RL78/G10

Infrared Human Sensor

R01AN4069EC0100
Rev.1.00
Dec 31, 2017

Introduction

This document describes a Renesas microcontroller RL78/G10 application for an infrared human sensor.

Target Device

RL78/G10

When applying the sample program covered in this document 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

Renesas microcontroller RL78/G10 is a 10-pin LSSOP general purpose microcontroller, it is very suitable for assisted applications of household appliance, battery chargers, electric tools etc.

Based on the reflective infrared induction principle, this document describes a low-cost infrared human sensor. This sensor is inexpensive and provides energy saving, it is ideal for temporary lighting in entrances, porches, stairs and bathrooms. When people come close, the bulb lights up, and when they leave, the bulb goes out automatically.

1.2 Specifications and Main Technical Parameters

Technical Parameters

- Power supply: 220 VAC
- Low power consumption current (MCU): 0.5 ~ 1.5 m
- Lighting power: 1 W
- Lighting time: 10 s
- Relay output: 3A/250 VAC

Specifications

- Operating temperature: -40 °C ~ 85 °C
- Operating humidity: 0 ~ 100% RH

2. RL78/G10 Microcontroller

2.1 RL78/G10 Block Diagram

Figure 2.1 shows the block diagram of RL78/G10 (10-pin products).

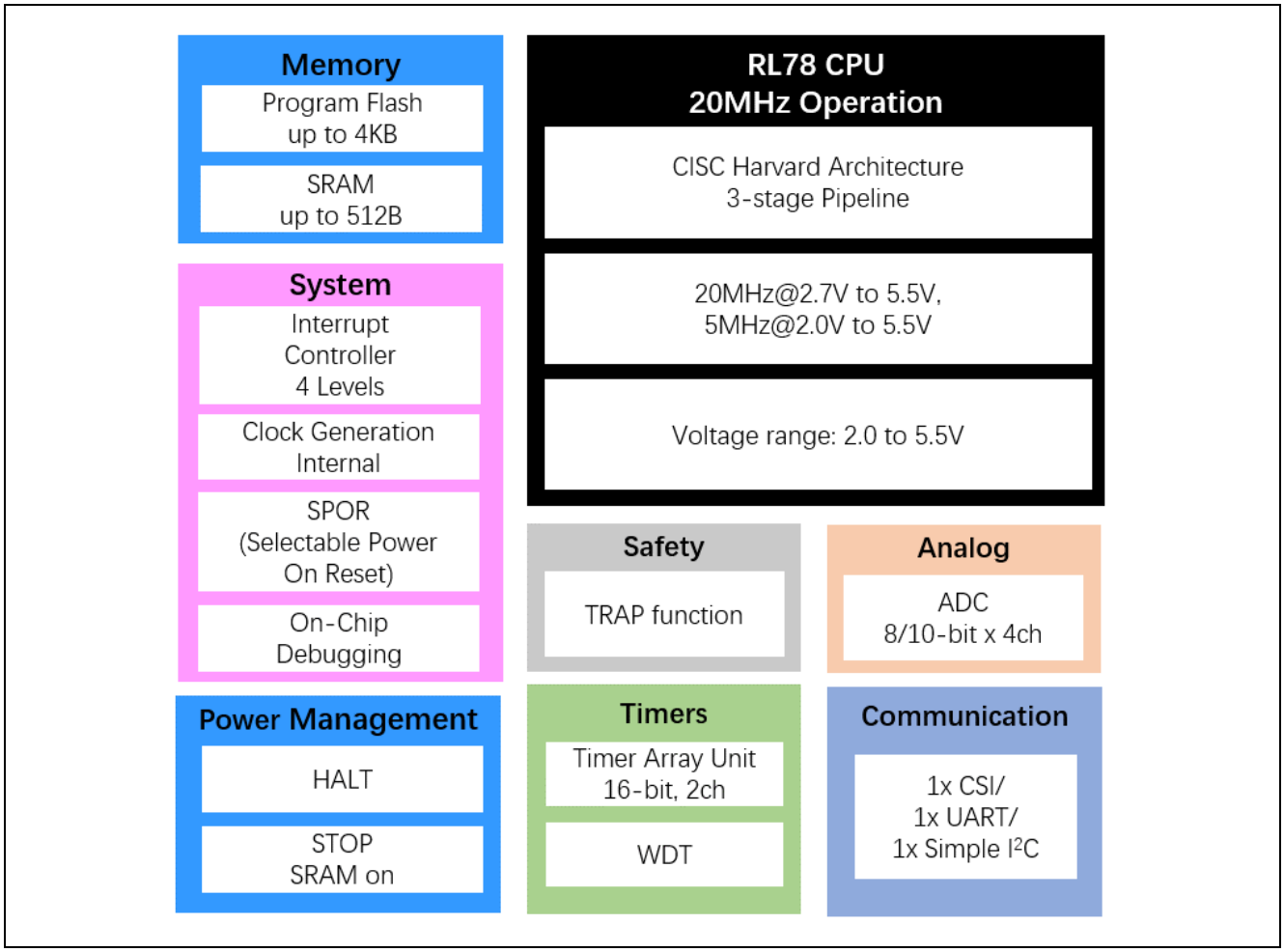

Figure 2.1 RL78/G10(10-pin products) Block Diagram

2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.05 μs @ 20 MHz operation with high-speed on-chip oscillator) to low speed (1.0 μs @ 1 MHz operation)
- General-purpose registers: 8-bit register × 8
- ROM: 1 to 4 KB, RAM: 128 to 512 bytes
- Selectable high-speed on-chip oscillator clock: 20/10/5/2.5/1.25 MHz (TYP.)
- On-chip single power supply flash memory
- On-chip debug function
- On-chip selectable power-on-reset (SPOR) circuit
- On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator)
- On-chip key interrupt function: 6 key interrupt input pins
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 8
- Timer
  8/16-bit timer: 2 channels
- Serial interface
  CSI: 1 channel
  UART: 1 channel
  Simplified I^2C communication: 1 channel
- 8/10-bit resolution A/D converter: 4 channels
- Standby function: HALT or STOP mode
- Power supply voltage: V_{DD} = 2.0 to 5.5 V
- Operating ambient temperature: T_A = -40 to +85 °C

RL78/G10 is widely used in small consumer electronics, includes of common technologies for industry, office, home appliance, healthcare, security and city application.

