RL78/G11

Portable Environment (Temperature, Humidity, Luminance) Monitor

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Introduction

This user's manual describes a Renesas microcontroller RL78/G11 application for a portable environment (temperature, humidity, luminance) monitor.

Target Device

RL78/G11

Contents

1. Outline of Function

1.1 Introduction of the Portable Environment Monitor

In people's lives, with the growing interest in the living environment, and with the changes of temperature, humidity and luminance in the air, which have a direct impact on human body comfort and emotions, temperature, humidity and luminance detection is very necessary. The Portable Environment Monitor can detect these properties in the air in real time. According to the range of most comfortable environmental values, the user can set a high limit and low limit alarm by key.

The demo board is composed of the main control board (power supply circuit, AD collection circuit, etc.) and LCM board (LCM12864).

The portable environment (temperature, humidity, luminance) monitor is shown in Figure 1.1.

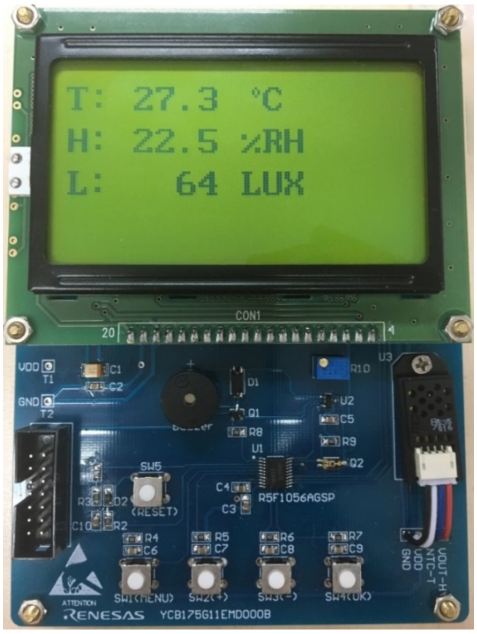

Figure 1.1 The Portable Environment (Temperature, Humidity, Luminance) Monitor

1.2 Brief Introduction of the Portable Environment Monitor Demo Board

The Portable Environment Monitor uses 3 AAA batteries as power supply. The detected temperature, humidity and luminance are displayed on the LCM, and the user can set alarm high limit and alarm low limit by key. When one of the three detected values is above its high limit or below its low limit, the buzzer will alarm, and at the same time, LCM will display corresponding up arrow icon or down arrow icon. The high limit value and low limit value are stored in the RL78/G11 internal data flash. The block diagram of demo board is shown in Figure 1.2.

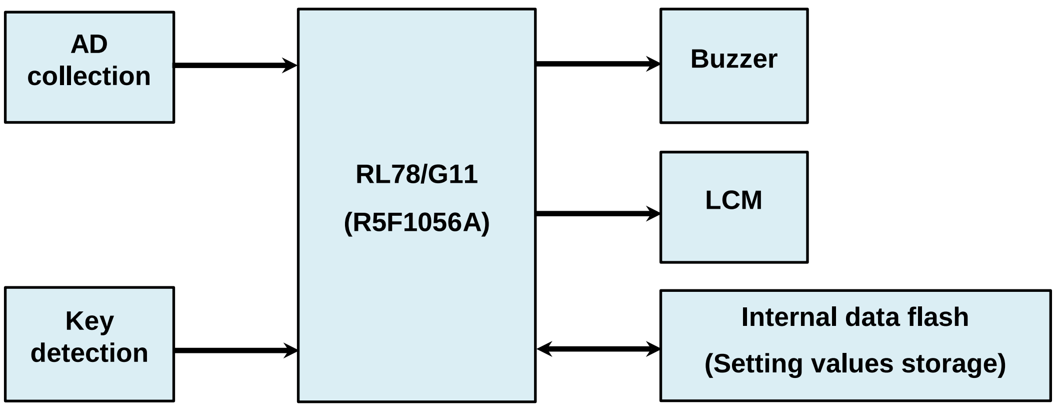

Figure 1.2 Block Diagram of the Portable Environment Monitor Demo Board

1.3 Introduction of Operation

1.3.1 Enter Menu Display State

In the normal display state, press the “MENU” key for entering menu display state. On the first screen, the LCM displays high temperature limit.

The process of entering menu display state is shown in Figure 1.3.

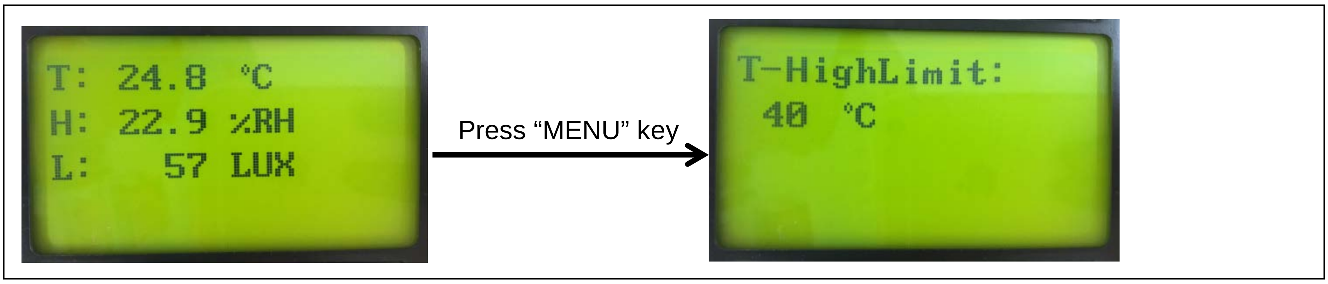

Figure 1.3 Process of Entering Menu Display State

1.3.2 Change Display Menu

In the menu display state, each time you press the “MENU” key, the menu interface cycles to display the low temperature limit, the high humidity limit, the low humidity limit, the high luminance limit, the low luminance limit, and the high temperature limit.

The process of changing display menu is shown in Figure 1.4.

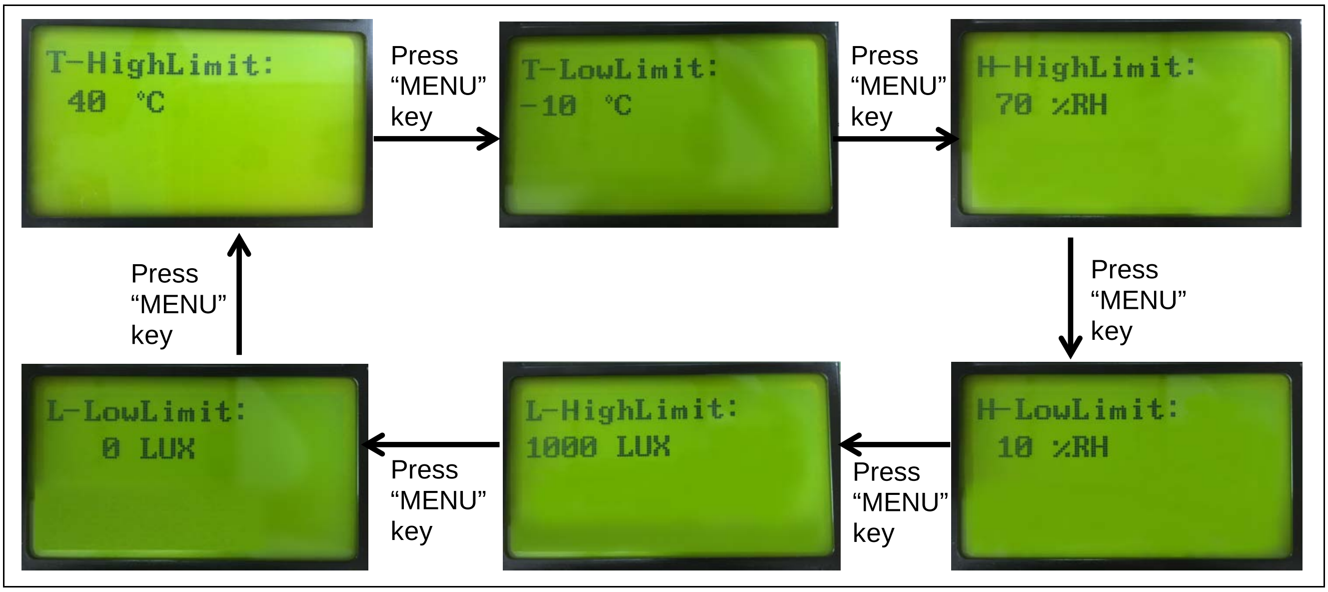

Figure 1.4 Process of Changing Display Menu

1.3.3 Set High Limit Value and Low Limit Value

In any of the menu interfaces, you can press the "+" key or "-" key for setting its high limit value or low limit value. The setting ranges of high temperature limit and low temperature limit is from -40 ºC to 100 ºC. The setting ranges of high humidity limit and low humidity limit is from 0 %RH to 100 %RH. The setting ranges of high luminance limit and low luminance limit is from 0 LUX to 1200 LUX. Each time you press the "+" key or "-" key, the high temperature limit, the low temperature limit, the high humidity limit and the low humidity limit plus 1or minus 1. Each time you press the "+" key or "-" key, the high luminance limit and the low luminance limit plus 50 or minus 50.

