AN13794

Random Number Generation Using ROM API in LPC553x (Non-Secure) Devices

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Document Information

Information	Content
Keywords	AN13794, LPC553x, random number generator (RNG), ROM API
Abstract	This application note provides an overview of how the RNG module can be used through ROM API to generate random numbers for LPC553x devices.

1 Introduction

This application note provides an overview of how the RNG module can be used through the ROM API to generate random numbers for LPC553x devices. RNG produces a sequence of numbers that are highly unpredictable and can be used to mask data or produce a key. RNG can also be used for security and cryptographic purposes. However, for applications requiring high security, NXP secure parts, such as LPC55S3x, provide a better option.

1.1 Acronyms

Table 1 defines the acronyms used in this document.

Table 1. Acronyms

Acronym	Definition
RNG	Random number generator
API	Application programming interface
DRBG	Deterministic random bit generator
TRNG	True random number generator

1.2 ROM API structure

Figure 1 shows the ROM API structure. It contains several API drivers with absolute ROM API function addresses, which can be called using function pointers. Some of the functionalities provided by the ROM API enable serial NOR flash, eFuse OTP memory read and programming, support for crypto functions, in-application programming, and so on. In LPC553x, the DRBG generates a random number. Here, the output of a TRNG is used as an entropy source to determine the seed of a DRBG. The ROM API table is located at address 0x0302FC00. The RNG API can be accessed using the NBOOT API driver located at address 0x0302FC28.

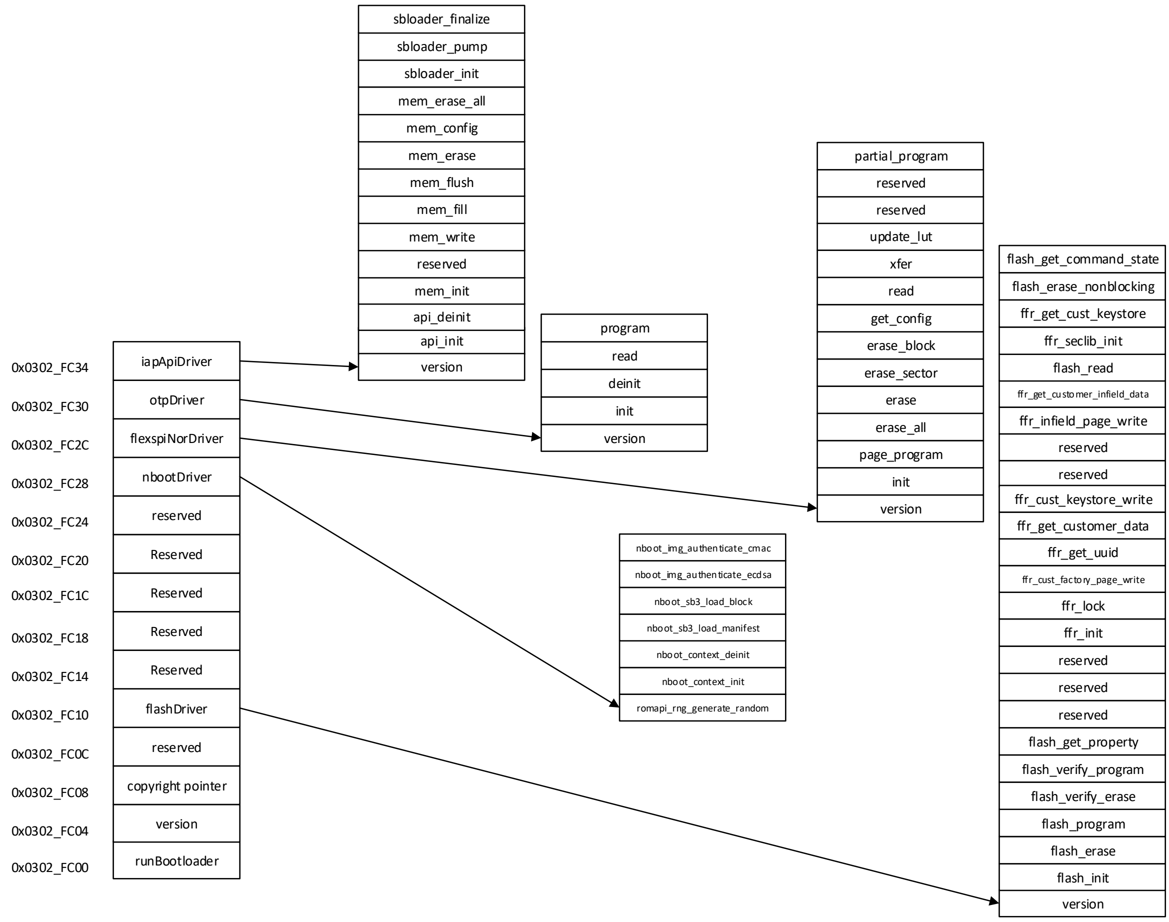

Figure 1. ROM API structure

1.3 NBOOT API driver

The main purpose of the NBOOT ROM API is to provide access to the functions used and implemented in ROM to generate random numbers and authenticate application images. Other NBOOT API functions, such as NBOOT SB3.1 API functions, can also verify the SB3.1 header (manifest) signature and decrypt individual data blocks without processing the entire SB file.

