RX113 Group

Programming Guide for Intermittent Operation

Using Low-Power Timer Function

Summary

This application note describes how to implement power-saving intermittent operation using Low-Power Timer (LPT) function of RX113 and Firmware Integration Technology (FIT) modules

Operation Confirmation Device

RX113 Group R5F51138ADFP

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Related Application Notes

Application notes related to this application note are listed below. Refer to them in conjunction with this document.

- Firmware Integration Technology User's Manual (R01AN1833)
- RX Family Adding Firmware Integration Technology Modules to Projects (R01AN1723)
- RX Family Adding Firmware Integration Technology Modules to CS+ Projects (R01AN1826)
- RX Family Board Support Package Module Using Firmware Integration Technology (R01AN1685)
- RX Family LCD Module Using Firmware Integration Technology (R01AN1980)
- RX Family LPT Module Using Firmware Integration Technology (R01AN2571)
- RX Family LPC Module Using Firmware Integration Technology (R01AN2769)
- RX Family ELC Module Using Firmware Integration Technology (R01AN3066)
- RX113 Group Renesas Starter Kit User's Manual (R20UT2756JG)
- Renesas Starter Kit for RX113 CPU Board Schematics (R20UT2755EG)

Contents

RENESAS

1. Overview

1.1 About This Application Note

In intermittent operation, MCU is switched between normal operating mode and low-power mode, which optimizes power usage, to extend battery operation time on battery-powered devices
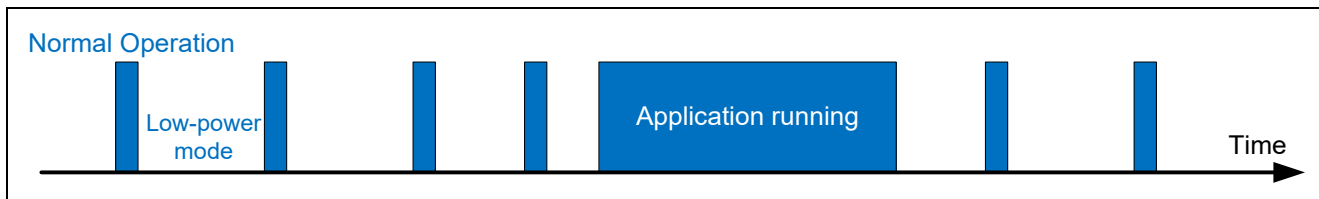
Figure 1.1   Overview of Intermittent Operation

The intermittent operation cycle and normal operation time will differ depending on system requirement, so it is desirable to have a simple and effective method of implementing intermittent operation.

The sample program described in this application note uses a Wait() instruction to transition from the normal operating state to low-power mode (software standby mode), then uses the event signal from the low-power timer (LPT), which continues to function in low-power mode, to cancel low-power mode.

During the process, it is possible to transition to low-power mode (software standby mode) without changing LCD display state.

Figure 1.2   Intermittent Operation Example

Figure 1.3   System Flowchart

1.2   Operating Environment

The operation of the sample program described in this application note has been confirmed in the operating environment shown in Table 1.1.

Table 1.1   Operating Environment

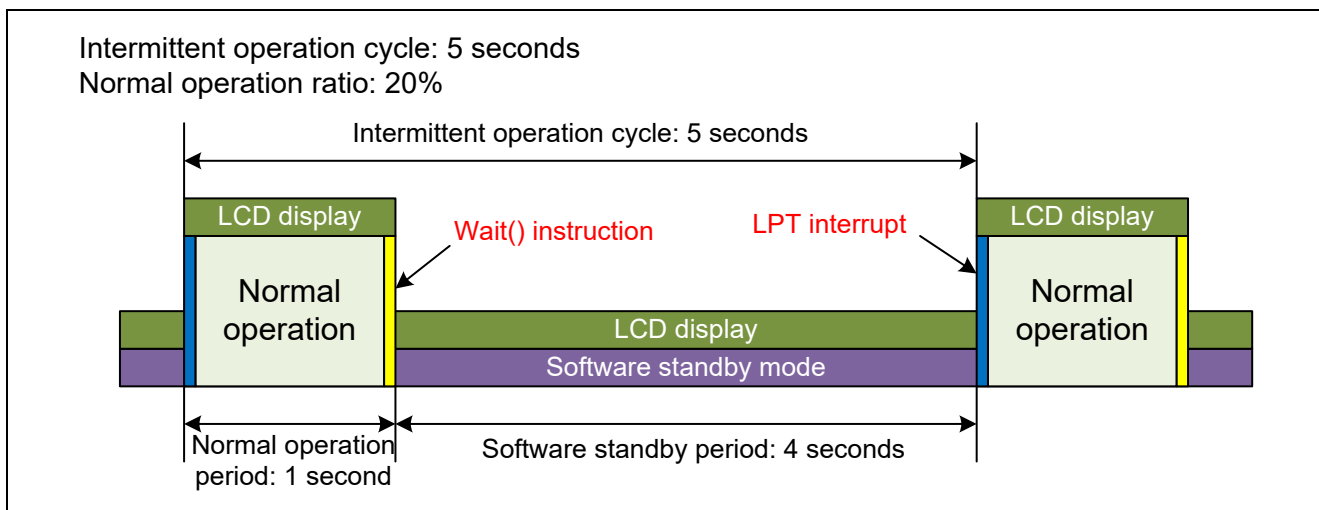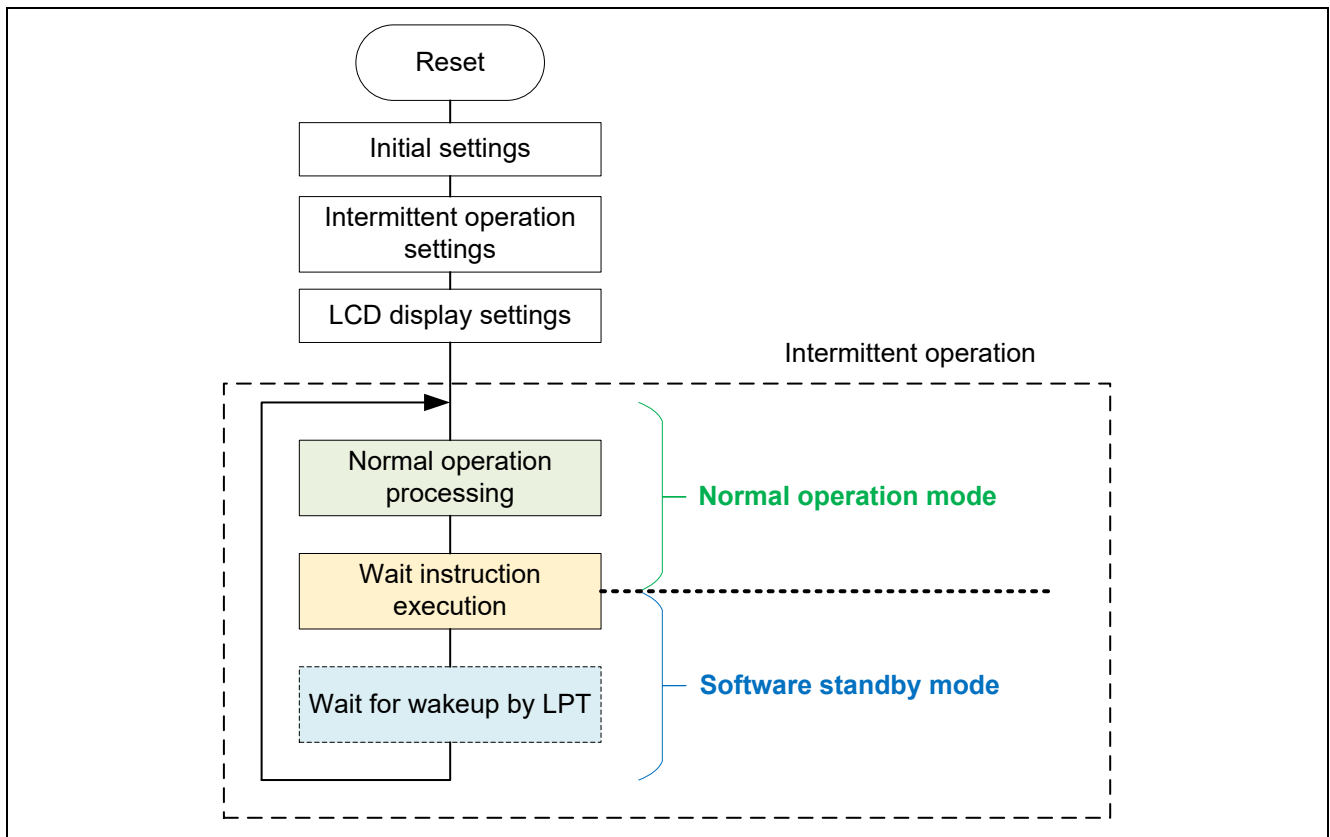| Item	Description
MCU used	R5F51138ADFP (RX113 Group)
Board used	Renesas Starter Kit for RX113 (product No.: R0K505113S900BE)
	LCD Application Board V2 (product No.: R0K0APPBDB030BE)
CPU operating frequency	High-speed on-chip oscillator (HOCO) = 32 MHz
	Watchdog clock = 15 kHz
Integrated development environment	Renesas Electronics
	e^2 studio Version 7.0.0
C compiler	Renesas Electronics
	C/C++ Compiler Package for RX Family V.2.08.00
Emulator	E2 and E1
Endian order	Little endian

The sample program described in this application note uses Firmware Integration Technology (FIT) modules to control the peripheral functions of the MCU. The FIT modules used by the sample program are listed in Table 1.2

Table 1.2   FIT Modules

Type	Name of Application Note (Product No.)	Name of FIT Module	Rev.
BSP	RX Family Board Support Package Module Using Firmware Integration Technology (R01AN1685)	r_bsp_rx	3.80
Device driver	RX Family LPT Module Using Firmware Integration Technology (R01AN2571)	r_lpt_rx	1.21
Device driver	RX Family LPC Module Using Firmware Integration Technology (R01AN2769)	r_lpc_rx	1.40
Device driver	RX Family ELC Module Using Firmware Integration Technology (R01AN3066)	r_elc_rx	1.20
Device driver	RX Family LCD Module Using Firmware Integration Technology (R01AN1980)	r_lcdc_rx	1.00

The sample program described in this application note uses the two operating modes listed in Table 1.3, to implement power-saving operation.

