

Advanced F021 Flash API Erase/Program Usage

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ABSTRACT

This application report gives the user of the F021 Flash API the ability to write program and erase code in a way that is optimized to their applications.

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1 Introduction

The 65nm Flash Technology used on Hercules devices generally requires the use of the F021 Flash API to do program and erase operations. Since these functions need to cover all possible uses, they are generic, and not the most efficient functions available for all applications. Therefore, this document is designed to allow the user to write erase and program functions that are optimized for their application needs. The F021 Flash API is still required for Flash initialization and bank selection. For recommended erase and program operation flows, see the *F021 Flash API Reference Guide* ([SPNU501](#)).

NOTE: *This document applies to all versions of the F021 Flash API starting with v2.00.00.*

2 Flash Registers Used

In addition to the registers listed in the *F021 Flash Module* chapter in the device-specific technical reference manual, [Table 1](#) lists registers specifically needed for program and erase operations.

Table 1. Additional Flash Control Registers

| Offset | Acronym | Register Description | Section |
|-----------|--------------|---|-------------|
| FFF8 7110 | FADDR | The absolute address of the data that the CPU would use to access the location. | Section 2.1 |
| FFF8 7120 | FWPWRITE0 | WPDATA[31:00] | Section 2.2 |
| FFF8 7124 | FWPWRITE1 | WPDATA[63:32] | Section 2.2 |
| FFF8 7128 | FWPWRITE2 | WPDATA[95:64] | Section 2.2 |
| FFF8 712C | FWPWRITE3 | WPDATA[127:96] | Section 2.2 |
| FFF8 7130 | FWPWRITE4 | WPDATA[159:128] | Section 2.2 |
| FFF8 7134 | FWPWRITE5 | WPDATA[191:160] | Section 2.2 |
| FFF8 7138 | FWPWRITE6 | WPDATA[223:192] | Section 2.2 |
| FFF8 713C | FWPWRITE7 | WPDATA[255:224] | Section 2.2 |
| FFF8 7140 | FWPWRITE_ECC | Contains the ECC bits for the FWPWRITE7:0 registers | Section 2.3 |
| FFF8 720C | FSM_COMMAND | The command to be executed | Section 2.4 |
| FFF8 72B4 | FSM_EXECUTE | Execute the command in the FSM_COMMAND register | Section 2.5 |

2.1 Flash Address Register (FADDR)

This register contains the absolute address of the location to be programmed, or area to be erased. For FSM operations, this register can contain the main Flash, data Flash or Customer OTP addresses. The ECC regions at 0xF01x_xxxx or 0xF02x_xxxx are illegal regions because the ECC programs must be done using the address of the data that ECC protects and the FWPWRITE_ECC register. FADDR is used by Program and Erase commands.

The Flash address register is shown in [Figure 1](#) and described in [Table 2](#).

Figure 1. Flash Address Register (FADDR) [offset = FFF8 7110h]

| | |
|------|---|
| 31 | 0 |
| ADDR | |
| RWP | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode with FLOCK=any value

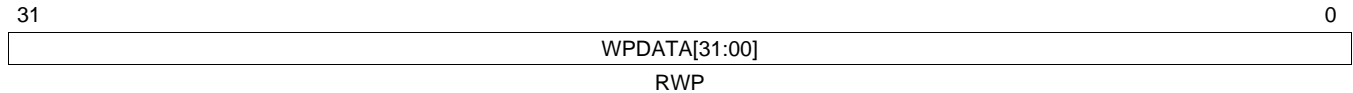
Table 2. Flash Address Register (FADDR) Field Descriptions

| Bit | Field | Value | Description |
|------|-------|--|---|
| 31:0 | ADDR | CPU address to be operated on by the command | Absolute address of the data that the CPU would use to access the location. |

2.2 Flash Wide Programming Write Data Register (FWPWRITE0-7)

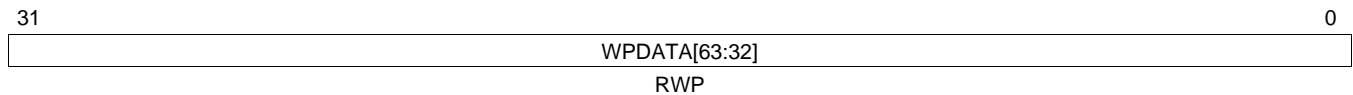
The Flash wide programming write data register is shown in [Figure 2](#) through [Figure 9](#) and described in [Table 3](#).

