RISC-V

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 RISC-V MCU.

Device on Which Operation Has Been Confirmed

RISC-V

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, the following function call are executed.

```
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, the following function call are executed.

```
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 as following.

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. For error checking in the processing flowchart, only the error conditions are listed and the description of specific checking procedure is omitted.

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

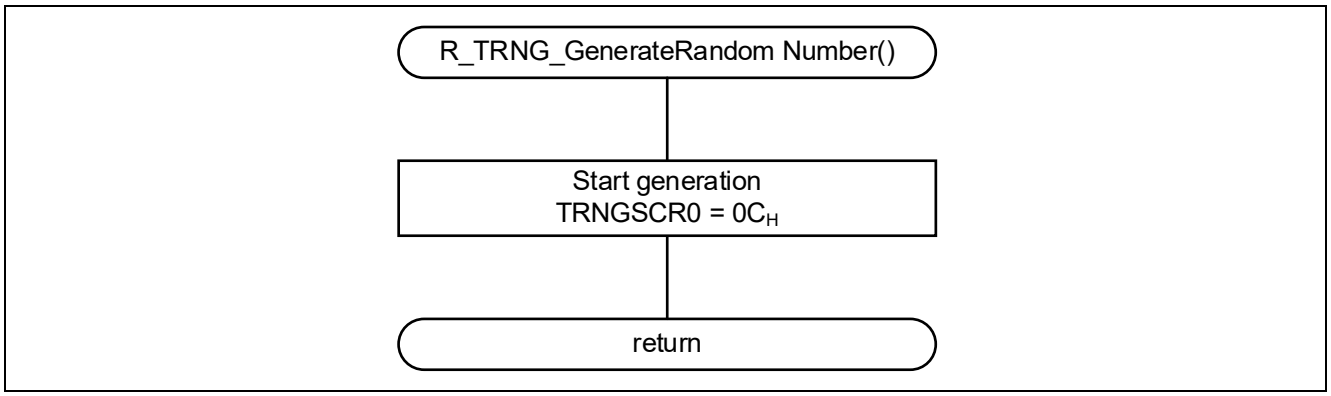

Figure 2.1 R_TRNG_GenerateRandomNumber Function Processing Flowchart

2.2.2 R_TRNG_GetRandomNumber Function

Table 2.3 R_TRNG_GetRandomNumber Function Specifications

Format	R_TRNG_GetRandomNumber(uint8_t *random)
Description	Checks whether random number generation is complete, if generation is complete, gets 32 bits (8bits x 4) of data.
Arguments	uint8_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

