

Renesas RA Family

Getting Started with ADC Interleaved Mode Application

Introduction

This application note describes implementing an analog-to-digital converter (ADC) in an interleaved mode in an RA device by utilizing two ADC units that convert the same ADC input pin alternately to double the data sampling rate. The implementation uses a synchronous trigger from a General-Purpose Timer (GPT) to synchronize A/D conversion timing between the two ADC units.

The typical application for ADC interleaved mode requires a double data rate for faster signal processing.

This application note guides you through the steps to implement ADC interleaved mode, including:

- Board setup.
- Application overview.
- FSP/Driver configuration.
- Application design highlights.
- Interleaving ADC units for a higher sample rate using ADC interleave mode in RA MCUs.
- Setting up the ADC, GPT, and DMAC modules.

Required Resources

Development tools and software

- The e² studio IDE v2025-04.1
- Renesas Flexible Software Package (FSP) v6.0.0

Hardware

- Renesas EK-RA6M5 kit (RA6M5 MCU Group) (<u>https://www.renesas.com/us/en/products/microcontrollers-microprocessors/ra-cortex-m-mcus/ek-ra6m5-evaluation-kit-ra6m5-mcu-group</u>)
- Waveform generator

Reference Manuals

- RA Flexible Software Package Documentation
- Renesas RA6M5 Group User's Manual Rev.1.40
- EK-RA6M5-v1.0 Schematics



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1. Introduction to Interleaving

ADC interleaving is a technique that enables two or more ADC cores to be operated together to achieve an effective sample rate that is higher than the rate that either ADC can produce on its own. It is a commonly used method to increase the system's overall performance and, when applied correctly, can have great benefits. However, the implementation has its challenges, and performance limitations should be considered carefully.

1.1 Sample Timing Control

Consider the case where two ADC cores are interleaved. In this case, we refer to the cores as the "odd" and "even" ADCs, as they will be used to successively sample the analog input signal and produce digital conversion results that are aligned with the odd-number data points and the even-number data points.





From Figure 1, we can see the relationship between the sample clock applied to the odd and even ADC cores. The sample clock, oscillating at $2f_s$, is divided by two to ensure a 50:50 mark-space ratio and split into two signals with a 180° phase shift (by simple inversion in one of the outputs).

Each ADC core samples the analog signal on the rising edge of its sample clock, which, due to the divide by two, is now f_s . The odd ADC core produces the first result, followed by the even ADC core half a cycle later. The resulting output data stream, after the two converters' outputs have been combined, provides a sample rate that is back to $2f_s$.

For the interleaving to work correctly and provide a spurious-free output data stream, the phase relationship between the odd and even ADCs must be predictable, stable, and precisely 180°. The implementation of this phase relationship is the most important aspect of achieving correct interleaving.

For an AC system where the ADC is used to sample an input signal, if the phase relationship is not precisely 180°, spurs will appear in the output spectrum. These spurs will appear as a function of the sample rate f_s and the input frequency, so $f_s/2 \pm f_{in}$. See Figure 2.



Figure 2. Sampled Data Spectrum due to Timing Error

For DC applications where a slow-moving signal is sampled and provided as feedback to a control loop, the phase angle error will create an amplitude error that can lead to uncertainty within the control loop if the timing irregularity is not considered.









Figure 4. Sample Timing with Error with 60:40 Phase Alignment

1.2 Gain and Offset Mismatch

Other errors that can be present within the ADC output stream are related to gain and offset mismatch between the two ADC cores.

Gain mismatch can be present where individual PGAs are used prior to the odd and even ADC cores. Any mismatch between the absolute gain value of these two PGAs will result in a sample-by-sample error being present, causing the value created by the two ADC cores to be mismatched, diverging by an increasing amount as the signal approaches full scale. This effect can also be caused if individual or unstable voltage references are used. A spur will appear in the output spectrum at $f_s/2 \pm f_{in}$.





Offset mismatch can occur when the DC offset value of the odd and even ADC cores is not the same. Any mismatch results in a sample-by-sample error in the output values. In this case, a spur will appear at half of the combined sampling frequency, which is f_s . The magnitude of the spur is defined by the amplitude of the mismatch.