Table 1.3   CPU Operating Modes

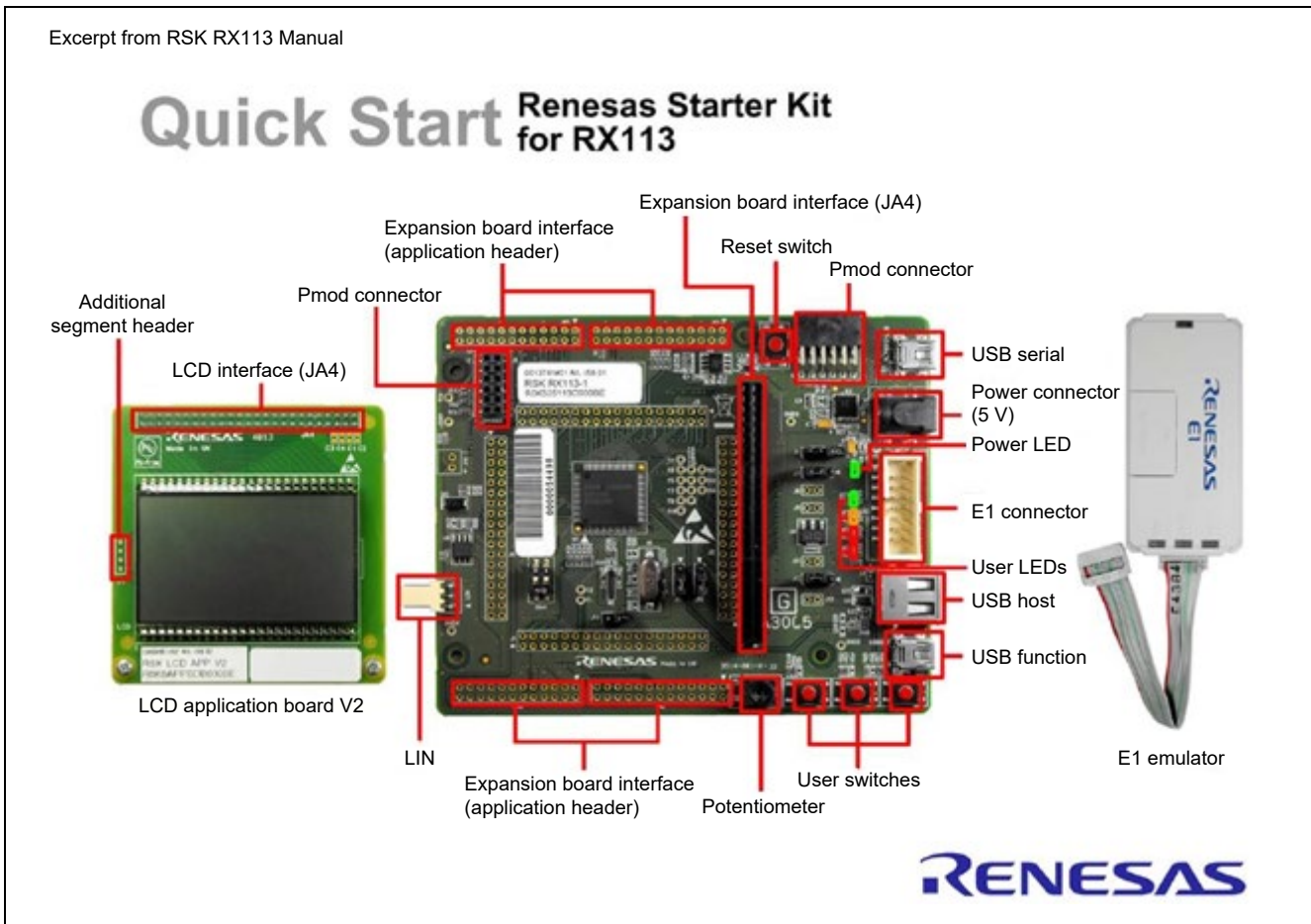| CPU Operating Mode	Transition Condition
Normal mode	Transition from standby mode by LPT event signal
Software standby mode	Transition by Wait() instruction execution after bit 15 (SSBY) in standby control register (SBYCR) is set to 1

2. Hardware

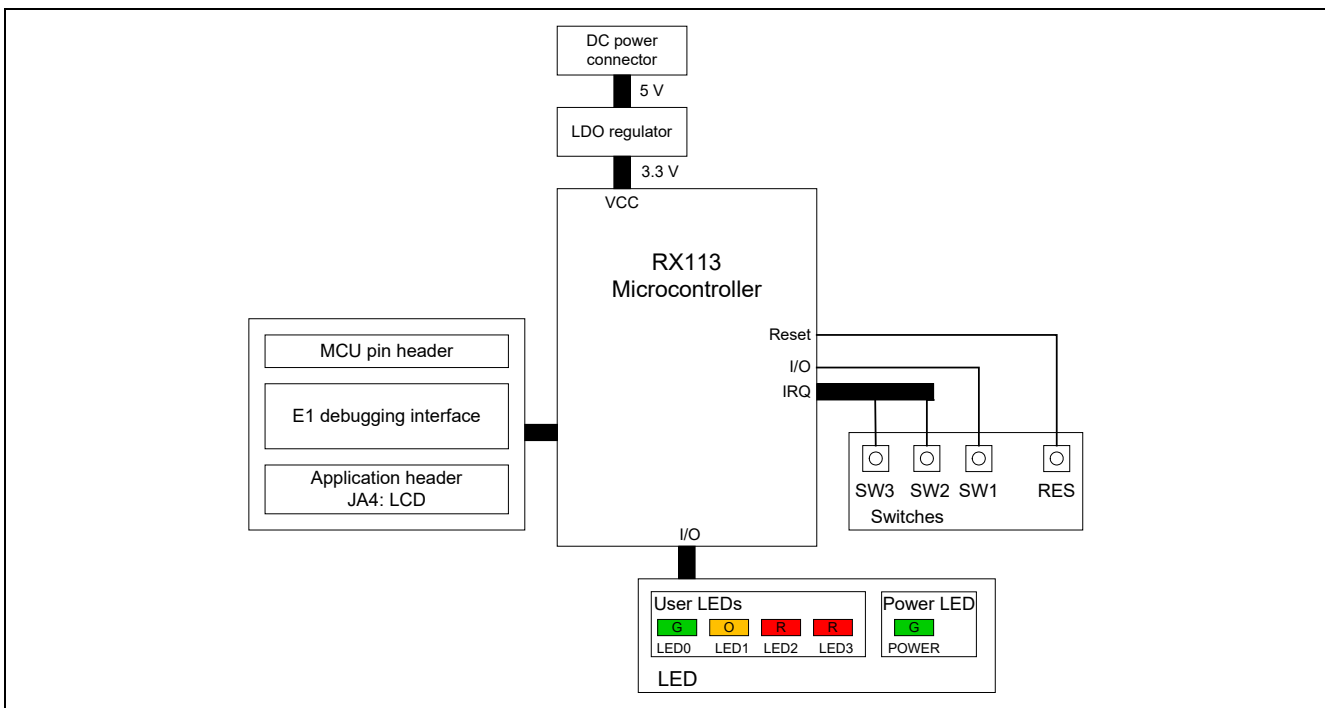## 2.1 RSK RX113 Overview

Figure 2.1　RSK RX113

Figure 2.2　Internal Board Connections

2.2 Pins Used

MCU pin connections are listed below.

Table 2.1 Switch Operation

Pin Name	I/O	Description
PA4	Input	SW1 input: Change setting value in setting mode (UP).
P32	Input	SW2 input: Not used.
P27	Input	SW3 input: Switch between intermittent operation and setting mode.

Table 2.2 LCD Display [JA4]

Pin	Port	Circuit Name	LCD Pin	Pin	Port	Circuit Name	LCD Pin
1	PC6	VL4	V1	2	PC7	VL3	V2
3	P54	VL2	V3	4	P55	VL1	V4
5	—	GND	GND	6	—	GND	GND
7	PC5	COM0	COM1	8	PC4	COM1	COM2
9	PC3	COM2	COM3	10	PC2	COM3	COM4
11	P13	SEG0	SEG3	12	P12	SEG1	SEG4
13	P11	SEG2	SEG5	14	P10	SEG3	SEG6
15	P56	SEG4	SEG7	16	P53	SEG5	SEG8
17	P52	SEG6	SEG9	18	P51	SEG7	SEG10
19	P50	SEG8	SEG11	20	PC1	SEG9	SEG12
21	PC0	SEG10	SEG13	22	PB7	SEG11	SEG14
23	PB6	SEG12	SEG15	24	PB5	SEG13	SEG16
25	PB4	SEG14	SEG17	26	PB3	SEG15	SEG18
27	PB2	SEG16	SEG19	28	PB1	SEG17	SEG20
29	PA7	SEG18	SEG21	30	PA5	SEG19	SEG22
31	PA4	SEG20	SEG23	32	PA3	SEG21	SEG24
33	PA2	SEG22	SEG25	34	PA1	SEG23	SEG26
35	PA0	SEG24	SEG27	36	PF7	SEG25	SEG28
37	PF6	SEG26	SEG29	38	PE5	SEG27	SEG30
39	PE4	SEG28	SEG31	40	PE3	SEG29	SEG32
41	PE2	SEG30	SEG33	42	PE1	SEG31	SEG34
43	PE0	SEG32	SEG35	44	PF7	SEG33	SEG36
45	PE6	SEG34	SEG37	46	PD4	SEG35	SEG38
47	PD3	SEG36	SEG39	48	PD2	SEG37	SEG40
49	PD1	SEG38	SEG41	50	PD0	SEG39	SEG42

Note: The shaded portions of the table indicate pin connections with the display block that are not used in the sample program.

LCD panel wiring
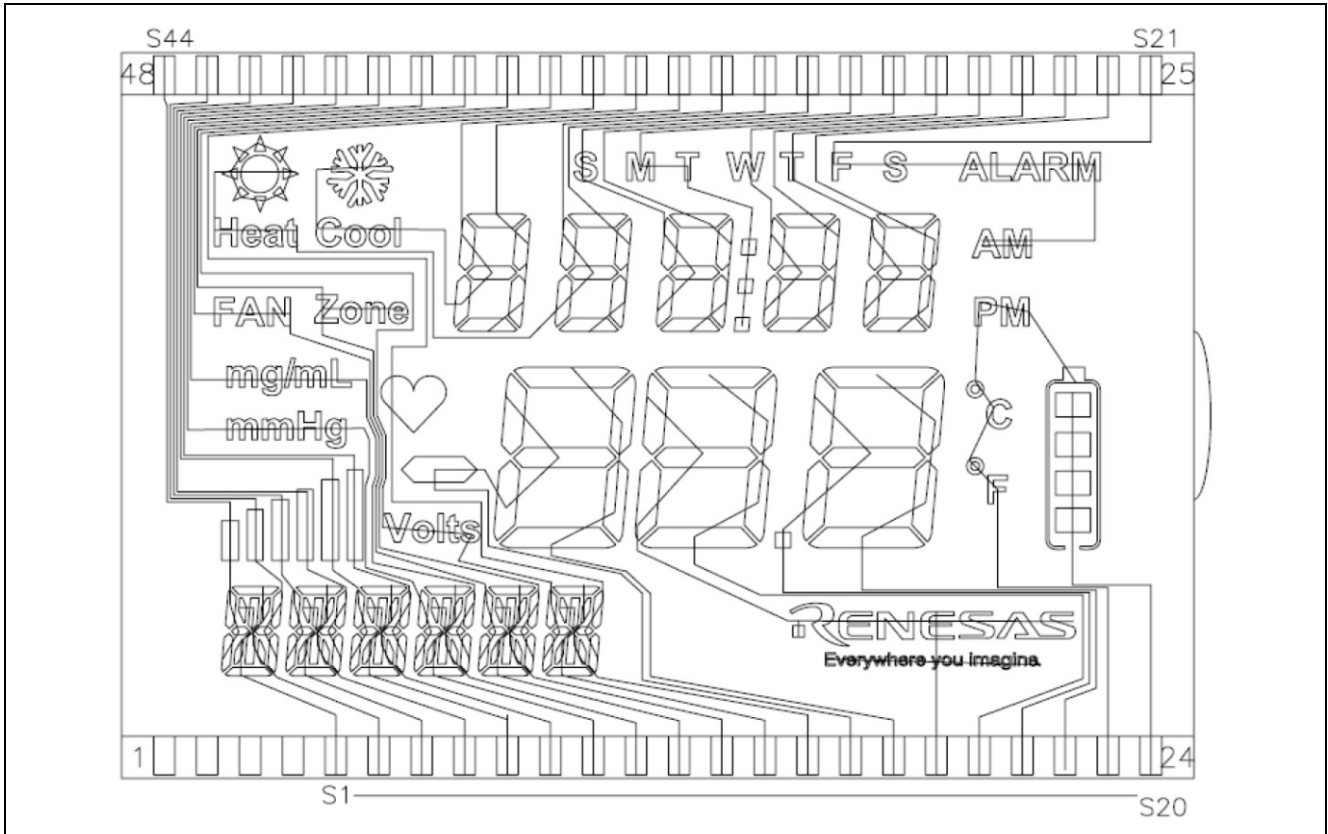
Figure 2.3   LCD Segment Wiring
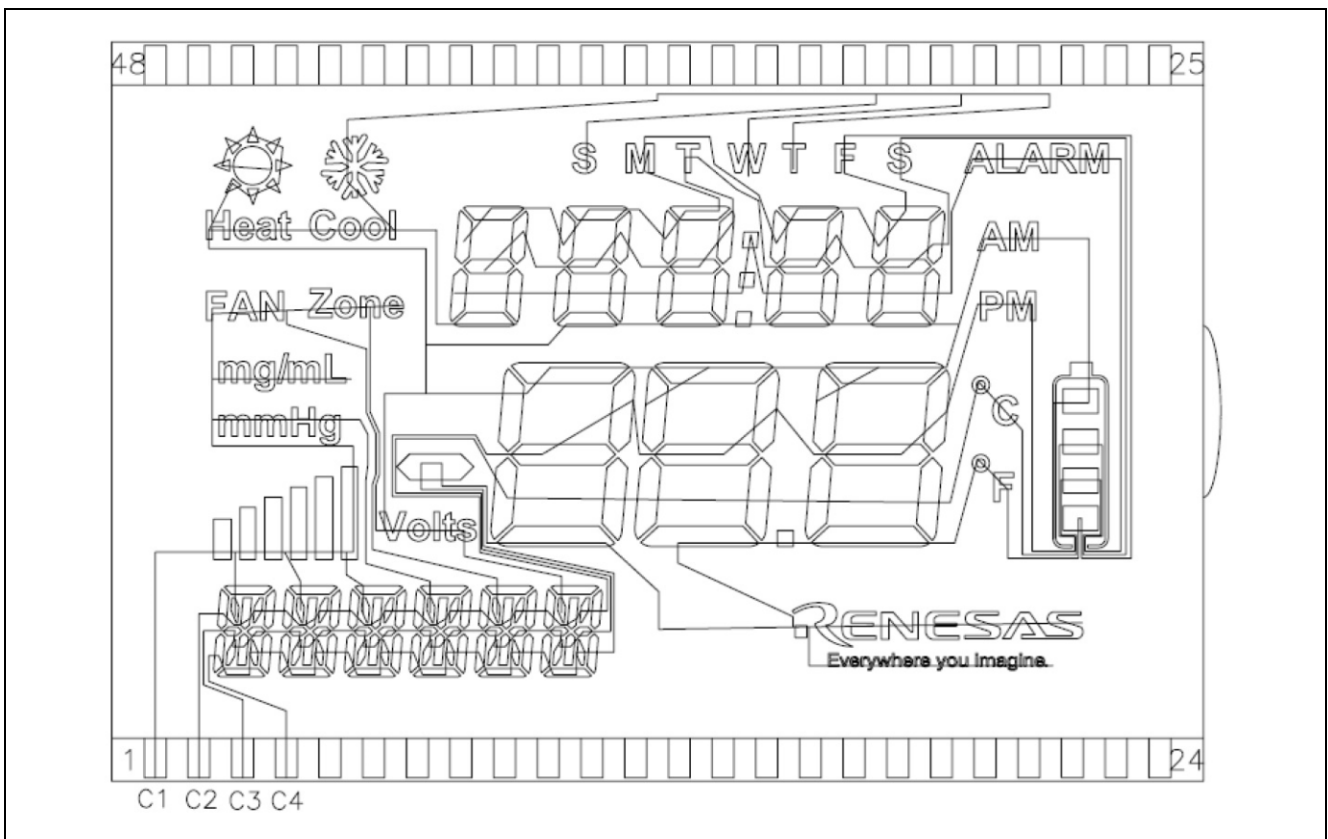
Figure 2.4   LCD COM Wiring

