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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

Artix-7 FPGA
AC701 Evaluation Kit
(Vivado Design Suite 2012.4)

Getting Started Guide

UG967 (v1.0) January 10, 2013

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Revision History

The following table shows the revision history for this document.

Date	Version	Revision
01/10/13	1.0	Initial Xilinx release.

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Getting Started with the Artix-7 FPGA AC701 Evaluation Kit

Introduction

The Artix™-7 FPGA AC701 Evaluation Kit (see Figure 1) provides a comprehensive, high-performance development and demonstration platform based on the XC7A200T-2-FBG676 FPGA for high-bandwidth and high-performance applications in multiple market segments. The built-in self-test (BIST) and the Artix-7 FPGA Base Targeted Reference Design (TRD) are developed on this Kit.

Figure 1: **AC701 Evaluation Kit**

This Getting Started Guide is divided into two sections:

- Basic Hardware Bring-up: Enables hands-on operation of all the features in the BIST as well as evaluation of Analog Mixed Signal (AMS) using the AMS101 evaluation card.
- Advanced Bring-up: Enables hands-on operation with the base TRD, which features PCIe, DDR3 memory, AXI stream interconnect, and AXI virtual FIFO controller IP cores—all supported through a custom evaluation graphical user interface (GUI).

AC701 Evaluation Kit Contents

- AC701 evaluation board featuring the XC7A200T-2-FBG676 FPGA
- AMS101 evaluation board
- Full seat Vivado Design Suite device-locked to the Artix-7 XC7A200T-2-FBG676 FPGA
- Board Design Files
  - Schematics
  - Board layout files
  - Bill of Materials
- Documentation
  - Hardware User Guide
  - Getting Started Guide
  - Reference Design User Guide
- 12V AC-adapter Power Supply
- Cables
  - RJ45 Ethernet Cable
  - HDMI cable
  - Digilent USB JTAG Cable
  - USB-A to USB-mini-B cable
- Software and reference designs, demos, and documents to quickly get started
  - The BIST files (RDF0220) can be found at www.xilinx.com/ac701 in the Docs & Designs tab.

The tutorials and reference designs available on the AC701 Web page can be used to further explore the capabilities of the AC701 and the Artix-7 FPGA. For additional information, see the Artix-7 Family FPGAs Product Table. For the most up-to-date information on the tutorial content provided with the AC701 Evaluation Kit, see the AC701 Reference Design Web page by visiting www.xilinx.com/ac701 and clicking the Docs & Designs tab.

Basic Hardware Bring-up with Built-In Self-Test

Introduction

The BIST tests many of the features offered by the Artix-7 FPGA AC701 Evaluation Kit. The test is an available reference design for the AC701 Evaluation Kit and can be programmed into the FPGA via the JTAG interface.

Figure 2 and Table 1 provide an overview of the board features utilized by the BIST and the AMS101 evaluation card.

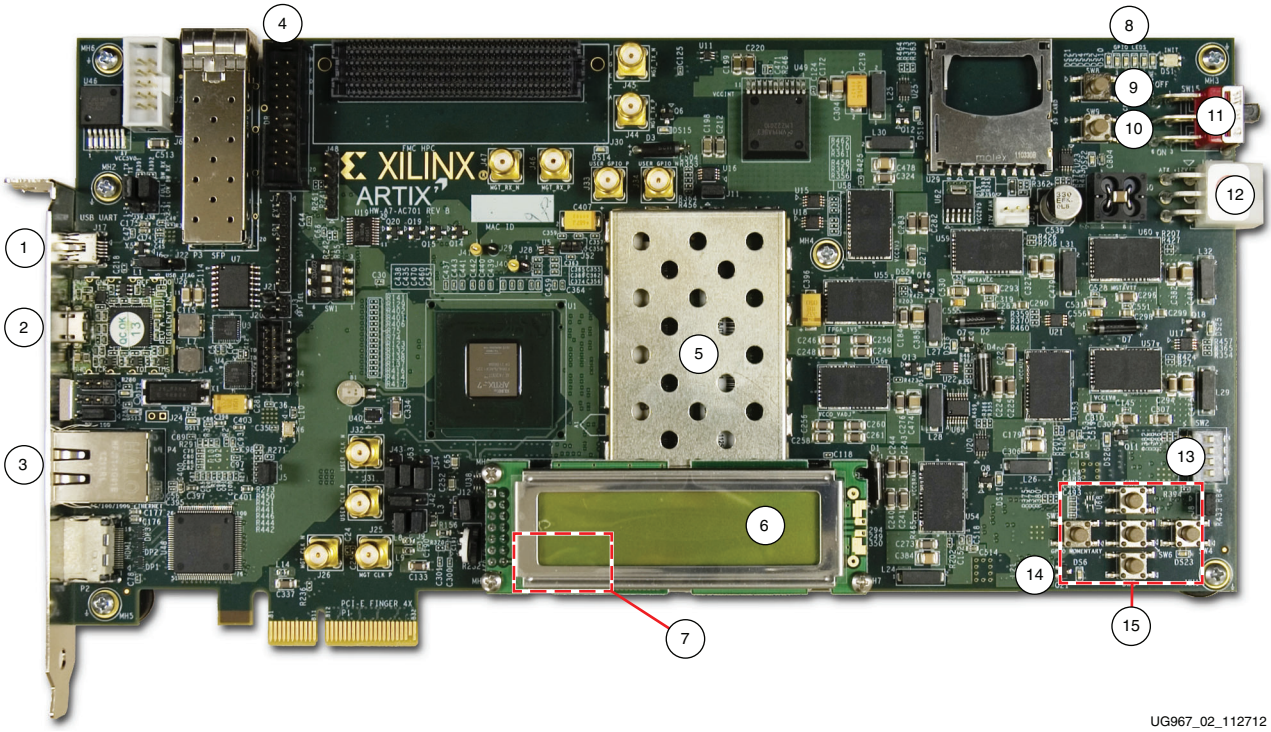

Figure 2: **AC701 Board Detail**

Table 1: **AC701 Board Features**

Callout	Component Description
1	USB-UART connector
2	Diligent JTAG connector
3	RJ45 Ethernet connector
4	XADC header
5	DDR3 external memory
6	LCD display

Table 1: **AC701 Board Features *(Cont'd)***

Callout	Component Description
7	Rotary switch (under LCD)
8	Status LEDs
9	CPU reset button
10	Prog button
11	Power slide switch
12	12V power connector
13	User DIP switch
14	User LEDs
15	User push buttons

For a diagram of all features on the AC701 Board, see UG952, *AC701 Evaluation Board for the Artix-7 FPGA User Guide*.

Hardware Test Setup Requirements

The prerequisites for testing the design in hardware are:

- AC701 evaluation board with XC7A200T-2-FBG676 FPGA
- USB-to-Mini-B cable (for UART)
- USB-to-Micro-B JTAG Digilent cable
- AC Power Adapter (12 VDC)
- TeraTerm Pro or other terminal program
- USB-UART drivers from SiLabs [Ref 1]

Hardware Test Board Setup

This section details the hardware setup and use of the terminal program for running the BIST application. It details step-by-step instructions for board bring-up.

