DSPIRA GnuRadio Lessons: Introduction and Simple Spectrometer
Lesson 1: Building a Waveform Generator

GNURadio is very popular and robust software defined radio package. It is open source and is relatively easy to use. All "coding" is done using flowgraphs comprised of interconnected Digital Signal Processing (DSP) blocks. Most commonly used blocks come predefined as part of the software package. One can program one's own blocks as well.

Let's get Familiar – Building a Waveform Generator

For our first project we will build a program that generates a real-valued cosine signal with a frequency of 400 Hz, and outputs it to a speaker. We will also display the signal in a time domain graph and in a frequency domain graph. Then we will modify it so that we can adjust the frequency in real time.

Step 1. Open GNURadio

To open GNURadio, open a terminal window. Type "gnuradio-companion" and hit Enter; the program should open. The canvas window will be mostly empty. On the right side of the canvas is a list of the block categories that are available. Click on a triangle next to a category to see what blocks are available in that category. Look under the *waveform generator* category and look for the **signal source** block. Alternatively, we can click on the magnifying/looking glass to the top right and search for the block we need. Add the **signal source** block to the canvas by dragging it into the canvas window.
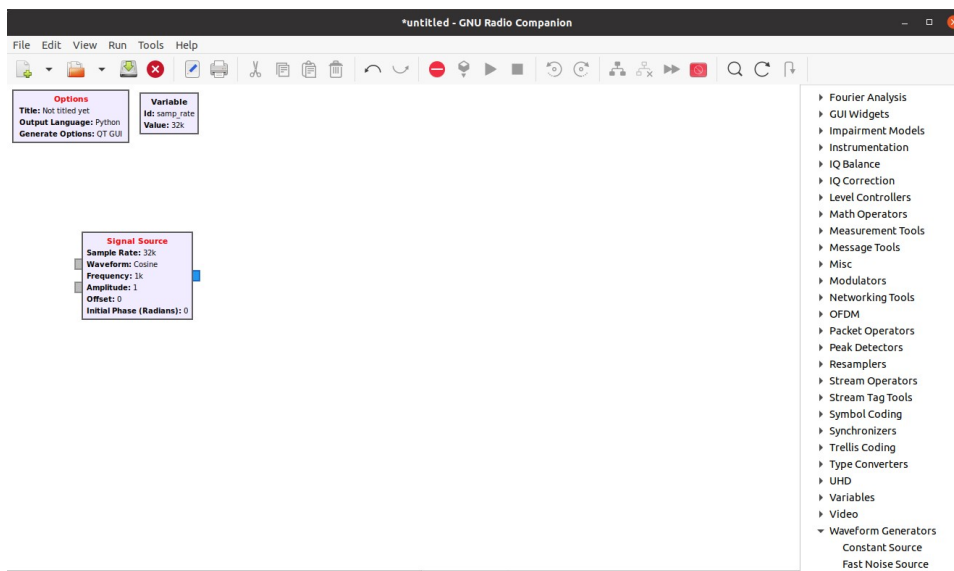
Some Helpful Information About GNURadio

Block Port Colors

Notice that the **Signal Source** block has one or two gray ports on the left and a blue one on the right. The color of a port indicates the type of data generated for an output port or the type of data accepted for an input. The most common data types that we will use are:

- Orange is for "Float" data types, which are real-valued 32-bit floating point data samples.
- Blue is for "Complex" data types, which are complex-valued 32-bit floating point data samples. [Electrical engineering and digital signal processing often use complex functions and data.]

Connecting Blocks

To connect two blocks, click on the output port of the first block and then click on the input port of the second block. An arrow will appear connecting the two ports. For the flowgraph to work both ports must use the same data type (i.e., both ports must be of the same color). If they are of different types, then the arrow of the connection will be red instead of black, indicating a problem.

NOTE: If you see any red arrows or red writing in a flowgraph you will not be able to run the flowgraph until the offending condition has been fixed.

Back to building a waveform generator:

Step 2. Change the "Output Type" in the **signal source** block to "float" and hit Ok.
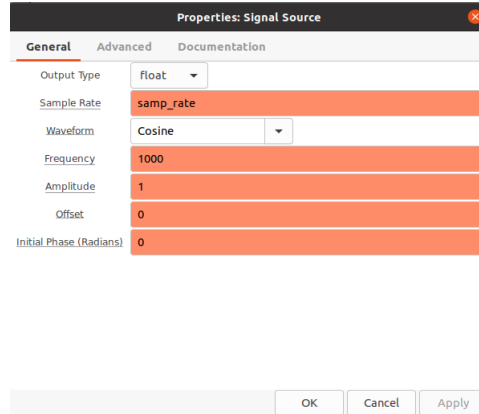
The output terminal on this block should now be orange.

