Getting Started Guide

Version 1.0

ZedBoard™

AVNET®
electronics marketing

Revision History

DATE	VERSION	REVISION
08/06/2012	1.0	Initial Release

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GETTING STARTED WITH ZEDBOARD

The ZedBoard enables hardware and software developers to create or evaluate Zynq-7000 EPP designs.

The expandability features of this evaluation and development platform make it ideal for rapid prototyping and proof-of-concept development. The ZedBoard includes Xilinx XADC, FMC (FPGA Mezzanine Card), and Digilent Pmod™ compatible expansion headers as well as many common features used in system design. ZedBoard enables embedded computing capability by using DDR3 memory, Flash memory, gigabit Ethernet, general purpose I/O, and UART technologies.

This Getting Started Guide will outline the steps to setup the ZedBoard hardware. It documents the procedure to run a simple Linux design to show a Linux application running on the ARM® dual-core Cortex™-A9 MPCore™ and interacting with the tightly coupled 7 series 85K Programmable Logic Cells. Xilinx Embedded Development tools are also introduced where the design can be built from scratch and customization options can be discovered. If Xilinx ISE WebPACK or Design Suite software is not already installed, further resources to install the software, get updated and generate a license are provided in Appendix I.

WHAT'S INSIDE THE BOX?

ZedBoard Kit contents:

- ZedBoard
- 12 volt / 5 ampere power supply with US, European AC adapter
- USB-A to Micro-USB-B cable
- Micro-USB-B to Type A Female adapter cable
- 4GB SD card
- Software
  - Xilinx ISE WebPACK Edition DVD
  - Xilinx ChipScope™ Pro License Voucher for ZedBoard designs
- Documentation
  - Getting Started Card

WHAT'S ON THE WEB?

ZedBoard is a community-oriented kit, with all materials being made available through the ZedBoard.org community website.

Official Documentation:

- Schematics
- Layout
- Hardware manual

Tutorials and Reference Designs:

- Introductory material for beginners
- Design examples

ZEDBOARD KEY FEATURES

- Processor
  - Zynq-7000 EPP XC7Z020-CLG484-1
- Memory
  - 512 MB DDR3
  - 256 Mb Quad-SPI Flash
  - 4 GB SD card
- Communication
  - Onboard USB-JTAG Programming
  - 10/100/1000 Ethernet
  - USB OTG 2.0 and USB-UART
- Expansion connectors
  - FMC-LPC connector (68 single-ended or 34 differential I/Os)
  - 5 Pmod™ compatible headers (2x6)
  - Agile Mixed Signaling (AMS) header
- Clocking
  - 33.33333 MHz clock source for PS
  - 100 MHz oscillator for PL
- Display
  - HDMI output supporting 1080p60 with 16-bit, YCbCr, 4:2:2 mode color
  - VGA output (12-bit resolution color)
  - 128x32 OLED display
- Configuration and Debug
  - Onboard USB-JTAG interface
  - Xilinx Platform Cable JTAG connector
- General Purpose I/O
  - 8 user LEDs
  - 7 push buttons
  - 8 DIP switches

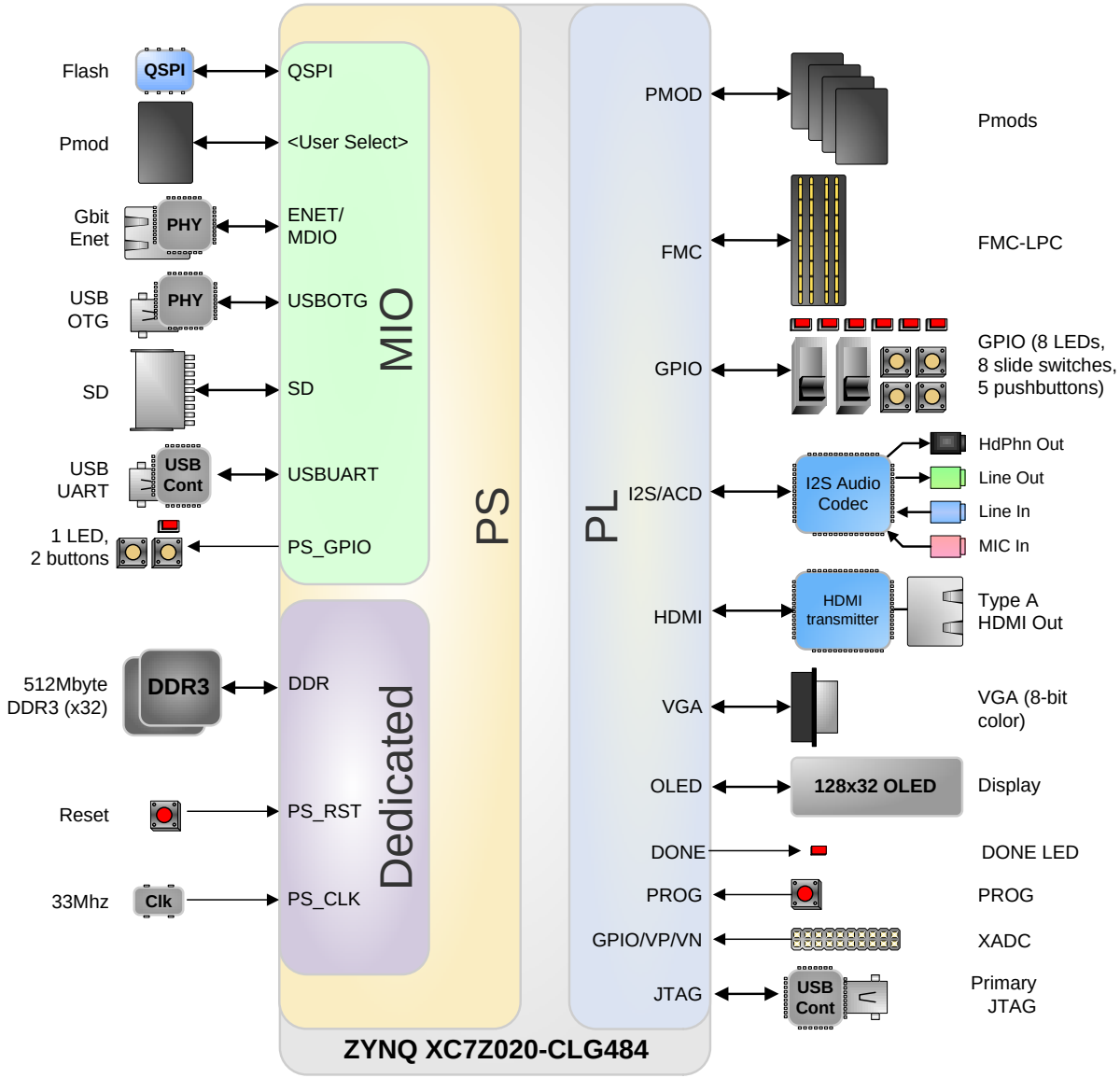


Figure 1 - ZedBoard Block Diagram

ZEDBOARD BASIC SETUP AND OPERATION

The ZedBoard SD card is preloaded with an example open source Linux build with a RAMdisk filesystem. The host PC must run Windows (XP/Vista/7) and have a wired (RJ-45 connector) Network Interface Card (NIC) that can operate at 100 Mbps or 1000 Mbps.

Hardware Setup

1. Connect 12 V power to barrel jack (J20).
2. Connect the USB-UART port of ZedBoard (J14) which is labeled **UART** to a PC using the MicroUSB cable.
3. Insert the 4GB SD card included with ZedBoard into the SD card slot (J12) located on the underside of ZedBoard PCB. This SD card comes preloaded with demo software and contains a basic Linux configuration used to implement the demos listed in the later sections.
4. Verify the ZedBoard boot mode jumpers (JP7-JP11) are set to SD card mode as described in the Hardware Users Guide.

   www.zedboard.org/sites/default/files/ZedBoard_HW_UG_v1_1.pdf
5. Turn power switch (SW8) to the ON position. ZedBoard will power on and the Green Power Good LED (LD13) should illuminate.
6. The PC may pop-up a dialog box asking for driver installation.

   ZedBoard has a USB-UART bridge based on the Cypress CY7C64225 chipset. Use of this feature requires that a USB driver be installed on your Host PC.

   If Windows recognizes the USB-UART and loads the software driver, then amber LED D6 will light. Please skip ahead to the next section. However, if the host PC does not recognize the USB-UART and enumerate it as a COM port device refer to the "ZedBoard_USB-UART_Setup_Guide.pdf" document in the link below for instructions on installing this driver. When driver installation is complete, continue to the next step.

   www.zedboard.org/sites/default/files/CY7C64225_Setup_Guide_1_0.pdf
7. Wait approximately 15 seconds. The blue Done LED (LD12) should illuminate, and a default image will be displayed on the OLED (DISP1).
8. If the amber USB-Link Status (LD11) does not flicker to indicate activity, check the driver installation to determine if the device driver is recognized and enumerated successfully and that there are no errors reported by Windows.
9. Use Device Manager to determine the COM Port.

   Note: Each unique USB-UART device attached will enumerate under the next available COM port. Here in this example, the Cypress CY7C64225 USB-UART device is enumerated as COM13.

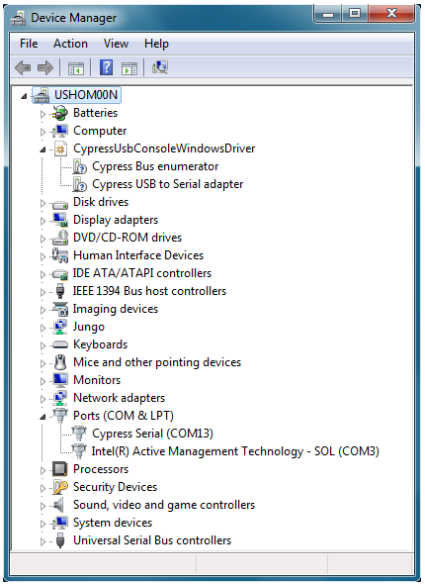
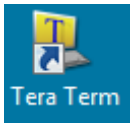


Figure 2 – Device Manager Showing Enumerated USB-UART as COM13

10. On your PC, open a serial terminal program. For this demo, Windows 7 was used which does not come with a built in terminal application. Tera Term was used in this example which can be downloaded from the Tera Term project on the SourceForge Japan page: ttssh2.sourceforge.jp

11. Once Tera Term is installed, Tera Term can be accessed from the desktop or start menu shortcuts.



12. To configure baud rate settings, open the Serial Port Setup window from the **Setup→Serial port** menu selection. Select the USB-UART COM port enumeration that matches the listing found in Device Manager. Also set the Baud rate option to 115200, the Data width option to 8-bit, the Parity option to none, the Stop bit option to 1 bit, and the flow control to none. Finally, assign the transmit delay parameters to 10 msec/char and 100 msec/line, and then click OK.