2.3   Clock Settings

Table 2.3 lists the settings for the clock signals used by the sample program.

Table 2.3   Clock Settings

Name	Operating Frequency	Clock Source	Divider
Main clock	Stopped	-	-
Sub-clock	Stopped	-	-
High-speed on-chip oscillator (HOCO)	32 MHz	Internal	-
Low-speed on-chip oscillator (LOCO)	Stopped	-	-
IWDT on-chip oscillator	15 kHz	Internal	-
PLL circuit	Stopped	-	-
USB clock	Stopped	-	-
System clock (ICLK)	32 MHz	HOCO	1/1
Peripheral clock B (PCLKB)	32 MHz	HOCO	1/1
Peripheral clock D (PCLKD)	32 MHz	HOCO	1/1
Flash IF clock (FCLK)	32 MHz	HOCO	1/1
LCD clock	15 kHz	IWDT	-

2.4   Hardware Modifications

To confirm low power consumption of low-power-consumption modes described in this application note, a hardware modification of RSK board is implemented to measure current consumption.

RX113 RSK board is designed with jumper J11 for measuring the current consumption of MCU, however jumper J11 is not installed on the board in its factory shipment state. Instead, resistor R221 is used to make the setting "Shorted Pin1-2." Therefore, the following modifications are necessary:

1. Remove resistor R221.
2. Solder a pin header (2-pin) to the board at the jumper J11 location.

Refer to Figure 2.5 and Figure 2.6 as reference information necessary for making the modifications.

6.3   Power Supply Configuration

Table 6-3 and **Table 6-4** below details the function of the option links associated with power supply configuration.

Reference	Jumper Position	Explanation	Related Ref.
J6	Shorted Pin1-2	Connects EXT_BATT to 5V Power rail.	-
	Shorted Pin2-3	Connects VBUS to 5V Power rail.	-
	All open	Disconnects EXT_BATT and VBUS from 5V Power rail.	-
J9 *1	Shorted Pin1-2	Enables 1.8V regulator output.	-
	All open	Enables 3.3V regulator output.	-
J11 *2	Shorted Pin1-2	Connects Board_3V3 to UC_VCC.	R221
	All open	Enables current probe for MCU current consumption.	R221

Table 6-3: Power Supply Option Links (1)

*1: By default, jumper J9 is not fitted to the RSK.
*2: By default, jumper J11 is not fitted to the RSK. R221 is fitted by default and becomes the same setting as 'J11 Shorted Pin1-2'.

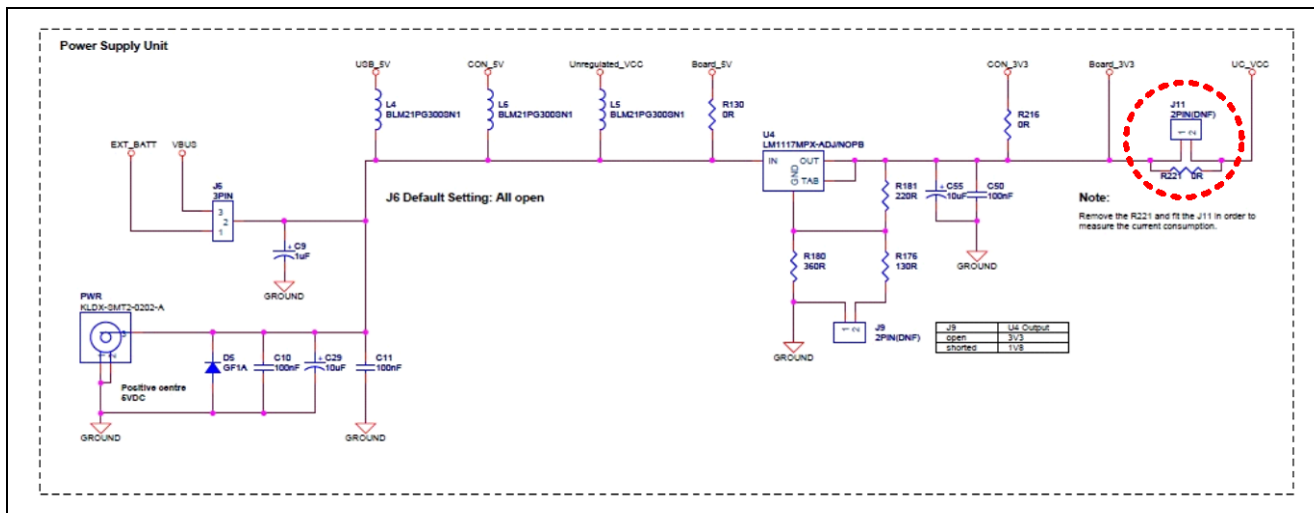**Figure 2.5   Excerpt from RSK RX113 User's Manual**

Figure 2.6   Excerpt from RSK RX113 Board Schematics

3. Software

The composition and functions of the sample software program described in this application note are described below.

3.1 FIT Modules

The folders of FIT modules used by the sample program are listed below.

Table 3.1 FIT Module Folders

Folder	Module	Description
r_bsp	Board support package module	Perform initial MCU setting, board setting and so on
r_elc_rx	Event link controller module	Create links between peripheral modules.
r_lcdc_rx	LCD controller/driver module	Display data on LCD panel.
r_lpc_rx	Low-power-consumption (LPC) module	Configure MCU low power consumption mode and operating power control
r_lpt_rx	Low-power timer (LPT) module	Generate a signal to exit software standby mode
r_config	FIT header files	Header files of FIT modules used

Note: For the composition and functions of FIT modules, refer to application note of each module.

3.2 File Composition

The file composition of the sample program is shown below.

Note that files generated automatically by the Integrated Development Environment (IDE) and FIT modules are not listed here.

Table 3.2 User Files

Folder	File Name	Description	Remarks
demo	main.c	Main processing source file	Created by user

Note: The cg_src folder within the demo folder contains the automatically generated files of IDE.

3.3 Constants

Table 3.3 lists the segment pattern setting values used to display numeric values on 7-segment LCD panel.

Table 3.3 LCD Segment Patterns

Constant Name	Setting Value	Description
seg_l[11]	{5,0,6,2,3,3,7,0,7,3,0}	Left-side segment pattern of 3-digit display block.
seg_r[11]	{0xf,6,0xb,0xf,6,0xd,0xd,7,0xf,0xf,0}	Right-side segment pattern of 3-digit display block
seg2_l[11]	{0xa,0,6,4,0xc,0xc,0xe,0,0xe,0xc,0}	Left-side segment pattern of 5-digit display block
seg2_r[11]	{0xf,6,0xd,0xf,6,0xb,0xb,0xe,0xf,0xf,0}	Right-side segment pattern of 5-digit display block

Table 3.4 shows the typical current during normal operation used to calculate the average current consumption.

Table 3.4 Typical Current During Operation

Constant Name	Setting Value	Description
op_current	8500	Current consumption [µA] when using LCD display on RSK RX113 board

Note: This is a typical value set based on actual measured values that is used to verify the operation of the program. It is not intended to be a guaranteed value.

3.4 Variables

Table 3.5 lists the global variables used by the sample program described in this application note.

Table 3.5 Global Variables

Type	Valiable Name	Description
unsigned int32	cycle_time	Intermittent operation cycle [seconds]. Initial value: 5 seconds
unsigned int32	pon_ratio	Normal operation ratio per cycle [%]. Initial value: 10%
unsigned int32	op_time	Normal operation duration [ms]. Calculated from cycle_time and pon_ratio.
unsigned int32	i_average	Average current consumption [mA]. Calculated from op_current and pon_ratio.
unsigned int32	op_count	Counter value for display during normal operation

3.5 Functions

Table 3.6 lists the functions used in the user file (main.c).

Table 3.6 User Functions

Function Name	Description
main()	System main function
initialize()	Intermittent operation initial settings, FIT module initial settings
user_main()	Processing executed during intermitted operation.
set_parameters()	Processing executed during setting mode
lcd_disp3_2()	Displays a 2-digit numeric value on the LCD 3-digit display block.
lcd_disp5_3()	Displays a 3-digit numeric value on the LCD 5-digit display block.
set_op_ratio()	Change normal operation ratio.

The API functions of each FIT modules used in the sample program are listed below.

Table 3.7 LPC Module Functions

Function Name	Description	Contained in File
R_LPC_LowPowerModeConfigure()	Makes settings for the low-power state when the WAIT instruction is executed.	r_lpc_rx
R_LPC_LowPowerModeActivate()	Transitions to the low-power state.	r_lpc_rx

Table 3.8 BSP Module Functions

Function Name	Description	Contained in File
R_BSP_RegisterProtectDisable()	Disables write protection for the selected register.	cpu.c
R_BSP_RegisterProtectEnable()	Enables write protection for the selected register.	cpu.c
R_BSP_InterruptsDisable()	Disables interrupts generally.	cpu.c
R_BSP_SoftwareDelay()	Inserts a delay of the specified duration.	r_bsp_common.c

Table 3.9 ELC Module Function

Function Name	Description	Contained in File
R_ELC_Set()	Specifies the event link source and event link destination.	r_elc_rx.c

Table 3.10 LPT Module Functions

Function Name	Description	Contained in File
R_LPT_Open()	Initializes the LPT module.	r_lpt_rx.c
R_LPT_Control()	LPT count start/stop/reset	r_lpt_rx.c

Table 3.11 LCDC Module Functions

Function Name	Description	Contained in File
R_LCDC_Open()	Makes LCDC initial settings.	r_lcdc_rx.c
R_LCDC_Write()	Makes display data settings.	r_lcdc_rx.c
R_LCDC_DispOn()	Turns on the LCD display.	r_lcdc_rx.c

3.6   Function Specifications

The user setting functions are described below.

