Ultra96 Getting Started Guide

Version 1.0
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1 Getting Started with Ultra96
The Avnet Ultra96 enables hardware and software developers to explore the capabilities of the Zynq® UltraScale+™ MPSoC. Designers can create or evaluate designs for both the Zynq Processor Subsystem (PS) and the Programmable Logic (PL) fabric.

![Ultra96 developers board](image)

Figure 1 – Ultra96

This Getting Started Guide will outline the steps to setup the Ultra96 hardware. It documents the procedure to run a PetaLinux design running on the Quad-core ARM Cortex-A53 MPCore Processing System (PS).

2 What’s Inside the Box?
- Ultra96 development board
- Pre-programmed 16GB microSD card with SD adapter and jewel case
- Voucher for SDSoC license from Xilinx
- Quick Start Instruction card

2.1 Optional add-on items:
- External 96Boards compliant power supply kit (12V, 2A, US plug) (AES-ACC-U96-PWR)
- USB-to-JTAG/UART pod for Ultra96 (AES-ACC-U96-JTAG)
- Seeed Studio’s Grove Starter Kit for 96Boards
- Many more documented here: [Ultra96 Compatible Accessories](#)
3 What’s on the Web?
Ultra96 is a community-oriented kit, with all materials being made available through the Ultra96.org community website.

3.1 Official Documentation:
- Getting started guide
- Hardware user guide
- Schematics
- Bill of materials
- Layout
- PCB net lengths
- Mechanical drawing
- 3D Model
- Board definition files for Vivado integration
- Programmable logic (PL) master user constraints

3.2 Tutorials and Reference Designs:
- Ultra96 Bare Metal Hardware Platform Creation
- Ultra96 Bare Metal Microchip USB-UART
- Ultra96 Bare Metal Test Application Development
- Ultra96 Bare Metal Boot Techniques
- Ultra 96 Factory Restore Image
- Ultra96 Accelerated Image Classification

3.3 Trainings and Videos:
- Introduction to Ultra96
4 Ultra96 Key Features

- Zynq UltraScale+ MPSoC ZU3EG SBVA484
- Memory
  - Micron 2 GB (512M x32) LPDDR4 Memory
  - MiroSD Socket
    - Ships with Delkin Utility MLC 16GB card
- Wi-Fi / Bluetooth
- DisplayPort
- 1x USB 3.0 Type Micro-B upstream port
- 2x USB 3.0 Type A downstream ports
- 40-pin Low-speed expansion header
- 60-pin High speed expansion header
- Mounted on thermal bracket with fan

Note that there is no on-board, wired Ethernet interface. All communications must be done via USB, Wi-Fi, JTAG, or expansion interface.
Figure 2 – Ultra96 Block Diagram
5 Ultra96 Basic Setup and Operation

The functionality of the Ultra96 is determined by the application booted from the non-volatile memory – by default that is the SD Card. This Getting Started Guide allows system developers to exercise and demonstrate multiple circuits through PetaLinux, including:

- SSH Terminal Access
- GPIO LEDs
- Wi-Fi
- I2C Sensor Detect

In addition to the items included in the kit, you will also need the following to complete the exercises in this tutorial.

- **Wi-Fi connection**

An Ultra96 image in its expected out-of-box configuration is shown below along with various topology components highlighted.

![Ultra96 Topology](image)

**Figure 3 – Ultra96 Topology**
6 Example Design
The Ultra96 ships with an example image loaded in the 16GB microSD Card. If your microSD Card image has been corrupted or deleted, there is Ultra96 Factory Restore available at www.Ultra96.org that will go into detail on how to restore your factory image.

7 Hardware Setup
1. A terminal program is required. TeraTerm was used in this example which can be downloaded from the TeraTerm project on the SourceForge Japan page: ttssh2.sourceforge.jp Install TeraTerm or another terminal program of your choice.

2. Plug in your 12V Barrel Jack power supply into a wall outlet and then connect the barrel jack to J5 on your Ultra96. Your Ultra96 should be powered down at this point. Note: DC power supply is not included in the Ultra96 kit but can be purchased separately.

3. Set the Ultra96 boot mode switch SW2 to SD Card boot mode as shown below.

![Ultra96 Switch Location]

Figure 4 – Ultra96 Switch Location
8 Connect to Webserver

1. Press and release the power button (SW3). The Green Power On LED (DS9), Red INIT_B LED (DS7) and the Green User LEDs should illuminate. After a few seconds, INIT_B LED will turn off and the Green DONE LED (DS6) will illuminate. At 15 seconds, the Blue Bluetooth Enable LED (DS1) will illuminate. At 30 seconds, the Yellow Wireless LAN Enable LED (DS8) will illuminate.

2. After about 40 seconds, a new Wi-Fi SSID will be discoverable, named “Ultra96_<MAC_ID>” which is unique for each board. Connect the Wi-Fi on your PC to this SSID.
3. Now that we are connected to the Ultra96, we should open up the webserver. Open an internet browser window and navigate to the following address: http://192.168.2.1

4. You will be directed to the webserver’s home page for Ultra96. Here you will be able to view example projects, custom contents and various tutorials for Ultra96.
9 Ultra96 GPIO LEDs Example Project

1. Next we want to access the Ultra96 GPIO LEDs example project. From the Ultra96 home page select **Ultra96 GPIO LEDs** example project.

![Ultra96 Home](image)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra96 GPIO LEDs</td>
<td>Be able to control the four GPIO LEDs on the Ultra96 Board. Can have them in a constant state or as a trigger.</td>
</tr>
</tbody>
</table>

![Figure 7 – Ultra96 GPIO LEDs](image)

2. All LEDs will be at an unknown state to begin with. Select the drop down menus and begin changing the status of the GPIO LEDs. You will notice that the four LEDs (located in between the two USB connectors J8/J9) update in real time.

3. Scroll to the bottom of the webpage and you will see a definition table for various LED selection options.

4. Something of interest may be setting LEDs 0 and LEDs 1 to phy0tx and phy0rx respectively.

5. Now as you navigate throughout this webserver you will notice the Wi-Fi transmitting and receiving LEDs flickering as you are sending and receiving data from the Ultra96.
10 OpenAMP Matrix Multiplication

1. Select **Example Projects** up at the top of the page. You will see a list of projects along with descriptions of each.

2. Select **OpenAMP Matrix Multiplication** which is the second in the list.

### Example Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra96 GPIO LEDs</td>
<td>Be able to control the four GPIO LEDs on the Ultra96 Board. Can have them in a constant state or as a trigger.</td>
</tr>
<tr>
<td><strong>OpenAMP Matrix Multiplication</strong></td>
<td>Provides a complex test that generates two matrices on the Linux master which are then sent to the remote to multiply them. Then they are sent back to the master to display the result.</td>
</tr>
<tr>
<td>OpenAMP Proxy Application</td>
<td>Application creates a proxy between the Linux master and the remote core, which allows the remote firmware to use console and execute file I/O on the master.</td>
</tr>
<tr>
<td>Hello World with LCD</td>
<td>How to display text on the Grove RGB LCD module and change the color of the backlight (Linux IO).</td>
</tr>
<tr>
<td>Touch Sensor and Relay</td>
<td>A system that toggles a relay on and off when the touch sensor is tapped (Linux IO).</td>
</tr>
<tr>
<td>Drive LED with Button</td>
<td>Control an LED with the use of a button (Atmega IO).</td>
</tr>
<tr>
<td>Buzzer and Light Sensor</td>
<td>Use the Grove light sensor and Grove buzzer to be silent when there is light and emit noise when it is dark (Atmega IO).</td>
</tr>
<tr>
<td>Temperature and Humidity Display</td>
<td>Read data using the Digital-Humidity and Temperature sensor and display the readings on the LCD Display (Linux/Atmega IO).</td>
</tr>
<tr>
<td>Tweeting Doorbell</td>
<td>Sends a message out to twitter every time the button is pressed (Linux/Atmega IO).</td>
</tr>
</tbody>
</table>

**Figure 8 – OpenAMP Matrix Multiplication**

3. Read through the description which goes over what is going to happen in the OpenAMP Matrix Multiplication Design and then select **Run Project**

4. In the Output section you will see the two input matrices and then the matrix multiplication results.

11 Additional Example Projects

1. Return back to the **Example Projects** page by selecting the Example Project tab at the top.

2. As you can see there are seven additional example projects available to you. Feel free to explore them. However some require additional hardware such as the **Grove Starter Kit** to complete.
12 Custom Content Tutorial

1. Now select the **Tutorial** tab at the top of the page. You will be directed to a Tutorials/Guides page

![Ultra96 Tutorials/Guides](image)

<table>
<thead>
<tr>
<th>Tutorial/Guide</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grove Starter Kit</td>
<td>Learn all about the accessories that came with the Grove Starter Kit for 96Boards and how to connect it to the Ultra96.</td>
</tr>
<tr>
<td>Custom Content</td>
<td>Learn how to create custom projects and webpages or upload your own local documents.</td>
</tr>
<tr>
<td>Run Example Project</td>
<td>Learn how to run example project and edit project code.</td>
</tr>
<tr>
<td>Smart</td>
<td>Learn how to use the Smart Package Manager through an example.</td>
</tr>
<tr>
<td>Using Ultra96</td>
<td>Learn about the different ways that you can do actions and/or access the board.</td>
</tr>
</tbody>
</table>

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**Figure 9 – Ultra96 Tutorials/Guides**

2. This sections goes into how to get started with the out of box microSD card image we have been exploring up to this point. As of now we have explored the **Run Example Projects** section.

3. Let’s take a look at the **Custom Content** tutorial. Select **Custom Content**.

4. This Tutorial goes over the three different ways custom content can be added to this out of box image. The three different ways being

   1) Uploading custom files
   2) Making custom webpages
   3) Making custom projects

5. To access these options select the **Custom Content** tab at the top of the webpage.
13 Smart Tutorial

1. Now return back to the Ultra96 Tutorials page. This time select Smart from the tutorial list.

2. This tutorial goes into explaining how to use the Smart Package Manager (smart) to update/install packages.

3. This tutorial also provides an example that you can follow along with that will showcase a use case of how to write a simple “Hello World” application, compile it, create a RPM package with CMake, install/remove it with smart, and then run it.

14 Using Ultra96 Tutorial

1. Return back to the Tutorials page and now select the Using Ultra96 tutorial.

2. This tutorial goes over the various ways you can interact with the Ultra96. As of now we have only done this using the Webapp.

3. We will not be exploring accessing your Ultra96 over miniDP or UART since by default you would need additional hardware to access it through these two peripherals.

4. Read through the SSH section, it states we can access the Ultra96 terminal using TeraTerm or a PuTTY terminal application.

5. Since we have already downloaded and installed TeraTerm at the beginning of this guide let’s access the Ultra96’s Linux terminal over SSH using TeraTerm.
15 Access Ultra96 Linux Terminal over SSH

1. Verify that your PC is still connected to the Ultra96 Webserver by checking your wireless network.

2. Open TeraTerm and then select **File** → **New connection**… as seen in the image below.

![Figure 10 – TeraTerm New Connection](image)

**Figure 10 – TeraTerm New Connection**
3. A new **TeraTerm: New connection** window will open. We now want to connect to Ultra96 over SSH, select TCP/IP and then configure your Terminal settings the same as the below figure.

![Figure 11 – SSH Terminal Settings](image)

4. Select **OK**

5. You will then be prompted to enter **SSH Authentication** information. In our case it is looking for the Linux terminal’s user name and passphrase which are **root** and **root**.

6. Please type in **root** for the **User name** and then type in **root** for the **Passphrase** as well. Then select **OK**.

![Figure 12 – SSH Authentication](image)
7. You now have access to the Ultra96 Terminal!

![Image of Ultra96 Terminal]

**Figure 13 – Ultra96 Terminal**

### 16 INA226 Current Sensor

1. Now that we have access to the Linux Terminal let’s try and read from the INA226 Current Sensor on our board.

2. Type in your console `i2cdetect -y -r 1`

   ![Image of I2C detect output]

   **Figure 14 – I2Cdetect**

3. As you can see some devices are coming back as unavailable under I2C detect, this means they may already be monitored by some other driver within the system. That is the case for the INA226 Current Sensor on Ultra96.

4. It turns out there is a Linux sysfs drive for INAxxx devices that is already built into the kernel:
5. Based on this it turns out that you can actually just read the system current from the INAv26 device by using the sensor command.

6. In your terminal type `sensors`

```
root@Ultra96:~ # sensors
ina226-i2c-7-40
  Adapter: i2c-i-mux (chan_id 5)
  in0: +0.000 U
  in1: +12.30 U
  power1: 4.42 U
  curr1: +0.16 A

  iio_hwmon-isa-0000
  Adapter: ISA adapter
  in1: +0.05 U
  in2: +0.82 U
  in3: +1.81 U
  in4: +1.00 U
  in5: +1.70 U
  in6: +1.70 U
  in7: +1.70 U
  in8: +1.70 U
  in9: +0.90 U
  in10: +1.80 U
  in11: +0.60 U
  temp1: +44.1 C
  temp2: +43.7 C
```

**Figure 15 – Reading INA226 Device**

7. As you can see the current, voltage, and temperature measurements are reported back.

8. This is one of the lesser known but highly useful Linux subsystems.

### 17 Power Off

1. When you are done experimenting with your Ultra96 and wish to power off the board, press and release the Power button (SW3) located on the top side of your Ultra96 next to the barrel jack.

