

## RL78 Family

### Infrared communication sample software using SIS (using low-power mode)

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#### Introduction

This application note describes a sample application that performs infrared reception using the IR Receiver Driver module SIS (Software Integration System).

This program uses the RL78's low-power modes (HALT mode and STOP mode) to reduce power consumption.

#### Target Device

RL78/G24

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## 1. Specifications Overview

This application note describes a sample application that implements a slave function in infrared (IR) communication.

The IR Receiver Driver module SIS is used for the infrared communication protocol stack in the sample application.

For the IR Receiver Driver module SIS, please refer to the following documents for more information:

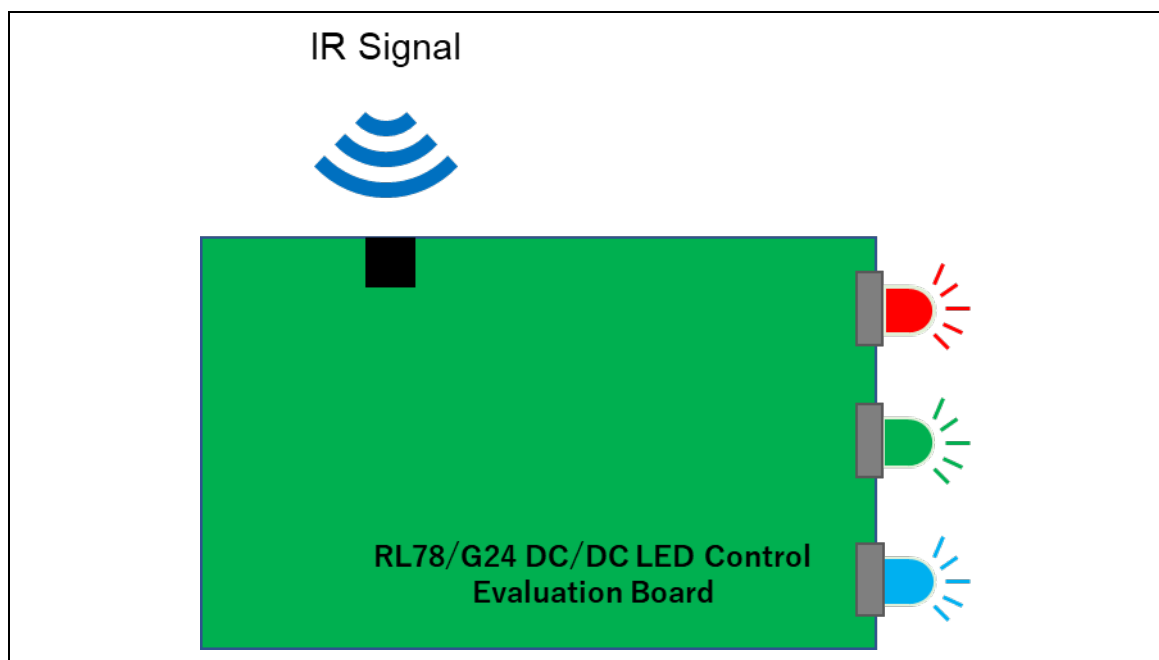
- RL78 Family IR Receiver Module Software Integration System (R01AN7215)

The following is a diagram of the operation of the sample application. The sample application works with the RL78/G24 DC/DC LED Control Evaluation Board. The three LEDs on the slave board are used as illuminators, and the LEDs are dimmed according to the data received by the infrared receiver.

In addition, depending on the reception status of the infrared signal and the lighting status of the LED, it is possible to transition to HALT mode or STOP mode\*1 to reduce power consumption.

注1. STOP mode is an optional feature.

illustration 1-1 Overview of IR Receiver Sample Application



## 2. Operation check conditions

The sample application has been tested in the following environments.

table 2.1 Operating environment

| item                                     | substance                                                                                                                                                                                     |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Microcontrollers used                    | RL78/G24 (R7F101GLG2DFB)                                                                                                                                                                      |
| Boards used                              | Renesas Electronics<br>RL78/G24 DC/DC LED Control Evaluation Board                                                                                                                            |
| Operating Frequency                      | <ul style="list-style-type: none"><li>• High-speed on-chip oscillator clock (fHOCO): 8 MHz</li><li>• PLL clock (fPLL): 96MHz</li><li>• CPU/peripheral hardware clock (fCLK): 48 MHz</li></ul> |
| Operating Voltage                        | 5.0V                                                                                                                                                                                          |
| Integrated Development Environment (CS+) | Renesas Electronics<br>CS+ for CC 8.10.00                                                                                                                                                     |
| C Compiler (CS+)                         | Renesas Electronics<br>CC-RL V1.12.01                                                                                                                                                         |
| Integrated Development Environment (IAR) | Manufactured by IAR Systems<br>IAR Embedded Workbench IDE V5.10.3                                                                                                                             |
| C Compiler (IAR)                         | Manufactured by IAR Systems<br>IAR C/C++ Compiler for Renesas RL78 V5.10.3                                                                                                                    |
| Smart Configurator (SC)                  | V1.8.0                                                                                                                                                                                        |
| emulator                                 | E2 Emulator Lite                                                                                                                                                                              |

