

**DG0584**  
**Demo Guide**  
**SmartFusion2 SoC FPGA In-Application Programming**  
**Using PCIe Interface - Libero SoC v11.8**



**Power Matters.™**

**Microsemi Corporate Headquarters**

One Enterprise, Aliso Viejo,  
CA 92656 USA

Within the USA: +1 (800) 713-4113

Outside the USA: +1 (949) 380-6100

Fax: +1 (949) 215-4996

Email: [sales.support@microsemi.com](mailto:sales.support@microsemi.com)

[www.microsemi.com](http://www.microsemi.com)

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# 1 Revision History

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The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

## 1.1 Revision 5.0

Updated the document for Libero v11.8 software release.

## 1.2 Revision 4.0

Updated the document for Libero v11.6 software release (SAR 71564).

## 1.3 Revision 3.0

Updated the document for Libero v11.5 software release (SAR 68427).

## 1.4 Revision 2.0

The following changes are done in revision 2.0 of this document.

- Added [Appendix: Implementing Workaround to Access Fabric LSRAM after IAP/ISP Program Operation](#), page 31.
- Added [Known Issue](#), page 22.

## 1.5 Revision 1.0

Revision 1.0 was the first publication of this document.

## 2 In-Application Programming Using PCIe Interface

In-application programming (IAP) is a SmartFusion2 device programming feature used to reprogram the device to accommodate design iterations and field upgrades. Using the IAP feature the application can re-program the flash components of the SmartFusion2 devices. SmartFusion2 devices support IAP using a number of different interfaces. In this demo design, PCIe is used to transfer new programming data. This document describes how to program SmartFusion2 devices through the PCIe interface, and use SmartFusion2 system controller services.

For more information about the different programming modes supported by SmartFusion2 SoC FPGAs, see the *UG0451: IGLOO2 and SmartFusion2 Programming User Guide*. For more information about system controller programming services, see the *UG0450: SmartFusion2 SoC and IGLOO2 FPGA System Controller User Guide*.

### 2.1 Design Requirements

The following table lists the hardware and software design required to run the design.

**Table 1 • Design Requirements**

Design Requirements	Description
<b>Hardware</b>	
SmartFusion2 Security Evaluation Kit (M2S090TS): – 12 V adapter (provided along with the kit) – USB A to Mini-B cable (provided along with the kit)	Rev D or later
Host PC or Laptop	Any 64-bit Windows
<b>Software</b>	
Libero® System-on-Chip (SoC)	v11.8
FlashPro programming software	v11.8
Softconsole	4.0
Host PC Drivers (provided along with the design files)	–
PCIe Demo application	PCIe Demo GUI Installer

### 2.2 Demo Design

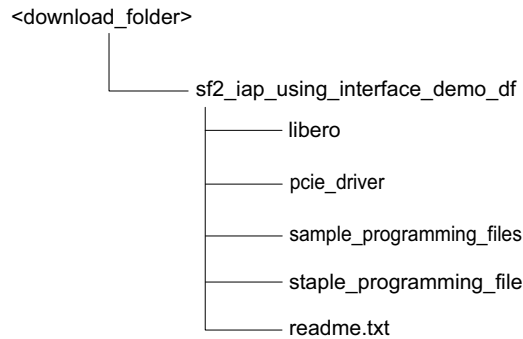
The demo design files are available for download at:  
[http://soc.microsemi.com/download/rsc/?f=m2s\\_dg0584\\_liberov11p8\\_df](http://soc.microsemi.com/download/rsc/?f=m2s_dg0584_liberov11p8_df)

The demo design files include:

- Libero SoC software project
- PCIe driver
- STAPL programming file
- Sample programming files
- Readme file

The following figure shows the top-level structure of the design files. For more information, see the `Readme.txt` file.

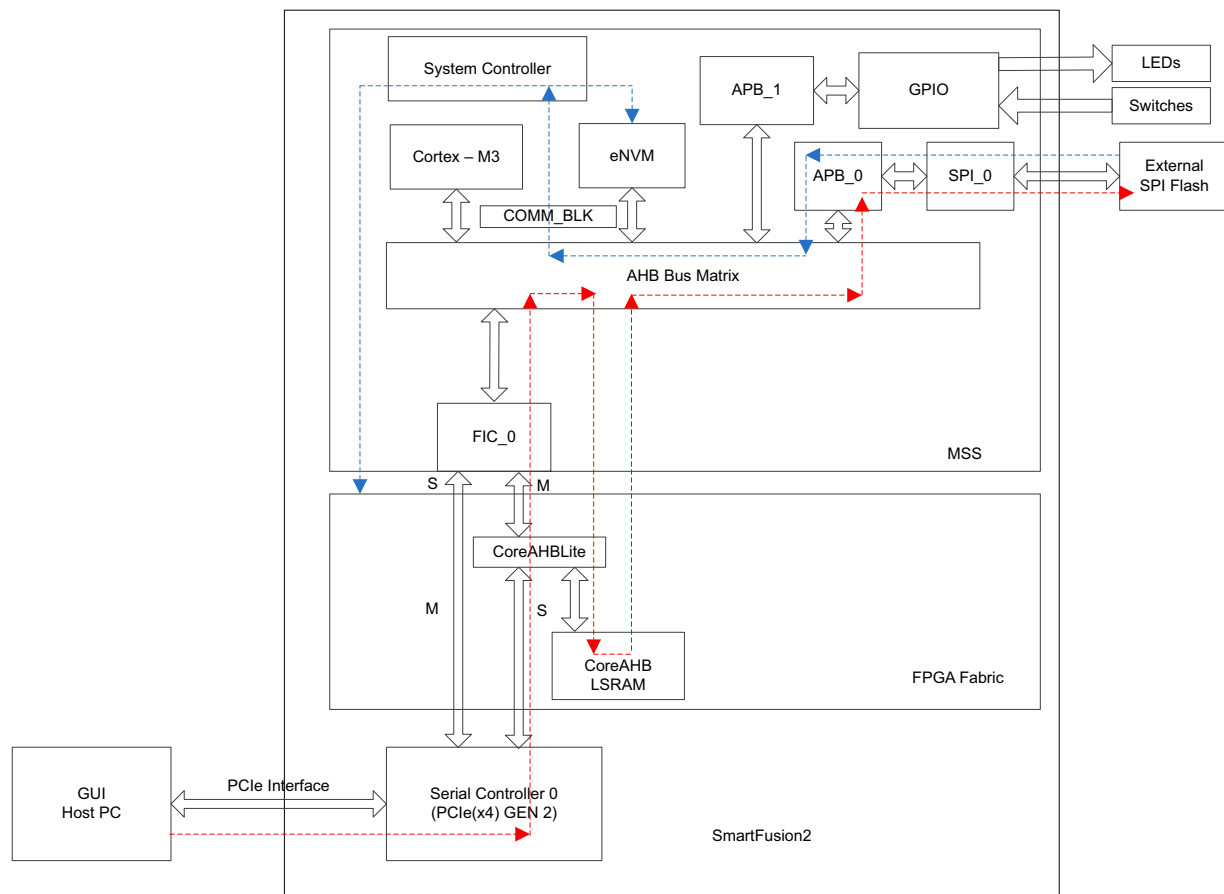
**Figure 1 • Demo Design Files Top-Level Structure**



The following figure describes the demo design. The arrows in red show the data flow between the host PC and the on-board external serial peripheral interface (SPI) flash memory using the PCIe interface. The ARM® Cortex®-M3 processor copies the programming data from the host PC to the SPI flash by using the large static random access memory (LSRAM) memory as a temporary buffer.

The lines in blue show the system controller reading data from the external SPI flash memory to program the SmartFusion2 device. For more information about IAP process, see [Description](#), page 4.

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



- - - **Step1** Transferring data bitstream from host PC to external Flash through PCIe interface
- - - **Step2** System controller reads data bitstream from the external flash to program the SmartFusion2 device



## 2.2.1 Features

The demo design performs the following types of programming based on the input provided by the programming file:

- **eNVM programming:** The IAP programming service programs only eNVM. In this case, the input programming file has only eNVM content.
- **FPGA Fabric programming:** The IAP programming service programs only the FPGA fabric. In this case, the input programming file has only the FPGA fabric content.
- **eNVM and FPGA Fabric programming:** The IAP programming service programs both the FPGA fabric and eNVM. In this case, the input programming file has both the FPGA fabric and eNVM content.

## 2.2.2 Description

IAP in SmartFusion2 devices is a two-step process as follows:

### Step 1: Loading SPI Flash with Programming Bitstream

The Cortex-M3 processor receives bitstream data in blocks of 2 KB from the host PC through the PCIe interface, and stores the bitstream data in the LSRAM 2 KB temporary buffer. The Cortex-M3 processor reads the bitstream data stored in the LSRAM temporary buffer and writes to the external SPI Flash attached to the microcontroller subsystem (MSS) SPI\_0 controller. The Cortex-M3 processor continues to receive blocks of 2 KB bitstream data through the PCIe interface until the entire programming file gets transferred from the host PC to the external SPI Flash.

### Step 2: Initiating the IAP Service

The bitstream data is verified by requesting the AUTHENTICATE IAP service from the system controller. The system controller reads the bitstream data from the external SPI Flash using the SPI interface to check the data integrity of the bitstream data. During authentication, the rest of the device functions normally. On successful authentication, the Cortex-M3 processor initiates a PROGRAM IAP system controller system service. The system controller fetches the bitstream data from the SPI Flash and programs the flash components of the SmartFusion2 device. IAP can be used to program the FPGA fabric, eNVM, or both FPGA fabric and eNVM.

The Cortex-M3 processor in the SmartFusion2 device can execute an application image from embedded SRAM (eSRAM), eNVM or DDR/SDR memories. For more information about remapping techniques, see [AC390: SmartFusion2 SoC FPGA Remapping eNVM, eSRAM, and DDR/SDR SDRAM Memories Application Note](#). In this demo design, the Cortex-M3 processor executes the IAP application image from eSRAM while the eNVM programming takes place, that is, during the Program operation mode. To execute the application image from eSRAM, the Cortex-M3 processor copies the IAP application image that resides in eNVM data client to eSRAM and remaps the eSRAM to the Cortex-M3 processor code region. For the Verify and Authenticate operation modes, the application image can be executed from either eNVM or eSRAM as the eNVM programming does not take place.

The system controller executes the IAP programming service in the following modes:

- **Authenticate:** The system controller IAP service validates the integrity of the programming bitstream.
  - For security and reliability reasons, Microsemi recommends that the bitstream must be authenticated before the program is executed, using the Authenticate Operation mode. The SmartFusion2 device application must commit the bitstream for programming, only after successful authentication and validation of the integrity of the bitstream.
- **Program:** Depending on the programming bitstream, system controller IAP service programs the following:
  - eNVM
  - FPGA fabric
  - Both eNVM and FPGA fabric
- **Verify:** The system controller IAP service verifies the contents of the SmartFusion2 device against the programming bitstream data stored in the SPI Flash.

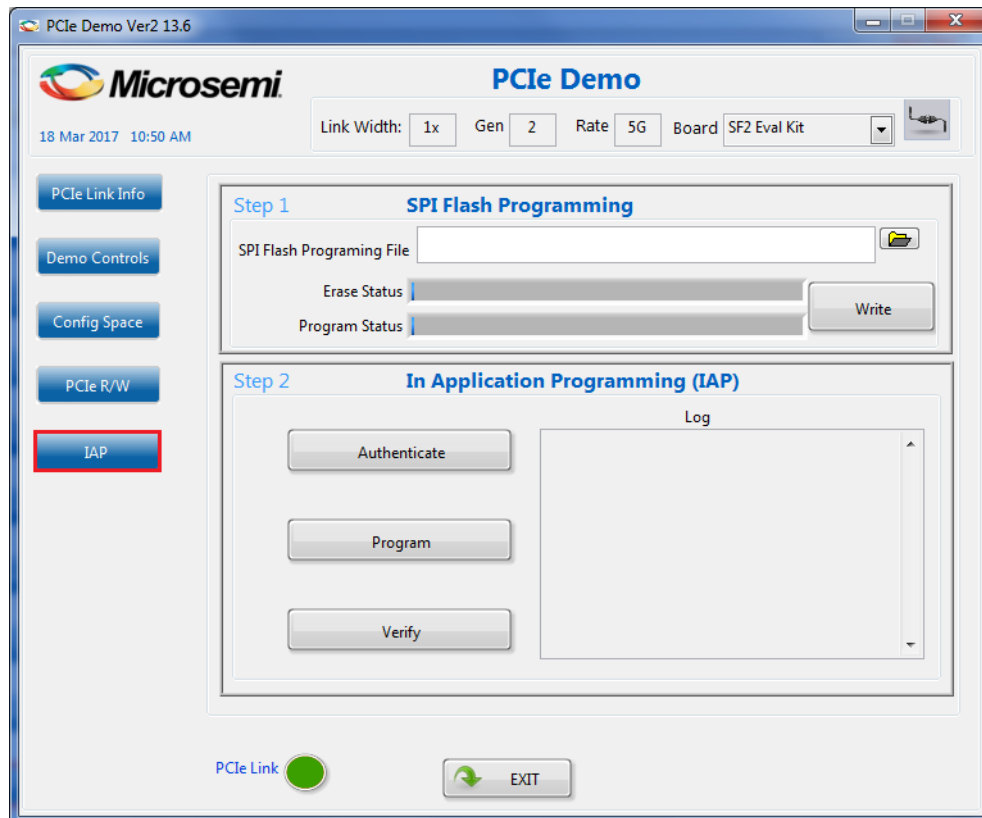
**Note:** The FPGA fabric is not operational during Program or Verify operations as the device enters into Flash\*Freeze (F\*F) mode. During Program or Verify operations, the PCIe communication link is in reset

state. On completion of the Verify operation, the PCIe communication link is up. On completion of the Program operation, the PCIe communication link is restored to the active state when the device is programmed with the PCIe-enabled programming file. For more information on hardware implementation, see [Appendix: Hardware Implementation](#), page 27.

## 2.3 Running GUI Application on Host PC

The GUI application is an executable program running on the host PC that transfers the programming file (\*.spi) from the host PC to the SmartFusion2 Security Evaluation Kit on-board SPI Flash through the PCI interface. The GUI also allows the user to perform the IAP operations (Authenticate, Program, and Verify) by clicking the corresponding options, as shown in the following figure.

**Figure 3 • IAP GUI Application**



### 2.3.1 Programming Files

Sample programming files with the file extension .spi are provided to program the following:

- eNVM
- FPGA fabric
- Both eNVM and FPGA fabric

The folder `<download_folder>\sf2_iap_using_interface_demo_df\sample_programming_files` contains the following sample programming files:

- `iap_envm_only.spi`: Programs only eNVM. The eNVM client has a light-emitting diode (LED) counter logic.
- `iap_fabric_only.spi`: Programs only the FPGA fabric. The FPGA fabric has an LED blinking logic.
- `iap_fabric_and_envm.spi`: Programs both the FPGA fabric and eNVM. The eNVM client has an LED counter logic and the FPGA fabric has an LED blinking logic. The folder `<download_folder>\sf2_iap_using_interface_demo_df\sample_programming_files\fabric_and_envm` contains the Libero design to generate this sample programming file.

- `pcie_iap_top.spi`: This is the .spi file format version of the `pcie_iap_top.stp` file provided in `<download_folder>\sf2_iap_using_interface_demo_df\stapl_programming_file`.

**Note:** For more information on generating .spi programming files, see [Appendix: Generating .spi Programming File using Libero](#), page 25.

## 2.3.2 IAP Execution Flow

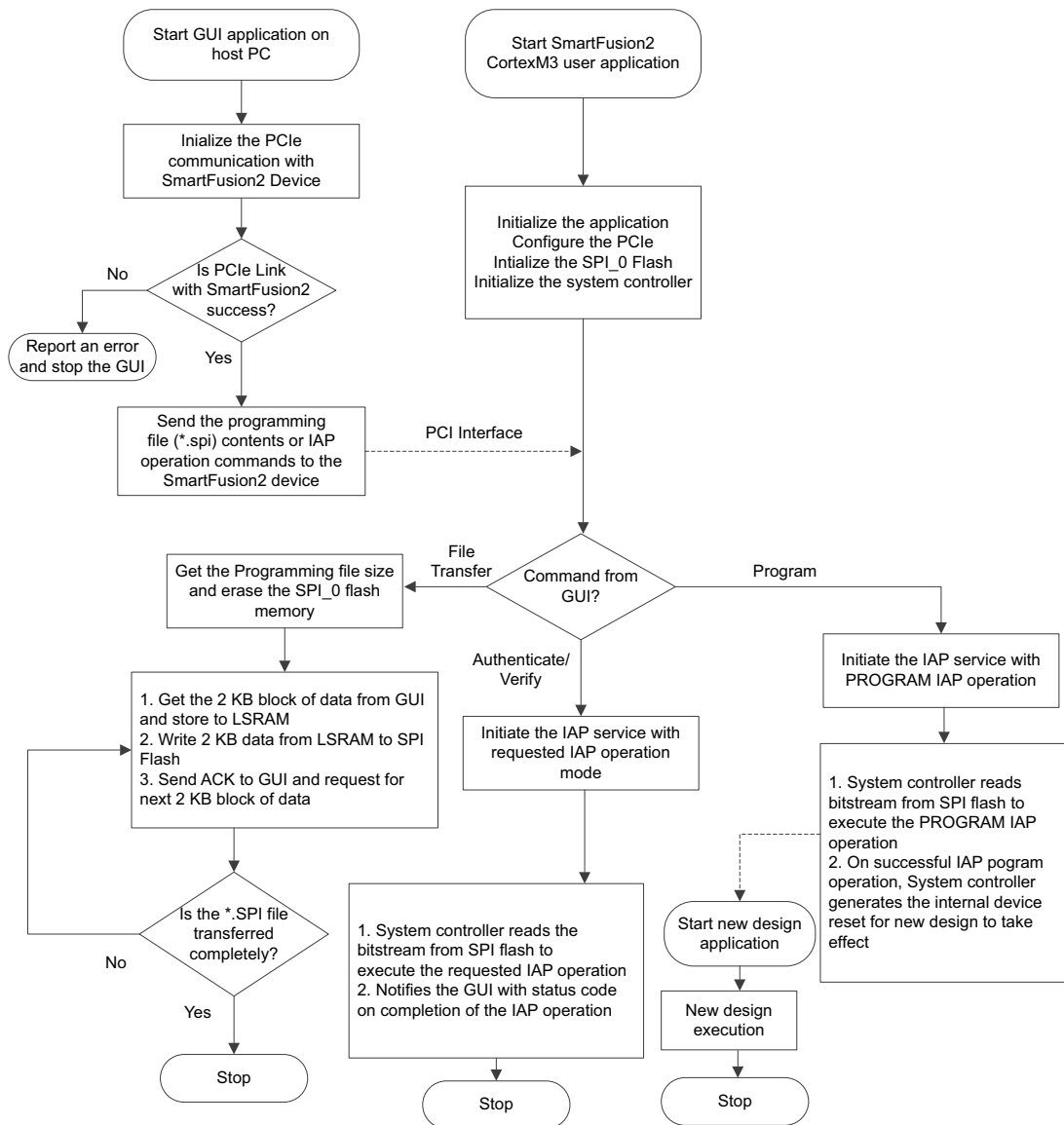
Browse to the .spi programming file and click WRITE in the GUI. The GUI application running on the host PC starts communicating with the SmartFusion2 device using the PCIe interface. On connecting with the SmartFusion2 device, the GUI sends the programming file size to the Cortex-M3 processor user application and requests to erase the external SPI Flash contents available on the SmartFusion2 Security Evaluation Kit for storing the bitstream data. The Cortex-M3 processor user application receives the bitstream data from the GUI through the PCIe interface and stores the data into the SPI Flash. The GUI application copies 2 KB bitstream data from the programming file to the host PC buffer. The Cortex-M3 processor user application reads the bitstream data from the host PC buffer through the PCIe interface and copies the data to LSRAM 2 KB temporary buffer. The Cortex-M3 processor writes the SPI Flash memory with the data bitstream stored in the LSRAM. The Cortex-M3 processor user application sends the acknowledgment to the GUI for every 2 KB block of bitstream data and requests the GUI for the next block of 2 KB data. The GUI sends the bitstream data in 2 KB blocks until the entire programming file is transferred from the host PC to the external SPI Flash.

The IAP services can be executed using the GUI. If the Authenticate or Verify option is selected from the GUI, the Cortex-M3 processor user application initiates the IAP service with the requested IAP Operation mode and notifies the GUI with a status code indicating the completion of the authentication or verification service. For Program mode, the Cortex-M3 user application does not notify the GUI with any status code as the Flash components of the device are programmed with new bitstream data. On successful IAP program operation, an internal device reset is generated for the new design to take effect.

**Note:** You can modify/edit the programming file (\*.spi) contents and run the authenticate operation to get the authentication fail message with the corresponding error code. For information about error codes, see [Appendix: Error Codes](#), page 24.

The following figure shows the IAP execution flow.

**Figure 4 • IAP Execution Flow**



## 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 jumpers on the SmartFusion2 Security Evaluation Kit board as shown in the following table.

**CAUTION:** Switch **OFF SW7** while connecting the jumpers.

**Note:** Snapshots of the SmartFusion2 Security Evaluation Kit board with the complete set up is given in the Appendix: SmartFusion2 Security Evaluation Kit Board, page 23.

**Table 2 • SmartFusion2 Security Evaluation Kit Jumper Settings**

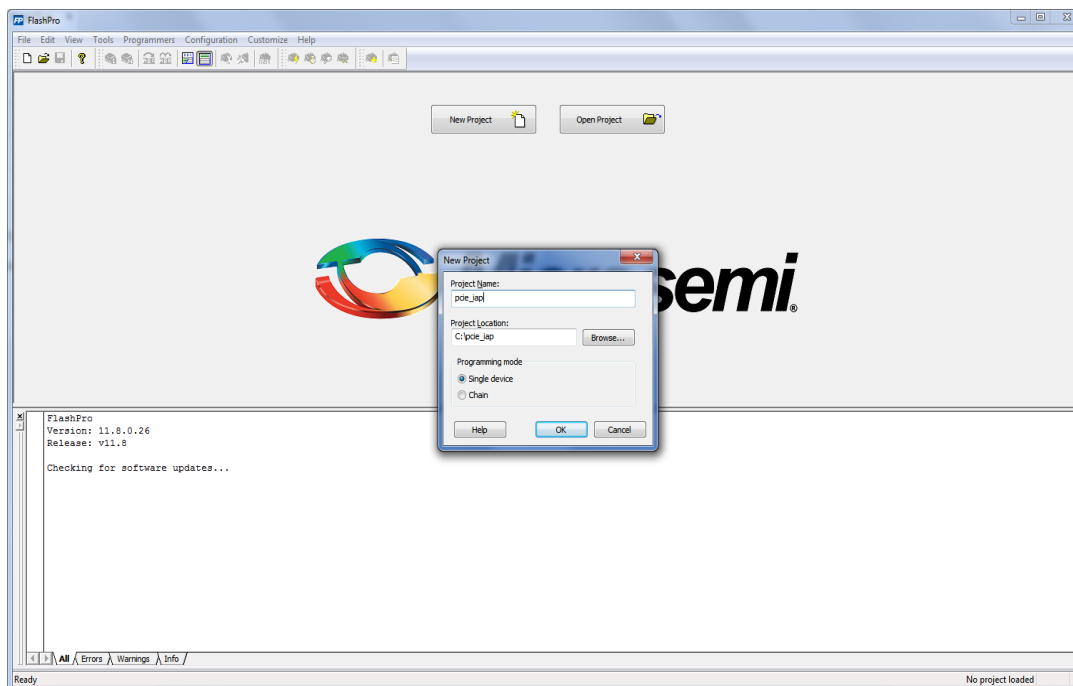
Jumper	Pin From	Pin To	Comments
J22	1	2	Default
J23	1	2	Default
J24	1	2	Default
J8	1	2	Default
J3	1	2	Default

## 2.4.1 Programming the SmartFusion2 Security Evaluation Kit Board

The following steps describe how to program the SmartFusion2 Security Evaluation Kit board:

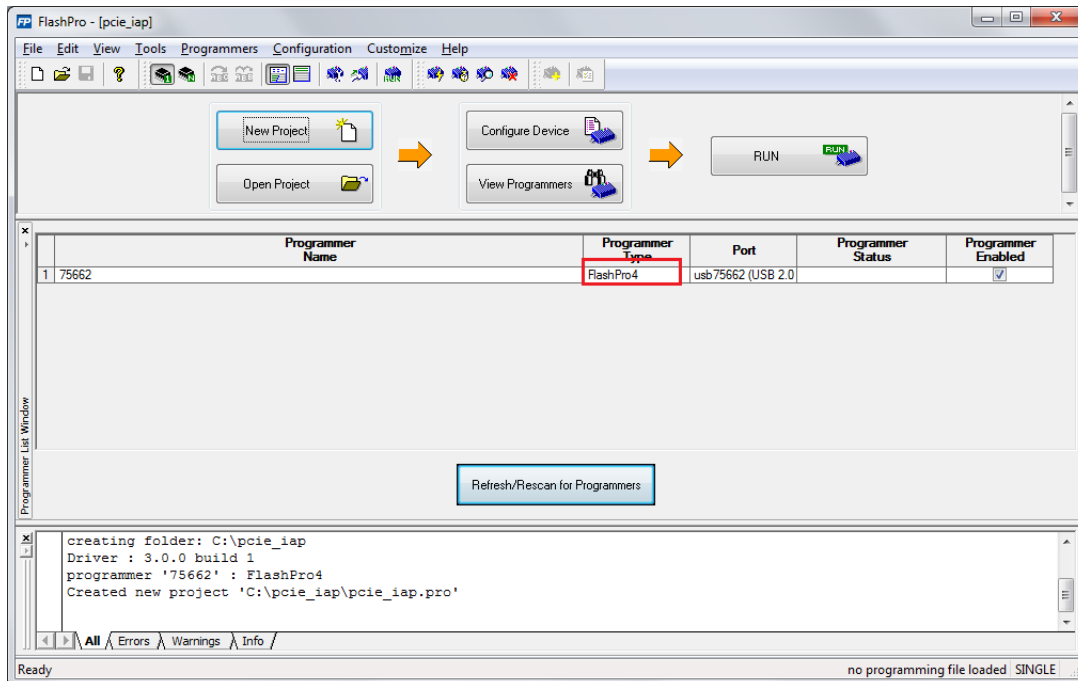
1. Download the demo design from:  
[http://soc.microsemi.com/download/rsc/?f=m2s\\_dg0584\\_liberov11p8\\_df](http://soc.microsemi.com/download/rsc/?f=m2s_dg0584_liberov11p8_df)
2. Switch **ON** the power supply switch, SW7.
3. Launch the FlashPro software.
4. Click New Project.
5. In the **New Project** window, enter the project name as **pcie\_iap**.
6. Click Browse and navigate to the location where you want to save the project.
7. Select Single device as Programming mode.
8. Click **OK** to save the project.

**Figure 5 • FlashPro New Project**



The following figure shows the programmer type as FlashPro4.

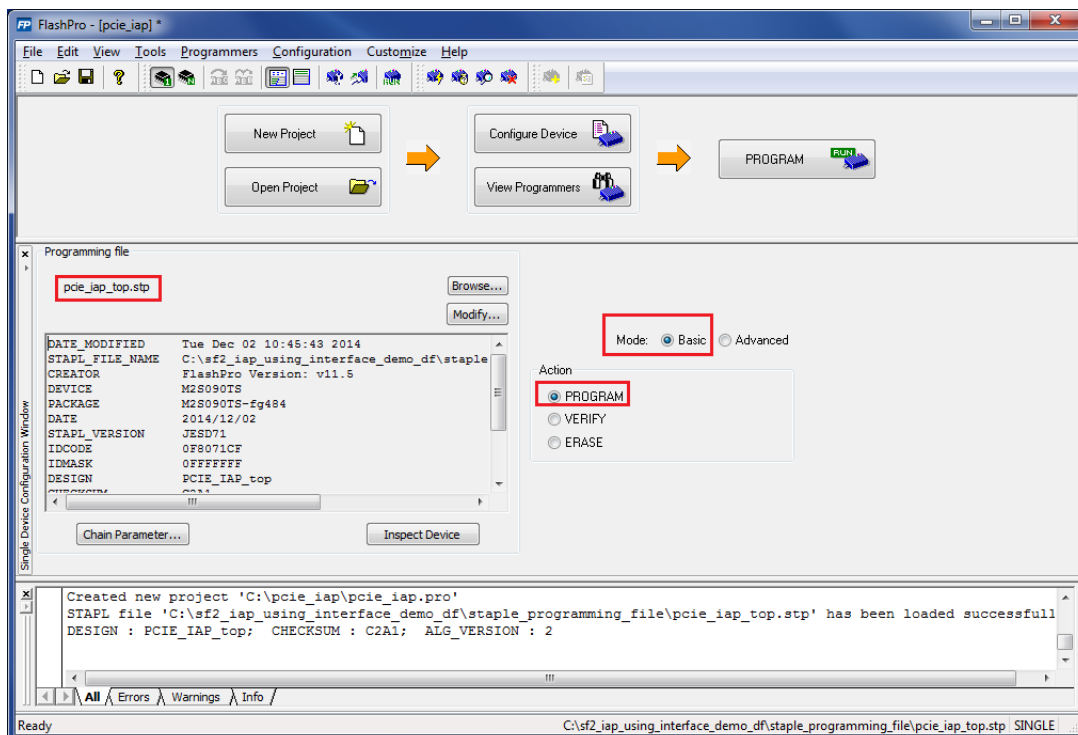
**Figure 6 • FlashPro4 Programmer Type**



The following steps describe how to configure the device:

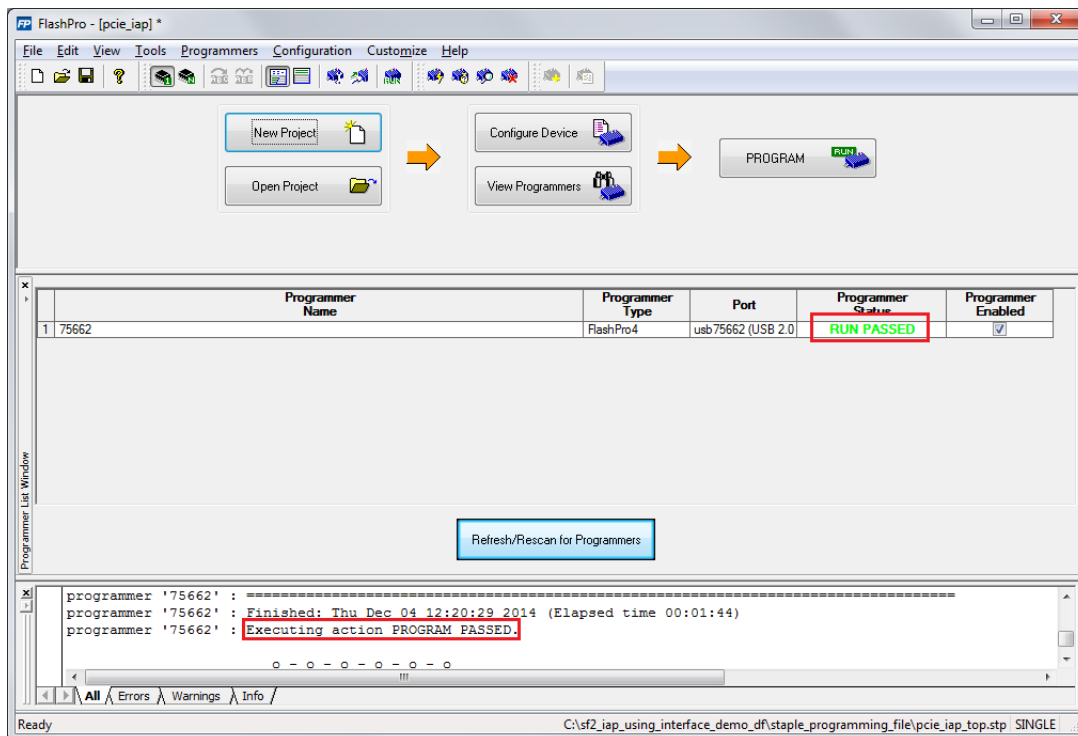
1. Click **Configure Device**.
2. Click **Browse** and navigate to the location where `pcie_iap_top.stp` is located and select the file. The default location is: `<download_folder>sf2_iap_using_interface_demo_dfstapl_programming_file`
3. Click **Open**. The required programming file is selected and is ready to be programmed in the device.

**Figure 7 • FlashPro Project Configuration**



- Click PROGRAM to start programming the device. Wait until the Programmer Status is changed to RUN PASSED, as shown in the following figure.

**Figure 8 • FlashPro Programming Passed**



## 2.5 Connecting the SmartFusion2 Security Evaluation Kit Board to Host PC

The following steps describe how to connect the Security Evaluation Kit board to the host PC:

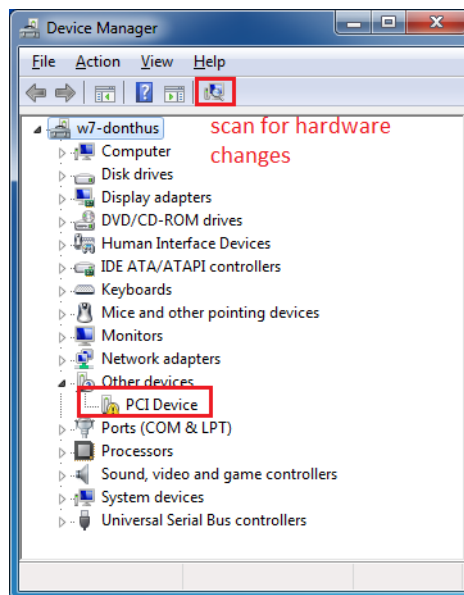
- After successful programming, switch OFF the SmartFusion2 Security Evaluation Kit board and shut down the host PC.
- The following steps describe how to connect the CON1–PCIe Edge Connector either to the host PC or laptop:
  - Connect the CON1–PCIe Edge Connector to the host PC PCIe Gen2 slot or Gen1 slot. This demo is designed to run in any PCIe Gen2 compliant slot. If the host PC does not support the Gen2 compliant slot, the design switches to the Gen1 mode.
  - Connect the CON1–PCIe Edge Connector to the laptop PCIe slot using the express card adapter. If you are using a laptop, the express card adapters support only Gen1 and the design works on Gen1 mode.

**Note:** The host PC or laptop must be switched OFF while inserting the PCIe Edge Connector. If the system is not switched OFF, the PCIe device detection and selection of Gen1 or Gen2 do not occur properly.

- Switch ON the power supply switch, SW7.

4. Switch on the host PC and check the Device Manager for PCIe Device. The following figure shows the example Device Manager window. If the device is not detected, power cycle the SmartFusion2 Security Evaluation Kit and click option in the Device Manager.

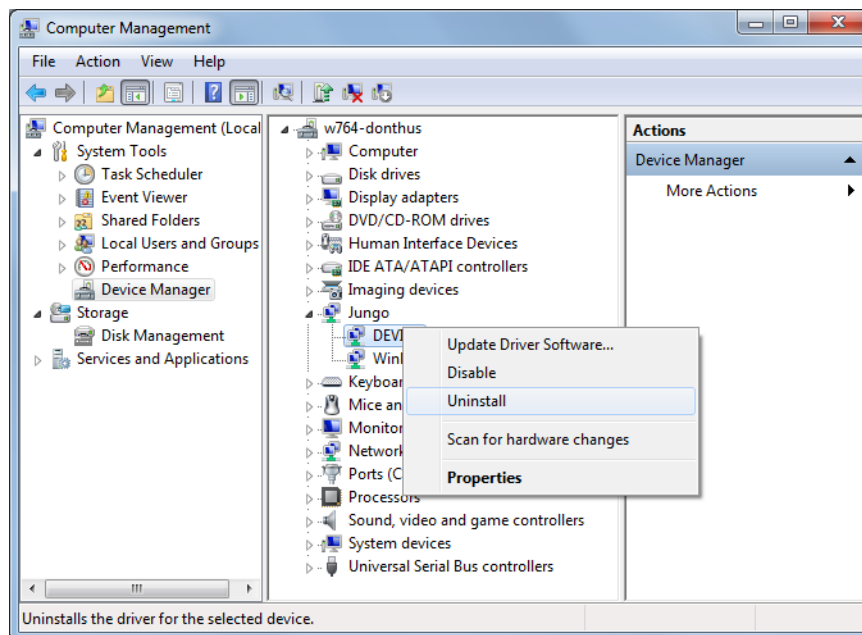
**Figure 9 • Device Manager - PCIe Device Detection**



**Note:** If the device is still not detected, check if the BIOS version in the host PC is latest and PCI is enabled in the host PC BIOS.

5. If the host PC has any other installed drivers such as previous versions of Jungo drivers for the PCIe device, uninstall them. To uninstall previous versions of Jungo drivers, follow steps i and ii.
  - To uninstall previous Jungo drivers, go to **Device Manager** and right-click **DEVICE**, as shown in the following figure.

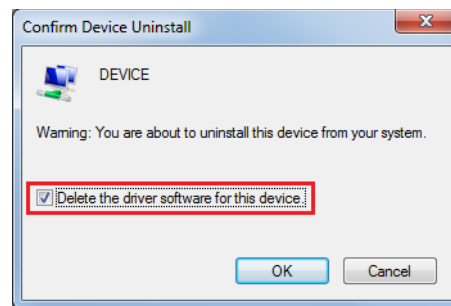
**Figure 10 • Uninstall Jungo Driver**





- In the **Confirm Device Uninstall** dialog box, select **Delete the driver software for this device** and click **OK**, as shown in the following figure. After uninstalling previous Jungo drivers, ensure that the PCI device is detected in the **Device Manager** window.

**Figure 11 • Confirm Device Uninstall Dialog**



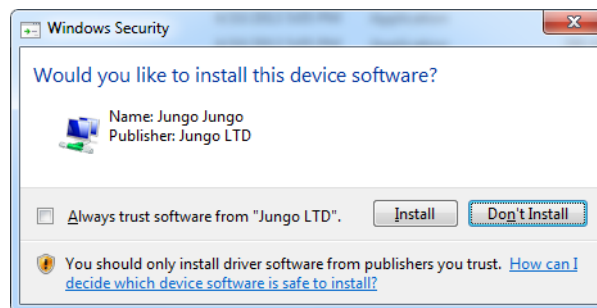
## 2.6 Drivers Installation

The PCIe demo uses a driver framework provided by Jungo WinDriverPro.

The following steps describe how to install the PCIe drivers on the host PC:

1. Extract the PCIe\_Demo.rar to drive C. The PCIe\_Demo.rar is at `<download_folder>\sf2_jap_using_interface_demo_df\pcie_driver\Drivers_64bitOS\PCIe_Demo.rar`
  2. Run the batch file `Jungo_KP_install.bat` located at `C:\PCIe_Demo\DriverInstall\`
- Note:** Installing these drivers require administration rights.
3. When the **Windows Security** dialog box appears asking to install or not, click **Install**.

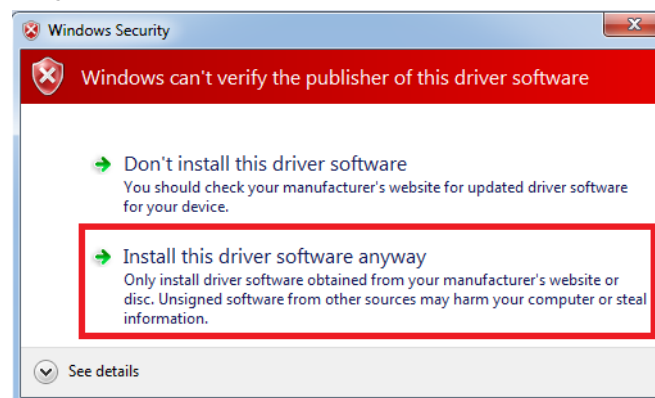
**Figure 12 • Jungo Driver Installation**



**Note:** If the installation fails, invoke the **Command Prompt** in administrator mode and run the batch file `Jungo_KP_install.bat` located at `C:\PCIe_Demo\DriverInstall\`

4. When the **Windows Security** dialog box appears, click **Install this driver software anyway**.

**Figure 13 • Windows Security**



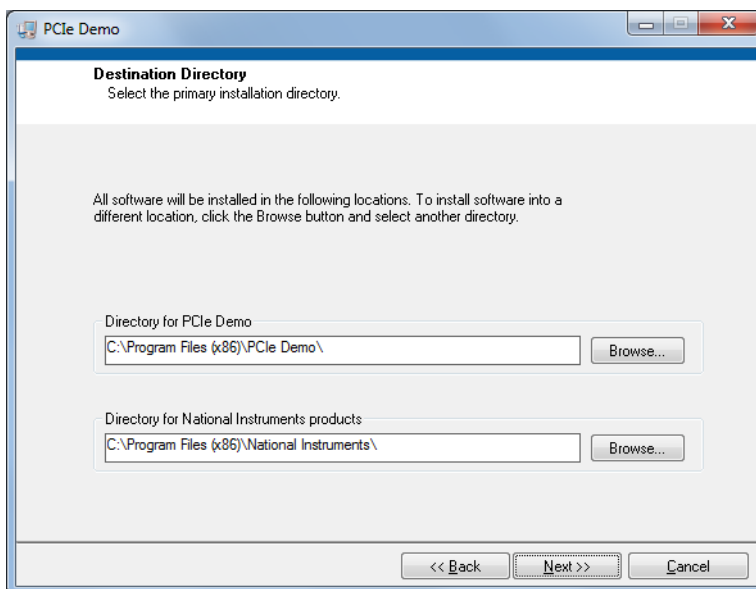
## 2.6.1 Installing PCIe\_Demo Application GUI

The PCIe\_demo application is a GUI that runs on the host PC to communicate with the SmartFusion2 PCIe endpoint device. It provides PCIe link status, driver information, and demo controls. The PCIe\_demo application invokes the PCIe driver installed on the host PC and provides commands to the driver according to the selection made.

The following steps describe how to install the PCIe\_demo application:

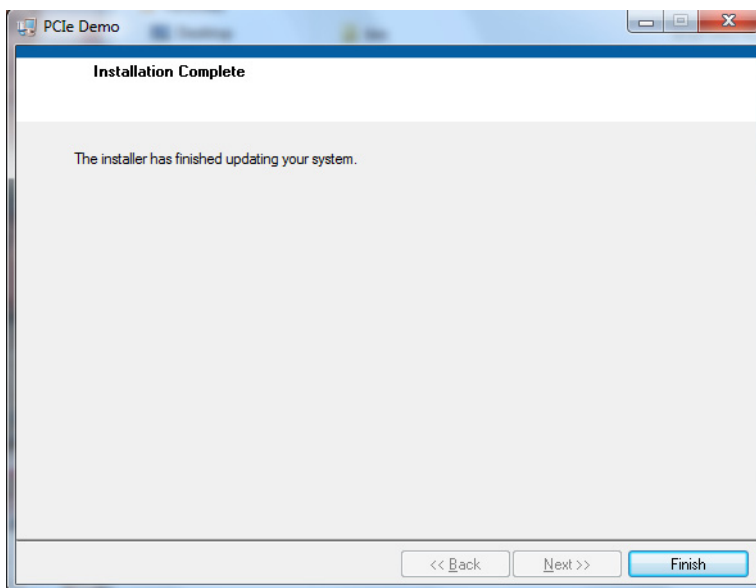
1. Download the PCIe Demo application from [PCIe\\_Demo\\_GUI\\_Installer](#). Go to <download\_folder> *PCIe\_Demo\_GUI\_Installer* and double-click **setup**. Do not change the default options.

**Figure 14 • GUI Installation**



2. Click **Next** to complete the installation. The following figure is displayed after successful installation.

**Figure 15 • Successful Installation of GUI**



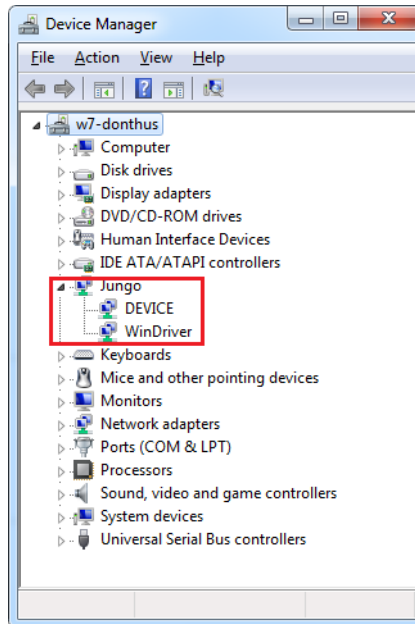
3. Shut down the host PC.
4. Power cycle the SmartFusion2 Security Evaluation Kit.
5. Restart the host PC.

## 2.7 Running the Demo Design

The following steps describe how to run the demo design:

1. Check the host PC **Device Manager** for the drivers. If the device is not detected, power cycle the SmartFusion2 Security Evaluation Kit board and click **scan for hardware changes** in **Device Manager**. Ensure that the board is switched **ON**.

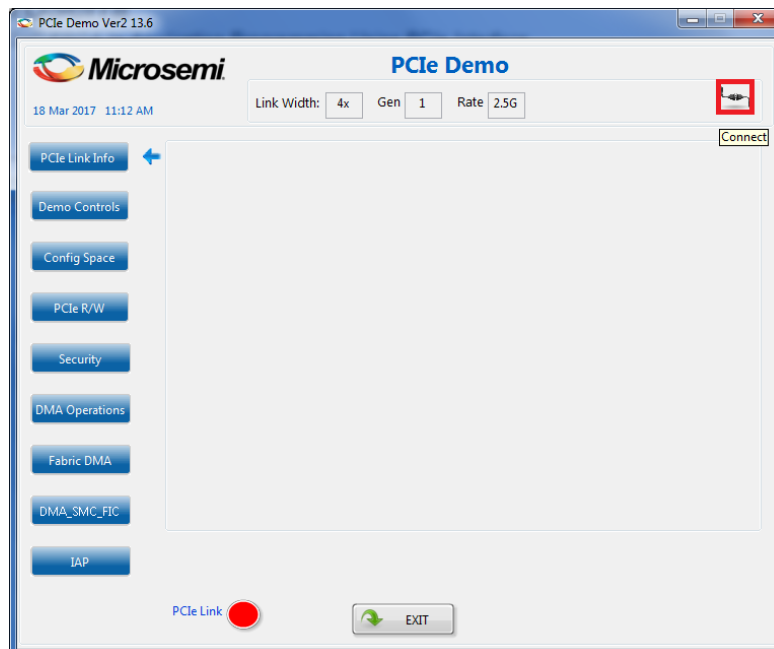
**Figure 16 • Device Manager - PCIe Device Detection**



**Note:** If a warning symbol appears on the **DEVICE** or **WinDriver** icons in **Device Manager**, uninstall them and start from step1 of **Drivers Installation**, page 12.

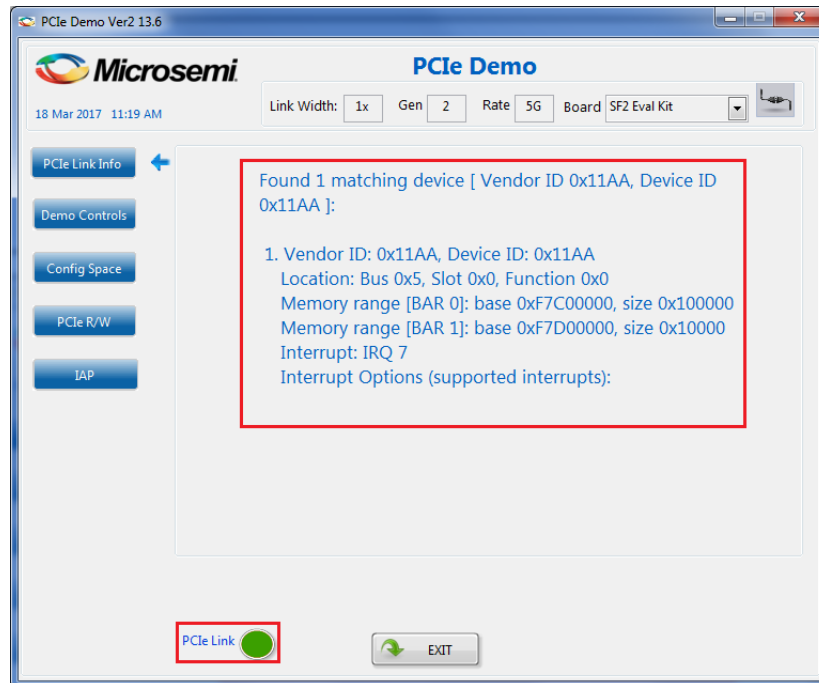
2. Invoke the GUI from **All Programs > PCIeDemo > PCIe Demo GUI**. The GUI is displayed as shown in the following figure.

**Figure 17 • PCIe Demo GUI**



3. Click **Connect**. The application detects and displays the connected Kit, demo design, and PCIe link. The following figure shows the example messages after the connection is established.

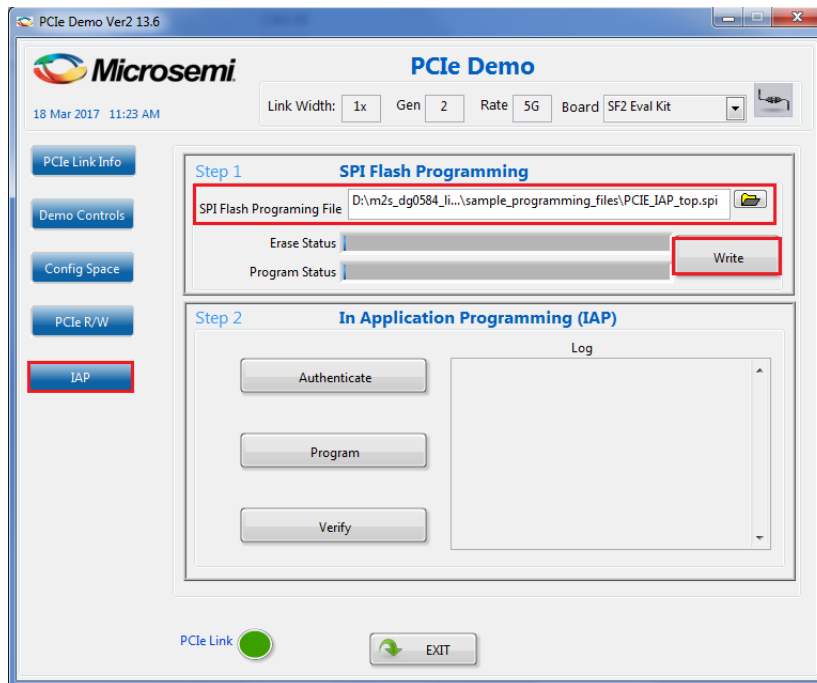
**Figure 18 • PCIe Device Information**



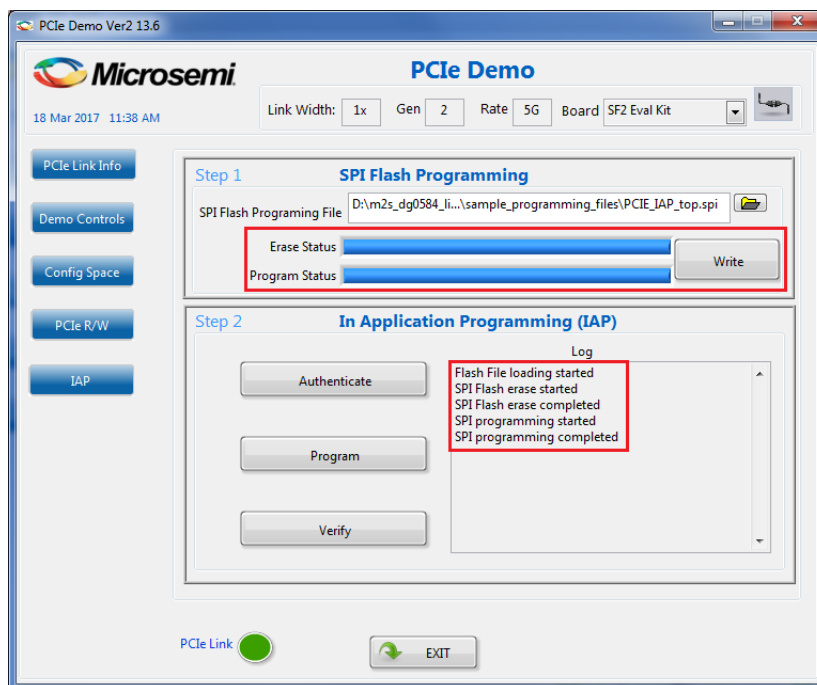
## 2.8 IAP Step1: Loading SPI Flash with Programming Bitstream

The following steps describe how to load the SPI Flash with programming bitstream:

1. Click **IAP**, as shown in Figure 19, page 16.
2. Click **Browse** to select the \*.spi programming file to write the bitstream data to the SPI Flash memory as shown in Figure 19, page 16. The sample \*.spi programming file can be selected from `<download_folder>\sf2_iap_using_interface_demo_df\sample_programming_files`.

**Figure 19 • Selecting Programming File in PCIe\_Demo Application**


- Click **write** to move the programming file to the external SPI Flash memory. The SPI Flash memory is erased according to the programming file size and the programming file bitstream is written to the SPI Flash memory. The status of the SPI Flash erase and SPI Flash program operations can be observed on the status bars and also using the messages on the log window, as shown in the following figure.

**Figure 20 • SPI Flash Programming**


## 2.9 IAP Step2: Initiating the IAP Services

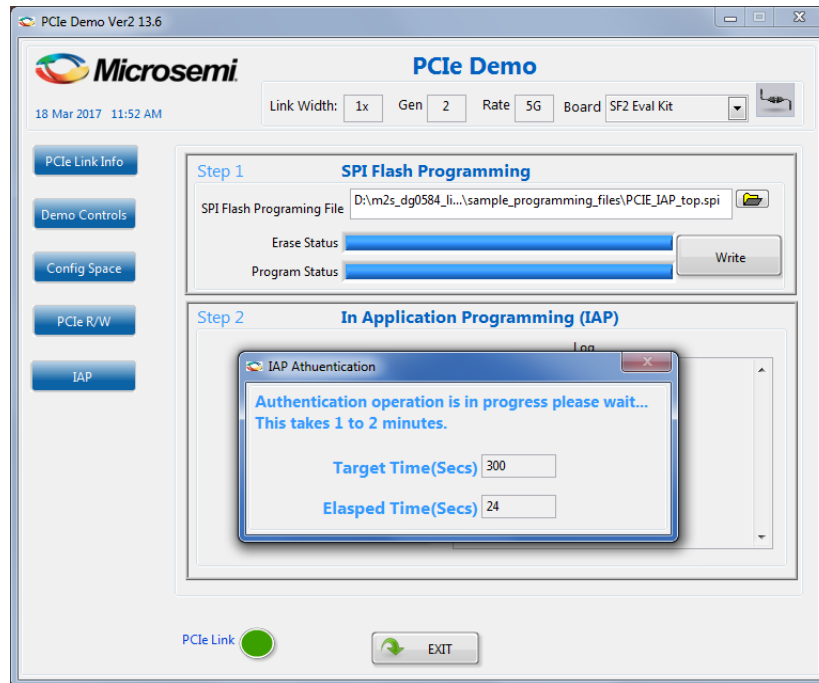
The IAP services can be executed by clicking Authenticate, Verify, or Program on the GUI.

### 2.9.1 Authenticate and Program Operation Mode

The following steps describe how to authenticate and program the operation mode:

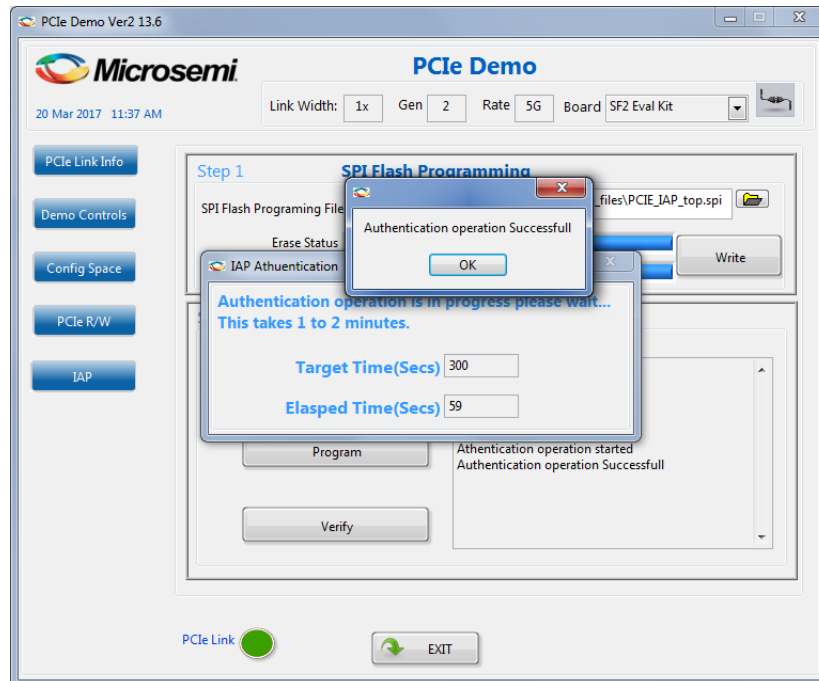
1. Click **Authenticate** in GUI to check the data integrity of the bitstream data stored in the SPI Flash.  
The following figure shows the **IAP operation is in progress** message.

**Figure 21 • IAP Authentication Status**



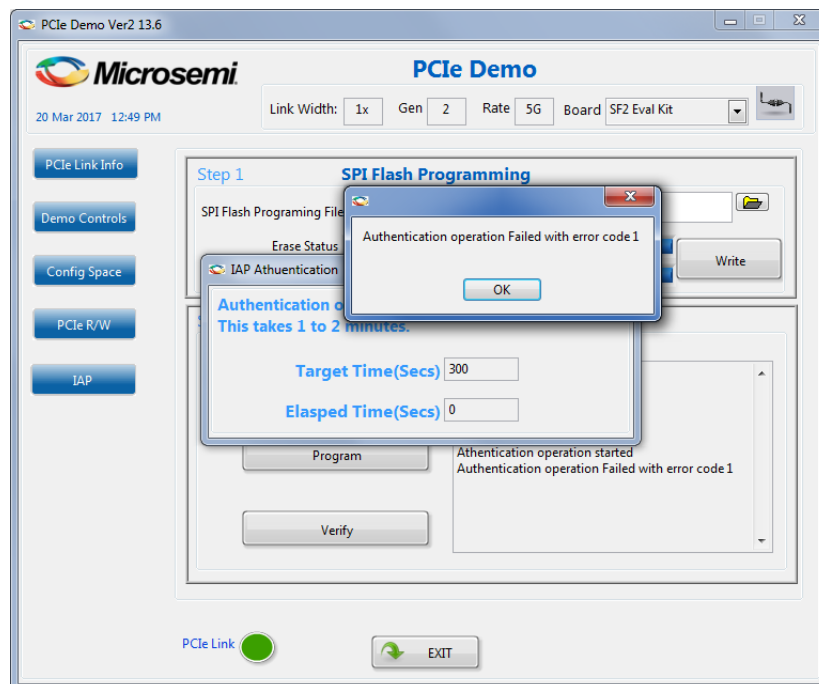
On completion of the IAP authentication, the GUI displays an **Authentication operation successful** message as shown in the following figure.

**Figure 22 • Authentication Success Message in PCIe Demo GUI**



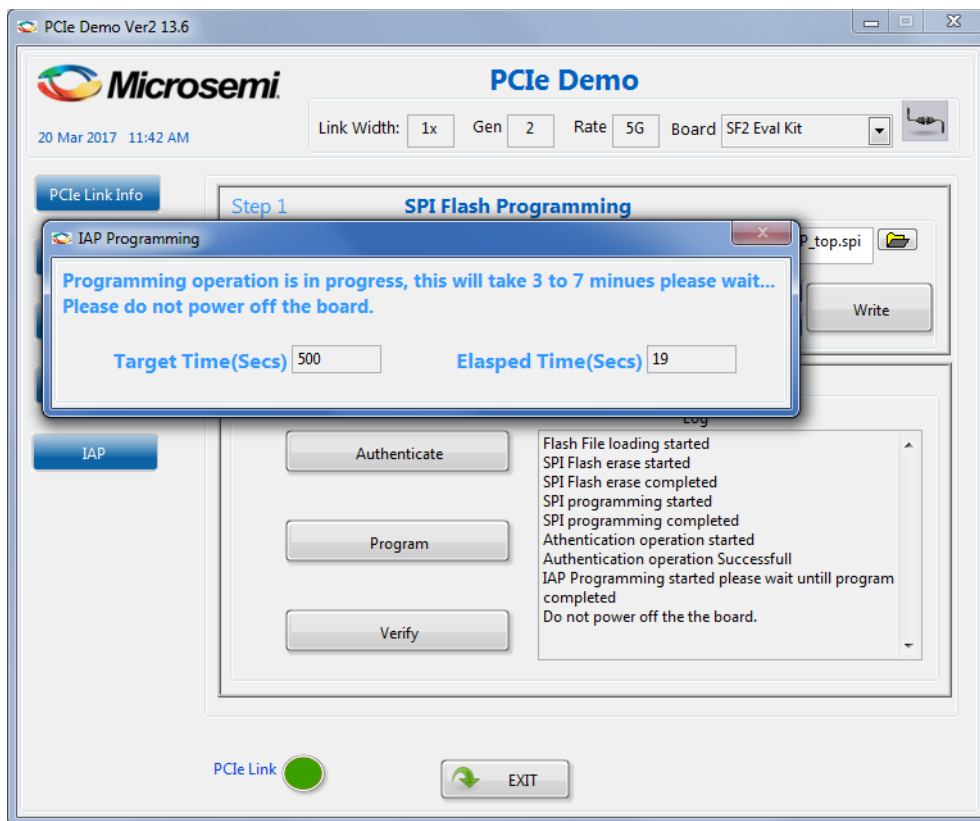
The demo GUI also provides an option to create an authentication failure scenario, which can be achieved by modifying the programming file (\*.spi) contents and running the authenticate operation. The following figure shows a sample authentication failed error scenario message. For information about error codes, see [Appendix: Error Codes](#), page 24.

**Figure 23 • Authentication Failed**



- Click Program in the GUI to reprogram the FPGA fabric and the eNVM of the SmartFusion2 device. It takes about 3 to 5 minutes for the IAP service to complete and program the FPGA fabric and eNVM. The following figure shows the IAP programming status.

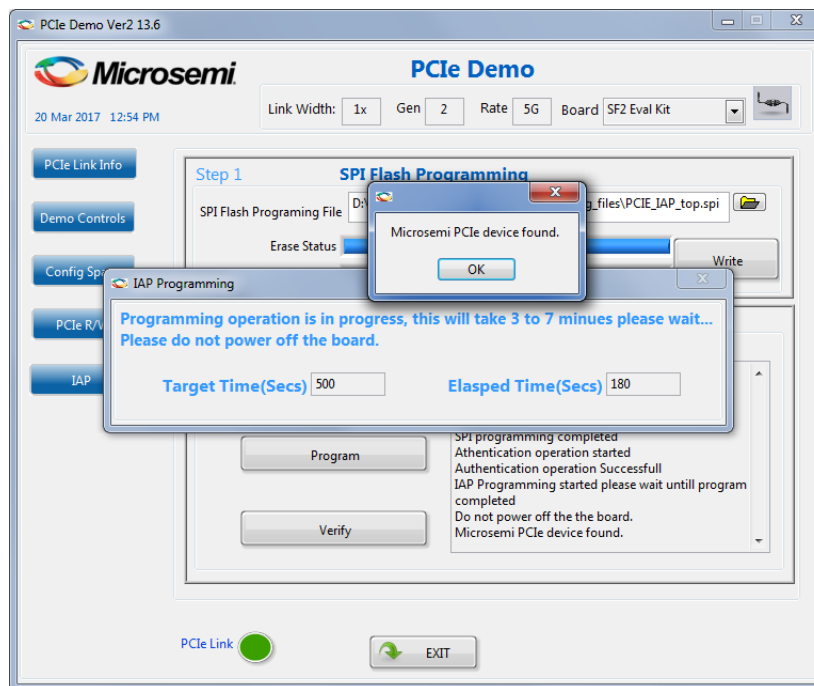
**Figure 24 • IAP Programming Status**





On completion of the IAP program, the GUI displays a Microsemi PCIe Device Found message as shown in the following figure. This indicates that the SmartFusion2 device is programmed with the PCIe enabled design and the PCIe communication link status is restored to the active state. If the SmartFusion2 device is programmed without the PCIe enabled design, the GUI displays a No Microsemi PCIe Device Found message. For more information on design type and programming results, see Table 3, page 20.

**Figure 25 • Microsemi PCIe Device Found Message in PCIe Demo GUI**



### 2.9.1.1 Programming Results

The following table shows the possible results for the IAP program operation mode for sample programming files provided in the folder:

<download\_folder>sf2\_iap\_using\_interface\_demo\_df\sample\_programming\_files.

All the .spi files listed in the following table are not demonstrated.

**Table 3 • IAP Programming Results**

*.spi Programming File Name	Design Type	eNVM Programming Result	FPGA Fabric Programming Result
iap_envm_only.spi	PCIe is not enabled	SmartFusion2 LED 4-bit counter logic (LEDs DS4 to DS7)	NA
iap_fabric_only.spi	PCIe is not enabled	NA	SmartFusion2 LEDs DS0 to DS3 blink
iap_fabric_and_envm.spi	PCIe is not enabled	SmartFusion2 LED 4-bit counter logic (LEDs DS4 to DS7)	SmartFusion2 LEDs DS0 to DS3 blink
pcie_iap_top.spi	PCIe is enabled	Retains original eNVM program.	Retains original FPGA fabric logic

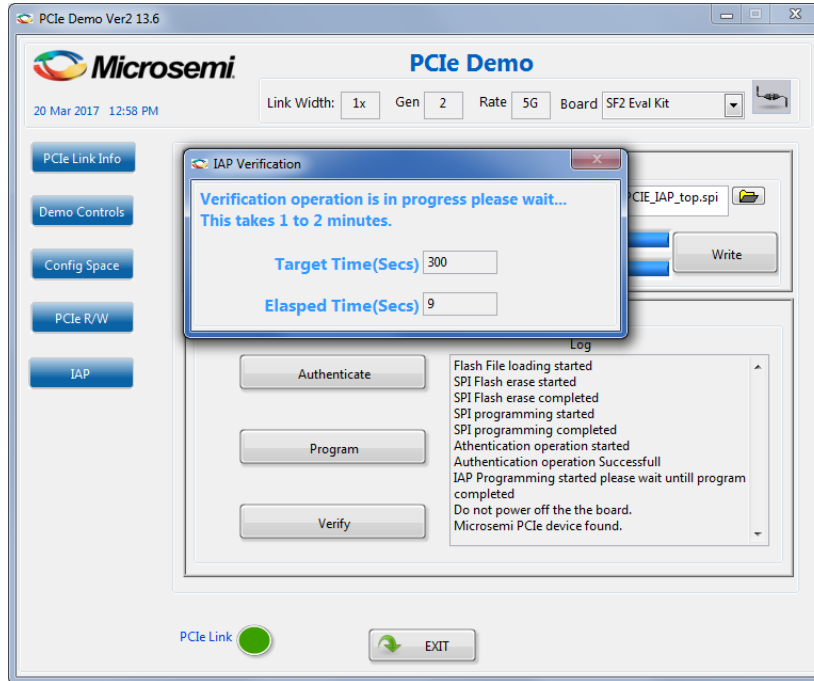
**Note:** After the successful IAP program operation, the SmartFusion2 Security Evaluation Kit must be reprogrammed with the original pcie\_iap\_top.stp file to try the IAP operation modes again, if the design type is not PCIe enabled.

## 2.9.2 Verify Operation Mode

The following steps describe how to verify operation mode:

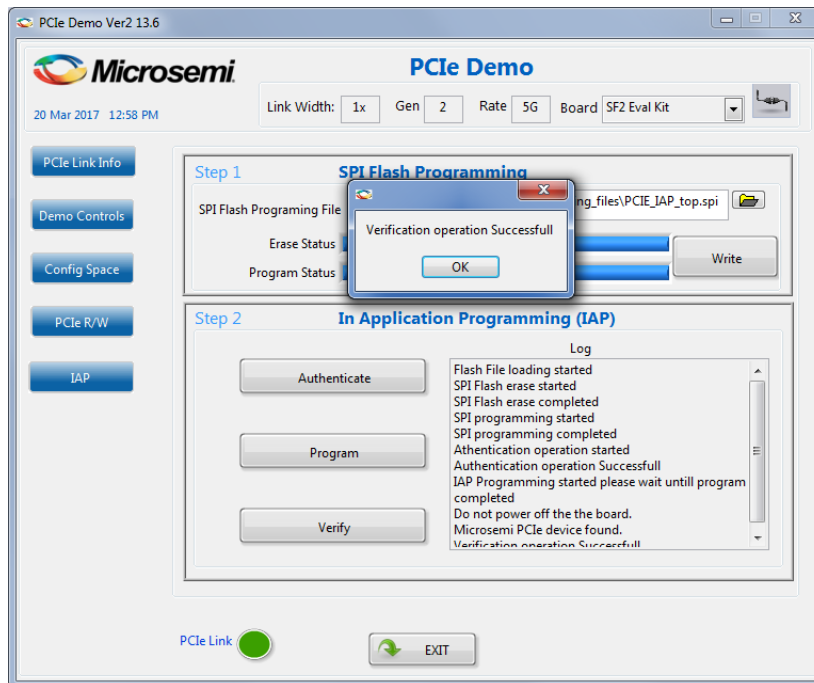
1. Click **Verify** in the GUI to verify the SmartFusion2 device FPGA fabric and eNVM contents. The following figure shows the **Verification operation is in progress** message.

**Figure 26 • IAP Verification Status**



The following figure shows the **Verification operation successful** message.

**Figure 27 • IAP Verification Success**



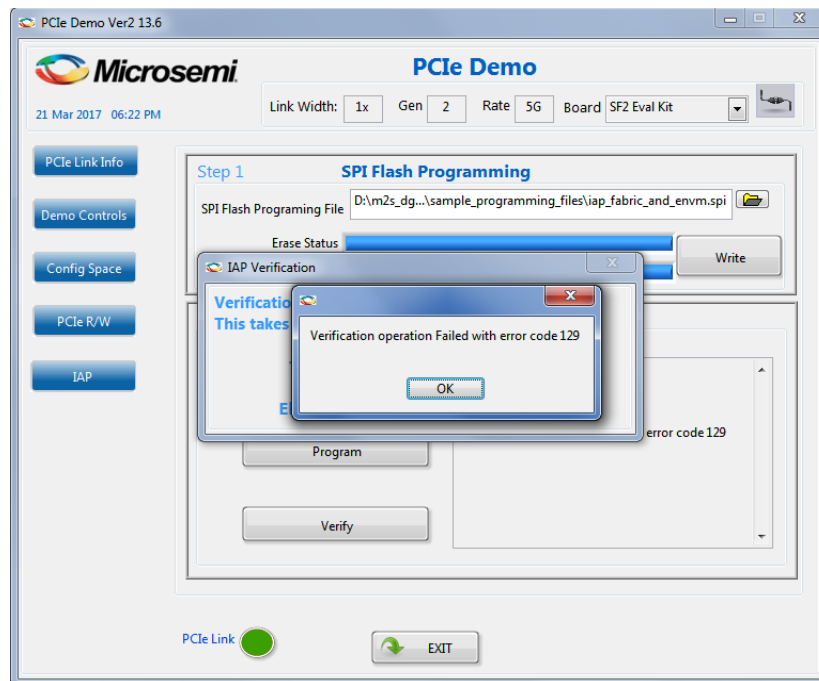
The verification operation is successful when the SmartFusion2 device contents match the programming bitstream data stored in the SPI Flash. If the verification fails, the GUI displays an error message with an error code. For information about error codes, refer to the [Appendix: Error Codes](#), page 24.

The sample programming files are at- `<download_folder>\sf2_iap_using_interface_demo_df\sample_programming_files`.

All the files do not pass the verification. Only the `pcie_iap_top.spi` file passes the **verification** operation as it matches the SmartFusion2 device contents (`pcie_iap_top.stp`). The other programming files fail verification.

The following figure shows the verification error message.

**Figure 28 • IAP Verification Error Message**



## 2.10 Known Issue

After successful completion of the two-step IAP or CM3 ISP, LSRAM read and write access fails from the fabric path. This is a known silicon issue, which is documented in the [ER0196: SmartFusion2 Device, Errata](#). The workaround for this problem is to reset the system after the IAP or ISP program operation. Microsemi recommends that this workaround is implemented for any design, which accesses LSRAM after IAP or ISP. For more information about how to implement this workaround, see [Appendix: Implementing Workaround to Access Fabric LSRAM after IAP/ISP Program Operation](#), page 31.

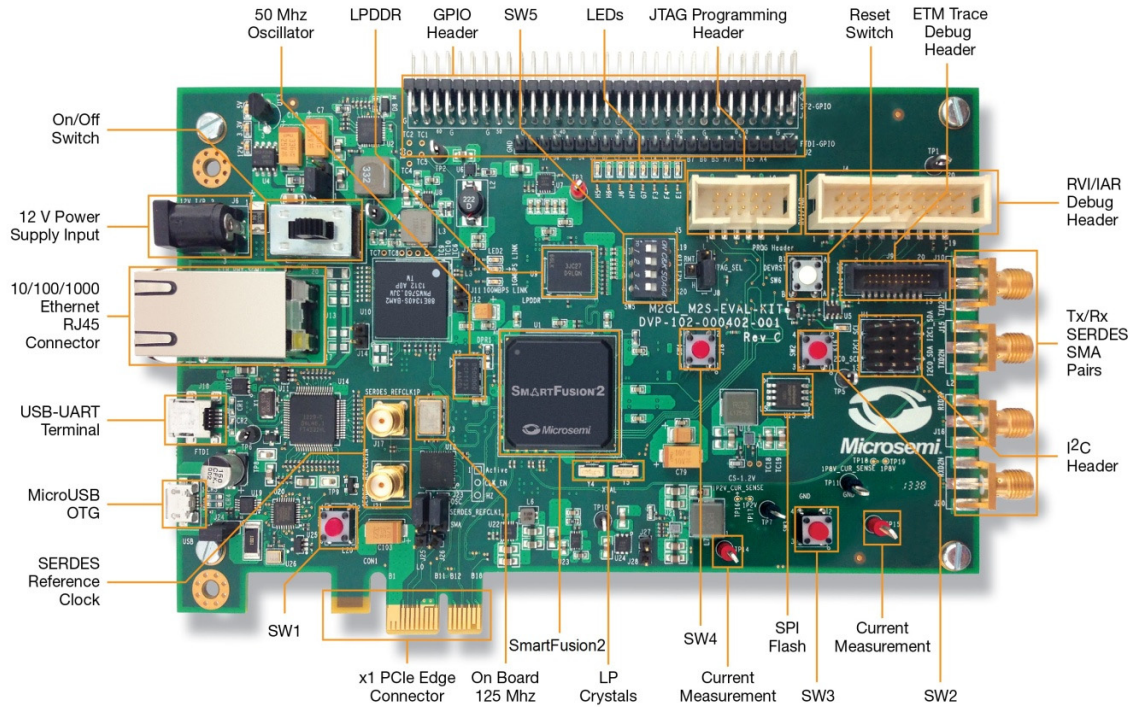
The design example provided in this demonstration implements the workaround for accessing LSRAM after implementing the IAP or ISP program operation in the Libero software. The design files are available in the following location:

`<download_folder>\sf2_iap_using_interface_demo_df\sample_programming_files\LSRAM_Workaround\PCIE_IAP_Tamper.rar`

# 3 Appendix: SmartFusion2 Security Evaluation Kit Board

The following figure shows the SmartFusion2 Security Evaluation Kit board.

**Figure 29 • SmartFusion2 Security Evaluation Kit Board**



## 4 Appendix: Error Codes

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The following table lists the information about the error codes.

**Table 4 • Error Codes**

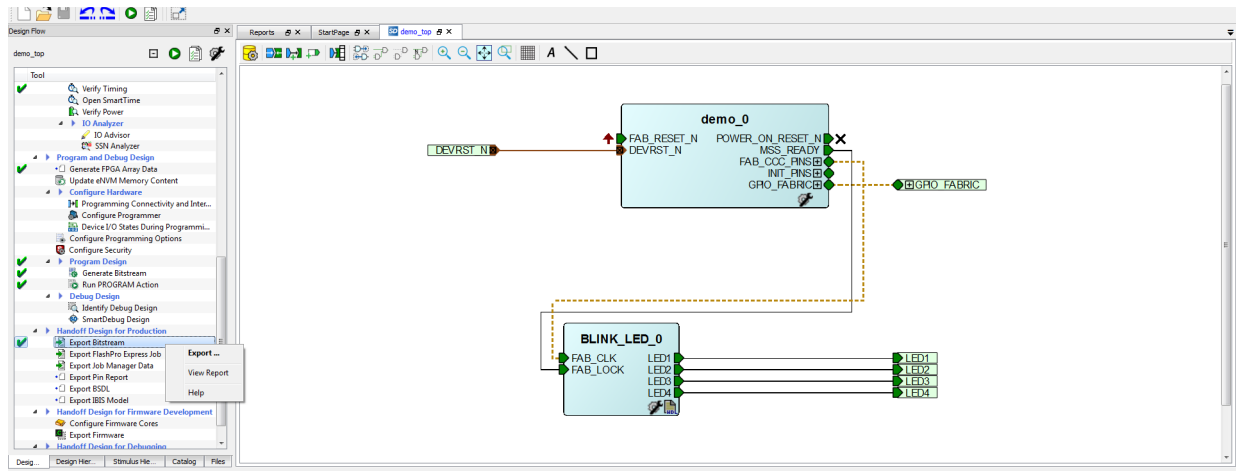
Define	Error Code	Description
#define MSS_SYS_CHAINING_MISMATCH	1	Device contents mismatch
#define MSS_SYS_UNEXPECTED_DATA_RECEIVED	2	Data is not supported
#define MSS_SYS_INVALID_ENCRYPTION_KEY	3	Invalid encryption key
#define MSS_SYS_INVALID_COMPONENT_HEADER	4	Invalid file
#define MSS_SYS_BACK_LEVEL_NOT_SATISFIED	5	Corrupted/ Invalid file
#define MSS_SYS_DSN_BINDING_MISMATCH	7	Corrupted/ Invalid file
#define MSS_SYS_ILLEGAL_COMPONENT_SEQUENCE	8	Corrupted/ Invalid file
#define MSS_SYS_INSUFFICIENT_DEV_CAPABILITIES	9	Invalid Device capabilities
#define MSS_SYS_INCORRECT_DEVICE_ID	10	Invalid Device ID
#define MSS_SYS_UNSUPPORTED_BITSTREAM_PROT_VER	11	Bitstream not supported
#define MSS_SYS_VERIFY_NOT_PERMITTED_ON_BITSTR	12	Verification not allowed for input bitstream
#define MSS_SYS_ABORT	127	Operation aborted
#define MSS_SYS_NVM_VERIFY_FAILED	129	eNVM verification failed
#define MSS_SYS_DEVICE_SECURITY_PROTECTED	130	Device secured
#define MSS_SYS_PROGRAMMING_MODE_NOT_ENABLED	131	Programming mode not enabled

## 5 Appendix: Generating .spi Programming File using Libero

The following steps describe how to generate .spi programming file using Libero:

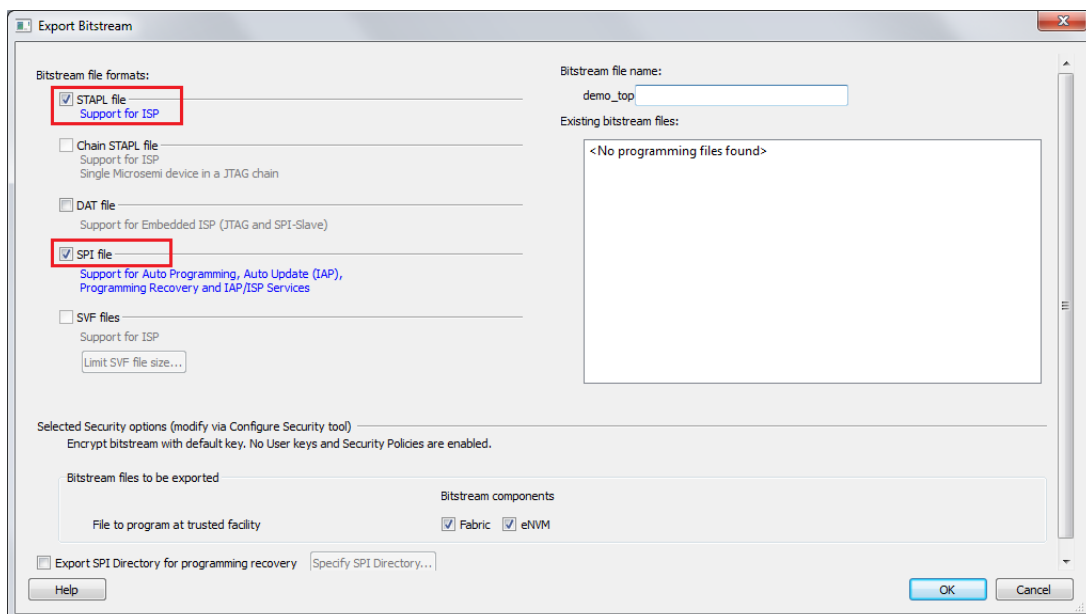
1. Launch the Libero SoC software to open a project for the iap\_fabric\_and\_envm.spi programming file. The Libero design file is provided in `<download_folder>\sf2_iap_using_interface_demo_df\smample_programming_files\fabric_and_envm`.
2. Right-click **Export Bitstream** under **Handoff Design for Production** in the **Design Flow** tab, and click **Export...** from the context menu.

**Figure 30 • Configuring Export Bitstream**



3. Select the **SPI file** check box in the **Export Bitstream** window.

**Figure 31 • Export Bitstream Window**



4. Click **OK**.

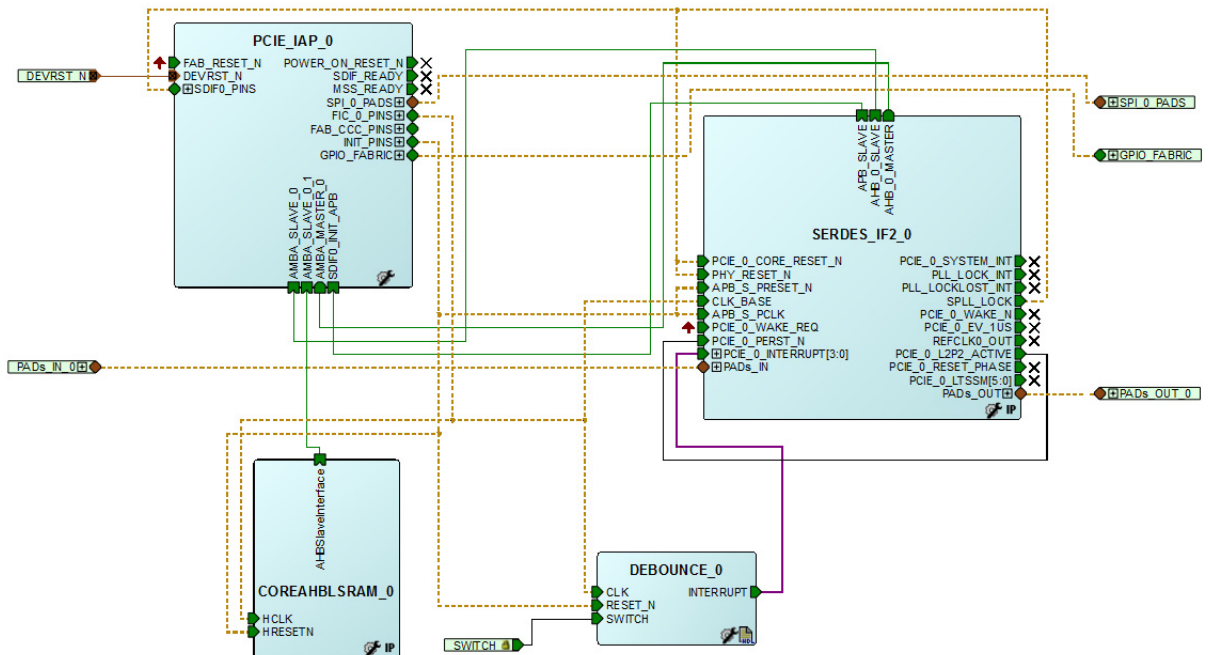


## 6 Appendix: Hardware Implementation

In this demo design, the following blocks are configured in Libero hardware project:

- The SERDES\_IF\_1 in the SmartFusion2 device is configured for PCIe 2.0, x4 lanes, and Gen2 rate.
- The CoreAHBLSRAM IP is configured to use the 4 KB of LSRAM.
- The advanced high-performance bus (AHB) master interface of SERDES\_IF\_1 is enabled and connected to the AHB slave interface of FIC\_0 to access the MSS peripherals. The AHB slave interface of SERDES\_IF\_1 and CoreAHBLSRAM IP are connected to the AHB master interface of FIC\_0 to access the PCIe interface and the fabric LSRAM from the MSS.
- BAR0 and BAR1 are configured in the 32-bit memory mapped memory mode. The advanced extensible interface (AXI) master window 0 is enabled and configured to map the BAR0 memory address space to the MSS GPIO address space to control the MSS GPIOs. The AXI master window 1 is enabled and configured to map the BAR1 memory address space to the eSRAM address space to perform read and write operations from the PCIe interface. The AXI slave window 0 is enabled and configured to map the SmartFusion2 local address space to the host PC address space.
- The MSS GPIO block is enabled and configured: – GPIO\_0 to GPIO\_7 as outputs and connected to LEDs – GPIO\_8 to GPIO\_11 as inputs and connected to DIP switches.
- The M3\_CLK clock and Serial Controller 1 clock base are configured to 50 MHz.
- The MSS SPI\_0 controller is enabled to access the external SPI Flash memory.

**Figure 33 • Demo Design Libero Top-Level Diagram**

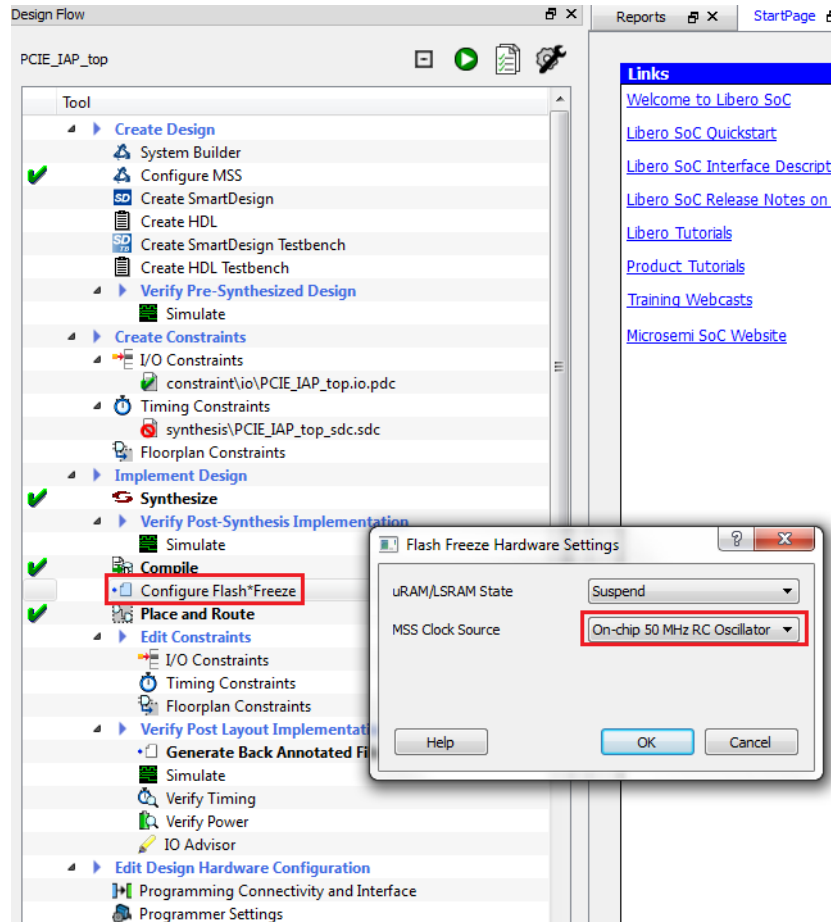




## 6.1 Standby Clock Source Configuration

The standby clock source for the MSS in the F\*F mode is configured to **On-chip 50 MHz RC Oscillator** using the **Flash\*Freeze Hardware Settings** dialog box in the Libero SoC software, as shown in the following figure. A higher MSS clock frequency is required in the F\*F mode to meet the SPI communication speed requirements.

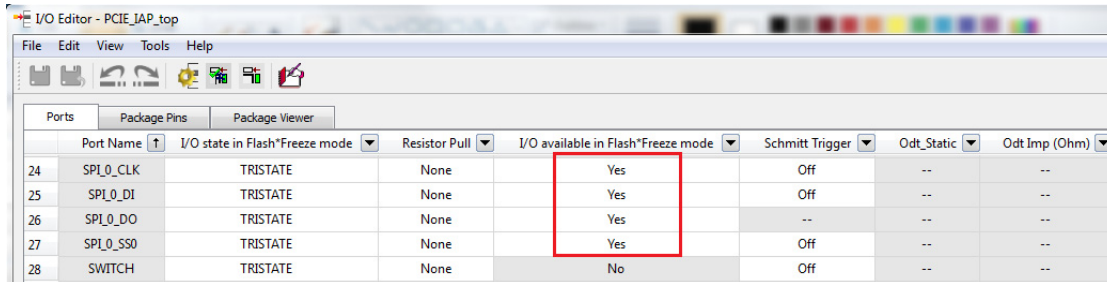
**Figure 34 • Flash\*Freeze Hardware Settings**



## 6.2 Configuring I/Os for Flash\*Freeze Mode

The FPGA fabric is not operational during the Program or Verify IAP operations as the device enters into the Flash\*Freeze (F\*F) mode. On the SmartFusion2 Security Evaluation Kit board, the SPI\_0 is interfaced to the on-board SPI Flash memory for loading the programming bitstream data to the SPI Flash using the SPI interface. During the F\*F mode, the fabric and I/Os are not available. Therefore, all the SPI\_0 ports are configured using the I/O Editor to be available during the F\*F mode, as shown in the following figure. **Commit and Check** the settings from the File menu after configuring the SPI\_0 ports.

Figure 35 • Configuring SPI\_0 Ports Available During F\*F

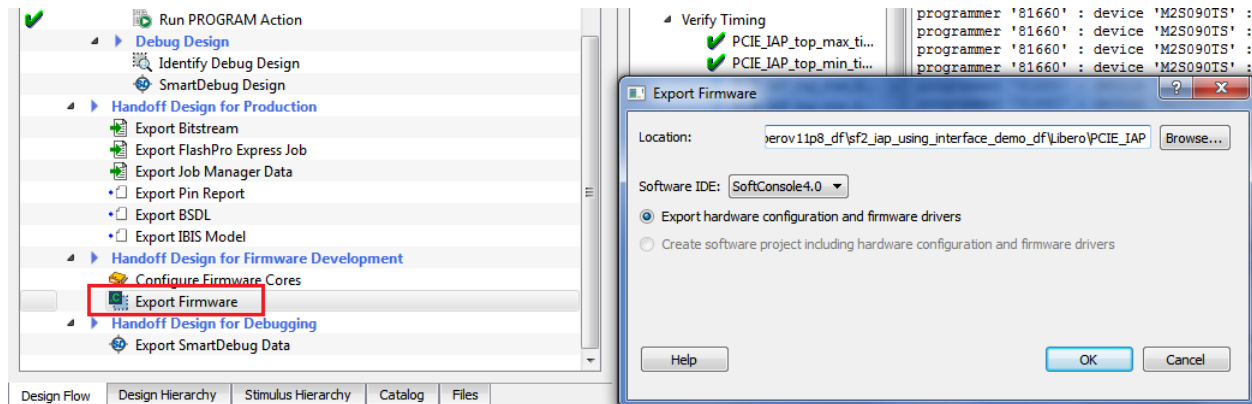


Port Name	I/O state in Flash*Freeze mode	Resistor Pull	I/O available in Flash*Freeze mode	Schmitt Trigger	Odt_Static	Odt Imp (Ohm)
24	SPI_0_CLK	TRISTATE	Yes	Off	--	--
25	SPI_0_DI	TRISTATE	Yes	Off	--	--
26	SPI_0_DO	TRISTATE	Yes	--	--	--
27	SPI_0_SS0	TRISTATE	Yes	Off	--	--
28	SWITCH	TRISTATE	No	Off	--	--

## 6.3 SoftConsole Project Generation

The firmware and SoftConsole project workspace can be generated by selecting the **Create project for selected Software Tool Chain** check box and selecting a **Software ToolChain** option from the drop-down list, as shown in the following figure.

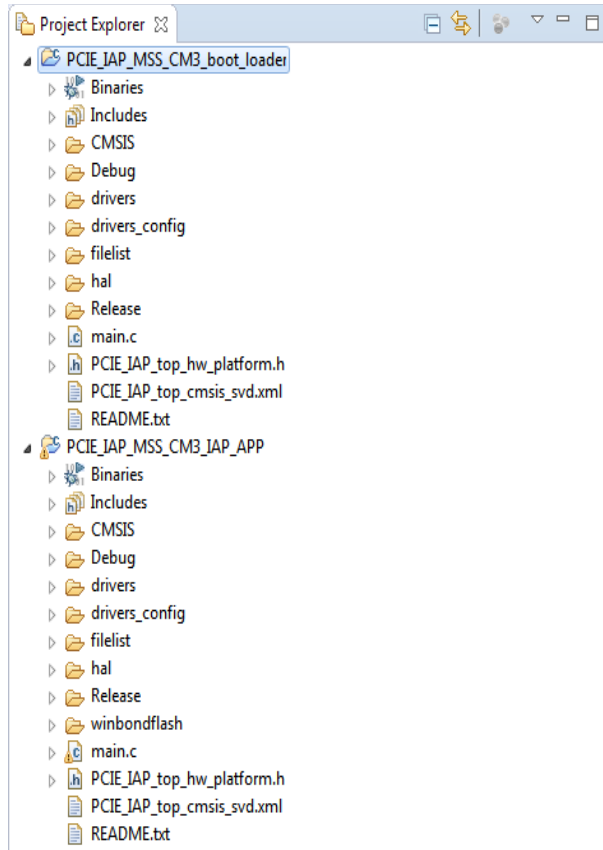
Figure 36 • Export Firmware Options



After successful firmware generation, the firmware and SoftConsole folders are generated at `<download_folder>\sf2_iap_using_interface_demo_df\libero` as specified in the **Location** field of **Export Firmware** dialog box shown in the above figure.

For software modifications, open the SoftConsole project workspace (located at `<download_folder>\sf2_iap_using_interface_demo_df\libero\PCIE_IAP\SoftConsole4.0`) using SoftConsole IDE v4.0. The following figure shows the SoftConsole project workspace.

**Figure 37 • SoftConsole Project Workspace**



The SoftConsole workspace consists the following projects:

- **PCIE\_IAP\_MSS\_CM3\_IAP\_APP:**  
Receives the bitstream from the host PC through the PCIe interface and invokes the system controller programming services.
- **PCIE\_IAP\_MSS\_CM3\_boot\_loader:**  
Implements remapping of eSRAM to the Cortex-M3 processor code space after copying the IAP code from eNVM to eSARM.
- Both the projects contain all the firmware and hardware abstraction layers of the hardware design.

# 7 Appendix: Implementing Workaround to Access Fabric LSRAM after IAP/ISP Program Operation

The LSRAM write and read accesses are denied after implementing the IAP or ISP program operation. The workaround for this problem is to apply System Reset after the IAP or ISP program operation.

