# Set-up and Usage

**USE A 30dB ATTENUATOR IF USING THE LOOPBACK KIT TO CONNECT TWO USRPS**

## General

Each kit includes:
1. USRP N210 with XCVR2450 Daughterboard
2. A loopback cable (2 parts)
3. 2x30dB attenuators
4. Single omnidirectional 2.4/5GHz antenna
5. Power Supply
6. 1x Ethernet Cable

**1. What are RF1 and RF2?**
Antenna port RF1 is connected to port J1
Antenna port RF2 is connected to port J2

**2. Where can I use Simulink with the USRP?**
The necessary software is available on the Linux machines linux00-linux11 in EE365. You will NOT be able to use the USRP on the windows machines in the labs. This is due to hardware differences.

**3. How do I begin using the USRP on the Linux machines?**
First, you will connected the USRP through an Ethernet cable to the OPEN Ethernet jack on the back of one of the indicated machines (linux00-linux11). Next you will start MATLAB and run:

```
addpath('/home/lab.apps/usrp_v3_0_1_R2012a');
setupsdru;
```

Then after waiting a few seconds, you may run Simulink. You will be able to see the "Communications with USRP" in the list of Simulink blocksets. If you use a version of MATLAB newer than *2012a* you may see the blockset listed as "USRP Target" or something similar. You can also run:

```
findsdru
```

to verify that the USRP was detected. Alternatively you can run:

```
help sdru
```

to get a help listing with additional information.

**4. How can I use the USRP with a personal machine?**

You will need as a prerequisite:

1. Gigabit Ethernet Port (The USRP only works with 1000 Mbps network adapters.)
2. MATLAB 2012a and higher
3. Simulink
4. Signal Processing Toolbox
5. DSP Toolbox
6. Communications Toolbox

Next, you will need to navigate to http://www.mathworks.com/discovery/sdr/usrp.html and download "Communications System Toolbox Support Package for USRP". Follow the installation instructions. If you install the package locally on your machine, you will have to modify the addpath command issued in the instructions above.

**5. Why does a machine need two network adapters?**

This is an issue in case you use the network to check out your MATLAB licenses. If so, you need to maintain a normal network connection for that purpose while using a secondary connection to connect the USRP. This does not apply if your MATLAB license is served locally. If you are able to get your MATLAB license through WiFi, feel free to do so.

**6. What are the network settings for the USRP?**

The USRP will carry a static IP address of 192.168.10.2. You can set your own network card to carry a static IP address of 192.168.10.x where x is not 2. You can set your gateway to the IP address of the USRP.

**7. How can I set up two networks in Linux?**

To do this, you will likely have to use the addpath command. Look it up online for the details as each machine will be different. In essence, you will have to set the default router to travel through your main NIC (the one not connected to the USRP) but all routes destined for 192.168.10.x to travel through your second NIC.

**8. What is the peak seen at 0Hz?**

This is a DC offset. It will be present and does not mean that there are any issues with your setup. Your signal level should be high enough to make it insignificant in most cases.

**9. DO I need to use two attenuators in loopback tests?**

If you connect the USRPs using the loopback cable, USE a 30dB attenuator to avoid any damage to the XCVR cards in the USRPs. The power to a USRP should never exceed the maximum receive power rating which is +10dBm. Also the maximum transmit power of a USRP is 20dBm. If you use one attenuator you will get 30dB attenuation. So, 20-30 = -10dBm is less than max receive power rating. So one attenuator is enough.

**10. How to remove DC offset?**

You can use a FIR lowpass filter. There is a digital filter block in MATLAB that you can use. You need to subtract the average (DC value) which is the output of the FIR filter from the signal.

## Troubleshooting

**1. I ran the commands listed in Q3 above but I cannot see the blocks listed in Simulink.**
Try closing MATLAB and re-running the addpath and setupsdru steps, this time, wait a bit before starting Simulink. If issues persist, set up an appointment or attend one of the office/lab hours to get some help. You can also try selecting the refresh toolbox option from the menu.

# Lab Tips

## Lab 1

1. Make sure when you observe the spectrum of the signal from the USRP, you correctly set the sampling time of the USRP. The USRP relies on this information to set the bin size of the FFT used in the spectrum scope. i.e. if you set the sample time to 1 seconds and take a 256 point FFT, the X axis (frequency) will be around the milli-hertz range.
2. When observing the output of the AM demodulator (Simulink only experiments), your received signal should be identical to your transmitted signal once you account for some constant attenuation.

## Lab 2

1. In this lab, you are provided with a file titled “charToBitsAndBack.m”. This file is actually aimed to do 2 different things. All the necessary code for performing both tasks is included in the m file, but it is best if you split the file into two parts. You should be able to read through the code and make sense of the operations and generate the following two files:
    a. Char to bits – you convert characters to bit strings
    b. Bits to char – you convert the received bit string to characters
2. In section 4.3.2: you may need to do the following changes in order to get correct decoding and receiving 'Hello World' sequence at the receiver:
    a. Setting the group delay to a proper small value (e.g. 1) for the raised cosine shaping block.
    b. Set the sample time fields of the barker sequence and data sequence to 1/BitRate*179/13 and 1/BitRate*179 respectively. Also set BitRate = 100e3.
3. In DBPSK decoder and Mueller-Muller Timing Recovery you may need to reset the block after receiving each frame (enable “reset everyframe”) which is due to the fact that this block does not work correctly when the timing offset is near zero. You may need this while debugging your system (loopback test) and not transmitting over the air.

## Lab 3

For this lab, we highly recommend looking at blocks such as the buffer block to achieve turn on/turn off behavior. You can in essence use the buffer to trigger a stop condition (e.g. when buffer is full, stop the simulation). This block can be used effectively in conjunction with the rest of your system to terminate a simulation at certain intervals.

If you chose to implement an energy detector for this experiment, we suggest observing the output of the detector in order to establish a safe threshold.

Completing this lab will provide you with much of the work and ideas necessary for Lab 4.

## Lab 4

1. If you have successfully completed Lab 3, you will be well on your way for this assignment. First focus on completing one cycle of the TX/RX/SWITCH mechanism before looping repeatedly. Also, do not expect your system to work every time. Very little has been done in the previous labs to establish reliability, so you can expect (and will likely observe) your system breaking down every so often. This is expected and outside the scope of this class/experiment to correct.
2. OFDM part: symbol period need to be adjusted properly in AWGN block to obtain the desired that EbN0 at the output.
3. For those of you who are interested in learning more about FFT and windowing effects, there are two references/tutorials [ (TI1, 2009), (TI2, 2011)] from National Instruments that you may find useful. See references.

# General Tips

The single most important skill in implementing the systems described in the labs is methodical build-up and trouble shooting. Most labs can be implemented partially in Simulink only (without touching the USRP) which allows for easier trouble shooting of the initial steps. Furthermore, building up the system step by step and observing the output (to compare to expected output) is far more effective than starting the troubleshooting process on a COMPLETE system.

This bears repeating, DO NOT build up a system completely and THEN try to troubleshoot. Build it up slowly and confirm it works every step of the way. Make sure you know what to expect at each step of the system and don't hesitate to use scopes and displays to confirm your expectations.

## Textbook

In your textbook, on page 148, the frequency spacing is miscalculated. The correct formula is $\Delta f = k\ f_s/(2\mathrm{N})$ , where $k$ is the bin index. So "Fsize" should be replaced by the sampling frequency. In general frequency spacing is $f_s/\mathrm{N}$.

## Bibliography


TI1. (2009). *The Fundamentals of FFT-Based Signal Analysis and Measurement in LabVIEW and LabWindows/CVI.* National Instruments.

TI2. (2011). *Windowing: Optimizing FFTs Using Window Functions.* National Instruments.