2. You will notice your board does not power down immediately. It will take roughly 10-20 seconds for your board to completely power down. The reason behind this is it is adhering to the various power down sequencing requirements.

3. Please note, if you do not let your Ultra96 power off as per the power down sequencing requirements (such as unplugging the barrel jack), your SD Card may get corrupted or damaged.

4. To power off the Ultra96 you can also press and hold Sw3 for 10 seconds to force a power off. This is useful for when the soft power-off appears to no work.
18 Getting Help and Support

18.1 Avnet Support
The Ultra96 is a versatile development kit that allows evaluation of the Zynq MPSoC, which can help you adopt Zynq into your next design. All technical support is offered through www.Ultra96.org website support forums. Ultra96 users are encouraged to participate in the forums and offer help to others when possible.

http://zedboard.org/forums/zed-english-forum

To access the most current collateral for Ultra96 please visit the community support page at:

www.Ultra96.org/content/support – Hardware/Vivado Support
www.96boards.org – Software Support

Once on the Ultra96.org support page:

To access the latest Ultra96 documentation, click on the Documentation link:

![Documentation](image)

To access the latest reference designs for Ultra96, click on the following link:

![Reference Designs Tutorials](image)

To access the Ultra96 technical forums, click on the following link:

![Support Forums](image)
To view online training and videos, click on the following link:

![Training and Videos](image)

**18.2 Xilinx Support**
For questions regarding products within the Product Entitlement Account, visit the Contact Support site for Xilinx:

[https://www.xilinx.com/support/service-portal/contact-support.html](https://www.xilinx.com/support/service-portal/contact-support.html)

For technical support including the installation and use of the product license file, contact Xilinx Online Technical Support at [www.xilinx.com/support](http://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
19 Installing and Licensing Xilinx Software

19.1 Install Vivado Design Suite, Design Edition

The Zynq device on the Ultra96 is supported in Vivado Design Suite, Design Edition. Version 2018.1 or later is required to use the pre-installed board definition file.

You must license your Vivado Design Suite, Design Edition with the license that came with your Ultra96. To obtain your free license, visit the following website and insert the voucher code from the certificate included in your kit:

http://www.xilinx.com/getlicense

1. Log in
2. Fill out information at Product Licensing - Name and Address Verification, then click Next
3. Select your Account

![Xilinx Website Screenshot](image)

4. Enter your voucher code here, then click Redeem Now.
5. At the confirmation screen, click Yes.

![Figure 16 – Voucher Confirmation](image)


![Figure 17 – Generate Node-Locked](image)
7. Create or select your Host ID. Click Next.
8. Review the license request, then click **Next** again.

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


For detailed instructions on installing and licensing the Xilinx tools, please refer to the latest version of *Vivado Design Suite User Guide Release Notes, Installation, and Licensing* (UG973).
20 Certification Disclaimer
Both CE and FCC certifications are necessary for system level products in those countries governed by these regulatory bodies.

Because Avnet boards are intended for evaluation kits only and destined for professionals (you) to be used solely at research and development facilities for such purposes, they are considered exempt from the EU product directives and normally are not tested for CE or FCC compliance.

If you choose to use your board to transmit using an antenna, it is your responsibility to make sure that you are in compliance with all laws for the country, frequency, and power levels in which the device is used. Additionally, some countries regulate reception in certain frequency bands. Again, it is the responsibility of the user to maintain compliance with all local laws and regulations.

This board should be used in a controlled lab environment by professional developers for prototype and development purposes only. The board included in the kit is not intended for production use unless additional end product testing and certification is performed.

21 Safety Warnings
This product shall only be connected to an external power supply that is 96boards compliant.

Only compatible plug-in modules shall be connected to Ultra96. The connection of incompatible devices may affect compliance or result in damage to the unit and void the warranty.

This product shall be operated in a well-ventilated environment. If a case is used, it shall have adequate ventilation.

22 RF Certification
The frequency range is 2.4 to 2.4835GHz.

The max power complies with 802.11b, which is 17dBm (typ).

More information on RF certification for the TI WiLink8 module is available here: