RISC-V

# A/D Converter (Software trigger wait mode)

## Introduction

This application note describes how to use the software trigger wait mode (in addition to select mode and one-shot conversion mode) of the A/D converter on the RISC-V to convert analog voltages into digital values.

In this application note, A/D conversion results are stored in the internal RAM.

## Target Device

RISC-V

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

## Contents

# 1. Specifications

## 1.1 Overview of Specifications

This application note describes an example of using the software trigger wait mode (as well as select mode and one-shot conversion mode) of the A/D converter. The A/D converter converts analog voltages that are input to the P400 / ANI2 pin into digital values. Conversion results are then stored in the internal RAM.

Table 1.1 shows the peripheral function to be used and its use.

**Table 1.1 Peripheral Function and Use**

| Peripheral Function | Use |
|---|---|
| A/D converter | Converts the analog voltages that are input to the P400 / ANI2 pin into digital values. |

## 1.2 Outline of Operation

The sample code uses the software trigger wait mode (as well as select mode and one-shot conversion mode) of the A/D converter to convert the analog voltages that are input to the ANI2 pin into digital values. The CPU waits for the end of A/D conversion in Sleep mode. When A/D conversion ends, the conversion results are stored in the internal RAM.

(1) Initialize the A/D converter.
<Setting conditions>
— As the A/D conversion channel selection mode, use select mode.
— Use the P400/ANI2 pin for analog input.
— As the A/D conversion mode, use one-shot conversion mode.
— As the A/D conversion start condition, use software triggers.
— As the A/D conversion resolution, use 12 bits.
— As the A/D conversion reference voltages, use Vcc for the positive side and Vss for the negative side.
— As the A/D conversion time, use 2816/PCLKB in low voltage 1 mode.
— As the A/D conversion result comparison upper limit (ADUL), use 255. As the lower limit (ADLL), use 0.
— Use A/D conversion end interrupts (ADC_ENDI).

(2) To place the A/D converter in wait mode, stop the A/D converter by setting the ADCE bit in the ADM0 register to 0.

(3) Set the ADCS bit in the ADM0 register to 1 to start A/D conversion. Execute a Sleep instruction to place the CPU in Sleep mode and wait for an A/D conversion end interrupt.

(4) When the A/D converter finishes converting the voltage that is input to the ANI2 pin into a digital value, it transfers the result of A/D conversion to the ADCR0 register and generates an A/D conversion end interrupt (ADC_ENDI). Because the A/D converter is in one-shot conversion mode, the ADCS bit is automatically set to 0 at this point.

(5) When the A/D conversion end interrupt (ADC_ENDI) releases the CPU from Sleep mode, the A/D interrupt processing reads the result of A/D conversion from the ADCR0 register and stores it in the internal RAM.

(6) Set the ADCS bit to 1 again to place the CPU in Sleep mode and wait for an A/D conversion end interrupt.

## 2. Operation Confirmation Conditions

The operation of the sample code provided with this application note has been tested under the following conditions.

**Table 2.1 Operation Confirmation Conditions**

| Item | Description |
|---|---|
| MCU used | RISC-V (R9A02G021) |
| Board used | RISC-V-48p Fast Prototyping Board (RTK9FPG021S000W0BJ) |
| Operating frequency | High-speed on-chip oscillator clock : 48 MHz |
| Operating voltage | 3.3 V (can be operated at 1.6 V to 5.5 V) |
| Integrated development environment (e$^2$studio) | e$^2$studio V2024-01.1 (24.1.1) from Renesas Electronics Corp. |
| C compiler (e$^2$studio) | LLVM for RISC-V 17.0.2.202401 |
| Smart configurator (SC) | Smart Configurator for RISC-V V24.1.1.v20240125-1623 |
| Board support package (BSP) | V1.00 from Renesas Electronics Corp. |

# 3. Hardware Descriptions

## 3.1 Example of Hardware Configuration

Figure 3.1 shows an example of the hardware configuration used in the application note.

