# USB OTG Capabilities of SmartFusion2 SoC FPGA Devices

## Demo Guide

June 2014

**Microsemi**

# Revision History

| Date | Revision | Change |
|---|---|---|
| 23 June 2014 | 2 | Third Release |
| 29 November 2013 | 1 | Second release |
| 10 October 2013 | 0 | First release |

## Confidentiality Status

This is a non-confidential document.

# Table of Contents

# Preface

## About this document

This demo is for 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.

## Intended Audience

SmartFusion2 devices are used by:

- FPGA designers
- Embedded designers
- System-level designers

## References

### Microsemi® Publications

- SmartFusion2 Microcontroller Subsystem User Guide
- Configuring Serial Terminal Emulation Programs Tutorial

Refer to the following web page for a complete and up-to-date listing of SmartFusion2 device documentation: www.microsemi.com/soc/products/smartfusion2/docs.aspx.

# USB OTG Capabilities of SmartFusion2

## Introduction

Microsemi offers a reference design for SmartFusion2 SoC FPGA devices that demonstrates the USB controller OTG feature of the SmartFusion2 FPGA and implements the USB mass storage class. The reference design runs on the SmartFusion2 Development 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 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 *SmartFusion2 Microcontroller Subsystem User Guide* for more information on USB OTG controller and its operations.

*Table 1 •* **Resource Details**

| Resource Details | Description |
|---|---|
| **Hardware Resources** | |
| • SmartFusion2 Development Kit, Rev C or later that has:<br>– FlashPro4 programmer<br>– 12 V adapter<br>– USB A to Mini-B cable (for serial communication)<br>– Micro-A to B receptacle USB cable (to connect to the USB drive)<br>– Micro-B to A USB cable (to connect the SmartFusion2 Development Kit board with the host PC) | Rev C or Later |
| Host PC (or Laptop) | Any 64-bit windows operating system |
| **Software Resources** | |
| Libero® System-on-Chip (SoC) for viewing the design files | v11.3 |
| FlashPro programming software | v11.3 |
| USB to UART drivers | – |

# Demo Design

## Introduction

The demo design files are available for download from the following path in the Microsemi website:

*http://soc.microsemi.com/download/rsc/?f=sf2_usb_otg_demo_df*.

The demo design files include:

- Libero SoC project
- STAPL programming file
- readme.txt file

Figure 1 shows the top level structure of the design files. For further details, refer to the readme.txt file.
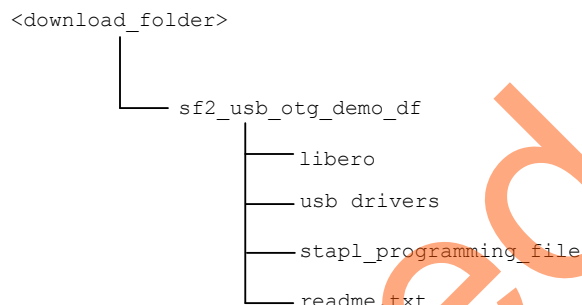
```
<download_folder>

          sf2_usb_otg_demo_df

                    libero

                    usb drivers

                    stapl_programming_file

                    readme.txt
```

*Figure 1* • **Demo Design Files Top Level Structure**
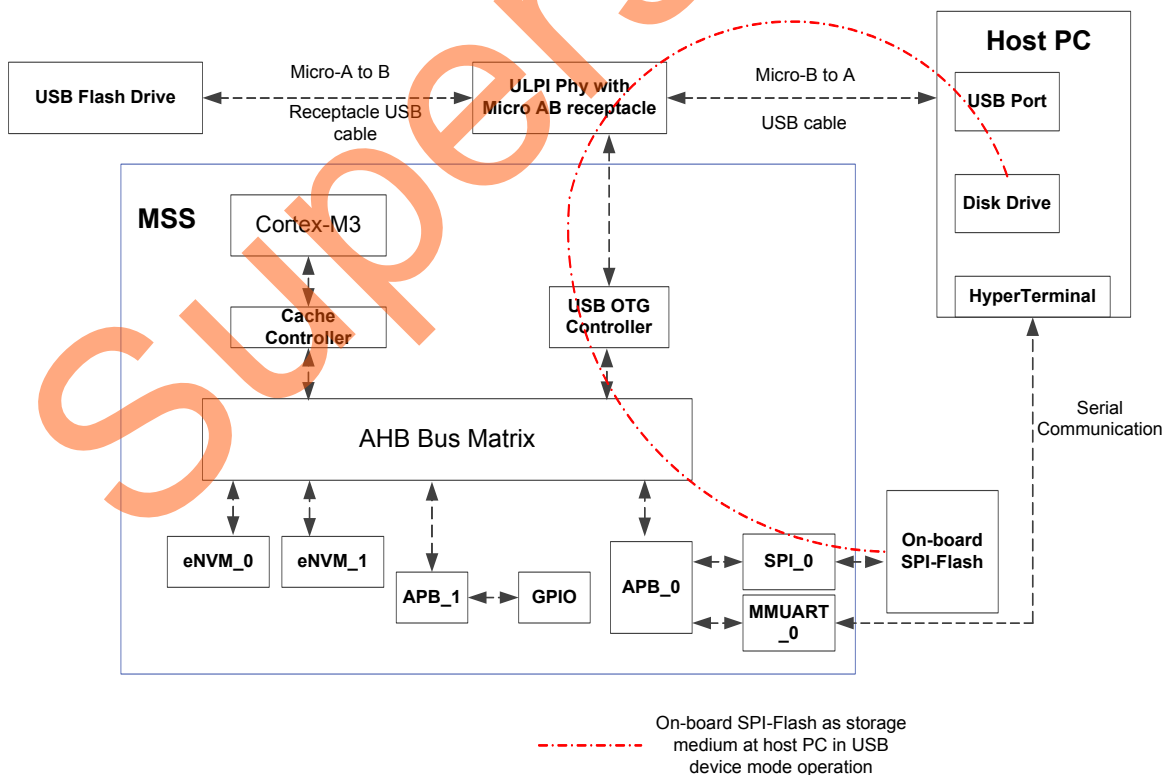
Figure 2 describes the demo architecture.



