UM1021
User manual

STM32F105/107xx USB Host library

Introduction

The STM32F105/7 USB host library is intended to provide a framework for USB host applications development.

The library stands on top of the STM32F105/7 USB OTG peripheral low-level driver. It implements the necessary software blocks that aim to facilitate the developement of USB host applications.

The STM32F105/7 USB host stack library supports the following two USB standard class applications:

- Mass Storage Class (MSC) for accessing USB flash pendrives
- Human Interface Device (HID) class for keyboard and mouse devices

Contents

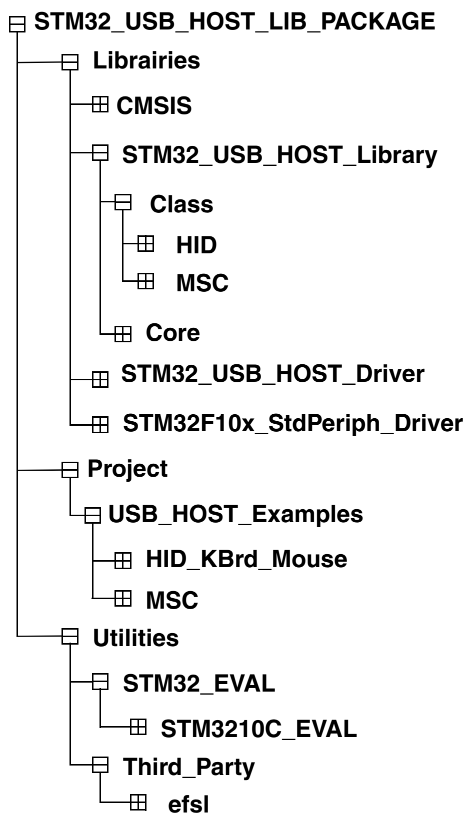
List of tables

List of figures

1 Folder organization of the USB host package

The STM32 USB host library package has the following folder organization:

Figure 1. Folder organization



The package folders are organized as follows:

- **Libraries**:
  - **CMSIS**: Cortex Microcontroller Software Interface Standard files
  - **STM32_USB_HOST_Library**: USB Host library files
  - **STM32_USB_HOST_Driver**: STM32 USB 2.0 OTG peripheral low-level driver
  - **STM32F10x_StdPeriph_Driver**: STM32 standard peripheral drivers
- **Project**:
  - **USB_HOST_EXAMPLES/HID_KBrd_Mouse** : HID mouse and keyboard demo files
  - **USB_HOST_EXAMPLES/MSC**: Mass Storage Class demo files
- **Utilities**:
  - **STM32_EVAL/STM3210C_EVAL** : STM3210C_EVAL evalboard functions (configuration of GPIOs, LCD, clocks,..)
  - **Third_Party/efsl**: EFSL FAT filesystem, used for the mass storage demo

File organization of the USB host library

The USB host library folder "**STM32_USB_HOST_Library"** is composed of two main subfolders:

- **Core**: this folder contains the USB host library core files. Those files implement the necessary functions, state machines and data structures required for:
  - device detection and enumeration,
  - USB Control transfer management,
  - low-level functions for issuing control, bulk or interrupt USB transactions,
  - configuration of the USB host channels.
- **Class**: this folder contains the necessary files for USB class management. The USB host library supports two USB classes:
  - **MSC**: Mass Storage Class
  - **HID**: Human Interface Device class for boot mouse and keyboard devices

The following tables detail the **Core** and **Class** files:

Table 1. Core files

File	Description
usbh_core.c / .h	Implements the core, the device enumeration and the control transfer state machines
usbh_stdreq.c / .h	USB standard requests needed during device enumeration (USB chapter 9)
usbh_ioreq.c /.h	USB I/O requests: USB transaction requests for control, bulk and interrupt pipes
usbh_hcs.c /.h	USB host channel control (channel configuration, allocation, freeing...)
usbh_def.h	Definitions used throughout the USB host library

Table 2. Class files

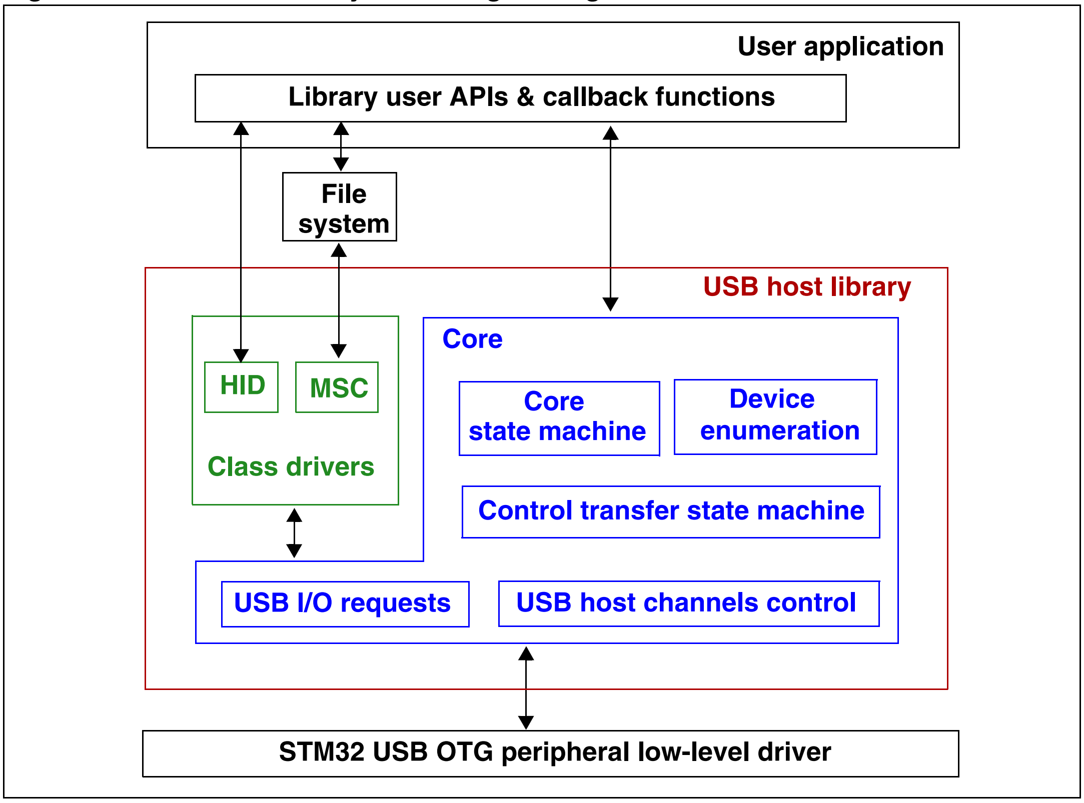
Class	File	Description
HID	usbh_hid_core.c /.h	HID class management
	usbh_hid_mouse.c ./h	HID mouse specific routines
	usbh_hid_keyboard.c /.h	HID keyboard specific routines
MSC	usbh_msc_core.c /.h	Mass Storage Class management
	usbh_msc_bot.c ./.h	BOT "Bulk Only Transport" protocol implementation
	usbh_msc_scsi.c /.h	SCSI standard command implementation
	usbh_msc_fs_interface.c ./h	Interface with a filesystem for file access operations

2 USB host library architecture

2.1 Library block diagram organization

The USB host library has the following block diagram organization:

Figure 2. USB host library block diagram organization



As shown in the above figure, the USB host library is composed of two main parts: the core and the class drivers.

The library core is composed of five main blocks:

- core state machine
- device enumeration
- control transfer state machine
- USB I/O requests
- USB host channels control

For all class-related operations, the core state machine hands over operation to a specific class driver. In the current release version of the USB host libray, two class drivers - HID and MSC - are implemented. These class drivers use core layer services for communicating with the low-level driver.

Both the core and the class drivers communicate with the user application mainly through defined callback functions.

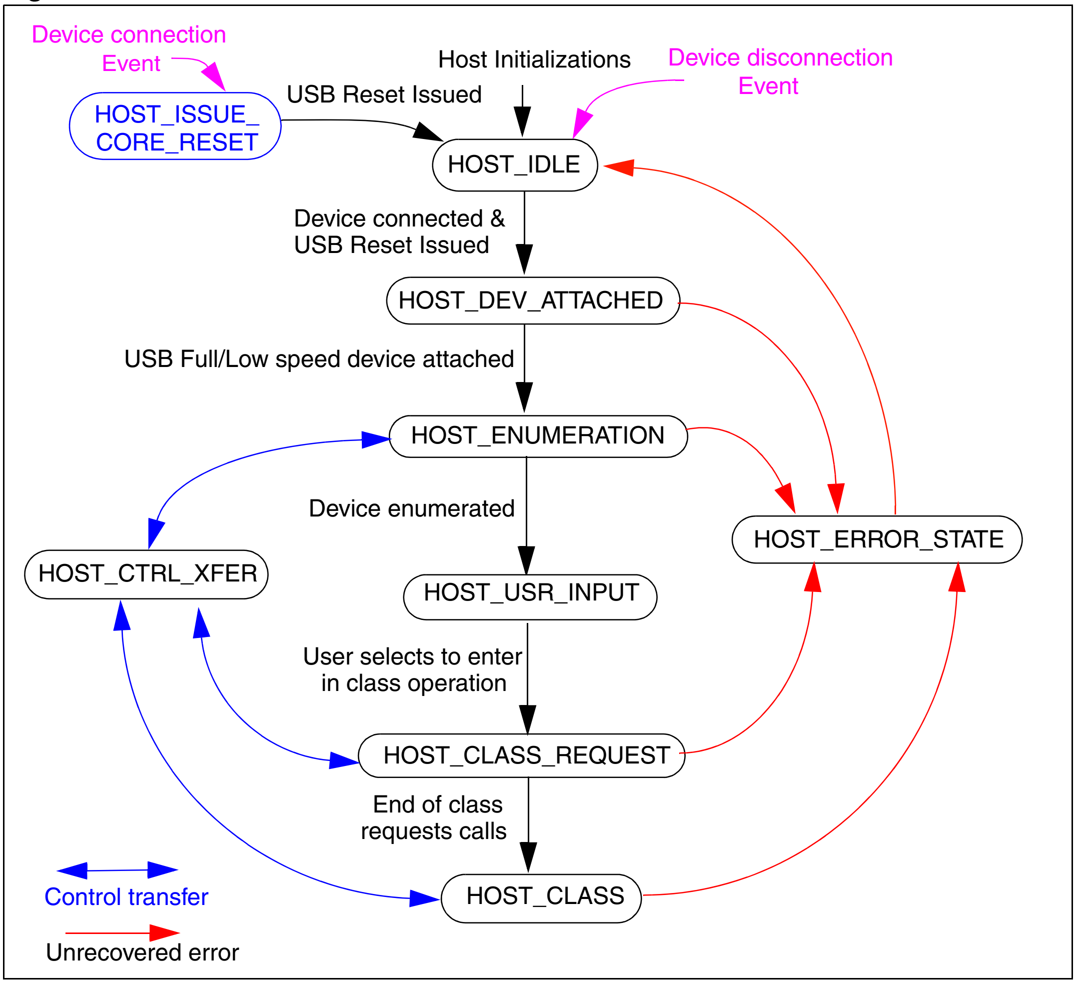
The various host library blocks are described below.

2.2 Description of the library core

2.2.1 Core state machine

The following figure describes the library state machine:

Figure 3. Core state machine



The core state machine shows 8 states:

- **HOST_IDLE**: after host initialization , the core starts in this state, where it polls for a USB device connection. This state is also entered when a device disconnection event is detected, and also when an unrecovered error occurs.
- **HOST_ISSUE_CORE_RESET**: this state is entered when a device is connected in order to issue a USB bus RESET.
- **HOST_DEV_ATTACHED**: the core enters in this state when a device is attached. When a full-speed or low-speed device is detected, the state machine moves to the HOST_ENUMERATION state.
- **HOST_ENUMERATION**: in this state, the core proceeds with a basic enumeration of the USB device. At the end of enumeration process, the default device configuration (configuration 0) is selected.

- **HOST_USR_INPUT**: this is an intermediary state which follows the enumeration and which includes a wait for user input in order to enter in USB class operation.
- **HOST_CLASS_REQUEST**: starting from this state, the class driver takes over, and a class request state machine is called in order to handle all the initial class control requests (ex: Get_Report_Descriptor for HID). After finishing the needed class requests, the core moves to the HOST_CLASS state.
- **HOST_CLASS**: in this state, the class state machine is called for class-related operation (non-control and control operation).
- **HOST_CTRL_XFER**: this state is entered whenever there is a need for a control transfer.
- **HOST_ERROR_STATE**: this state is entered whenever there is an unrecovered error from any library state machine; in such case, a user-callback function is called (for example for displaying an unrecovered error message). Then the host library is reinitialized.

The core state machine process is implemented by function ***USBH_Process***. This function should be called periodically from the application main loop.

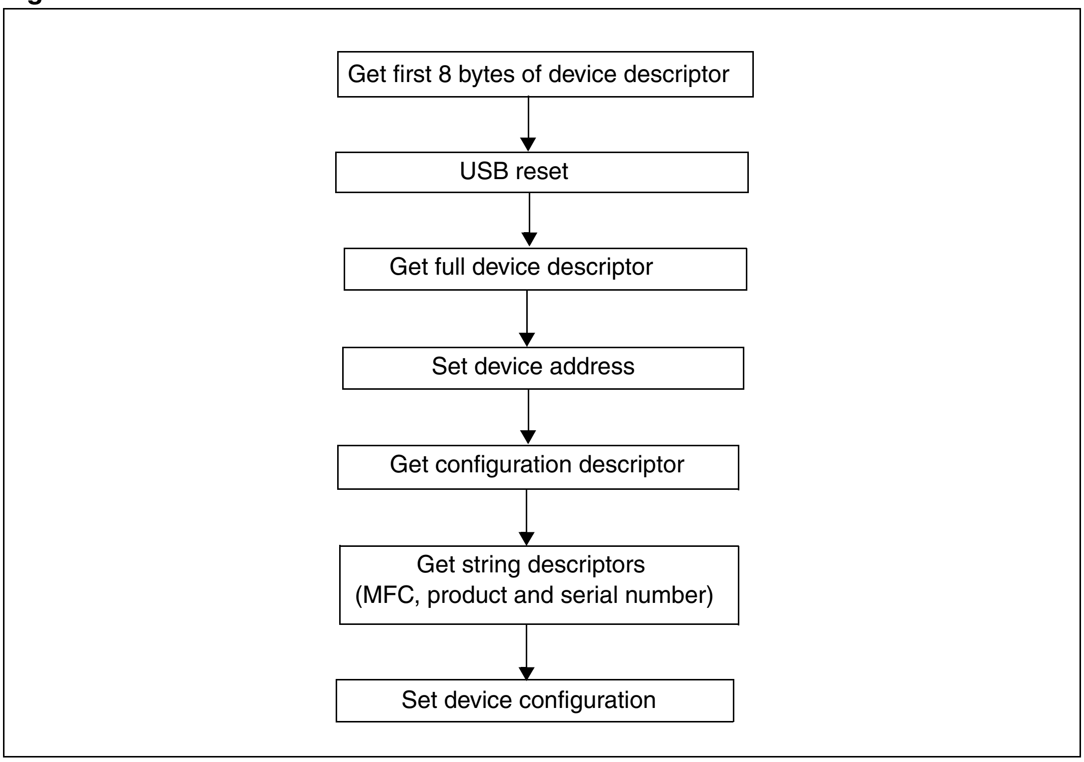
The initalization of the USB host library is implemented by function ***USBH_init***. This function should be called from the user application during initialization. More details regarding this function are provided in *Section 3*.

2.2.2 Device enumeration

After detecting a full- or low-speed device, the host library proceeds with a basic enumeration of the device.

The following diagram shows the different steps involved in the device enumeration.

Figure 4. Device enumeration



The enumeration state machine is implemented in library function ***USBH_HandleEnum***, which is called from the core state machine process.

USBH_HandleEnum function makes calls to the following library routines (implemented in file usbh_stdreq.c):

Table 3. Device enumeration requests

Function	Description
USBH_Get_CfgDesc	Get configuration descriptor request
USBH_Get_DevDesc	Get device descriptor request
USBH_Get_StringDesc	Get string descriptor request
USBH_GetDescriptor	Generic get descriptor request
USBH_SetCfg[1)]	Set configuration request
USBH_SetAddress[2)]	Set address request
USBH_ClrFeature	Clear feature request

Note: 1 USBH_SetCfg calls select the default configuration (configuration 0)

2 USBH_SetAddress calls set the device address to 0x1.

A user callback will be called at the end of enumeration phase in order to enable the user to process the descriptor information (such as displaying descriptor data, for example). For more details, please refer to *Section 3*.

2.2.3 Control transfer state machine

The control transfer state machine is entered from core or class driver whenever a control transfer is required. This state machine implements the standard stages for a control transfer, i.e. the setup stage, the optional data stage and, finally, the status stage.

The control transfer state machine is implemented in function ***USBH_HandleControl*** . It is called from the core state machine process.

2.2.4 USB I/O requests module

The USB I/O requests module is located in the low layer of the core. It interfaces with the USB low-level driver for issuing control, bulk or interrupt USB transactions.

Table 4 shows the main functions in the I/O request module. These functions are implemented in file usbh_ioreq.c.

Table 4. USB I/O requests module

Function	Description
USBH_CtlSendSetup	Issue a setup transaction
USBH_CtlSendData	Issue a control data OUT stage transaction
USBH_CtlReceiveData	Issue a control data IN stage transaction
USBH_CtlReq	high level function for issuing a control transfer (setup, data, status stages)
USBH_BulkSendData	Issue a bulk OUT transaction
USBH_BulkReceiveData	Issue a bulk IN transaction
USBH_InterruptSendData	Issue an interrupt OUT transaction
USBH_InterruptReceiveData	Issue an interrupt IN transaction

2.2.5 Host channels control module

The host channels control module is located in the lower layer of the core, it allows the configuration of a host channel for a particular operation (control, bulk or interrupt transfer type) also the allocation of a selected host channel to a device endpoint for creating a USB pipe.

The main functions for USB channel control module are defined in Table 6. These functions are implemented in file usbh_hcs.c.

Table 5. Host channels control module

Function	Description
USBH_Open_Channel	Open and configure a new host channel
USBH_Modify_Channel	Modify an existing host channel
USBH_Alloc_Channel	Allocate a host channel to a device endpoint (creation of a USB pipe)
USBH_Free_Channel	Free a host channel

2.3 Class drivers

At the end of the enumeration, the core calls a specific class driver function to manage all class-related operations.

Please note that the proper class driver selection is not based on the result of device enumeration, but it is “pre-defined” when initializing the host library with function call ***USBH_Init***.

