RZ/A2M Group

RZ/A2M RIIC Driver

Introduction

This application note describes the operation of the software RIIC Driver for the RZ/A2 device on the RZ/A2M CPU Board.

It provides a comprehensive overview of the Driver. For further details please refer to the software driver itself.

The user is assumed to have knowledge of e² studio and to be equipped with an RZ/A2M CPU Board.

Target Device

RZ/A2M Group

Driver Dependencies

This driver depends on:

- Middleware:
  - Renesas OS Abstraction (FreeRTOS, RTX or OSless version).
- Drivers
  - STDIO
  - INTC Driver
  - CPG Driver
  - GPIO Driver

Referenced Documents

Document Type	Document Name	Document No.
User's Manual	RZ/A2M Hardware Manual	R01UH0746EJ
Application Note	RZ/A2M Smart Configurator User's Guide: e² studio	R20AN0583EJ
Application Note	OS Abstraction Middleware	R11AN0309EG

List of Abbreviations and Acronyms

Abbreviation	Full Form
ACK	ACKnowledge
ANSI	American National Standards Institute
API	Application Programming Interface
ARM	Advanced RISC Machine
CPG	Clock Pulse Generator
CPU	Central Processing Unit
FIFO	First In First Out
GPIO	General Purpose Input/Output
HLD	High Layer Driver
I^2C	Inter-Integrated Circuit
IDE	Integrated Development Environment
INTC	INTerrupt Controller
LLD	Low Layer Driver
MCU	Microcontroller Unit
MHz	MegaHertz
MODEM	MOdulate DEModulate
NACK	Not ACKnowledged
OS	Operating System
RISC	Reduced Instruction Set Computer
RTX	Short for CMSIS-RTOS Keil RTX real-time operating system
RX	Receive
RXI	Receive FIFO data full Interrupt
RIIC	Renesas Inter-Integrated Circuit
SCL	Serial Clock
STDIO	Standard Input/Output
TX	Transmit
TXI	Transmit data empty Interrupt

Table 1-1 List of Abbreviations and Acronyms

Contents

1. Outline of RIIC Driver

The MCU provides the ‘Renesas Inter-Integrated Circuit (RIIC)’ peripheral. The peripheral has four channels that support I^2C communication at a clock frequency up to 1MHz.

For further information regarding the hardware specifics of the RIIC peripheral please refer to the appropriate hardware manual.

2. Description of the Software Driver

The key features of the driver include selectable:

- Channels
- Clock Frequency
- Clock Duty Cycle
- Noise Filter
- Slave Device Addressing
- Timeout monitoring

2.1 Structure

The RIIC driver is split into two parts: High Layer Driver (HLD) and Low Layer Driver (LLD). The HLD includes platform-independent features of the driver, implemented via the STDIO Standard functions. The LLD includes all the hardware-specific functions.

```
r_riic
  doc
    r01an4645eg0101-rza2-riic-driver.pdf
  inc
    r_riic_drv_api.h
    r_riic_drv_link.h
    r_riic_drv_sc_cfg.h
    r_riic_hld_api.h
    r_riic_hld_prv.h
    r_rza2m_riic_lld_api.h
    r_rza2m_riic_lld_cfg.h
    r_rza2m_riic_lld_prv.h
  src
    hld
      r_riic_drv_api.c
      r_riic_hld_prv.c
    lld
      r_rza2_riic_lld_int.c
      r_rza2_riic_lld.c
```

2.2 Description of each file

Each file's description can be seen in the following table.

Filename	Usage	Description
Application-Facing Driver API		
r_riic_drv_api.h	Application	The only API header file to include in application code.
High Layer Driver (HLD) Source		
r_riic_hld_prv.h	Private (HLD only)	Private header file intended ONLY for use in High Layer Driver (HLD) source. NOT for application or Low Layer Driver (LLD) use.
r_riic_drv_api.c	Private (HLD only)	High Layer Driver (HLD) source code enabling the driver API functions.
r_riic_hld_prv.c	Private (HLD only)	High Layer Driver (HLD) private source code enabling the functionality of the driver, abstracted from the low-level access.
High Layer to Low Layer API		
r_riic_hld_api.h	Private (HLD/LLD only)	High Layer Driver (HLD) header file intended to interface to the Low Layer Driver (LLD) to provide callback functions for various interrupt events. Not for use in application
r_xxxx_riic_lld_api.h	Private (HLD/LLD only)	Low Layer Driver (LLD) header file (where "xxxx" is a device and board-specific identification). Intended ONLY to provide access for High Layer Driver (HLD) to required Low Layer Driver functions (LLD). Not for use in application or directly in High Layer Driver (HLD). For the HLD it should be included indirectly in the file r_riic_drv_link.h only to provide abstraction for the HLD.
Abstraction Link between High and Low Layer Drivers (HLD/LLD Link)		
r_riic_drv_link.h	Private (HLD/LLD only)	Header file intended as an abstraction between low and high layer. This header will include the device specific config file "r_xxxx_riic_lld_api.h".
Low Layer Driver (LLD) Source		
r_xxxx_riic_lld.c	Private (LLD only)	(Where "xxxx" is a device and board specific identification). Provides the source code for the Low Layer Driver interface.
r_xxxx_riic_lld_int.c	Private (LLD only)	(Where "xxxx" is a device and board specific identification). Source code for the device interrupt handling code.
r_xxxx_riic_lld_cfg.h	Private (LLD only)	Provides device specific information for the Low Layer Driver only. NOT for application or High Layer Driver (HLD) use.
r_xxxx_riic_lld_prv.h	Private (LLD only)	Private header file intended ONLY for use in Low Layer Driver (LLD) source. NOT for application or High Layer Driver (HLD) use.
Smart Configurator		
r_riic_drv_sc_cfg.h	Private (HLD/LLD only)	This file is intended to be used by Smart Configurator to pass setup information to the driver. This is not for application use.

2.3 Driver API

The driver can be either used through STDIO or through direct access. It is recommended not to mix both access methods.

The API functions can be seen in the below table:

Return Type	Function	Description	Arguments	Return
int_t	**RIIC_hld_open(** st_stream_ptr_t p_stream**)**	Driver initialisation interface is mapped to open function called directly using the st_r_driver_t RIIC driver handle g_RIIC_driver: i.e. **g_RIIC_driver.open()**	[in] **p_stream** driver handle.	**DRV_SUCCESS** on success **DRV_ERROR** on failure
void	**RIIC_hld_close(** st_stream_ptr_t p_stream**)**	Driver close interface is mapped to close function called directly using the st_r_driver_t RIIC driver structure g_RIIC_driver: i.e. **g_RIIC_driver.close()**	[in] **p_stream** driver handle.	**None**
int_t	**RIIC_hld_control(** st_stream_ptr_t p_stream**,** uint32_t ctl_code**,** void* p_ctl_struct**)**	Driver control interface function. Maps to ANSI library low level control function. Called directly using the st_r_driver_t RIIC driver structure g_RIIC_driver: i.e. **g_RIIC_driver.control()**	[in] **p_stream** driver handle. [in] **ctl_code** The type of control function to use. [in/out] **p_ctl_struct** required parameter is dependent upon the control function.	**DRV_SUCCESS** on success **DRV_ERROR** on failure
int_t	**RIIC_get_version(** st_stream_ptr_t p_stream**,** st_ver_info_ptr_t p_ver_info **)**	Driver get_version interface function Maps to extended non-ANSI library low level get_version function. Called directly using the st_r_driver_t RIIC driver structure g_RIIC_driver: i.e. **g_RIIC_driver.get_version()**	[in] **p_stream** handle to the (pre-opened) channel. [out] **p_ver_info** handle to the (pre-opened) channel.	**DRV_SUCCESS** on success Does not return any other values

2.3.1 Available Control Commands

The control functionality of the RIIC driver is defined in the enumeration e_ctrl_code_riic_t and supports the commands listed below. They can be accessed via the STDIO control function in the following way:

result = control(driver_handle, Control Command, Pointer to appropriate structure);

The command is defined in the enumeration e_ctrl_code_riic_t

See section 4 for examples of usage.