*Figure 2* • **Top Level Block Diagram of the Demo**

Note: MSS USB drivers are provided along with the design files. These drivers are customized and used in the demo.

## Demo Design Features

The main objective of the demo is to show OTG capability with basic 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 the 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.

The current firmware implementation is tested with following USB 2.0 complaint USB mass storage devices (USB flash drives) that fall under the **Memory stick** category:

- Sandisc Cruzer Blade^TM -   16 GB/8 GB/4 GB/1 GB
- Kingston DataTraveler^® -   4 GB/2 GB
- Kingston^® DataTraveler^®109 -   8 GB
- Transcend JetFlash^® -   4 GB

## 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 the 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 Host mode. Host mode flag is set to 1.

If the Micro-B end of the cable is plugged in, the USB controller goes into Peripheral mode and 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 USB OTG mode. When the USB OTG controller enters into Device mode, the application initializes the USB mass storage class and registers with the MSS USB Device mode driver. 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 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 website for more information on FatFs file system:
*http://elm-chan.org/fsw/ff/00index_e.html.*

### *USB OTG Mode Execution Flow*

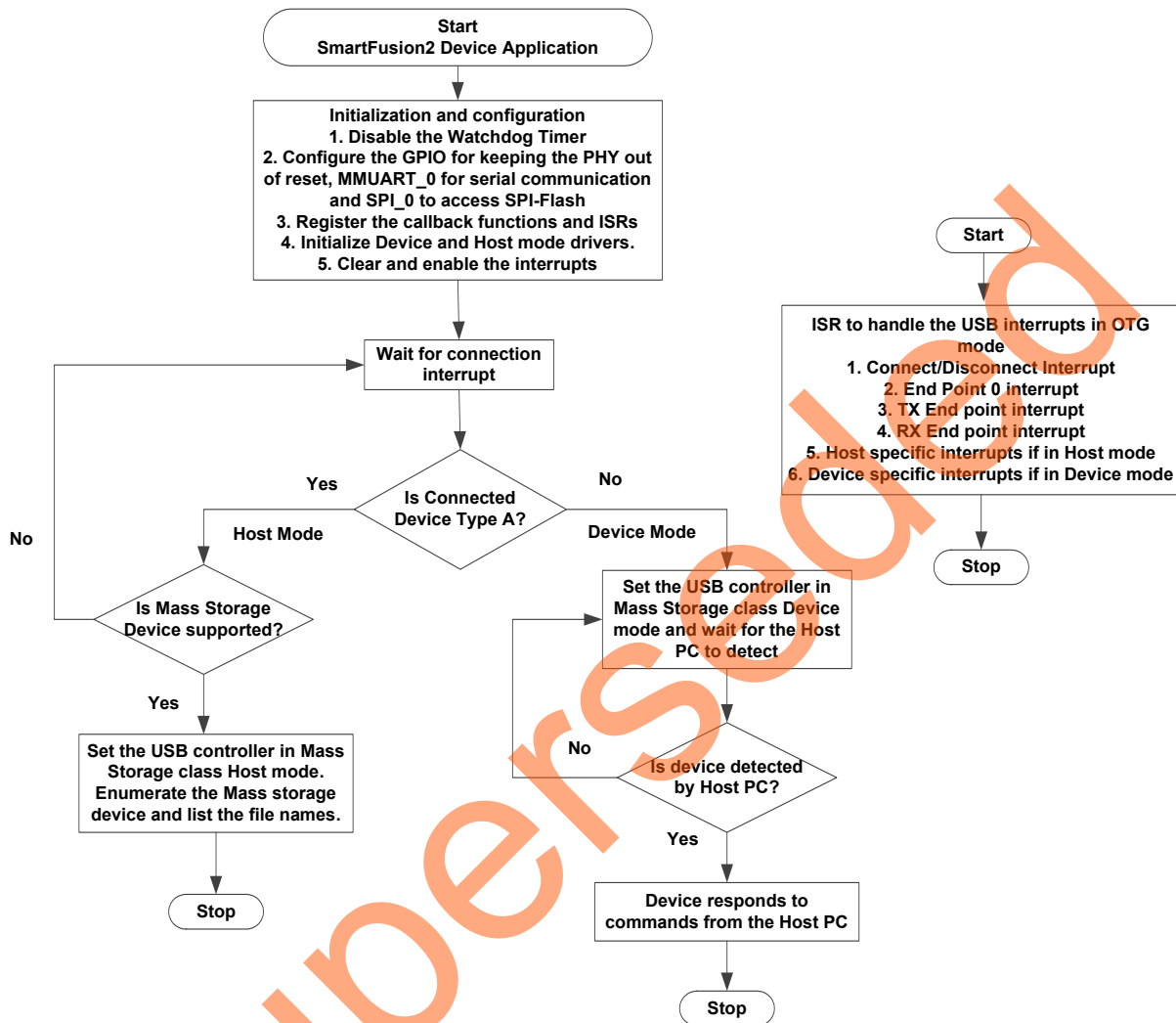Figure 3 describes the USB OTG mode execution flow.



