User Manual

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Flash Self-Programming Library

FSL - T06

Flash Self-Programming Library for RC03F Flash based V850 devices

Renesas Electronics
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Preface

Readers	This manual is intended for users who want to understand the functions of the concerned libraries.
Purpose	This manual presents the software manual for the concerned libraries.
Organization	This document describes the following sections: • Architecture • Implementation and Usage • API
Note	Additional remark or tip
Caution	Item deserving extra attention
Numeric notation	Binary: xxxx or xxxB Decimal: xxxx Hexadecimal xxxxH or 0x xxxx
Numeric prefixes	Representing powers of 2 (address space, memory capacity): K (kilo): 2^{10} = 1024 M (mega): $2^{20} = 1024^2$ = 1,048,576 G (giga): $2^{30} = 1024^3$ = 1,073,741,824
Register contents	X, x = don’t care
Diagrams	Block diagrams do not necessarily show the exact software flow but the functional structure. Timing diagrams are for functional explanation purposes only, without any relevance to the real hardware implementation.

How to Use This Manual

(1) Purpose and Target Readers

This manual is designed to provide the user with an understanding of the library itself and the functionality provided by the library. It is intended for users designing applications using libraries provided by Renesas. A basic knowledge of software systems as well as Renesas microcontrollers is necessary in order to use this manual. The manual comprises an overview of the library, its functionality and its structure, how to use it and restrictions in using the library.

Particular attention should be paid to the precautionary notes when using the manual. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

The revision history summarizes the locations of revisions and additions. It does not list all revisions. Refer to the text of the manual for details.

(2) List of Abbreviations and Acronyms

Abbreviation	Full Form
API	Application Programming Interface
Boot Cluster	A number of flash blocks is combined to a cluster (used for swapping and protection) located at reset address
Bootloader	A piece of software located in the Boot Cluster handling the reprogramming of the device
Code Flash	Embedded Flash where the application code or constant data is stored.
Dual Operation	Dual operation is the capability to access flash memory during reprogramming another flash memory range. Dual operation is available between Code Flash and Data Flash. Between different Code Flash macros dual operation depends on the device implementation
ECC	Error Correction Code
Firmware	Firmware is a piece of software that is located in a hidden area of the device, handling the interfacing to the flash.
Flash	Electrically erasable and programmable nonvolatile memory. Different to ROM this type of memory can be re-programmed several times.
Flash Area	Area of Flash consists of several coherent Flash Blocks
Flash Block	A flash block is the smallest erasable unit of the flash memory.
Flash Macro	A certain number of Flash blocks are grouped together in a Flash macro.
FSL	Flash Self-Programming Library
FSS	Flash Self-Programming System
FSW	Flash Shield Window
FW	Firmware

NVM	Non volatile memory. All memories that hold the value, even when the power is cut off. E.g. Flash memory, EEPROM, MRAM...
RAM	“Random access memory” - volatile memory with random access
REE	Renesas Electronics Europe GmbH
REL	Renesas Electronics Japan
ROM	“Read only memory” - nonvolatile memory. The content of that memory can not be changed.
SCI	Status check internal mode (See "Internal mode")
SCU	Status check user mode (See "User mode")
Self-Programming	Capability to reprogram the embedded flash without external programming tool only via control code running on the microcontroller.
Serial programming	The onboard programming mode is used to program the device with an external programmer tool.
SPL	See "Self-Programming Library"

Table of Contents

Chapter 1 Introduction

This user’s manual describes the internal structure, the functionality and software interface (API) of the Renesas V850 Flash Self-Programming Library (FSL) type T06. The library type T06 is suitable for all Renesas V850 Flash based on the RC03F Flash technology.

Caution Do not use this library for devices based on other Flash technologies than RC03F, as this might lead to unwanted behaviour or demolition of the device.

The device features differ depending on the used Flash implementation and basic technology node. Therefore, pre-compile and run-time configuration options allow adaptation of the library to the device features and to the application needs.

The libraries are delivered in source code. However it has to be considered carefully to do any changes, as not intended behaviour and programming faults might be the result.

The development environments of the companies Green Hills (GHS), IAR and Renesas are supported. Due to the different compiler and assembler features, especially the assembler files differ between the environments. So, the library and application programs are distributed using an installer tool allowing selecting the appropriate environment.

For support of other development environments, additional development effort may be necessary. Especially, but maybe not only, the calling conventions to the assembler code and compiler dependent section defines differ significantly.

The libraries are delivered together with device dependent application programs, showing the implementation of the libraries and the usage of the library functions.

The different options of setup and usage of the libraries are explained in detail in this document.

Caution Please read all chapters of the application note carefully.
Much attention has been put to proper conditions and limitations description. Anyhow, it can never be ensured completely that all not allowed concepts of library implementation into the user application are explicitly forbidden. So, please follow exactly the given sequences and recommendations in this document in order to make full use of the libraries functionality and features and in order to avoid any possible problems caused by libraries misuse.

The Flash Self-Programming Libraries together with application samples, this manual and other device dependent information can be downloaded from the following URL:

http://www.renesas.eu/update

1.1 Flash versus EEPROM

Major difference between Flash and EEPROM (or E^2PROM) is the reprogramming granularity. EEPROM can be reprogrammed wordwise, where the size of one word depends on the organization and interface. It can vary in the wide range between 8 bit and 256 bytes.

Depending on the implementation, Flash may also be programmed wordwise, but the Erase can only be done on a complete block. This is the major limitation of Flash against EEPROM, but due to that the memory hardware effort can be reduced significantly, making the embedded non volatile memory for program code affordable.

1.2 Dual Operation

Common for all Flash implementations is, that during Flash modification operations (Erase/Write) a certain amount of Flash memory is not accessible for any read operation (e.g. program execution or data read).

This does not only concern the modified Flash range, but a certain part of the complete Flash system. The amount of not accessible Flash depends on the device architecture.

A standard architectural approach is the separation of the Flash into Code Flash and Data Flash. By that, it is possible to read from the Code Flash (to execute program code or read data) while Data Flash is modified, and vice versa.

To check whether Dual Operation is supported by a device, please refer to the device user manual.

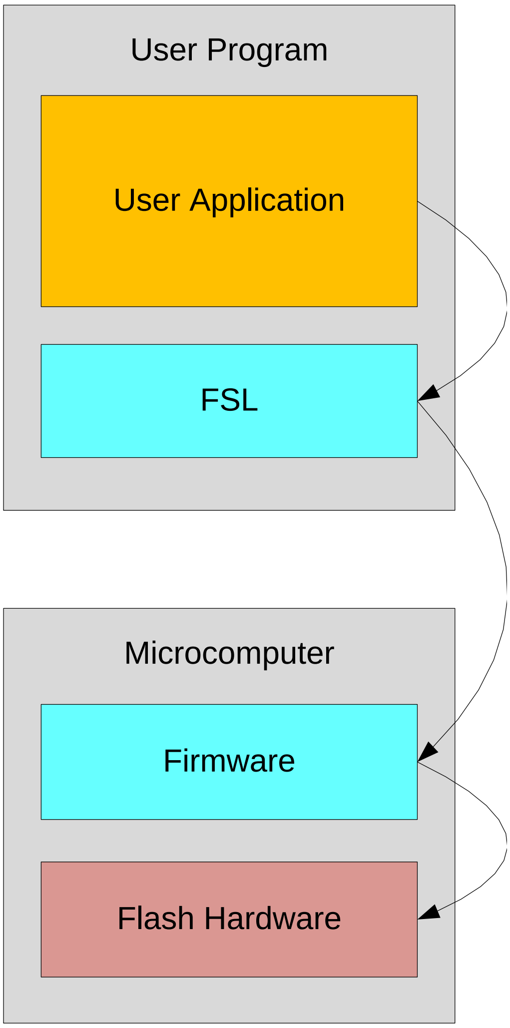
Note **It is not possible to modify Code Flash and Data Flash in parallel**

Chapter 2 FSL Architecture

This chapter describes the function of all blocks belonging to the Flash Self-Programming System.

Even though this manual describes the functional block FSL, a short description of all concerned functional blocks and their relationship can be beneficial for the general understanding.

Figure 2-1



Rough relationship between functional system blocks of the FSS

Application The functional block “Application” is the user application (including a potential bootloader) provided by the customer.

Flash Self-Programming Library (FSL) The functional block “Flash Self-Programming Library” offers all functions and commands necessary to reprogram the application using a user friendly C language interface.

Firmware The block firmware provides the device internal functionality to control the Flash programming hardware.

Chapter 3 FSL Implementation

3.1 File structure

The library is delivered as a complete compilable sample project which contains the FSL and in addition an application sample to show the library implementation and usage in the target application.

The application sample initializes the *FSL* and does some dummy data set *Erase and Write* operations.

Differing from former Self-Programming Libraries, this one is realized not as an IDE related specific sample project, but as a standard sample project which is controlled by makefiles.

