XMC4500 USB Host Mass Storage Example

Getting Started V1.0

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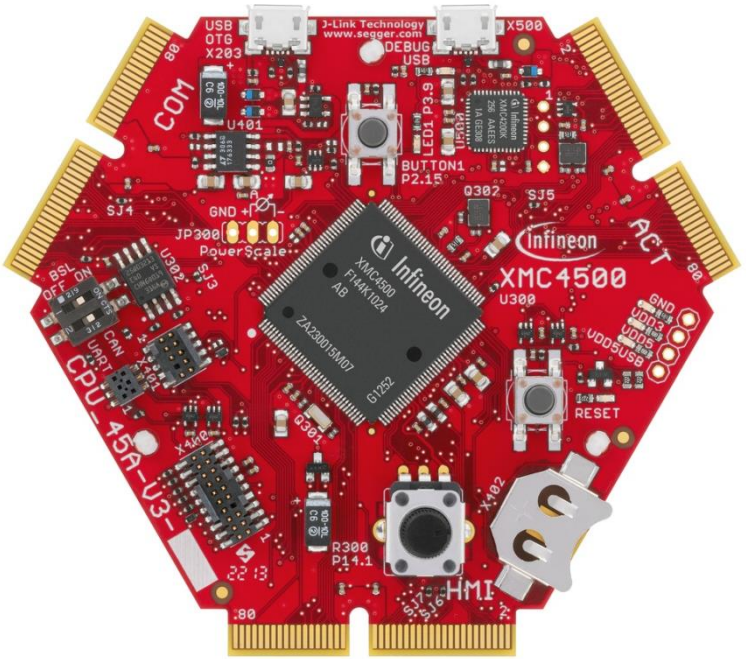
Overview



- This example demonstrates the implementation of USB host mass storage functionality. It is based on the free LUFA USB host stack implementation which is ported to XMC4500 family and provided within this example. The example creates a directory plus 3 files on a USB Flash drive
- Within this documentation you will be guided through all the building blocks of a typical USB host mass storage application on the XMC4500 family. You will be able to connect a USB flash drive device supporting the FAT file system to the host and perform file read and write access to the device.
- As a result you will be enabled to implement your own USB host mass storage functionality on the XMC4500 family.

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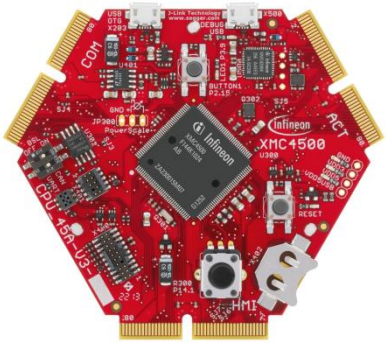
Requirements - hardware



XMC4500 General Purpose board CPU_45A-V3



USB cable micro-A plug to standard-A receptacle for host example



USB cable micro-B plug to standard-A plug for debugging



USB flash drive

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Requirements – hardware & software



- Windows laptop
- DAVE™ installed

- DAVE™ (v4.1.4 or Higher)
- Download DAVE™ free of charge

  Link : DAVE™ v4 Download

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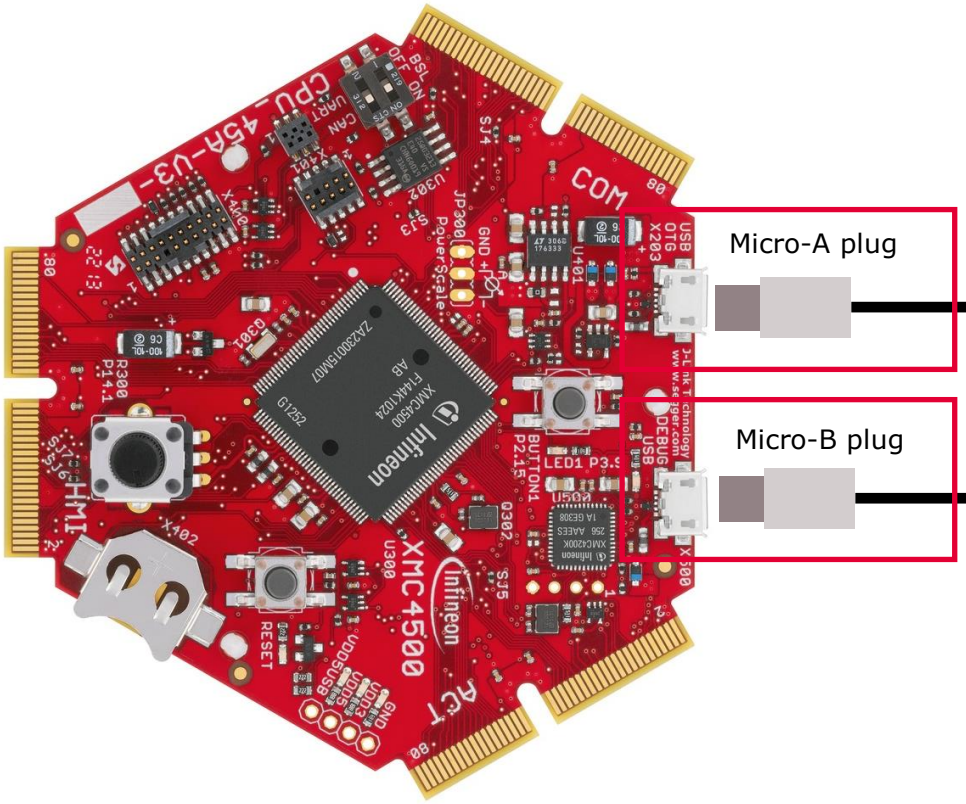
Setup - hardware