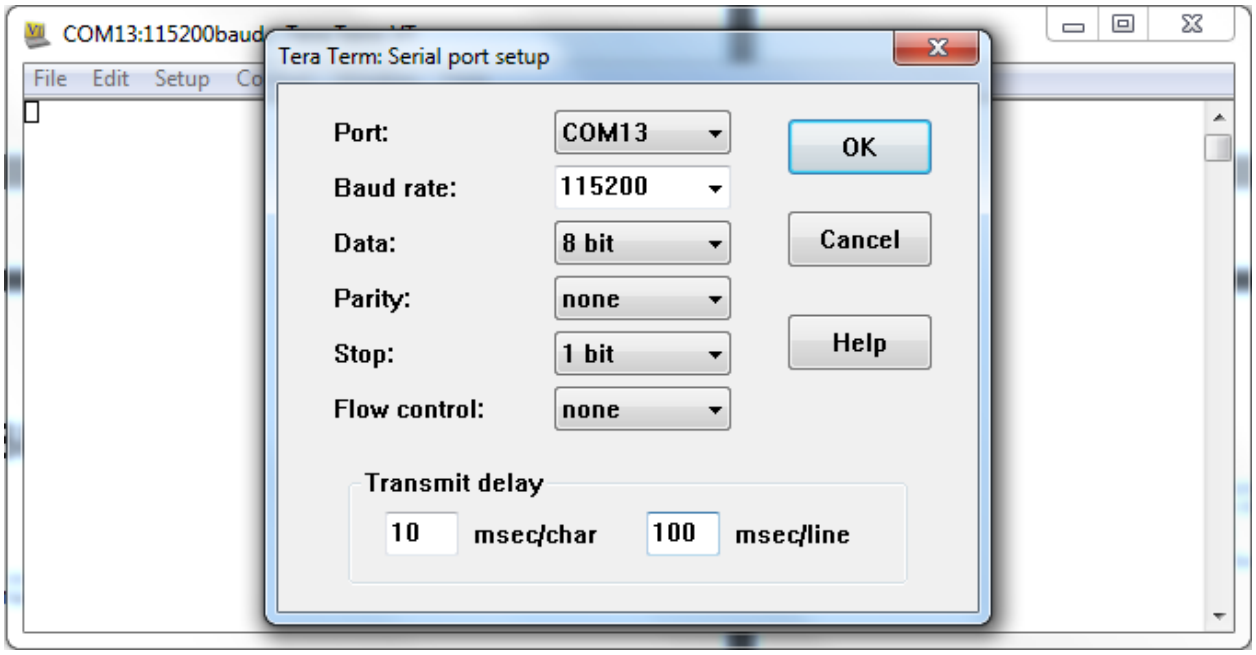


Figure 3 – Tera Term Serial Port Setup Settings

13. Optionally, at this point, the terminal settings can be saved for later use. To do this, use the **Setup→Save setup** menu selection and overwrite the existing TERATERM.INI file.

Linux Startup and Shutdown

1. Cycle power once by turning the power switch (SW8) from ON to OFF and then back ON.
2. In the Terminal Window, a simple Linux image should boot with functionality that demonstrates the basic capabilities of ZedBoard.

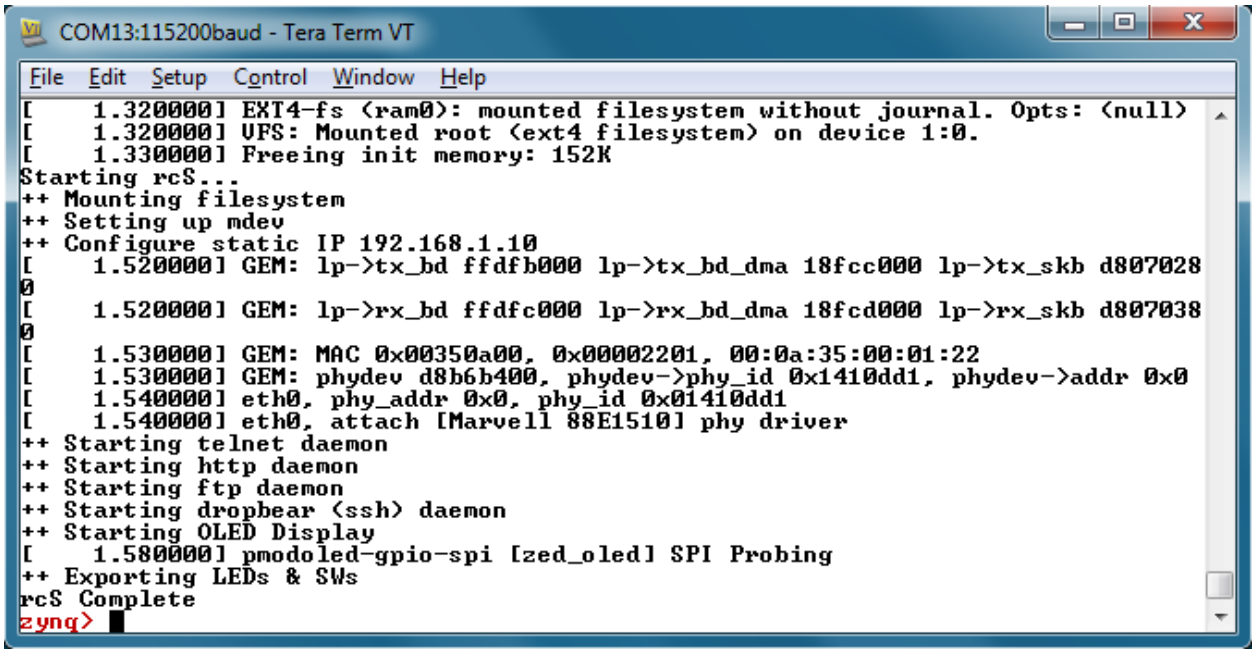


Figure 4 – Linux Command Prompt Following Boot

3. When you are done using Linux, run the command `poweroff` and then switch off ZedBoard by positioning the power switch (SW8) from ON to OFF.

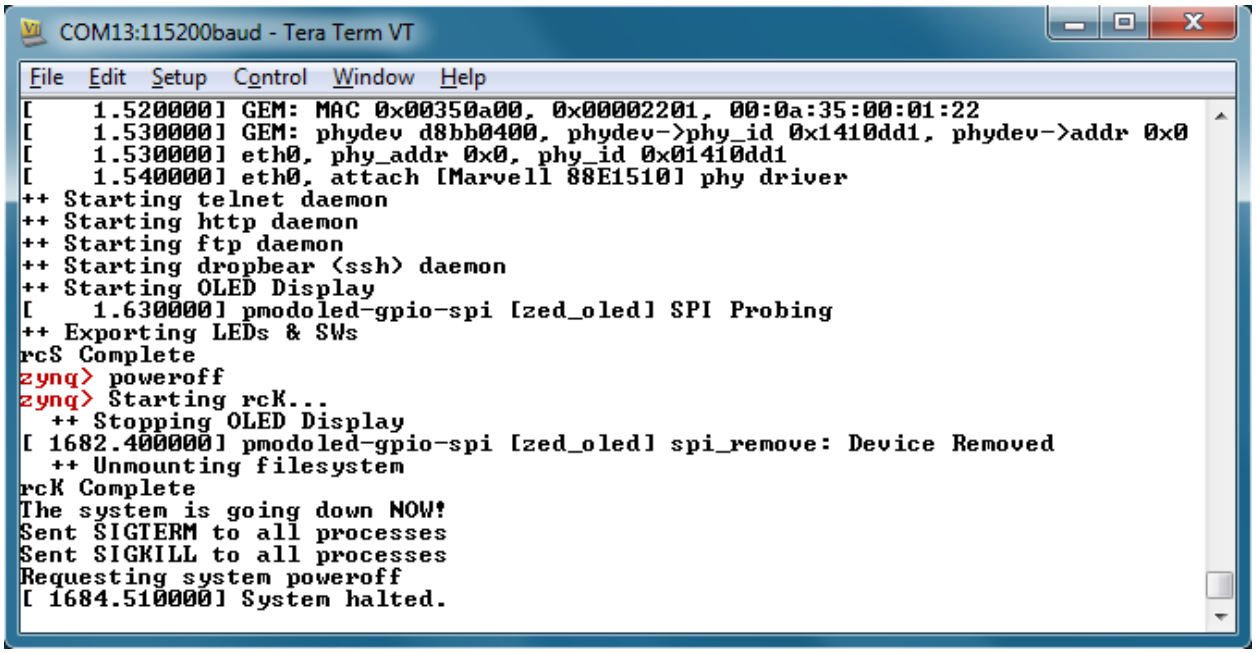


Figure 5 – Linux Command Prompt Following Shutdown

Example Design Description

Zynq-7000 EPP™ System Block Diagram

The following figure illustrates the system design that serves to demonstrate the subsequent interface demos.

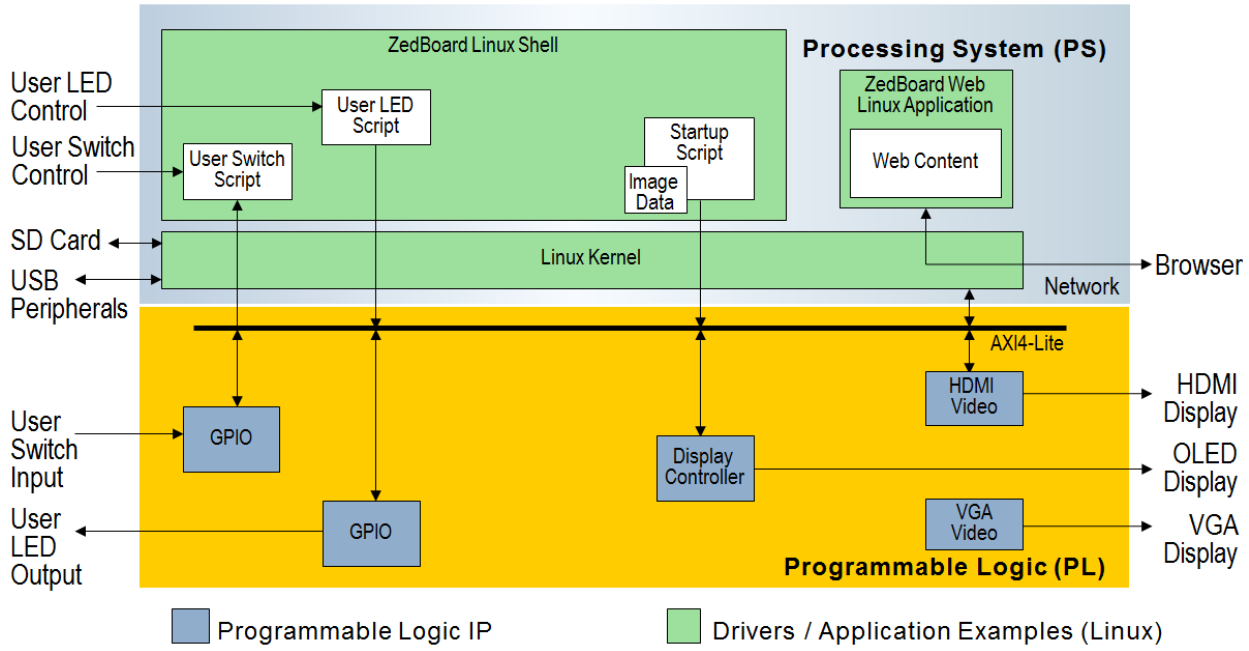


Figure 6 - ZedBoard Example Design Block Diagram

This example design platform is what is included (Programmable Logic provided in Bitstream form) on the ZedBoard SD card and can be used as one of the starting points from which custom designs can be built.

Demo 1 – Interacting with GPIO Switches and LEDs

Purpose

This demo shows how software running on the Processing System (PS) of Zynq-7000 EPP can interact with the Programmable Logic (PL) hardware to process inputs and outputs through the GPIO implemented in the programmable fabric. This section will also help demonstrate some of the Linux infrastructure that is operational right out of the box.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware and boot into Linux as described in the previous section ZedBoard Basic Setup and Operation.
2. A set of scripts are included in the `/usr/bin` directory for interacting with the hardware. To read the state of the switches, first set the postion of the switches as desired and then run the `read_sw` script. The state of the switches will be returned as an output in both hexadecimal and decimal formats.

