



DEVICE FIRMWARE UPGRADE (DFU) IMPLEMENTATION IN ST7 USB DEVICES

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1 INTRODUCTION

This application note presents the implementation of a Device Firmware Upgrade (DFU) capability in ST7 USB microcontrollers. It follows the DFU class specification defined by the USB Implementers Forum, for reprogramming an application through USB. The DFU principle is particularly well suited to USB applications that require need to be reprogrammed in the field: The same USB connector can be used both for the standard operating mode, and for the reprogramming process.

This operation is made possible by the IAP capability featured by most of the ST7 microcontrollers, which allows a FLASH MCU to be reprogrammed by any communication channel (Please refer to AN1575 for more details).

The DFU process, like any other IAP process, is based on the execution of firmware located in Sector 0 of the ST7 Flash memory which manage the Flash operations (erasing and programming) of Sectors 1 and 2.

This application note covers then two main aspects:

The firmware located in Sector 0,

The Interface between the firmware in Sector 0 and the firmware in Sectors 1 & 2.

The proposed implementation is demonstrated with 2 different projects: the USB Low-Speed devices Evaluation Kit and the ST7265 Full-Speed 5-in-1 demoboard. In this document these projects are referred to as “LS project” and “FS project”.

A basic DFU protocol is also used in these projects. The modular approach used in the implementation based on a DFU library allows you to adapt it easily to other higher level protocols or new types of hardware.

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2 DFU CLASS

2.1 INTRODUCTION

The DFU class uses the USB as a communication channel between the ST7 and the programming tool, generally a PC host. The DFU class specification states that, all the commands, status and data exchanges have to be performed through Control Endpoint 0. The command set, as well as the basic protocol are also defined, but the higher level protocol (Data format, error message, ..) remain vendor specific. This means that the DFU class does not define the format of the data transferred (*.s19*, *.hex*, pure binary, etc...).

2.2 PHASES

There are four distinct phases required to accomplish a firmware upgrade:

1. **Enumeration:** The device informs the host of its capabilities. A DFU class-interface descriptor and associated functional descriptor embedded within the device's normal run-time descriptors serve this purpose and provide a target for class-specific requests over the control pipe.
2. **Reconfiguration:** The host and the device agree to initiate a firmware upgrade. The host issues a USB reset to the device, and the device then exports a second set of descriptors in preparation for the Transfer phase. This deactivates the run-time device drivers associated with the device and allows the DFU driver to reprogram the device's firmware unhindered by any other communications traffic targeting the device.
3. **Transfer:** The host transfers the firmware image to the device. The parameters specified in the functional descriptor are used to ensure correct block sizes and timing for programming the nonvolatile memories. Status requests are employed to maintain synchronization between the host and the device.
4. **Manifestation:** Once the device reports to the host that it has completed the reprogramming operations, the host issues a USB reset to the device. The device re-enumerates and executes the upgraded firmware.

To ensure that only the DFU driver is loaded, it is considered necessary to change the *id-Product* field of the device when it enumerates the DFU descriptor set. This ensures that the DFU driver will be loaded in cases where the operating system simply matches the vendor ID and product ID to a specific driver.

LS project Example: the Product ID of the Evaluation Kit with the DFU class is the FF03h and 0003h for the standard Evaluation Kit without the DFU.

2.3 REQUESTS

A number of DFU class-specific requests are needed to accomplish the upgrade operations. The following table summarizes the DFU class-specific requests.

Table 1. Summary of DFU Class-Specific Requests

bmRequestType	bRequest	wValue	wIndex	wLength	Data
00100001b	DFU_DETACH (0)	wTimeout	Interface	Zero	None
00100001b	DFU_DNLOAD (1)	wBlocknum	Interface	Length	Firmware
10100001b	DFU_UPLOAD (2)	Zero	Interface	Length	Firmware
10100001b	DFU_GETSTATUS (3)	Zero	Interface	6	Status
00100001b	DFU_CLRSTATUS (4)	Zero	Interface	Zero	None
10100001b	DFU_GETSTATE (5)	Zero	Interface	1	State
00100001b	DFU_ABORT (6)	Zero	Interface	Zero	None

For additional information about these requests, please refer to the DFU Class specification.

2.4 ENUMERATION PHASE

A device with DFU capability must be able to be enumerated in two ways by the host:

- As a single device with only DFU capability.
- As a composite device: HID, Mass storage, or any functional class, and with DFU capability.

During the enumeration phase, the device exposes two distinct and independent descriptor sets, one each at the appropriate time:

- Run-time descriptor set: shown when the device performs normal operations.
- DFU mode descriptor set: shown when host and device agree to perform DFU operations.

2.4.1 Run-Time Descriptor Set

During normal run-time operation, the device exposes its normal set of descriptors plus two additional descriptors:

- Run-Time DFU Interface descriptor
- Run-Time DFU Functional descriptor

Note: The number of interfaces in each configuration descriptor that supports the DFU must be incremented by one to accommodate the addition of the DFU interface descriptor.

2.4.2 DFU Mode descriptor Set

After the host and the device agree to perform DFU operations, the host re-enumerates the device. At this time the device exports this descriptor set:

- DFU Mode Device descriptor
- DFU Mode Configuration descriptor
- DFU Mode Interface descriptor
- DFU Mode Functional descriptor: identical to the Run-Time DFU Functional descriptor

For detail information on these descriptors see the *USB Device Firmware Upgrade Specification*.