Typically, the causes of these effects are minimized on a monolithic device such as an MCU, where the two ADC cores are fabricated next to each other. If any effects are noticeable, they can be digitally compensated for in firmware quite simply with data manipulation for gain and offset.

2. Application Overview

The application project accompanying this document serves as a reference to create the ADC Interleave Mode in an RA device by utilizing two ADC units, ADC0 and ADC1. The ADC units convert the same ADC input pin alternately to double the data sampling rate, using a synchronous trigger from a GPT to synchronize A/D conversion timing between 2 channels. The conversion data is transferred to the same buffer using a DMAC.

Figure 7 shows the application diagram.



Figure 7. Block Diagram

3. Interleaving Two ADC Units for a Higher Sample Rate

ADC Interleave mode in the RA6M5 MCU allows the use of two identical ADC units to process regular sample data series at a faster rate than the operating sample rate of each individual data converter.

As shown in the Figure 8, two ADC units convert the same ADC input pin alternately to double the data sampling rate.



Figure 8. Interleaving 2 Channels of 2 ADC Units



4. 12-Bit ADC Converter (ADC12)

The RA6M5 MCU includes 12-bit successive approximation A/D converter (ADC12) units. In unit 0, up to 13 analog input channels are selectable. In unit 1, up to 16 analog input channels, temperature sensor output, and internal reference voltage can be selected for conversion in respective units.

The A/D conversion accuracy is selectable among 12-bit, 10-bit, and 8-bit, making it possible to optimize the trade-off between speed and resolution in generating a digital value.

The ADC12 supports the following operating modes and features:

- Single scan mode to convert analog inputs of selected channels in ascending order of channel number.
- Continuous scan mode to continuously convert analog inputs of selected channels in ascending order of channel number.
- Group scan mode to divide analog inputs of channels into two groups (group A and group B) and convert the analog inputs of selected channels for each group in ascending order of channel number.
- Conversion time is 0.4 microseconds/channel (when 12-bit A/D conversion clock PCLKC (ADCLK) is operating at 50 MHz).
- Support for interleave function.

Refer to the ADC12 chapter in the RA6M5 MCU User's Manual for more details.

Figure 9 and Figure 10 show the timing in interleaved operation.



Figure 9. Trigger Input Timing in Interleaved Operation

Parameter		Symbol	Min	Мах
Trigger issuance delay	Single scan	t _{TRD}	t _{SPL} + 2PCLKC	t _{TRP} - t _{SPL} - 2PCLKC
penoa	Continuous scan	t _{TRD}	t _{SPL} + 2PCLKC	t _{SAM} - 2PCLKC
Trigger issuance period		t _{TRP}	tSCAN	_





5. FSP Configuration

One of the first things you must do when writing an FSP application is to configure the FSP. Refer to the *Renesas Flexible Software Package (FSP) User's Manual* for more information.

In this application, the FSP configuration is stored in a file named configuration.xml. Double-clicking on this file opens the project's RA Configuration tab.

✓ 🎏 RA_ADC_Interleave_EK_RA6M5 [Debug]	
> 👯 Binaries	
> 🔊 Includes	
> 😂 ra	
> 😂 ra_gen	
V 😂 src	
> 🗁 SEGGER_RTT	
> 🖻 adc_hal.c	
> 🖻 adc_hal.h	
> 🖻 adc_periodic_scan.h	
> 🖻 common_utils.h	
> 🖻 dmac_hal.c	
> 🖻 dmac_hal.h	
> 🖻 elc_hal.c	
> 🖻 elc_hal.h	
> 🖻 gpt_hal.c	
> 🖻 gpt_hal.h	
> 🖻 hal_entry.c	
> 🗁 Debug	
> 🗁 ra_cfg	
> 🗁 script	
🔯 configuration.xml	
R7FA6M5BH3CFC.pincfg	
RA_ADC_Interleave_EK_RA6M5 Debug_Flat.jlink	
RA_ADC_Interleave_EK_RA6M5 Debug_Flat.launch	
i ra_cfg.txt	
> ⑦ Developer Assistance	

Figure 11. configuration.xml on the Project Plane

5.1 Stacks Tab

The **Stacks** tab allows you to add and configure the threads that the FSP automatically creates for your application. You define a new thread by clicking the solution and then entering a unique name for your new thread. Once you add a new thread, you must define the Modules that the thread will use along with any thread objects that will be used by your thread.