*Figure 3 •* **USB OTG Execution Flow**

The demo application configures MMUART_0 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 a SmartFusion2 device is connected to the host PC with Micro-B to A USB cable, the USB connect interrupt is generated and Host mode flag is set to 0. Now the USB controller enters into mass storage class device mode and starts responding to commands from host PC. The SmartFusion2 on-board SPI-Flash is accessed by the host PC as a disk drive/volume in USB Device mode.

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

# Setting up the Demo Design

Use the following steps to setup the demo:

1. Connect the FlashPro4 programmer to the J59 connector of the SmartFusion2 Development Kit board.

2. Connect the host PC to the J24 connector provided on the SmartFusion2 Development Kit board using the USB A to Mini-B cable.

3. Make sure 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 USD Serial Converter D**. Figure 4 shows an example of **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.
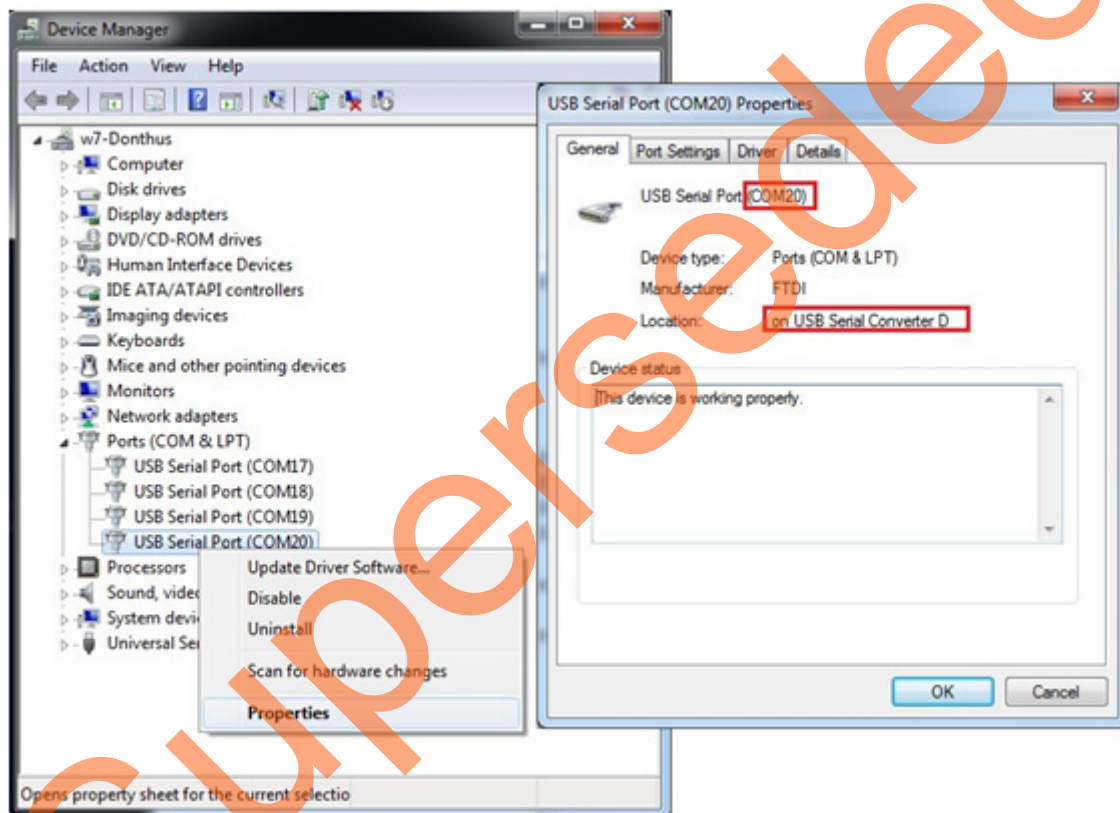


*Figure 4 •* USB to UART Bridge Drivers

5. Connect the jumpers on the SmartFusion2 Development Kit board, as shown in Table 2 on page 10. For more information on jumper locations, refer to "Appendix 3: Jumper Locations" on page 17.

   – **Caution:** Before making the jumper connections, switch off the power supply switch, SW7.

*Table 2 •* **SmartFusion2 Development Kit Jumper Settings**

| Jumper Number | Settings | Notes |
|---|---|---|
| J70, J93, J94, J117, J123, J142, J157, J160, J167, J225, J226, J227 | 1-2 closed | These are the default jumper settings of the SmartFusion2 Development Kit board. Make sure these jumpers are set properly. |
| J2 | 1-3 closed | |
| J23 | 2-3 closed | |
| J129, J133 | 2-3 closed | Jumper settings for MMUART_0 |
| J110, J118, J119, J121 | 1-2 closed | Jumper settings for SPI to SPI-Flash interface. |
| J139 | 1-2 closed | Jumper to select USB reset |
| J163 | 1-2 closed | Jumper to select USB OTG mode of operation. |
| J164 | 1-2 closed | Jumper to provide the VBUS supply to USB when using in host mode. |

6. Connect the power supply to the J18 DC jack.

## Board Setup

Snapshots of the SmartFusion2 Development Kit board with the complete set up for both types of connections are given in the following appendices:

- "Appendix 1: Board Set up for USB OTG Controller in USB Device Mode" on page 15
- "Appendix 2: Board Setup for USB OTG Controller in USB Host Mode" on page 16

# Running the Demo Design

1. Download the demo design from:
   *http://soc.microsemi.com/download/rsc/?f=sf2_usb_otg_demo_df.*

2. Switch **ON** the SW7 power supply switch.

3. Start any serial terminal emulation program such as:
   – HyperTerminal
   – PuTTY
   – Tera Term

   The configuration for the program is:
   – Baud Rate: 57600
   – 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**.
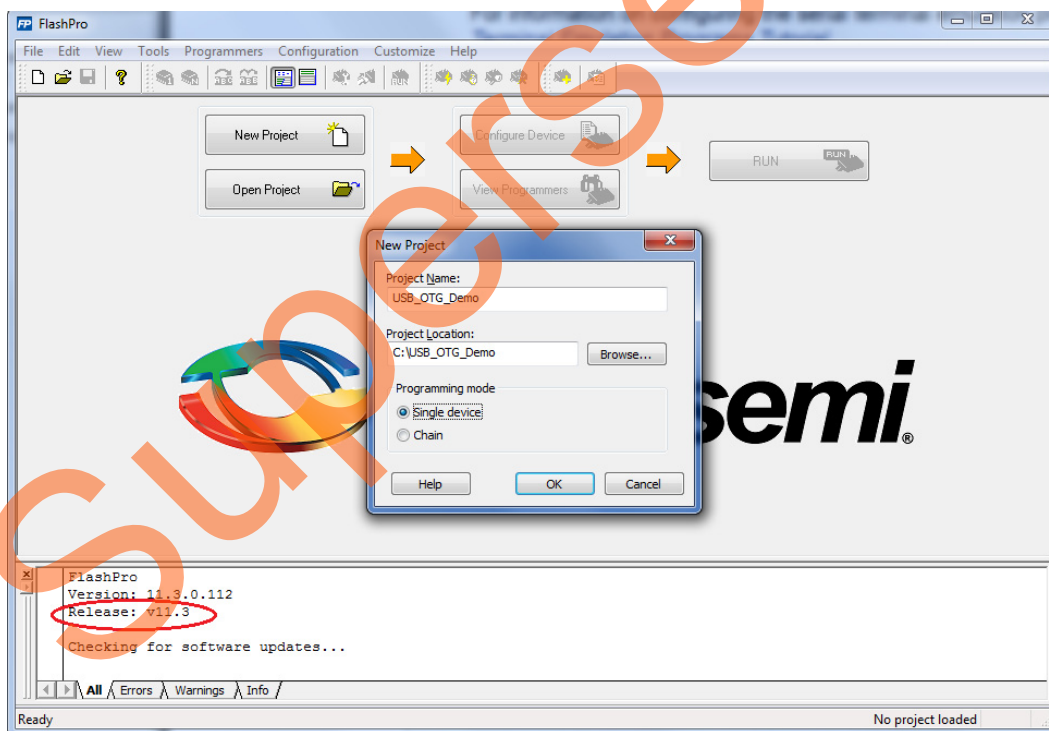
6. In the **New Project** window, type the project name.