Figure 2. Flash Wide Programming Write Data Register (FWPWRITE0) [offset = FFF8 7120h]



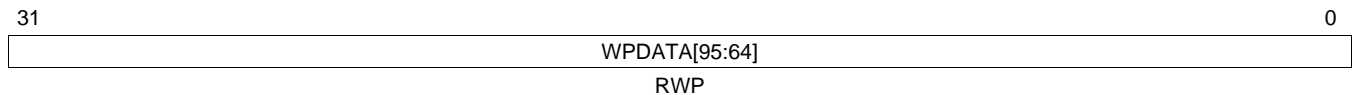
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 3. Flash Wide Programming Write Data Register (FWPWRITE1) [offset = FFF8 7124h]



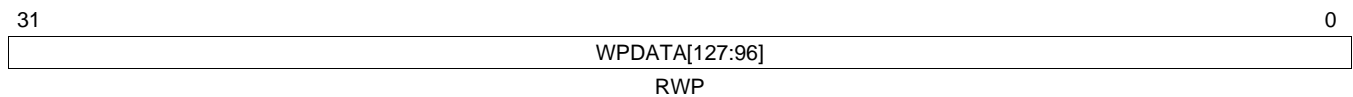
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 4. Flash Wide Programming Write Data Register (FWPWRITE2) [offset = FFF8 7128h]



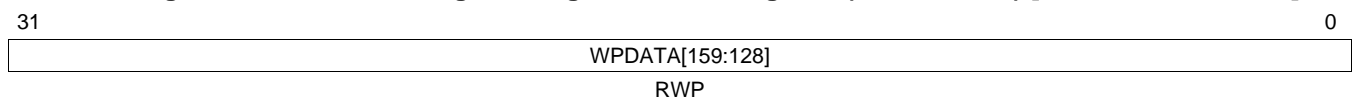
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 5. Flash Wide Programming Write Data Register (FWPWRITE3) [offset = FFF8 712Ch]



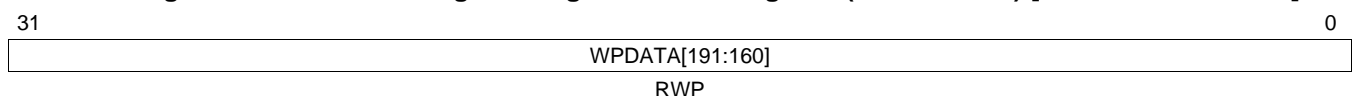
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 6. Flash Wide Programming Write Data Register (FWPWRITE4) [offset = FFF8 7130h]



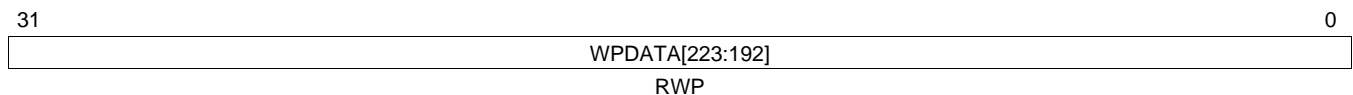
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 7. Flash Wide Programming Write Data Register (FWPWRITE5) [offset = FFF8 7134h]



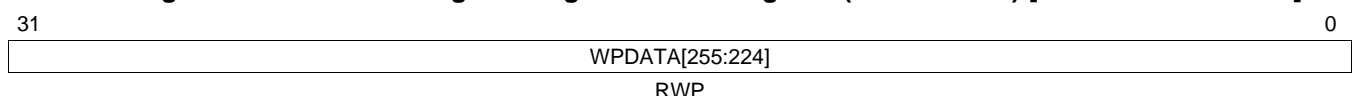
LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 8. Flash Wide Programming Write Data Register (FWPWRITE6) [offset = FFF8 7138h]



LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Figure 9. Flash Wide Programming Write Data Register (FWPWRITE7) [offset = FFF8 713Ch]



LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Table 3. Flash Wide Programming Write Data Register (FWPWRITE0) Field Descriptions

| Bit | Field | Value | Description |
|-------|----------------|-----------------------|--|
| 255:0 | WPDATA [255:0] | Data to be programmed | <p>This register contains the data to program into the flash memory. Each write will set data bits and another internal byte enable bit for each byte to be written by the FSM. The FWPWRITE register is set to all ones after writing to the FADDR register or when the FSM completes an operation.</p> <p>For 128-144-bit banks, only FWPWRITE0-3 are used during programming. FWPWRITE4-7 are unused. For 64-72-bit banks, use only FWPWRITE0-1 are used during programming.</p> <p>Unused bits can be written and read but they will not be part of the bank operations.</p> <p>NOTE: Do not write to this register while a FSM operation is active.</p> |

2.3 Flash Wide Programming Write Data ECC Register (FWPWRITE_ECC)

The Flash wide programming write ECC register is shown in [Figure 10](#) through [Figure 12](#) and described in [Table 4](#).

