RL78 Family

RL78 I2C Multimaster

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Introduction

This application note describes the RL78 serial interface driver for IICA in the multi-master mode.

Target Device

The following is a list of devices that are currently supported by this API:

RL78/G13: R5F100LE

Contents

1. Introduction

The RL78 MCU family, IICA interface supports multimaster communication. Its arbitration-loss detection function makes multimaster communication possible in the I2C network. This application note describes the multimaster driver developed for RL78/G13 platform.

Note: I2C-BUS is a registered trademark of Royal Philips Electronics of the Netherlands.

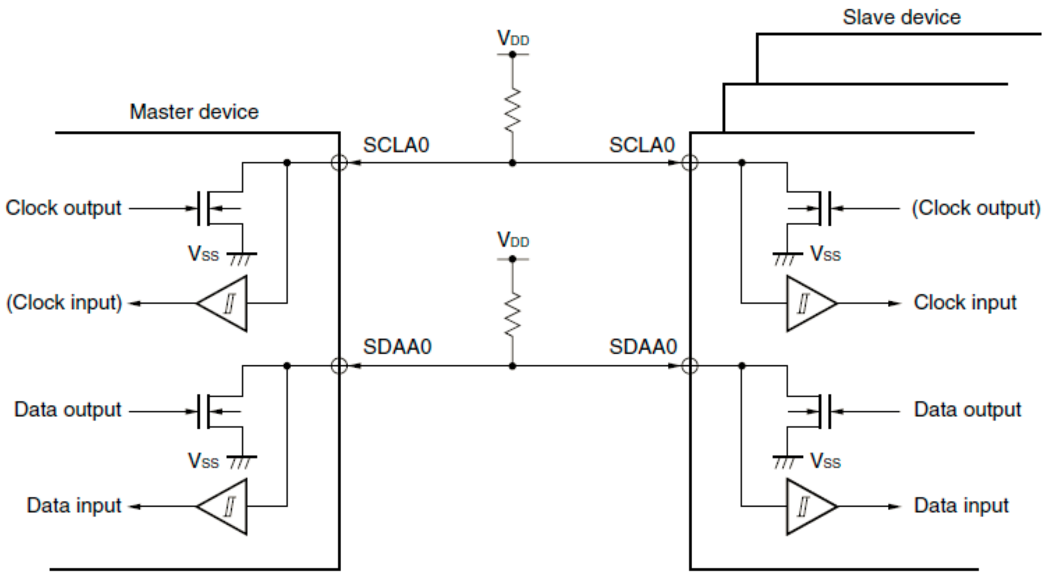
2. Overview

2.1 Hardware Interface

The I2C Multi-master driver interfaces with the IICA0 hardware level driver. For the correct data and clock lines/pins for your microcontroller please refer to the hardware manual.

It is important to note, to avoid floating grounds you must also connect all devices to the same ground line.

Since outputs from the serial clock line and the serial data bus line are N-ch open-drain outputs, an external pull-up resistor is required on both SCLA0 and SDAA0 line.



2.2 Timeout

The timer will begin countdown when you initiate either a master read or master write event. If the event does not complete (and issue a callback to the application level) before the timeout occurs then the driver will reset completely as if the Open command had just been called. Please note that this driver uses the 7th channel of timer 0, it is not possible to change this without directly modifying the driver source code.

3. Driver Control and interface

3.1 Configuration

Configurable options can be found in r_i2c_multimaster_cfg.h. To configure the driver, modify this file according to this section, referring to the hardware manual when necessary.

3.1.1 Interrupt priority

I2C_INT_PRIORITY is a configurable option for setting the interrupt priority of the I2C driver interrupt. This value ranges from 0 (highest) to 3 (lowest)

3.1.2 Main Clock Frequency

MAIN_CLKFREQ specifies the main clock frequency. The driver uses this to calculate bit rate.

3.1.3 Timeout

The configuration file provides a few example timeout values (100ms, 500ms, and 1000ms) which are used to initialize the timer. Select a value by defining R_I2C_USE_TIMEOUT_xxxx. The default for this is the 1000ms.

The driver allows you to define any value for a clock timer. If you wish to define a custom timeout value you must define the CK divisors as well as the counter value. To find the values you will need please reference the hardware manuals section on the Timer Array Unit. Once you have determined the divisors and counter value needed, set the CKxx_DIVISOR and TIMER_COUNTER_VALUE for your custom timeout configuration.

3.2 API Structures

3.2.1 i2c_baud_t

The baud selection allows for the selection of the I2C bitrate. The speed selections are either 100kbps, 400kbps, or 1000kbps. Each bitrate has a corresponding minimum requirement of the main clock to run effectively. The requirements are as follows

- I2C_BAUD_100K
  - minimum main clock value is 1MHz
- I2C_BAUD_400K
  - minimum main clock value is 3.5MHz
- I2C_BAUD_1000K
  - minimum main clock value is 10MHz

3.2.2 i2c_slave_callback_events_t

All possible events for the I2C slave callback.

