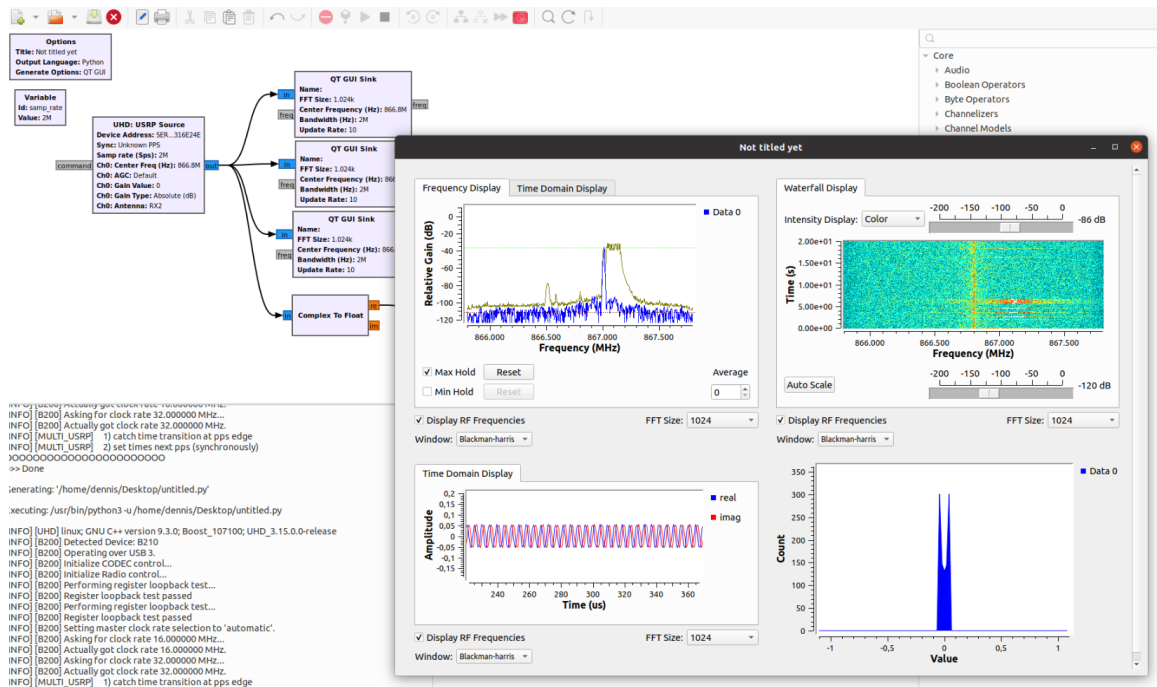


Installation guide: GNU Radio Companion & USRP Hardware Driver



II-Communication Systems - Laboratory sessions

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Preface

This guide will help you with installing the software that is needed for the lab sessions which are part of the master course [II-Communication-systems](#). This document involves installing GNU Radio Companion and the USRP Hardware Driver as well as some troubleshooting will be touched upon.

Do not hesitate to reach out via [mail](#) when you get stuck or run into other problems which are not described in this document.

1 Installing GNU Radio Companion

Prerequisites:

- Native Linux machine or Linux VM (**preferably latest Ubuntu/Debian LTS version**)

1.1 Getting started

There are a few ways to install GNU Radio Companion. We highly advise to use a native Linux machine preferably Ubuntu. When using Ubuntu, open up a terminal and type:

```
user@PC:~$ sudo apt update
user@PC:~$ sudo apt install gnuradio
```

This installs the latest stable version of GNU Radio. Version **3.9** or **3.10** is ok to use.

The latest release can be checked at [\[1\]](#) or at [\[2\]](#).

This default installation should suffice for the lab sessions.

If for some reason your installation did not work, other ways to install the software are:

- Install an older version
- Install from source [\[3\]](#)
- Install with PyBOMBS[\[4\]](#)

For more information on how to do this go to GitHub repo of GNU Radio [\[5\]](#).