As an example, if you click the **HAL/Common**, you should see something like the screen capture shown in Figure 12. This shows that the project requires multiple modules, such as the r_gpt driver, which is used to control the GPT unit.

Stacks Configuration		Generate Project Content
Threads	HAL/Common Stacks	🕢 New Stack > 😤 Extend Stack > 🏦 Remove
All Common G g.joport I/O Port (r.joport) G g.dot ADC (r.adc) g.g.dot ADC (r.adc) g.g.dot TADC (r.adc) G g.el: Event Link Controller (r.gel) G g.el: Event Link Controller (r.gel) G g.transfer_add Transfer (r.dmac) ADCI SCAN END (E g.transfer_add Transfer (r.dmac) ADCI SCAN END (E Sobjects New Objects All Remove		timef0 Timer, General
Summary BSP Clocks Pins Interrupts Event Links Linker Sections S	dss Components	

Figure 12. Modules Using for the Application



You can add modules to any thread by clicking the New Stack 1 button. If you have chosen the appropriate components prior to adding Modules to your threads, you should not receive any errors. As an example, Figure 13 shows you how to add a GPT timer to the HAL/Common. The timer is added by choosing 1 New Stack > Search > r_gpt.

If you pick a module for which you have not preselected the appropriate component first, the FSP automatically selects the component for you. If the FSP detects errors with the module addition, it prefaces the module with an error. You can examine the errors by hovering over the module name.

🗟 New Thread 🛍 Remove 📄	НА	New Stack			×		🐔 New Stack > 🗍
non t I/O Port (r_ioport) ADC (r_adc) ADC (r_adc) 0 Timer, General PWM (r_gpt) rent Link Controller (r_elc) fer_adc0 Transfer (r_dmac) ADC0 SCAN END (End fer_adc1 Transfer (r_dmac) ADC1 SCAN END (End		r_gpt ✓ ➢ Timers ⊕ Three-Phase PWM (r_gpt_three_phase) ⊕ Timer, General PWM (r_gpt)			×	=r0 Timer, General (r_gpt)	g_elc Event Link Controller (r_elc)
	<		New	Cancel			

Figure 13. Adding r_gpt Driver

5.2 Module Configuration

Once you have added a module to your project, you need to configure its properties. The properties depend on the module(s) that you have added. Use the **Properties** tab to configure them.

5.2.1 ADC Input

In this application note, P000 is used as a single input pin for both ADC channels (AN000 and AN100) in interleave mode. The interleave function is also available with AN001/AN101 or AN002/AN102.



Figure 14. ADC Input Pin



5.2.2 ADC, Pin Configuration

In **Pins** tab, navigate to **Peripherals > Analog:ADC** at the **Pin Selection** window. Then, in the **Pin Configuration** window, set P000 as both inputs AN000 and AN100, as shown in the following figures:

Type filter text		Name	Value	Lock	Link	
PB	^	Operation Mode	Custom			
Other Pins		✓ Input/Output				
Peripherals		ADTRG0	None	n n n	4	
		AN000	P000	l 🖞	4>	
	_	AN001	None		\Rightarrow	
ADC1		AN002	None		⇒	
Apalog:ANALOG		AN003	None	- É	⇒	
Analog:DAC		AN004	None		4	
Connectivity:CANFD Connectivity:CEC	~	Module name: ADC0				
Pin Eurotion Pin Number						

Figure 15. Configure P000 as AN000

RA6M5 EK	Y Manage	configurations	🗹 Generate data	g_bsp_pin_cf	g	
Pin Selection	≣ ⊞ ⊟ ↓ªz	Pin Configuration				😲 Cycle Pin Group
Type filter text		Name	Value	Lock	Link	^
PB	^	Operation Mode	Custom			
• Other Pins		✓ Input/Output				
×		ADTRG1	None	- B	\Rightarrow	
× × Analog:ADC		AN100	P000	i i i i i i i i i i i i i i i i i i i		
ADC0		AN101	None		\Rightarrow	
✓ ADC1		AN102	None	n n n n n n n n n n n n n n n n n n n	\Rightarrow	
Analog ANALOG		AN116	None	n n n n n n n n n n n n n n n n n n n	\Rightarrow	
Analog:DAC		AN117	None	n	\Rightarrow	~
 Connectivity:CANFD Connectivity:CFC 	*	Module name: ADC1				

Figure 16. Configure P000 as AN100

5.2.3 GPT Configuration

The following figures show the setup for ADC continuous scan mode. In the r_gpt configuration, enable Capture A Interrupt and Overflow interrupt to trigger ADC 0 and ADC1 conversions.

The timer is configured in One-Shot mode since it only needs to trigger once in ADC continuous scan mode.

g_timer0 Timer, General PWM (r_gpt) Value Settings Property Value API Info > Common ✓ General > Compare Match g_timer0 Name g_timer0 Channel 0 Mode One-Shot Period Unit Nanoseconds > Output 230 Period Unit Nanoseconds Callback NULL Overflow/Crest Interrupt Priority Priority 2 Capture/Compare match & Interrupt Priority Disabled Underflow/Trough Interrupt Priority Disabled	g_timer0 Timer, General PWM (r_gpt) Settings Property Value API Info > Common Module g_timer0 Timer, General PWM (r_gpt) - > Compare Match	g_timer0 Timer, General PWM (r_gpt) Value Property > Common > Module g_timer0 Timer, General PWM (r_gpt) - > General	Problem	s Console	Properties \times	Smart Browser	Smart Ma	nual	Search	Memory
Settings Property Value > Common > > Module g_timer0 Timer, General PWM (r_gpt) > > General	Settings Property Value > Common > • Module g_timer0 Timer, General PWM (r_gpt) - • General	Settings Property Value > Common > Module g_timer0 Timer, General PWM (r_gpt) > General	g_timer0	Timer, Genera	al PWM (r_gpt)					
 Forber Forskunge 	> Extra Features	> Extra Features > Pins	g_timer0 Settings API Info	Property Common General Common General Compan Channee Channee Channee Period Period Period Output Input Input Callbact Overflor Capture Capture Underfli	al PWM (r_gpt) ner0 Timer, Genera re Match I Jnit k w/Crest Interrupt i c/Compare match ow/Trough Interru	al PWM (r_gpt) Priority A Interrupt Priority B Interrupt Priority pt Priority		Value g_timer 0 One-Sh 230 Nanose Null Priority Disablee Disablee	0 ot conds 2 d	
> EXtra reatures		✓ Pins		Underfl > Extra Feat	ow/Trough Interru ures	pt Priority		Disable	b	

Figure 17. GPT Driver Configuration



The GPT timer's timing setting is the trigger issuance delay period (t_{TRD}) mentioned in Figure 10. The t_{SPL} , T_{SAM} and t_{SCAN} in Figure 10 can be found in Table 43.27 of the *RA6M5 User's Manual* (<u>R01UH0891</u>).

The minimum setting of t_{TRD} is as follows:

 $t_{TRD} = t_{SPL} + 2PCLKC$, where $t_{SPL} = ADSSTRn$ (initial value = 0Bh) x ADCLK + 0.5 ADCLK.

t_{TRD} = 11ADCLK + 0.5 ADCLK = 11.5 ADCLK (where ADCLK = 50 MHz).

t_{TRD} = 230 ns.

5.2.4 ADC Configuration

The ADC0 and ADC1 units will be configured in continuous scan mode, triggered by GPT0 Compare Match A and Overflow interrupts. ADC0 and ADC1 Scan End interrupts are used to trigger DMAC transfer from A/D data registers to a buffer in SRAM.

The GPT Compare Match A interrupt triggers at half the timer cycle, while the GPT Overflow interrupt triggers at the full-timer cycle.

Note: Since the ADC Scan End interrupt is always generated by hardware, it is unnecessary to enable it in the ADC driver configuration to trigger DMAC transfer.

The detailed settings are shown in the following figures.

g_adc0 A	DC (r_adc)	
Settings API Info	Property > Common	Value
	 Module g_adc0 ADC (r_adc) General 	
	Name	g_adc0
	Unit Resolution	0 12-Bit
	Alignment	Right
	Clear after read	On Continuous Scan
	Double-trigger	Disabled
	✓ Input Changel Carp Mark (changel availability varias by MCI))	
	Channel 0	
	Channel 1	
	Channel 2	
	Channel 2 Channel 3	
	Channel 2 Channel 3 Channel 4	
	Channel 2 Channel 3 Channel 4 Channel 5 Channel 6	

Figure 18. Configure ADC0 in Continuous Scan Mode, Channel 0 as Input

Settings	Property	Value
second	> Common	
API Info	✓ Module g_adc0 ADC (r_adc)	
	> General	
	> Input	
	✓ Interrupts	
	Normal/Group A Trigger	GPT0 CAPTURE COMPARE A (Capture/Compare match A)
	Group B Trigger	Disabled
	Group Priority (Valid only in Group Scan Mode)	Group A cannot interrupt Group B
	Callback	NULL
	Scan End Interrupt Priority	Disabled
	Scan End Group B Interrupt Priority	Disabled
	Window Compare A Interrupt Priority	Disabled
	Window Compare B Interrupt Priority	Disabled
	> Evtra	

Figure 19. Set Trigger to Start ADC0 Conversion



g_adc1 A	.DC (r_adc)	
Settings	Property	Value
ADUnfo	> Common	
APTIMO	 Module g_adc1 ADC (r_adc) 	
	✓ General	
	Name	g_adc1
	Unit	1
	Resolution	12-Bit
	Alignment	Right
	Clear after read	On
	Mode	Continuous Scan
	Double-trigger	Disabled
	∽ Input	
	 Channel Scan Mask (channel availability varies by MCU) 	
	Channel 0	
	Channel 1	
	Channel 2	
	Channel 3	
	Citatilers	
	Channel 4	
	Channel 4 Channel 5	
	Channel 4 Channel 5 Channel 6	

Figure 20. Configure ADC1 in Continuous Scan Mode, Channel 0 as Input

Settings	Property	Value
ADLInfo	> Common	
API INIO	 Module g_adc1 ADC (r_adc) 	
	> General	
	> Input	
	✓ Interrupts	
	Normal/Group A Trigger	GPT0 COUNTER OVERFLOW (Overflow)
	Group B Trigger	Disabled
	Group Priority (Valid only in Group Scan Mode)	Group A cannot interrupt Group B
	Callback	NULL
	Scan End Interrupt Priority	Disabled
	Scan End Group B Interrupt Priority	Disabled
	Window Compare A Interrupt Priority	Disabled
	Window Compare B Interrupt Priority	Disabled
	> Extra	

Figure 21. Set Trigger to Start ADC1 Conversion



6. DMAC Controller Setup

The ADC0 Scan End interrupt, and the ADC1 Scan End interrupt trigger DMAC0 and DMAC1 transfers, respectively.

The following figures show the detailed settings.

ansfe	er_adc0 Transfer (r_dmac) ADC0 SCAN END (End of A/D scanning operation)			
inas	Property	Value		
nfo	✓ Common			
'i Into	Parameter Checking	Default (BSP)		
	✓ Module g_transfer_adc0 Transfer (r_dmac) ADC0 SCAN END (End of A/D scanning operation)			
	Name	g_transfer_adc0		
	Channel	0		
	Mode	Repeat		
	Transfer Size	2 Bytes		
	Destination Address Mode	Offset addition		
	Source Address Mode	Fixed		
	Repeat Area (Unused in Normal Mode)	Source		
	Number of Transfers	512		
	Number of Blocks (Valid only in Repeat, Block or Repeat-Block Mode)	2		
	Activation Source	ADC0 SCAN END (End of A/D scanning operation)		
	Callback	g_transfer_adc0_cb		
	Transfer End Interrupt Priority	Priority 4		
	Interrupt Frequency	Interrupt after each block, or repeat size is transferred		
	Offset value (Valid only when address mode is \'Offset\')	4		
	Source Buffer Size	2		

