RL78/G11

Automatic Liquid Dispenser

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Introduction

This document describes a Renesas microcontroller RL78/G11 application for automatic liquid dispenser.

Target Device

RL78/G11

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. Description

1.1 Abstract

An automatic liquid dispenser is specifically a hands-free dispenser of liquids such as soap, hand sanitizer, shampoos, or hand lotions. As touch-free design eliminates bacterial transmission, automatic liquid dispenser is popular in public places and private institutions. Dispenser only distributes a set amount of liquid per motion activation to minimize waste. This document provides an automatic liquid dispenser solution based on Renesas low cost microcontroller RL78/G11.

1.2 Specifications and Main Technical Parameters

Technical Parameters

- Power supply: 6 V (4 AAA batteries)
- Low power consumption current: 34 μA when MCU is in STOP mode
- Sensing method: Infrared
- Sensing distance: 0 ~ 15 cm
- Amount of liquid per motion activation: 0.5 / 0.8 ml selectable

Specifications

- Low power consumption function: When power switch is set to OFF, the power supply of the system is cut off and no current consumption is achieved. After the system is powered on, it operates in low power consumption mode in most conditions to obtain longer battery life.
- Audible and visual indication function: If hands are placed under the nozzle, LED and buzzer are turned on to indicate liquid dispensing.
- Dispensing time limit function: Even if hands are always under the nozzle, a maximum duration of 2 seconds dispensing is accomplished.
- Low battery voltage warning: When battery voltage is lower than 4.8 V in which condition drive capability of battery is too low to operate motors, LED blinks to indicate this low power condition when hands are placed under the nozzle.
- Dispensing amount selectable: Switch is used to select amount of liquid dispensing per motion.
- Operating temperature: -10°C ~ 60°C
- Operating humidity: 5 ~ 99% RH (No condensate water)

2. RL78/G11 Microcontroller

2.1 RL78/G11 Block Diagram

Figure 2.1 shows the block diagram of RL78/G11 (20-pin products).

