AN14562

LPC553x/LPC55S3x FLASH APIs Implementation

Rev. 1.0 — 28 February 2025 Application note

Document information

Information	Content
Keywords	AN14562, LPC553x/LPC55S3x, API
Abstract	The ROM API in LPC553x/LPC55S3x devices helps manage and program the programmable Flash region and the Flash firewall region.

1 Introduction

The ROM API in LPC553x/LPC55S3x devices helps manage and program two main areas:

- The ***programmable Flash region***, which stores the application code and data.
- The ***Flash firewall region***, which holds device configurations and settings.

It enables Serial NOR FLASH programming through the FlexSPI NOR API and supports reading and programming One-Time Programmable (OTP) settings. The ROM API also includes built-in cryptographic functions for secure applications.

The structure of the API includes several components:

- The FLASH API is used to update the FLASH area.
- The FLEXSPI API supports various Serial NOR devices.
- The OTP API manages critical one-time programmable parameters.
- The NBOOT APIs help generate random numbers and verify the integrity of application images.
- The In-Application Programming (IAP) API provides flexibility for programming while an application is running, using either a unified memory interface or a dedicated secondary bootloader.

2 ROM API structure

The ROM API table locates at address `0x1302fc00`.

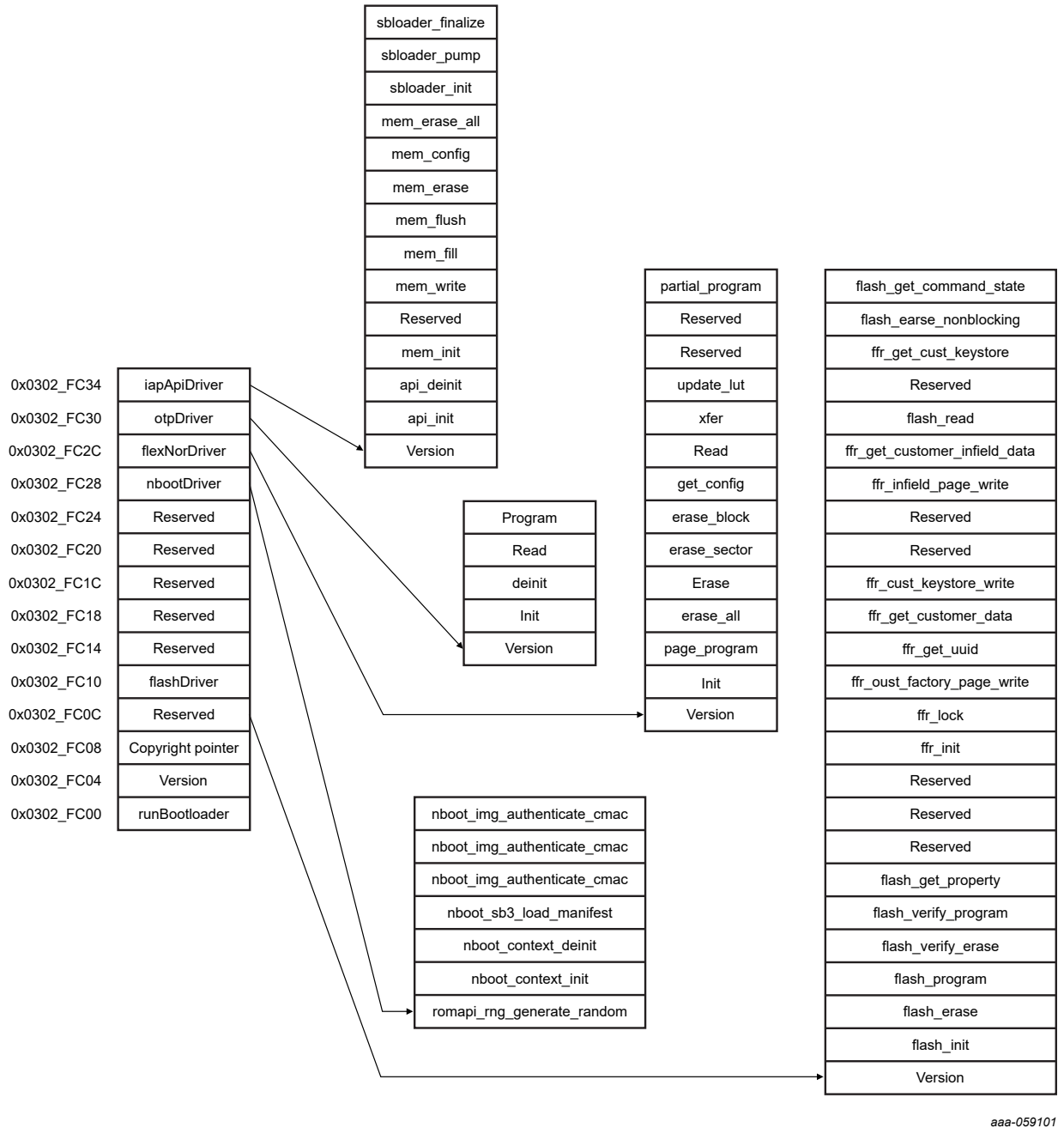

Figure 1. ROM API structure

3 FLASH APIs

The FLASH API set enables the following features:

- Initialize the FLASH controller.
- Erase and verify the specified FLASH area.
- Program and verify the specified FLASH page.
- Retrieve FLASH properties.
- Initialize or Lock the FFR.
- Program and Read CMPA.
- Program and Read CFPA.
- Non-blocking FLASH Erase/Status Check API for timing-critical use cases.

3.1 FLASH driver API interface

The FLASH APIs are organized in the FLASH Driver API Interface structure.

3.1.1 FLASH driver API prototypes

```
typedef struct FLASHDriverInterface
{
standard_version_t version; //!< flash driver API version number.
// FLASH driver
status_t (*flash_init)(flash_config_t *config);
status_t (*flash_erase)(flash_config_t *config, uint32_t start, uint32_t lengthInBytes,
 uint32_t key);
status_t (*flash_program)(flash_config_t *config, uint32_t start, uint8_t *src,uint32_t
 lengthInBytes);
status_t (*flash_verify_erase)(flash_config_t *config, uint32_t start, uint32_t
 lengthInBytes);
status_t (*flash_verify_program)(flash_config_t *config,
uint32_t start,
uint32_t lengthInBytes,
const uint8_t   *expectedData,
uint32_t *failedAddress,
uint32_t *failedData);
status_t (*flash_get_property)(flash_config_t *config, flash_property_tag_t
 whichProperty,uint32_t *value);
uint32_t reserved0[3];
// FLASH FFR driver
status_t (*ffr_init)(flash_config_t *config);
status_t (*ffr_lock)(flash_config_t *config);
status_t (*ffr_cust_factory_page_write)(flash_config_t *config, uint8_t *page_data, bool
 seal_part);
status_t (*ffr_get_uuid)(flash_config_t *config, uint8_t *uuid);
status_t (*ffr_get_customer_data)(flash_config_t *config, uint8_t *pData, uint32_t
 offset,uint32_t len);
status_t (*ffr_cust_keystore_write)(flash_config_t *config, ffr_key_store_t *pKeyStore);
status_t reserved1;
status_t reserved2;
status_t (*ffr_infield_page_write)(flash_config_t *config, uint8_t *page_data, uint32_t
 valid_len);
status_t (*ffr_get_customer_infield_data)(flash_config_t *config, uint8_t *pData,
 uint32_t offset,uint32_t len);
status_t (*flash_read)(flash_config_t *config, uint32_t start, uint8_t *dest, uint32_t
 lengthInBytes);
status_t reserved3;status_t (*flash_get_cust_keystore)(flash_config_t *config, uint8_t
 *pData, uint32_t offset,uint32_t len);
status_t (*flash_erase_non_blocking)(flash_config_t *config, uint32_t start, uint32_t
 lengthInBytes,uint32_t key);
```

```
status_t (*flash_get_command_state)(flash_config_t *config);
} flash_driver_interface_t;
```

3.1.2 FLASH configuration structure

Each FLASH API depends on a common FLASH context structure named `flash_config_t` to perform the proper FLASH operation.

```
/*! @brief FLASH driver state information.
*
* An instance of this structure is allocated by the user of the flash driver and
* passed into each of the driver APIs.
*/
typedef struct
{
uint32_t PFlashBlockBase; /*!< A base address of the first PFlash block */
uint32_t PFlashTotalSize; /*!< The size of the combined PFlash block. */
uint32_t PFlashBlockCount; /*!< A number of PFlash blocks. */
uint32_t PFlashPageSize; /*!< The size in bytes of a page of PFlash. */
uint32_t PFlashSectorSize; /*!< The size in bytes of a sector of PFlash. */
flash_ffr_config_t ffrConfig;
flash_mode_config_t modeConfig;
uint32_t *nbootCtx;
} flash_config_t;
```

4 Implementing FLASH APIs in MCUXpresso

First, define the following macros to facilitate the access to ROM and flash memory APIs in a firmware context.

```
#define ROM_API_TREE ((uint32_t *)0x1302FC00U)
#define DO_DEINIT 0
#define FLASH_API_TREE ((flash_driver_interface_t*)ROM_API_TREE[4])
```

4.1 `version`

`version` field in the FLASH API table indicates the current FLASH API version in the ROM bootloader.

Prototype:

```
standard_version_t version;
```

Parameter	Description
`version`	Pointer to version structure to store current Flash driver version information

Implementation:

```
/*Flash version api call*/
uint32_t FlashDriverVersion = FLASH_API_TREE-> version.version;
```

Output: It gives the version of the Flash driver.

4.2 ffr_lock

This API is used for initializing the FFR controller and the flash_ffr_config context. It must be called before calling other FFR APIs.

Flash FFR initialization must be done by invoking the ffr_init API of the MCUXpresso SDK before calling the ffr_lock.

Prototype:

```
status_t (*ffr_lock)(flash_config_t *config);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.

Implementation:

```
/*FRR init*/
status_t (*ffr_init)(flash_config_t *config);
uint32_t status_t = FLASH_API_TREE-> ffr_init (&flashConfig);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the FFR region has been locked.

4.3 ffr_cust_factory_page_write

The API is used for writing the CMPA data into the CMPA region, and the API should be called after the flash_init and ffr_init.

Prototype:

```
status_t (*ffr_cust_factory_page_write)(flash_config_t *config, uint8_t *page_data, bool seal_part);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
page_data	Pointer to a value address that will be written to the destination address.
seal_part	If set as true or the page_data includes the non-zero CMAC data, the CMPA CMAC will be calculated and programed into the CMPA region.

Implementation:

```
/*ffr_cust_factory_page write api*/
uint32_t cmpa_buffer_cust[512] = {0};
uint32_t status_cmpa = FLASH_API_TREE-> ffr_cust_factory_page_write
(&flashConfig, (uint8_t *)cmpa_buffer_t, false);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the cmpa_buffer data has been programmed into the CMPA region.

4.4 ffr_get_uuid

The API is used for getting the UUID data of the device, and the API should be called after the flash_init and ffr_init.

Prototype:

```
status_t (*ffr_get_uuid)(flash_config_t *config, uint8_t *uuid);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
uuid	Pointer to value address, the value is read back from the nmpa configuration uuid.

Implementation:

```
/*UUId api*/
uint32_t uuid_buffer [4];
uint32_t status_uuid = FLASH_API_TREE-> ffr_get_uuid(&flashConfig,
(uint8_t *)uuid_buffer);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the UUID data has been got from the UUID of the device.

4.5 ffr_get_customer_data

This API is used to read data stored in the Customer Factory page, and the API should be called after flash_init and ffr_init.

Prototype:

```
status_t (*ffr_get_customer_data)(flash_config_t *config, uint8_t *pData, uint32_t
 offset, uint32_t len);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
pData	Point to the destination buffer of date that stores data read from the Customer Factory Page.
offset	Point to the offset value based on the CMPA address (0x3e200) of the device.
len	The length in bytes to be read back, and the offset + len <= 512 B.

Implementation:

```
/*ffr_get_customer_data api*/
uint32_t cmpa_buffer[4];
uint32_t offset = 0;
uint32_t status_custdata = FLASH_API_TREE->ffr_get_customer_data
(&flashConfig, (uint8_t *)cmpa_buffer, offset, sizeof(cmpa_buffer));
```

Output: If the status is kStatus_FLASH_Success return value, it means that the CMPA data has been successfully read from the CMPA region and stored into the cmpa_buffer.

4.6 ffr_cust_keystore_write

The API is used for programing the customer key store data into the customer key store region (from 0x3e400 to 0x3e600), and the API should be called after flash_init and ffr_init.

Prototype:

```
status_t (*ffr_cust_keystore_write)(flash_config_t *config, ffr_key_store_t *pKeyStore);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
pKeyStore	Pointer to the customer key store data buffer, which will be programed into the customer key store region.

Implementation:

```
/*ffr_cust_keystore_write api*/
uint32_t cust_keystore_buffer={4};
uint32_t status_custkeywrite = FLASH_API_TREE->ffr_cust_keystore_write
(&flashConfig, (ffr_key_store_t *) cust_keystore_buffer);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the customer key store data has been programmed into the customer key store region.

4.7 flash_read

The API is used for getting internal flash data, including the FLASH and FFR data, and the API should be called after the flash_init.

Prototype:

```
status_t (*flash_read)(flash_config_t *config, uint32_t start, uint8_t *dest, uint32_t
 lengthInBytes);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
start	Point to the start address where will be read.
dest	Pointer to the buffer used for storing the read data.
lengthInBytes	Point to the read data length

Implementation:

```
/*Flash read api call*/
uint32_t start_addr = 0x1000;
uint8_t read_buffer[512] = {0};
uint32_t length_b = 512;
uint32_t status_flashread = FLASH_API_TREE-> flash_read(&flashConfig,
start_addr, (uint8_t *) read_buffer, length);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the expected read region has been loaded into the read_buffer.

4.8 ffr_get_cust_keystore

API is used for getting the customer key store data from the customer key store region (from 0x3e400 to 0x3e600), and the API should be called after flash_init and ffr_init.

Prototype:

```
status_t (*flash_get_cust_keystore)(flash_config_t *config, uint8_t *pData, uint32_t
 offset, uint32_t len);
```

Parameter	Description
config	Pointer to flash_config_t data structure in memory to store driver runtime state.
pData	Pointer to the customer key store data buffer, which got from the customer key store region.
offset	Point to the offset value based on the customer key store address (0x3e400) of the device.
len	Point to the length of the expected to get customer key store data, and the offset + len <= 512 B.

Implementation:

```
/*ffr_get_cust_keystore api*/
uint8_t cust_keystore_buffers[512] = {0};
uint32_t offset_b = 0;
uint32_t length = 512;
uint32_t status_get_cust_key = FLASH_API_TREE-> flash_get_cust_keystore
(&flashConfig, (uint8_t *) cust_keystore_buffers, offset, length);
```

Output: If the status is kStatus_FLASH_Success return value, it means that the customer key store data has been got from the customer key store region and stored into the cust_keystore_buffer.

5 Acronyms

Table 1. Acronyms

Abbreviations	Full Forms
ROM	Read Only Memory
FlexSPI	Flexible Serial Peripheral Interface
IAP	In-Application Programming
OTP	One Time Program
CMPA	Customer Manufacturing Programming Area
CFPA	Customer Factory Programming Area
UUID	Universal Unique Identifier
FFR	Another name for PFR (Protected Flash Region)

6 References

- *LPC553x Reference Manual* (document LPC553xRM)

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8 Revision history

Table 2 summarizes the revisions to this document.

Table 2. Revision history

Document ID	Release date	Description
AN14562 v1.0	28 February 2025	Initial public release

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Contents