2.5 RECONFIGURATION PHASE

Once the operator has identified the device and supplied the filename, the host and the device must negotiate to perform the upgrade.

An example of negotiation could be as follows:

- The host issues a Vendor Specific request containing a key (optional).
- The device checks the key received and sends back a status on the acknowledgement of the flash read or write request.
- If the host receives a negative acknowledgement then the host aborts the firmware upgrade. otherwise the following operations are performed:
- The host issues a DFU_DETACH request to Control Endpoint EP0.
- The host issues a USB reset to the device. This USB Reset is not possible on some Windows versions. To bypass this issue, the USB reset is performed by the device (USB regulator is powered-off then powered-on).
- The device enumerates with the DFU Mode descriptor set, as described above.

To support entering the transfer phase, a variable mapped in RAM keeps the DFU_DETACH request status: DETACH received or not

When a USB reset signal is received, the USB reset interrupt routine checks this variable. If a DETACH has previously been received, the device exports the DFU Mode descriptor set, otherwise it exports its normal run-time descriptor set.

2.6 TRANSFER PHASE

The Transfer phase begins after the device has processed the USB reset and exported the DFU Mode descriptor set. Both downloads and uploads of firmware can take place during this phase. This transfer phase consists of a succession of DFU requests according to the state diagram defined in the DFU Class specification (Fig A1 page 26).

2.6.1 Downloading

The host slices the firmware image file into N pieces and sends them to the device by means of control-write operations in the default endpoint (Endpoint 0).

The maximum number of bytes that the device can accept per control-write transaction is specified in the *wTransferSize* field of the DFU Functional Descriptor.

There are several possible download mechanisms . The third mechanism described in chapter 6.1 of the *USB Device Firmware Upgrade Specification* is implemented in this project:

1. A large portion of memory is erased. In our case all of Sector 1 and/or all of Sector 2.
2. Small firmware blocks are written. 8 bytes in the LS project, 128 bytes in the FS project.

Note: The number of bytes sent to the device in a control-write transfer is indicated by the *wTransferSize* field of the DFU Functional Descriptor.

2.6.2 Uploading

The purpose of an Upload is to retrieve and archive a device's firmware. It is by definition the reverse of a Download. After Upload the Host should have a DFU suffix in the file where the data are saved. This suffix contains useful information like the VendorID, ProductID, Firmware Version, etc...

2.7 MANIFESTATION PHASE

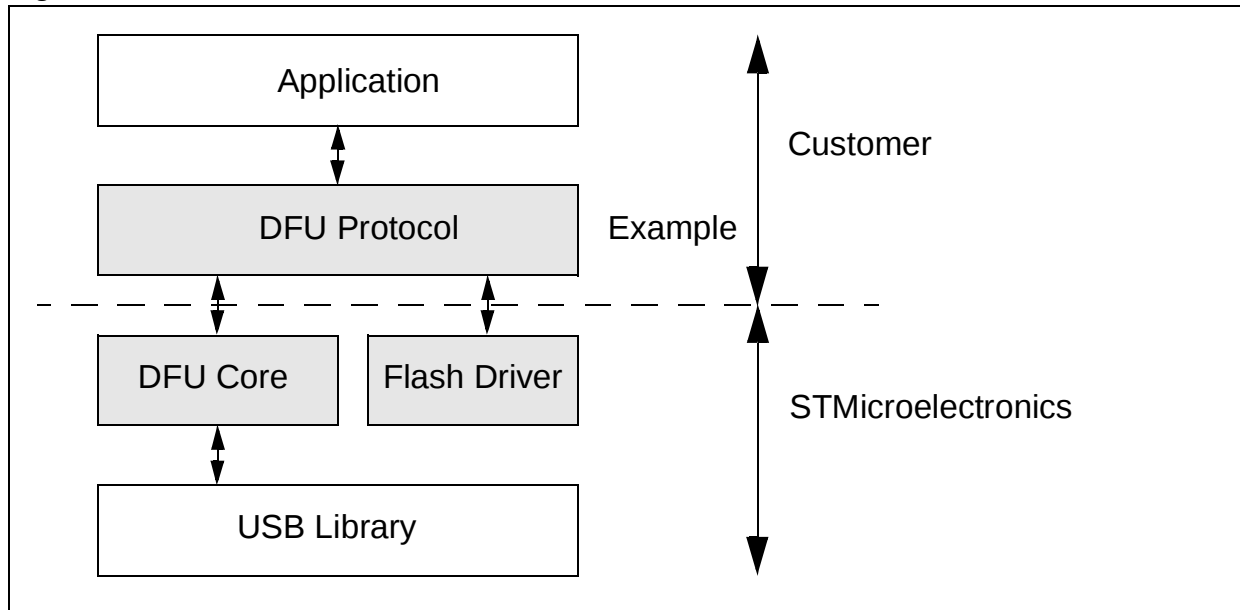
After the transfer phase is terminated, the device is ready to execute the new firmware. To do this the host must send a USB reset to re-enumerate the device in normal run-time operation.

3 DFU IMPLEMENTATION

3.1 FIRMWARE ORGANIZATION

Both LS and FS projects are organized in the same way in terms of their DFU implementation. Figure 1 shows the different software layers that have been added between the Library and the Application:

Figure 1. Firmware Overview



3.2 DFU MECHANISM

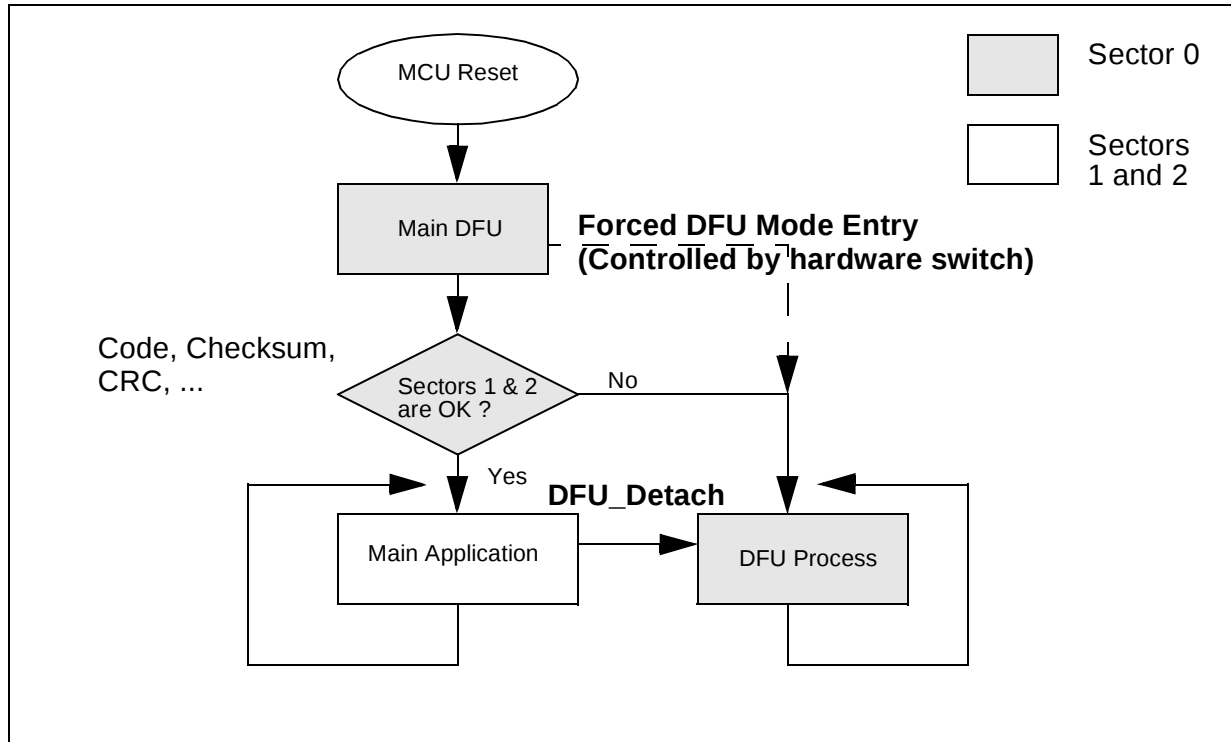
The solution proposed by STMicroelectronics provides a mechanism for selecting entry into DFU Mode (See Figure 2). To accomplish this task it is very important to understand that only the Sectors 1 and 2 can be erased and programmed during DFU operation. Sector 0 contains the USB Standard Library and the DFU class routines.

After MCU Reset, the Reset Vector points to the DFU main routine. Just afterward, a verification of the integrity of Sectors 1 and 2 is performed. This check can be done in several ways: Checksum, CRC, Code etc... If this test is OK (meaning that Sectors 1 and 2 are correct), then the application main routine is executed. Otherwise the DFU process takes place.

There are two other ways to enter DFU mode:

1. By receiving a DFU_DETACH request while the application is running.
2. By Hardware after an MCU Reset. This solution allows the user to force entry into DFU mode. This solution is only given as example and is implemented in the LS project only. It is not described in the DFU specification.

Figure 2. DFU Mode Entry Mechanism



3.3 FLASH SECTOR MANAGEMENT

In order for the DFU mode entry mechanism described above to function correctly, it is necessary to place the firmware routines in the right sectors.

Basically, Sector 0 contains all routines that must be preserved during DFU erasing and programming. It principally contains the USB standard Library and the DFU layer routines.

Note: Application routines or constants can also be present in this sector, but in this case they cannot be updated in DFU mode.

The Sectors 1 and 2 contain all routines and data that can be erased or changed in DFU mode. They contain the Application routines and the “jump table” (see below).

The DFU_DETACH request decoding must also be present in these sectors. We can imagine a “one shot DFU”, where the DFU_DETACH request decoding is not implemented in the new firmware just downloaded (software protection). The only way to recover is by using a Hardware switch (see Figure 2).

3.3.1 SECTOR 1 AND 2 INTEGRITY CHECK

As we have seen previously, we need to check if Sectors 1 and 2 are correct before calling the main application routine. This will insure that these sectors are not corrupted due bad erasing or bad programming. This check is not described in the DFU specification. and it can be easily removed from the DFU protocol.

In the LS project, the solution adopted for this check is the following:

- the last byte of sector 1 is reserved.
- after the erasing operation this byte contains FFh.
- at the end of downloading this byte is written with 6Dh.
- after each MCU Reset this byte is checked. If it contains 6Dh we jump to the Application main routine, otherwise we jump to the DFU process routine.

So, if the download operation is aborted or if something wrong happens the MCU will always enumerate in DFU mode.