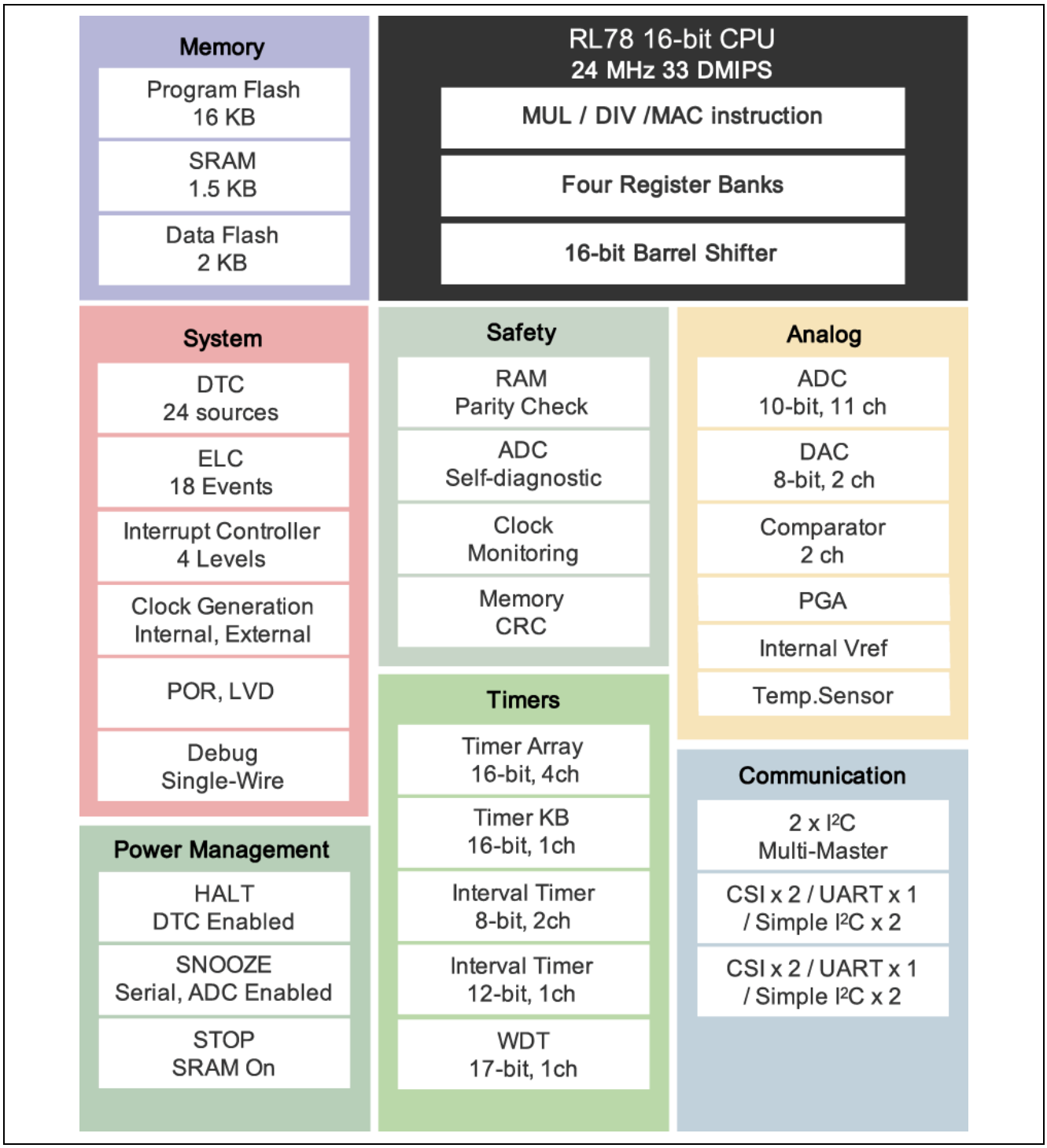

Figure 2.1 RL78/G11 (20-pin products) Block Diagram

2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.04167 µs: @ 24 MHz operation with high-speed on-chip oscillator) to ultra-low speed (66.6 µs: @ 15 kHz operation with low-speed on-chip oscillator clock)
- General-purpose registers: (8-bit register × 8) × 4 banks
- ROM: 16 KB, RAM: 1.5 KB, data flash: 2 KB
- Selectable high-speed on-chip oscillator clock: 48/24/16/12/8/6/4/3/2/1 MHz (TYP.)
- Selectable middle-speed on-chip oscillator clock: 4/2/1 MHz (TYP.)
- On-chip debug function
- On-chip selectable power-on-reset (POR) circuit
- On-chip voltage detector (LVD)
- On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator)
- On-chip key interrupt function: 8 key interrupt input pins
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 17 to 21
- Timer
  16-bit timer (TAU): 4 channels
  TKB: 1 channel
  12-bit interval timer: 1 channel
  8-bit interval timer: 2 channels
- Serial interfaces
  CSI: 4 channels
  UART: 2 channels
  I²C/Simplified I²C communication: 4 channels
  Multimaster I²C: 2 channels
- 8/10-bit resolution A/D converter: 10 to 11 channels
- 8/10-bit resolution D/A converter: 2 channels
- Comparator: 2 channels
  Operating modes: Comparator high-speed mode, comparator low-speed mode, window mode
- PGA: 1 channel
- Data transfer controller (DTC)
- Event link controller (ELC)
- Standby function: HALT or STOP mode
- Power supply voltage: VDD = 1.6 to 5.5 V
- Operating ambient temperature: TA = -40 to +85°C

RL78/G11 is widely used in common technologies for industry, office, home appliance, healthcare, security, city and detectors application.

2.3 Pin Configuration

Figure 2.2 shows the pin configuration of RL78/G11 (20-pin products).

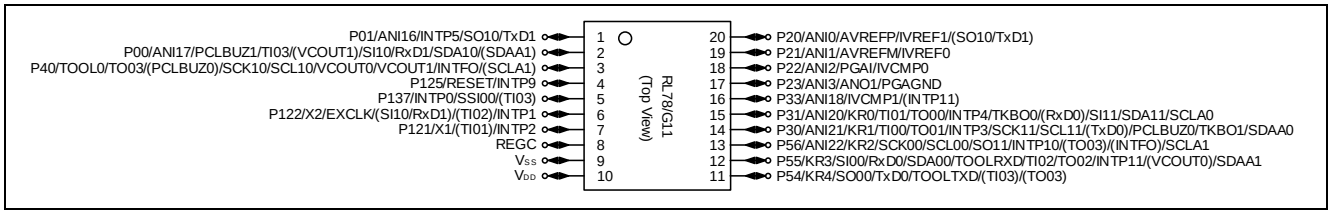

Figure 2.2 RL78/G11 (20-pin products) Pin Configuration

3. System Outline

3.1 Principle Introduction

After system initialization is completed, STOP mode is entered for low power consumption. Every 50 milliseconds MCU is waked up from STOP mode for hand detection. The infrared LED is turned on and status of phototransistor is checked. If there are hands placed in the beam of light emitted by infrared LED, MCU detects the status change of phototransistor and activates LED, buzzer and motor. Liquid is pumped through the nozzle by motor.

Figure 3.1 shows the system block diagram for this document.

