# RL78/G15

## A/D Converter

### Introduction

This application note describes how to use the the A/D converter on the RL78/G15 to convert analog voltages into digital values.

The sample program discussed in this application note performs data conversion on the A/D conversion results (shifting the data right by six bits) and places the converted values in the internal RAM.

### Target Device

RL78/G15

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 A/D converter. The A/D converter converts analog voltages that are input to the P03/ANI2 pin into digital values. Conversion results are then stored in the internal RAM.

Subsequently, the conversion result is subjected to data conversion (shifting the data right by six bits) and the result is 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 level of the analog signal input from the P03/ANI2 pin. |

## 1.2 Outline of Operation

The sample code uses 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 HALT mode. When A/D conversion ends, the conversion results are stored in the internal RAM.

(1) Initialize the A/D converter.

<Setting conditions>

- Use the P03/ANI2 pin for analog input.
- As the A/D conversion resolution, use 10 bits.
- Use A/D conversion end interrupts (INTAD).

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

(3) 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 ADCR register and generates an A/D conversion end interrupt (INTAD). the ADCS bit is automatically set to 0 at this point.

(4) On release from the HALT mode in response to the A/D conversion end interrupt, the sample program reads the result of A/D conversion from the ADCR register, shifts the result right by six bits, and stores the shifted data in the internal RAM

(5) Set the ADCS bit to 1 again to place the CPU in HALT 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

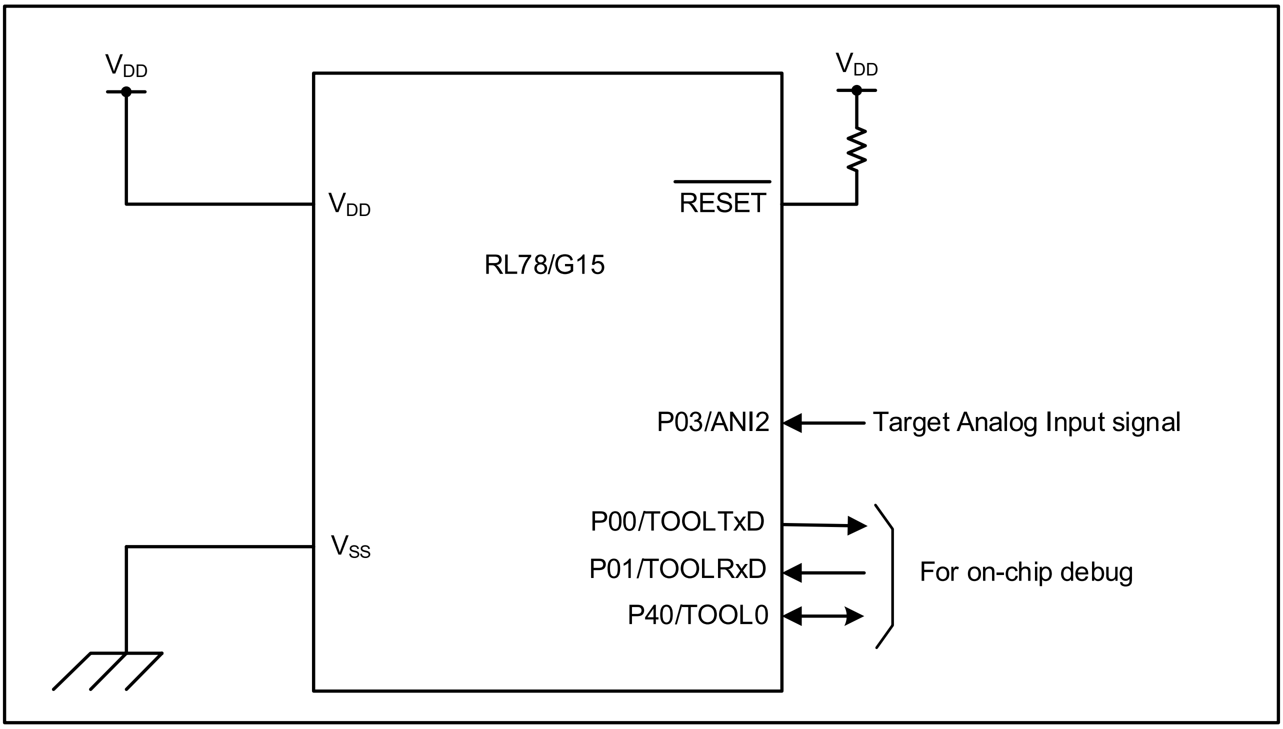
| Item | Description |
|---|---|
| MCU used | RL78/G15 (R5F12068) |
| Board used | RL78/G15-20p Fast Prototyping Board (RTK5RLG150CLG00000BJ) |
| Operating frequency | High-speed on-chip oscillator clock ($f_{IH}$): 16 MHz |
| Operating voltage | 5.0 V (can be operated at 2.4 V to 5.5 V)<br>SPOR operations ($V_{SPOR}$)<br>At rising edge TYP. 2.57V (2.44 V to 2.68 V)<br>At falling edge TYP. 2.52V (2.40 V to 2.62 V) |
| Integrated development environment (CS+) | CS+ for CC 8.09.00 from Renesas Electronics Corp. |
| C compiler (CS+) | CC-RL V1.12.00 from Renesas Electronics Corp. |
| Integrated development environment (e2studio) | e2studio V2023-01 (23.1.0) from Renesas Electronics Corp. |
| C compiler (e2studio) | CC-RL V1.12.00 from Renesas Electronics Corp. |
| Integrated development environment (IAR) | IAR Embedded Workbench for Renesas RL78 V5.10.1 from IAR Systems Corp. |
| C compiler (IAR) | IAR C/C++ Compiler for Renesas RL78 V5.10.1.2667 from IAR Systems Corp. |
| Smart configurator (SC) | V1.50 from Renesas Electronics Corp. |
| Board support package (BSP) | V1.40 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 $V_{DD}$ or $V_{SS}$ through a resistor).

