RL78/G23

True Random Number Generator (TRNG) Software Driver

Summary

This document describes the specifications and usage of the software driver that generates random numbers using the true random number generator (TRNG) on an RL78 Family MCU.

Device on Which Operation Has Been Confirmed

RL78/G23

For product numbers of devices incorporating TRNG functionality, refer to the user's manuals of the various RL78 Family MCUs.

Contents

1. Overview

1.1 Functions

TRNG stands for “true random number generator.” The TRNG driver generates random numbers and stores the generated random numbers in the RAM.

1.2 TRNG Driver Usage Examples

Usage examples for the TRNG driver are shown below.

1.2.1 Generating a Single Random Number

To generate a single 4-byte random number, function calls are executed as shown below.

```
R_TRNG_GenerateRandomNumber ();

/* Run any necessary processing here. */

while (TRNG_SUCCESS != R_TRNG_GetRandomNumber(&data))
{
  ;
}
```

Figure 1.1 Generating a Single Random Number

1.2.2 Generating Multiple Random Numbers

To generate multiple 4-byte random numbers, function calls are executed as shown below.

```
R_TRNG_GenerateRandomNumber ();

/* Run any necessary processing here. */

while (TRNG_SUCCESS != R_TRNG_GetRandomNumber(&data1))
{
  ;
}

R_TRNG_GenerateRandomNumber ();

/* Run any necessary processing here. */

while (TRNG_SUCCESS != R_TRNG_GetRandomNumber(&data2))
{
  ;
}
```

Figure 1.2 Generating Two Random Numbers

2. TRNG Driver Specifications

2.1 Error Codes

The error codes returned by the functions of the module are listed below.

Table 2.1 Error Codes

Symbol	Value	Description
TRNG_SUCCESS	0	Normal end
TRNG_BUSY	−1	Command running

2.2 Function Specifications/Function Reference

The specifications and a processing flowchart of each function of the TRNG driver are shown below. When error checking appears in a processing flowchart, only the error condition is listed and the specific checking procedure is not enumerated.

2.2.1 R_TRNG_GenerateRandomNumber Function

Table 2.2 R_TRNG_GenerateRandomNumber Function Specifications

Format	R_TRNG_GenerateRandomNumber(void)
Description	Enables operation of the random number generator and starts random number generator operation.
Arguments	None
Return values	TRNG_SUCCESS(0): Normal end
Note	Reentrancy: not supported