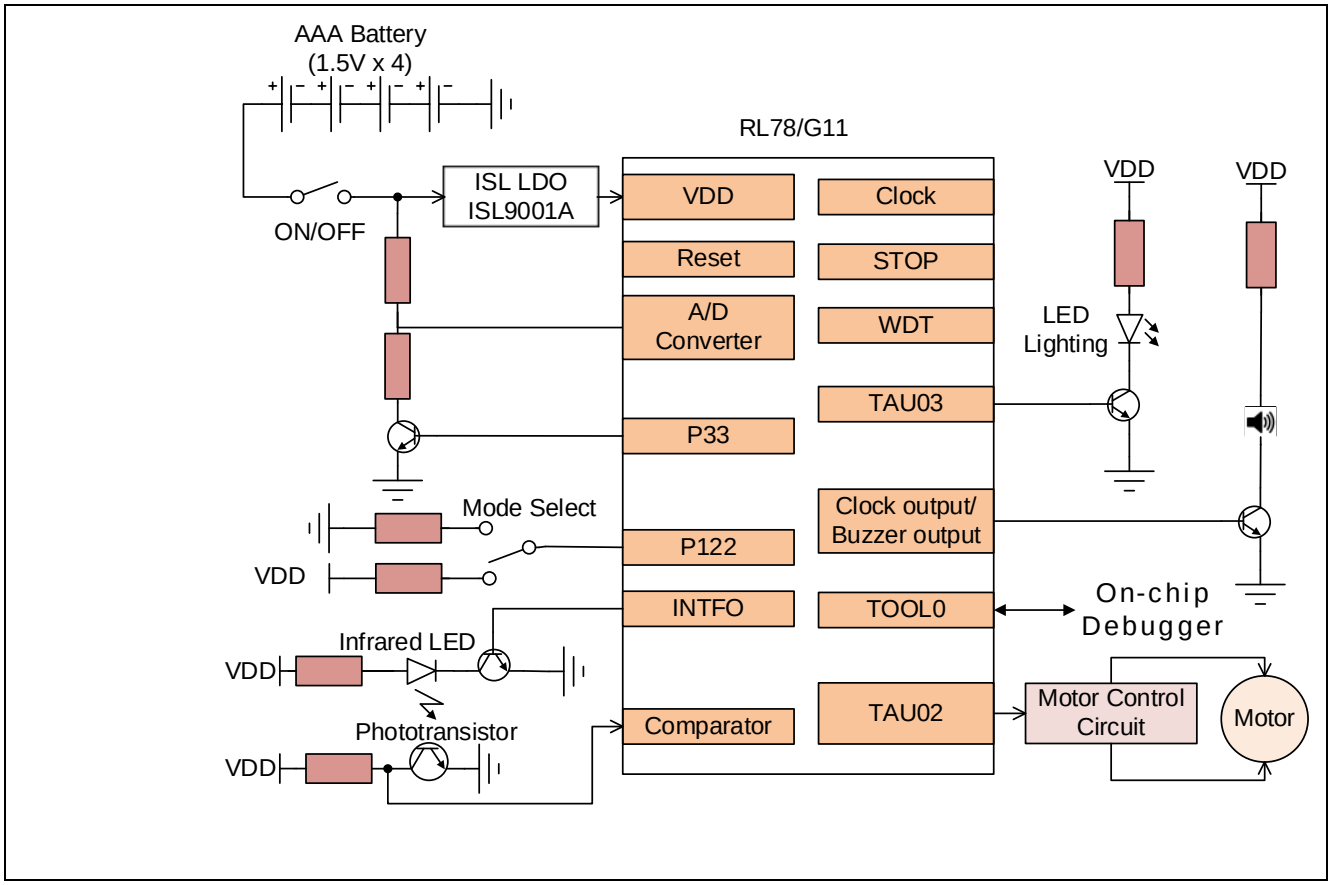

Figure 3.1 System Block Diagram

3.2 Peripheral Functions to be Used

Table 3.1 lists the peripheral functions to be used and their usages.

Table 3.1 Peripheral Functions to be Used

Peripheral Function	Usage
8-bit Interval Timer Channel 0	Generate 50 milliseconds interval to wake up MCU from STOP mode
12-bit Interval Timer	Control the lasting time of infrared LED on Control the timing of checking phototransistor status indicating whether hands are placed between the beam light emitted by infrared LED
Comparator	Compare the voltage on phototransistor collector with internal reference voltage 1.45 V
Interrupt Function	Use the INTFO function to enable infrared LED emitter
PCLBUZ0	Output a square wave to drive the buzzer
A/D Converter	Monitor the battery voltage
I/O port	Detect the mode select of dispensing liquid
Timer Array Unit	Output PWM to drive the motor and the LED

3.3 Pins to be Used

Table 3.2 lists the pins to be used and their descriptions.

Table 3.2 Pins to be Used

Pin Name	Description
P40/TOOL0	On-chip debug
P125/RESET	Hardware reset
P122	Normal/Light mode selection of dispensing liquid
V_{SS}	Ground
V_{DD}	Power supply voltage
P22/IVCMP0	Phototransistor collector voltage
P31/ANI20	Battery voltage
P33	Enable the input of half battery voltage to A/D converter
P30/PCLBUZ0	Drive speaker
P56/INTFO	Control ON/OFF of infrared LED
P55/TO02	Drive motor
P54/(TO03)	Drive LED

3.4 Operating Instructions

(1) After OFF-NORMAL-LIGHT switch is selected to NORMAL, the system is powered on and normal mode is selected in which 0.8 ml of liquid is distributed per motion activation. If hands are placed between the infra LED and the phototransistor, motor is activated to pump liquid from tank. LED and buzzer are turned on to indicate liquid dispensing. As soon as hands are removed, dispensing is terminated.

(2) When OFF-NORMAL-LIGHT switch is selected to LIGHT, light mode is selected in which 0.5 ml of liquid is distributed per motion activation. All the other operations are the same as that in normal mode.

(3) Even if hands are kept placed under the nozzle without any leave, the system dispenses liquid for a maximum time of 2 seconds.

(4) Each time hands are placed under the nozzle; battery voltage is checked and low-voltage warning is indicated through buzzer alarming if battery is in low power status.

4. Hardware

There is an infrared LED and phototransistor, buzzer, LED and motor in the system. Infrared LED gives light which is sensed by phototransistor. When hands are placed under the nozzle, the beam light is cut off and the status of phototransistor is changed. MCU detects that change and drives buzzer, LED and motor. Liquid is pumped through the nozzle with motor running.

Figure 4.1 shows the board picture.