2.3 Pin Configuration

Figure 2.2 shows the pin configuration of RL78/G10.

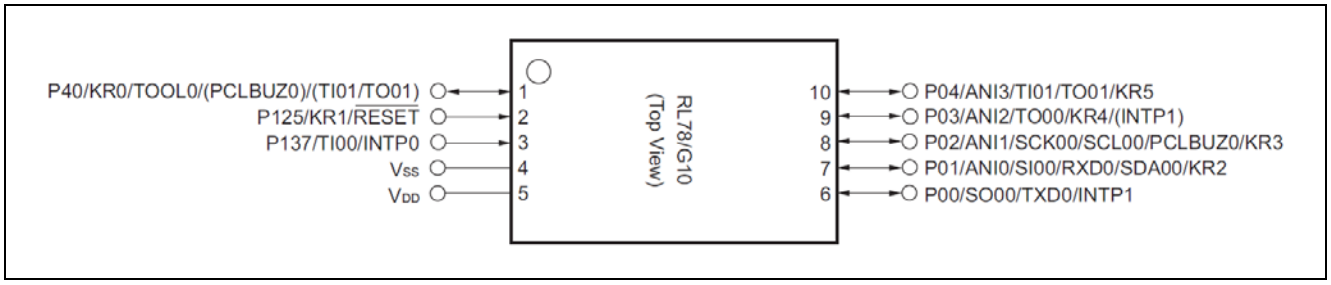

Figure 2.2 RL78/G10 Pin Configuration

3. System Outline

3.1 Principle Introduction

Figure 3.1 shows the system block diagram for this document.

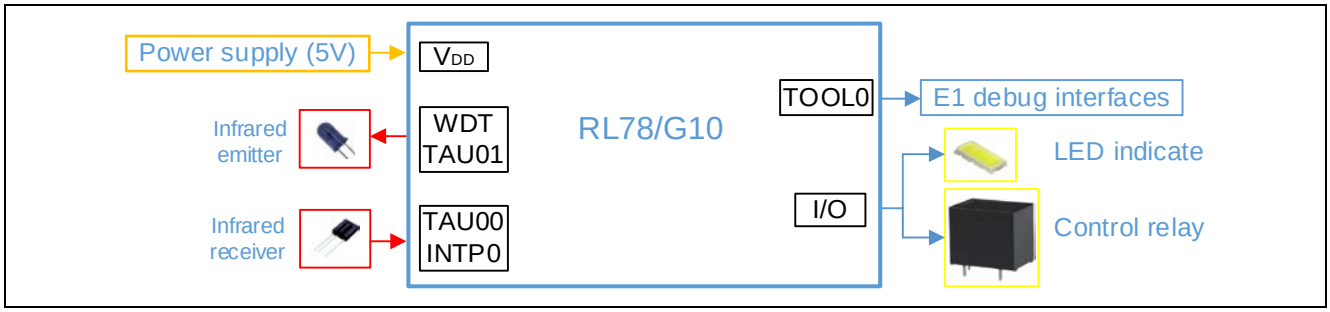

Figure 3.1 System Block Diagram

3.2 Peripheral Functions to be Used

Table 3.1 lists the peripheral functions to be used, as well as their usages.

Table 3.1 Peripheral Functions to be Used

Peripheral Function	Usage
Channel 0 of TAU0	Infrared receiver
Channel 1 of TAU0	Infrared emitter
Watchdog timer	Wake up MCU from STOP mode every 400ms
INTP0	Detect the infrared signal

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	Function	Description
P40/KR0/TOOL0/(PCLBUZ0)/(TI01/TO01)	TOOL0	On-chip debugging
P125/KR1/RESET	RESET	Hardware reset
P137/TI00/INTP0	INTP0	Infrared receiving signal input
V_{SS}	V_{SS}	Ground
V_{DD}	V_{DD}	Power supply voltage
P00/SO00/TXD0/INTP1	P00	Lighting circuit and relay output control
P04/ANI3/TI01/TO01/KR5	TO01	Infrared emitting driver control

3.4 Operating Instructions

After initialization, human body infrared detection is executed by the watchdog timers interrupt. To reduce the interference, the system uses a 40 kHz infrared carrier wave signal. During the infrared detection, MCU emits infrared signal in square wave output mode of TAU01. When the emitted infrared signal is reflected to an infrared receiving module by a human body, the output wave of the infrared receiving module is input to double edged of INTP0. In interval timer mode, TAU00 measures the interval time of the INTP0 interrupt, judging whether the human body is detected or not. If the human body is detected, MCU turns on LED lighting for 10 s through an I/O port, and when the LED is ON, infrared detection stops. After 10 s, LED goes out, MCU continues to detect whether the human body comes close or not according to the interval time controlled by watchdog timer interrupt.

4. Hardware

This section describes the circuits related to MCU, including the power supply circuit, the infrared signal emit circuit, the infrared receiving detection circuit, LED lighting and the relay driver circuit.

Figure 4.1 shows the picture of the infrared human sensor board.