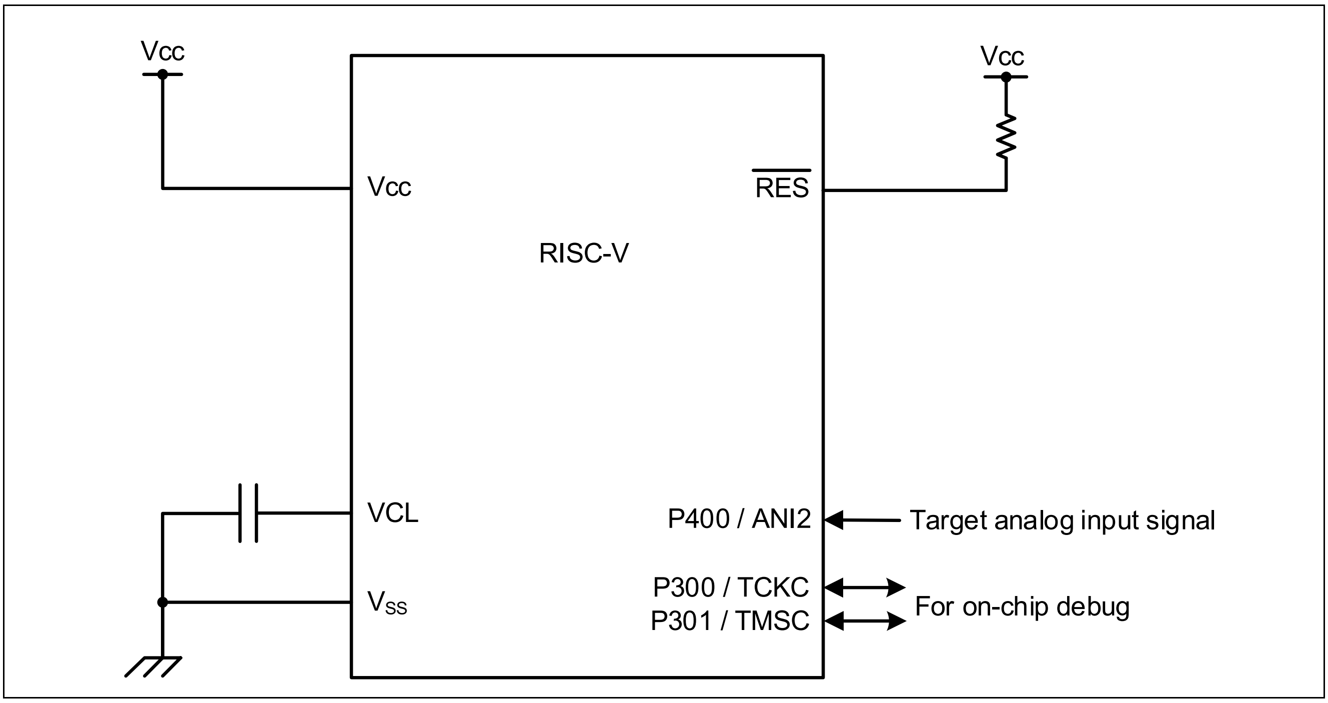


**Figure 3.1 Hardware Configuration**

Note 1. This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes appropriate pin handling and meets electrical characteristic requirements (connect each input-only port to Vcc or Vss through a resistor).

Note 2. Vcc must not be lower than the reset release voltage ($V_{LVD0}$) that is specified for the LVD0.

## 3.2 List of Pins to be Used

Table 3.1 lists the pins to be used and their functions.

**Table 3.1 Pins to be Used and Their Functions**

| Pin name | I/O | Function |
|---|---|---|
| P400 / ANI2 | Input | A/D converter analog input port |

Caution In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

# 4. Software Explanation

## 4.1 Setting of Option Byte

Table 4.1 shows the option byte settings. Set the values that are most suited to your system as necessary.

**Table 4.1 Option Byte Settings**

| Address | Setting Value | Contents |
|---|---|---|
| 0000_0400H | FFFF_FFFFH | Disables the watchdog timer.<br>(Counting stopped after reset) |
| 0000_0404H | FFFF_CFDFH | High-speed on-chip oscillator clock: 48 MHz |
| 0101_0008H | FFFF_FFFFH | Enables on-chip debugging |

## 4.2 List of Variables

**Table 4.2 Global Variables**

| Type | Variable Name | Description | Function Used |
|---|---|---|---|
| uint16_t | g_result_buffer | A/D conversion result storage area | main()<br>r_Config_ADC_interrupt() |

## 4.3 List of Functions

Table 4.3 shows a list of functions.

**Table 4.3 Functions**

| Function name | Outline |
|---|---|
| r_Config_ADC_interrupt() | A/D interrupt processing |

## 4.4 Specification of Functions

The function specifications of the sample code are shown below.

**r_Config_ADC_interrupt()**

| | |
|---|---|
| Outline | A/D interrupt processing |
| Header | r_cg_interrupt_handlers.h |
| Description | When A/D conversion ends, this processing reads the result of A/D conversion from the ADCR0 register and stores it in the internal RAM. |
| Argument | None |
| Return Value | None |

## 4.5 Flowcharts

### 4.5.1 Main Processing

Figure 4.1 shows the flowchart of the main processing.