Step 3. Let's add a speaker to hear the signal output.

- **Change the Signal Source frequency:** Double-click the **Signal Source** block. Then type in "400" for the frequency value.

- **Add a speaker to the output:** Choose "Audio" under "Instrumentation" (or just simply search for "Audio Sink") and click and drag (or double-click) an **Audo Sink**. Connect this to the output of the **Signal Source** block.

- **Add a graphic output:** Choose "QT" under "Instrumentation" (or just simply search for "QT GUI Sink") and add a **QT GUI Sink** to the canvas. This block will allow you to see the waveform at the input in the frequency as well as in the time domain. Connect this to the output of the **Signal Source** block. Be sure that all of the data types are properly set.

- The program won't run until you rename it. Double-click the Options block in the upper left corner, and give it a title.

  The program now should look like the following:
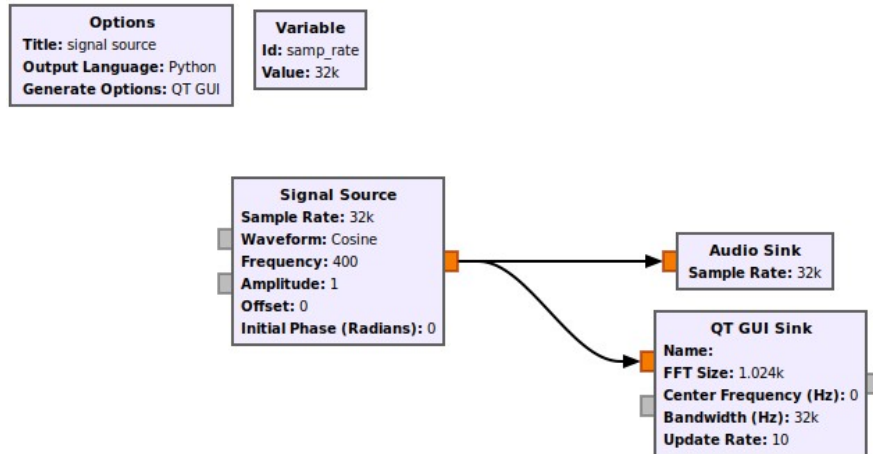
- **Save the file:** Save the file to an appropriate folder.

- **Run the program:** Now you can run the flow graph by clicking on the green triangle above the canvas or by clicking "Run" on the menu bar. To view the graphs, you can choose between the "Frequency Display" and the "Time Domain Display" tabs. Study some of the other graphical displays too.

Let's Make Some Modifications

Let's add a few features to the program:

- **Add a frequency variable:** Search for "QT GUI Range" and double-click on **QT GUI Range** to add it to the canvas. This block will allow you to define and control a variable.

 Set the *Id, Default Value, Start, Stop,* and *Step* as shown in the diagram below:

- In the **Signal Source** block, change the Frequency value to "freq" to match the variable we defined in the **QT GUI Range** block.

- **Speaker volume Control:**
  - Add a **QT GUI Range** variable called "amplitude", with a default of 1 and a range from 0 to 1, step 0.01.
  - In the **Signal Source** block, change the Amplitude value to "amplitude" to match the variable we defined in the **QT GUI Range** block.

- Your canvas should look like the following:
-
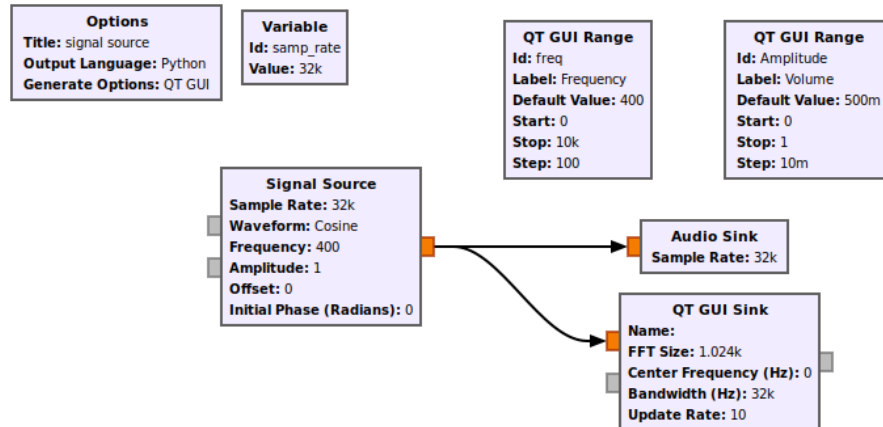
Re-run the program: Change the frequency and amplitude sliders, and observe changes in the Time domain graph and the Frequency domain graph.