In the FS project a Checksum calculation is used:

- during downloading the Checksum is calculated on all the data received.
- at the end of download the Checksum is written at the end of Sector 1.
- after MCU Reset the Checksum is re-calculated and compared to the value written in the last bytes of Sector 1.

Note: This second solution takes more execution time than the first one.

3.3.2 LIBRARY FUNCTIONS CALLED BY THE APPLICATION

The Application calls several functions from the USB Library.

For the LS project the Library functions called are:

Init_USB_HW, Disable_USB_HW, Handle_USB_Events, Enable_STATUS_Stage, Test_EP_Ready, Set_EP_Ready, Write_EP_Buffer, Read_EP_Buffer.

These Library routines are placed in Sector 0 and their content and address locations are not changed in DFU mode. The problem we face is that the Application firmware is also linked with these Library routines. The location of these Library routines can be different from the location chosen by the linker when the Library is compiled on its own...

A simple way to solve this issue is to access the Library functions using their direct address.

LS project example:

```
#define Init_USB_HW ((void*)(void)) 0xF635)
```

The call to the function remains the same:

```
Init_USB_HW();
```

Special case: Functions with Parameters

Some Library routines need parameters with a number of bytes greater than 2. These are:

In the LS project: Set_EP_Ready, Write_EP_Buffer, Read_EP_Buffer.

If the MetroWerks compiler is used, the third and any subsequent bytes are saved in the Overlap area. However, this is not compatible with DFU operation, because the same area could be used by a new application firmware (See RAM management for more details).

For these routines the parameters are passed through a structure of global variables.

LS project example:

```
#define Set_EP_Ready(EndPointPrm,DirectionPrm,LengthPrm) {\nGParams.SEPRParams.EndPoint=EndPointPrm;\nGParams.SEPRParams.Direction=DirectionPrm;\nGParams.SEPRParams.Length=LengthPrm;\nSet_EP_Ready_NP(); }\n#define Set_EP_Ready_NP ((void(*) (void)) 0xF70E)
```

In the Application firmware we still use the same call to the Library routine:

```
Set_EP_Ready(0, EP_IN, 8);
```

But here the 3 parameters are saved in RAM. Then the Set_EP_Ready_NP routine is called. The purpose of this routine is to retrieve the parameters previously saved in RAM and then to call the Library routine located in Sector 0:

```
void Set_EP_Ready_NP (void) {\nSet_EP_Ready(GParams.SEPRParams.EndPoint,GParams.SEPRParams.Direction,GPar-\nams.SEPRParams.Length);\n}
```

Note: In the FS project, none of the Library functions use parameters. So, the issue does not occur in this project.

3.3.3 APPLICATION FUNCTIONS CALLED BY THE LIBRARY

Also called 'Call-back' functions.

The Application routines called by the Library can have their address location changed after a download. The address of these routines must be saved somewhere in order to allow the Library to call them. This area is called a 'Jump Table' (see below for details).

The Application functions called by the Library are:

In the LS and FS projects:

- the main application routine
- all the interrupt routines

In the LS project:

- the MCU_Init routine called when an USB EndSuspend interrupt occurs
- the USB specific routines Appli_Status_In and Appli_Status_Out for each Status IN/OUT stage

In the FS project: all USER_USB_xxx functions.

3.3.4 JUMP TABLE

As already mentioned, this table is used to store the address of the Application routines called by the Library.

In the LS project: In order to use fewer bytes (when routines are called) this table is defined in assembly. It simply contains a JP to the routine address.

This table is placed at a fixed address at the end of Sector 1: EFC0h

It is important to note that two assembly files are used for this Jump Table. One is used during the compilation of the Library in Sector 0, and contains dummy addresses. The second one is used during the compilation of the Application in Sectors 1 and 2. At this time the addresses of the routines are known.

In the FS project: the call is performed in C language directly using a double function call. Dummy functions placed at a fixed address are used for this purpose.

FS project example: The Library calls the USER_USB_Setup function. This function calls the dummy function Vec_USB_Setup. It is located at a fixed address and it in turn calls the application function App_USB_Setup.

3.4 RAM MANAGEMENT

3.4.1 SHARED VARIABLES

Some variables are accessed by both Library and Application functions. These variables are located at a fixed addresses in 16-bit RAM.

Some variables used:

In the LS project: UsbLibStatus, USBbRequest, USBwValue, USBwIndex, etc...

In the FS project: EPs_DataAddress, EPs_Length, etc...

The EndPoint buffers are also shared variables.

The location of these variables is done using pragmas or using the "@" symbol after the variable declaration.

3.4.2 LOCAL VARIABLES

This refers to all variables which are not shared between the Library and the Application functions. Library variables and Application variables are located in different areas in order to avoid overlapping when an application firmware is upgraded. See the PRM files for details on the location of these variables.