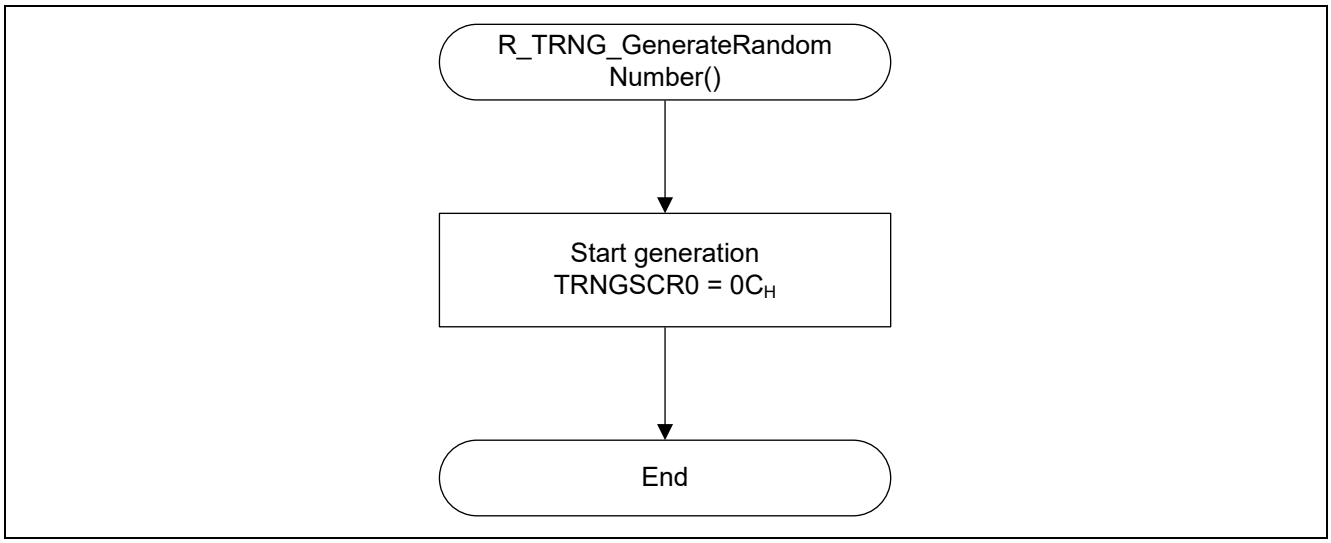

Figure 2.1 R_TRNG_GenerateRandomNumber Function Processing Flowchart

2.2.2 R_TRNG_GetRandomNumber Function

Table 2.3 R_TRNG_GetRandomNumber Function Specifications

Format	R_TRNG_GetRandomNumber(unit32_t *random)
Description	Checks if generation of a random number has finished and, if finished, gets 32 bits (8 bits × 4) of data. Stops operation of the random number generator.
Arguments	unit32_t *random: Pointer to area for storing random number that is read
Return values	TRNG_SUCCESS(0): Normal end
	TRNG_BUSY(-1): Command running
Note	Reentrancy: not supported

