NEC

Preliminary Application Note

78K0

8-Bit Single-Chip Microcontrollers

Flash Memory Self Programming

Kx2/Fx2/Lx2/Dx2/Lx3/LIN4/uCFL/Ix2/Kx2-L

Document No. U18990EE2V0AN00

Date published Feb 2009

Printed in Germany

Legal Notes

- **The information contained in this document is being issued in advance of the production cycle for the product. The parameters for the product may change before final production or NEC Electronics Corporation, at its own discretion, may withdraw the product prior to its production.**

- No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Electronics. NEC Electronics assumes no responsibility for any errors that may appear in this document.

- NEC Electronics does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC Electronics products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Electronics or others.

- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of a customer's equipment shall be done under the full responsibility of the customer. NEC Electronics assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.

- While NEC Electronics endeavors to enhance the quality, reliability and safety of NEC Electronics products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC Electronics products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment and anti-failure features.

- NEC Electronics products are classified into the following three quality grades: "Standard", "Special", and "Specific". The "Specific" quality grade applies only to NEC Electronics products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of an NEC Electronics product depend on its quality grade, as indicated below. Customers must check the quality grade of each NEC Electronics products before using it in a particular application.
  "Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots.
  "Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support).
  "Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

The quality grade of NEC Electronics products is "Standard" unless otherwise expressly specified in NEC Electronics data sheets or data books, etc. If customers wish to use NEC Electronics products in applications not intended by NEC Electronics, they must contact an NEC Electronics sales representative in advance to determine NEC Electronics' willingness to support a given application.

(Note)
(1) "NEC Electronics" as used in this statement means NEC Electronics Corporation and also includes its majority-owned subsidiaries.
(2) "NEC Electronics products" means any product developed or manufactured by or for NEC Electronics (as defined above).

Regional Information

Some information contained in this document may vary from country to country. Before using any NEC product in your application, please contact the NEC office in your country to obtain a list of authorized representatives anddistributors. They will verify:

- Device availability
- Ordering information
- Product release schedule
- Availability of related technical literature
- Development environment specifications (for example, specifications for third-party tools and components, host computers, power plugs, AC supply voltages, and so forth)
- Network requirements

In addition, trademarks, registered trademarks, export restrictions, and otherlegal issues may also vary from country to country.

NEC Electronics Corporation
1753, Shimonumabe, Nakahara-ku,
Kawasaki, Kanagawa 211-8668, Japan
Tel: 044 4355111
http://www.necel.com/

[America]

NEC Electronics America, Inc.
2880 Scott Blvd.
Santa Clara, CA 95050-2554,
U.S.A.
Tel: 408 5886000
http://www.am.necel.com/

[Europe]

NEC Electronics (Europe) GmbH
Arcadiastrasse 10
40472 Düsseldorf, Germany
Tel: 0211 65030
http://www.eu.necel.com/

United Kingdom Branch
Cygnus House, Sunrise Parkway
Linford Wood, Milton Keynes
MK14 6NP, U.K.
Tel: 01908 691133

Succursale Française
9, rue Paul Dautier, B.P. 52
78142 Velizy-Villacoublay Cédex
France
Tel: 01 30675800

Tyskland Filial
Täby Centrum
Entrance S (7th floor)
18322 Täby, Sweden
Tel: 08 6387200

Filiale Italiana
Via Fabio Filzi, 25/A
20124 Milano, Italy
Tel: 02 667541

Branch The Netherlands
Steijgerweg 6
5616 HS Eindhoven,
The Netherlands
Tel: 040 2654010

[Asia & Oceania]

NEC Electronics (China) Co., Ltd
7th Floor, Quantum Plaza, No. 27
ZhiChunLu Haidian District,
Beijing 100083, P.R.China
Tel: 010 82351155
http://www.cn.necel.com/

NEC Electronics Shanghai Ltd.
Room 2511-2512, Bank of China
Tower,
200 Yincheng Road Central,
Pudong New Area,
Shanghai 200120, P.R. China
Tel: 021 58885400
http://www.cn.necel.com/

NEC Electronics Hong Kong Ltd.
12/F., Cityplaza 4,
12 Taikoo Wan Road, Hong Kong
Tel: 2886 9318
http://www.hk.necel.com/

NEC Electronics Taiwan Ltd.
7F, No. 363 Fu Shing North Road
Taipei, Taiwan, R.O.C.
Tel: 02 27192377

NEC Electronics Singapore Pte. Ltd.
238A Thomson Road,
#12-08 Novena Square,
Singapore 307684
Tel: 6253 8311
http://www.sg.necel.com/

NEC Electronics Korea Ltd.
11F., Samik Lavied'or Bldg., 720-2,
Yeoksam-Dong, Kangnam-Ku, Seoul,
135-080, Korea Tel: 02-558-3737
http://www.kr.necel.com/

Table of Contents

Chapter 1 General Information

1.1 Overview

The 78K0/Kx2/Fx2/Lx2/Dx2/Lx3/LIN4/uCFL/Ix2/Kx2-L series products are equipped with an internal firmware, which allows to rewrite the flash memory without the use of an external programmer. In addition to this internal firmware NEC provide the socalled self-programming library. This library offer an easy-to-use interface to the internal firmware functionality. By calling the self programming library functions from user program, the contents of the flash memory can easily be rewritten in the field.

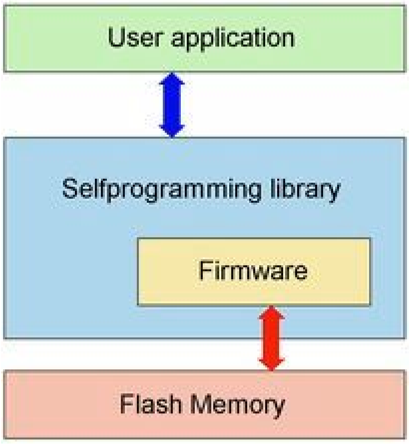

Figure 1-1 Flash Access

Caution

- The self programming library rewrites the contents of the flash memory by using the CPU, registers, and RAM. Thus the user program cannot be executed while the self programming library is in process.
- The self programming library uses the CPU (register bank 3) and a work area (entry RAM of 100 bytes).

Operation Modes There are three operation modes during selfprogramming.

Mode	Description
Normal Mode	- execute user application - after RESET operation starts in this mode
Mode A1	- set up self-programming environment - the firmware can be executed via CALL 08100H
Mode A2	- used by the firmware only to perform the command - not visible to the user

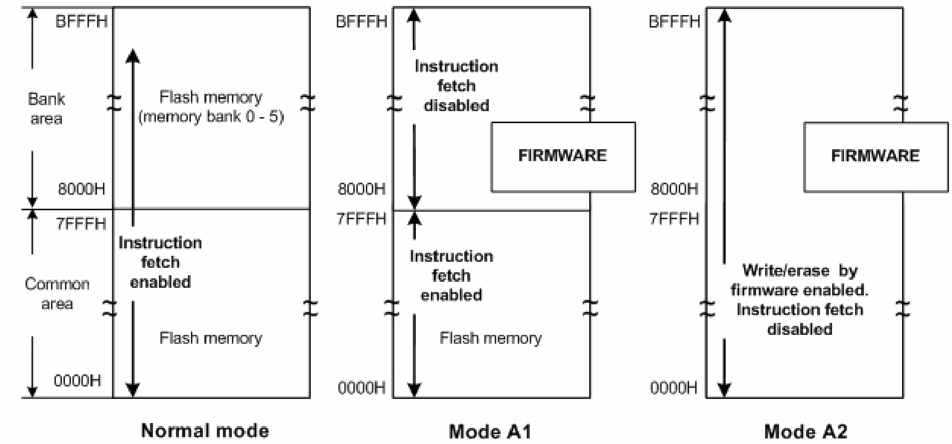

Figure 1-2 Operation Modes

1.2 Work Flow

The self programming library can be used by a user program written in either C- or assembly language.

The following flowchart illustrates a sample procedure of rewriting the flash memory by using the self programming library.

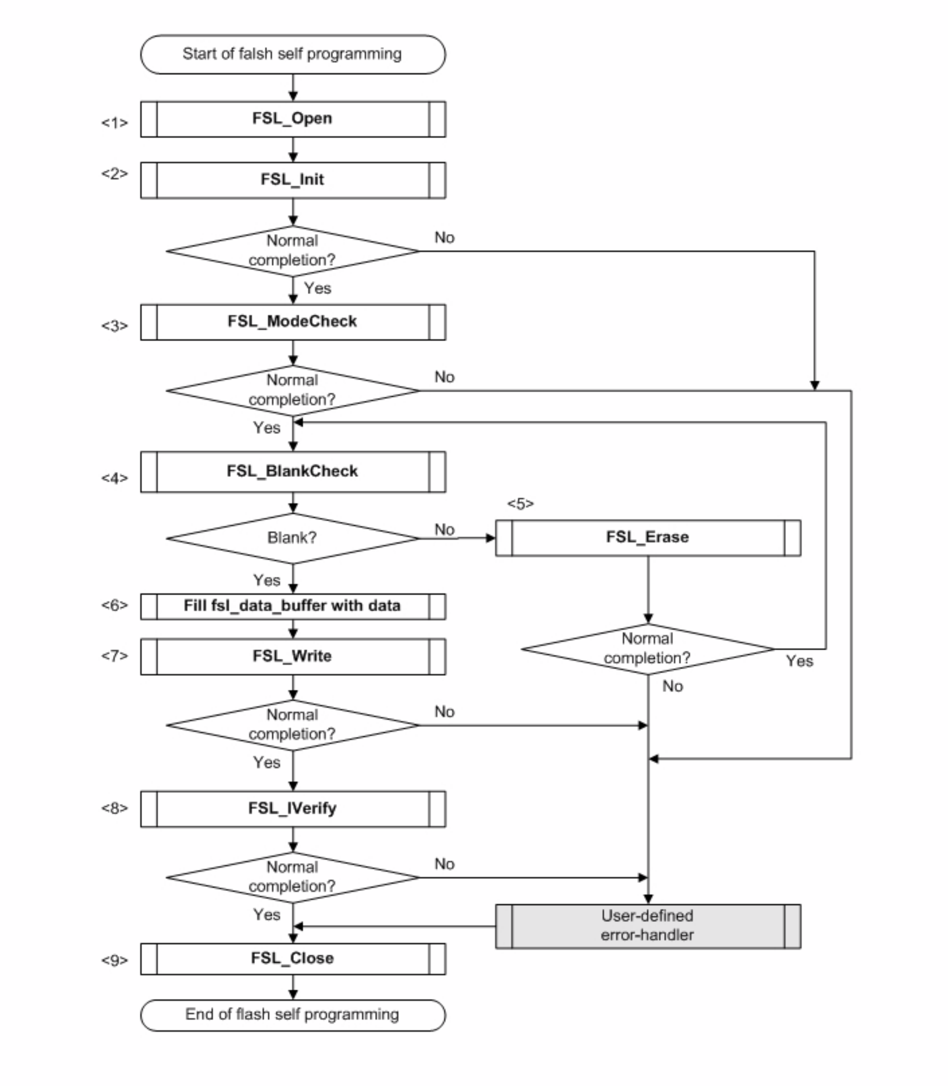

Figure 1-3 Flow of Self Programming (rewriting contents of flash memory)

Flow Explanation

1. Preprocessing, call the open function **FSL_Open**.
   Preserve and configurate interrupt. (optional)
   Set FLMD0 pin level to HIGH.
2. Call the initialize function **FSL_Init** to initialize the entry RAM.
3. Call the mode check function **FSL_ModeCheck** to examine the FLMD0 voltage level.
4. Call the block blank check function **FSL_BlankCheck** to prove if the specified block (1KB) is blank.
5. Call the block erase function **FSL_Erase** to erase the data of a specified block (1KB).
6. Fill the data buffer with data. This data will be written into the flash.
7. Call the word write function **FSL_Write** to update 1 to 64 words (each word equals 4 bytes) of data to a specified address.
8. Call the block verify function **FSL_IVerify** to verify a specified block (1KB) (internal verification).
9. Postprocessing, call the close function **FSL_Close**.
   Set FLMD0 pin level to LOW.
   Retrieve preserved interrupt masks. (optional)

1.3 Bank Number and Block Number

General

The flash memory of all products of the 78K devices are divided in blocks of 1 KB, but the flash memory addressing in normal operation mode differs from that in self programming mode.

Furthermore each device is equipped with two boot clusters.

The primary boot cluster (boot cluster 0) addresses from 0000H to 0FFFH, and temporary boot cluster (boot cluster 1) from 1000H to 1FFFH. Each boot cluster has 4K bytes of flash size.

A boot cluster stores information like the vector table data, option bytes, self programming functionlity, etc. For details on the boot cluster, please refer to the following chapter "Boot Swapping".

under 60K products

Application view:

The memory can be accessed over the whole 60KB using a 16bit addressing.

Self programming view:

Erasing, blank checking, and verifying (internal verification) of self programming are performed in block units. To call these self programming functions, a block number has to be specified.

The write command is performed in word units (4 bytes). The destination address must be multiple of 4 and has to be given as 32bit address.

over 60KB products

Application view:

The memory is split in a common and a banked area. The common area is located from 0000H to 07FFFH and can be accessed by using a 16bit address. The bank area is located from 08000H to 0BFFFH, where each bank (up to 6 in all, bank 0 to bank 5) can be selected by the bank select register.

Self programming view:

Erasing, blank checking, and verifying (internal verification) of self programming are performed in block units. To call these self programming functions, a block number has to be specified.

The write command is performed in word units (4 bytes). The destination address must be multiple of 4 and has to be given as 32bit address.

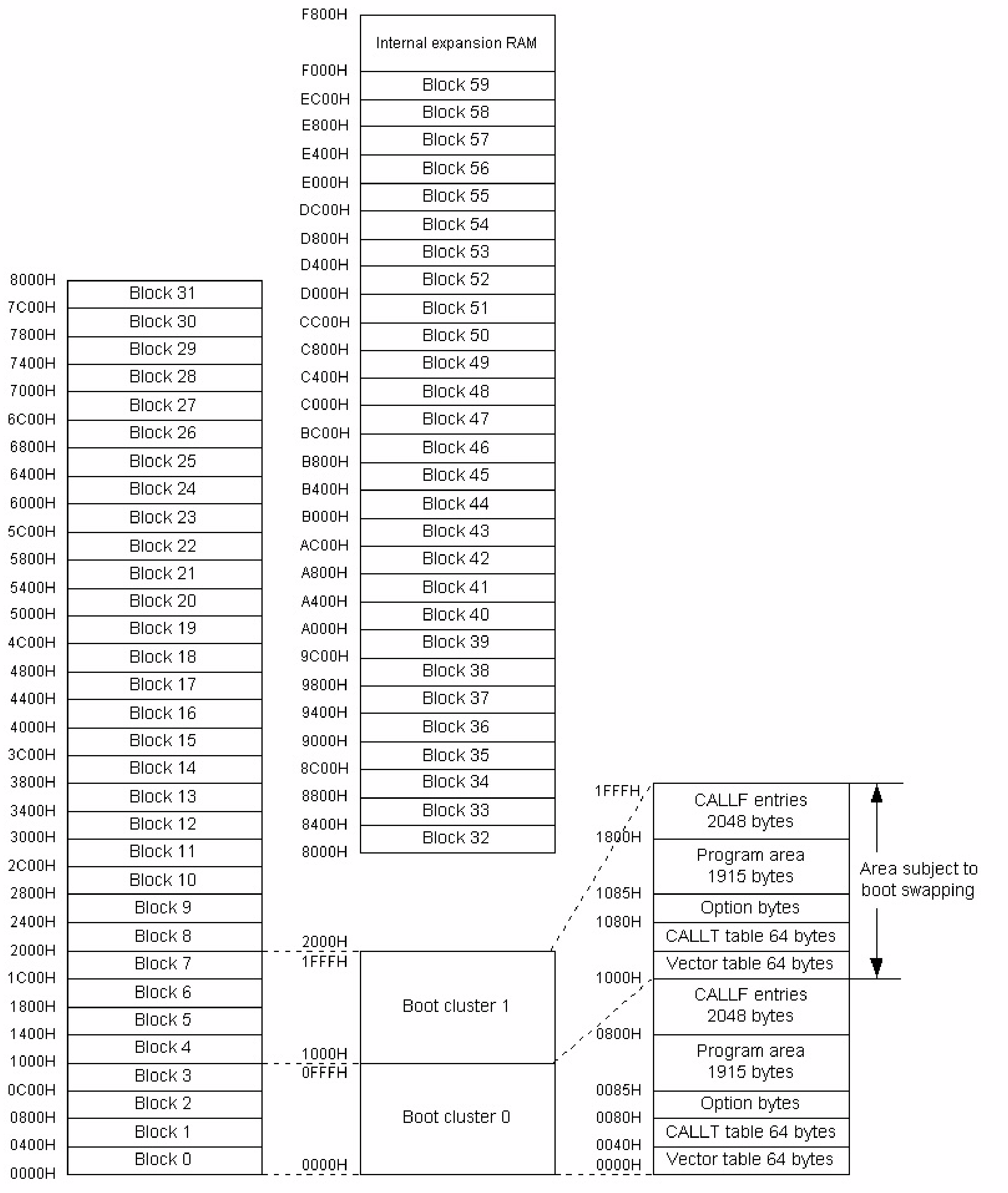

Figure 1-4 Block Numbers and Boot Clusters (flash memory of up to 60KB)

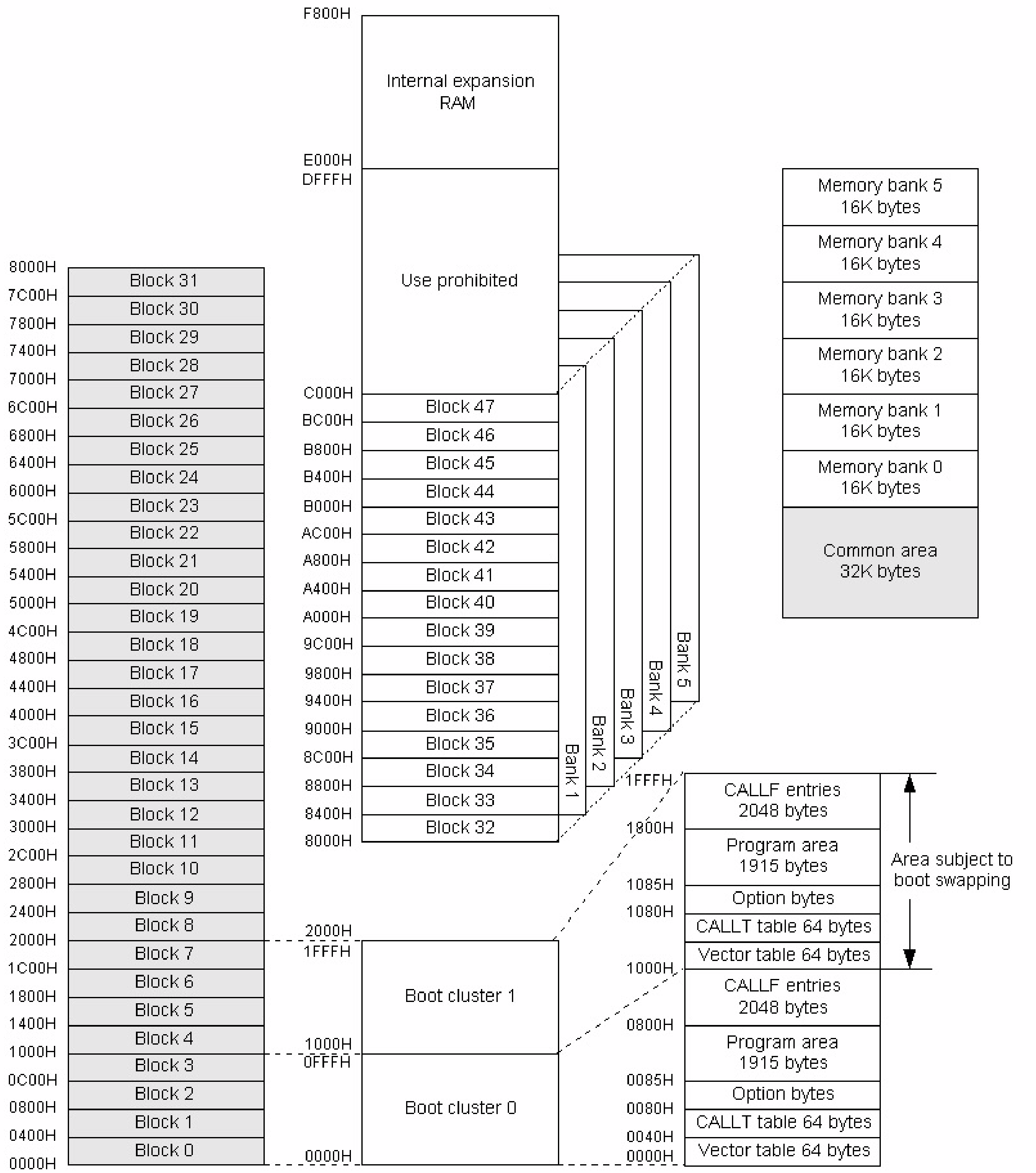

Figure 1-5 Block Numbers and Boot Clusters (flash memory of more than 60KB)

Application View		Flash Controller View		Application View		Flash Controller View		Application View		Flash Controller View	
bank	start addr	block	flash addr	bank	start addr	block	flash addr	bank	start addr	block	flash addr
C0	000	0	000	1	8000	30	C000	4	8000	60	18000
C0	400	1	400	1	8400	31	C400	4	8400	61	18400
C0	800	2	800	1	8800	32	C800	4	8800	62	18800
C0	C00	3	C00	1	8C00	33	CC00	4	8C00	63	18C00
C1	000	4	1000	1	9000	34	D000	4	9000	64	19000
C1	400	5	1400	1	9400	35	D400	4	9400	65	19400
C1	800	6	1800	1	9800	36	D800	4	9800	66	19800
C1	C00	7	1C00	1	9C00	37	DC00	4	9C00	67	19C00
C	000	8	2000	1	A000	38	E000	4	A000	68	1A000
C	400	9	2400	1	A400	39	E400	4	A400	69	1A400
C	800	A	2800	1	A800	3A	E800	4	A800	6A	1A800
C	C00	B	2C00	1	AC00	3B	EC00	4	AC00	6B	1AC00
C	000	C	3000	1	B000	3C	F000	4	B000	6C	1B000
C	400	D	3400	1	B400	3D	F400	4	B400	6D	1B400
C	800	E	3800	1	B800	3E	F800	4	B800	6E	1B800
C	C00	F	3C00	1	BC00	3F	FC00	4	BC00	6F	1BC00
C	000	10	4000	2	8000	40	10000	5	8000	70	1C000
C	400	11	4400	2	8400	41	10400	5	8400	71	1C400
C	800	12	4800	2	8800	42	10800	5	8800	72	1C800
C	C00	13	4C00	2	8C00	43	10C00	5	8C00	73	1CC00
C	000	14	5000	2	9000	44	11000	5	9000	74	1D000
C	400	15	5400	2	9400	45	11400	5	9400	75	1D400
C	800	16	5800	2	9800	46	11800	5	9800	76	1D800
C	C00	17	5C00	2	9C00	47	11C00	5	9C00	77	1DC00
C	000	18	6000	2	A000	48	12000	5	A000	78	1E000
C	400	19	6400	2	A400	49	12400	5	A400	79	1E400
C	800	1A	6800	2	A800	4A	12800	5	A800	7A	1E800
C	C00	1B	6C00	2	AC00	4B	12C00	5	AC00	7B	1EC00
C	000	1C	7000	2	B000	4C	13000	5	B000	7C	1F000
C	400	1D	7400	2	B400	4D	13400	5	B400	7D	1F400
C	800	1E	7800	2	B800	4E	13800	5	B800	7E	1F800
C	C00	1F	7C00	2	BC00	4F	13C00	5	BC00	7F	1FC00
0	8000	20	8000	3	8000	50	14000				
0	8400	21	8400	3	8400	51	14400				
0	8800	22	8800	3	8800	52	14800				
0	8C00	23	8C00	3	8C00	53	14C00				
0	9000	24	9000	3	9000	54	15000				
0	9400	25	9400	3	9400	55	15400				
0	9800	26	9800	3	9800	56	15800				
0	9C00	27	9C00	3	9C00	57	15C00				
0	A000	28	A000	3	A000	58	16000				
0	A400	29	A400	3	A400	59	16400				
0	A800	2A	A800	3	A800	5A	16800				
0	AC00	2B	AC00	3	AC00	5B	16C00				
0	B000	2C	B000	3	B000	5C	17000				
0	B400	2D	B400	3	B400	5D	17400				
0	B800	2E	B800	3	B800	5E	17800				
0	BC00	2F	BC00	3	BC00	5F	17C00				

non-banked model

Figure 1-6 Block number in self programming view

1.4 Processing Time and Interrupt Acknowledging

The processing time of interrupt varies depending on oscillator in use. For exact processing time, please refer to the device corresponding user manual.

The following two tables show examples of the processing time of the self programming library and whether interrupts can be acknowledged. The difference between this tables is the usage of the source to the main oscillator (internal high-speed oscillator or external system clock).

The self programming functions which acknowledge interrupts will check if non-masked interrupt is generated during execution and then interrupt the self-programming functionality.

For details on interrupt, please refer to the chapter "Interrupt Services During Self-Programming".

Table 1-1 Processing Time and Acknowledging Interrrupt (with internal high-speed oscillator)

Function name	Processing Time (Unit: Microseconds)				Interrupt Acknowledgement
	Outside short direct addressing range		Inside short direct addressing range		
	Min	Max	Min	Max	
FSL_Open	4.25				Acknowledged
FSL_Close	4.25				Acknowledged
FSL_Init	977.75		443.5		Not acknowledged
FSL_Mode Check	753.875		219.625		Not acknowledged
FSL_Blank Check	12770.875		12236.625		Acknowledged
FSL_Erase	36909.5	356318	36363.25	355771.75	Acknowledged
FSL_IVerify	25618.875		25072.625		Acknowledged
FSL_Write	1214(1214.375)	2409(2409.375)	679.75(680.125)	1874.75(1875.125)	Acknowledged
FSL_EEPROMWrite	1496.5(1496.875)	2691.5(2691.875)	962.25(962.625)	2157.25(2157.625)	Acknowledged
FSL_GetSecurityFlags	871.25 (871.375)		337 (337.125)		Not acknowledged
FSL_GetActiveBootCluster	863.375 (863.5)		329.125 (239.25)		Not acknowledged
FSL_GetBlockEndAddr	1042.75 (1043.625)		502.25 (503.125)		Not acknowledged
FSL_Setxxx, FSL_Invertxxx	105524.75	790809.375	104978.5	541143.125	Acknowledged (*)

- Values in parentheses are used when the write start address structure is placed outside internal high-speed RAM area.
- **This is only an example, for correct timings of the device, please refer to the corresponding user manual.**

(*) Please refer to command description for details.

Table 1-2 Processing Time and Acknowledging Interrrupt (using external system clock)

Function name	Processing Time (Unit: Microseconds)				Interrupt Acknowledgement
	Outside short direct addressing range		In short direct addressing range		
	Min	Max	Min	Max	
FSL_Open	$34/fx^{Note}$				Acknowledged
FSL_Close	$34/fx^{Note}$				Acknowledged
FSL_Init	$49/fx^{Note}+485.8125$		$49/fx^{Note}+224.6875$		Not acknowledged
FSL_Mode Check	$35/fx^{Note}+374.75$		$35/fx^{Note}+113.625$		Not acknowledged
FSL_Blank Check	$174/fx^{Note}+6382.0625$		$174/fx^{Note}+6120.9375$		Acknowledged
FSL_Erase	$174/fx^{Note}+31093.875$	$174/fx^{Note}+298948.125$	$174/fx^{Note}+30820.75$	$174/fx^{Note}+298675$	Acknowledged
FSL_IVerify	$174/fx^{Note}+13448.5625$		$174/fx^{Note}+13175.4375$		Acknowledged
FSL_Write	$318(321)/fx^{Note}+644.125$	$318(321)/fx^{Note}+1491.625$	$318(321)/fx^{Note}+383$	$318(321)/fx^{Note}+1230.5$	Acknowledged
FSL_EEPROMWrite	$318(321)/fx^{Note}+799.875$	$318(321)/fx^{Note}+1647.375$	$318(321)/fx^{Note}+538.75$	$318(321)/fx^{Note}+1386.25$	Acknowledged
FSL_GetSecurityFlags	$171(172)/fx^{Note}+432.4375$		$171(172)/fx^{Note}+171.3125$		Not acknowledged
FSL_GetActiveBootCluster	$181(182)/fx^{Note}+427.875$		$181(182)/fx^{Note}+166.75$		Not acknowledged
FSL_GetBlockEndAddr	$404(411)/fx^{Note}+496.125$		$404(411)/fx^{Note}+231.875$		Not acknowledged
FSL_Setxxx, FSL_Invertxxx	$75/fx^{Note}+79157.6875$	$75/fx^{Note}+652400$	$75/fx^{Note}+78884.5625$	$75/fx^{Note}+527566.875$	Acknowledged (*)

Note

- fx: Operating frequency of external system clock.
- Values in parentheses are used when the write start address structure is placed outside internal high-speed RAM area.
- **This is only an example, for correct timings of the device, please refer to the corresponding user manual.**

(*) Please refer to command description for details.

Chapter 2 Programming Environment

This chapter explains the necessary hardware and software environment which is used to rewrite flash memory with the self programming library.

2.1 Hardware Environment

In the 78K0/Kx2/Fx2/Lx2/Dx2/Lx3/LIN4/uCFL serie devices, there is a FLMD0 pin controlling flash memory operation mode. To run user program, FLMD0 pin has to be set to low level (normal operation mode). To update flash memory content, FLMD0 pin should be set to high level.

If the FLMD0 pin is low during selfprogramming, the firmware can still be executed, but the circuit for rewriting flash memory does not operate. Therefore, the content of the flash memory will not be rewritten, and self programming functions return an error message.

Setting FLMD0 pin FLMD0 pin is not an output pin, and cannot be manipulated directly. Connect this pin with a general-purpose pin. And then switch the general-purpose pin to output mode.

Caution Make sure that the dedicated general purpose pin (**must be an I/O-pin**) is able to drive the pulldown connected to the FLMD0-pin.

The self programming open function FSL_Open can thus switch the FLMD0 pin to high, by changing the value of the connected general-purpose pin.

Following is an exemple circuit that allows to change the voltage on the FLMD0 pin by manipulating the dedicated general purpose I/O-pin.

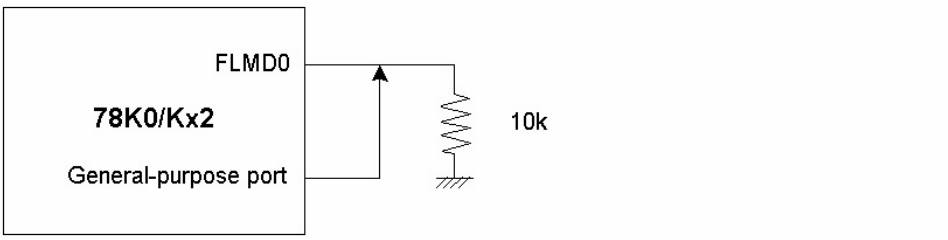

Figure 2-1 **FLMD0 Voltage Generator**

There are two predefined macros(FSL_FLMD0_LOW and FSL_FLMD0_HIGH) for the general-purpose port configuration, which can be adapted by the user(see **fsl_user.h**).

Caution **On 78K0/Ix2/Kx2-L devices the FLMD0 will be controlled internally via SFR (FPCTL). For detailed information please refer to the device users manual.**

2.2 Software Environment

The self programming library allocates its program to a user area and consumes up to about 400 bytes of the program area. The self programming library itself uses the CPU (register bank 3), work area (i.e. entry RAM), stack, and data buffer.

The following table lists the required software resources.

Table 2-1 Software Resources

Item	Description	Restriction
CPU	Register Bank 3	cannot be used by the application
Work area	Entry RAM: 100 bytes	Within internal high-speed RAM outside short addressing range or Within short direct addressing range only when first address is FE20H (Please refer to the following Entry RAM description..)
Stack	additional 50 bytes max. **Note** Use the same stack as for the user program	Internal high-speed RAM other than FE20H to FE83H (Please refer to the following Stack and data buffer description).
Data buffer	5 to 256 bytes **Note** The size of this buffer varies depending on the writing unit specified by the user program.	Internal high-speed RAM other than FE20H to FE83H (Please refer to the following Stack and data buffer description).
Program area	xxx-405 bytes **Note** Code size of the self-programming library varies depending on the Compiler and user configuration(Please refer to the following table).	Within 0000H to 7FFFH (32KB) **Caution** The self programming library and the user program which uses the library must always be located within the above range, because in the self-programming mode A1 the built-in firmware is mapped to address starting from 8000H

Caution
- The self programming operation is not guaranteed if the user manipulates the above resources. Do not manipulate these resources during a self programming session.
- The user must release the above resources before calling the self programming library.

Table 2-2 Code size of the library depends on the compiler and user configuration

	NEC V3.70 (static model)	NEC V3.70 (static model)	IAR V3.xx	IAR V4.xx
Min. bytes	353	330	180***	162***
Max. bytes	405	382	392	372

Note *** This code size is calculated without FSL_SetXXX, FSL_InvertXXX and FSL_GetXXX functions. The IAR-Linker excludes this functions automatically, if they are not referenced.

2.2.1 Entry RAM

The self programming firmware uses a work area of 100 bytes, which is thereinafter called entry RAM.

To specify the entry RAM in internal high-speed RAM, the first address can be within the range from FB00H to FDBBH.

To specify the entry RAM in short direct addressing range, the first address must be FE20H.

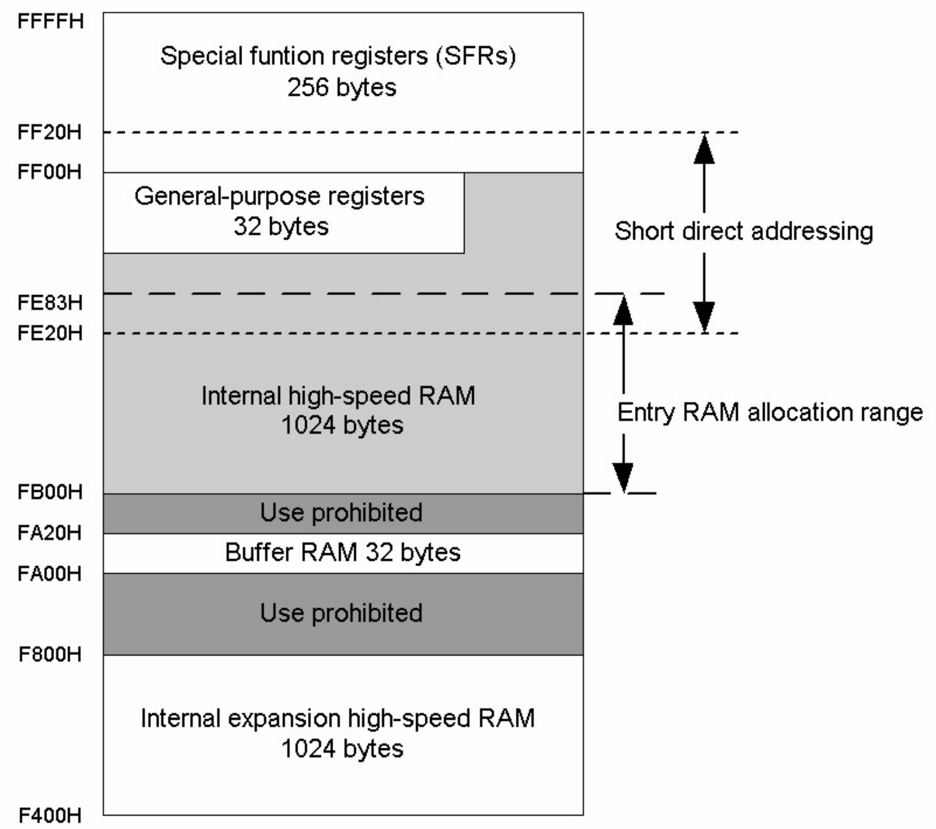

Figure 2-2 Allocation Range of Entry RAM

Note
- The size of the internal expansion high-speed RAM varies depending on the product. For the size of the internal expansion high-speed RAM, please refer to the user manual of each product.
- **The entry RAM must not start in internal high-speed RAM, and end in the short direct addressing range.**
- **To allocate the entry RAM in the internal high-speed RAM within the short direct addressing range, the first address has to be set to FE20H.**

2.2.2 Stack and data buffer

Stack The stack is used to store data and instruction pointers during selfprogramming. It must be allocated within the internal high-speed RAM but outside memory area from FE20H to FE83H.

Data Buffer The data buffer is used for data-exchange between the firmware and the self programming library.

Caution The data buffer has to be located outside memory area from FE20H to FE83H.

Note Data to be written to the flash memory must be appropriately set and processed before the word write function is called. The length of the data buffer must be min. 5 bytes.

Sample The following figure shows a sample device and the range, in which the stack pointer and data buffer can be allocated.

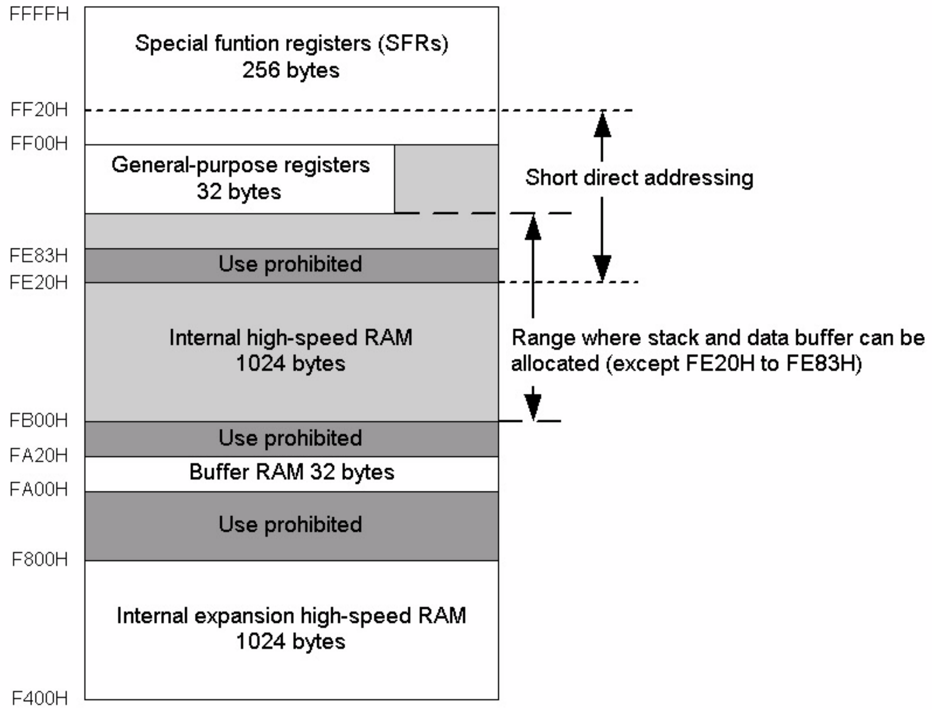

Figure 2-3 **Allocatable Range for Stack Pointer and Data Buffer**

Caution The size of the internal expansion high-speed RAM varies depending on the product. For the exact size please refer to the user manual of each product.

Chapter 3 Interrupt Services During Self Programming

3.1 Overview

The self programming operation can be interrupted by each interrupt source.

The following figures show the differences between a normal and an interrupted self-programming operation.

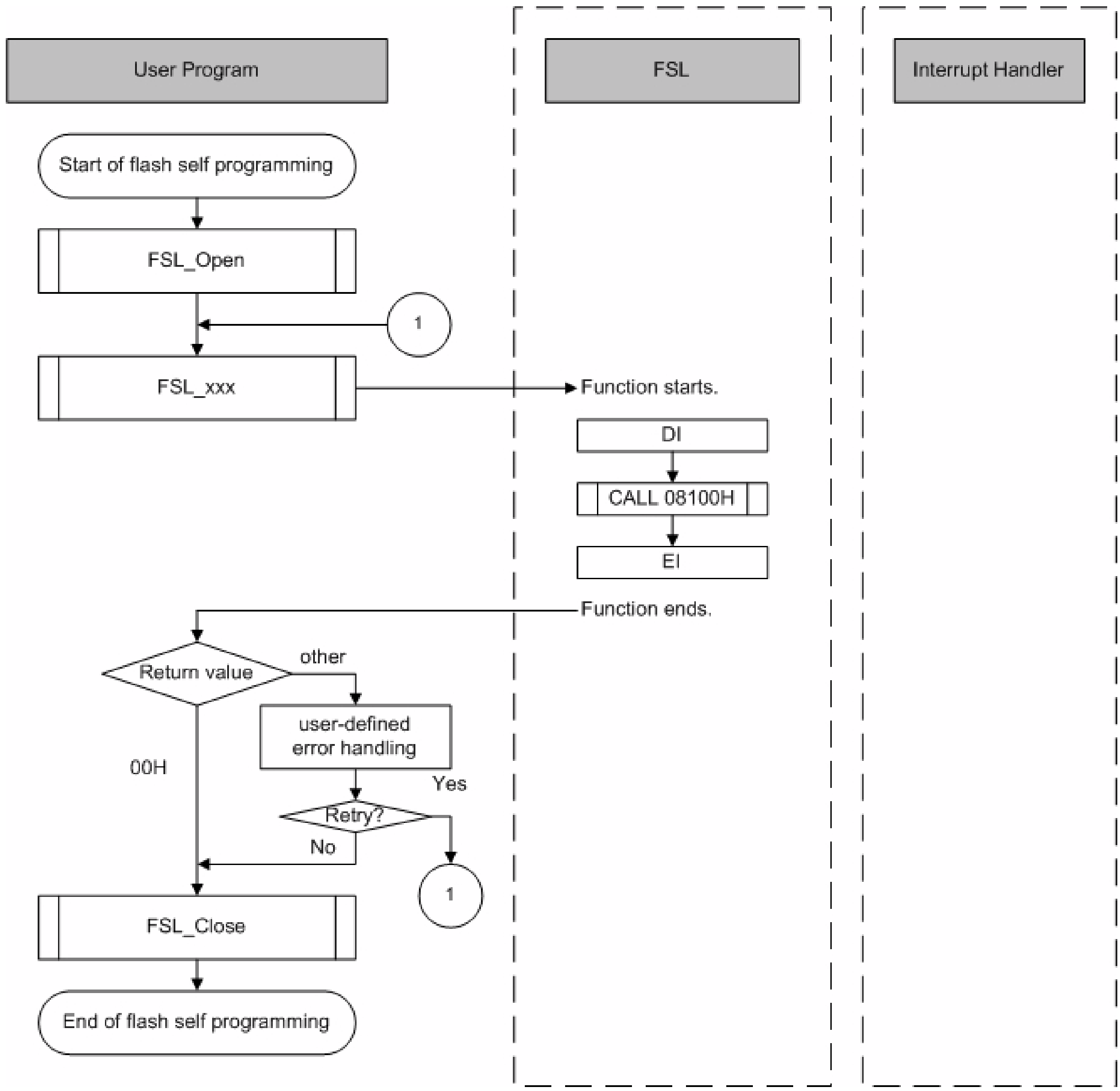

Figure 3-1 Flow of Processing without Interrupt

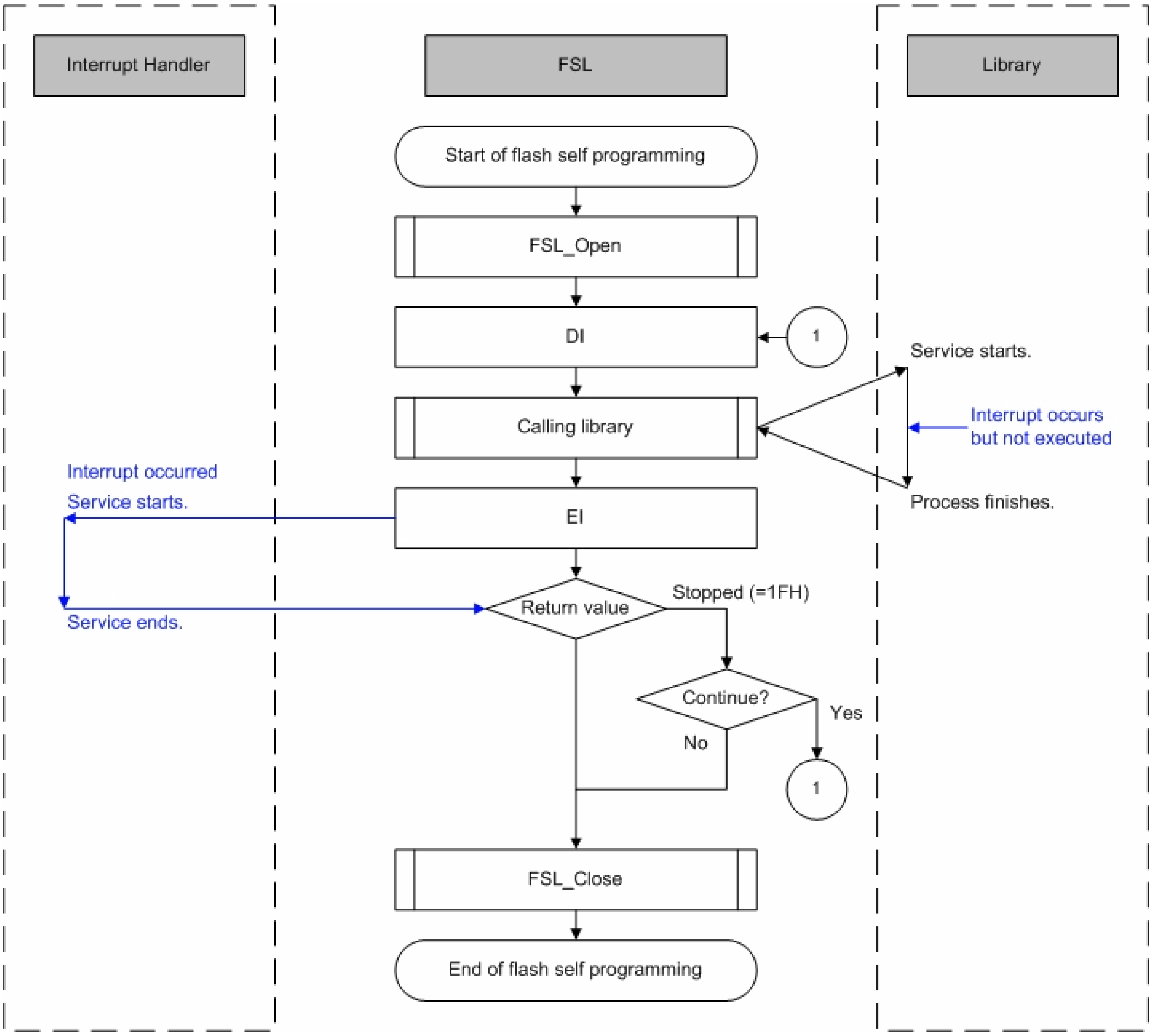

Figure 3-2 Flow of Processing in Case of Interrupt

The firmware will check automatically if there is any pending interrupt. As illustrated in figure above, if interrupt occurs during execution, return value is set to 0x1F. In this case, user application should recall the function to resume the processing.

