Instructions for System Setup and Configuration

This document provides instructions for attendees to setup and configure their laptop or desktop computer system for use with the hands-on exercises and labs for the "USRP Open-Source Toolchain: UHD and GNU Radio" workshop/tutorial.

Note that all of this is optional. You only have to do this if you want to use the USRP in the workshop to do the hands-on exercises and actually use the USRP radio. If you do not want to do this and just watch the instructor's presentation, then you can skip all of this and just come to the workshop.

This document assumes that you are using a USRP B200/B210 radio, although the USRP X300/X310, N300, N310, N320, N321, X410 may be used.

In some sessions the radio will be provided to you; in other sessions you will need to provide your own radio. Check this with the organizer of your session.

Your laptop or desktop computer should be no more than around six or seven years old, with an Intel i5, i7, or i9 CPU or AMD equivalent and at least 4 cores, running at a 3.5 GHz clock speed or higher, with 8 GB memory, and at least one USB 3.0 port (for USRP B200/B210 radios) and one RJ-45 Ethernet port (for other USRP radios). You will need about 30 GB of free disk space for the Linux installation. You will need to have internet access during the entire installation, set-up, and configuration process.

Install Xubuntu 24.04.4. Note that you may instead install Ubuntu itself, or any other Ubuntu flavor such as Kubuntu, Lubuntu, Cinnamon, MATE, or Linux Mint. However, we recommend using Xubuntu because it is very light-weight, and the user interface is easy-to-use and intuitive, and it runs well on older or resource-constrained hardware. We have only tested with Ubuntu and Xubuntu.

https://ubuntu.com/desktop/flavors

Please install on-the-metal, and not in a Virtual Machine (VM). Please install specifically version 24.04.4.

If you already have an existing Windows or Linux installation on your computer, then you can install Ubuntu or Xubuntu alongside your already-existing operating system, in a dual-boot configuration. The installer will ask you about this, and it supports installing in a dual-boot configuration. However, note that there can be some challenges when dual-booting with Windows 11, and this may not be easy to set up and may not work well.

You can download the ISO images for Xubuntu from the links below. Whichever version you choose: Write the ISO image to a USB 3.0 drive, and boot from it, and install it. The USB drive capacity must be a minimum of 16 GB.

https://xubuntu.org/download/

https://cdimage.ubuntu.com/xubuntu/releases/noble/release/

During the Xubuntu installation process, set the username to be "ettus". This is not strictly necessary, but if you do this, then it will make all the commands in the installation instructions and in the exercises work more easily. The hostname does not matter. Do not use any disk encryption. Do not enable any volume management.

Once the installation is complete, boot into it, and open a terminal window, and apply updates. Run the commands listed below, in a terminal window.

```
sudo apt update
sudo apt upgrade
```

Install the package dependencies for UHD, GNU Radio, and other tools. Run the commands listed below, in a terminal window.

```
sudo apt-get install openssh-server htop tree lshw meld git libfftw3-bin ncurses-bin libncurses6 libncursesw6 net-tools ethtool aptitude s

sudo apt-get install autoconf automake build-essential ccache cmake cpufrequtils doxygen ethtool g++ git inetutils-tools libboost-all-dev

sudo apt-get install git cmake g++ libboost-all-dev libgmp-dev swig python3-numpy python3-mako python3-sphinx python3-lxml doxygen libfftw
```

Create a folder to hold all the GIT repositories. Run the commands listed below, in a terminal window.

```
mkdir $HOME/git
```

Create a folder to hold workshop materials and for running exercises. Run the commands listed below, in a terminal window.

```
mkdir $HOME/workarea
```

Download the slides and materials for the workshop from the Ettus Knowledge Base (KB). Run the commands listed below, in a terminal window.

```
wget -P $HOME/workarea https://kb.ettus.com/images/a/ab/Workshop_GnuRadio_Materials_20171212.tar.gz
wget -P $HOME/workarea https://kb.ettus.com/images/f/fd/Workshop_GnuRadio_Slides_20250802.pdf
```

Unzip the workshop materials file. Run the commands listed below, in a terminal window.

```
cd $HOME/workarea
tar zxvf Workshop_GnuRadio_Materials_20171212.tar.gz
```

Install UHD version 4.9, and download all the USRP FPGA image files. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone http://github.com/EttusResearch/uhd.git
cd uhd/host
mkdir build
cd build
git checkout v4.9.0.0
cmake ../
make -j4
sudo make install
sudo ldconfig
```

```
sudo uhd_images_downloader
```

Install the VOLK library. This used to be bundled with GNU Radio, but now it's broken out as a separate library. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone --recursive https://github.com/gnuradio/volk.git
cd volk
mkdir build
cd build
git checkout v3.3.0
cmake -DCMAKE_BUILD_TYPE=Release -DPYTHON_EXECUTABLE=/usr/bin/python3 ../
cd ../
git submodule update --init --recursive
ls cpu_features/CMakeLists.txt           #it should show cpu_features/CMakeLists.txt
cd build
cmake -DCMAKE_BUILD_TYPE=Release -DPYTHON_EXECUTABLE=/usr/bin/python3 ../
make -j4
sudo make install
sudo ldconfig
```

Install GNU Radio version 3.10.12. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone http://github.com/gnuradio/gnuradio.git
cd gnuradio
mkdir build
cd build
git checkout v3.10.12.0
cmake ../
make -j4
sudo make install
sudo ldconfig
```

Add the following lines the end of your `$HOME/.bashrc` file. Use your preferred editor such as the graphical ones Gedit or Mousepad or a console-based text editor such as vi or emacs.

First, open the file using either the text editor.

```
mousepad $HOME/.bashrc
gedit $HOME/.bashrc
emacs $HOME/.bashrc
```

Next, add the two lines listed below to the very end of the file:

```
export LD_LIBRARY_PATH=/usr/local/lib:$LD_LIBRARY_PATH
export PYTHONPATH=/usr/local/lib/python3.12/dist-packages:/usr/local/lib/python3.12/site-packages:$PYTHONPATH
```

Then, save the file, exit and close the text editor, exit and close the terminal window, and open a brand-new terminal window. Run the following command to verify that the PYTHONPATH variable is set:

```
python3 -c "import sys; print(sys.path)" | tr ',' '\n' | grep "\-packages"
```

and both of the paths above should be listed.

Apply the USB udev rules for the USRP B200/B210. If you are not using a USRP B200/B210, but some other Ethernet-based radio, then you can skip this step, although it is still good to do. Run the commands listed below, in a terminal window.

```
cd /usr/local/lib/uhd/utils
sudo cp uhd-usrp.rules /etc/udev/rules.d/
sudo udevadm control --reload-rules
sudo udevadm trigger
```

Install the gr-osmosdr Out-Of-Tree (OOT) module. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone https://github.com/osmocom/gr-osmosdr
cd gr-osmosdr
mkdir build
cd build
cmake ../
make -j4
sudo make install
sudo ldconfig
```

Install the gr-rds Out-Of-Tree (OOT) module. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone https://github.com/bastibl/gr-rds
cd gr-rds
mkdir build
cd build
git checkout maint-3.10
cmake ../
make -j4
sudo make install
sudo ldconfig
```

Install GQRX. You will also need to install two more package dependencies. Run the commands listed below, in a terminal window.

```
sudo apt-get install libqt5svg5 libqt5svg5-dev
cd $HOME/git
git clone https://github.com/gqrx-sdr/gqrx
cd gqrx
```

```
mkdir build
cd build
git checkout v2.17.7
cmake ../
make -j4
sudo make install
sudo ldconfig
```

Install gr-paint. Run the commands listed below, in a terminal window.

```
cd $HOME/git
git clone https://github.com/drmpeg/gr-paint
cd gr-paint
mkdir build
cd build
cmake ../
make -j4
sudo make install
sudo ldconfig
```

If you did not see any errors in any of the previous steps, then your installation and configuration should now be complete. You can run a few simple and quick tests to verify that your system is running correctly and is ready for the workshop/tutorial.

First, run the commands below, even if you do not have any USRP radio connected to your computer.

```
uhd_find_devices
uhd_usrp_probe
```

You should see output similar to what is listed below when there is no USRP device connected.

```
ettus@lenovo-t480s:~$ uhd_find_devices
[INFO] [UHD] linux; GNU C++ version 13.3.0; Boost_108300; UHD_4.9.0.HEAD-0-g9ec1f582
No UHD Devices Found
ettus@lenovo-t480s:~$ uhd_usrp_probe
[INFO] [UHD] linux; GNU C++ version 13.3.0; Boost_108300; UHD_4.9.0.HEAD-0-g9ec1f582
Error: LookupError: KeyError: No devices found for ----->
Empty Device Address
ettus@lenovo-t480s:~$
```

You should see output similar to what is listed below when there is one USRP B200 device connected.

```
ettus@lenovo-t480s:~$ uhd_find_devices
[INFO] [UHD] linux; GNU C++ version 13.3.0; Boost_108300; UHD_4.9.0.HEAD-0-g9ec1f582
[INFO] [B200] Loading firmware image: /usr/local/share/uhd/images/usrp_b200_fw.hex...
---------------------------------------------------
-- UHD Device 0
---------------------------------------------------
Device Address:
    serial: 3304B90
    name: 4B200
    product: B200
    type: b200


ettus@lenovo-t480s:~$ uhd_usrp_probe
[INFO] [UHD] linux; GNU C++ version 13.3.0; Boost_108300; UHD_4.9.0.HEAD-0-g9ec1f582
[INFO] [B200] Detected Device: B200
[INFO] [B200] Loading FPGA image: /usr/local/share/uhd/images/usrp_b200_fpga.bin...
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Detecting internal GPSDO....
[INFO] [GPS] No GPSDO found
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Setting master clock rate selection to 'automatic'.
[INFO] [B200] Asking for clock rate 16.000000 MHz...
[INFO] [B200] Actually got clock rate 16.000000 MHz.
  _____________________________________________________
 /
|       Device: B-Series Device
|     _____________________________________________________
|    /
|   |       Mboard: B200
|   |   serial: 3304B90
|   |   name: 4B200
|   |   product: 1
|   |   revision: 5
|   |   FW Version: 8.0
|   |   FPGA Version: 16.0
|   |
|   |   Time sources:  none, internal, external, gpsdo
|   |   Clock sources: internal, external, gpsdo
|   |   Sensors: ref_locked
|   |     _____________________________________________________
|   |    /
|   |   |       RX DSP: 0
|   |   |
|   |   |   Freq range: -8.000 to 8.000 MHz
|   |     _____________________________________________________
|   |    /
|   |   |       RX Dboard: A
|   |   |     _____________________________________________________
|   |   |    /
|   |   |   |       RX Frontend: A
|   |   |   |   Name: FE-RX1
|   |   |   |   Antennas: TX/RX, RX2
|   |   |   |   Sensors: temp, rssi, lo_locked
|   |   |   |   Freq range: 50.000 to 6000.000 MHz
|   |   |   |   Gain range PGA: 0.0 to 76.0 step 1.0 dB
|   |   |   |   Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz
|   |   |   |   Connection Type: IQ
|   |   |   |   Uses LO offset: No
|   |   |     _____________________________________________________
```

```
|   |   |    /
|   |   |   |       RX Codec: A
|   |   |   |   Name: B200 RX dual ADC
|   |   |   |   Gain Elements: None
|   |   |    ____________________________________________________
|   |   |    /
|   |   |   |       TX DSP: 0
|   |   |   |
|   |   |   |   Freq range: -8.000 to 8.000 MHz
|   |   |    ____________________________________________________
|   |   |    /
|   |   |   |       TX Dboard: A
|   |   |   |    ________________________________________________________
|   |   |   |    /
|   |   |   |   |       TX Frontend: A
|   |   |   |   |   Name: FE-TX1
|   |   |   |   |   Antennas: TX/RX
|   |   |   |   |   Sensors: temp, lo_locked
|   |   |   |   |   Freq range: 50.000 to 6000.000 MHz
|   |   |   |   |   Gain range PGA: 0.0 to 89.8 step 0.2 dB
|   |   |   |   |   Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz
|   |   |   |   |   Connection Type: IQ
|   |   |   |   |   Uses LO offset: No
|   |   |   |    ________________________________________________________
|   |   |   |    /
|   |   |   |   |       TX Codec: A
|   |   |   |   |   Name: B200 TX dual DAC
|   |   |   |   |   Gain Elements: None

ettus@lenovo-t480s:~$
```

Second, you can run the GNU Radio Companion (GRC) tool. Run the commands below, and verify that the GRC window appears.

```
gnuradio-companion
```

Third, you can connect the USRP B200/B210 to the computer, and then run the command listed below.

```
lsusb
```

You should see the USRP listed in the output, as shown below.

```
ettus@lenovo-t480s:~$ lsusb
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 001 Device 004: ID 03f0:6a41 HP, Inc HP USB Optical Mouse
Bus 001 Device 005: ID 2500:0020 Ettus Research LLC USRP B210
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 002 Device 002: ID 0bda:0316 Realtek Semiconductor Corp. Card Reader
Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
ettus@lenovo-t480s:~$
```

Fourth, you can run the command below, to confirm that GNU Radio is configured correctly, and that you are running the correct version.

```
ettus@lenovo-t480s:~$ gnuradio-config-info --print-all
/usr/local/
/usr/local/etc
/usr/local/etc/gnuradio/conf.d
/home/ettus/.config/gnuradio
/home/ettus/.local/state/gnuradio
Fri, 09 Jan 2026 14:37:15Z
testing-support;python-support;post-install;doxygen;man-pages;gnuradio-runtime;common-precompiled-headers;gr-ctrlport;gnuradio-companion;J
3.10.12.0
cc (Ubuntu 13.3.0-6ubuntu2~24.04) 13.3.0
Copyright (C) 2023 Free Software Foundation, Inc.
This is free software see the source for copying conditions.  There is NO
warranty not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
c++ (Ubuntu 13.3.0-6ubuntu2~24.04) 13.3.0
Copyright (C) 2023 Free Software Foundation, Inc.
This is free software see the source for copying conditions.  There is NO
warranty not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
/usr/bin/cc:::-O3 -DNDEBUG  -fvisibility=hidden -Wsign-compare -Wall -Wno-uninitialized -Wignored-qualifiers -Wcast-qual
/usr/bin/c++:::-O3 -DNDEBUG  -fvisibility=hidden -Wsign-compare -Wall -Wno-uninitialized -Wignored-qualifiers -Wcast-qual
2.11.1
ettus@lenovo-t480s:~$
```

If the simple tests of the installation listed above worked without any errors, then you are now finished, and you are now ready for the workshop/tutorial.

We look forward to seeing you in the workshop/tutorial.