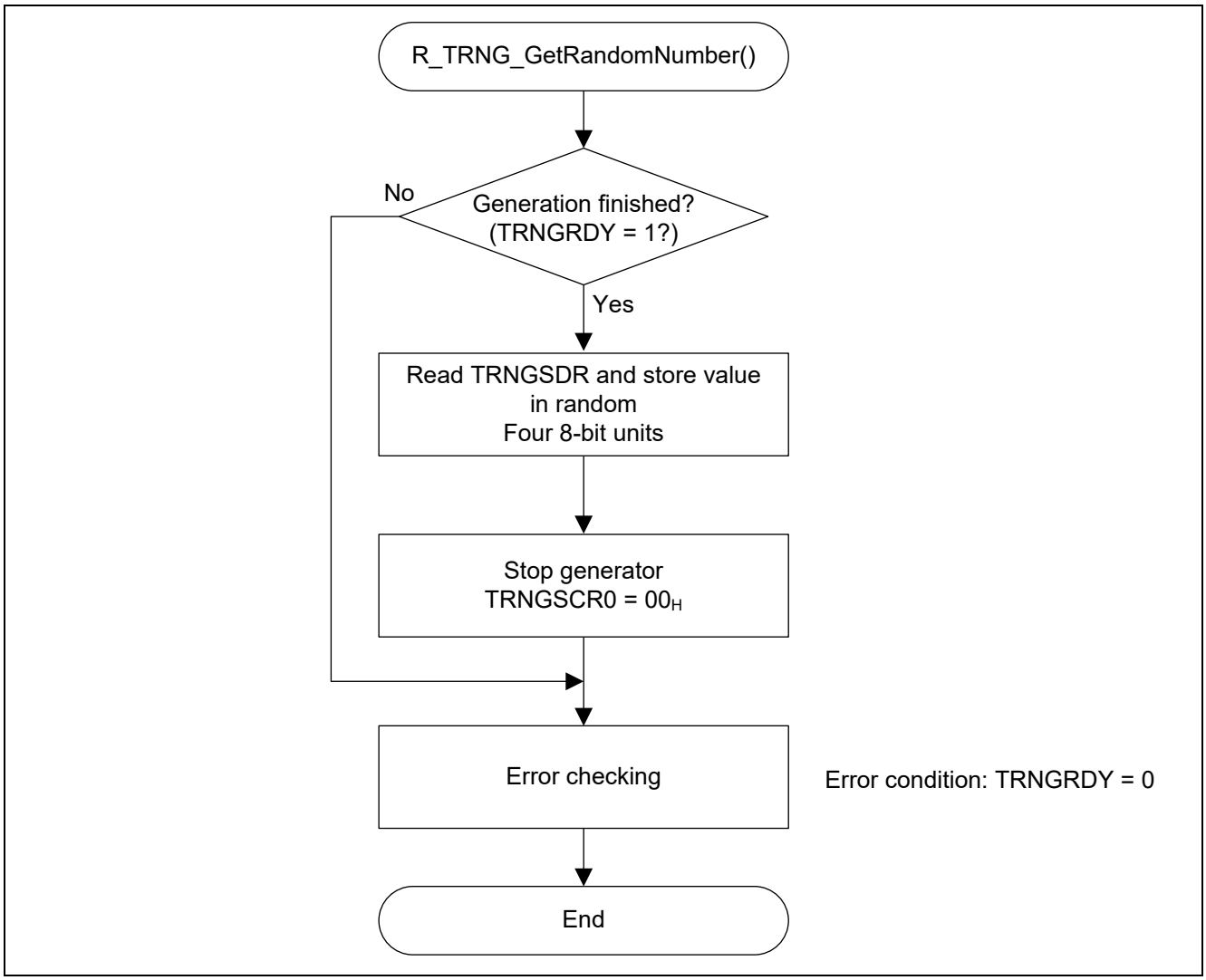

Figure 2.2 R_TRNG_GetRandomNumber Function Processing Flowchart

3. Sample Program

A sample program that uses the TRNG driver is described below. The sample program generates random numbers and then fetches the generated random numbers.

3.1 Development Environment

The operation of the sample code accompanying this application note has been confirmed under the following conditions.

Item	Description
MCU	RL78/G23
Integrated development environment(CS+)	CS+ for CC V8.05.00
C compiler(CS+)	CC-RL V1.10
Integrated development environment(e^2 studio)	e^2 studio 2021-04 (21.4.0)
C compiler(e^2 studio)	CC-RL V1.10
Integrated development environment(IAR)	IAR Systems IAR Embedded Workbench for Renesas RL78 V4.21.1
C compiler(IAR)	
Board	RL78/G23 Fast Prototyping Board

3.2 File Structure

\r20an0617_rl78g23_TRNG <DIR>	Sample code folder
\doc <DIR>	
r20an0617jj0100_rl78g23_TRNG.pdf	Application note (Japanese)
r20an0617ej0100_rl78g23_TRNG.pdf	Application note (this document)
\workspace <DIR>	workspace
CS+	CS+ project
r20an0617_rl78g23_TRNG <DIR>	Project folder
\src <DIR>	Folder containing program files
sample_main.c	Sample code
sample_main.h	Sample code header file
\libsrc <DIR>	Folder containing driver files
\src <DIR>	Folder containing TRNG driver files
r_trng.c	TRNG driver function file
\include <DIR>	Folder containing TRNG driver header
r_trng.h	TRNG driver header file
\src_gen <DIR>	Folders automatically generated by Smart Configurator
Config_UART0	Folder containing UART0 driver files
general	Folder containing common header files and source files
r_bsp	Folder containing initialization code, register definitions, etc.
r_config	Folder containing driver initialization configuration header files
e^2 studio	Folder containing e^2 studio project
r20an0617_rl78g23_TRNG <DIR>	Project folder
IAR	Folder containing IAR project
r20an0617_rl78g23_TRNG <DIR>	Project folder