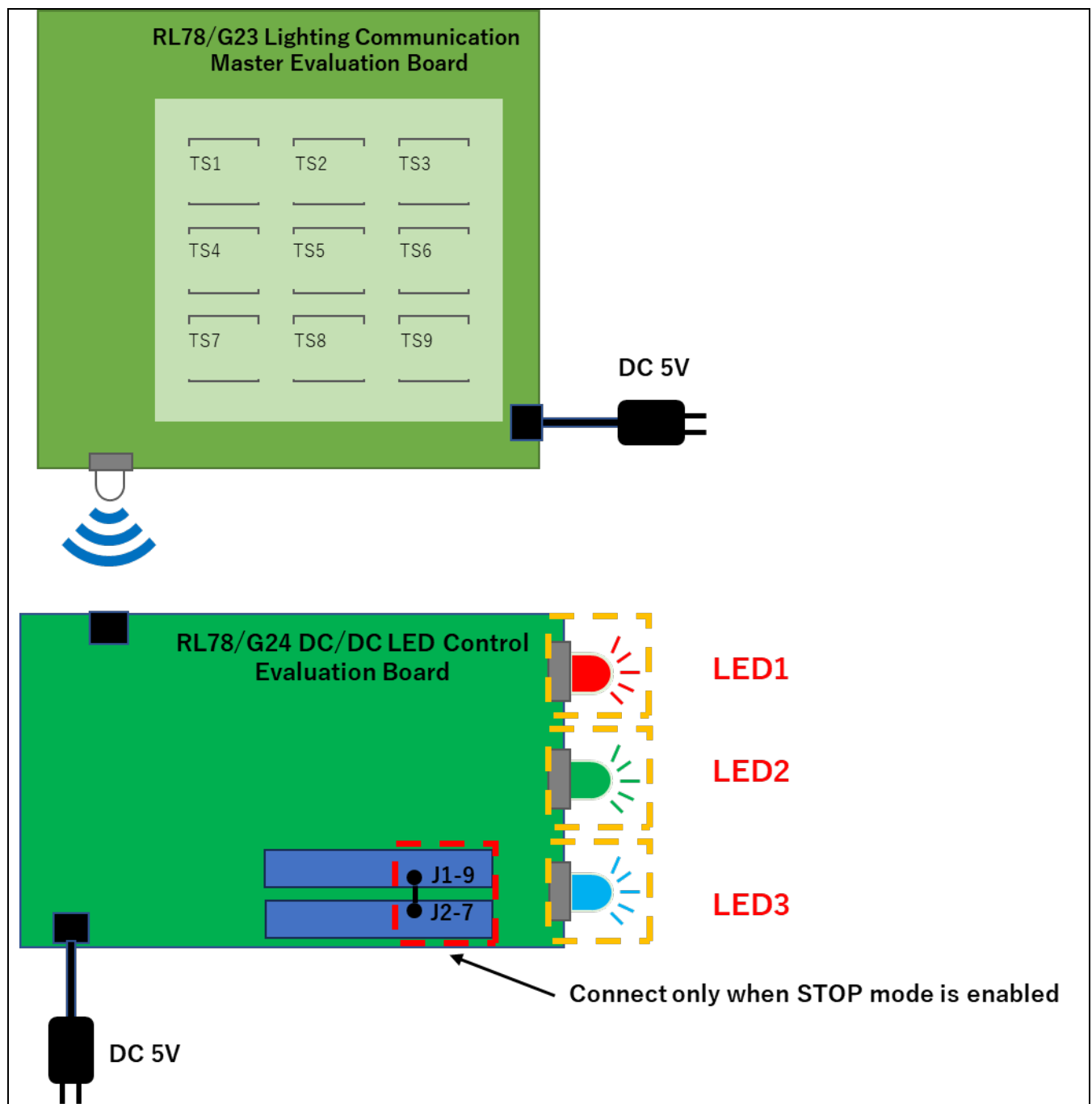
### 3. Hardware Description

#### 3.1 System configuration

The configuration of the system is shown below.

The RL78/G23 Lighting Communication Master Evaluation Board (master board) is used as a counterweight to transmit the infrared signal of this sample application, and the RL78/G24 DC/DC LED Control Evaluation Board ( Slave side board).

illustration 3-1System Configuration Diagram



### 3.2 List of terminals used

The terminals and functions of the receiving devices used in the sample application are shown below.

table 3.1 Pins and Functions Used (Master)

| Pin Name  | I/o   | substance                                                                        |
|-----------|-------|----------------------------------------------------------------------------------|
| P17/TI02  | input | IR receiver terminal                                                             |
| P50/INTP1 | input | External interrupt pin when STOP mode is canceled<br>(when STOP mode is enabled) |

## 4. Software Description

### 4.1 Environment construction

#### 4.1.1 Software Installation

In order to write the firmware, the flash programming software Renesas Flash Programmer (hereinafter abbreviated as RFP) is required. Please download it from the Renesas Electronics website.

For basic operations of RFP, refer to the following user's manual.

- Renesas Flash Programmer V3.13 Flash Programming Software User's Manual(R20UT5352)

#### 4.1.2 Writing Firmware

Write the target firmware to the master and slave boards. Motorola in the project folder • Since the file in S type format is stored, Use RFP and flash writing. For information about the storage folder, see 4.5.1 Folder Structure Please check more.

Master: rl78g23\_tcm\_key\_IR.mot

Slave: IRReceiver\_Sample.mot

When writing firmware to the RL78/G24 DC/DC LED Control Evaluation Board, it is necessary to configure the SW1 settings on the board according to the connection method.

illustration 4-1 RL78/G24 DC/DC LED Control Evaluation Board SW1

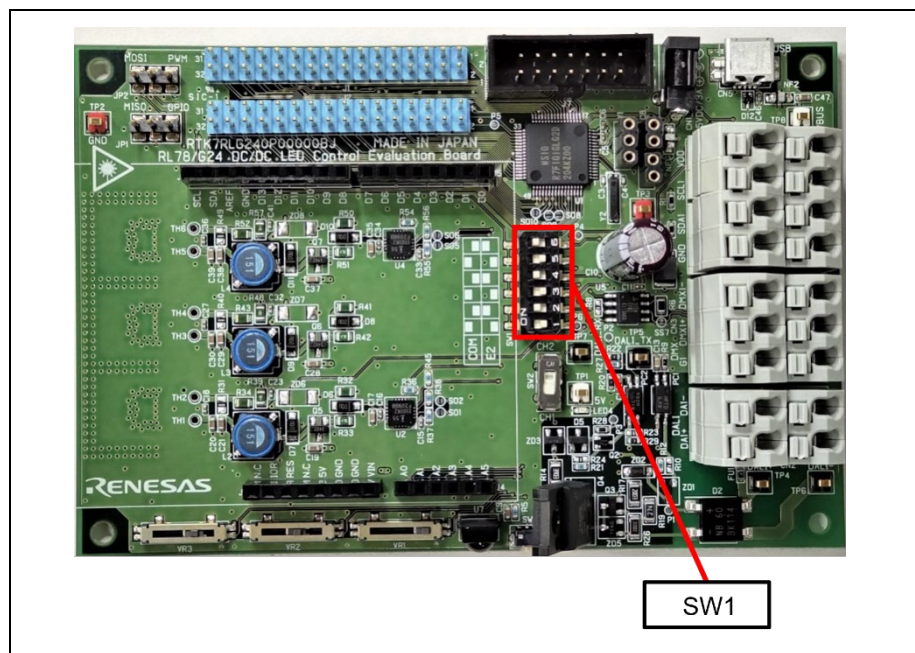


table 4.1 RL78/G24 DC/DC LED Control Evaluation Board SW1 Settings

| SW1 | COM port | E2  |
|-----|----------|-----|
| 1   | ON       | OFF |
| 2   | OFF      | ON  |
| 3   | ON       | OFF |
| 4   | OFF      | ON  |
| 5   | ON       | OFF |
| 6   | OFF      | ON  |
| 7   | ON       | OFF |
| 8   | OFF      | ON  |

#### 4.1.3 How to connect the hardware of the sample application

Describes how to connect the hardware. Connect the AC adapter to the master board and the slave board and supply power.

If the STOP mode is enabled, connect J1-9 on the slave side to J2-7 to set an external interrupt for release.

#### 4.1.4 STOP mode activation (optional feature)

To enable the low-power mode STOP mode, the following macro definitions are required:

You can change the macro definition from the project settings in the development environment.

The default is disabled.