For information on FIT module functions, refer to application note of each FIT module.

3.6.1   main Function

Table 3.12   main Function

Item	Description
Function	main()
Outline	System main function
Declaration	void main(void)
Description	Performs overall system control.
Functions called	R_LCD_Create() R_LCDC_Open() R_LCDC_DispOn() lcd_disp3_2() lcd_disp5_3() set_op_ratio() initialize() R_LPT_Control() R_LPC_LowPowerModeActivate() user_main()
Arguments	-
Return values	-

3.6.2   initialize Function

Table 3.13   initialize Function

Item	Description
Function	initialize()
Outline	Initialization function
Declaration	void initialize(uint32_t)
Description	Makes initial settings for each function module.
Functions called	R_LPC_LowPowerModeConfigure() R_BSP_RegisterProtectDisable() R_BSP_RegisterProtectEnable() R_BSP_InterruptsDisable() R_ELC_Set() elc_start_all_eventlink() R_LPT_Open()
Arguments	uint32_t period: LPT cycle [µs]
Return values	-

3.6.3 user_main Function

Table 3.14 user_main Function

Item	Description
Function	user_main()
Outline	Processing executed during intermittent operation
Declaration	void user_main(uint32_t)
Description	Implements the processing during intermittent operation ● Counter display ● Switch to setting mode according to SW3 operation
Functions called	set_parameters() R_BSP_SoftwareDelay()
Arguments	op_time: Normal operation duration [ms]
Return values	-

3.6.4 set_parameters Function

Table 3.15 set_parameters Function

Item	Description
Function	set_parameters()
Outline	Processing executed during setting mode
Declaration	void set_parameters (void)
Description	Changes normal operation duration ratio by switch operation.
Functions called	R_LPT_Control() lcd_disp3_2() lcd_disp5_3() set_op_ratio()
Arguments	-
Return values	-

3.6.5 lcd_disp3_2 Function

Table 3.16 lcd_disp3_2 Function

Item	Description
Function	lcd_disp3_2()
Outline	Displays a 2-digit numeric value on the LCD 3-digit display block.
Declaration	void lcd_disp3_2(uint32_t)
Description	Displays the numeric value specified by an argument on the LCD 3-digit display block in two digits.
Functions called	R_LCDC_Write()
Arguments	uint32_t num1: Numeric value to be displayed (2-digit decimal value)
Return values	-

3.6.6   lcd_disp5_3 Function

Table 3.17   lcd_disp5_3 Function

Item	Description
Function	lcd_disp5_3()
Outline	Displays a 3-digit numeric value on the LCD 5-digit display block.
Declaration	void lcd_disp5_3(uint32_t)
Description	Displays the numeric value specified by an argument on the LCD 5-digit display block in three digits.
Functions called	R_LCDC_Write()
Arguments	uint32_t num2: Numeric value to be displayed (3-digit decimal value)
Return values	-

3.6.7   set_op_ratio Function

Table 3.18   set_op_ratio Function

Item	Description
Function	set_op_ratio()
Outline	Specifies the normal operation duration ratio relative to the intermittent operation cycle
Declaration	int set_op_ratio(int)
Description	Changes the normal operation duration ratio for intermittent operation by switch operation. ● Display: Upper 2 digits of LCD 3-digit display block ● Setting range: 10 to 90 [%] in 10% increase. ● Switches used: SW1 (UP), SW3 (ENTER)
Functions called	R_LCDC_Write()
Arguments	int t_ratio: Current operation duration ratio [%]
Return values	int i_data: Changed operation duration ratio [%]

4. Flowcharts

Flowcharts of the functions used by the user file described in this application note are shown below.

4.1 main Function: main()

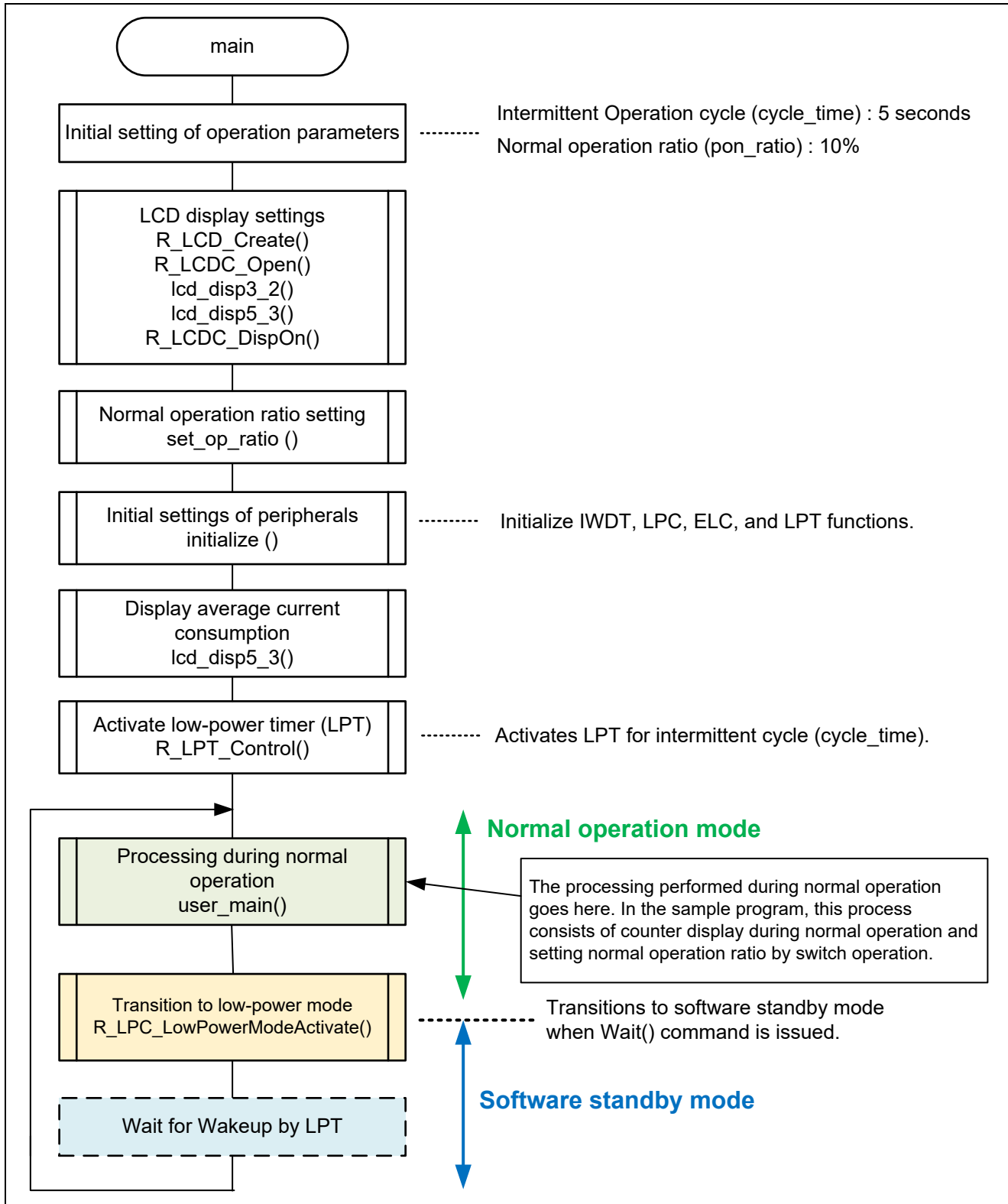Figure 4.1 is the flowchart of the main processing routine.

Figure 4.1   main Function

4.2   Initial Settings Function: initialize()

Figure 4.2 is the flowchart of peripheral initialization setting process of FIT modules used in the sample program.
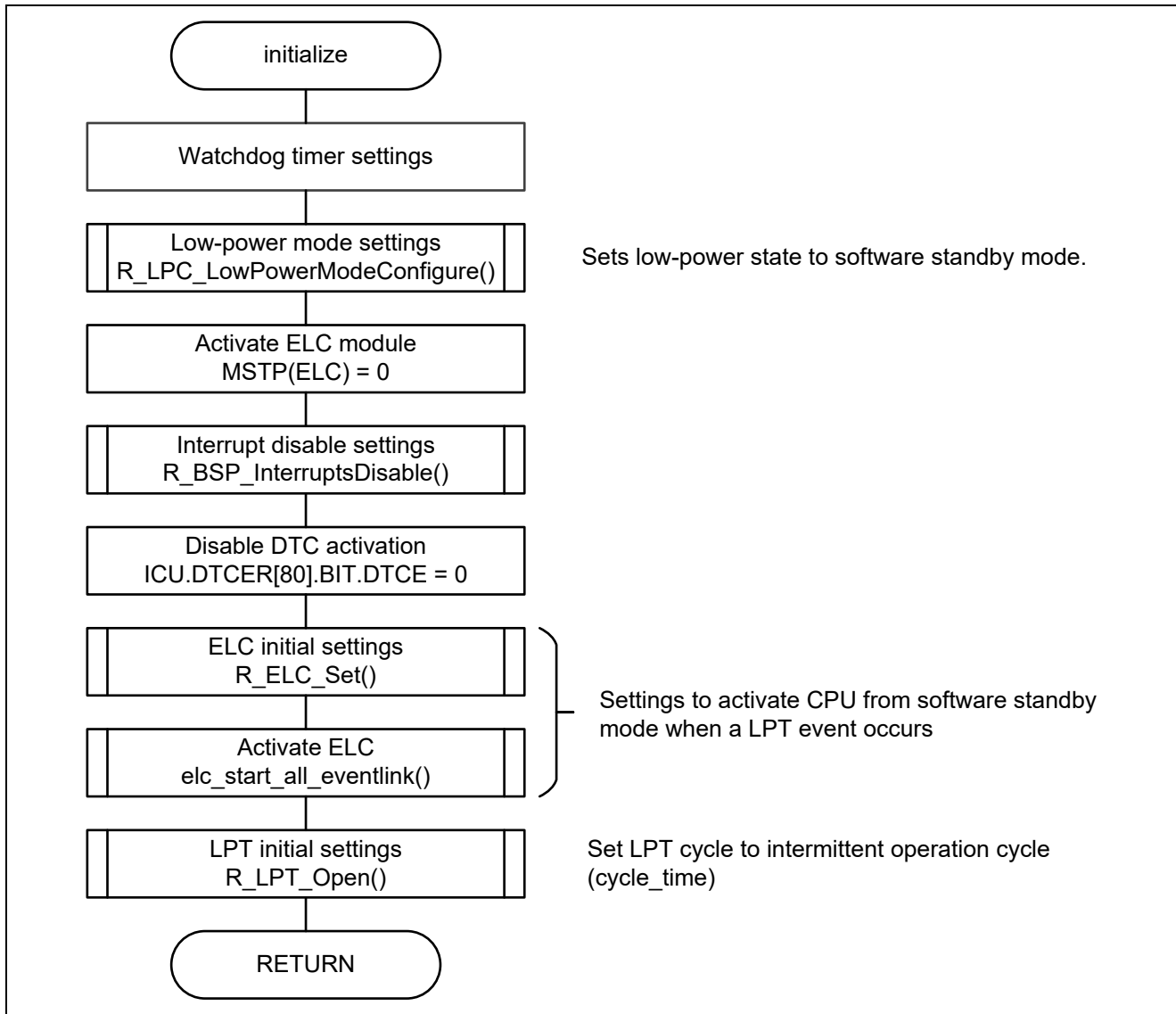

Figure 4.2   initialize Function

4.3 User Processing Function: user_main()

This function contains the processing that is implemented during normal operation.