*Figure 5* • **FlashPro New Project**

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>sf2_usb_otg_demo_stapl_programming_file*. The required programming file is selected and is ready to be programmed in the device.
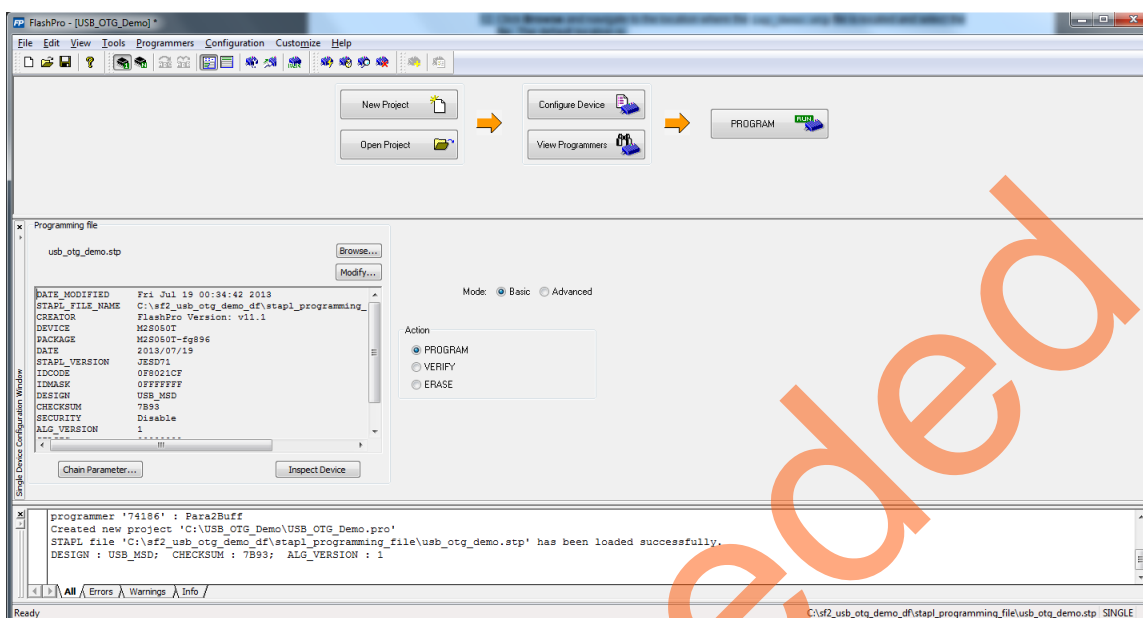


*Figure 6* • **FlashPro Project Configured**

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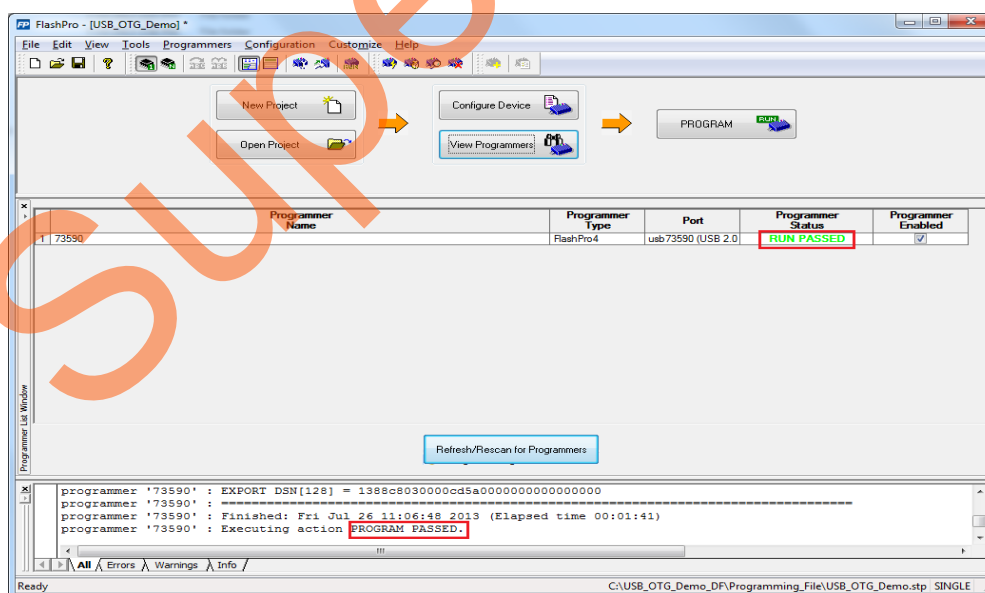