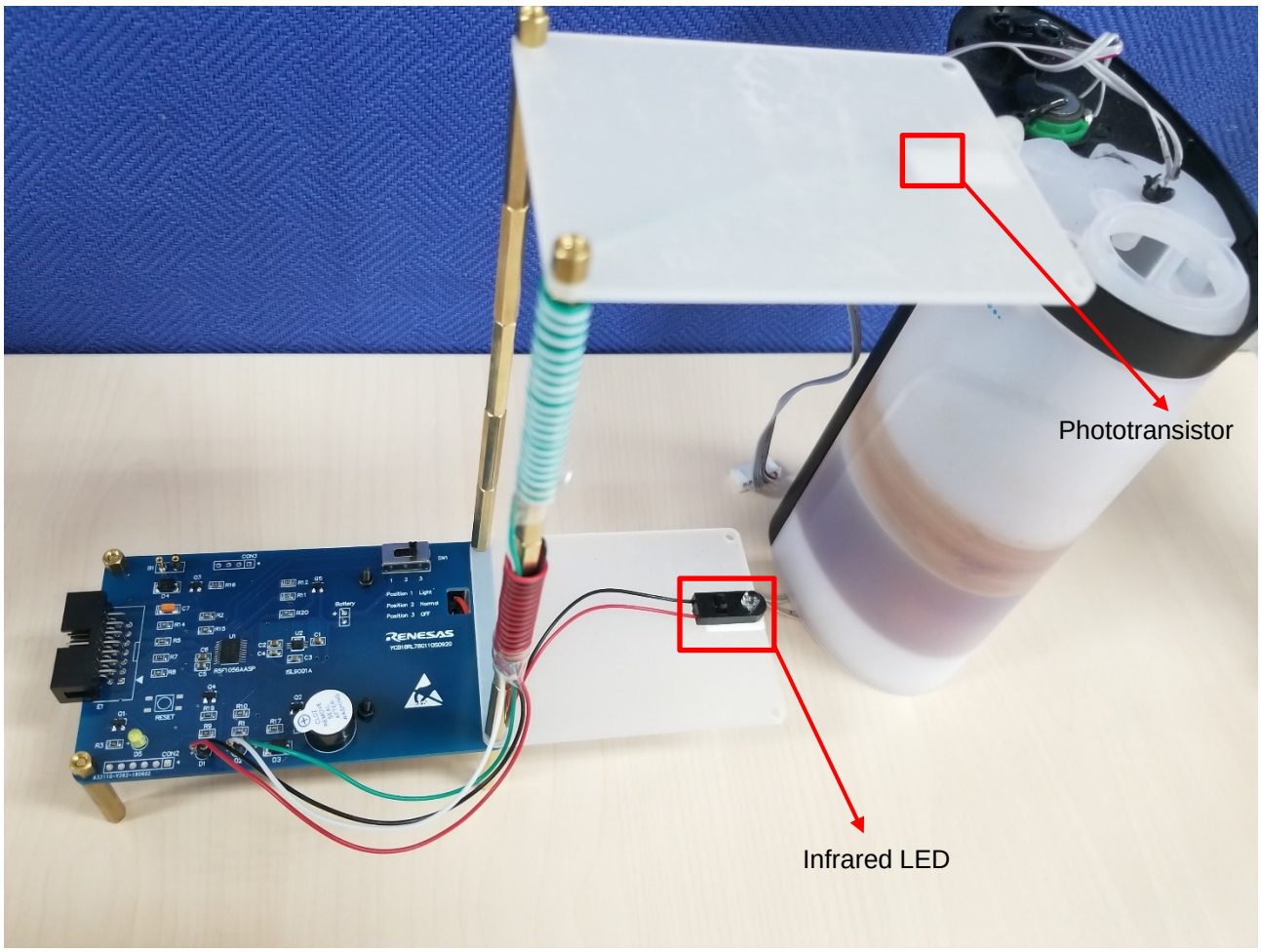

Figure 4.1 Board Picture

4.1 Power Supply

Figure 4.2 shows the schematic of power supply.

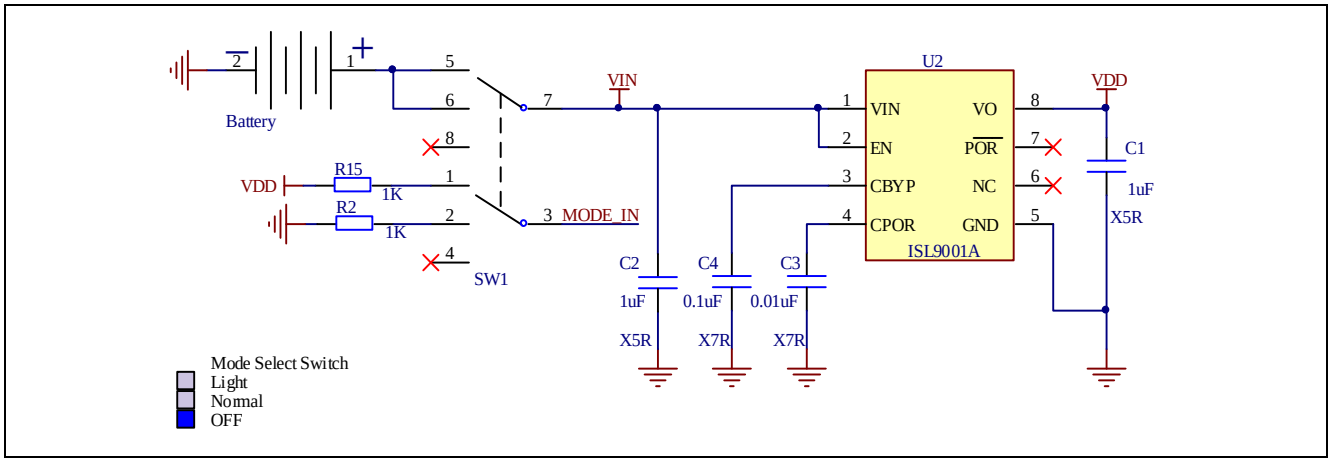

Figure 4.2 Power Supply

ISL9001AIRNZ-T is a high performance Low Dropout linear regulator capable of sourcing 300 mA current which is larger than the system current consumption.

3.3 V fixed output of ISL9001AIRNZ-T supplies power for MCU, infrared LED and phototransistor, LED and buzzer.

Extremely low quiescent current of 25 µA makes the battery life longer.

4.2 Infrared LED and Phototransistor

Figure 4.3 shows the schematics of infrared LED and phototransistor.

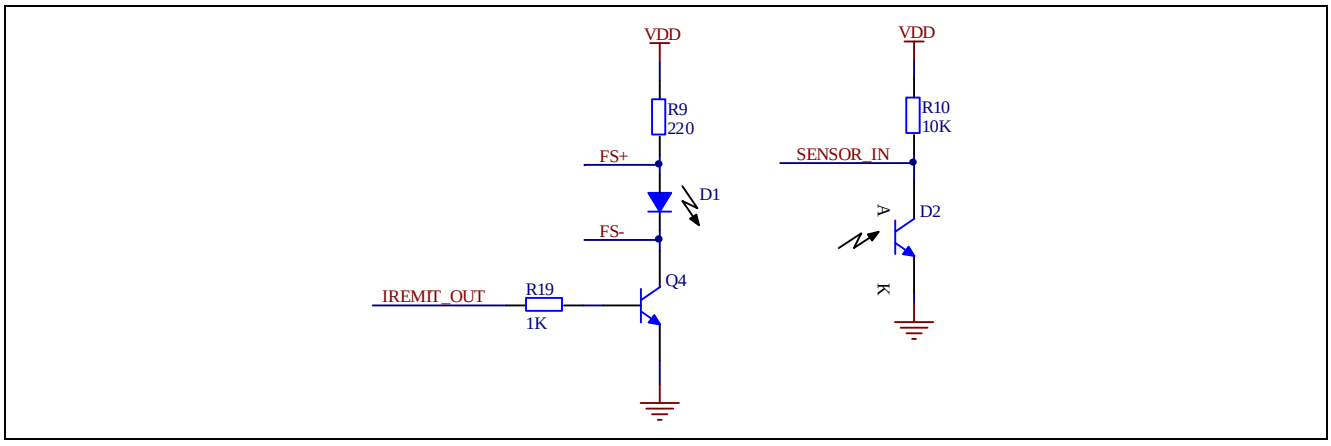

Figure 4.3 Infrared Emitter LED and Phototransistor

OPB100Z is used in this system for infrared emitter and sensor.