Figure 4.3 is the flowchart of the processing to display the operation counter on LCD and to implement setting of normal operation ratio by means of switch operation.
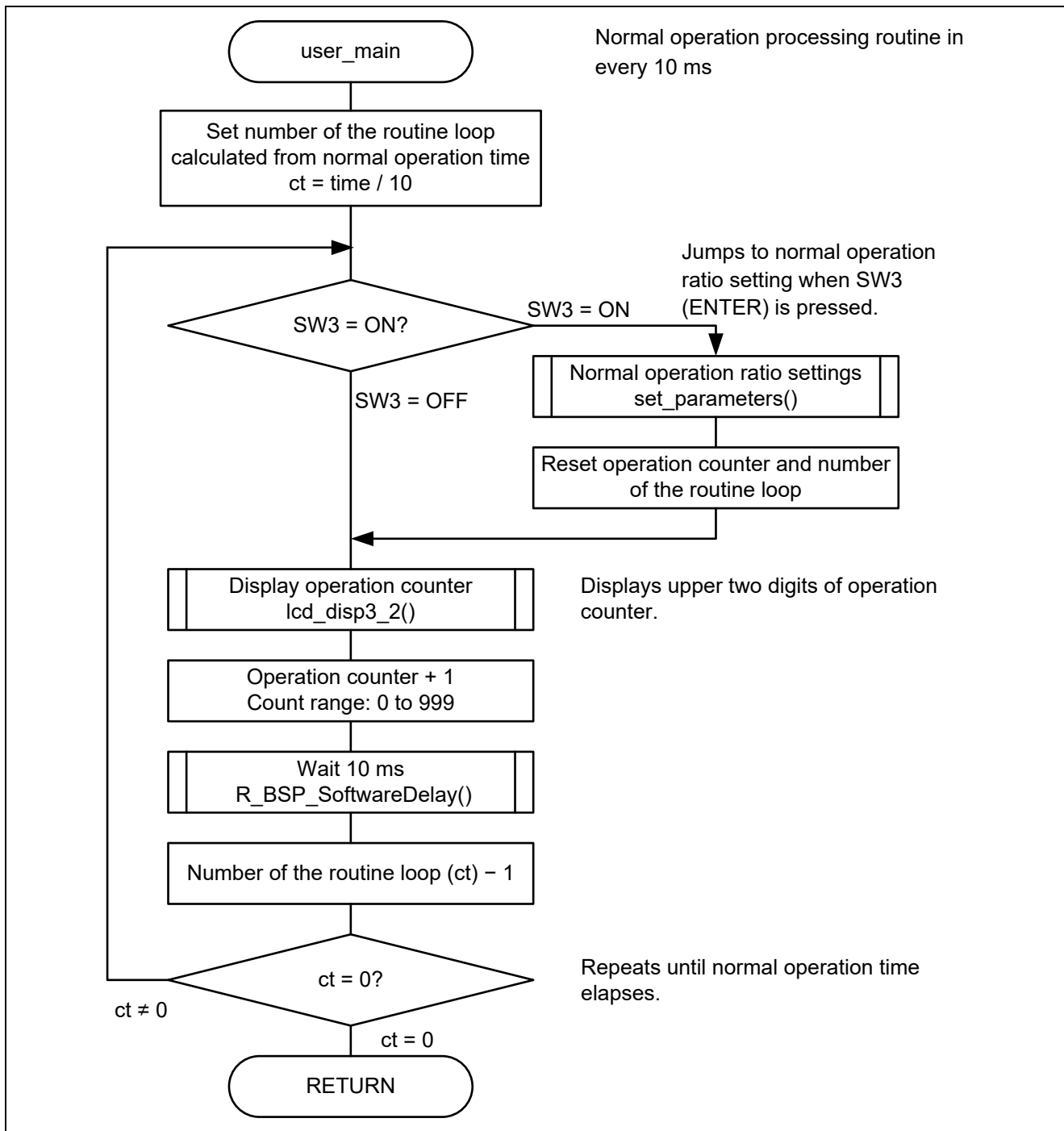

Figure 4.3   user_main Function

4.4   Intermittent Operation Setting Function: set_parameters()

Figure 4.4 is the flowchart of the processing for changing intermittent operation setting items.
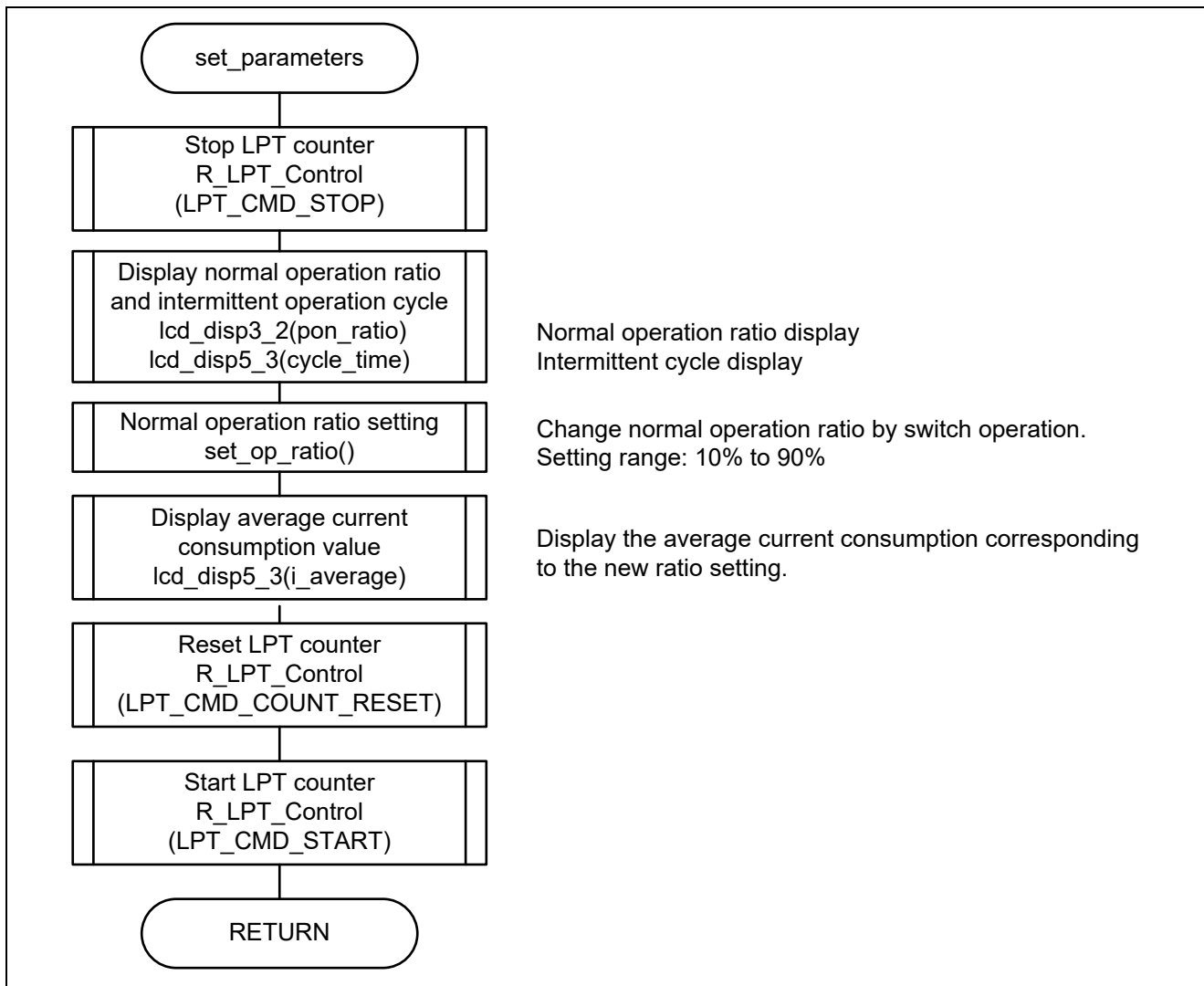

Figure 4.4   Intermittent Operation Setting Function

4.5   LCD 3-Digit Display Block Function: lcd_disp3_2()

Figure 4.5 is the flowchart of the processing to display a 2-digit numeric value on 3-digit display block of LCD.
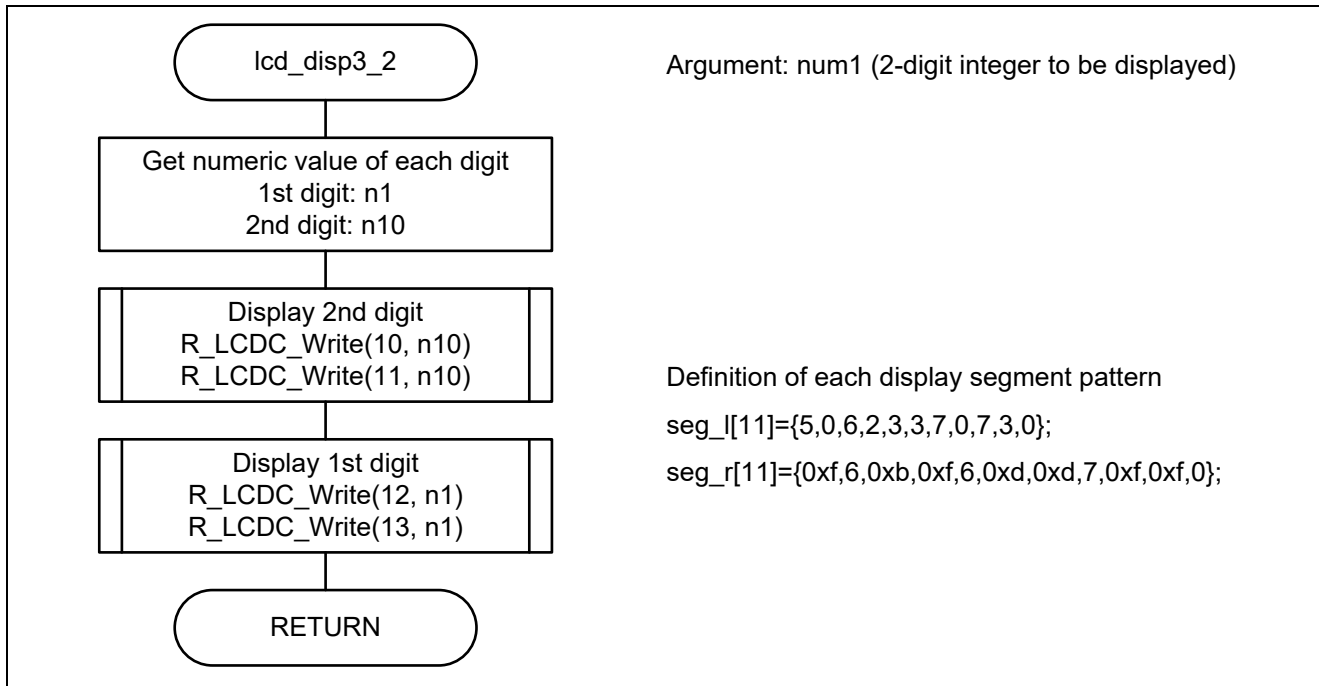