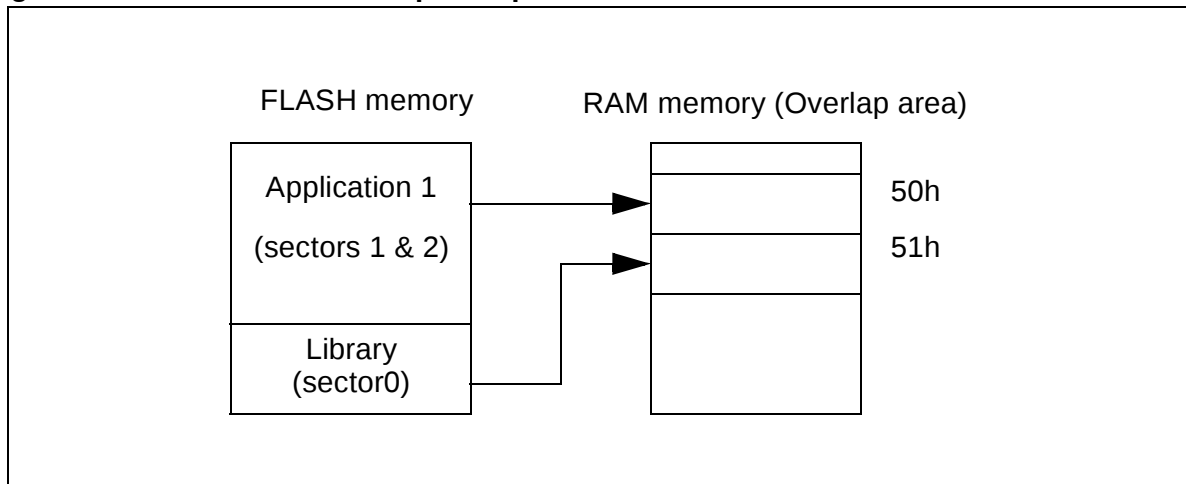
3.4.3 OVERLAP AREA

The Overlap area is not used by the Library of the FS project. So no precautions are necessary for this project.

But the Library of the LS project is strongly impacted. A lot of Library functions have parameters. When more than 2 bytes are used, the parameter passing is done through the Overlap area. An overlapping problem can occur when a firmware is upgraded. See the example below:

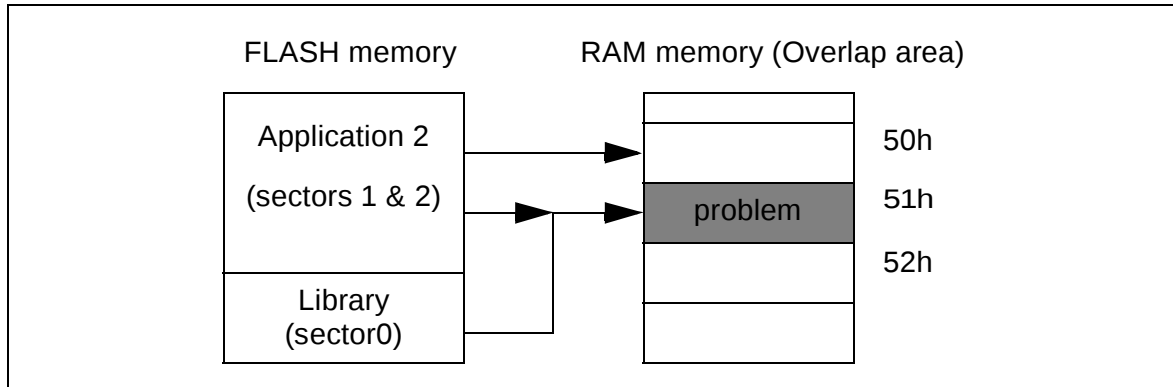
Initial state: the linker has placed a variable used by the application at address 50h and a variable used by a Library function at address 51h. The Library and Application firmware are written in Sectors 0, 1, 2 using an EPB programming board:

Figure 3. Initial State of Overlap area prior to DFU



The problem appears when a new application firmware is written in the Flash and the overlap area is modified. Suppose now that the application function uses a second variable. The linker will locate this second variable at address 51h and the Library function variable at address 52h. But in DFU programming, the Library in Sector 0 is not changed and still uses the address 51h:

Figure 4. Problem of Overlap area conflict after DFU



So, it is necessary also in this case to separate the Library and the Application Overlap areas.

Note: The same thing must also be done for the ZeroPage area. Refer to the project PRM file for details about the location of these areas.

3.4.4 STACK

The stack area is shared by the Library and the Application. No special precautions are needed in normal mode, but a minimum amount of free stack must be available before calling any of the Embedded Commands used for HDFlash programming. This is explained in detail further on.

3.5 DESCRIPTORS

3.5.1 STANDARD DESCRIPTORS

The normal run-time descriptors have to be modified to support DFU capability.

Device descriptor

The Product ID must be changed because when DFU is implemented, the device becomes composite.

In the LS project: Evaluation Kit + DFU has the number FF03h (instead of 0003h for Evaluation Kit alone)

In the FS project: 5-in-1 + DFU has the number 0320h (instead of 1307h for 5-in-1 alone).

Note: When the device is in DFU mode only, its Product ID is the number DF11h. This number is common for any project with DFU support.

Configuration descriptor

The bNumInterfaces of each configuration that supports DFU must be incremented by one.

For LS project: bNumInterfaces = 2 (HID + DFU)

For FS project: bNumInterfaces = 2 (MASS STORAGE + DFU)

Furthermore, 2 additional descriptors must be added at the end of the Configuration descriptor: the Run-Time DFU Interface descriptor and the Run-Time DFU Functional descriptor. These descriptors are described in detail below.

