This document explains how to use the flash command controller to perform flash read and write operations, which can be more efficient than using calls to the ROM API.
1 Introduction

This document explains how to use the flash command controller to perform flash read and write operations, which can be more efficient than using calls to the ROM API. In some complex applications, it is required to have non-blocking flash operations. However, the command write sequence can be more difficult to use. The purpose of this document is to provide instructions on how to program internal flash on MCXNx4x using the command write sequence.

2 Overview

The process follows a generic flash command write sequence, as shown in Figure 1.

![Figure 1. Command write sequence](image-url)
2.1 High-level overview

Following is the high-level overview of the steps used:

1. Initialize the necessary clocks and registers.
2. Erase **0x10_0000 -> 0x1F_FFFF** one sector 8192 bytes of internal flash at a time using the erase sector command.
3. Program **0x10_0000 -> 0x1F_FFFF** one page 128 bytes at a time using the program page command.
4. Verify that the values stored match the expected values.
5. Additionally, between each command, check the **FSTAT** registers for error handling and wait for **CCIF** to be set before continuing with the next command.

For more details, see Figure 2.

![Figure 2. Flash erase-write flow](image-url)

3 Use case example

An example use case is provided, which includes an MCUXpresso project that erases and programs the second half of flash, size 1 MB. The example can be found in the associated software package of this application note.

As outlined in Section 1, this process follows the generic command write sequence. The following subsections highlight the commands used in this example.

3.1 Erase sector

These steps show the process for erasing one sector 8192 bytes. For the example project, the process gets repeated until the entire second half of the flash is erased. And, it begins with a destination address \( \text{destAddr} = 0x10_0000 \), the first index in the second half of flash.

1. Check **FMU_FSTAT** register to ensure that **CCIF** is set. The previous command is completed.

```c
if (((FMU0->FSTAT & FMU_FSTAT_CCIF(1)) >> FMU_FSTAT_CCIF_SHIFT) == 1)
```
{  
    //continue with programming  
}

If the CCIF register is not set, then we cannot continue with the operation and must wait until the previous operation is completed before starting another flash controller command. In the example code, a while loop is used to accommodate for a wait until the CCIF register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.

2. Handle and clear any error flags present in FMU FSTAT register.

    //clear previous errors  
    FMU0->FSTAT = 0x34;

    The value for FSTAT_CLEARERR is 0x34.

3. Specify the command as erase sector by setting FMU FCCOB[0] to 0x42 (ERSSCR).

    //42h is erase sector command ERSSCR  
    //specify command  
    FMU0->FCCOB[0] = 0x42;

4. Clear CCIF register to launch the command.

    //clear ccif to launch  
    FMU0->FSTAT = 0x80;

    The value for FSTAT_CLEARCCIF is 0x80. This writes a 1 to FSTAT[CCIF] bit, which clears it.

5. Check FMU FSTAT PEWEN == 1, writes are enabled for one phrase.

    if (((FMU0->FSTAT & FMU_FSTAT_PEWEN(value)) >> FMU_FSTAT_PEWEN_SHIFT) == 1)  
    {  
        //continue  
    }

We cannot continue with the operation of the erase sector command until FSTAT PEWEN is equal to 1. In the example code, a while loop is used to accommodate for a wait until the PEWEN register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.

6. Write four consecutive words to the flash, with the first write being phrase or sector aligned.

    Note: The contents of these writes are insignificant, as the sector is to be erased, but we must perform four consecutive writes for the command to execute per the implementation of the erase sector command.

    The destination address at the beginning of the example is 0x100000. This is the first index in the second half of flash.

    *(volatile uint32_t *)(destAdrss) = 0x0;  
    *(volatile uint32_t *)(destAdrss + 4) = 0x0;  
    *(volatile uint32_t *)(destAdrss + 8) = 0x0;  
    *(volatile uint32_t *)(destAdrss + 12) = 0x0;

7. Check for PERDY == 1, the operation is ready to execute.

    if (((FMU0->FSTAT & FMU_FSTAT_PERDY(1)) >> FMU_FSTAT_PERDY_SHIFT) == 1)  
    {  
        //continue  
    }

We cannot continue with this operation unless PERDY is set to 1, which means that the operation is ready to execute.