- I2C_CALLBACK_EVENT_SLAVE_ADDRESS_RECEIVED
  - the slave address of this device has been received
- I2C_CALLBACK_EVENT_SLAVE_BYTE_RECEIVED

  - a byte of data has been received
- I2C_CALLBACK_EVENT_SLAVE_TRANSMIT_REQUEST
  - a request to transmit data has been received
- I2C_CALLBACK_EVENT_SLAVE_STOP_RECEIVED
  - a stop bit has been detected

3.2.3 i2c_master_callback_events_t

All possible events for the I2C slave callback.

- I2C_CALLBACK_EVENT_MASTER_WRITE_COMPLETE
  - master write completed
- I2C_CALLBACK_EVENT_MASTER_READ_COMPLETE
  - master read completed
- I2C_CALLBACK_EVENT_MASTER_TIMEOUT
  - the last command has timed out
- I2C_CALLBACK_EVENT_MASTER_ARBITRATION_LOST
  - arbitration has been lost
- I2C_CALLBACK_EVENT_MASTER_EXIT_CODE_RECEIVED
  - Exit code received
- I2C_CALLBACK_EVENT_MASTER_NAK_RECEIVED
  - NAK received

3.2.4 i2c_err_t

All possible error messages.

- I2C_SUCCESS
  - No error occurred
- I2C_ERR_ILL_PARAMETER
  - argument contained an illegal value
- I2C_ERR_NOT_INITIALIZED,
  - operation attempted without initialization
- I2C_ERR_ALREADY_INITIALIZED,
  - driver already initialized
- I2C_ERR_BUSY
  - another operation is still in progress
- I2C_ERR_ILLEGAL_MAINCLOCK
  - main clock cannot support baud rate selected
- I2C_ERR_LOST_ARBITRATION
  - arbitration was lost
- I2C_ERR_FAILED_START

    - arbitration resulted in neither master nor slave operation
- I2C_ERR_NAK
    - NAK was received
- I2C_ERR_RECEIVED_EXITCODE
    - Exit code was received

3.2.5 i2c_command_t

Defines the commands for the Control function.

- I2C_CHANGE_SLAVE_ADDRESS
    - allows the driver to modify its slave address at any given time
    - the data argument is the new address (1 byte)
- I2C_SET_SLAVE_ACK
    - Configure this device to ACK when another master on the line reads or writes to this address
    - data is not used in this instance
- I2C_SET_SLAVE_NAK
    - Configure this device to NAK when another master on the line reads or writes to this address
    - data is not used in this instance

3.2.6 i2c_config_t

Elements needed for the Open command.

- i2c_baud_t baud;
    - selects the baud rate
- uint8_t slave_address;
    - the address this device responds to
- void (*slave_callback)(i2c_slave_callback_events_t event, uint8_t *p_data);
    - pointer to the slave callback function
- void (*master_callback)(i2c_master_callback_events_t event, uint8_t *p_data);
    - pointer to the master callback function

3.3 API Functions

3.3.1 Open

```
i2c_err_t R_I2C_Multimaster_Open(i2c_config_t *param);
```

Initializes performs all functions necessary to run the I2C driver. Including initializing the timer driver.

Parameters:

- i2c_config_t *param
    - Structure for all parameter values, please review section 3.2.6i2c_config_t for information regarding this data structure

Error codes:

- I2C_SUCCESS
- I2C_ERR_ALREADY_INITIALIZED
- I2C_ERR_ILL_PARAMETER
- I2C_ERR_ILLEGAL_MAINCLOCK

Example:

```
    i2c_err_t err;

    param.baud = I2C_BAUD_100K;
    param.slave_callback = &i2c_slv_callback;
    param.master_callback = &i2c_mst_callback;
    param.slave_address = myAddress;


    err = R_I2C_Multimaster_Open(&param);
```

3.3.2 Master Write

```
i2c_err_t R_I2C_Multimaster_Master_Write(uint8_t addr,
                uint8_t *p_buffer,
                uint16_t size);
```

This function transmits “size” bytes of data from “p_buffer” to the device located at “addr”. **Warning**: The data located at “p_buffer” should not be modified until transmission has completed.

Parameters:

- uint8_t addr
  - Address to send message to
- uint8_t *p_buffer
  - Pointer to a buffer containing the message to be sent
- uint16_t size
  - Size of the message to be sent

Error codes:

- I2C_SUCCESS
- I2C_ERR_NOT_INITIALIZED
- I2C_ERR_BUSY
- I2C_ERR_ILL_PARAMETER
- I2C_ERR_FAILED_START

Example:

```
    i2c_err_t err;

    uint8_t remoteAddress = DEVICE_ADDRESS;
    uint8_t txbuf[MSG_SIZE] = {'h', 'e', 'l', 'l', 'o', 0};

    err = R_I2C_Multimaster_Master_Write(remoteAddress, txbuf, MSG_SIZE);
```

3.3.3 Master Read

```
i2c_err_t R_I2C_Multimaster_Master_Read(uint8_t addr,
                  uint8_t *p_buffer,
                  uint16_t size);
```

This function stores “size” bytes of data from “addr” into the buffer pointed to by “p_buffer”. Warning: Contents of the buffer are not considered to be valid until a receive-complete event occurs.

Parameters:

- uint8_t addr
  - Address to retrieve data from
- uint8_t *p_buffer
  - Pointer to a buffer for the data to be stored in
- uint16_t size
  - Size of the message to be retrieved

Error codes:

- I2C_SUCCESS
- I2C_ERR_NOT_INITIALIZED
- I2C_ERR_BUSY
- I2C_ERR_ILL_PARAMETER
- I2C_ERR_FAILED_START

Example:

```
i2c_err_t err;

uint8_t remoteAddress = DEVICE_ADDRESS;
uint8_t rxbuf[MSG_SIZE];

err = R_I2C_Multimaster_Master_Read(remoteAddress, rxbuf, MSG_SIZE);
```

3.3.4 Control

```
i2c_err_t R_I2C_Multimaster_Control(i2c_command_t function, void *data);
```

This function is used for special driver operations at runtime. The data parameters are discussed in more detail in Section 3.2.5.

Parameters:

- i2c_command_t function
  - Function to be performed by the control method
- void *data
  - Parameter data to be used by the command function
  - Please refer to 3.2.5i2c_command_t for information on the format for each individual command

Error codes:

- I2C_SUCCESS
- I2C_ERR_NOT_INITIALIZED
- I2C_ERR_ILL_PARAMETER

Examples:

```
//Change address example
uint8_t address = 0x80;
R_I2C_Multimaster_Control(I2C_CHANGE_SLAVE_ADDRESS, (void *) &address);


//Set ACK example
R_I2C_Multimaster_Control(I2C_SET_SLAVE_ACK, NULL);


//Set NAK example
R_I2C_Multimaster_Control(I2C_SET_SLAVE_NAK, NULL);
```

3.3.5 Close

```
i2c_err_t R_I2C_Multimaster_Close(void);
```

Parameters:

- None

Error codes:

- I2C_SUCCESS
- I2C_ERR_NOT_INITIALIZED

Closes operation of the driver. To use the driver again it must re-opened.

3.4 Callbacks

3.4.1 Slave Callback

The slave callback function is used to notify the application layer of an event which has occurred on the slave side of the Multimaster protocol so that special processing (if desired) may be done.

Example:

```
void i2c_slv_callback(i2c_slave_callback_events_t event, uint8_t *p_data)
{
    switch (event)
    {
        case I2C_CALLBACK_EVENT_SLAVE_ADDRESS_RECEIVED:
            //Notifies the Application layer that
            //our address has been received on the I2C bus
            break;
        case I2C_CALLBACK_EVENT_SLAVE_BYTE_RECEIVED:
            //Notifies the Application layer that
            //we have received a byte of data
            //p_data will hold the value of the byte received (Only 1 byte)
            break;
        case I2C_CALLBACK_EVENT_SLAVE_TRANSMIT_REQUEST:
            //Notifies the Application layer that
            //there is a request to transmit the next byte
            //pass into p_data the value to send to the master (Only 1 byte)
            break;
        case I2C_CALLBACK_EVENT_SLAVE_STOP_RECEIVED:
            //Notifies the Application layer that
            //there has been a stop signal on the bus
            break;
    }
}
```

3.4.2 Master Callback

The master callback function is used to notify the application layer of an event which has occurred on the master side of the Multimaster protocol.

Example:

```
void i2c_mst_callback(i2c_master_callback_events_t event, uint8_t *p_data)
{
    switch (event)
    {
    case I2C_CALLBACK_EVENT_MASTER_WRITE_COMPLETE:
        //Notifies the Application layer that
        //the write request has been completed
        break;
    case I2C_CALLBACK_EVENT_MASTER_READ_COMPLETE:
        //Notifies the Application layer that
        //the read request has been completed
        break;
    case I2C_CALLBACK_EVENT_MASTER_TIMEOUT:
        //Notifies the Application layer that
        //a timeout has occurred
        break;
    case I2C_CALLBACK_EVENT_MASTER_ARBITRATION_LOST:
        //Notifies the Application layer that
        //arbitration has been lost, retry last operation
        break;
    case I2C_CALLBACK_EVENT_MASTER_EXIT_CODE_RECIEVED:
        //Notifies the Application layer that
        //Exit code received, retry last operation
        break;
    case I2C_CALLBACK_EVENT_MASTER_NAK_RECEIVED:
        //Notifies the Application layer that
        //a NAK was received on the line
        break;
    }
}
```

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	08/30/2018		Initial Release

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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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Renesas Electronics Corporation
TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

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