*Figure 7* • **FlashPro Program Passed**

13. On 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.
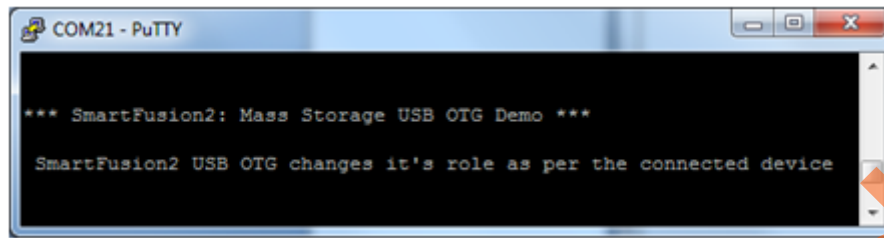


*Figure 8 •* **UART Message**

## SmartFusion2 USB OTG Controller Acting as USB Device

1. Connect the host PC to micro AB receptacle (P1 connector) provided on the SmartFusion2 Development Kit board using the Micro-B to A USB cable.

2. Observe a new disk drive/volume in the host PC and properties of this disk drive (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 SmartFusion2 Development Kit on-board SPI-Flash.
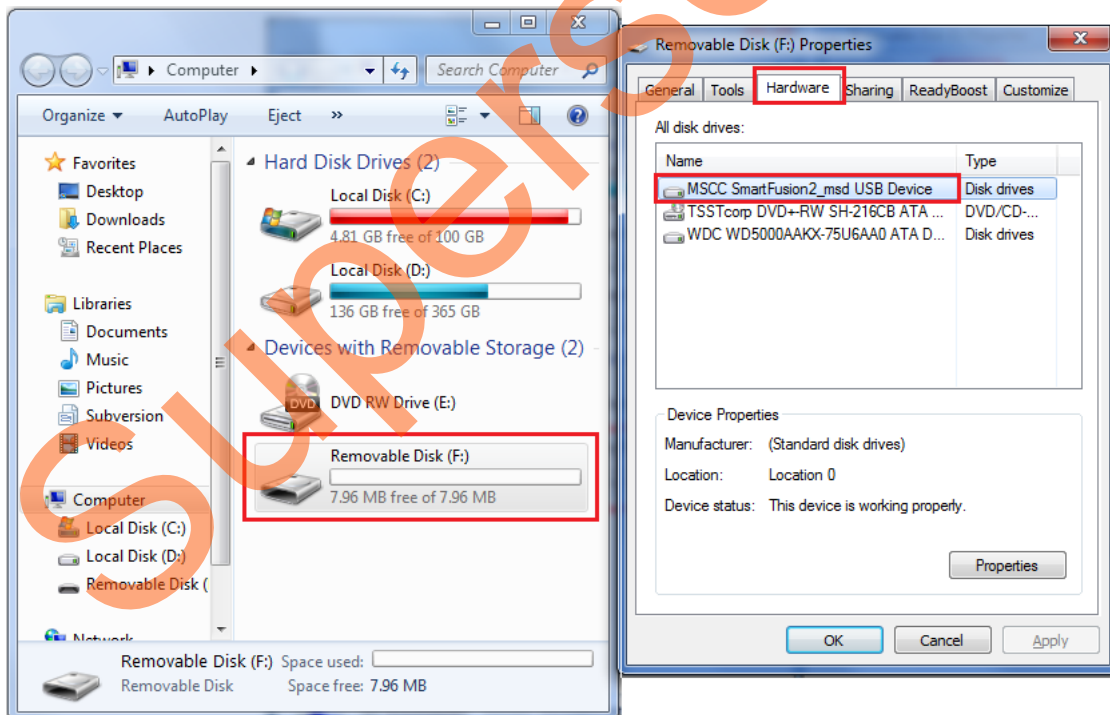


*Figure 9 •* **SmartFusion2 USB Device Detection on Host PC/Laptop**

## SmartFusion2 USB OTG Controller Acting as USB Host

1. Unplug the Micro-B to A USB cable from the P1 connector of SmartFusion2 Development 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 the mass storage device is preformatted.