    The PERDY must get set to one directly after the fourth consecutive *(volatile uint32_t *)(destAdrss + 12) = 0x0 write in the sequence of step 6. In the example code, a while loop is used to accommodate for a wait until the PERDY register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.
8. Clear PERDY by writing 1 to it. The operation stalls until it is cleared.

```c
//controller should erase AND verify after we clear PERDY
FMU0->FSTAT = 0x80000000;
```

9. Check for any errors in FSTAT register.

```c
if (((FMU0->FSTAT & FMU_FSTAT_ACCERR(1)) >> FMU_FSTAT_ACCERR_SHIFT) == 1) {
    PRINTF("\r\n Access Error \r\n");
} else if (((FMU0->FSTAT & FMU_FSTAT_PVIOL(1)) >> FMU_FSTAT_PVIOL_SHIFT) == 1) {
    PRINTF("\r\n Protection Violation \r\n");
} else if (((FMU0->FSTAT & FMU_FSTAT_CMDABT(1)) >> FMU_FSTAT_CMDABT_SHIFT) == 1) {
    PRINTF("\r\n Operation Is Aborted \r\n");
} else if (((FMU0->FSTAT & FMU_FSTAT_FAIL(1)) >> FMU_FSTAT_FAIL_SHIFT) == 1) {
    PRINTF("\r\n Command Failed \r\n");
}
```

10. Before continuing with another command controller operation, ensure that FSTAT CCIF is set. This command is completed.

```c
if (((FMU0->FSTAT & FMU_FSTAT_CCIF(1)) >> FMU_FSTAT_CCIF_SHIFT) == 1) {
    //continue with programming
}
```

In the example code, a while loop is used to accommodate for a wait until the CCIF register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.

3.2 Program page command

The following steps demonstrate the process for executing one program page command. The example project continues to perform the program page command until 0x10_0000 -> 0x1F_FFFF is successfully programmed.

1. Check FMU FSTAT register to ensure that CCIF is set. This signifies that the previous command has been completed.

```c
if (((FMU0->FSTAT & FMU_FSTAT_CCIF(1)) >> FMU_FSTAT_CCIF_SHIFT) == 1) {
    //continue with programming
}
```

The CCIF register must be set to 1 for us to continue with a new operation. In the example code, a while loop is used to accommodate for a wait until the CCIF register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.

2. Handle and clear any error flags present in FMU FSTAT register.

```c
//clear previous errors
FMU0->FSTAT = 0x34;
```

The value for FSTAT_CLEARERR is 0x34.

3. Specify the command as program page by setting FMU FCCOB[0] to 0x23 (PGMPG).

```c
//only need to specify command at call time
```
FMU0->FCCOB[0] = PGMPG;

4. Clear CCIF register to launch the command.

    //clear ccif to launch
    FMU0->FSTAT = 0x80;

Clear CCIF register by writing 1 to it, and launch the command.

5. Check for FMU FSTAT PEWEN == 2, writes are enabled for page programming - one page.

    if (((FMU0->FSTAT & FMU_FSTAT_PEWEN(value)) >> FMU_FSTAT_PEWEN_SHIFT) == 2)
    {
        //continue
    }

The FSTAT PEWEN must be set to 2 to continue with the operation. In the example code, a while loop is used to accommodate for a wait until the PEWEN register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel.

6. Write 32 consecutive words to flash space.

    //write 32 consecutive words to flash space
    //one word = 4 bytes
    for (int i = 0; i < 32; i++)
    {
        *(volatile uint32_t *)(destAdrrss + index + (i*4)) = 0x12345678;
    }

7. Check for FMU FSTAT PERDY == 1, the program command operation ready to execute.

    if (((FMU0->FSTAT & FMU_FSTAT_PERDY(1)) >> FMU_FSTAT_PERDY_SHIFT) == 1)
    {
        //continue
    }

In the example code, a while loop is used to accommodate for a wait until PERDY register is set. However, it is up to the developer to consider whether the application needs to be running other tasks in parallel. **Note: Before we execute the command, the FSTAT PERDY must be set to 1.**

8. Clear FMU FSTAT PERDY by writing 1 to it, otherwise, the operation remain stalled.

    //clear PERDY
    FMU0->FSTAT = 0x80000000;

9. Check for errors in FSTAT register.

    if (((FMU0->FSTAT & FMU_FSTAT_ACCERR(1)) >> FMU_FSTAT_ACCERR_SHIFT) == 1)
    {
        PRINTF("\r\n Access Error \r\n");
    }
    else if (((FMU0->FSTAT & FMU_FSTAT_PVIOL(1)) >> FMU_FSTAT_PVIOL_SHIFT) == 1)
    {
        PRINTF("\r\n Protection Violation \r\n");
    }
    else if (((FMU0->FSTAT & FMU_FSTAT_CMDABT(1)) >> FMU_FSTAT_CMDABT_SHIFT) == 1)
    {
        PRINTF("\r\n Operation Is Aborted \r\n");
    }
    else if (((FMU0->FSTAT & FMU_FSTAT_FAIL(1)) >> FMU_FSTAT_FAIL_SHIFT) == 1)
    {
        PRINTF("\r\n Command Failed \r\n");
    }
10. Before continuing with another command controller operation, ensure that FSTATCCIF is set. This command is completed.

```c
if (((FMU0->FSTAT & FMU_FSTAT_CCIF(1)) >> FMU_FSTAT_CCIF_SHIFT) == 1)
{
    //continue with programming
}
```

4 Run demo

Requirements:
1. MCUXpresso 11.7.1 or newer
2. MCXNx4x EVK or FRDM
3. USB cable
4. SDK version 2.13.0

Steps:
1. Download the associated software package.
2. Import the project to MCUXpresso IDE - Quickstart Panel. Click Import project(s) from file system..., see Figure 3.

```
Figure 3. Quickstart panel - import project
```

3. Click Browse..., see Figure 4.
Figure 4. Import archived project

4. Navigate through the file browser and select the downloaded IAP Flash Commands.zip.

Figure 5. Selecting file from file browser

5. Click Open, see Figure 5.
6. Click Next, see Figure 6.
7. Click Finish, see Figure 7.
Once the project is downloaded and imported into MCUXpresso, connect a micro-USB cable between the PC host and the MCU-Link USB port J5 on the board when using MCX-N9XX-EVK, J17 when using FRDM-MCXN947.

Open a serial terminal with the following settings:

- 115200 baud rate
- 8 data bits
- No parity
- One stop bit
- No flow control

1. Click Launch Serial Terminal option from the toolbar, see Figure 8.

2. Launch Terminal windows pop up.

3. From the drop-down list of Choose terminal -> Select Serial Terminal, see Figure 9.
4. Select Serial port associated with the connected device, see Figure 10.

5. Select the following settings, see Figure 10.
   • Baud rate -> 115200.
   • Data size -> 8.
   • Parity -> None.
   • Stop bits -> 1.

6. Click OK.

7. Click Build in Quickstart Panel, see Figure 11.
8. Click **Debug**, see **Figure 12**.

9. Click **OK**, see **Figure 13**.
10. Now, you must be able to step through the code. Click Step Over option in the toolbar, see Figure 14.

11. Step through line 215, see Figure 15.

12. Now that we have reached the first step of the erase sector command, open the peripheral viewer. Click Peripherals+ tab, see Figure 16.

13. Expand FMU0, see Figure 17.
14. We can see that the FSTATCCIF register is set to 1, meaning that no commands are still being executed, and we can execute a command using the command controller, see Figure 18.

15. Continue stepping through the code and stop on line 222, see Figure 19.

16. The peripheral viewer shows that we have set FMU -> FSTAT -> FCCOB[0] to 0x42, which is the erase sector command, see Figure 20.

17. Step through the code one additional step, and we can see that we have cleared CCIF, causing the command to execute, see Figure 21.
18. Continue stepping through and stop on line 229. Recall that we need to perform four writes, with the first being sector-aligned. We have stopped on the fourth write in the sequence, see Figure 22.

19. Stepping over this, we must see that PEWEN is cleared and PERDY is set, see Figure 23.

20. Step over line 233, which clears PERDY, see Figure 24.

21. In the peripheral viewer, CCIF is set to 1, meaning that the command has been completed, see Figure 25.

Note: The erase starts at 0x10_0000 and erases one sector.

22. On Peripherals+ tab, Click three vertical dots and select Add memory monitor -> PROGRAM_FLASH1, see Figure 26.

23. After completing the erase sector command, on Memory->0x100000: 0x100000 <Hex> tab, we must find FFFFFFFFF and continues until 0x102000, which means one sector of flash has been erased, see Figure 27 and Figure 28.
24. You may now choose to continue stepping through the code or terminate the debug session as the flash program command follows a similar sequence.

25. After all the flash commands have been executed, the memory monitor must be filled with 0x1234_5678 hexadecimal in each 4-byte area, see Figure 29.

26. The following message is displayed in the terminal window, which confirms that the example code runs successfully.

Flash Command Erase / Programming example:
This application erases the flash area from 0x0010_0000 -> 0x001F_FFFF and then programs with 0x1234_5678.
Begin erase: Success!
Begin Program: Success!

End of Flash Programming Example!

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6 Revision history

Table 1 summarizes the revisions to this document.

<table>
<thead>
<tr>
<th>Document ID</th>
<th>Release date</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AN14178 v.1.0</td>
<td>24 January 2024</td>
<td>Initial public release</td>
</tr>
</tbody>
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