Control Command	Description	Arguments	Return
CTL_RIIC_SET_CONFIG	Set Driver configuration according to the values in the st_riic_config_t structure passed as a parameter to the control call.	[in] **st_riic_config_t * riic_config_ptr** Pointer to config structure containing required configuration.	**DRV_SUCCESS** on success **DRV_ERROR** on failure
CTL_RIIC_GET_CONFIG	Place the current Driver settings into the st_riic_config_t structure passed as a parameter to the control call.	[out] **st_riic_config_t * riic_config_ptr** Pointer to the config structure into which the current settings are to be placed.	**DRV_SUCCESS** on success **DRV_ERROR** on failure
CTL_RIIC_READ	Read data from I²C slave device on selected channel, using the details defined in the st_r_drv_riic_transfer_t parameter provided to the control call.	[in] **st_r_drv_riic_transfer_t * riic_transfer_ptr** Pointer to configuration structure for the read operation.	**DRV_SUCCESS** on success **DRV_ERROR** on failure
CTL_RIIC_WRITE	Write data to I²C slave device on selected channel, using the details defined in the st_r_drv_riic_transfer_t parameter provided to the control call.	[in] **st_r_drv_riic_transfer_t * riic_transfer_ptr** Pointer to configuration structure for the write operation.	**DRV_SUCCESS** on success **DRV_ERROR** on failure

3. Accessing the Driver

3.1 STDIO

The API can be accessed through the ANSI ‘C’ Library <stdio.h>. The following table details the operation of each function:

Operation	Return	Function Details
open	gs_stdio_handle, unique handle to driver	open (DEVICE_IDENTIFIER "RIIC0", O_RDWR); [Note that multiple openings for the driver are possible on the same channel. However once opened, the channel configuration cannot be altered unless the all instances of the driver on the channel are first closed. The channel can then be re-opened with the updated configuration.]
close	DRV_SUCCESS successful operation, or driver specific error	close (gs_stdio_handle);
read	Number of characters read, -1 on error	read (gs_stdio_handle, buff, data_length);
write	Number of characters written, -1 on error	write (gs_stdio_handle, buff, data_length);
control	DRV_SUCCESS control was process, or driver specific error	control (gs_stdio_handle, CTRL, &struct);
get_version	DRV_SUCCESS drv_info was updated, or DRV_ERROR drv_info was not updated	get_version (DEVICE_IDENTIFIER "RIIC0", &drv_info);

3.2 Direct

The following table shows the available direct functions.

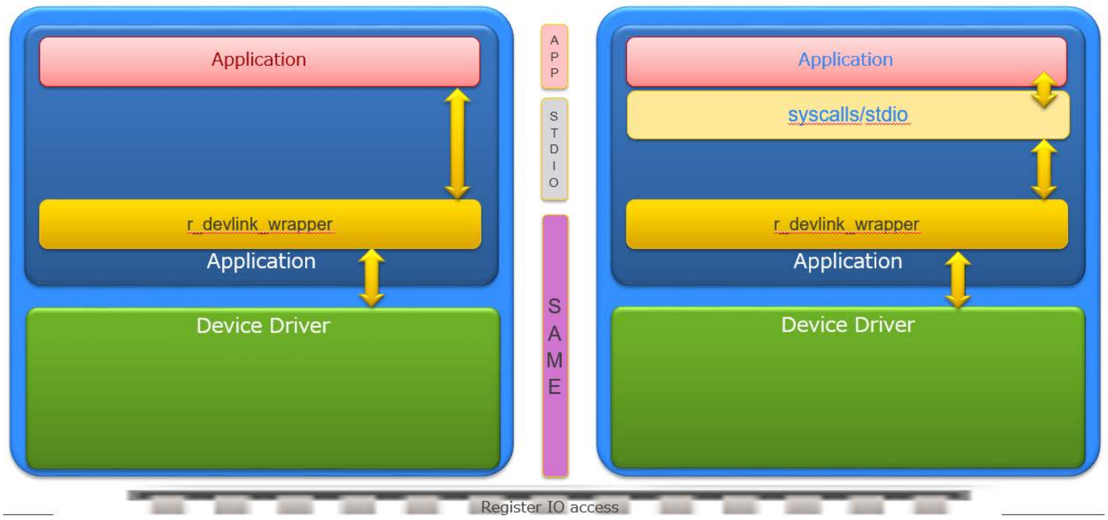
Operation	Return	Function details
open	gs_direct_handle unique handle to driver	direct_open ("riic3", 0);
close	DRV_SUCCESS successful operation, or driver specific error	direct_close (gs_direct_handle);
read	Number of characters read, -1 on error	direct_read (gs_direct_handle, buff, data_length);
write	Number of characters written, -1 on error	direct_write (gs_direct_handle, buff, data_length);
control	DRV_SUCCESS control was process, or driver specific error	direct_control (gs_direct_handle, CTRL, &struct);
get_version	DRV_SUCCESS drv_info was updated, or DRV_ERROR drv_info was not updated	direct_get_version ("riic3", &drv_info);

3.3 Comparison

The below diagram illustrates the difference between the Direct and ANSI STDIO methods.