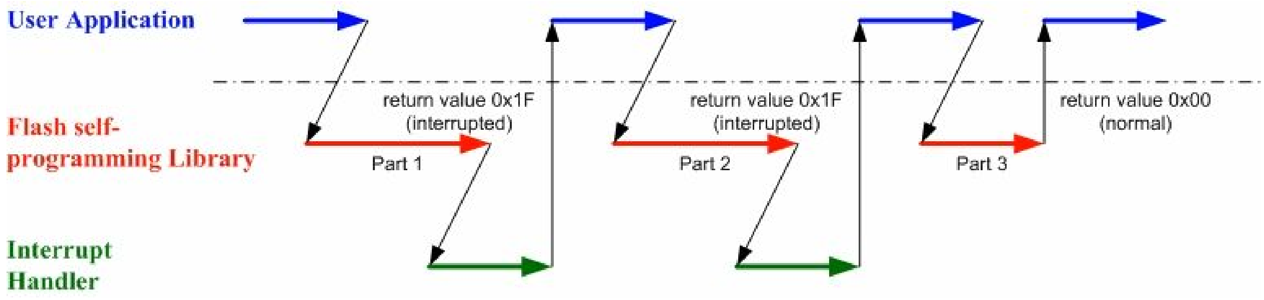

Figure 3-3 FSL Function Process with Resuming Mechanism

The following table shows how the processing of the self programming library functions that acknowledge interrupts is resumed after the processing has been stopped by the occurence of an interrupt. When resumed, the in-call function does not restart the whole process, but resumes from the interrupted point. To assure complete execution, the user has to take care to resume the interrupted process by calling the function again with the same parameters, until 0x00 is returned.

Caution The FSL_SetXXX function will not be resumed. This function will be restarted from the beginning each time.

```
 do
{
   my_status_u08 =  FSL_BlankCheck (block_u08);

   // in case of FSL_ERR_INTERRUPTION is returned here,
   // the corresponding ISR is already executed !!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);
```

Table 3-1 Resume/Restart process for interrupted self-programming functions

Function name	Resume/Restart method
FSL_BlankCheck	Call the block blank check function FSL_BlankCheck to resume the process stopped by the occurrence of an interrupt.
FSL_Erase	Call the block erase function FSL_Erase to resume erase process that is stopped by the occurrence of an interrupt.
FSL_Write	Call the word write function FSL_Write to resume writing process that is stopped by the occurrence of an interrupt.
FSL_IVerify	Call the block verify function FSL_IVerify to resume block verifying process stopped by the occurrence of an interrupt.
FSL_Setxxx, FSL_Invertxxx	Call the set information functions FSL_Setxxx to **restart** flash information setting process stopped by the occurrence of an interrupt.
FSL_EEPROMWrite	Call the EEPROM write function FSL_EEPROMWrite to resume writing of the EEPROM data stopped by the occurrence of an interrupt.

Caution All self-programming functions other than above cannot be interrupted, because these functions execute with interrupts disabled.

3.2 Interrupt Response Time

Unlike the case for an ordinary interrupt, an interrupt generated during selfprogramming is handled via post-interrupt servicing in the firmware (i.e. setting 0x1F as return value of a selfprogramming function). Consequently, the response time is longer than that of an ordinary interrupt.

Note For exact response time, please refer to the corresponding user manual.

The following tables illustrates the interrupt response time depending on the main clock source.

Table 3-2 Interrupt Response Time (with Internal High-Speed Oscillator)

Function name	Interrupt Response Time (Unit: Microseconds)			
	Entry RAM outside short direct addressing range		Entry RAM inside short direct addressing rang (from FE20H)	
	Min.	Max.	Min.	Max.
FSL_BlankCheck	391.25	1300.5	81.25	727.5
FSL_Erase	389.25	1393.5	79.25	820.5
FSL_Write	394.75	1289.5	84.75	716.5
FSL_IVerify	390.25	1324.5	80.25	751.5
FSL_Setxxx and FSL_Invertxxx	387	852.5	77	279.5
FSL_EEPROMWrite	399.75	1395.5	89.75	822.5

Caution All self-programming functions other than above cannot be interrupted, because these functions execute with interrupts disabled.
*** This is only an example, for correct timings of the device, please refer to the corresponding user manual.**

Table 3-3 Interrupt Response Time (with External System Clock)

Function name	Interrupt Response Time (Unit: Microseconds)			
	Entry RAM outside short direct addressing range		Entry RAM inside short direct addressing rang (from FE20H)	
	Min.	Max.	Min.	Max.
FSL_BlankCheck	18/fx[Note]+192	28/fx[Note]+698	18/fx[Note]+55	28/fx[Note]+462
FSL_Erase	18/fx[Note]+186	28/fx[Note]+745	18/fx[Note]+49	28/fx[Note]+509
FSL_Write	22/fx[Note]+189	28/fx[Note]+693	22/fx[Note]+52	28/fx[Note]+457
FSL_IVerify	18/fx[Note]+192	28/fx[Note]+709	18/fx[Note]+55	28/fx[Note]+473
FSL_Setxxx and FSL_Invertxxx	16/fx[Note]+190	28/fx[Note]+454	16/fx[Note]+53	28/fx[Note]+218
FSL_EEPROMWrite	22/fx[Note]+191	28/fx[Note]+783	22/fx[Note]+54	28/fx[Note]+547

Note fx: Operating frequency of external system clock.

Caution All self-programming functions other than above cannot be interrupted, because these functions execute with interrupts disabled.
*** This is only an example, for correct timings of the device, please refer to the corresponding user manual.**

3.3 Cautions

Cautions related to interrupt servicing during self-programming.

- Do not call any further self-programming function or change related settings during interrupt servicing.
- Do not use register bank 3 during interrupt servicing, because the self programming library uses register bank 3.
- Because the set information function may exceed the maximum watchdog overflow time, please take care to disable in this case the watchdog during execution of the set information command.
- If an interrupt occurs successively during a specific period while the set information is in process, an infinite loop may occur if the set information function is resumed after being stopped by the same interrupt, because the process starts over from the very beginning. Therefore, do not allow an interrupt to occur successively at an interval shorter than the period, within which the set information function will be completed.
- Allocate an interrupt service function to an area other than that of the blocks to be rewritten, just as for the self programming functions.
- If the self programming function on one block is stopped by an interrupt and not resumed, while process on another block is to be performed, the initialize function must be called before the process on another block is started.

Example To execute the erase function on block 1, do not resume the interrupted erase function on block 0.
Call the initialize function first and then start the erase function on block 1.

Chapter 4 Boot Swapping

Reason for Bootswapping

A permanent data loss may occur when rewritting the vector table, the basic functions of the program, or the self programming area, due to one of the following reasons:

- a temporary power failure
- an externally generated reset

The user program is thus not able to be restarted through reset. Likewise the rewrite process can no longer be performed. This potential risk can be avoided by using a boot swap functionality.

Boot swap Function

The boot swap function FSL_InvertBootClusterFlag replaces the current boot area, boot cluster 0[Note], with the boot swap target area, boot cluster 1[Note].

Before swapping, user program should write the new boot program into boot cluster 1. And then swap the two boot cluster and force a hardware reset. The device will then be restarting from boot cluster 1.

As a result, even if a power failure occurs while the boot program area is being rewritten, the program runs correctly because after reset the circuit starts from boot cluster 1. After that, boot cluster 0 can be erased or written as required.

Note

Boot cluster 0 (0000H to 0FFFH): Original boot program area
Boot cluster 1 (1000H to 1FFFH): Boot swap target area

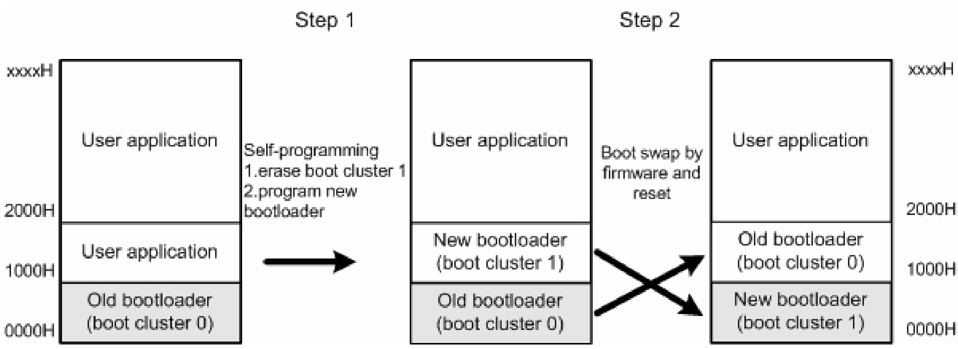

Figure 4-1 Summary of Boot Swapping Flow

Caution

To rewrite the flash memory by using a programmer (such as the PG-FP4) after boot swapping, follow the procedure below.

1. **Chip erase**
2. **PV (program, verify) or EPV (erase, program, and verify)**

(Unless step 1 is performed, data may not be correctly written.)

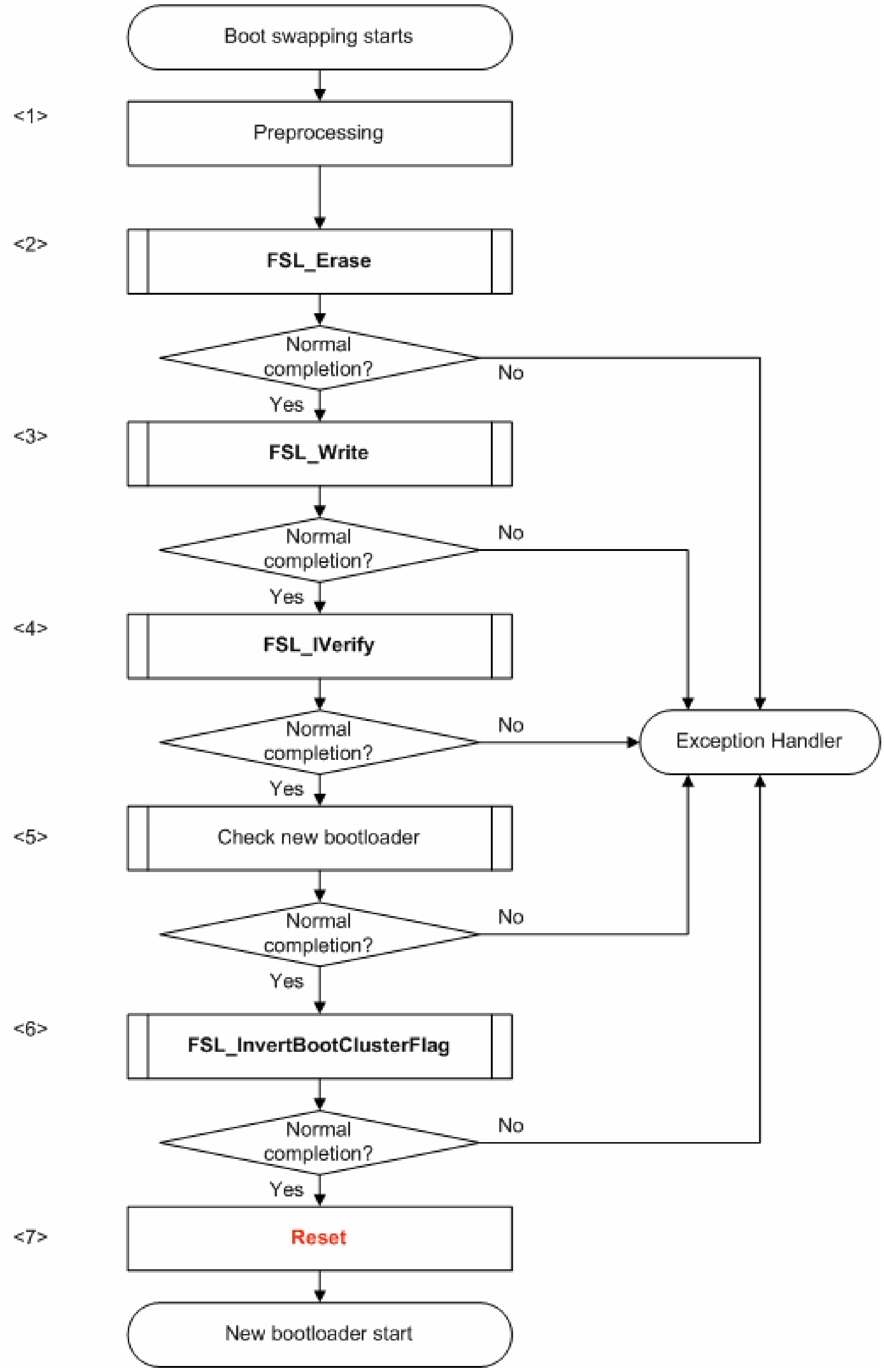

Figure 4-2 Flow of Boot Swapping

<1> Preprocessing

The following preprocess of boot swapping is performed.

- Set up software environment
- Set up hardware environment
- Initialize entry RAM
- Check FLMD0 voltage level

<2> Erasing blocks 4 to 7

Call the erase function FSL_Erase to erase blocks 4 to 7.

Note The erase function erases only a block at a time. Call it once for each block.

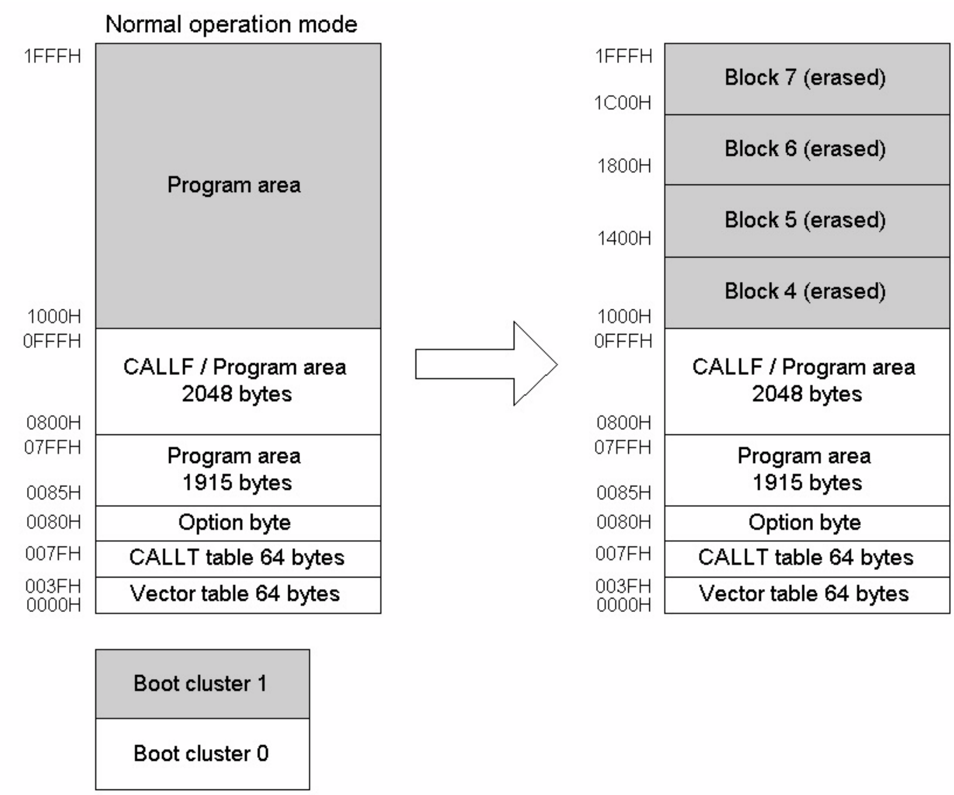

Figure 4-3 Erasing Boot Cluster 1

<3> Writing new program to boot cluster 1

Call the FSL_Write function to write the new bootloader (1000H to 1FFFH).

Note The write function writes data in word units (256 bytes max.).

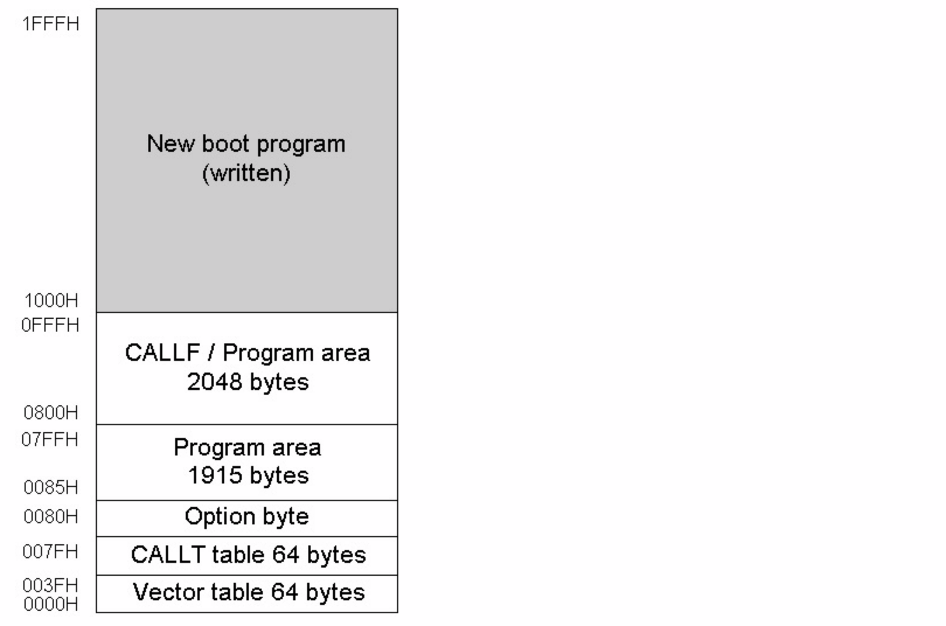

Figure 4-4 Writing New Program to Boot Cluster 1

<4> Verifying Blocks 4 to 7

Call the verify function FSL_IVerify to verify Blocks 4 to 7.

