Zynq®-7000 All Programmable SoC / AD9361 Software-Defined Radio Evaluation Kit Getting Started Guide

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Contents

Avnet Design Kit Technical Support Files and Downloads Web Access Instructions

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2 Introduction

The Zynq®-7000 All Programmable SoC / AD9361 Software-Defined Radio Evaluation Kit is based on the Avnet ZedBoard™ with Xilinx Zynq-7000 All Programmable (AP) SoC. The kit features the Analog Devices AD-FMCOMMS2-EBZ FMC module, with AD9361 integrated RF Agile Transceiver. Tuned to a narrower RF range in the 2400 – 2500 MHz region, the kit is ideal for the RF engineer seeking optimized system performance meeting datasheet specifications in a defined range of RF spectrum.

This Getting Started Guide will proceed through the steps to setup the Zynq-7000 AP SoC / AD9361 Software- Defined Radio Evaluation Kit and run the out-of-box demonstration.

2.1 What's Inside the Box

- Avnet ZedBoard 7020 baseboard
  - Zynq-7000 SoC XC7Z020-CLG484-1
  - 512 MB DDR3
  - 256 Mb Spansion® Quad-SPI Flash
  - Onboard USB-JTAG Programming
  - 10/100/1000 Ethernet
  - USB OTG 2.0 and USB-UART
  - FMC expansion (low pin count)
  - Multiple displays (Analog Devices ADV7511 1080p HDMI, 12-bit VGA, 128 x 32 OLED)
- Analog Devices AD-FMCOMMS2-EBZ high-speed analog FMC Module
  - Software tunable across wide frequency range (70 MHz to 6.0 GHz)
  - Factory-tuned for optimal RF performance at 2400 – 2500 MHz1
  - Programmable channel bandwidth at the ADC inputs ranging from <200 kHz to 56 MHz
  - RF section bypass for baseband sampling
  - Phase and frequency synchronization on both transmit and receive paths
  - Powered from single FMC connector
  - Supports MIMO radio, with less than 1 sample sync on both ADC and DAC
  - Includes schematics, layout, BOM, HDL, Linux drivers and application software
  - Supports add on cards for spectrum specific designs (PA, LNA, etc.)
- 8 GB SD card,factory-programmed
  - FAT32 partition: bootloader, devicetree blob and kernel image for system boot to UBUNTU Linux
  - EXT4 partition Linaro Ubuntu ARM root file system, Analog Devices IIO Oscilloscope
- Four Pulse 4G LTE blade antennas, SMA mount
- Micro USB cable
- USB dongle (male micro-B to female standard-A)
- Xilinx Vivado® Design Edition (device locked to XC7Z020)
- Documentation
  - Getting Started with the Zynq-7000 AP SoC / AD9361 Software-Defined Radio Evaluation Kit

[1]Getting Started with the Zynq-7000 AP SoC / AD9361 Software-Defined Radio Evaluation Kit

3 Getting Started with Zynq Software-Defined Radio

The Zynq-7000 All Programmable SoC / AD9361 Software-Defined Radio Evaluation Kit comes with a 'Getting Started' demonstration design flashed onto the SD card, which enables a single-board computer on the Avnet ZedBoard running UBUNTU desktop Linux. The system includes programmable logic-based interfaces and ARM- based Linux drivers for the Analog Devices AD9361 integrated RF Agile Transceiver on the FMC module.

Two example waveforms are shown in a transmit □receive loopback of the RF signal:

- A pair of single tones generated in the digital domain by a programmable logic-based direct digital synthesizer (DDS);
- Pre-defined waveforms from data files stored in the filesystem within the SD card.

The digital signals are driven from the Zynq SoC to the dual-DAC within the AD9361 to produce a complex analog I&Q output, then mixed with an adjustable frequency RF carrier through the quadrature modulator. The resulting RF signal is transmitted over the air through the TX-side antenna and captured at the receiver. The incoming RF signal is converted to baseband through the quadrature de-modulator, digitized through the ADC and sent to the Zynq SoC. It may be displayed in the ADI 'IIO oscilloscope' Linux application, in the time or frequency domain.

3.1 Overview of the 'Getting Started' Reference Design

The design illustrates the following capabilities of the Zynq / Analog Devices Software-Defined Radio Kit:

- Driving the 12-bit dual-DAC within the AD9361 with a programmable logic-based digital signal
- Complex mixing of baseband signal and RF local oscillator through the quadrature modulator within the AD9361
- Complex mixing to baseband of the received RF signal through the quadrature de-modulator within the AD9361
- Sampling the baseband signal at 30.72 MSPS through 12-bit dual-ADC within the AD9361
- Driving Linux-generated video content on the Analog Devices ADV7511 HDMI output interface

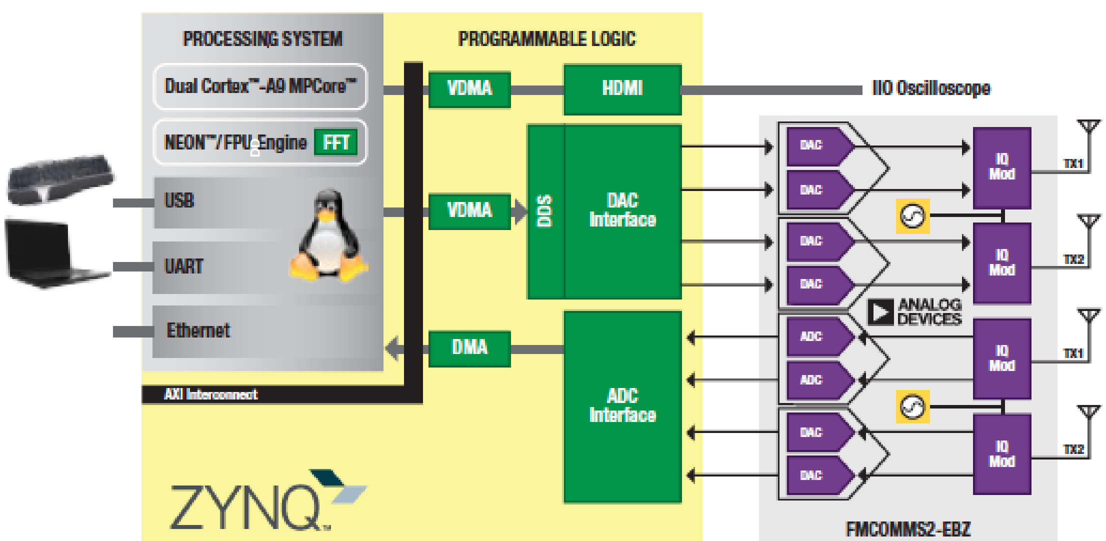

Figure 1: Zynq Software-Defined Radio Reference Design - Simplified Block Diagram

3.2 Demo Preparations

a. Insert the SD Card into the ZedBoard. The 8 GB SD card is factory-programmed with the Zynq firmware, Linux kernel image, user-space application software and filesystem for a stand-alone bootable system.

Figure 2: Insert the SD Card

b. **IMPORTANT:** Set the FMC IO voltage jumper to 2.5 V to avoid any damage to the AD-FMCOMMS2-EBZ.

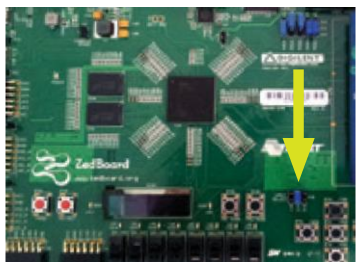

Figure 3: Setting FMC IO Voltage to 2.5 V

c. Set the boot-mode jumpers to boot from the SD card:

Figure 4: Setting boot-mode jumpers to boot from the SD card

3.3 Demo Requirements

Accessories required for this demonstration, which are not included in the kit:

- HDMI monitor
- USB mouse
- USB keyboard and USB hub (optional if you wish to type in any numeric values)

3.4 Assembling the Hardware

1. Assemble as shown below:
    a. ZedBoard
    b. Analog Devices AD-FMCOMMS2-EBZ
    c. Antennas
    d. USB dongle (male micro-B to female standard-A)
    e. HDMI cable to display
    f. 12 V power supply

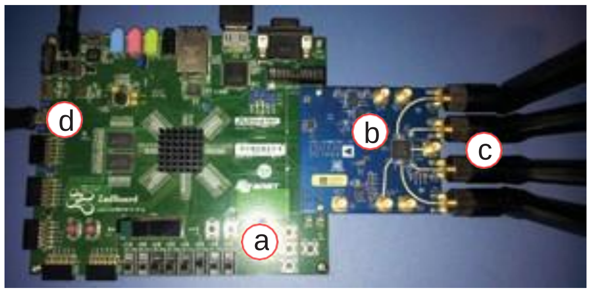

Figure 5: Assembling the hardware for 'Getting Started Demo'

2. Connect an HDMI monitor. You may also use a DVI monitor with an HDMI to DVI-D adapter.
3. Connect a USB mouse. Optionally, you may also connect a USB keyboard through a USB hub.
4. Power up ZedBoard by turning the baseboard slider power switch ON.

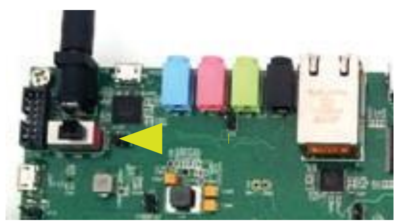

Figure 6: Apply power to ZedBoard

3.5 Getting Started with Zynq Software Defined Radio

1. After a delay of approximately 45 seconds from power-on, while the bitstream is loaded from the SD card to configure the programmable logic and Linux boots on the ARM9 processor within the Zynq processing system, the UBUNTU desktop should appear and Analog Devices IIO oscilloscope application will launch.

2. Configure the following parameters in IIO Oscilloscope, leaving all others at their default values:

    a. Capture tab

- Active channels: ‘in_voltage0’, de-delect the other channels
- Plot type: ‘Frequency Domain’
- FFT Average: 5

Figure 7: UBUNTU Desktop with Analog Devices IIO Oscilloscope

b. From FMComms2 tab, set the following parameters, leaving all others at their default values.
   - **TX LO Frequency** = 2400 MHz
     - Check that TX and RX LO frequencies match
   - **Save settings**

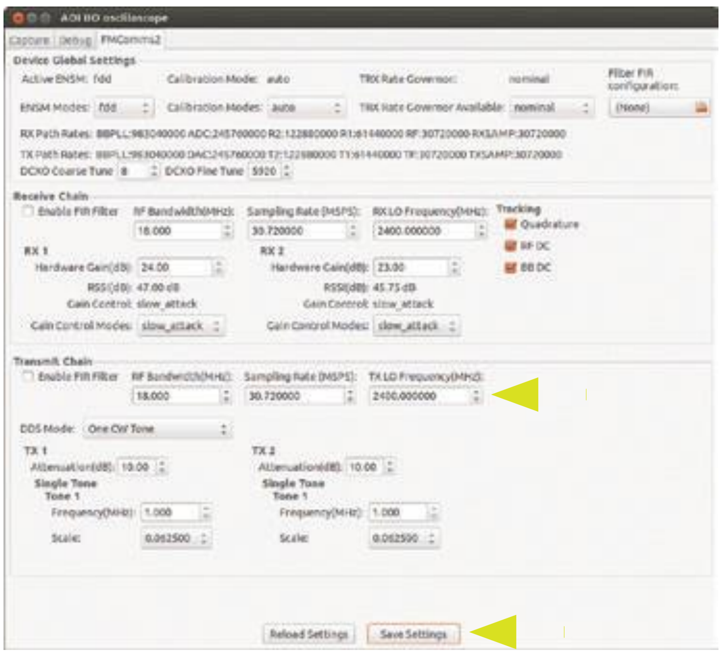

Figure 8: Setting parameters in IIO Oscilloscope

c. From the **Capture** tab, click ‘capture’ (triangle icon) to start data acquisition.
   – There are actually 2 tones of same frequency, generated by TX1 and TX2.

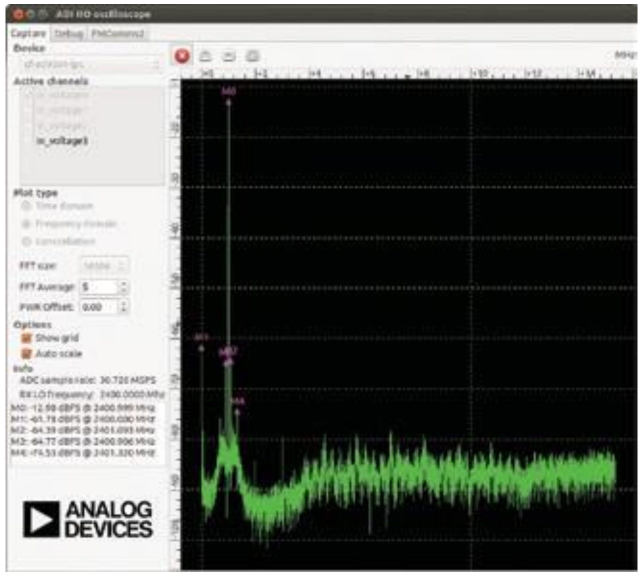

Figure 9: Spectrum of Incoming ADC data

d. Stop data capture and select the **FMComms2** tab.

   – Change the output frequency generated by TX2. (show signal chain BD)
   – Click **Save Settings**

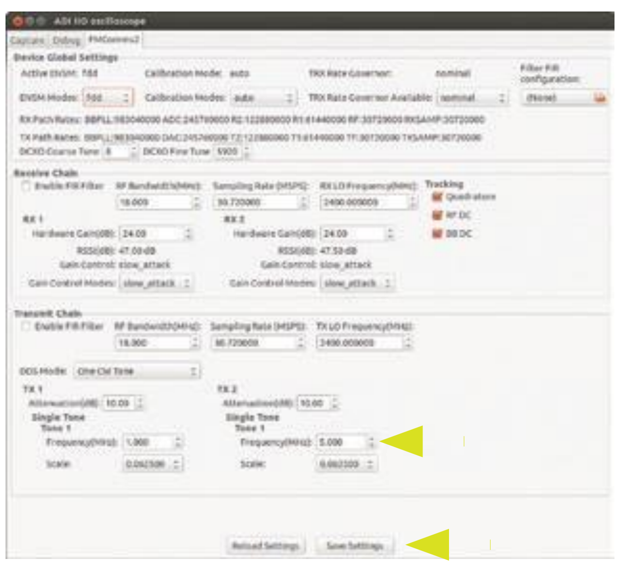

Figure 10: Changing DDS Output Frequency

e. Return to the **Capture** tab. Click the triangle icon to start data acquisition.

   – Observe the 2 tones at different frequencies.

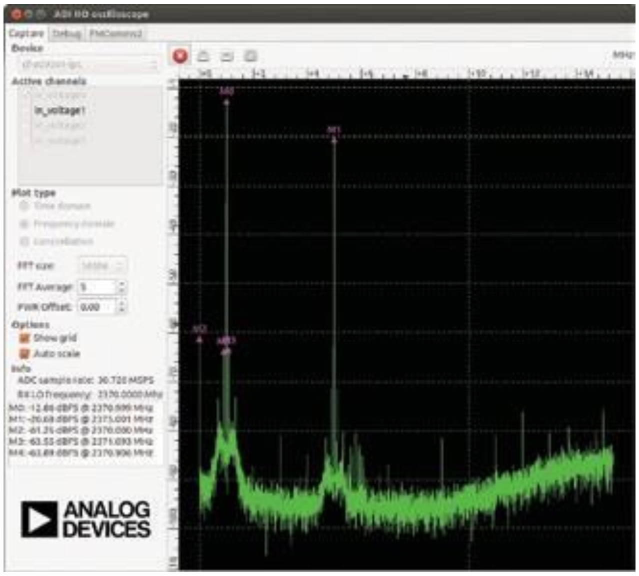

Figure 11: Tones at Different Frequencies

We now prepare to generate pre-defined waveforms from data files stored in the filesystem within the SD card.

f. Stop data capture and select the **FMComms2** tab.

   – For **TX1 DDS Mode**, select DAC Buffer Output

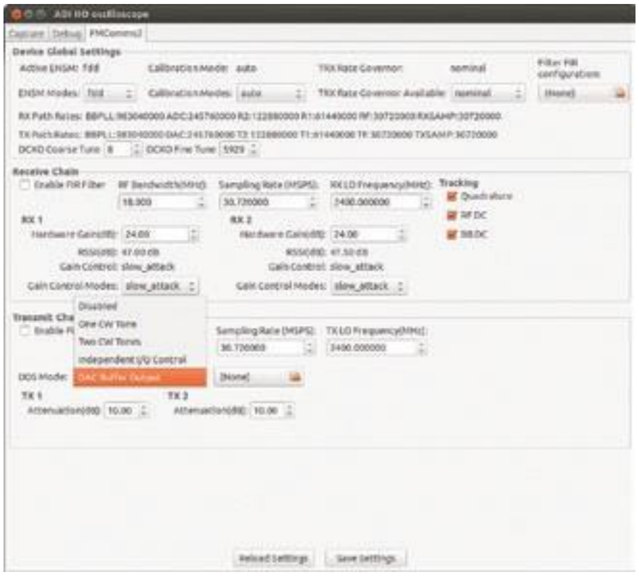

Figure 12: Generating Pre-defined Waveforms

g. From the adjacent pull-down menu:

   – From the waveforms folder, select the file ‘qpskwithfilt_30.72M.txt’
   – Click ‘Open’
   – Save settings

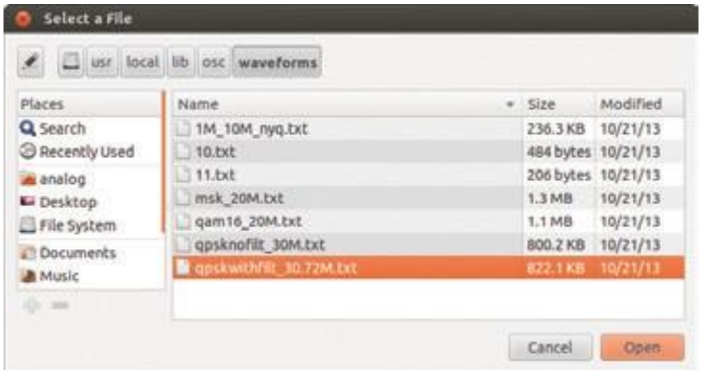

Figure 13: Selecting the Waveform Data File

h. Return to the Capture tab.

   – **Active channels**: select ‘in_voltage0’ and ‘in_voltage1’
   – Click the triangle icon to start data acquisition
   – Observe the spectral content of the QPSK signal (real part only)

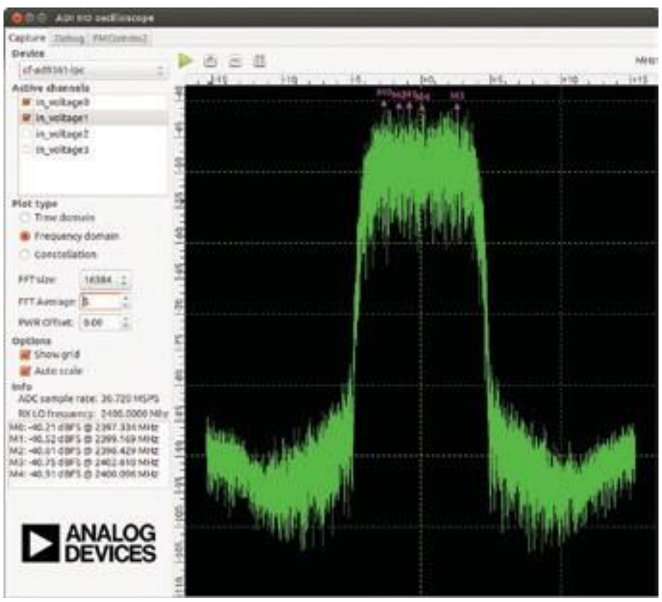

Figure 14: Spectral Content of the QPSK Signal (real part only)

This concludes the Getting Started demonstration.

Congratulations!

You have now run the Getting Started demonstration with the Zynq-7000 AP SoC / AD9361 Software-Defined Radio Evaluation Kit. Using this fully functional framework with embedded LINUX, you may now develop your wireless communications applications.

4 Restoring the SD Card image

During the course of development, should the 8 GB SD card become corrupted or otherwise need to be restored to a known good state, the directions below will restore the Zynq-7000 AP SoC / AD9361 Software-Defined Radio Evaluation Kit SD card to the factory state.

These steps will overwrite the contents of the SD card, so be certain that there is no existing data that needs to be retrieved from the SD card prior to following these steps.

The following directions were performed on a Windows 7 Professional machine, but the commands should work in a similar manner with later versions of Windows.

1. Download the image archive from ZedBoard.org. The instructions in this document assume that the archive is downloaded to a temporary folder which on this example system is under the C:\ADI\ directory. http://www.zedboard.org/product/zynq-sdr-ii-eval
2. Power down ZedBoard and remove the 8 GB SD card. Insert the SD card into the Windows PC.
   Note: The provided image file is a byte-for-byte copy of an 8 GB SD card. Ensure the size of your target SD card is an 8 GB device.
3. Open a Windows Command Prompt session with Administrator privileges by right clicking the **Start□Accessories□Command Prompt** menu item and selecting the **Run as administrator** option.

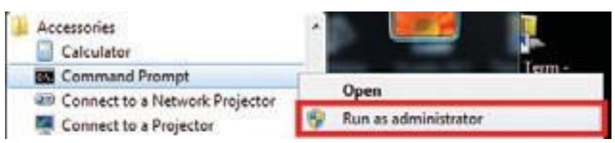

Figure 15: Opening the Windows Command Prompt with Administrator Privileges

4. If multiple partitions exist on the SD card, each of the partitions should be removed using the diskpart utility. This will enable the entire SD card block range to be utilized for writing the image. Launch the diskpart tool from the Windows Command Prompt.

Figure 16: Launching Microsoft DiskPart

5. Discover the disk number of the SD card device by using the list disk DiskPart command. In this example, the SD card device is enumerated as the Disk 1 device.

```
DISKPART> list disk
```

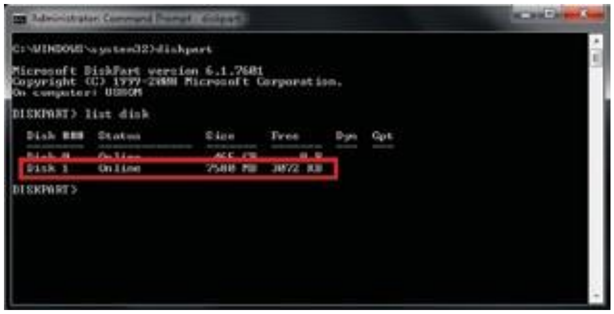

Figure 17: Listing the Enumerated Disk Devices

6. Select the disk listing that matches the SD card device using the select disk DiskPart command. In this example, the SD card device is enumerated as the Disk 1 device. If the SD card is listed as a different disk on your system, be sure to substitute the appropriate value here.

   WARNING: Selecting the incorrect disk at this point can corrupt critical data on your local machine, be sure to check that the selected disk value is the intended device.

```
DISKPART> select disk 1
```

7. List the partitions on the currently selected SD card using the list partition DiskPart command.

Figure 18: Listing the Partitions on the Selected SD Card

8. Remove the partitions from the currently selected SD card using the clean DiskPart command.

```
DISKPART> clean
```

9. Exit the DiskPart tool.

```
DISKPART> exit
```

10. Extract the image contents of the archive obtained from Step 1 above using an **xz** compatible utility such as 7-Zip.

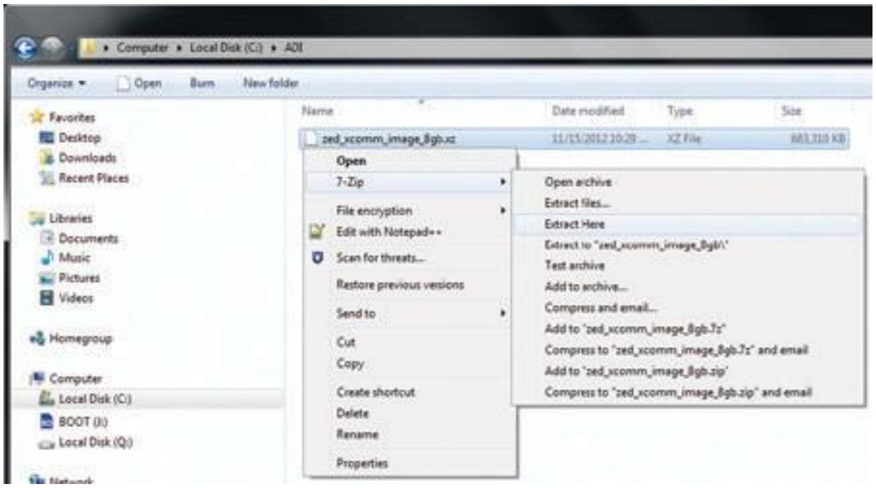

Figure 19: Extracting the Archived Image

11. Launch a disk imaging utility such as Win32 Disk Imager. Click on the folder icon adjacent to the Image File entry box and set the Save as type filter option to *.* in order to make the all file extensions visible.

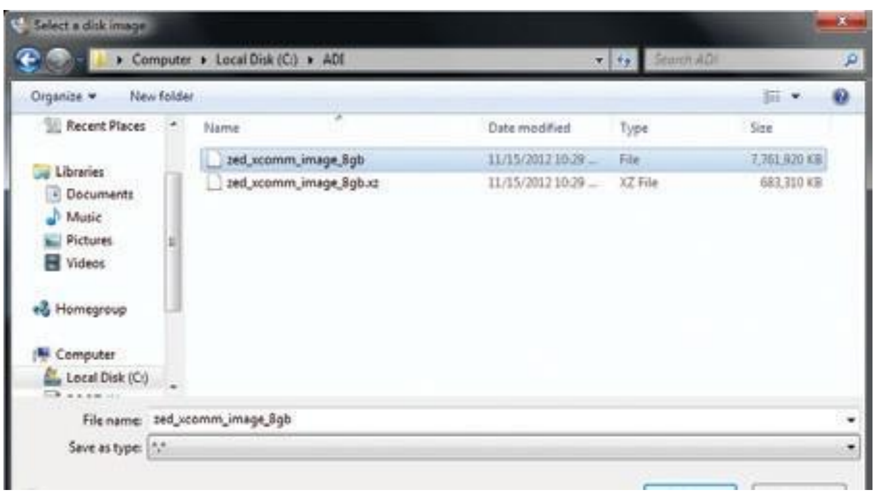

Figure 20: Selecting the Source Image File

12. Select the source image file **zed_fmcomms2_image_8gb** as well as the target drive device. In this example, the image is located in the **C:\ADI** folder and the target SD card is assigned to the J:\ drive.

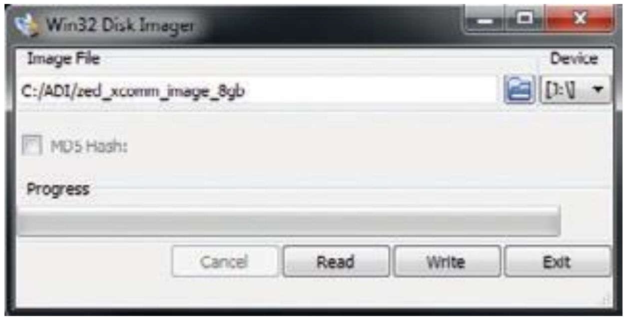

Figure 21: Source Image File Selected

13. (Optional) Verify the integrity of the extracted image file using the Win32 Disk Imager MD5 Hash tool by clicking on the checkbox option. The checksum calculation make take a few minutes. The result from the MD5 Hash tool should match the string bb4c6f92a1731eab79b53e5068a98019. If the checksums do not match, the firmware

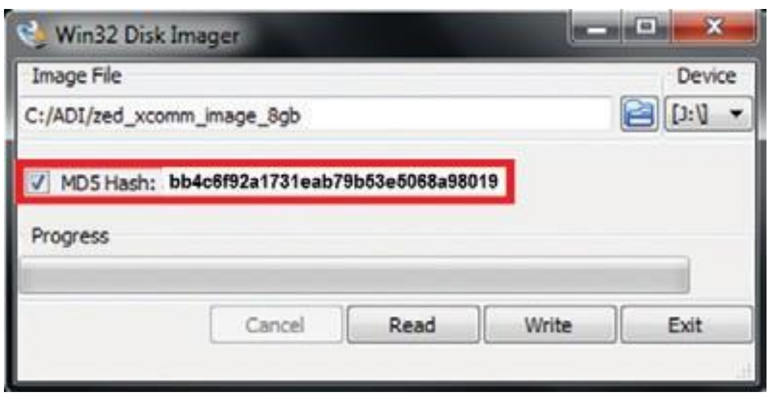

image is corrupt or out of date.2

Figure 22: Verifying Image File Integrity via MD5 Hash

14. Click the Write button to begin writing the source image file contents to the SD card. The SD imaging process can take around 20 to 30 minutes to complete.

[2] Note: checksum current at the time of writing (Nov 2013). For updates consult http://www.zedboard.org/product/zynq-sdr-ii-eval

15. Use Windows “safely remove” to eject the SD card.

Figure 23: Windows “safely remove” to eject the SD card

16. Replace the re-imaged SD card into ZedBoard. The Zynq-7000 SoC / AD9361 Software-Defined Radio Evaluation Kit is ready for operation with the latest SD card image.

Figure 24: Insert the re-imaged SD card into ZedBoard

This concludes the procedure of re-imaging the SD card.

5 Additional Documentation and Support

To access the most current collateral for the Zynq-7000 SoC / AD9361 Software-Defined Radio Evaluation Kit please visit the product website:

http://www.zedboard.org/product/zynq-sdr-ii-eval

http://www.em.avnet.com/adizynqsdr2

To access the Avnet Technical Community Forums, please visit the following web page:
http://www.zedboard.org/support

To order stand-alone AD-FMCOMMS2-EBZ high-speed analog module:
http://www.em.avnet.com/fmcomms2

Analog Devices AD-FMCOMMS2-EBZ high-speed analog module user guide and wiki:
http://wiki.analog.com/resources/eval/user-guides/ad-fmcomms2-ebz

Analog Devices AD9361 datasheet:
http://www.analog.com/AD9361_design_files

To search the Xilinx database of silicon and software questions and answers or to create a technical support case in WebCase, see the Xilinx website:
http://www.xilinx.com/support

6 Next Steps

Ensure Xilinx ISE Design Suite Embedded Edition 14.4 or later is installed on your computer. A voucher for licensing the Xilinx software is included with this kit. For technical support, including the installation and use of a product license file, contact Xilinx Online Technical Support at http://www.support.xilinx.com

Download Zynq embedded system source files for this Getting Started demonstration design as a starting point for your system customization.[3]

http://wiki.analog.com/resources/eval/user-guides/ad-fmcomms2-ebz/reference_hdl

Consult the Zynq-7000 SoC / AD9361 Software-Defined Radio Evaluation Kit product website for notification of technical training.

- http://www.zedboard.org/product/zynq-sdr-ii-eval
- http://www.em.avnet.com/adizynqsdr

[3]Zynq embedded system source files are available for subsequent customization of the reference design, but are not required to run this Getting Started demonstration. The system is stand-alone bootable from the SD card provided with the kit, which includes the bitstream within the BOOT.BIN file in the FAT32 partition.