

STR7 family Flash programming

Introduction

This reference manual describes how to program the Flash memory of an STR7 microcontroller.

The STR7 embedded Flash memory can be programmed using In-Circuit Programming or In-Application programming.

The **In-Circuit programming (ICP)** method is used to update the entire contents of the Flash memory, using the JTAG protocol to load the user application into the microcontroller. ICP offers quick and efficient design iterations and eliminates unnecessary package handling or socketing of devices.

In contrast to the ICP method, **In-Application Programming (IAP)** can use any communication interface supported by the microcontroller (I/Os, USB, CAN, UART...) to download the data to be programmed in memory. IAP allows you to re-program the Flash memory while the application is executing. Nevertheless, part of the application has to have been previously programmed in one of the Flash banks using ICP.

The MCUs supported by this reference manual are the STR71x, STR73x and STR75x.

Glossary

This section gives a brief definition of acronyms and abbreviations used in this document:

FPEC (FLASH Program/Erase controller): The write operations to the 2 banks are managed by an embedded FPEC.

IAP (In-Application Programming): The IAP is the ability to re-program the Flash memory of a microcontroller while the user program is running.

ICP (In-Circuit Programming): The ICP is the ability to program the Flash memory of a microcontroller using JTAG protocol while the device is mounted on the user application board.

JTAG (Joint Test Action Group): The debug interface of the ARM7TDMI core is based on the Joint Test Action Group (JTAG) protocol.

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1 Flash module organization

The on-chip Flash is divided in 2 banks that can be read and modified independently one from the other: one bank can be read while another bank is being modified.

[Table 1](#) shows the Flash Module Organization, while [Table 2](#) shows the Control Register interface, with the registers that can be addressed by the CPU.

Table 1. Flash module organization

Bank	Sector	Addresses (Offset)	Size (bytes)
Bank 0 256 Kbytes Program Memory + 8K SystemMemory ⁴⁾	Bank 0 Flash Sector 0 (B0F0)	0x00 0000 - 0x00 1FFF	8K
	Bank 0 Flash Sector 1 (B0F1)	0x00 2000 - 0x00 3FFF	8K
	Bank 0 Flash Sector 2 (B0F2)	0x00 4000 - 0x00 5FFF	8K
	Bank 0 Flash Sector 3 (B0F3)	0x00 6000 - 0x00 7FFF	8K
	Bank 0 Flash Sector 4 (B0F4)	0x00 8000 - 0x00 FFFF	32K
	Bank 0 Flash Sector 5 (B0F5)	0x01 0000 - 0x01 FFFF	64K ²⁾
	Bank 0 Flash Sector 6 (B0F6)	0x02 0000 - 0x02 FFFF	64K ¹⁾²⁾
	Bank 0 Flash Sector 7 (B0F7)	0x03 0000 - 0x03 FFFF	64K ¹⁾²⁾
	Bank 0 SystemMemory Sector ⁴⁾	0x10 C0000 - 0x10DFFF ⁴⁾	8K ⁴⁾
Bank 1 16 Kbytes Data Memory ³⁾	Bank 1 Flash Sector 0 (B1F0)	0x0C 0000 - 0x0C 1FFF	8K
	Bank 1 Flash Sector 0 (B1F1)	0x0C 2000 - 0x0C 3FFF	8K

¹⁾ Not available in 128K versions. ²⁾ Not available in 64K versions. ³⁾ Not available in STR73x.

⁴⁾ Available only in STR73x and STR75x.

Table 2. Control and Protection Register Interface

Name	Description	Addresses	Size
FLASH_CR1-0	Flash Control Registers 1-0	0x10 0000 - 0x10 0007	2 x 32-bit
FLASH_DR1-0	Flash Data Registers 1-0	0x10 0008 - 0x10 000F	2 x 32-bit
FLASH_AR	Flash Address Register	0x10 0010 - 0x10 0013	32-bit
FLASH_ER	Flash Error Register	0x10 0014 - 0x10 0017	32-bit
FLASH_NVWPR	Non Volatile Write Protection Register	0x10 DFB0 - 0x10 DFB3	32-bit
FLASH_NVAPR1-0	Non Volatile Access Protection Register 0-1	0x10 DFB8 - 0x10 DFBF	2 x 32-bit

The Flash program memory is organized in 32-bit wide memory cells which can be used for storing both code and data constants. The flash module is located at a specific base address in the memory map of each STR7 Microcontroller type. For the base address, please refer to the related STR7 Microcontroller Reference Manual.

SystemMemory is a sector used to boot the device in SystemMemory Boot Mode. The area is reserved for use by STMicroelectronics. It is programmed by ST when the device is manufactured and protected against spurious write/erase operations.

Bank 1 contains 16 Kbytes of Data Memory: it is divided into 2 sectors (8 Kbytes each). You can program application data in this area.

You can Program Bank 0 and Bank 1 independently, i.e. you can read from one bank while writing to the other.

The write operations of the two banks are managed by an embedded Flash Program/Erase Controller (FPEC). The high voltage needed for Program/Erase operations is internally generated.

The Flash memory can be protected against different types of unwanted access (read/write/erase). There are two types of protection:

- Sector Write Protection
- Flash DEBUG/READOUT Protection

Refer to [Section 3](#) for more details.

During a Flash write operation any attempt to read the bank under modification will output invalid data. This means that the Flash bank is not fetchable when a write operation is active.

Note: *The write operation commands must be executed from another bank or another memory (internal RAM or external memory).*

You can program Flash memory using In-Circuit Programming and In-Application programming.

2 Read/program the STR7 embedded Flash

2.1 Introduction

This section describes how to read or to program the STR7 embedded Flash.

2.2 Read operation

The embedded flash module can be addressed directly, as a common memory space. Any 32-bit data read operation accesses the content of the Flash module through dedicated read senses and provides the requested data.