Figure 10. Flash Wide Programming Write Data ECC Register - 288-Bit Bank (FWPWRITE_ECC)
[offset = FFF8 7140h]

| | | | | | | | |
|-------------------|----|--------------------|----|---------------------|---|---------------------|---|
| 31 | 24 | 23 | 16 | 15 | 8 | 7 | 0 |
| ECC for Bytes 7:0 | | ECC for Bytes 15:8 | | ECC for Bytes 23:16 | | ECC for Bytes 31:24 | |
| RWP | | | | | | | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode with FLOCK=any value

Figure 11. Flash Wide Programming Write Data ECC Register - 144-Bit Bank (FWPWRITE_ECC)
[offset = FFF8 7140h]

| | | | | | |
|-------------------|----|----|----|------------------------|---|
| 31 | 24 | 23 | 16 | 15 | 0 |
| ECC for Bytes 7:0 | | | | ECC for Bytes 15:8 | |
| | | | | Reserved | |
| RWP | | | | RWP=FF FF_FFFF h | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode with FLOCK=any value

Figure 12. Flash Wide Programming Write Data ECC Register - 72-Bit Bank (FWPWRITE_ECC)
[offset = FFF8 7140h]

| | | | |
|--------------------|----|----|---|
| 31 | 24 | 23 | 0 |
| ECC for Bytes 7:0 | | | |
| Reserved | | | |
| RWP | | | |
| RWP=FFF F_FFFFh | | | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode with FLOCK=any value

Table 4. Flash Wide Programming Write Data ECC Register (FWPWRITE_ECC) Field Descriptions

| Bit | Field | Value | Description |
|------|------------|---------------------------|---|
| 31:0 | ECC [31:0] | ECC Data to be programmed | <p>This register contains the ECC bits for the FWPWRITE7:0 registers. The location of the ECC bits corresponding to the data depends on the device configuration. The three supported configurations are shown above.</p> <p>Unused bits can be written and read but they will not be part of the bank operations.</p> <p>This register is an extension of the FWPWRITE register. Do not write to this register while a FSM operation is active. This register is set to all ones just like the FWPWRITE registers.</p> |

2.4 Flash State Machine Command Register (FSM_COMMAND)

The Flash state machine command register is shown in [Figure 13](#) and described in [Table 5](#).

Figure 13. Flash State Machine Command Register (FSM_COMMAND) [offset = FFF8 720Ch]

| | | | | | | | | |
|----------|--|---|---|---|---|---|---------|---|
| 31 | | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | | | | | | | FSM_CMD | |
| R-0 | | | | | | | RWP | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Table 5. Flash State Machine Command Register (FSM_COMMAND) Field Descriptions

| Bit | Field | Value | Description |
|------|----------|-------|--|
| 31:6 | Reserved | 0 | These are reserved bits |
| 5:0 | FSM_CMD | | Refer to the supported commands listed in Appendix A of <i>F021 Flash API Reference Guide</i> (SPNU501). Writes to this register are blocked if the state machine is busy. The only exception is to write the suspend command. |

2.5 Flash State Machine Command Execute Register (FSM_EXECUTE)

The Flash state machine command execute register is shown in [Figure 14](#) and described in [Table 6](#).

