UltraZed Programmable Clock Reference Design

Introduction

The necessity for high density, low-latency, mass storage is increasing amongst embedded applications. As data storage demands increase, the ability to objectively measure storage read/write performance when using an embedded operating system becomes essential.

DISCLAIMER: This tutorial is provided for reference/educational purposes only and may not reflect results observed with other test equipment.

There are a number of factors which can impact SATA storage read/write performance and throughput in addition to transmission overheads, including latency, read/write block size, and system caching such that the calculated throughput typically does not reflect the maximum achievable throughput. As a result, the throughput between the host system and the SATA storage device can be substantially lower than the theoretical limits.

UltraZed-EG Starter Kit Overview

The UltraZed-EG™ Starter Kit from Avnet Electronics Marketing provides engineers with a complete system for prototyping and evaluating systems based on the Xilinx powerful Zynq® UltraScale+™ MPSoC device family.

The versatility of this platform offers an excellent prototyping or proof-of-concept vehicle for your new product. Once you are finished prototyping your new product design and are ready to go into production, most of the components found on this platform can be purchased directly from Avnet. Indeed, the UltraZed-EG SOM is a great way to integrate a complete Zynq UltraScale+ solution into your product without worrying about the design complexities of designing your own chip-down system. Please contact your local Avnet FAE for further details.
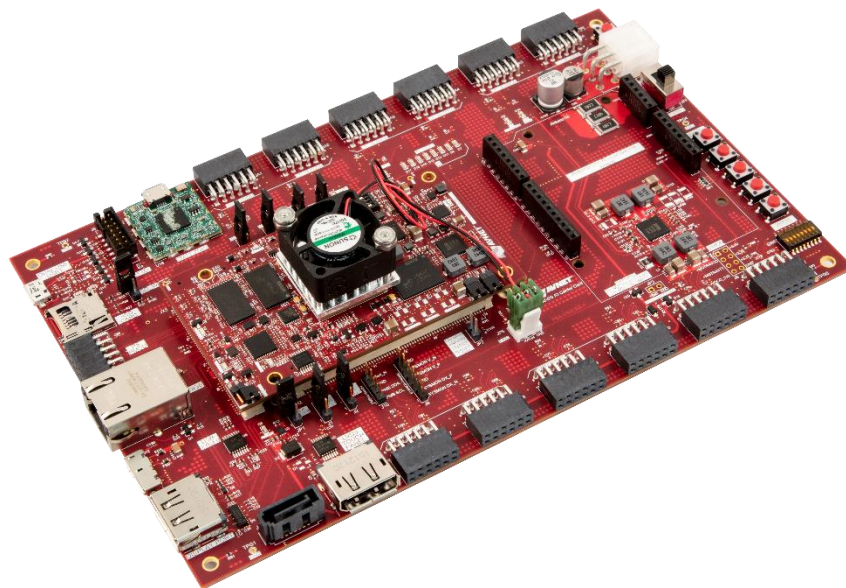
Design Objectives

This UltraZed tutorial offers system developers an example of how to:
- Target a prebuilt Xilinx release of open source Linux to UltraZed
- Launch SATA drive read/write performance tests on Zynq platform using a test script running a prebuilt open source Linux build created with Xilinx PetaLinux Tools

Experiment Setup

This tutorial builds upon the concepts and lab activities of the Avnet UltraZed Tutorials which cover the use of Xilinx Vivado Design Suite in creating/testing a basic Zynq UltraScale MPSoC hardware platform and running software applications. Please refer back to this reference material on the UltraZed community website for further information on how to configure the underlying UltraZed hardware platform.

The experiments in this tutorial use **dd** from the Coreutils Linux package which is a very simple tool which can be used to perform read/write throughput measurements to target storage devices.

For the example SATA test configuration that was used in this tutorial, see the section **Troubleshooting: SATA Connection** later in this document for further information.

The instructions in this tutorial assume that the cross build platform is an Ubuntu 16.04 LTS installation running natively on an x86-based host. Though other systems may work using the same or similar instructions, those systems are not supported.

