



PicoZed™ SDR Development Kit Getting Started Guide

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1.0	9/29/2015	First release
1.1	1/16/2016	Added section 'Restoring the SD Card image'
1.2	3/2/2016	Added "Demo Setup" section; Updated Figures 2, 3, and 6
1.3	7/14/2016	Added Live data streaming to MATLAB and Simulink
1.4	11/15/2016	Updated Appendix A to 'make' under CYGWIN

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1 Getting Started with PicoZed SDR Development Kit

The PicoZed™ SDR Development Kit bundles everything required to start your software-defined radio (SDR) design. The kit includes the low-power, small footprint, rugged PicoZed SDR 2X2 system-on-module (SOM) and a carrier card for prototyping with standard high bandwidth interfaces like USB, Gigabit Ethernet, SFP+, and RF power modules. The carrier also includes HDMI, audio, FMC expansion and a camera module interface to enable a host of new SDR applications requiring audio/video and embedded vision.

Data acquisition is managed under Ubuntu Linux running on the dual ARM-9 processor within the Zynq SoC, supporting fast data exchange over Ethernet to MATLAB® and Simulink®. Open source reference design source code can be downloaded and reused in your design. Also included are the cables, power supplies, and software required to use the kit immediately for software development and application prototype. Supported by robust simulation and code generation tools that integrate seamlessly with Xilinx Vivado® Design Suite, PicoZed SDR enables dramatic reduction in design cycles of your software-defined radio products.



Figure 1 – PicoZed SDR Development Kit
(shown with RF Personality Module – optional)

This *Getting Started Guide* will outline the steps to setup the PicoZed SDR Development Kit, and perform data acquisition for visualization of signals in the time and frequency domains.

2 What's Inside the Box?



Figure 2 – PicoZed SDR Development Kit Contents

2.1 PicoZed SDR Development Kit (AES-Z7PZ-SDR2-DEV-G)

- PicoZed SDR 2x2 SOM with Z-7035 and AD9361 (AES-Z7PZ-SDR2-G)
- PicoZed SDR FMC Carrier Card (AES-PZSDRCC-FMC-G)
- Pulse LTE/MIMO 2x2 antenna (WA700-2700)
- U.FL to SMA coax cables (4)
- Ethernet, HDMI, and USB cables
- 12V power supply
- microSD memory card
- JTAG HS3 High Speed Xilinx Programming Cable
- Schematics, BOM, HDL, Linux drivers and application software
- Quick Start Card

NOTE: An RF Module with PA/LNA is available as an option but not included within the kit:

[AD-PZSDR2400TDD-EB](#)
2.4GHz optimized RF power TX with LNA and TDD switch

3 What's on the Web?

3.1 Official Documentation:

- Available on <http://picozed.org/product/picozed-sdr-development-kit>
 - PicoZed SDR Development Kit Getting Started Guide (this document)
 - PicoZed SDR Hardware User Guide
 - Schematics (PDF format)
 - Bill of materials

Analog Devices AD9361 and AD9364 Integrated RF Agile Transceiver Design Resources
<http://www.analog.com/en/design-center/landing-pages/001/ad9361-ad9364-integ-rf-agile-transceiver-design-res.html>

3.2 Tutorials and Reference Designs:

Analog Devices HDL Reference Designs
<https://github.com/analogdevicesinc/hdl>

Analog Devices Reference Designs HDL User Guide
<http://wiki.analog.com/resources/fpga/docs/hdl>

AD9361 RF Transceiver and Support Ecosystem
<http://www.analog.com/en/education/education-library/videos/2753072929001.html>

4 PicoZed SDR Development Kit – Key Features

PicoZed SDR 2x2 SOM (AES-Z7PZ-SDR2-G) System-on-Module

- Fully-verified, low-power, system-on-module (SOM) ready for end-product deployment
- Supported by MATLAB® and Simulink® for data streaming and Zynq targeting
- Xilinx Zynq XC7Z035-2L FBG676I AP SoC
- 1GB DDR3 SDRAM
- 256Mb QSPI Flash
- microSD Card Interface
- 10/100/1000 Ethernet PHY
- USB 2.0 OTG ULPI PHY
- Analog Devices AD9361-BBCZ Integrated RF Agile Transceiver™
 - RF 2 × 2 transceiver with integrated 12-bit DACs and ADCs
 - Band: 70 MHz to 6.0 GHz
 - TDD and FDD operation
 - Tunable channel BW: <200 kHz to 56 MHz
 - Supports MIMO radio: < 1 sample sync on both ADC and DAC
 - Miniature RF connectors – 4 TX, 4 RX, 2 TX monitor

PicoZed SDR FMC Carrier Card (AES-PZSDRCC-FMC-G)

- 10/100/1000 Mbps Ethernet PHY and connector
- 10/100/1000 Mbps Ethernet connector
- USB2.0 OTG micro-USB Type AB connector
- SFP+ connector and cage
- 1 user GTX channel
- HDMI Output – AD7511 Transmitter
- Audio CODEC – ADAU1761
- Avnet Camera Module connector
- FMC (Low Pin Count; 1 GTX)
- 2 Pmod™ interfaces (1 PL; 1 PS)
- Standard SD card interface
- USB-to-UART
- PC4 JTAG configuration port
- Avnet RF Module (PA/LNA) connector (for optional AES-PZSDR-RFMOD-TDD-G)

Pulse LTE/MIMO 2x2 antenna (WA700-2700)

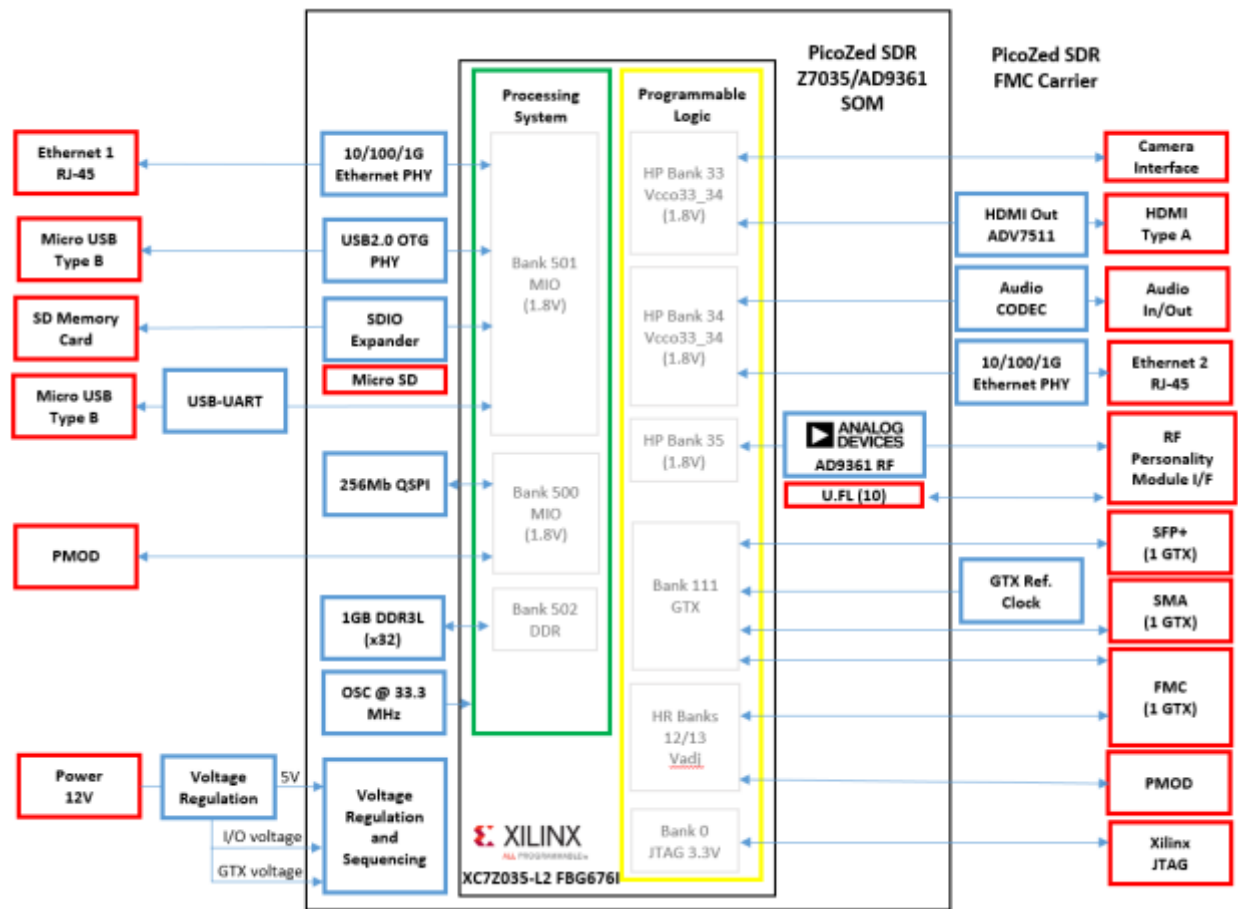


Figure 3 – PicoZed SDR Development Kit – Simplified Block Diagram

5 PicoZed SDR Development Kit Getting Started Design

The Getting Started design implements the data interfaces to/from the AD9361 RF transceiver through which baseband signals are mixed to RF for over-the-air loopback from transmitter to receiver. It provides visualization of time and frequency domains in Analog Devices IIO Oscilloscope, a Linux user-space application running on the processing system of the Zynq SoC. Data path and control signals between the AD9361 and Zynq SoC are shown below.

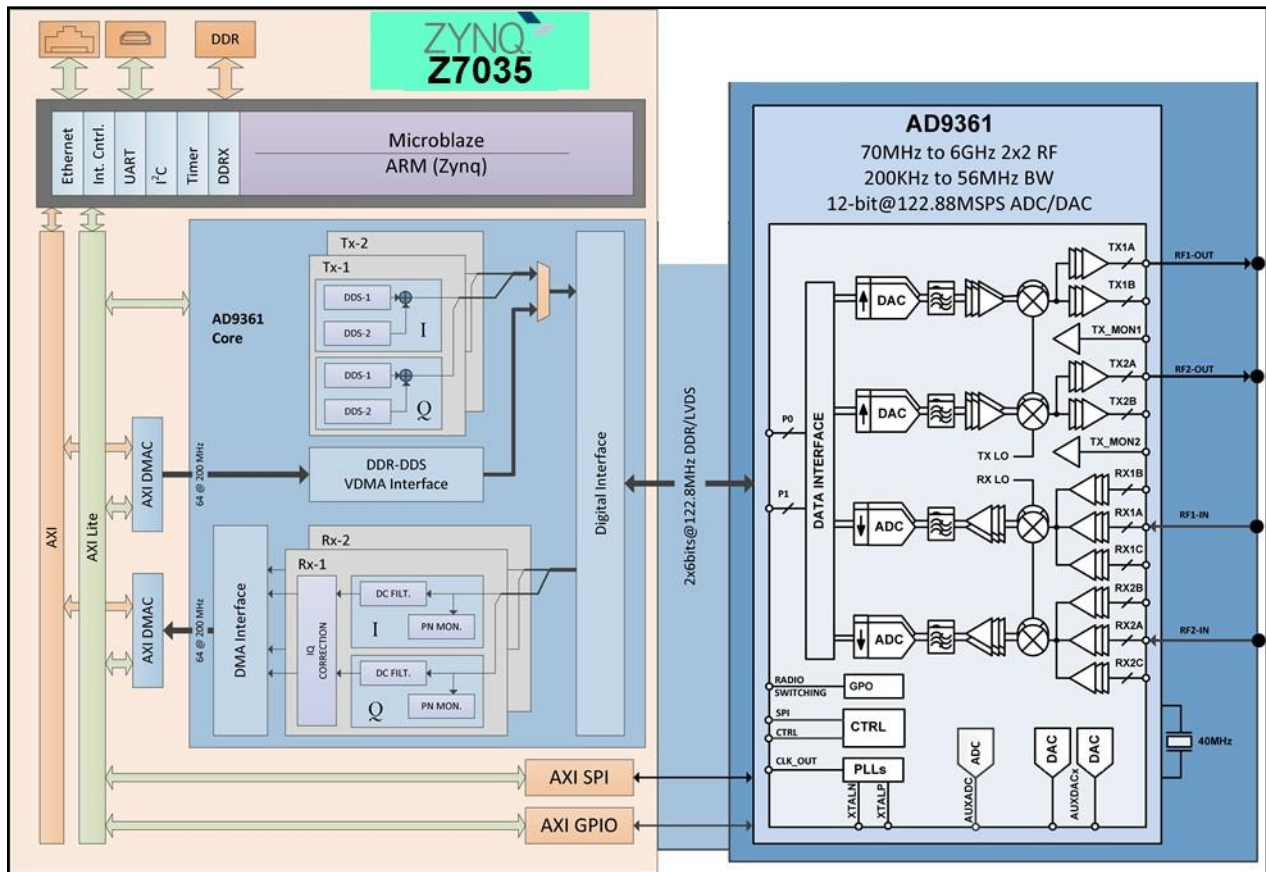


Figure 4 – PicoZed SDR HDL Reference Design

The following section will guide you through running the 'Getting Started' design on the PicoZed SDR Development Kit from pre-compiled configuration files included on the SD card that ships with the kit. Alternatively, for detailed instructions on re-building the design in the form of a complete Vivado project, see [Appendix A: Building the PicoZed SDR Getting Started Design](#).

6 PicoZed SDR Development Kit – Setup and Operation

In addition to the items included in the kit, you will also need the following to run the *Getting Started* design on your PicoZed SDR Development Kit.

- Ethernet router with DHCP server

An image of the PicoZed SDR Development Kit in its expected out-of-box configuration is shown below.