AC701 Evaluation Board Setup

1. Set all three of the AC701 board SW1 switches to the OFF position as shown in Figure 3.

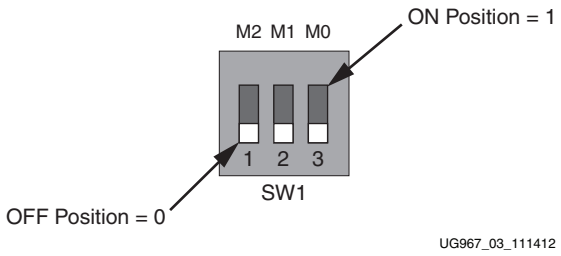

Figure 3: **SW1 Switch Settings for JTAG Programming Mode**

Note: For this application, the board should be set up as a standalone system, powered with the AC-adapter provided with the AC701 Evaluation Kit.

Hardware Bring-up

This section details the steps for hardware bring-up.

1. With the board switched off, connect a USB-mini-B cable into the UART port of the AC701 and the host PC (see Figure 4).

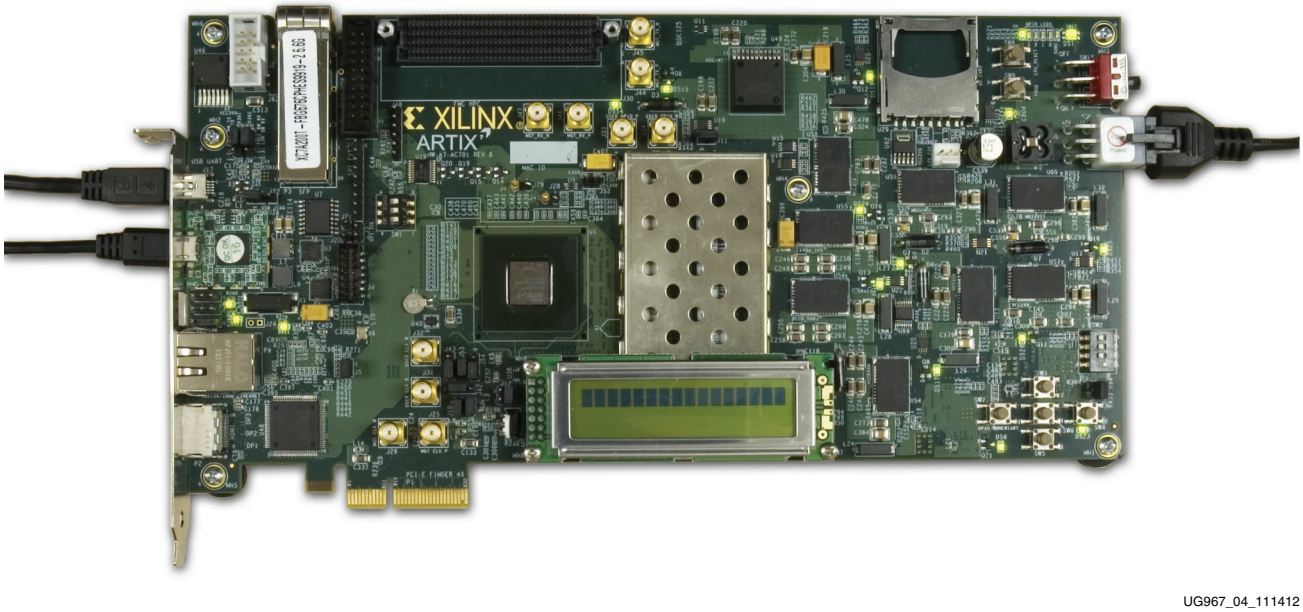

Figure 4: **AC701 Board with UART, Digilent JTAG, and 12V Adapter Cables Attached**

2. Connect the 12V adapter cable.
3. Connect the Digilent JTAG cable.
4. Switch AC701 Power to ON.

Install the Silicon Labs UART Device Driver.

1. Run the downloaded executable UART-USB driver file, listed in Hardware Test Setup Requirements (see Figure 5). This enables UART-USB communications with a host PC.

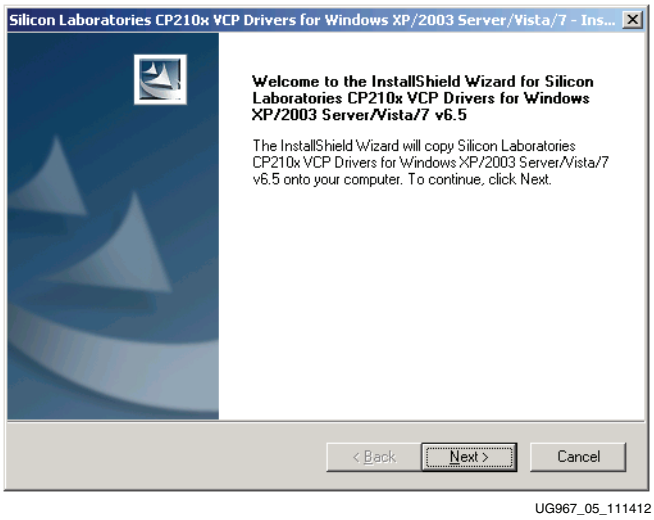

Figure 5: **UART Cable Driver Installation Dialog**

2. Set the USB-UART connection to a known PORT in the Device Manager:
   a. Right-click the **Computer** desktop icon and select **Properties**.
   b. Click **Device Manager**.
   c. Right-click the Cypress device in the list, and select **Properties** (see Figure 6).
   d. Click the **Port Settings** tab, then click the **Advanced...** button.
   e. Select an open COM port between COM1 and COM4 (see Figure 7).

   Note: Steps and diagrams refer to a Windows host PC.

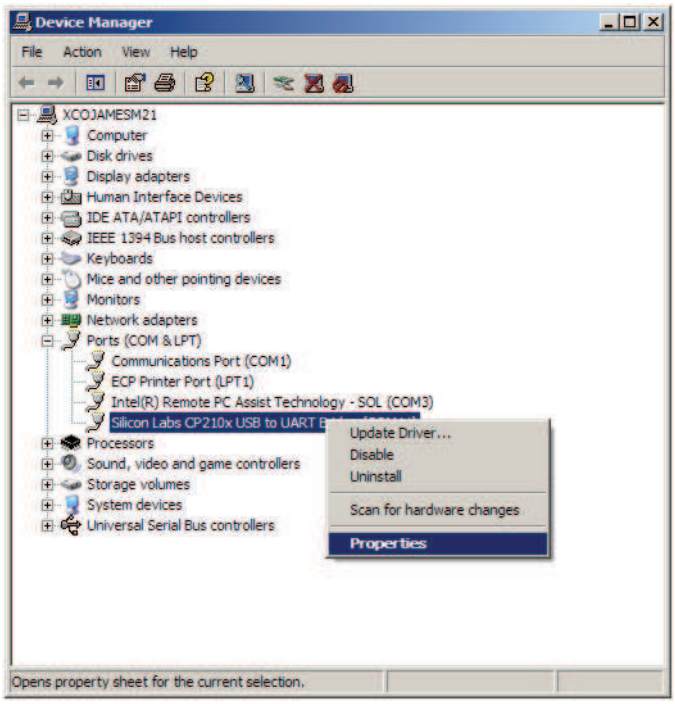

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Figure 6: **Selecting the Cypress Driver in the Device Manager**

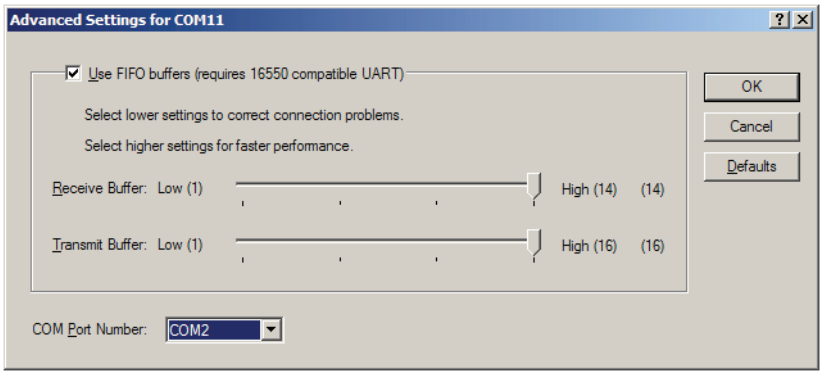

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Figure 7: **Setting the Port for the Cypress Driver**

Run the BIST Application

1. Download RDF0220 from the web at www.xilinx.com/ac701 under the Docs & Designs tab.
2. Unzip the design files to the `C:\` directory.
3. Open an ISE® Design Suite command prompt and type:

```
cd C:\ac701_bist\ready_for_download
```

```
ac701_bist.bat
```

4. Start the installed terminal program.
5. Select **Setup > Serial Port...** and ensure that the settings match those shown in Figure 8:
   - **Baud Rate**: 9600
   - **Data**: 8 bit
   - **Parity**: none
   - **Stop**: 1 bit
   - **Flow control**: none

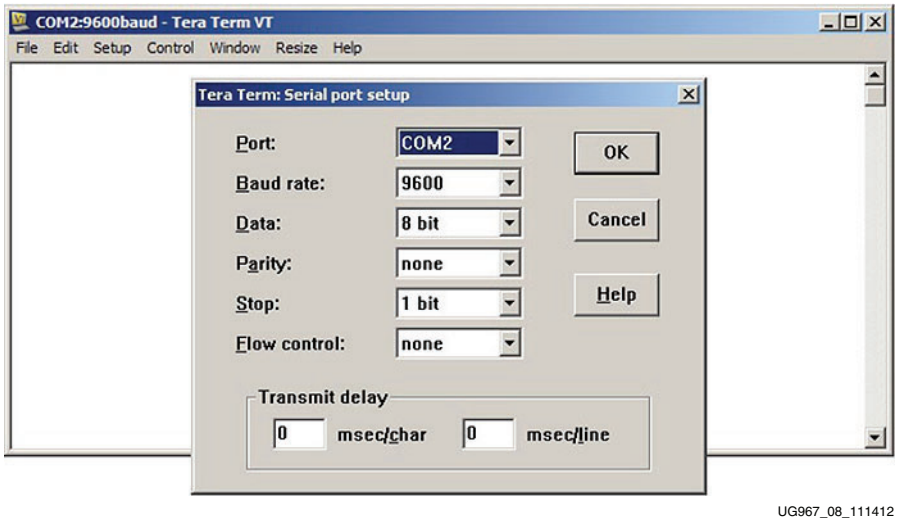

Figure 8: **Serial Port Setup**

6. Select the desired tests to run and observe the test results (see Figure 9).

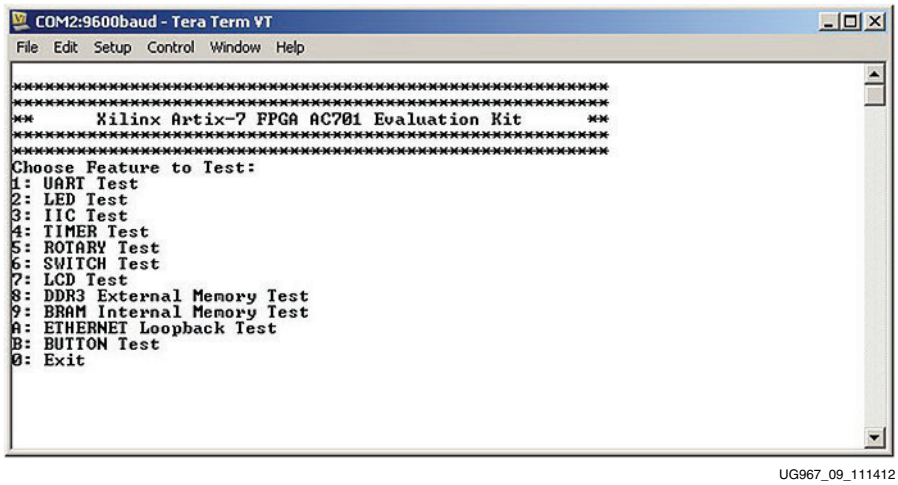

Figure 9: **BIST Main Menu**

For more information on the BIST software and additional tutorials, including how to restore the default content of the on-board non-volatile storage, see the AC701 Evaluation Kit at www.xilinx.com/ac701.

AMS Bring-up with the AMS101 Evaluation Card

Introduction

The Artix-7 XC7A200T-2-FBG676 FPGA features two 1 Mega-samples per second (MSPS), 12-bit, Analog-to-Digital Converters (ADCs) built into the device for a range of applications including simple analog monitoring to more signal processing-intensive tasks such as linearization, calibration, oversampling, and filtering. The AC701 Evaluation Kit includes the hardware and software to evaluate the ADC feature. The AC701 Evaluation Kit also includes voltage, current and power monitoring for nine of the analog power supplies on the board. For evaluation of Xilinx Analog Mixed Signal (AMS) capability, the following items in the kit are needed:

- Access to the AC701 board XADC header (see Figure 2)
- AMS101 evaluation card (see Figure 10 and Table 1)
- Design and software files downloaded from the Docs & Designs tab at www.xilinx.com/ac701
- FPGA design programming files
- USB-UART drivers from Silicon Labs

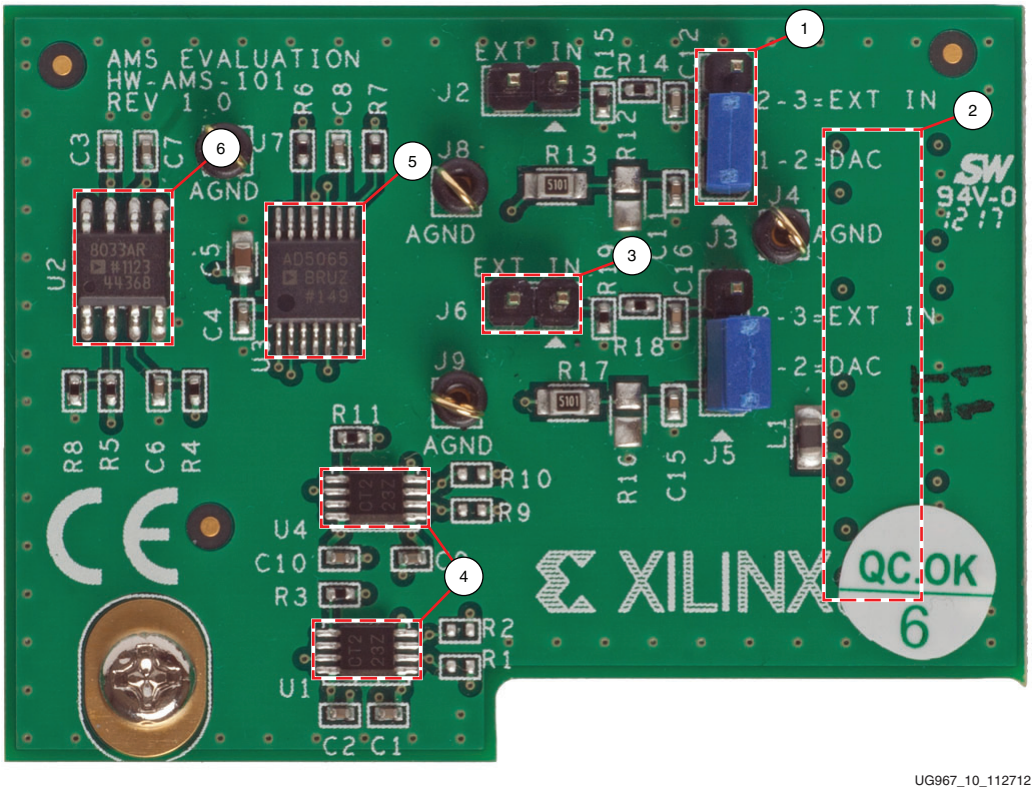

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Figure 10: **AMS101 Evaluation Card**

Table 2: **AMS101 Evaluation Card Features**

Callout	Component Description
1	Jumpers to select DAC or external signal source.
2	20-pin connector to the XADC header on the AC701 board.
3	Pins for external analog input signals.
4	Digital I/O level translators.
5	16-bit DAC to set analog test voltage.
6	Reference buffer for DAC.

Getting Started

1. Verify the USB/UART Silicon Labs drivers are installed as described in Install the Silicon Labs UART Device Driver., page 10.
2. The AMS101 evaluation card requires a Windows host PC to install the National Instruments LabVIEW run-time engine. Install the AMS101 Evaluator tool by unzipping the AC701 AMS Evaluator installer files from Example Designs on the Docs and Designs tab at www.xilinx.com/ac701. After opening the zip folder, click the `setup.exe` file to begin installing the GUI software. When loading the National Instruments LabView

run-time engine, click **OK** to accept the license agreement. Running the setup program loads the AMS101 Evaluator GUI with the red Xilinx logo on the desktop.

3. After the AMS Evaluator has successfully installed, restart the host PC.
4. Unzip the AC701 AMS design files from Example Designs on the Docs and Designs tab at the AC701 support page to access the AMS bitstream (`xadc_eval_design.bit`)

Evaluating AMS

1. Connect and apply power to the hardware.
   a. Connect the AMS101 evaluation card to the AC701 board, making sure the notch on the XADC header lines up correctly with the connector on the AMS101 evaluation card.
2. Download the design to the Artix-7 XC7A200T-2-FBG676 FPGA from the AC701 AMS design files.
   a. Open the ChipScope analyzer in the Vivado Design Suite (select **Flow > Launch ChipScope Analyzer**)
   b. Click the **Open_cable** command.
   c. Select **Device**, choose **Configure**, and click **Select New File**.
   d. Open `xadc_eval_design.bit` from the AC701 board AMS design files folder.
3. Open the AMS Evaluator tool.
   a. Running the setup program loads the AMS101 Evaluator GUI with the red Xilinx logo on your desktop. Figure 11 shows the AMS101 Evaluator after opening. From here, click the **Collect Data** button in the center to quickly evaluate the analog signals in the time and frequency domain, display linearity, verify the XADC register settings, and measure the internal temperature sensor and supply voltages.
   b. Figure 12 shows the XADC results in the frequency domain.
   c. The AMS101 evaluation card provides a dual 16-bit DAC for use as an analog test source. External analog signals can also be applied to the card. For a more extensive explanation of the AMS101 evaluation card and the various functions in the AMS Evaluator tool, refer to UG886, *AMS101 Evaluation Card User Guide*.

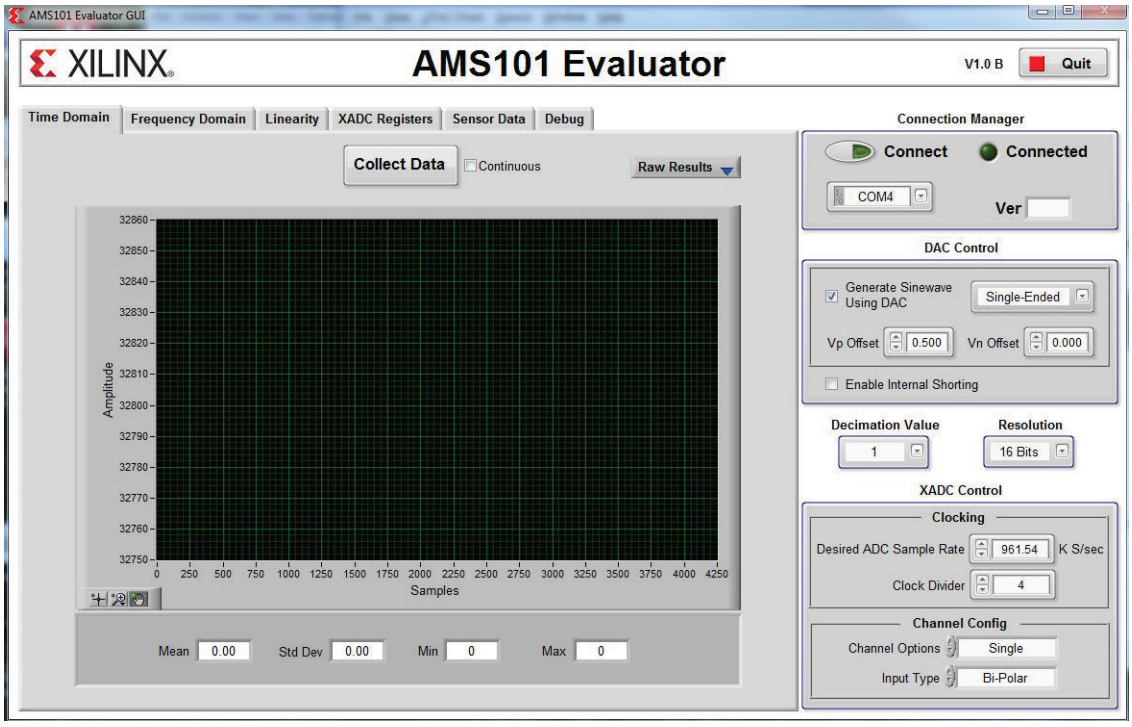

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Figure 11: **AMS Evaluator Tool**

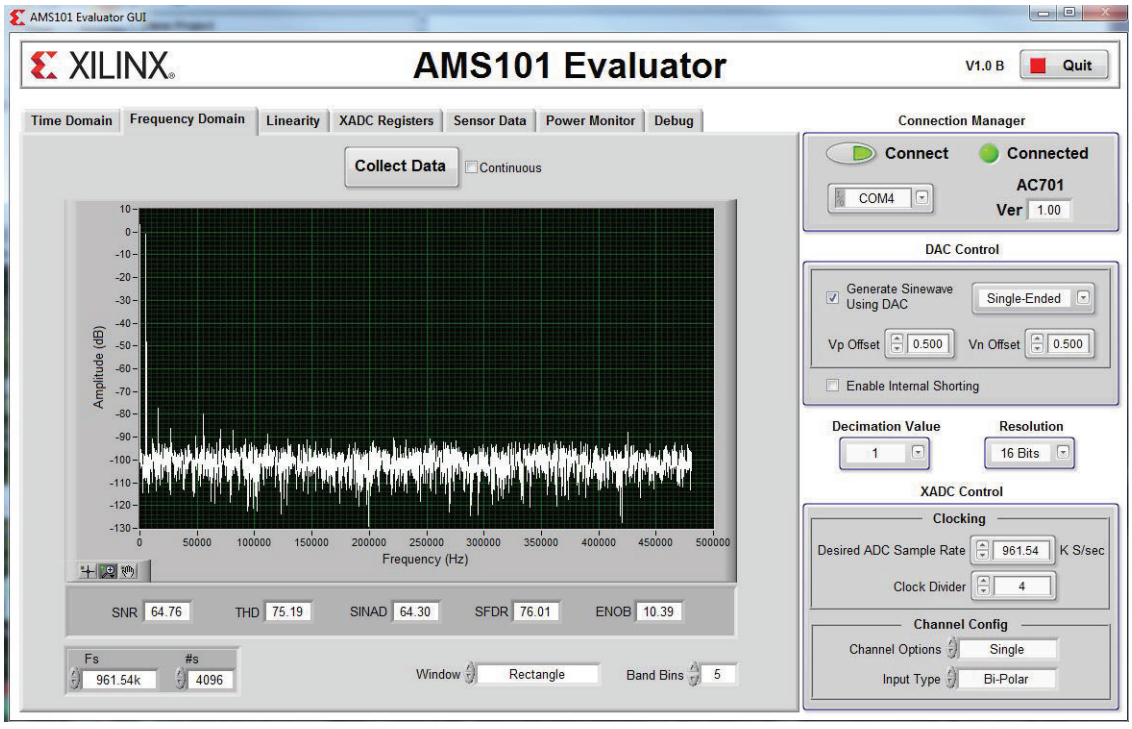

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Figure 12: **XADC Fast Fourier Transform Result**

Power Monitoring

In addition to measuring the analog signals from the AMS101 evaluation card, the AC701 also uses the XADC as a system monitoring solution for measuring the voltage, load current and calculated power for nine of the AC701 board analog power supplies. By offering 12-bits, 1 MSPS and up to 17 externally multiplexed inputs, the XADC is a good solution for monitoring voltage and current on all Artix-7 FPGA applications. Figure 13 shows an example of the AC701 monitoring V_{CCINT}, V_{CCAUX}, V_{CCBRAM} and the 1.5V supply.

In conjunction with the AMS Evaluator, the AC701 AMS reference design also measures the voltages, current and power for V_{CCO_ADJ}, the 1.8V supply, the 3.3V supply, MGTAVCC and MGTAVTT.

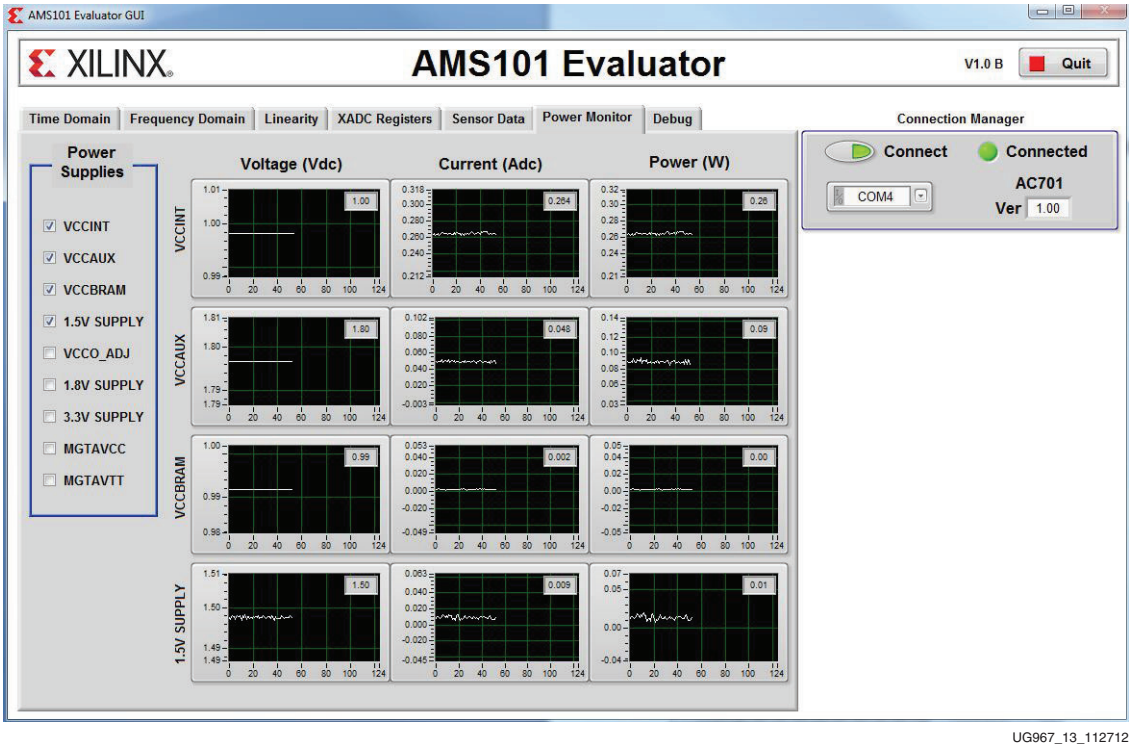

Figure 13: **Voltage, Current and Power Monitoring on AC701 Board Supplies**

Advanced Bring-up with Base Targeted Reference Design

Introduction

Figure 14 depicts the block-level overview of the Artix-7 FPGA base Targeted Reference Design (TRD) which delivers up to 10 Gb/s of performance per direction.

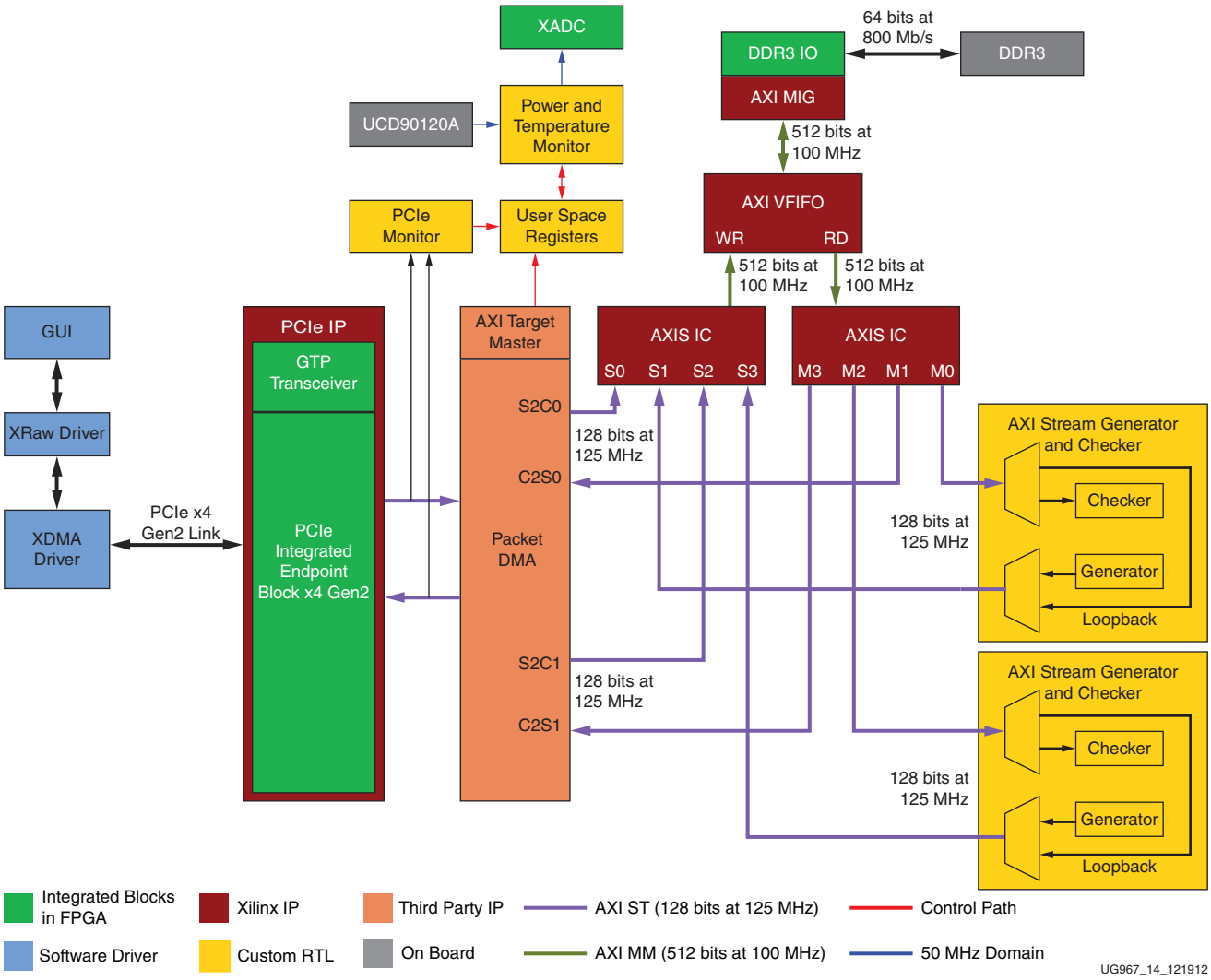

Figure 14: **Artix-7 FPGA Base TRD Block Diagram**

The intent of this design is to demonstrate a high performance data transfer system using the PCI Express® x4 GEN2 endpoint with a high performance scatter-gather packet DMA controller from NorthWest Logic and DDR3 64-bit SODIMM memory operating at 800 Mb/s.

The PCIe® endpoint and DMA controller together are responsible for the movement of data between a PC and an FPGA. S2C implies data movement from a PC to an FPGA and C2S implies data movement from an FPGA to a PC. A DDR3 SDRAM (64-bit, 800 Mb/s or 400 MHz) is used for packet buffering — a virtual FIFO layer facilitates the use of DDR3 memory as multiple FIFOs. Additionally, the design provides power monitoring capability based on a PicoBlaze™ embedded processor.

For software, the design provides 32-bit Linux drivers targeting the Fedora 16 platform and a graphical user interface (GUI) which controls the tests and monitors the status.

Features

Base Features

This section lists the features of the Targeted Reference Design.

- PCI Express v2.1 compliant x4 endpoint operating at 5Gb/s/lane/direction
  - PCIe transaction interface utilization monitor
  - MSI & Legacy interrupt support
- Bus Mastering Scatter-gather DMA
  - Multi-channel DMA
  - AXI4-Stream interface for data
  - AXI4 interface for register space access
  - DMA performance monitor
  - Full duplex operation
    - Independent transmit and receive channels
- Virtual FIFO layer over DDR3 memory
  - Provides 4 channel design (4 FIFOs in DDR3 SODIMM)

Application Features

- PicoBlaze processor-based PVT Monitoring
  - Built-in hardware to monitor power by reading the TI UCD90120A power controller chip included on the AC701 evaluation board
  - Built-in hardware to monitor die temperature by way of a Xilinx Analog-to-Digital Converter

Test Setup Requirements

The prerequisites for testing the design in hardware are

- AC701 evaluation board with XC7A200T-2-FBG676 FPGA
- Design consisting of:
  - Design source files
  - Device driver files
  - FPGA programming files
  - Documentation
- Vivado™ Design Edition v2012.4
- Micro USB cable
- Fedora 16 LiveDVD
- A PC with PCIe v2.1 compliant slot. For a complete list of recommended machines, and all known issues, refer to the Artix-7 FPGA Base Targeted Reference Design Release Notes and Known Issues Master Answer Record at http://www.xilinx.com/support/answers/53372.htm.

  Note: The PC could also have Fedora 16 Linux OS installed.

Hardware Demonstration Setup

This section details the hardware setup and use of the provided control and monitoring application and GUI to assist in getting started quickly with the hardware. Step-by-step explanations are provided on hardware bring-up, software bring-up, and the use of the application GUI.

Board Setup

This section details how to set up the AC701 evaluation board as required for demonstrating the TRD.

Setting the AC701 jumpers and switches

1. Verify the switch and jumper settings are as shown in Table 3, Table 4, and Figure 15.

Table 3: **AC701 Board Required Jumper Settings**

Jumper	Function	Setting
J12	PCIe endpoint configuration width; 4-lane design	3-4

Table 4: **AC701 Board Required Switch Settings**

Switch	Function/Type		Setting
SW15	Board power slide-switch		off
SW2	User GPIO DIP switch		
	4		off
	3		off
	2		off
	1		off
SW1	Positions 1, 2, and 3 set configuration mode		
	3	001 – Master SPI 101 – JTAG	on
	2		off
	1		off

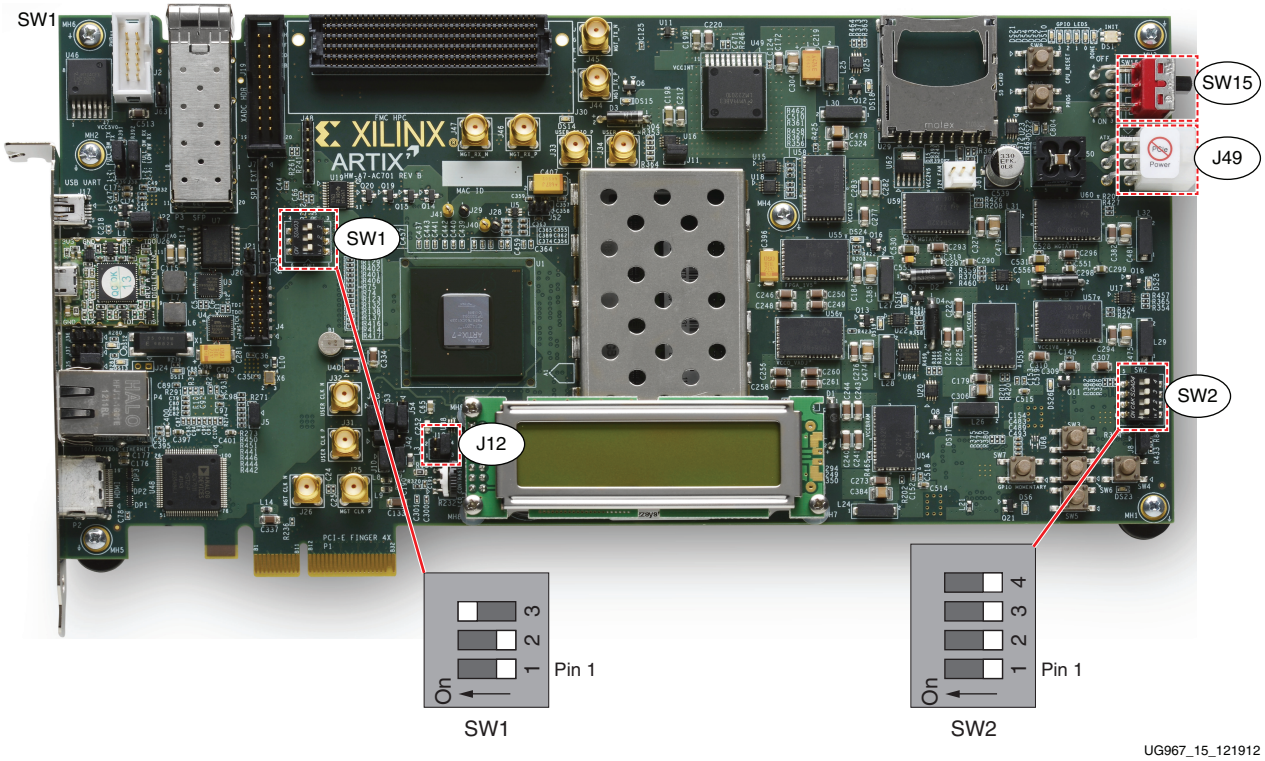

Figure 15: **AC701 Board Switch and Jumper Locations**

Hardware Bring up

All procedures listed in the following sections require super-user access on a Linux PC. When using the Fedora 16 LiveDVD provided with the kit, super-user access is granted by default due to the manner in which the kernel image is built; If not using the LiveDVD, it is important to ensure that super-user access is granted.

1. With the host PC powered off, insert the AC701 board into the selected PCIe x4 (or wider) edge connector (see Figure 16). The PCI Express specification allows for a smaller lane width endpoint to be installed into a larger lane width PCIe connector.

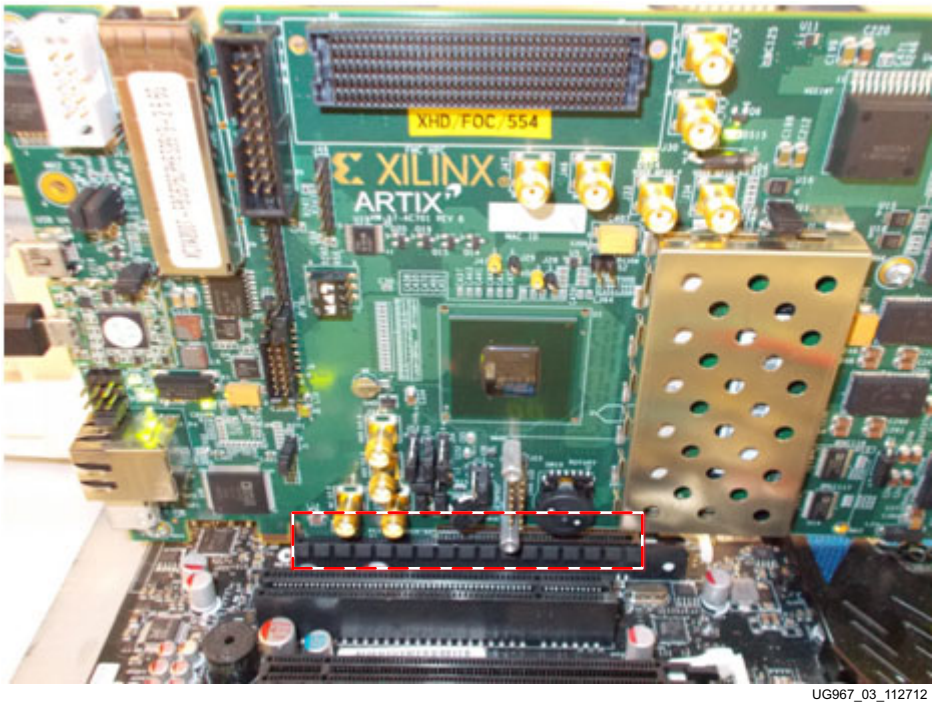

Figure 16: **AC701 Board Installed in a PCIe x16 Connector**

2. Connect the 12V ATX power supply 4-pin connector to the board as shown in Figure 17.

   Note: A 6-pin ATX supply cannot be connected directly to the AC701 board; A 4-pin adapter is necessary in this instance.

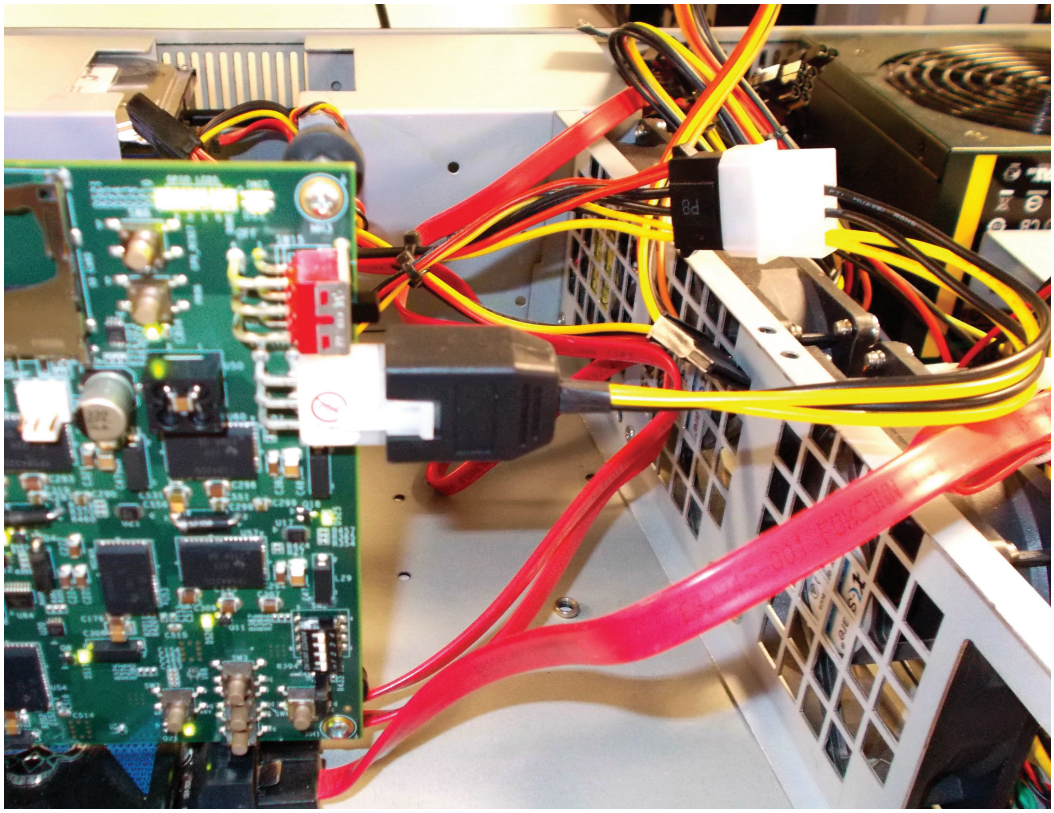

Figure 17: **Power Supply Connection**

3. To avoid loose contact issues, make sure the connections are secure. Turn ON the SW15 switch and then apply power to the system.

4. Check the status of the design using the AC701 board LEDs. The design provides status with the GPIO LEDs located on the upper right portion of the AC701 board. When the PC is powered on and the TRD has successfully configured, the LED status from left to right indicates:
   - **LED position 1**: ON if DDR3 is calibrated
   - **LED position 2**: Heart beat LED, flashes if PCIe user clock is present
   - **LED position 3**: ON if the lane width is x4, else flashing
   - **LED position 4**: ON if the PCIe link is up

   Figure 18 shows the location of the status LEDs.

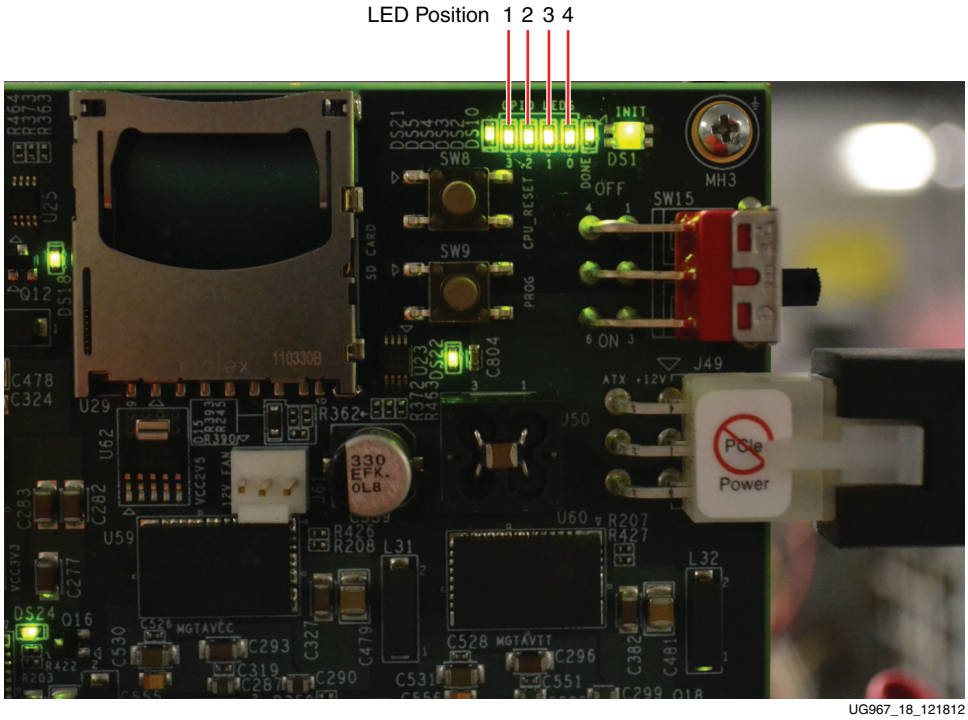

Figure 18: **GPIO LEDs Indicating TRD Status**

Linux Driver Installation

The following sections describe installing the device drivers for the Artix-7 FPGA base TRD after completion of the prior steps.

1. If the Fedora 16 Linux OS is currently installed on the PC, boot as a root-privileged user and skip to step 4.
2. To boot from the Fedora 16 LiveDVD provided in the kit, place the DVD in the PC DVD-ROM drive. The Fedora 16 Live Media is for Intel-compatible PCs. The DVD contains a complete, bootable 32-bit Fedora 16 environment with the proper packages installed