Example Design Requirements

Software

The software used to test this reference design is:

- Ubuntu 16.04 LTS64-bit installer image

- Xilinx Vivado Design Suite 2016.2 (Free WebPACK license and download from Xilinx website)

- Git SCM toolset (Exact version used for this tutorial is V2.7.4)

Hardware

The hardware setup used to test this reference design includes:

- Lenovo ThinkPad T420 Laptop

    o Intel® Core i5-2540M CPU - 2.60 GHz

    o 4GB DDR3 Memory

    o SD card slot on PC or external USB-based SD card reader

    o Ubuntu 16.04 LTS 64-bit Desktop

- Stock Avnet UltraZed-3EG SOM Rev. 1 (AES-ZU3EGES-1-SOM-G)

- Avnet UltraZed IO Carrier Card (AES-ZU-IOCC-G)

- USB cable (Type A to Micro-USB Type B)

- 8GB MicroSD card

- Micron M500IT SATA SSD

- SATA III data and power combo cable

- 12V/5V 4-pin Molex 2A power adapter

Experiment Setting Up the UltraZed-EG with IO Carrier Card

Refer to the following figure and perform the following steps to set up the board.
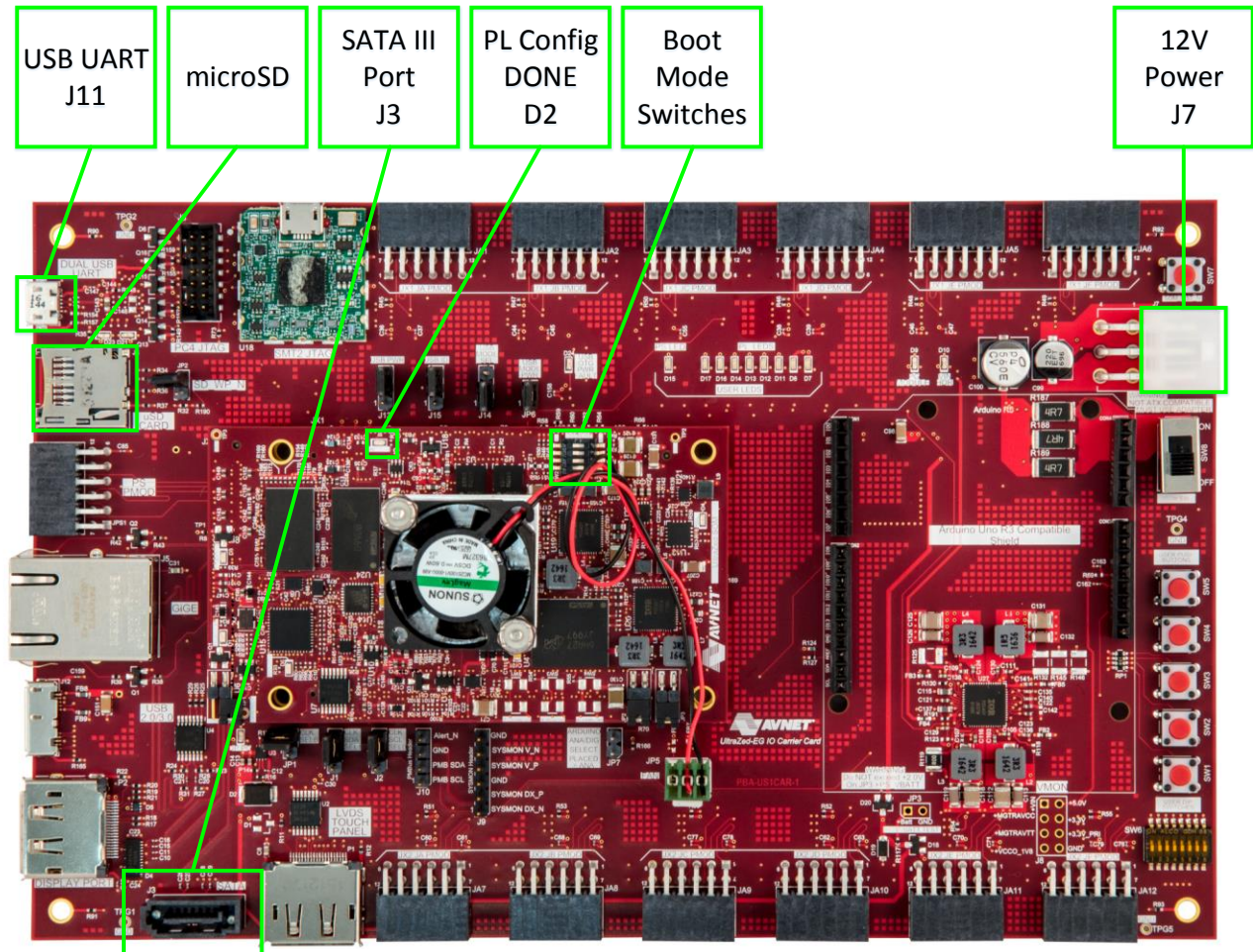
1. Plug the UltraZed-EG SOM onto the IO Carrier Card via JX1/JX2/JX3 connectors and connect the fan to the fan header (JP5) on the IO Carrier Card.

