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1 Preface

1.1 Purpose

This demo is for the SmartFusion®2 system-on-chip (SoC) field programmable gate array (FPGA) devices. It explains the universal serial bus (USB) 2.0 on-the-go (OTG) feature with the help of USB mass storage class.

1.2 Intended Audience

This demo guide is intended for:

• FPGA designers
• Embedded designers
• System-level designers

1.3 References

The following documents are referred in this demo guide.

• UG0331: SmartFusion2 Microcontroller Subsystem User Guide
• Configuring Serial Terminal Emulation Programs Tutorial
• TU0546: SoftConsole v4.0 and Libero SoC v11.7 Tutorial

Refer to the following web page for a complete and up-to-date listing of SmartFusion2 device documentation: www.microsemi.com/products/fpga-soc/soc-fpga/sf2docs#documents.
2 USB OTG Capabilities of SmartFusion2

2.1 Introduction

Microsemi offers a reference design for the SmartFusion2 SoC FPGA devices that demonstrates the USB controller OTG feature and implements the USB mass storage class. The reference design runs on the SmartFusion2 Security Evaluation Kit. The SmartFusion2 SoC FPGA device contains a USB OTG controller as part of the microcontroller subsystem (MSS). This demo guide describes the mechanism for the USB communication between the SmartFusion2 device and the external USB host/USB device/USB OTG protocol compliant devices provided by the SmartFusion2 USB OTG controller.

OTG is the USB 2.0 mode of operation, where USB 2.0 OTG controller works as either the USB host or the USB device based on the target device and type of the plug connected to the USB OTG controller. Refer to the UG0331: SmartFusion2 Microcontroller Subsystem User Guide for more information on USB OTG controller and its operations.

2.2 Design Requirements

Table 1 lists the hardware and software design requirements.

<table>
<thead>
<tr>
<th>Design Requirements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>SmartFusion2 Security Evaluation Kit:</td>
<td>Rev D or later</td>
</tr>
<tr>
<td>• FlashPro4 programmer</td>
<td></td>
</tr>
<tr>
<td>• 12 V adapter</td>
<td></td>
</tr>
<tr>
<td>• USB A to Mini-B cable (for serial communication)</td>
<td></td>
</tr>
<tr>
<td>• Micro-A to B receptacle USB cable (to connect to the USB drive)</td>
<td></td>
</tr>
<tr>
<td>• Micro-B to A USB cable (to connect the SmartFusion2 Security Evaluation Kit board with the host PC)</td>
<td></td>
</tr>
<tr>
<td>Host PC or Laptop</td>
<td>Any 64-bit Windows operating system</td>
</tr>
<tr>
<td><strong>Software Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>Libero® SoC</td>
<td>v11.7</td>
</tr>
<tr>
<td>FlashPro programming software</td>
<td>v11.7</td>
</tr>
<tr>
<td>SoftConsole</td>
<td>v3.4 SP1*</td>
</tr>
<tr>
<td>USB to UART drivers</td>
<td>–</td>
</tr>
</tbody>
</table>
| **Notes:** For this tutorial, SoftConsole v3.4 SP1 is used. For using SoftConsole v4.0, see the TU0546: SoftConsole v4.0 and Libero SoC v11.7 Tutorial.
2.3 Demo Design

2.3.1 Introduction

The demo design files are available for download from the following path in the Microsemi website: [http://soc.microsemi.com/download/rsc/?f=m2s_dg0476_liberov11p7_df](http://soc.microsemi.com/download/rsc/?f=m2s_dg0476_liberov11p7_df)

The demo design files include:

- Libero
- USB drivers
- Stapl programming file
- Readme file

Figure 1 shows the top-level structure of the design files. For details, refer to the readme.txt file.

**Figure 1 • Demo Design Files Top-Level Structure**

```
<download_folder>
    m2s_dg0476_liberov11p7_df
        libero
        usb drivers
        stapl_programming_file
        readme.txt
```

**Figure 2 shows the demo architecture.**

**Figure 2 • Top-Level Block Diagram**

**Note:** MSS USB drivers are provided along with the design files. These drivers are customized and used in the demo.
2.3.2 **Demo Design Features**

The main objective of the demo is to show OTG capability with USB mass storage class. The demo design performs the following operations:

- Switching the USB OTG controller operation between Host mode and Device mode based on the target device and type of plug connected to the USB OTG controller.
  - Device mode operation:
    - Displaying the on-board SPI flash (8 MB) as storage medium in host PC.
  - Host mode operation:
    - Detecting the USB 2.0 complaint USB mass storage device connected to the USB OTG controller and listing the file names.

2.3.3 **Demo Design Description**

The USB OTG controller in the SmartFusion2 device can be configured to operate in the USB device mode/USB host mode/USB OTG mode. In USB OTG mode, the USB OTG controller acts as either USB device or USB host based on the target device and type of plug connected to the USB OTG controller.

If the Micro-A end of the cable is plugged into the SmartFusion2 device through the external PHY, the USB controller takes the role of the host and goes into the Host mode. The Host mode flag is set to 1.

If the Micro-B end of the cable is plugged in, the USB controller goes into the Peripheral mode and the Host mode flag is set to 0.

The demo design application initializes the USB Host mode stack and USB Device mode stack to operate in the USB OTG mode. When the USB OTG controller enters into the Device mode, the application initializes the USB mass storage class and registers with the MSS USB Device mode driver. The on-board SPI flash memory (8 MB) is used as a storage medium in the USB Device mode operation and read/write operations can be performed.

When the USB OTG controller enters into the Host mode, the application registers the USB mass storage class with the MSS USB Host mode driver. The application detects the connected mass storage device and lists the files names. The application uses the FatFs file system library to access the files from the target USB mass storage device. Refer to the following link for more information on FatFs file system:

http://elm-chan.org/fsw/ff/00index_e.html.
2.3.3.1 USB OTG Mode Execution Flow

Figure 3 describes the USB OTG mode execution flow.

**Figure 3 • USB OTG Execution Flow**

The demo application configures MMUART_1 for serial communication, SPI_0 to access SPI-Flash, and GPIO to keep the USB controller out of reset. The application registers the USB callback functions and USB interrupt service routine to handle the USB events like connect/disconnect, Host mode specific events, and Device mode specific events.

When the SmartFusion2 device is connected to the host PC with Micro-B to A USB cable, the USB connect interrupt is generated and the Host mode flag is set to 0. The USB controller enters into mass storage class device mode and starts responding to the commands from the host PC. The SmartFusion2 on-board SPI-Flash is accessed by the host PC as a disk drive/volume in the USB Device mode.

When the Micro-A to B receptacle USB cable with the USB mass storage device is connected to the SmartFusion2 device, the connect interrupt is generated and the Host mode flag is set to 1. The USB controller switches to the Host mode from the Device mode and accesses the USB mass storage device. When the USB mass storage device is unplugged from the SmartFusion2 device, the Host mode flag is set to 0 and disconnect interrupt is generated. The application releases the Host mode driver and waits to enter into either the Device mode or Host mode based on the target device and type of plug connected to the USB controller.
2.4 Setting Up the Demo Design

The following steps describe how to setup the demo design:

1. Connect the FlashPro4 programmer to the J5 connector of the SmartFusion2 Security Evaluation Kit board.
2. Connect the host PC to the J18 connector on the SmartFusion2 Security Evaluation Kit board using the USB A to Mini-B cable.
3. Ensure that the USB to UART bridge drivers are automatically detected. Download and install the drivers from www.microsemi.com/soc/documents/CDM_2.08.24_WHQL_Certified.zip.
4. Of the four COM ports, select the one with Location as on USB Serial Converter D. Figure 4 shows an example of the Device Manager window that has the USB Serial Port and its properties showing the port number and location. The COM port number is required to run the demo design, make a note of it.

**Figure 4 • USB to UART Bridge Drivers**

5. Connect the jumpers on the SmartFusion2 Security Evaluation Kit board, as shown in Table 2. For more information on jumper locations, refer to "Appendix: Jumper Locations" on page 17. **CAUTION:** Switch OFF the power supply switch, SW7, before connecting the jumpers.

<table>
<thead>
<tr>
<th>Jumper Number</th>
<th>Pin (From)</th>
<th>Pin (To)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J22, J23, J8, J3</td>
<td>1</td>
<td>2</td>
<td>These are the default jumper settings of the SmartFusion2 Security Evaluation Kit board. Ensure that these jumpers are set properly.</td>
</tr>
<tr>
<td>J24</td>
<td>1</td>
<td>2 (closed)</td>
<td>USB Host mode jumper settings</td>
</tr>
<tr>
<td>J24</td>
<td>1</td>
<td>2 (open)</td>
<td>USB Device mode jumper settings</td>
</tr>
</tbody>
</table>
6. Connect the power supply to the J6 DC jack.

2.4.1 Board Setup

Snapshots of the SmartFusion2 Security Evaluation Kit board with the complete set up for both types of connections are given in the following sections:

- "Appendix: Board Set up for USB OTG Controller in USB Device Mode" on page 15
- "Appendix: Board Setup for USB OTG Controller in USB Host Mode" on page 16

2.5 Running the Demo Design

The following steps describe how to run the demo design:

1. Download the demo design from:
   http://soc.microsemi.com/download/rsc/?f=m2s_dg0476_liberov11p7_df
2. Switch ON the power supply switch, SW7.
3. Start any serial terminal emulation program such as:
   - HyperTerminal
   - PuTTY
   - TeraTerm
   The configuration for the program is:
   - Baud Rate: 115200
   - 8 Data bits
   - 1 Stop bit
   - No Parity
   - No Flow Control
   For information on configuring the serial terminal emulation programs, refer to the Configuring Serial Terminal Emulation Programs Tutorial.
4. Launch the FlashPro software.
5. Click New Project.
6. In the New Project window, enter the Project Name.
7. Click Browse and navigate to the location where you want to save the project.
8. Select Single device as the Programming mode.
9. Click OK to save the project.
10. Click Configure Device on the FlashPro GUI.
11. Click Browse and navigate to the location where the usb_otg_demo.stp file is located and select the file. The default location is: <download_folder>stapl_programming_file. The required programming file is selected and is ready to be programmed in the device.

Figure 6 • FlashPro Project Configured

12. Click PROGRAM to start programming the device. Wait until a message is displayed indicating that the program passed. This demo requires the SmartFusion2 device to be preprogrammed with the application code to activate the USB OTG functionality. Therefore, the SmartFusion2 device is preprogrammed with the usb_otg_demo.stp file using the FlashPro software.

Figure 7 • FlashPro Program Passed
13. After successfully programming the SmartFusion2 device using FlashPro, the serial terminal emulation program shows the initialization messages, as shown in Figure 8. The SmartFusion2 USB OTG controller is now set to perform the USB OTG functionality.

**Figure 8 • UART Message**

![UART Message](image)

### 2.5.1 SmartFusion2 USB OTG Controller Acting as USB Device

The following steps describe how to use the SmartFusion2 USB OTG Controller as a USB device:

1. Connect the host PC to the micro AB receptacle (P1 connector) on the SmartFusion2 Security Evaluation Kit board using the Micro-B to A USB cable. A new disk drive/volume is created in the host PC.
2. Right-click the drive and select properties, as shown in Figure 9 to verify the USB device functionality of the SmartFusion2 USB OTG controller.

**Note:** Format the disk drive when prompted by the host PC and ensure that there is no important data on the SmartFusion2 Security Evaluation Kit on-board SPI-Flash.

**Figure 9 • SmartFusion2 USB Device Detection on Host PC/Laptop**

![SmartFusion2 USB Device Detection](image)
2.5.2 SmartFusion2 USB OTG Controller Acting as USB Host

The following steps describe how to use the SmartFusion2 USB OTG Controller as a USB host:

1. Unplug the Micro-B to A USB cable from the P1 connector of the SmartFusion2 Security Evaluation Kit board.
2. Insert the Micro-A to B USB cable with USB mass storage device at the B type end of the cable, as shown in Figure 10. Ensure that the mass storage device is preformatted.

The SmartFusion2 USB OTG controller switches to the USB Host mode and detects the connected USB mass storage device to perform transactions as the USB host. The application enumerates the USB mass storage device and reads all file names on the USB drive to display the list on the serial terminal emulation program, as shown in Figure 11.

To verify the USB OTG functionality again repeat the process of the SmartFusion2 USB OTG controller acting as a USB device and USB host.
3 Appendix: Board Set up for USB OTG Controller in USB Device Mode

*Figure 12• Setup for USB OTG Controller in USB Device Mode*
4 Appendix: Board Setup for USB OTG Controller in USB Host Mode

Figure 13 • Setup for USB OTG Controller in USB Host Mode
5 Appendix: Jumper Locations

Figure 14 shows the jumper locations in the SmartFusion2 Security Evaluation Kit board.

Notes:
- Jumpers highlighted in red (J22, J23, J8, J3) are set as default.
- Jumpers highlighted in green (J24) need to be set manually.
- The locations of the jumpers in Figure 14 are searchable.
## Revision History

The following table shows important changes made in this document for each revision.

<table>
<thead>
<tr>
<th>Revision</th>
<th>Changes</th>
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<tbody>
<tr>
<td>Revision 6 (March 2016)</td>
<td>Updated the document for Libero v11.7 software release (SAR 76712).</td>
</tr>
<tr>
<td>Revision 5 (October 2015)</td>
<td>Updated the document for Libero v11.6 software release (SAR 72555).</td>
</tr>
<tr>
<td>Revision 4 (February 2015)</td>
<td>Updated the document for Libero v11.5 software release (SAR 64193).</td>
</tr>
<tr>
<td>Revision 3 (October 2014)</td>
<td>Updated the document for Libero v11.4 software release (SAR 61626).</td>
</tr>
<tr>
<td>Revision 2 (June 2014)</td>
<td>Updated the document for Libero v11.3 software release (SAR 58734).</td>
</tr>
<tr>
<td>Revision 1 (November 2013)</td>
<td>Updated the document for Libero v11.2 software release (SAR 52961).</td>
</tr>
<tr>
<td>Revision 0 (October 2013)</td>
<td>Initial Release</td>
</tr>
</tbody>
</table>
7 Product Support

Microsemi SoC Products Group backs its products with various support services, including Customer Service, Customer Technical Support Center, a website, electronic mail, and worldwide sales offices. This appendix contains information about contacting Microsemi SoC Products Group and using these support services.

7.1 Customer Service

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

From North America, call 800.262.1060
From the rest of the world, call 650.318.4460
Fax, from anywhere in the world, 408.643.6913

7.2 Customer Technical Support Center

Microsemi SoC Products Group staffs its Customer Technical Support Center with highly skilled engineers who can help answer your hardware, software, and design questions about Microsemi SoC Products. The Customer Technical Support Center spends a great deal of time creating application notes, answers to common design cycle questions, documentation of known issues, and various FAQs. So, before you contact us, please visit our online resources. It is very likely we have already answered your questions.

7.3 Technical Support


7.4 Website


7.5 Contacting the Customer Technical Support Center

Highly skilled engineers staff the Technical Support Center. The Technical Support Center can be contacted by email or through the Microsemi SoC Products Group website.

7.5.1 Email

You can communicate your technical questions to our email address and receive answers back by email, fax, or phone. Also, if you have design problems, you can email your design files to receive assistance. We constantly monitor the email account throughout the day. When sending your request to us, please be sure to include your full name, company name, and your contact information for efficient processing of your request.

The technical support email address is soc_tech@microsemi.com.

7.5.2 My Cases

Microsemi SoC Products Group customers may submit and track technical cases online by going to My Cases.
7.5.3 Outside the U.S.

Customers needing assistance outside the US time zones can either contact technical support via email (soc_tech@microsemi.com) or contact a local sales office. Visit About Us for sales office listings and corporate contacts.

7.6 ITAR Technical Support

For technical support on RH and RT FPGAs that are regulated by International Traffic in Arms Regulations (ITAR), contact us via soc_tech@microsemi.com. Alternatively, within My Cases, select Yes in the ITAR drop-down list. For a complete list of ITAR-regulated Microsemi FPGAs, visit the ITAR web page.
Microsemi Corporation (Nasdaq: MSCC) offers a comprehensive portfolio of semiconductor and system solutions for communications, defense & security, aerospace and industrial markets. Products include high-performance and radiation-hardened analog mixed-signal integrated circuits, FPGAs, SoCs and ASICs; power management products; timing and synchronization devices and precise time solutions, setting the world's standard for time; voice processing devices; RF solutions; discrete components; Enterprise Storage and Communication solutions, security technologies and scalable anti-tamper products; Ethernet solutions; Power-over-Ethernet ICs and midspans; as well as custom design capabilities and services. Microsemi is headquartered in Aliso Viejo, Calif, and has approximately 4,800 employees globally. Learn more at www.microsemi.com.