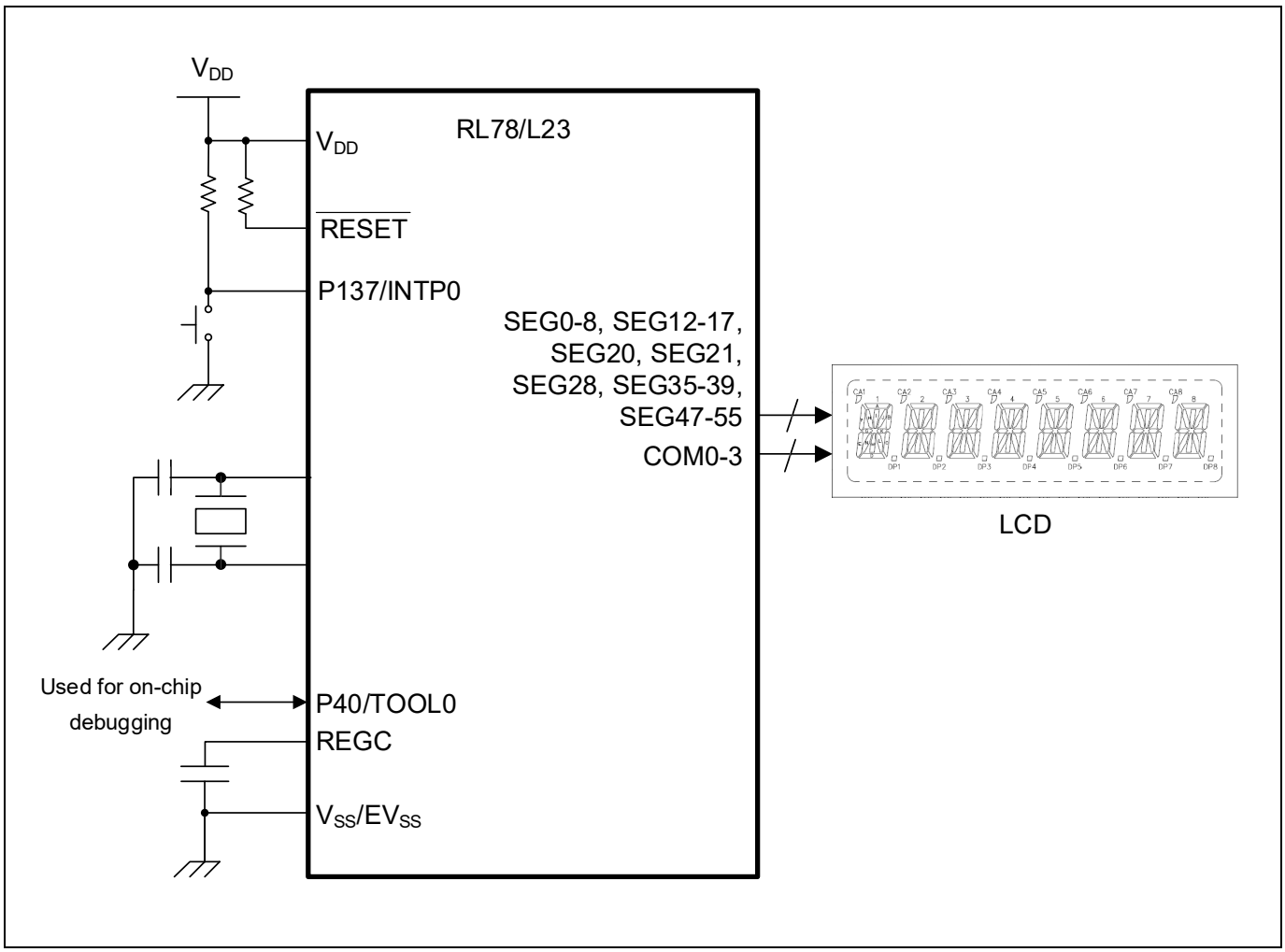

Figure 4.1 Hardware Configuration

Cautions:1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to V_{DD} or V_{SS} via a resistor).

2. Connect any pins whose name begins with EV_{SS} to V_{SS} and any pins whose name begins with EV_{DD} to V_{DD}, respectively.

3. V_{DD} must be held at not lower than the reset release voltage (V_{LVD0}) that is specified as LVD0.

4.2 LCD panel

Figure 4.2 shows the configuration of the LCD panel used in the sample code. Tables 4.1 and 4.2 show the connections between the RL78/L23 and the LCD.

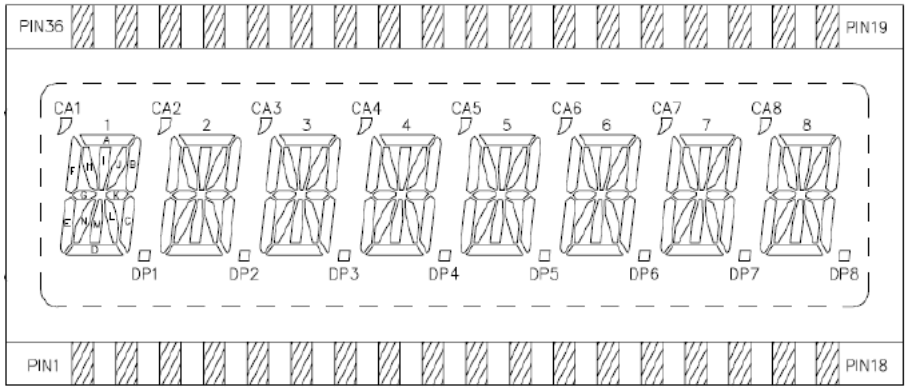

Figure 4.2 LCD Panel Configuration

Table 4.1 Connecting RL78/L23 to LCD Panel (1/2)

PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PORT	P54	P53	P52	P51	P50	P97	P96	P95	P94	P07	P06	P05	P04	P14	P13	P12	P90	P91
SEG/COM	SEG8	SEG7	SEG6	SEG5	SEG4	SEG3/COM7	SEG2/COM6	SEG1/COM5	SEG0/COM4	SEG50	SEG49	SEG48	SEG47	SEG39	SEG38	SEG37	COM0	COM1
COM0	1D	1L	2D	2L	3D	3L	4D	4L	5D	5L	6D	6L	7D	7L	8D	8L	COM0	-
COM1	1E	1K	2E	2K	3E	3K	4E	4K	5E	5K	6E	6K	7E	7K	8E	8K	-	COM1
COM2	1F	1J	2F	2J	3F	3J	4F	4J	5F	5J	6F	6J	7F	7J	8F	8J	-	-
COM3	CA1	1I	CA2	2I	CA3	3I	CA4	4I	CA5	5I	CA6	6I	CA7	7I	CA8	8I	-	-

Table 4.2 Connecting RL78/L23 to LCD Panel (2/2)

PIN	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
PORT	P92	P93	P11	P10	P145	P144	P143	P142	P141	P130	P31	P30	P75	P74	P73	P72	P71	P70
SEG/COM	COM2	COM3	SEG36	SEG35	SEG55	SEG54	SEG53	SEG52	SEG51	SEG28	SEG21	SEG20	SEG17	SEG16	SEG15	SEG14	SEG13	SEG12
COM0	-	-	DP8	8M	DP7	7M	DP6	6M	DP5	5M	DP4	4M	DP3	3M	DP2	2M	DP1	1M
COM1	-	-	8C	8N	7C	7N	6C	6N	5C	5N	4C	4N	3C	3N	2C	2N	1C	1N
COM2	COM2	-	8B	8G	7B	7G	6B	6G	5B	5G	4B	4G	3B	3G	2B	2G	1B	1G
COM3	-	COM3	8A	8H	7A	7H	6A	6H	5A	5H	4A	4H	3A	3H	2A	2H	1A	1H

4.3 List of Pins to be Used

Table 4.3 lists the pins to be used and their functions.