3.3 System Block Diagram

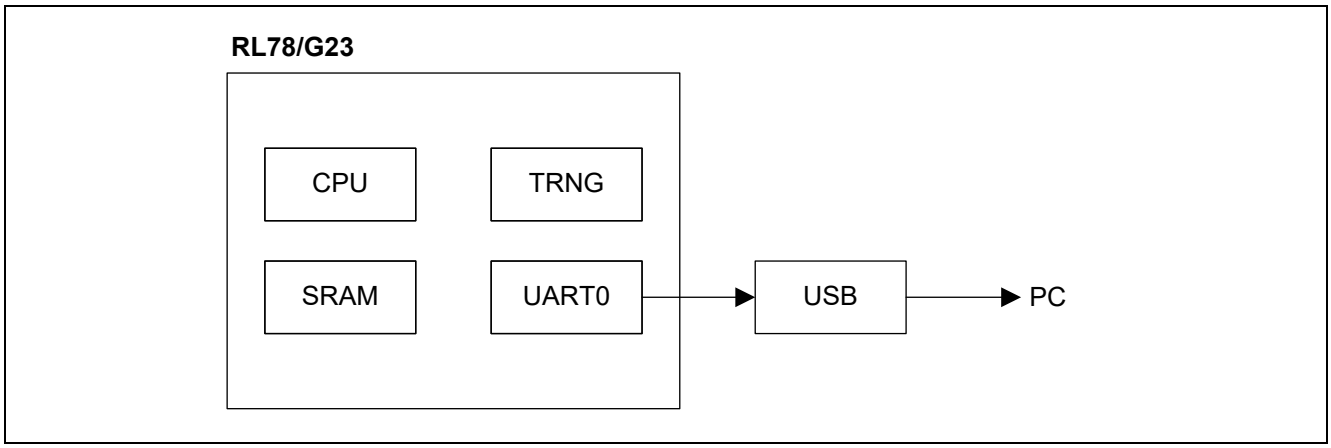

Figure 3.1 System Block Diagram

3.4 Operation

The sample code uses the TRNG driver to generate random numbers and stores them in the RAM. It then uses UART0 to output the random number values stored in RAM on pin P12.

The sample code generates five random numbers. The number of random numbers generated is defined by #define DATA_NUMBER, so by changing it to a different value of your choice you can change the number of random numbers that are generated.

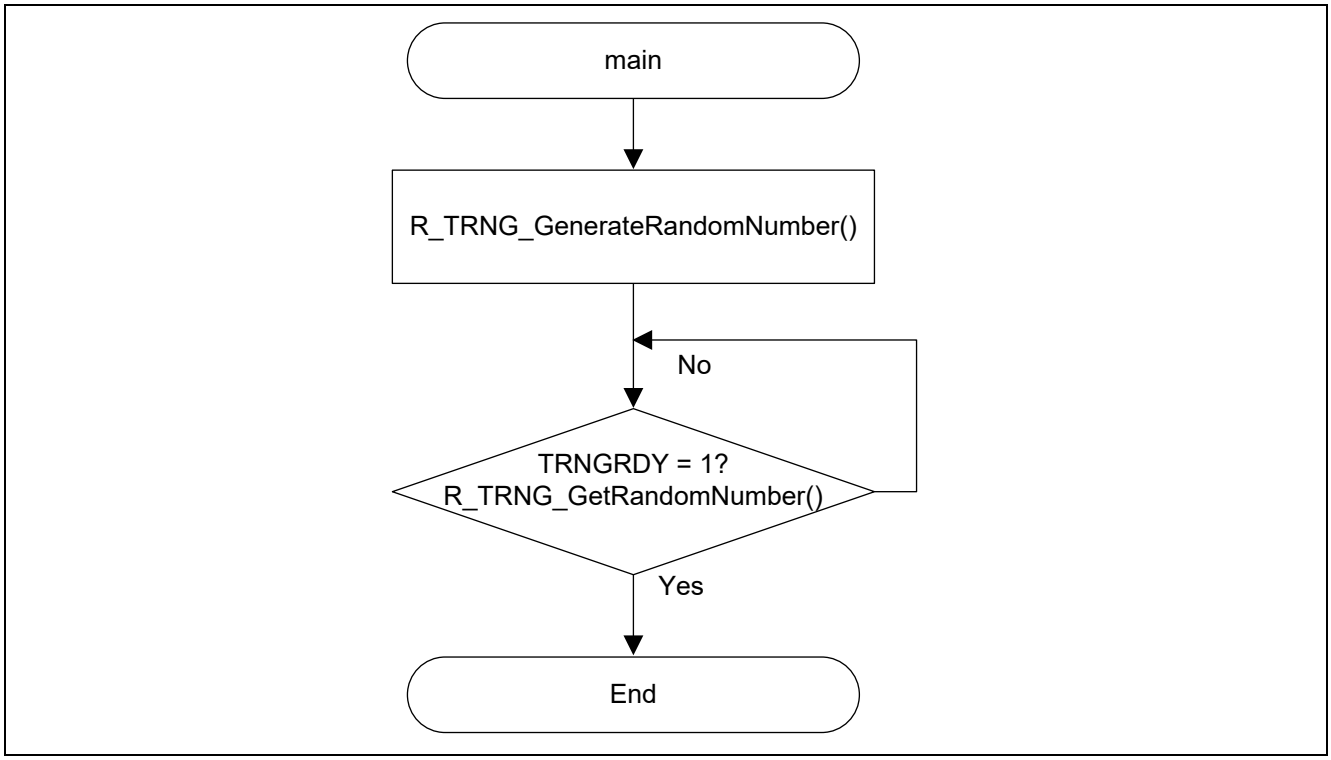

Figure 3.2 Sample Program Flowchart

The UART0 settings used by the sample program are as follows.

