RZ/A2M Group

ADC Driver

Introduction

This application note describes the operation of the software ADC 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 e^2 studio and to be equipped with an RZ/A2M CPU Board.

Target Device

RZ/A2M Group

Driver Dependencies

This driver depends on:

- Drivers
  - STDIO
  - INTC Driver
  - STB Driver
  - GPIO Driver
  - CBUFFER 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
ADC	Analogue to Digital Converter
ANSI	American National Standards Institute
API	Application Programming Interface
ARM	Advanced RISC Machines
CPU	Central Processing Unit
GPIO	General Purpose Input Output
HLD	High Layer Driver
IDE	Integrated Development Environment
INTC	INTerrupt Controller
LLD	Low Layer Driver
LSB	Least Significant Byte
OS	Operating System
STB	STandBy
STDIO	Standard Input/Output

Table 1-1 List of Abbreviations and Acronyms

Contents

1. Outline of the Software Driver

The ADC driver sequentially digitises the voltage level on up to eight input pins (AN000 to AN007) and can then interrupt the CPU to inform it that the conversions are complete. The conversion accuracy can be set to 8, 10, or 12-bit depending on whether speed or resolution is most important.

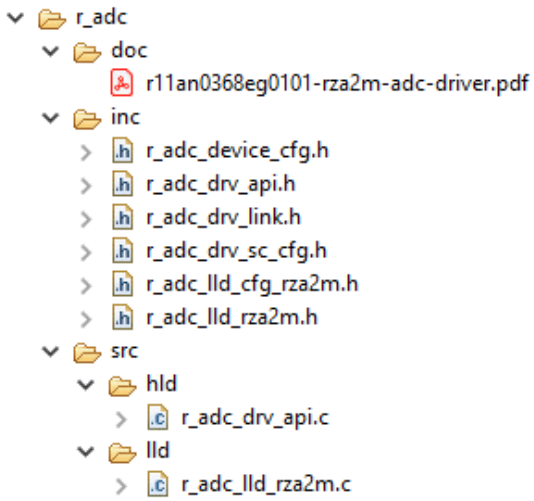
2. Description of the Software Driver

The key features of the driver include selectable:

- Analogue input channels (up to 8)
- Resolution (8, 10, or 12-bit)
- Left or right data alignment
- Whether to block during the conversion scan, or invoke a callback function on completion
- Channel sample time

2.1 Structure

The ADC driver is split into two parts: the High Layer Driver (HLD) and the 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.



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_adc_drv_api.h	Application	The only API header file to include in application code
High Layer Driver (HLD) Source		
r_adc_drv_api.c	Private (HLD only)	High Layer Driver (HLD) source code enabling the driver API functions
High Layer to Low Layer API		
r _adc_lld_xxxx.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, not to define any device specific enumerations or structures
r_adc_lld_cfg_xxxx.h	Private (HLD/LLD only)	Low Layer Driver (LLD) header file (where "xxxx" is a device and board-specific identification). Intended for definitions of device specific settings (in the form of enumerations and structures). No LLD functions to be defined in this file
Abstraction Link between High and Low Layer Drivers (HLD/LLD Link)		
r_adc_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 configuration file "r_adc_lld_xxxx.h"
r_adc_device_cfg.h	Should be included in "r_adc_drv_api.h"	Header file intended as an abstraction between low and high layer. This header will include the device specific configuration file "r_adc_lld_cfg_xxxx.h"
Low Layer Driver (LLD) Source		
r_adc_lld_xxxx.c	Private (LLD only)	(Where "xxxx" is a device and board specific identification). Provides the definitions for the Low Layer Driver interface.
Smart Configurator		
r_adc_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 table below:

Type	Function	Arguments	Return Values
int_t	**adc_hld_open(** *st_stream_ptr_t* p_stream **)**	[in] driver handle	>0: the handle to the driver **DRV_ERROR** Open failed
	Driver initialisation interface is mapped to open function Called directly using the st_r_driver_t ADC driver handle g_adc_driver: i.e. **g_adc_driver.open()**		
void	**adc_hld_close(** *st_stream_ptr_t* p_stream **)**	[in] driver handle	**None**
	Driver close interface is mapped to close function. Called directly using the st_r_driver_t ADC driver structure g_adc_driver: i.e. **g_adc_driver.close()**		
int_t	**adc_hld_read(** *st_stream_ptr_t* p_stream, *uint8_t* *p_buffer, *uint32_t* count **)**	[in] driver handle [out] pointer to data buffer [in] the length of the buffer	The number of bytes read on success **DRV_ERROR** Read failed
	Driver read interface is mapped to the read function. Reads ADC conversion data for enabled channels. Called directly using the st_r_driver_t ADC driver structure g_adc_driver: i.e. **g_adc_driver.read()** The buffer length must be a multiple of the number of enabled channels and the bytes needed to contain each value (1 for 8-bit conversions, 2 for 10- and 12- bit conversions).		
int_t	**adc_hld_control(** *st_stream_ptr_t* p_stream**,** *uint32_t* ctl_code**,** *void* * p_ctl_struct **)**	[in] driver handle [in] requested function code [in/out] dependent on ctl_code	**DRV_SUCCESS** Operation succeeded **DRV_ERROR** Operation failed
	Driver control interface function. Maps to ANSI library low level control function. Called directly using the st_r_driver_t ADC driver structure g_adc_driver: i.e. **g_adc_driver.control()**		
int_t	**adc_get_version(** *st_stream_ptr_t* p_stream**,** *st_ver_info_ptr_t* *p_ver_info **)**	[in] driver handle [out] pointer to version structure	**DRV_SUCCESS** Operation succeeded
	Driver get_version interface function. Maps to extended non-ANSI library low layer get_version function. Called directly using the st_r_driver_t ADC driver structure g_adc_driver: i.e. **g_adc_driver.get_version()**		