3.5.2 DFU DESCRIPTORS

The table below summarizes the 5 DFU descriptors to be created and in which mode they appear:

Table 2. DFU Descriptors

Name	Run-Time Mode	DFU Mode
DFU Device Descriptor		X
DFU Configuration Descriptor		X
DFU Interface Descriptor		X (**)
DFU Run-time Interface Descriptor	X (*)	
DFU Functional Descriptor	X (*)	X (**)

(*) Descriptor included in the Run-Time Configuration descriptor

(**) Descriptor included in the DFU Mode Configuration descriptor

These descriptors are placed in Sector 0 in the following files:

In the LS project: `DFUDescript.c`, `DFUDescript.h`

In the FS project: `DFU_desc.c`

3.5.3 DFU STRING DESCRIPTORS

DFU string descriptors are in theoretically optional. But three descriptors are created for the DFU in the LS and FS projects. These allow the host to get some useful information when Sectors 1 & 2 are incorrect.

DFU Language ID: 0409h (US English code)

DFU Manufacturer Name: STMicroelectronics

DFU Product Name: DFU Demo

These descriptors are located in Sector 0 in the same files as listed above.

3.6 PROTOCOL

3.6.1 DOWNLOAD STRATEGY

The strategy adopted in the LS and FS projects is exactly the same:

- 1) Sector 1 and/or Sector 2 are erased.
- 2) Blocks of data are transferred and programmed: 8 bytes for LS project and 128 bytes for the FS project.
- 3) A code or a checksum is written at the end of Sector 1. This code certifies that the download operation has been performed correctly.

The Host selects the data to be downloaded into the device. In order to decrease the downloading time, blocks of data containing only FFh are not transferred. To achieve this strategy the wBlockNum field of the DFU_DNLOAD request is used.

3.6.2 wBlockNum VALUES

As already mentioned, this field is used to pass certain information during download. The same field is also used in the DFU_UPLOAD request to read the flash memory. The table below summarizes the values used:

Table 3. wBlockNum values

wBlockNum	Description
FFFFh	Erase Sectors 1 and 2
FFFEh	Erase Sector 1 only
FFFDh	Erase Sector 2 only
FFFC to 1E000h	Not Used
1DFFh to 1000h	Flash address divided by 8
0FFFh to 0000h	Not Used

Note: The fact that the Flash address is given divided by 8 is only a protocol example.

3.7 HARDWARE CONSIDERATIONS

3.7.1 VPP

The HDFlash memory needs 12V on the Vpp pin during erasing and programming operations. This 12V is provided using a ST662A device. This device is already present on the Evaluation

Kit and the 5-in-1 boards. A specific I/O port is used to control the presence of the 12V on the Vpp pin:

LS project: I/O Port PB1

FS project: I/O Port PE4

Please refer to the “ST7 Family Flash Programming Reference Manual” for implementation details concerning the ST662A device.

3.7.2 FORCED DFU MODE ENTRY

In the LS project only, there is a possibility to enter DFU mode directly without checking the integrity of Sectors 1 & 2. To do this, the SW1 Switch must be pressed while the Reset button is released. This mechanism is very useful when a problem occurs in the Application and the DFU_DETACH command cannot be interpreted. If this happens in the FS project, the only way to recover is to erase Sector 1 using an EPB programming board.

3.8 HDFLASH DRIVERS

Erasing and programming the HDFlash memory is done using the Embedded Commands in the System Memory of the ST7 device.

Some routines (drivers) have been created to access these Embedded Commands easily. These routines can be used in any project that needs to erase or program the HDFlash.

For more information on these drivers see the AN1576.

3.8.1 FUNCTIONS USED

Only few driver functions are used in the DFU project. They are:

RASS_Disable: to unlock the FCSR register

HDFlashEraseSector: to erase a sector

HDFlashWriteByte: to write a single byte

HDFlashWriteBlock: to write a block

Note: The FS project uses the WriteBlock function to program the bytes into the Flash, while the LS project uses the WriteByte function.

3.8.2 STACK AND RAM

Caution: Before launching any Embedded Command, the Stack Pointer must be greater than or equal to 017Ch. This is due to the fact that 124 bytes are used in the Stack by the Embedded commands.

In the LS project, the Stack area of the ST72F62 and ST72F63B devices contains only 128 bytes. So, we must have a maximum of 2 function calls (starting from the main routine) before

launching a HDFlash function. This limitation does not exist in the FS project because the Stack area is bigger in the ST72F65 device.

Embedded commands also use the RAM from F0h to FFh for parameter passing and local variables. This area must not be used by the application while the Embedded commands are running.

4 DFU LOW-SPEED PROJECT

The LS DFU project has been created starting from the ST7 USB LS Evaluation Kit project and the ST7 USB LS Library. Two other parts have been added: the DFU specific files and the HDFlash drivers (in bold in the next section).

4.1 DIRECTORIES

ST7USBL-DFU

- +-- EvalKit: ST7 USB LS Evaluation Kit project
- +-- Config: project configuration files (mak, prm, etc...)
- +-- Appli: application files
- +-- **DFU: DFU layer files**
- +-- Objects: output from compilation
- +-- **HDFlashDriver: Flash routines to erase and program**
- +-- Library: ST7 USB LS Library project
- +-- Config: project configuration files (mak, prm, etc...)
- +-- Macro: macros definitions
- +-- Micro: devices mapping files
- +-- Usb: ST7 USB Low-Speed Library kernel files
- +-- Objects: output from compilation

As you can see the Library can be compiled alone without the EvalKit project. This is because the RAM area of the Library is completely separated from the RAM area of the EvalKit project. So, a different prm file is needed. The S19 file generated from the Library can then be loaded into Sector 0 even if the EvalKit project is not ready.

4.2 DFU FILES

All these files are placed inside the “DFU” directory. Files in bold are files that depend on the protocol and/or the application, and may be modified by the user.

Table 4. LS Project DFU Files

File Name	Description
DFUCore.c / DFUCore.h	Contain the DFU Kernel routines. Not protocol nor application dependant.
DFUDescript.c / DFUDescript.h	Contain the DFU descriptors. They are dependant on the application.
DFUJumpTable_XXX.asm	Contain the Jump Tables used by the Library to access the application routines. Dependant on the application.
DFULibFuncAdd.h	Contain the address of the Library routines called by the Application. Must be modified each time the Library function addresses are changed.
DFUProtocol.c / DFUProtocol.h	Contain the DFU protocol routines. They are dependant on the application.

4.3 DFU CALL-BACK FUNCTIONS

These functions are called by the DFU Kernel routines. They are dependant on the protocol and/or the application. All these functions are located in the “DFUProtocol.c” file. The content of these functions is only a DFU implementation example. Depending on the protocol adopted, these functions can be modified by the user.

Table 5. LS Project DFU Call-back Functions

Function Name	Description
DFU_Abort_User	Called by the DFU_Abort function when a DFU_ABORT request is received. Used to set Vpp to 5V.
DFU_ClearStatus_User	Called by the DFU_ClearStatus function when a DFU_CLRSTATUS request is received.
DFU_Download_User	Called by the DFU_Download function when a DFU_DNLOAD request is received. Used to received and decode the data from the Host.
DFU_Init_User	Called by the DFU_Init function when entering DFU mode. Used to initialize variables, Vpp, etc...

Table 5. LS Project DFU Call-back Functions

Function Name	Description
DFU_ManifestWaitReset_User	Called by the DFU_GetStatus function at the end of the downloading phase. This function is used to write the End Of Programming code in the last byte of Sector 1.
DFU_S1S2Valid	Used to check the integrity of Sectors 1 and 2. This is the first function called by DFU_Main after Reset.
DFU_Upload_User	Called by the DFU_Upload function when a DFU_UPLOAD request is received. Used to prepare and send the data to the Host.
HDFlashProcess	Called by the DFU_Main function. This function manages the call to all HDFlash routines.
VbusCheck	Used to check the presence of the Vbus when device is in self-powered mode. This function is compiled if the SELF_POWERED compilation variable is defined.

4.4 OTHER DFU FUNCTIONS

These functions are not called by the Library. They are utility routines used during DFU processing.

Table 6. LS Project Other DFU Functions

Function Name	Description
SetVpp12V	Used to set the Vpp voltage to 12V needed during erasing or programming operations.
SetVpp5V	Used to set the Vpp Voltage to 5V when not erasing or programming.

4.5 DFU VARIABLES

These variables are shared by the DFU kernel and the DFU protocol functions.

Table 7. LS Project DFU Variable

Variable Name	Description
DFUDataReceived	Buffer for storing data coming from the host after a Down-Load request.
DFUDataToSend	Buffer containing data to send to the host for UpLoad, Get-State or GetStatus requests.
DFUDeviceState	Contains the current DFU state of the device as defined in the DFU specification. Sent after a GetState or GetStatus request.
DFUDeviceStatus	Contains the current DFU status of the device as defined in the DFU specification. Sent after a GetStatus request.
DFUPollTimeOutH	Contains the high byte of the Polling TimeOut. Sent after a GetStatus request.
DFUPollTimeOutL	Contains the low byte of the Polling TimeOut. Sent after a GetStatus request.

4.6 RESTRICTIONS

This project is compatible with MetroWerks compiler only and with ST72F62-16K and ST72F63B-16K devices due to RAM size restriction.

5 DFU FULL-SPEED PROJECT

The FS DFU project has been created from the ST7265 5-in-1 project and the ST7 USB FS Library. Two other parts have been added: the DFU specific files and the HDFlash drivers (in bold in the next section).

5.1 DIRECTORIES

ST7USBFS-DFU

+-- Object: output from compilation

+-- Sources

+-- MassSto

+-- Mcl

+-- Usb: ST7 USB Full-Speed Library kernel files

+-- Usb_App: USB application specific files

+-- Usb_DFU: USB DFU specific files (kernel + application + HD Flash drivers)

For details of “MassSto” and “Mcl” directories please refer to AN1475 “Developing an ST7265X Mass Storage Application”.

5.2 DFU FILES

All these files are located in the “Usb_DFU” directory. Files in bold are files that depend on the protocol and/or the application, and can be modified by the user.

Table 8. FS Project DFU Files

File Name	Description
DFU.c / DFU.h	Contain all DFU kernel and Protocol routines.
DFU_Desc.c	Contains the DFU descriptors.
DFU_Var.asm	Contains the definition of DFU variables.
Flashing.h	Contains the HDFlash routines.
User_USB.c / User_USB.h	Contain all call-back functions called by the Library. These functions call the DFU functions described in the DFU.c file.

5.3 DFU CALL-BACK FUNCTIONS

These functions are not directly called by the Library. Instead they are called by intermediate layer functions like “USER_USB_Reset”, etc... They are protocol and application dependant, and you can modify them to fit with yours application/protocol.

Table 9. FS Project DFU Call-back Functions

Function Name	Description
DFU_App_Valid	Used to check if the Application code in Sectors 1 and 2 is valid. A Checksum is calculated and compared with the Checksum previously saved in the last bytes of Sector 1. Returns 0 if Checksum is false.
DFU_Status_In	Processes some of the DFU OUT requests during the Status stage. For example DownLoad and Detach.
DFU_Status_Out	Processes some of the DFU IN requests during the Status stage. For example UpLoad and GetStatus.
DFU_CopyDataIN	Not used in this project.
DFU_CopyDataOUT	Used to copy data returned by a DownLoad request into the EndPoint 0 Out buffer.
DFU_Setup	Used to decode and process all DFU requests.

5.4 OTHER DFU FUNCTIONS

These functions are not call-back functions. They are utility routines used during DFU processing.

Table 10. FS Project Other DFU Functions

Function Name	Description
CheckSum_ROM	Used to calculate a checksum on Sectors 1 and 2.
CRC_ROM	Used to calculate a CRC on Sectors 1 and 2. Not used in this project, only given as example.
DFU_Init	Used to initialize all DFU variables.
DFU_Manifest	Called after Downloading is finished. Calculates and writes the Checksum in the Flash.

Table 10. FS Project Other DFU Functions

Function Name	Description
Flashing_End	Sets Vpp to 5V. Called when Flash operations are finished.
Flashing_Start	Sets Vpp to 12V and unlock FCSR register. Called before Flash operations start.
Jmp_Label	Jumps to the address previously saved by the Set_Label function.
Replug_Device	Powers down and Power up the USB voltage regulator to simulate a replug to the Host. Used after a Detach and after programming is finished.
Set_Label	Saves current PC in a variable. This variable is used to jump to the right place after a Detach request for example.
Setup_Timer	Initializes the timer used to count the timeout value after a Detach request is received.

5.5 DFU VARIABLES

Table 11. FS Project DFU Variables

Variable Name	Description
DFU_Action	Used to keep trace of the current DFU action.
DFU_BlockNum	Contains the wBlockNum value present in DownLoad and UpLoad DFU requests.
DFU_BlockSiz	Contains the number of bytes to program or read.
DFU_Buffer	Used to store the data received from the Host (DownLoad request) or to send to the Host (UpLoad request).
DFU_Capability	Contains information on DownLoad and UpLoad capabilities.
DFU_Request	Contains the current DFU request received.
DFU_State	Contains the current DFU State. Sent by GetState and Get-Status requests.
DFU_Status	Contains the current DFU Status. Sent by GetStatus request.
DFU_Timeout	Contains the TimeOut value sent by Detach request.

5.6 RESTRICTIONS

This project is compatible with MetroWerks compiler and with the ST72F65 device only.

6 RELATED DOCUMENTS

Table 12. External Documents

Name	Version/Date
Universal Serial Bus Specification	1.1 Sept 23, 1998
Universal Serial Bus Device Class Specification for Device Firmware Upgrade	1.0 May 13, 1999

Table 13. STM Documents

Name
ST7 Family Flash Programming Reference Manual
AN1575 “On-Board Programming Methods for XFlash and HDFlash ST7 MCUs”
AN1576 “In-Application Programming Drivers for XFlash and HDFlash ST7 MCUs”
AN1475 “Developing a ST7265X Mass Storage Application”
AN1603 “Using the ST7 USB Device Firmware Upgrade Development Kit (DFU-DK)”
ST7 USB Device Firmware Upgrade Demonstrator User Manual

7 RELATED SOFTWARE

Table 14. Microcontroller Software

Name	Description
ST7 USB Full Speed DFU Project: DFU for ST72F65x devices	This is the example referred to in this application note (AN1577) of a user application firmware with DFU capability for the ST72F65x devices. The project is supplied as a zip file containing all the necessary source and project files ready for compilation by the Metroworks C Compiler. It can be used to test the DFU process and can be easily adapted by the user to another application.
ST7 USB Low Speed DFU Project: DFU for ST7262/63B devices	This is the example referred to in this application note (AN1577) of a user application firmware with DFU capability for the ST72F62 or ST72F63B devices. The project is supplied as a zip file containing all the necessary source and project files ready for compilation by the Metroworks C Compiler. It can be used to test the DFU process and can be easily adapted by the user to another application.

Table 15. PC Software

Name	Description
ST7 DFU Demo Package	This an example of a Graphical User Interface for starting a DFU session. It can be used with the ST7 USB Full Speed and Low Speed Projects listed in Table 14 or with any user-developed project that uses the same protocol. It has been developed in Visual C++ and is supplied as an installation file ready to be installed on a Windows PC.
DFU-DK Development Kit Package	This a set of library routines and device drivers that can be used to develop a Windows GUI application such as the ST7 DFU Demo Package listed above. Refer to AN1603 for more information.

8 TERMS AND ABBREVIATIONS

Table 16. Terms and Abbreviations

Term	Definition
DFU	Device Firmware Upgrade
Firmware	Executable software stored in a write-able, nonvolatile memory on a USB device
Upgrade	(1) To overwrite the firmware of a device, (2) the act of overwriting the firmware of a device, (3) new firmware intended to replace a device's existing firmware
Download	To transmit information from host to device
Upload	To transmit information from device to host
LS project	Low Speed Evaluation Kit project (for ST72F62 and 72F63B devices)
FS project	Full Speed 5-in-1 board project (for ST72F65 device)

DEVICE FIRMWARE UPGRADE (DFU) IMPLEMENTATION IN ST7 USB DEVICES

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