Figure 14. Flash State Machine Command Execute Register (FSM_EXECUTE) [offset = FFF8 72B4h]

| | | | | | | | | | | |
|----------|--|--|--|--|-------------|----|----|----|----|---|
| 31 | | | | | 20 | 19 | 18 | 17 | 16 | |
| Reserved | | | | | SUSPEND_NOW | | | | | |
| R-0 | | | | | RWP-1010 | | | | | |
| 15 | | | | | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | | | | | FSMEXECUTE | | | | | |
| R-0 | | | | | RWP-01010 | | | | | |

LEGEND: -n = value after reset, R=Read, WP=Write in Privilege Mode

Table 6. Flash State Machine Command Register (FSM_COMMAND) Field Descriptions

| Bit | Field | Value | Description |
|-------|-------------|-------|---|
| 31:20 | Reserved | 0 | These are reserved bits |
| 19:16 | SUSPEND_NOW | 0101 | Writing a 5 to this register will suspend the Program or Erase sector command. Writes to this register are ignored unless the FSM is busy with one of these commands. This field resets to '0101' when the FSM enters the standby state where it waits for the next command. It will not retain the written value for long. The Bank erase command and every command except those two commands above are not suspendable and will ignore the suspend command. A suspend operation will exit the FSM with the proper setup and hold times for the various modes. |
| 15:5 | Reserved | 0 | These are reserved bits |
| 4:0 | FSMEXECUTE | 01010 | To invoke a FSM command this register must be written with a value of 10101. This register is reset back to 01010 by the FSM upon completion of the command operation. Writes to this register are ignored while the FSM is busy. All others registers must be set up before writing to this command. Writing a 15h to this field is the last step to starting an FSM operation. |

3 Example Usage

The following examples show some typically use cases in writing code using the Flash Memory Controller registers. The example code segments make use of the following framework code. For API functions used in these examples, see the *F021 Flash API Reference Guide* ([SPNU501](#)). For proper initialization of the device prior to any Flash operations, see the device-specific initialization document. All FMC register writes require the device to be in a privilege state.

```
#include "F021.h"

int main (void)
{
    Fapi_StatusType oReturnCheck = Fapi_Status_Success;
    FwpWriteByteAccessorType * oFwpWriteByteAccessor    = FWPWRITE_BYTE_ACCESSOR_ADDRESS;
    FwpWriteByteAccessorType * oFwpWriteEccByteAccessor = FWPWRITE_ECC_BYTE_ACCESSOR_ADDRESS;
    FwpWriteDWordAccessorType * oFwpWriteDWordAccessor  = FWPWRITE_DWORD_ACCESSOR_ADDRESS;

    uint8 au8MainDataBuffer[16] = {0x78, 0x17, 0x19, 0x2E, 0x0A, 0xB9, 0x11, 0x70,
    0x5F, 0xC1, 0x9C, 0xFD, 0x54, 0x51, 0xED, 0x86};
    uint32 u32Index;

    /*
        For proper initialization of the device prior to any Flash
operations,
        see the device-specific initialization document.

        Assumes, unless otherwise noted, device has 144bit wide Flash Banks.
    */

    oReturnCheck = Fapi_initializeFlashBanks(180); /* Example code is assuming operating
frequency of 180 MHz */

    if((oReturnCheck == Fapi_Status_Success) &&
        (FLASH_CONTROL_REGISTER->FmStat.FMSTAT_BITS.Busy != Fapi_Status_FsmBusy))
    {
        oReturnCheck = Fapi_setActiveFlashBank(Fapi_FlashBank0);

        /* Place specific example code here */

        /* Wait for FSM to finish */
        while(FLASH_CONTROL_REGISTER->FmStat.FMSTAT_BITS.Busy == Fapi_Status_FsmBusy);

        /* Check the FSM Status to see if there were no errors */
        if (FLASH_CONTROL_REGISTER->FmStat.u32Register != 0)
        {
            /* Put Error handling code here */
        }
    }
}
```

3.1 Typical Command Execution Flow

Figure 15 shows the typical flow for issuing an erase or program command.

