

Construction of an FM Receiver

Introduction:

GNU Radio is an open source signal processing software package that is used to implement software defined radio. This package is designed to be used in parallel with Universal Software Radio Peripheral products created by Ettus Research. Not much documentation exists for beginners looking to start exploring this technology. These instructions, which double as a tutorial, give a step by step procedure to construct a functioning software-defined FM receiver using GNU Radio Companion. They assume that the reader has a functioning computer running on the Ubuntu 10.04 operating system that has the most current, UHD version of GNU Radio properly installed.

Theory of operation:

Typical FM receivers are constructed entirely using hardware that must be fabricated in a plant. This procedure will demonstrate the power of software defined radio and how easy it is to use. A good background in Communication Theory would provide for better understanding of this procedure, however, these instructions are written so that such is not required to complete the task at hand.

List of equipment:

1. USRP2 or USRP N210 board with installed UHD firmware, image file, and daughterboard that is in the FM frequency range (WBX for example)
2. Ethernet cable, antenna attachment, power cord
3. Speakers

Procedure:

1. Connect the USRP board to the computer using the Ethernet cable.
2. Attach the antenna to the receiver end of the daughterboard and power up the board by simply plugging in the power cord.
3. Assign the location of the Ethernet cable to the address of the board by opening a command window and entering:

```
sudo ldconfig  
sudo ifconfig eth0 192.168.10.1
```

Note: You will have to use your administrative password when using the sudo command.
4. Check to see if the location is set properly by next entering into the command window:

```
sudo uhd_find_devices
```

This should return the location of the device. If it returns that no devices were found, repeat step 3.
5. Open another command terminal and run GNU Radio Companion by entering the command: `sudo gnuradio-companion`.
6. Add the necessary blocks from the libraries on the right side of the screen and arrange them as shown in figure 1. (Most should be self explanatory as to which menu they are under).
7. Open the parameter window for the Audio sink by double clicking on the block.
8. Change the number of inputs to 2.

9. Match the data types for each block, corresponding with figure 2, making the selection in the parameter window. A blue tab represents complex and orange represents float.
10. Make the connections shown by clicking on the tabs marked 'in' and 'out' on the appropriate blocks.
11. Set up parameters as shown in figure 2 by opening each parameter window. Parameters that cannot be directly determined from the figure are listed as follows.
 - a. Enter `addr=192.168.10.2` for 'Device Addr' in the UHD: USRP Source.
 - b. Enter `firdes.low_pass(1,samp_rate,100e3,1e3)` for the Value in the Variable block with ID filter_taps.
 - c. Enter `rf_gain` and `usrp_freq` in Ch0: Gain and Ch0: Center Freq parameters respectively in the USRP Source block.
 - d. Enter `xlate_freq` in the Center Frequency parameter of the FIR Filter
 - e. Enter `af_gain` in Constant parameter for both Multiply Const blocks
12. Compile the program by clicking the icon. If there is an error, double check all connections, parameters, and data types of the blocks.
13. Execute the flow graph by clicking the icon. A graphic should appear similar to the one in figure 3. If it is blank, click on the auto scale button to bring the FFT into view.
14. Tune into any of your local FM stations using the `usrp_freq` slider bar. Finer tuning can be done using the `xlate_tune` slider bar. Volume can also be adjusted using the `rf_gain` and `af_gain` slider bars.

Figures:

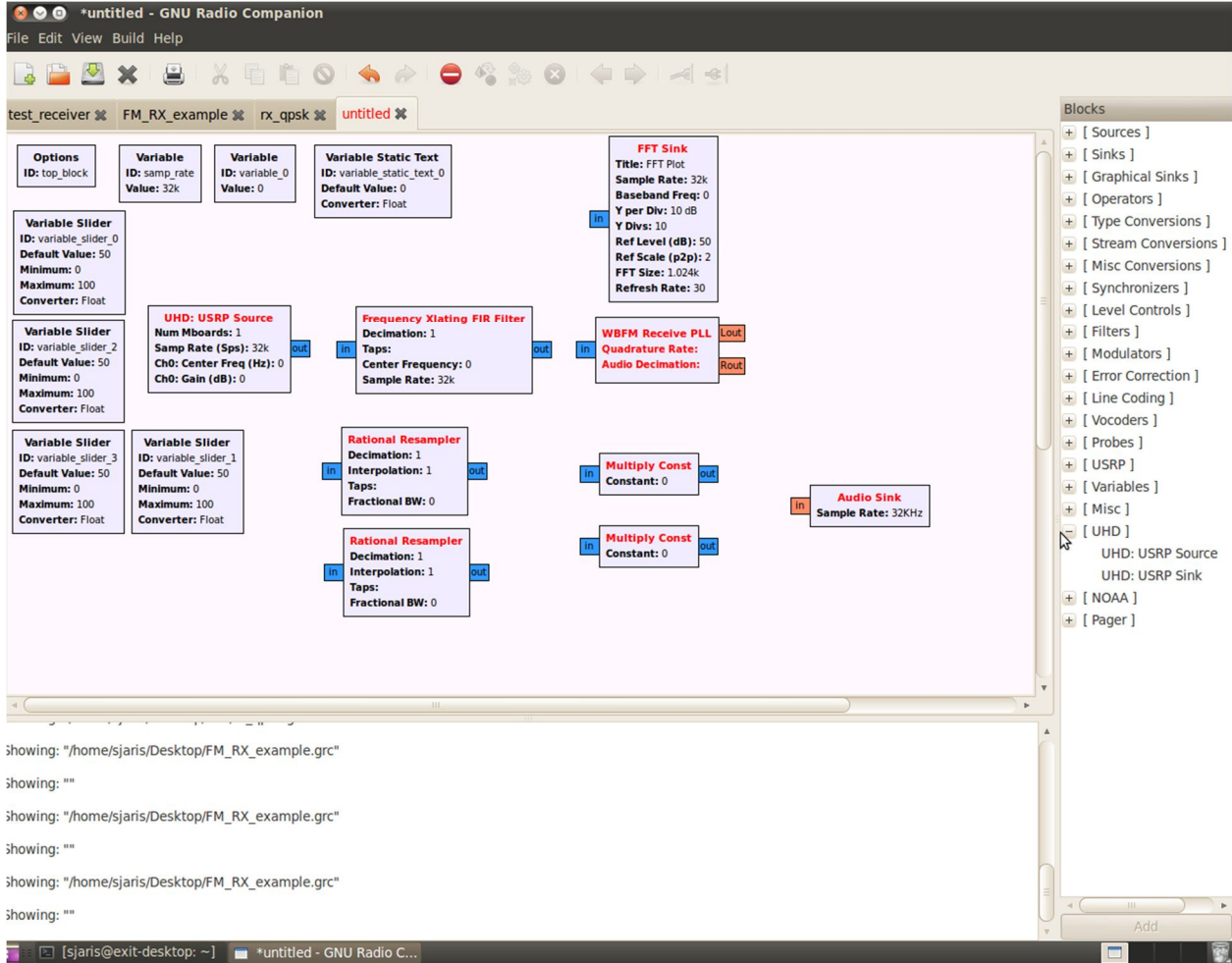


Figure 1 – Blocks to be added in step 6.

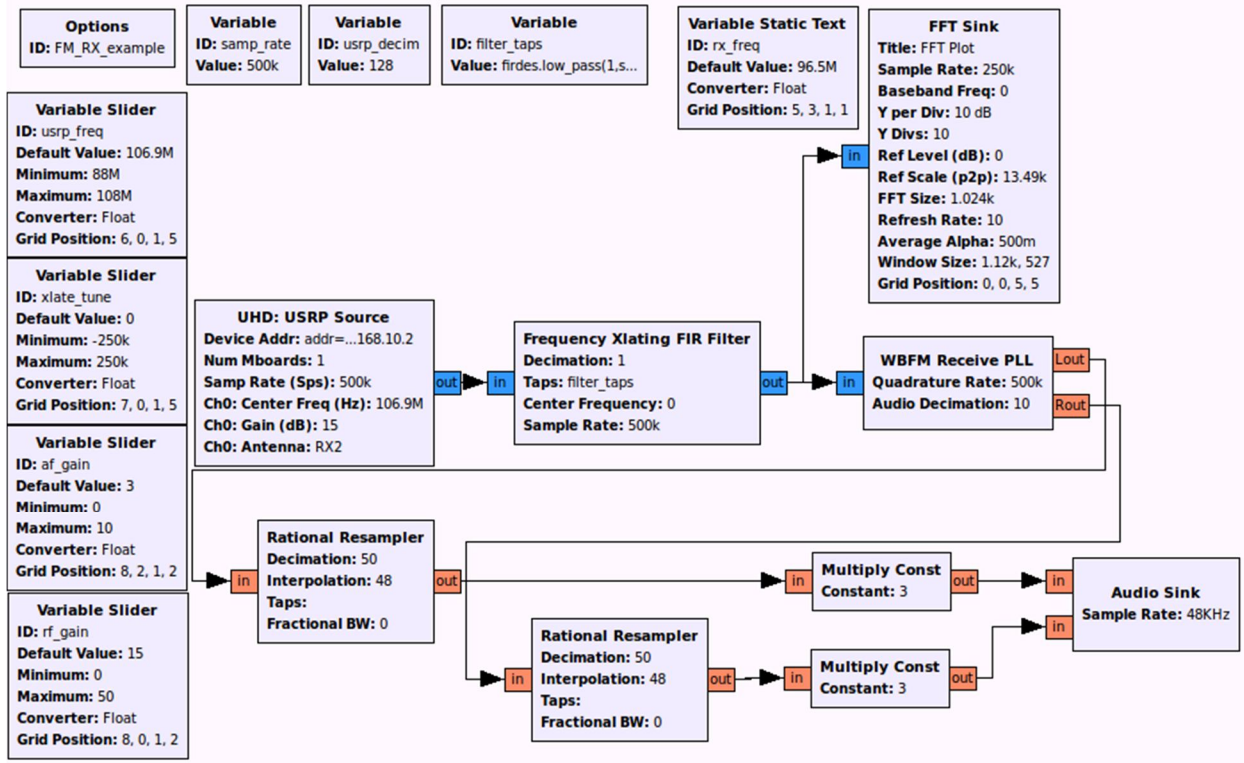


Figure 2 – Complete flowgraph with appropriate connections, data types, and parameters as mentioned in steps 9, 10, and 11

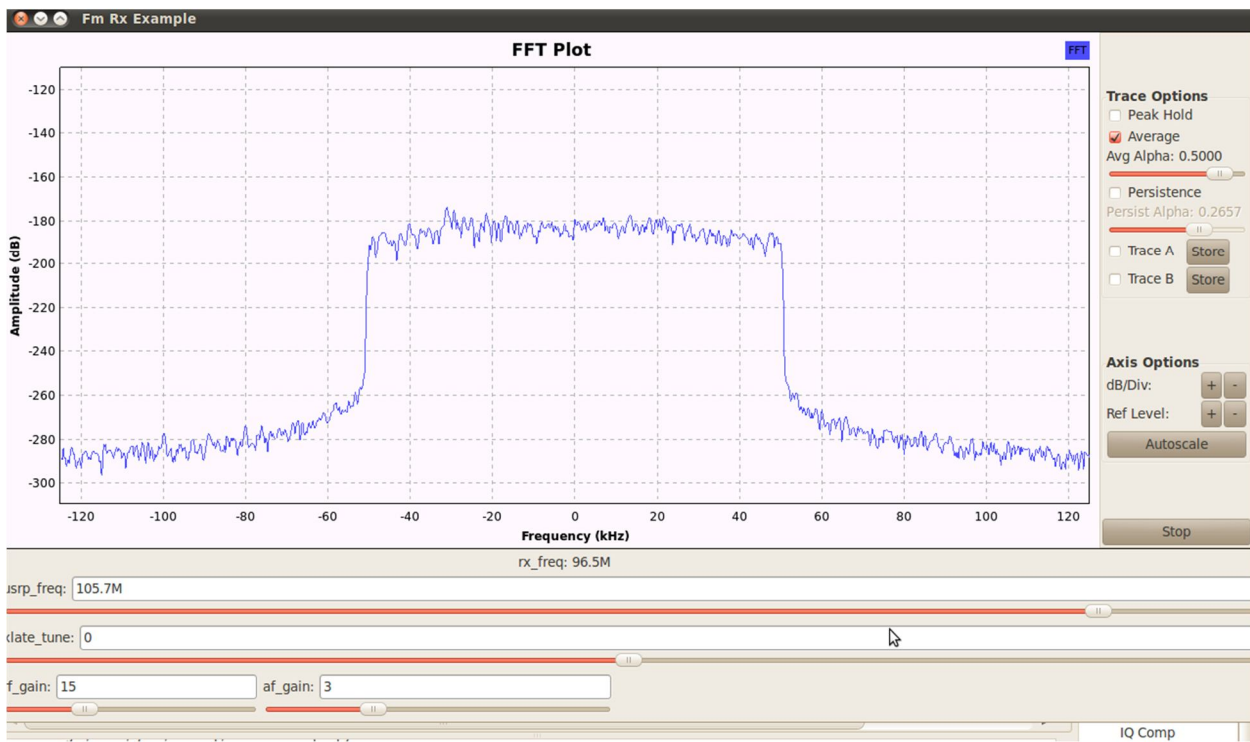


Figure 3 – Spectrum plot from the FFT sink showing the filtered frequency range being received

Conclusion:

Having completed a functioning FM receiver, you should now be more comfortable working with GNU Radio Companion and the USRP boards and hopefully are beginning to understand the flexibility and potential of software defined radio technology.