A class driver is implemented using a structure of type ***USBH_Class_cb_TypeDef***:

```
typedef struct _Device_cb
{
  USBH_Status  (*Init) (USB_OTG_CORE_HANDLE *pdev , USBH_DeviceProp_TypeDef *hdev);
  void         (*DeInit) (USB_OTG_CORE_HANDLE *pdev , USBH_DeviceProp_TypeDef *hdev);
  USBH_Status  (*Requests)(USB_OTG_CORE_HANDLE *pdev, USBH_DeviceProp_TypeDef\
*hdev);
  USBH_Status  (*Machine) (USB_OTG_CORE_HANDLE *pdev , USBH_DeviceProp_TypeDef\
*hdev);

} USBH_Class_cb_TypeDef;
```

The structure members are described below:

- **Init**: this function is called at the start-up of class operation for assuring all needed initializations. This includes:
  - parsing interface and endpoint descriptors (please note that the current USB host library supports only one interface),
  - opening and allocating host channels for non-control endpoints,
  - call to a user callback (see *Section 3*), in case the device is not supported by the class.
- **Denit**: this function is called for freeing allocated host channels when reinitializing the host. It is called when a device is unplugged or in case of unrecovered error.
- **Request**: this function implements the class request state machine. It is called duringthe HOST_CLASS_REQUEST state; its purpose is to process initial class requests.
- **Machine**: implements the class core state machine. It is called during the HOST_CLASS core state.

2.3.1 USB Mass Storage Class (MSC) driver

The Mass Storage Class driver is intended to support common USB flash pendrives, using the BOT “Bulk-Only Transport” protocol.

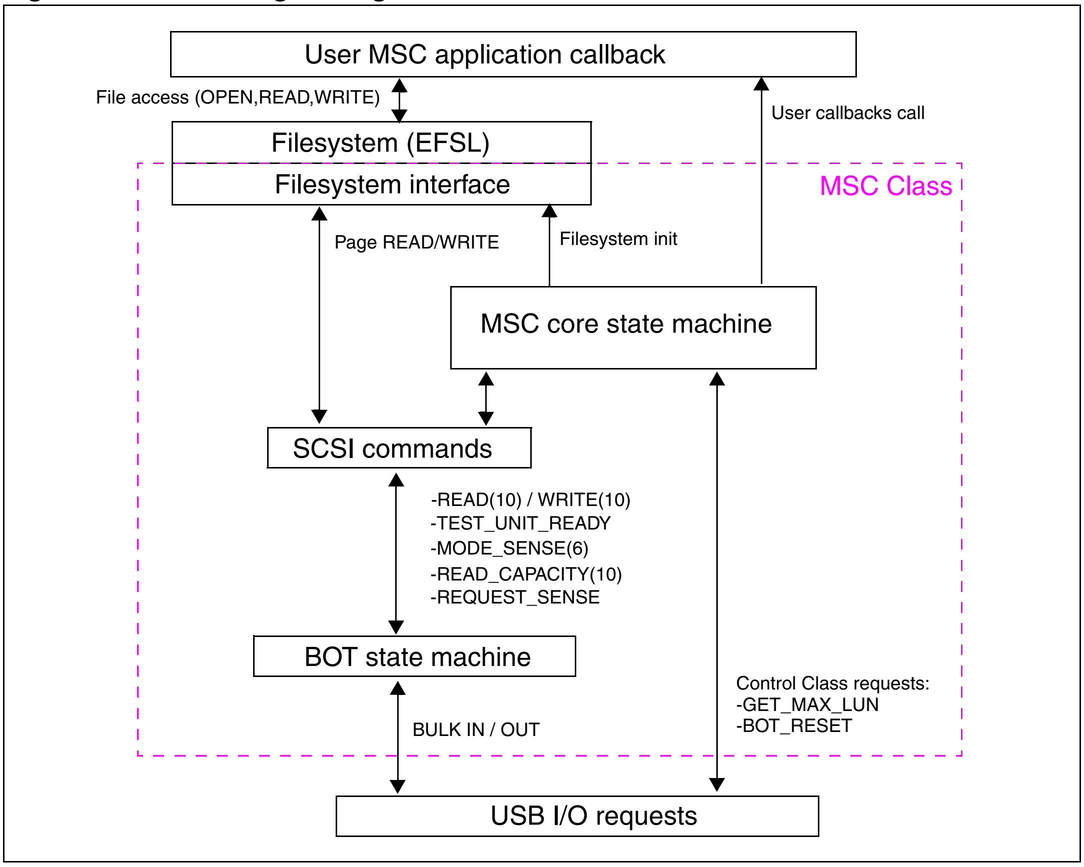
The following modules, located in the **class\MSC** folder, are used to implement the MSC driver:

Table 6. Mass Storage Class modules

Module	Description
usbh_msc_core.c /.h	MSC core state machine implementation
usbh_msc_bot.c ./.h	BOT “Bulk-Only Transport” protocol implementation
usbh_msc_scsi.c /.h	SCSI command implementation
usbh_msc_fs_interface.c ./h	Functions for interfacing with a filesystem for file access operations

The block diagram in *Figure 5* shows the interactions between those modules.

Figure 5. Block diagram organization of the MSC driver



Operation flow description:

The MSC core state machine starts with the required device initializations, which are:

- Issuing GET_MAX_LUN class request for detecting the number of device logical units present on the device. Please note that only devices with one logical unit are supported.
- Issuing BOT_RESET class requests for resetting the device BOT state machine.
- Issuing SCSI commands: MODE_SENSE for detecting if the device is write-protected and READ_CAPACITY for detecting the size of the flash pendrive.

After the above device initializations, the MSC core state machine calls the application user callback.

The user callback can do any type of file access into the used filesystem. This operation is translated into a logical page read or write operation. The filesystem interface provides the connection between the used filesystem and the MSC driver.

At the SCSI level, the logical page read or write operations are converted into SCSI commands: READ(10) or WRITE(10). Those commands are transfered to the flash pendrive device using the “Bulk-Only Tranport” protocol.

The BOT layer state machine issues the required Bulk IN and Bulk OUT transactions using the core USB I/O request module.

Each MSC module is described below.

MSC core module:

The MSC core module “usb_msc_core.c” implements the MSC driver, which is defined in the structure ***MSC_cb*** of type ***USBH_Class_cb_TypeDef*** (see section 2.3).

```
USBH_Class_cb_TypeDef  MSC_cb =
{
  USBH_MSC_InterfaceInit,
  USBH_MSC_InterfaceDeInit,
  USBH_MSC_ClassRequest,
  USBH_MSC_Handle,
};
```

Table 7. MSC core module

Function	Description
USBH_MSC_InterfaceInit	Parses interface and endpoints descriptors and configures host channels (bulk IN and bulk OUT pipes)
USBH_MSC_InterfaceDeInit	De-initialization routine (freeing host channels)
USBH_MSC_ClassRequest	In case of MSC, this function only moves the library core state machine to the HOST_CLASS state
USBH_MSC_Handle	Implements the MSC handler core state machine
USBH_MSC_Issue_BOTReset	Issues a BOT reset class request
USBH_MSC_Issue_GETMaxLUN	Issues a GET_MAX_LUN class request
USBH_MSC_ErrorHandle	MSC error handling

MSC BOT module:

The MSC “Bulk-Only Transport” (BOT) module implements the transport protocol for sending the SCSI commands (such as READ (10) or WRITE(10)). This module is implemented in file “usbh_msc_bot.c”.

For details about the BOT protocol, please refer to the usb.org mass storage class document.

The BOT module has the following functions:

Table 8. MSC BOT module

Function	Description
USBH_MSC_Init	Initialize BOT state machine
USBH_MSC_HandleBOTXfer	BOT transfer state machine

MSC SCSI module:

The SCSI “Small Computer System Interface” module “usb_msc_scsi.c” stands on top of the BOT. It implements the set of SCSI commands required to access the flash pendrives.

The implemented commands are:

Table 9. MSC SCSI commands

Function	Description
USBH_MSC_Read10	Command for logical block read
USBH_MSC_Write10	Command for logical block write
USBH_MSC_TestUnitReady	Command for checking device status
USBH_MSC_ReadCapacity10	Command for requesting the device capacity
USBH_MSC_ModeSense6	Command for checking the Write-protect status of the mass storage device
USBH_MSC_RequestSense	Command for getting error information

MSC filesystem interface module

The MSC filesystem interface module "usbh_msc_fs_interface.c" allows interfacing of filesystems with the MSC driver. This module should be ported to the selected filesystem.

The current USB host library package comes with the open source, EFSL FAT filesystem support (see next section for an overview about the EFSL API).

The implemented functions in the filesystem interface are:

Table 10. MSC filesystem interface functions

Function	Description
if_initInterface	Allows initalization of the filesystem (for example, reading capacity of flash pendrive)
if_readBuf	Interface function for a logical page read
if_writeBuf	Interface function for a logical page write
if_TestUnitReady	Interface function for testing if unit is ready
if_RequestSense	Interface function for requesting error information using SCSI command Request Sense

Note: *For the EFSL filesystem, the page size is fixed to 512 bytes. Flash pendrives with higher page granularity are not supported.*

EFSL filesystem overview

The EFSL "Embedded Filesystem Library" is an open source library for filesystems. It is intended for embedded devices and supports the Microsoft FAT12, 16 and 32 filesystems.

The following table summarizes the EFSL main API functions. For more details about EFSL, please refer to http://efsl.be/

Table 11. EFSL main API

Function	Prototype	Description
efs_init	`esint8 efs_init(EmbeddedFileSystem *efs, eint8* opts);`	Initializes the filesystem
file_fopen	`esint8 file_fopen(File *file, FileSystem *fs, eint8 *filename, eint8 mode);`	Opens a file
file_fclose	`esint8 file_fclose(File *file);`	Closes a file
file_read	`euint32 file_read (File *file, euint32 size, euint8 *buf);`	Reads a file
file_write	`euint32 file_write(File *file, euint32 size, euint8 *buf);`	Writes a file
rmfile	`esint16 rmfile(FileSystem *fs,euint8* filename);`	Removes file
mkdir	`esint8 mkdir(FileSystem *fs,eint8* dirname);`	Creates directory
ls_openDir	`esint8 ls_openDir(DirList *dlist,FileSystem *fs,eint8* dirname);`	Opens directory
ls_getNext	`esint8 ls_getNext(DirList *dlist);`	Gets next file in directory

2.3.2 USB Human Interface Device (HID) class driver for mouse and keyboard devices

The HID class implementation in v1.0 of the USB host library is intended to support HID boot mouse and keyboard devices.

HID reports are received using the interrupt IN transfer.

The following modules, located in **class\HID** folder, are used to implement the HID class:

Table 12. HID class modules

file (module)	Description
usbh_hid_core.c /.h	This module implements the HID class core state machine
usbh_hid_mouse.c ./h	HID mouse specific routines
usbh_hid_keyboard.c /.h	HID keyboard specific routines

The main functions of each module are described below.

HID class core:

The HID core module "usb_hid_core.c" implements the HID class driver structure ***HID_cb*** of type ***USBH_Class_cb_TypeDef*** (see section 2.3).

```
USBH_Class_cb_TypeDef  HID_cb =
{
  USBH_HID_InterfaceInit,
  USBH_HID_InterfaceDeInit,
  USBH_HID_ClassRequest,
  USBH_HID_Handle
};
```

The following table summarizes the functions implemented in the HID core module.

Table 13. MSC core module functions

Function	Description
USBH_HID_InterfaceInit	Parses interface and endpoint descriptors and configures a host channel in order to have an interrupt IN pipe (for getting HID reports)
USBH_HID_InterfaceDeInit	Frees the allocated interrupt IN pipe
USBH_HID_ClassRequest	Implements a state machine of the required class requests for HID mouse and keyboard devices (ex: getting HID report descriptors, setting IDLE time, setting Protocol).
USBH_HID_Handle	HID class core state machine (processing of interrupt IN transfers)
USBH_Get_HID_ReportDescriptor	Class request for getting HID report descriptor
USBH_ParseClassDesc	Function used for parsing HID report descriptor
USBH_Set_Idle	Class request for setting IDLE time
USBH_Set_Report	Class request for sending Report OUT data (not used in the demonstration software)
USBH_Set_Protocol	Class request for setting the HID protocol: Boot or Report(1)

1. USB_Set_Protocol is called to set the Boot protocol mode.

HID mouse & keyboard specific management:

The detection of mouse or keyboard device will be done when parsing interface descriptor in function ***USBH_HID_InterfaceInit***.

The specific initialization for each type of device and the decoding of the received report IN data is done by two functions which are declared in a structure of type ***HID_cb_TypeDef***, which is defined as follows:

```
typedef struct HID_cb
{
  void  (*Init)   (void);
  void  (*Decode) (uint8_t *data);

} HID_cb_TypeDef;
```

The implementation of the above structures in case a mouse or keyboard is respectively found in HID_MOUSE_cb and HID_MOUSE_cb is as follows:

```
HID_cb_TypeDef HID_MOUSE_cb =
{
  MOUSE_Init,
  MOUSE_Decode,
};
HID_cb_TypeDef HID_KEYBRD_cb=
{
  KEYBRD_Init,
  KEYBRD_Decode
};
```

Table 14. Mouse and keyboard intialization & HID report decoding functions

Function	Description
MOUSE_Init	Initialization routine for USB mouse
MOUSE_Decode	HID report decoding for mouse (decoding mouse x, y positions, pressed buttons)
KEYBRD_Init	Initialization routine for USB keyboard(1)
KEYBRD_Decode	HID report decoding for keyboard (decoding of the key pressed on the keyboard)

1. Selection of AZERTY or QWERTY keyboard is done through the defines #QWERTY_KEYBOARD , #AZERTY_KEYBOARD in file usbh_hid_keybrd.h.

3 Library user API and callback functions

3.1 Library user API

The library user API functions are limited to the following two functions:

- ***void USBH_Process (void)***: this function implements core state machine process. It should be called periodically from the user main loop.
- ***USBH_Init***: this function should be called for the initialization of the USB host hardware and library.

USBH_Init has the following function prototype:

```
void USBH_Init(USB_OTG_CORE_HANDLE *pdev,
               USBH_Class_cb_TypeDef *class_cb,
               USBH_Usr_cb_TypeDef *usr_cb)
```

- ***pdev:*** pointer on the USB host core registers structure (needed for future use)
- ***class_cb***: pointer to a class structure of type ***USBH_Class_cb_TypeDef***. It can be either ***MSC_cb*** for handling MSC devices or ***HID_cb*** for handling HID mouse/keyboard devices.
- ***usr_cb***: pointer to a structure of type ***USBH_Usr_cb_TypeDef***. This structure defines class-independent callbacks (see section 3.2.2).

3.2 User callback functions

User callbacks are declared in user template file usbh_usr.c.

Two types of user callbacks are defined:

- Callback functions related to the class operations (MSC or HID)
- Callbacks functions independent from class operations; they are mainly called during the enumeration phase. These callbacks are defined in a structure of type ***USBH_Usr_cb_TypeDef***.

3.2.1 Class callback functions

MSC user callback functions

For MSC, the following callback is used: ***int USR_MSC_Application (void)***.

After the end of the class initializations, this function is called by the MSC state machine in order to give hand to the user for filesystem access operations.

In this callback, the user can implement any access to the FAT filesystem (file open, file read, file write...) using the EFSL filesystem API.

Also, the user can have access to an exported structure variable from the library MSC class driver, ***USBH_MSC_Param***. This variable provides some information about the mass storage key.

This variable is defined using a structure of type ***MassStorageParameter_TypeDef*** defined as follows:

```
typedef struct __MassStorageParameter
{
  uint32_t MSCapacity; /*MS device capacity in bytes */
  uint32_t MSSenseKey; /*Request Sense SCSI command returned value */
  uint16_t MSPageLength; /* MS device Page length */
  uint8_t MSBulkOutEp; /* Bulk OUT endpoint address */
  uint8_t MSBulkInEp; /*Bulk IN endpoint address */
  uint8_t MSWriteProtect; /*Write protection status, 0: non protected, 1:protected */
} MassStorageParameter_TypeDef;
```

HID user callback functions

For the HID class, the following callbacks are defined:

- ***void USR_MOUSE_Init(void)***: user initialization for mouse application
- ***void USR_KEYBRD_Init(void)***: user initializations for keyboard application
- ***void USR_MOUSE_ProcessData(HID_MOUSE_Data_TypeDef *data)***: this callback is called when an input parameter data of type HID_MOUSE_Data_TypeDef (see Note 1 below) is available.
- ***void USR_KEYBRD_ProcessData (uint8_t data)***: this callback is called when a new ASCII character is typed. The character is received in input parameter data.

*Note: 1 **HID_MOUSE_Data_TypeDef** is defined as follows:*

```
typedef struct _HID_MOUSE_Data
{
  uint8_t x;
  uint8_t y;
  uint8_t z;   /* Not Supported */
  uint8_t button; /*Bitmap showing pressed buttons 1:pressed, 0: non pressed */
}
HID_MOUSE_Data_TypeDef;
```

3.2.2 Class-independent callback functions

The class-independent callback functions are defined in a structure of type ***USBH_Usr_cb_TypeDef*** defined as follows:

```
typedef struct _USBH_USR_PROP
{
  void (*Init)(void);
  void (*DeviceAttached)(void);
  void (*ResetDevice)(void);
  void (*DeviceDisconnected)(void);
  void (*OverCurrentDetected)(void);
  void (*DeviceSpeedDetected)(uint8_t DeviceSpeed);
  void (*DeviceDescAvailable)(void *);
  void (*DeviceAddressAssigned)(void);
  void (*ConfigurationDescAvailable)(USBH_CfgDesc_TypeDef *,
                                     USBH_InterfaceDesc_TypeDef *,
                                     USBH_EpDesc_TypeDef *);
  void (*ManufacturerString)(void *);
  void (*ProductString)(void *);
  void (*SerialNumString)(void *);
  void (*EnumerationDone)(void);
  USBH_USR_Status (*UserInput)(void);
  void (*USBH_USR_DeviceNotSupported)(void);
  void (*UnrecoveredError)(void);
}
USBH_Usr_cb_TypeDef;
```

The above callback functions are described below.

– ***Init***: called during initialization by *USBH_Init* core function. In this function, the user can implement any specific intialization related to his application.
– ***DeviceAttached***: called when a USB device is attached. It can be useful to informthe user of any device attachement using a display screen.
– ***DeviceReset***: called after an USB reset is issued from the host.
– ***DeviceDisconnect***: called when a device is disconnected.
– ***OverCurrentDetected***: called when an overcurrent is detected on USB VBUS.
– ***DeviceSpeedDetected***: called when the device speed is detected[1)].
– ***DeviceDescAvailable***: called when a device descriptor is available[2)].
– ***DeviceAddressAssigned***: called when the device address is assigned.
– **ConfigurationDescAvailable**: called when configuration, interface and endpoints descriptors are available[3)].
– **ManufacturingString**: called when manufacturing string is extracted.
– **ProductString**: called when product string is extractcted.
– **SerialNumString**: called when serial num string is extracted.
– **EnumerationDone**: called when enumeration finished.
– ***UserInput***: called after the end of the enumeration process, for prompting the user for further action, such as pressing a button to start a host class operation[4)].
– ***USBH_USR_DeviceNotSupported:*** called when the detected device is not supported by the current class driver.
– ***UnrecoveredError:*** called when the core state machine is in "*HOST_ERROR_STATE*" state. It allows the user to handle any error, by displaying an error message on the LCD screen, for example.