3. Connect the Micro-A end of the Micro-A to B USB cable to the P1 connector of the SmartFusion2 Development Kit board.

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



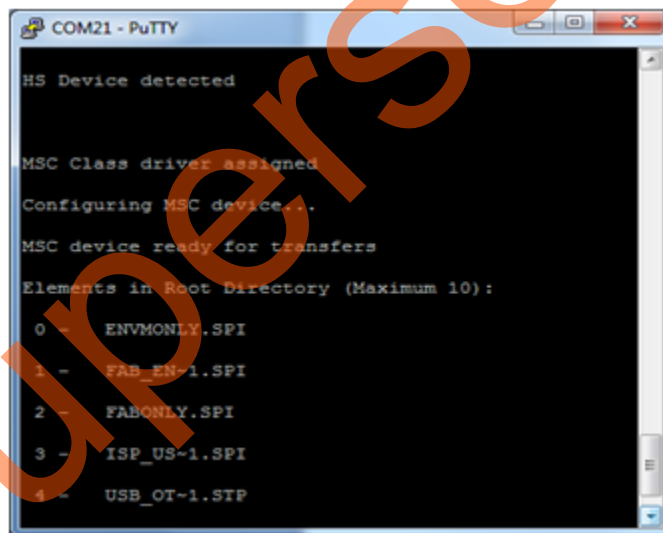*Figure 10* • **Micro-A to B USB Cable with Mass Storage at the End B**



*Figure 11* • **USB Host Mode Results**

4. To verify the USB OTG functionality again repeat the process of SmartFusion2 USB OTG controller acting as USB Device and USB Host.

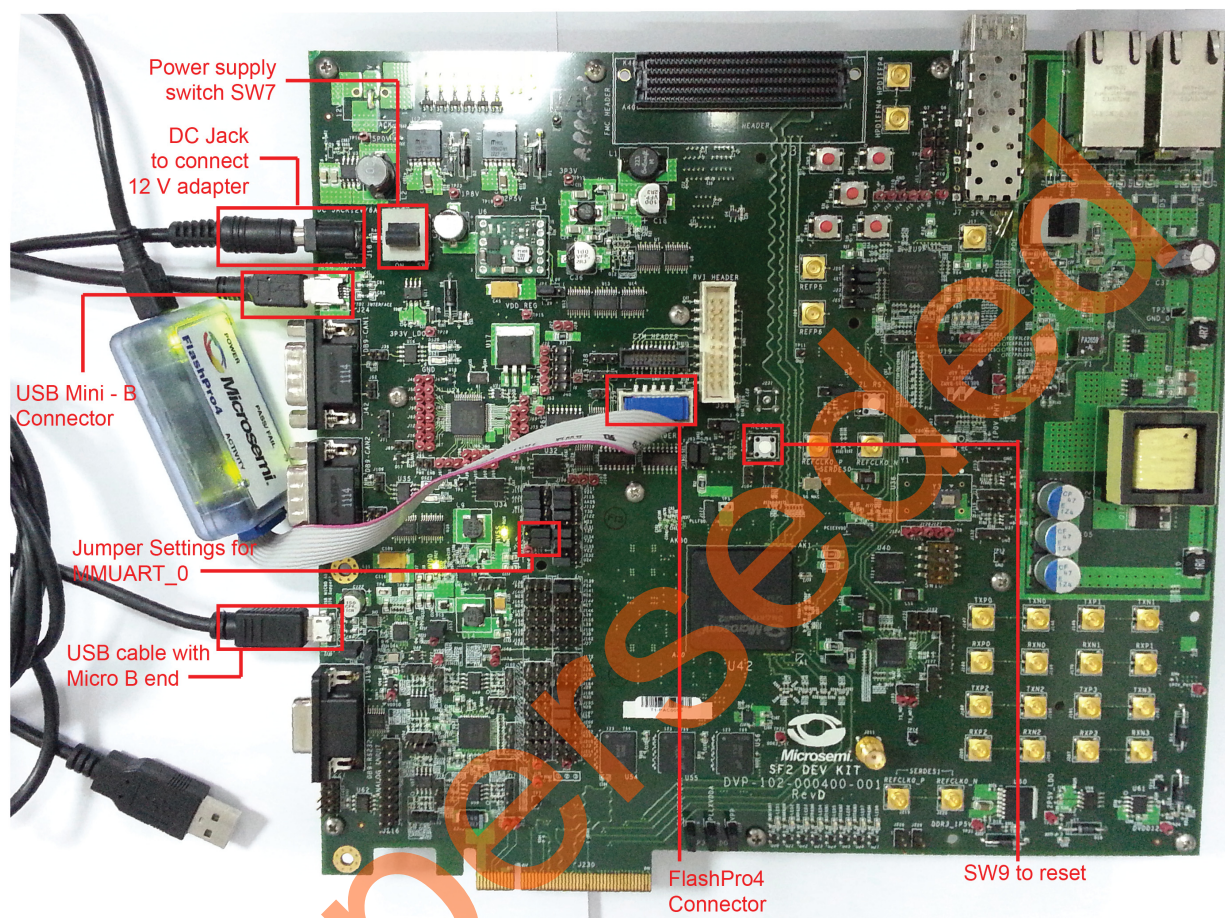# Appendix 1: Board Set up for USB OTG Controller in USB Device Mode