The OPB100Z series consists of an infrared LED (D1 in Figure 4.3) and phototransistor (D2 in Figure 4.3) in separate plastic housings. The emitter and sensor are not apertured, which allows separation distances in excess of 36" (91.4 cm) without concern for precise alignment.

When the LED emits radiation, it reaches the sensor and voltage on D2 collector is pulled down to low level. If there are hands cutting off the beam light emitted by infrared LED, the voltage on D2 collector goes high.

At fixed interval (50 milliseconds) MCU enables the LED emitting and checks the status of phototransistor to identify if hands are placed under the nozzle.

4.3 Buzzer Driver Circuit

Figure 4.4 shows the schematic of the buzzer driver circuit.

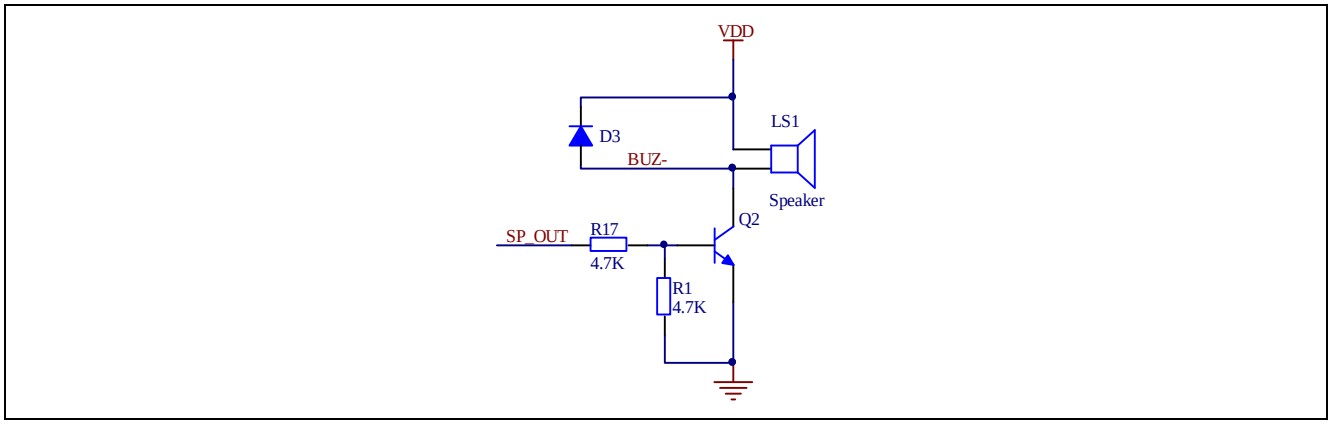

Figure 4.4 Buzzer Driver Circuit

The buzzer with 2300±500 Hz resonant frequency, 25 mA rated current and 3.5 V ~ 5.5 V rated voltage is used in the system to indicate liquid dispensing and battery low-voltage warning.

MCU outputs square wave of 1.8 kHz with PCLBUZ0 to SP_OUT to make the buzzer sound when hands are placed under the nozzle.

If the system detects the voltage of the battery is lower than 4.8 V, output of PCLBUZ0 is toggled between on and off every 50 milliseconds to indicate low power.

4.4 LED Driver Circuit

Figure 4.5 shows the schematic of the LED driver circuit.

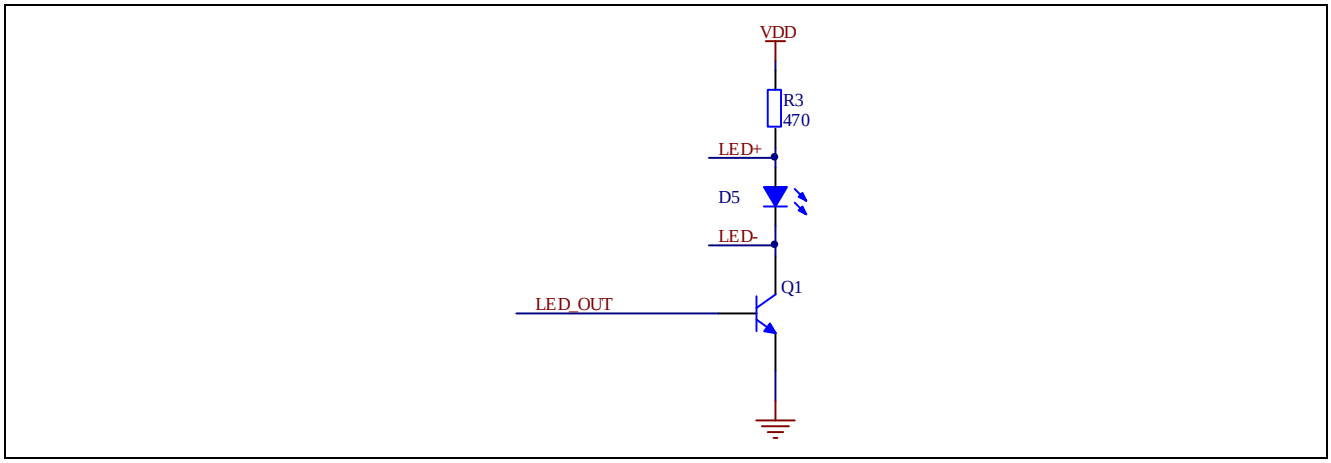

Figure 4.5 LED Driver Circuit

A basic yellow 3mm LED with 2.0 ~ 2.4 V forward drop, 20 mA maximum current and 40 ~ 100 mcd luminous intensity is used to indicate liquid dispensing in the system.

MCU drives the LED with PWM of Timer Array Unit to LED_OUT.

4.5 Motor Driver Circuit

Figure 4.6 shows the schematic of the motor driver circuit.

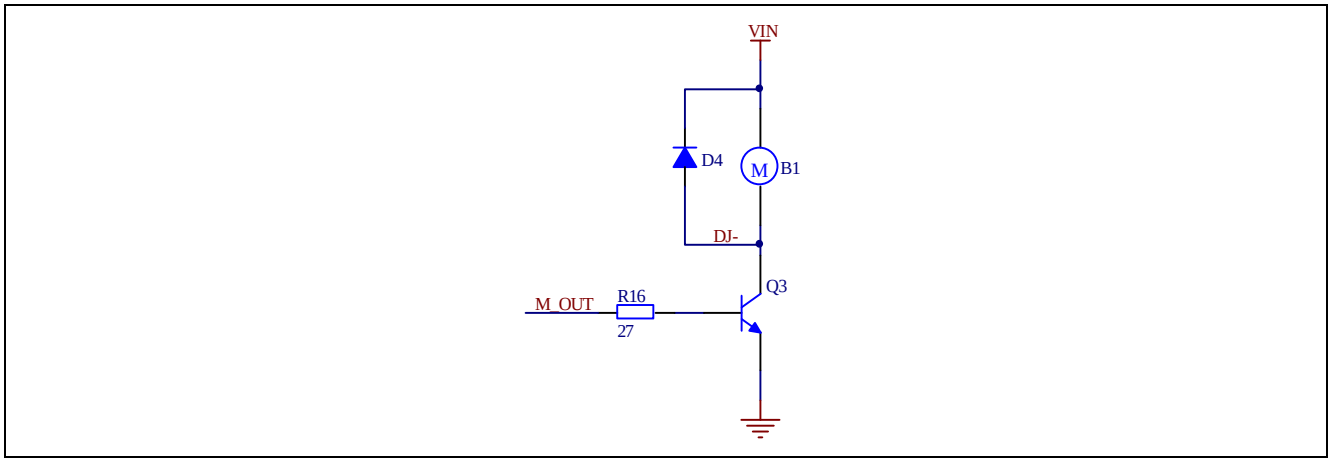

Figure 4.6 Motor Driver Circuit

DC motor of 5 V rated voltage, 0.49 mN·m rated load and 11600 min-1 is used in this system to drive the fan to pump liquid from tank.

MCU drives the motor with PWM of Timer Array Unit to M_OUT.

PWM with a duty cycle of 100% is used to drive motor for liquid pumping in NORMAL mode while 75% in LIGHT mode.

5. Software

5.1 Integrated Development Environment

The sample code described in this chapter has been checked under the conditions listed in the table below.

Table 5.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G11 (R5F1056AA)
Operating frequency	Middle-speed on-chip oscillator clock: 1 MHz CPU/peripheral hardware clock: 1 MHz
Operating voltage	3.3 V (can run on a voltage range of 2.7 V to 5.5 V.) SPOR detection voltage When power supply falls: TYP. 2.75V (2.70 V to 2.96 V) When power supply rises: TYP. 2.81V (2.76 V to 3.02 V)
Integrated development environment (CS+)	CS+ V6.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.05.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V6.0.0 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.05.00 from Renesas Electronics Corp.

5.2 Option Byte

Table 5.2 summarizes the settings of the option bytes.

Table 5.2 Option Byte Settings

Address	Value	Description
000C0H/010C0H	11101111B	Watchdog timer counter operation disabled (counting stopped after reset)
000C1H/010C1H	01111111B	LVD off
000C2H/010C2H	10101101B	Operating frequency: 1 MHz (1.8 V ~ 5.5 V)
000C3H/010C3H	00000100B	Disables on-chip debug operation

5.3 Operation Outline

The tasks of the entire system are listed as below: reset/initialization, STOP mode, normal dispensing, light dispensing and battery low voltage warning.

Figure 5.1 shows the block diagram for the tasks transition.

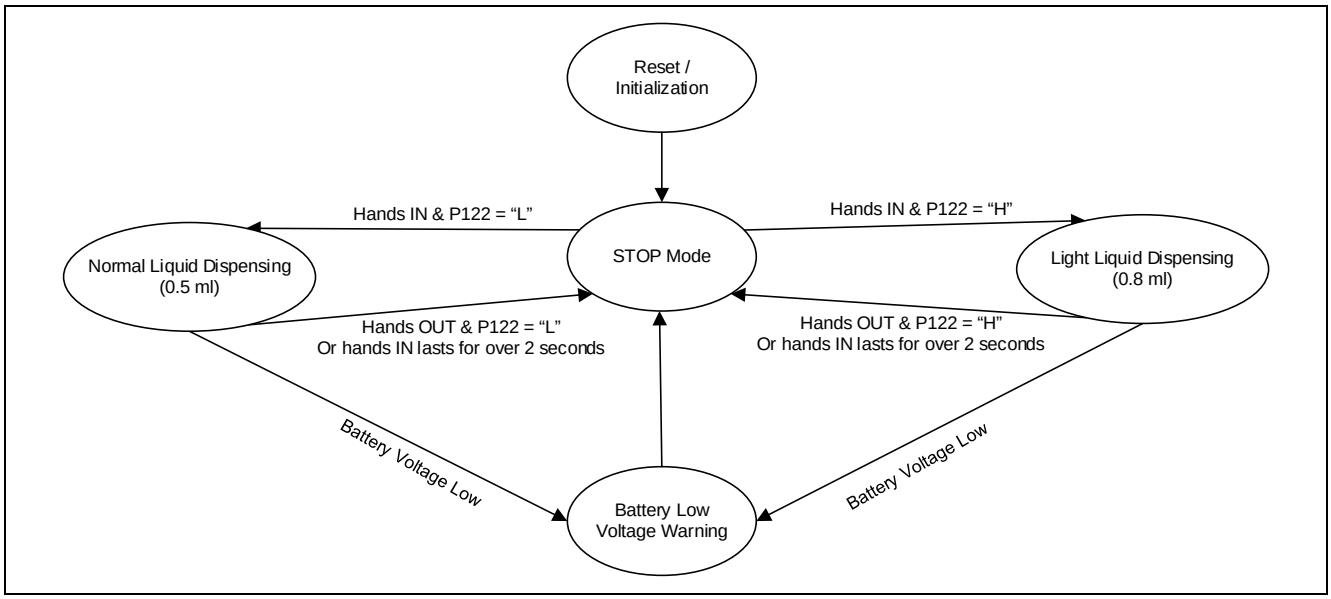

Figure 5.1 Tasks Transition Block Diagram

(1) Reset / Initialization

After OFF-Light-Normal is activated, the system is powered on and initialization routine of each module is executed.

(2) STOP Mode

After initialization, STOP mode is entered for low power consumption.

(3) Light Liquid Dispensing

OFF-Normal-Light switch is in Light position. When hands are detected between the infrared LED and phototransistor, motor is driven to pump liquid from tank. LED and buzzer are activated to indicate liquid dispensing.

(4) Normal Liquid Dispensing

OFF-Normal-Light switch is in Normal position. When hands are detected between the infrared LED and phototransistor, motor is driven to pump liquid from tank. LED and buzzer are activated to indicate liquid dispensing.

(5) Battery Low Voltage Warning

When battery voltage is lower than 4.8 V, each time hands are detected, buzzer is alarmed while LED and motor are kept not working.

5.4 Flow Chart

5.4.1 Main Processing

Figure 5.2 and Figure 5.3 show the flowchart for main processing routine.

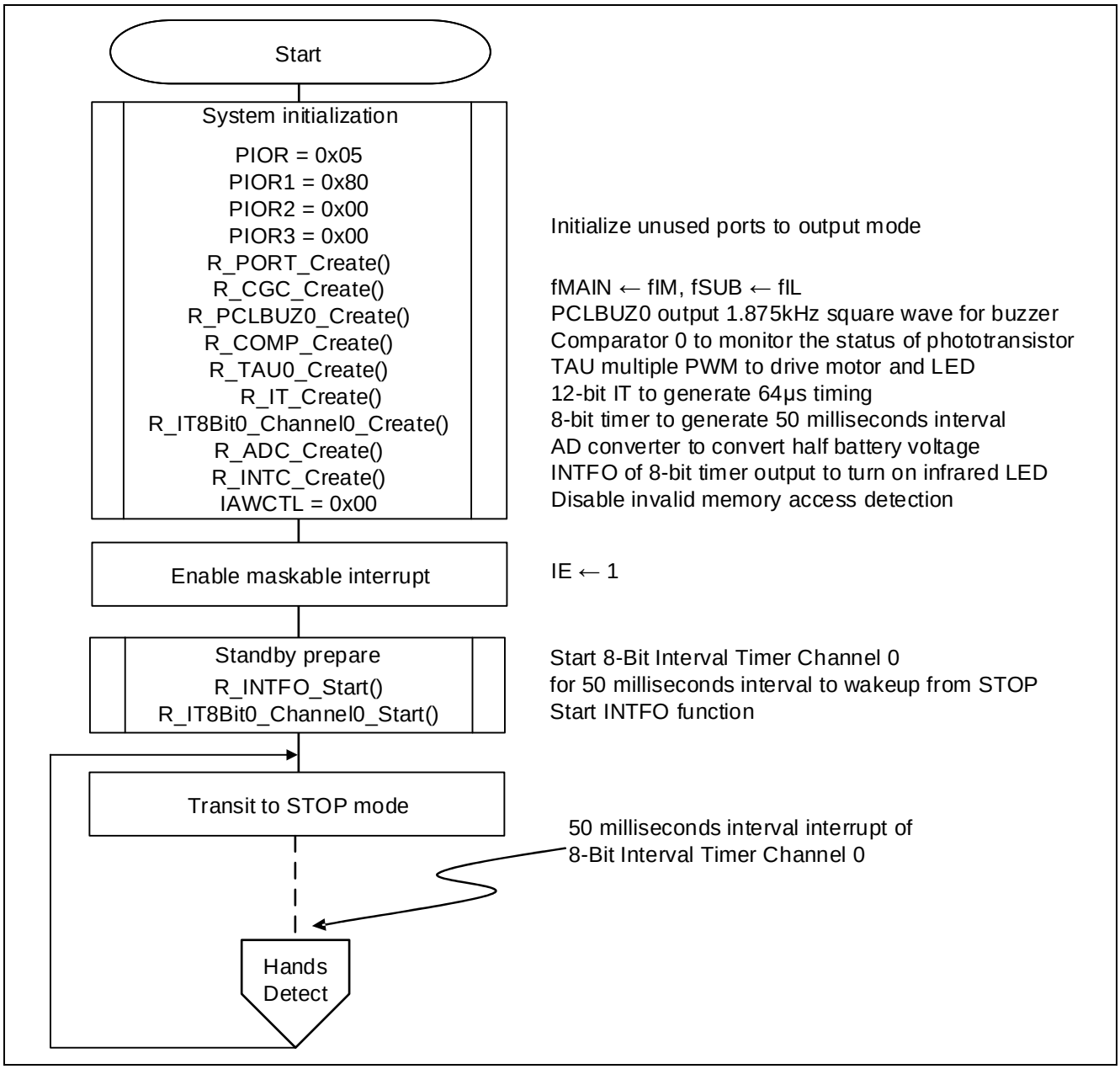

Figure 5.2 Main Processing (1)