The process of setting high limit value and low limit value is shown in Figure 1.5.

Below figures show an example of how to set the high temperature limit value.

Below figures show an example of how to set the low luminance limit value.

Figure 1.5 Process of Setting High Limit Value and Low Limit Value

1.3.4 Quit Menu Display State and Save Setting Values

In any of the menu interfaces, press the “OK” key for returning normal display state, and the new setting value of high limit and low limit will be stored in the RL78/G11 internal data flash.

The process of quitting menu display state is shown in Figure 1.6.

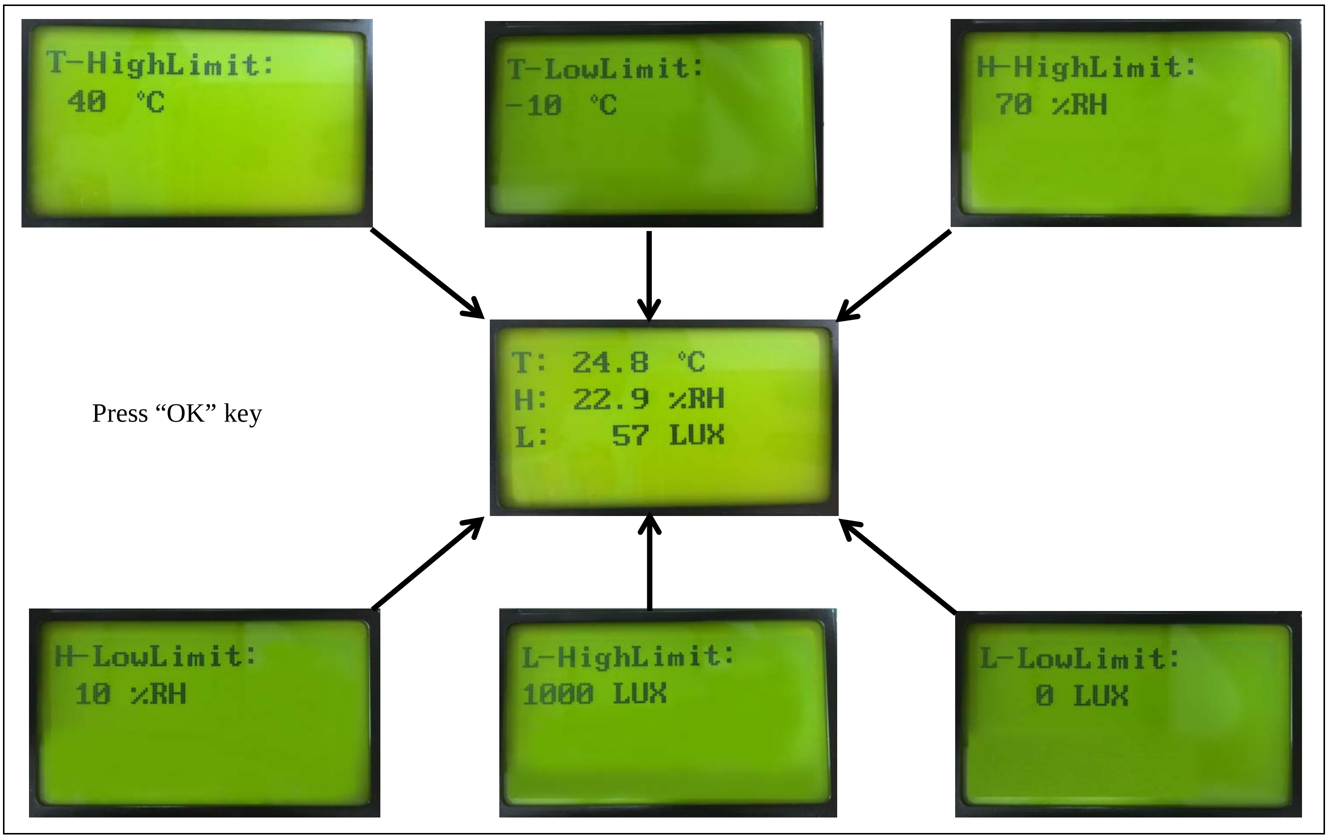

Figure 1.6 Process of Quitting Menu Display State

2. Introduction of Hardware

2.1 Introduction of PCB

The top view of the portable environment monitor is shown in Figure 2.1.

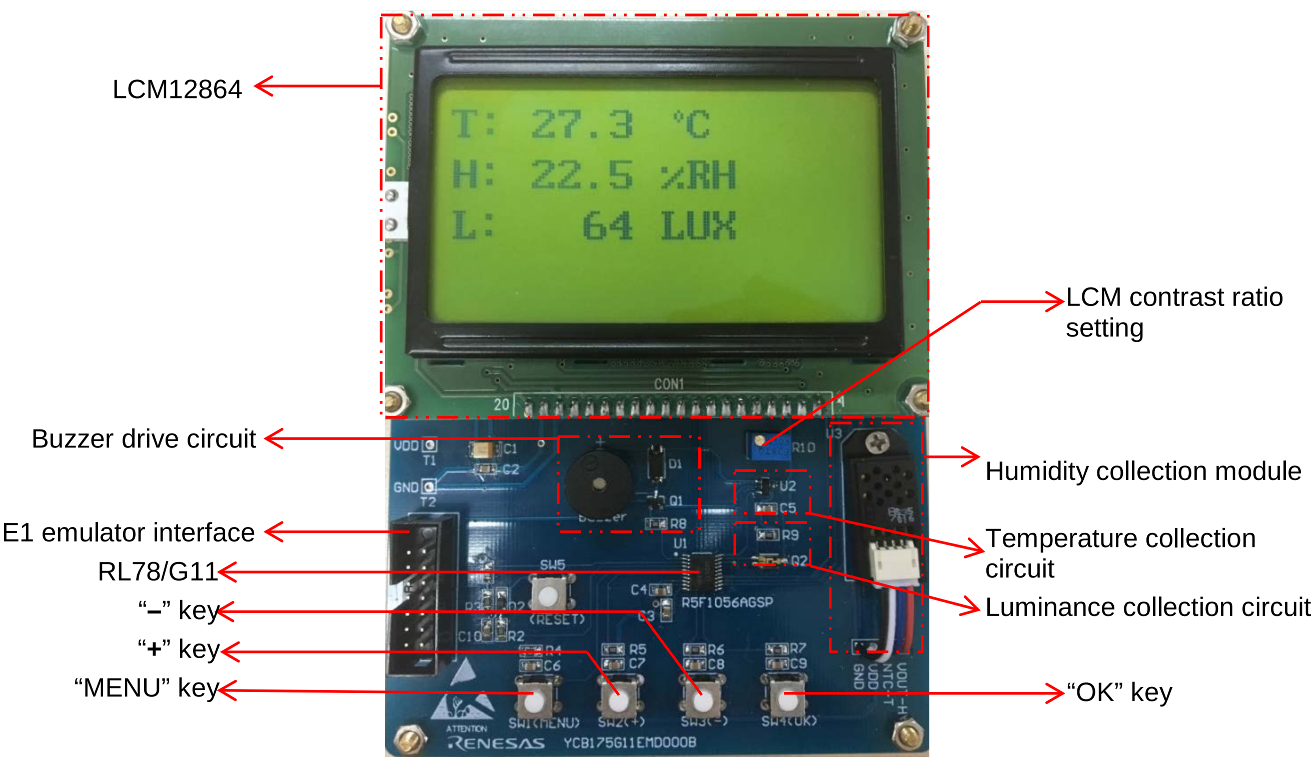

Figure 2.1 Top View of the Portable Environment Monitor

The bottom view of the portable environment monitor is shown in Figure 2.2.

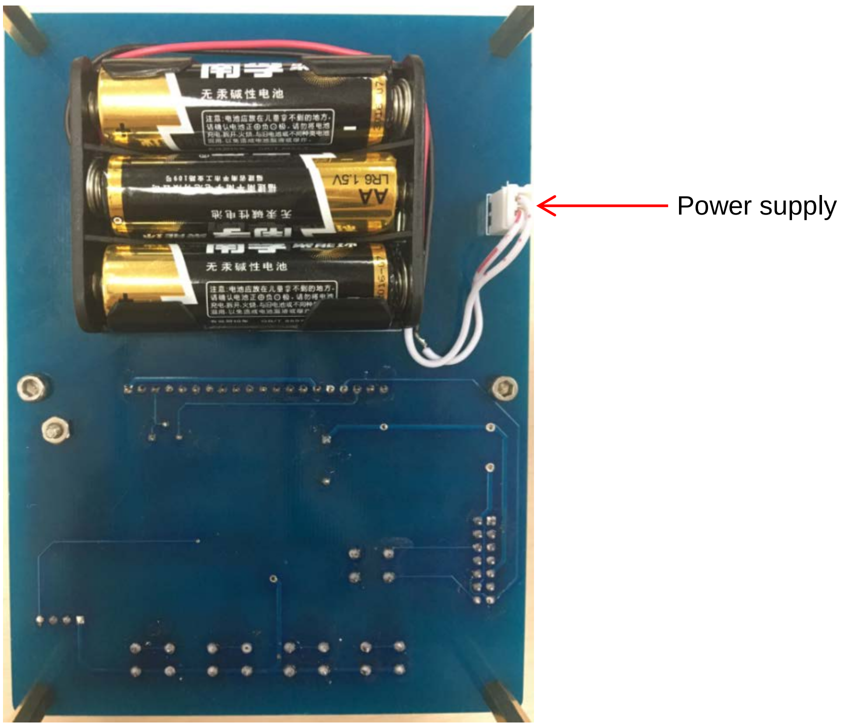

Figure 2.2 Bottom View of the Portable Environment Monitor

2.2 Hardware Block Diagram

The hardware block diagram of the portable environment monitor is shown in Figure 2.3.

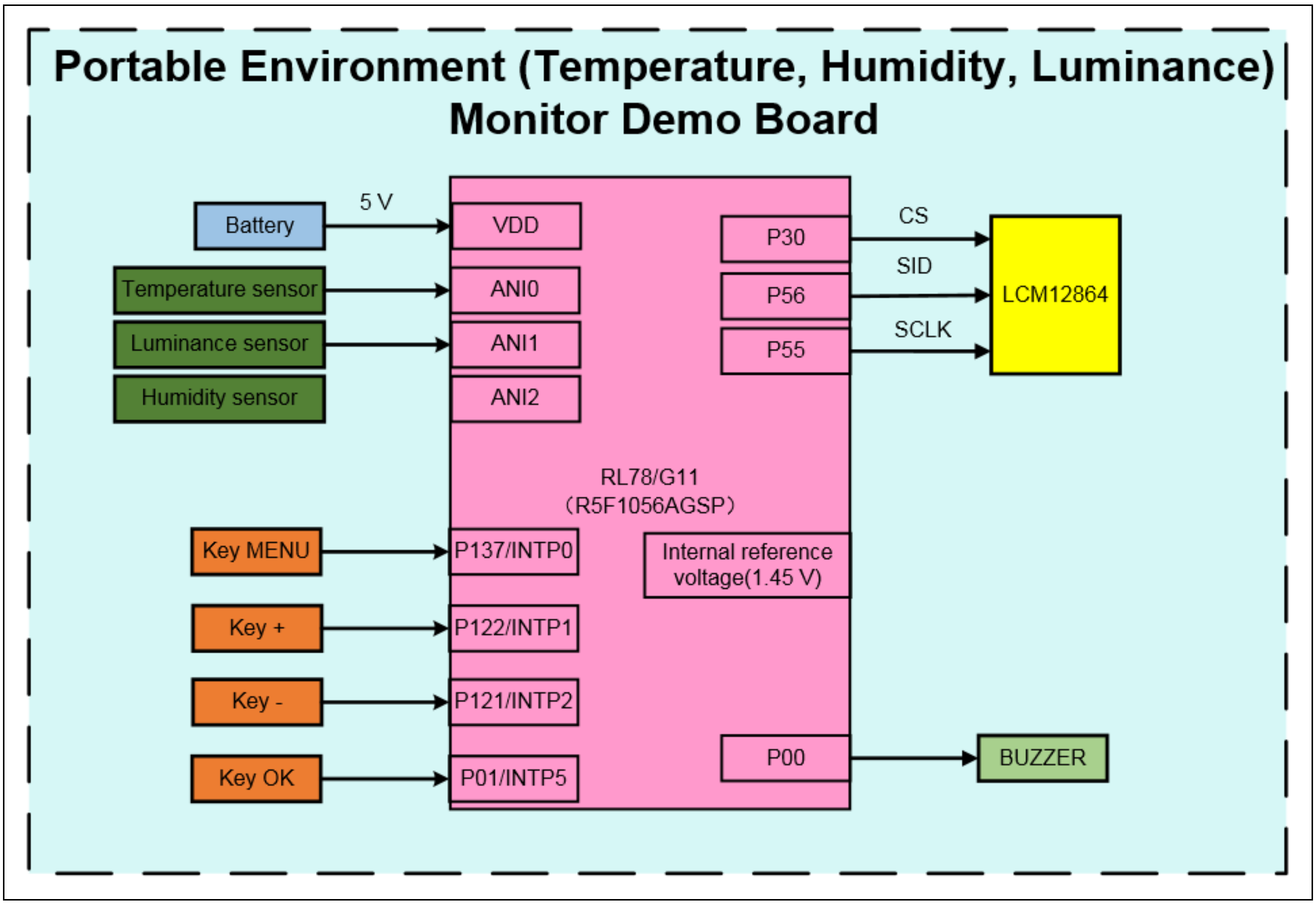

Figure 2.3 Hardware Block Diagram of the Portable Environment Monitor

2.3 Main MCU

The demo board of the portable environment monitor uses RL78/G11 as main MCU. The Flash ROM size of RL78/G11 is 16 KB and the RAM size is 1.5 KB. The peripheral functions of RL78/G11 and their applications are shown in Table 2.1.

Table 2.1 Peripheral Functions and Their Applications

Peripheral functions	Usage
P20/ANI0	A/D sampling: the detection of temperature voltage
P21/ANI1	A/D sampling: the detection of luminance voltage
P22ANI2	A/D sampling: the detection of humidity voltage
P137/INTP0	External interrupt: the detection of “MENU” key
P122/INTP1	External interrupt: the detection of “+” key
P121/INTP2	External interrupt: the detection of “-” key
P01/INTP5	External interrupt: the detection of “OK” key
P30	LCM driver: the chip selection port (CS)
P56	LCM driver: the serial data output port (SID)
P55	LCM driver: the serial clock output port (SCLK)
Channel 0 of TAU0	1ms timer for LCM display
P00	Buzzer driver

The interface control circuit of RL78/G11 is shown in Figure 2.4.

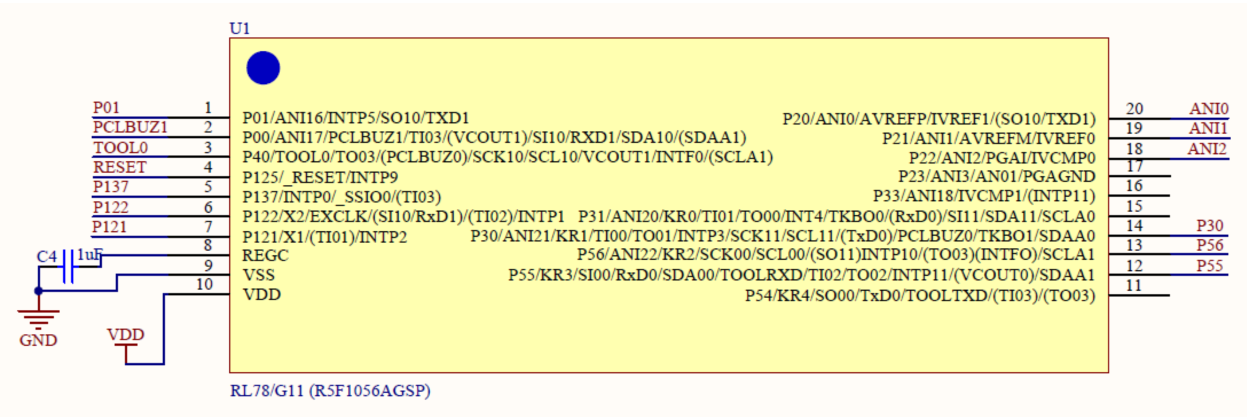

Figure 2.4 Interface Control Circuit of RL78/G11

2.4 Power Supply Circuit

The portable environment monitor uses 3 AAA batteries as power supply.