Table 4.3 Pins to be Used and their Functions

Pin Name	I/O	Description
P137/INTP0	Input	Switch Input
P04/SEG47	Output	LCD controller/driver segment signal
P05/SEG48		
P06/SEG49		
P07/SEG50		
P10/SEG35		
P11/SEG36		
P12/SEG37		
P13/SEG38		
P14/SEG39		
P30/SEG20		
P31/SEG21		
P50/SEG4		
P51/SEG5		
P52/SEG6		
P53/SEG7		
P54/SEG8		
P70/SEG12		
P71/SEG13		
P72/SEG14		
P73/SEG15		
P74/SEG16		
P75/SEG17		
P94/SEG0		
P95/SEG1		
P96/SEG2		
P97/SEG3		
P130/SEG28		
P141/SEG51		
P142/SEG52		
P143/SEG53		
P144/SEG54		
P145/SEG55		
P90/COM0	Output	LCD controller/driver common signal
P91/COM1		
P92/COM2		
P93/COM3		

5. Software

5.1 Option Byte Settings

Table 5.1 lists the option byte settings.

Table 5.1 Option Byte Settings

Address	Value	Description
000C0H/040C0H	01101110B	Disables the watchdog timer. (Stops counting after the release from the reset state.)
000C1H/040C1H	11111110B	LVD0 operating mode: reset mode Detection voltage: Rising edge 1.90V Falling edge 1.86V
000C2H/040C2H	11101000B	HS mode, HOCO: 32 MHz
000C3H/040C3H	10000100B	Enables the on-chip debugger.

5.2 List of Constants

Tables 5.2 and 5.3 lists the constants used in the sample code.

Table 5.2 List of Constants (1/2)

Constant	Setting	Description
FLAG_CLEAR	0	Flag clear value
FLAG_SET	1	Flag set value
BLINK_OFF	1	Blink process OFF value
BLINK_ON	2	Blink process ON value
BLINK_SKIPPED	0	Blink process not executed
BLINK_HANDLED	1	Blink process executed
WATCH_DISPLAY	0	Clock display mode
HOUR_ADJUST	1	Hour adjustment mode
MINUTE_ADJUST	2	Minute adjustment mode
MAX_MIN	59	Maximum value for minutes
MAX_HOUR	23	Maximum value for hours
LONG_PRESS_THRESHOLD	100	Threshold for long press of the switch

Table 5.3 List of Constants (2/2)

Constant	Setting	Description
g_show_segdata[15][4]	{0x77, 0x00, 0x00, 0xEE}, {0x00, 0x00, 0x00, 0x66}, {0x33, 0x22, 0x44, 0xCC}, {0x11, 0x22, 0x44, 0xEE}, {0x44, 0x22, 0x44, 0x66}, {0x55, 0x22, 0x44, 0xAA}, {0x77, 0x22, 0x44, 0xAA}, {0x44, 0x00, 0x00, 0xEE}, {0x77, 0x22, 0x44, 0xEE}, {0x55, 0x22, 0x44, 0xEE}, {0xFF, 0xFF, 0xFF, 0xFF}, {0x00, 0x00, 0x00, 0x11}, {0x00, 0x00, 0x00, 0x00}, {0x00, 0x44, 0x22, 0x00}, {0x00, 0x88, 0x11, 0x00},	Display data for the LCD panel 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, All segments, Comma, Space, Slash, Colon
g_blinking_show_segdata[15][4]	{0x07, 0x00, 0x00, 0x0E}, {0x00, 0x00, 0x00, 0x06}, {0x03, 0x02, 0x04, 0x0C}, {0x01, 0x02, 0x04, 0x0E}, {0x04, 0x02, 0x04, 0x06}, {0x05, 0x02, 0x04, 0x0A}, {0x07, 0x02, 0x04, 0x0A}, {0x04, 0x00, 0x00, 0x0E}, {0x07, 0x02, 0x04, 0x0E}, {0x05, 0x02, 0x04, 0x0E}, {0x0F, 0x0F, 0x0F, 0x0F}, {0x00, 0x00, 0x00, 0x01}, {0x00, 0x00, 0x00, 0x00}, {0x00, 0x04, 0x02, 0x00}, {0x00, 0x08, 0x01, 0x00},	Display data for the LCD panel (for blinking) 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, All segments, Comma, Space, Slash, Colon
g_digit_segdata[8][4]	{0x08, 0x07, 0x0C, 0x0D}, {0x06, 0x05, 0x0E, 0x0F}, {0x04, 0x03, 0x10, 0x11}, {0x02, 0x01, 0x14, 0x15}, {0x00, 0x32, 0x1C, 0x33}, {0x31, 0x30, 0x34, 0x35}, {0x2F, 0x27, 0x36, 0x37}, {0x26, 0x25, 0x23, 0x24},	LCD display data registers corresponding to each digit of the LCD panel

5.3 List of Variables

Table 5.5 lists global variables.

Table 5.5 List of Global Variables

Type	Variable Name	Contents	Function Used
uint8_t	g_watch_status	mode stored variable	main, r_Config_IT00_interrupt, r_main_userinit, r_handle_watch_display, r_handle_time_adjust, r_handle_blink
uint8_t	g_time_setting_flag	Time adjustment flag (Flag for short press of the switch)	r_handle_time_adjust, r_Config_IT00_interrupt
uint8_t	g_mode_change_flag	Mode switch flag (Flag for long press of the switch)	r_handle_watch_display, r_handle_time_adjust
uint8_t	g_blink_flag	Blink process execution flag	r_handle_blink
uint8_t	g_lcd_second	Second data of the clock	r_increment_time, r_rtc_get_counter_value, r_rtc_set_counter_value
uint8_t	g_lcd_minute	Minute data of the clock	main, r_time_show, r_rtc_get_counter_value, r_rtc_set_counter_value
uint8_t	g_lcd_hour	Hour data of the clock	main, r_time_show, r_rtc_get_counter_value, r_rtc_set_counter_value
uint16_t	g_interrupt_cnt	Interrupt counter	r_Config_IT00_interrupt

5.4 List of Functions

Table 5.6 lists the functions.

Table 5.6 List of Functions

Function Name	Outline
r_main_userinit	Initialization processing
r_rtc_operation_start	RTC operation start processing
r_handle_watch_display	Clock display processing
r_handle_time_adjust	Time adjustment processing
r_time_show	LCD display update processing
r_handle_blink	LCD blinking display processing
r_increment_time	Time data increment processing
r_lcd_show	Display data setting processing
r_lcd_blinking_show	Blinking display data setting processing
r_rtc_get_counter_value	RTC register read processing
r_rtc_set_counter_value	RTC register write processing
r_Config_INTC_intp0_interrupt	External interrupt processing
r_Config_IT01_interrupt	8-bit IT01 interrupt processing
r_Config_IT00_interrupt	8-bit IT00 interrupt processing

5.5 Function Specifications

This section describes the specifications for the functions that are used in this sample program

[Function Name] r_main_userinit

Synopsis	Initialization processing
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h
Declaration	void r_main_userinit(void);
Explanation	Displays the time “00:00” on the LCD panel, and enables RTC and external interrupts.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_rtc_operation_start

Synopsis	RTC operation start processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_RTC.h
Declaration	void r_rtc_operation_start(void);
Explanation	Enable the RTC operation. Next, wait for 2 clocks using the count clock.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_handle_watch_display

Synopsis	Clock display processing
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h
Declaration	void r_handle_watch_display(void);
Explanation	Read the time information from the RTC registers and update the display on the LCD panel.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_handle_time_adjust

Synopsis	Time adjustment processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	void r_handle_time_adjust(uint8_t *val, uint8_t max_val, uint8_t blink_digit);	
Explanation	In hour adjustment mode, the "hour" display blinks. When a short press of the switch is detected, one hour is added and displayed on the LCD panel. In minute adjustment mode, the "minute" display blinks. When a short press of the switch is detected, one minute is added and displayed on the LCD panel.	
Arguments	uint8_t *val	Clock hour or minute data
	uint8_t max_val	Maximum value for clock hour or minute
	uint8_t blink_digit	Value of the digit to be blinked
Return value	None	
Remarks	None	