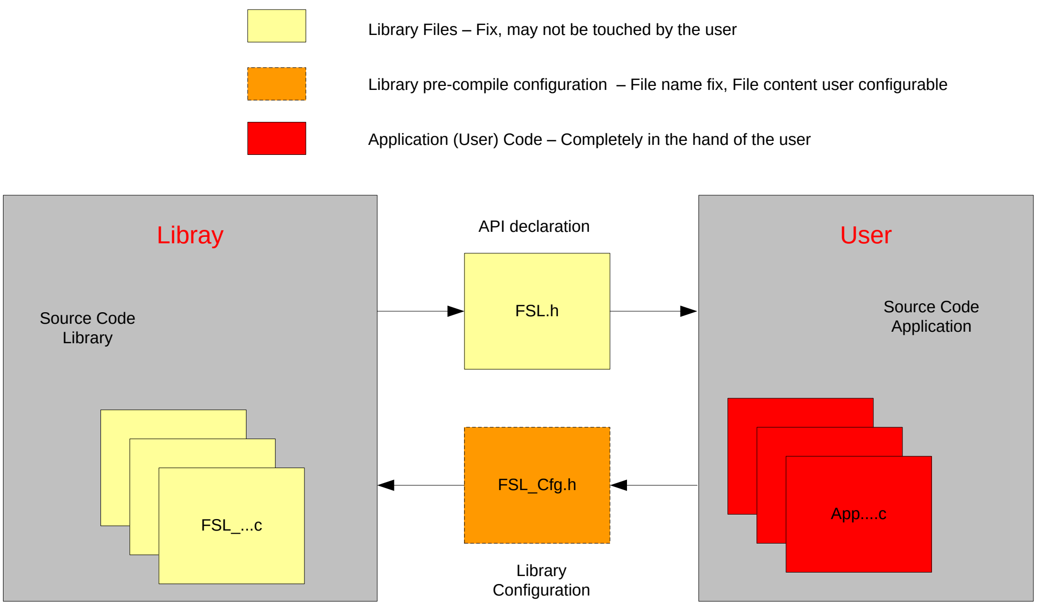
Following that, the sample project can be built in a command line interface and the resulting elf file can be run in the debugger.

The delivery package contains dedicated directories for the library containing the source and the header files.

3.1.1 Overview

The following picture contains the library and application related files:

Figure 3-1



Library and application file structure

The library code consists of different source files, starting with FSL_... The files shall not be touched by the user, independently, if the library is distributed as source code or pre-compiled.

The file FSL.h is the library interface functions header file. It also includes library interface parameters and types.

In case of source code delivery, the library must be configured for compilation. The file FSL_Cfg.h contains defines for that. As it is included by the library source files, the file contents may be modified by the user, but the file name may not.

Caution **Wrong configuration of the FSL might lead to undefined results.**

FSL_User.c and FSL_User.h do not belong to the libraries themselves, but to the user application. These files reflect an example, how to activate the Flash environment and handle the FLMD0 pin.

If overtaking the files FSL_User.c/h into the user application, only the file FSL_User.c need to be adapted by the user, while FSL_User.h may remain unchanged.

3.1.2 Delivery package directory structure and files

The following table contains all files installed by the library installer.

- Files in red belong to the build environment, controlling the compile, link and target build process
- Files in blue belong to the sample application
- Files in green are description files only
- Files in black belong to the FSL

[root]	
Release.txt	Installer package release notes
[root]\[make]	
GNUPublicLicense.txt	Make utility license file
libiconv2.dll	DLL-File required by make.exe
libintl3.dll	DLL-File required by make.exe
make.exe	Make utility
[root]\[<device name>]\[compiler]	
Build.bat	Batch file to build the application sample
Clean.bat	Batch file to clean the application sample
Makefile	Makefile that controls the build and clean process

[root]\ [<device name>]\[<compiler>]\[sample]		
Main.c	Main source code	
target.h	target device and application related definitions	
device header files	GHS	df<device number>.h
		df<device number>_irq.h
		io_macros_v2.h
	IAR	io_70f< device number>.h
		io_macros.h
		lxx.h
startup file	GHS	cfi.h
	IAR	l07.s85
	REC	cstartup.s85
linker directive file	GHS	df<dev. num.>.ld
	IAR	lnk70f<dev. num.>.xcl
	REC	df<dev. num.>.dir
[root]\ [<device name>]\[<compiler>]\[sample] \[FSL]		
FSL_cfg.h	Header file with definitions for library setup at compile time	
linker directive file	Header file containing function prototypes, error and status codes	
FSL_User.h	User file header including Flash environment activation / deactivation and FLMD0 handling. To be edited by the user.	
startup file	User file including Flash environment activation / deactivation and FLMD0 handling. Maybe modified by the user.	
[root]\ [<device name>]\[<compiler>]\[sample] \[FSL] \[lib]		
FSL_Global.h	Library internal defines, function prototypes and variables	
FSL_UserIF_Init.c	Source code for the FSL initialization	
linker directive file	Source code for the normal FSL operations	
FSL_FirmwareIF.c	Interface to the firmware	
FSL_BasicFct.c	Source code of basic functions used during Self-Programming	
GHS	FSL_BasicFct_Asm.850	Assembler code of basic functions used during Self-Programming
IAR	FSL_BasicFct_Asm.s85	
REC	FSL_BasicFct_Asm.asm	

3.2 FSL Linker sections

The following sections are Flash Self-Programming Library related.

FSL data sections

- FSL_DATA

  This section contains the variables required for FSL. It can be located either in internal or in external RAM.

FSL code sections

- FSL_CODE_ROM

  This section contains the code executed at the beginning of Self-Programming. This code is executed at the original location, e.g. internal Flash. The library initialization is part of this section.

- FSL_CODE_ROMRAM

  The section contains the user interface. Depending on the library configuration, code from this section has to be executed in a Memory area outside the Flash area affected by the Self-Programming operation (typically executed in RAM) or not.

- FSL_CODE_RAM

  This section contains the firmware interface and has to be executed in a Memory area outside the Flash area affected by the Self-Programming operation (typically executed in RAM).

- FSL_CODE_RAM_USRINT

  This section may contain user interrupt handler functions.

- FSL_CODE_RAM_USR

  This section may contain user functions and has to be executed in a Memory area outside the Flash area affected by the Self-Programming operation (typically executed in RAM). User functions may contain code for the Self-Programming control flow.

- FSL_CODE_RAM_EX_PROT

  This is a dummy section to avoid prefetch errors at the borders of the copied sections during RAM execution.

Caution **It is not allowed to place any section in between the FSL code sections. A violation of that rule or a reordering of the sections will cause a crash of the library.**

3.3 MISRA Compliance

The FSL has been tested regarding MISRA compliance.

The used tool is the QAC Source Code Analyzer which tests against the MISRA 2004 standard rules.

All MISRA related rules have been enabled. Remaining findings are commented in the code while the QAC checker machine is set to silent mode in the concerning code lines.

Chapter 4 FSL Usage

4.1 Flash Security

4.1.1 Strategy

In most cases application software contains important intellectual property and/or data that may not be distributed to others or manipulated by others. In order to ensure Flash data integrity and to prevent unintended data read-out, Renesas implements a set of features and mechanisms into Flash devices.

As these mechanisms may also limit the flexibility required for the application and the programming or reprogramming, it has to be decided carefully what level of protection is intended.

Two major items to be considered in the protection concept are:

- Illegal read-out of Flash content
- Illegal or accidental reprogramming of Flash

The following descriptions explain the strategies regarding these items are described in detail:

Illegal read-out of Flash content

Read-out, legal and illegal, can be done on different ways. The following describes major ways and the appropriate counter measures against illegal operations:

- *Direct read-out via on-chip debug interface*

  Some devices contain the N-Wire / Nexus debug interface. This allows full control over all data stored in the device. It can be protected by a password. As the protection is not directly a Flash feature, it is just mentioned for reference. Please refer to the device user manual or the tools description for details.

- *Direct read-out via programming interface*

  The standard programming interface (e.g. PG-FP5) supports a command to read out the Flash contents on all current devices. This feature helps a lot in the developing and debugging phase and for failure analysis. This command can be disabled by a protection flag (see chapter 4.1.2 Configuration options for details)

- *Direct read-out by the application itself (via any interface)*

  E.g. a debug command in the application can be used to dump memory. Please ensure that this possibility is not implemented or at least protected in your application.

- *Indirect read-out by spy software, programmed into the internal Flash*

  Software can be programmed into Flash in two different ways:

  - By the application itself using Self-Programming

    Please ensure that this possibility is not implemented or at least protected in your application.

- By the programmer interface

  In order to disable this feature, the commands Flash Write and Flash Block Erase can be disabled (see chapter 4.1.2 Configuration options for details). By doing so, Flash writing via this interface is only possible after erasing the complete Flash.

<u>Illegal or accidental reprogramming of Flash</u>

For many applications protection against the illegal Flash read-out is already sufficient. In other cases reprogramming the device either completely or partly must be disabled. V850 devices provide features for both:

- *Partly reprogramming by the programmer interface*

  See Illegal read-out of Flash content

- *Complete reprogramming by the programmer interface*

  If also the complete erasing and reprogramming by this interface shall be disabled, in addition to Flash Write and Flash Block Erase commands also the Chip Erase command can be disabled (see chapter 4.1.2 Configuration options for details). By doing so the reprogramming via programmer interface is no longer possible, neither by unauthorized nor by authorized use. Reprogramming by the application using Self-Programming is still possible.

- *Reprogramming by the application using Self-Programming*

  It is also possible to protect a certain number of Flash blocks (called boot cluster) against reprogramming via the application, starting from 0x00000000. The number of blocks is configurable from 1 up to the complete Flash.

  So it is possible to protect e.g. a Bootloader or more code and data up to the complete application.

  In addition a configurable Flash Shield Window is able to protect parts of the Flash. This Window is configurable via Self-Programming. Only the Flash blocks covered by the FSW can be reprogrammed via Self-Programming.

Note When disabling reprogramming of blocks via the application, the secured part can no longer be reprogrammed in any way any more.

4.1.2 Configuration options

This chapter explains the protection relevant settings and mechanisms, implemented in RC03F based Flash devices.