Direct

ANSI STDIO



4. Example of Use

This section describes a simple example of opening the driver, configuring the driver, transmitting and receiving data and closing a driver.

4.1 Open

```
int_t gs_riic_handle;

/* open riic driver on channel 3 */
uint8_t ch3_drv_name[] = "\\\\.\\riic3";

/* Note that the text “\\\\.\\” in the drive name signifies to the STDIO
interface that the handle is to a peripheral and is not an access to a
standard file-based structure */

gs_riic_handle = open(ch3_drv_name, O_RDWR);
```

4.2 Control – Set Configuration Settings

```
st_riic_config_t set_cfg;
set_cfg.riic_mode = RIIC_MODE_MASTER;
set_cfg.slave_address_enable[0] = false;
set_cfg.slave_address_length[0] = RIIC_SUB_ADDR_WIDTH_16_BITS;
set_cfg.frequency = RIIC_FREQUENCY_100KHZ;
set_cfg.duty = RIIC_DUTY_50;
set_cfg.rise_time = 0u;
set_cfg.fall_time = 0u;
set_cfg.noise_filter_stage = RIIC_FILTER_NOT_USED;
set_cfg.timeout = RIIC_TIMEOUT_NOT_USED ;
set_cfg.format = RIIC_FORMAT_I2C;
set_cfg.host_address_enabled = false;
set_cfg.tei_priority = 9u;
set_cfg.ri_priority = 9u;
set_cfg.ti_priority = 9u;
set_cfg.spi_priority = 9u;
set_cfg.sti_priority = 9u;
set_cfg.naki_priority = 9u;
set_cfg.ali_priority = 9u;
set_cfg.tmoi_priority = 9u;

result = control(gs_riic_handle, CTL_RIIC_SET_CFG, &set_cfg);
```

4.3 Control – Get Configuration Settings

```
st_riic_config_t get_cfg;

result = control(gs_riic_handle, CTL_RIIC_GET_CFG, &get_cfg);
```

4.4 Control – Read

```
st_r_drv_riic_transfer_t transfer_parameters;

/* device I2C address */
transfer_parameters.device_address = 0xA0u;

/* device internal addressing mode */
transfer_parameters.sub_address_type = RIIC_SUB_ADDR_WIDTH_16_BITS;

/* device internal address to read from */
transfer_parameters.sub_address = 0u;

/* Number of bytes to read from device */
transfer_parameters.number_of_bytes = 8u;

/* where to store data read from device */
transfer_parameters.p_data_puffer = &buffer_location;

result = control(gs_riic_handle, CTL_RIIC_READ, &transfer_parameters);
```

4.5 Control – Write

```
st_r_drv_riic_transfer_t transfer_parameters;

/* device I2C address */
transfer_parameters.device_address = 0x85u;

/* device internal addressing mode */
transfer_parameters.sub_address_type = RIIC_SUB_ADDR_WIDTH_16_BITS;

/* device internal address to write to */
transfer_parameters.sub_address = 0u;

/* Number of bytes to write to device */
transfer_parameters.number_of_bytes = 8u;

/* Location of data to write to device */
transfer_parameters.p_data_puffer = &buffer_location;

result = control(gs_riic_handle, CTL_RIIC_WRITE, &transfer_parameters);
```

4.6 Close

```
close(gs_riic_handle);
```

4.7 Get Version

```
st_ver_info_t info;
result = get_version(gs_riic_handle, &info);
```

5. OS Support

This driver supports any OS through using the OS abstraction module. For more details about the abstraction module please refer to the OS abstraction module application note.

6. How to Import the Driver

6.1 e^2 studio

Please refer to the RZ/A2M Smart Configurator User's Guide: e^2 studio R20AN0583EJ for details on how to import drivers into projects in e^2 studio using the Smart Configurator tool.

6.2 For Projects created outside e^2 studio

This section describes how to import the driver into your project.
Generally, there are two steps in any IDE:

1) Copy the driver to the location in the source tree that you require for your project.
2) Add the link to where you copied your driver to the compiler.

Other required drivers, e.g. r_cbuffer, must be imported similarly.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jan.03.19	All	Created document.
1.01	May.08.19	All	Added Section 6.1 for importing driver in e^2 studio

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. 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

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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