Figure 4.5   LCD 3-Digit Display Block Function

4.6   LCD 5-Digit Display Block Function: lcd_disp5_3()

Figure 4.6 is the flowchart of the processing to display a 3-digit numeric value on 5-digit display block of LCD.
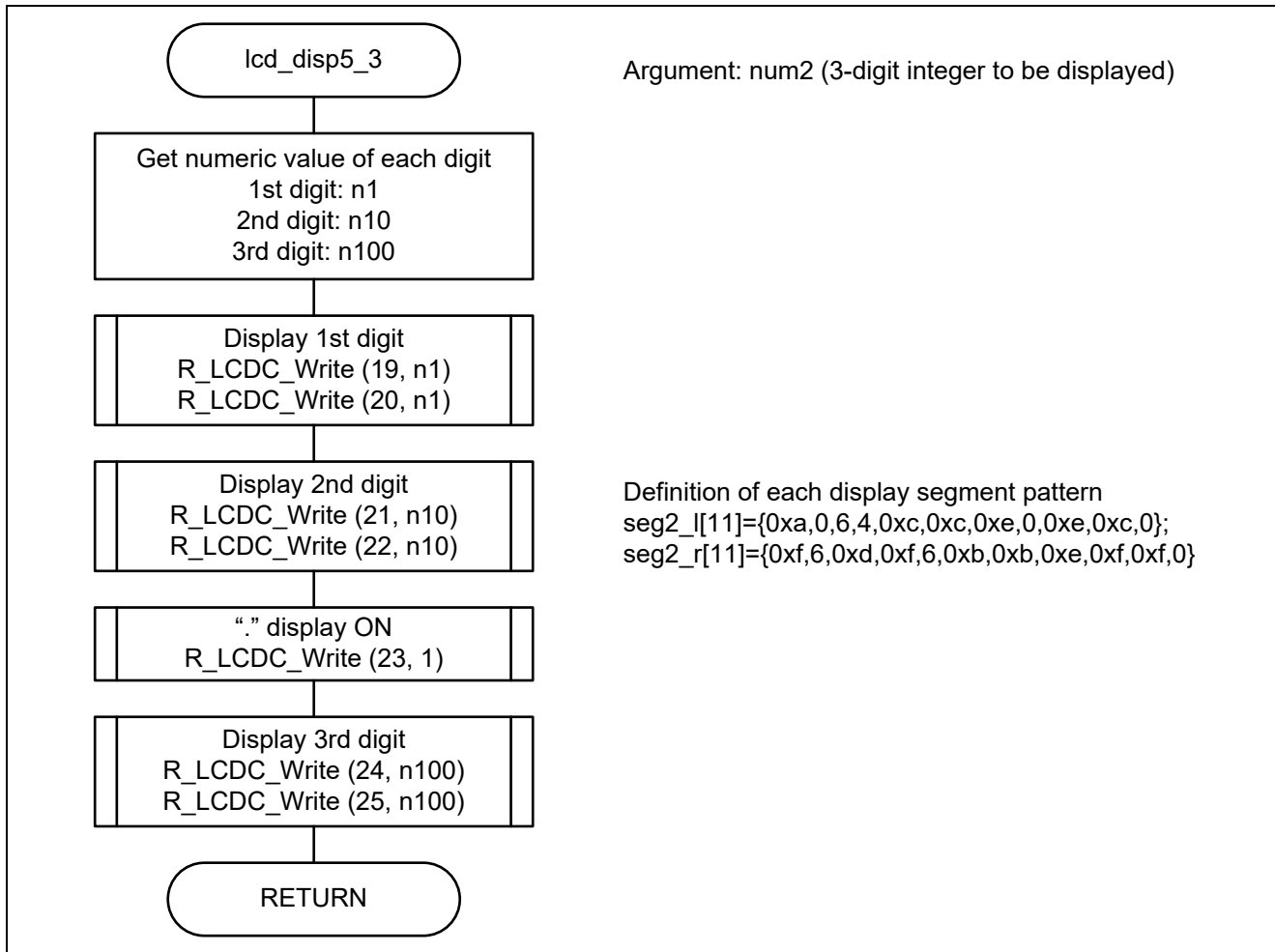
```
          ┌──────────────────────┐
          │     lcd_disp5_3      │        Argument: num2 (3-digit integer to be displayed)
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │ Get numeric value of each digit │
          │        1st digit: n1         │
          │        2nd digit: n10        │
          │       3rd digit: n100        │
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │     Display 1st digit        │
          │   R_LCDC_Write (19, n1)     │
          │   R_LCDC_Write (20, n1)     │
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │     Display 2nd digit        │     Definition of each display segment pattern
          │  R_LCDC_Write (21, n10)     │     seg2_l[11]={0xa,0,6,4,0xc,0xc,0xe,0,0xe,0xc,0};
          │  R_LCDC_Write (22, n10)     │     seg2_r[11]={0xf,6,0xd,0xf,6,0xb,0xb,0xe,0xf,0xf,0}
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │      "." display ON          │
          │   R_LCDC_Write (23, 1)      │
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │     Display 3rd digit        │
          │  R_LCDC_Write (24, n100)    │
          │  R_LCDC_Write (25, n100)    │
          └──────────┬───────────┘
          ┌──────────┴───────────┐
          │        RETURN               │
          └──────────────────────┘
```

Figure 4.6   LCD 5-Digit Display Block Function

4.7   Normal Operation Ratio Setting Function: set_op_ratio()

Figure 4.7 is the flowchart of the processing to change the normal operation ratio of intermittent operation by switch operation.
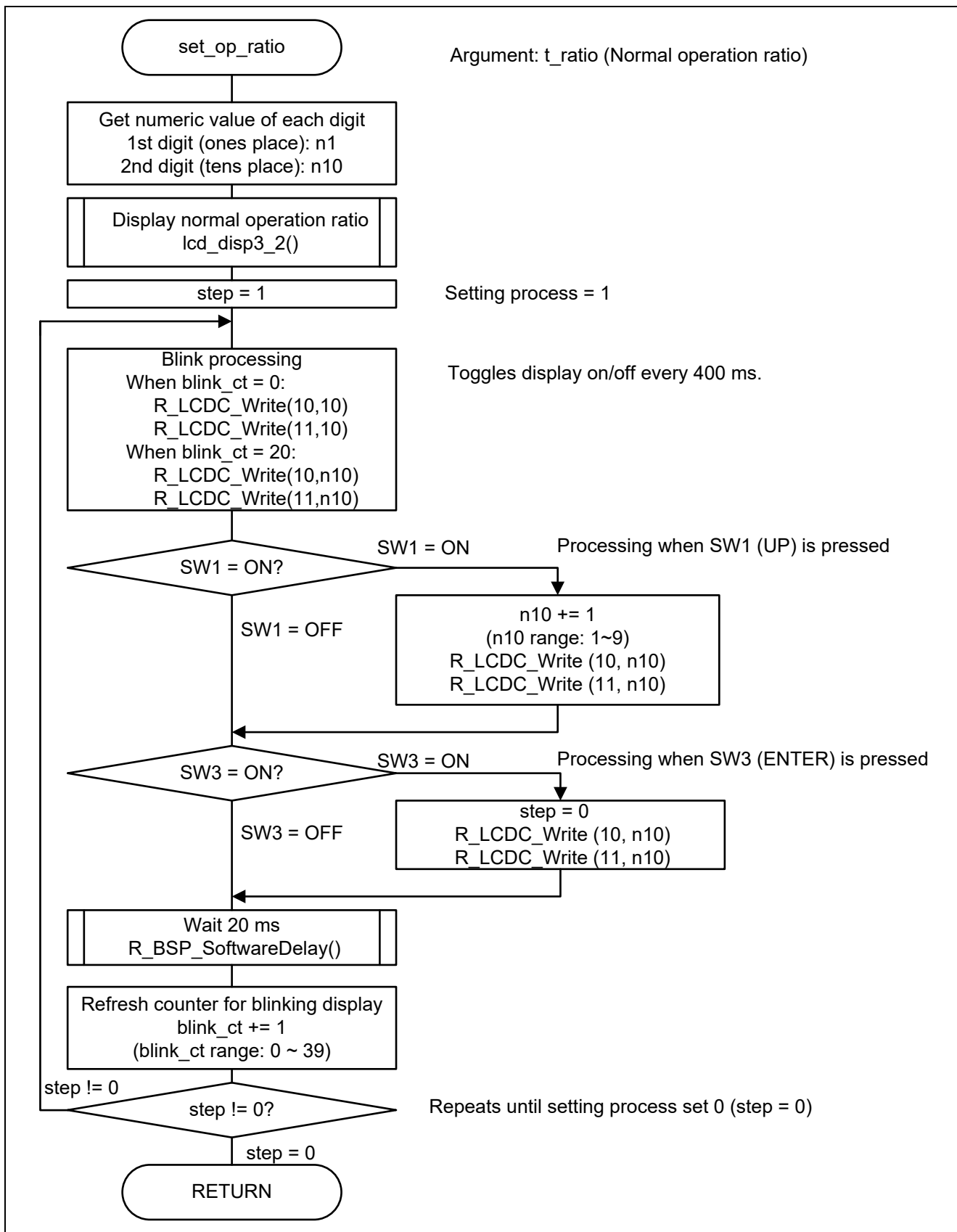

Figure 4.7   Operation Duration Ratio Setting Function

5. Intermittent Operation

The intermittent operation described in this application note is implemented on RSK RX113 evaluation board.

The steps for implementing intermittent operation on the RSK RX113 evaluation board are described below.
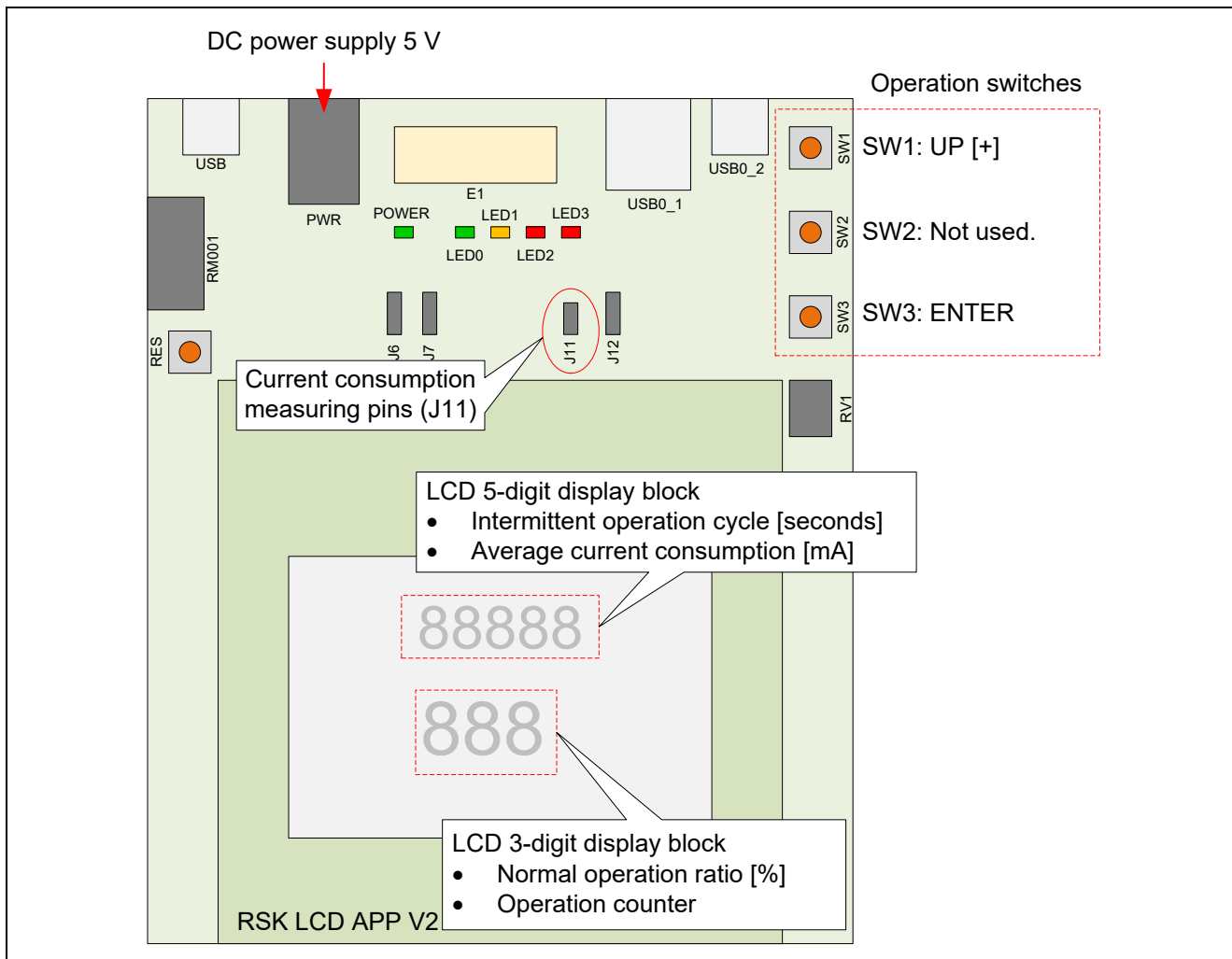
5.1 RSK RX113 Board Layout

Figure 5.1   RSK RX113 Evaluation Board

5.2   LCD Display and Setting Range

The setting parameters of the sample program described in this application note are displayed on the LCD. The setting ranges of each item are listed below.