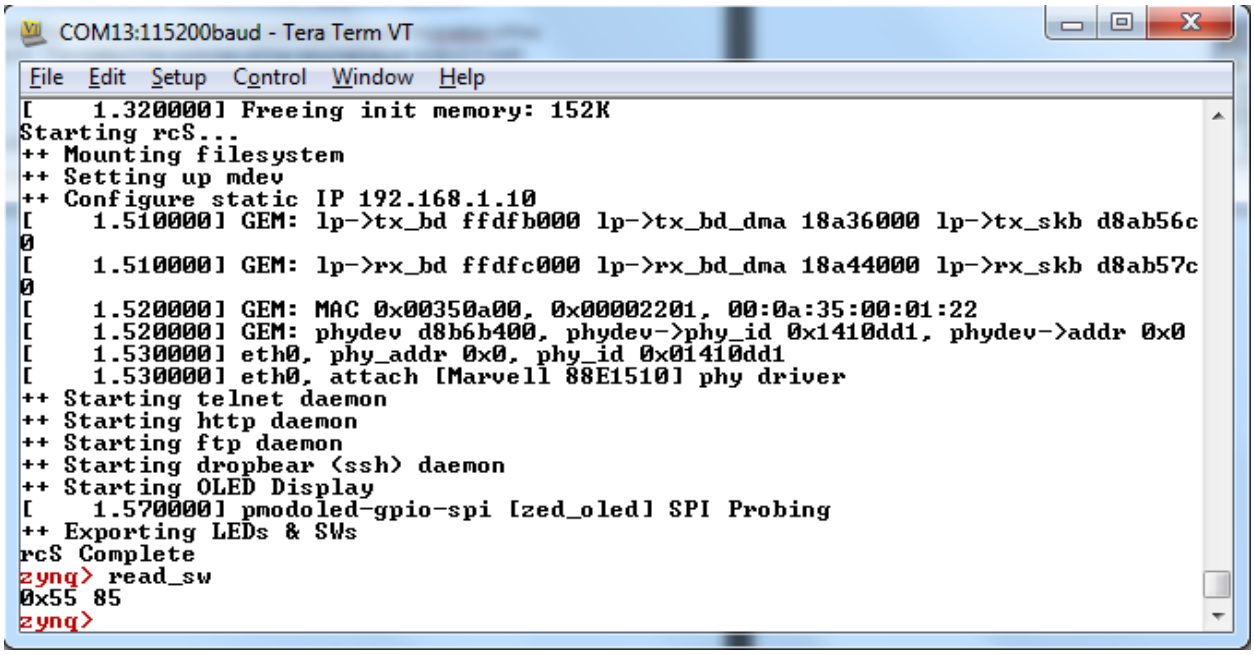


Figure 7 - ZedBoard Example Switch Input

3. The `read_sw` script handles the details of reading the GPIO states from the `/sys/class/gpio/gpio$sw/value` sysfs nodes. The position of the switches can be modified and the updated GPIO values read again by running the `read_sw` script.

4. A script for changing the state of the LEDs is also included. To set the state of the user LEDs (LD0-LD7), use the script `write_led` and specify the byte value to be written to the LEDs. For example, running the script `write_led 0xFF` or even the command `write_led 255` will result in each of the user LEDs LD0-LD7 illuminating as seen in Figure 8.

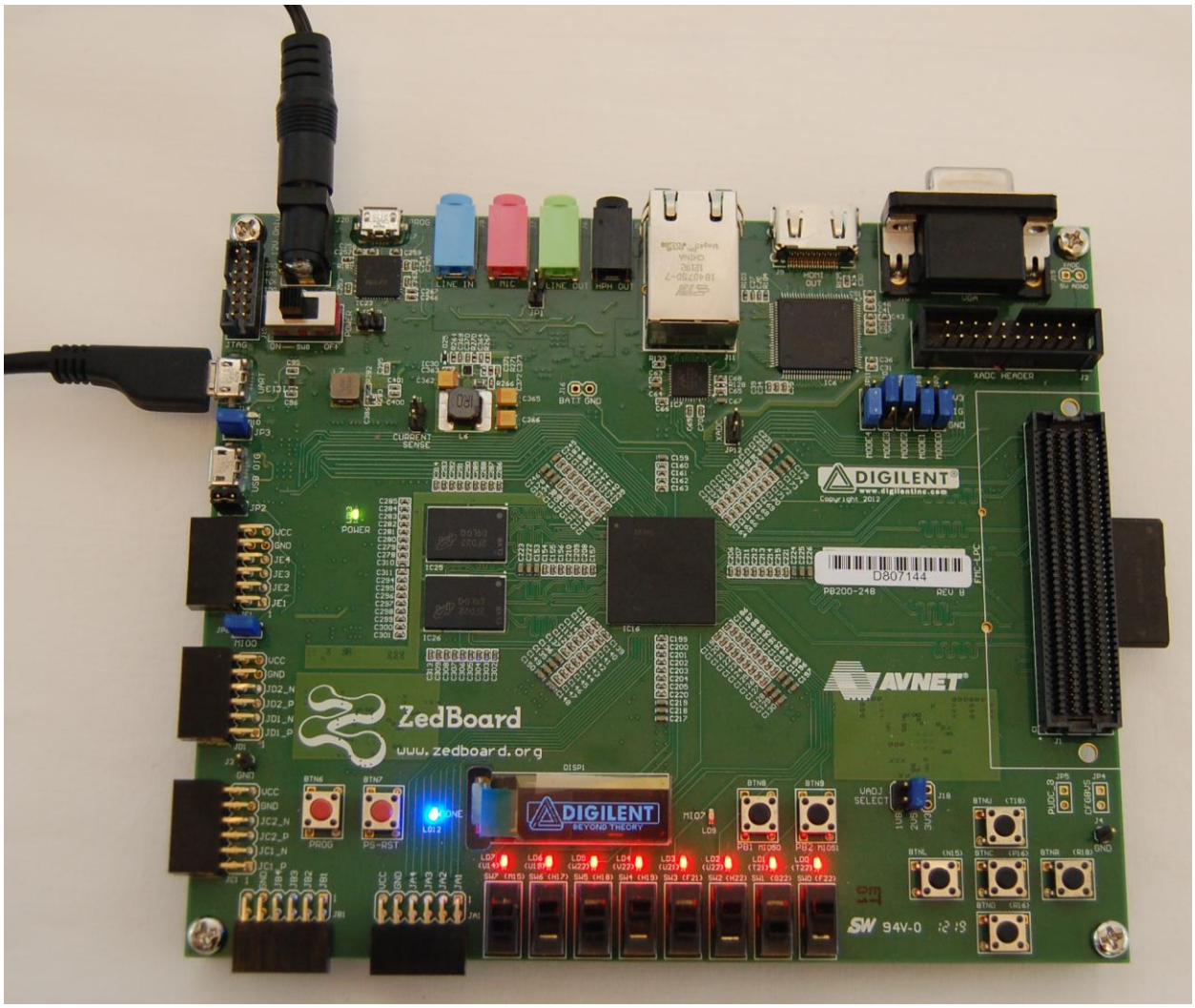


Figure 8 - ZedBoard Example LED Output

5. The `write_led` script handles the details of writing the specified values to the `/sys/class/gpio/gpio$led/value` sysfs nodes. The state of the LEDs can be modified again by running the `read_sw` script with another output value.

6. This concludes Demo 1. Continue to experiment with this demo, proceed to another demo, or run the Linux command `poweroff` and then switch off ZedBoard.

Demo 2 – OLED Display

Purpose

This demo shows how software running on the Processing System (PS) of Zynq-7000 EPP can interact with the Programmable Logic (PL) hardware via a device driver.

A default Digilent Logo image is displayed on the OLED display (DISP1) after Linux has finished booting. In order to prolong the life of the OLED display, the manufacturer suggests that a specific powerdown sequence be used. Running the `poweroff` command before switching the ZED board off will ensure that this procedure is correctly followed. This section will help demonstrate some of the Linux infrastructure that is used to facilitate the OLED feature.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware and boot into Linux as described in the previous section ZedBoard Basic Setup and Operation.
2. A set of scripts are included in the `/usr/bin` directory for interacting with the hardware. To power off the OLED display, run the `unload_oled` script. By running this script, the OLED device driver module *pmodoled-gpio.ko* will be dynamically removed from the kernel during which the OLED is powered off using the recommended sequence and will no longer display the Digilent logo.

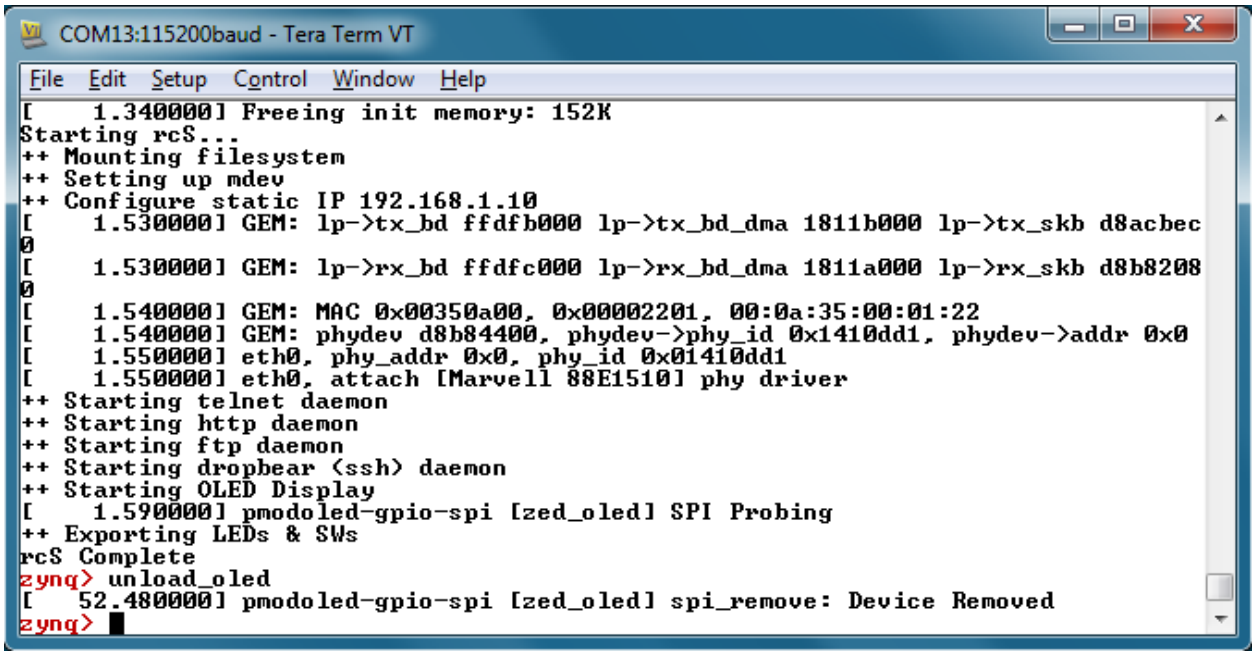


Figure 9 – Turning the OLED Display Off

3. To power on the OLED display again, run the `load_oled` script. By running this script, the OLED device driver module `pmodoled-gpio.ko` will be dynamically inserted into the kernel during which it will power on the OLED display using the recommended sequence. Next, the source logo image file `/root/logo.bin` is transferred to the OLED display device node `/dev/zed_oled` and the driver configures the OLED in order to display the Digilent logo.