Baud rate	115,200
Data bits	8
Parity	None
Stop bits	1
Flow control	None

4. Usage Notes

The following items should be borne in mind when using the driver.

4.1 Interrupts when Functions Are Running

If processing of an interrupt starts while a TRNG driver function is running, it may not be possible to fetch the random number value correctly. Therefore, TRNG driver functions do not support reentrancy (calling the same function more than once concurrently). Specific examples are described below.

4.1.1 Interrupt Occurs after R_TRNG_GenerateRandomNumber

If the processing sequence is as follows:

R_TRNG_GenerateRandomNumber [1] → R_TRNG_GenerateRandomNumber [2] → R_TRNG_GetRandomNumber [2] → RETI

It will not be possible to fetch the random number using R_TRNG_GetRandomNumber [1] after returning to the main processing routine.

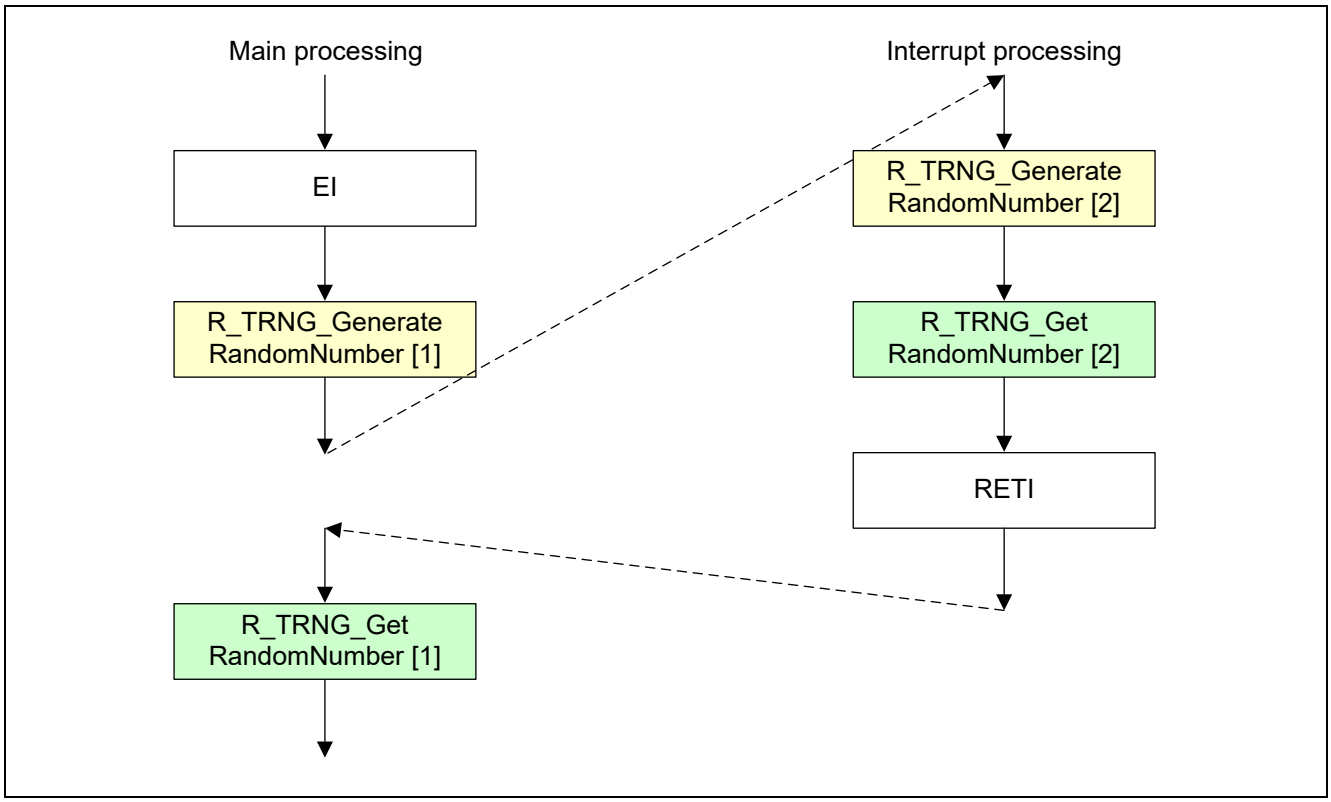

Figure 4.1 Interrupt Occurs after R_TRNG_GenerateRandomNumber Runs

4.1.2 Interrupt Occurs while R_TRNG_GenerateRandomNumber Is Running

If the processing sequence is as follows:

R_TRNG_GetRandomNumber [1] in progress → R_TRNG_GenerateRandomNumber [2] → R_TRNG_GetRandomNumber [2] → RETI

It will not be possible to fetch the random number using R_TRNG_GetRandomNumber [1] after returning to the main processing routine.

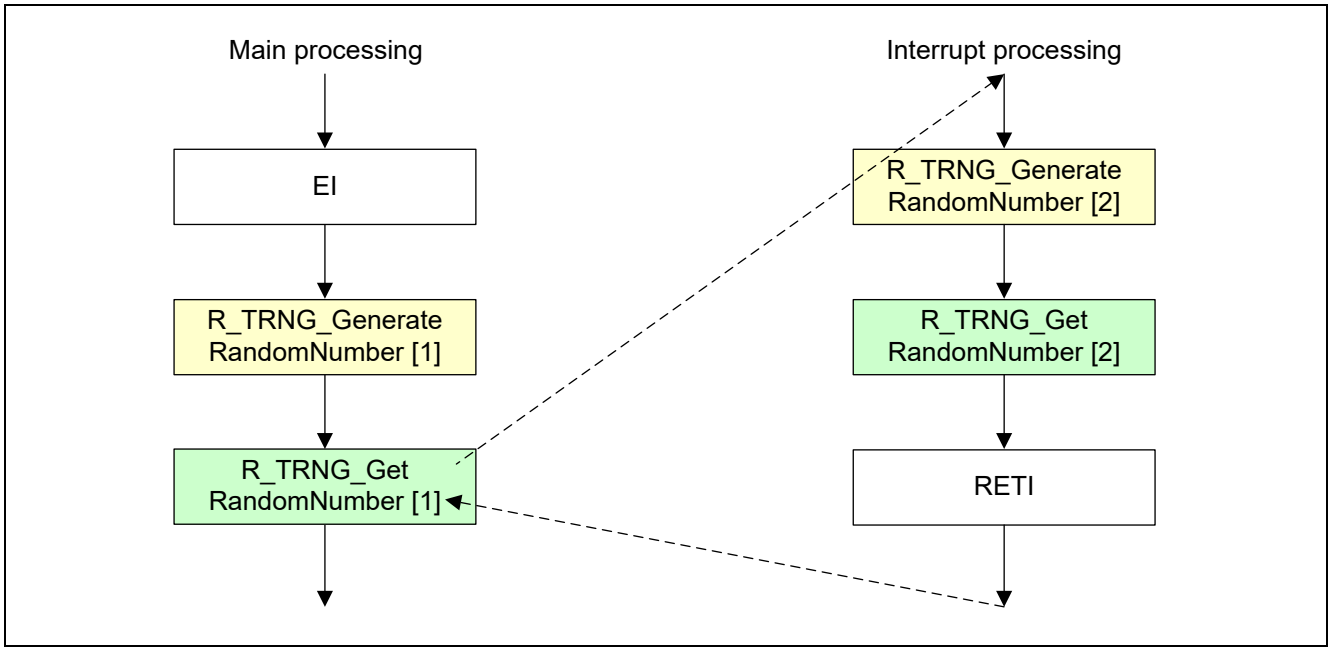

Figure 4.2 Interrupt Occurs while R_TRNG_GetRandomNumber Is Running

4.2 Notes on Debugging

Keep the following point in mind when running R_TRNG_GenerateRandomNumber() and R_TRNG_GetRandomNumber(). Failure to do so can result in random number values not being stored correctly.

- When displaying the contents of an SFR in the debugger, make sure that no break occurs after R_TRNG_GenerateRandomNumber() runs until R_TRNG_GetRandomNumber() terminates normally.