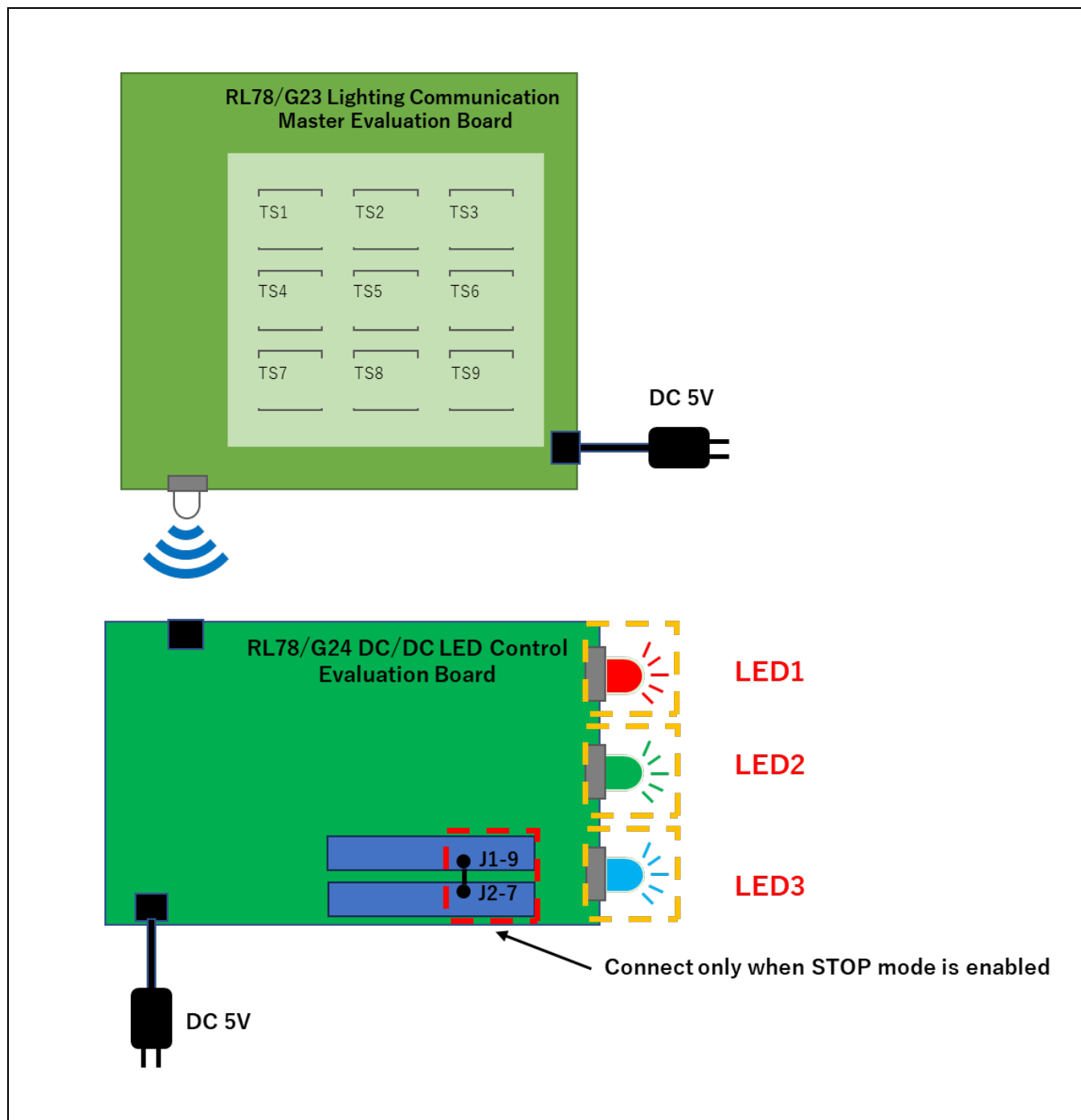
table 4.2 STOP Mode Function Macro Definition

|                     |
|---------------------|
| Macro Definitions   |
| R_STOP_MODE_ENABLED |

## 4.2 Operation Overview

The following is an overview of the operation of this sample application.

illustration 4-2System configuration



The transmitter presses each touch sensor and transmits an infrared signal from the infrared LED.

The receiver controls the dimming of the LED according to the data of the received infrared signal.

In addition, depending on the reception status of the infrared signal and the lighting status of the LED, the camera transitions to HALT mode or STOP mode.

#### 4.2.1 Communication Format Specification

In this sample application, an infrared communication format called NEC format is adopted.

For more information, please refer to the following documents.

RL78 Family IR Receiver Module Software Integration System (R01AN7215)

#### 4.2.2 Application Operation Specifications

This section describes the operation specifications of this sample application.

##### 4.2.2.1 LED Dimming Operation

The dimming control of the LED is performed according to the data of the received infrared signal.

Dimming can also be controlled by receiving repeat codes to increase and decrease the light intensity.

table 4.3LED Dimming Operation

| Infrared Reception Data | LED Status                                 |
|-------------------------|--------------------------------------------|
| 0x00                    | Maximum light intensity lighting           |
| 0x01                    | Intermediate light intensity lighting      |
| 0x02                    | Off                                        |
| 0x03                    | Increased light intensity (repeat enabled) |
| 0x04                    | Light intensity down (repeat enabled)      |

#### 4.2.2.2 Low-power mode operation

The low-power consumption mode function (HALT mode, STOP mode) is used to save power when the infrared signal is on standby or when the LED is off.

In normal operation mode, it mainly analyzes infrared signals and processes LED dimming.

If no infrared signal is detected, the system will enter a reception standby state and enter HALT mode.

When an infrared signal is received from the HALT mode state or a certain period of time has elapsed, the HALT mode is canceled, and infrared reception processing and dimming processing are performed.

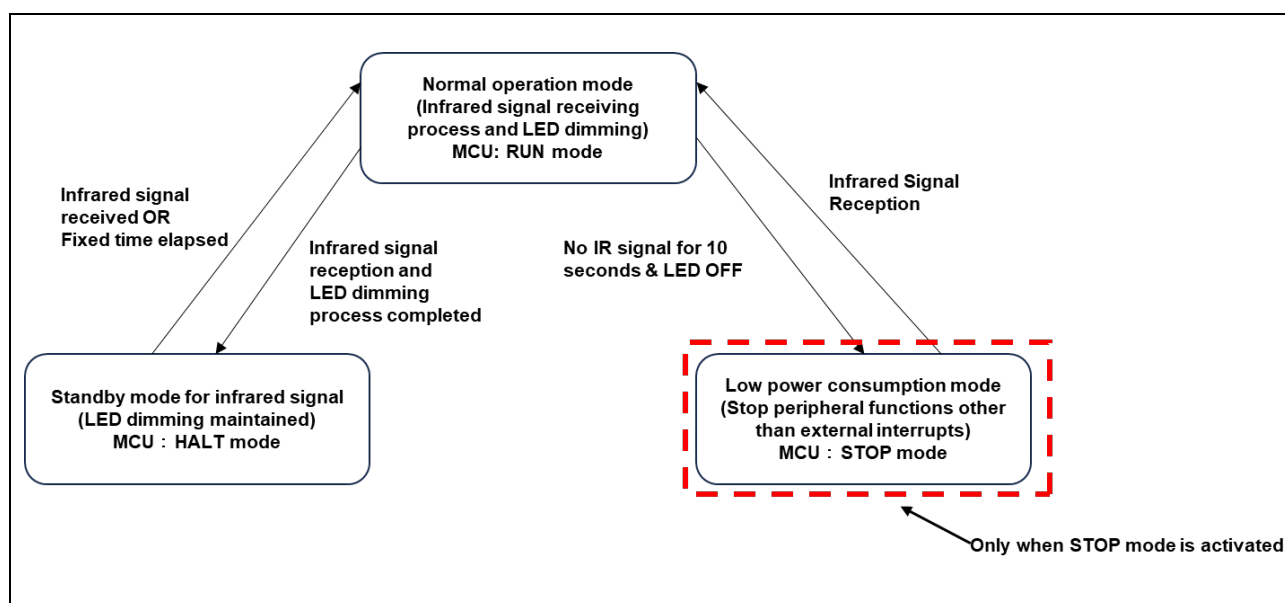
If 10 seconds have elapsed since the infrared signal was received and the LED is OFF, the camera will switch to STOP mode.

When an infrared signal is received in the STOP mode state, the STOP mode is canceled and the infrared reception and dimming processing are performed.

For information on each low-power mode, please refer to the following documents.

RL78/G24 User's Manual: Hardware (R01UH0961)

Illustration 4-3 Power Consumption Mode State Transition Diagram



### 4.3 Procedure

An example of the operation procedure of this application is described.

1. 4.1 Environment construction Follow the instructions to connect and supply power to each board.
2. Touch the touch sensor key on the master board to transmit infrared rays and check that the dimming of the LED on the slave side can be controlled.