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

## 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 |
|---|---|---|
| P03 / 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 |
|---|---|---|
| 000C0H / 040C0H | 11101111B | Disables the watchdog timer.<br>(Counting stopped after reset) |
| 000C1H / 040C1H | 11111110B | LVD0 detection voltage: reset mode<br>At rising edge TYP. 2.57 V (2.44 V to 2.68 V)<br>At falling edge TYP. 2.52 V (2.40 V to 2.62 V) |
| 000C2H / 040C2H | 11101000B | High-speed on-chip oscillator clock ($f_{IH}$): 16 MHz |
| 000C3H / 040C3H | 10000100B | Enables on-chip debugging |

## 4.2 List of Variables

Table 4-2 lists global variables.

Table 4-2 Global Variables

| Type | Variable Name | Description | Function Used |
|---|---|---|---|
| unsigned short | 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()**

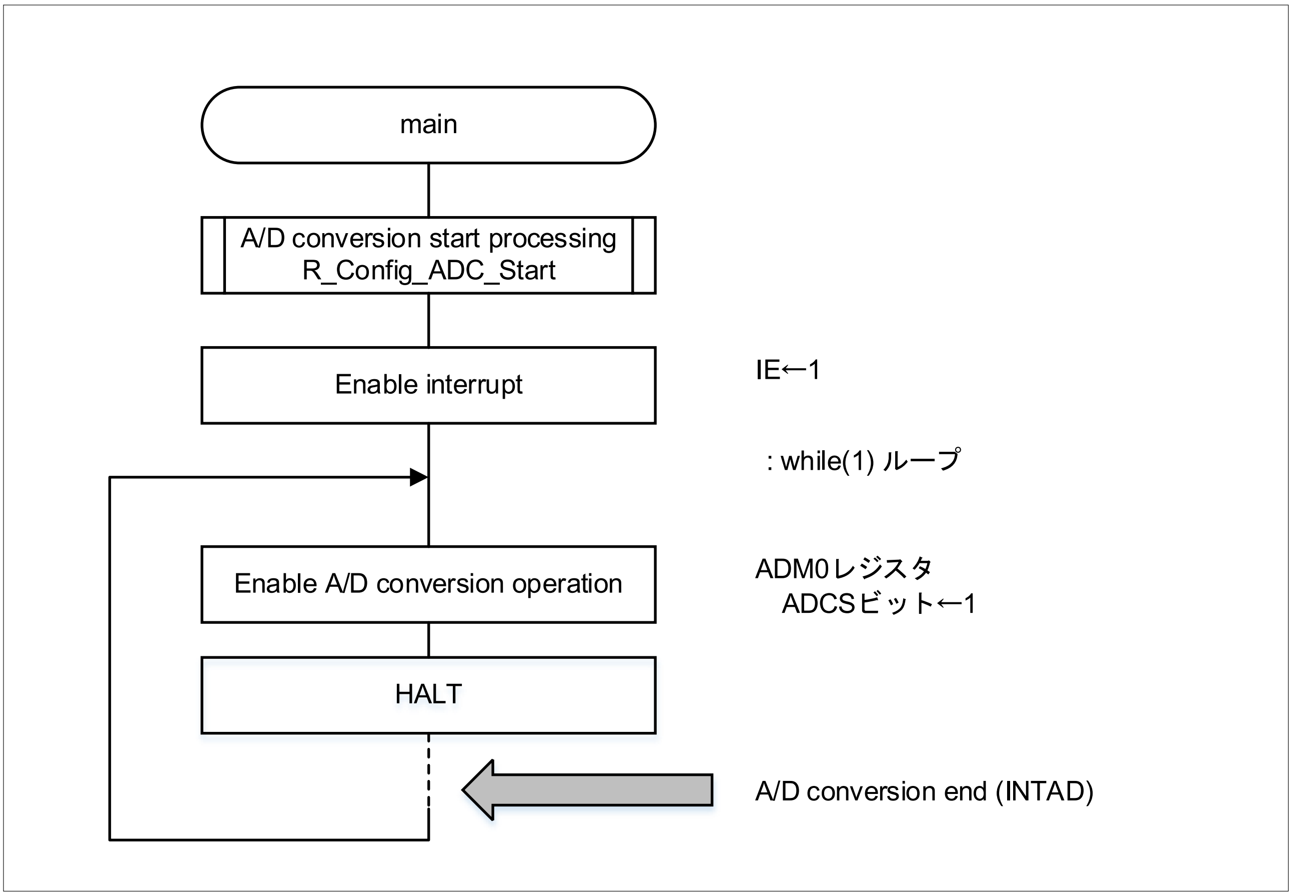
| | |
|---|---|
| Outline | A/D interrupt processing |
| Header | r_cg_macrodriver.h, r_cg_userdefine.h, Config_ADC.h |
| Declaration | static void __near r_Config_ADC_interrupt(void) |
| Description | When A/D conversion ends, this processing reads the result of A/D conversion from the ADCR register 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.

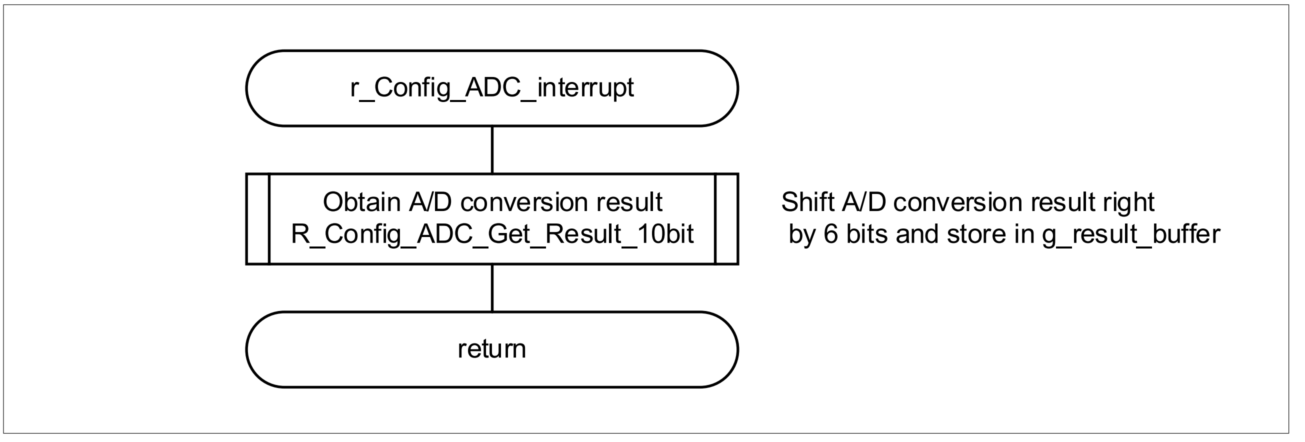
Figure 4-1 Main Processing



### 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

RL78/G15 User’s Manual: Hardware (R01UH0959E)
RL78 family user's manual software (R01US0015E)
RL78 Smart Configurator User’s Guide: CS+ (R20AN0580E)
RL78 Smart Configurator User’s Guide: e2 studio (R20AN0579E)
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 | 2022.12.10 | - | First Edition |
| 1.01 | 2023.3.22 | Page.4 | Update the Operation Confirmation Conditions<br>・Add IAR<br>・Update CS+ and e2studio, Compiler Revision |
| | | | |

## General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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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.).
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