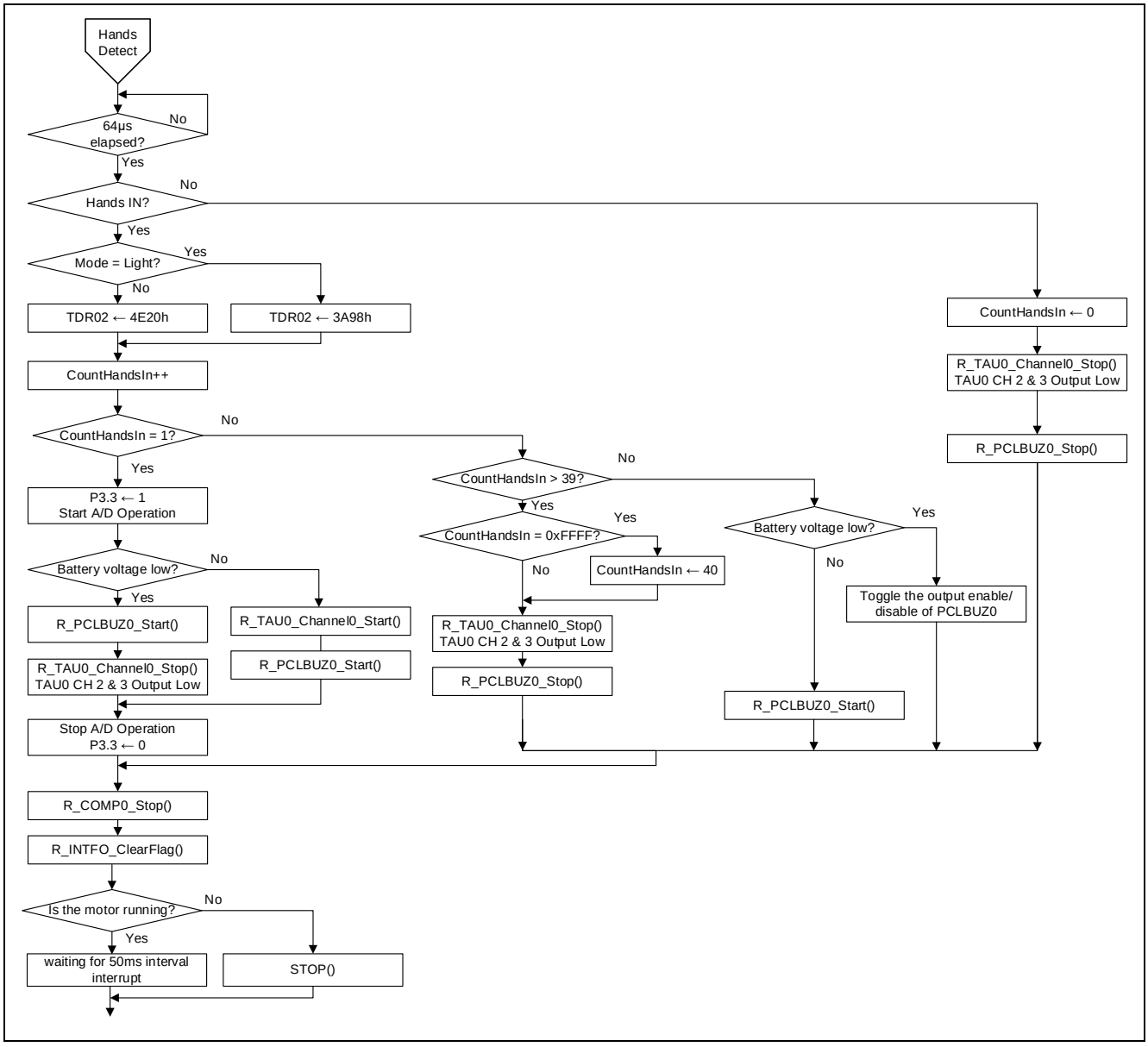

Figure 5.3 Main Processing (2)

5.4.2 8-Bit Interval Timer Interrupt

8-bit interval timer interrupt wakes up MCU from STOP mode every 50 milliseconds.

Figure 5.4 shows the flowchart for 8-bit interval timer.

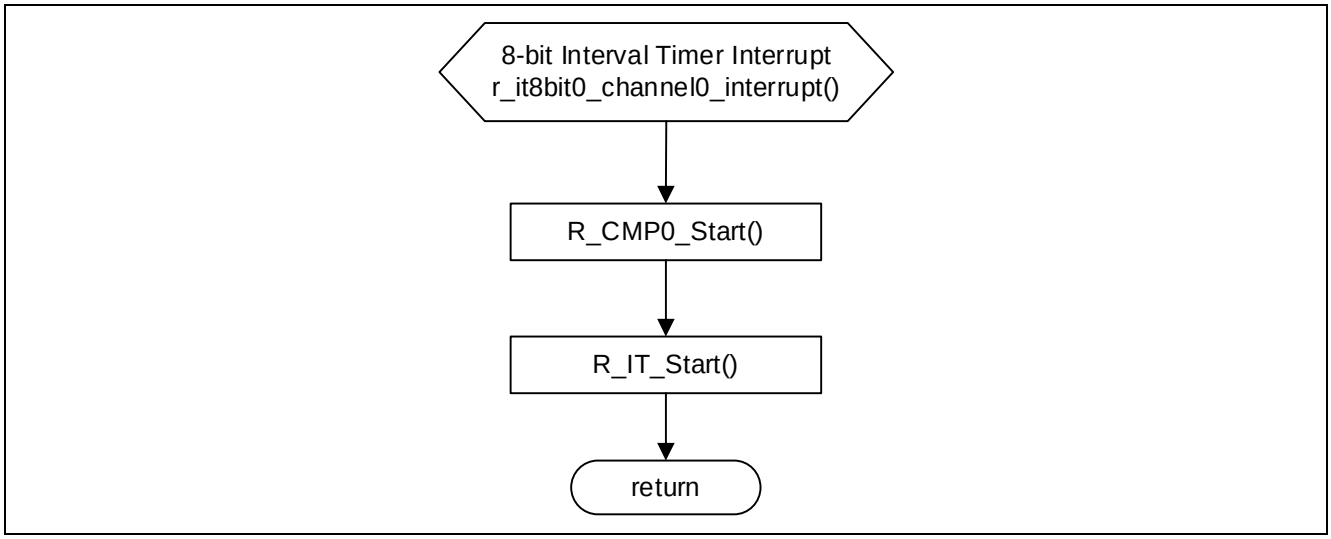

Figure 5.4 8-bit Interval Timer Interrupt

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

RL78/G11 User's Manual: Hardware (R01UH0637)

RL78 Family User's Manual: Software (R01US0015)

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

Technical Updates/Technical News

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Sep. 30, 2018	—	First edition issued
1.10	Dec. 31, 2018	15	Modified Figure 5.3

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.

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   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.

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