To run GRC, open up a terminal:

```
user@PC:~$ gnuradio-companion
```

2 Installation of the USRP Hardware Driver

The Universal Software Radio Peripheral ([USRP B200/B210](#)) is a medium/high end Software Defined Radio developed by Ettus Research which is a National Instruments company that focuses on the development of highly versatile SDR's. ([more info](#)). We will be using the [USRP B200/B210](#) for the lab sessions.

The USRP needs the UHD (USRP Hardware Driver) to properly work with GRC.

2.1 Installing the driver

Make sure to **close GRC**. Open up a terminal on the Linux machine and execute the following commands:

```
user@PC:~$ sudo add-apt-repository ppa:ettusresearch/uhd
user@PC:~$ sudo apt-get update
user@PC:~$ sudo apt-get install libuhd-dev
user@PC:~$ sudo apt-get install libuhd3.15.0 uhd-host
```

Connect a USRP to your PC and run the `uhd_find_devices` command in a terminal.

2.2 UHD version check

To check if the driver is installed correctly:

```
user@PC:~$ apt search "libuhd"
```

```
dennis@dennis-Inspiron-7380 ~ $ apt search 'libuhd'
Sorting... Done
Full Text Search... Done
libuhd-dev/bionic 3.10.3.0-2 amd64
  universal hardware driver for Ettus Research products - headers
libuhd003.010.003/bionic,now 3.10.3.0-2 amd64 [installed,automatic]
  universal hardware driver for Ettus Research products - library
```

Figure 1: Checking the current UHD version

2.3 FPGA images

If the UHD (source/sink) block in GNU Radio can not find the FPGA images, make sure to check if the directory `/usr/share/uhd/images/` exists and if it is empty or not. Check that the binaries `usrp_b200_fpga.bin` and `usrp_b210_fpga.bin` are present in this folder. One of these files is uploaded to the FPGA on the USRP when running a GRC flowgraph containing a USRP source and/or sink.

```
dennis@dennis-inspiron-7380 /usr/share/uhd/images $ ls
003.010.003.000.tag      usrp_b200_fw.hex        usrp_n210_fw.bin
bit                     usrp_b200mini_fpga.bin  usrp_n210_r2_fpga.bin
LICENSE                 usrp_b205mini_fpga.bin  usrp_n210_r3_fpga.bin
octoclock_bootloader.hex usrp_b210_fpga.bin       usrp_n210_r4_fpga.bin
octoclock_r4_fw.hex     usrp_e100_fpga_v2.bin    usrp_n230_fpga.bit
usrp1_fpga_4rx.rbf       usrp_e110_fpga.bin       usrp_x300_fpga_HG.bit
usrp1_fpga.rbf          usrp_e310_fpga.bit       usrp_x300_fpga_HG.lvbitx
usrp1_fw.ihx            usrp_e310_fpga_sg3.bit   usrp_x300_fpga_XG.bit
usrp2_fpga.bin          usrp_e3xx_fpga_idle.bit  usrp_x300_fpga_XG.lvbitx
usrp2_fw.bin            usrp_e3xx_fpga_idle_sg3.bit usrp_x310_fpga_HG.bit
usrp_b100_fpga_2rx.bin   usrp_n200_fw.bin         usrp_x310_fpga_HG.lvbitx
usrp_b100_fpga.bin       usrp_n200_r2_fpga.bin    usrp_x310_fpga_XG.bit
usrp_b100_fw.thx        usrp_n200_r3_fpga.bin    usrp_x310_fpga_XG.lvbitx
usrp_b200_fpga.bin       usrp_n200_r4_fpga.bin    winusb_driver
```

Figure 2: Directory of the FPGA images

If this directory does not exist or is empty, execute:

```
user@PC:~$ sudo uhd_images_downloader
```

or another way:

```
user@PC:~$ cd /usr/lib/uhd/utils/
user@PC:~$ cd python3 uhd_images_downloader.py
```

Make sure that the FPGA images are in the `/usr/share/uhd/images` directory.

```
dennis@dennis-inspiron-7380 ~ $ sudo uhd_images_downloader
Images destination: /usr/share/uhd/images
Downloading images from: http://files.ettus.com/binaries/images/uhd-images_003.010.003.000-release.zip
Downloading images to: /tmp/tmpa61l8t/uhd-images_003.010.003.000-release.zip
57009 kB / 57009 kB (100%)
Images successfully installed to: /usr/share/uhd/images
```

Figure 3: Downloading the FPGA images

3 Hello SDR, are you there?

3.1 Check the SDR

To get any SDR working in GRC we need to make sure we can "talk" to the device. Most SDR's are equipped with a software tool to check if the communication with the hardware is working. For the USRP device this can be checked in a terminal:

```
user@PC:~$ uhd_find_devices
```

or

```
user@PC:~$ uhd_usrp_probe
```

uhd_usrp_probe provides more information regarding the connected USRP and RF front end. This includes more information about gain, bandwidth, channels, firmware version, unit names, revision numbers,...

GRC needs the serial number of the USRP device to identify which devices it is using. Open a terminal and type:

```
user@PC:~$ uhd_find_devices | grep serial:
```

3.2 Notes

Note that you need to connect the USRP to a USB 3.0/3.1 port preferably. A USB 2.0 port should also work but will be much slower when uploading the image to the FPGA and samples will get lost when capturing data.

When one device is connected to your PC you do not have to worry about the serial number. The only available device is initialized by default. However, it is good practice to always fill it in. When attaching a second device this serial number becomes really important.

```
dennis@dennis-VirtualBox:~$ uhd_find_devices
[INFO] [UHD] linux; GNU C++ version 9.3.0; Boost_107100; UHD_3.15.0.0-release
No UHD Devices Found
```

Figure 4: USRP device not found

```
dennis@dennis-VirtualBox: ~
dennis@dennis-VirtualBox:~$ uhd_find_devices
[INFO] [UHD] linux; GNU C++ version 9.3.0; Boost_107100; UHD_3.15.0.0-release
-- UHD Device 0
-----
Device Address:
  serial: 316E24E
  name: MyB210
  product: B210
  type: b200
dennis@dennis-VirtualBox:~$
```

Figure 5: USRP device found

It could be that you have to replug the device to get it visible on your computer. The first attempt sometimes fails.

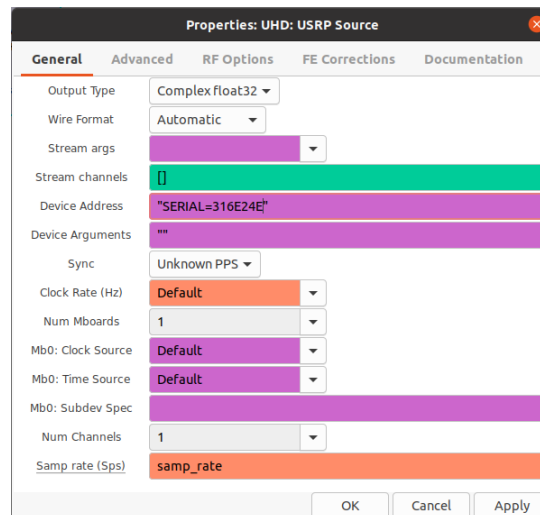


Figure 6: USRP source block in GNU Radio

3.3 Troubleshooting

If for any reason the installation of the UHD driver fails, you can always install the driver manually. Browse to ([UHD images](#)) and extract the downloaded zip file.

```
user@PC:~$ cd uhd-images_003.010.003.000-release/share/uhd/  
user@PC:~$ cd cp -r images/ /usr/share/uhd
```

Open up GRC. Connecting to the USRP should work fine now.

4 VM connection issues

4.1 USRP in VirtualBox

Tested on:

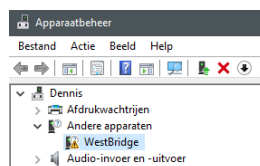
- Windows 10 machine with VirtualBox 6.1
- Linux Ubuntu 20.04.1 LTS image
- Ettus USRP B200/B210 SDR

Note that you need to have the USRP connected to a USB 3.0 port preferably.

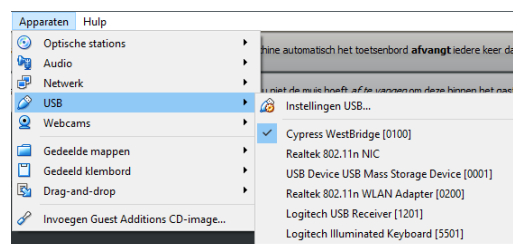
Execute the following steps:

- Install VirtualBox: [6]
- Install a Linux VM: [7]
- Install the VirtualBox Extension Pack
- Install GRC as stated in section 1

When connecting the USRP to the Windows machine it will not be recognized. However when going into Device Manager, you see a device called Cypress Westbridge (i.e. the USB host controller chip of the USRP).



Also when you connect this device in VirtualBox, the same name shows. Note that you will not get this device working from here in your VM.

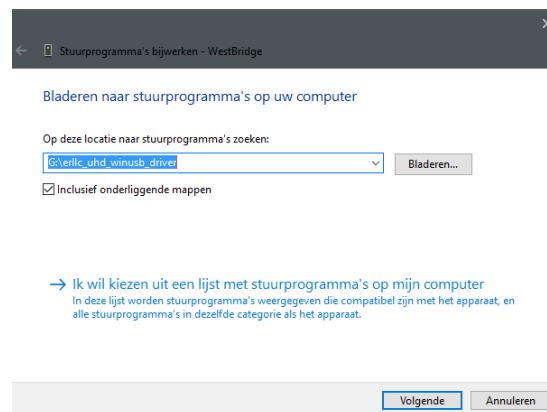


To get it working in VirtualBox, you need to install the USRP driver on Windows (in this case the host machine). Go to the following source to download the Windows driver:

http://files.ettus.com/binaries/misc/erllc_uhd_winusb_driver.zip

General page: https://files.ettus.com/manual/page_install.html

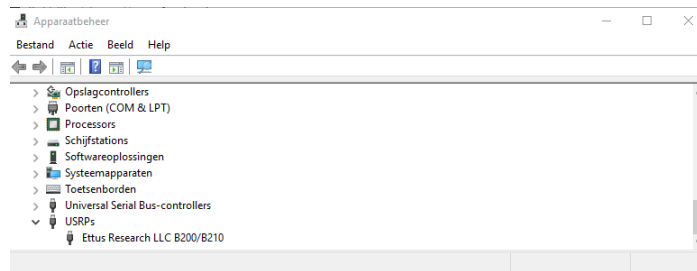
Go to **Device Manager** (⌨+X) in Windows and manually select the driver that you have downloaded.



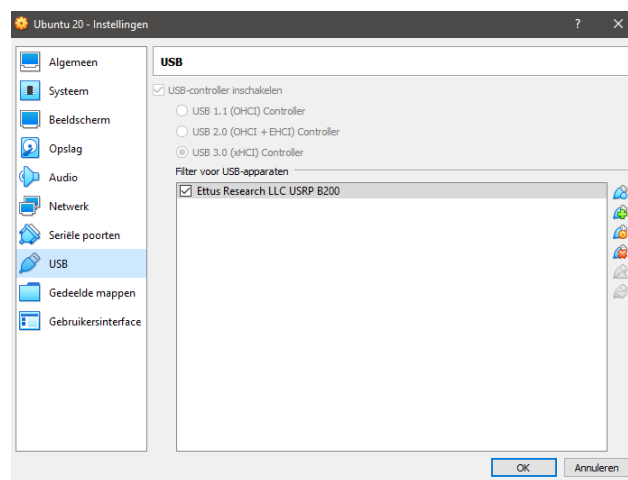
Windows might tell you that there is a problem. This is not the case. Just unplug and replug the USRP and/or reboot your PC. Afterwards it will show up in **Device Manager**.



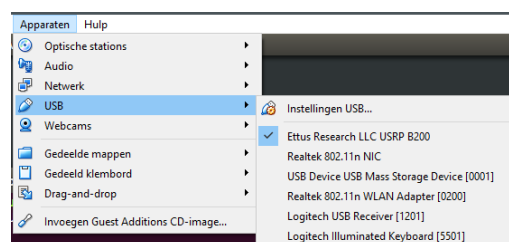
When opening the **Device Manager**, the USRP should be visible now.



Open VirtualBox. Add the device by creating a filter and make sure to select the USB 3.0 Controller. It could be that the Ettus Research LLC USRP B200 option is not available, shutdown and reboot the VM to fix this.



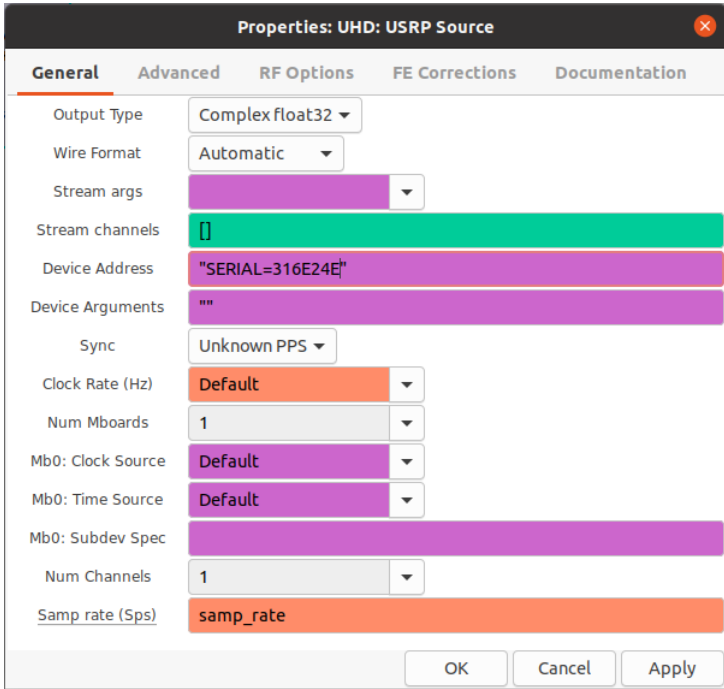
When the VM is booted go to **Devices** and select **USB**. The Cypress Westbridge name should be changed.



Open a terminal in the VM and execute the following command. This should properly state the device.

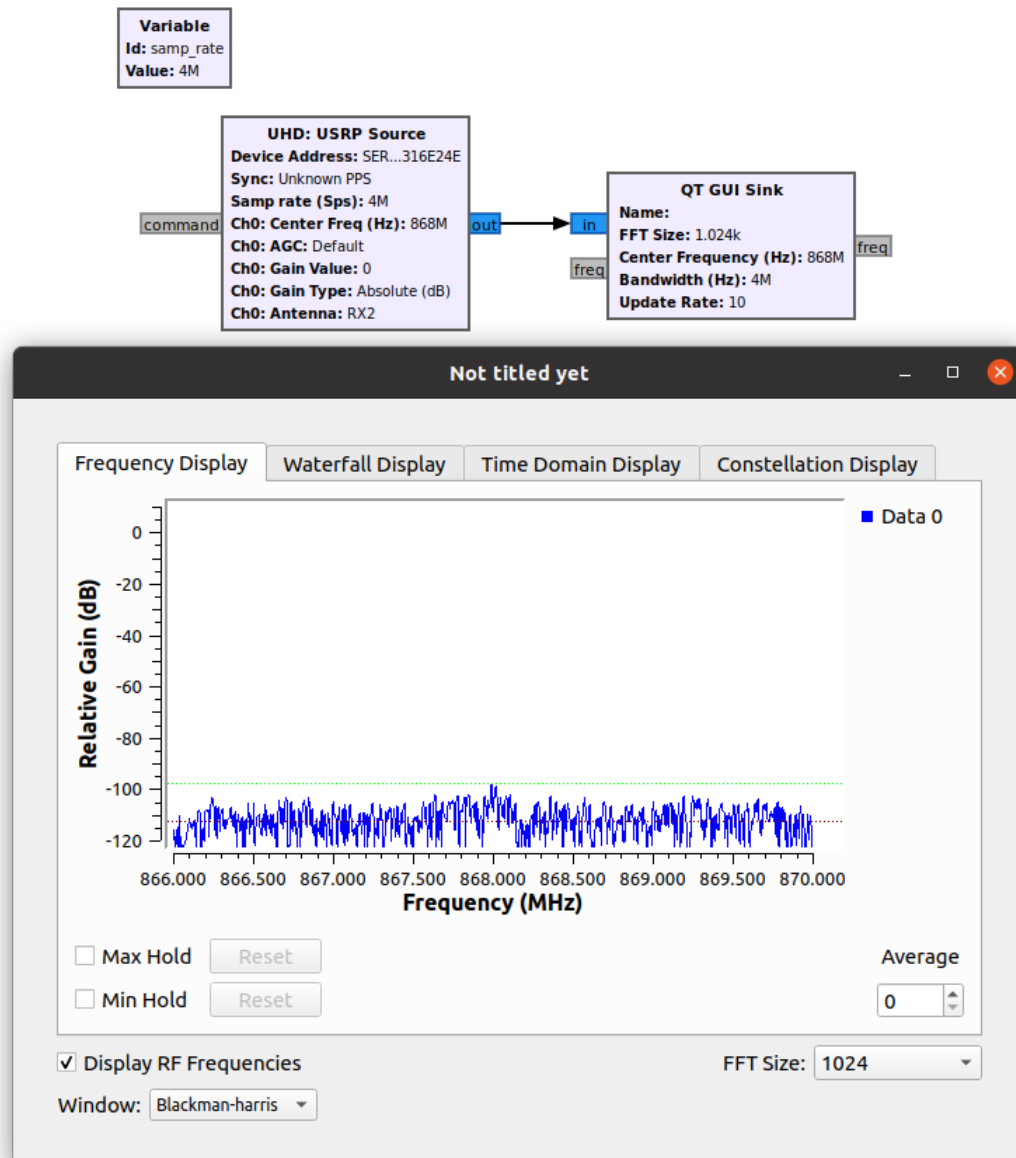
```
dennis@dennis-VirtualBox: ~  
dennis@dennis-VirtualBox:~$ uhd_find_devices  
[INFO] [UHD] linux; GNU C++ version 9.3.0; Boost_107100; UHD_3.15.0.0-release  
-----  
-- UHD Device 0  
-----  
Device Address:  
  serial: 316E24E  
  name: MyB210  
  product: B210  
  type: b200  
  
dennis@dennis-VirtualBox:~$
```

Create a GRC flowgraph with a USRP source and a GUI sink. Change the **Device Address** to the corresponding address of the USRP:



Properties: UHD: USRP Source				
General	Advanced	RF Options	FE Corrections	Documentation
Output Type	Complex float32			
Wire Format	Automatic			
Stream args				
Stream channels	[]			
Device Address	"SERIAL=316E24E"			
Device Arguments	""			
Sync	Unknown PPS			
Clock Rate (Hz)	Default			
Num Mboards	1			
Mb0: Clock Source	Default			
Mb0: Time Source	Default			
Mb0: Subdev Spec				
Num Channels	1			
Samp rate (Sps)	samp_rate			
OK Cancel Apply				

Now you can run the flowgraph:



4.2 USRP in VMware

Tested on:

- Windows 10 machine with VMWare Player or Workstation [8]
- Linux Ubuntu LTS version
- Ettus Research USRP B200/B210 SDR

Install Ubuntu in VMware.

Install GNU Radio Companion.

The same issues seem to appear in VMware (Workstation Pro/Player). This is resolved the same way as in section 4.1. The approach could deviate slightly due to the fact that VMWare works a bit different than VirtualBox.

References

- [1] Gnuradio. *GNU Radio - The Free & Open Source Radio Ecosystem · GNU Radio*. URL: <https://www.gnuradio.org>.
- [2] Gnuradio. *gnuradio*. URL: <https://github.com/gnuradio/gnuradio/releases>.
- [3] Gnuradio. *install from source*. URL: <https://wiki.gnuradio.org/index.php?title=InstallingGR>.
- [4] Gnuradio. *install with pybombs*. URL: <https://github.com/gnuradio/pybombs/blob/master/README.md>.
- [5] Gnuradio. *gnuradio*. URL: <https://github.com/gnuradio/gnuradio>.
- [6] *Download Oracle VM VirtualBox | Oracle*. URL: <https://www.virtualbox.org>.
- [7] *Download Ubuntu Desktop | Ubuntu*.
- [8] *Download VMware Workstation Player | VMware*. URL: <https://www.vmware.com/products/workstation-player/workstation-player-evaluation.html>.