RL78 Family

IR Receiver Driver Module Software Integration System

Introduction

This application note describes the IR Receiver Driver (IRRDRV) module.

Target Device

RL78/G24

Related Documents

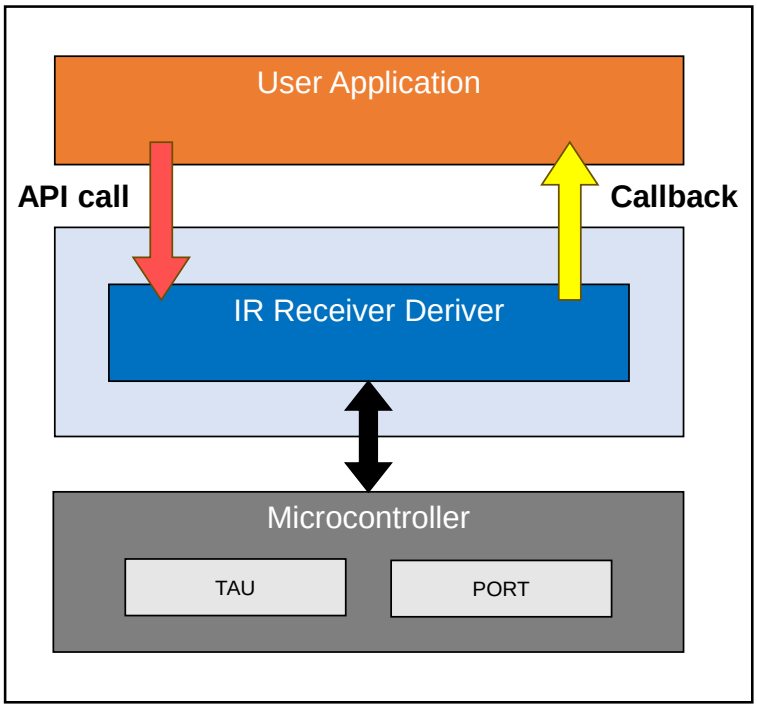
- RL78/G24 User's Manual: Hardware (R01UH0961)
- Lighting Communications Using RL78/I1A (Reception) (R01AN1115)

Contents

1. Overview

This module uses a timer array unit (TAU) and a port (PORT) to provide a receive driver for the NEC infrared communication protocol.

Figure 1-1 Module construction



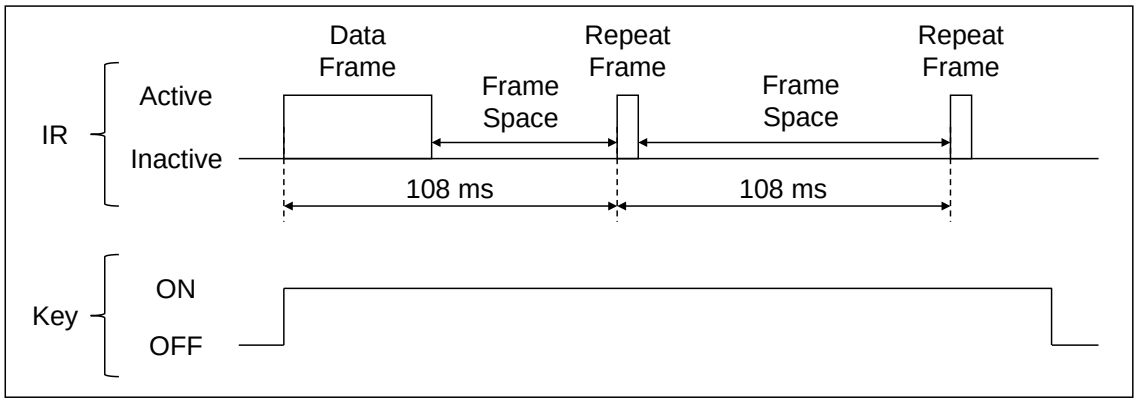
2. NEC infrared communication protocol

The NEC Infrared Communication Protocol uses infrared light at approximately 950 nm to transmit several bytes of information at low speeds. The binary data (0/1) to be transmitted is encoded by the pulse length. NEC Infrared Communication Protocol is one of the widely used infrared communication protocols in industry around the world.

2.1 General communication

When the Key turns ON, a Data Frame is sent, and a Repeat Frame is sent at 108 ms intervals until the Key turns OFF. This makes it easier to distinguish between repeated key presses and long presses, and reduces power consumption.

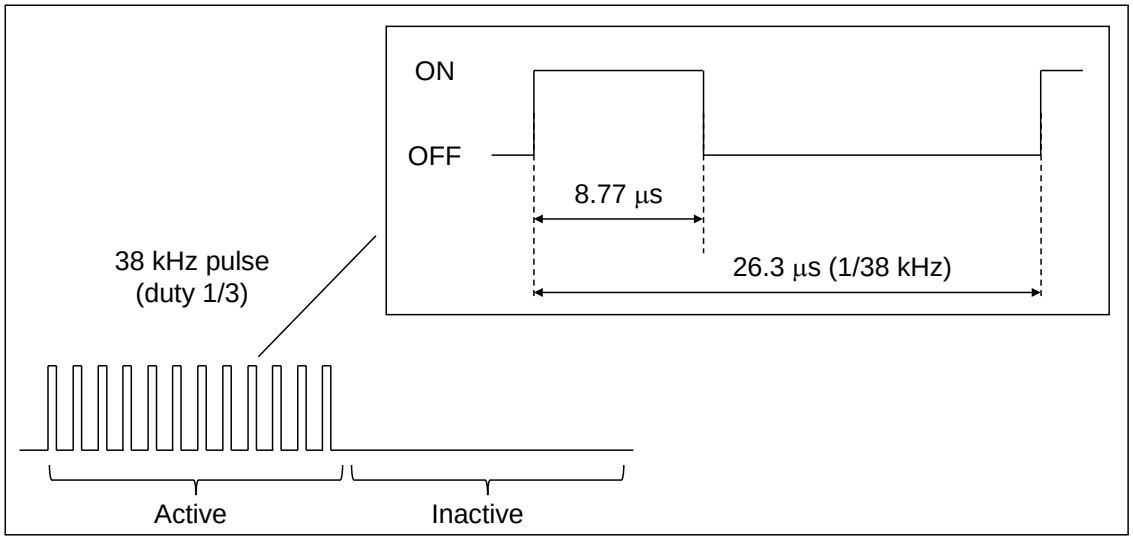
Figure 2-1 General communication



2.2 Modulation of carrier frequency

The actual output of infrared rays is not output continuously even during the Active section, but repeatedly switches between ON and OFF periods at a fixed cycle (called the "carrier frequency"). The typical carrier frequency is 38 kHz and the recommended carrier duty ratio is 1/3. This setting helps minimize power consumption.

Figure 2-2 Modulation of carrier frequency



2.3 Data Frame

Data Frame consists of "Leader Code, Custom Code (16 bit), Data Code (8 bit + 8 bit), Stop Bit" and is sent only once at the beginning of communication.

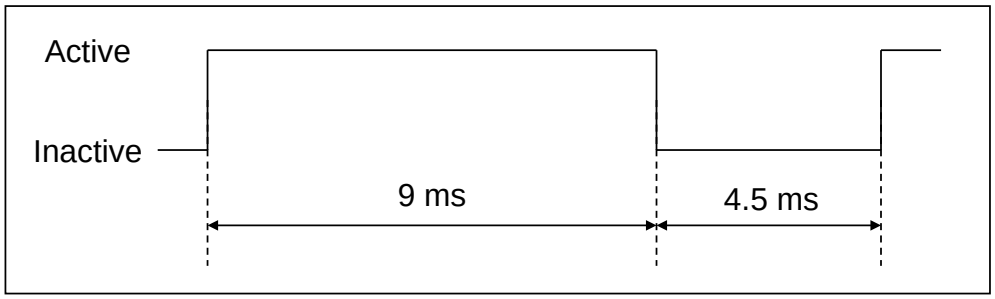
Figure 2-3 Data Frame structure

Leader Code	Custom Code (16 bit)	Data Code (8 bit + 8 bit)	Stop Bit

2.3.1 Leader Code

The leader code of a Data Frame consists of an active interval of 9 ms and an inactive interval of 4.5 ms, and the type of frame is distinguished by the length of the inactive interval.

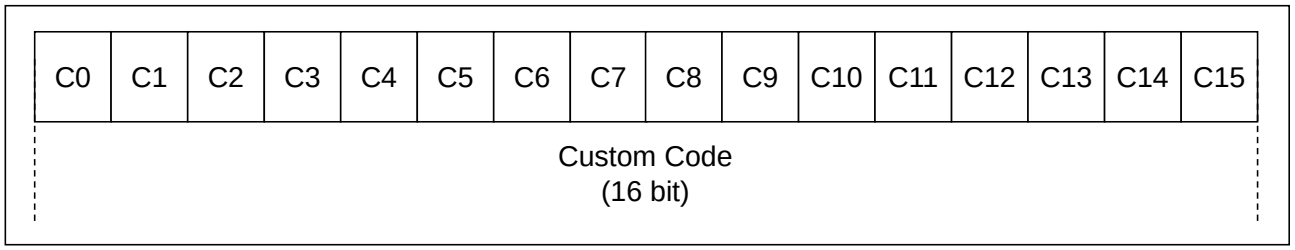
Figure 2-4 Leader Code structure (Data Frame)



2.3.2 Custom Code

The Custom Code is a 16-bit manufacturer identification code and is sent from the LSB. Each bit is encoded like "2.6 Bit encoding" instead of simple Active/Inactive.

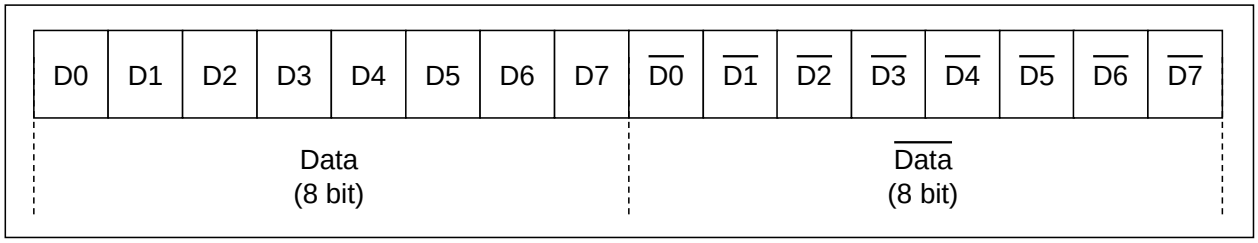
Figure 2-5 Custom Code structure



2.3.3 Data Code

The data code consists of 8-bit data and bit-inverted data, and is transmitted from the LSB. The receiving side checks for errors by comparing the normal data and the inverted data. Each bit is encoded like "2.6 Bit encoding" instead of simple Active/Inactive.

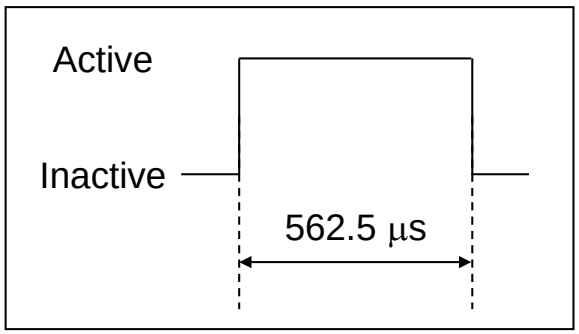
Figure 2-6 Data Code structure



2.3.4 Stop Bit

Stop Bit indicates the end of Frame in the active interval of 562.5 μs.

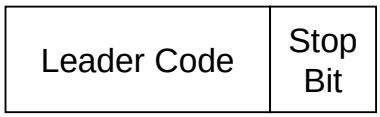
Figure 2-7 Stop Bit structure



2.4 Repeat Frame

Repeat Frame consists of "Leader Code and Stop Bit" and is sent at 108 ms intervals after Data Frame.

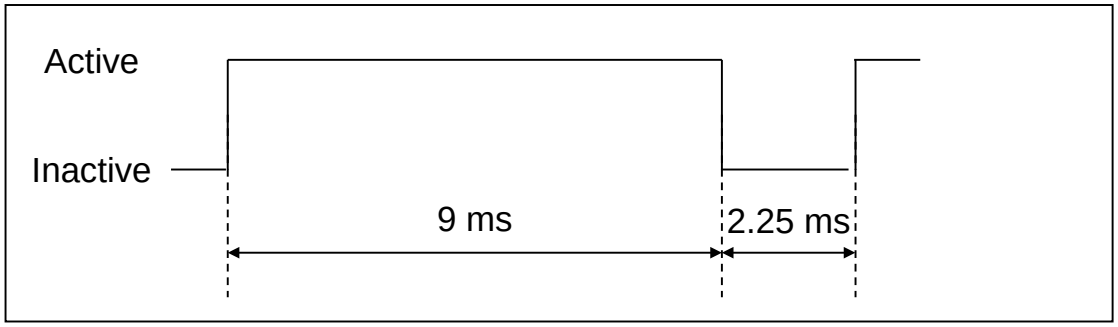
Figure 2-8 Repeat Frame structure



2.4.1 Leader Code

The Repeat Frame Leader Code consists of a 9 ms Active section and a 2.25 ms Inactive section, and the type of Frame is distinguished by the length of the Inactive section.

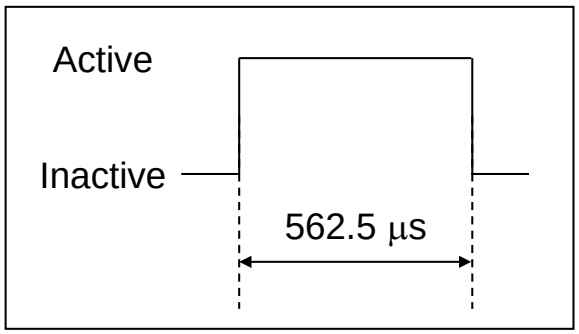
Figure 2-9 Leader Code structure (Repeat Frame)



2.4.2 Stop Bit

Stop Bit indicates the end of Frame in the active interval of 562.5 μs.

Figure 2-10 Stop Bit structure



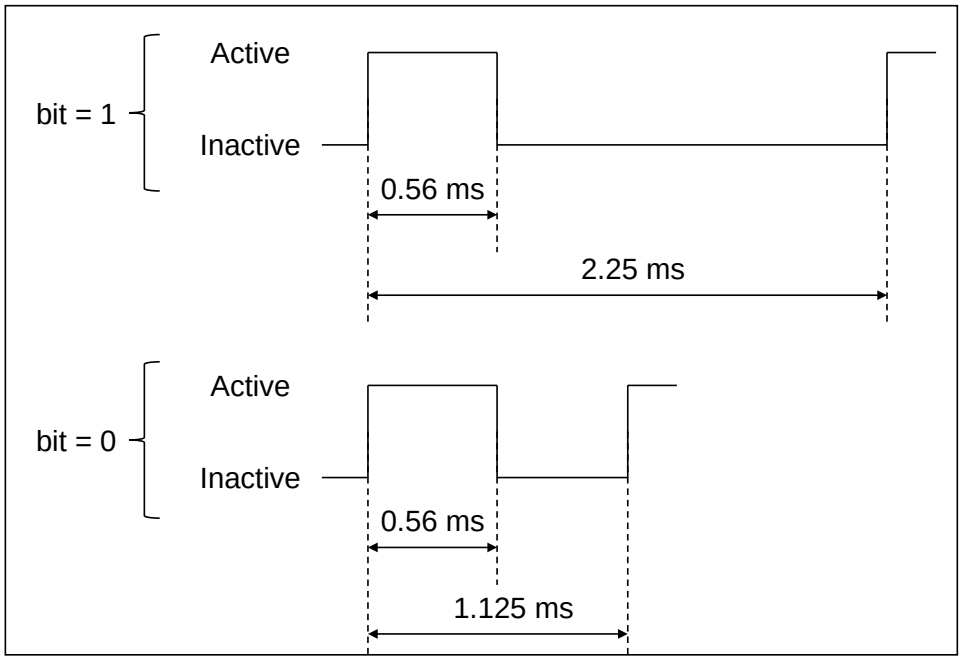
2.5 Frame Space

This is the section following Frame that does not emit infrared rays.

2.6 Bit encoding

The value of each bit of the Custom Code and Data Code is encoded by the pulse length as shown below.

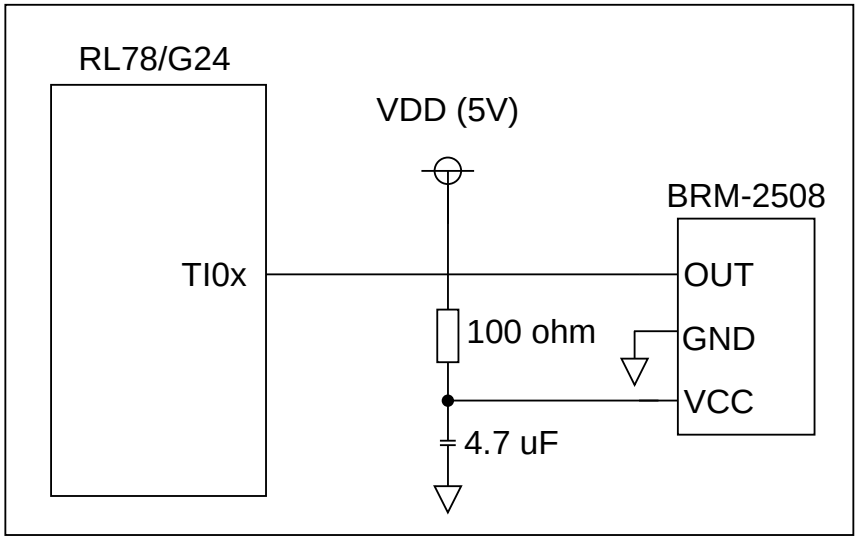
Figure 2-11 Bit encoding



3. Hardware specifications

The infrared control interface is achieved by simply connecting a 5 V 38 kHz infrared remote control receiver to the RL78/G24's TI terminal (either TI00-TI03). No other interface circuitry is required. Figure 3-1 shows the interface circuit when using BRM-2508.

Figure 3-1 Infrared control interface



4. Software specifications

Perform infrared reception processing using Interval timer and Capture timer.

4.1 Interval timer

Detects the Leader Code by checking the port every 100 μs.

Table 4-1 Interval timer settings

Item	Setting value
Mode	Interval Timer (16 bit)
Main Clock	CK00
Clock source	fCLK
Interval time	100 μs
Resource (Channel)	Select with smart configurator
Interrupt level	Select with smart configurator

4.2 Capture timer

Measures the pulse width and receives Custom Code and Data Code bits.

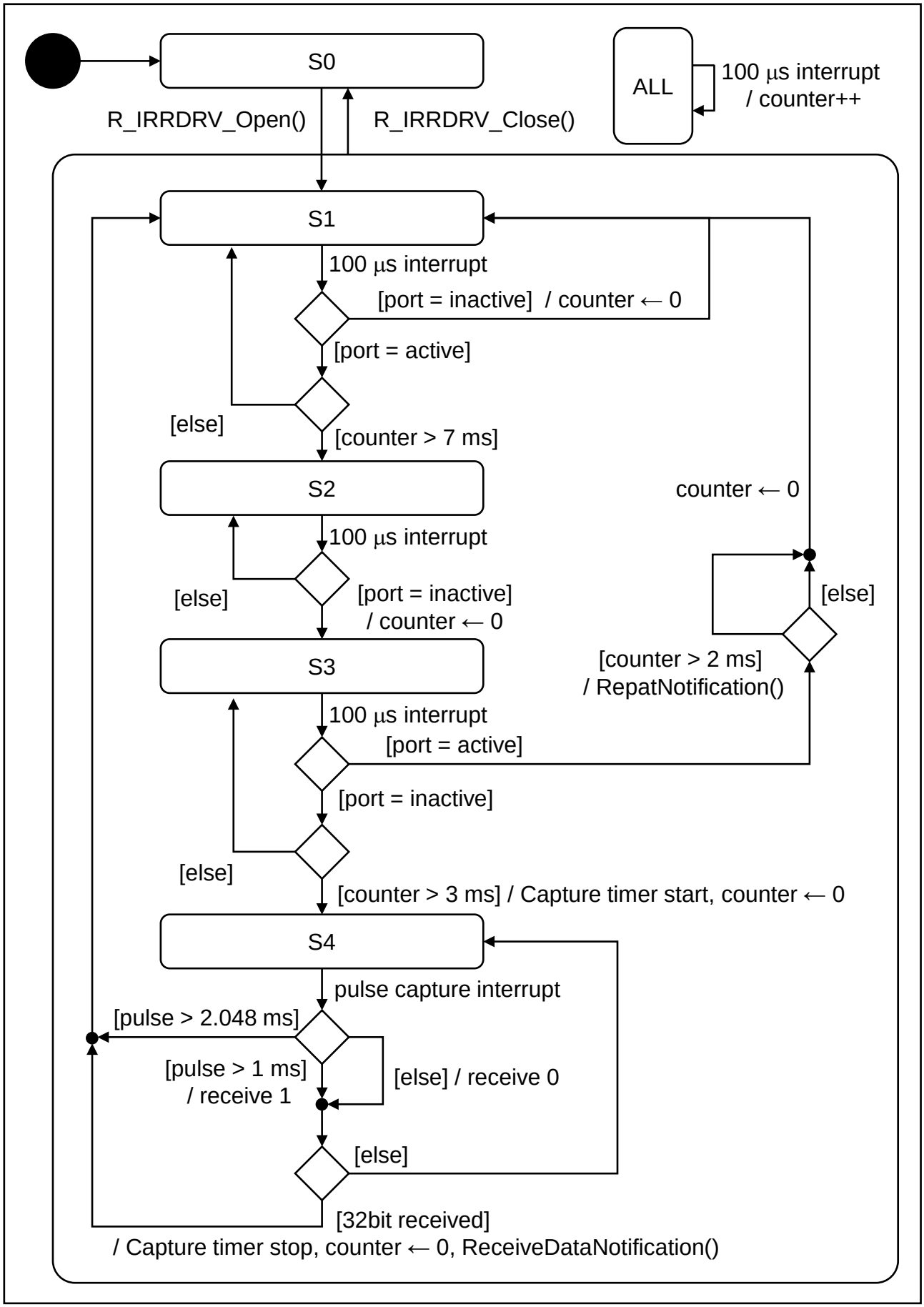
Table 4-2 Capture timer settings

Item	Setting value
Mode	Measurement of high-/low-level width of input signal
Main Clock	CK00
Clock source	fCLK
TI terminal noise filter	Use
Resource (Channel)	Select with smart configurator
Interrupt level	Select with smart configurator

4.3 State transition diagram

Figure 4-1 shows the state transition diagram of this module.

Figure 4-1 State transition diagram



5. API Information

This section describes the API information for this module.

5.1 Hardware Requirements

The MCU to be used must support the following pins

- One of TI00, TI01, TI02, TI03

Target products: 20, 24, 25, 30, 32, 40, 44, 48, 52, 64-pin products

5.2 Software Requirements

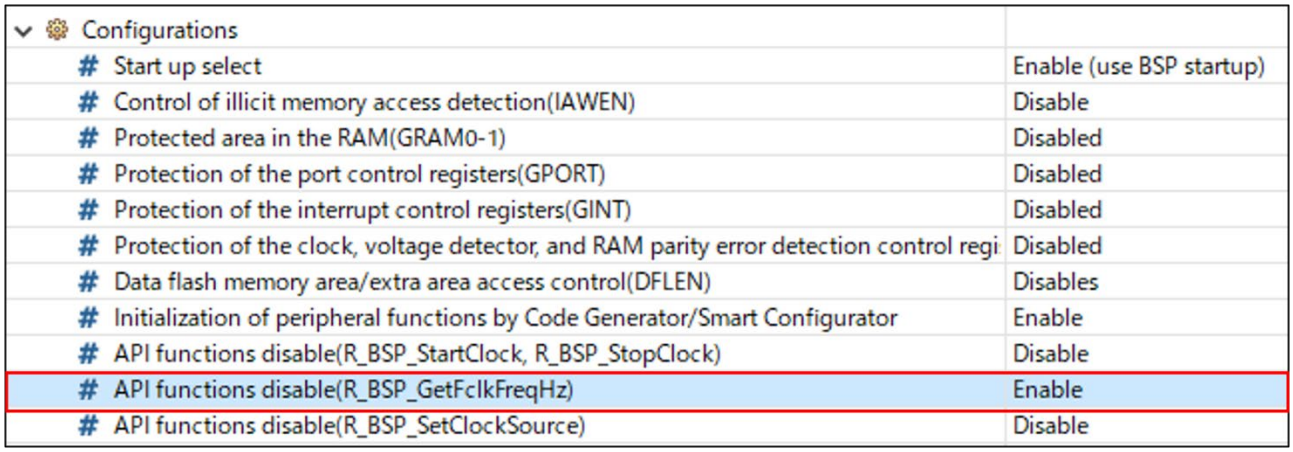
This driver depends on the following modules

- Board Support Package (r_bsp) v1.61 or later

In addition, the following API functions of r_bsp must be enabled, which can be configured from the Software Component Settings screen on the Smart Configurator.

- R_BSP_GetFclkFreqHz
  (BSP_CFG_GET_FREQ_API_FUNCTIONS_DISABLE = 0)

Figure 5-1 Smart Configurator BSP Setting



5.3 Supported Tool Chains

This module has been tested with the following toolchains.

- Renesas CC-RL Toolchain v1.12.01
- IAR Embedded Workbench for Renesas RL78 v5.10.3

5.4 Header files

API calls and I/F definitions used are described in "r_irrdrv_api.h"".

5.5 Integer Type

This driver uses C99. These types are defined in "stdint.h".

5.6 Code Size

The ROM and RAM size will increase or decrease depending on the settings on Smart Configurator and compiler option settings. Here, the default settings on Smart Configurator, the default compilation options on CC-RL compiler, and the size when "NDEBUG" is added to the definition macro are listed as reference values.

ROM 744 [byte]

RAM 24 [byte]

6. Configuration Specifications

A list of configuration items that can be set in the Smart Configurator is shown below.

Item	Possible values	Description
Custom code	0x0000-0xFFFF	Set Custom code.
IR receiving port	P00(TI00), P01(TI00), P03(TI00), P15(TI01), P16(TI01), P71(TI01), P17(TI02), P120(TI02), P121(TI02), P11(TI03), P31(TI03), P50(TI03)	Specify the infrared receiving terminal. Select the port of the TI terminal set on the terminal screen.
Interval timer channel[Note 1]	TAU0_0, TAU0_1, TAU0_2, TAU0_3	Select the timer channel used for reader code detection.
Capture timer channel[Note 1]	TAU0_0, TAU0_1, TAU0_2, TAU0_3	Select the timer channel used to measure the bit length of Custom and data codes. Please select the same channel as the TI terminal set on the terminal screen.
Interrupt level for the interval timer	Level 0(Highest), Level 1, Level 2, Level 3(Lowest)	Select the interrupt priority of Interval timer.
Interrupt level for the capture timer	Level 0(Highest), Level 1, Level 2, Level 3(Lowest)	Select the capture timer interrupt priority.
Port active level	Active High, Active Low	Select the port's active level.

Note1. Different channels must be selected for Interval timer channel and Capture timer channel.

7. API Specification

7.1 API Typedef Definitions

This section describes the Typedef definition provided by this module.

7.1.1 st_irrdrv_callback_t

This typedef defines the return value of the user callback function.

```
typedef struct
{
   void (*ReceiveDataNotification)(uint8_t data);
   void (*RepeatNotification)(uint8_t data);
} st_irrdrv_callback_t;
```

Description

This is a structure containing user callback functions used in this module. Used when registering a callback function with the R_IRRDRV_Open function.

(a) ReceiveDataNotification (Mandatory)

Called when the Custom code and data code are successfully received. However, it will not be called if the Custom code does not match or if the data code is invalid.

* This function is called from Capture timer interrupt processing.

(b) RepeatNotification (optional)

Called when a repeat code is received. However, it will not be called if the Custom code does not match or if the data code is invalid. If not used, please specify NULL.

*This function is called from Interval timer interrupt processing.

7.2 API Function Specifications

This section describes the API function specifications provided by this module.

7.2.1 R_IRRDRV_Open

This function initializes the module and starts receiving operations.

Format

```
void R_IRRDRV_Open(const st_irrdrv_callback_t * p_callback_set)
```

Parameters

`p_callback_set`

Pointer to user callback function structure

Return Values

None

Properties

Prototype declared in r_irrdrv_api.h.

Description

Initialize the module and start receiving operation. It also registers the user callback function passed as an argument. This function sets TAU0EN to 1 and starts supplying the TAU0 input clock.

Example

```
/** User function */
static void receive_data_notification(uint8_t data);
static void repeat_notification(uint8_t data);

/** User Init */
st_irrdrv_callback_t callback = {receive_data_notification, repeat_notification};
R_IRRDRV_Open(&callback);
```

7.2.2 R_IRRDRV_Close

This function will stop the module and end the reception operation.

Format

```
void R_IRRDRV_Close(void)
```

Parameters

None

Return Values

None

Properties

Prototype declared in r_irrdrv_api.h.

Description

Stops the module and ends the reception operation. This function does not set TAU0EN to 0. If it is necessary to stop input clock supply, set TAU0EN to 0 with all TAU0 resources unused.

Example

```
/** Terminate IR Receiver Driver */
R_IRRDRV_Close();
```

8. Website and Support

Renesas Electronics Website

http://www.renesas.com/

Contact information

http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Apr.19, 2024	-	First edition issued

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

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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

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