Setting parameters:

- Normal operation ratio: 10 to 90 [%]. Changeable by switch operation.
- Intermittent operation cycle: 5 [seconds]. To change this parameter, it must to change cycle_time variable in the program shown in in Figure 5.2

```
Located in \demo\main.c function main()

op_current = 8500;      // operation current 8.50mA [uA]
cycle_time = 5;         // initial = 5S
pon_ratio = 10;         // initial = 10%
op_count = 1;
```

Figure 5.2   cycle_time Variable

Display items

- Intermittent operation cycle: 3-digit display. Value fixed at 5.00 [seconds].
- Average current consumption: 3-digit display. 0.00 to 9.99 [mA]
- Normal operation ratio: 2-digit display. 10 to 90 [%]
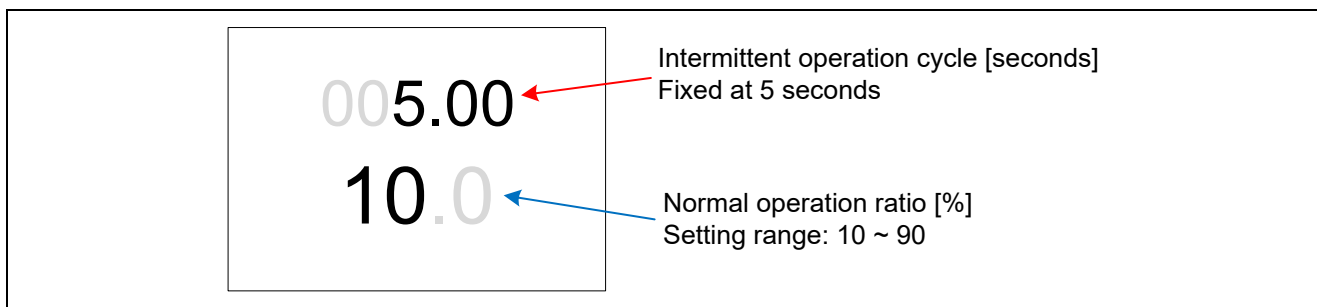- Operation counter: 2-digit display. 00 to 99, incremented every 0.1 seconds.

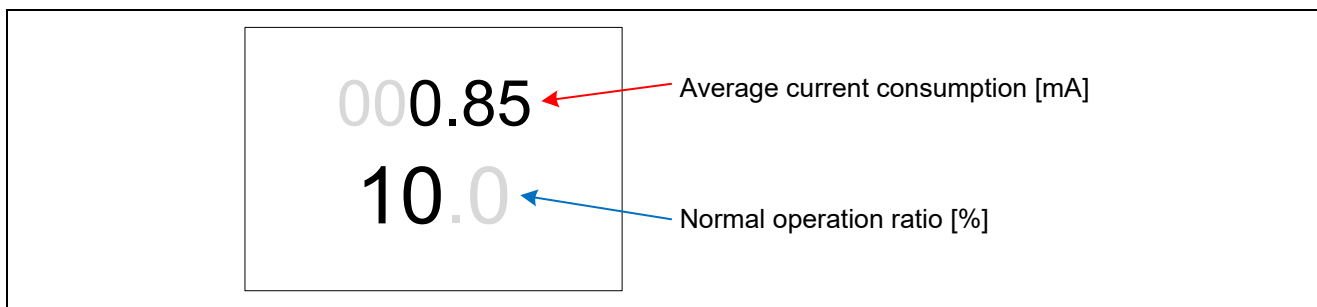**Figure 5.3   Display when Setting Parameters**

Figure 5.4   Average Current Consumption Display

5.3   Operation Procedure

5.3.1   Setting Normal Operation Ratio

After startup, the initial setting values of the intermittent cycle duration (5 [seconds]) and the normal operation ratio (10%) are displayed on the LCD panel, and the tens place of the normal operation ratio to be set blinks on and off. The intermittent cycle duration is fixed at 5 seconds.
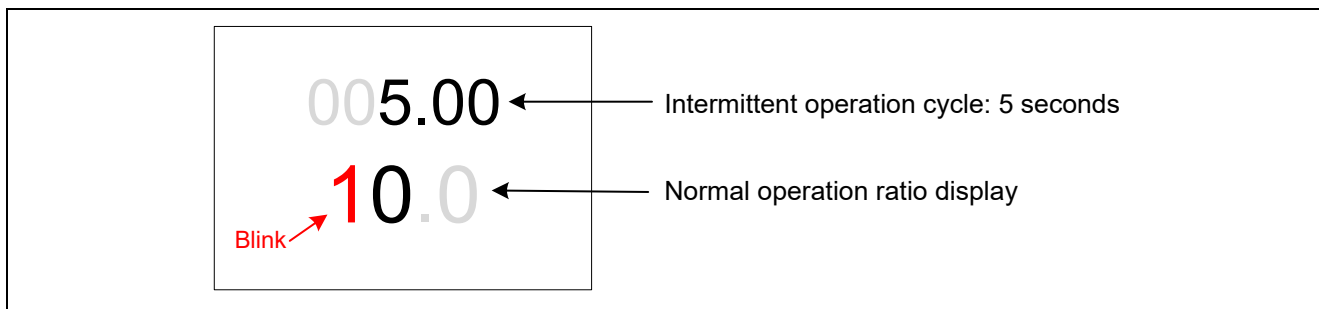

Figure 5.5   Normal Operation Ratio Setting Display

1. The blinking numeric value is changed using SW1 (numeric value UP).
    (Normal operation ratio setting range: 10 to 90 [%] in 10% increments.)
2. Press SW3 (ENTER) to set the display to stop blinking. The normal operation ratio setting is finalized, and the display switches to the average current consumption display

5.3.2   Average Current Consumption Display

The average current consumption of RSK RX113 evaluation board, calculated from the normal operation ratio, is displayed in three digits in the upper portion of the panel (unit: mA).

This value is calculated based on the current consumption of the RSK RX113 evaluation board during normal operation (8.5 mA, reference value).
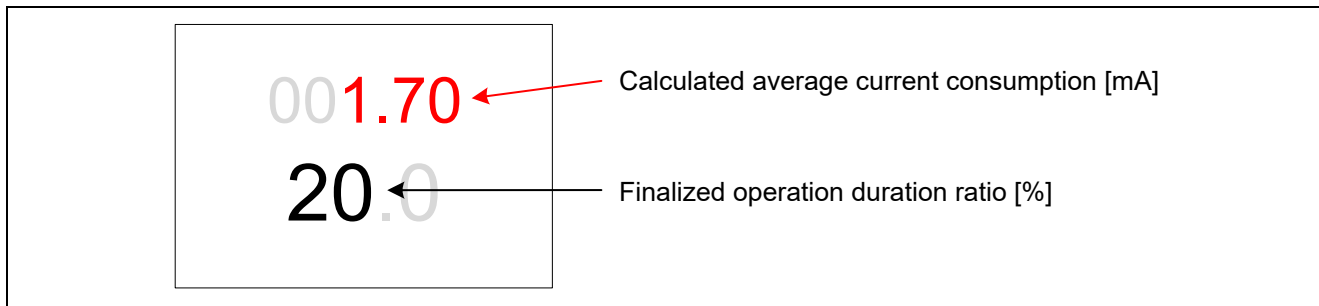

Figure 5.6   Average Current Consumption Display

5.3.3   Executing Intermittent Operation

1. When the average current consumption is displayed, press SW3 (ENTER) to start intermittent operation.
2. When intermittent operation starts, the lower portion of the display panel displays the operation counter value. The counter is incremented by 100 ms (display value: 00 to 99).
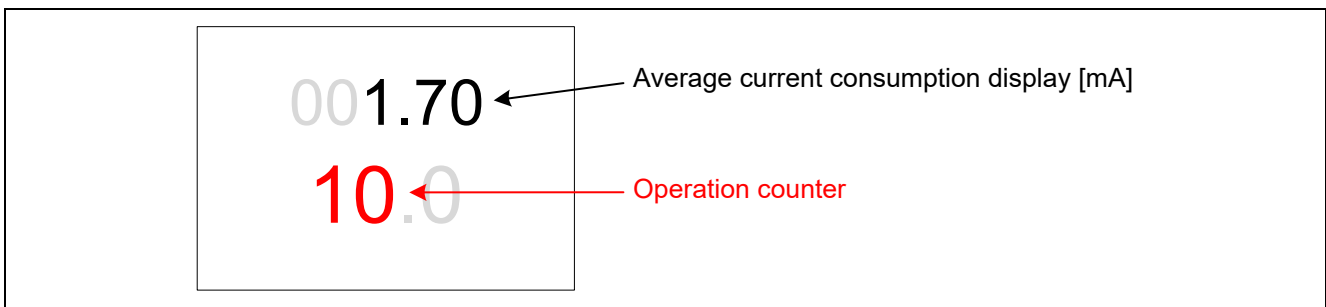

001.70 ← Average current consumption display [mA]

10.0 ← Operation counter

Figure 5.7   Intermittent Operation Display

3. After the normal operation duration set by the operation duration ratio has elapsed, the state transitions to software standby mode and the operation counter stops counting. During this period, LCD display is maintained.
4. During intermittent operation, LCD state switches repeatedly between the normal operating mode and software standby mode.
   Normal operating mode: Operation counter is incremented.
   Software standby mode: Operation counter is stopped.

5.3.4   Stopping Intermittent Operation and Resetting the Normal Operation Ratio

1. In the normal operating mode (counter operating), press SW3 (ENTER). Alternatively, if SW3 (ENTER) is being pressed when the mode switches from standby mode to normal operation mode, intermittent operation stops, and the program changes to normal operation ratio setting mode as occurs at startup.
2. The LCD panel switches to the normal operation ratio setting display.

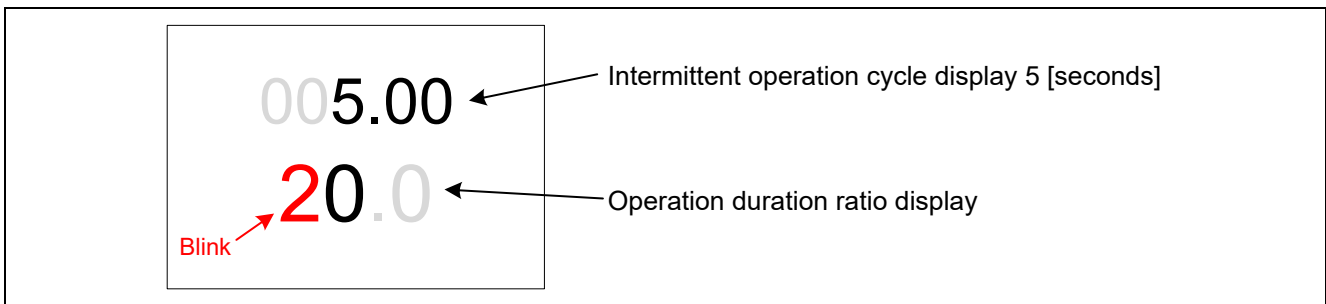005.00 ← Intermittent operation cycle display 5 [seconds]

20.0 ← Operation duration ratio display

Blink

Figure 5.8   Operation Duration Ratio Reset Display

3. You can re-setup the normal operation ratio by the same way as described previously.

6. Current Consumption Measurement

The procedure for measuring the current consumption using the RSK RX113 evaluation board is described below.

The RSK RX113 evaluation board is provided with current consumption measurement pins (J11). In the initial state the current measurement pins (J11) are shorted on the board by a resistor (R221 (0 Ω)). It is, therefore, necessary to perform the procedure described in 2.4, Hardware Modifications.

6.1 Measuring the Current Consumption

As shown in Figure 6.1, Ammeter Connection, connect an ammeter to the current measurement pins (J11) on the RSK RX113 evaluation board.
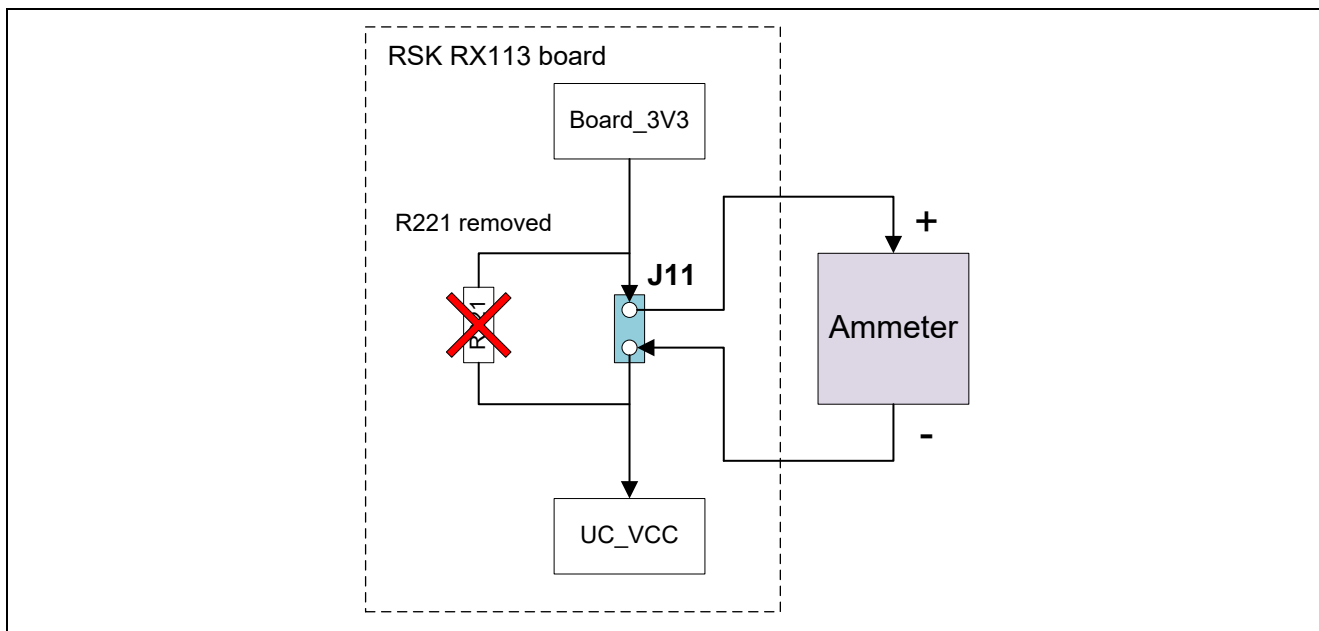

Figure 6.1   Ammeter Connection

Table 6.1, Operation Clocks and Current Consumption, lists the operation clocks of the sample program described in this application note and the associated current consumption on the RSK RX113 evaluation board.

Table 6.1   Operation Clocks and Current Consumption

System Clock	LPT Clock	LCD Clock	Normal Operation	Standby
HOCO 32 MHz	IWDT (15 kHz)	IWDT (15 kHz)	8.5 mA	11.1 µA
PLL (Main) 32 MHz	IWDT (15 kHz)	IWDT (15 kHz)	8.8 mA	11.1 µA

Note: ICLK = PCLKB = PCLKD = FCLK = 32 MHz

The current consumption measurement results above are reference values used to verify the operation of the program. They are not intended to be a guaranteed value.

6.2   Measuring Current Waveforms

To confirm intermittent operation by current waveforms during operation, the current measurement pins (J11) are also employed for current consumption measurement using oscilloscope.

As shown in Figure 6.2, Oscilloscope Connection, connect a 47 Ω current detection resistor to the current measurement pins (J11) and then connect an oscilloscope to both ends.
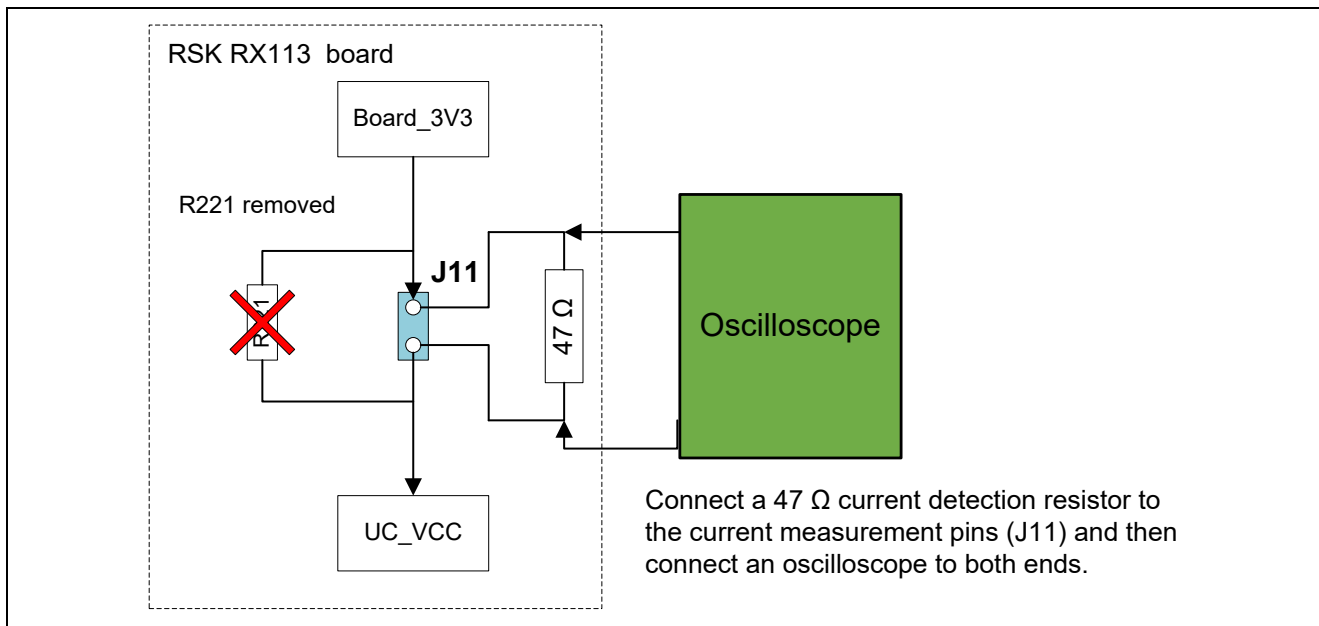

Figure 6.2   Oscilloscope Connection

Current waveform during intermittent operation

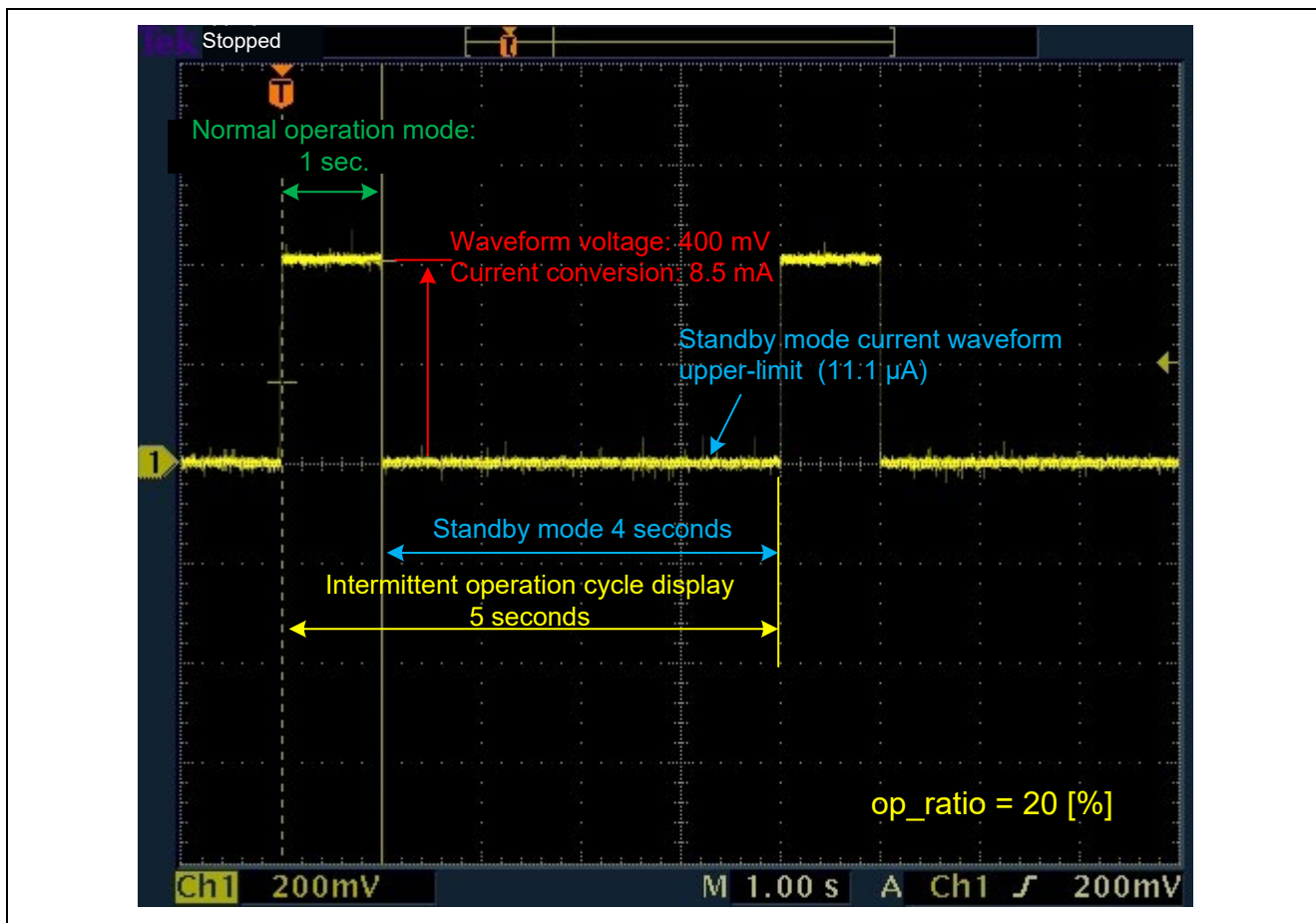Intermittent operation cycle = 5 seconds, normal operation ratio = 20%

Figure 6.3   Current Waveform During Intermittent Operation

Normal operation duration = 1 second

Standby duration = 4 seconds

Current in normal operation mode: I = E / R = 400 mV/47 Ω= 8.5 mA

7. Clock Selection [Reference]

Table 7.1 Clocks

System Clock (CKSEL)	LPT Clock	LCD Clock
LOCO (4 MHz)	IWDT (15 kHz)	LOCO (4 MHz)
HOCO (32 MHz)	Sub-clock (32.768 kHz)	HOCO (32 MHz)
Main (external oscillator)		Main (external oscillator)
Sub-clock (32.768 kHz)		Sub-clock (32.768 kHz)
PLL (Main)		IWDT (15 kHz)

Note: This table shows a list of selectable clocks. It does not list settings for intermittent operation. The combination of clock settings used should be decided based on a consideration of the functions used and system operation.

You can change clock settings by overwriting the applicable setting values in the \r_config\r_bsp_config.h file in the FIT library.

```
  /* System clock source select (CKSEL).
     0 = Low Speed On-Chip Oscillator (LOCO)
     1 = High Speed On-Chip Oscillator (HOCO)
     2 = Main Clock Oscillator
     3 = Sub-Clock Oscillator
     4 = PLL Circuit
  */
  #define BSP_CFG_CLOCK_SOURCE                                     (1)


  /* LPT (Low-Power Timer) Clock source select (LPTCR1.LPCNTCKSEL)
     0 = Sub-clock
     1 = IWDT
  */
  #define BSP_CFG_LPT_CLOCK_SOURCE                                 (1)


  /* USB Clock source select (UCKUPLLSEL).
     0 = System Clock (ICLK)
     1 = USB PLL Circuit
  */
  #define BSP_CFG_USB_CLOCK_SOURCE                                 (0)


  /* LCD Clock source select (LCDSCLKSEL).
     0 = Low Speed On-Chip Oscillator (LOCO)
     1 = High Speed On-Chip Oscillator (HOCO)
     2 = Main Clock Oscillator
     3 = Sub-Clock Oscillator
     4 = IWDT-dedicated Oscillator    (IWDTCLK)
        NOTE: Application must allow 50us for the IWDTCLK to stabilize before
  using LCD
  */
  #define BSP_CFG_LCD_CLOCK_SOURCE                                 (4)
```

Figure 7.1 Clock Settings

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Sep.26, 2018	—	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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

    "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

    "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

    Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.