[Function Name] r_time_show

Synopsis	LCD display update processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	void r_time_show(uint8_t blinking_colon);	
Explanation	Updates the display on the LCD panel.	
Arguments	uint8_t blinking_colon	Colon display settings for steady on / blinking modes
Return value	None	
Remarks	None	

[Function Name] r_handle_blink

Synopsis	LCD blinking display processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	uint8_t r_handle_blink(uint8_t blink_digit);	
Explanation	To make the LCD panel blink, processes for turning the display on and off are performed.	
Arguments	uint8_t blink_digit	Setting value for the digit to blink
Return value	[BLINK_HANDLED]	Blink processing executed
	[BLINK_SKIPPED]	Blink processing not executed
Remarks	None	

[Function Name] r_increment_time

Synopsis	Time data increment processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	void r_increment_time(uint8_t *time_val, uint8_t max_val);	
Explanation	Adds 1 hour or 1 minute to the time data and sets it in the RTC register.	
Arguments	uint8_t *time_val	Clock hour or minute data
	uint8_t max_val	Maximum value for clock hour or minute
Return value	None	
Remarks	None	

[Function Name] r_lcd_show

Synopsis	Display data setting processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	void r_lcd_show(uint8_t value, uint8_t digit);	
Explanation	Stores the data to be displayed on the LCD panel into the LCD display data register.	
Arguments	uint8_t value	Data to be displayed on the LCD
	uint8_t digit	LCD display data register number
Return value	None	
Remarks	None	

[Function Name] r_lcd_blinking_show

Synopsis	Blinking display data setting processing	
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h	
Declaration	void r_lcd_blinking_show(uint8_t value, uint8_t digit);	
Explanation	Stores the data to be displayed on the LCD panel into the LCD display data register.	
Arguments	uint8_t value	Data to be displayed on the LCD
	uint8_t digit	LCD display data register number
Return value	None	
Remarks	None	

[Function Name] r_rtc_get_counter_value

Synopsis	RTC register read processing
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h
Declaration	void r_rtc_get_counter_value(void);
Explanation	Reads the hour and minute data from the RTC registers.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_rtc_set_counter_value

Synopsis	RTC register write processing
Header	r_cg_macrodriver.h, Config_LCD.h, Config_INTC.h, Config_RTC.h, Config_IT00.h, Config_IT01.h, Pin.h, r_cg_it8bit_common.h, r_cg_rtc_common.h, r_cg_lvd_common.h, r_cg_userdefine.h
Declaration	void r_rtc_set_counter_value(void);
Explanation	Writes hour, minute, and second data to the RTC registers.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_Config_INTC_intp0_interrupt

Synopsis	External interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_INTC.h, Config_IT00.h
Declaration	#pragma interrupt r_Config_INTC_intp0_interrupt(vect=INTP0)
Explanation	Enables operation of the 8-bit IT00 to measure the switch press duration.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_Config_IT01_interrupt

Synopsis	8-bit IT01 interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_IT01.h
Declaration	#pragma interrupt r_Config_IT01_interrupt(vect=INTIT01)
Explanation	Sets the blink process execution flag.
Arguments	None
Return value	None
Remarks	None

[Function Name] r_Config_IT00_interrupt

Synopsis	8-bit IT00 interrupt processing
Header	r_cg_macrodriver.h, r_cg_userdefine.h, Config_IT00.h, Config_IT01.h
Declaration	#pragma interrupt r_Config_IT00_interrupt(vect=INTIT00)
Explanation	Determines whether the switch press is a short press or a long press based on the press duration.
Arguments	None
Return value	None
Remarks	None

5.6 Flowcharts

5.6.1 Main Processing

Figure 5.1 shows the flowchart of the main processing.

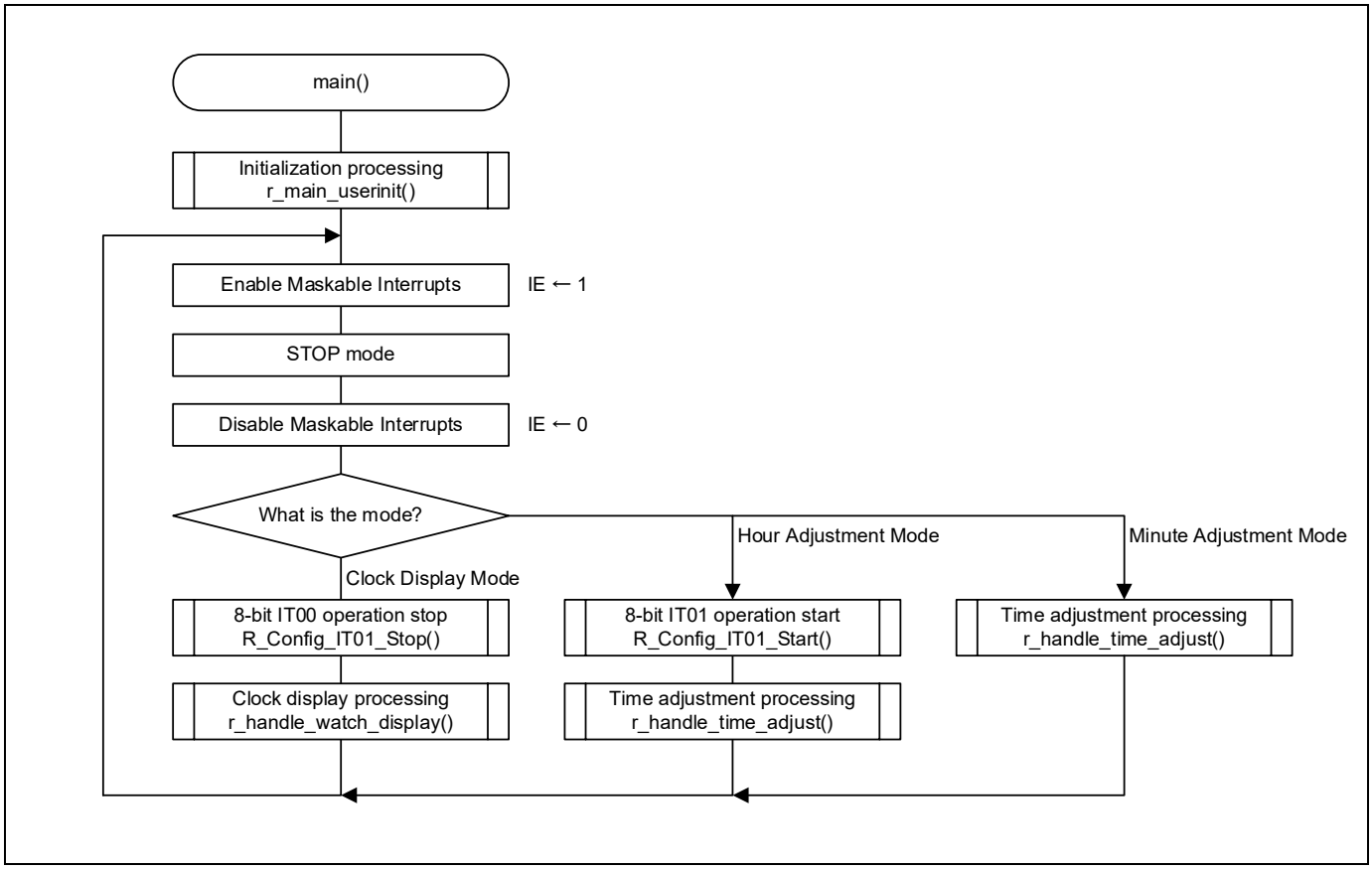

Figure 5.1 Main Processing

5.6.2 Initialization Processing

Figure 5.2 shows the flowchart of the initialization processing.