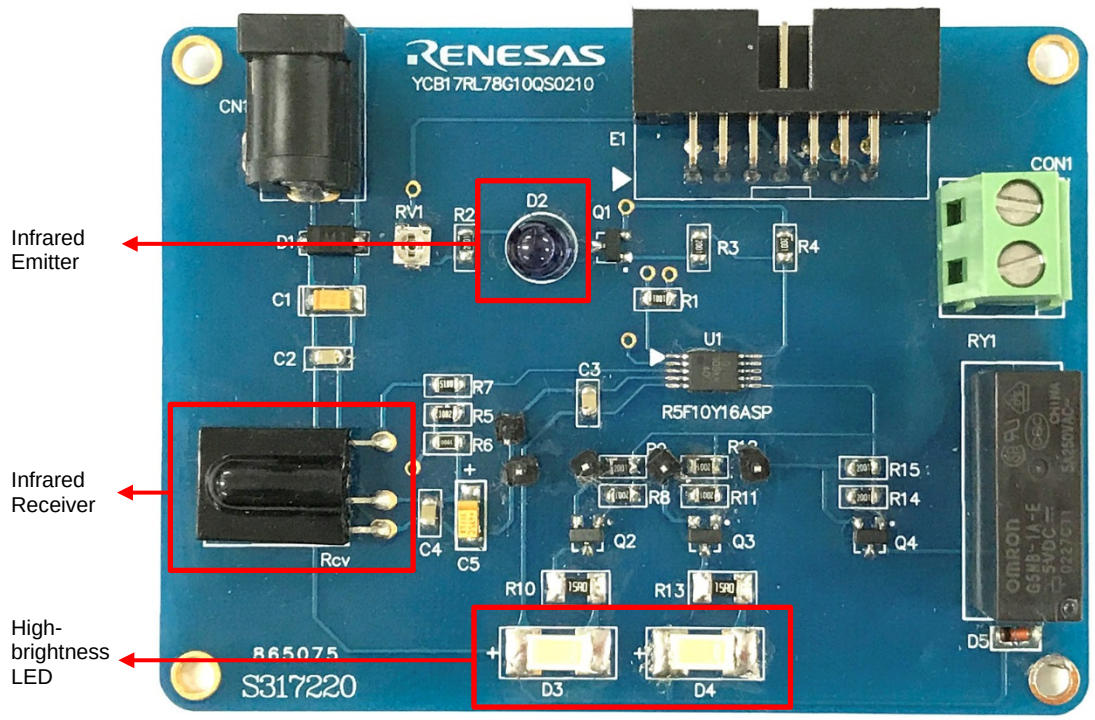

Figure 4.1 Picture of the Infrared Human Sensor Board

4.1 Power Supply Circuit

Figure 4.2 shows the schematics of the power supply circuit.

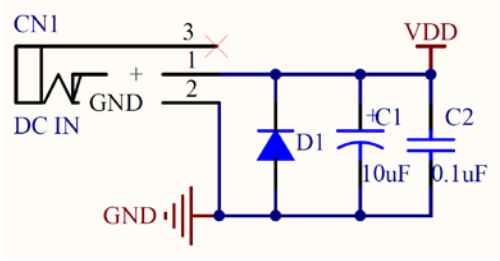

Figure 4.2 Power Supply Circuit

The power supply in this system uses 220 V to 5 V AC power transformer and full bridge rectifier circuit. After full bridge rectification, power supply provides 5 V DC by connecting a voltage regulator named 7805 in series. The power supply is about 2 W, which meets the operating requirements of lighting, relay and MCU.

4.2 Infrared Signal Emitting Circuit

Figure 4.3 shows the schematics of the infrared signal emitting circuit.

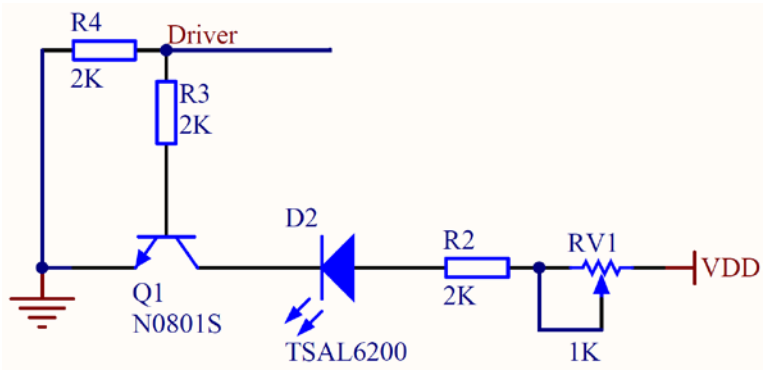

Figure 4.3 Infrared Signal Emitting Circuit

The infrared detection function in this system includes both an infrared signal emitting circuit, and an infrared receiving detection circuit. Infrared emitting tube TSAL6200, produced by VISHAY Corporation, emits the infrared signal. The signal generated by TAU01 is output from TO01, and it is driven by Renesas NPN triode N0801S. The operating power of the infrared emitting tube can be regulated by RV1, note that enhancing emitting power can extend the detection distance. It must also be noted that the setting angle of this solution will distinguish the detected object from the background interference, such as the wall, etc.

In order to enhance the detection sensitivity and reliability, infrared detection uses an infrared carrier wave signal with 40 kHz carrier wave frequency. Figure 4.4 shows the definition of infrared carrier wave signal. The carrier wave signal emitted each time by the infrared emitter is "0101B" according to the definition in Figure 4.4.

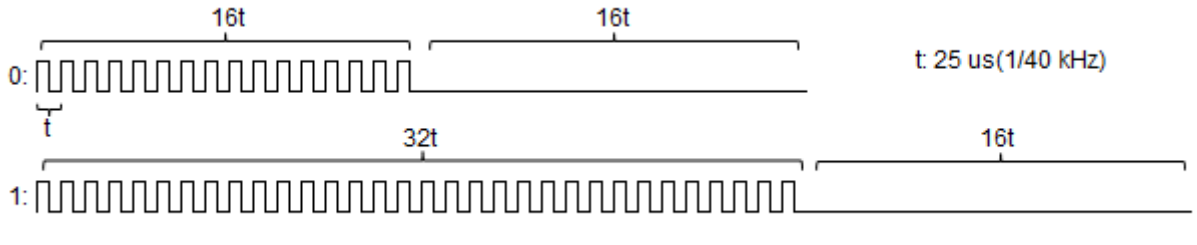

Figure 4.4 Infrared Emitting Carrier Wave Signal Definition

4.3 Infrared Receiving Detection Circuit

Figure 4.5 shows the schematics of the infrared receiving detection circuit.

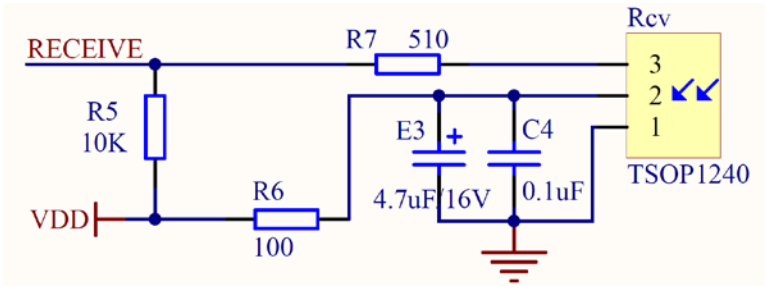

Figure 4.5 LED Driver Circuit

The infrared detection function in this system includes an infrared signal emitting circuit, as well as an infrared receiving detection circuit. Integrated infrared receiving head TSOP1240 produced by VISHAY Corporation receives and detects the infrared signal. If no infrared carrier wave signal is input, the output port of integrated infrared receiving head TSOP1240 will output a high level. When the infrared carrier wave signal, reflected by a human body, is received the integrated infrared receiving head TSOP1240 outputs a modulated characteristic curve. Figure 4.6 shows the characteristic curve in this solution. The modulation signal from the infrared receiving head is output to INTP0 pin, and the INTP0 interrupt with double edges will occur. TAU00 measures the waveform toggle time, depending on this toggle time the MCU can judge whether a person has come close or not.

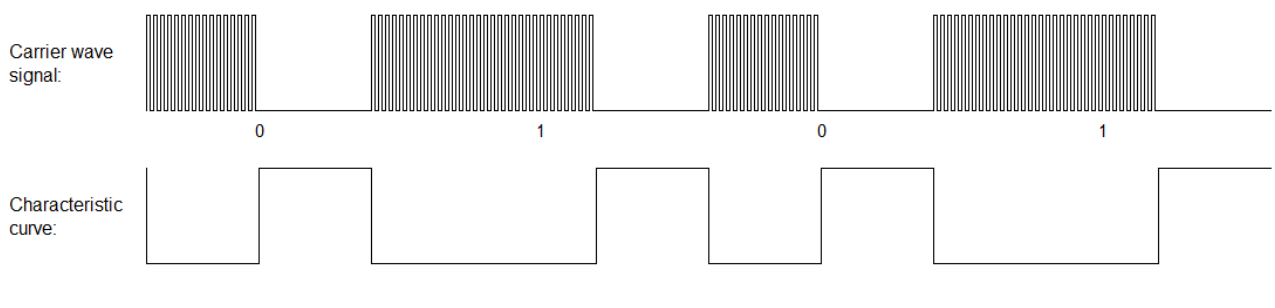

Figure 4.6 Characteristic Curve Outputted from Infrared Receiving Head

4.4 LED Lighting and Relay Driver Circuit

Figure 4.7 shows the schematics of the LED lighting and relay driver circuit.

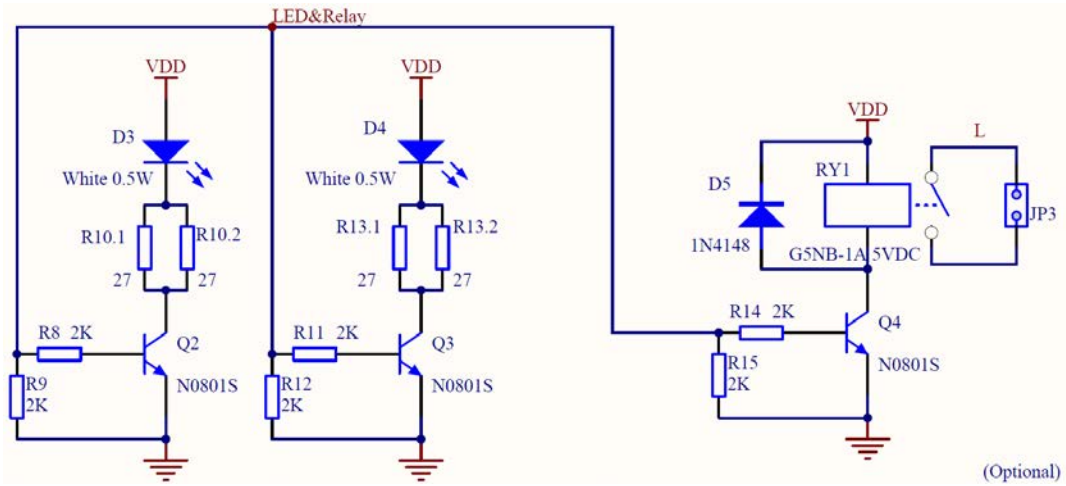

Figure 4.7 LED Lighting and Relay Driver Circuit

The LED lighting circuit in this system includes two high-brightness LEDs with SMD package in parallel, each of them is about 0.5 W and driven by Renesas NPN triode N0801S. OMRON single channel relay G5NB-1A driven by Renesas NPN triode N0801S can control the external related devices, such as an external lighting device.

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/G10 (R5F10Y16)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 20 MHz CPU/peripheral hardware clock: 20 MHz
Operating voltage	4.5V (can run on a voltage range of 2.7 V to 5.5 V.) SPOR detection voltage When power supply falls: TYP. 4.2V When power supply rises: TYP. 4.28V
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 (e2 studio)	e2 studio V6.0.0 from Renesas Electronics Corp.
C compiler (e2 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	11111010B	Enables the watchdog timer. (Starts counting after the release from the reset state.) Interval interrupt time: 546.07 ms
000C1H	11110011B	SPOR detection voltage When power supply falls: TYP. 4.2V When power supply rises: TYP. 4.28V
000C2H	11111001B	Operating frequency: 20 MHz (2.7 V ~ 5.5 V)
000C3H	10000101B	Enables the on-chip debugger.

5.3 Operation Outline

The tasks of the whole system are listed as below: reset/initialization task, timing interrupt service, infrared signal emitting task, infrared signal receiving task, receiving detection judgment task and LED lighting and relay control task.

Figure 5.1 shows the block diagram for the tasks transition.