2.3 Write operation

In this section, a Flash write operation refers either to a program operation, or an erase operation:

- A program operation is a word, a double word or set protection programming operation of the Flash module (writing '0' to some bits of the selected word)
- An erase operation is a sector erase of the Flash module (writing '1' to all bits of the selected sector).

2.3.1 Executing the first Write operation from RAM

After an MCU reset, the Flash module is ready and the CPU can start fetching code from it. However, the built-in Flash Erase/Program procedures are not initialized during the MCU reset phase, this is only done when the first Flash Erase/Program instruction is executed.

The Erase/Program procedures are stored in a reserved area of bank 0. While they are being initialized Flash bank 0 is not accessible for the user.

The first Flash Erase/Program operation is started when the WMS bit is set. After setting this bit, Bank 0 is no longer accessible. For this reason the code to be executed after setting the WMS bit (Polling the bits LOCK, BSYA0 and BSYA0) must be fetched from RAM.

Also, due to this initialization, the first Erase/Program operation will take more time than other subsequent Erase/Program operations.

2.3.2 Generic Write Operation Description

In general, each *write* operation is started through a sequence of 3 steps:

- The first step selects the desired operation (Program or Erase) by setting the corresponding selection bit in the Flash Control Register 0 (FLASH_CR0).
- The second step defines the information needed for the write operation:
- Address in the Flash Address Register (FLASH_AR) and data in the Flash Data Registers (FLASH_DR0, FLASH_DR1) for program operation
- Or sectors in Flash Control Register 1 (FLASH_CR1) for erase operation.
- The last step starts the write operation, setting the start bit WMS in the FLASH_CR0.

Once selected, but not yet started, the operation can be canceled by resetting the operation selection bit from Flash Control Register 0 (FLASH_CR0).

Once the write operation is started, the Flash controller checks the validity of the operation (see [Section 2.3.7 on page 9](#)). When validity has been verified, it sets the BSY bits in FLASH_CR0 while processing the operation. The Flash controller releases the BSY bits when the operation is completed.

The Flash controller can only manage one write operation at a time. For example, it is not possible to program a word while erasing a sector even if the word belongs to a different sector. During a write operation to a user bank, any access to the bank is forbidden and will return undefined data.

This means that code or data fetches cannot be made while a write operation on the bank is being performed.

To bypass this limitation, for long operations like a sector erase, a suspend mechanism enables to temporary stop it to perform higher priority tasks. After the high priority tasks complete, the previous operation can be completed.

The bits in the FLASH_CR0 register allow you to monitor the Flash controller status and to check if a write operation is on going.

An interrupt request can be generated at the end of each write operation if the INTM bit in the FLASH_CR0 register is set.

It is recommended to read the Flash Error Register (FLASH_ER), at the end of a write operation, to check that the operation was completed successfully.

2.3.3 Erase Operation Description

An erase operation allows you to erase a sector or the full content of a bank:

- Select the erase operation, setting the Sector Erase (SER) bit in the Flash Control Register 0 (FLASH_CR0).
- Select the sectors to be erased in Flash Control Register 1 (FLASH_CR1).
- Start the erase operation, setting the start bit WMS in the FLASH_CR0.

Note: To erase the full content of a bank, just set all the BxFy bits in Flash Control Register 1 (FLASH_CR1).

2.3.4 Word Program Operation Description

A single word program operation allows you to program a single word in the Flash module:

- Select the single word program operation, by setting the Word Program (WPG) bit in the Flash Control Register 0 (FLASH_CR0).
- Write the word to be programmed in the Flash Data Register (FLASH_DR0).
- Write the address where to program in the Flash Address Register (FLASH_AR).
- Start the program operation, by setting the start bit WMS in the FLASH_CR0.

2.3.5 Double Word Program operation description

A double word program operation allows you to program two words in the Flash module:

- Select the double word program operation, by setting the Double Word Program (DWPG) bit in the Flash Control Register 0 (FLASH_CR0).
- Write the least significant word to be programmed in the Flash Data Register 0 (FLASH_DR0) and the most significant word to be programmed in the Flash Data Register 1 (FLASH_DR1).
- Write the address of the location to be programmed in the Flash Address Register (FLASH_AR).
- Start the *program* operation, setting the start bit WMS in the FLASH_CR0.

Note: The address where the double word is to be programmed should be aligned on a double word boundary. In case the address is not at a double word boundary, the SEQER flag of the Flash Error Register will be set.

2.3.6 Suspend Operation Description

As described in the above [Section 2.3 on page 6](#), the Flash controller can only manage one *write* operation at a time. This might be a limitation for long operations like a sector erase: the application may need to quickly access the bank while the operation still needs some time to complete.

A suspend mechanism enables to suspend an on-going operation and resume it afterward:

- Set the SUSP bit in FLASH_CR0, to suspend the operation.
- Wait until the Flash controller acknowledges the suspend of the operation resetting both BSY bits and the LOCK bit in the FLASH_CR0 register.

To resume the operation:

- Clear the SUSP bit in the FLASH_CR0 register.
- Configure FLASH_CR0 with the operation that has been suspended and needs to be resumed.
- Restart the write operation, by setting the start bit WMS in the FLASH_CR0.

Note: To resume a suspended operation, only the FLASH_CR0 needs to be reconfigured with the operation to be resumed. All data in FLASH_CR1, FLASH_DR0, FLASH_DR1 and FLASH_AR are saved when the suspend is requested. A Resume Error (See [Section 2.3.7 on page 9](#)) will be generated when the resumed operation configured in FLASH_CR0 does not match with the suspended operation.

Not all operations are available during *suspend*:

- When in *program suspend*, the Flash controller accepts only the following operations: *read* and *program resume*.
- When in *erase suspend*, the Flash controller accepts only the following operations: *read*, *erase resume* and *program*. Program operation can be performed in any sector with the exception of the sectors in *erase suspend*.

Note: Single/double Word Program operations **cannot** be suspended during *erase suspend*.

Note: Erase operations are not allowed during *program suspend*.

2.3.7 Errors during Write Operation

A complete set of checks is done by the Flash controller after each write operation to verify that the operation completed successfully.

The FLASH_ER register provides dedicated flags for each error type that might arise during a write operation as well as a global flag triggered on any error.

The following errors may occur during write operation:

- Hardware errors:
 - Program Error: this error reports a physical failure of a Flash cell that can no more be programmed. The word where this error occurred must be rejected.
 - Erase Error: this error reports a physical failure of a Flash cell that can no more be programmed. The sector where this error occurred must be rejected.
- Software errors:
 - 1 over 0 error: this error reports an attempt to program at '1' a bit, whereas it was already programmed at '0'. The data should be masked with the current value, or the sector should be erased before reprogramming this data.
 - Sequence error: this error reports that an incorrect sequence has been executed to trigger the write operation. The code applying the sequence should be checked.
 - Resume error: this error reports that a suspend write operation has not been correctly resumed. The full operation sequence has to be redone.
 - Protection error: this error reports an attempt to write a sector which is write protected. If the sector effectively needs to be written, the sector should first be temporary unprotected, then the full operation sequence has to be reexecuted.

2.3.8 Interrupted Write Operation

A failing write operation is normally flagged in the Flash Error Register (FLASH_ER). Nevertheless, if during a write operation, the internal 1.8V Vdd supply drops below the internal Flash low voltage detector threshold or if a reset is triggered, the operation is suddenly interrupted and the Flash controller is reset to Read mode without updating the FLASH_ER.

The sectors or words that were under modification while the write operation has been interrupted becomes undefined. The interrupted write operation must be repeated to recover these resources.

2.3.9 Write Operation Summary

A summary of the available Flash controller write operations is shown in [Table 3](#)

Table 3. Flash Write Operations

Operation	Select bit	Address and Data	Start bit
Word Program	WPG	FLASH_AR + FLASH_DR0	WMS
Double Word Program	DWPG	FLASH_AR + FLASH_DR0 + FLASH_DR1	WMS
Sector Erase	SER	FLASH_CR1	WMS
Set Protection ¹⁾	SPR	FLASH_AR + FLASH_DR0	WMS
Program/Erase Suspend	SUSP	None	None ²⁾

¹⁾ See [Section 3](#) for details on memory protection.

²⁾ The FLASH_CR0 register needs to be reconfigured with the operation to be resumed.

2.4 Register description

In this section, the following abbreviations are used:

Table 4. Abbreviations

read/write (rw)	Software can read and write to these bits.
read-only (r)	Software can only read these bits.
read/clear (rc_w0)	Software can read as well as clear this bit by writing '0'. Writing '1' has no effect on the bit value.
read/set (rs)	Software can read as well as set this bit. Writing '0' has no effect on the bit value.
reserved (Res.)	Reserved bit, must be kept at reset value.

2.4.1 Flash Control Register 0 (FLASH_CR0)

Address offset: 0x10 0000h

Reset value: 0x0000 0000h

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
WMS	SUSP	WPG	DWPG	SER	Res.	Res.	SPR	Res.	SMBM ²⁾	INTM	INTP	Reserved			
rs	rw	rw	rw	rw			rw		rc_w0	rw	rc_w0				
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PWD ³⁾	Reserved										LOCK	Res.	BSYA1 ¹⁾	BSYA0	Res.
rw											r		r	r	

¹⁾ Not available in STR73x. ²⁾ Available only in STR73x. ³⁾ Not available in STR75x.

The Flash Control Register 0 (FLASH_CR0) is used to enable and to monitor all the write operations for the Flash controller.

Note: If two or more operation selection bits (WPG, DWPG or SER) are set at the same time, they will be ignored and the current operation will be cancelled.

- Bit 31 **WMS: Write Mode Start.**
This bit must be set to start a write operation (program or erase) in the Flash module. At the end of the write operation or during a suspend, this bit is automatically reset.
Resetting this bit by software has no effect.
- Note:* *Setting WMS if bit ERR in the FLASH_ER register is high has no effect: the operation is ignored.*
- Note:* *It is forbidden to start a new write operation (by setting WMS high) with bit SUSP in the FLASH_CR0 register is high. To resume a suspended operation, SUSP must be first cleared and then WMS must be set again.*
- Bit 30 **SUSP: Suspend (Read/Write).**
This bit must be set to suspend the current single/double word program or sector erase operation in order to read data in the same bank under modification or to program data in another bank. The Suspend operation resets the Flash bank to normal read mode (automatically resetting bits BSYA1, BSYA0).
This bit must be reset by the user when the suspend request has been served. WMS bit must be set again, together with the appropriate bit (WPG, DWPG, SER) to resume a suspended operation.
- Note:* *In Program Suspend, the Flash controller accepts only the following operations: Read and Program Resume. When in Erase Suspend, the Flash controller accepts only the following operations: Read, Erase Resume and Program (single/double Word Program operations **cannot** be suspended during Erase Suspend).*
- Note:* *It is forbidden to start a new Write operation when this bit is already set.*
- Bit 29 **WPG: Word Program (Read/Write).**
This bit must be set to select the single Word (32-bit) Program operation in the Flash module. The single Word Program operation allows to program 0s in place of 1s. The Flash Address to be programmed must be written in the FLASH_AR register, while the Flash Data to be programmed must be written in the FLASH_DR0 register before starting the execution by setting bit WMS. This bit is automatically reset at the end of the Word Program operation.
- Bit 28 **DWPG: Double Word Program.**
This bit must be set to select Double Word (64 bits) Program operation in the Flash module. The Double Word Program operation allows to program 0s in place of 1s. The Flash Address to be programmed (aligned with even words) must be written in the FLASH_AR register, while the 2 Flash Data to be programmed must be written in the FLASH_DR0 register (even word) and FLASH_DR1 register (odd word) before starting the execution by setting bit WMS. This bit is automatically reset at the end of the Double Word Program operation.

- Bit 27 SER: *Sector Erase*.
This bit must be set to select the Sector Erase operation in the Flash module. The Sector Erase operation allows erasure of all the flash locations in the selected sector back to a value of 0xFFFFFFFF. The sectors to erase are selected by setting bits BxFy in the FLASH_CR1 register (In the STR73x, the SystemMemory sector is excluded from this operation). The SER bit must be programmed before starting the execution by setting the WMS bit. It is not necessary to pre-program the sectors to 0x00, because this is done automatically. This bit is automatically reset at the end of the Sector Erase operation.
- Bit 26:25 Reserved, must be kept at reset value (0).
- Bit 24 SPR: *Set Protection*.
This bit must be set to select the Set Protection operation. The Set Protection operation allows to program 0s in place of 1s in the Flash Non Volatile Protection Registers. After selecting the write protection operation you must write the address of the FLASH_NVWPARx register in the FLASH_AR register and write the protection bit data in the FLASH_DR0 register. Then set the WMS bit to execute the operation. See [Section 3.5](#) for an example. A sequence error is flagged by bit SEQER of FLASH_ER if the address written in FLASH_AR out of range. This bit is automatically reset at the end of the Set Protection operation.
- Bit 23 Reserved, must be kept at reset value (0).
- Bit 22 SMBM: *SystemMemory Boot Mode (Read/Clear)*.
This bit is set automatically by the FPEC during initialization phase if M1/M0 = "10".
0: User Boot mode.

1: *SystemMemory* Boot Mode. The *SystemMemory* sector is mirrored in 0x0, allowing the Flash Reset Vector at 0x10C000 to be fetched in *SystemMemory* Boot Mode. *SystemMemory* can be accessed both in 0x0 and in 0x10C000 while sector BOF0 is not accessible.

Note: *In STR73x, the SystemMemory code does not perform this re-mapping operation so this bit has to be cleared by user software after booting from SystemMemory.*
- Bit 21 INTM: *end of write Interrupt Mask (Read/Write)*.
If this bit is set, the Flash controller generates an interrupt at the end of each Write Operation.
- Bit 20 INTP: *end of write Interrupt Pending (Read/Clear)*.
This bit is automatically set at the end of a write operation in the Flash, if bit INTM is set. This bit has to be software reset by the interrupt service routine.
- Bit 19:16 Reserved, must be kept at reset value (0).

- Bit 15 PWD: *Power Down Mode* (Read/Write).
When the microcontroller is put in a specific low power mode (see note below), the Flash module can be put into two different low power modes.
0: Normal Mode (default), Flash Stand-by mode is selected (immediate read from Flash is possible, but some residual power consumption is present).
1: The Flash module enters Power-Down mode. (recovery time of 20µs needed before reading, but lower power consumption)
Note: *In the STR71x family the PWD bit acts only in STOP and LPWFI modes. Whereas in the STR73x it acts only in LPWFI mode. For further details, refer to the specific STR7 microcontroller reference manual and datasheet, Power section.*
- Bit 14:5 Reserved, must be kept at reset value (0).
- Bit 4 LOCK: *Flash Register Access Locked* (Read Only).
When this bit is set, it means that the access to all the Flash control registers is locked: any read access to the registers will output invalid data (0xE6000010) and any write access will be ineffective. Please note that the “1” of the invalid data is located exactly in the position of the LOCK bit: therefore it is the only bit the user can always access to detect the status of the Flash registers. The LOCK bit is automatically set when the Flash bit WMS is set.
Once it is found low, the rest of FLASH_CR0 and all the other Flash registers are user accessible.
- Bit 3 Reserved, must be kept at reset value (0).
- Bit 2:1 BSY[1:0]: *Bank 1:0 Busy* (Read Only).
These bits indicate that a write operation is ongoing in the corresponding bank. They are automatically set when bit WMS is set. A Set Protection operation sets bit BSY0. When these bits are set any read access to the corresponding bank will output invalid data, while any write access to the bank will be ignored. At the end of the write operation or during a Program or Erase Suspend these bits are automatically reset and the bank returns to read mode. After a Program or Erase Resume these bits are automatically set again. All BSY[1:0] bits remain high for a maximum of 20µs after Power-Up and when exiting Power-Down mode, meaning that the Flash banks are not yet ready to be accessed.
- Bit 0 Reserved, must be kept at reset value (0).

2.4.2 Flash Control Register 1 (FLASH_CR1)

Address offset: 0x10 0004h

Reset value: 0x0000 0000h

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved						B1S ¹⁾	B0S ¹⁾	Reserved						B1F1 ¹⁾	B1F0 ¹⁾
						rs	rs							rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved								B0F7	B0F6	B0F5	B0F4	B0F3	B0F2	B0F1	B0F0
								rw	rw	rw	rw	rw	rw	rw	rw

¹⁾ Not available in STR73x.

The Flash Control Register 1 (FLASH_CR1) is used to specify the Sectors or the Banks to be erased, or during any write operation started with the WMS bit to monitor the status of each sector and each bank of the module.

Bit 31:26 Reserved, must be kept at reset value (0).

Bit 25:24 B1S, B0S: *Bank 1-0 Status*.
 At the end of any Sector Erase operation these bits are automatically modified by hardware to give the status of the 2 banks:
 0: No errors detected during erase operation on bank x,
 1: Error detected during the erase operation on bank x.

Bit 23:18 Reserved, must be kept at reset value (0).

Bit 17:16 B1F[1:0]: *Bank 1 Flash Sector 1:0 Control/Status*.
 These bits must be set by the user during a Sector Erase operation to select the sectors to be erased in bank 1. If no errors are detected these bits are automatically cleared at the end of the Sector Erase operation. The meaning of B1Fy bits for sector y of bank 1 is given in [Table 5](#).

Bit 15:8 Reserved, must be kept at reset value (0).

Bit 7:0 B0F(7:0): *Bank 0 Flash Sector 7:0 Control/Status*.
 These bits must be set by the user during a Sector Erase operation to select the sectors to be erased in bank 0. If no errors are detected, these bits are automatically reset at the end of the Sector Erase operation. The meaning of B0Fy bits for sector y of Bank 0 is provided in [Table 5](#).

Table 5. Sectors (BxFy) Status Bits Meaning

FLASH_ER.ERR	FLASH_CR0.BSYx	FLASH_CR0.SUSP	FLASH_CR1.BxFy	FLASH_CR1.BxFy = 1 meaning
1	-	-	1	Erase Error in Sector y of Bank x
0	1	-	1	Erase operation on-going in Sector y of Bank x
0	0	1	1	Erase Suspended in Sector y of Bank x
0	0	0	0	Erase completed with no errors

2.4.3 Flash Data Registers (FLASH_DR1-DR0)

Address offset (FLASH_DR1): 0x10 000Ch

Address offset (FLASH_DR0): 0x10 0008h

Reset value: 0xFFFF FFFFh

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
DIN31	DIN30	DIN29	DIN28	DIN27	DIN26	DIN25	DIN24	DIN23	DIN22	DIN21	DIN20	DIN19	DIN18	DIN17	DIN16
rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DIN15	DIN14	DIN13	DIN12	DIN11	DIN10	DIN9	DIN8	DIN7	DIN6	DIN5	DIN4	DIN3	DIN2	DIN1	DIN0
rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW

The Flash Address Register (FLASH_AR) and the Flash Data Registers (FLASH_DR1-0) must be written by software, prior to starting a programming operation, to specify the target address and the data to be programmed in Flash.

Bit 31:0 DIN[31:0]: *Data Input 31:0* (Read/Write).
 These bits must be written with the Data to be programmed in the Flash using any of the following operations: Word Program, Double Word Program and Set Protection.

2.4.4 Flash Address Register (FLASH_AR)

Address offset: 0x10 0010h
 Reset value: 0x0000 0000h

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved											ADD20	ADD19	ADD18	ADD17	ADD16
											rw	rw	rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADD15	ADD14	ADD13	ADD12	ADD11	ADD10	ADD9	ADD8	ADD7	ADD6	ADD5	ADD4	ADD3	ADD2	Reserved	
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw		

- Bit 31:21 Reserved, must be kept at reset value (0).
- Bit 20:2 ADD(20:2): *Address 20:2* (Read/Write).
 These bits must be written with the Address of the Flash location to program in the following operations: single/double Word Program.
 In Double Word Program the ADD2 bit must be 0.
- Bit 1:0 Reserved, must be kept at reset value (0).

2.4.5 Flash Error Register (FLASH_ER)

Address offset: 0x10 0014h
 Reset value: 0x0000 0000h

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	
Reserved																
Reserved								WPF	RESER	SEQER	Res.	Res.	10ER	PGER	ERER	ERR
								rc_w0	rc_w0	rc_w0	-	-	rc_w0	rc_w0	rc_w0	rc_w0

- Bit 31:9 Reserved, always read as 0.
- Bit 8 WPF: *Write Protection Flag*.
 This bit is automatically set when trying to program or erase a write protected sector. This bit has to be cleared by software.
- Bit 7 RESER: *Resume Error*.
 This bit is automatically set when a suspended Program or Erase operation is not resumed correctly due to a protocol error. In this case, the suspended operation is aborted. This bit has to be cleared by software.
- Bit 6 SEQER: *Sequence Error*.
 This bit is automatically set when the control registers (FLASH_CR1-0, FLASH_AR, FLASH_DR1-0) are not correctly filled to execute a valid Write Operation. In this case, no Write Operation is executed. This bit has to be cleared by software.
- Bit 5:4 Reserved, must be kept at reset value (0).

Bit 3	<p>10ER: <i>1 over 0 Error.</i></p> <p>This bit is automatically set when trying to program to 1 bits previously programmed to 0 (this does not happen when programming the Protection bits). This error is not due to a failure of the Flash cell, but only flags that the desired data has not been written. This bit has to be cleared by software.</p>
Bit 2	<p>PGER: <i>Program Error.</i></p> <p>This bit is automatically set when a Program error occurs during a Flash write operation. This error is due to a real failure of a Flash cell, that can no longer be programmed. The word where this error occurred must be discarded. This bit has to be cleared by software.</p>
Bit 1	<p>ERER: <i>Erase Error.</i></p> <p>This bit is automatically set when an Erase error occurs during a Flash write operation. This error is due to a real failure of a Flash cell, that can no longer be erased. This kind of error is fatal and the sector where it occurred must be discarded. This bit has to be cleared by software.</p>
Bit 0	<p>ERR: <i>Write Error.</i></p> <p>This bit is automatically set when an error occurs during a Flash write operation or due to a bad write operation setup. Once the error has been discovered and understood, ERR bit must be cleared by software.</p>

2.5 Write Operation Examples

2.5.1 Word Program

Example: Word Program of data 0xAAAAAAAA at address 0x05554 in the Flash Module.

```
FLASH_CR0 |= 0x20000000; /*Set WPG in FLASH_CR0*/
FLASH_AR = 0x00005554; /*Load Add in FLASH_AR*/
FLASH_DR0 = 0xAAAAAAAA; /*Load Data in FLASH_DR0*/
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

2.5.2 Double Word Program

Example: Double Word Program of data 0x55AA55AA at address 0x05558 and data 0xAA55AA55 at address 0x0555C in the Flash Module.

```
FLASH_CR0 |= 0x10000000; /*Set DWPG*/
FLASH_AR = 0x00005558; /*Load Add in FLASH_AR*/
FLASH_DR0 = 0x55AA55AA; /*Load Data in FLASH_DR0*/
FLASH_DR1 = 0xAA55AA55; /*Load Data in FLASH_DR1*/
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Note: Double Word Program is always performed on the Double Word aligned on a even Word: bit ADD2 of FLASH_AR is ignored.

2.5.3 Sector Erase

Example: Sector Erase of sectors B0F1 and B0F0 of Bank 0 in the Flash Module.

```
FLASH_CR0 |= 0x08000000; /*Set SER in FLASH_CR0*/
FLASH_CR1 |= 0x00000003; /*Set B0F1, B0F0*/
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

2.5.4 Suspend and Resume

Word Program, Double Word Program and Sector Erase operations can be suspended in the following way:

```
FLASH_CR0 |= 0x40000000; /*Set SUSP in FLASH_CR0*/
```

Then the operation can be resumed in the following way:

```
FLASH_CR0 |= 0x80000000; /*Operation resume*/
```

Note: *Original setup of Select Operation bits in FLASH_CR0 must be restored before the operation resume, otherwise the operation is aborted and bit RESER of FLASH_ER is set.*

Note: *Before resuming a suspended erase, FLASH_CR1 must be read to check if the Erase is already completed (FLASH_CR1=0x00000000 if Erase is completed).*

2.5.5 Erase Suspend, Program and Resume

A Sector Erase operation can be suspended in order to program (Word or Double Word) in another Sector or Bank.

Example: Sector Erase of sector B0F1 of Bank 0 in the Flash Module.

```
FLASH_CR0 |= 0x08000000; /*Set SER in FLASH_CR0*/
FLASH_CR1 |= 0x00000002; /*Set B0F1*/
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example: Sector Erase Suspend.

```
FLASH_CR0 |= 0x40000000 ; /*Set SUSP in FLASH_CR0*/
while (FLASH_CR0 & 0x00000012) {} /*Loop to Wait LOCK=0 && BSY=0*/
```

Example: Word Program of data 0x5555AAAA at address 0x05554 in the Flash Module.

```
FLASH_CR0 |= 0x20000000; /*Set WPG in FLASH_CR0*/
FLASH_AR = 0x00005554; /*Load Add in FLASH_AR*/
FLASH_DR0 = 0x5555AAAA; /*Load Data in FLASH_DR0*/
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Once the Program operation is finished, the Erase operation can be resumed in the following way:

```
FLASH_CR0 |= 0x08000000; /*Set SER in FLASH_CR0*/
FLASH_CR0 |= 0x80000000; /*Operation resume*/
```

Note: *Note that during the Program Operation in Erase suspend, bit SER and SUSP are low.*

3 Flash memory protection

Two kind of protections are available: sector *Write protection* to prevent unwanted writes and *DEBUG/READOUT Protection* to avoid software piracy. They are described in the following subsections.

The protection bits are stored in non-volatile Flash cells that are read once at reset and stored in 3 volatile registers:

- FLASH_NVWPAR used to store the *write protection* bits for each sector of the Flash Module
- FLASH_NVAPR1-0 used to store the *DEBUG/READOUT protection* bit.

The first time you program FLASH_NVWPAR or FLASH_NVAPR0 both the non-volatile and volatile part of the register are written. At any later stage, any write to these registers will affect only the volatile part, which will be restored with the content of the corresponding non-volatile part at the next reset event.

The content of the non-volatile part of the register FLASH_NVAPR1 is also copied at every reset event into the corresponding volatile register. In this case however any write will always update both the volatile and the non-volatile parts.

Note: Before being configured by the reset process, all the available protections are forced active during reset.

The protection registers are not directly accessible for writing. They can be programmed using a **set protection** operation and writing them as a normal write operation.

3.1 Write protection

The Flash module provides a write protection, which can be independently activated for each sector of each bank. When a sector is *Write Protected*, any attempt to program or erase will result in a *Protection Error*.

A flash sector can be *Write Protected* by programming at 0 the related bit WyPx of the FLASH_NVWPAR register.

Note: The Write protection operation can be executed from all the internal/external memories including Flash Bank 0 of the Flash module.

3.2 Debug/Readout protection

If the DEBUG or READOUT bits in the FLASH_NVAPR0 are programmed at 0, the device becomes DEBUG or READOUT protected: debug features JTAG pins and Flash *SystemMemory* mode are disabled.

Note: The Debug/Readout protection operation can be executed from all the internal/external memories except Flash Bank 0 of the Flash module.

- In **Embedded Flash Boot Mode**: the FLASH is kept enabled and the user program will execute normally. But the debugger host can not take the control over the CPU. In addition, if a JTAG sequence is initiated (by simply releasing the NJTRST) then the Flash is automatically disabled and the user program execution will fail. The user has to

ensure that the software does not provide a way for a hacker to download the Flash memory content.

- In **Embedded SRAM Boot Mode (STR75x)**: the embedded Flash is automatically disabled and thus it is not possible to download its content (it is also not possible to execute it).
- In **External Memory Boot Mode**
 - In the STR71x, it is not possible to use EMI boot mode when DEBUG protection is enabled.
 - In the STR75x, it is possible to use SMI boot mode when READOUT protection is enabled, but the embedded Flash is automatically disabled and its content cannot be downloaded or executed.
- In **SystemMemory Boot Mode (STR73x/STR75x)**, then the program executed from SystemMemory ensures that it is not possible to output the embedded Flash memory contents.

3.3 Unprotection strategy

3.3.1 Temporary unprotection

You can temporarily unprotect a *Write* protected sector, or a *DEBUG/READOUT* protected Flash module.

A *write protected* sector can be temporarily unprotected by executing the *set protection* operation and writing 1 in the associated WypX bits of FLASH_NVWPAR. Refer to [Section 3.5](#) for examples. The temporary unprotection write operation can be executed from all the internal/external memories including Flash Bank 0 of the Flash module.

The *DEBUG/READOUT* protected Flash module can be temporarily unprotected by executing the *set protection* operation and writing 1 into this DEBUG bit but only if these instructions are executed from the Flash Module.

To restore the write and DEBUG/READOUT protection bits, it is necessary to reset the microcontroller or to execute a *set protection* operation and write '0' in the corresponding bits.

'Temporary' means that FLASH_NVWPAR or FLASH_NVAPR0 bits will maintain the unprotected state until their value will be overwritten either by a reset event or through a new *set protection* operation.

3.3.2 Permanent unprotection

You can permanently unprotect a *DEBUG/READOUT* protected Flash Module. You may need to use this feature under certain circumstances, for example to analyze rejects. DEBUG/READOUT protection can be disabled by programming the PDSx bits in the FLASH_NVAPR1 register.

If the DEBUG bit is programmed to 0, disabling the protection by programming the PDSx bits can be done only by a program executed from the Flash Module. The user software design can ensure that this is accessible only to authorized users.

DEBUG/READOUT protection can be enabled again by programming the PENx bits in the FLASH_NVAPR1 register. The PDSx and PENx bits can be programmed once only, however 16 bits are provided, so you can disable and re-enable DEBUG/READOUT

Protection up to a maximum of 16 times. PEN_n can be programmed to 0 only if PDS_n has been already programmed to 0. PDS_n can be programmed to 0 only if PDS_{n-1}/PEN_{n-1} have been already programmed to 0.

Note: You can not permanently unprotect a write protected sector.

3.4 Register description

3.4.1 Flash non volatile write protection register (FLASH_NVWPAR)

Address offset: 0x10 DFB0h
 Delivery value: 0xFFFF FFFF



¹⁾ Not available in STR73x.

- Bit 31:18 Reserved, must be kept at reset value (1).
- Bit 17-16 W1P1-0: *Write Protection Bank 1 sectors 1-0.*
 These bits, if programmed to 0, disable any writes to the sectors of bank 1. The sectors corresponding to bits set to '0' are *Write* protected.
- Bit 15:8 Reserved, must be kept at reset value (1).
- Bit 7:0 W0P(7:0): *Write Protection Bank 0 sectors 7-0.*
 These bits, if programmed to 0, disable any writes to the respective sectors of bank 0. The sectors corresponding to bits set to '0' are *Write* protected.

3.4.2 Flash NV access protection register 0 (FLASH_NVAPR0)

Address offset: 0x10 DFB8

Delivery value: 0x3569 ACFFh

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved														DEBUG 1)	READ OUT2)
														rw	rw

1) Not available in STR75x.

2) Not available in STR71x and STR73x.

Bit 31:2 Reserved, always read as 0.

Bit 1 DEBUG: *Debug Protection*.

If this bit is erased to 1, protections are by-passed and the Flash is accessible through its JTAG interface.

If DEBUG is programmed at 0 the device is DEBUG protected, the JTAG interface is disabled.

Note: In STR73x devices, when debug protection is enabled, the SystemMemory Mode is also disabled.

Note: If this bit is programmed to '0', STMicroelectronics will not be able to access the device to run a possible failure analysis.

Bit 0 READOUT: *Readout Protection*.

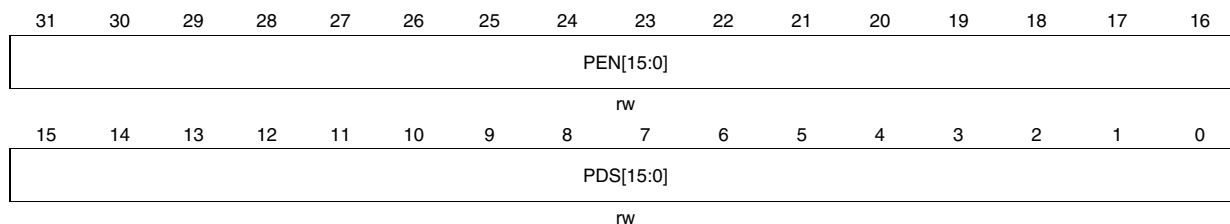
If this bit is erased to 1, protections are by-passed and the Flash is accessible through its JTAG interface.

If READOUT is programmed at 0 the device is READOUT protected, the JTAG interface is disabled.

Note: If this bit is programmed to '0', STMicroelectronics will not be able to access the device to run a possible failure analysis.

3.4.3 Flash NV access protection register 1 (FLASH_NVAPR1)

Address offset: 0x10 DFBC
 Delivery value: 0xFFFF FFFF



The FLASH_NVAPR1 register is organized as 16 pairs of bits (PENx - PDSx). The delivery value of The FLASH_NVAPR1 register is 0xFFFFFFFF. The first time you disable the *DEBUG/READOUT* protection you must program to PDS0 '0'. To re-enable the protection you must program to bit PEN0 '0': this is possible only if PDS0 has been already programmed to '0'. This cycle of disabling/re-enabling the protection can be repeated with the next PDS1/PEN1 pair of bits and so on. PDS1 can be programmed to '0' only if PEN0 has been already programmed to '0', PEN1 can be programmed to '0' if and only if PDS1 has been already programmed to '0'. The programming to '0' of the bits of the FLASH_NVAPR1 register must therefore follow the PDS0-PEN0-PDS1-PEN1-PDS2-PEN2-...-PEN15 sequence, obtaining up to 16 unprotection/protection cycles.

Note: At any reset event the non-volatile part of FLASH_NVAPR1 register is copied into its volatile part. Unlike with the FLASH_NVAPR0 and FLASH_NVWPAR register, any write will always update both the volatile and the non-volatile parts: i.e. no temporary unprotection is possible with FLASH_NVAPR1 register.

Bit 31:16 PEN15-0: *Protection Enable 15-0.*
 If bit PENx is programmed at 0 and bit PDSx+1 is erased to 1, the action of bit DEBUG is enabled again. Bit PENx can be programmed to 0 only if bit PDSx has been already programmed to 0.

Bit 15:0 PDS15-0: *Protection Disable 15-0.*
 If bit PDSx is programmed at 0 and bit PENx is erased to 1, the action of bit DEBUG is disabled (i.e. *DEBUG/READOUT* protection is no longer in place). Bit PDS0 can be programmed at 0 only if bit DEBUG is already programmed at 0. Bit PDSx can be programmed to 0 only if bit PENx-1 has already been programmed to 0.

Note: All the STR73x Flash protection registers (FLASH_NVWPAR, FLASH_NVAPR0 and FLASH_NVAPR1) are write only in User boot modes and Read/Write when booting from SystemMemory mode.

3.5 Protection code examples

Example 1: Enable Write Protection of sectors B0F3-0 of Bank 0.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFB0; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFF0; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example 2: Disable Write Protection of sectors B0F3-0 of Bank 0 temporarily.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFB0; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFF; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example 3: Enable Debug Protection.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFB8; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFFD; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example 4: Disable Debug Protection temporarily.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFB8; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFF; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example 5: Disable Debug Protection permanently.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFBC; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFFE; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Example 6: Re-Enable Debug Protection permanently, after having disabled it.

```
FLASH_CR0 |= 0x01000000; /*Set SPR in FLASH_CR0*/  
FLASH_AR = 0x0010DFBC; /*Load Add in FLASH_AR*/  
FLASH_DR0 = 0xFFFFFFFF; /*Load Data in FLASH_DR0*/  
FLASH_CR0 |= 0x80000000; /*Operation start*/
```

Note: You can disable and re-enable the **DEBUG/READOUT Protection** permanently (as shown in examples 5 and 6) a maximum of 16 times.

4 Flash register map

Table 6. Flash Register map

Addr. Offset	Register Name	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0x10 0000	FLASH_CR0	WMS	SUSP	WPG	DWPG	SER	Res.	SPR	Res.	SMBM	INTM	INTP	Reserved				PWD	Reserved							LOCK	Res.	BSY1	BSY0	Res.					
0x10 0004	FLASH_CR1	Reserved						B1S	B0S	Reserved				B1F1	B1F0	Reserved					B0F(7:0)													
0x10 0008	FLASH_DR0	DIN(31:0)																																
0x10 000C	FLASH_DR1	DIN(31:0)																																
0x10 0010	FLASH_AR	ADD(31:0)																																
0x10 0014	FLASH_ER	Reserved																								WPF	RESER	SEQER	Res.	Res.	10ER	PGER	ERER	ERR
0x10 DFB0	FLASH_NVWPAR	Reserved														W1P1	W1P0	Reserved					W0P(7:0)											
0x10 DFB8	FLASH_NVAPR0	Reserved																														DEBUG		READOUT
0x10 DFBC	FLASH_NVAPR1	PEN(15:0)															PDS(15:0)																	

5 Revision history

Table 7. Revision History

Date	Revision	Description of changes
31-Jan-2005	1	First Issue
13-Jul-2005	2	<p>Updated introduction on page 1</p> <p>Updated the Table 1 to support STR73x embedded Flash, Added a new table (Table 2) with Control and Protection Register Description.</p> <p>Updated the register bits in line with the STR73x Flash registers.</p> <p>Added two new bits (SMBM and JBM) related to STR73x SystemMemory Boot Mode in the FLASH_CR0 register, Added note on page 25: All the STR73x Flash protection registers (FLASH_NVWPAR, FLASH_NVAPR0 and FLASH_NVAPR1) are write only.</p> <p>Updated Section 4: Flash register map</p> <p>Modified Address offset (0x10) in all Registers</p>
04-Jan-2006	3	<p>Updated Table 1 and Table 2 on page 1</p> <p>Modified STR730 by STR73x</p> <p>Removed the 2nd paragraph on page 5</p> <p>Changed “Flash matrix” by “Flash module”</p> <p>Added a note on page 6</p> <p>Removed the 2nd sentence in the 1st paragraph on page 7</p> <p>Removed the note on page 7</p> <p>Removed the 1st paragraph on page 10</p> <p>Removed the JBM bit from the FLASH_CR0 register</p> <p>Updated the bit 30 description on page 12</p> <p>Updated the bit 27 and bit 22 descriptions on page 13</p> <p>Removed the bit 19 description on page 14</p> <p>Updated the bit 15 description on page 14</p> <p>Updated the bit 4 description on page 14</p> <p>Updated the bits 2:1 description on page 15</p> <p>Updated the description of bits 20:2 on page 18</p> <p>Updated the Flash write examples on pages 20 and 21</p> <p>Added 2 notes on pages 22 and 23</p> <p>Updated the Flash protection section</p> <p>Updated the Flash register map</p>
20-Sep-2006	4	<p>Updated protection description for STR750 READOUT.</p> <p>Add a new section Section 2.3.1 on page 6.</p> <p>Changed DBGP bit name to DEBUG.</p>

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