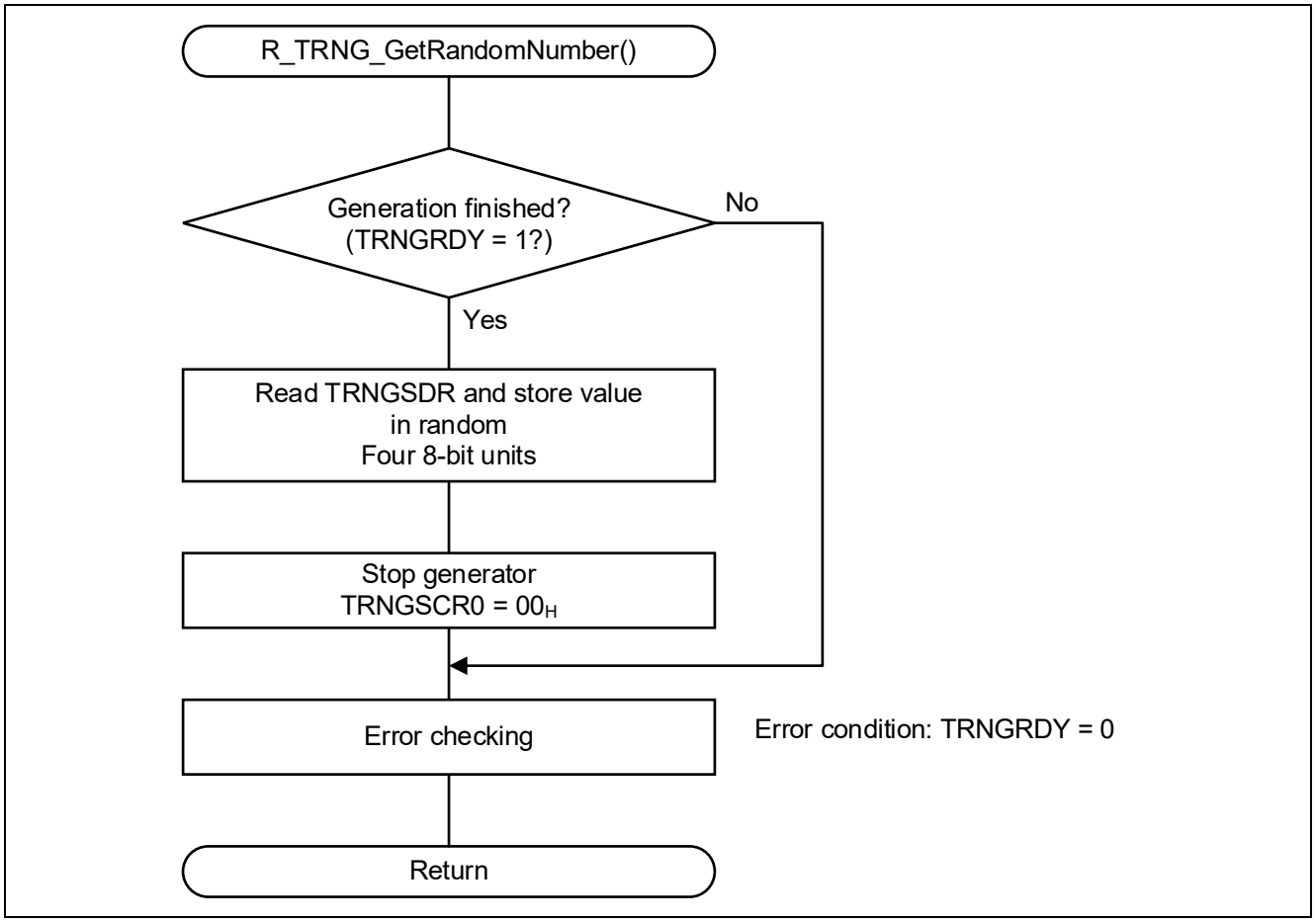

Figure 2.2 R_TRNG_GetRandomNumber Function Processing Flowchart

3. Sample Program

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

3.1 Development Environment

The sample code in this application note has been confirmed under the following conditions.

Item	Description
MCU	RISC-V (R9A02G021)
Board used	RISC-V-48p Fast Prototyping Board (RTK9FPG021S000W0BJ)
Integrated development environment (e^2 studio)	e2studio 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.

3.2 File Structure

\r01an7164xx0100-risc-v-mcu-trng <DIR>	Sample code folder
\doc <DIR>	
r01an7164ej0100-risc-v-mcu-trng.pdf	Application note (this document)
\e² studio	Folder containing e2 studio project
\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
r_pincfg	Folder containing Pin number files

