PicoZed™ SDR Breakout Carrier
Getting Started Guide
Version 1.0
Document Control

Document Version: 1.0
Document Date: 8/15/2016

Prior Version History

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1 Getting Started with PicoZed SDR Breakout Carrier

The PicoZed™ SDR Breakout Carrier Card is a simple prototyping platform for all PicoZed SDR System-on-Modules (SOMs), including PicoZed SDR 1x1 SOM (AES-Z7PZ-SDR1-G) with Z-7020/AD9364 and PicoZed SDR 2x2 SOM (AES-Z7PZ-SDR2-G) with Z-7035/AD9361.

The Breakout Carrier provides easy access to user I/O, Ethernet, USB, JTAG, and serial connections. Four 100-pin Micro Headers on the carrier card mate with the PicoZed SDR SOM, connecting the user I/O to 6 banks of 0.1” through-hole connector footprints. The Breakout Carrier generates the necessary power rails for PicoZed SDR, providing 5V to the SOM plus user selectable bank voltages for the Zynq PL I/O. In addition, the carrier provides multiple access points to supply external I/O bank voltages and measure power consumption of the SOM.

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

## 2 What’s Inside the Box?

**PicoZed SDR Breakout Carrier (AES-PZSDRCC-BRK-G)**

- PicoZed SDR Breakout Carrier
- 8GB Micro SD Card (programmed)
- 5.0V (2A) Power Supply
- Micro-USB Type B cable
- Ethernet Cable
- U.FL-to-U.FL RF loopback cable
- U.FL-to-SMA cables
- U.FL antennae - cellular 6-band
- (2) SMA antennae - cellular 5-band
- Quick Start Card
- Schematics, BOM, HDL, Linux drivers and application software
3 What’s on the Web?

3.1 Official Documentation:
- PicoZed SDR Breakout Carrier Getting Started Guide (this document)
- PicoZed SDR Breakout Carrier Hardware User Guide
- Schematics (PDF format)
- Bill of materials

Analog Devices AD9361 and AD9364 Integrated RF Agile Transceiver Design Resources

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
4 PicoZed SDR Breakout Carrier – Key Features

- 10/100/1000 Mbps Ethernet
- USB2.0 OTG
- USB-UART
- PC4 JTAG interface
- 162 User I/O pins
  - Two 60-pin (2x30) 0.1" footprints
  - Four 32-pin (2x16) 0.1" footprints
- 4 user push buttons
- 4 user switches
- 4 user LEDs
- 5V @ 2A input
- Select 1.8V, 2.5V, or 3.3V for SOM I/O or insert an external supply
- Measure Zynq PL I/O bank current with convenient access points

![Simplified Block Diagram](image)

Figure 2 – PicoZed SDR Breakout Carrier with SOM – Simplified Block Diagram
5 PicoZed SDR Breakout Carrier Getting Started Design

The Getting Started design implements the data interfaces to/from the AD936x 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.

The following section will guide you through running the ‘Getting Started’ design on the PicoZed SDR Breakout Carrier with either PicoZed SDR 1x1 SOM or 2x2 SOM, 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 Breakout Carrier – Setup and Operation

An image of the PicoZed SDR Breakout Carrier in its expected out-of-box configuration is shown below with PicoZed SDR 2x2 SOM (AES-Z7PZ-SDR2-G). The Breakout Carrier is also fully compatible with PicoZed SDR 1x1 SOM (AES-Z7PZ-SDR1-G) featuring Z-7020/AD9364.

![Image of PicoZed SDR Breakout Carrier](image)

**Figure 4 – PicoZed SDR Breakout Carrier with PicoZed SDR 2x2 SOM**

6.1 Hardware Setup

1. Assemble the Breakout Carrier as shown above, with either PicoZed SDR 1x1 or 2x2 SOM.
2. Attach the antenna to PicoZed SDR using the included U.FL-to-SMA cables.
3. Provide an internet connection by attaching the Ethernet cable between the Ethernet RJ45 connector on the carrier and either a direct connection to the PC, or a networked router with DHCP server.
4. **Remove** the micro SD card from the PicoZed SDR SOM.
5. Connect the 5V power supply.

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**DO NOT APPLY POWER YET!**
A functional block diagram of the system is shown below.

![System Block Diagram](image)

Figure 5 – System Block Diagram

6.2 Demo Setup

1. Insert the included micro SD Card into a laptop or PC.
2. For PicoZed SDR 2x2 SOM with Z-7035 / AD9361 (AES-Z7PZ-SDR2-G)
   - Navigate to SD card folder named `zynq-picozed-sdr2-brk`
   
   For PicoZed SDR 1x1 SOM with Z-7020 / AD9364 (AES-Z7PZ-SDR1-G)
   - Navigate to SD card folder named `zynq-picozed-sdr1-brk`
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.
6.3 Running the Design

PicoZed SDR Breakout Carrier card does not include an HDMI video output. In this case, the IIO Oscilloscope network application will run on the PC and connect to the board over TCP/IP, either through a direct connection using hard IP address or connected to a router with DHCP.

1. Apply power to PicoZed SDR Breakout Carrier. After a few seconds, you should see the blue DONE LED illuminate.

2. A terminal program may be used to verify and / or set the IP address of the board through the UART IP in the FPGA design. 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.

3. On the PC, open a serial terminal program. Tera Term is used to show the example output for this lab document. Follow the instructions in the CP210x Setup Guide to set the terminal as shown in, using the higher PC COM port number that you discover on your own machine.

4. At the Linux command line in Tera Term run the ADI Update Tools utility to get the latest version of ADI Linux applications. (The password for “root” account is “analog”)

    sudo ad_update_tools.sh
5. At the Linux command line in Tera Term run the ADI Update Boot utility to get the latest version of Zynq boot files.

   `sudo adi_update_boot.sh`

6. At the command line reboot PicoZed SDR.

   `sudo reboot`

At this point the user may choose to connect the PC to the board either through a direct connection using hard IP address or connected to a router with DHCP.

**Direct Ethernet connection with hard IP address**

a. Before setting a hard Ethernet IP address on the SOM the Linux NetworkManager daemon must be halted with the following command:

   `stop network-manager`

b. Next you may verify the IP address of the SOM with the following command:

   `ifconfig`

c. Windows Start → Control Panel → Network and Sharing Center → Change adapter Settings → TCP/IPv4
d.  Set a hard IP address on the same subnet as PicoZed SDR SOM. For example, if the IP address of PicoZed SDR SOM as reported by `ifconfig` was 192.168.1.100, you may set the PC IP address to 192.168.1.xyz, where xyz ≠ 100.

![Image of Internet Protocol Version 4 (TCP/IPv4) Properties]

Figure 7 – Hard IP address on Windows PC

**Ethernet connection to DHCP router**

7.  If the Ethernet connection to the board is through a router with DHCP, you may repeat the above steps, omitting step a).
8. Launch the ADI IIO Oscilloscope application from your Windows PC.

![Figure 8 – ADI IIO Oscilloscope](image)

9. Open the IIO Devices tab by selecting the ADI IIO Oscilloscope Settings tab, then click Connect. Enter the IP address assigned to PicoZed SDR into the IP address field. Click Refresh and then click OK.

![IIO Devices Tab](image)
10. Select File → New Plot to launch an ADI IIO Oscilloscope window.
11. Configure the following parameters in IIO Oscilloscope
   a. FMComms2/3/4 tab → Controls
      i. Set RX and TX LO Frequency =< 70 MHz < LO < 6 GHz >
      ii. **IMPORTANT:** ensure 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

![Image of ADI IIO Oscilloscope settings]

**Figure 9 – Setting parameters in IIO Oscilloscope**
12. Now click on the “Capture” button at the top of the GUI. You will need to click on Capture twice each time you make a change to stop then restart the capture.

Figure 10 – ADI IIO Oscilloscope Frequency Domain Plot

This completes the Getting Started design for PicoZed SDR SOM on Breakout Carrier card.
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.

![Tera Term: Serial port setup](image)

Figure 11 – 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 anal og and type if con fig. Note the IP address.

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.

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.

8 Getting Help and Support

8.1 Avnet Support
PicoZed SDR Breakout Carrier home page
http://picozed.org/product/picozed-sdr-breakout-carrier

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

PicoZed SDR Development Kit home page
http://picozed.org/product/picozed-sdr-som-development-kit

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

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

Analog Devices SD card image for Zynq SoC (Appendix B: Restoring the SD Card image)
https://wiki.analog.com/resources/tools-software/linux-software/zynq_images
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
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/zZP4vbChzM

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 13 – 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 14 -- Extracting Analog Devices HDL Code Release](image)

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

![Figure 15 – Start Cygwin64 Terminal](image)
5. Enter commands as shown below to build the ‘Getting Started’ Vivado project for PicoZed SDR1x1 SOM on Breakout Carrier.

```bash
cd C:/hdl-2015_r2
make pzsdr1.ccbrk
```

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

![Open Project Window](image)

Figure 16 – Completed ‘Getting Started’ Vivado project
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.

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**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 (2016_R2)
- Actual file
- Checksum 2015_R2-2016_07_26.img.xz 15280974B6A0A410E784C41E86C40264
- Checksum 2015_R2-2016_07_26.img E0D5748101D476FC4B07C26EFF03E788

– 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 before replacing the SD card into PicoZed SDR SOM, make sure to copy the contents of `zynq_picozed_sdr 1/2 b r k` folder to the BOOT partition of the SD card. PicoZed SDR is now fully updated and ready to re-boot.