The power supply circuit is shown in Figure 2.5.

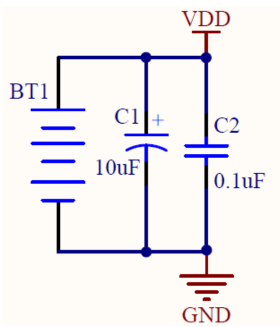

Figure 2.5 Power Supply Circuit

2.5 Temperature Sampling Circuit

The temperature sampling circuit directly uses a linear voltage output temperature sensor (TC1047A), whose output voltage is directly proportional to the temperature. The TC1047A accurately measures the temperature from -40 ° C to + 125 ° C and its supply voltage range is 2.5 V to 5.5 V.

The correspondence formula between TC1047A output voltage and the temperature:

Vout = 10 mV/°C × (Temperature°C) + 500 mV

The temperature TC1047A output voltage and the temperature sampling circuit are shown in Figure 2.6.

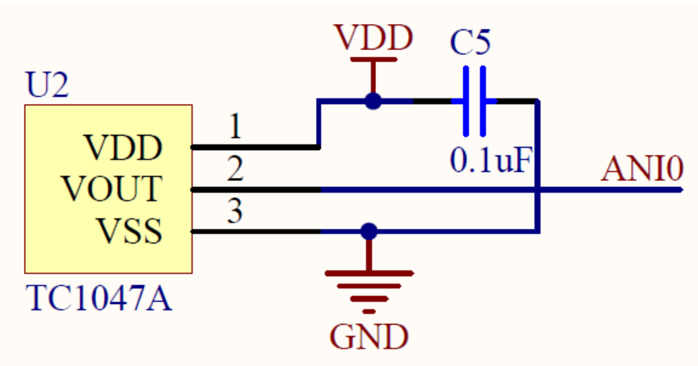

Figure 2.6 Temperature sampling Circuit

The characteristic curve between TC1047A output voltage and the temperature is shown in Figure 2.7.

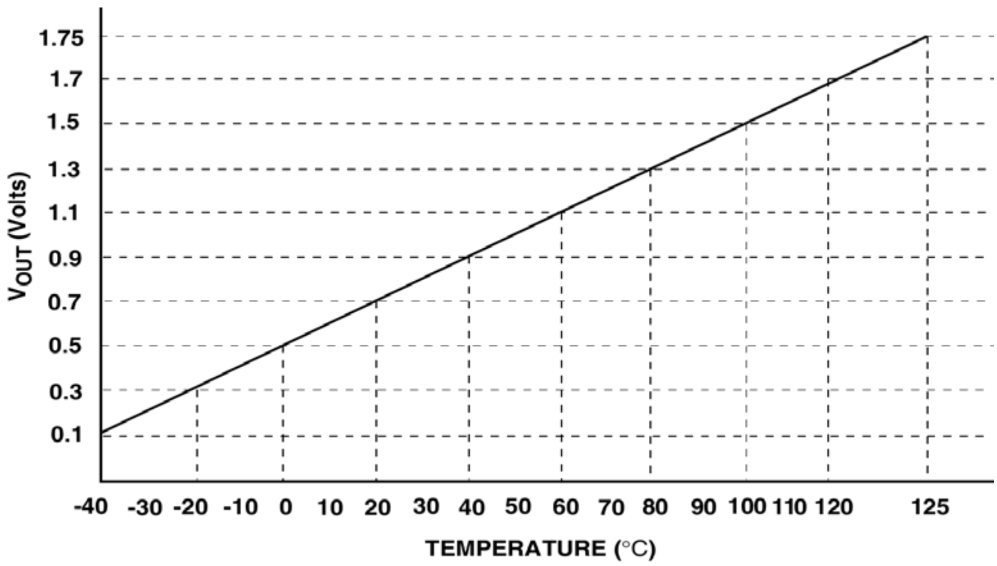

Figure 2.7 Characteristic Curve Between Voltage and the Temperature

2.6 Humidity Sampling Circuit

The humidity sampling circuit uses a module sensor (HTG3515CH) to acquire humidity, whose output voltage is directly proportional to the humidity. HTG3515CH can measure the humidity from 0 %RH to 100 %RH.

The correspondence formula between output voltage and the humidity:

Humidity = 0.0376×Vout - 41.4 (The unit of Vout is mv.)

The humidity sampling circuit is shown in Figure 2.8.

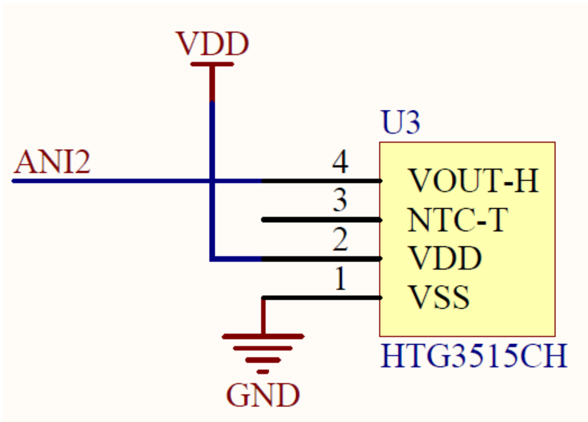

Figure 2.8 Humidity Sampling Circuit

2.7 Luminance Sampling Circuit

The luminance sampling circuit is a series voltage divider circuit that is composed of a photoelectric transistor (TEMT6000) and resistance R9. There is a linear relationship between the collector light current (I_{PCE}) of TEMT6000 and luminance. The output interface can get a voltage value that changes with the I_{PCE}, resulting in the corresponding luminance value.

The correspondence formula between interface output voltage (Vout) and the luminance:

Luminance = $I_{PCE} \times 2$, I_{PCE} = Vout / 10 K ×1000 (The unit of Vout is v.)

The luminance sampling circuit is shown in Figure 2.9.

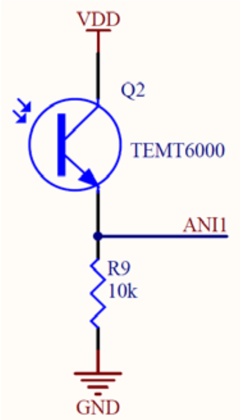

Figure 2.9 Luminance Sampling Circuit

The characteristic curve between collector light current (I_{PCE}) and the luminance is shown in Figure 2.10.

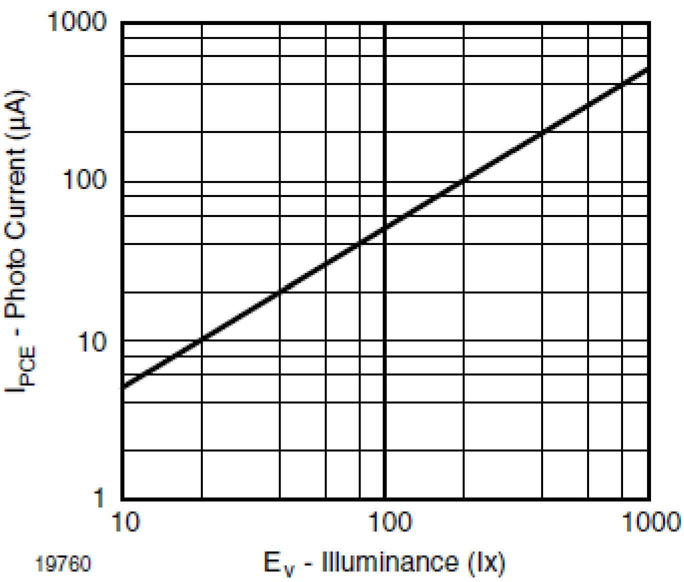

Figure 2.10 Characteristic Curve between Emitter Current and Luminance

2.8 Buzzer Alarm Circuit

The buzzer is used for the alarm function. When the measured values exceed the high limit or the low limit, the buzzer will sound.