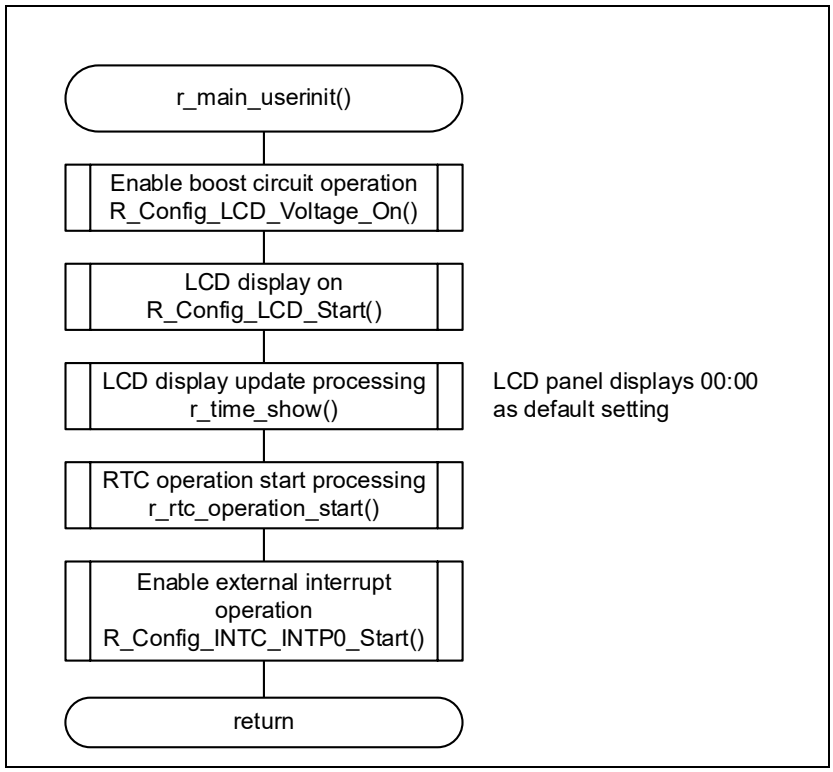

Figure 5.2 Initialization Processing

5.6.3 RTC Operation Start Processing

Figure 5.3 shows the flowchart of the RTC operation start processing.

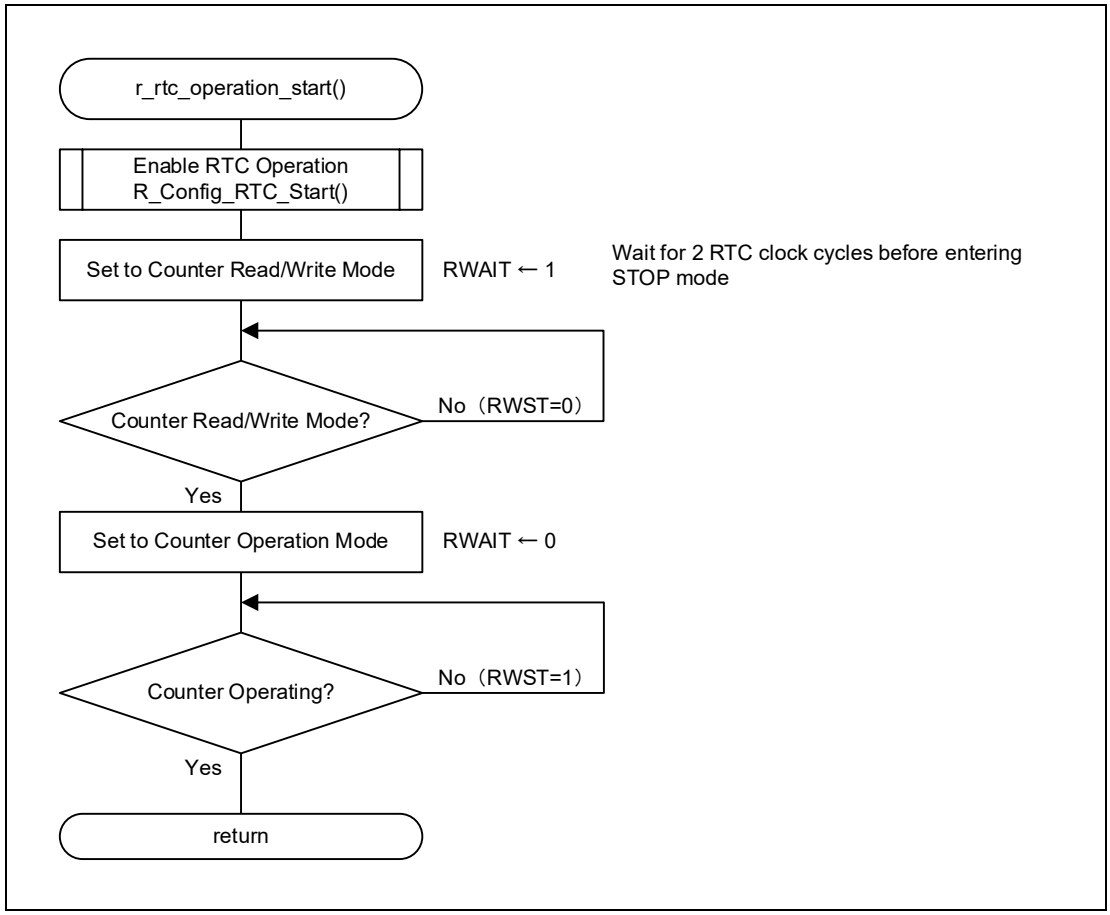

Figure 5.3 RTC Operation Start Processing

5.6.4 Clock Display Processing

Figure 5.4 shows the flowchart of the clock display processing.

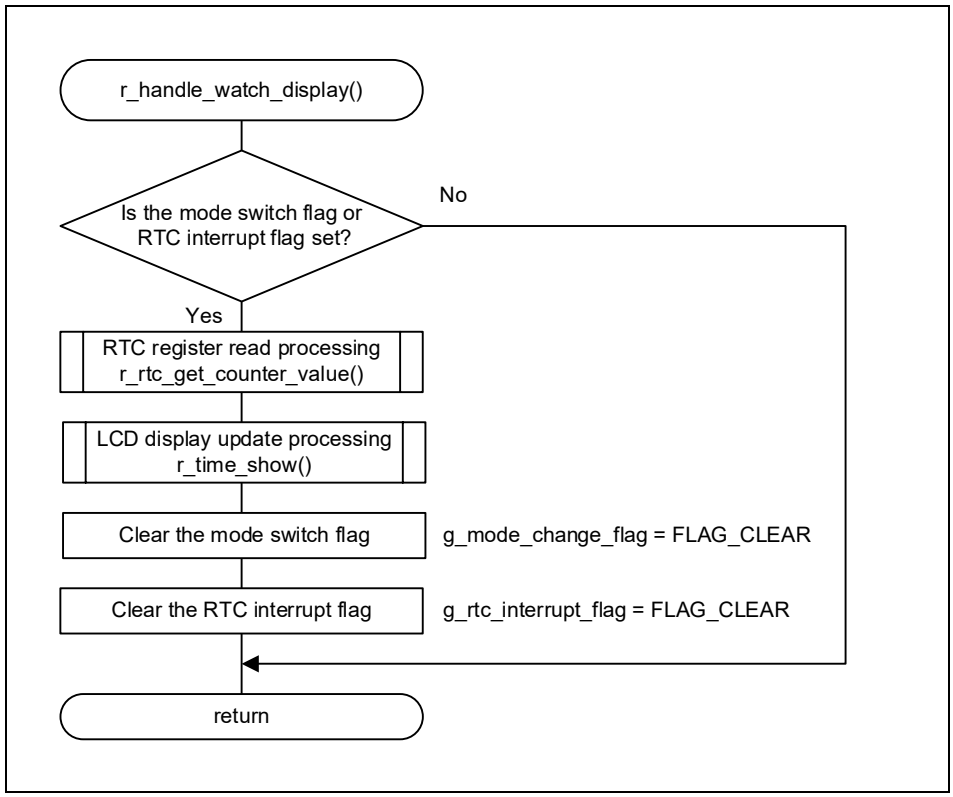

Figure 5.4 Clock Display Processing

5.6.5 Time Adjustment Processing

Figure 5.5 shows the flowchart of the time adjustment processing.

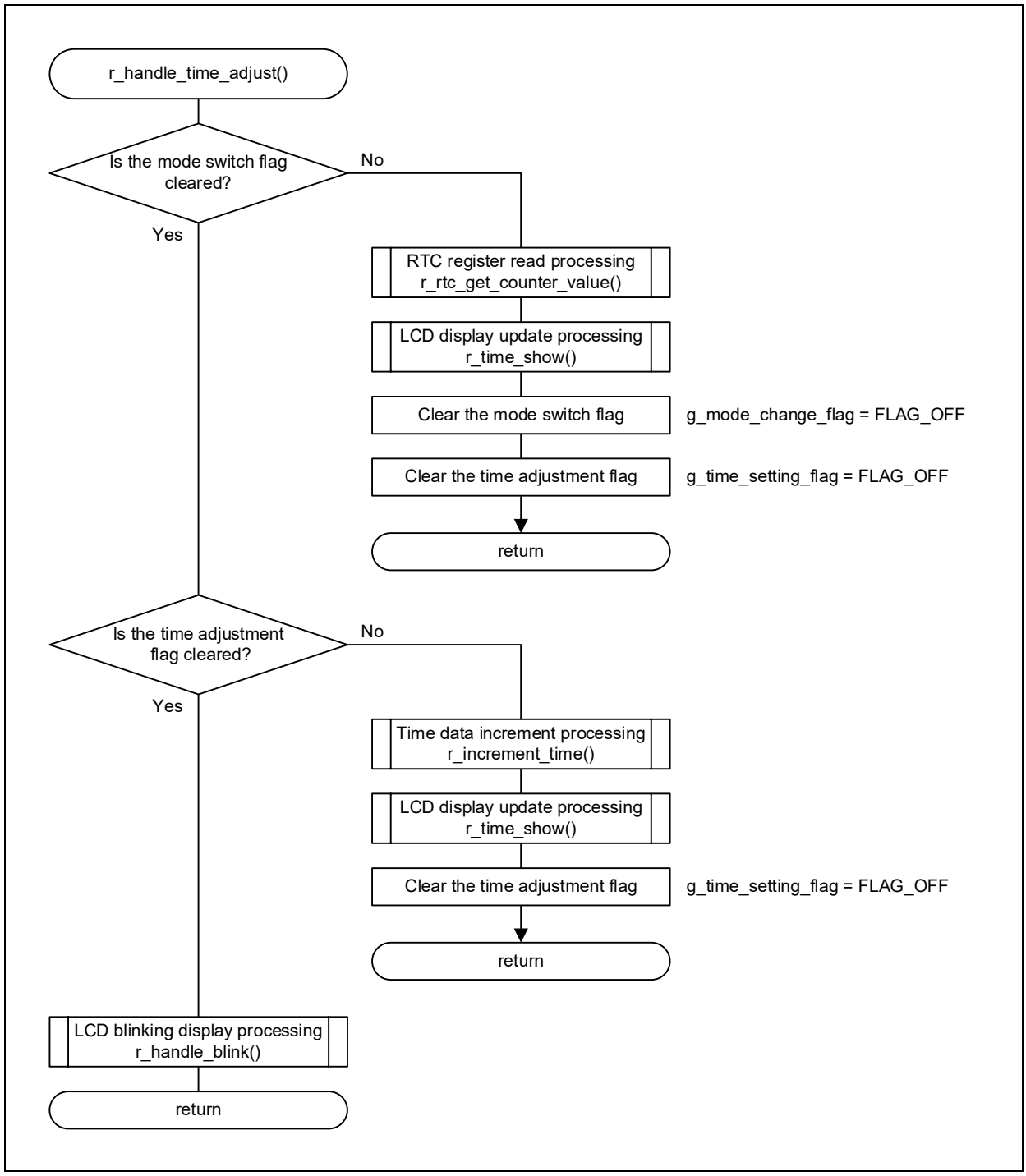

Figure 5.5 Time Adjustment Processing

5.6.6 LCD Display Update Processing

Figure 5.6 shows the flowchart of the LCD display update processing.

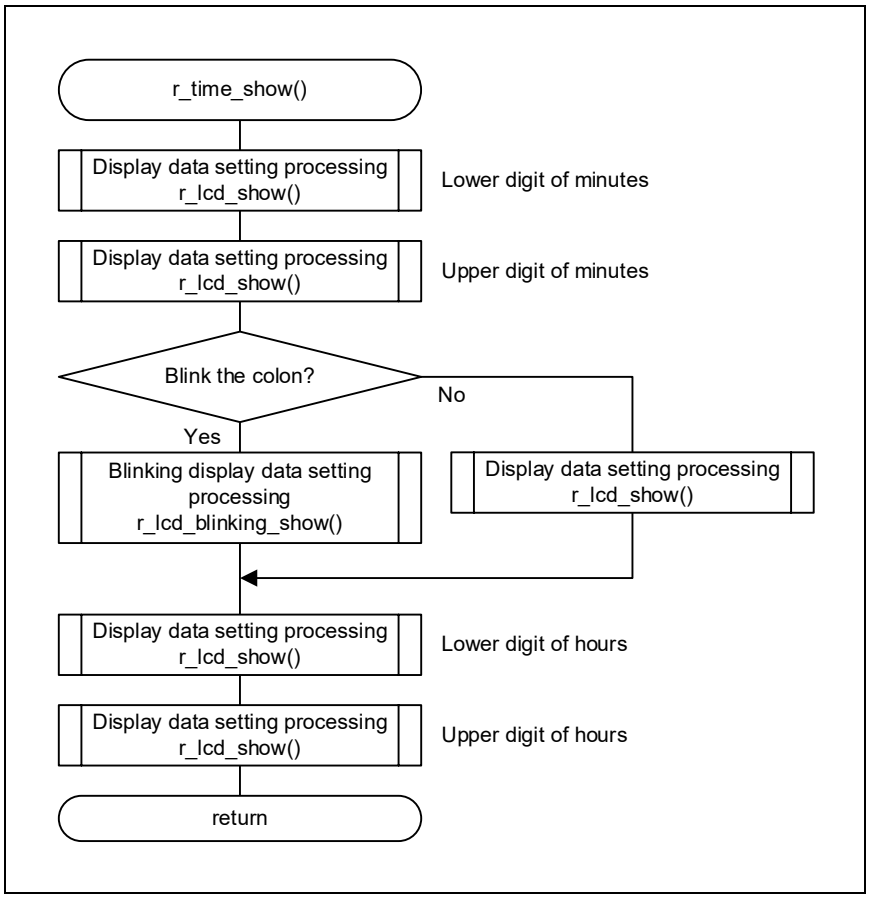

Figure 5.6 LCD Display Update Processing

5.6.7 LCD Blinking Display Processing

Figure 5.7 shows the flowchart of the LCD blinking display processing.

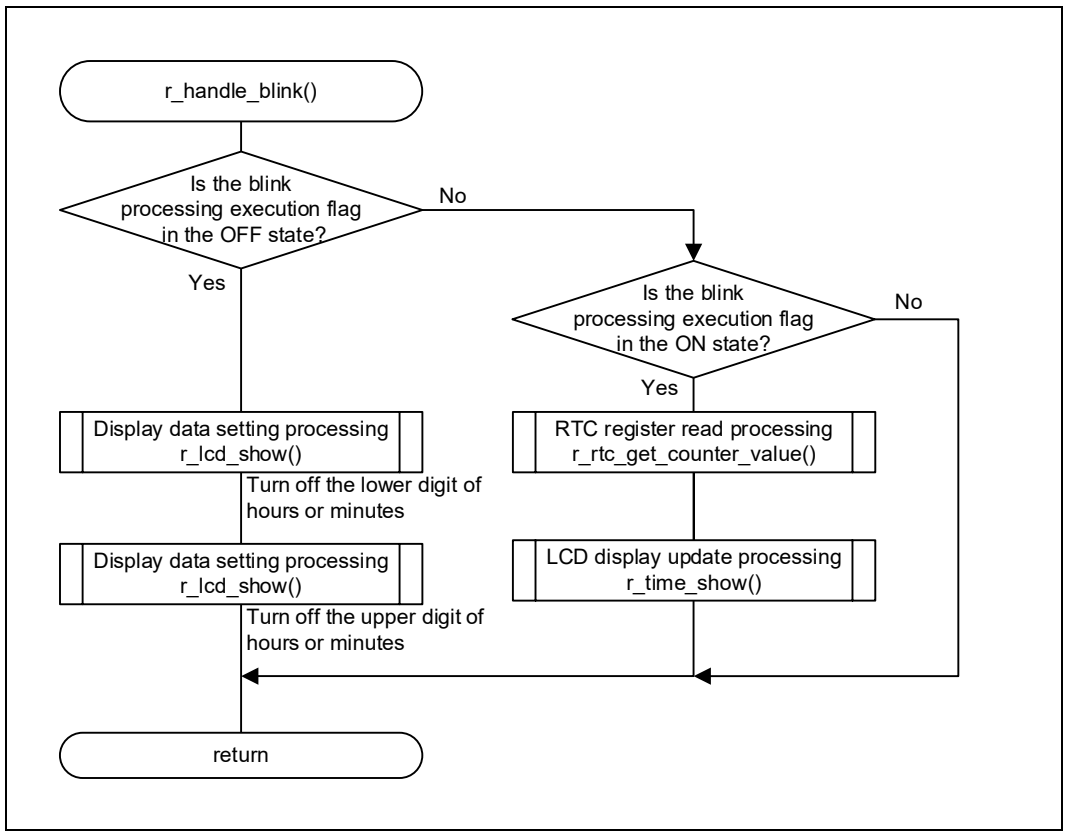

Figure 5.7 LCD Blinking Display Processing

5.6.8 Time Data Increment Processing

Figure 5.8 shows the flowchart of the time data increment processing.

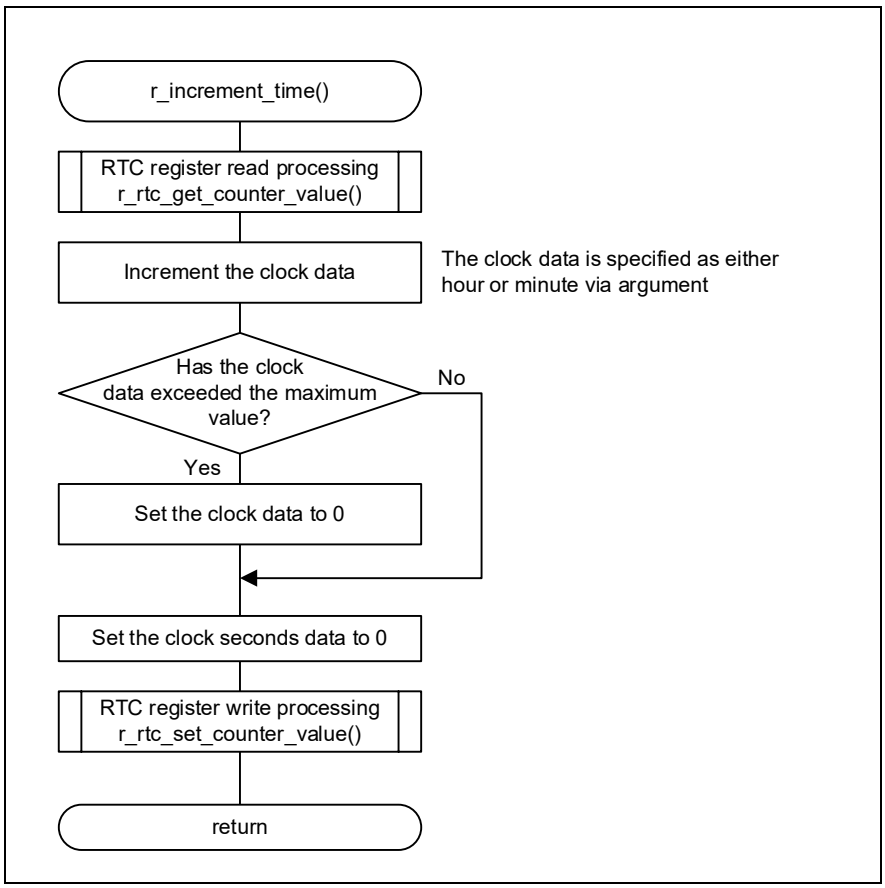

Figure 5.8 Time Data Increment Processing

5.6.9 Display Data Setting Processing

Figure 5.9 shows the flowchart of the display data setting processing.

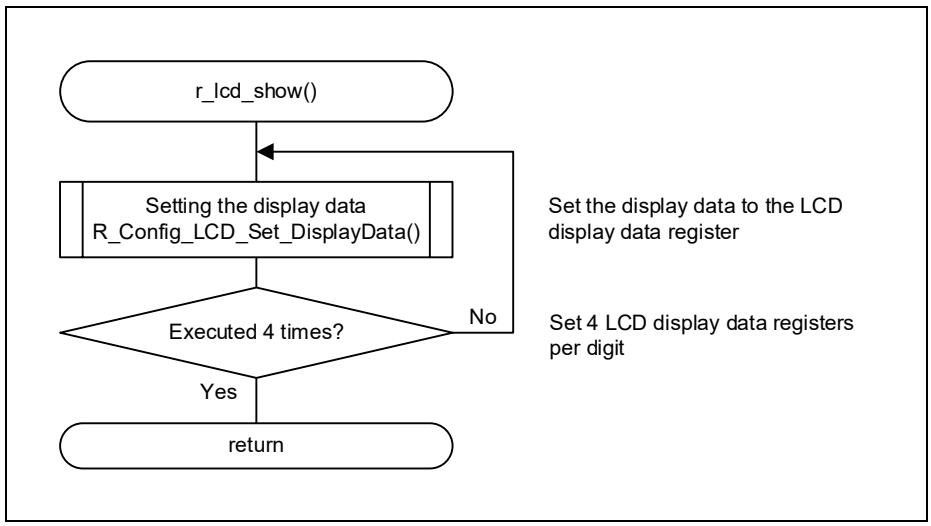

Figure 5.9 Display Data Setting Processing

5.6.10 Blinking Display Data Setting Processing

Figure 5.10 shows the flowchart of the blinking display data setting processing.

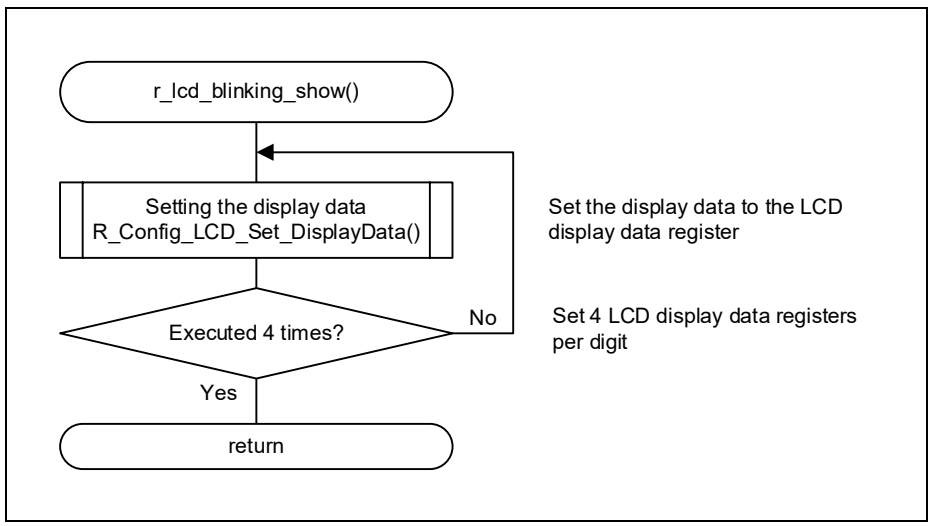

Figure 5.10 Blinking Display Data Setting Processing

5.6.11 RTC Register Read Processing

Figure 5.11 shows the flowchart of the RTC register read processing.

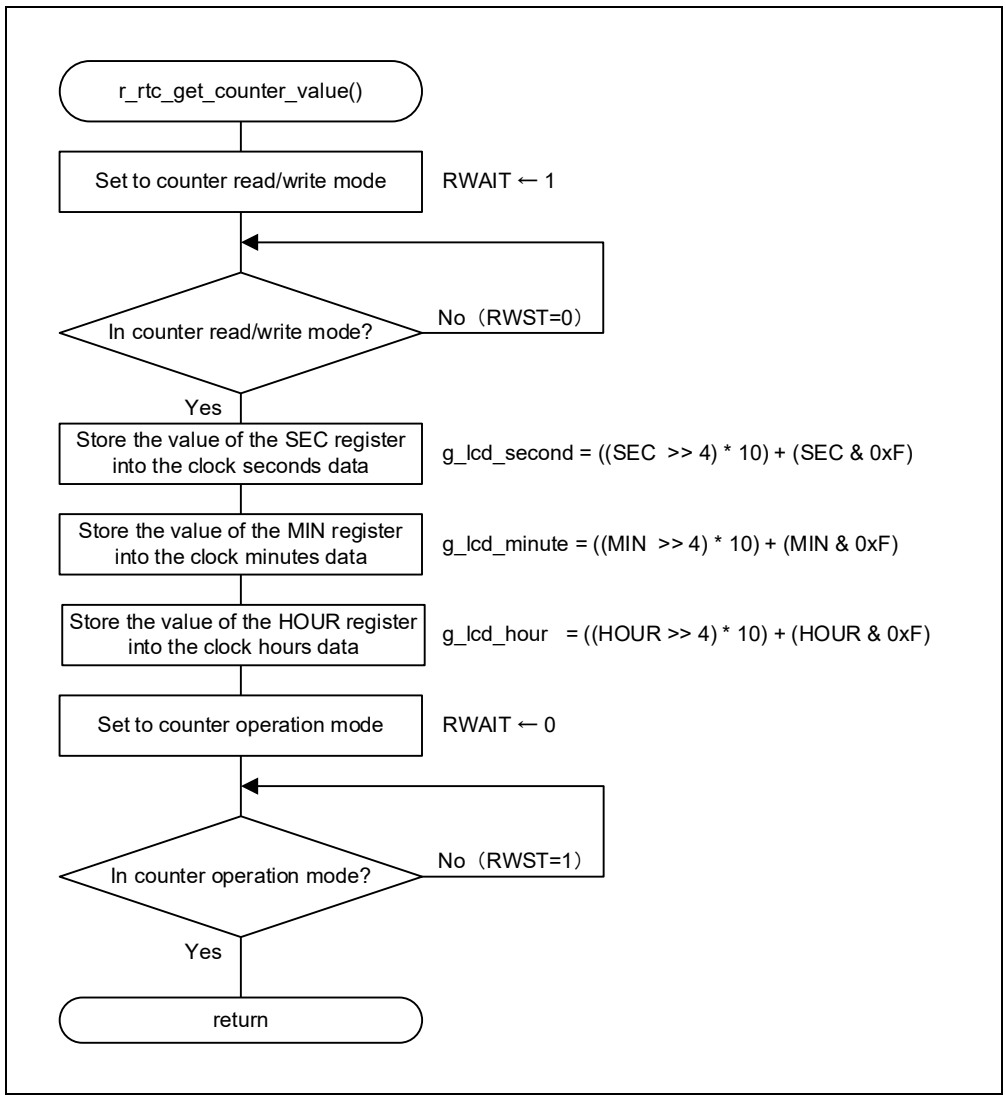

Figure 5.11 RTC Register Read Processing

5.6.12 RTC Register Write Processing

Figure 5.12 shows the flowchart of the RTC register write processing.

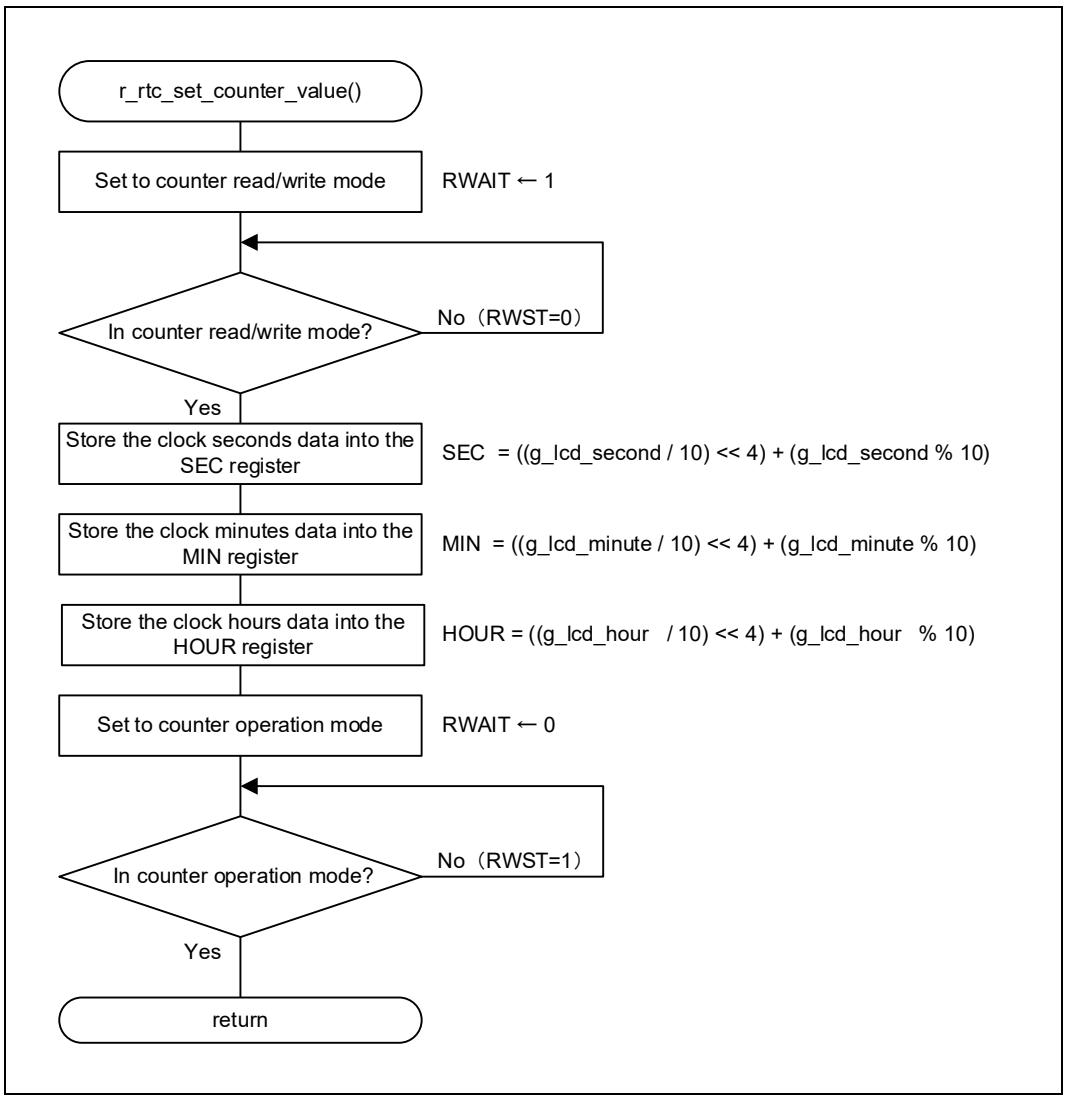

Figure 5.12 RTC Register Write Processing

5.6.13 External Interrupt Processing

Figure 5.13 shows the flowchart of the external interrupt processing.