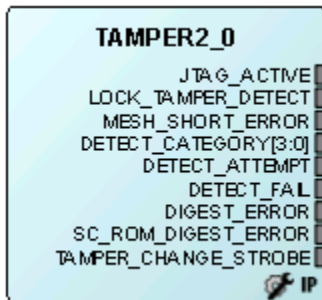
## 7.1 Changes Required in Libero Design

### 7.1.1 Option 1: Creating SmartDesign

The following steps describe how to apply System Reset:

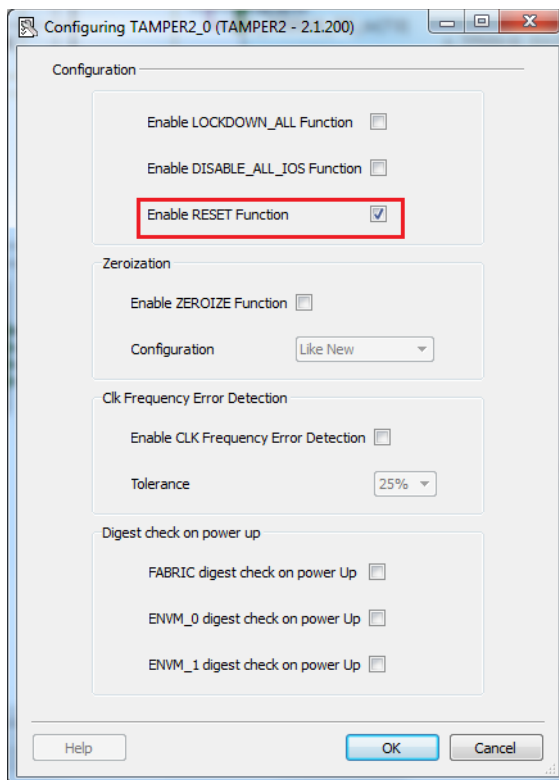
1. Choose **File > New > SmartDesign**.
2. Enter the **Name** as **Dev\_Restart\_after\_IAP\_blk** in the **Create New SmartDesign** window.
3. Navigate to **Libero Catalog** to open **Tamper Macro**.
  - a. Drag the **Tamper Macro** (shown in the following figure) available in **Libero Catalog** to the **Dev\_Restart\_after\_IAP\_blk SmartDesign** canvas.

Figure 38 • Tamper Macro - Before Configuration



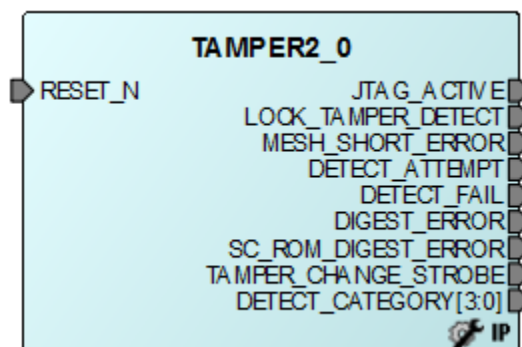
- b. Select the **Enable RESET Function** check box in the **Configuring Tamper 2\_0** window, as shown in [Figure 39](#), page 32.
- c. Click **OK**. The **System Reset** is enabled.

**Figure 39 • Tamper Macro Configuration Window**



The following figure shows the TAMPER2\_0 macro after configuration.

**Figure 40 • Tamper Macro - After Configuration**



4. Instantiate the **FSM Module** provided in the design files. This FSM logic performs three consecutive address writes to the two-port large SRAM with the known data pattern and then reads back data from those three consecutive address locations to compare. If the read back data pattern does NOT match the written data pattern, the FSM asserts the RESET\_N input to Tamper Macro, which in turn causes a System Reset. If the read back data pattern matches the written data pattern, the FSM does not do anything.

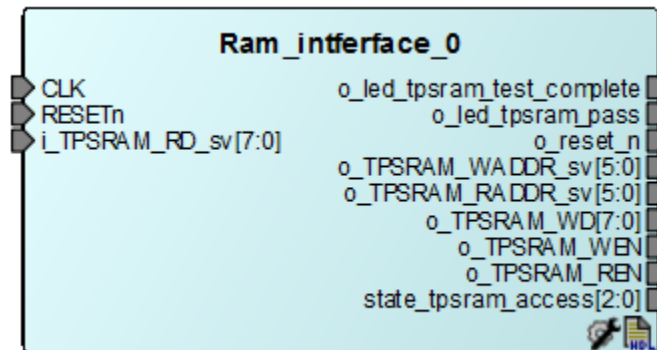
Follow these steps to add the FSM logic to the PCIe IAP design:

- a. Choose **File > Import > HDL Source Files**.
- b. Browse to the Ram\_interface.v file location in the design files folder.

`<download_folder>\sf2_iap_using_interface_demo_dfsample_programming_files\LSRAM_Work-around\Sourcefiles`

c. Click the **Dev\_Restart\_after\_IAP\_blk** tab and drag the **Ram\_interface** component from the **Design Hierarchy** to the **Dev\_Restart\_after\_IAP\_blk SmartDesign** canvas. Figure 41 shows the **Ram\_interface** component.

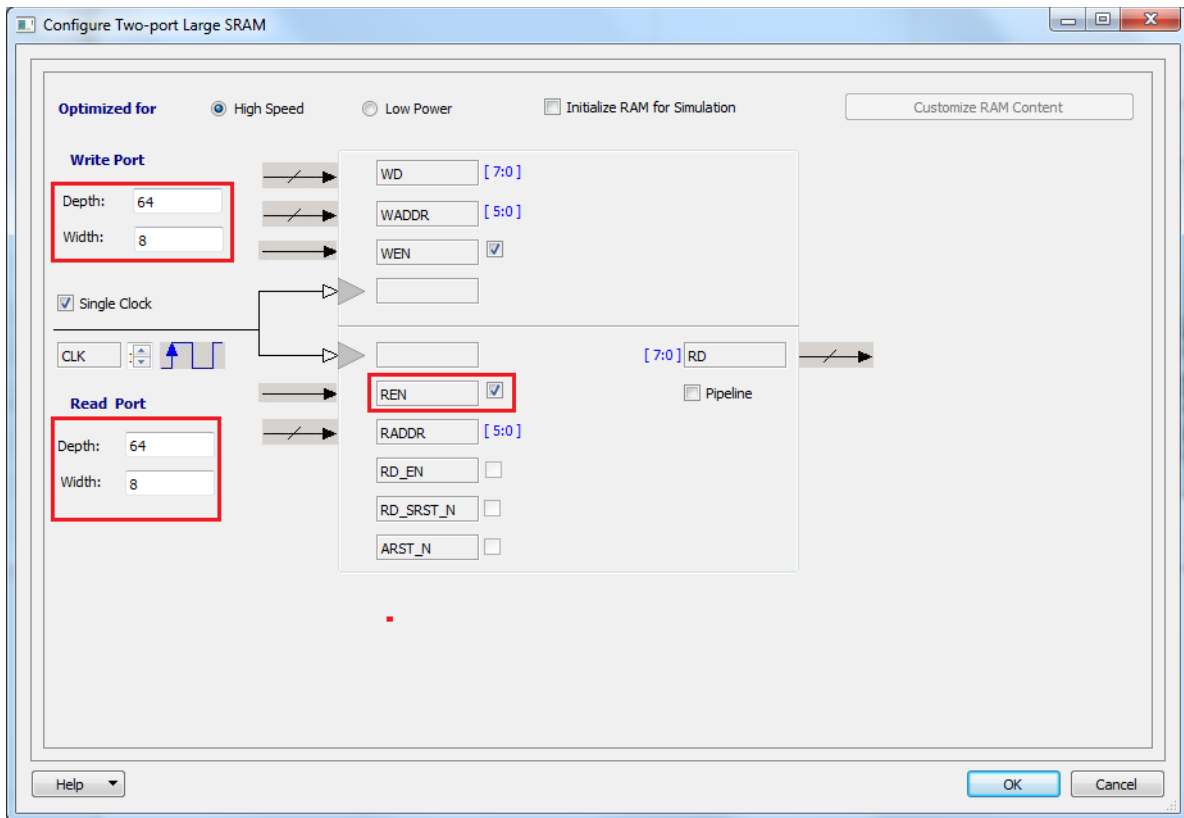
**Figure 41 • Ram\_interafce FSM Component**



After the completion of the IAP programming, the System Controller asserts **POWER\_ON\_RESET\_n** to the FPGA fabric. This triggers the **RESETn** signal and initiates the state machine in the FSM module.

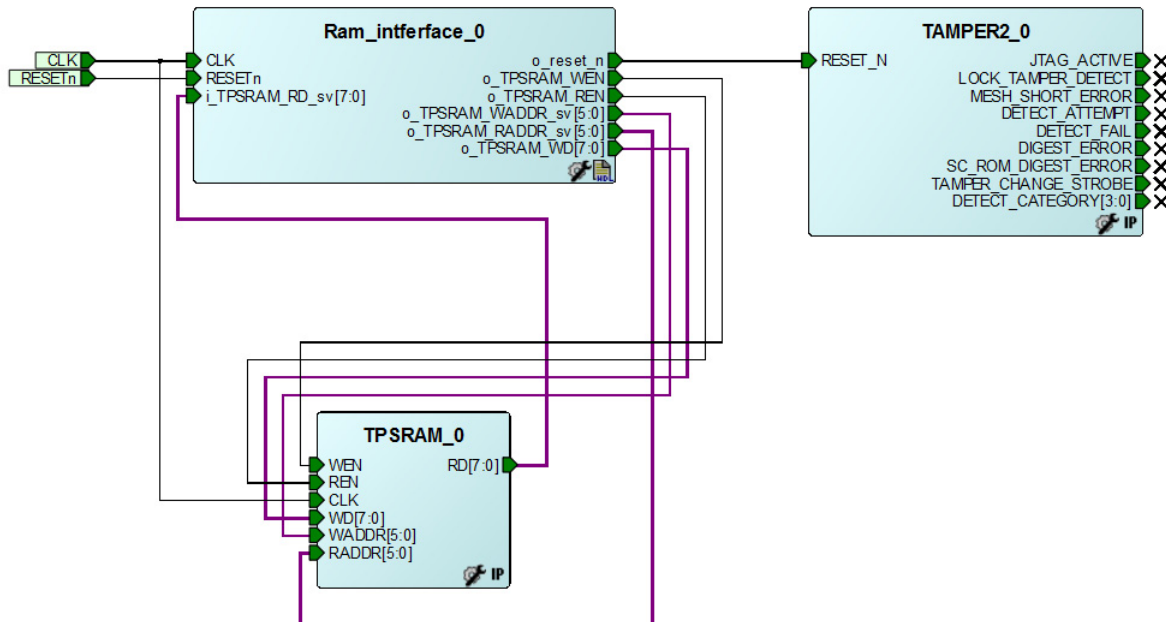
5. Drag the **Two-Port Large SRAM (TPSRAM)** available in the **Libero Catalog** to the **Dev\_Restart\_after\_IAP\_blk SmartDesign** canvas.
6. Configure the **TPSRAM** with the following settings:
  - Write Port
    - Depth: 64
    - Width: 8
  - Read Port
    - Depth: 64
    - Width: 8
  - Select **Check REN** check box

**Figure 42 • Two-Port SRAM Configurator Window**



7. Connect **Tamper Macro, FSM, and TPSRAM**, as shown in the following figure.

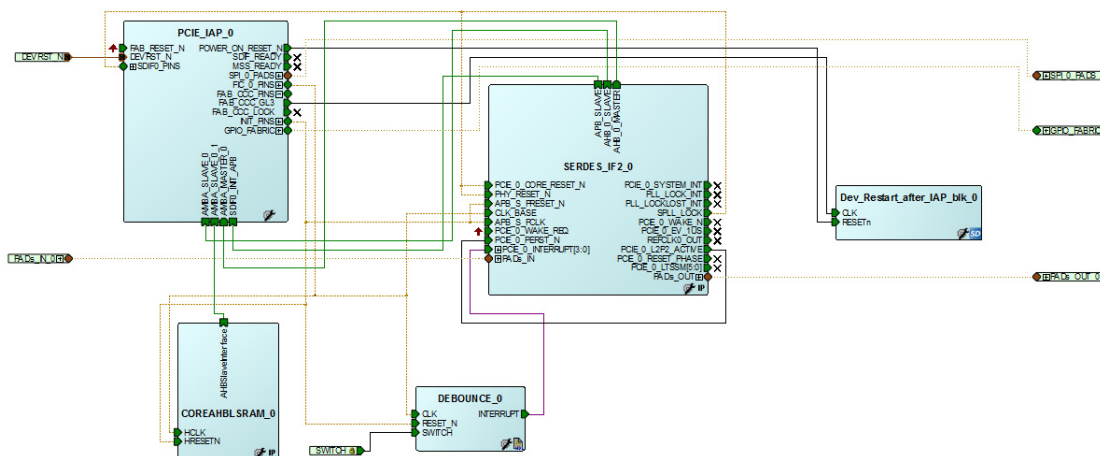
**Figure 43 • Dev\_Restart\_after\_IAP\_blk SmartDesign**



8. Click the **PCIE\_IAP\_top** tab and drag the **Dev\_Restart\_after\_IAP\_blk** component from the **Design Hierarchy** to the **PCIE\_IAP\_top** SmartDesign canvas.

- Connect the blocks as shown in the following figure and generate **PCIE\_IAP\_top SmartDesign**. This completes the implementation of the workaround.

**Figure 44 • PCIE\_IAP\_top SmartDesign**



**Note:** This workaround is applicable for v11.6 software release or later, and must be implemented in the Libero design, which is used to generate the .spi programming file. Older versions of Libero may prune Tamper Macro during synthesis. To avoid pruning, one of the recommended options is to promote the DETECT\_ATTEMPT signal of Tamper Macro to the top-level.

## 7.1.2 Option 2: Importing the .cxf file in Libero Design

Another option to implement this workaround is to import the .cxf file for SmartDesign Dev\_Restart\_after\_IAP\_blk. The .cxf file is provided with the design files and it has all the component instantiations and connections mentioned in [Option 1: Creating SmartDesign](#), page 31 from Step 1 to Step 6.

The following steps describe how to import .cxf file.

- Extract the files.  
`<download_folder>\sf2_iap_using_interface_demo_df/sample_programming_files\LSRAM_Workaround\PCIE_IAP_Tamper.rar`
- Choose **File > Import > Others**.
- Browse to the following **Dev\_Restart\_after\_IAP\_blk.cxf** file location in the design files folder.  
`<download_folder>\sf2_iap_using_interface_demo_df/sample_programming_files\LSRAM_Workaround\PCIE_IAP_Tamper\PCIE_IAP\component\work\Dev_Restart_after_IAP_blk`
- Browse to the **Ram\_interface.v** file location in the design files folder.  
`<download_folder>\sf2_iap_using_interface_demo_df/sample_programming_files\LSRAM_Workaround\Sourcefiles`
- Repeat Step 7 and Step 8 of Option 1 to instantiate **Dev\_Restart\_after\_IAP\_blk** in **PCIE\_IAP\_top SmartDesign**.