Note The verify function verifies only a block at a time. Call it once for each block.

<5> Checks the new bootloader.

E.g. CRC check on the new bootloader.

<6> Setting of boot swap bit

Call the function FSL_InvertBootClusterFlag. The inactive boot cluster with new bootloader becomes active after hardware reset.

<7> Force of reset

New bootloader is active after hardware reset.

Chapter 5 Appendix - NEC library

This chapter explains details on the self programming library for the NEC Compiler/Assembler.

5.1 Self Programming Library - function prototypes

The self programming library consists of the following functions.

Table 5-1 Self Programming Library - function prototypes

Function prototype	Outline
void FSL_Open(void)	Opens a self programming session.
void FSL_Close(void)	Closes a self programming session.
fsl_u08 FSL_Init(fsl_u08* data_buffer_pu08)	Initializes entry RAM.
fsl_u08 FSL_ModeCheck(void)	Checks FLMD0 voltage level.
fsl_u08 FSL_BlankCheck(fsl_u08 block_u08)	Checks if specified block (1KB) is empty.
fsl_u08 FSL_Erase(fsl_u08 block_u08)	Erases a specified block (1KB).
fsl_u08 FSL_IVerify(fsl_u08 block_u08)	Verifies a specified block (1KB) (internal verification).
fsl_u08 FSL_Write(fsl_u16 s_addressH_u16, fsl_u16 s_addressL_u16, fsl_u08 word_count_u08)	Writes up to 64 words (each word equals 4 bytes) to a specified address.
fsl_u08 FSL_EEPROMWrite(fsl_u16 s_addressH_u16, fsl_u16 s_addressL_u16, fsl_u08 word_count_u08)	Blankcheck,writes and verify up to 64 words to a specified address.
fsl_u08 FSL_GetSecurityFlags(fsl_u08 *destination_pu08)	Reads the security information.
fsl_u08 FSL_GetActiveBootCluster(fsl_u08 *destination_pu08)	Reads the current value of the boot flag in extra area.
fsl_u08 FSL_GetBlockEndAddr(fsl_u16 *dest_addrH_pu16, fsl_u16 *dest_addrL_pu16, fsl_u08 block_u08)	Puts the last address of the specified block into *dest_addrH_pu16 and dest_addrL_pu16*
fsl_u08 FSL_InvertBootClusterFlag(void)	Inverts the current value of the boot flag in the extra area.
fsl_u08 FSL_SetChipEraseProtectFlag(void)	Sets the chip-erase-protection flag in the extra area.
fsl_u08 FSL_SetBlockEraseProtectFlag(void)	Sets the block-erase-protection flag in the extra area.
fsl_u08 FSL_SetWriteProtectFlag(void)	Sets the write-protection flag in the extra area.
fsl_u08 FSL_SetBootClusterProtectFlag(void)	Sets the bootcluster-update-protection flag in the extra area.

5.2 Explanation of Self Programming Library

Each self programming function is explained in the following format.

Self Programming Function name

Outline Outlines the self programming function.

Function prototype Shows the C-Compiler function prototype of the current function.

Note In this manual, the data type name is defined as followed.

Definition	Data Type
fsl_u08	unsigned char
fsl_u16	unsigned int

Argument Indicates the argument of the self programming function.

Return Value Indicates the return value from the self programming function.

Register status after calling Indicates the status of registers after the self programming function is called.

Call example Indicates an example of calling the self programming function from a user program written in C language.

Flow Indicates the program flow of the self programming function.

5.2.1 Open

Outline This function may optionally preserve interrupt flag settings, and then FLMD0 pin will be pulled up by the user defined general purpose port, allowing further self programming functions.

After this function is called, program enters the so-called "user room".

Note

- Call this function at the beginning of the self programming operation.
- User may customize this function in the source files **fsl_user.h** and **fsl_user.c**, do a few more preprocesses, so as to adapt personal requirements.

Function prototype void FSL_Open (void)

Pre-condition None

Argument None

Return value None

Flow The following figure shows the flow of the self programming open function.

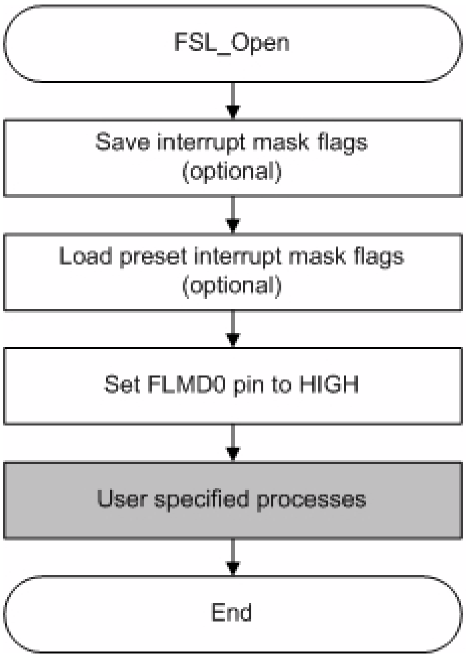

Figure 5-1 Flow of Self Programming Open Function

Note The preset interrupt mask flags are defined in the FSL user-configurable source file **fsl_user.h**

```
 // customizable interrupt controller configuration during selfprogramming period
/* all interrupts disabled during selfprogramming */
#define   FSL_MK0L_MASK   0xFF
#define   FSL_MK0H_MASK   0xFF
#define   FSL_MK1L_MASK   0xFF
#define   FSL_MK1H_MASK   0xFF
/*For the correct settings please refer to the chapter "Interrupt Functions"
of the corresponding device user's manual.*/
```

Interrupt backup If backup of interrupt mask flags is not necessary, user may comment out the following line.

```
 #define  FSL_INT_BACKUP
```

FLMD0 port setting example Following example shows the macro definition for the FLMD0 control.

```
 /* fsl_user.h */
/* FLMD0_port control macros(FLDM0<->P3.0 connection pulled-down by 10kOhm resistor)
#define  FSL_FLMD0_HIGH   {P3.0 = 1; PM3.0 = 0; }
#define  FSL_FLMD0_LOW    {P3.0 = 0; PM3.0 = 1; }

 /* fsl_user.c */
#define   FSL_PUSH_PSW_AND_DI      { __OPC(0x22); DI();} /* PUSH PSW; DI; */
#define   FSL_POP_PSW                __OPC(0x23);       /* POP PSW      */


/* FSL_Open();    */
FSL_PUSH_PSW_AND_DI;
FSL_FLMD0_CTRL_PORT_HIGH;
FSL_POP_PSW;
```

5.2.2 Close

Outline This funtion first switches the FLMD0 pin to LOW. Further selfprogramming procedures will be then disabled.

After that, user may optionally restore the interrupt flag settings, and do other user-specified processes. The program will then leave the "user room" for the self-programming.

Note

- Call this function at the end of the self programming operation.
- User may customize this function in the source files **fsl_user.h** and **fsl_user.c**.

Function prototype void FSL_Close (void)

Pre-condition None

Argument None

Return value None

Flow The following figure shows the flow of the self programming end function.

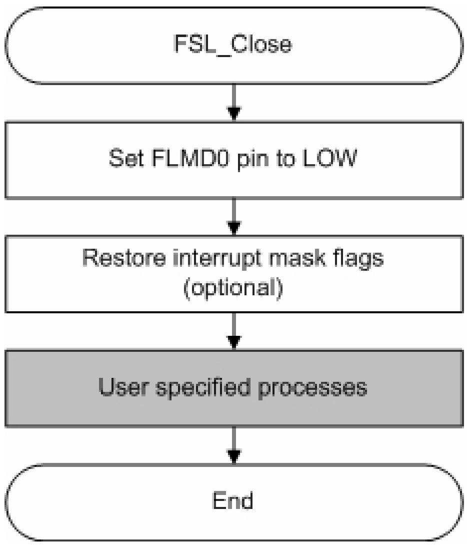

Figure 5-2 Flow of Self Programming End Function

5.2.3 Init

Outline

This function Initializes internal selfprogramming environment. It prepares 100 bytes entry RAM specified by the Link Directive file[Note1].It is used as a work area during self programming.

After initialization the start address of the data-buffer is stored in the entry RAM.

Note

1. The definition below locates in the FSL Link Direktive file(***.dr**).

```
 ; -----------------------------------------------------------
; entry RAM within high speed RAM
; -----------------------------------------------------------
MERGE FSL_DATA:=RAM
```

Caution

The entry RAM may be allocated at any address of the internal high-speed RAM outside of the short direct addressing range.
To allocate the entry RAM in the internal high-speed RAM within the short direct addressing range, the first address has to be set to FE20H.

Function prototype

fsl_u08 FSL_Init (fsl_u08* data_buffer_pu08)

Pre-condition

The function FSL_Open() was successfully called.

Argument

Argument	C Language	Assembly
First address of data buffer[Note]	fsl_u08* data_buffer_pu08	AX

Note

For details on data buffer, please refer to the chapter "Programming Environment".

Return Value

The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion - Pointer to the data-buffer is stored in the entry RAM.
OTHER	Error

Register status after calling

Normal model: C = return value;, AX = destroyed
Static model: A = return value; X = destroyed

Call example

```
 extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE]; /* see fsl_user.c */

my_status_u08 = FSL_Init((fsl_u08*)&fsl_data_buffer);

if( my_status_u08 != 0x00 ) my_error_handler();
```

5.2.4 Mode Check

Outline This function checks the voltage level at FLMD0 pin, ensuring the hardware requirement of self programming.

For details on FLMD0 and hardware requirement, please refer to the chapter "Hardware Environment".

Note Call this function after calling the self programming open function FSL_Open to check the voltage level of the FLMD0 pin.

Caution If the FLMD0 pin is at low level, operations such as erasing and writing the flash memory cannot be performed. To manipulate the flash memory by self programming, it is necessary to call this function and confirm, that the FLMD0 pin is at high level.

Function prototype fsl_u08 FSL_ModeCheck (void)

Pre-condition The self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument None

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion -FLMD0 pin is at high level.
01H	Abnormal termination -FLMD0 pin is at low level.

Register status after calling **Normal model: C = return value**
Static model: A = return value

Call example

```
my_status_u08 = FSL_ModeCheck();

if( my_status_u08 != 0x00 )
   my_error_handler();
```

5.2.5 Blank Check

Outline This function checks if a specified block (1KB) is blank (erased).

Note
- If the block is not blank, it should be erased and blank checked again.
- Because only one block is checked at a time, call this function once for each block.

Function-prototype fsl_u08 FSL_BlankCheck (fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C Language	Assembly
block number to be checked	fsl_u08 block_u08	A (static model), X (normal model)

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion Specified block is blank (erase operation is completed).
05H	Parameter error Specified block number is outside the allowed range.
1BH	Black check error Specified block is not blank (erase operation is not completed).
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **Normal model: C = return value**
Static model: A = return value

Call example

```
my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_BlankCheck(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

5.2.6 Erase

Outline This function erases a specified block (1KB).

Note Because only one block is erased at a time, call this function once for each block.

Function prototype fsl_u08 FSL_Erase (u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C Language	Assembly
block number to be erased	fsl_u08 block_u08	A (static model), X (normal model)

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Specified block number is outside the allowed range.
10H	Protect error Specified block is included in the boot area and rewriting the boot area is disabled.
1AH	Erase error An error occurred during this function in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **Normal model: C = return value**
Static model: A = return value

Call example

```
my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_Erase(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

5.2.7 Verify

Outline This function verifies (internal verification) a specified block (1KB).

Note

- Because only one block is verified at a time, call this function once for each block.
- This internal verification is a function to check if written data in the flash memory is at a sufficient voltage level.
- It is different from a logical verification that just compares data.

Caution After writing data, verify (internal verification) the block including the range in which the data has been written. If verification is not executed, the written data is not guaranteed.

Function prototype fsl_u08 FSL_IVerify (fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
the to-verify block number	fsl_u08 block_u08	A (static model), X (normal model)

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Specified block number is outside the allowed range.
1BH	Verify (internal verify) error An error occurs during this function is in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **Normal model: C = return value**
Static model: A = return value

Call example

```
my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_IVerify(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION); // FSL_ERR_INTERRUPTION = 0x1F

// exit if error occurs
if (my_status_u08 != FSL_OK)             // FSL_ERR_NO = 0x00
    my_error_handler(....)
```

5.2.8 Write

Outline This function writes the specified number of words (each word equals 4 bytes) to a specified address.

Note
- Set a RAM area as a data buffer, containing the data to be written and call this function.
- Data of up to 256 bytes (i.e. 64 words) can be written at one time.
- Call this function as many times as required to write data of more than 256 bytes.

Caution
- After writing data, execute verification (internal verification) of the block including the range in which the data has been written. If verification is not executed, the written data is not guaranteed.
- It is not allowed to overwrite data in flash memory.
- Only blank flash cells can be used for the write.

Function prototype fsl_u08 FSL_Write(fsl_u16 s_addressH_u16, fsl_u16 s_addressL_u16, fsl_u08 word_count_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Starting address(MSB) of the data to be written[Note]	fsl_u16 s_addressH_u16	Normal model: AX Static model: AX
Starting address(LSB) of the data to be written[Note]	fsl_u16 s_addressL_u16	Normal model: over stack Static model: BC
Number of the data to be written (1 to 64)	fsl_u08 word_count_u08	Normal model: over stack Static model: H

Note
- **(s_addressH_u16, s_addressL_u16)** + (Number of data to be written x 4 bytes)) must not straddle over the end address of a single block.
- **(s_addressH_u16, s_addressL_u16)** must be a multiple of 4
- Most significant byte (MSB) of the **s_addressH_u16**has to be 0x00 In other words, only *0x00abcdef* is a valid flash address.
- **word_count_u08***4 has to be smaller than the size of data buffer. The firmware does not check this.