3.3 System Block Diagram

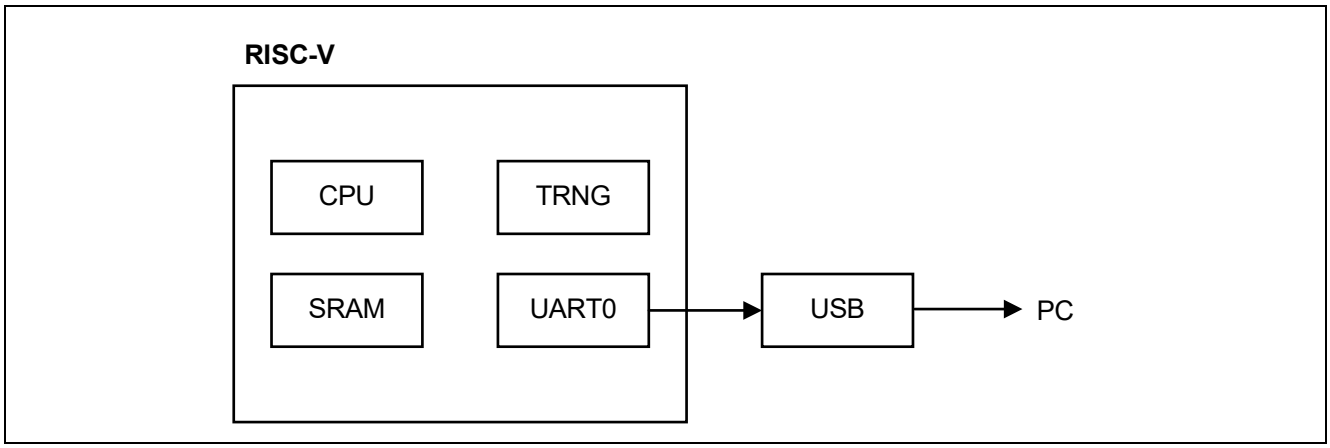

Figure 3.1 System Block Diagram

3.4 Operation

The sample code uses the TRNG driver to generate random numbers and stores them in the RAM. The random numbers stored in RAM are output from the pin P12 using UART0.

The sample code generates five random numbers. The number of random numbers generated is defined by #define DATA_NUMBER, which can be changed to any value to change the number of random number generation times.

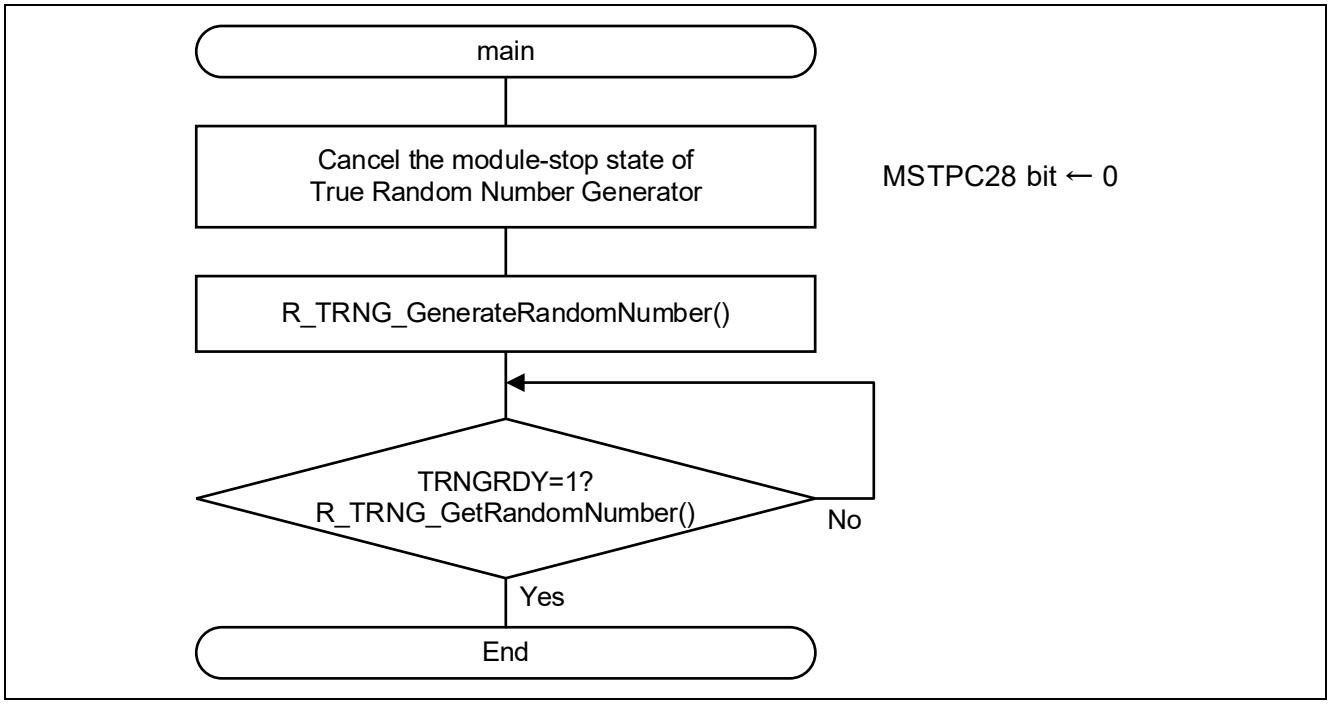

Figure 3.2 Sample Program Flowchart

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 precautions should be borne in mind when using this driver.

4.1 Interrupts when Functions Are Running

If interrupt processing is started while the TRNG driver function is executing, it may not be possible to get the correct random number values. Therefore, TRNG driver functions are unsupported for "Reentrant "(calling the same function more than once concurrently).

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.

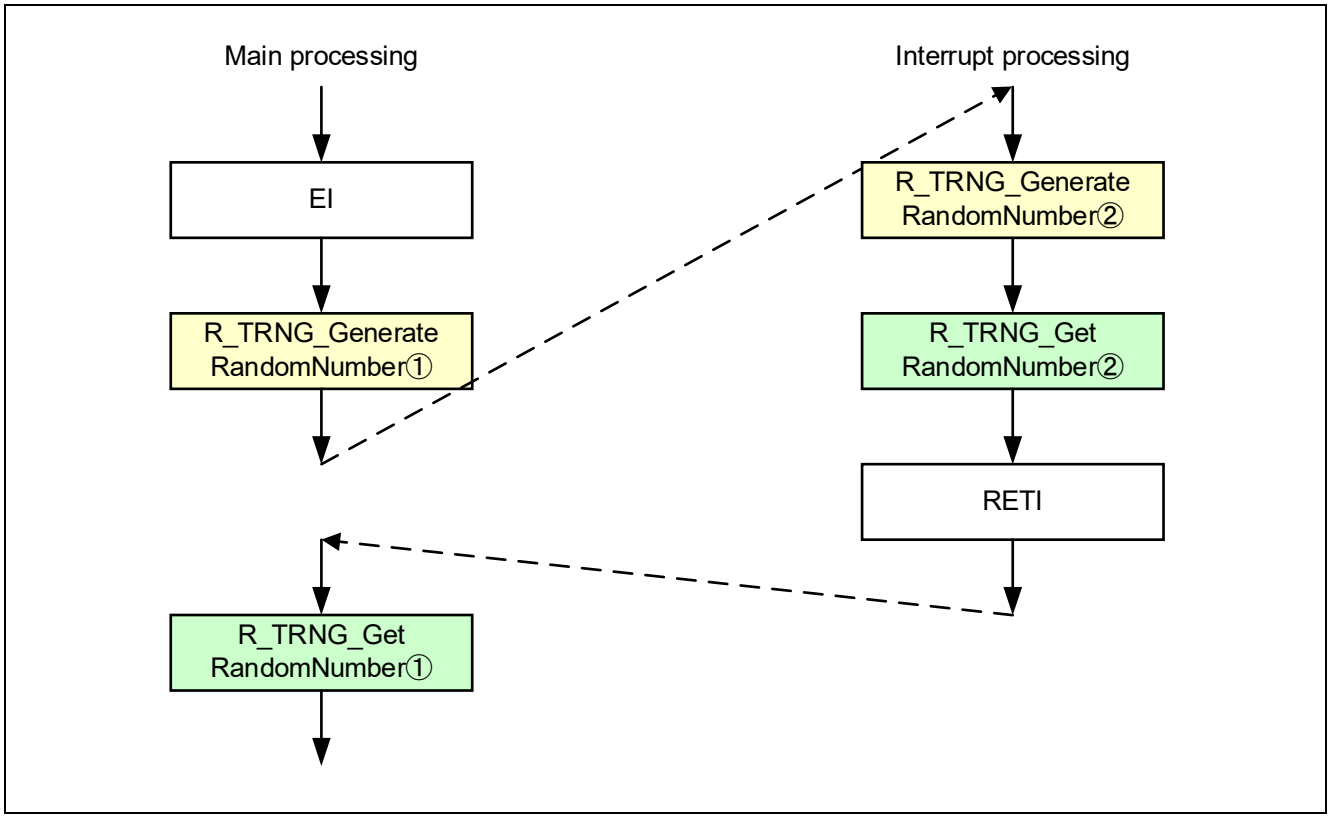

Figure 4.1 Interrupt Occurs after R_TRNG_GenerateRandomNumber Runs

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.

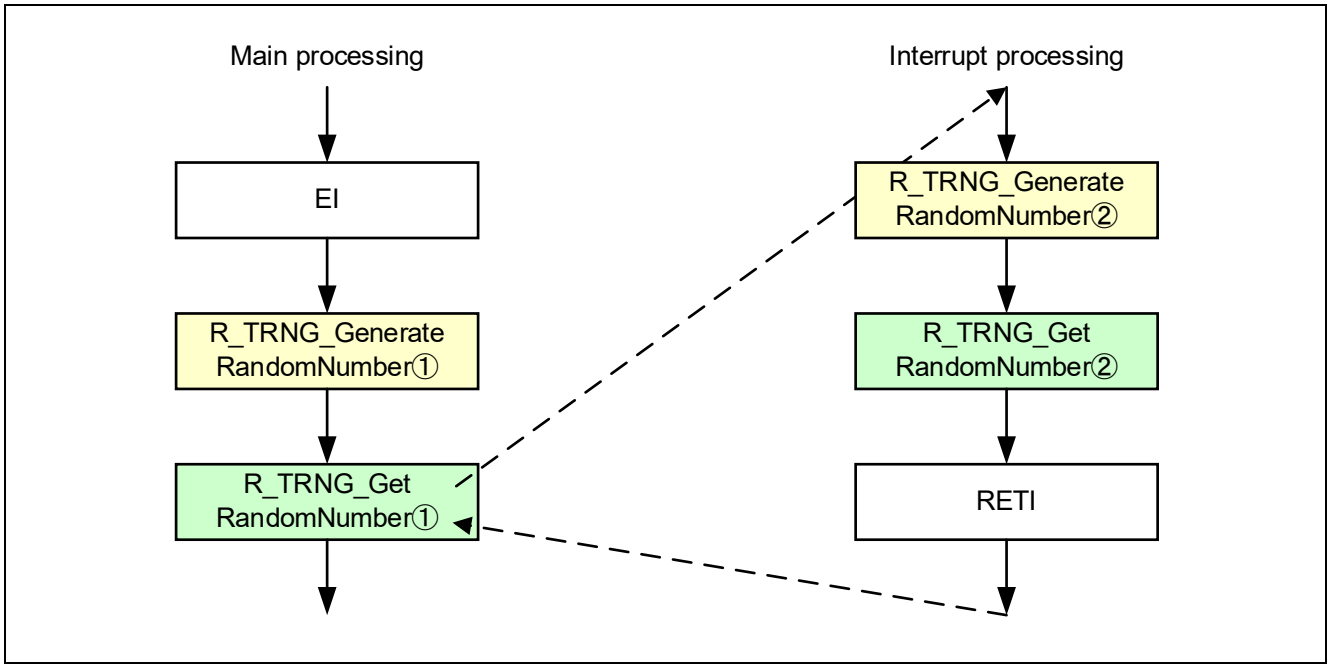

Figure 4.2 Interrupt Occurs while R_TRNG_GetRandomNumber Is Running

4.2 Notes on Debugging

When executing R_TRNG_GenerateRandomNumber() and R_TRNG_GetRandomNumber(), please note the following points. The random numbers are not stored correctly.

- When displaying SFRs on the debugger, do not break until R_TRNG_GenerateRandomNumber() has been executed and R_TRNG_GetRandomNumber() has completed successfully.

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.

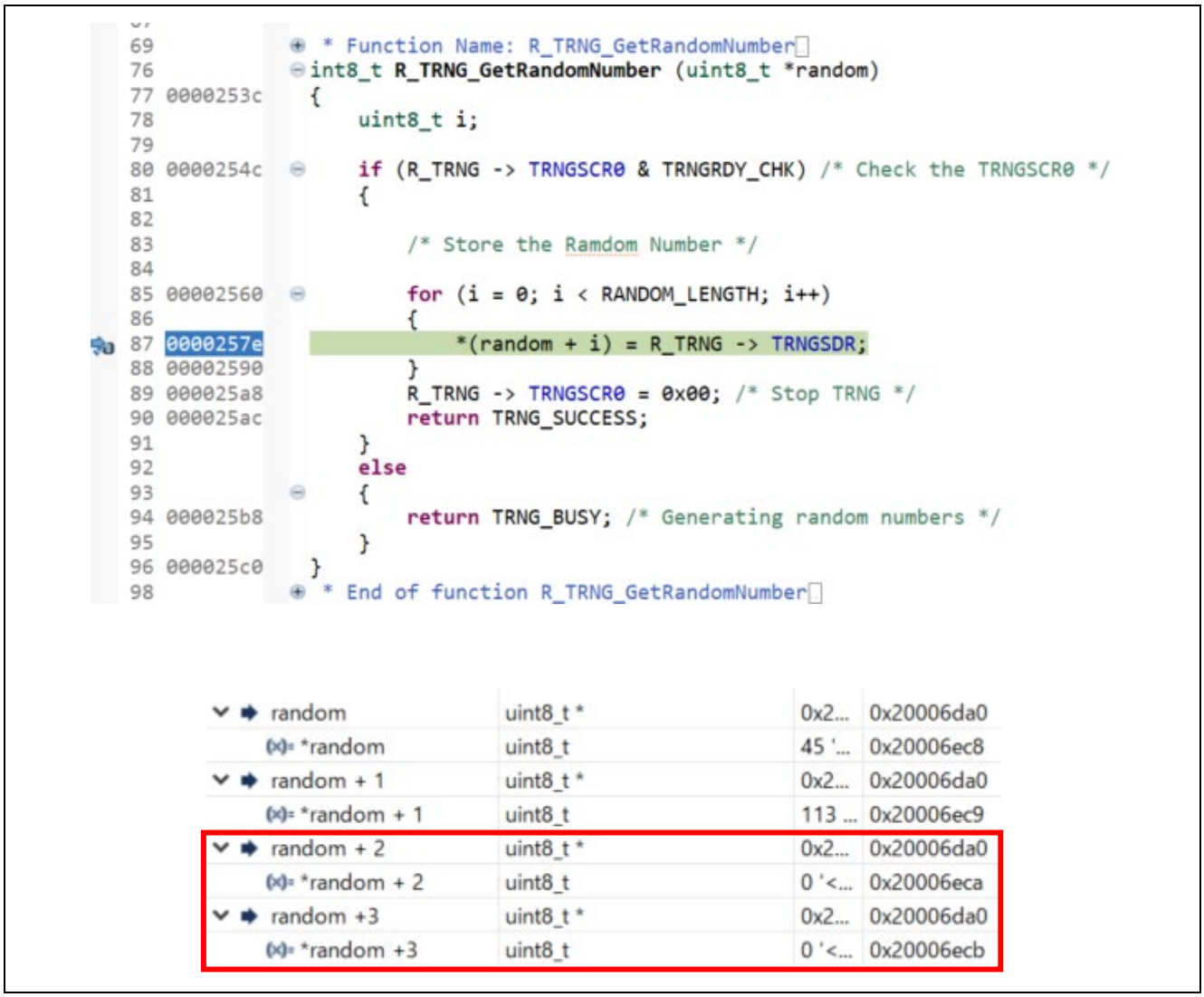

Figure 4.3 Break Occurs R_TRNG_GetRandomNumber while Is Running

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.18.24	—	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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