For the usage of these settings and the protection strategy, please refer to section 4.1.1 Strategy.

(1) Security Flags

The protection configuration can be set by the dedicated Flash programmers, like PG-FP5 or via Self-Programming.

The following flags and settings are available:

- *Read command disable (Programmer interface)*

  Reading the Flash contents via the programming interface is disabled. It does not affect Self-Programming (see FSL_SetReadProtectFlag).

- *Program command disable (Programmer interface)*

  Writing to the Flash via programming interface is disabled. It does not affect Self-Programming (see FSL_SetWriteProtectFlag).

- *Block Erase command disable (Programmer interface)*

  Erasing single blocks via programming interface is disabled. It does not affect Self-Programming. The Flag is valid for the complete Flash (see FSL_SetBlockEraseProtectFlag).

- *Boot Cluster Protection*

  If set, erasing and writing on the Flash by the application using the Self-Programming is disabled for the boot cluster (see FSL_SetBootClusterProtectFlag).

Caution **If set once, resetting is only possible for the read and write protection flag.**

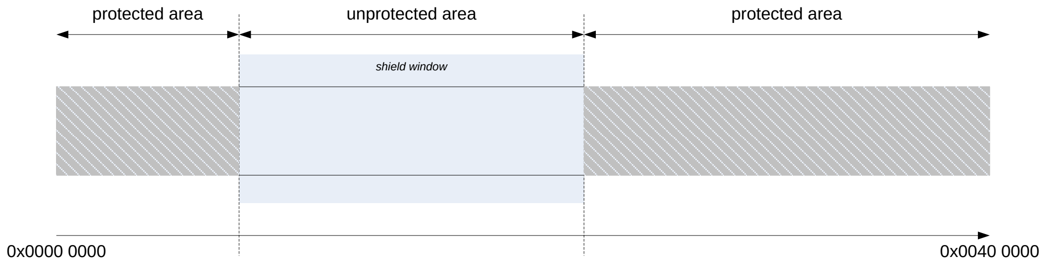
(2) ID Code Protection

Flash access via N-Wire / Nexus debug interface can be secured via an internal ID. The ID is stored in the Extra Area and has to match the configure ID in the N-Wire interface configuration of the debugger to allow Flash access. For details about the ID, please refer to FSL_SetID.

(3) Flash Shield Window

Internal Flash can be protected from accidental reprogramming by a shield window. This window is configurable during runtime. It allows to program or to erase all Flash blocks covered by the window and denies destructive access to all other blocks. Per default all Flash blocks are covered by the Flash Shield Window. For details how to configure the Flash Shield Window, please refer to FSL_SetFSW.

Figure 4-1



Flash Shield Window

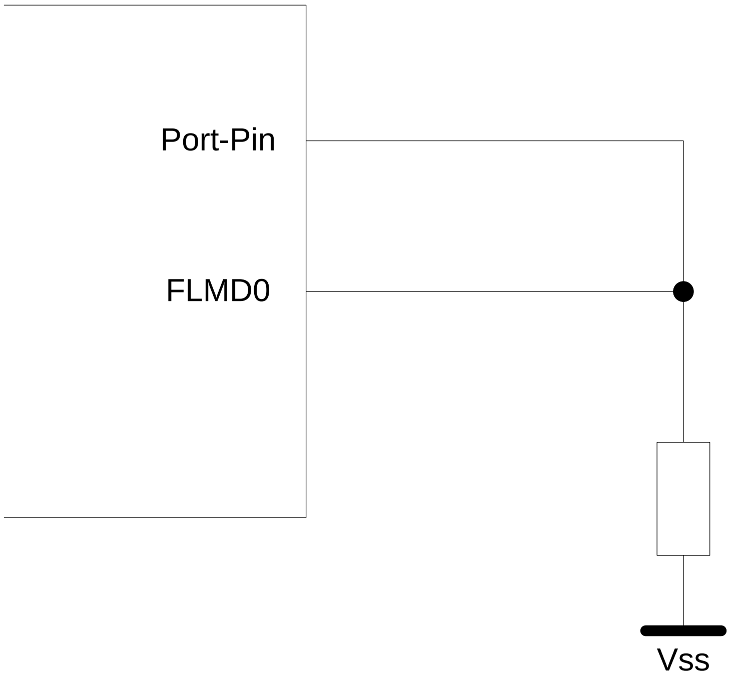
4.2 Flash Safety

All RC03F based Flash devices are equipped with dedicated safety features. The features have to be separated for normal operation, where data retention is important and for reprogramming, where safe reprogramming in case of power fail or other problems is important.

4.2.1 Hardware Protection

Device Reprogramming is disabled if FLMD0 Pin is low. By using a port pin or an external logic FLMD0 must be set to “1” to allow Self-Programming. Additionally reprogramming can be enabled by a register if supported by the device. Please refer to the device user manual for further details.

Figure 4-2



FLMD0 sample circuit

In the sample circuit, the port pin is input on reset. Thus FLMD0 is held to V_{SS} on reset. During Self-Programming the port is set to output and to the value “1”. By that the FLMD0 pin is set to $V_{DD.}$

4.2.2 Normal operation (Error Correction Circuit – ECC)

RC03F based Flash devices contain Error Correction Circuits (ECC) to provide correct Flash data. During Flash write operations, beside the user data, also redundant ECC data is written into additional Flash cells in order to be able to correct detected Flash errors during Flash read. ECC is an on-line method. That means from user point of view ECC has no impact on the data read performance.

4.2.3 Safe reprogramming using Self-Programming

When talking about safe Self-Programming, that naming needs to be exactly defined, as several different ways of understanding are possible.

Basic idea of safe Self-Programming is that if anything during reprogramming process goes wrong, it must be possible to keep basic application functionality alive. Usually it is solved by separation of the application into the application that is updated and therefore temporarily not valid during reprogramming, and a specific bootloader that must always be executable again after power up or reset.

Two major options with different advantages and disadvantages have to be considered. Depending on the application and bootloader the appropriate solution has to be selected:

- Safe Self-Programming without bootloader update
- Safe Self-Programming with bootloader update

Safe Self-Programming without bootloader update

The easiest way of safe Self-Programming is to occupy some complete Flash blocks for the bootloader and do not reprogram them again. By that it never happens, that an interruption of the reprogramming (e.g. power fail) causes an invalid bootloader.

Although this method might waste some space if the bootloader does not occupy a complete Flash block, the handling of reprogramming is easy.

Furthermore, increased safety by protection against reprogramming the bootloader due to program failures is possible. The block protection feature can be used to protect the bootloader forever against any reprogramming. In that case, please consider that the block cannot be reprogrammed in any way any more.

Safe Self-Programming with bootloader update

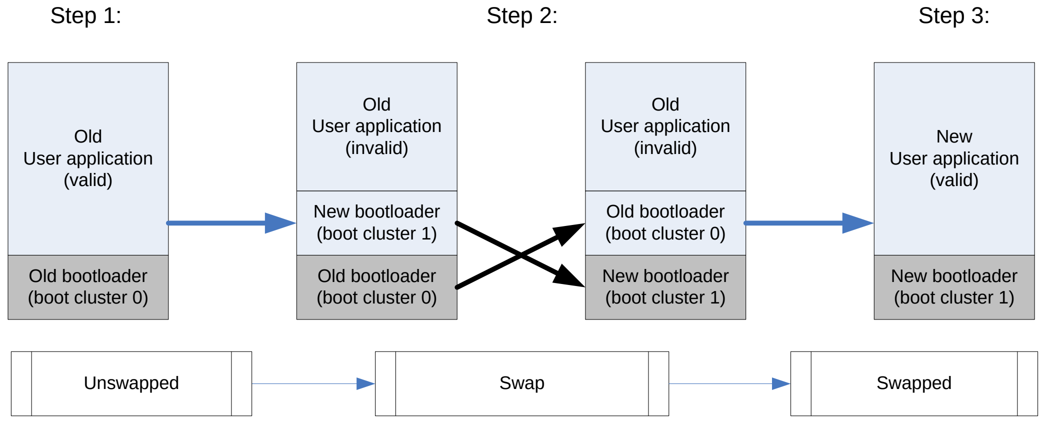
Bootloader block update might be necessary due to the following items:

- Keep the option to fix bootloader bugs.
- Application code/data, that needs to be updated, is stored in the same block as the bootloader.

If the bootloader has to be updated, it needs to be ensured, that always a working version of the bootloader is available, even during the update procedure. Furthermore, in case of a power failure the valid bootloader needs to be detected and the program has to be started there. To fulfil these requirements, the Boot Swap functionality is implemented.

Boot swap means, that a certain number of Flash blocks (clusters) can be swapped in the address range. This swapping is done depending on Boot Swap bits, set in the Flash Extra Areas. When a valid bootloader is contained in the corresponding cluster and the swap bit is set accordingly, the block is automatically swapped to the address 0x00000000 on device start-up. By that and by the correct reprogramming sequence can be ensured, that even a block containing a bootloader can be updated safely.

Figure 4-3



Safe bootloader update

Two methods are implemented in the Library to swap the boot cluster.

1. Swap the boot cluster only temporary. The boot cluster will be unswapped again after a device reset. For details, please refer to FSL_ChangeSwapState.
2. Invert the boot flag. The boot cluster will remain changed after a reset. An additional parameter forces the device to swap the boot cluster immediately in addition to changing the swap flag. Please refer to FSL_ChangeSwapFlag.