Section 1.3.1 describes the API for generating a random number.

1.3.1 romapi_rng_generate_random API

This ROM API function is used to generate a random number with specified length.

Prototype:

```
romapi_status_t (*romapi_rng_generate_random)(uint8_t *output, size_t
 outputByteLen);
```

Parameters:

- `output [in]`: Pointer to random number buffer

- `outputByteLen [in]`: Length of generated random number in bytes. The length has to be in the range from 1 to 2^{16}

Return values:

- `kStatus_NBOOT_InvalidArgument`: Invalid input parameters (input pointers point to NULL or length is invalid)
- `kStatus_NBOOT_Success`: Operation successfully finished
- `kStatus_NBOOT_Fail`: Error occurred during operation

2 Setup and SDK example

There is a software package available to download with this application note. The package contains the demo project for MCUXpresso, Keil, and IAR platforms that demonstrates the use of the ROM API to generate random numbers. The projects can be imported into their respective IDEs and similar steps mentioned in the below sections can be followed for each IDE.

A respective SDK package for each IDE is required for building and flashing the project onto the MCU. The SDK packages for the different platforms are available at https://mcuxpresso.nxp.com/en/welcome.

2.1 Hardware setup

The LPCXpresso55S36 development board is used for the hardware setup, which is connected to the host computer through the J1 debug probe. The J1 debug probe uses the MCU-LINK VCOM output, which acts as a USB-to-serial bridge to the host computer and provides the CMSIS-DAP debug interface.

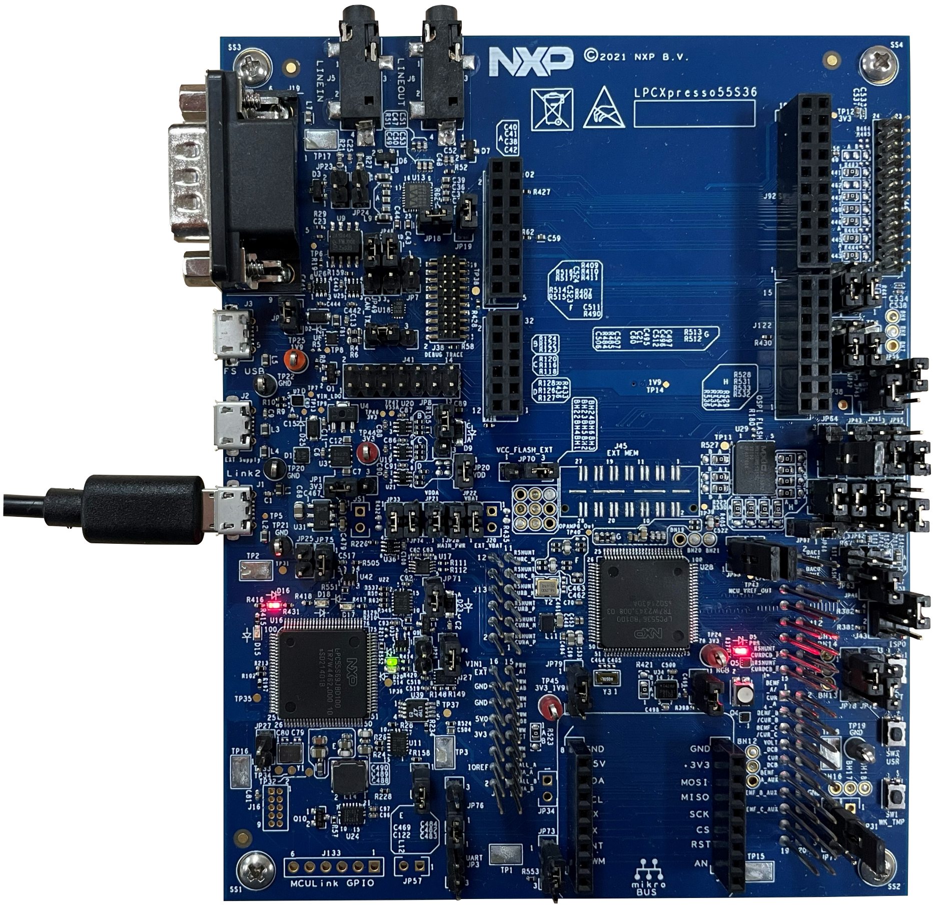

Figure 2. LPCXpresso55S36 development board; USB Micro-B cable connected to J1 debug probe

2.2 Software setup

For the below provided application example, MCUXpresso IDE v11.8 is used (available for download at https://www.nxp.com/design/software/development-software/mcuxpresso-software-and-tools-/mcuxpresso-integrated-development-environment-ide:MCUXpresso-IDE). An SDK for LPC5536 is also required for building and debugging the code. SDK_2.14.0 is used for the below example. The output can be displayed on either the Terminal window in MCUXpresso IDE or a terminal application, such as, Tera Term. While using Tera Term or any other terminal application, the below settings must be used:

- 115,200 baud rate
- No parity
- 8 data bits
- 1 stop bits

2.3 SDK example

The below example code shows how to generate a random number by using the ROM API.

```
/*
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```

```
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 */
#include "fsl_device_registers.h"
#include "fsl_debug_console.h"
#include "pin_mux.h"
#include "clock_config.h"
#include "board.h"
#include "fsl_nboot.h"
/*******************************************************************************
 * Prototypes
 ******************************************************************************/
/*! @brief Interface for the NBOOT API driver.*/
typedef struct
{
romapi_status_t (*romapi_rng_generate_random)(uint8_t *output, size_t outputByteLen);
nboot_status_t (*nboot_context_init)(nboot_context_t *context);
nboot_status_t (*nboot_context_deinit)(nboot_context_t *context);
nboot_status_protected_t (*nboot_sb3_load_manifest)(nboot_context_t *context,
uint32_t *manifest,
nboot_sb3_load_manifest_parms_t *parms);
nboot_status_protected_t (*nboot_sb3_load_block)(nboot_context_t *context,
uint32_t *block);
nboot_status_protected_t (*nboot_img_authenticate_ecdsa)(nboot_context_t *context,
uint8_t imageStartAddress[],
nboot_bool_t *isSignatureVerified,
nboot_img_auth_ecdsa_parms_t *parms);
nboot_status_protected_t (*nboot_img_authenticate_cmac)(nboot_context_t *context,
uint8_t imageStartAddress[],
nboot_bool_t *isSignatureVerified,
nboot_img_authenticate_cmac_parms_t *parms);
} nboot_interface_t;
/*******************************************************************************
 * Definitions
 ******************************************************************************/
/* Locating the random number generation API using the ROM API structure */
#define ROM_API_TREE *((uint32_t *)(0x1302fc00)+10)
#define NBOOT_API_TREE ((nboot_interface_t *) ROM_API_TREE)
/*******************************************************************************
 * Code
 ******************************************************************************/
/*!
 * @brief Main function
 */
int main(void)
{
 char ch;
 uint8_t rndBuffer[32];
 static nboot_context_t contextt;
 /* Init board hardware. */
 /* attach main clock divide to FLEXCOMM0 (debug console) */
 CLOCK_SetClkDiv(kCLOCK_DivFlexcom0Clk, 0u, false);
 CLOCK_SetClkDiv(kCLOCK_DivFlexcom0Clk, 1u, true);
 CLOCK_AttachClk(BOARD_DEBUG_UART_CLK_ATTACH);
 BOARD_InitPins();
 BOARD_BootClockPLL150M();
 BOARD_InitDebugConsole();
 /* Initialization of nboot context data structure */
 nboot_status_t status_nboot = NBOOT_API_TREE->nboot_context_init(&contextt);
/* Initialization of nboot context data structure */
 nboot_status_t status_nboot = NBOOT_API_TREE->nboot_context_init(&contextt);
 for(int x=0;x<11;x++){
 /* Generate random number with specified length */
 romapi_status_t status_romapi = NBOOT_API_TREE->romapi_rng_generate_random(&rndBuffer[0], 32);
 /* If operation is successful, print the random number generated */
 if(status_romapi == kStatus_NBOOT_Success){
```
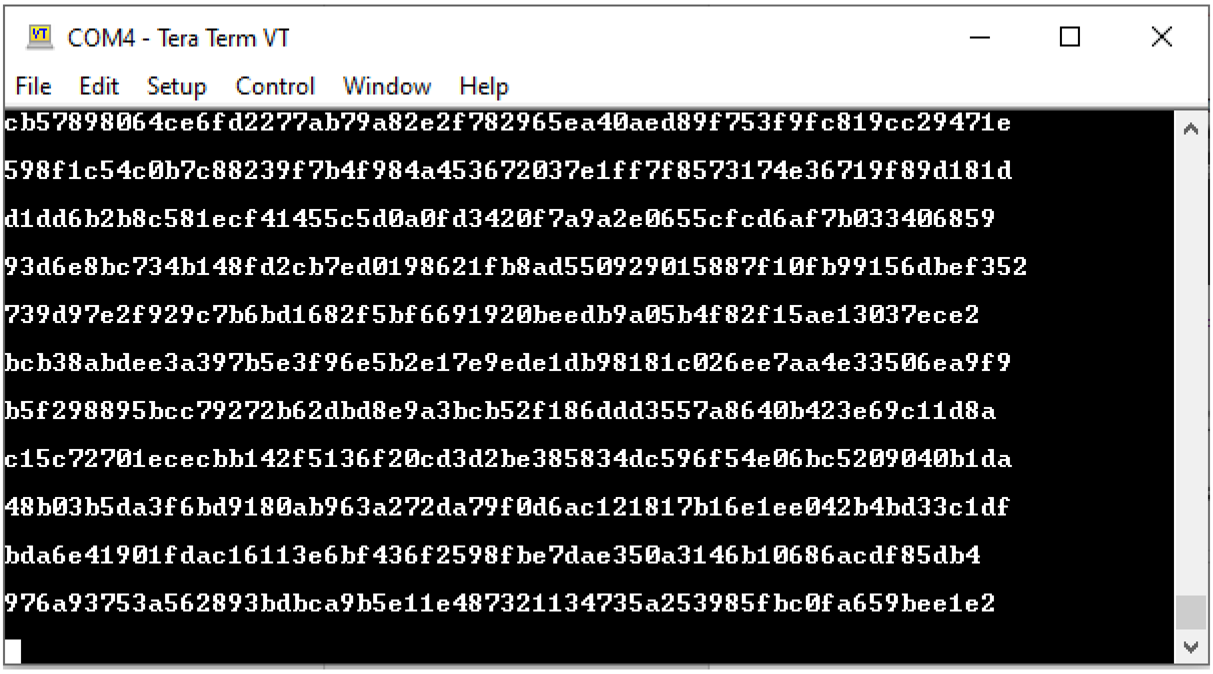

```
 //PRINTF("Generated Random Number: \r\n");
 for(int i=0;i<32;i++)
 PRINTF("%x", rndBuffer[i]);
 PRINTF("\r\n");
 }
 /* Print error message if invalid arguments */
 if(status_romapi == kStatus_NBOOT_InvalidArgument){
 PRINTF("Invalid Arguments\n");
 }
 /* Print error message if operation failed */
 if(status_romapi == kStatus_NBOOT_Fail){
 PRINTF("Random Number Generation Failed!\n");
 }
 PRINTF("\r\n");
 }
 while (1)
 {
 ch = GETCHAR();
 PUTCHAR(ch);
 }
}
```

3 Output

The output is displayed on the Tera Term application using the UART COM4 port. After the successful build and flashing of the code onto the MCU, the output is displayed, as shown in Figure 3. 11 strings of random numbers are printed, with each number printed in a new line and having a length of 32 bytes. Hex format is used for displaying the generated random numbers.

Note: *All the random numbers generated are different, ensuring the proper working of the RNG module.*



```
cb57898064ce6fd2277ab79a82e2f782965ea40aed89f753f9fc819cc29471e
598f1c54c0b7c88239f7b4f984a453672037e1ff7f8573174e36719f89d181d
d1dd6b2b8c581ecf41455c5d0a0fd3420f7a9a2e0655cfcd6af7b033406859
93d6e8bc734b148fd2cb7ed0198621fb8ad550929015887f10fb99156dbef352
739d97e2f929c7b6bd1682f5bf6691920beedb9a05b4f82f15ae13037ece2
bcb38abdee3a397b5e3f96e5b2e17e9ede1db98181c026ee7aa4e33506ea9f9
b5f298895bcc79272b62dbd8e9a3bcb52f186ddd3557a8640b423e69c11d8a
c15c72701ececbb142f5136f20cd3d2be385834dc596f54e06bc5209040b1da
48b03b5da3f6bd9180ab963a272da79f0d6ac121817b16e1ee042b4bd33c1df
bda6e41901fdac16113e6bf436f2598fbe7dae350a3146b10686acdf85db4
976a93753a562893bdbca9b5e11e487321134735a253985fbc0fa659bee1e2
```

Figure 3. Generated output displayed on Tera Term

4 References

The following document is referred:

- *LPC553x Reference Manual* (document LPC553xRM)

5 Note about the source code in the document

Example code shown in this document has the following copyright and BSD-3-Clause license:

6 Revision history

Table 2 summarizes the revisions to this document.

Table 2. Revision history

Revision number	Release date	Description
1	21 August 2023	Initial public release

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