2. Set the UltraZed-EG SOM Boot Mode switch (SW2) (MODE[3:0] = SW2[4:1]) to ON, ON, ON, and ON positions (Boot Mode set to SD card, MODE[3:0] = 0x0).

3. Connect the USB-UART port on the I/O Carrier Card (J11) to a free USB port on your PC.

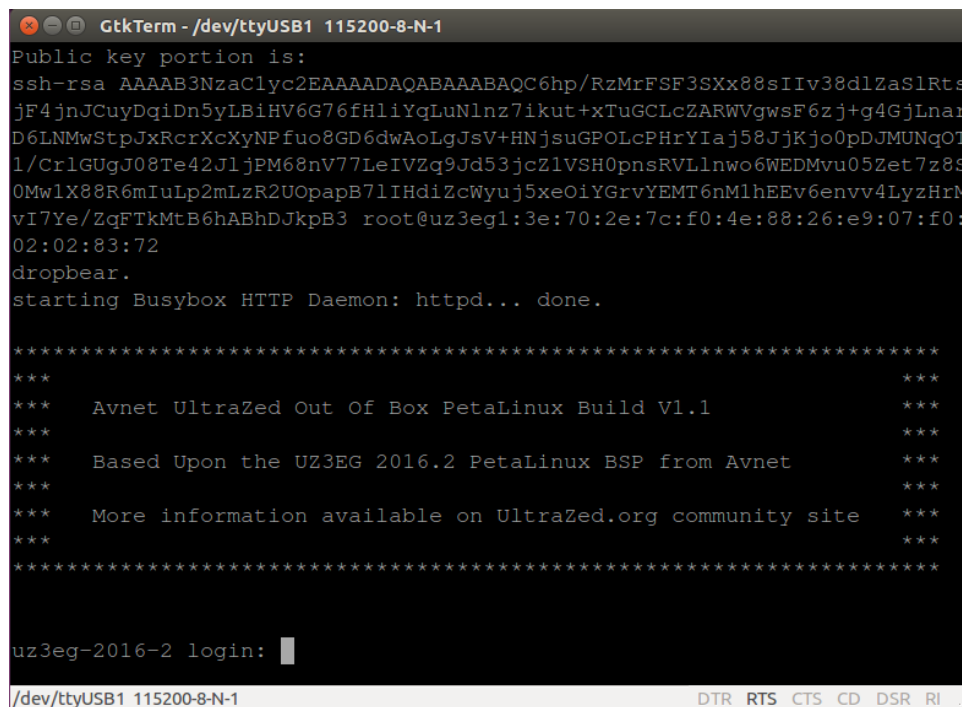4. Connect the 12V power cable, but do not turn on the board yet.

Experiment 1: Setup Linux for UltraZed

The experiments in this tutorial are based upon the Linux build that is provided by Avnet as part of this tutorial.

1. Copy the **BOOT.BIN** and **image.ub** files from the accompanying archive into the top level of the microSD card.

   Replace any existing versions of these files that may already be on the microSD card.

2. Insert the microSD card, prepared using the steps above, into the UltraZed IO Carrier J4 slot.

3. Set the UltraZed IO Carrier power switch SW8 to the ON position. The UltraZed system will power on and the Power Good LED (D3) should illuminate.

4. Launch a terminal program with the 115200/8/n/1/n settings. For the example output shown here, **gtkterm** was used. For information on setting up **gtkterm** to use with the UltraZed USB-UART port, see the section **Appendix II: Troubleshooting Serial Connection** later in this document for further information.