4.3 Code execution in RAM

The application, including the control program and the FSL are usually located in the internal flash. As the memory location of the application is not permanently available during Self-Programming, parts of the program need to be copied to a "save" location, where they can be executed. This may be the internal RAM, but also external RAM, if available, is acceptable.

To copy necessary code parts into available RAM, three different methods are possible:

- C-Startup
- FSL_CopySections
- User specific

C-Startup

The code is linked to the destination address. The compiler start-up routines copy the code from a ROM image to the RAM. Please refer to the compiler documentation for details.

FSL_CopySections

By calling the function FSL_CopySections all specified sections are copied to the destination address.

User specific

In case of a user specific implementation, the user is responsible for the correct location of the sections.

Note During RAM execution as well as during ROM execution, the device tries to speed up execution time by a code prefetch mechanism. This prefetch mechanism is responsible for ECC errors in case of uninitialized RAM areas. Therefore the user has to initialize 32 Bytes behind the RAM placed code in case of a user specific implementation.

Depending on the configured mode (see section 5.1 Pre-compile configuration) following linker sections need to be copied to RAM:

User mode

- FSL_CODE_RAM_USRINT
- FSL_CODE_RAM_USR
- FSL_CODE_RAM
- FSL_CODE_ROMRAM
- FSL_CODE_EX_PROT

Internal mode

- FSL_CODE_RAM_USRINT
- FSL_CODE_RAM_USR
- FSL_CODE_RAM
- FSL_CODE_EX_PROT

For further information regarding the linker sections please refer to chapter 3.2 “FSL Linker sections”

Caution **Beside the mentioned sections, Self-Programming needs additional 4kByte of RAM located on the top of the RAM. These RAM addresses are reserved for the internal firmware. The RAM content in this address range will be destroyed during Self-Programming.**

4.4 User code execution during Self-Programming

The activation and deactivation of the Self-Programming Environment can be handled by the FSL automatically or by the user application.

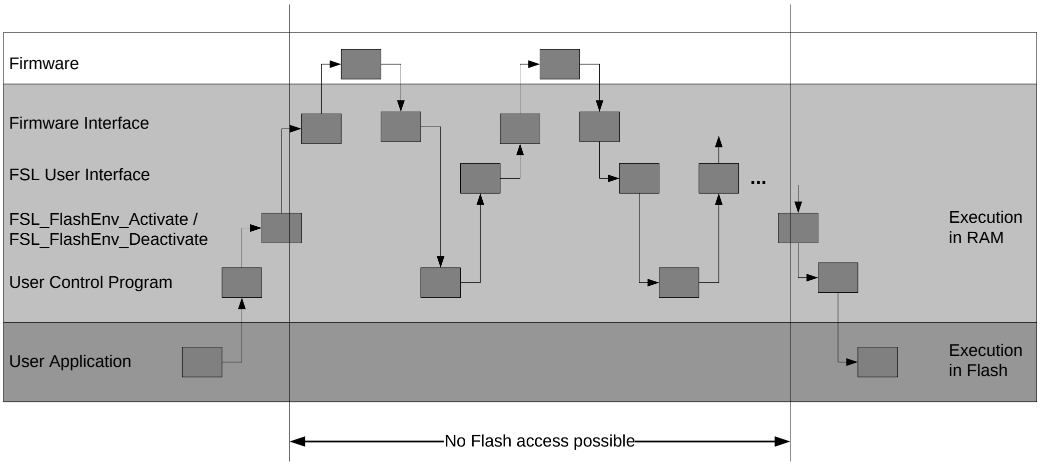
Especially activation is time consuming. In order to achieve fast reprogramming the environment should be kept activated during the whole reprogramming. On the other hand, during activated environment the program execution cannot be done from Flash. So other memory like internal RAM or external memory is required. If not sufficient memory is available, sequential activation and deactivation is necessary and only small code parts are executed from internal RAM.

Following two major scenarios may be considered for Self-Programming. These are reflected by the library modes:

User mode

Most parts of the Self-Programming Library are executed in the internal RAM, additionally the reprogramming control functions and other user code to be executed during Self-Programming. In order to realise fast reprogramming the activation/deactivation sequence is done only once for the complete reprogramming. Every code to be executed between activation and deactivation needs to be executed outside the Flash.

Figure 4-4



Reprogramming sequence in user mode

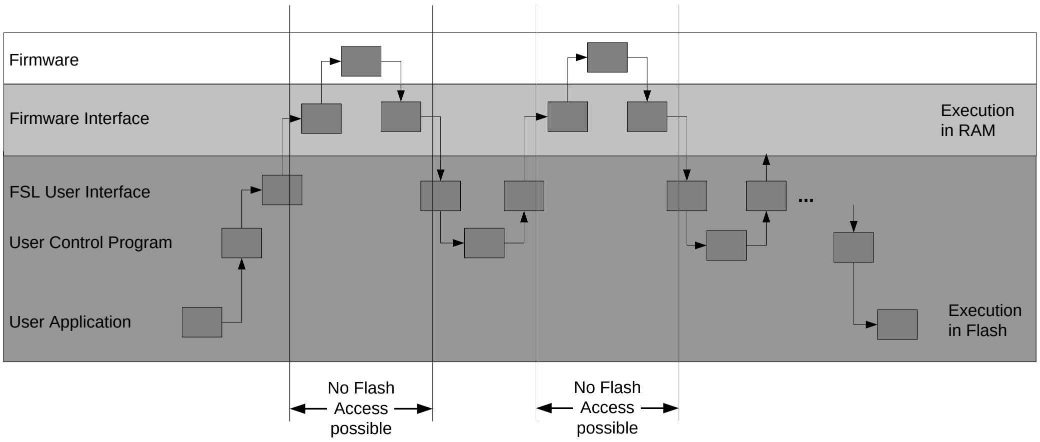
This sequence is best for devices with sufficient internal RAM. User code execution is always possible during Self-Programming, because a Flash operation is just initiated by the FSL command. While the FSL returns control to the user application, the Flash operation is executed in background. The user has to poll the command status via the status check function. Interrupt as well as user code execution is possible if all related functions are located in RAM.

To enable this mode, the library must be configured to use the user mode (see 5.1 Pre-compile configuration).

Internal mode

Only small parts of the library are executed in RAM, the rest is executed in the Code Flash. Frequent activation and deactivation of the Flash Environment is necessary and therefore programming time will increase.

Figure 4-5



Basic RAM saving reprogramming sequence

Less internal RAM is used as only the device firmware interface need to be executed in RAM. On the other hand, normal user code execution during Self-Programming is impossible, because a FSL function starting a command does not return until the operation is finished. Therefore only interrupts are possible during Self-Programming.

To enable this mode, the library must be configured to use the internal mode (see 5.1 Pre-compile configuration).

4.5 Interrupts in RAM

As mentioned before, Code Flash is not accessible during Self-Programming. Therefore the interrupt vector table as well as interrupt handler routines, which are normally located in the Flash, are not accessible. Interrupt vectors and handler routines have to be re-routed to not affected memory like external or internal RAM.

Two methods exist to execute interrupts from RAM:

- Single interrupt vector

  All interrupts are mapped to the single interrupt vector of interrupt channel 0. Based on this interrupt, the interrupt handler routine has to handle all pending interrupts.

- Interrupt table mapped to RAM

  The base address of the interrupt vector table is mapped to a different location in RAM. In this case the offset of the different channels is added to the new base address.

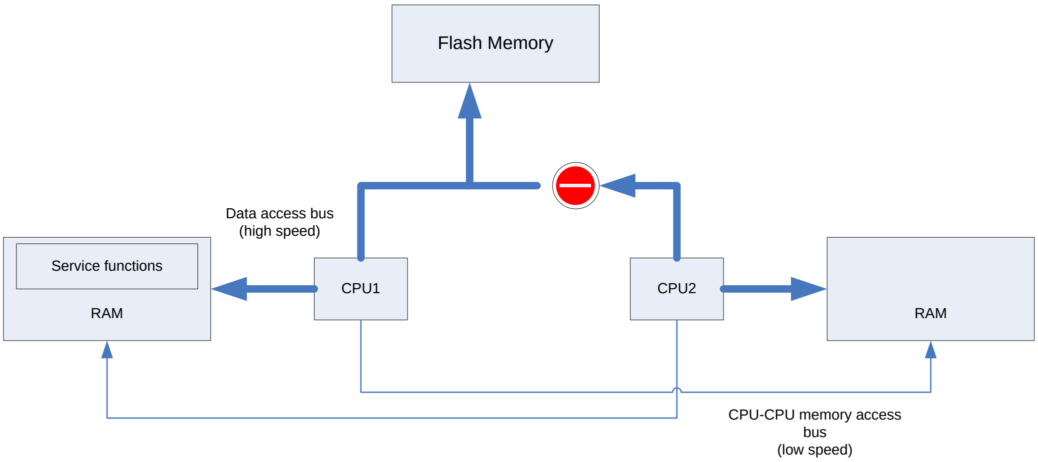
Regardless which method is used, interrupt service routines have to be executed from and therefore copied to RAM. For details how to copy the routines to RAM, please refer to chapter 4.3 “Code execution in RAM”.

Note Further information about interrupt handling from RAM can be found in the device user manual and in the CPU architecture description (see “*V850E2R-V3 Architecture*”).

4.6 Dual CPU operation

In case of a dual CPU device the usage of the FSL is not limited to one CPU. The Flash memory can be controlled by each CPU.

Figure 4-6



Dual CPU operation

Dual CPU operation causes some smaller restrictions. The service functions are always located in RAM area of CPU1. Therefore the function response time will increase in case of control by CPU2.

A second restriction is access control in general. To provide a fail safe mechanism, only access by one CPU at a time is allowed. Simultaneous access by the other CPU is prohibited. Access rights are controlled automatically by the library.

4.7 Option Bytes

The Extra Area contains user specific configuration data called Option Bytes. These configuration settings are adjustable via Self-Programming. The size of the Option Bytes is 4Byte. For details about possible configuration settings please refer to the device user manual.

Chapter 5 User Interface (API)

5.1 Pre-compile configuration

The pre-compile configuration of the FSL is located in the FSL_cfg.h. The user has to configure all parameters and attributes by adapting the related constant definition in that header-file.

This file may also contain device or application specific defines. The define *FSL_STATUS_CHECK* needs to be configured. It defines whether the status check should be performed by the firmware or by the user to allow execution of user code in between the status checks.

```
#define FSL_STATUS_CHECK            FSL_STATUS_CHECK_INTERNAL
```

Following configuration options are possible:

- FSL_STATUS_CHECK_INTERNAL
- FSL_STATUS_CHECK_USER

As described in the previous chapter the library behaviour changes depending on the configure mode.

User mode (FSL_STATUS_CHECK_USER)

Advantages:

- less CPU time
- less activation / deactivation time
- user code execution during Self-Programming

Disadvantages:

- more RAM consumption
- status polling necessary

Additionally, in status check user mode, user can enable or disable polling in the activation and deactivation functions of the library by setting following define:

```
#define FSL_ACTIVATION_POLLING
```

If the activation polling is disabled, the function will automatically return after the activation operation is finished. The activation / deactivation process needs longer execution time than any other operation. As this operation is normally executed once at the beginning, the longer execution time is acceptable. By setting the pre-processor define, the process is split up and the execution is controlled by the status check like normal Flash operations. So the function execution time is reduced.

Internal mode (FSL_STATUS_CHECK_INTERNAL)

Advantages:

- no polling necessary
- less RAM consumption

Disadvantages:

- more activation / deactivation time
- no return to the application during Self-Programming
- user code execution during Self-Programming only by interrupts

For details refer to chapter 4.4 User code execution during Self-Programming.

Synchronization between Code and Data Flash

It is not possible to access Code Flash during Data Flash access and vice versa due to similar hardware and limited internal resources, e.g. a single charge pump. To protect and synchronize Code Flash and Data Flash accesses a synchronization mechanism is implemented. This mechanism will postpone all Code Flash access if a Data Flash access is ongoing until the Data Flash access is terminated. A Data Flash access during Code Flash accesses is very unlikely, because code execution is only possible from RAM during Self-Programming. Therefore the access from Data Flash is not synchronized.

To enable the synchronization mechanism, following define is necessary:

```
#define FSL_CODE_DATA_FLASH_SYNC_ENABLED
```

5.2 Data Types

Figure 5-1

Error	Value	Explanation	Responsible process	FSL Impact
FSL_OK	0x00	The operation finished successfully		Correct result
FSL_IDLE	0x30	No operation is ongoing		A new function call is possible
FSL_BUSY	0xFF	The operation has been started successfully and is still running.		Correct result

FSL status codes

Figure 5-2

Error	Value	Explanation	Responsible process	FSL Impact
FSL_ERR_FLMD0	0x01	The FLMD0-Pin is not at a High level.		Current command rejected
FSL_ERR_PARAMETER	0x05	A new operation should be initiated, but an error in the given parameter occurred.		Current command rejected
FSL_ERR_PROTECTION	0x10	A new operation should be initiated although this operation is forbidden due to a security feature.		Current command rejected
FSL_ERR_ERASE	0x1A	The current operation stopped due to an error while erasing.		Current command aborted.
FSL_ERR_WRITE	0x1C	The current operation stopped due to an error while writing.		Current command aborted.
FSL_ERR_FLOW	0x1F	A new operation should be initiated although the state machine is still busy.		Current command rejected
FSL_ERR_INTERNAL	0xAA	The current operation stopped due to an internal error.		Current command aborted.

FSL error codes

5.3 Library Functions

Functions represent the application interface to the FSL which the user SW can use. Following list is an overview of all available functions (in alphabetic order).

- FSL_CalcFctAddr
- FSL_ChangeSwapFlag
- FSL_ChangeSwapState
- FSL_CopySections
- FSL_Erase
- FSL_FlashEnv_Activate
- FSL_FlashEnv_Deactivate
- FSL_GetBlockCnt
- FSL_GetBlockEndAdd
- FSL_GetBootClusterSize
- FSL_GetDevice
- FSL_GetFSW
- FSL_GetID
- FSL_GetOPB
- FSL_GetSecurityFlags
- FSL_GetSwapFlag
- FSL_GetSwapState
- FSL_GetVersionString
- FSL_Init
- FSL_ModeCheck
- FSL_Read
- FSL_SetBlockEraseProtectFlag
- FSL_SetBootClusterProtectFlag
- FSL_SetBootClusterSize
- FSL_SetFrequency
- FSL_SetFSW
- FSL_SetID
- FSL_SetOPB
- FSL_SetReadProtectFlag
- FSL_SetWriteProtectFlag
- FSL_StatusCheck
- FSL_Write

5.3.1 Initialization

5.3.1.1 FSL_Init

Description

Function is executed before any execution of other FSL function. It initializes internal Self-Programming environment and internal variables.

Interface

```
void FSL_Init( void )
```

Arguments

None

Return types / values

None

Pre-conditions

None

Post-conditions

None

Example

```
/* Initialze and start Self-Programming Library */
FSL_Init( );
```

5.3.1.2 FSL_CopySections

Description

If it is necessary to copy the FSL functions to another location than the linked one, e.g. to a RAM location, the function copies all routines to the specified destination address. Please refer to chapter 4.3 “Code execution in RAM” for further details. The function is executed before any execution of other FSL function, but must be executed after FSL_Init.

Interface

```
void FSL_CopySections( fsl_u32 addDest_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	addDest_u32	Destination address of Self-Programming Library

Return types / values

None

Pre-conditions

Library must be initialized (call function FSL_Init).

Post-conditions

None

Example

```
/* Copy FSL to internal RAM address 0xffff7000 */
FSL_CopySections( 0xffff7000 );
```

5.3.1.3 FSL_CalcFctAddr

Description

Function calculates the new address of a function copied from ROM to RAM. To locate the new address of the function, the copied function must be located in on of the FSL linker segments (see chapter 3.2 “FSL Linker sections”).

Interface

```
fsl_u32 FSL_CalcFctAddr( void *pAddFct_ptr, fsl_u32 destAddr_u32 )
```

Arguments

Type	Argument	Description
void	pAddFct_ptr	Pointer to ROM address of copied function
fsl_u32	destAdd_u32	Destination address of Self-Programming Library, e.g. value used for FSL_CopySections.

Return types / values

Type	Argument	Description
fsl_u32		New RAM address of function

Pre-conditions

Library must be initialized (call function FSL_Init) and copied (call function FSL_CopySections).

Post-conditions

None

Example

```
/* Calculate new address of FSL_Write function */
/* FSL copied to RAM addess 0xffff7000 */
fsl_u32 (*fpFct)( void );

fpFct = (fsl_u32(*)())FSL_CalcFctAddr( ( void * )FSL_Write,
        0xffff7000 );
```

5.3.1.4 FSL_FlashEnv_Activate

Description

Function initializes the Flash control macro and activates and prepares the Flash environment.

Interface

```
fsl_status_t FSL_FlashEnv_Activate( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_FLMD0 • FSL_ERR_INTERNAL [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init) and copied (call function FSL_CopySections).

Post-conditions

In case of user mode and activated polling, call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Enable Flash environment */
fsl_status_t   status_enu;

status_enu = FSL_FlashEnv_Activate( );
#ifdef FSL_ACTIVATION_POLLING
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif
/* Error treatment */
```

5.3.1.5 FSL_FlashEnv_Deactivate

Description

Function terminates all Flash operations and deactivates the Flash environment.

Interface

```
fsl_status_t FSL_FlashEnv_Deactivate( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_FLMD0 • FSL_ERR_INTERNAL [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode and activated polling, call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Deactivate Flash environment */
fsl_status_t    status_enu;

status_enu = FSL_FlashEnv_Deactivate( );
#ifdef FSL_ACTIVATION_POLLING
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif
/* Error treatment */
...
```

5.3.1.6 FSL_SetFrequency

Description

The function informs the Self-Programming routines about the configured **CPU** frequency. A frequency fractional part need to be rounded up, e.g.: 25.3MHz need to be rounded up to 26MHz.

CPU frequency setting condition:
The Flash programming hardware is provided with a clock, derived from the CPU frequency. The frequency divider of this derived clock is device family dependent. The resulting $f_{\text{Flash hardware}}$ must be in the range of 8 to 50MHz.

E.g.: Fx4-L, Px4-L:
$f_{\text{Flash hardware}} = f_{\text{Cpu}} / 2$
⇨ 16MHz <= f_{Cpu} <= mimimum of <100MHz> or <maximum device frequency>

Caution: The CPU frequency must be set correctly. If not, malfunction may occur such as unstable Flash data without data retention, programming failure, operation blocking.

Interface

```
fsl_status_t FSL_SetFrequency( fsl_u32 FreqData_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	FreqData_u32	Rounded up CPU clock in MHz (boundaries see above) Example: clock is 25.7MHz → FreqData_u32 = 26

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_PARAMETER • FSL_ERR_INTERNAL [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate).