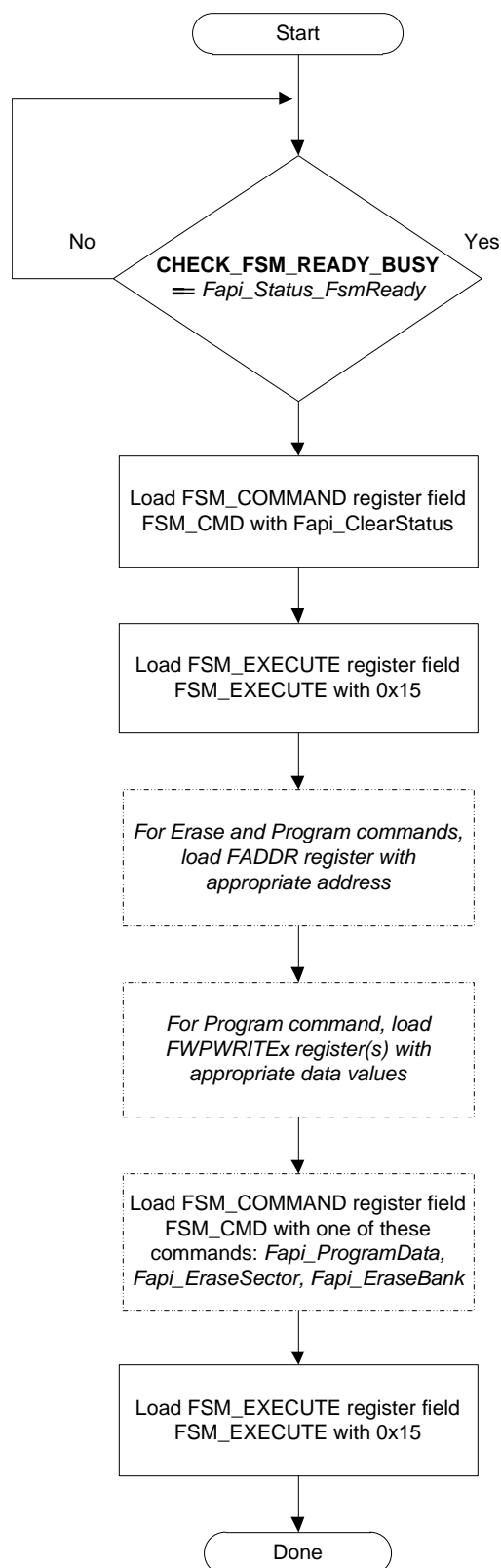


Figure 15. Recommended Command Execution Flow

3.2 Programming Operations

3.2.1 Programming a Single Byte

The following code segment will write a single byte to the address specified.

```
FLASH_CONTROL_REGISTER->Fbprot.u32Register = 1U; /* Disable Level 1 Protection */

/* Enable all sectors of current bank for erase and program. For EEPROM banks with more
than 16 sectors, this must be 0xFFFF */
FLASH_CONTROL_REGISTER->Fbse.u32Register = 0xFFFF;

FLASH_CONTROL_REGISTER->Fbprot.u32Register = 0U; /* Enable Level 1 Protection */

/*Unlock FSM registers for writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x5U;

/* Set command to "Clear the Status Register" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ClearStatus;
/* Execute the Clear Status command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* Write address to FADDR register */
FLASH_CONTROL_REGISTER->Faddr.u32Register = 0x0100U;

/* Placing byte at address 0x0102 */
oFwpWriteByteAccessor[2] = 0xA5;

/* Set command to "Program" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ProgramData;
/* Execute the Program command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* re-lock FSM registers to prevent writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x2U;
```