2.3.1 Operation

Due to the nature of the peripheral, the driver only supports a single thread and only one handle to it can be open at once. In a multi-threaded application where different threads need access to different ADC channels (inputs), then it is recommended to write an ADC manager thread to control the ADC and communicate conversion values to other threads within the application.

When the driver is opened, the ADC peripheral is initially configured using the settings in the **ADC_SC_TABLE** in the **r_adc/inc/r_adc_drv_sc_cfg.h** header file. However, these settings can be changed by calling **control (CTL_ADC_SET_CONFIGURATION)**.

When the conversion is started by calling **control(CTL_ADC_SOFTWARE_TRIGGER)**, the ADC performs a conversion scan, and converts each enabled channel. If a conversion complete callback has been configured, then the call to **control(CTL_ADC_SOFTWARE_TRIGGER)** will return immediately, and the callback function will be invoked when the conversion scan completes. If a conversion complete callback has not been configured, then the **control(CTL_ADC_SOFTWARE_TRIGGER)** call will block until the conversion scan is complete.

Please note that the conversion complete callback is called under interrupt context, and so should be written accordingly.

Conversion values are retrieved by calling **read()** and are returned in ascending channel order (AN000 → AN007) and only for enabled channels. The number of bytes returned for each conversion depends on the ADC resolution setting, so if it is set to 8-bits, then a single byte will be received for each one. Multi-byte conversion values are returned LSB first.

For example two channels are enabled (AN003 and AN006) and the conversion resolution is set to 10-bits. Each conversion value is thus 2 bytes long, and after calling **control(CTL_ADC_SOFTWARE_TRIGGER)** and the conversion has completed, there will be 4 bytes returned by a call to **read()**.

Conversion values accumulate within the ADC driver conversion buffer, so if two conversion scans are performed before calling **read()**, in this example 8 bytes will be returned. The order will be AN003 first conversion, AN006 first conversion, AN003 second conversion, AN006 second conversion.

In order to prevent misalignment issues with conversion data packets, the read() function must be called with a buffer length that is a multiple of the conversion packet size. It will return DRV_ERROR if this is not the case. So in the above example with two channels enabled and 10-bit resolution the packet size is 4 bytes, and so the buffer length must be a multiple of 4.

3. Accessing the Driver

3.1 STDIO

The Driver API can be accessed through the ANSI ‘C’ Library <stdio.h>, or directly. The following table details the operation of each function when used with the STDIO library:

Operation	Return	Function Details
open	gs_stdio_handle, unique handle to driver	open(DEVICE_IDENTIFIER "adc0", O_RDWR);
close	DRV_SUCCESS successful operation, or driver specific error	close(gs_stdio_handle);
read	The number of bytes read (>= 0) or DRV_ERROR on failure	read(gs_stdio_handle, buffer, buffer_length)
write	DRV_ERROR (write is not implemented in this ADC driver)	write(gs_stdio_handle, buffer, data_length)
control	DRV_SUCCESS control was processed, 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 "adc0", &drv_info);