Post-conditions

In case of user mode and activated polling, call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set clock to 32MHz */
fsl_status_t   status_enu;

status_enu = FSL_SetFrequency( 32 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.2 Operation

5.3.2.1 FSL_Erase

Description

Function erases a range of blocks.

Interface

```
fsl_status_t FSL_Erase( fsl_u32 blockNoStart_u32,
                        fsl_u32 blockNoEnd_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	blockNoStart_u32	First block number to be erased. (It is not the block address, but the number of the Flash block.)
fsl_u32	blockNoEnd_u32	Last block number to be erased. (It is not the block address, but the number of the Flash block.)

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_PROTECTION • FSL_ERR_PARAMETER • FSL_ERR_ERASE [1] • FSL_ERR_INTERNAL [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Erase check block 3 to 20 */
fsl_status_t   status_enu;

status_enu = FSL_Erase( 3, 20 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.2.2 FSL_Write

Description

Function writes the specified number of words from a buffer to consecutive Flash addresses starting at the specified address.

Interface

```
fsl_status_t FSL_Write( fsl_u32 *pAddSrc_pu32,
                        fsl_u32 addDest_u32,
                        fsl_u32 length_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	pAddSrc_pu32	Pointer to buffer of data to be written
fsl_u32	addDest_u32	64 word aligned destination address of data to be written
fsl_u32	length_u32	64 word aligned length of data in words

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_PROTECTION • FSL_ERR_PARAMETER • FSL_ERR_WRITE [1] • FSL_ERR_INTERNAL [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Write 64 words of data to address 0x00000000 onwards */
fsl_status_t  status_enu;
fsl_u32     buf_u32[64];

/* fill buffer */
...

status_enu = FSL_Write( &buf_u32[0], 0x00000000, 64 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.2.3 FSL_Read

Description

Function reads the specified number of words from consecutive Flash addresses starting at the specified address and writes it into a buffer.

Interface

```
fsl_status_t FSL_Read( fsl_u32 addSrc_u32,
                       fsl_u32 *pDest_pu32,
                       fsl_u32 length_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	addSrc_u32	Word aligned source address of data to be read
fsl_u32	pDest_pu32	Pointer to buffer of read data
fsl_u32	length_u32	Word aligned length of data in words

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2]

		• FSL_ERR_FLOW • FSL_ERR_PARAMETER • FSL_ERR_INTERNAL [1]
fsl_u32	pDest	Pointer to buffer filled with read data

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Read 64 words from address 0x00000000 onwards */
fsl_status_t   status_enu;
fsl_u32        buf_u32[64];

status_enu = FSL_Read( 0x00000000, &buf_u32[0], 64 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.2.4 FSL_StatusCheck

Description

This function handles the complete state machine. It shall be called frequently, but the calling style depends on the user application (refer to chapter 4.4 User code execution during Self-Programming).

Note This command is only available in the user mode.

Interface

```
fsl_status_t FSL_StatusCheck( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_IDLE

		• FSL_BUSY • FSL_ERR_FLOW • FSL_ERR_ERASE • FSL_ERR_WRITE • FSL_ERR_INTERNAL

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Show FSL_StatusCheck usage */
fsl_status_t    status_enu;

/* start some FSL operation (e.g. FSL_Erase ) */
status_enu = FSL_Erase( 3, 20 );

/* Status Check */
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.3 Security

5.3.3.1 FSL_GetSecurityFlags

Description

Function reads stored security information.

Interface

```
fsl_status_t FSL_GetSecurityFlags( fsl_u32 *pFlags_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pFlags_pu32	Pointer to buffer of read security information

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pFlags_pu32	Pointer to buffer filled with bit coded security information • x1xxxx : Read permission • x0xxxx : Read prohibition • xx1xxx : Write permission • xx0xxx : Write prohibition • xxxx1x : Block erase permission • xxxx0x : Block erase prohibition • xxxxx1 : Permission of boot block cluster programming • xxxxx0 : Prohibition of boot block cluster programming

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read security flags */
fsl_u32         flags_u32;
fsl_status_t    status_enu;

status_enu = FSL_GetSecurityFlags( &flags_u32 );

/* Error treatment */
...
```

5.3.3.2 FSL_ModeCheck

Description

Function checks whether the FLMD0 pin (hardware protection shield) is pulled up or not. In case of pulled down no Flash programming is possible.

Interface

```
fsl_status_t FSL_ModeCheck( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLMD0 • FSL_ERR_FLOW

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Check level of FLMD0 */
fsl_status_t   status_enu;

status_enu = FSL_ModeCheck( );

/* Error treatment */
...
```

5.3.3.3 FSL_SetBlockEraseProtectFlag

Description

Function enables block erase protection by setting the according protection flag.

Interface

```
fsl_status_t FSL_SetBlockEraseProtectFlag( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set block erase protection */
fsl_status_t   status_enu;

status_enu = FSL_SetBlockEraseProtectFlag( );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.3.4 FSL_SetWriteProtectFlag

Description

Function enables write protection by setting the according protection flag.

Interface

```
fsl_status_t FSL_SetWriteProtectFlag( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set write protection */
fsl_status_t   status_enu;

status_enu = FSL_SetWriteProtectFlag( );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.3.5 FSL_SetBootClusterProtectFlag

Description

Function enables boot cluster protection by setting the according protection flag.

Interface

```
fsl_status_t FSL_SetBootClusterProtectFlag( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_PROTECTION • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set boot cluster protection */
fsl_status_t status_enu;

status_enu = FSL_SetBootClusterProtectFlag( );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.3.6 FSL_SetReadProtectFlag

Description

Function enables read protection by setting the according protection flag.

Interface

```
fsl_status_t FSL_SetReadProtectFlag( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set read protection */
fsl_status_t   status_enu;

status_enu = FSL_SetReadProtectFlag( );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.3.7 FSL_GetFSW

Description

Function returns the start and the end block of the actual Flash shield window.

Interface

```
fsl_status_t FSL_GetFSW( fsl_u32 *pBlockNoStart_pu32,
                         fsl_u32 *pBlockNoEnd_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pBlockNoStart_pu32	Pointer to buffer for starting block number of FSW
fsl_u32	pBlockNoEnd_pu32	Pointer to buffer for ending block number of FSW

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pBlockNoStart_pu32	Buffer including starting block number of FSW
fsl_u32	pBlockNoEnd_pu32	Buffer including ending block number of FSW

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read Flash Shield Window range */
fsl_status_t   status_enu;
fsl_u32        blockStart_u32;
fsl_u32        blockEnd_u32;

status_enu = FSL_GetFSW( &blockStart_u32, &blockEnd_u32 );

/* Error treatment */
...
```

5.3.3.8 FSL_SetFSW

Description

Function sets a new Flash shield window to protect the range of blocks from unwanted Flash operations.

Interface

```
fsl_status_t FSL_SetFSW( fsl_u32 blockNoStart_u32,
                         fsl_u32 blockNoEnd_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	BlockNoStart_u32	Starting block number of FSW
fsl_u32	BlockNoEnd_u32	Ending block number of FSW

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_PARAMETER • FSL_ERR_PROTECTION • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set Flash Shield Window for block 2 up to block 3 */
fsl_status_t   status_enu;

status_enu = FSL_SetFSW( 2, 3 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.4 Administration

5.3.4.1 FSL_GetVersionString

Description

This function returns the pointer to the library version string. The version string is the zero terminated string identifying the library. The length of the string is up to 19 characters.

Interface

```
const fsl_u08* FSL_GetVersionString( void )
```

Arguments

None

Return types / values

<table>
<tr><th>Type</th><th>Argument</th><th colspan="2">Description</th></tr>
<tr><td rowspan="7">fsl_u08</td><td rowspan="7"></td><td colspan="2">Pointer to version string
Version string format:
“SV850T06xxxxxYabcde”</td></tr>
<tr><td>xxxxx</td><td>Coded information about the supported compiler including the version and the used register model. If no information is coded, the library is a generic library valid for different compiler.</td></tr>
<tr><td rowspan="2">Y</td><td>“E” for engineering version</td></tr>
<tr><td>“V” for final version</td></tr>
<tr><td>abc</td><td>Library version number Va.b.c.</td></tr>
<tr><td colspan="2">optional:</td></tr>
</table>

		de	customer specific version information

Pre-conditions

None

Post-conditions

None

Example

```
/* Read library version */
fsl_u08   *version_pu08;

version_pu08 = FSL_GetVersionString( );
```

5.3.4.2 FSL_GetDevice

Description

Function returns the device number to identify the used device.

Interface

```
fsl_status_t FSL_GetDevice( fsl_u32 *pDeviceNo_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pDeviceNo_pu32	Pointer to buffer of read device number

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pDeviceNo_pu32	Pointer to buffer filled with device number Format: “0000000000000000xxxxxxxxxxxxxxxx” Example: uPD70F3377 →3377 = 0x0D31 →xxxxxxxxxxxxxxxx = 000110100110001

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read device name */
fsl_u32         device_u32;
fsl_status_t    status_enu;

status_enu = FSL_GetDevice( &device_u32 );

/* Error treatment */
...
```

5.3.4.3 FSL_GetBlockCnt

Description

Function returns number of blocks of the device.

Interface

```
fsl_ status_t FSL_GetBlockCnt( fsl_u32 *pBlockCnt_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pBlockCnt_pu32	Pointer to buffer of read block count information

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pBlockCnt_pu32	Pointer to buffer filled with block count information

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read block count */
fsl_u32        cnt_u32;
fsl_status_t   status_enu;

status_enu = FSL_GetBlockCnt( &cnt_u32 );

/* Error treatment */
...
```

5.3.4.4 FSL_GetBlockEndAdd

Description

Function returns the end address of the specified block.

Interface

```
fsl_status_t FSL_GetBlockEndAdd( fsl_u32 blockNo_u32,
                                 fsl_u32 *pBlockEndAddr_pu32)
```

Arguments

Type	Argument	Description
fsl_u32	blockNo_u32	Block number
fsl_u32	pBlockEndAddr_pu32	Pointer to buffer of read block end address information

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pBlockEndAddr_pu32	Pointer to buffer filled with requested end address of the block

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read block end address of block 3*/
fsl_u32         addr_u32;
fsl_status_t    status_enu;

status_enu = FSL_GetBlockEndAdd( 3, &addr_u32 );

/* Error treatment */
...
```

5.3.4.5 FSL_GetSwapState

Description

Function reads the current swap status.