The result when a break occurs while R_TRNG_GetRandomNumber() is running in the sample code is shown below. The third and fourth random number values, enclosed in red, are 00H, indicating that the random number values were not stored correctly.

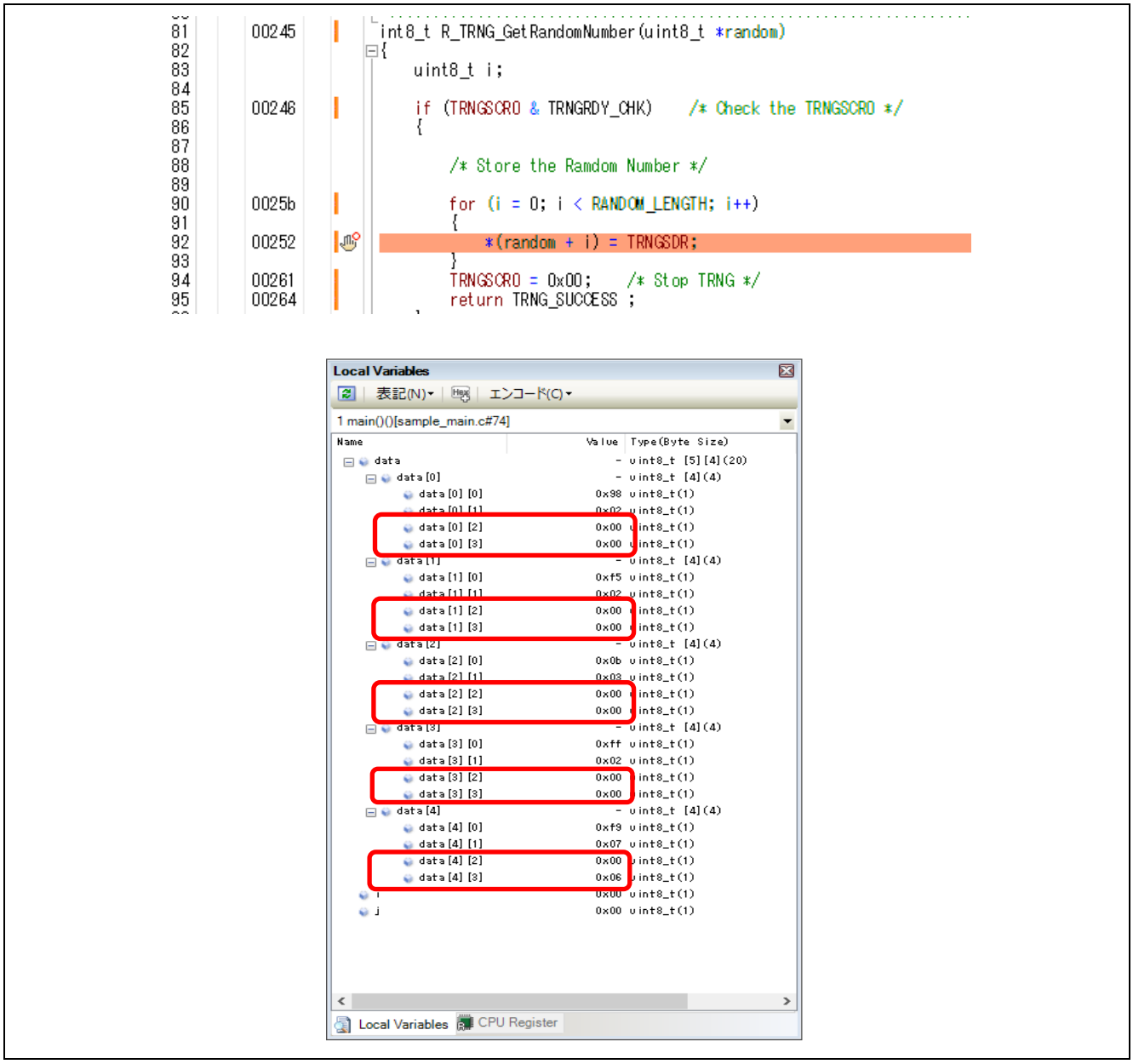

Figure 4.3 Break Occurs R_TRNG_GetRandomNumber while Is Running

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Apl. 13, 21	—	First edition issued

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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