Figure 22. DMAC0 Configuration

Property	Value
✓ Common	
Parameter Checking	Default (BSP)
✓ Module g_transfer_adc1 Transfer (r_dmac) AD	SCAN END (End of A/D scanning operation)
Name	g_transfer_adc1
Channel	1
Mode	Repeat
Transfer Size	2 Bytes
Destination Address Mode	Offset addition
Source Address Mode	Fixed
Repeat Area (Unused in Normal Mode)	Source
Number of Transfers	512
Number of Blocks (Valid only in Repeat, Blo	or Repeat-Block Mode) 2
Activation Source	ADC1 SCAN END (End of A/D scanning operation
Callback	g_transfer_adc1_cb
Transfer End Interrupt Priority	Priority 5
Interrupt Frequency	Interrupt after each block, or repeat size is transfe
Offset value (Valid only when address mod	s \'Offset\') 4
Source Buffer Size	2

Figure 23. DMAC1 Configuration



7. Application Code Highlights

This section details the highlights of the code in this application project. Figure 24 and Figure 25 show the code needed to initialize and configure DMAC channels. Both channels are configured to transfer converted data to the same buffer named g_buffer_adc.

```
/* Initialize DMAC instance and reconfigure for instance unit 0 */
err = init_hal_dmac(&g_transfer_adc0_ctrl, &g_transfer_adc0_cfg);
handle_error(err,"\r\n** init_hal_damc for unit 0 failed ** \r\n", ELC_DMAC0);
/* Update the DMAC ch 0 settings */
p_info_tmp = g_transfer_adc0_cfg.p_info;
p_info_tmp->p_src = (void const*) &R_ADC0->ADDR[ZER0];
p_info_tmp->p_dest = (void*) &g_buffer_adc[ZER0];
err = dmac_hal_reconfigure(&g_transfer_adc0_ctrl, p_info_tmp);
handle_error(err,"\r\n** dmac_reconfiguration for unit 0 failed ** \r\n", ELC_DMAC0);
```

Figure 24. Initialize and Configure DMAC0 Transfer

```
/* Initialize DMAC instance and reconfigure for instance unit 1 */
err = init_hal_dmac(&g_transfer_adc1_ctrl, &g_transfer_adc1_cfg);
handle_error(err,"\r\n** dmac_init for unit 1 failed ** \r\n", ELC_DMAC01);
/* Update the DMAC ch 1 settings */
p_info_tmp = g_transfer_adc1_cfg.p_info;
p_info_tmp->p_src = (void const*) &R_ADC1->ADDR[ZER0];
p_info_tmp->p_dest = (void*) ((&g_buffer_adc[ZER0])+1);
err = dmac_hal_reconfigure(&g_transfer_adc1_ctrl, p_info_tmp);
handle_error(err,"\r\n** dmac_reconfiguration for unit 1 failed ** \r\n", ELC_DMAC01);
```

Figure 25. Initialize and Configure DMAC1 Transfer

8. Board Setup

The EK-RA6M5 kit has a few switch settings that must be configured prior to running the application associated with this application note. In addition to these switch settings, the boards also contain a USB debug port and connectors to access the J-Link[®] programming interface.

Switch	Setting
J8	Jumper on pins 1-2
J9	Open



Figure 26. J8 and J9 on EK-RA6M5



Figure 27 shows a picture of the EK-RA6M5 kit.



Figure 27. EK-RA6M5 Kit

9. Importing and Building the Project

To bring the application into the e^2 studio, follow these steps:

- 1. Launch e² studio.
- 2. In the workspace launcher, browse to the workspace location of your choice.
- 3. Close the Welcome window.
- 4. In e² studio, select **File > Import**.
- 5. In the Import Dialog Box, pick **Existing Projects into Workspace**.
- 6. Select the archive file bundled with this document.
- 7. Select the project and click Finish.
- 8. Open configuration .xml.
- 9. Click on Generate Project Content on the FSP configurator window.
- 10. Build the project.



10. Downloading the Executable to the EK-RA6M5 Kit

To connect and run the code, follow these steps:

- 1. Connect input signal to P000 (J4 Pin 34). We used a waveform generator to generate input signals for testing.
- 2. Connect your PC to the USB port labeled DEBUG using a USB cable.
- 3. Go to **Run > Debug configurations.**
- 4. Click **Debug**. The program will break at the reset handler.
- 5. Click "Switch" to the **Debug perspective** when prompted by e² studio.
- 6. Click **Run > Resume**.

11. Verify ADC Conversion

After running the project, ensure that the **Memory** tab is open in the Console window, normally located at the bottom of the screen in Debug view. Click the small green plus (+) sign in the Monitors Pane to add a memory monitor. You should see a Monitor Memory dialog as shown in Figure 28. Enter the ADC buffer start address **&g_buffer_adc** and click OK.

Console Registers	Problems Debugger Console Smart Browser Memory $ imes$
Monitors	+ X %
	Monitor Memory ×
	Enter address or expression to monitor: &g_buffer_adc[0]
	OK Cancel

Figure 28. Memory Tab in e² studio

The Memory viewer shows the ADC buffer.

Console	Registers	Problems Debugg	er Console	Smart Brow	vser Memor	ry ×	
Nonitors	+ 🗙	🍇 &g_buffer_adc[0] : 0x20	000D14 <hex ir<="" td=""><td>nteger> × &</td><td>g_buffer_adc[0]</td><td>: 0x20000D14 <waveform></waveform></td><td>New Renderings</td></hex>	nteger> × &	g_buffer_adc[0]	: 0x20000D14 <waveform></waveform>	New Renderings
&g_but	ffer_adc[0]	Address	0 - 3	4 - 7	8 - B	C - F	
		000000020000D10	00000000	0CA80D35	0D500D18	0D9E0D83	
		000000020000D20	0DC60DB5	0D910DB5	0D630D75	0D4C0D53	
		000000020000D30	0D420D45	0D390D3B	0D380D3B	0D010D39	
		000000020000D40	0CB20CD1	0C8E0C9B	0C7F0C84	0C760C77	
		000000020000D50	0C6E0C73	0C4F0C6B	0BEC0C11	OBBFOBCF	
		000000020000D60	0BA60BAF	0B9C0BA0	0B930B95	0B8B0B8F	
		000000020000D70	0B1B0B46	0ADE0AF3	0AC20ACA	0AB00AB7	
		000000020000D80	0AA50AA8	0AA00AA3	0A3E0A77	09F60A0F	
		000000020000D90	09D309E1	09BD09C3	09B409B2	09AD09AD	

Figure 29. ADC Buffer in Hexadecimal

Click the (+) New Rendering and select Waveform rendering as shown in Figure 30.





Figure 30. Waveform Rendering

Configure the waveform properties.

8	_	
Waveform Properties		
Enter buffer size		
Data Size:	16bit	~
Y-axis settings:		
Y-axis precision:	24bit	~
User specified		
Minimum value:	0	
Maximum value:	4096	
Channel:		
Mono	⊖ Stereo	
Buffer Size:	2048	
	ОК	Cancel

Figure 31. Configure Waveform Rendering



11.1 Rendering Sinewave on e² studio

The following figures show the captured Sinewave input from a waveform generator.



Figure 32. Rendering of Sinewave Input



Figure 33. Rendering of Sinewave Input (Zoom in: a complete cycle)





Figure 34. Rendering of Sinewave Input (Zoom in: 16-point data)

11.2 Rendering Ramp Input on e² studio

The following figures show captured Ramp input from a waveform generator.



Figure 35. Rendering of Ramp Input



Figure 36. Rendering Ramp Input (Zoom in: a Full Cycle)





Figure 37. Rendering Ramp Input (Zoom in: 16 Data Points)

You can export the ADC buffer to various formats for further processing. Click the Export button marked in red in Figure 38 and select the data format.



Figure 38. Select Data Format to Export Rendering Data

11.3 Set up J-Link RTT Viewer Output

To show information on the RTT Viewer, configure the SEGGER J-Link RTT Viewer as shown in Figure 39.



🔝 J-Link RTT Viewer V8.44a Co	nfiguration	×
Connection to J-Link USB 	SN / Nickname	
◯ TCP/IP		
O Existing Session		
Specify Target Device		
R7FA6M5BH		~
Force go on connect		
Script file (optional)		
Target Interface & Speed		
SWD	•	4000 kHz 🔹
RTT Control Block		
O Auto Detection O Addres	s 💿 Search	Range
Enter one or more address range(s) the Syntax: <rangestart [hex]=""> <rangesiz Example: 0x10000000 0x1000, 0x20000</rangesiz </rangestart>	RTT Control block can be loca e>[, <range1start [hex]=""> <r 00 0x1000</r </range1start>	ated in. Range1Size>,]
0x20000000 0x1000		
	ОК	Cancel

Figure 39. Configure SEGGER RTT Viewer

After completing the conversion of 2048 samples, the RTT Viewer stops and prints out the messages shown in Figure 40.



Figure 40. SEGGER RTT Viewer Output

12. Change Project Configuration to Support ADC Single Scan Mode

By default, the application project is configured to work in ADC continuous scan mode. You can change it to work in ADC single scan mode by changing the GPT timer to periodic mode since ADC units need to be triggered repeatedly. Both ADC channels are configured in single scan mode.

The following figures show the settings of the GPT timer, ADC0, and ADC1 needed for ADC single scan mode.



g_timer0 Timer, General PWM (r_gpt)							
Settings	Property ~ Common	Value					
API Into	Parameter Checking	Default (BSP)					
	Pin Output Support	Enabled					
	Write Protect Enable	Disabled					
	✓ Module g_timer0 Timer, General PWM (r_gpt)						
	✓ General						
	> Compare Match						
	Name	g_timer0					
	Channel	0					
	Mode	One-Shot					
	Period	230					
	Period Unit	Nanoseconds					
	> Output						
	> Input						
	> Interrupts						
	> Extra Features						
	✓ Pins						
	GTIOC0A	None					
	GTIOC0B	None					

Figure 41. GPT Timer in Periodic Mode

g_adc0 ADC (r_adc)				
Settings	Property	Value		
ADLInfo	✓ Common			
APTINIO	Parameter Checking	Default (BSP)		
	✓ Module g_adc0 ADC (r_adc)			
	✓ General			
	Name	g_adc0		
	Unit	0		
	Resolution	12-Bit		
	Alignment	Right		
	Clear after read	On		
	Mode	Continuous Scan		
	Double-trigger	Disabled		
	> Input			
	> Interrupts			
	> Extra			

Figure 42. ADC0 Configuration in Single Scan Mode

g_adc1 A	c1 ADC (r_adc)			
Settings	Property	Value		
API Info	Parameter Checking	Default (BSP)		
	 Module g_adc1 ADC (r_adc) 			
	✓ General			
	Name	g_adc1		
	Resolution	12-Bit		
	Alignment	Right		
	Clear after read	On		
	Mode	Continuous Scan		
	Double-trigger	Disabled		
	> Input			
	> Interrupts			
	✓ Pins			

Figure 43. ADC1 Configuration in Single Scan Mode



13. Conclusion

You can utilize two ADC units that convert the same ADC input pin alternately to greatly increase the system's overall performance.



14. Website and Support

Visit the following vanity URLs to learn about key elements of the RA family, download components and related documentation, and get support.

RA Product Informationwww.renesas.com/raRA Product Support Forumwww.renesas.com/ra/forumRA Flexible Software Packagewww.renesas.com/FSPRenesas Supportwww.renesas.com/support



Revision History

		Description			
Rev.	Date	Page	Summary		
1.00	Nov.11.22	-	Initial version		
1.01	Jun.28.23	-	Updated to FSP v4.4.0		
1.02	May.01.24	-	Updated to FSP v5.2.0		
1.03	Jul.09.25	-	Updated to FSP v6.0.0		



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 is supplied until the power is supplied until the power reaches the level at which reseting 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 systemevaluation test for the given product.

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