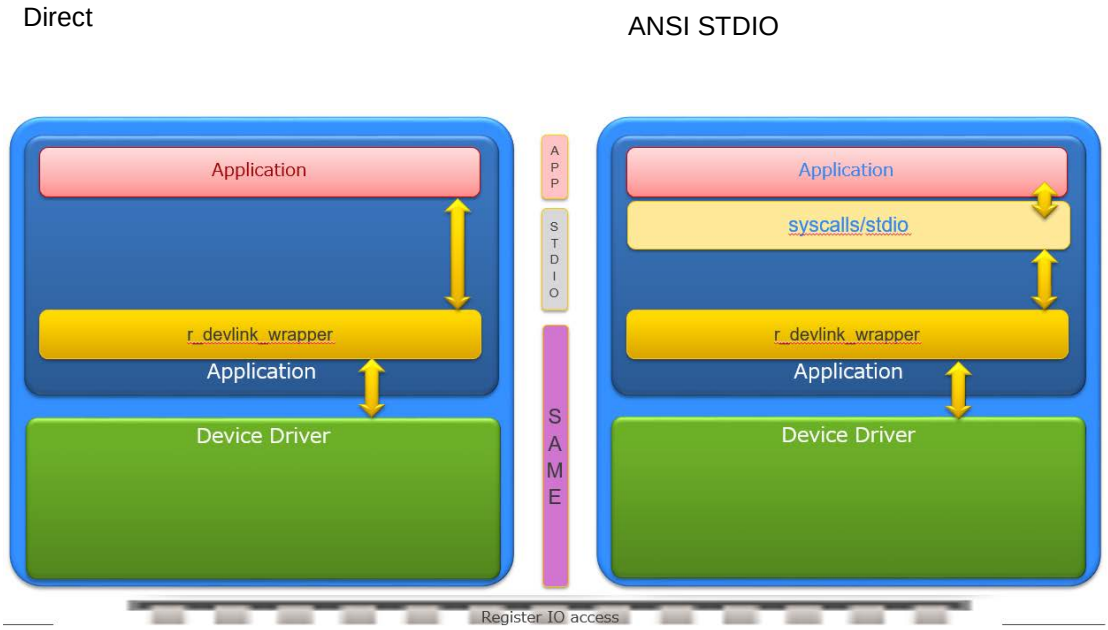
3.2 Direct

The following table shows the available direct functions.

Operation	Return	Function details
open	gs_direct_handle unique handle to driver	direct_open("adc0", 0);
close	DRV_SUCCESS successful operation, or driver specific error	direct_close(gs_direct_handle);
read	The number of bytes read (>= 0) or DRV_ERROR on failure	direct_read(gs_direct_handle, buff, data_length);
write	DRV_ERROR (write not implemented in this ADC driver)	direct_write(gs_direct_handle, buff, data_length);
control	DRV_SUCCESS control was processed, 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("adc0", &drv_info);

3.3 Comparison

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



4. Example of Use

This section gives simple examples for opening the driver, setting the configuration, getting the configuration, software triggering a conversion scan, reading the conversion data, closing the driver, and finally getting the driver version.

4.1 Open

```
int_t gs_adc_handle;
char_t *adc_drv_name = "\\\\.\\adc0";

/* 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_adc_handle = open(adc_drv_name, O_RDWR);
```

4.2 Control – ADC Set Configuration

```
st_r_drv_adc_config_t adc_cfg;
int_t result;

adc_config.config.alignment = ADC_ALIGN_LEFT;
adc_config.config.interrupt_priority = INTC_PRIORITY_13;
adc_config.config.resolution = ADC_RESOLUTION_10;
adc_config.config.scan_mode = ADC_SCAN_MODE_SINGLE;
adc_config.config.p_adcCallback = adcCallback;
adc_config.config.channels[ADC_CHANNEL_AN000].sample_time = 20;
adc_config.config.channels[ADC_CHANNEL_AN000].trigger_source =
    ADC_TRIGGER_NORMAL;
                              :
                              :
adc_config.config.channels[ADC_CHANNEL_AN007].sample_time = 42;
adc_config.config.channels[ADC_CHANNEL_AN007].trigger_source =
    ADC_TRIGGER_DISABLED;

result = control(gs_adc_handle, CTL_ADC_SET_CONFIGURATION, (void *)
    &adc_cfg);
```

4.3 Control – ADC Get Configuration

```
result = control(gs_adc_handle, CTL_ADC_GET_CONFIGURATION, (void *)
    &adc_cfg);
```

4.4 Control – ADC Software Trigger

```
result = control(gs_adc_handle, CTL_ADC_SOFTWARE_TRIGGER, NULL);
```

4.5 Write

```
The stdio write() function is not supported by the ADC device driver.
```

4.6 Read

```
uint8_t buffer[20];
int_t count;

count = read(gs_adc_handle, buffer, 20);
```

4.7 Close

```
close(gs_adc_handle);
```

4.8 Get Version

```
st_ver_info_t info;
result = get_version(gs_adc_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 middleware application note (R11AN0309EG).

6. How to Import the Driver

6.1 e² studio

Please refer to the RZ/A2M Smart Configurator User's Guide: e² studio (R20AN0583EJ) for details on how to import drivers into projects in e2 studio using the Smart Configurator tool.

6.2 For Projects created outside e² 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

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Mar.04.19	All	Created document.
1.01	May.08.19	All	Removed Low Layer Driver interface. Added section 6.1 for using driver in e^2 studio Updated template.

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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.
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