5. You should observe terminal output from U-Boot and then Linux output appear in the **gtkterm** window.

Experiment 2: Running SATA File Read/Write Tests

Now that the embedded target software has been setup and UltraZed is booted with Linux to a login prompt, the file Read/Write Tests can be launched on the attached SATA drive.

1. Use the terminal window to enter the login **root** along with password **root** in order to gain access

2. Check the SATA device enumeration to verify that the SATA interface speed is configured correctly and that the target SATA drive is detected correctly. If the **/dev/sda1** device listing does not appear as expected, verify your SATA cable connection matches the one shown in Appendix I: **Troubleshooting SATA Connection** further into this document.

```
# ls /dev/sda1

# dmesg | grep -i sata | grep 'link up'
```
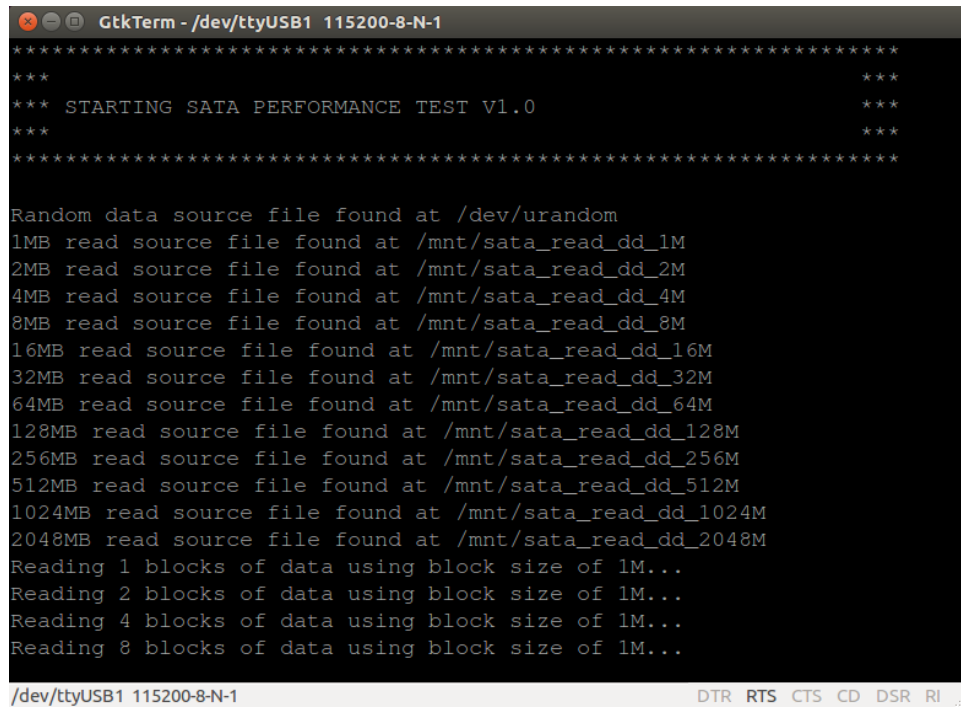
3. At the UltraZed serial terminal launch the included **sata_performance_test.sh** script using the following command:

```
# ./sata_performance_test.sh
```


GtkTerm - /dev/ttyUSB1 115200-8-N-1

```
****************************************************************
***                                                        ***
*** STARTING SATA PERFORMANCE TEST V1.0                    ***
***                                                        ***
****************************************************************

Random data source file found at /dev/urandom
1MB read source file found at /mnt/sata_read_dd_1M
2MB read source file found at /mnt/sata_read_dd_2M
4MB read source file found at /mnt/sata_read_dd_4M
8MB read source file found at /mnt/sata_read_dd_8M
16MB read source file found at /mnt/sata_read_dd_16M
32MB read source file found at /mnt/sata_read_dd_32M
64MB read source file found at /mnt/sata_read_dd_64M
128MB read source file found at /mnt/sata_read_dd_128M
256MB read source file found at /mnt/sata_read_dd_256M
512MB read source file found at /mnt/sata_read_dd_512M
1024MB read source file found at /mnt/sata_read_dd_1024M
2048MB read source file found at /mnt/sata_read_dd_2048M
Reading 1 blocks of data using block size of 1M...
Reading 2 blocks of data using block size of 1M...
Reading 4 blocks of data using block size of 1M...
Reading 8 blocks of data using block size of 1M...
```