Interface

```
fsl_status_t FSL_GetSwapState ( fsl_u32 *pSwapState_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pSwapState_pu32	Pointer to buffer of read swap status

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pSwapState_pu32	Pointer to buffer filled with swap status: • 0x00: not swapped • 0x01: swapped

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read boot cluster */
fsl_u32         state_u32
fsl_status_t    status_enu

status_enu = FSL_GetSwapState( &state_u32 );

/* Error treatment */
...
```

5.3.4.6 FSL_ChangeSwapState

Description

Function swaps the boot cluster 0 and boot cluster 1 physically without setting the boot flag. After reset the boot cluster will be activated regarding the boot flag.

Interface

```
fsl_status_t FSL_ChangeSwapState( void )
```

Arguments

None

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PROTECTION • FSL_ERR_INTERNAL • FSL_ERR_WRITE

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Swap boot cluster */
fsl_status_t   status_enu;

status_enu = FSL_ChangeSwapState( );

/* Error treatment */
...
```

5.3.4.7 FSL_GetSwapFlag

Description

Function reads the current value of the boot swap flag from the extra area.

Interface

```
fsl_status_t FSL_GetSwapFlag ( fsl_u32 *pSwapFlag_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pSwapFlag_pu32	Pointer to buffer of read swap flag

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u32	pSwapFlag_pu32	Pointer to buffer filled with current value of the boot swap flag: • 0x00: not swapped • 0x01: swapped

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read boot cluster */
fsl_u32        flag_u32;
fsl_status_t   status_enu

status_enu = FSL_GetSwapFlag( &flag_u32 );

/* Error treatment */
...
```

5.3.4.8 FSL_ChangeSwapFlag

Description

The function inverts the bootswap. Depending on the parameter, additionally the current swap state is inverted.

Interface

```
fsl_status_t FSL_ChangeSwapFlag( fsl_u32 immediateSwap_u32 )
```

Arguments

Type	Argument	Description
fsl_u32	immediateSwap_u32	Swap boot cluster immediately: • 0x00: Do not swap boot cluster • 0x01: Swap boot cluster

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_PROTECTION • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Swap the boot flag, but do not generate a reset signal */
fsl_status_t   status_enu;

status_enu = FSL_ChangeSwapFlag( 0x00 );
while( status_enu == FSL_BUSY )
{
    status_enu = FSL_StatusCheck( );
}

/* Error treatment */
...
```

5.3.4.9 FSL_GetBootClusterSize

Description

Function reads current size of protectable boot cluster.

Interface

```
fsl_status_t FSL_GetBootClusterSize( fsl_u32 *pSize_pu32 )
```

Arguments

Type	Argument	Description
fsl_u32	pSize_pu32	Pointer to buffer of read boot cluster size

Return types / values

<table>
<tr><th>Type</th><th>Argument</th><th colspan="3">Description</th></tr>
<tr><td>fsl_status_t</td><td></td><td colspan="3">Function return values:
• FSL_OK
• FSL_ERR_FLOW
• FSL_ERR_PARAMETER</td></tr>
<tr><td rowspan="6">fsl_u32</td><td rowspan="6">pSize_pu32</td><td colspan="3">Pointer to buffer filled with boot cluster size in number of blocks.</td></tr>
<tr><td>size_u32</td><td>Boot Block Cluster size</td><td>Boot Swap Cluster size</td></tr>
<tr><td>0x00</td><td>32KB</td><td>32KB</td></tr>
<tr><td>0x01</td><td>64KB</td><td>64KB</td></tr>
<tr><td>0x02-0x03</td><td>96-128KB</td><td>128KB</td></tr>
<tr><td>0x04-0xE3</td><td>160-7296KB</td><td>256KB</td></tr>
</table>

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read boot cluster size */
fsl_u32        size_u32;
fsl_status_t   status_enu;

status_enu = FSL_GetBootClusterSize( &size_u32 );
/* Error treatment */
...
```

5.3.4.10 FSL_SetBootClusterSize

Description

Function sets protectable boot cluster size in the range from 0x00 to 0xE3 (see also function FSL_SetBootClusterProtectFlag to enable protection).

Interface

```
fsl_status_t FSL_SetBootClusterSize( fsl_u32 size_u32 )
```

Arguments

<table>
<tr><th>Type</th><th>Argument</th><th colspan="3">Description</th></tr>
<tr><td rowspan="6">fsl_u32</td><td rowspan="6">size_u32</td><td colspan="3">Boot cluster size (range: 0x00-0xE3)</td></tr>
<tr><td>size_u32</td><td>Boot Block Cluster size</td><td>Boot Swap Cluster size</td></tr>
<tr><td>0x00</td><td>32KB</td><td>32KB</td></tr>
<tr><td>0x01</td><td>64KB</td><td>64KB</td></tr>
<tr><td>0x02-0x03</td><td>96-128KB</td><td>128KB</td></tr>
<tr><td>0x04-0xE3</td><td>160-7296KB</td><td>256KB</td></tr>
</table>

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_PARAMETER • FSL_ERR_FLOW • FSL_ERR_PROTECTION • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Set boot cluster size to 0x04 */
fsl_status_t   status_enu;

status_enu = FSL_SetBootClusterSize( 0x04 );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.4.11 FSL_GetID

Description

Function reads the current ID data information (12 bytes).

Interface

```
fsl_status_t FSL_GetID( fsl_u08 *pID_pu08 )
```

Arguments

Type	Argument	Description
fsl_u08	pID_pu08	Pointer to buffer of read ID

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u08	pID_pu08	Pointer to buffer filled with ID

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read ID */
fsl_status_t    status_enu;
fsl_u08         id_u08[12];

status_enu = FSL_GetID( &id_u08[0] );

/* Error treatment */
...
```

5.3.4.12 FSL_SetID

Description

Function writes new ID settings (12 bytes) into the extra area.

Interface

```
fsl_status_t FSL_SetID( fsl_u08 *pID_pu08 )
```

Arguments

Type	Argument	Description
fsl_u32	pID_pu32	Pointer to source data of ID

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_PARAMETER • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Write ID */
fsl_status_t    status_enu;
fsl_u08         id_u08[] =  {
                              0x00, 0x01, 0x02, 0x03, 0x04, 0x05,
                              0x06, 0x07, 0x08, 0x09, 0x0A, 0x8B
                             };     /* OCD on -> bit 95 = 1 */

FSL_SetID( &id_u08[0] );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status == FSL_BUSY )
    {
        status = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

5.3.4.13 FSL_GetOPB

Description

Function reads current OPB settings (4 bytes) from the device.

Interface

```
fsl_status_t FSL_GetOPB( fsl_u08 *pOPB_pu08 )
```

Arguments

Type	Argument	Description
fsl_u08	pOPB_pu08	Pointer to buffer of read option byte

Return types / values

Type	Argument	Description
fsl_status_t		Function return values: • FSL_OK • FSL_ERR_FLOW • FSL_ERR_PARAMETER
fsl_u08	pOPB_pu08	Pointer to buffer filled with option byte

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

None

Example

```
/* Read option byte */
fsl_status_t   status_enu;
fsl_u08        data_u08[4];

status_enu = FSL_GetOPB( &data_u08[0] );

/* Error treatment */
...
```

5.3.4.14 FSL_SetOPB

Description

Function writes new OPB settings (4 bytes) into the extra area.

Interface

```
fsl_status_t FSL_SetOPB( fsl_u08 *pOPB_pu08 )
```

Arguments

Type	Argument	Description
fsl_u08	pOPB_pu08	Pointer to source data of option bytes

Return types / values

Type	Argument	Description
fsl_status_t		Operation status when returned from function call: • FSL_OK [1] • FSL_BUSY [2] • FSL_ERR_PARAMETER • FSL_ERR_FLOW • FSL_ERR_INTERNAL [1] • FSL_ERR_WRITE [1]

[1] Status check is performed internally by the firmware
[2] Status check is performed by the user

Pre-conditions

Library must be initialized (call function FSL_Init), copied (call function FSL_CopySections) and active (call function FSL_FlashEnv_Activate). Additionally the library must be informed about FBUS clock by using function FSL_SetFrequency.

Post-conditions

In case of user mode call FSL_StatusCheck till function return value is different from FSL_BUSY.

Example

```
/* Write option byte */
fsl_status_t   status_enu;
fsl_u08        data_u08[4] = { 0xFF, 0xFF, 0xFF, 0xFF};

FSL_SetOPB( &data_u08[0] );
#if FSL_STATUS_CHECK == FSL_STATUS_CHECK_USER
    while( status_enu == FSL_BUSY )
    {
        status_enu = FSL_StatusCheck( );
    }
#endif

/* Error treatment */
...
```

Chapter 6 Integration into the user application

6.1 First steps

It is very important to have theoretic background about the Code Flash and the FSL in order to successfully implement the library into the user application. Therefore it is important to read this user manual in advance. The best way after initial reading of the user manual will be testing the FSL application sample.

6.2 Application sample

After a first compile run, it will be worth playing around with the library in the debugger. By that you will get a feeling for the source code files and the working mechanism of the library.

Note: **Before the first compile run, the compiler path must be configured in the application sample file "makefile":**

Set the variable COMPILER_INSTALL_DIR to the correct compiler directory

Later on, the sample might be reconfigured to use the internal mode to get a feeling of the CPU load and execution time during different modes.

After this exercise it might be easier to understand and follow the recommendations and considerations of this document

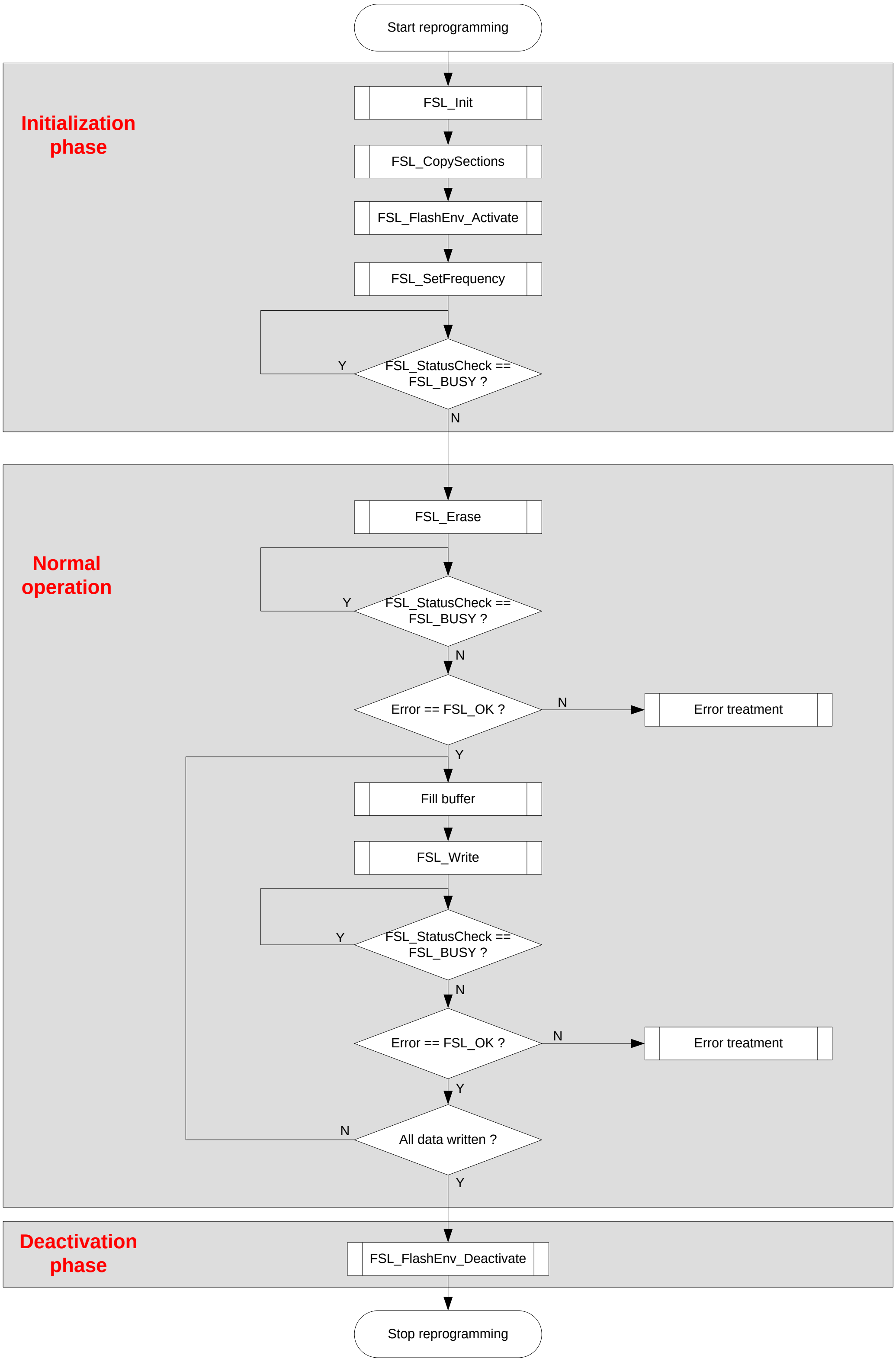
6.3 FSL life cycle

The following flow charts represent typical FSL life cycles during device operation including the API functions to be used.

Note Error treatment of the FSL function themselves are not detailed described in the flow chart for simplification of the flow charts.

Device reprogramming in user mode

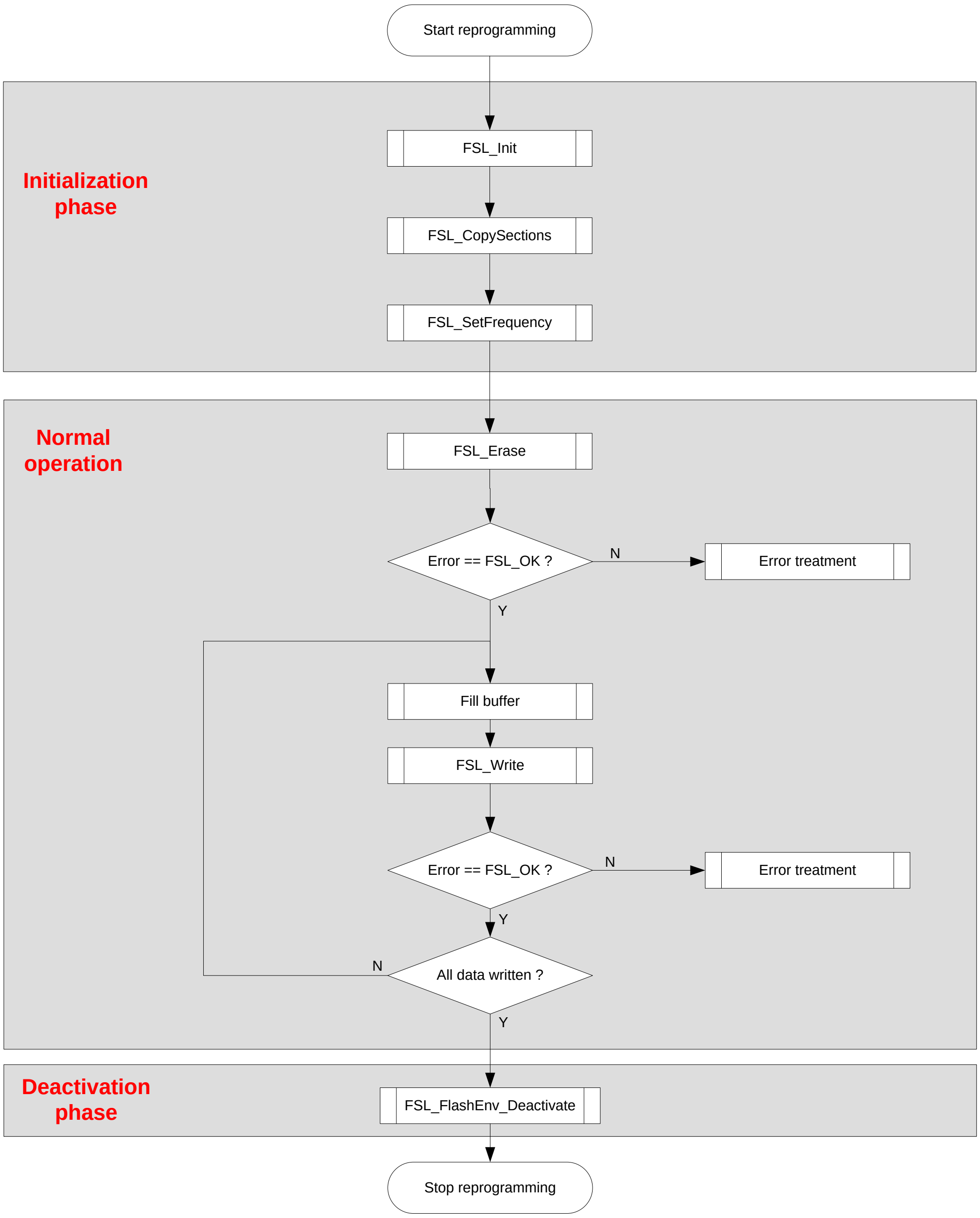
Figure 6-1



Reprogramming flow – user mode

Device reprogramming in internal mode

Figure 6-2



Reprogramming flow – internal mode

6.4 Special considerations

Due to the underlying hard- and software concepts, the user application must take care of some constrains if using the library.

Function re-entrancy

All functions are not re-entrant. So, re-entrant calls of any FSL functions must be avoided

Entering power safe mode

Entering power safe modes is prohibited during Self-Programming.

Code Flash access during Self-Programming

Code Flash accesses during an active Self-Programming Environment are not possible at all. The user application needs to be executed from other memory during that time. Please refer to chapter 4.4 “User code execution during Self-Programming” for further information.

Revision History

Chapter	Page	Description
Rev 1.00		
		Initial version
Rev 1.01		
		Updated frequency setting description

Flash Self-Programming Library

Renesas Electronics Corporation

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