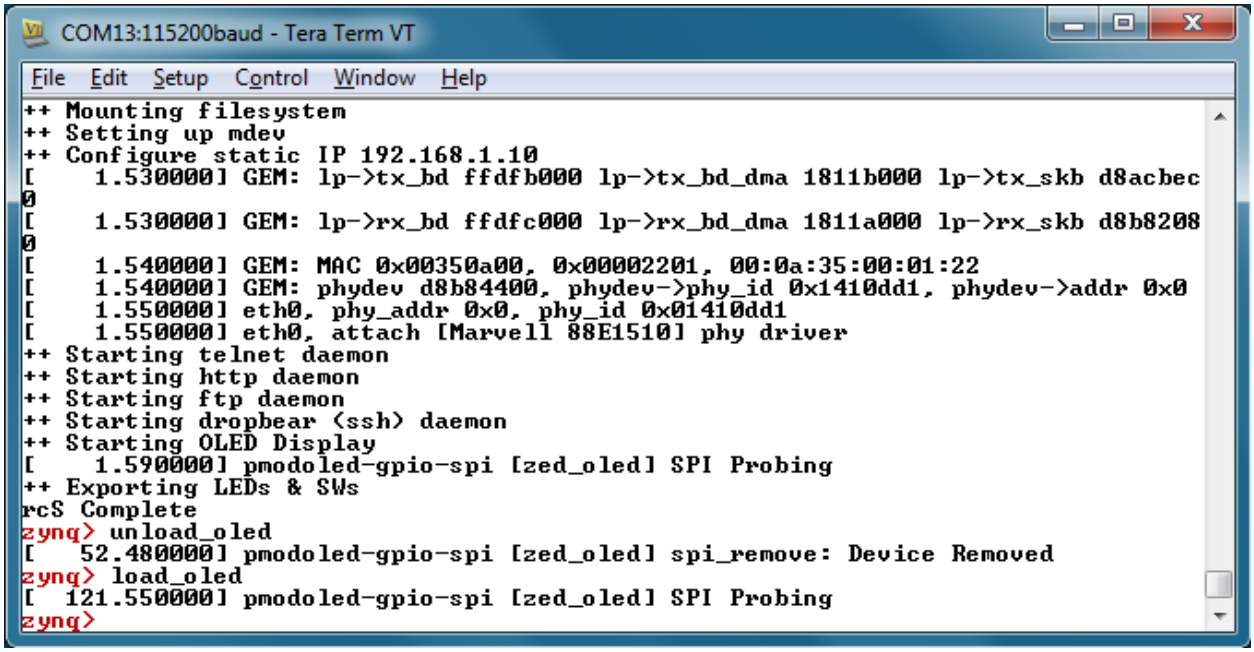


Figure 10 – Turning the OLED Display On

4. This concludes Demo 2. Continue to experiment with this demo, proceed to another demo, or run the Linux command `poweroff` and then switch off ZedBoard.

Demo 3 – VGA Display

Purpose

This demo shows how Programmable Logic (PL) can drive hardware independently of the software running on the Processing System (PS) of Zynq-7000 EPP once the PL Bitstream is loaded. During this demo a test pattern generated by the PL can be observed on a display connected to the video output on the VGA connector.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware described in the previous section ZedBoard Basic Setup and Operation.
2. Using a15-pin D-subminiature VGA cable, attach a VGA display capable of displaying a resolution of at least 640x480 to the ZedBoard video output connector J10 which is labeled **VGA**.
3. Turn power switch (SW8) to the ON position. ZedBoard will power on and the Green Power Good LED (LD13) should illuminate.
4. Wait approximately 15 seconds. The blue Done LED (LD12) should illuminate, and a default image will be displayed on the OLED (DISP1). The VGA test pattern will also show on the display as seen in Figure 11.

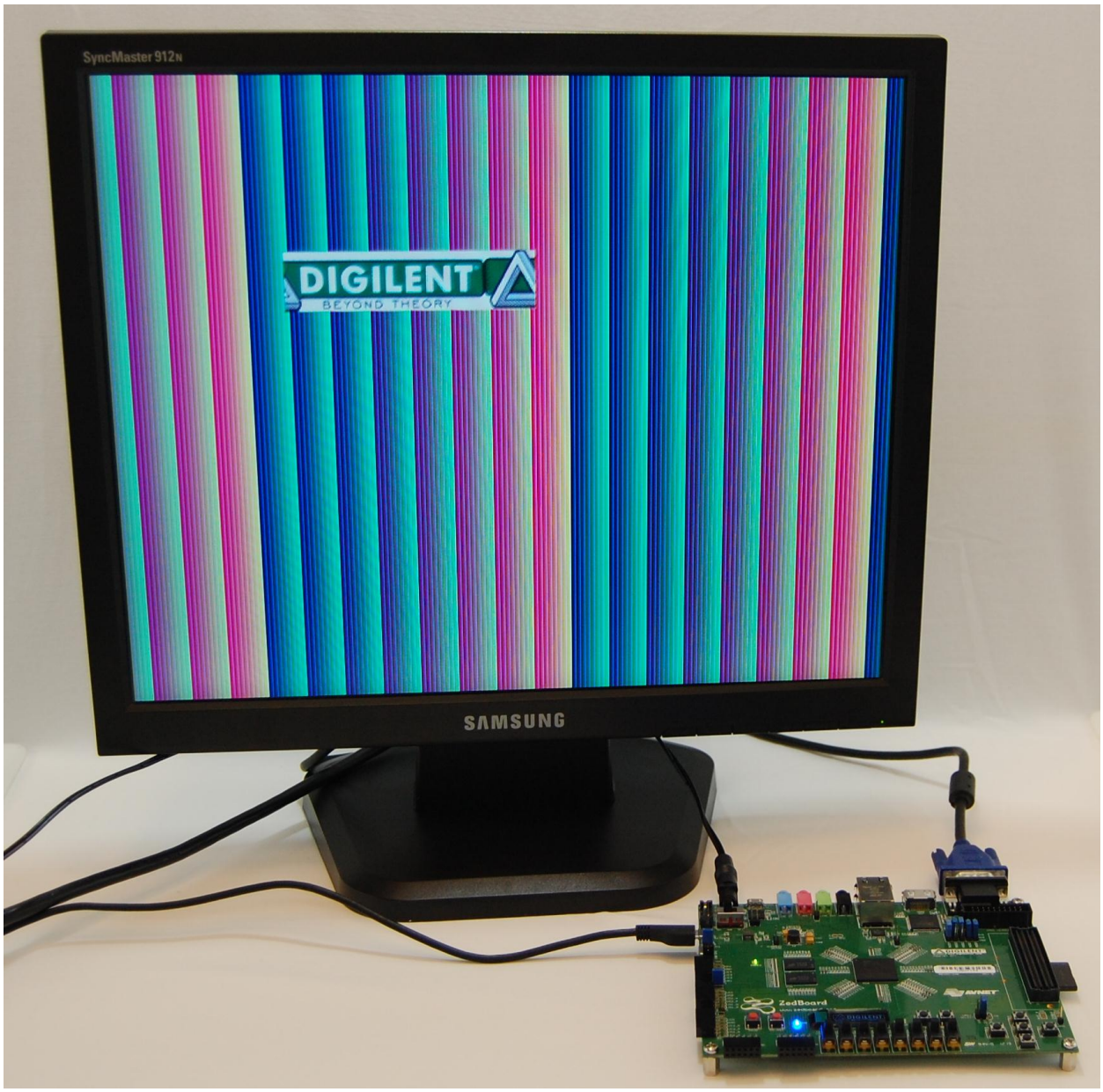


Figure 11 – VGA Output Test Pattern

5. This concludes Demo 3. Continue to experiment with this demo, proceed to another demo, or run the Linux command `poweroff` and then switch off ZedBoard.

Demo 4 – HDMI Display

Purpose

This demo shows how software running on the Processing System (PS) of Zynq-7000 EPP can interact with the Programmable Logic (PL) hardware via a device driver. During this demo, a default "Tux" Linux logo image is displayed to the HDMI display port after Linux begins booting.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware as described in the previous section ZedBoard Basic Setup and Operation.
2. Using an HDMI-to-HDMI cable, attach a HDMI display capable of displaying a resolution of at least 1080p60 to the ZedBoard HD video output connector J9 which is labeled **HDMI OUT**.
3. Turn power switch (SW8) to the ON position. ZedBoard will power on and the Green Power Good LED (LD13) should illuminate.
4. Wait approximately 15 seconds. The blue Done LED (LD12) should illuminate, and a default image will be displayed on the OLED (DISP1). The HDMI output pattern will also show on the display as seen in Figure 12.

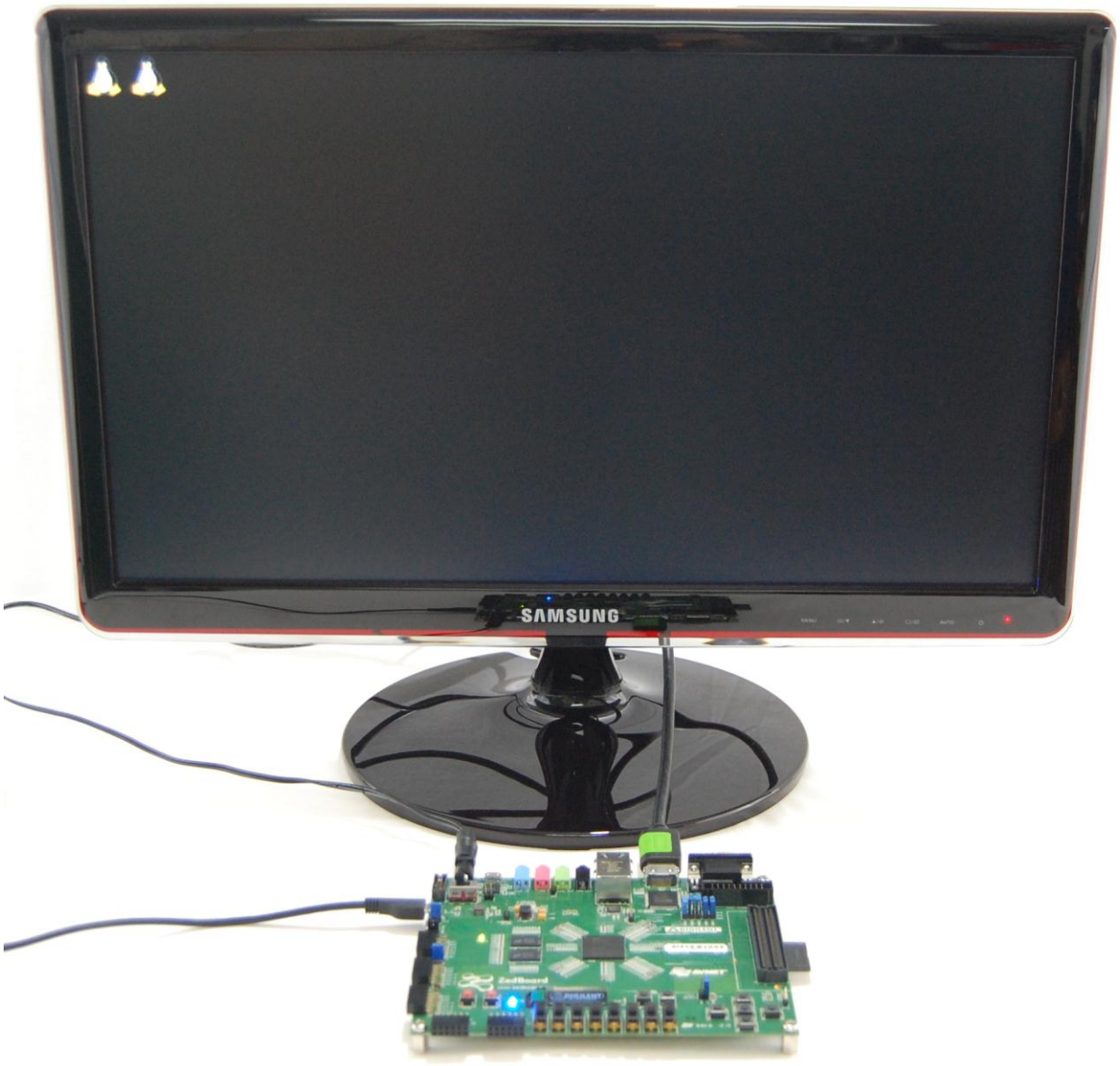


Figure 12 – HDMI Output Pattern

5. This concludes Demo 4. Continue to experiment with this demo, proceed to another demo, or run the Linux command `poweroff` and then switch off ZedBoard.

Demo 5 – Ethernet

Purpose

ZedBoard example Linux system found on the included SD card implements a Dropbear SSH server, fttpd FTP server, and Busybox httpd HTTP server at startup. Refer to the documentation on each of these server implementations if you are interested in using them beyond the scope of this document.

Host PC Networking Configuration

This demo shows the Gigabit Ethernet hardware and networking capability of ZedBoard. To run this demo, you may have to configure the network properties on your PC. The following steps will guide you through this process for a Windows 7 host PC.

1. Attach a standard Ethernet Cable between ZedBoard Gigabit Ethernet Port (J11) and the host PC network interface adapter.
2. Open the **Change adapter settings** from the **Start→Control Panel→Network and Sharing Center**.

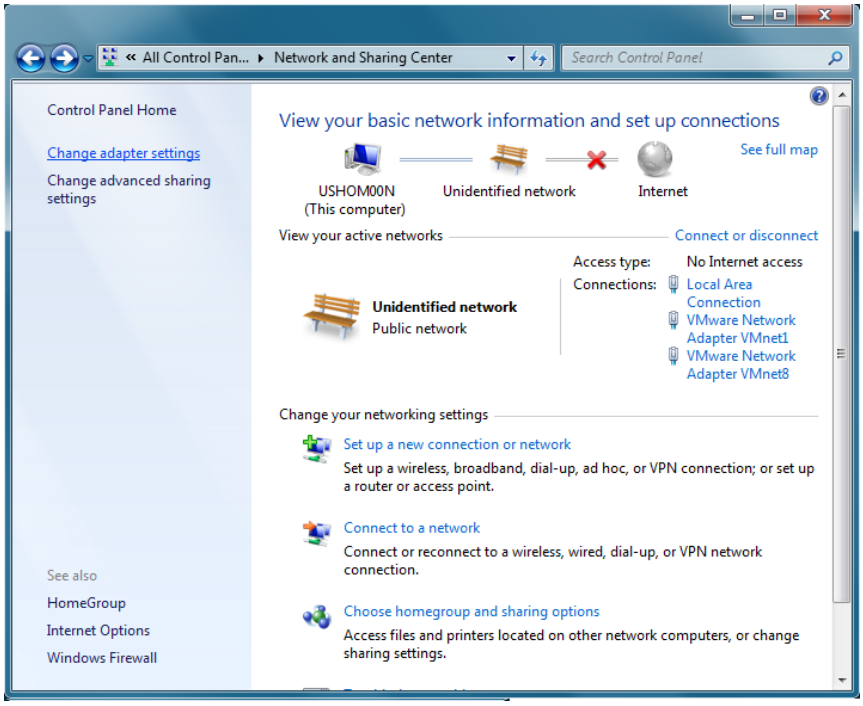


Figure 13 – Network and Sharing Center

3. In the **Network Connections** window, right-click on the Local Area Connection adapter entry corresponding to the network interface that is connected to ZedBoard and select **Properties**.

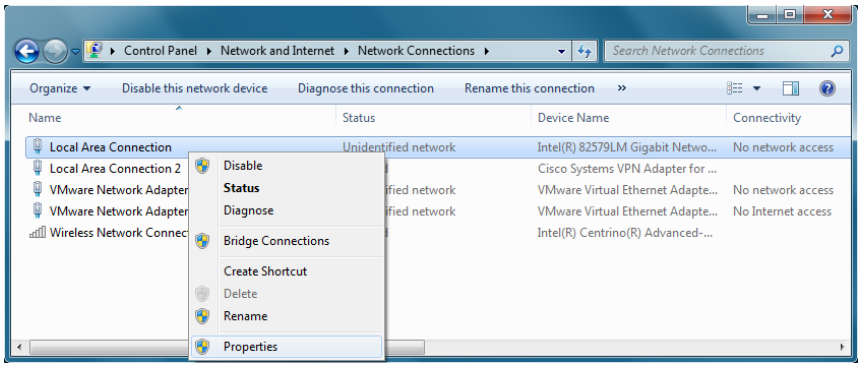


Figure 14 – Network Connections

4. In **Local Area Connection Properties**, select **Internet Protocol Version 4 (TCP/IPv4)**, then click the **Properties** button.

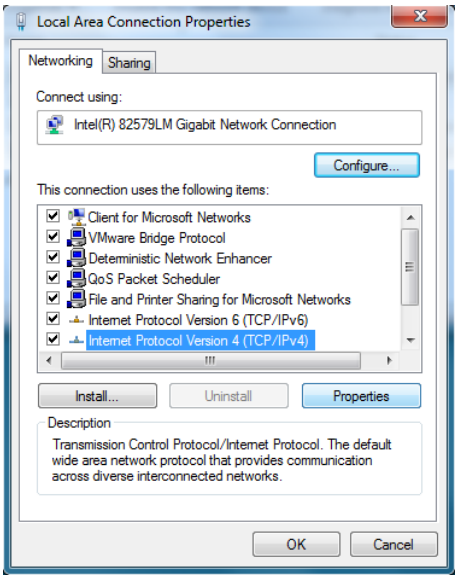


Figure 15 – Local Area Connection Properties

5. Set the IP address to 192.168.1.1 and the Subnet mask to 255.255.255.0 in the **Internet Protocol Version 4 (TCP/IPv4) Properties** window and then click the OK button.

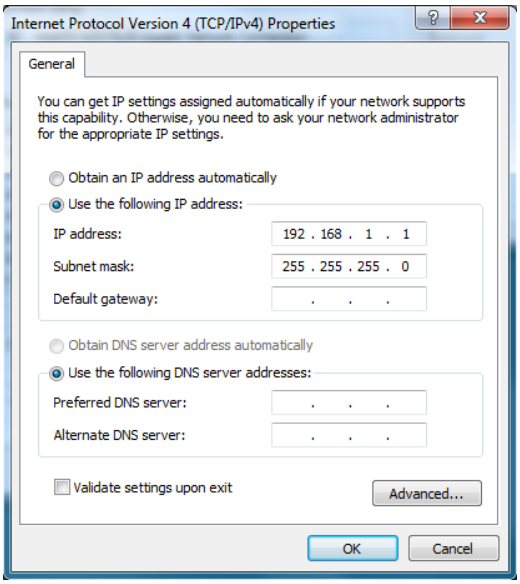


Figure 16 – Internet Protocol Version 4 (TCP/IPv4) Properties

6. The host PC networking is now configured and ready to proceed with the networking hardware demo.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware and boot into Linux as described in the previous section ZedBoard Basic Setup and Operation.
2. Verify that a standard Ethernet Cable is connected between ZedBoard Gigabit Ethernet Port (J11) and the host PC network interface adapter.

3. The default IP address of ZedBoard Ethernet is set to 192.168.1.10 and this can be verified with the output returned by the `ifconfig` command.

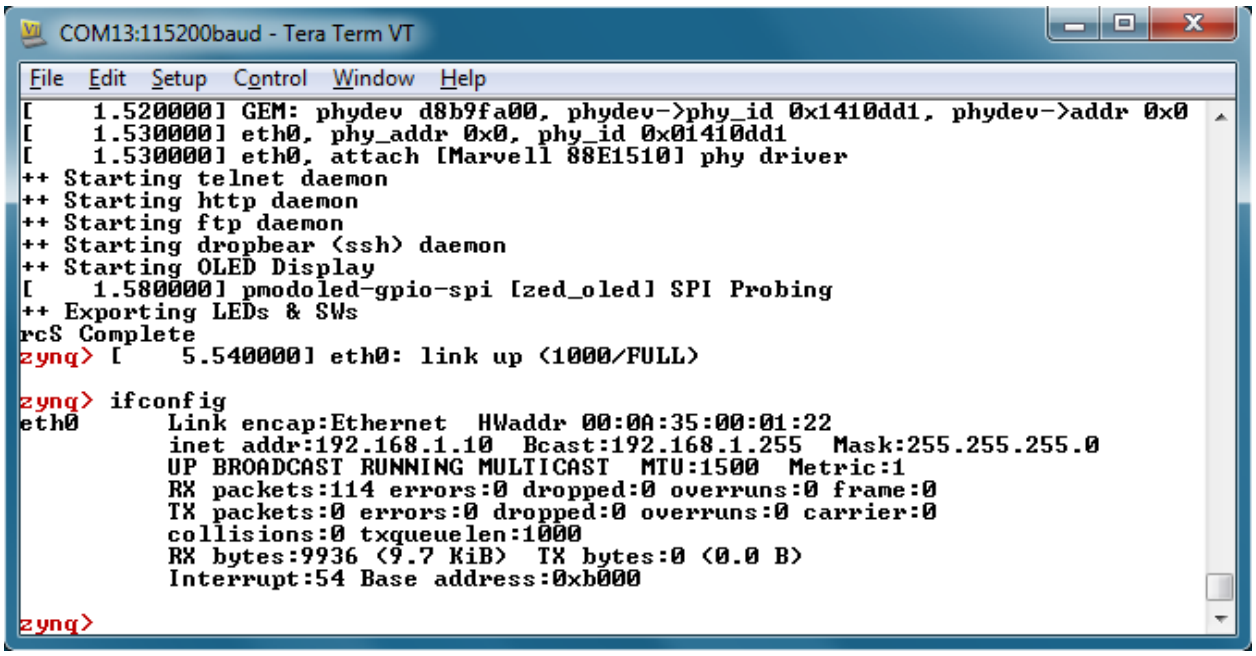


Figure 17 – ZedBoard IP Address Revealed with ifconfig Command

4. To vied the ZedBoard embedded webpage, open a web browser (such as Firefox) and browse to the ZedBoard IP address http://192.168.1.10/ as the URL. The ZedBoard webpage should open in the browser to display as seen in Figure 18.