*Note: 1 Device speed information is returned in the **DeviceSpeed** parameter. Possible values are: 0x1 for full-speed devices and 0x2 for low-speed devices.*

*2 Device descriptor information is returned in the pointer **DeviceDesc**, which points to a structure of type **USBH_DevDesc_TypeDef*** defined as follows:

```
typedef struct _DeviceDescriptor
{
  uint8_t   bLength;
  uint8_t   bDescriptorType;
  uint16_t  bcdUSB;        /* USB Specification Number which device complies too */
  uint8_t   bDeviceClass;
  uint8_t   bDeviceSubClass;
  uint8_t   bDeviceProtocol;
  uint8_t   bMaxPacketSize;
  uint16_t  idVendor;      /* Vendor ID (Assigned by USB Org) */
  uint16_t  idProduct;     /* Product ID (Assigned by Manufacturer) */
  uint16_t  bcdDevice;     /* Device Release Number */
  uint8_t   iManufacturer;  /* Index of Manufacturer String Descriptor */
  uint8_t   iProduct;       /* Index of Product String Descriptor */
  uint8_t   iSerialNumber;  /* Index of Serial Number String Descriptor */
  uint8_t   bNumConfigurations; /* Number of Possible Configurations */
}
USBH_DevDesc_TypeDef;
```

3 *Device configuration information (config, interface and endpoint descriptors) are returned with pointers on structures **USBH_CfgDesc_TypeDef**, **USBH_InterfaceDesc_TypeDef** and **USBH_EpDesc_TypeDef** defined as follows:*

```
typedef struct _ConfigurationDescriptor
{
  uint8_t   bLength;
  uint8_t   bDescriptorType;
  uint16_t  wTotalLength;
  uint8_t   bNumInterfaces;
  uint8_t   bConfigurationValue;
  uint8_t   iConfiguration;
  uint8_t   bmAttributes;
  uint8_t   bMaxPower;
}
USBH_CfgDesc_TypeDef;


typedef struct _InterfaceDescriptor
{
  uint8_t bLength;
  uint8_t bDescriptorType;
  uint8_t bInterfaceNumber;
  uint8_t bAlternateSetting;    /* Value used to select alternative setting */
  uint8_t bNumEndpoints;        /* Number of Endpoints used for this interface */
  uint8_t bInterfaceClass;      /* Class Code (Assigned by USB Org) */
  uint8_t bInterfaceSubClass;   /* Subclass Code (Assigned by USB Org) */
  uint8_t bInterfaceProtocol;   /* Protocol Code */
  uint8_t iInterface;           /* Index of String Descriptor Describing this
interface */

}
USBH_InterfaceDesc_TypeDef;


typedef struct _EndpointDescriptor
{
  uint8_t   bLength;
  uint8_t   bDescriptorType;
  uint8_t   bEndpointAddress;   /* indicates what endpoint this descriptor is
describing */
  uint8_t   bmAttributes;       /* specifies the transfer type. */
  uint16_t  wMaxPacketSize;    /* Maximum Packet Size this endpoint is capable of
sending or receiving */
  uint8_t   bInterval;         /* is used to specify the polling interval of certain
transfers. */
}
USBH_EpDesc_TypeDef;
```

4 *In order to move the core state machine to HOST_CLASS_REQUEST state, **UserInput*** callback should return the value ***USBH_USR_RESP_OK*** of type ***USBH_USR_Status***

```
typedef enum {
  USBH_USR_NO_RESP   = 0, /*no response from user */
  USBH_USR_RESP_OK = 1,
}
USBH_USR_Status;
```

4 Demo firmware

4.1 Mass storage class demo

4.1.1 Software initializations

The following code extract from main.c file shows the initializations required before calling the ***USBH_Process*** for managing the core state machine.

USB_Init is called with parameters defining the class driver, which is the MSC class driver, and also the user callbacks.

```
int main(void)
{
   /* Setup STM32 Hardware Configuration */
   BSP_Init();

   /* Init Host Library */
   USBH_Init(&USB_OTG_FS_dev, &MSC_cb , &USR_Callbacks);

    while (1)
   {
      /* Host Task handler */
      USBH_Process();
   }
}
```

4.1.2 Mass storage device enumeration

When attaching a full-/low-speed device to the STM3210C_eval board, the LCD displays the following text (for example, when plugging the Kingston DataTraveler G2 flash pendrive):

Figure 6. MS device enumeration

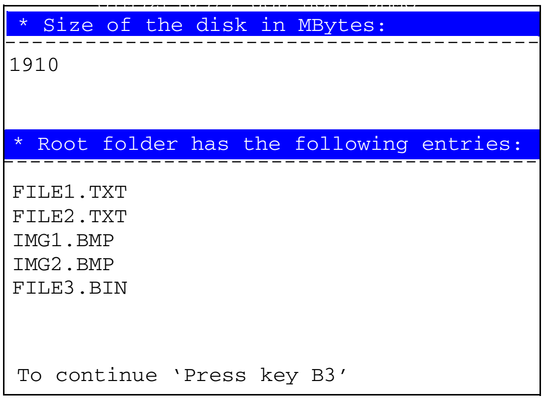
```
STM32F105/7 USB HOST DEMO

> DEVICE ATTACHED
> DEVICE IS FULL SPEED

> DEVICE SUPPORTS MASS STORAGE CLASS

VID = 0951h
PID = 1624h
NumEndpoints = 2

Manufacturer : Kingston
Product : DataTraveler G2
Serial Number : 001CC0EC309BF9C196A50D64

> ENUMERATION COMPLETED


-----------------------------------------
To see the root content of the disk :
‘ Press Key B3 ...’
```

4.1.3 Accessing mass storage device content

After the end of enumeration, pressing button B3 displays the screen below, which provides the following information:

- Flash pendrive capacity (in Mbytes)
- Root folder files

Figure 7. MS device content access



Please note that, after browsing the mass storage device content, a simple text file "HostDemo.txt" is written into the flash pendrive (assuming that it is not write-protected).

For testing file read access, the user can start an image slideshow on the LCD screen, assuming that some bmp images are available in the root folder of the flash pendrive.

Note: 1 *Some bmp images with LCD screen size are provided in the project folder.*

2 *If the device is write-protected, a warning message is displayed on the LCD screen.*

3 *Mass storage devices with multiple logical units are not supported (an error message is displayed on the LCD screen).*

4 *If no bmp image is available in the flash pendrive root folder, a warning message is displayed on the LCD screen and, after 2 seconds, the host re-initializes (restarts enumeration of the flash pendrive).*

4.1.4 Flash pendrive tests

Because an embedded USB host is considered limited, these interoperability tests:

1. Enumeration,
2. Cold Boot with device attached,
3. Hot detach/attach,
4. Browsing root content,
5. Creation of "hostdemo.txt" file,
6. Data read from device to TFT-LCD: images slide-show,
7. Messaging to TFT-LCD (no silent failure)

are successfully applied to the following table selection of various flash pendrives using the STM32F105/7 USB host library and the demonstration provided with the mass storage example.