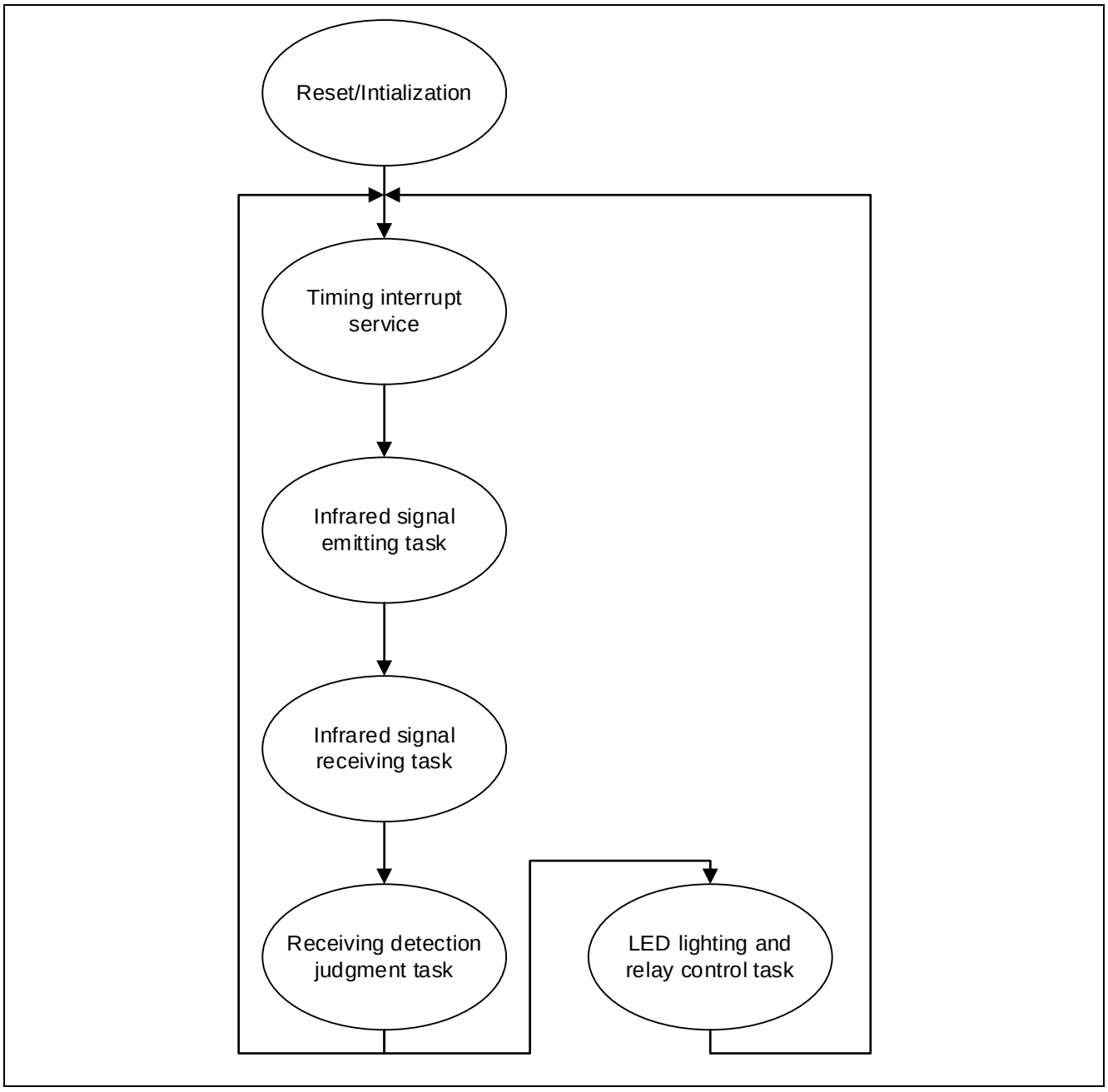

Figure 5.1 Tasks Transition Block Diagram

(1) The Reset/Initialization Task

After the system is powered on, it executes reset/initialization task. In this task, the system status and related variables will be initialized.

(2) The Timing Interrupt Service

The system uses watchdog timer timing interrupts, TAU00 and TAU01. It sets an operation flag every 400 ms for watchdog timer interrupt service, and sets infrared signal output operation flag in the TAU01 interrupt service, and increases the receiving waveform timing counter to calculate the length of the receiving wave in the TAU00 interrupt service.

(3) The Infrared Signal Emitting Task

When the system is idle, it enters infrared detection status every 400 ms. In infrared detection mode, the system executes an infrared signal emitting task and infrared receiving detection task at the same time. In the infrared signal emitting task, the system makes infrared emitting tube emit an infrared carrier wave signal of 40 kHz through the TO01 pin of TAU01. The carrier wave in Figure 4.5 shows the infrared signal waveform.

(4) The Infrared Signal Receiving Task

In infrared detection status, the system executes the infrared signal emitting task and the infrared receiving detection task at the same time. Integrated infrared receiving head modulates infrared carrier wave signal and generates a characteristic curve waveform. The characteristic curve waveform is input to INTP0 pin and an interrupt with double edge occurs. INTP0 interrupt makes TAU00 start to count and record the counter value of waveform toggle. The characteristic curve in Figure 4.5 shows the input waveform of INTP0 pin.

(5) The Receiving Detection Judgment Task

In infrared detection status, system compares the TAU00 counter value, controlled and recorded by the INTP0 interrupt, with a pre-set characteristic wave counter array value. If the compared difference, which is calculated from the first edge interrupt to the last edge interrupt is within the allowable range, the detected object can be confirmed and system transits to detection confirmation status.

(6) The LED Lighting and Relay Control Task

In detection confirmation status, system executes LED lighting and relay control task. In this task, the signal from I/O is amplified to drive the LED and relay. At the same time the infrared detection function for every 400 ms is stopped. After 10 s, the LED lighting and relay turns off, system transits to system idle status.

5.4 Flow Chart

5.4.1 Main Processing

Figure 5.2 shows the flowchart for main processing routine.