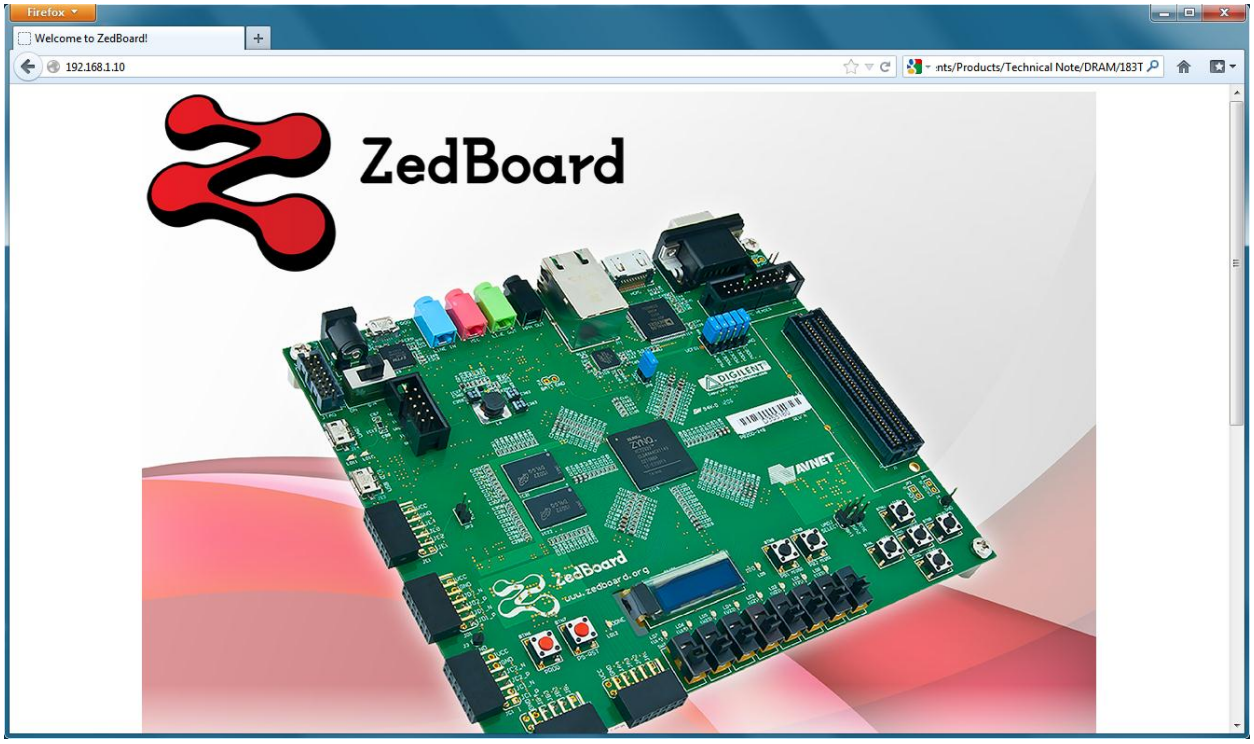


Figure 18 – ZedBoard Webpage Shown In PC Host Browser

5. Using an SSH client, such as PuTTY SSH, open a secure terminal connection to the target ZedBoard using the 192.168.1.10 IP address.

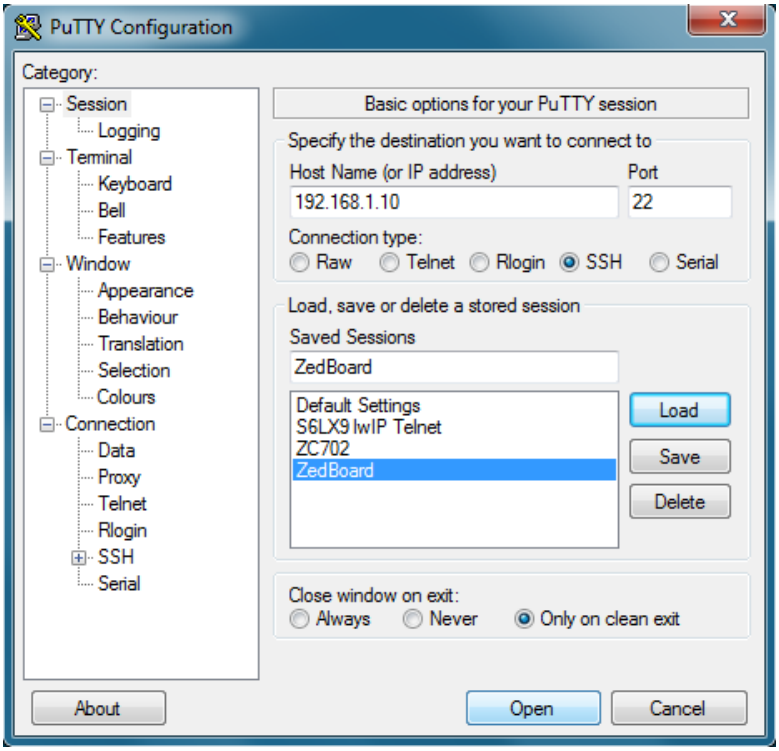


Figure 19 – ZedBoard Webpage Shown In PC Host Browser

6. Once the terminal connects, the remote system will prompt for a login. Use the user login **root** and the password **root** to complete the connection.

7. The session acts as a remote terminal and commands can be entered as you would on the local serial console.

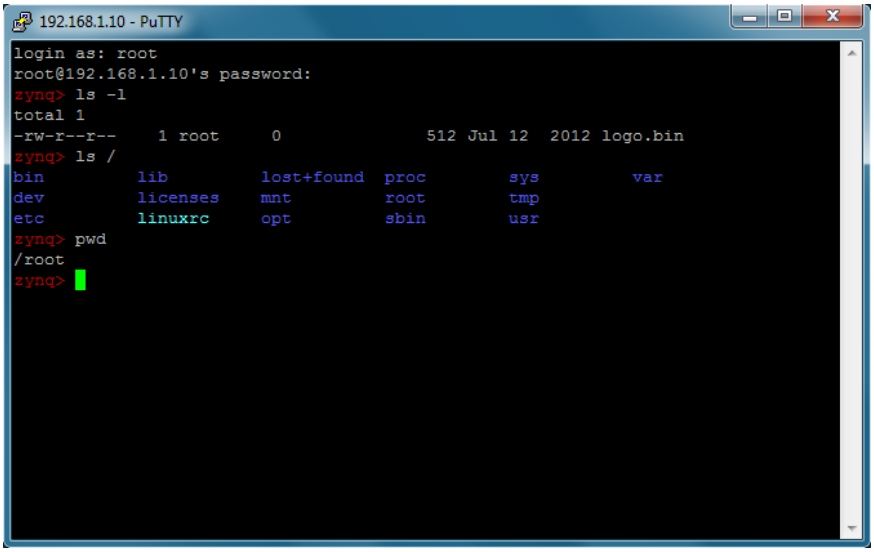


Figure 20 – Remote ZedBoard Terminal via SSH Session

8. Logout and close the remote session with the `exit` command.

9. Open a Windows Command Prompt.

10. Connect an FTP session to the remote host with the command `ftp 192.168.1.10` and use the login **root**.

11. You can use the ftp session to transfer files back and forth across the network to ZedBoard.

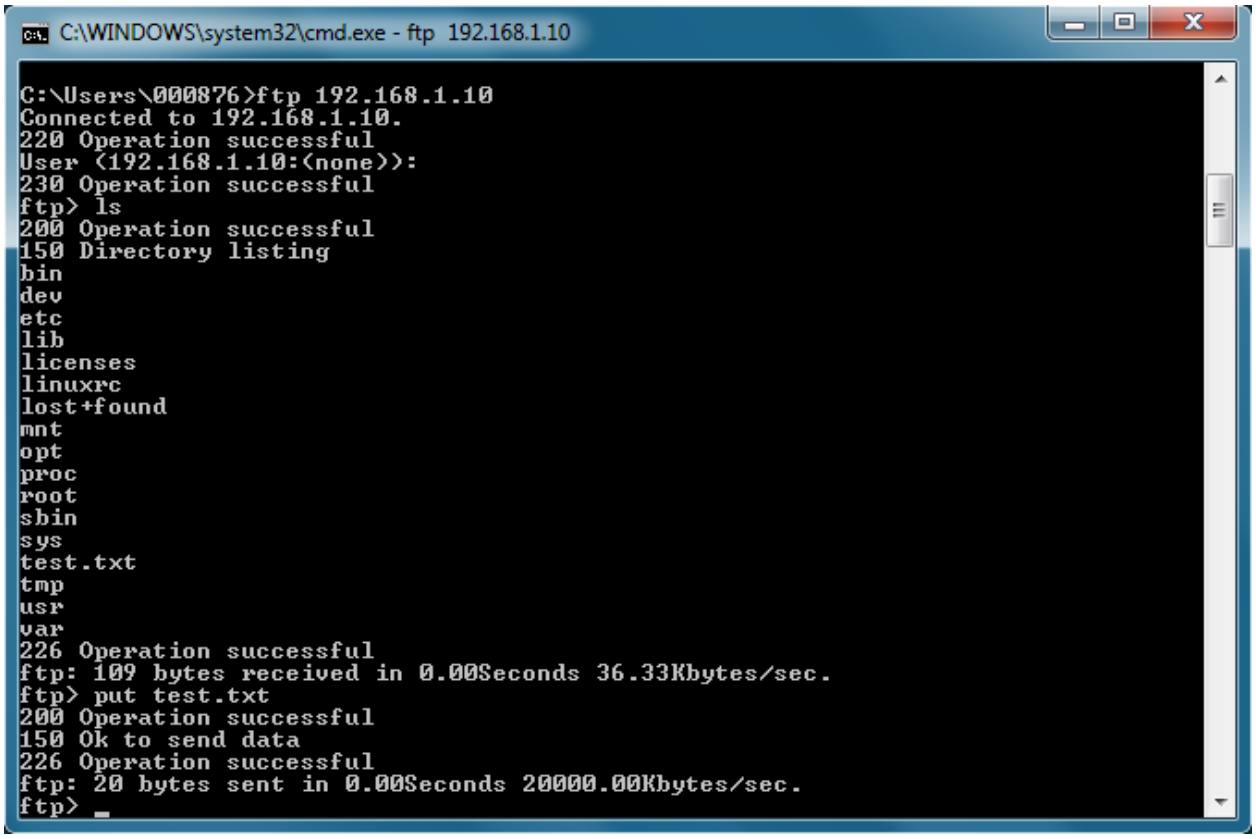


Figure 21 – ZedBoard FTP Session

12. Close the ftp session using the `bye` command.

13. This concludes Demo 5. Continue to experiment with this demo, proceed to another demo, or run the command `poweroff` and then switch off ZedBoard.

Demo 6 – USB-OTG

Purpose

This demo shows how a high speed communications peripheral connected to the Processing System (PS) of Zynq-7000 EPP can be used to extend the functionality of ZedBoard.

To connect additional USB devices with the ZED board, connect a powered hub to the USB-OTG port. USB devices attached to this hub can then also be accessed in Linux.

Running the Demo on ZedBoard Hardware

1. Set jumpers JP2 and JP3 to the 1-2 position. This will enable the OTG device for host mode and connect the ZedBoard USB 5V supply to the USB OTG (J13) VBUS line.
2. Setup the basic hardware and boot into Linux as described in the previous section ZedBoard Basic Setup and Operation.
3. Connect a USB thumb drives to the female end of the microUSB-to-Type A adapter cable included with ZedBoard.
4. Connect the microUSB end of the microUSB-to-Type A adapter cable to J13.
5. The USB thumb drive should enumerate and the device indication should display on the serial console. In this example, the primary partition of this USB thumb drive has been enumerated as device `/dev/sda1` as seen in Figure 22.

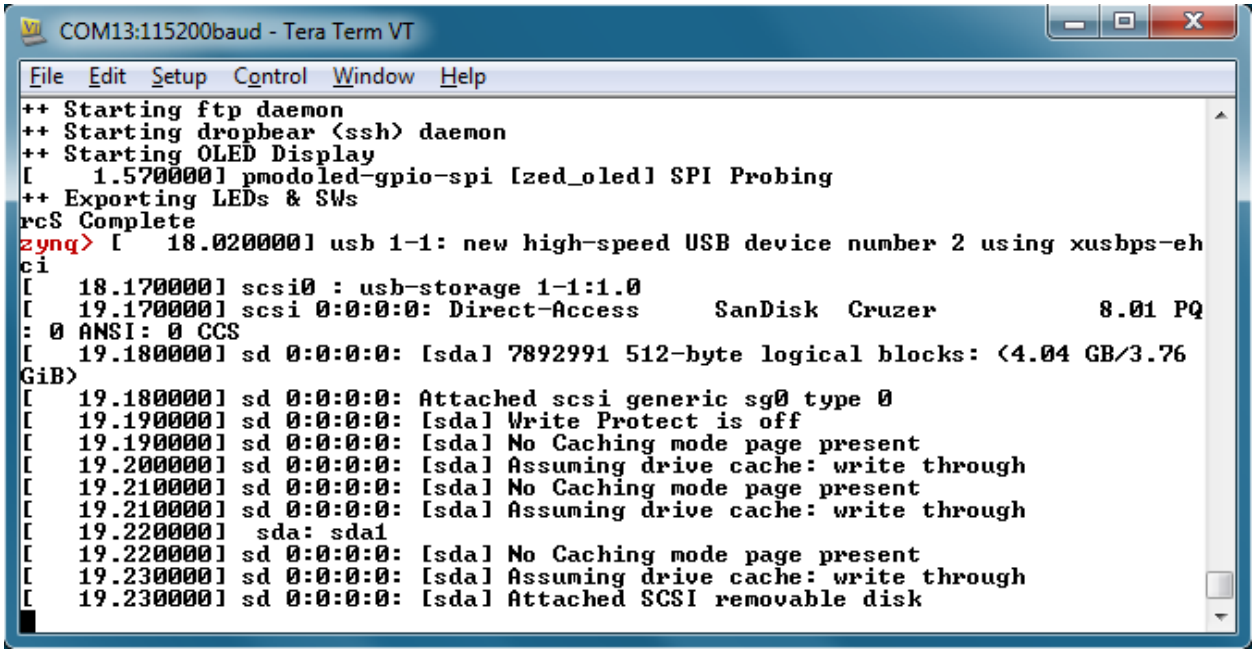


Figure 22 – USB Drive Enumeration After Device Insertion

6. Mount the enumerated device to the `/mnt` mount point using the `mount /dev/sda1 /mnt` command.

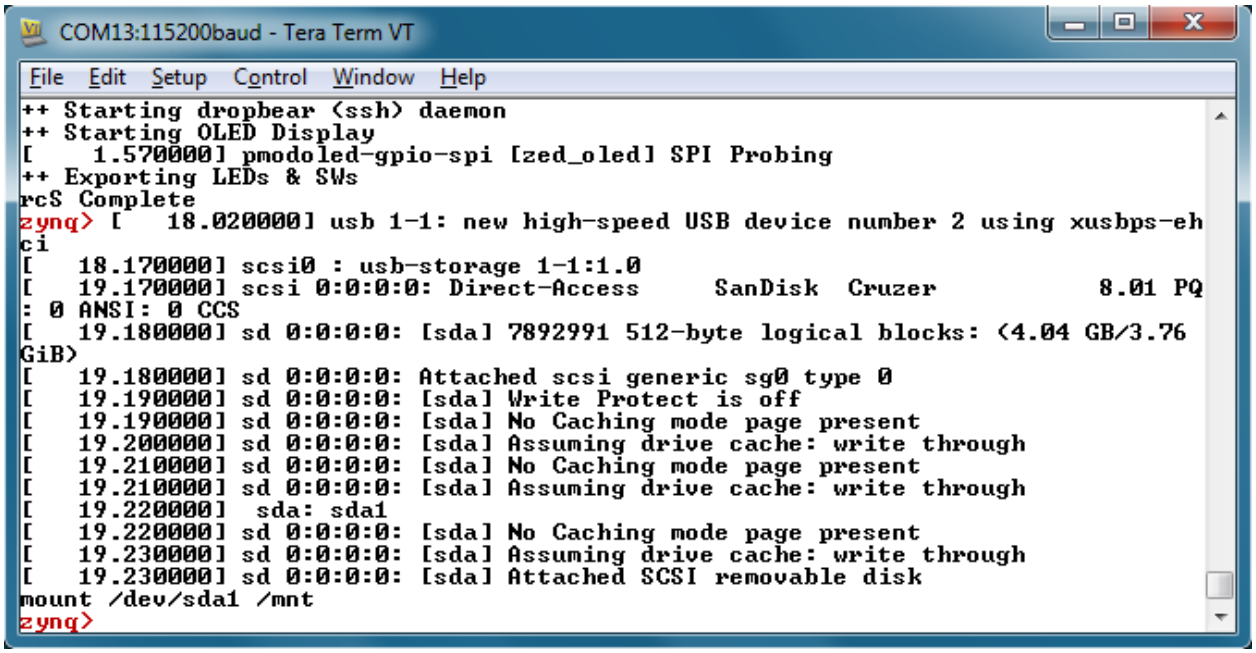


Figure 23 – USB Drive Mounted to /mnt

7. The USB drive is now mounted into the root file system at the mount point /mnt which enables read and write file operations to the devices file system. In this example, the thumb drive used has an NTFS file system format.

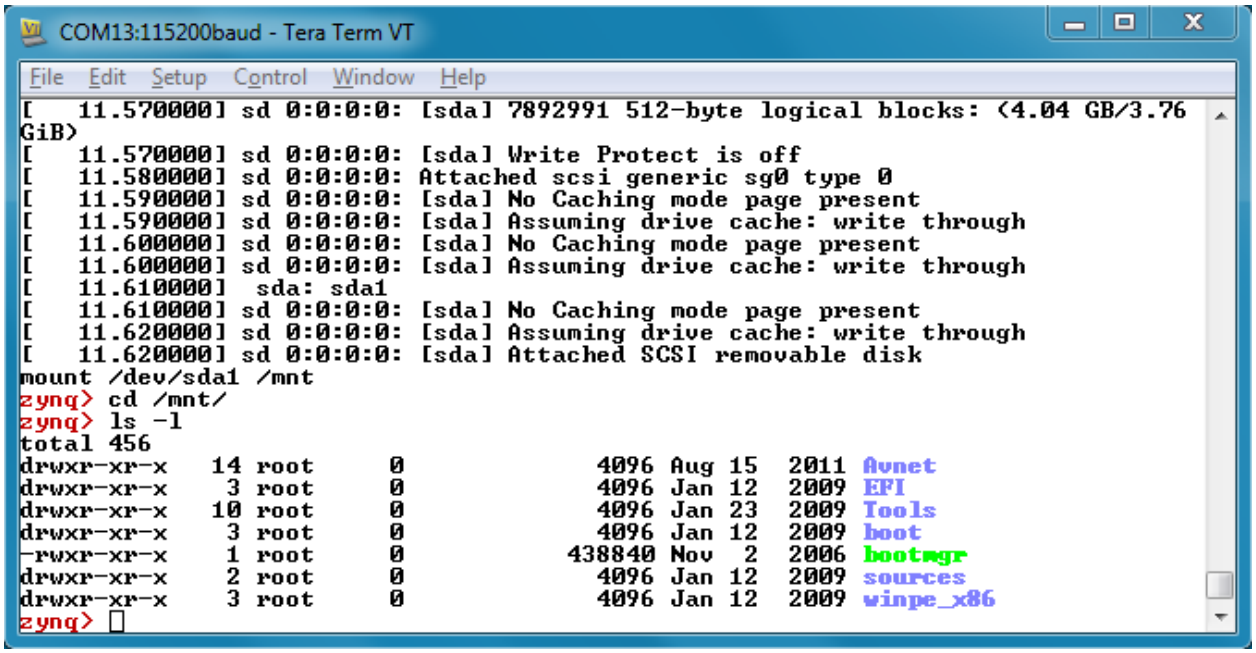


Figure 24 – Directory Listing of USB Drive

14. The device should be cleanly un-mounted from the system using the command `umount /mnt` before it is removed or the board powered off.

15. This concludes Demo 6. Continue to experiment with this demo, proceed to another demo, or run the command `poweroff` and then switch off ZedBoard.

Demo 7 – SD Card

Purpose

This demo shows how a storage device connected to the Processing System (PS) of Zynq-7000 EPP can be used to extend the functionality of ZedBoard.

The root file system for the example design comes from a RAMdisk image stored on the SD card. This RAMdisk image is copied into a fixed location in DDR3 memory by u-boot prior to Linux boot. Once Linux begins booting, it mounts the RAM file system from the fixed location in DDR3. Any subsequent changes to this file system while ZedBoard is running will not persist through a power cycle or reset.

Running the Demo on ZedBoard Hardware

1. Setup the basic hardware and boot into Linux as described in the previous section ZedBoard Basic Setup and Operation.
2. The SD card is enumerate as MMC block device `/dev/mmcblk0` and the primary partition on the device is enumerated as device `/dev/mmcblk0p1` as seen in Figure 25.

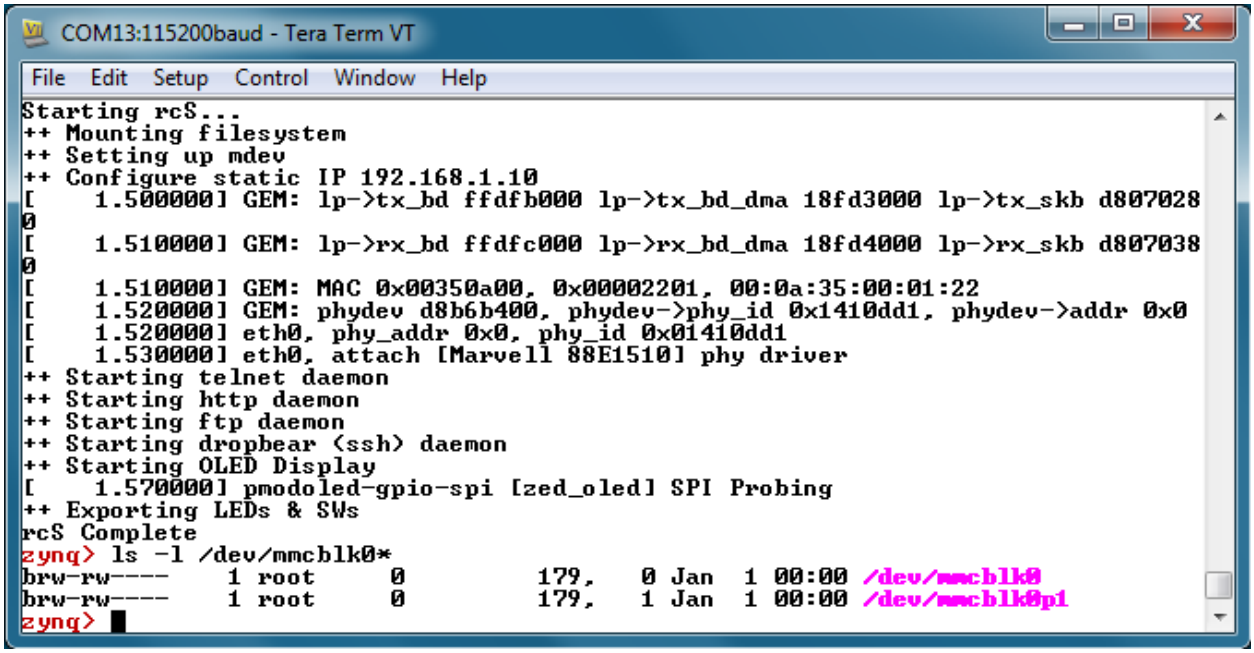


Figure 25 – SD Card Block Device Enumeration

3. Mount the enumerated SD card primary partition block device to the `/mnt` mount point using the `mount /dev/mmcblk0p1 /mnt` command.

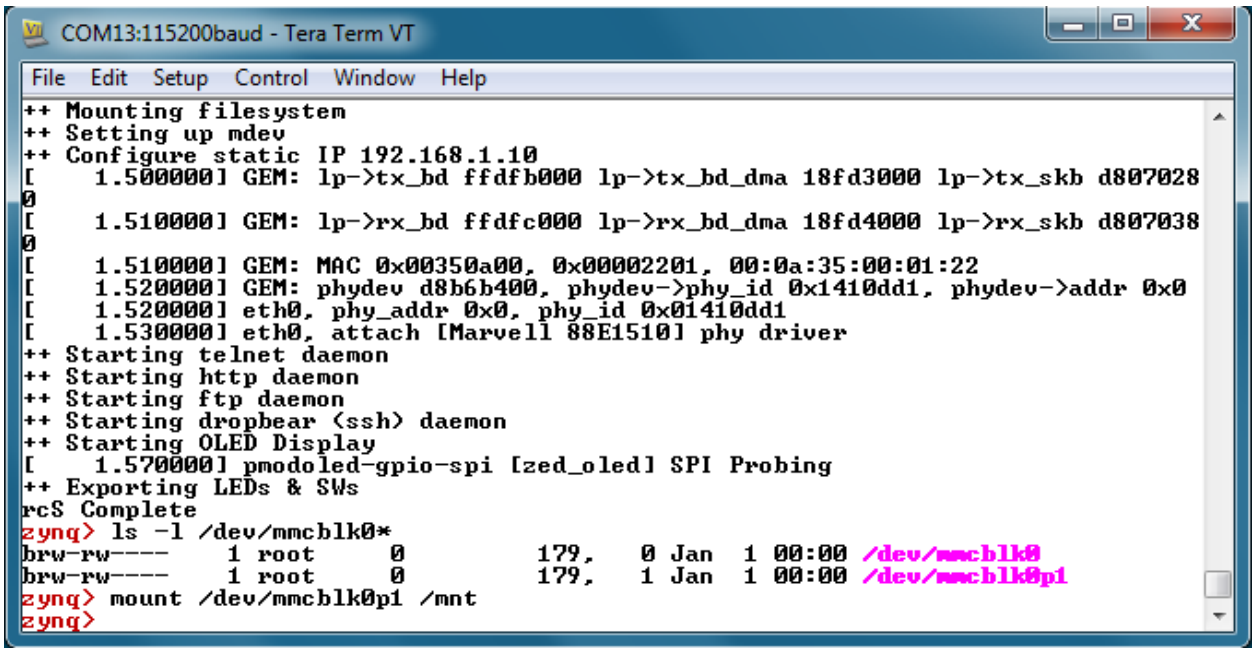


Figure 26 – SD Card Mounted to /mnt

4. The primary partition of the SD card is now mounted into the root file system at the mount point `/mnt` which enables read and write operations to files to the SD card file system. In this example, the thumb drive used has a FAT32 file system format.

   Note: User LED LD9 is used to indicate read/write activity on the SD card.

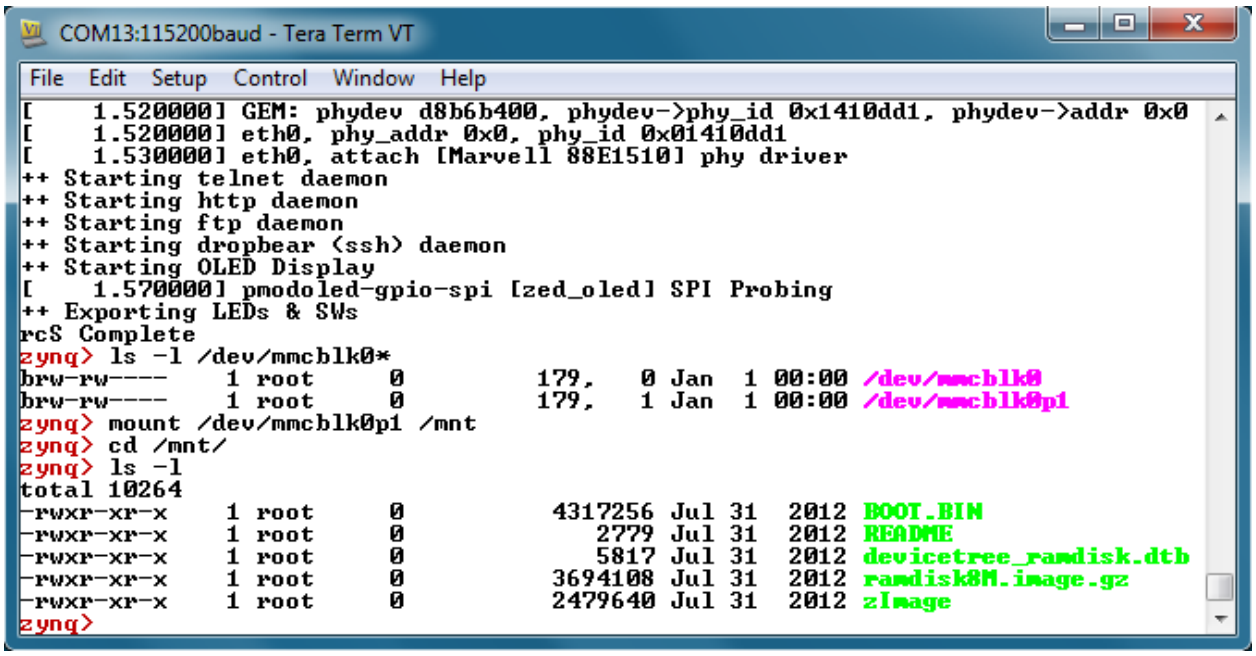


Figure 27 – Directory Listing of SD Card

5. The SD card device should be cleanly un-mounted from the system using the command `umount /mnt` before it is removed or the board powered off.
6. This concludes Demo 7. Continue to experiment with this demo, proceed to another demo, or run the command `poweroff` and then switch off ZedBoard.

What's Next

Now that the pre-built ZedBoard example design has been explored, it is time to take a deeper dive into the ZedBoard and see how to modify this design or create a custom design.

To install the Xilinx ISE WebPACK Edition tools, please see the installation instructions in Appendix I: Installing and Licensing Xilinx Software.

Where To Get More Information

- Overview and Features of ZedBoard
  - www.zedboard.org/content/overview
- ZedBoard – Hardware User Guide
  - www.zedboard.org/content/documentation

Xilinx Website

- Zynq-7000 EPP Product Information
  - www.xilinx.com/zynq
- ISE WebPACK Design Software
  - www.xilinx.com/products/design-tools/ise-design-suite/ise-webpack.htm

Cypress Website

- CY7C64225 USB-to-UART Driver Download
  - www.cypress.com/?rID=63794
- CY7C64225 USB-to-UART Device Data Sheet
  - www.cypress.com/?docID=36208

Getting Additional Help and Support

Avnet Support

ZedBoard is a community-oriented kit, with all technical support being offered through the ZedBoard.org community website support forums. ZedBoard users are encouraged to participate in the forums and offer help to others when possible.

For questions regarding the ZedBoard community website, please direct any questions to:

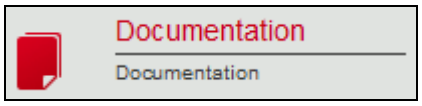
- ZedBoard.org Web Master – webmaster@zedboard.org

To access the most current collateral for ZedBoard please visit the community support page at:

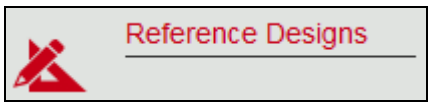
- www.zedboard.org/content/support

Once on the ZedBoard.org support page:

To access the latest ZedBoard documentation, click on the Documentation link:



To access the latest reference designs for ZedBoard, click on the following link:



To access the ZedBoard technical forums, click on the following link:

Xilinx Support

For questions regarding products within the Product Entitlement Account, 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

Appendix I: Installing and Licensing Xilinx Software

Install ISE WebPACK or Design Suite

The ZedBoard XC7Z020-CLG484-1 Zynq-7000 EPP device development is supported by ISE WebPACK licensing. ZedBoard also comes with entitlement voucher to a seat of ChipScope™ Pro that is device locked to a XC7Z020-CLG484-1 Zynq-7000 EPP device. This software can be installed from the included DVD or the latest version can be downloaded online at:

- www.xilinx.com/support/download/index.htm

If a full seat of ISE Embedded or System Edition has already been installed, then no further software will be needed. Please check online for any updates at:

- www.xilinx.com/support/download/index.htm

For detailed instructions on installing and licensing the Xilinx tools, please refer to the **Xilinx Design Tools: Installation and Licensing Guide** available on the Xilinx website:

- www.xilinx.com/support/documentation/sw_manuals/xilinx14_1/iil.pdf

Appendix II: QSPI Flash Example Application

Boot ZedBoard from QSPI

The ZedBoard comes from the factory with a very simple example application loaded into the Spansion QSPI Flash (IC14/IC15). If the contents of the QSPI flash are unaltered, it should be possible to boot the Zynq-7000 EPP device into the very simple application loaded from the QSPI Flash memory as described below.

Verify the ZedBoard boot mode jumpers (JP7-JP11) are set to QSPI flash mode as described in the Hardware Users Guide.

www.zedboard.org/sites/default/files/ZedBoard_HW_UG_v1_1.pdf

The example application will boot the Processing System using QSPI flash as the boot source and configure the Programmable Logic using a simple Bitstream file which displays a test pattern on User LEDs LD0-LD7 as seen in figure 28.

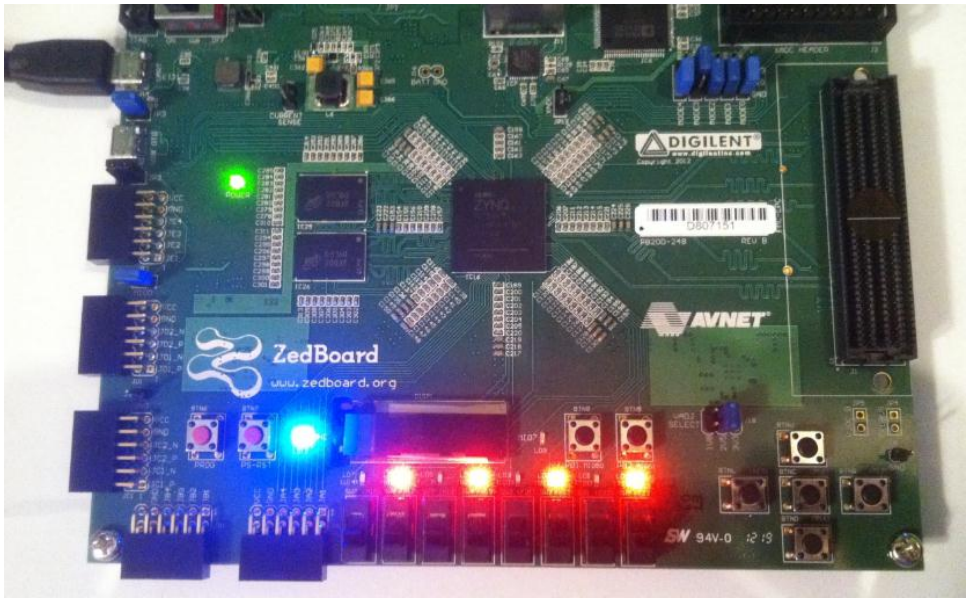


Figure 28 – QSPI Application Example Output

P/N: GS-AES-Z7EV-7Z020-G-14.1-V1