Return Value

The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error - Start address is not a multiple of 1 word (4 bytes). - The number of data to be written is 0. - The number of data to be written exceeds 64 words. - Write end address (Start address + (Number of data to be written x 4 bytes)) exceeds the flash memory area.
10H	Protect error Specified range includes the boot area and rewriting the boot area is disabled.
1CH	Write error Data is verified but does not match after this function operation is completed or FLMD0 pin is low.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling

Normal model: C = return value; AX = destroyed
Static model: A = return value; AX, BC and H = destroyed

Call example

```
// prepare data and write it into the data buffer for the writing process
..........
..........

my_addressH_u16 = 0x0001;   // set the MSB of the address for write procedure
my_addressL_u16 = 0xFC00;   // set the LSB of the address for write procedure
my_write_count_u08 = 0x02; // set word count
do
{
  my_status_u08 = FSL_Write(my_addressH_u16, my_addressL_u16,
                                                    my_write_count_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

5.2.9 EEPROMWrite

Outline

This function writes the specified number of words (each word equals 4 bytes) to a specified address.

Different to **FSL_Write**, blank check will be performed, before "writing" n words. After "writing" n words internal verify is performed.

Note

- Set a RAM area as a data buffer containing the data to be written and call this function.
- Data of up to 256 bytes (i.e. 64 words) can be written at one time.
- Call this function as many times as required to write data of more than 256 bytes.

Caution

- It is not allowed to overwrite data in flash memory.
- Only blank flash cells can be used for the write.

Function prototype

fsl_u08 FSL_EEPROMWrite(fsl_u16 s_addressH_u16, fsl_u16 s_addressL_u16, fsl_u08 word_count_u08)

Pre-condition

The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Starting address(MSB) of the data to be written[Note]	fsl_u16 s_addressH_u16	Normal model: AX Static model: AX
Starting address(LSB) of the data to be written[Note]	fsl_u16 s_addressL_u16	Normal model: over stack Static model: BC
Number of the data to be written (1 to 64)	fsl_u08 word_count_u08	Normal model: over stack Static model: H

Note

- **(s_addressH_u16, s_addressL_u16)** + (Number of data to be written x 4 bytes)) must not straddle over the end address of a single block.
- **(s_addressH_u16, s_addressL_u16)** must be a multiple of 4
- Most significant byte (MSB) of the **s_addressH_u16**has to be 0x00 In other words, only *0x00abcdef* is a valid flash address.
- **word_count_u08***4 has to be smaller than the size of data buffer. The firmware does not check this.

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error - Start address is not a multiple of 1 word (4 bytes). - The number of data to be written is 0. - The number of data to be written exceeds 64 words. - Write end address (Start address + (Number of data to be written x 4 bytes)) exceeds the flash memory area.
10H	Protect error Specified range includes the boot area and rewriting the boot area is disabled.
1CH	Write error Data is verified but does not match after this function operation is completed or FLMD0 pin is low..
1DH	Verify error Data is verified but does not match after it has been written.
1EH	Blank error Write area is not a blank area.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **Normal model: C = return value; AX = destroyed**
Static model: A = return value; AX, BC and H = destroyed

```
// prepare data and write it into the data buffer for the writing process
..........
..........

my_addressH_u16 = 0x0001;   // set the MSB of the address for write procedure
my_addressL_u16 = 0xFC00;   // set the LSB of the address for write procedure
my_write_count_u08 = 0x02; // set word count
do
{
  my_status_u08 = FSL_EEPROMWrite(my_addressH_u16, my_addressL_u16,
                                                     my_write_count_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

5.2.10 Get Security Flags

Outline This function reads the security (write-/erase-protection) information from the extra area.

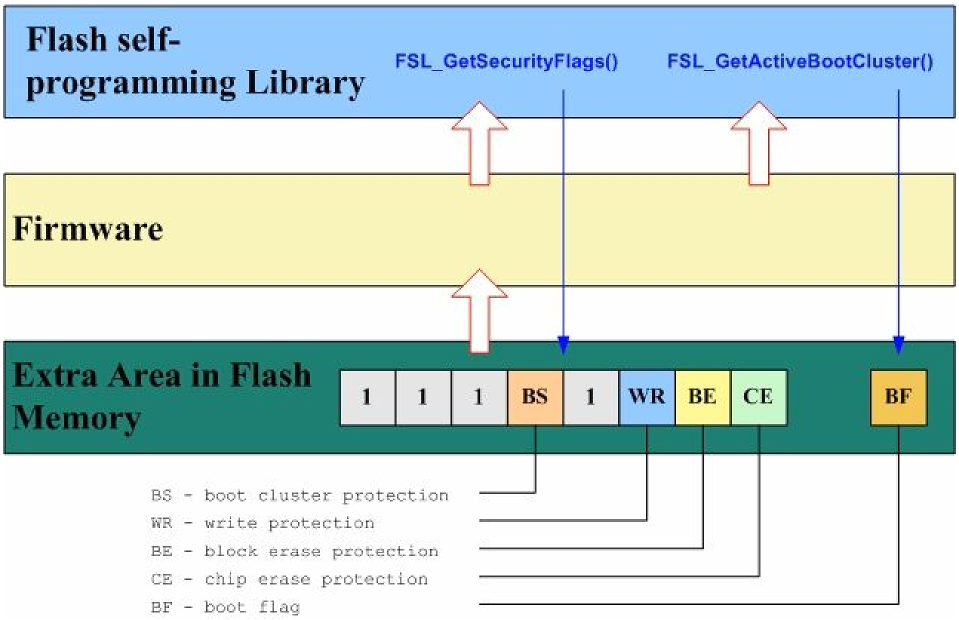

Figure 5-3 Security Information Structure

Function prototype fsl_u08 FSL_GetSecurityFlags (fsl_u08 *destination_pu08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Storage address of the security information	fsl_u08 *destination_pu08	AX

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error
20H	Read error

Change in the destination address.

Security flag will be written in the destination address.

Meaning of each bit of security flag.
Bit 0: Chip erase protection (0: Enabled, 1: Disabled)
Bit 1: Block erase protection (0: Enabled, 1: Disabled)
Bit 2: Write protection (0: Enabled, 1: Disabled)
Bit 4: Boot area overwrite protection (0: Enabled, 1: Disabled)
Bits 3, 5, 6 and 7 are always 1.

Example

If *EB*H (i.e. *11101011*) is written to destination address, boot area overwrite and write operations to the flash area are forbidden.

Register status after calling **Normal model: C = return value; AX = destroyed**
Static model: A = return value; X = destroyed

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE];

/* get security informations                              */
my_status_u08 = FSL_GetSecurityFlags ((fsl_u08*)&my_security_dest_u08);

if( my_status_u08 != 0x00 )
   my_error_handler();

if(my_security_dest_u08 & 0x01){ myPrintFkt("Chip erase protection disabled!"); }
else{ myPrintFkt("Chip erase protection enabled!"); }
```

5.2.11 Get Active Boot Cluster

Outline This function reads the current value of the boot flag in extra area.

Function prototype fsl_u08 FSL_GetActiveBootCluster (fsl_u08 *destination_pu08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Destination address of the security info	fsl_u08 *destination_pu08	AX

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error
20H	Read error

Changes in the destination address.

Boot flag will be written in the destination address.

00H: Boot area is not swapped.
01H: Boot area is swapped.

Example

If *01*H is written to destination address, boot area is swapped.

Register status after calling **Normal model: C = return value; AX = destroyed**
Static model: A = return value; X = destroyed

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE];

/* get boot-swap flag                                  */
my_status_u08 = FSL_GetActiveBootCluster((fsl_u08*)&my_bootflag_dest_u08);

if( my_status_u08 != 0x00 )
   my_error_handler();

if(my_bootflag_dest_u08){ myPrintFkt("Boot area is swapped!"); }
else{ myPrintFkt("Boot area is not swapped!"); }
```

5.2.12 Get Block End Address

Outline This function puts the last address of the specified block into the divided 32-Bit variable *dest_addrH_pu16 and *dest_addrL_pu16.

Note This function may be used to secure the write function **FSL_Write**. If write operation exceeds the end address of a block, the written data is not guaranteed. Use this function to check whether the (write address + word number * 4) exceeds the end address of a block before calling the write function.

Function prototype fsl_u08 FSL_GetBlockEndAddr(fsl_u16 *dest_addrH_pu16, fsl_u16 *dest_addrL_pu16, fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Destination address(MSB) of the security info	fsl_u16 *dest_addrH_pu16,	Normal model: AX Static model: AX
Destination address(LSB) of the security info	fsl_u16 *dest_addrL_pu16,	Normal model: over stack Static model: BC
Block number the end-address is asked for	fsl_u08 block_u08	Normal model: over stack Static model: H

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error

Changes in the destination address.

Block end address will be written in the destination address.

Example

If *6C*H is given as block number, *1B3FF*H will be written to the destination address.

Register status after calling **Normal model: C = return value; AX = destroyed**
Static model: A = return value; AX, BC and H = destroyed

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE];

fsl_u16 my_addressH_u16, my_addressL_u16;
fsl_u08 my_block_u08 = 0x7F;

/* get end adress of the block                         */
my_status_u08 = FSL_GetBlockEndAddr((fsl_u16*)&my_addressH_u16,
                                    (fsl_u16*)&my_addressH_u16, my_block_u08);

if( my_status_u08 != 0x00 )  my_error_handler();
```

5.2.13 Set and Invert Functions

Outline The selfprogramming library has 5 functions for setting security bits . Each dedicated function sets a corresponding security flag in the extra area.

These functions are listed below.

Funtion name	Outline
invert boot flag function	Inverts the current value of the boot flag*.
set chip-erase-protection function	Sets the chip-erase-protection flag*.
set block-erase-protection function	Sets the block-erase-protection flag*.
set write-protection function	Sets the write-protection flag*.
set boot-cluster-protection function	Sets the bootcluster-update-protection flag*.

* This flag is stored in the flash extra area.

Caution

1. **A recalled FSL_Setxx or FSL_Invertxxx command is allways restarted from the beginning and cannot be resumed. To execute such command mask all interrupts before using these commands(DI is not enough).**
2. **Chip-erase protection and boot-cluster protection cannot be reset by programmer.**
3. **The FSL_Setxx or FSL_Invertxxx functions cannot be performed in low current consumption mode. In that case the functions will return parameter error. This caution concerns to 78K0/Ix2/Kx2-L only. For detailed information please refer to the device users manual.**
4. After RESET the other boot-cluster is activated. Please ensure a valid boot-loader inside the area, before calling the function.
5. Each security flag can be written by the application only once until next reset.
6. Block-erase protection and write protection can be reset by programmer.

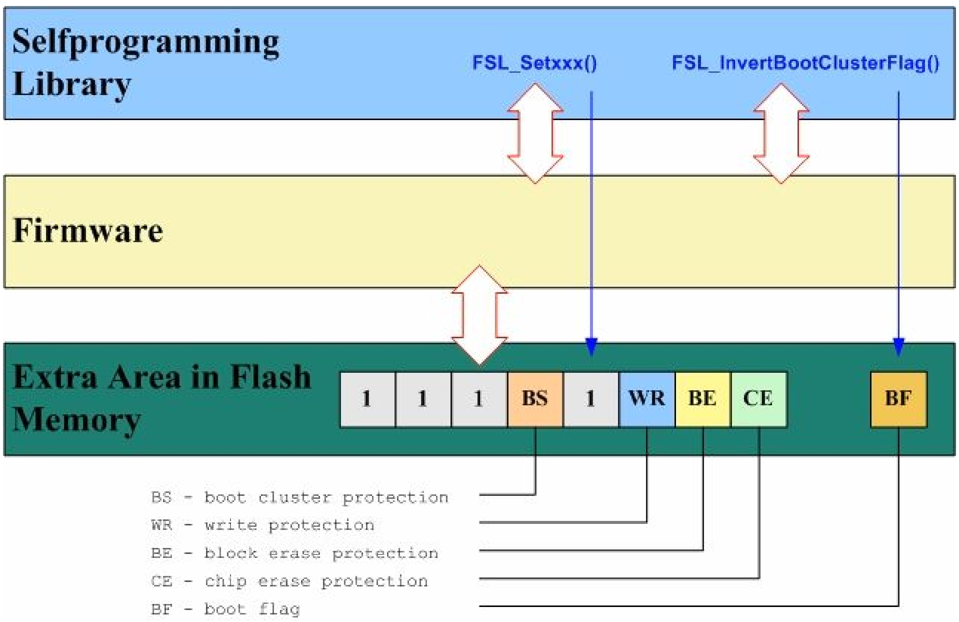

Figure 5-4 Extra Area

Function prototypes

Function name	Function prototype
invert boot flag function	fsl_u08 FSL_InvertBootClusterFlag(void)
set chip-erase-protection function	fsl_u08 FSL_SetChipEraseProtectFlag(void)
set block-erase-protection function	fsl_u08 FSL_SetBlockEraseProtectFlag(void)
set write-protection function	fsl_u08 FSL_SetWriteProtectFlag(void)
set boot-cluster-protection function	fsl_u08 FSL_SetBootClusterProtectFlag(void)

Argument None

Return Value The status is stored in *A register(static model) or C register(normal model)* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Bit 0 of the information flag value is cleared to 0 for a product that does not support boot swapping.
10H	Protection error - Attempt is made to enable a flag that has already been disabled. - Attempt is made to change the boot area swap flag while rewriting of the boot area is disabled.
1AH	Erase error An erase error occurs while this function is in process.
1BH	Internal verify error A verify error occurs while this function is in process.
1CH	Write error A write error occurs while this function is in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **A = return value**

Call example

```
my_status_u08 = FSL_SetBlockEraseProtectFlag();

if( my_status_u08 != 0x00 )
{
   if( my_status_u08 == 0x1F )
   {
      // retry FSL_SetBlockEraseProtectFlag ......
   }
   my_error_handler();
}
```

5.3 Sample - Link Directive File

The self-programming library uses two segments for data and code allocation:

- **FSL_CODE(code)**
  Within this segment the self-programming library will be located. Be sure to locate this segment within common area.
- **FSL_DATA(data)**
  Segment for the fsl_entry_ram.

Listed below is an example of the DR(Link Directive File) file for the self-programming library.

```
; ============================================================
; ============================================================
; =              Self-Lib Link Directive File                =
; ============================================================
; ============================================================

; ------------------------------------------------------------
; Redefined default code segment ROM
; ------------------------------------------------------------
MEMORY ROM:(2000H,5FFFH)

; ------------------------------------------------------------
; Define neu memory entry for boot cluster 0
; ------------------------------------------------------------
MEMORY BCL0:(0000H, 1000H )

; ------------------------------------------------------------
; Define neu memory entry for boot cluster 1
; ------------------------------------------------------------
MEMORY BCL1:(1000H, 1000H )

; ------------------------------------------------------------
; Merge Reset vector segment to BCL0 memory area
; ------------------------------------------------------------
MERGE @@VECT00:=BCL0

; ------------------------------------------------------------
; Merge FSL_CODE segment to BCL0 memory area
; ------------------------------------------------------------
MERGE FSL_CODE:=BCL0

; ------------------------------------------------------------
; OPTION BYTE location
; ------------------------------------------------------------
MERGE OPBYTE:AT(080H)=BCL0

; ------------------------------------------------------------
; Locate entry RAM within high speed RAM
; ------------------------------------------------------------
MERGE FSL_DATA:=RAM

; ------------------------------------------------------------
; Locate entry RAM within saddr RAM
; ------------------------------------------------------------
;MERGE FSL_DATA:AT(0FE20H)=RAM
```

5.4 Library integration/configuration

1. copy all the files into your project subdirectory
2. add the fsl*.* files into your project (workbench or make-file)
3. adapt project specific items following files:
   - fsl_user.h:
     - adapt the size of data-buffer you want to use for data exchange between firmware and application.
       User can define his own data-buffer. In that case the default fsl_data-buffer size(FSL_DATA_BUFFER_SIZE) should be set to 0.
   - - redefine the FLMD0-control-port macro
     - define the interrupt scenario (enable interrupts that should be active during selfprogramming)
     - define the back-up functionality during selfprogramming
   - fsl_user.c:
     - adapt FSL_Open() and FSL_Close() due to your requirements
4. adapt the *.DR file due to your requirements. The location of the fsl_entry_ram must be defined by FSL_DATA segment and the location of self-programming library code by FSL_CODE(see chapter " Sample - Link Directive File").
5. include fsl.h into your application file(s) which use the self-programming library
6. re-compile the project

Chapter 6 Appendix - IAR library

This chapter explains details on the self programming library for the IAR Compiler (Version V3.XX and V4.XX).

6.1 Self Programming Library - function prototypes

The self programming library consists of the following functions.

Table 6-1 Self Programming Library - function prototypes

Function prototype	Outline
void FSL_Open(void)	Opens a flash self programming session.
void FSL_Close(void)	Closes a flash self programming session.
fsl_u08 FSL_Init(fsl_u08* data_buffer_pu08)	Initializes entry RAM.
fsl_u08 FSL_ModeCheck(void)	Checks FLMD0 voltage level.
fsl_u08 FSL_BlankCheck(fsl_u08 block_u08)	Checks if specified block (1KB) is empty.
fsl_u08 FSL_Erase(fsl_u08 block_u08)	Erases a specified block (1KB).
fsl_u08 FSL_IVerify(fsl_u08 block_u08)	Verifies a specified block (1KB) (internal verification).
fsl_u08 FSL_Write(fsl_u32 s_address_u32, fsl_u08 word_count_u08)	Writes up to 64 words (each word equals 4 bytes) to a specified address.
fsl_u08 FSL_EEPROMWrite(fsl_u32 s_address_u32, fsl_u08 word_count_u08)	Blankcheck,writes and verify up to 64 words to a specified address.
fsl_u08 FSL_GetSecurityFlags(fsl_u08 *destination_pu08)	Reads the security information.
fsl_u08 FSL_GetActiveBootCluster(fsl_u08 *destination_pu08)	Reads the current value of the boot flag in extra area.
fsl_u08 FSL_GetBlockEndAddr(fsl_u32 *destination_pu32, fsl_u08 block_u08)	Puts the last address of the specified block into *destination_addr_H and destination_addr_L*
fsl_u08 FSL_InvertBootClusterFlag(void)	Inverts the current value of the boot flag in the extra area.
fsl_u08 FSL_SetChipEraseProtectFlag(void)	Sets the chip-erase-protection flag in the extra area.
fsl_u08 FSL_SetBlockEraseProtectFlag(void)	Sets the block-erase-protection flag in the extra area.
fsl_u08 FSL_SetWriteProtectFlag(void)	Sets the write-protection flag in the extra area.
fsl_u08 FSL_SetBootClusterProtectFlag(void)	Sets the bootcluster-update-protection flag in the extra area.

6.2 Explanation of Self Programming Library

Each self programming function is explained in the following format.

Self Programming Function name

Outline Outlines the self programming function.

Function prototype Shows the C-Compiler function prototype of the current function.

Note In this manual, the data type name is defined as followed.

Definition	Data Type
fsl_u08	unsigned char
fsl_u32	unsigned long int

Argument Indicates the argument of the self programming function.

Return Value Indicates the return value from the self programming function.

Register status after calling Indicates the status of registers after the self programming function is called.

Call example Indicates an example of calling the self programming function from a user program written in C language.

Flow Indicates the program flow of the self programming function.

6.2.1 Open

Outline This function may optionally preserve interrupt flag settings, and then FLMD0 pin will be pulled up by the user defined general purpose port, allowing further self programming functions.

After this function is called, program enters the so-called "user room".

Note

- Call this function at the beginning of the self programming operation.
- User may customize this function in the source files **fsl_user.h** and **fsl_user.c**, do a few more preprocesses, so as to adapt personal requirements.

Function prototype void FSL_Open (void)

Pre-condition None

Argument None

Return value None

Flow The following figure shows the flow of the self programming open function.

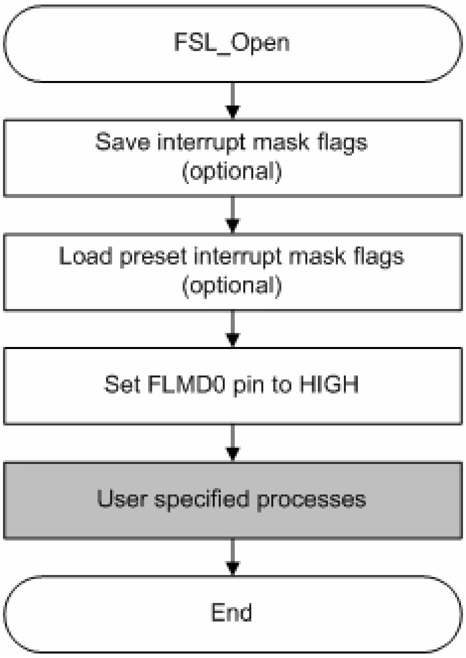

Figure 6-1 Flow of Self Programming Open Function

Note The preset interrupt mask flags are defined in the FSL user-configurable source file **fsl_user.h**

```
 // customizable interrupt controller configuration during selfprogramming period
/* all interrupts disabled during selfprogramming */
#define   FSL_MK0L_MASK   0xFF
#define   FSL_MK0H_MASK   0xFF
#define   FSL_MK1L_MASK   0xFF
#define   FSL_MK1H_MASK   0xFF
/*For the correct settings please refer to the chapter "Interrupt Functions"
of the corresponding device user's manual.*/
```

Interrupt backup If backup of interrupt mask flags is not necessary, user may comment out the following line.

```
 #define FSL_INT_BACKUP
```

FLMD0 port setting example Following example shows the macro definition for the FLMD0 control.

```
 /* fsl_user.h */
/*  FLDM0<->P3.0 connection pulled-down by 10kOhm resistor */
/*  IAR 4xx part */
#define  FSL_FLMD0_HIGH   {P3_bit.no0 = 1; PM3_bit.no0 = 0; }
#define  FSL_FLMD0_LOW    {P3_bit.no0 = 0; PM3_bit.no0 = 1; }

 /* fsl_user.c */
#define   FSL_PUSH_PSW_AND_DI       { asm("PUSH PSW");  asm("DI"); }
#define   FSL_POP_PSW                 asm("POP PSW");


/* FSL_Open();    */
FSL_PUSH_PSW_AND_DI;
FSL_FLMD0_HIGH;
FSL_POP_PSW;
```

6.2.2 Close

Outline
This funtion first switches the FLMD0 pin to LOW. Further selfprogramming procedures will be then disabled.

After that, user may optionally restore the interrupt flag settings, and do other user-specified processes. The program will then leave the "user room" for the self-programming.

Note
- Call this function at the end of the self programming operation.
- User may customize this function in the source files **fsl_user.h** and **fsl_user.c**.

Function prototype void FSL_Close (void)

Pre-condition None

Argument None

Return value None

Flow The following figure shows the flow of the self programming end function.

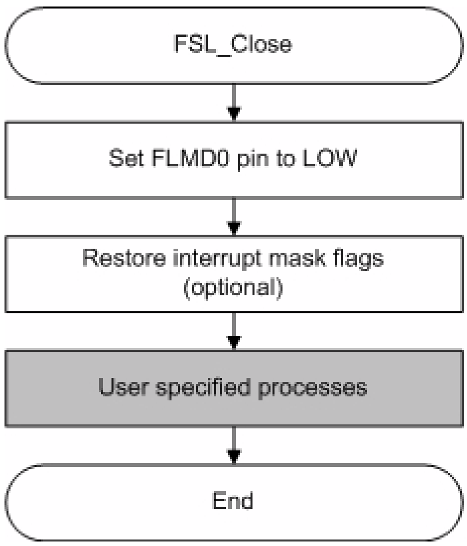

Figure 6-2 Flow of Self Programming End Function

6.2.3 Init

Outline

This function Initializes internal selfprogramming environment.

It prepares 100 bytes entry RAM specified by the user configurable XCL-file[Note1].It is used as a work area during self programming.

After initialization the start address of the data-buffer is stored in the entry RAM.

The areas other than data-buffer address and erase retry counter in the entry RAM are cleared to 0.

Note

1. The definition below locates in the FSL user-configurable **.xcl** file.

```
//------------------------------------------------------------
// Allocate saddr data segments.
//------------------------------------------------------------
-Z(DATA)FSL_DATA=FE20-FE83
```

Caution

The entry RAM may be allocated at any address of the internal high-speed RAM outside of the short direct addressing range.
To allocate the entry RAM in the internal high-speed RAM within the short direct addressing range, the first address has to be set to FE20H.

Function prototype

fsl_u08 FSL_Init (fsl_u08* data_buffer_pu08)

Pre-condition

The function FSL_Open() was successfully called.

Argument

Argument	C Language	Assembly
First address of data buffer[Note]	fsl_u08* data_buffer_pu08	AX

Note

For details on data buffer, please refer to the chapter "Software Environment".

Return Value

The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion - Pointer to the data-buffer is stored in the entry RAM.
OTHER	Error

Register status after calling

A = return value, X = destroyed

Call example

```
 extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE]; /* see fsl_user.c */

my_status_u08 = FSL_Init((fsl_u08*)&fsl_data_buffer);

if( my_status_u08 != 0x00 ) my_error_handler();
```

6.2.4 Mode Check

Outline This function checks the voltage level at FLMD0 pin, ensuring the hardware requirement of self programming.

For details on FLMD0 and hardware requirement, please refer tothe chapter "Hardware Environment".

Note Call this function after calling the self programming open function FSL_Open to check the voltage level of the FLMD0 pin.

Caution If the FLMD0 pin is at low level, operations such as erasing and writing the flash memory cannot be performed. To manipulate the flash memory by self programming, it is necessary to call this function and confirm, that the FLMD0 pin is at high level.

Function prototype fsl_u08 FSL_ModeCheck (void)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument None

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion -FLMD0 pin is at high level.
01H	Abnormal termination -FLMD0 pin is at low level.

Register status after calling **A = return value**

Call example

```
my_status_u08 = FSL_ModeCheck();
if( my_status_u08 != 0x00 ) my_error_handler();
```

6.2.5 Blank Check

Outline This function checks if a specified block (1KB) is blank (erased).

Note

- If the block is not blank, it should be erased and blank checked again.
- Because only one block is checked at a time, call this function once for each block.

Function-prototype fsl_u08 FSL_BlankCheck (fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C Language	Assembly
block number to be checked	fsl_u08 block_u08	A

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion Specified block is blank (erase operation is completed).
05H	Parameter error Specified block number is outside the allowed range.
1BH	Black check error Specified block is not blank (erase operation is not completed).
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **A = return value**

Call example

```
 my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_BlankCheck(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

6.2.6 Erase

Outline This function erases a specified block (1KB).

Note Because only one block is erased at a time, call this function once for each block.

Function prototype fsl_u08 FSL_Erase (fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C Language	Assembly
block number to be erased	fsl_u08 block_u08	A

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Specified block number is outside the allowed range.
10H	Protect error Specified block is included in the boot area and rewriting the boot area is disabled.
1AH	Erase error An error occurred during this function in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **A = return value**

Call example

```
 my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_Erase(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

6.2.7 Verify

Outline This function verifies (internal verification) a specified block (1KB).

Note

- Because only one block is verified at a time, call this function once for each block.
- This internal verification is a function to check if written data in the flash memory is at a sufficient voltage level.
- It is different from a logical verification that just compares data.

Caution After writing data, verify (internal verification) the block including the range in which the data has been written. If verification is not executed, the written data is not guaranteed.

Function prototype fsl_u08 FSL_IVerify (fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
the to-verify block number	fsl_u08 block_u08	A

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Specified block number is outside the allowed range.
1BH	Verify (internal verify) error An error occurs during this function is in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling **A = return value**

ROM capacity 9 bytes + 46 bytes (common routine)

Call example

```
 my_block_u08 = 0x7F;

do
{
  my_status_u08 = FSL_IVerify(my_block_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

6.2.8 Write

Outline

This function writes the specified number of words (each word equals 4 bytes) to a specified address.

Note

- Set a RAM area as a data buffer, containing the data to be written and call this function.
- Data of up to 256 bytes (i.e. 64 words) can be written at one time.
- Call this function as many times as required to write data of more than 256 bytes.

Caution

- After writing data, execute verification (internal verification) of the block including the range in which the data has been written. If verification is not executed, the written data is not guaranteed.
- It is not allowed to overwrite data in flash memory.
- Only blank flash cells can be used for the write.

Function prototype

fsl_u08 FSL_Write (fsl_u32 s_address_u32, fsl_u08 word_count_u08)

Pre-condition

The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init. Data buffer was filled with data, which will be written into the flash.

Argument

Argument	C language	Assembly
starting address of the data to be written[Note]	fsl_u32 s_address_u32	AX, BC
Number of the data to be written (1 to 64)	fsl_u08 block_u08	D*

*** IAR 3.xx version: block number passing over stack**

Note

- **s_address_u32** is a physical address(e.g. 1FC00H), not a logical address(e.g. 5BC00H)
- **(s_address_u32** + (Number of data to be written x 4 bytes)) must not straddle over the end address of a single block.
- **s_address_u32** must be a multiple of 4
- Most significant byte (MSB) of the **s_address_u32** has to be 0x00 In other words, only *0x00abcdef* is a valid flash address.
- **word_count***4 has to be less or equal than the size of data buffer. The firmware does not check this.

Return Value

The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error - Start address is not a multiple of 1 word (4 bytes). - The number of data to be written is 0. - The number of data to be written exceeds 64 words. - Write end address (Start address + (Number of data to be written x 4 bytes)) exceeds the flash memory area.
10H	Protect error Specified range includes the boot area and rewriting the boot area is disabled.
1CH	Write error Data is verified but does not match after this function operation is completed or FLMD0 pin is low.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling

A = return value; X, B and C destroyed

Call example

```
 // prepare data and write it into the data buffer for the writing process
..........
..........

my_address_u32 = 0x0001FC00;   // set address for write procedure
my_write_count_u08 = 0x02;     // set word count

do
{
  my_status_u08 = FSL_Write(my_address_u32, my_write_count_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

6.2.9 EEPROMWrite

Outline

This function writes the specified number of words (each word equals 4 bytes) to a specified address.

Different to **FSL_Write**, blank check will be performed, before "writing" n words. After "writing" n words internal verify is performed.

Note

- Set a RAM area as a data buffer containing the data to be written and call this function.
- Data of up to 256 bytes (i.e. 64 words) can be written at one time.
- Call this function as many times as required to write data of more than 256 bytes.

Caution

- It is not allowed to overwrite data in flash memory.
- Only blank flash cells can be used for the write.

Function prototype

fsl_u08 FSL_EEPROMWrite (fsl_u32 s_address_u32, fsl_u08 word_count_u08)

Pre-condition

The self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
starting address of the data to be written[Note]	fsl_u32 s_address_u32	AX, BC
Number of the data to be written (1 to 64)	fsl_u08 block_u08	D*

*** IAR 3.xx version: block number passing over stack**

Note

- **(s_address_u32** + (Number of data to be written x 4 bytes)) must not straddle over the end address of a single block.
- **s_address_u32** must be a multiple of 4
- Most significant byte (MSB) of the **s_address_u32** has to be 0x00 In other words, only *0x00abcdef* is a valid flash address.
- **word_count***4 has to be smaller than the size of data buffer. The firmware does not check this.

Return Value

The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error - Start address is not a multiple of 1 word (4 bytes). - The number of data to be written is 0. - The number of data to be written exceeds 64 words. - Write end address (Start address + (Number of data to be written x 4 bytes)) exceeds the flash memory area.
10H	Protect error Specified range includes the boot area and rewriting the boot area is disabled.
1CH	Write error Data is verified but does not match after this function operation is completed or FLMD0 pin is low..
1DH	Verify error Data is verified but does not match after it has been written.
1EH	Blank error Write area is not a blank area.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling

A = return value; X, B and C destroyed

```
 // prepare data and write it into the data buffer for the writing process
..........
..........

my_address_u32 = 0x0001FC00;   // set address for write procedure
my_write_count_u08 = 0x02;     // set word count

do
{
  my_status_u08 = FSL_EEPROMWrite(my_address_u32, my_write_count_u08);

  // in case of FSL_ERR_INTERRUPTION is returned here,
  // the corresponding ISR is already executed !!!

} while (my_status_u08 == FSL_ERR_INTERRUPTION);

// exit if error occurs
if (my_status_u08 != FSL_OK) my_error_handler(....)
```

6.2.10 Get Security Flags

Outline This function reads the security (write-/erase-protection) information from the extra area.

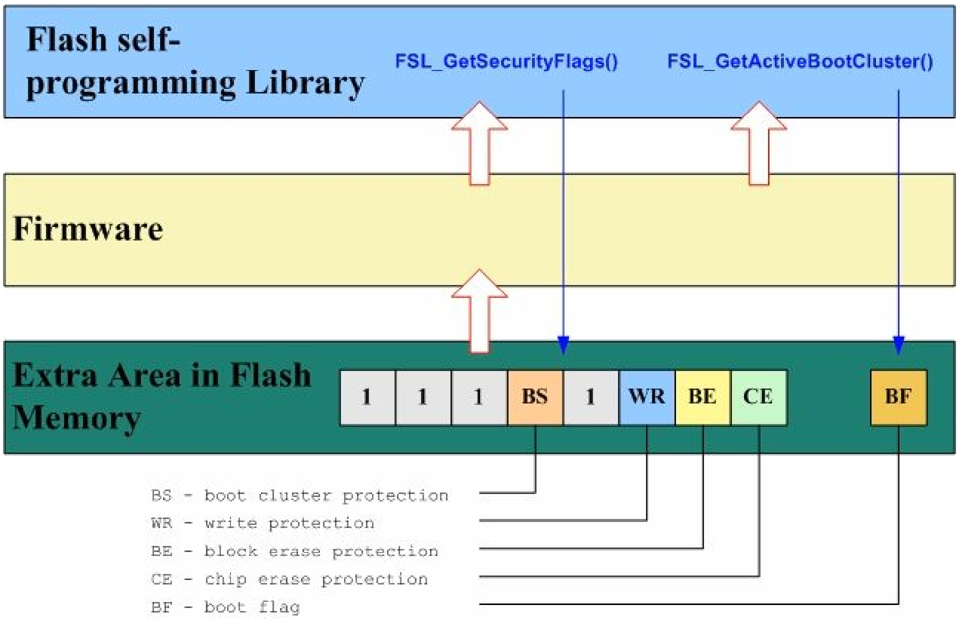

Figure 6-3 **Security Information Structure**

Function prototype fsl_u08 FSL_GetSecurityFlags (fsl_u08 *destination_pu08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Storage address of the security information	fsl_u08 *destination_pu08	AX

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error
20H	Read error

Change in the destination address.

Security flag will be written in the destination address.

Meaning of each bit of security flag.
Bit 0: Chip erase protection (0: Enabled, 1: Disabled)
Bit 1: Block erase protection (0: Enabled, 1: Disabled)
Bit 2: Write protection (0: Enabled, 1: Disabled)
Bit 4: Boot area overwrite protection (0: Enabled, 1: Disabled)
Bits 3, 5, 6 and 7 are always 1.

Example

If *EB*H (i.e. *11101011*) is written to destination address, boot area overwrite and write operations to the flash area are forbidden.

Register status after calling **A = return value, X = destroyed**

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE];

/* get security informations                          */
my_status_u08 = FSL_GetSecurityFlags ((fsl_u08*)&my_security_dest_u08);

if( my_status_u08 != 0x00 )
   my_error_handler();

if(my_security_dest_u08 & 0x01){ myPrintFkt("Chip erase protection disabled!"); }
else{ myPrintFkt("Chip erase protection enabled!"); }
```

6.2.11 Get Active Boot Cluster

Outline

This function reads the current value of the boot flag in extra area.

Function prototype

fsl_u08 FSL_GetActiveBootCluster (fsl_u08 *destination_pu08)

Pre-condition

The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Destination address of the boot swap info	fsl_u08 *destination_pu08	AX

Return Value

The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error
20H	Read error

Changes in the destination address.

Boot flag will be written in the destination address.

00H: Boot area is not swapped.
01H: Boot area is swapped.

Example

If *01*H is written to destination address, boot area is swapped.

Register status after calling

A = return value, X, B = destroyed

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[FSL_DATA_BUFFER_SIZE];

/* get boot-swap flag                                    */
my_status_u08 = FSL_GetActiveBootCluster((fsl_u08*)&my_bootflag_dest_u08);

if( my_status_u08 != 0x00 )
   my_error_handler();

if(my_bootflag_dest_u08){ myPrintFkt("Boot area is swapped!"); }
else{ myPrintFkt("Boot area is not swapped!"); }
```

6.2.12 Get Block End Address

Outline This function puts the last address of the specified block into *destination_pu32.

Note This function may be used to secure the write function **FSL_Write**. If write operation exceeds the end address of a block, the written data is not guaranteed. Use this function to check whether the (write address + word number * 4) exceeds the end address of a block before calling the write function.

Function prototype fsl_u08 FSL_GetBlockEndAddr ((fsl_u32*) destination_pu32, fsl_u08 block_u08)

Pre-condition The flash self-programming environment was successfully opened by the functions FSL_Open and FSL_Init.

Argument

Argument	C language	Assembly
Destination address of the block end address info	fsl_u32 *destination_pu32	AX
Block number the end-address is asked for	fsl_u08 block_u08	B

Return Value The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error

Changes in the destination address.

Block end address will be written in the destination address.

Example

If *6C*H is given as block number, *1B3FF*H will be written to the destination address.

Register status after calling **A = return value, X, B = destroyed**

Call example

```
/* extern variable declaration(see fsl_user.c) */
extern fsl_u08 fsl_data_buffer[DATA_BUFFER_SIZE];


fsl_u32 my_address_u32;
fsl_u08 my_block_u08 = 0x7F;

/* get end adress of the block                          */
my_status_u08 = FSL_GetBlockEndAddr((fsl_u32*)&my_address_u32, my_block_u08);

if( my_status_u08 != 0x00 )
   my_error_handler();

/*      ####### ANALYSE my_address_u32 #######          */
```

6.2.13 Set and Invert Functions

Outline The selfprogramming library has 5 functions for setting security bits . Each dedicated function sets a corresponding security flag in the extra area.

These functions are listed below.

Funtion name	Outline
invert boot flag function	Inverts the current value of the boot flag*.
set chip-erase-protection function	Sets the chip-erase-protection flag*.
set block-erase-protection function	Sets the block-erase-protection flag*.
set write-protection function	Sets the write-protection flag*.
set boot-cluster-protection function	Sets the bootcluster-update-protection flag*.

* This flag is stored in the flash extra area.

Caution

1. **A recalled FSL_Setxx or FSL_Invertxxx command is allways restarted from the beginning and cannot be resumed. To execute such command mask all interrupts before using these commands(DI is not enough).**
2. **Chip-erase protection and boot-cluster protection cannot be reset by programmer.**
3. **The FSL_Setxx or FSL_Invertxxx functions cannot be performed in low current consumption mode. In that case the functions will return parameter error. This caution concerns to 78K0/Ix2/Kx2-L only. For detailed information please refer to the device users manual.**
4. After RESET the other boot-cluster is activated. Please ensure a valid boot-loader inside the area, before calling the function.
5. Each security flag can be written by the application only once until next reset.
6. Block-erase protection and write protection can be reset by programmer.

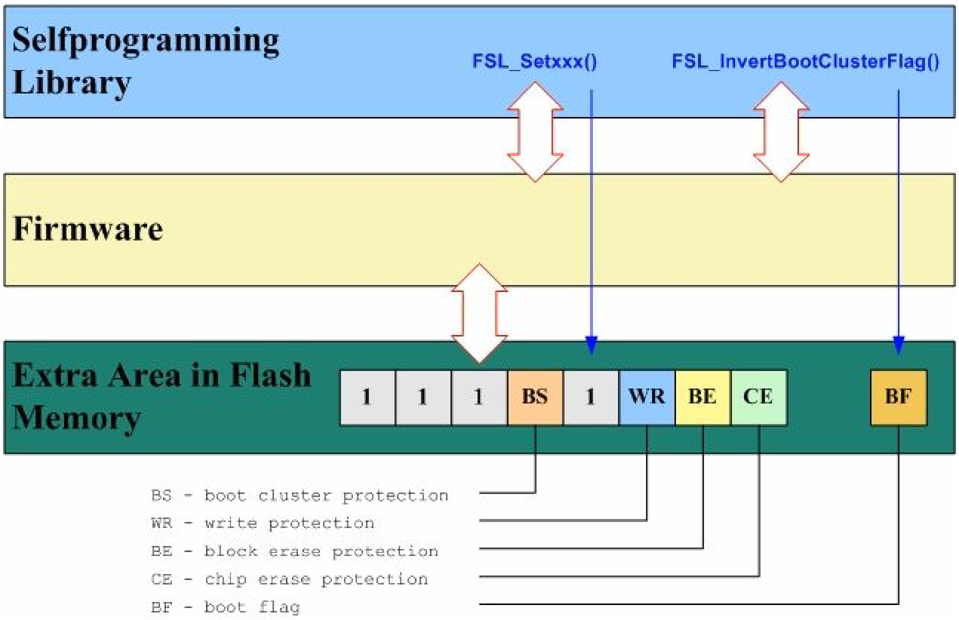

Figure 6-4 Extra Area

Function prototypes

Function name	Function prototype
invert boot flag function	fsl_u08 FSL_InvertBootClusterFlag(void)
set chip-erase-protection function	fsl_u08 FSL_SetChipEraseProtectFlag(void)
set block-erase-protection function	fsl_u08 FSL_SetBlockEraseProtectFlag(void)
set write-protection function	fsl_u08 FSL_SetWriteProtectFlag(void)
set boot-cluster-protection function	fsl_u08 FSL_SetBootClusterProtectFlag(void)

Argument

None

Return Value

The status is stored in *A register* in assembly language, and returned in the *fsl_u08* type variable in C language.

Status	Explanation
00H	Normal completion
05H	Parameter error Bit 0 of the information flag value is cleared to 0 for a product that does not support boot swapping.
10H	Protection error - Attempt is made to enable a flag that has already been disabled. - Attempt is made to change the boot area swap flag while rewriting of the boot area is disabled.
1AH	Erase error An erase error occurs while this function is in process.
1BH	Internal verify error A verify error occurs while this function is in process.
1CH	Write error A write error occurs while this function is in process.
1FH	Process interrupted. A user interrupt occurs while this function is in process.

Register status after calling

A = return value

Call example

```
my_status_u08 = FSL_SetBlockEraseProtectFlag();

if( my_status_u08 != 0x00 )
   my_error_handler();
```

6.3 Sample - Linker Command File

The self-programming library uses two segments for data and code allocation:

- **FSL_CODE(code)**
  Within this segment the flash self-programming library will be located. Be sure to locate this segment within common area.
- **FSL_DATA(data)**
  Segment for the fsl_entry_ram.

Listed below is an example of the XCL(Linker Command File) file for the self-programming library.

```
//--------------------------------------------------------------------------
//      Define CPU
//--------------------------------------------------------------------------
-c78000

//--------------------------------------------------------------------------
// Allocate the read only segments that are mapped to ROM.
//--------------------------------------------------------------------------

//--------------------------------------------------------------------------
// Allocate interrupt vector segment.
//--------------------------------------------------------------------------
-Z(CODE)INTVEC=0000-003F

//--------------------------------------------------------------------------
// Allocate CALLT segments.
//--------------------------------------------------------------------------
-Z(CODE)CLTVEC=0040-007D

//--------------------------------------------------------------------------
// Allocate OPTION BYTES segment.
//--------------------------------------------------------------------------
-Z(CODE)OPTBYTE=0080-0081

//--------------------------------------------------------------------------
// Allocate SECURITY_ID segment.
//--------------------------------------------------------------------------
-Z(CODE)SECUID=0084-008E

//--------------------------------------------------------------------------
// Allocate CALLF segment.
//--------------------------------------------------------------------------
//-Z(CODE)FCODE=0800-0FFF

//--------------------------------------------------------------------------
// flash self-programming library code segment.
//--------------------------------------------------------------------------
-Z(CODE)FSL_CODE=0100-0FFF

//--------------------------------------------------------------------------
// Startup, Runtime-library, Non banked, Interrupt
// and Calltable functions code segment.
//--------------------------------------------------------------------------
-Z(CODE)RCODE,CODE=1000-7FFF

//--------------------------------------------------------------------------
// Data initializer segments.
//--------------------------------------------------------------------------
-Z(CODE)NEAR_ID,SADDR_ID,DIFUNCT=1000-7FFF

//--------------------------------------------------------------------------
// Constant segments
//--------------------------------------------------------------------------
-Z(CODE)CONST,SWITCH=1000-7FFF
```

```
//-------------------------------------------------------------------------
// Banked functions code segment.
// The following code segments are available:
// - BCODE segment uses all banks
// - BANKx,BANKCx segments use only bank x
//-------------------------------------------------------------------------
-P(CODE)BCODE=[_CODEBANK_START-_CODEBANK_END]*_CODEBANK_BANKS+10000
-Z(CODE)BANK0,BANKC0=[(_CODEBANK_START+00000)-(_CODEBANK_END+00000)]
-Z(CODE)BANK1,BANKC1=[(_CODEBANK_START+10000)-(_CODEBANK_END+10000)]
-Z(CODE)BANK2,BANKC2=[(_CODEBANK_START+20000)-(_CODEBANK_END+20000)]
-Z(CODE)BANK3,BANKC3=[(_CODEBANK_START+30000)-(_CODEBANK_END+30000)]
-Z(CODE)BANK4,BANKC4=[(_CODEBANK_START+40000)-(_CODEBANK_END+40000)]
-Z(CODE)BANK5,BANKC5=[(_CODEBANK_START+50000)-(_CODEBANK_END+50000)]

//-------------------------------------------------------------------------
// Allocate internal extended RAM segment(s).
//
// Note: This segment(s) will not be automatically created by ICC78000/A78000
//       and it will not be initialised by CSTARTUP!
//-------------------------------------------------------------------------
-Z(DATA)IXRAM=E000-F7FF

//-------------------------------------------------------------------------
// Allocate Buffer RAM segment.
//
// Note: This segment will not be automatically created by ICC78000/A78000
//       and it will not be initialised by CSTARTUP!
//-------------------------------------------------------------------------
-Z(DATA)BUFRAM=FA00-FA1F

//-------------------------------------------------------------------------
// Allocate near data, heap and stack segments.
//-------------------------------------------------------------------------
-Z(DATA)HEAP+_HEAP_SIZE,CSTACK+_CSTACK_SIZE,NEAR_I,NEAR_Z,NEAR_N=FB00-FE1F

//-------------------------------------------------------------------------
// Allocate saddr data segments.
//-------------------------------------------------------------------------
-Z(DATA)FSL_DATA=FE20-FE87
-Z(DATA)SADDR_I,SADDR_Z,SADDR_N,WRKSEG=FE88-FEDF

//-------------------------------------------------------------------------
// Logical to physical address translation
//-------------------------------------------------------------------------
-M18000-1BFFF=0C000-0FFFF
-M28000-2BFFF=10000-13FFF
-M38000-3BFFF=14000-17FFF
-M48000-4BFFF=18000-1BFFF
-M58000-5BFFF=1C000-1FFFF

//-------------------------------------------------------------------------
// End of File
//-------------------------------------------------------------------------
```

6.4 Library integration/configuration

1. copy all the files into your project subdirectory
2. add the fsl*.* files into your project (workbench or make-file)
3. adapt project specific items following files:
   - fsl_user.h:
     - change the included device header-file to your need
   - - adapt the size of data-buffer you want to use for data exchange between firmware and application.
       User can define his own data-buffer. In that case the default fsl_data-buffer size(FSL_DATA_BUFFER_SIZE) should be set to 0.
     - redefine the FLMD0-control-port macro
     - define the interrupt scenario (enable interrupts that should be active during selfprogramming)
     - define the back-up functionality during selfprogramming
   - fsl_user.c:
     - adapt FSL_Open() and FSL_Close() due to your requirements
4. adapt the *.XCL file due to your requirements. The location of the fsl_entry_ram must be defined by FSL_DATA segment and the location of flash self-programming library code by FSL_CODE(see chapter "Sample - Linker Command File").
5. include fsl.h into your application file(s) which use the flash self-programming library
6. re-compile the project

Chapter 7 Appendix - Sample Code

The following example shows the typically call and interrupt handling sequence of the self-programming library.

```
// ==========================================================================================
// execute the selected command
// ==========================================================================================
 FSL_Open();
 (void)FSL_Init( &my_data_buffer);

 if (FSL_ModeCheck() == FSL_OK)
 {
   // check block by block if blank
   for (my_block_u08=my_block_s_u08; my_block_u08 <= my_block_e_u08; my_block_u08++)
   {
   // blank-check current block as long as not completed or error occurs
   // --------------------------------------------------------------------
     do
     {
       my_status_u08 = FSL_BlankCheck(my_block_u08);

       // in case of FSL_ERR_INTERRUPTION is returned here,
       // the corresponding ISR is already executed !!!

      } while (my_status_u08 == FSL_ERR_INTERRUPTION);

     // exit if error occurs
     if (my_status_u08 != FSL_ERR_NO) My_Error_Handler(....);
   }
 }
 FSL_Close();
// ==========================================================================================
```

Revision History

All changes of this document revision are related to the new supported devices (78K0/Ix2/Kx2-L/Dx2/uCFL/LIN4). All the characteristics like ROM/RAM consumption, execution time are changed according to the actual library version. The previous version of this document is U18990EE1V0AN00.

Chapter	Page	Description
2	17	Caution added for different FLMD0 control on 78K0/Kx2-L and 78K0/Ix2 devices.
5	49	Caution added for FSL_Setxx and FSL_Invertxxx functions regarding new devices support of 78K0/Kx2-L/Ix2.
6	71	Caution added for FSL_Setxx and FSL_Invertxxx functions regarding new devices support of 78K0/Kx2-L/Ix2.