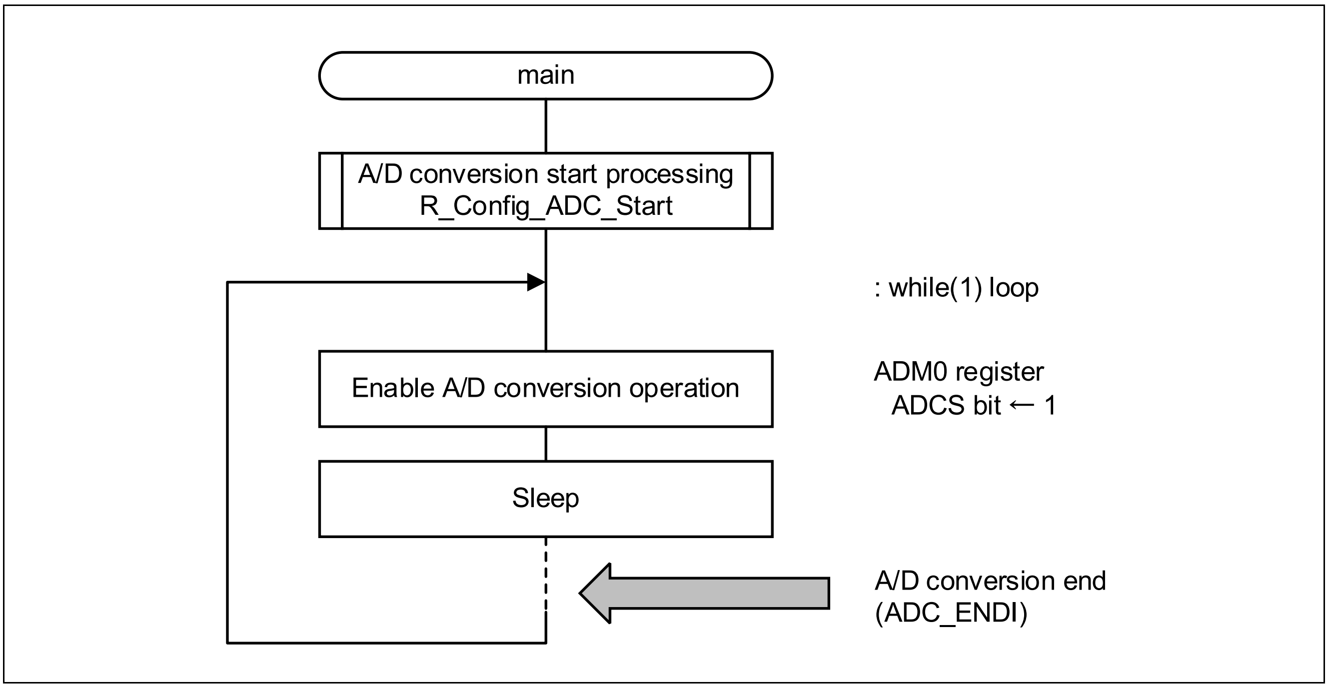


**Figure 4.1 Main Processing**

### 4.5.2 A/D Interrupt Processing

Figure 4.2 shows the flowchart of A/D interrupt processing.

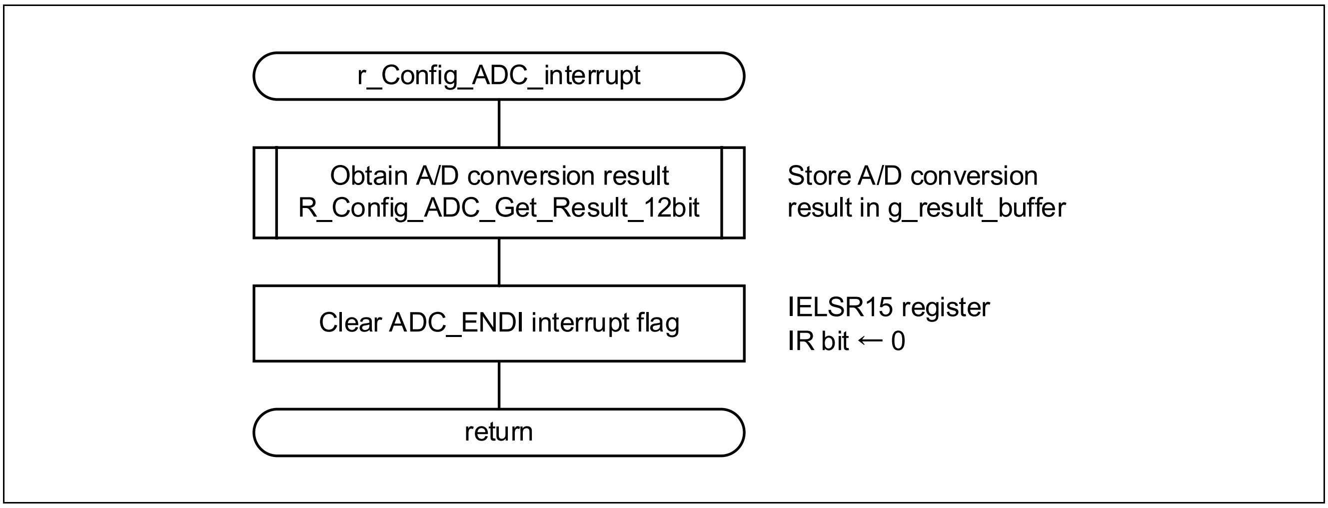


**Figure 4.2 A/D Interrupt Processing**

## 5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

## 6. Reference Documents

RISC-V User's Manual: Hardware (R01UH1036EJ)

The latest versions can be downloaded from the Renesas Electronics website.

Technical update

The latest versions can be downloaded from the Renesas Electronics website.

## Revision History

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.00 | Mar.18.24 | — | Initial release |

# 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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