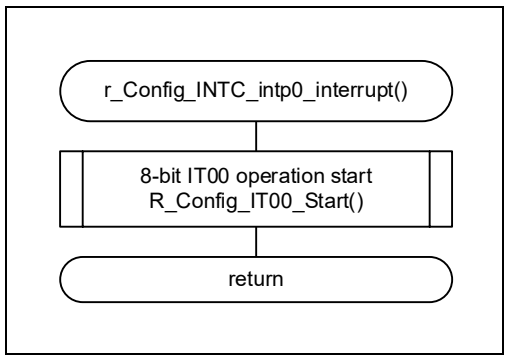

Figure 5.13 External Interrupt Processing

5.6.14 8-bit IT01 Interrupt Processing

Figure 5.14 shows the flowchart of the 8-bit IT01 interrupt processing.

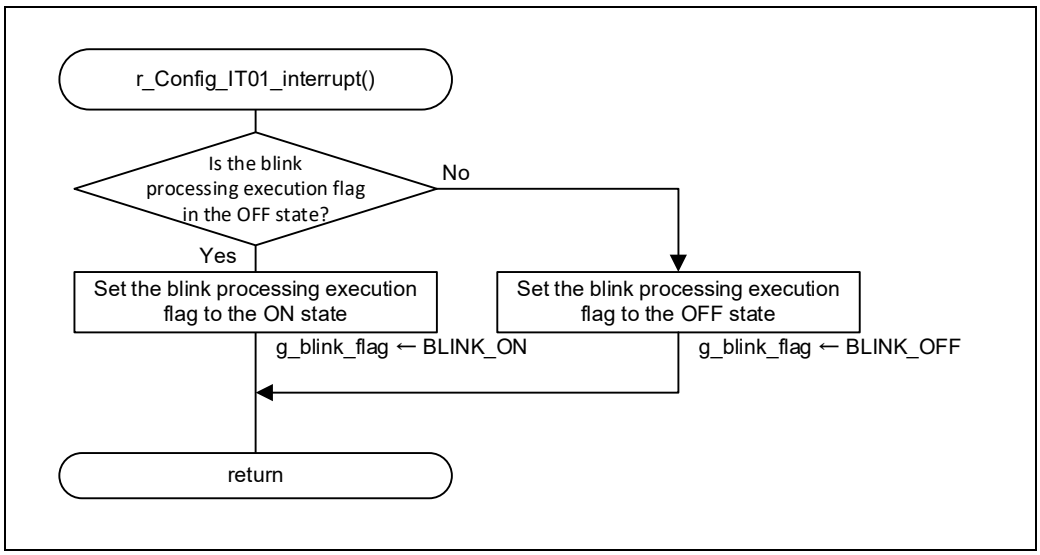

Figure 5.14 8-bit IT01 Interrupt Processing

5.6.15 8-bit IT00 Interrupt Processing

Figure 5.15 shows the flowchart of the 8-bit IT00 interrupt processing.

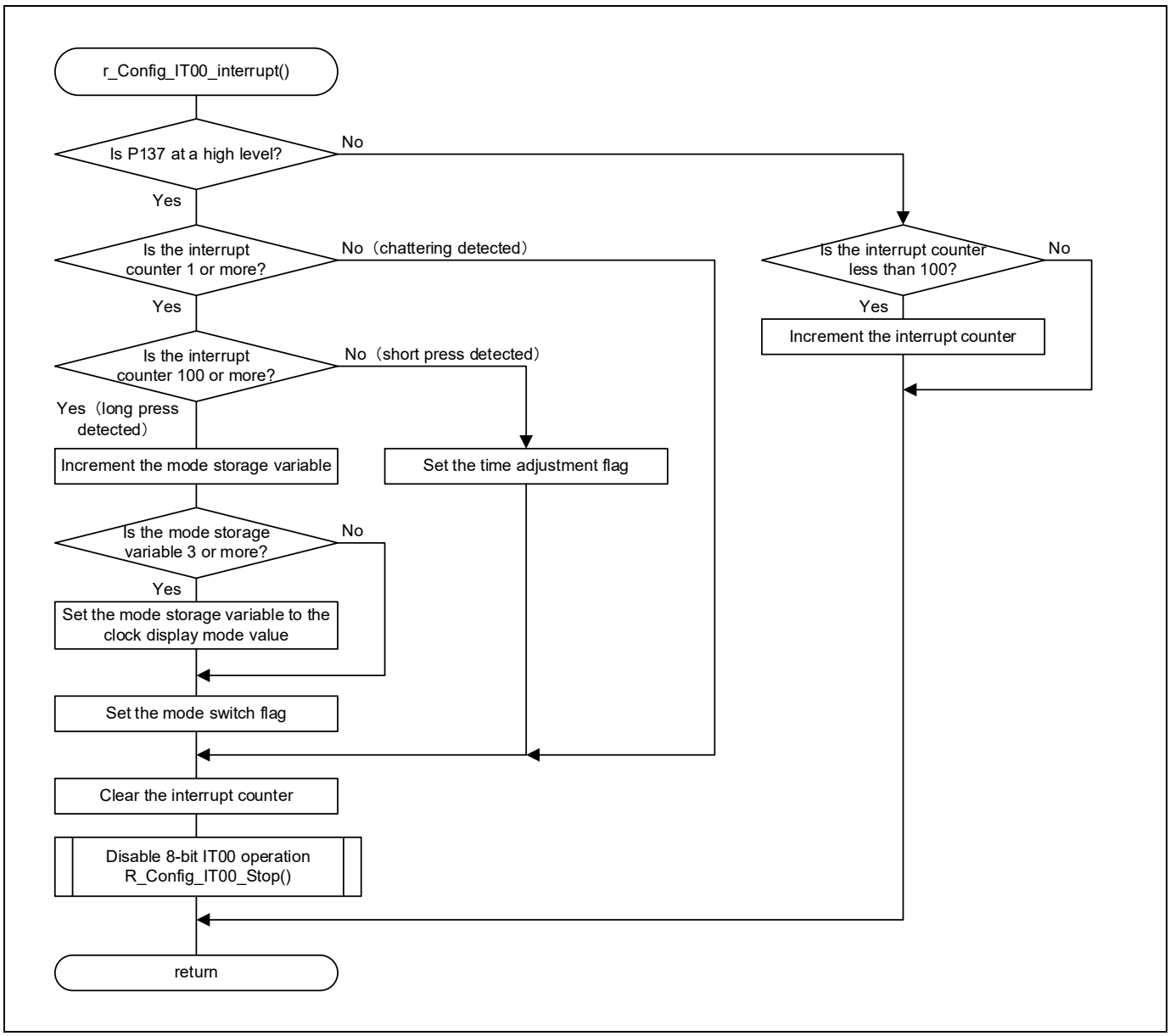

Figure 5.15 8-bit IT00 Interrupt Processing

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Documents for Reference

RL78/L23 User's Manual: Hardware (R01UH1082E)

RL78 Family User's Manual: Software (R01US0015E)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical Updates/Technical Brochures

(The latest versions of the documents are available on the Renesas Electronics Website.)

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug.27, 2025	-	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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