The buzzer alarm circuit is shown in Figure 2.11.

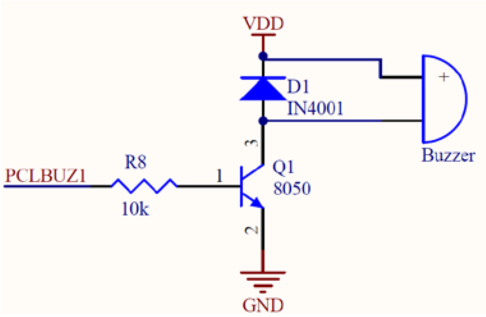

Figure 2.11 Buzzer Alarm Circuit

2.9 Key Detection Circuit

The key detection circuit has four independent keys, namely "MENU", "+", "-", "OK". You can set the high temperature limit, the low temperature limit, the high humidity limit, the low humidity limit, the high luminance limit and the low luminance limit through these four keys.

Normally, the key outputs a high level, and when the key is pressed, the key outputs a low level. Level changing becomes a falling edge signal, which will be detected by an external interrupt INTP, and in order to prevent chattering, key detection circuit in parallel with a 0.1 uf capacitor.

The key detection circuit is shown in Figure 2.12.

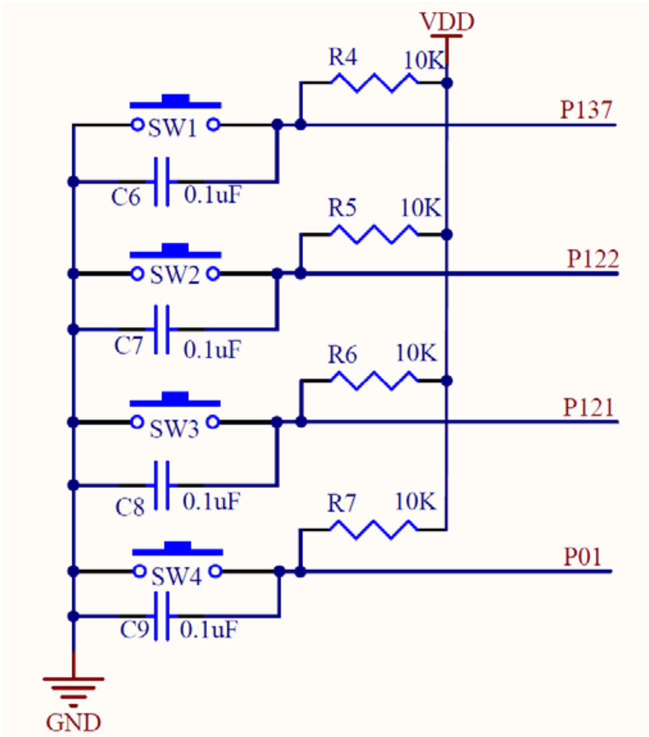

Figure 2.12 Key Detection Circuit

3. Schematic, PCB and Bill of Materials

3.1 Schematic

The schematic of the portable environment monitor is shown in Figure 3.1.

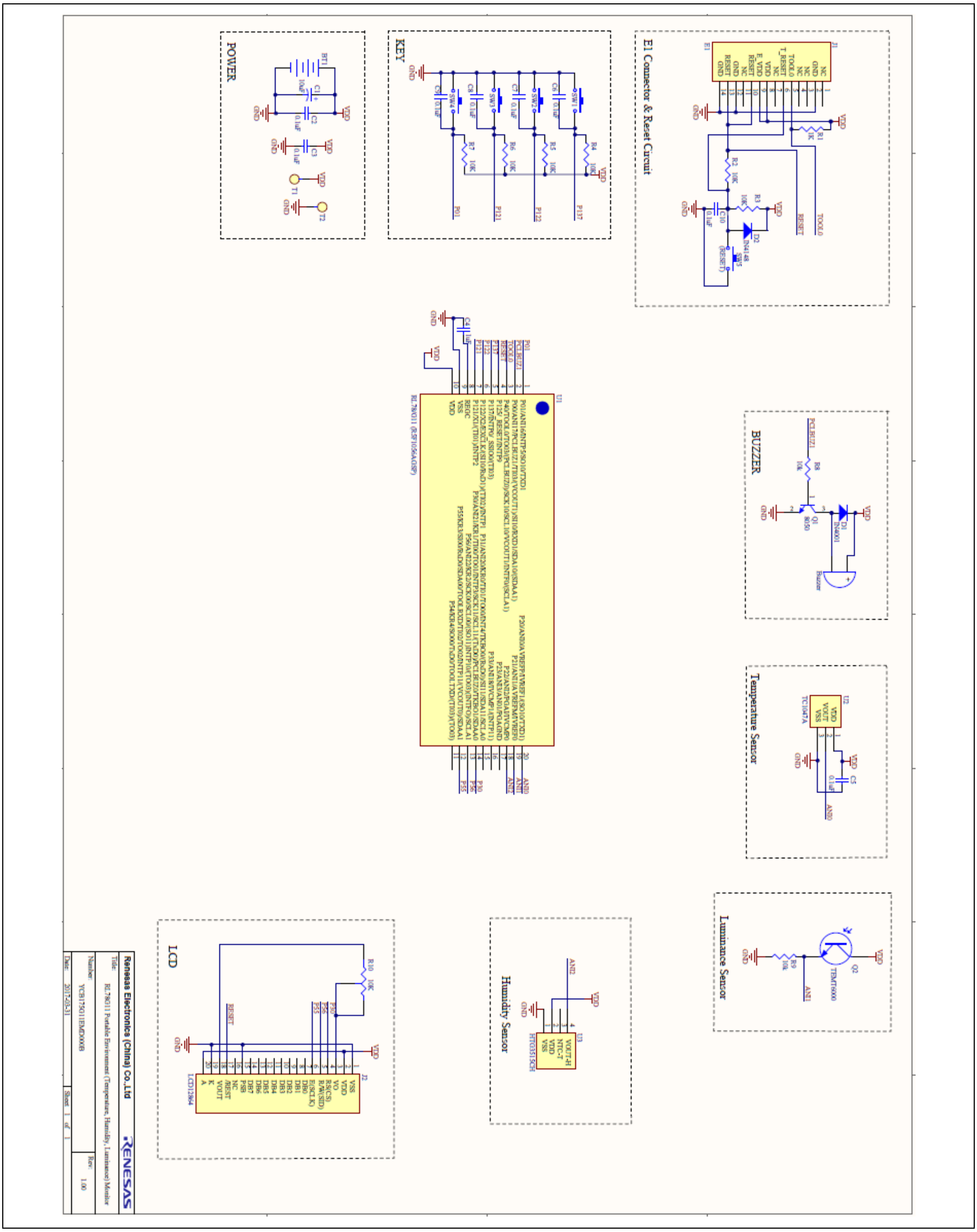

Figure 3.1 Schematic

3.2 PCB

The PCB of the portable environment monitor is shown in Figure 3.2.

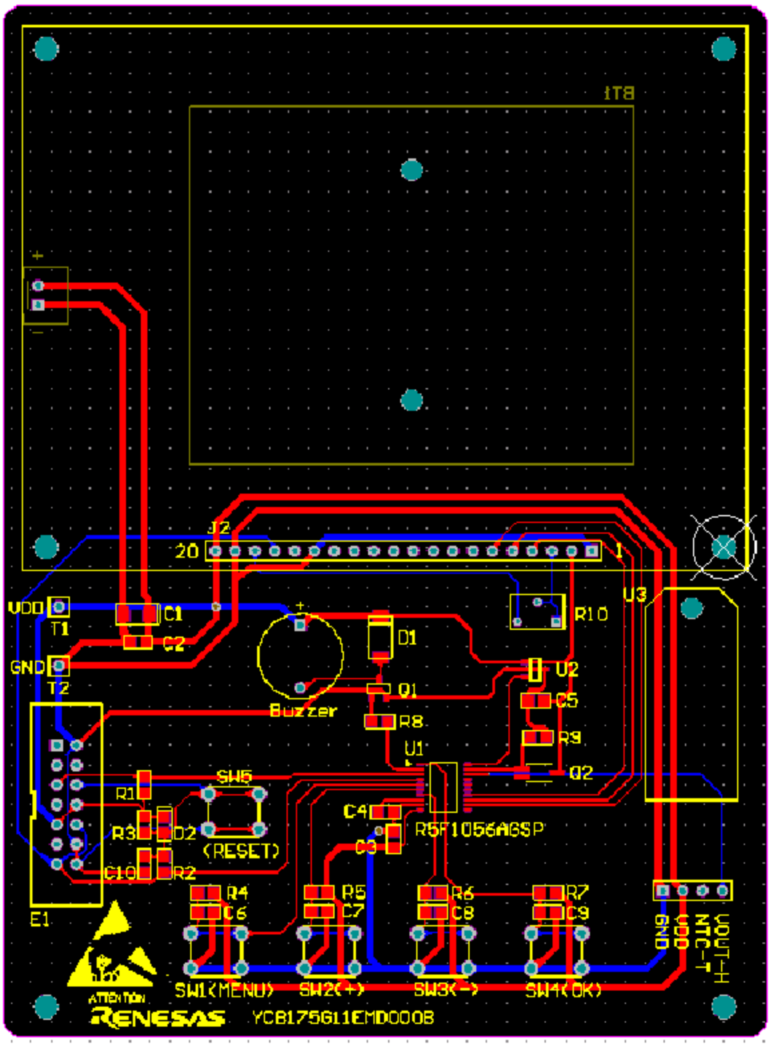

Figure 3.2 PCB

3.3 Bill of Materials

The bill of materials of the portable environment monitor is shown in Table 3.1.

Table 3.1 Bill of Materials

Designator	Quantity	Part Name	Manufacturer	Description
BT1	1	—	—	Battery Socket
Buzzer	1	12095	—	Buzzer (12*7.6 mm)
C1	1	GRT21BC81C106ME01L	Murata	Capacitor (10uF, 16VDC, ±10%, 0805)
C2, C3, C5, C6, C7, C8, C9, C10	8	GRM21BR71E104KA01L	Murata	Capacitor (0.1uF, 16VDC, ±10%, 0805)
C4	1	GRM21BR71A105KA01L	Murata	Capacitor (1uF,10VDC, ±10%, 0805)
D1	1	1N4001	Vishay	Diode (GF1A)
D2	1	1N4148	Vishay	Diode (SOD-323)
E1	1	2514-6002	3M Limited	CON (7X2, 2.54 mm)
J2	1	HG1286412-LYH	TSINGTEK Display Co., Ltd	LCM (5 V)
Q1	1	S8050	BILIN	Amplifier (SOT23A)
Q2	1	TEMT6000	Vishay	Luminance sensor (SOT23A)
R1	1	ERJ6GEYJ102V	BOURNS	Resistor (1 KΩ, ±5%, 0805)
R2, R3, R4, R5, R6, R7, R8, R9	8	ERJ6GEYJ103V	BOURNS	Resistor (10 KΩ, ±5%, 0805)
R10	1	3266	BOURNS	Potentiometer (10 KΩ)
SW1, SW2, SW3, SW4, SW5	5	B3W-1000	OMRON	Push Switch (6*6 mm, DIP)
T1, T2	2	—	—	Test Point
U1	1	G11	Renesas Electronics	R5F1056AGSP (LSSOP20_4.4*6.5_0.65 mm)
U2	1	TC1047A	Microchip	Temperature sensor(SOT23B)
U3	1	HTG3515	TE CONNECTIVITY (TE)	Humidity sensor (HTG3515 Module)

4. Introduction of Software

4.1 Integrated Development Environment

The integrated development environment of the portable environment monitor is shown in Table 4.1.

Table 4.1 Integrated Development Environments

Item	Contents
Integrated development environment	e2 studio V5.3.0.023 (Renesas Electronics Corporation) CS+ V6.00.00 (Renesas Electronics Corporation)
C compiler	CC-RL V1.02 (Renesas Electronics Corporation)
Debugger	E1 (Renesas Electronics Corporation)

4.2 List of Option Byte Setting

The option byte setting of the portable environment monitor is shown in Table 4.2.

Table 4.2 Option Byte Setting

Address	Setting	Description
000C0H/010C0H	00000000B	Watchdog timer operation is stopped (count is stopped after reset)
000C1H/010C1H	00010010B	LVD: interrupt & reset mode
000C2H/010C2H	11100000B	HOCO: 24 MHz, operation voltage range: 2.7 V~5.5 V
000C3H/010C3H	10000100B	On-chip debugging is enabled.

4.3 Installation Procedure

The following is necessary to build the sample application.

Download the Data Flash Library corresponding to your development environment from Renesas website and copy to the “Lib” folder in the project.

Data Flash Library for CC/RL78

https://www.renesas.com/en-us/software/D3016256.html

(Destination folder)…..\Lib

- pfdl.h
- pfdl.inc
- pfdl.lib
- pfdl_types.h

4.4 Flow Chart

4.4.1 Flow Chart of Main Function

The flow chart of the main function is shown in Figure 4.1.

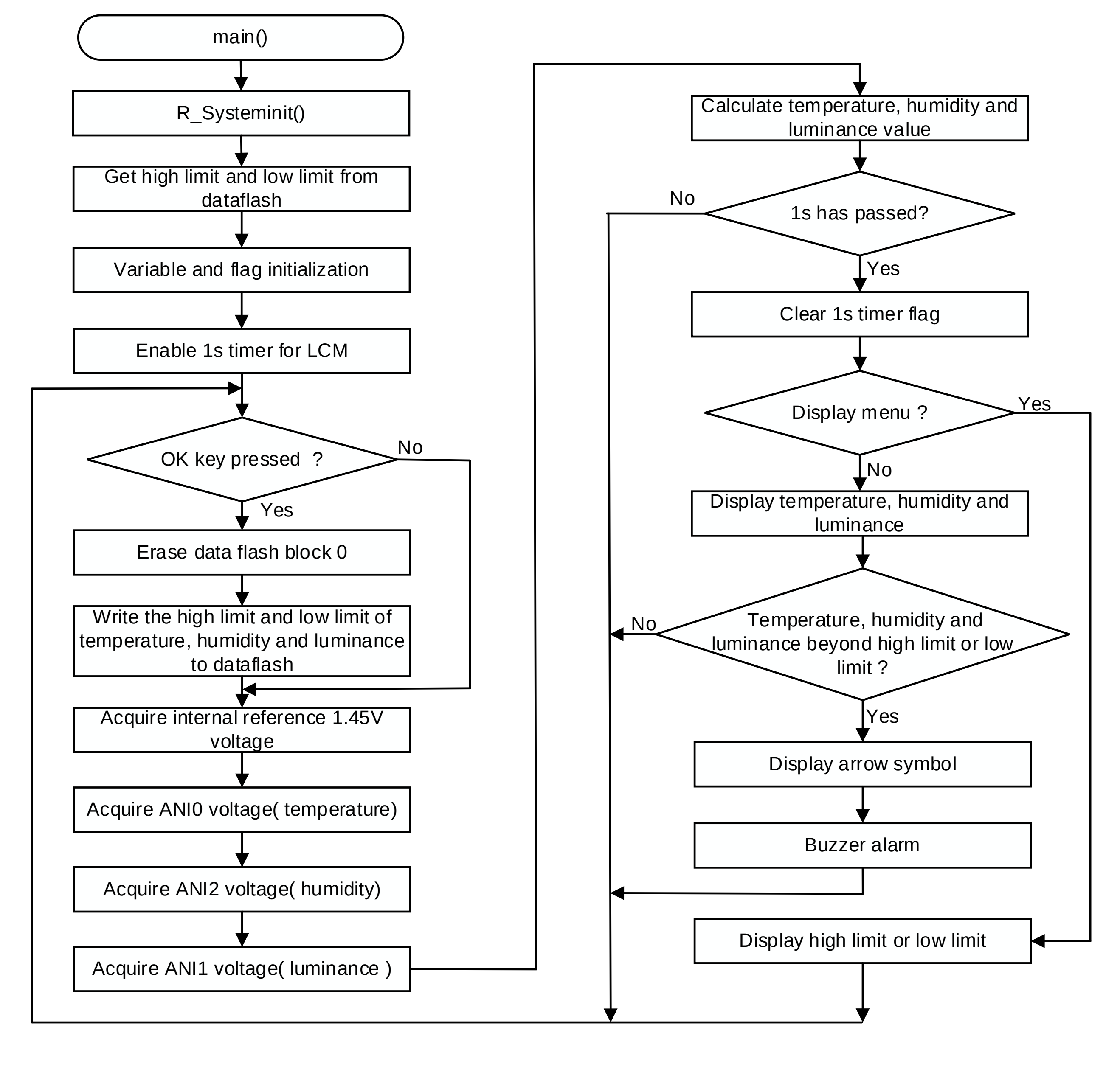

Figure 4.1 Flow Chart of Main Function

4.4.2 Flow Chart of System Initialization

The flow chart of system initialization is shown in Figure 4.2.

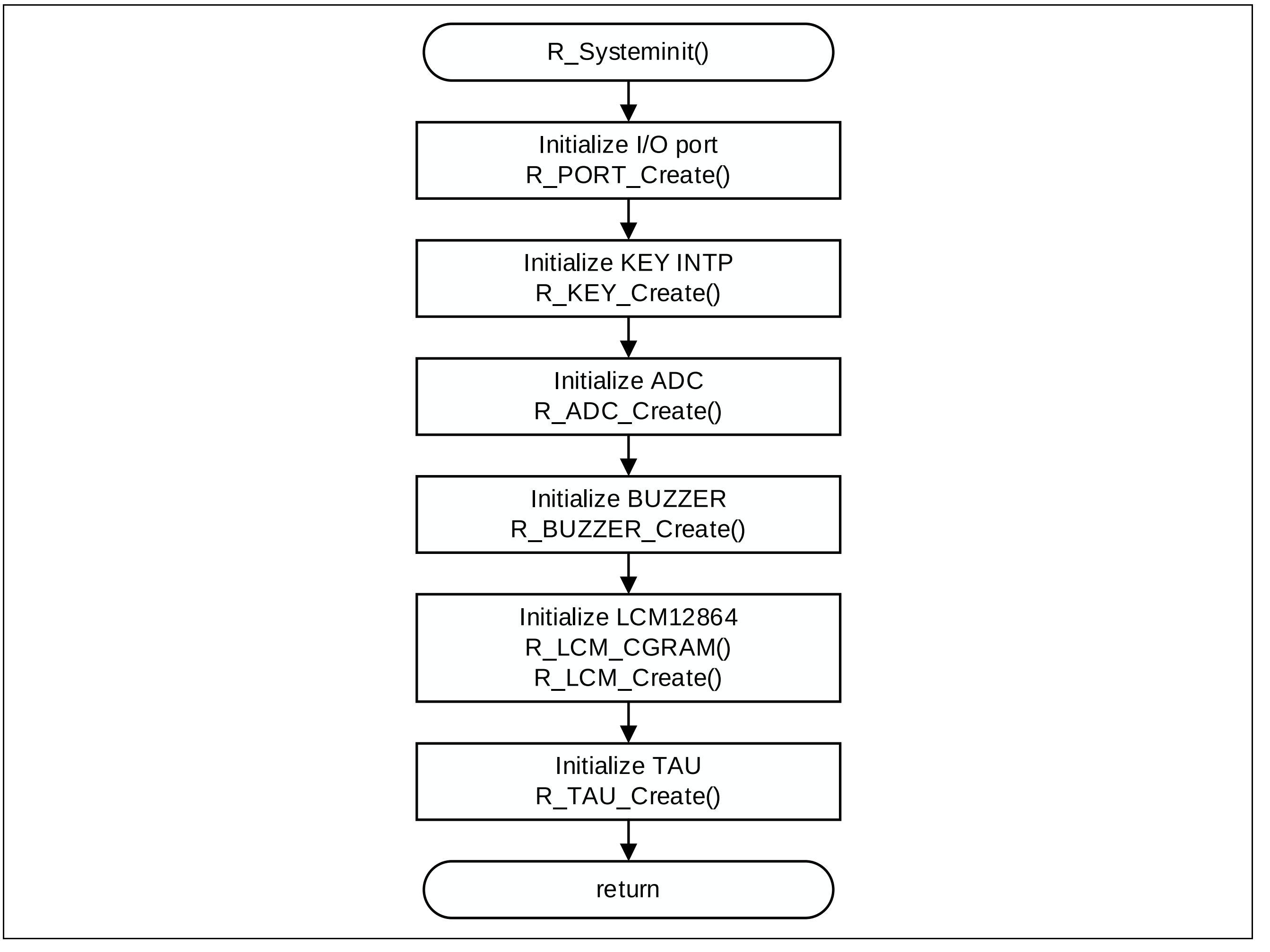

Figure 4.2 Flow Chart of System Initialization

4.4.3 Flow Chart of Key Module

The flow chart of key "MENU" function service interrupt subroutine is shown in Figure 4.3.

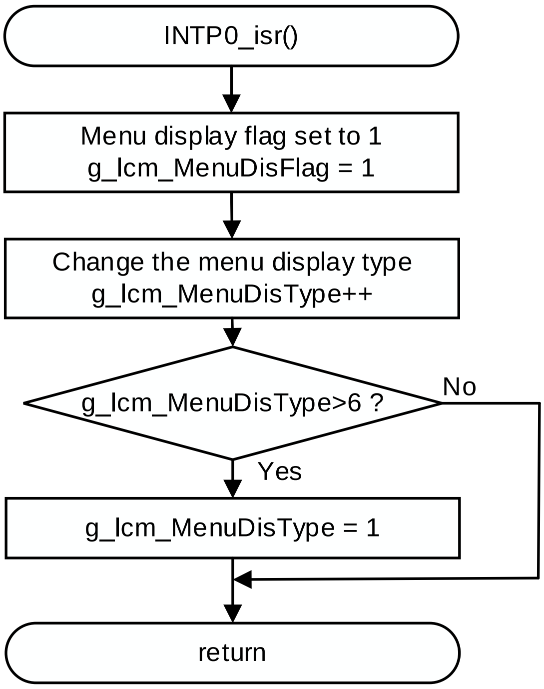

Figure 4.3 Flow Chart of Key "MENU" Function Service Interrupt Subroutine

The flow chart of key "OK" function service interrupt subroutine is shown in Figure 4.4.

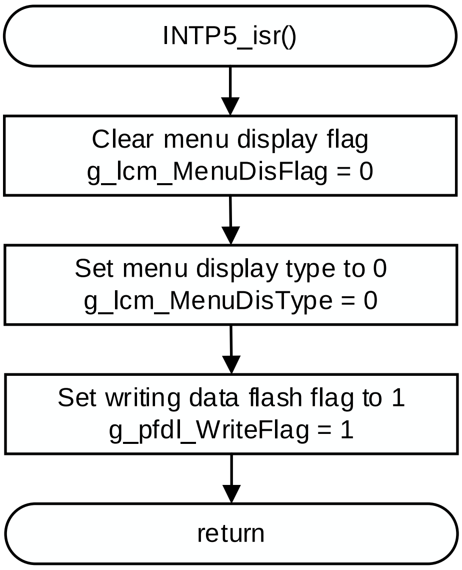

Figure 4.4 Flow Chart of Key "OK" Function Service Interrupt Subroutine

The flow chart of key "+" function service interrupt subroutine is shown in Figure 4.5.

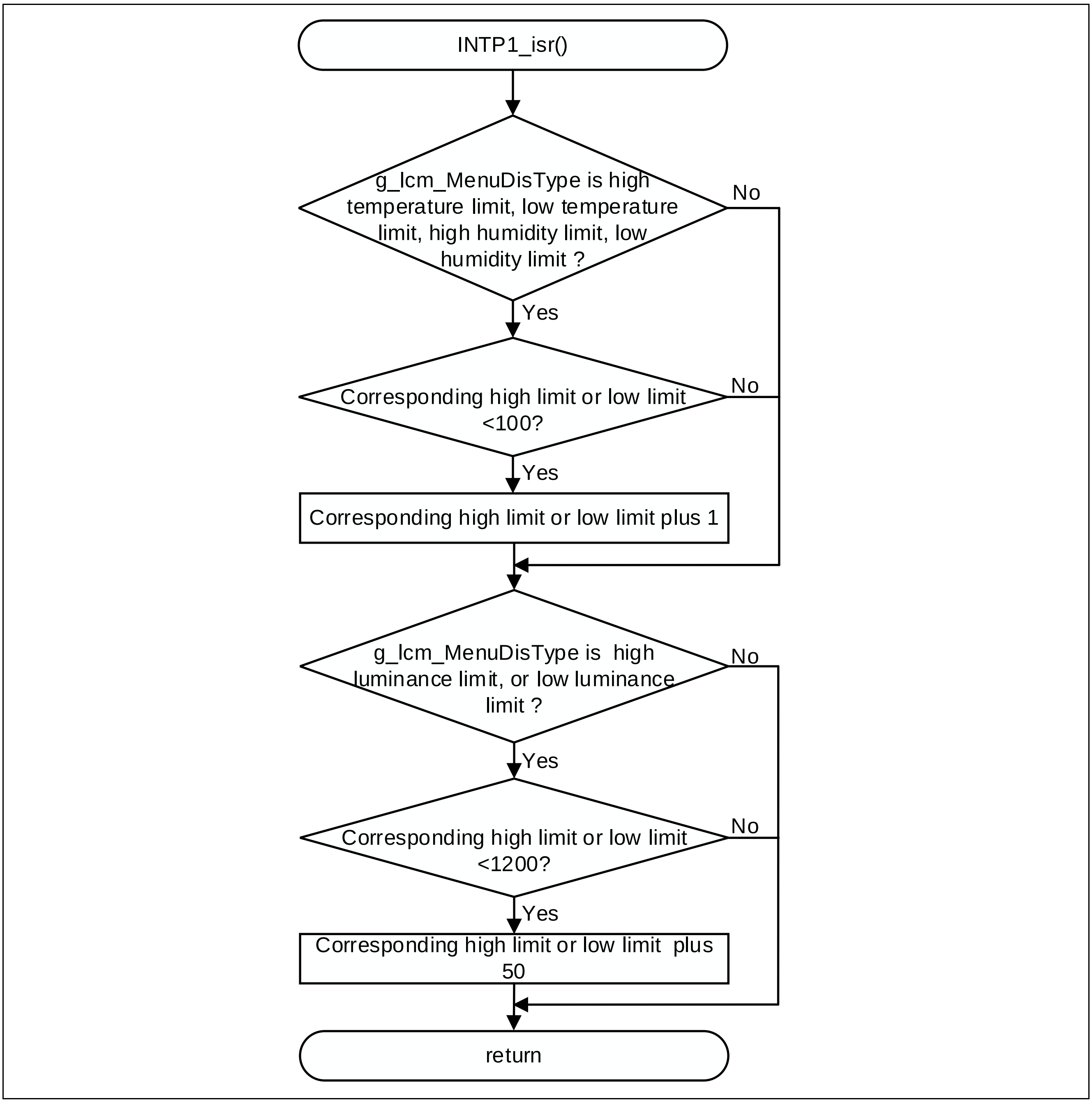

Figure 4.5 Flow Chart of Key "+" Function Service Interrupt Subroutine

The flow chart of key “-” function service interrupt subroutine is shown in Figure 4.6.

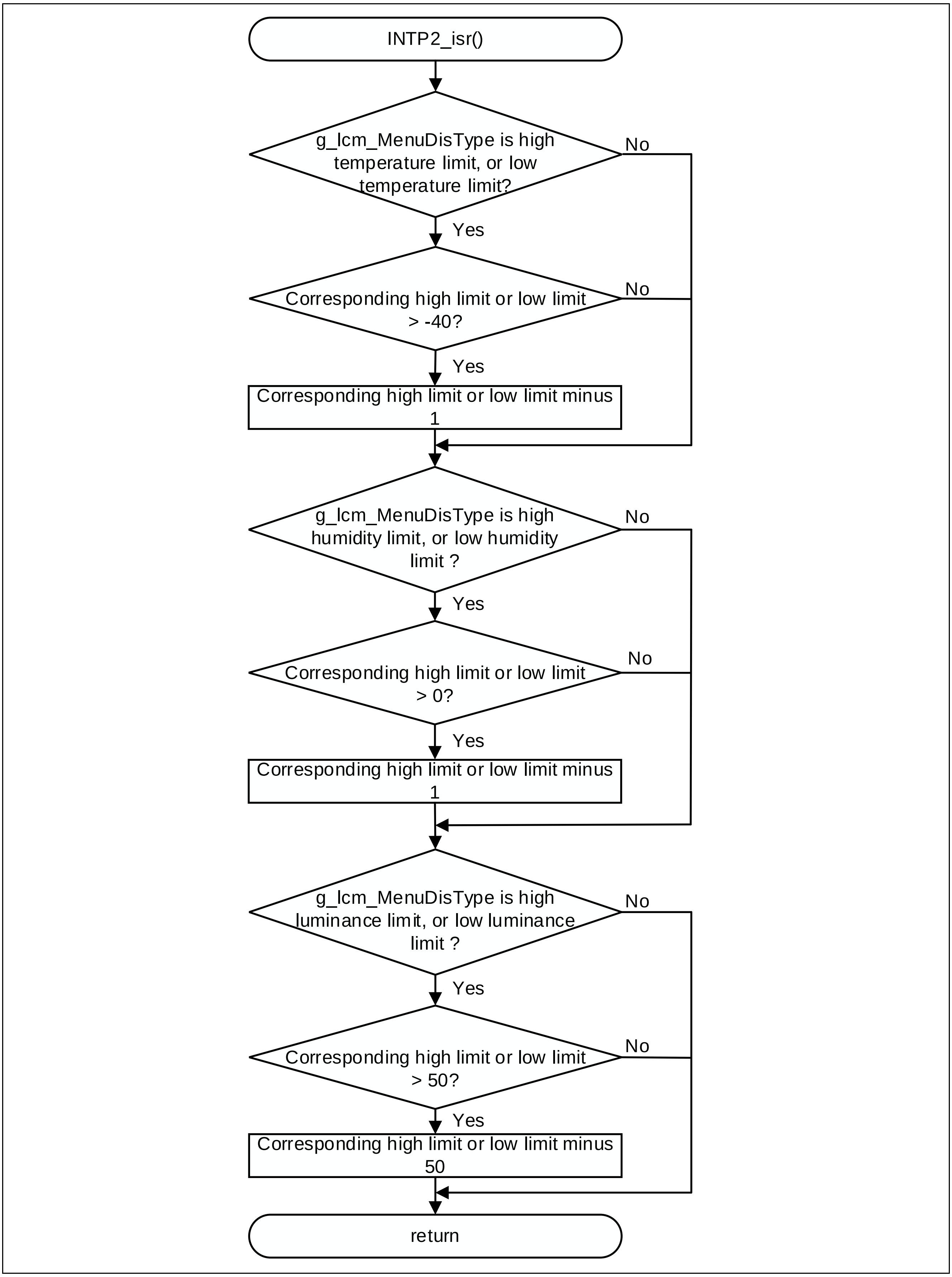

Figure 4.6 Flow Chart of Key “-” Function Service Interrupt Subroutine

5. Sample Code

The sample code is available on the Renesas Electronics Website.

6. Reference Documents

RL78/G11 User's Manual: Hardware (R01UH0637E)

RL78 Family User's Manual: Software (R01US0015E)

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

Technical Updates/Technical News
The latest information can be downloaded from the Renesas Electronics website.

Website and Support

Renesas Electronics Website
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http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 30, 2017	-	First edition issued
1.10	Sep.15, 2017	16	Modified the diode D1 from IN4001 to 1N4001 in schematic and BOM list.
1.10	Sep.15, 2017	16	Modified the diode D2 from IN4148 to 1N4148 in schematic and BOM list.
1.10	Sep.15, 2017	16	Added the manufacturer of J2 in BOM list.
1.10	Sep.15, 2017	16	Merge SW5 to SW1, SW2, SW3, SW4 in BOM list.
1.10	Sep.15, 2017	16	Modified the manufacturer of U3 from Hunirel to TE CONNECTIVITY in BOM list.
1.10	Sep.15, 2017	16	Changed the manufacturer of E1 from renesas to 3M Limited.

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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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.

RENESAS

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Refer to "http://www.renesas.com/" for the latest and detailed information.

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Colophon 6.0