3.2.2 Programming 128-Bit Data and 16-Bit ECC

The following code segment will write 16 bytes starting at the 128-bit aligned address specified.

```
FLASH_CONTROL_REGISTER->Fbprot.u32Register = 1U; /* Disable Level 1 Protection */

/* Enable all sectors of current bank for erase and program. For EEPROM banks with more
than 16 sectors, this must be 0xFFFF */
FLASH_CONTROL_REGISTER->Fbse.u32Register = 0xFFFF;

FLASH_CONTROL_REGISTER->Fbprot.u32Register = 0U; /* Enable Level 1 Protection */

/*Unlock FSM registers for writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x5U;

/* Set command to "Clear the Status Register" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ClearStatus;
/* Execute the Clear Status command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* Write address to FADDR register */
FLASH_CONTROL_REGISTER->Faddr.u32Register = 0x0100U;

/* Placing bytes at address 0x0100 - 0x010F */
```



```

for(u32Index=0;u32Index<16;u32Index++)
{
    oFwpWriteByteAccessor[u32Index] = au8MainDataBuffer[u32Index];
}

/* Supply the address where ECC is being calculated */
FLASH_CONTROL_REGISTER->FemuAddr.u32Register = 0x0100;

#ifdef _LITTLE_ENDIAN
/* Supply the lower 32bit word */
FLASH_CONTROL_REGISTER->FemuDlsw.u32Register = oFwpWriteDwordAccessor[1];
/* Supply the upper 32bit word */
FLASH_CONTROL_REGISTER->FemuDmsw.u32Register = oFwpWriteDwordAccessor[0];
#else
/* Supply the upper 32bit word */
FLASH_CONTROL_REGISTER->FemuDlsw.u32Register = oFwpWriteDwordAccessor[0];
/* Supply the lower 32bit word */
FLASH_CONTROL_REGISTER->FemuDmsw.u32Register = oFwpWriteDwordAccessor[1];
#endif

/* Place the Wrapper calculated ECC into FWPWRITE_ECC */
oFwpWriteEccByteAccessor[EI8(0)] = FLASH_CONTROL_REGISTER->FemuEcc.FEMU_ECC_BITS.EMU_ECC);

/* Supply the address where ECC is being calculated */
FLASH_CONTROL_REGISTER->FemuAddr.u32Register = 0x0108;

#ifdef _LITTLE_ENDIAN
/* Supply the lower 32bit word */
FLASH_CONTROL_REGISTER->FemuDlsw.u32Register = oFwpWriteDwordAccessor[3];
/* Supply the upper 32bit word */
FLASH_CONTROL_REGISTER->FemuDmsw.u32Register = oFwpWriteDwordAccessor[2];
#else
/* Supply the upper 32bit word */
FLASH_CONTROL_REGISTER->FemuDlsw.u32Register = oFwpWriteDwordAccessor[2];
/* Supply the lower 32bit word */
FLASH_CONTROL_REGISTER->FemuDmsw.u32Register = oFwpWriteDwordAccessor[3];
#endif

/* Place the Wrapper calculated ECC into FWPWRITE_ECC */
oFwpWriteEccByteAccessor[EI8(1)] = FLASH_CONTROL_REGISTER->FemuEcc.FEMU_ECC_BITS.EMU_ECC);

/* Set command to "Program" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ProgramData;
/* Execute the Program command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* re-lock FSM registers to prevent writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x2U;

```

3.3 Erasing Operations

3.3.1 Erasing a Single Sector With Bank Erase

The following code segment will erase a single Flash sector using the Bank erase command.

NOTE: The Bank Erase command is not a suspendable operation.

```
FLASH_CONTROL_REGISTER->Fbprot.u32Register = 1U; /* Disable Level 1 Protection */

/* Enable all sectors of current bank for erase and program. For EEPROM banks with more
than 16 sectors, this must be 0xFFFF */
FLASH_CONTROL_REGISTER->Fbse.u32Register = 0xFFFF;

FLASH_CONTROL_REGISTER->Fbprot.u32Register = 0U; /* Enable Level 1 Protection */

/*Unlock FSM registers for writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x5U;

FLASH_CONTROL_REGISTER->FsmSector.u32Register = 0xFFFE0000; /* Disable all sectors except for sector 0 from bank
operation */

/* Set command to "Clear the Status Register" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ClearStatus;
/* Execute the Clear Status command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* Write address to FADDR register. This address must be within the bank to be erased */
FLASH_CONTROL_REGISTER->Faddr.u32Register = 0x0100U;

/* Set command to "Program" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_EraseBank;
/* Execute the Program command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* re-lock FSM registers to prevent writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x2U;
```

3.3.2 Erasing a Single Sector With Sector Erase

The following code segment will erase a single Flash sector using the Sector erase command.

```
FLASH_CONTROL_REGISTER->Fbprot.u32Register = 1U; /* Disable Level 1 Protection */

/* Enable all sectors of current bank for erase and program. For EEPROM banks with more
than 16 sectors, this must be 0xFFFF */
FLASH_CONTROL_REGISTER->Fbse.u32Register = 0xFFFF;

FLASH_CONTROL_REGISTER->Fbprot.u32Register = 0U; /* Enable Level 1 Protection */

/*Unlock FSM registers for writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x5U;

/* Set command to "Clear the Status Register" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_ClearStatus;
/* Execute the Clear Status command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* Write address to FADDR register. This address must be within the bank to be erased */
FLASH_CONTROL_REGISTER->Faddr.u32Register = 0x0100U;

/* Set command to "Program" */
FLASH_CONTROL_REGISTER->FsmCommand.FSM_COMMAND_BITS.FSMCMD = Fapi_EraseSector;
/* Execute the Program command */
FLASH_CONTROL_REGISTER->FsmExecute.FSM_EXECUTE_BITS.FSMEXECUTE = 0x15U;

/* re-lock FSM registers to prevent writing */
FLASH_CONTROL_REGISTER->FsmWrEna.u32Register = 0x2U;
```

4 References

F021 Flash API Reference Guide ([SPNU501](#))

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