illustration 4-4How it works

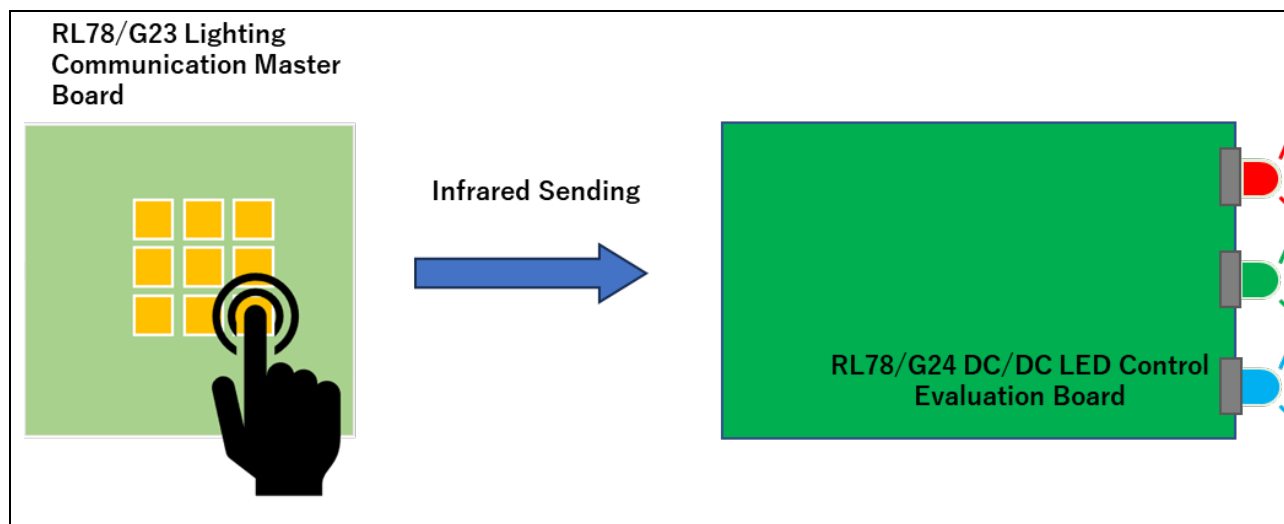


table 4.4LED Dimming Operation Assignment

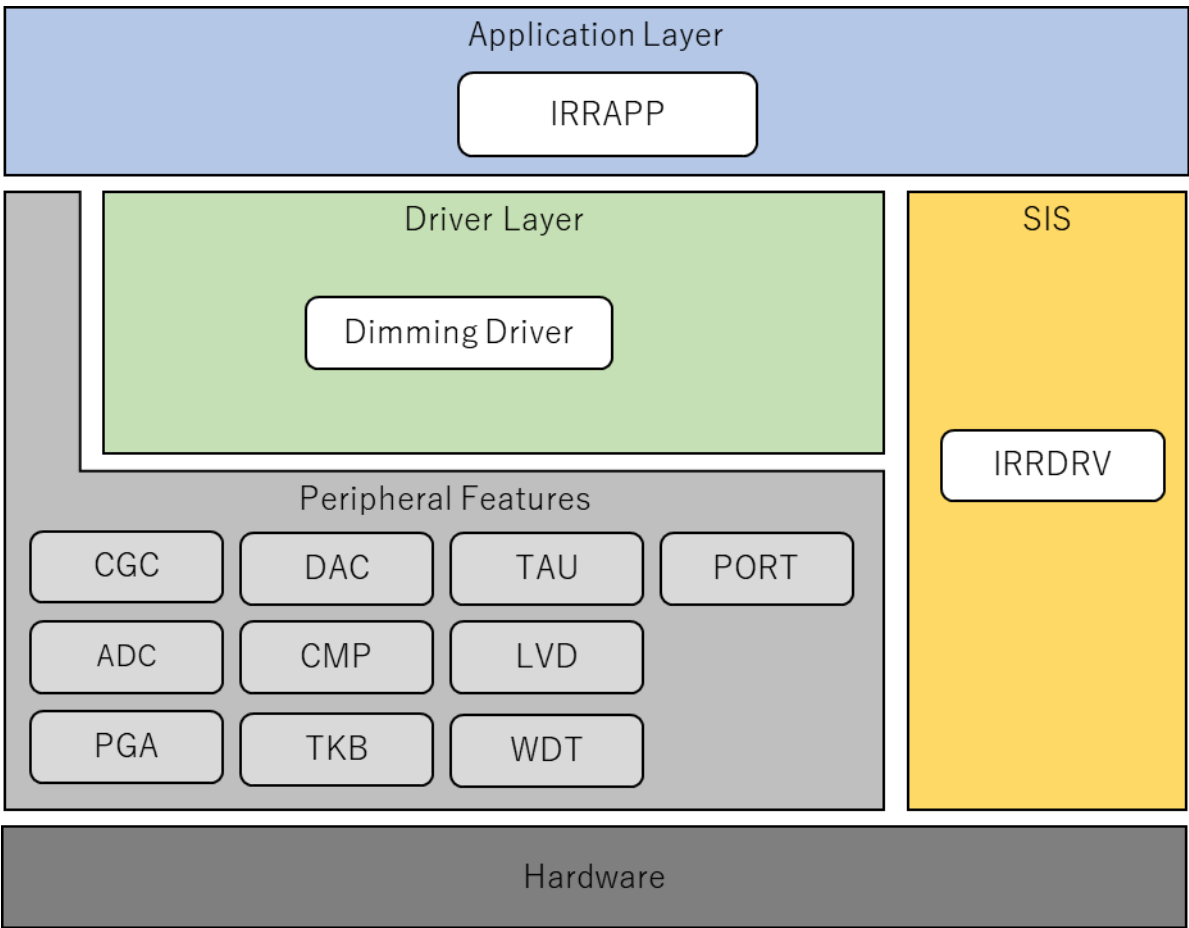
| Touch Keys | LED Dimming Operation                 |
|------------|---------------------------------------|
| TS1        | Maximum light intensity lighting      |
| TS2        | Intermediate light intensity lighting |
| TS3        | Off                                   |
| TS4        | Increased light intensity             |
| TS7        | Light intensity down                  |

4.4 Functional Overview

4.4.1 Functional Block Diagram

The functional block diagram of the sample application is shown below.

illustration 4-5Functional Block Diagram



#### 4.4.2 Driver Layer

##### 4.4.2.1 Dimming Drivers

This driver is a driver that targets three colors of LEDs (red, green, and blue).

The following peripheral functions are used to control the dimming of each LED.

- ADC
- PGA
- DAC
- CMP
- TKB

For more information, please refer to the following documents.

RL78/G24 LED control by RL78/G24 (R01AN6673)

#### 4.4.3 SIS (Software Integration System)

##### 4.4.3.1 IRRDRV (IR Receiver Driver)

**IR Receiver Driver Module** This is the driver part of SIS. A timer array unit is used to receive infrared signals.

For more information about the module, please refer to the following documents.

RL78 Family IR Receiver Driver Module Software Integration System(R01AN7215)

The configuration settings in this sample application are shown below.

table 4.5List of IR Receiver Driver settings

| item                                   | Setting Values  | explanation                                                                               |
|----------------------------------------|-----------------|-------------------------------------------------------------------------------------------|
| Custom code                            | 0x1234          | Set the customer code.                                                                    |
| IR receiving port                      | P17(TI02)       | Specifies the infrared receiver terminal.                                                 |
| Interval timer channel                 | TAU0_3          | Select the channel of the timer to use for leader code detection.                         |
| Capture timer channel                  | TAU0_2          | Select the timer channel to use to measure the bit length of the customer and data codes. |
| Interrupt level for the interval timer | Level 3(Lowest) | Select the interrupt priority for the Interval timer.                                     |
| Interrupt level for the capture timer  | Level 3(Lowest) | Select the interrupt priority for the Capture timer.                                      |
| Port active level                      | Active Low      | Select the active level of the port.                                                      |

#### 4.4.4 Application tier

##### 4.4.4.1 IRRAPP (IR Receiver Application)

This is the application part of the infrared communication function. Interprets the received data and performs the action when it is received.

#### (1) Handling callbacks from the IR Receiver Driver (IRRDRV) module

##### (a) ReceiveDataNotification Callback

It is called back from IRRDRV when the infrared signal in the data frame is received.

Set the received data into the internal data.

##### (b) RepeatNotification Callback

When a repeat frame is received, it is called back from IRRDRV.

Set the data received in the data frame into the internal data.

#### (2) Application Task Processing

The task processing of the application does the following:

##### (a) Set LED target values

The internal data set by the callback function is interpreted and the target value of the LED is reflected in the dimming driver.

##### (b) Controlling Low-Power Modes

It controls the state transition of the low-power mode according to the reception state of infrared communication and the LED dimming state.

## 4.5 Software Configurations

The software configuration of the sample application is described below.

### 4.5.1 Folder Structure

The folder structure of this sample application is shown below.

table 4.6 Folder Structure (Slave))

| folder, file name          | explanation                                                                                                            |
|----------------------------|------------------------------------------------------------------------------------------------------------------------|
| IRReceiver_Sample<DIR>     | Sample Application Folder                                                                                              |
| \App<DIR>                  | Application Program Storage Folder                                                                                     |
| r_main.c                   | Main source file                                                                                                       |
| r_irr_app.c                | Source files for the IRReceiver application                                                                            |
| r_irr_app.h                | IRReceiver Application Header File                                                                                     |
| r_lpmode_mger.c            | Source files that control the state of low-power mode                                                                  |
| r_lpmode_mger.h            | Header file to control the state of the low-power mode                                                                 |
| \Driver<DIR>               | Driver Program Storage Folder                                                                                          |
| r_led.c                    | Dimming driver source files                                                                                            |
| r_led.h                    | Dimming Driver Header File                                                                                             |
| r_led1.c                   | Source file of the dimming driver for LED1 (Red)                                                                       |
| r_led1.h                   | Header file of the dimming driver for LED1 (Red)                                                                       |
| r_led2.c                   | Source file of dimming driver for LED2 (Green)                                                                         |
| r_led2.h                   | Header file of the dimming driver for LED2 (Green)                                                                     |
| r_led3.c                   | Source file of dimming driver for LED3 (Blue)                                                                          |
| r_led3.h                   | Header file of the dimming driver for LED3 (Blue)                                                                      |
| \Utility<DIR>              | Common Program Storage Folder                                                                                          |
| r_timer16.c                | Timer module source files                                                                                              |
| r_timer16.h                | Timer module header file                                                                                               |
| r_usertype.h               | Type Definition Header File                                                                                            |
| \src<DIR>                  | Smart Configurator Generated File Storage Folder                                                                       |
| \smc_gen<DIR>              | Smart Configurator Generation Folder (omitted)<br>* The IR Receiver Driver module SIS code will be generated under the |
| \DefaultBuild<DIR> (CC-RL) | Project output file storage folder (CC-RL development environment only)                                                |
| IRReceiver_Sample.mot      | Motorola S-type format file used to write to the slave's firmware                                                      |
| rl78g23_tcm_key_IR.mot     | Motorola S-type format file used to write to the master firmware                                                       |
| \Release\Exe<DIR> (IAR)    | Project output file storage folder (IAR development environment only)                                                  |
| IRReceiver_Sample.mot      | Motorola S-type format file used to write to the slave's firmware                                                      |
| rl78g23_tcm_key_IR.mot     | Motorola S-type format file used to write to the master firmware                                                       |

#### 4.5.2 List of option byte settings

The option byte settings for the sample application are shown below.

table 4.7List of option byte settings

| address         | Setting Values | substance                                                            |
|-----------------|----------------|----------------------------------------------------------------------|
| 000C0H / 010C0H | 01111101B      | Watchdog timer operation permit (start counting after reset release) |
| 000C1H / 010C1H | 11111011B      | LVD Reset Mode (2.97V Fall, 2.91V Rise)                              |
| 000C2H / 010C2H | 11101010B      | HS mode, high-speed on-chip oscillator: 8 MHz                        |
| 000C3H / 010C3H | 10000100B      | On-chip debug permissions                                            |

## 5. Precautions

- This sample application is configured and operated according to the RL78/G24 DC/DC LED Control Evaluation Board.
- The operations provided by this sample application are only samples. The application layer should be redesigned and evaluated according to the purpose of use.

## 6. References

RL78/G24 User's Manual: Hardware (R01UH0961)

RL78/G24 LED control by RL78/G24 (R01AN6673)

RL78 Family IR Receiver Driver Module Software Integration System (R01AN7215)

Renesas Flash Programmer V3.12 Flash Programming Software User's Manual (R20UT5312)

(Please obtain the latest version from the Renesas Electronics website.) )

Technical Updates / Technical News

(Please obtain the latest version of the information from the Renesas Electronics website.) )

Revision Records

| Rev. | Publication date | Details of revision |                      |
|------|------------------|---------------------|----------------------|
|      |                  | page                | point                |
| 1.00 | Apr.19, 2024     | -                   | First edition issued |
|      |                  |                     |                      |

## Precautions for use of the product

This section describes the "Precautions for Use" that apply to all microcontroller products. For specific usage instructions, please refer to this document and technical updates.

### 1. Anti-Static Electricity

When handling CMOS products, keep in mind to prevent static electricity. CMOS products can cause gate breakdown due to strong static electricity. When transporting and storing, use conductive trays, magazine cases, conductive cushioning materials, metal cases, etc. that we use for shipping and packaging, and ground them during the assembly process. Do not leave it on a plastic plate or touch the terminals. Also, treat boards with CMOS products in the same way.

### 2. Power-on action

When the power is turned on, the state of the product is indeterminate. At power-up, the state of the internal circuit of the LSI is indeterminate, and the register settings and the state of each pin are indeterminate. In the case of a product that is reset by an external reset pin, the status of the terminal cannot be guaranteed from power-on until the reset takes effect. Similarly, for products that are reset using the built-in power-on reset function, the state of the terminals cannot be guaranteed from power-up until a certain voltage is reached to which the reset is applied.

### 3. Input signal when the power is turned off

Do not turn on the input signal or the input/output pull-up power when the power of the product is off. Current injection from the input signal or the input/output pull-up power supply may cause malfunction or cause abnormal current to flow and deteriorate the internal elements. If the product is described in the document as "input signal when the power is off", please observe the contents.

### 4. Handling Unused Terminals

Dispose of unused terminals in accordance with "Handling Unused Pins". The impedance of the input terminals of CMOS products is generally high impedance. If an unused pin is operated in an open state, noise around the LSI may be applied due to inductive phenomena, and there is a risk that shoot-through current may flow inside the LSI or malfunction due to recognition as an input signal.

### 5. About the Clock

When resetting, cancel the reset after the clock has stabilized. When switching the clock while the program is running, switch after the target clock is stable. When resetting, if the system starts operating with a clock that uses an external oscillator (or an external oscillator circuit), cancel the reset after the clock has stabilized sufficiently. Also, when switching to a clock that uses an external oscillator (or an external oscillator circuit) in the middle of the program, wait until the clock to be switched is sufficiently stable.

### 6. Applied waveform of the input terminal

Please note that waveform distortion due to input noise or reflected waves may cause malfunction. If the input of a CMOS product stays in the range from VIL (Max.) to VIH (Min.) due to noise or other reasons, it may cause malfunction. If the input level is fixed, of course, use it so that there is no chattering noise during the transition period that passes through the VIL (Max.) to VIH (Min.) region.

### 7. Prohibit access to reserved addresses (reserved areas)

Prohibit access to reserved addresses (reserved areas). The address space has reserved addresses that are allocated for future extensions. We cannot guarantee the behavior of these addresses when they are accessed, so please do not access them.

### 8. Differences between products

If you want to change to a product with a different model name, perform a system evaluation test for each product model name. If the model name of the same group of microcontrollers is different, the characteristic value, operating margin, noise immunity, noise width and emission may differ in the range of electrical characteristics due to differences in flash memory, layout pattern, etc. If you want to change the model name to a different product, perform a system evaluation test for each individual product.

## Notice

1. The circuits, software, and related information described in this document describe examples of the operation and application of semiconductor products. When using circuits, software, and related information, it is the customer's responsibility to design the customer's equipment and systems. Damages caused by the use of these products (including damages caused to either the customer or a third party) The same shall apply hereinafter. The Company shall not be liable for any such matters.
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  8. When using our products, please check the latest product information (data sheets, user's manuals, application notes, "General precautions for the use of semiconductor devices" described in the reliability handbook, etc.), and use them within the range of the maximum rating, operating power supply voltage range, heat dissipation characteristics, mounting conditions, and other specified conditions specified by our company. The Company shall not be liable for any malfunctions, malfunctions, or accidents caused by the use of the Company's products beyond the scope of the specified conditions.
  9. Although we strive to improve the quality and reliability of our products, there is a certain probability that semiconductor products will fail or malfunction depending on the conditions of use. In addition, our products are not designed to be radiation-resistant, except for those defined in data sheets as products for high-reliability and harsh environments. Even in the event of a failure or malfunction of our products, it is the customer's responsibility to guarantee the shipment of the customer's equipment and systems, such as redundant design, fire prevention design, and aging treatment, so as not to cause personal injury, fire accident, or other social damage. In particular, it is difficult to verify microcomputer software alone, so it is the customer's responsibility to verify the safety of the customer's equipment and system.
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(Rev.5.0-1 2020.10)

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