*Figure 12 •* **Setup for USB OTG Controller in USB Device Mode**

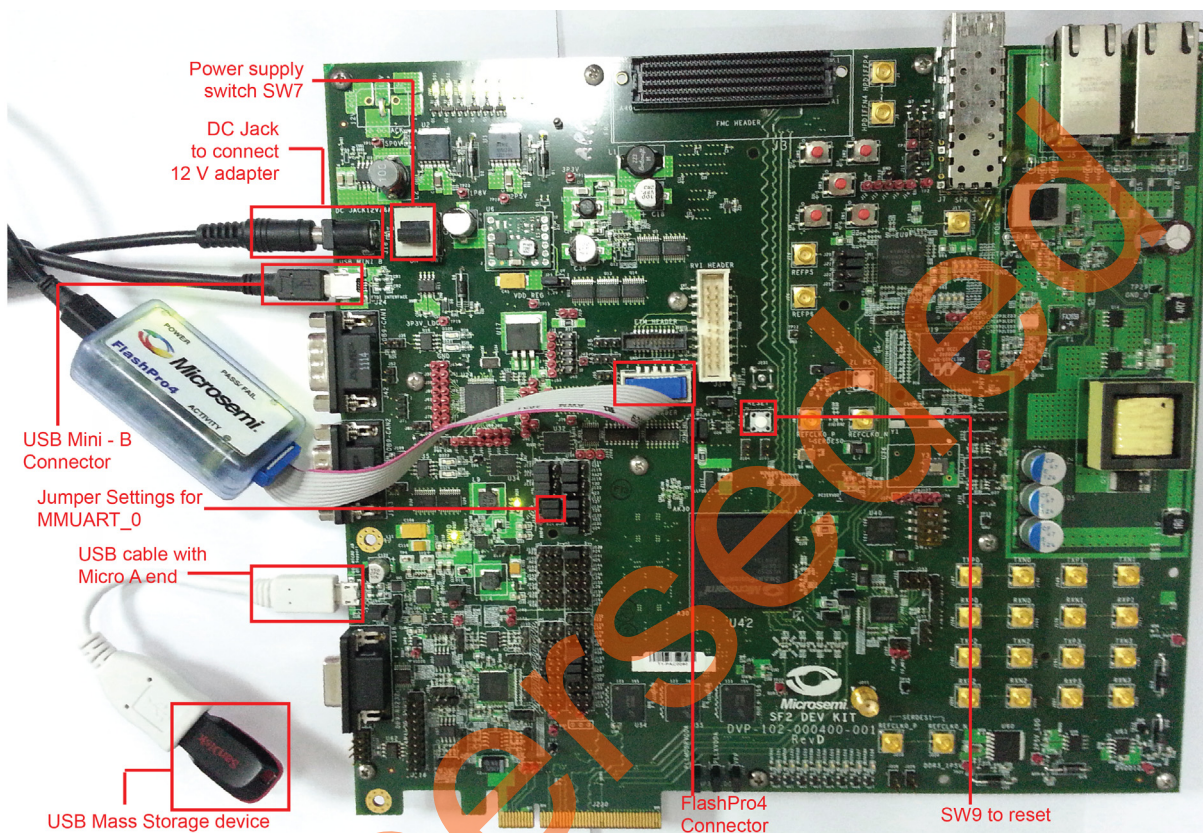# Appendix 2: Board Setup for USB OTG Controller in USB Host Mode



*Figure 13 •* **Setup for USB OTG Controller in USB Host Mode**

# Appendix 3: Jumper Locations



*Figure 14 •* **SmartFusion2 Development Kit Silkscreen Top View**

Figure 14 shows the jumper locations in the SmartFusion2 Development Kit board.

Notes:

- Jumpers highlighted in red (J2, J23, J70, J93, J94, J117, J123, J142, J157, J160, J167, J225, J226, J227) are set as default.
- Jumpers highlighted in green (J110, J118, J119, J121, J129, J133, J139, J163, J164) need to be set manually.
- The location of the jumpers in Figure 14 are searchable.

# A – List of Changes

The following table lists critical changes that were made in each revision of the chapter in the demo guide.

| Date | Changes | Page |
|---|---|---|
| Revision 2 (June 2014) | Updated the document for Libero v11.3 software release (SAR 58734). | NA |
| Revision 1 (November 2013) | Updated the document for Libero v11.2 software release (SAR 52961). | NA |
| Revision 0 (October 2013) | Initial Release | NA |

# B – Product Support

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

## 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.

## Technical Support

Visit the Customer Support website (www.microsemi.com/soc/support/search/default.aspx) for more information and support. Many answers available on the searchable web resource include diagrams, illustrations, and links to other resources on the website.

## Website

You can browse a variety of technical and non-technical information on the SoC home page, at www.microsemi.com/soc.

## 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.

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

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