/dev/ttyUSB1 115200-8-N-1   DTR **RTS** CTS CD DSR RI

4. Depending upon the read/write throughput capability of the attached SATA drive, the performance test script will complete in 20-40 minutes. Upon completion of all read/write tests, a throughput summary report will be shown which summarizes the total amount of data transferred along with the measured throughput rate over the course of the test.

```
GtkTerm - /dev/ttyUSB1  115200-8-N-1
*                                                                    *
*    SATA Write Performance Test Results - Fixed File Size Test      *
*                                                                    *
* File Size (MB):        Xfer time (ms): Rate (MB/s):     Block:     *
*                                                                    *
**********************************************************************
*                                                                    *
*         1024            68015            15.055          1K         *
*         1024            36869            27.774          2K         *
*         1024            19624            52.181          4K         *
*         1024            13354            76.681          8K         *
*         1024            10209            100.303         16K        *
*         1024            8413             121.716         32K        *
*         1024            7725             132.556         64K        *
*         1024            7446             137.523         128K       *
*         1024            7396             138.453         256K       *
*         1024            8112             126.232         512K       *
*         1024            9803             104.457         1M         *
*                                                                    *
**********************************************************************

SATA PERFORMANCE TEST COMPLETE!
root@uz3eg-2016-2:~#

/dev/ttyUSB1  115200-8-N-1                        DTR  RTS  CTS  CD  DSR  RI
```

5. Continue to experiment with reading and writing large files to the disk by modifying the test script or manually using **dd** commands until you have collected the type of information that you need for your own SATA performance testing. A sample report used to generate the results is provided in the **UltraZed – SATA III Performance Test Report.pdf** document provided in the archive accompanying this tutorial.

6. When you have completed your own SATA performance testing, be sure to un-mount any of the attached storage devices to avoid corruption of the disk file system.

   Alternatively, you can simply shutdown the UltraZed Linux system cleanly by using the command **shutdown -h now** to ensure the system is system is halted and file systems properly unmounted.

```
# cd /

# umount /mnt/
```

Appendix I: Troubleshooting SATA Connection

This section provides troubleshooting information for the SATA III connection used in this UltraZed Open Source Linux SATA Performance Test Tutorial.

1. The basic configuration for the UltraZed Open Source Linux SATA Performance Test Tutorial is shown below:
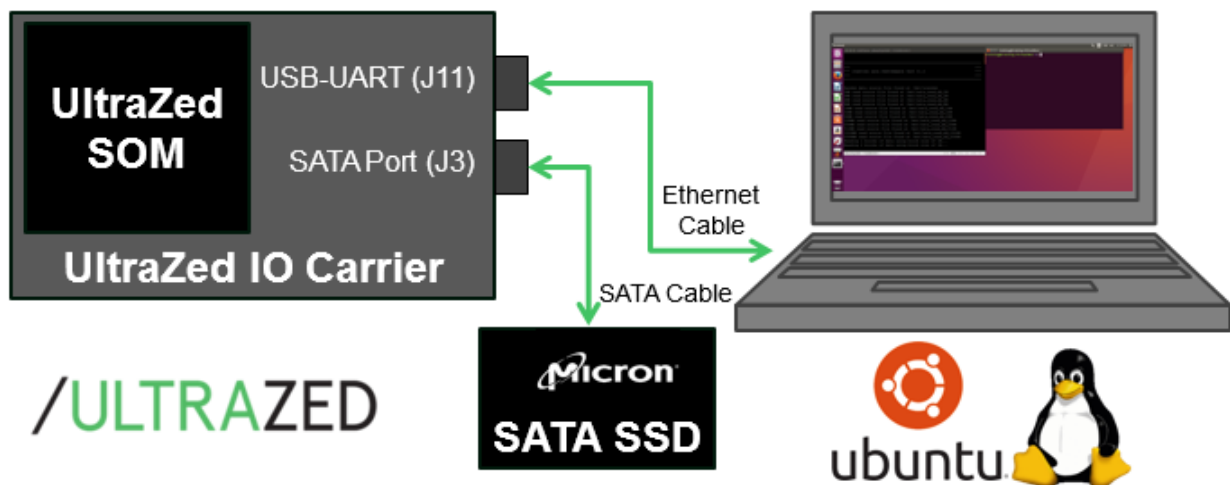
2. Verify that the SATA III drive is powered externally with 12V/5V adapter.

3. Verify that the SATA III drive is connected with a SATA III rated data cable.

4. Verify that the SATA III drive is partitioned and formatted with a file system that is compatible with the Linux build generated from the PetaLinux project. The FAT32 file system is supported with the provided pre-build image accompanying this tutorial but other file system types might also be supported while others may not.

Appendix II: Troubleshooting Serial Connection

This section provides troubleshooting information for the USB-UART serial connection used in this UltraZed Open Source Linux SATA Performance Test Tutorial. The experiments in this tutorial use Ubuntu **Serial port terminal** (gtkterm) as the serial terminal application is recommended for this tutorial but other serial terminal applications might work as well.

1. To make it easier to launch the terminal app (GtkTerm) without needing to provide the root password each time, open a command window and add the **current username** to the group for the **/dev/ttyUSBx** devices used for USB-UART:

```
$ sudo usermod -a -G dialout <current username>
```

2. Install the **gtkterm** package:

```
$ sudo apt-get install gtkterm
```

3. **Reboot the Virtual Machine to force the changes to take effect.**

4. Create a Desktop icon by copying and pasting **Serial port terminal** (gtkterm**)** application from the **/usr/share/applications** folder directly to the ~/Desktop folder:
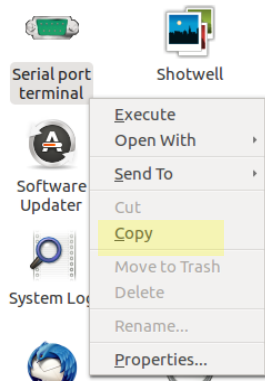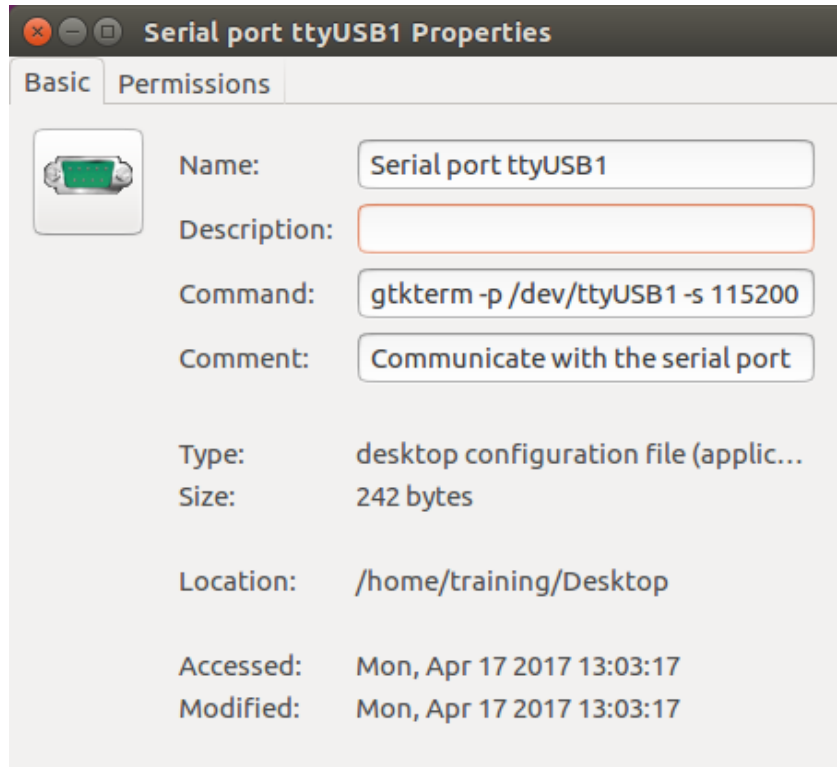

5. Right-click on the new **Serial port terminal** (gtkterm**)** application Desktop icon and select the **Properties** option.

6. Within the Properties window, set the ap attributes to match the USB-UART device attached to the system, in this example the USB-UART is attached to the **/dev/ttyUSB1** device entry:

Name: **Serial port ttyUSB1**
Command: **gtkterm -p /dev/ttyUSB1 -s 115200**

7. Close the Properties window.

8. Insert a bootable microSD card prepared with the prebuilt binaries available with this tutorial into the UltraZed IO Carrier Card J4 slot.

9. Set the UltraZed-EG SOM Boot Mode switch (SW2) (MODE[3:0] = SW2[4:1]) to ON, OFF, ON, and OFF positions (Boot Mode set to SD Card, MODE[3:0] = 0xA).

10. Make sure the UltraZed IO Carrier Card power switch SW8 is in the OFF position.

11. Insert the UltraZed-3EG SOM module onto the UltraZed IO Carrier Card using the JX1, JX2, and JX3 connectors.

12. Close or disconnect the terminal that may have previously been open on your PC.

13. Plug in the UltraZed USB-UART cable between the host PC and the UltraZed IO Carrier Card USB-UART port (J11).

14. Insert the appropriate country plug into the 12V AC/DC adapter. Plug it into the J7 2x3 power connector. (NOTE – this 2x3 connector is NOT compatible with ATX power supplies.)

15. Set the UltraZed IO Carrier power switch SW8 to the ON position. The UltraZed system will power on and the Power Good LED (D3) should illuminate.

16. Check the kernel output log for signs that the USB-UART device has enumerated and note the ttyUSB device that is enumerated. USB-UART device should enumerate as **/dev/ttyUSB0** or similar.

```
$ dmesg
```

17. Create system default udev rules to give USB-UART devices sufficient permissions for all users similar.

```
$ sudo cp /lib/udev/rules.d/50-udev-default.rules /etc/udev/rules.d/
```

18. Edit the system default udev rules with **vi** text editor.

```
$ sudo vi /etc/udev/rules.d/50-udev-default.rules
```

19. Add the following 2 lines to **50-udev-default.rules** somewhere just after the 'tty' section.

```
# relax the permissions just for ttyUSB0

KERNEL=="ttyUSB0",              MODE="0666"
```

20. Save the changes to the **50-udev-default.rules** file and exit **vi** text editor.

21. Run gtkterm again in normal user mode and check for terminal output.

Appendix III: Getting Support

Avnet Support

- Technical support is offered online through the ultrazed.org website support forums. UltraZed users are encouraged to participate in the forums and offer help to others when possible.
  http://ultrazed.org/forums/zed-english-forum
  http://ultrazed.org/forums/software-application-development

- For questions regarding the UltraZed community website, please direct questions to the ultrazed.org Web Master (webmaster@ultrazed.org).

- To access the most current collateral for the UltraZed, visit the community support page (www.ultrazed.org/content/support) and click one of the icons shown below:
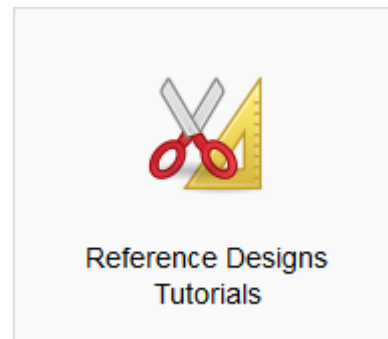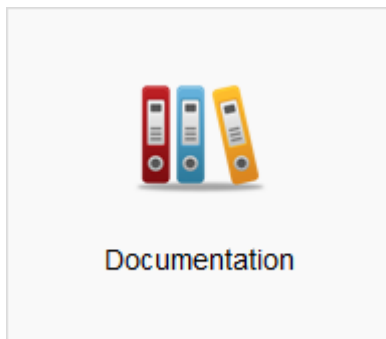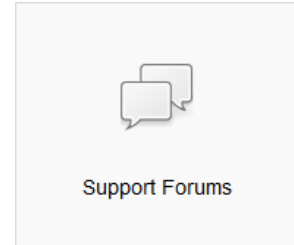
  o UltraZed-EG IO Carrier Card Documentation
    http://ultrazed.org/support/documentation/17596

  o UltraZed-EG IO Carrier Card Reference Designs
    http://ultrazed.org/support/design/17596/131

- Instructions for how to setup the Ubuntu virtual machine if using a Linux host PC
  http://ultrazed.org/sites/default/files/design/VirtualBox_Installation_Guide_2016_2.zip

Xilinx Support

For questions regarding products within the Product Entitlement Account, send an email 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

Revision History

Date	Version	Revision
03 Apr 17	01	Initial Release