- Ensure proper cable types
- Connect cables to the correct ports

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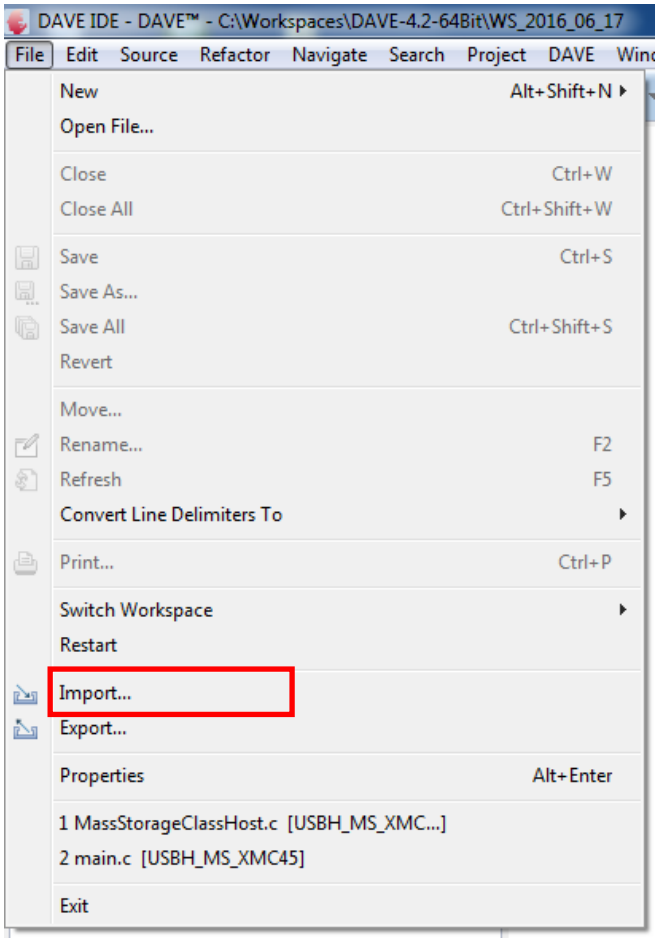
Importing of the Project when downloaded as zip File



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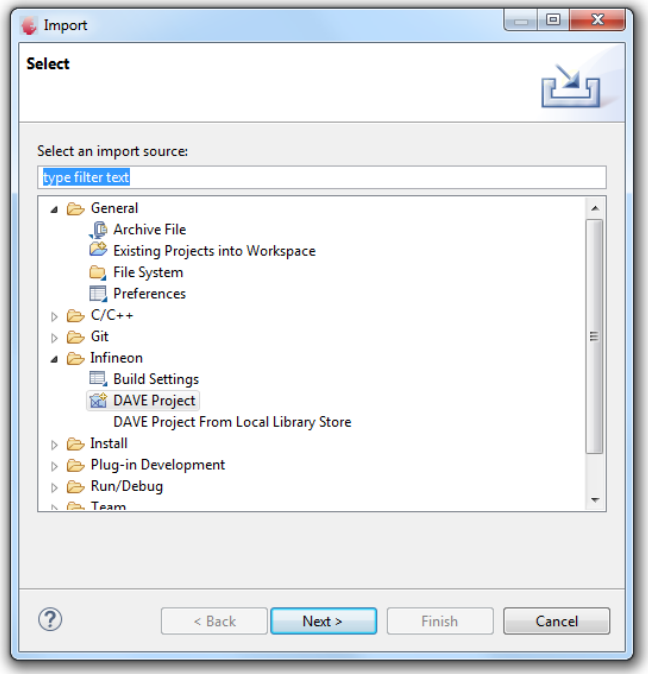

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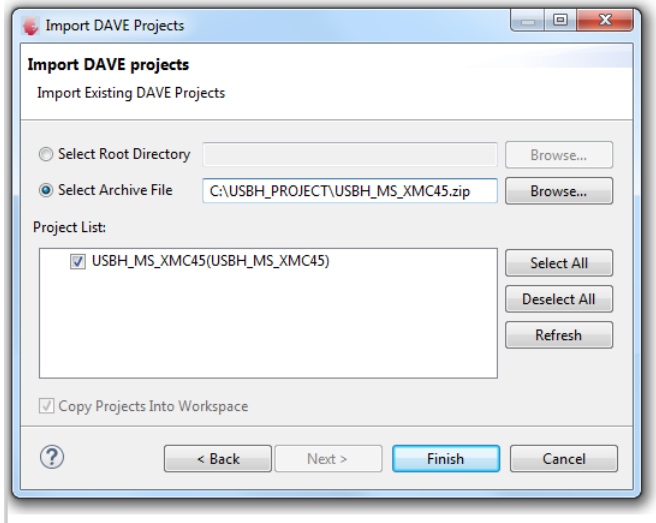

3

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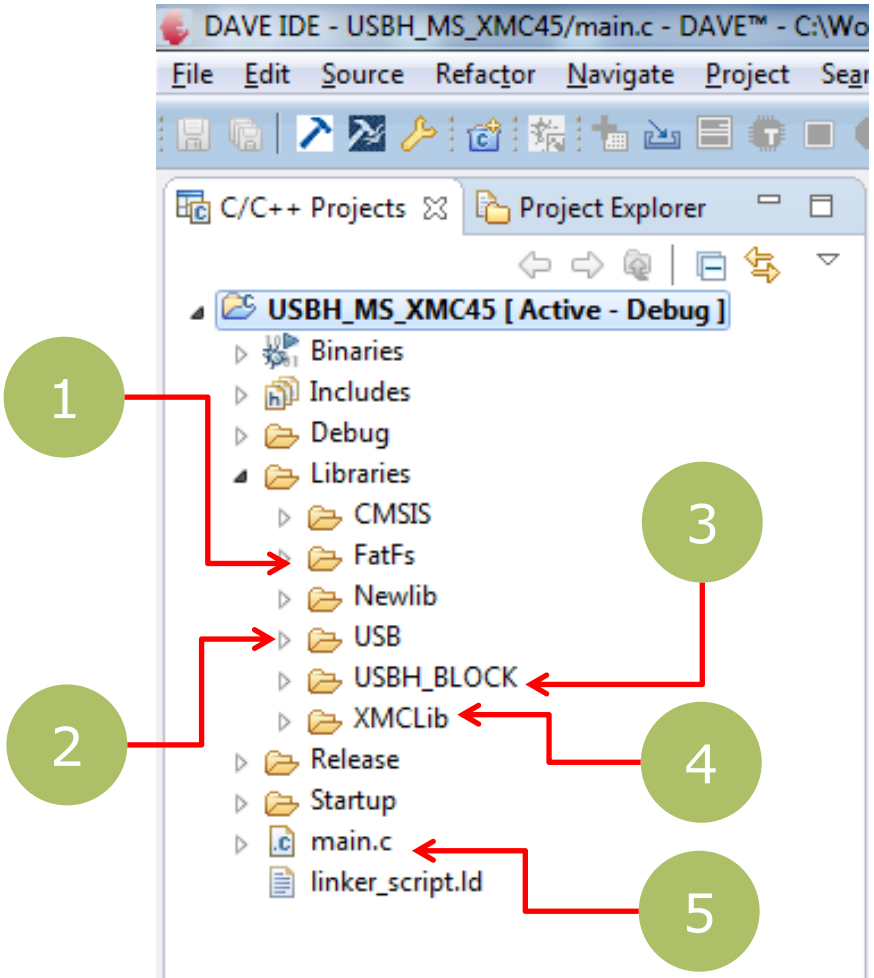
Folder structure of the project



1. Free FAT file system code
2. Free LUFA USB stack, mass storage class and glue layer for XMC low level driver
3. Code linking FAT file system and USB mass storage layer
4. XMCLib folder contains USB low level driver in file xmc_usb.c
5. The main file implementing the application

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Example application behavior

- XMC4500 General Purpose board is initialized as a USB host and provides VBUS on the USB port
- When a USB flash drive is connected, LED1 (on P3.9) is turned ON after device is successfully enumerated
- Host application creates a folder with the name ABSTEP and it creates 3 files, of sizes 1 KB, 2KB and 3KB using File IO calls.
- The files are read back and compared. LED blinks continuously if comparison is successful, else it stays ON continuously
- When USB flash drive is disconnected, LED1 is turned off

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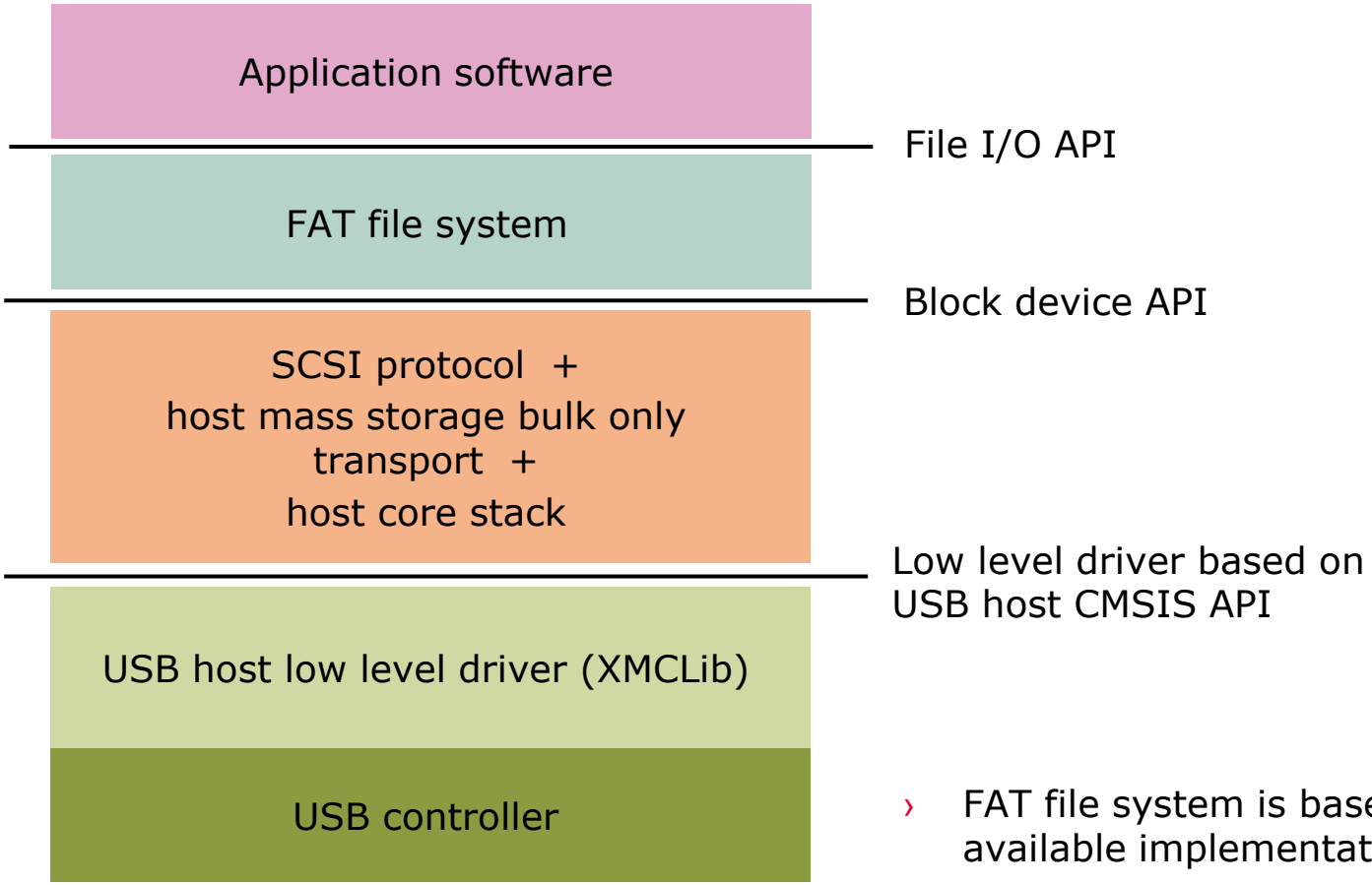
Simplified example application architecture



- FAT file system is based on a freely available implementation
- USB stack and mass storage class implementation is based on a freely available stack known as LUFA

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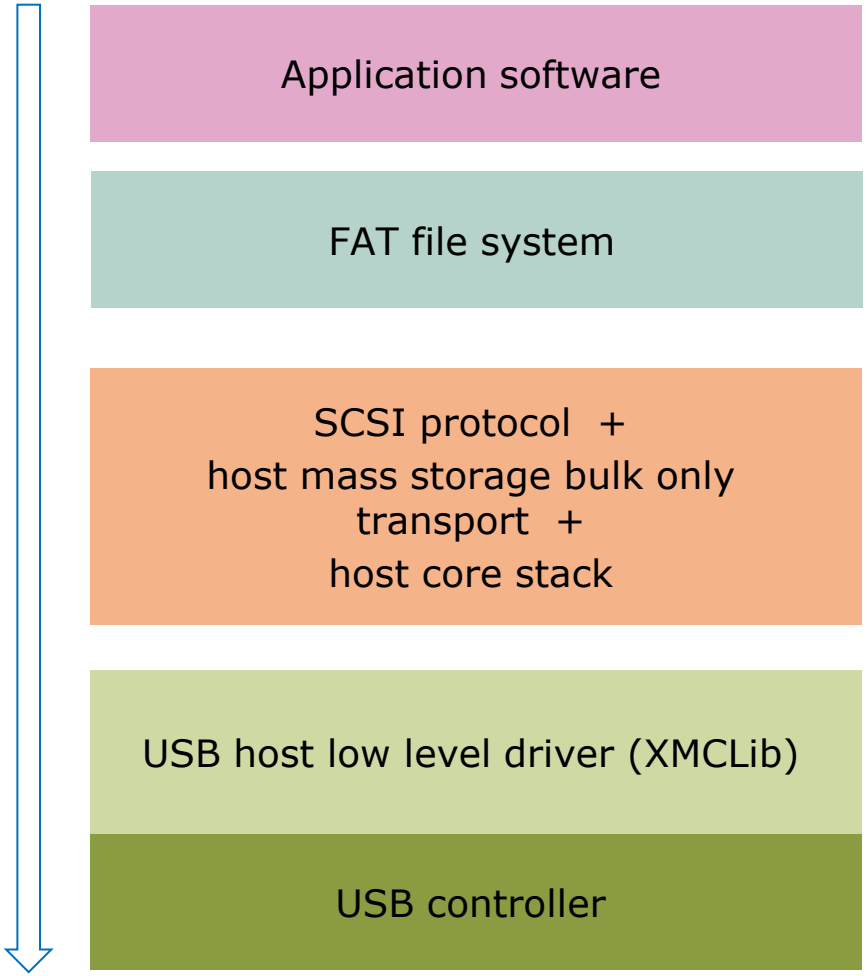
Example application data flow



- Application software launches a file IO request using FAT file IO API
- FAT file system converts the file IO calls in to block device calls.
- Blocks are read and written using the standard SCSI commands and the mass storage bulk only transport protocol state machine
- Data is transferred to/from USB mass storage device using low level driver APIs

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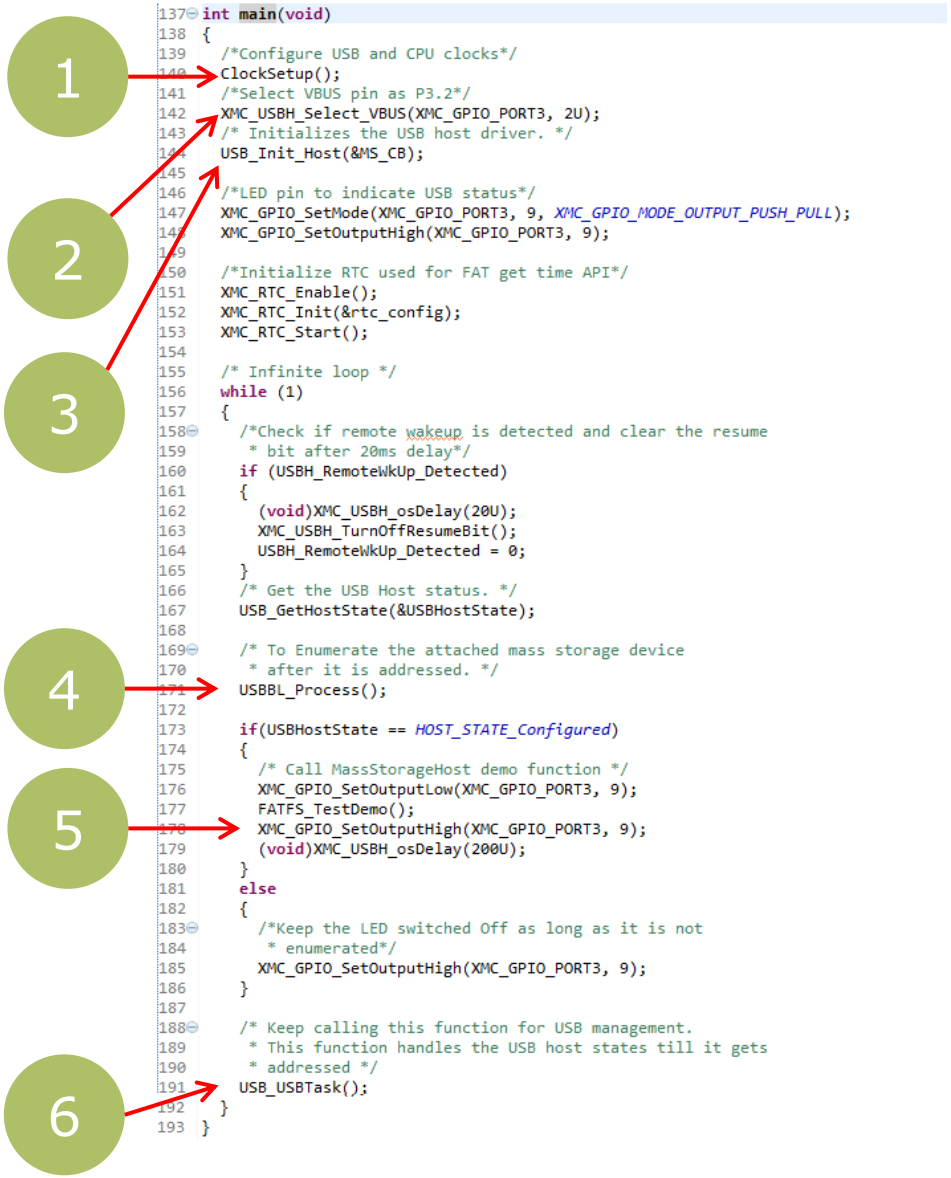
Application – overview of main.c




```c
int main(void)
{
  /*Configure USB and CPU clocks*/
  ClockSetup();
  /*Select VBUS pin as P3.2*/
  XMC_USBH_Select_VBUS(XMC_GPIO_PORT3, 2U);
  /* Initializes the USB host driver. */
  USB_Init_Host(&MS_CB);

  /*LED pin to indicate USB status*/
  XMC_GPIO_SetMode(XMC_GPIO_PORT3, 9, XMC_GPIO_MODE_OUTPUT_PUSH_PULL);
  XMC_GPIO_SetOutputHigh(XMC_GPIO_PORT3, 9);

  /*Initialize RTC used for FAT get time API*/
  XMC_RTC_Enable();
  XMC_RTC_Init(&rtc_config);
  XMC_RTC_Start();

  /* Infinite loop */
  while (1)
  {
    /*Check if remote wakeup is detected and clear the resume
     * bit after 20ms delay*/
    if (USBH_RemoteWkUp_Detected)
    {
      (void)XMC_USBH_osDelay(20U);
      XMC_USBH_TurnOffResumeBit();
      USBH_RemoteWkUp_Detected = 0;
    }
    /* Get the USB Host status. */
    USB_GetHostState(&USBHostState);

    /* To Enumerate the attached mass storage device
     * after it is addressed. */
    USBBL_Process();

    if(USBHostState == HOST_STATE_Configured)
    {
      /* Call MassStorageHost demo function */
      XMC_GPIO_SetOutputLow(XMC_GPIO_PORT3, 9);
      FATFS_TestDemo();
      XMC_GPIO_SetOutputHigh(XMC_GPIO_PORT3, 9);
      (void)XMC_USBH_osDelay(200U);
    }
    else
    {
      /*Keep the LED switched Off as long as it is not
       * enumerated*/
      XMC_GPIO_SetOutputHigh(XMC_GPIO_PORT3, 9);
    }

    /* Keep calling this function for USB management.
     * This function handles the USB host states till it gets
     * addressed */
    USB_USBTask();
  }
}
```

1. Clock setup for XMC4500
2. Select VBUS pin P3.2
3. Initialize USB host
4. Fetch descriptors and match it to mass storage device
5. Demo application function
6. Manage connection events and initiate enumeration

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Application – configure time delay API

- The USB stack uses timing delay of the order of several tens of milliseconds to comply with the specification
- Port the time delay API if required. In the example code, the SysTick timer is used.
- Ensure timer is calibrated

USB_Glue.c

```
622  uint8_t XMC_USBH_osDelay(uint32_t MS)
623  {
624    USBH_GLUE_StartTimer(MS);
625    while(USBH_GLUE_IsTimerRunning());
626
627    return 0;
628  }
```


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Application - callbacks

› Application registers for the following event callbacks

USB_Glue.h

```
106 /*Structure has members to interface the LUFA stack with
107  * class implementation and the application*/
108 typedef struct USBH_GLUE_APP_IF
109 {
110   USBH_Port_Event_Handler_cb PortEventHandler;        /*Callback function to be executed on
111                                                         occurance of a port event*/
112   USBH_Pipe_Event_Handler_cb PipeEventHandler;        /*Callback function to be executed on
113                                                         occurance of a pipe event*/
114   USBH_EnumerationComplete_cb EnumerationCompleteCb;  /*Callback function to be executed after
115                                                         device enumeration is complete*/
116   /*Following function pointers will be called from the implementation of certain LUFA APIs*/
117   USBH_BytesInPipe GetBytesInPipe;                    /*Function will be executed when a call
118                                                         to LUFA API Pipe_BytesInPipe is made.*/
119
120   USBH_PipeRead GetReadByte;                          /*Function will be executed when a call
121                                                         to LUFA API Pipe_Read_8 is made.*/
122
123   USBH_PipeIsINReceived IsINReceived;                 /*Function will be executed when a call
124                                                         to LUFA API Pipe_IsINReceived is made.*/
125 }USBH_GLUE_APP_IF_t;
```


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Application – Implement and register required callbacks

1 Implement call back function

1

```
/*USB port event callback function*/
void MS_USB_PortCb(uint8_t port, uint32_t event)
{
  if(event & XMC_USBH_EVENT_DISCONNECT)
  {
    /*Switch off the LED when device is disconnected*/
    XMC_GPIO_SetOutputHigh(XMC_GPIO_PORT3, 9);
    Driver_USBH0.PipeDelete(USBHost_Pipe_State[0].pipe_handle);
    Driver_USBH0.PipeDelete(USBHost_Pipe_State[1].pipe_handle);
    Driver_USBH0.PipeDelete(USBHost_Pipe_State[2].pipe_handle);
  }
  if(event & XMC_USBH_EVENT_REMOTE_WAKEUP)
  {
    /*This flag is set to remember the occurrence of remote wakeup event and
     * to return from ISR immediately. This helps to time a 20ms delay in
     * the context of the application main loop rather than inside the ISR context.
     * The reason for this is that the example uses a timer interrupt whose priority is
     * lower than the USB interrupt and therefore would result in a deadlock.*/
    USBH_RemoteWkUp_Detected = 1;
  }
}
```


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Application – Implement and register required callbacks

2

3

main.c

```
70  USBH_GLUE_APP_IF_t MS_CB =
71  {
72      .PortEventHandler = MS_USB_PortCb
73  };
74  /* Variable to access the current USB host state */
75  uint8_t USBHostState;
76
77  /**
78   * @brief main() - Application entry point
79   *
80   * <b>Details of function</b><br>
81   * This routine is the application entry point. It is invol
82   * The application enumerates a USB device and executes a c
83   */
84  int main(void)
85  {
86    /* Initializes the USB host driver. */
87    USB_Init_Host(&MS_CB);
```

2 Register call back function

3 Call initialization function

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Application – file transfer demo

- File I/O APIs are called to transfer files between host and device
- Function FATFS_TestDemo() demonstrates file accesses

main.c

```
131 /*Function to demonstrate FAT file access.
132  * Creates a folder with the name ABSTEP, writes 3 files each with 1KB, 2KB and 3KB
133  * of data, reads the content of the same files and compares with written data.
134  * A LED connected on P3.9 glows when the enumeration is complete and contiunues to glow
135  * when the file access is ongoing. When the file access is done, the LED starts blinking.*/
136 void FATFS_TestDemo(void)
137 {
138   volatile uint8_t DResult;
139   uint32_t data_index;
140
141   /* Mount USB device */
142   DResult =  f_mount(&myfsObject, "0:", 0);
143
144
145   /* Make directory  */
146   DResult =  f_mkdir("ABSTEP");
147
148   if ((DResult == FR_OK) || (DResult == FR_EXIST))
149   {
150     /*Directory already exists!!*/
151   }
152
153   /* Create File */
154   DResult = f_open( &fp, "ABSTEP/readme1.txt", (FA_CREATE_NEW | FA_WRITE | FA_READ));
```


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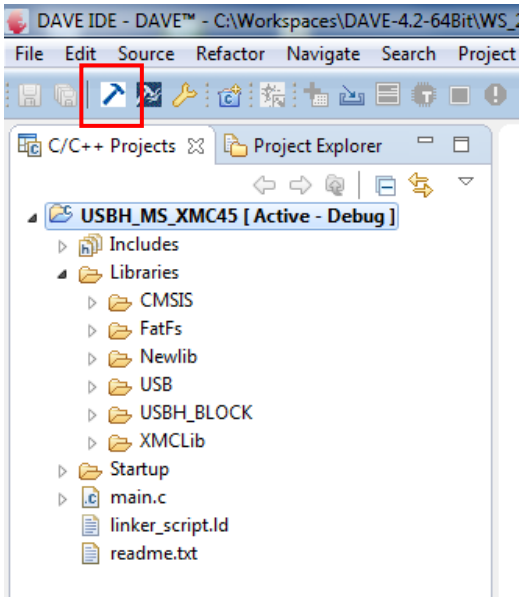
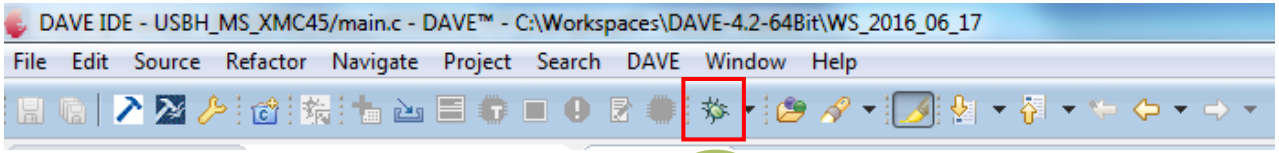
How to test



1

1. Build and download project into XMC4500 General Purpose board



2

2. Start debugger



3

3. Start the execution by pressing the run button

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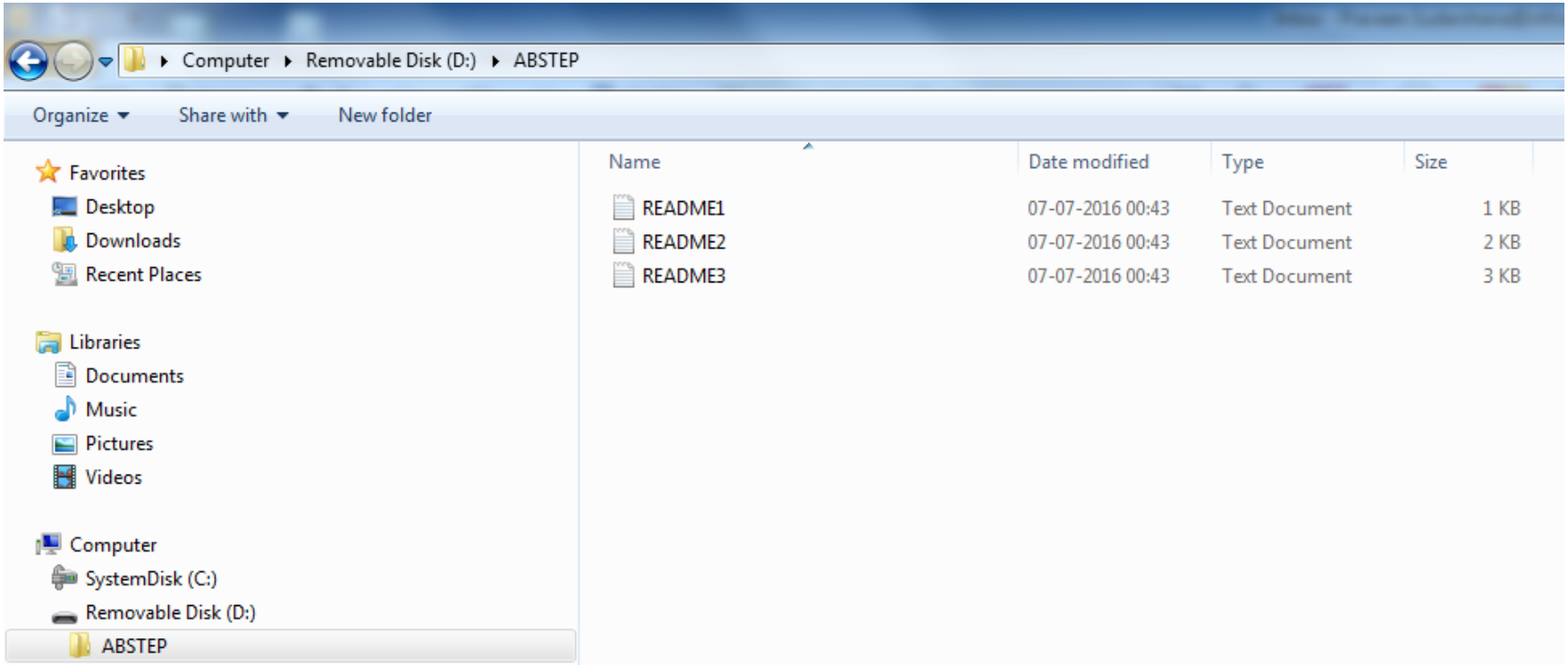
Example application behavior

Disconnect the USB flash drive and connect to a Windows laptop to confirm presence of files.



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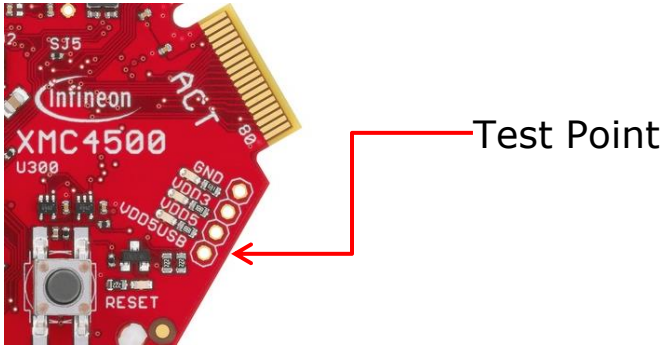
Debug Hints

- Check VBUS is available and within permissible range (4.4V to 5.25V) on the USB host port receptacle. Lower VBUS voltages due to excessive current draw may cause USB devices to disconnect intermittently or fail enumeration. Try connecting a different USB device.



- Long cables may cause malfunction due to signal quality issues. Use short cables if possible.

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Further reading

- USB specifications and Micro-USB cables and connectors specification

  http://www.usb.org/developers/docs/usb20_docs/

- Mass storage class specifications
  - Mass storage class specification overview
  - Mass storage class bulk only

  http://www.usb.org/developers/docs/devclass_docs/

- SCSI specifications

  www.t10.org

- CMSIS USB host API specification

  https://www.keil.com/pack/doc/CMSIS/Driver/html/group__usb__interface__gr.html

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Further reading

- FAT file system

  http://elm-chan.org/fsw/ff/00index_e.html

- LUFA USB stack

  http://www.fourwalledcubicle.com/index.php

- Books
  - USB Complete: The Developer's Guide, Jan Axelson
  - USB Mass Storage: Designing and Programming Devices and Embedded Hosts, Jan Axelson

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Limitations

- FAT File system supports only short file names i.e. in 8.3 format.
- USB Hubs are not supported
- Over current protection is not supported
- DMA Transfers are not supported
- Low level driver does not support isochronous transfers

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