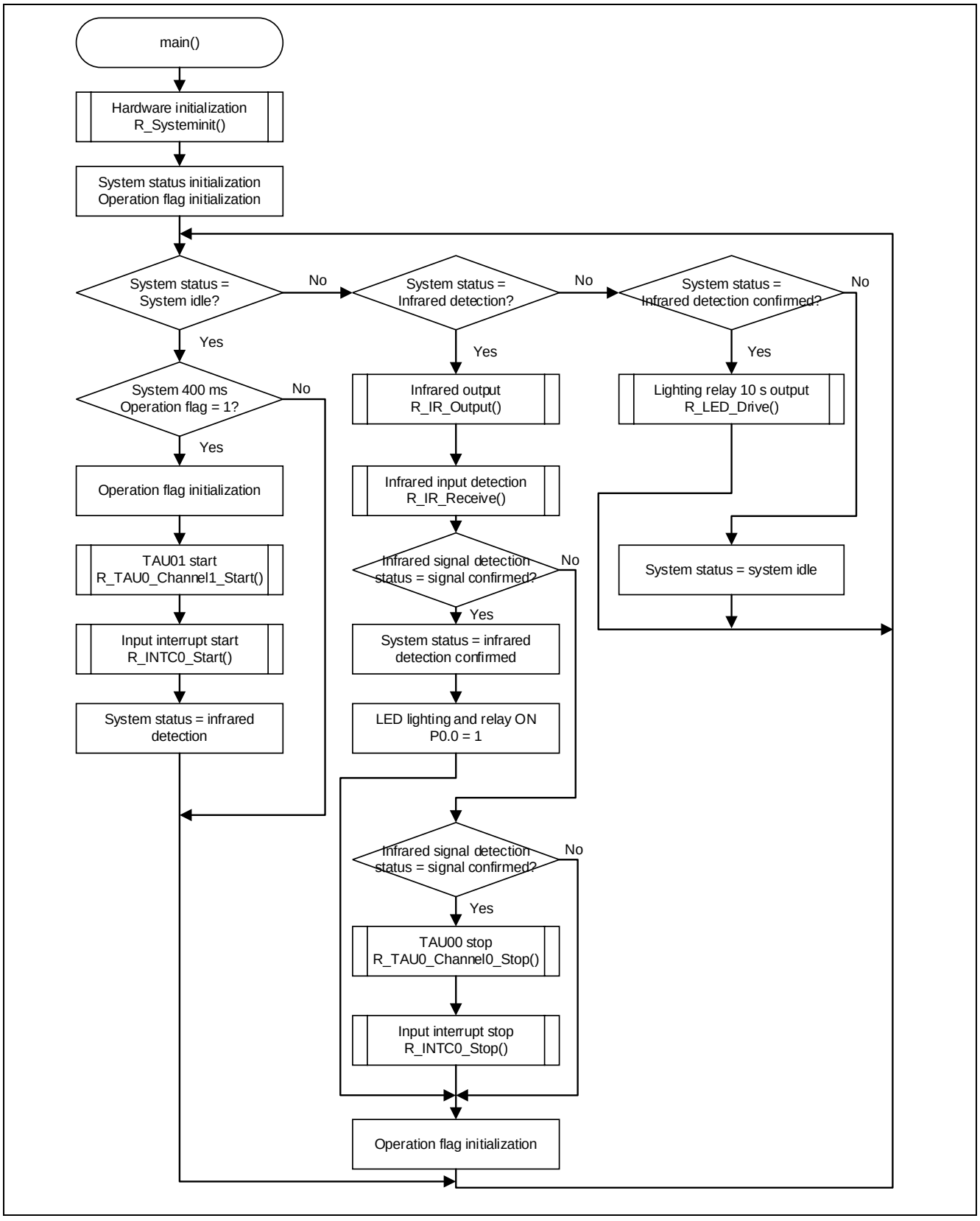

Figure 5.2 Main Processing

5.4.2 Infrared Signal Emitting Processing

Figure 5.3 shows the flowchart for infrared signal emitting processing.

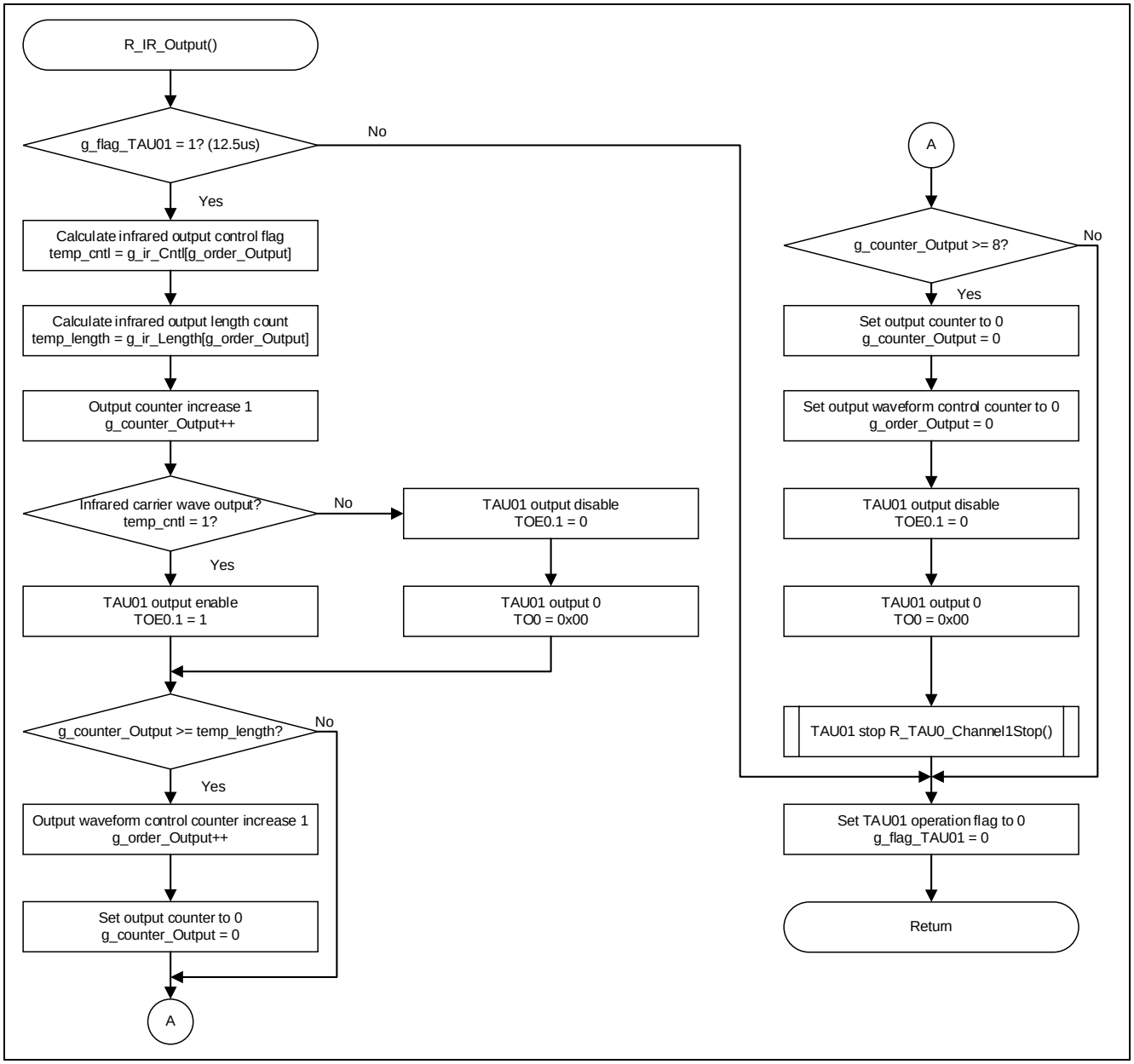

Figure 5.3 Infrared Signal Emitting Processing

5.4.3 Infrared Receiving Detection Processing

Figure 5.4 shows the flowchart for the infrared receiving detection processing.

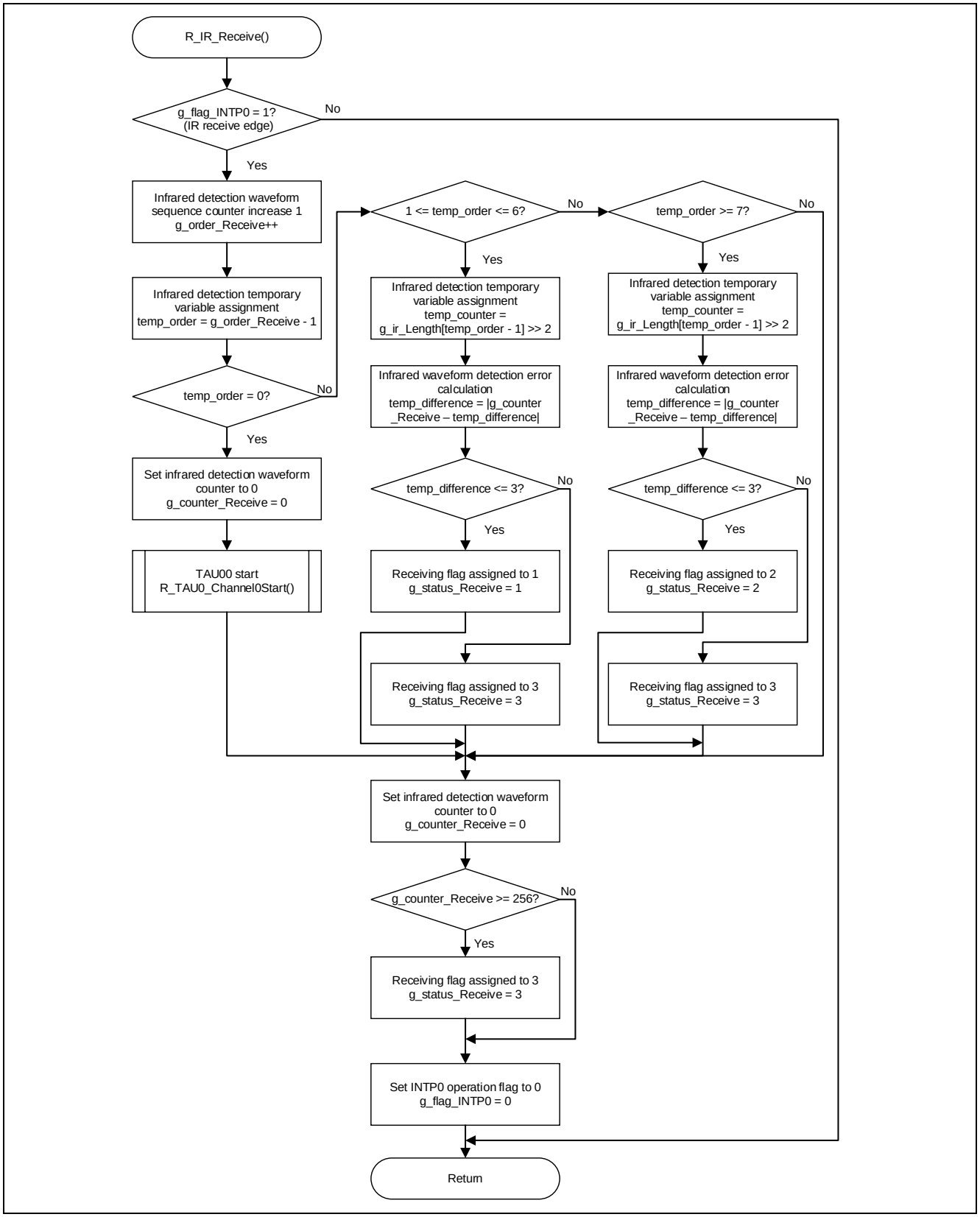

Figure 5.4 Infrared Receiving Detection Processing

5.4.4 LED Lighting and Relay Control Processing

Figure 5.5 shows the flowchart for the LED lighting and relay control processing.

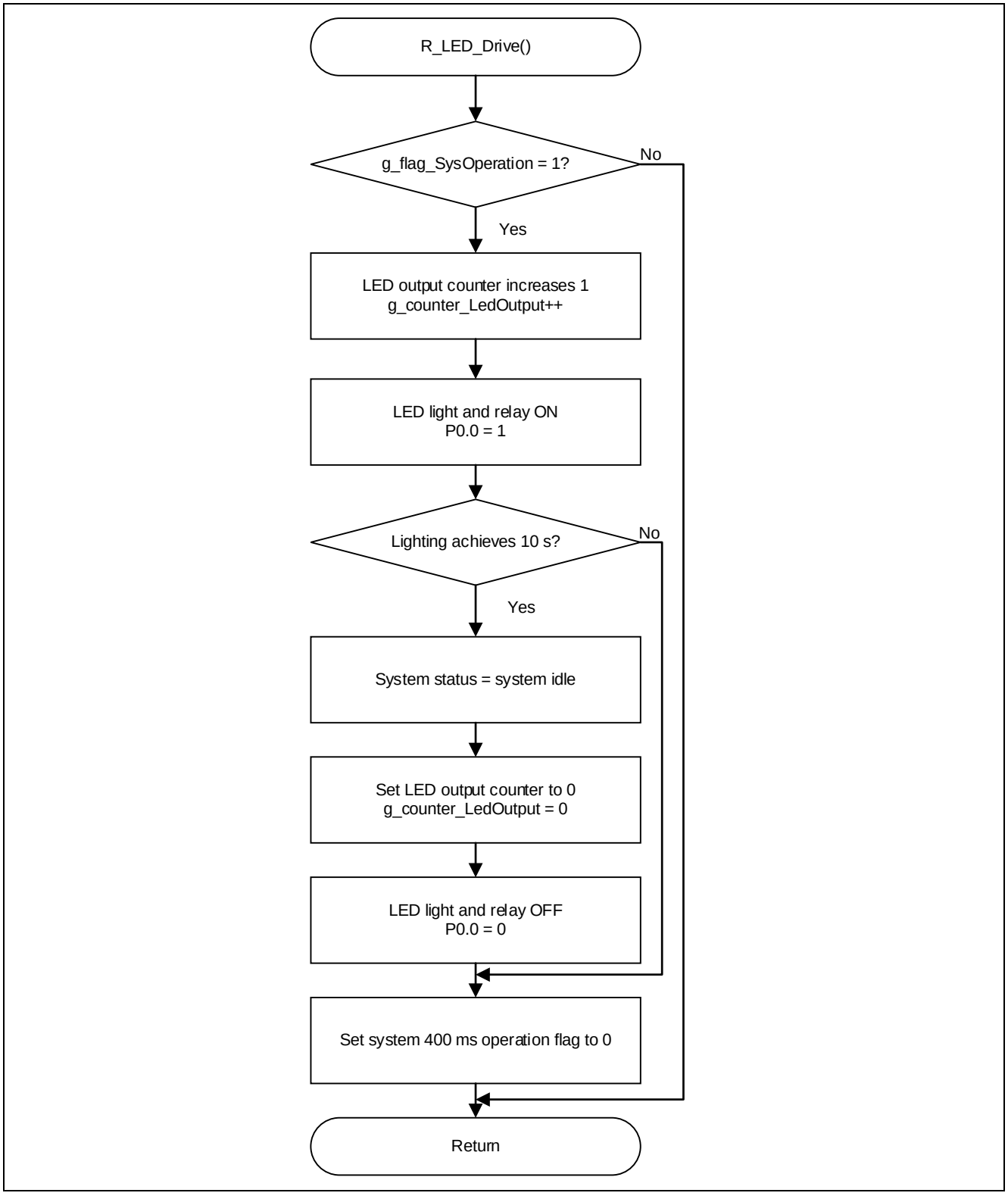

Figure 5.5 LED Lighting and Relay Control Processing

5.4.5 Interrupt Processing

Figure 5.6 shows the flowchart for the interrupt processing.

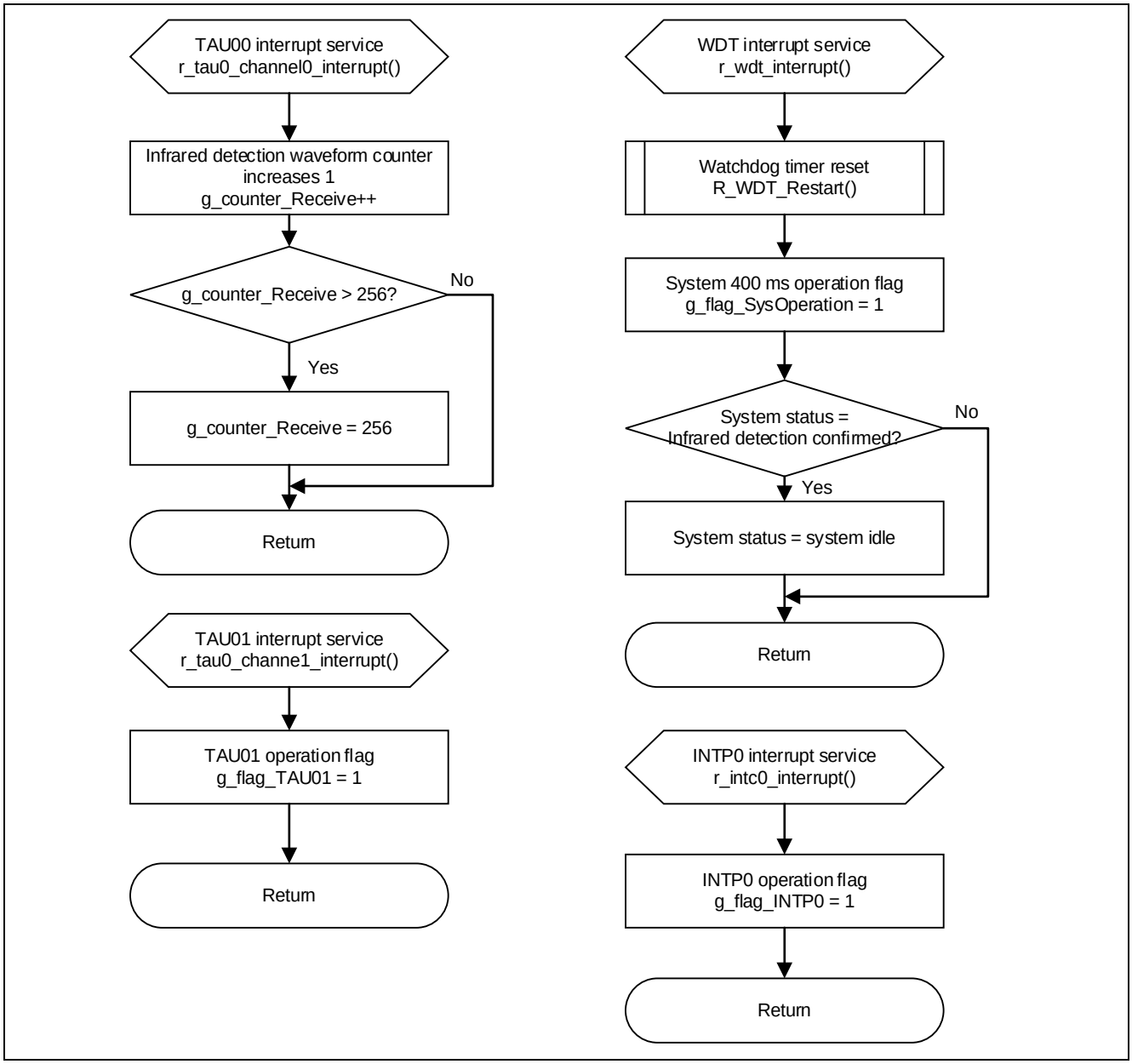

Figure 5.6 Interrupt Processing

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

RL78/G10 User's Manual: Hardware (R01UH0384)

RL78 Family User's Manual: Software (R01US0015)

(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.)

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Dec. 31, 2017	—	First edition issued

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

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1. Handling of Unused Pins

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   — 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.
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   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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(Rev.3.0-1 November 2016)

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