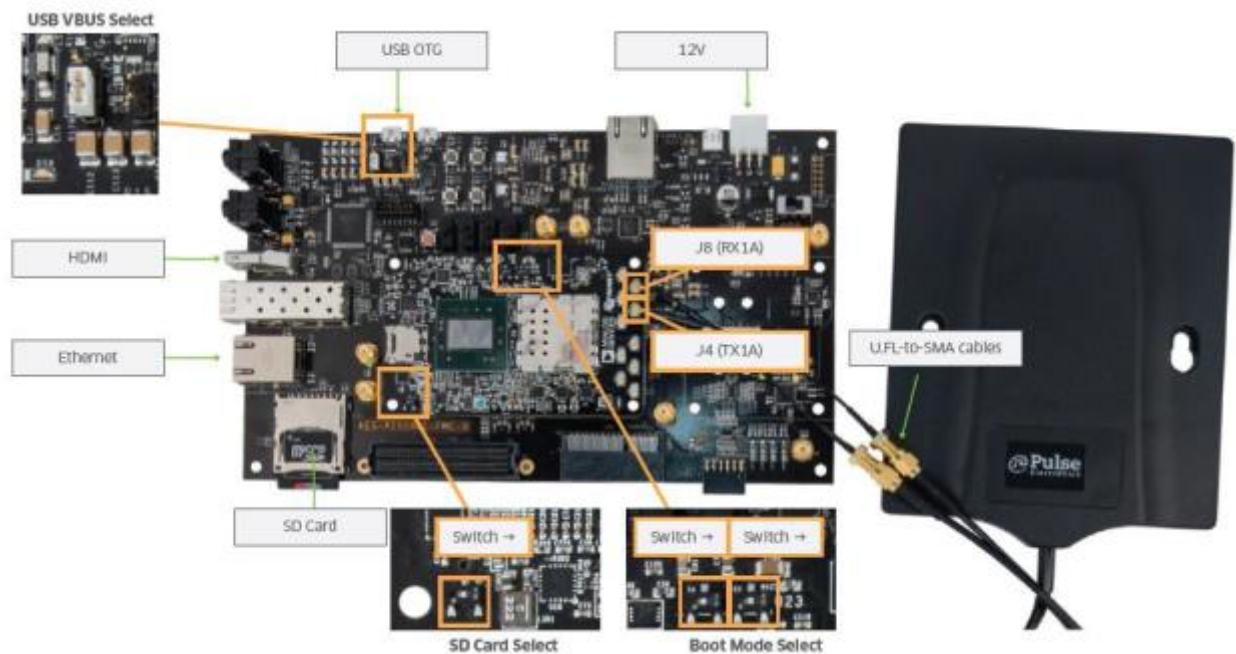


Figure 5 – PicoZed SDR Development Kit – Topology

6.1 Hardware Setup

1. Assemble the SOM and FMC Carrier boards as shown above.
2. Configure the FMC Carrier switches SW1, SW3, and SW4 as shown above.
3. Connect the included USB adapter to the USB OTG port and set the VBUS jumper as shown.
4. Attach the Pulse LTE/MIMO antenna to PicoZed SDR using the included U.FL-to-SMA cables, as shown above.
5. Connect a USB mouse and keyboard through a USB hub.
6. Provide an internet connection by attaching the Ethernet cable between the Ethernet 1 RJ45 connector on the carrier and a networked router with DHCP server.
7. Insert the SD card into the FMC Carrier.
8. Connect an HDMI monitor (resolution $\geq 720p$).
9. Connect the 12V power supply.

A functional block diagram of the system is shown below.

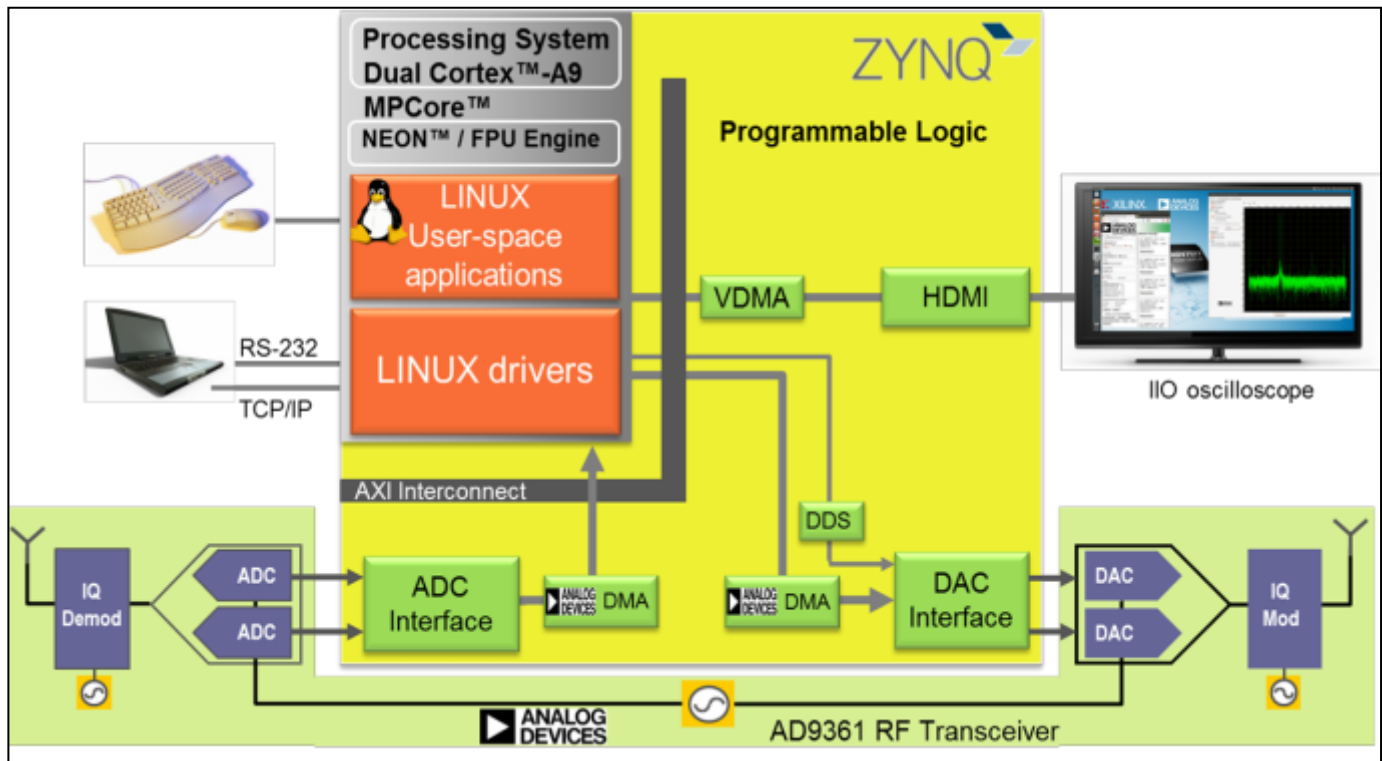


Figure 6 – System Block Diagram

6.2 Demo Setup

1. Insert the included micro SD Card into a laptop or PC.
2. Open the folder named zynq-picozed-sdr2-fmc
3. Copy files BOOT.BIN and devicetree.dtb into the SD card root directory.
4. Safely eject the microSD card and insert into the PicoZed SDR carrier using the SD adapter.

6.3 Running the Design

1. Turn the PicoZed SDR FMC Carrier power switch (S5) to ON.
2. Wait ~45 seconds for Linux to boot and display on your monitor.
3. Double-click the ADI Update Tools desktop icon to get the latest version of ADI Linux applications.

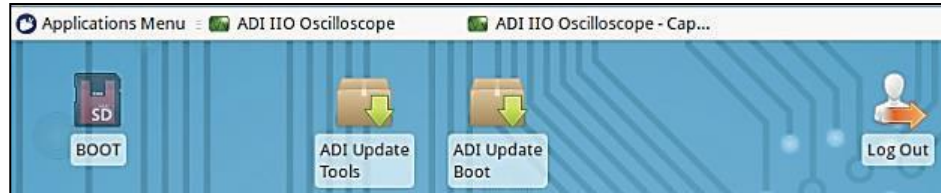


Figure 7 – ADI Update Utilities

4. Double-click the ADI Update Boot desktop icon to get the latest version of Zynq boot files.
5. Restart the system using the Log Out desktop icon.
6. Configure the following parameters in IIO Oscilloscope
 - a. FMComms2/3/4 tab → Controls
 - i. Set RX and TX LO Frequency = 2400 MHz
 - ii. Check that TX and RX LO frequencies match
 - iii. All other settings default
 - b. Capture window
 - i. Activate channel: 'voltage0', de-select the other channels
 - ii. Plot type: 'Frequency Domain'
 - iii. FFT Average: 5
 - iv. Click 'capture' (triangle icon) to start data acquisition

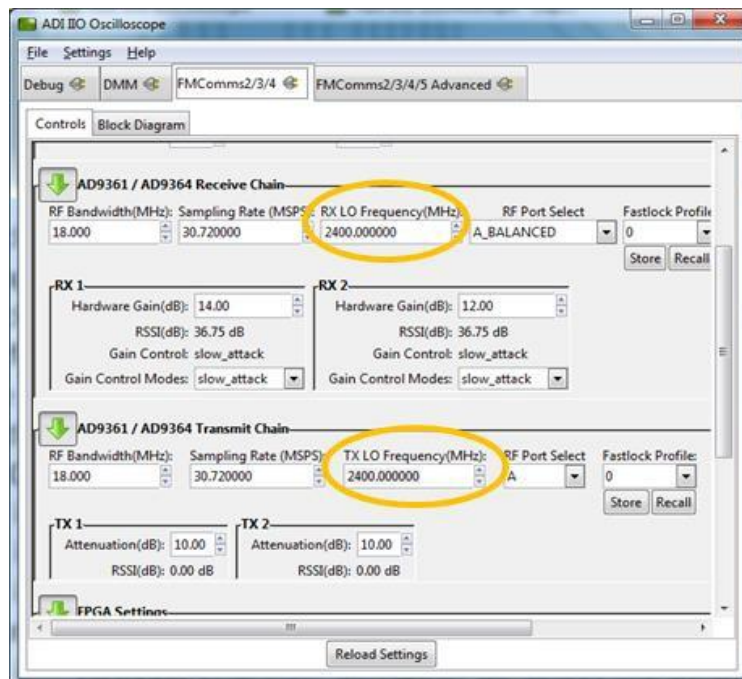


Figure 8 – Setting parameters in IIO Oscilloscope

7. Click on the “Capture” button at the top of the GUI to observe the frequency spectrum of the received AD9361 ADC data.

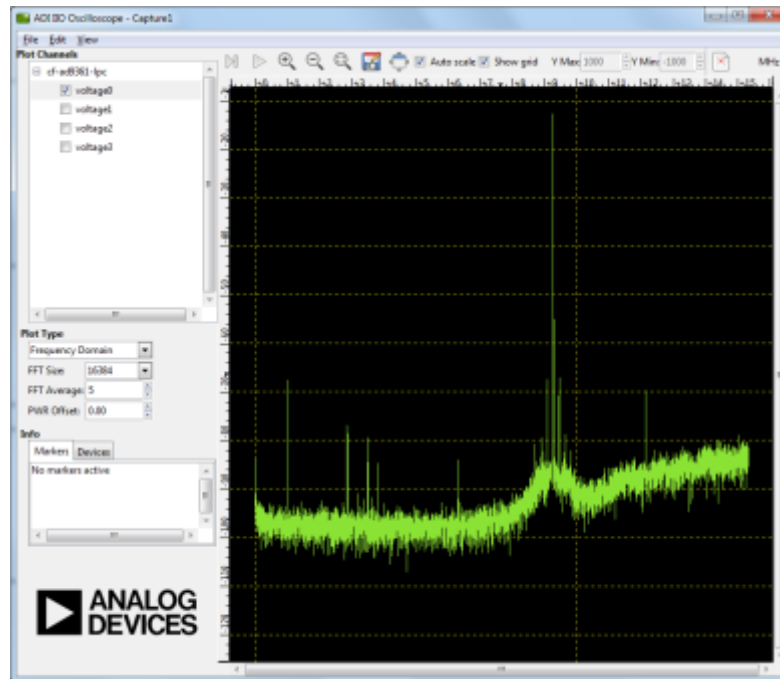


Figure 9 – Frequency spectrum in IIO Oscilloscope

6.4 Troubleshooting

1. If the system fails to boot to desktop Linux it may be useful to monitor the Linux boot process within the Zynq processing system through the serial port. Windows 7 does not come pre-installed with a terminal program. Tera Term was used in this example which can be downloaded from the Tera Term project on the SourceForge Japan page: ttssh2.sourceforge.jp Install Tera Term or another terminal program of your choice.
2. On the PC, open a serial terminal program. Tera Term is used to show the example output for this lab document. You may need to specify a PC COM port number that you discover on your own machine.

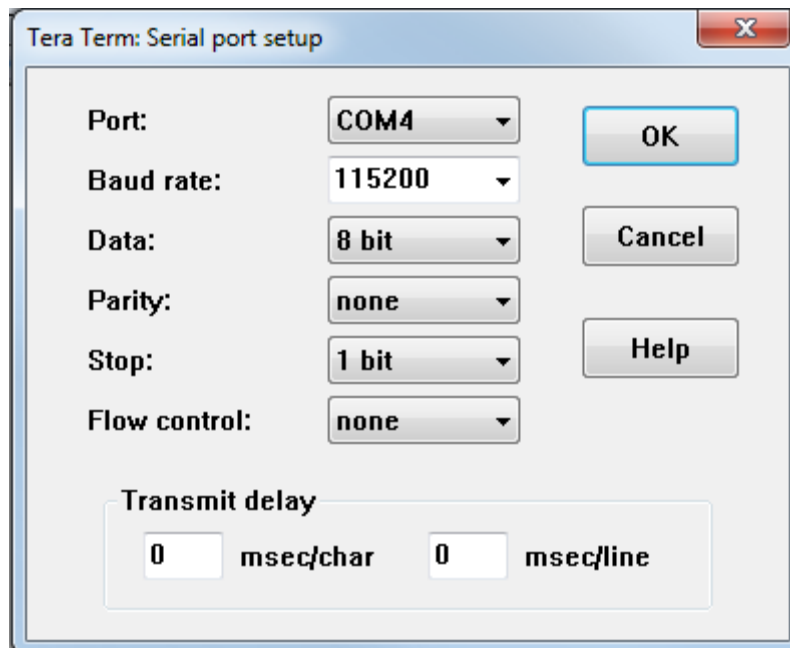


Figure 10 – Connect Tera Term to the proper COMx port

3. In the terminal window Linux will boot on the ARM Cortex A9 and the DHCP server within the router should assign an IP address. At the login prompt, login as `root` with password `analog` and type `ifconfig`. Note the IP address.
4. Report issues to <http://picozed.org/forums/picozed-sdr-software-defined-radio>

This completes the Getting Started design for PicoZed SDR Development Kit.

7 Live data streaming to MATLAB and Simulink

PicoZed SDR is supported within Communications System Toolbox™ Support Package for Xilinx® Zynq®-Based Radio from MathWorks. With the support package, you can use PicoZed SDR as a standalone peripheral for live RF data I/O to Simulink models, also known as radio-in-the-loop. When paired with HDL Coder™, customize the algorithms running on the FPGA hardware using HDL code generation and Vivado project creation.

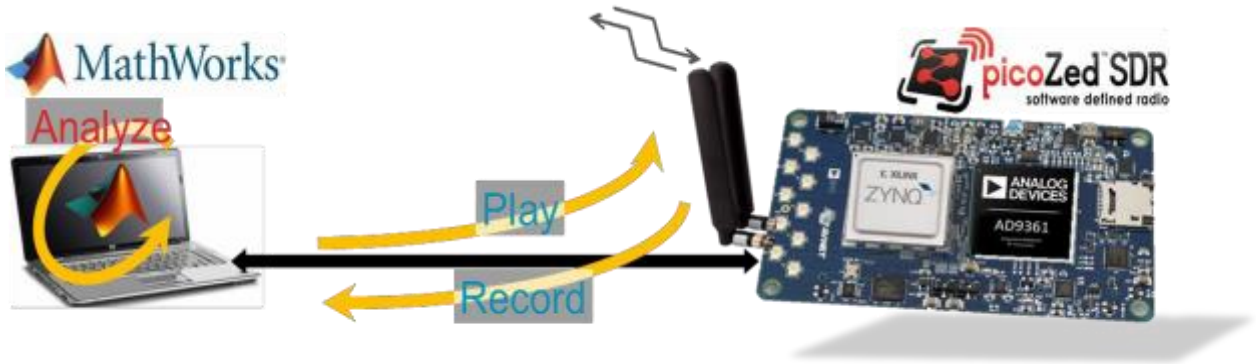


Figure 11 – Radio-in-the-Loop / live data streaming to MATLAB and Simulink

NOTE: PicoZed SDR Development Kit ships with an SD card containing HDL and Linux image from Analog Devices. For data streaming to MATLAB and Simulink you must re-image a fresh SD card

<http://www.mathworks.com/help/supportpkg/xilinxzynqbasedradio/index.html>

8 Getting Help and Support

8.1 Avnet Support

PicoZed SDR Development Kit home page

<http://picozed.org/product/picozed-sdr-development-kit>

To access the latest documentation, click on the Support Files & Downloads link.

PicoZed SDR support forum

<http://picozed.org/forums/picozed-sdr-software-defined-radio>

8.2 Analog Devices Support

Analog Devices AD9361 and AD9364 Integrated RF Agile Transceiver Design Resources

<http://www.analog.com/en/design-center/landing-pages/001/ad9361-ad9364-integ-rf-agile-transceiver-design-res.html>

Analog Devices FPGA Reference Designs Support Community on EngineerZone:

<http://ez.analog.com/community/fpga>

Analog Devices Reference Designs HDL User Guide

<http://wiki.analog.com/resources/fpga/docs/hdl>

8.3 Xilinx Support

For questions regarding Xilinx Zynq SoC, send an e-mail message to the Customer Service Representative in your region:

Canada, USA and South America – isscs_cases@xilinx.com

Europe, Middle East, and Africa – eucases@xilinx.com

Asia Pacific including Japan – apaccase@xilinx.com

For technical support including the installation and use of the product license file, contact Xilinx Online Technical Support at www.xilinx.com/support. The following assistance resources are also available on the website:

- Software, IP and documentation updates
- Access to technical support web tools
- Searchable answer database with over 4,000 solutions
- User forums

9 Appendix A: Building the PicoZed SDR Getting Started Design

NOTE: The 'Getting Started' design is based on the HDL code base maintained by Analog Devices. To manage dependencies in the build process for Vivado projects, Analog Devices provides makefiles for use with the Linux-based 'make' utility. It is recommended that Windows users build Vivado projects using 'make' under CYGWIN. Instructions to install a minimal version of CYGWIN that will provide a Linux-like environment under Windows are available here:

<https://avnet.egnyte.com/dl/zP4vbChzM>

For a complete description of the methodology used to build Analog Devices reference designs for Xilinx platforms, it is recommended to review the ADI Reference Designs HDL User Guide.

<http://wiki.analog.com/resources/fpga/docs/hdl>

1. From a web browser go to <https://github.com/analogdevicesinc/hdl/releases>
2. Select a code release. Vivado versions supported in each release are documented in the [README.md](#) file of each branch. Download as ZIP file, or clone the GIT repository. (The following instructions assume you chose to download the ZIP file.)



Figure 12 – Analog Devices HDL GIT Repository

3. Extract the archive to a convenient folder. The following instructions assume you chose to download release hdl-2015_r2 and extract to C:\.

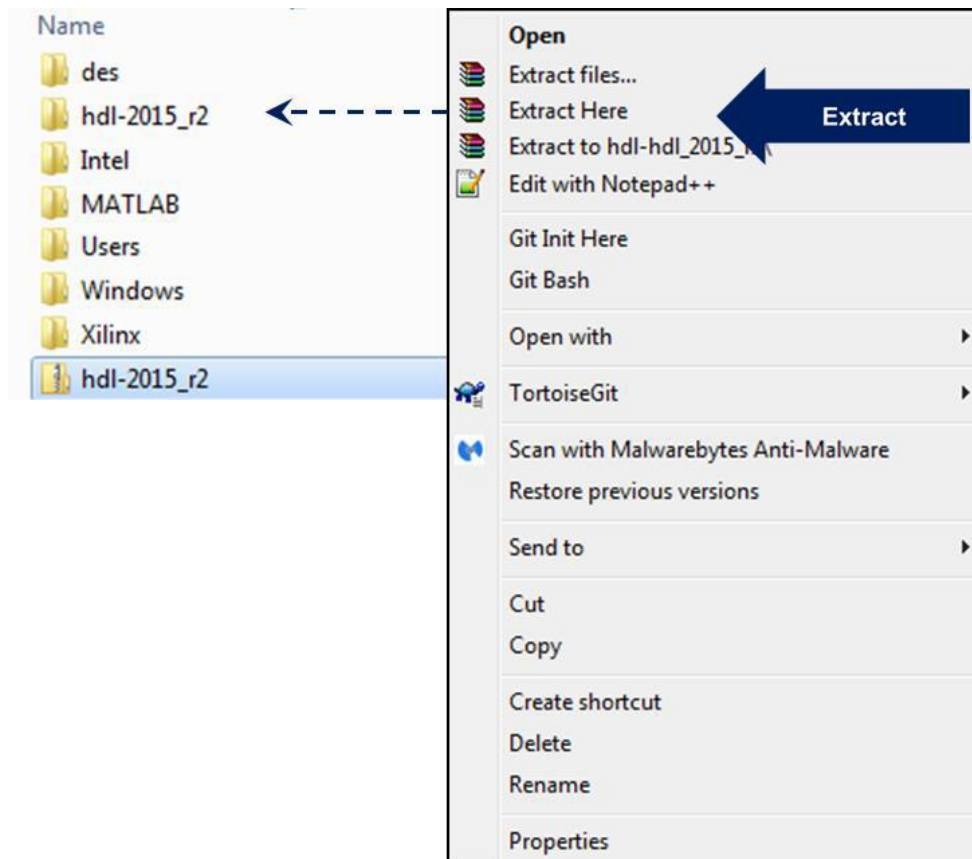


Figure 13 – Extracting Analog Devices HDL Code Release

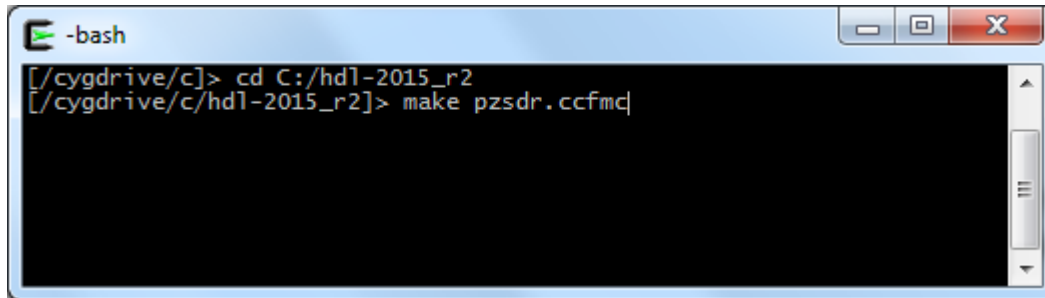
4. Open a Cygwin terminal from the start menu by selecting: Start Menu => All Programs => Cygwin => Cygwin64 Terminal



Figure 14 – Start Cygwin64 Terminal

5. Enter commands as shown below to build the 'Getting Started' Vivado project for PicoZed SDR Development Kit (PicoZed SDR 2x2 SOM on FMC Carrier).

```
cd C:/hdl-2015_r2  
make pzsdrc.ccfmc
```



6. You may open the project in the Vivado GUI when the build process is complete.

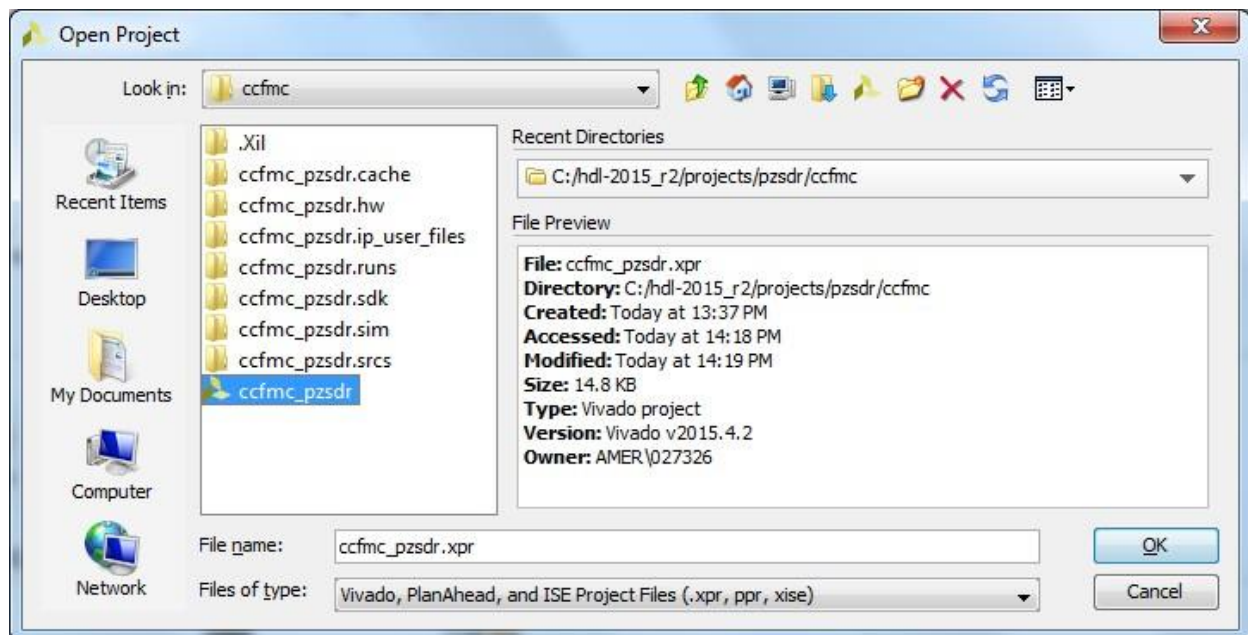


Figure 15 – Completed HDL Reference Design Vivado project

10 Appendix B: Restoring the SD Card image

During the course of development, should the 8 GB SD card become corrupted or otherwise need to be updated, the directions below will restore the system to the latest version.

Instructions are provided for both Linux and Windows hosts.

- If you wish to completely overwrite the SD card, you may download the latest image https://wiki.analog.com/resources/tools-software/linux-software/zynq_images

NOTE: 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.

Download Linux Image

The **BOLD** is what you should type. It's not too much more than w [Special Agent Oso's](#) three special steps, and it also allows you to go for that specialty coffee you have been craving.

For different platforms you'll need different images. Currently we provide a single pre-build images, that can work on all the platforms we support.



- **26 July 2016 release (2015_R2)**
- [Actual file](#)
- Checksum 2015_R2-2016_07_26.img.xz **1520D974FBAADA6107B4C41606C40264**
- Checksum 2015_R2-2016_07_26.img **E0D5748101D476FCA807C20EEF03E788**

- Otherwise, you may simply run the update scripts at the command line of PicoZed SDR: https://wiki.analog.com/resources/tools-software/linux-software/zynq_images#staying_up_to_date
- As a final step, make sure to copy the contents of '**zynq-picozed-sdr2-fmc**' folder to the BOOT partition of the SD card. PicoZed SDR is now fully updated and ready to re-boot.