Table 15. **Tested flash pendrives**

Manufacturer	Name	Size	VID	PID
Kingston	Data Traveler 2GB	2GB	0x0951	0x1603
Lexar	JumpDrive Sport	265MB	0x05DC	0xA410
Lexar	JumpDrive FireFly	265MB	0x05DC	0xA575
Lexar	JumpDrive2.0 pro	256MB	0x05DC	0x0200
Memorex	TravelDrive Classic 003C	512MB	0x08EC	0x0008
Memorex	TravelDrive Classic 003B	2 GB	0x12F7	0x1A00
Sandisk	USB Flash Drive	8 GB	0x0781	0x5541
Sandisk	USB Flash memory	8 GB	0x0781	0x6545
Sandisk	U3 Cruzer Micro -U3	1 GB	0x0781	0x5406
Sandisk	Cruzer Colors+	4 GB	0x0781	0x5170
Sandisk	Cruzer Pro	1 GB	0x08EC	0x0507
Sandisk	Cruzer Micro	512 MB	0x0781	0x5151
Kingmax	USB2.0FlashDisk	2 GB	0x1687	0x6211
Netac	USB Flash Disk	128 MB	0x0DD8	0XD202
PNY	Attaché 2.0	128 MB	0x08EC	0x0012
PNY	Attaché Pro	1 GB	0x13FF	0x1A23
Sony	Micro Vault Tiny	2 GB	0x054C	0x02A5
Toshiba	USB Flash memory	2 GB	0x0930	0x6545
Transcend	JetFlash V30	1 GB	0x058F	0x6387
Corsair	Flash Voyager Mini	8 GB	0x1B1C	0x0B29
Philips	FM01FD00B	1 GB	0x0471	0X082B

4.2 HID mouse and keyboard demos

4.2.1 Initializations

Same as for mass storage devices (see section 4.1.1), except that the HID class driver is selected in the ***USBH_Init*** function:

```
/* Init Host Library */
USBH_Init(&USB_OTG_FS_dev, &HID_cb , &USR_Callbacks);
```

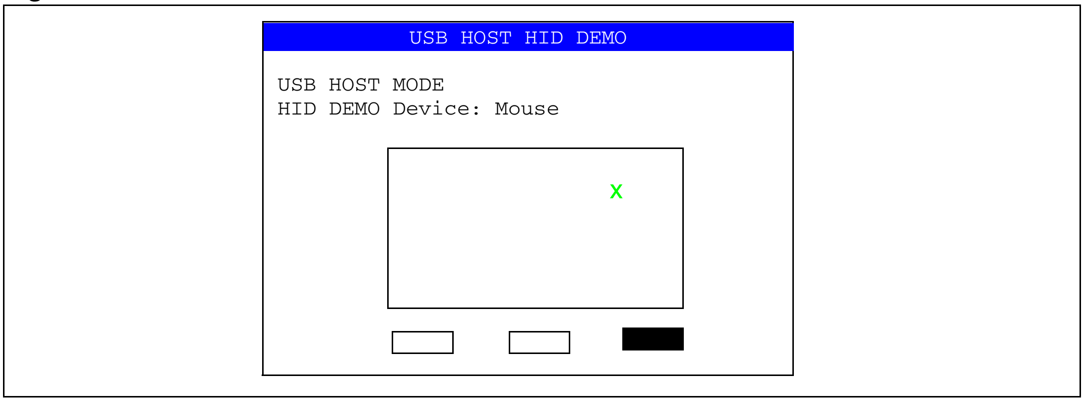
4.2.2 Mouse or keyboard device enumeration

Similar to mass storage devices (see section 4.1.2).

4.2.3 Mouse demo

After mouse device enumeration, pressing button B3 displays the following screen, which shows the mouse 3 buttons and the pointer (green cross).

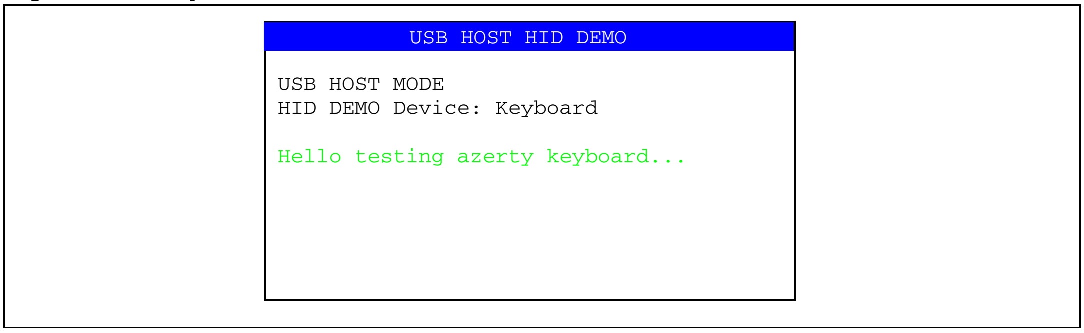
Figure 8. Mouse demo



4.2.4 Keyboard demo

After keyboard enumeration, pressing button B3 displays an LCD screen where the user can type some text:

Figure 9. Keyboard demo



4.3 Demo footprints

The following tables provide footprint data when the software is compiled using IAR EWARM v5.50.5 with high optimizations for size:

Table 16. Demo footprints

Demo	Code + RO data	RAM
Mass Storage class demo	~32 Kb	6.4 Kb
HID mouse & keyboard demo	~24 Kb	5 Kb

5 Known limitations

The current version of the STM32F105/7 USB host stack has the following known limitations:

1. It supports only two USB standard class applications, i.e:
   a) Mass Storage Class (MSC) for accessing USB flash pendrives,
   b) Human Interface Device (HID) class for keyboard and mouse devices.
2. It supports only one interface and one configuration selection (default config).
3. It does not support mass storage devices with multiple logical units.
4. It comes with the EFSL FAT filesystem support:
   a) The page size is fixed to 512 bytes. Flash pendrives with higher page granularity are not supported.
   b) Long filenames and Unicode are not supported.
5. Very short delay between device detach/attach may result in abnormal operation.
6. Compatibility issues have been encountered with some devices (not listed in *Table 15*) at the enumeration phase.
7. After connecting and disconnecting a non-supported class device and then attaching a supported class device, enumeration is done properly, but the device cannot be accessed. A device reset is needed.

6 Revision history

Table 17. Document revision history

Date	Revision	Changes
26-Nov-2010	1	Initial release.

Please Read Carefully: