College of Engineering Attingal

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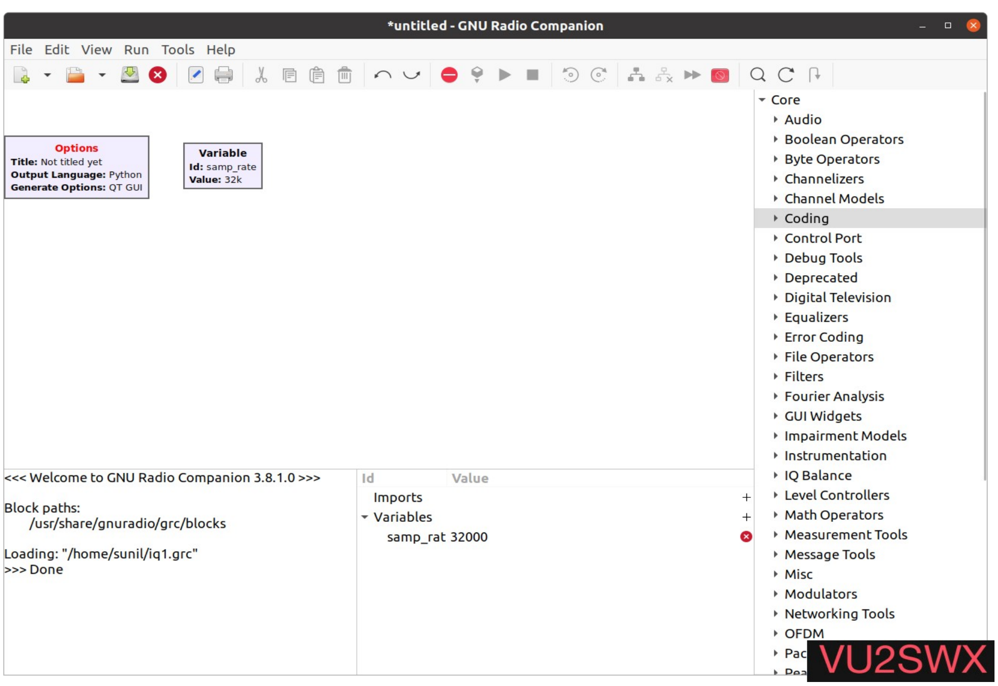
Lesson 1

Using GNU Radio Companion

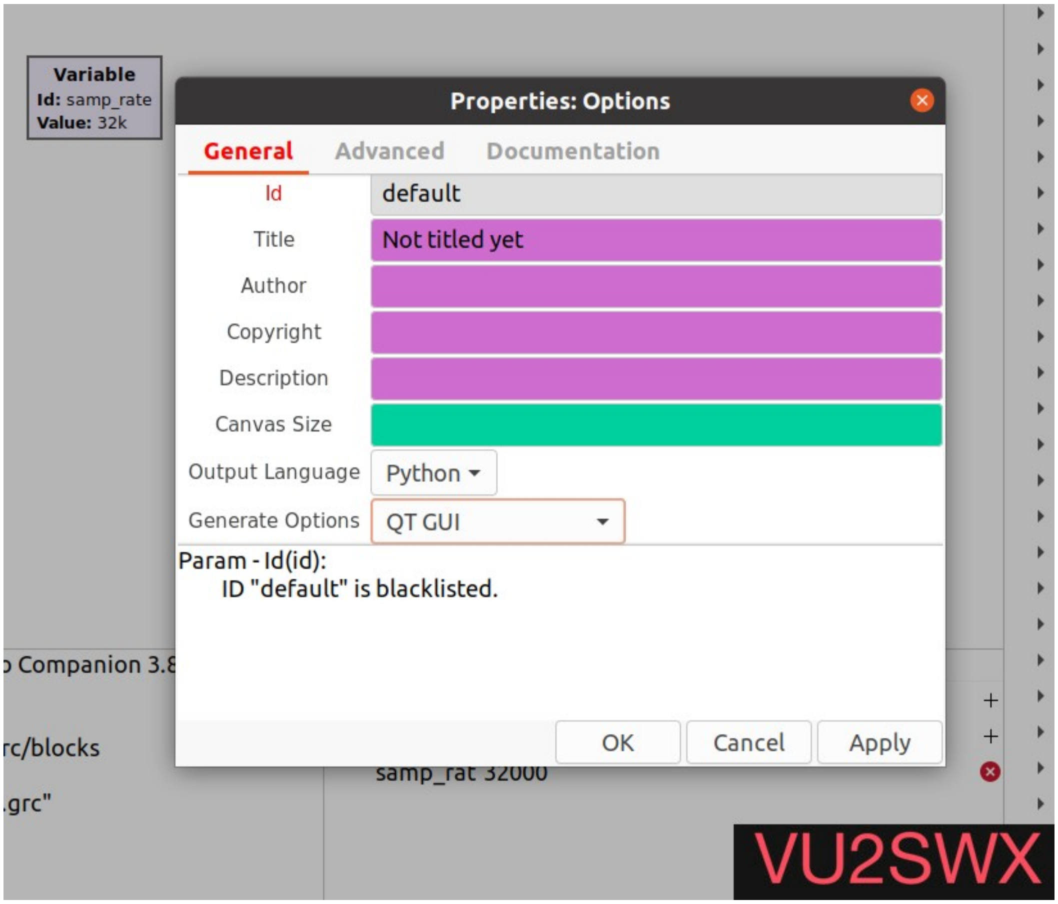
GNU Radio Companion (GRC) is a graphical user interface that allows you to build GNU Radio flow graphs. It is an excellent way to learn the basics of GNU Radio.

1. Open a terminal window using: Applications > Accessories > Terminal. At the prompt type: `gnuradio-companion.`

An untitled GRC window similar to the one below should open.

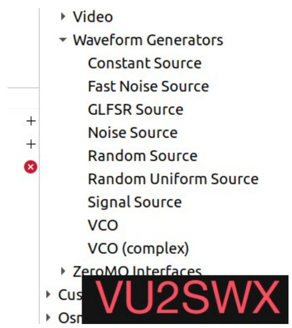


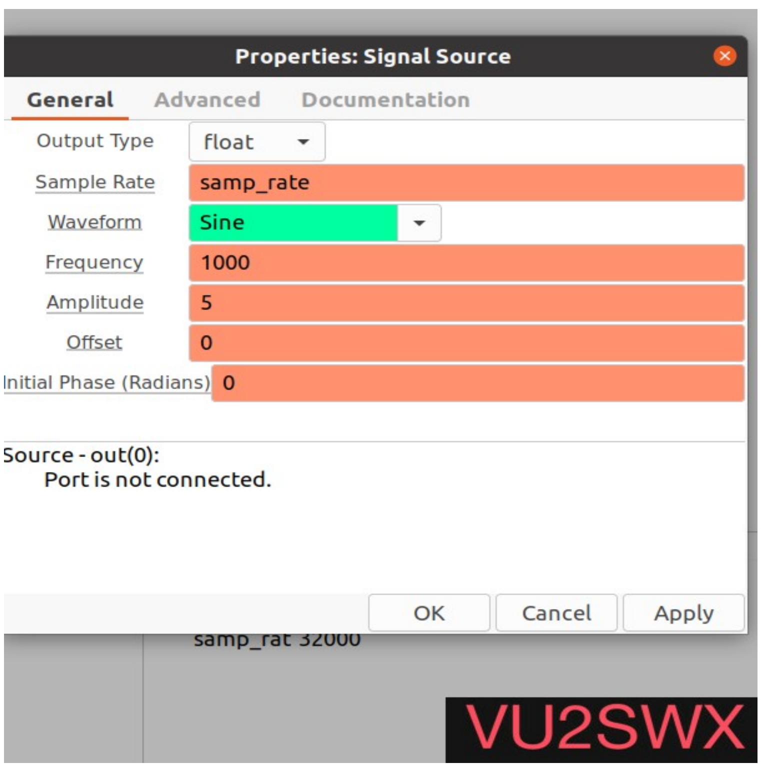
lesson1Double click on the Options block. This block sets some general parameters for the flow graph. Change the id to lesson1,   Type in a project title (such as lesson_demo1) and author. Set Generate Options to QT GUI,   Output language to Python. Then close the properties window. The other block that is present is the Variable block. It is used to set the sample rate. That will be discussed later in the tutorial.



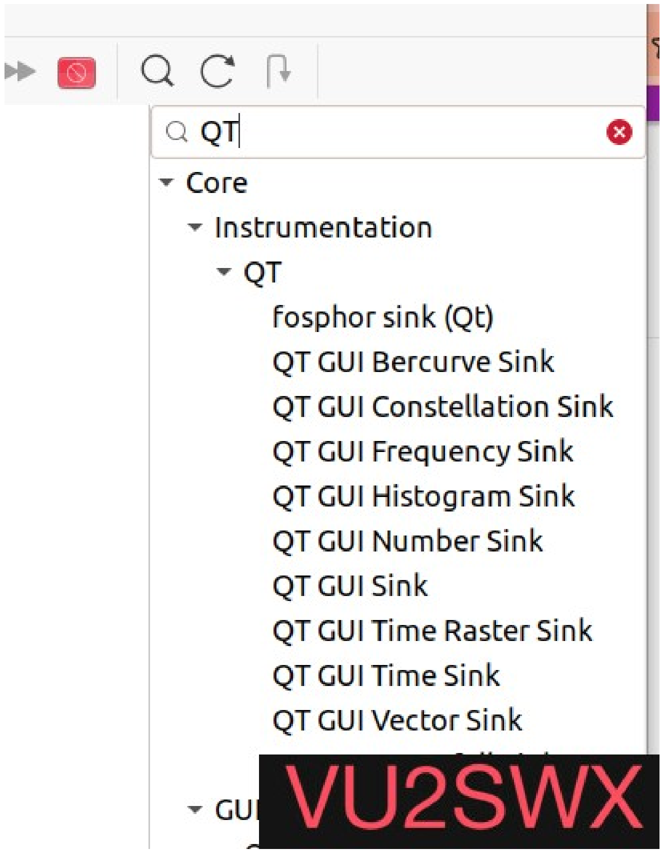
2. On the right side of the window is a list of the blocks that are available. By expanding any of the categories (click on triangle to the left) you can see the blocks available. Explore each of the categories so that you have an idea of what is available.

3. Open the Waveform generatos category and double click on the Signal Source. Note that a Signal Source block will now appear in the main window. Double click on the block and the properties window will open. Adjust the settings to match those as shown in the figure belowy and close the window. This Signal Source is now set to output a real valued 1KHz sinusoid with an amplitude of .5. Change the output type t float

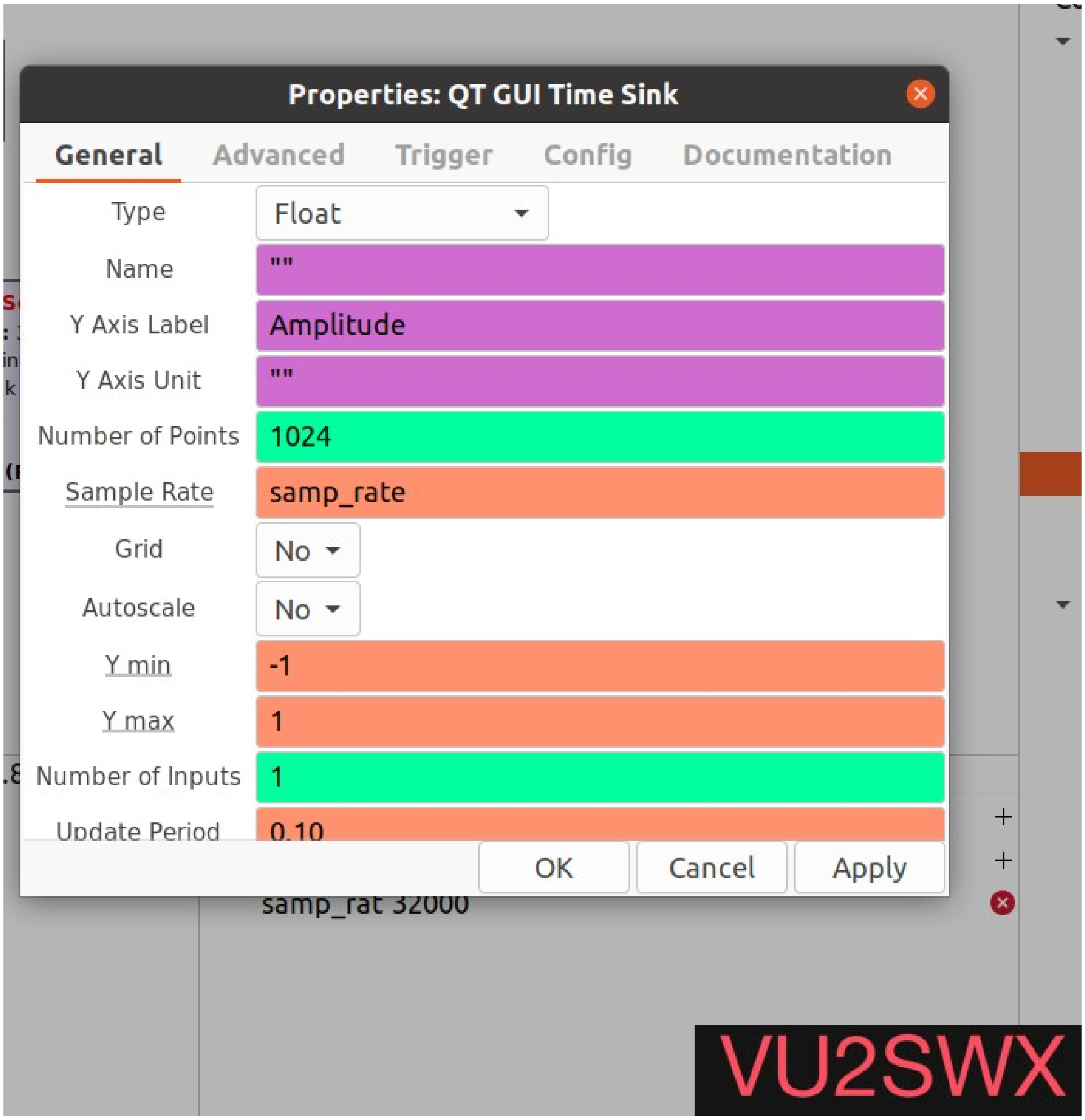




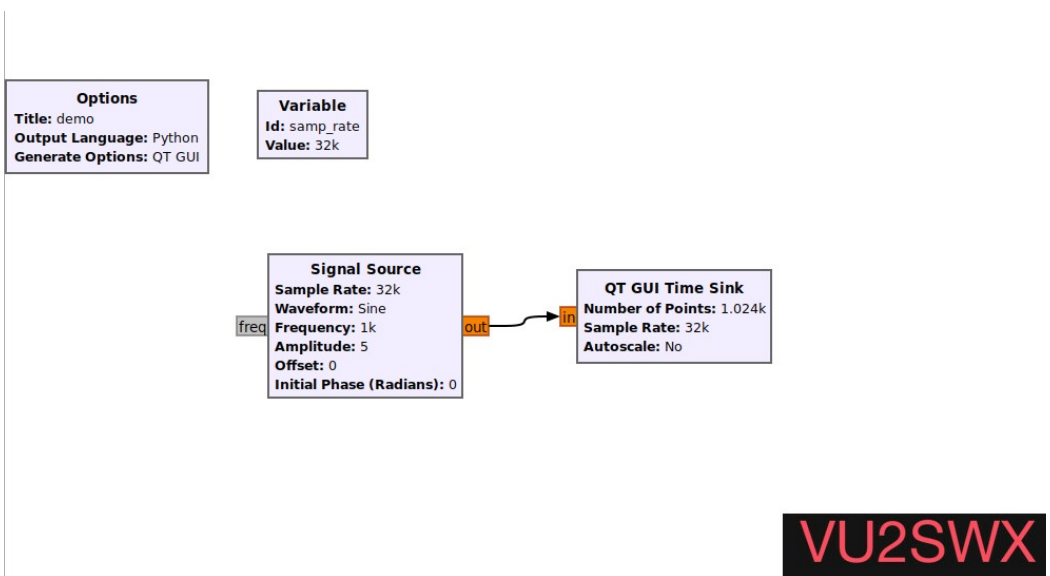
4. In order to view this wave we need one of the graphical sinks. . Choose Core → Instrumentation → QT → QT GUI Time sink and then double click on it



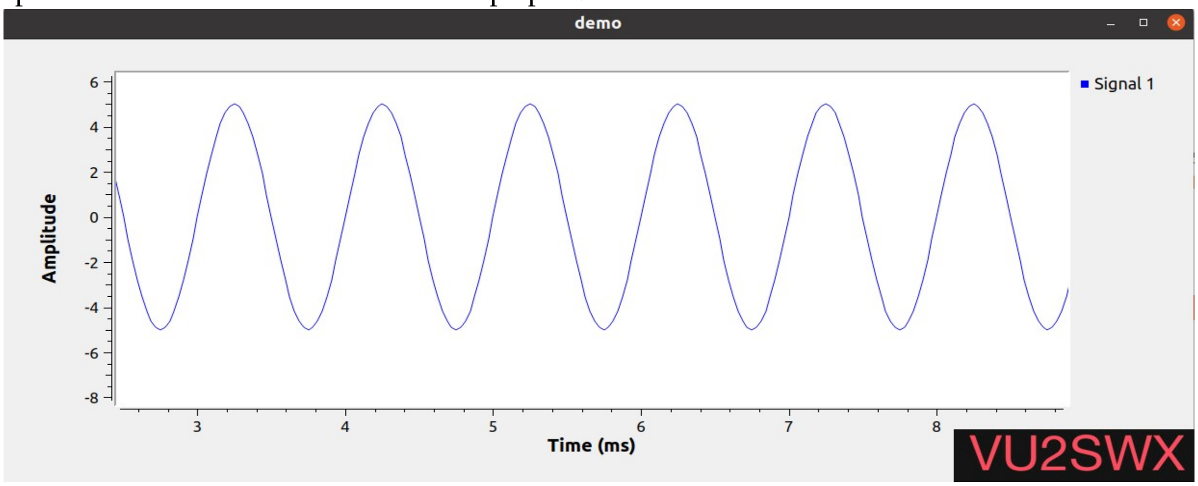
5. Change the type to float. This sink will act as an oscilloscope. If you want multiple channel , increase the number of inputs to 2. Explore various parameter such as labels



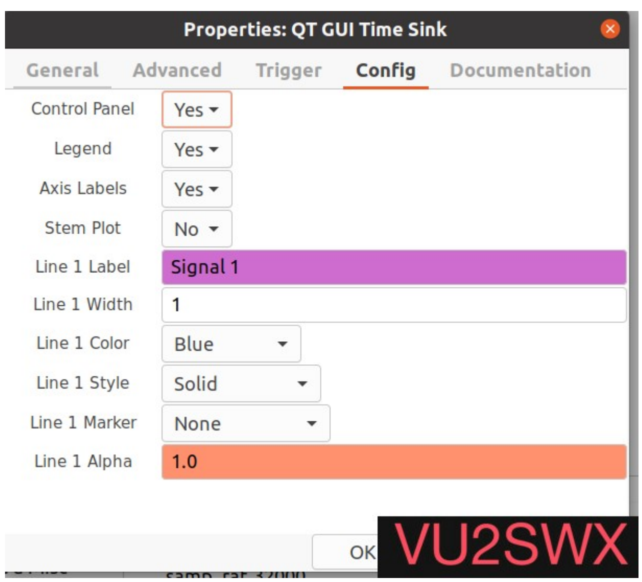
6. In order to connect these two blocks, click once on the "out" port of the Signal Source, and then once on the "in" port of the Scope Sink. The following flow graph should be displayed.



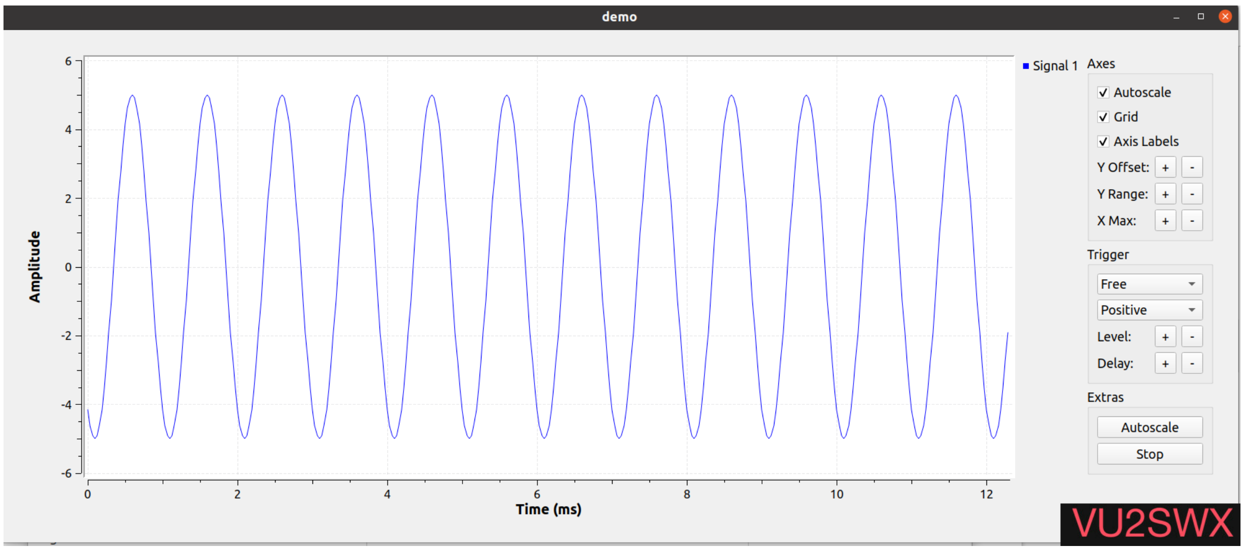
7. In order to observe the operation of this simple system we must generate the flow graph and then execute it. Click first on the "Generate the flow graph" icon. A box will come up in which you enter the name of the file. Name this file: tutorial1.grc and save. Click the "Execute the flow graph" icon. A scope plot should open displaying several cycles of the sinusoid. Confirm that the frequency and amplitude match the value that you expect. Experiment with the controls on the scope plot.



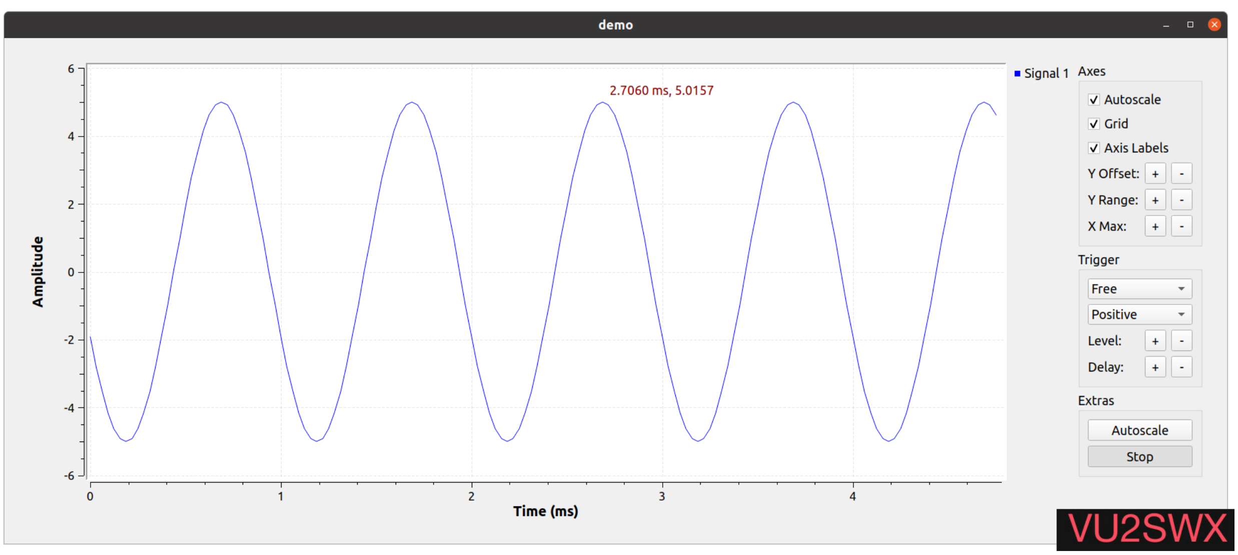
8. Go back to QT GUI sink properties and switch on control panel under config Re run the flow graph



9. You will get a screen as shown below. Experiment with various options.



10. Move the cursor over the curve you can see the actual sample values. Recall that the Variable block set the sampling rate to 32000 samples/second or 32 samples/ms. Note that there are in fact 32 samples within one cycle of the wave.

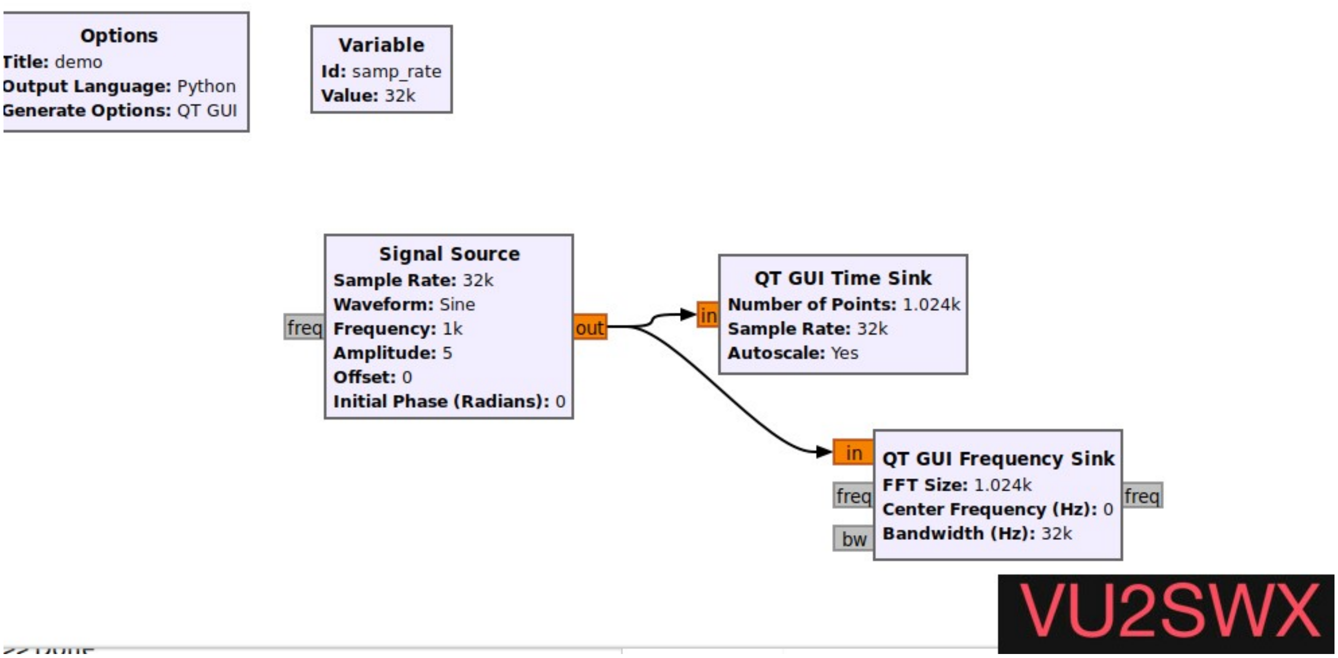


11. Close the Scope Plot and reduce the sample rate to 10000 by double clicking on the Variable block. Re-generate and execute the flow graph. Note that there are now fewer points per cycle. How low can you drop the sample rate? Recall that the Nyquist sampling theorem

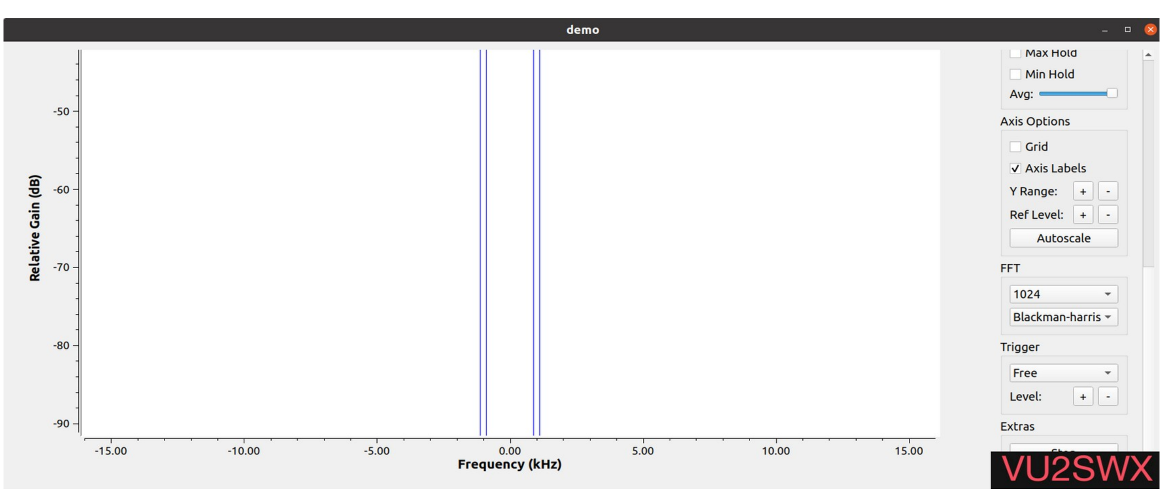
requires that we sample at more than two times the highest frequency. Experiment with this and see how the output changes as you drop below the Nyquist rate.

12. Close the Scope Plot and change the sample rate back to 32000. Add QT GUI frequency sink . Change the Type to Float and show control panel and leave the remaining parameters at their default values.

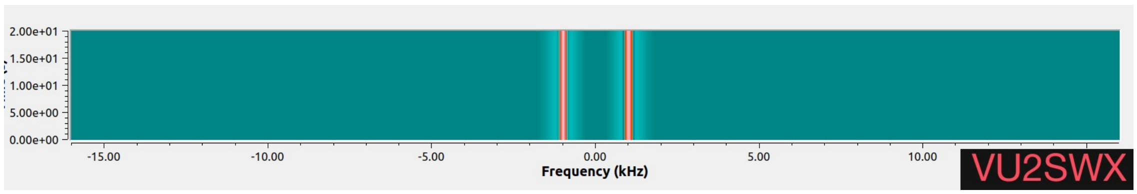
13. Connect this to the output of the Signal Source by clicking on the out port of the Signal Source and then the in port of the QT GUI Sink. Generate and execute the flow graph. You should observe the scope as before along with an FFT plot correctly showing the frequency of the input at 1KHz. Close the output windows.



14.



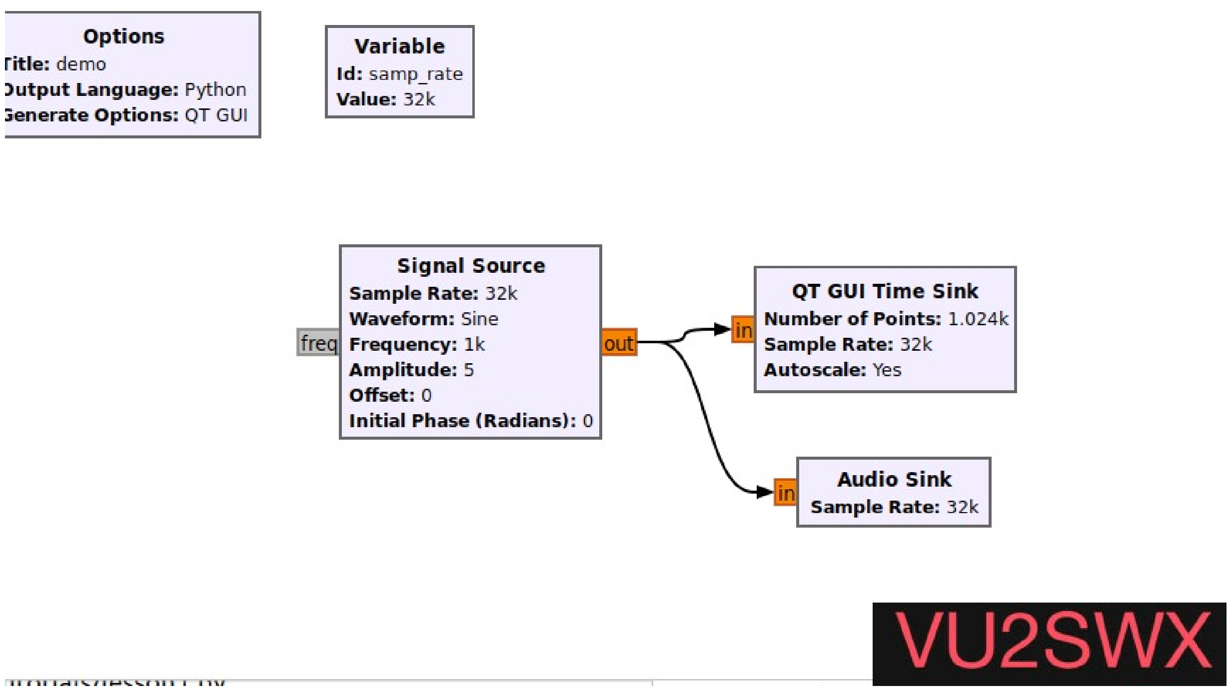
Explore the other QT GUI Sinks (Number Sink, Waterfall Sink, and Histo Sink) to see how they display the Signal Source. Water fall sink is shown below



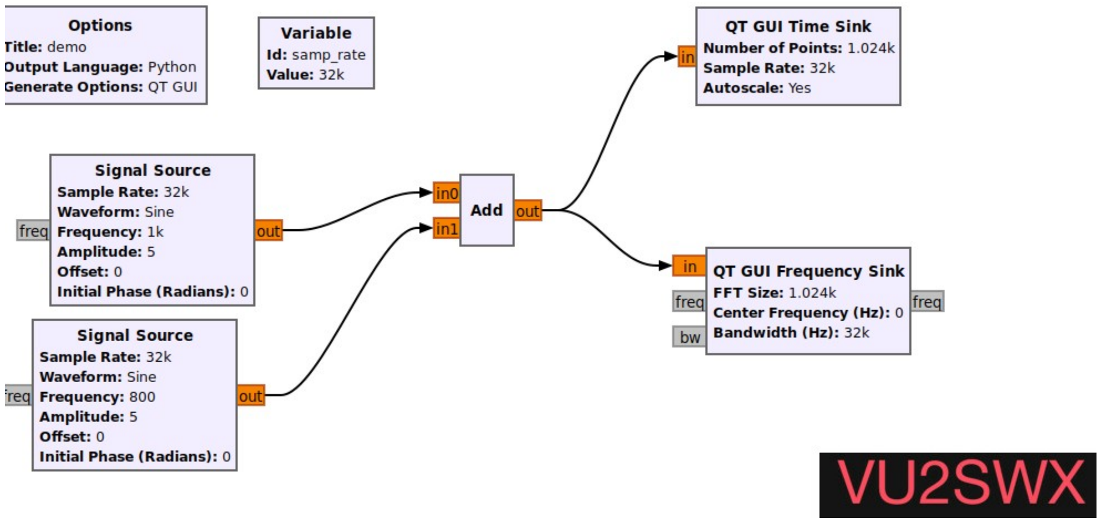
15.

Now bring in an Audio sink.

Create the flow graph shown below. The Audio Sink is found in Core->Audio -> Audio Sinks category. Generate and execute the flow graph. Along with graphical display of the signal you can hear the 1KHz tone.



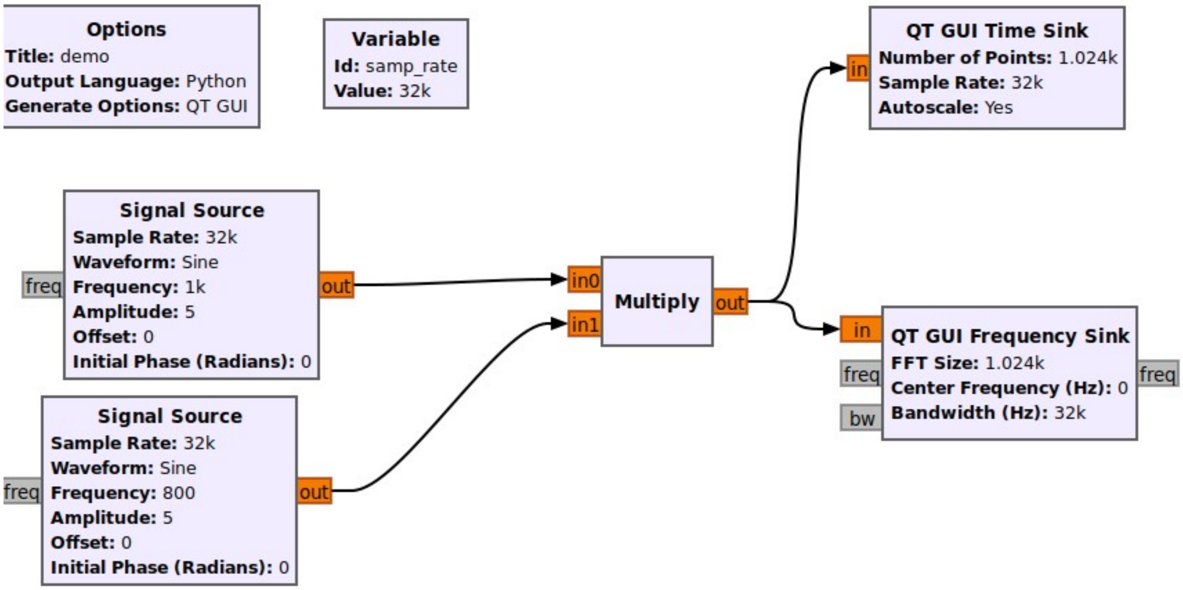
16. Construct the flow graph shown below. Set the sample rate to 32000. The two Signal Sources should have frequencies of 1000 and 800, respectively. The Add block is found in the Math Operators category.

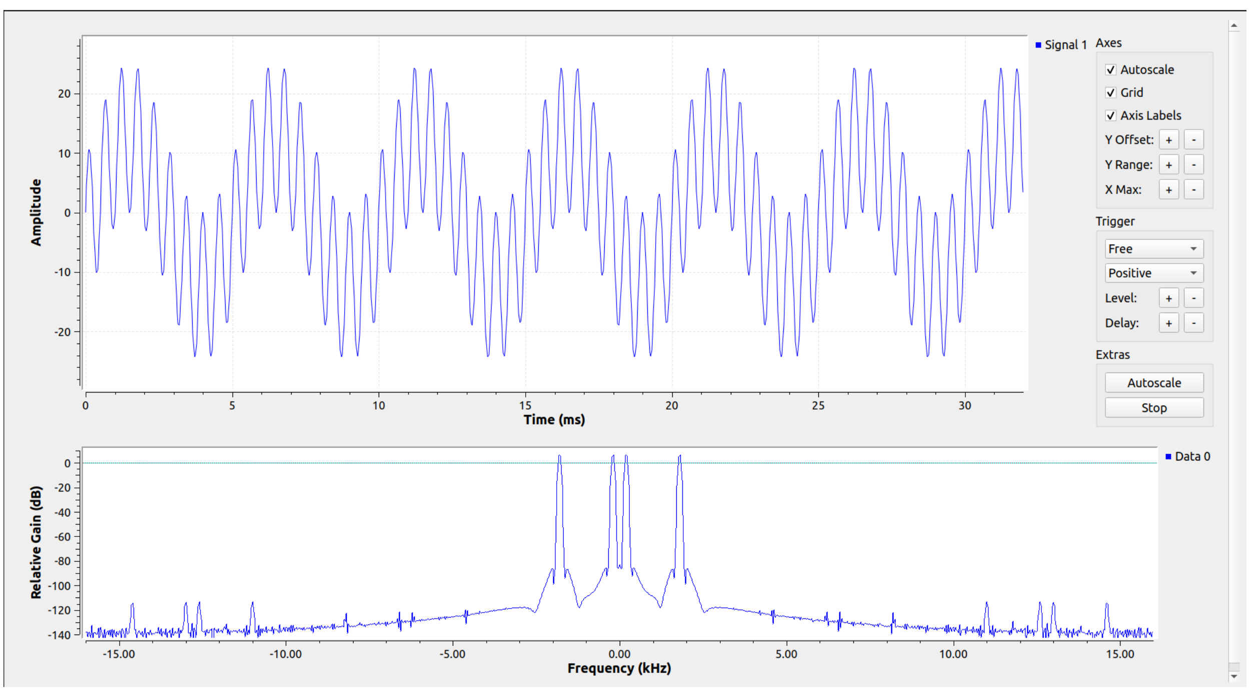


17.

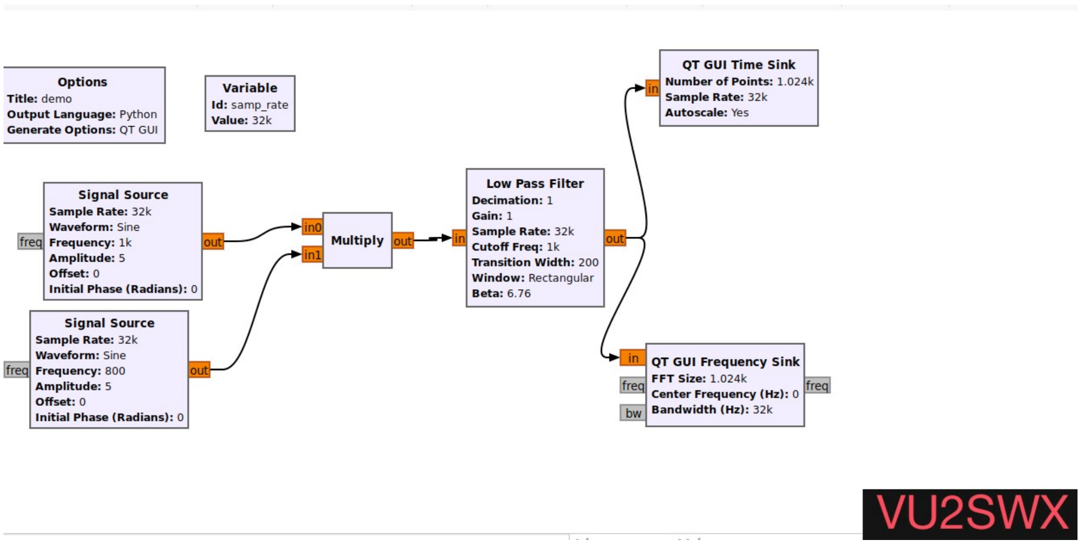
Generate and execute the flow graph. On the Scope plot you should observe a waveform corresponding to the sum of two sinusoids. On the FFT plot you should see components at both 800 and 1000 Hz. Try lowering the sample rate to 10KHz.

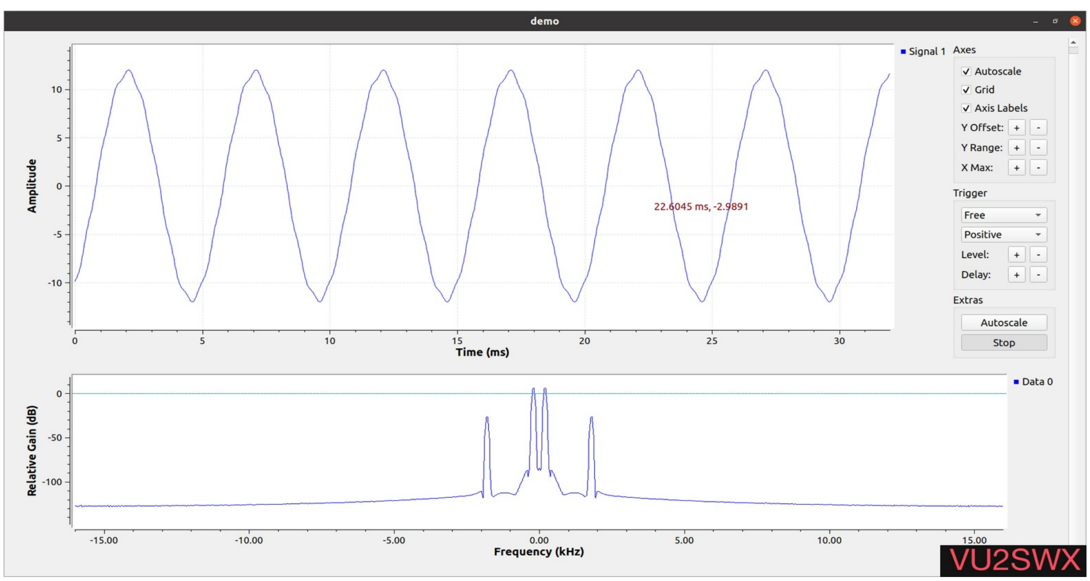
18. Replace the Add block with a Multiply block. What output do you expect from the product of two sinusoids? Confirm your result on the Scope and FFT displays.


Options
Title: demo
Output Language: Python
Generate Options: QT GUI
Variable
Id: samp_rate
Value: 32k
Signal Source
Sample Rate: 32k
Waveform: Sine
Frequency: 1k
Amplitude: 5
Offset: 0
Initial Phase (Radians): 0
Signal Source
Sample Rate: 32k
Waveform: Sine
Frequency: 800
Amplitude: 5
Offset: 0
Initial Phase (Radians): 0
freq
out
in0
in1
Multiply
out
in
QT GUI Time Sink
Number of Points: 1.024k
Sample Rate: 32k
Autoscale: Yes
in
QT GUI Frequency Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
freq
bw


Amplitude
Time (ms)
Signal 1
Axes
Autoscale
Grid
Axis Labels
Y Offset:
Y Range:
X Max:
Trigger
Free
Positive
Level:
Delay:
Extras
Autoscale
Stop
Relative Gain (dB)
Frequency (kHz)
Data 0

19. Modify the flow graph to include a Low Pass Filter block as shown in the figure below. This block is found in the Core→ Filters category. Recall that the Multiply block outputs a 200Hz and a 1.8KHz sinusoid. We want to create a filter that will pass the 200Hz and block the 1.8KHz component. Set the low pass filter to have a cutoff frequency of 1KHz and a transition width of 200 Hz. Use a Rectangular Window. Generate and execute the flow graph. You should observe that only the 200Hz component passes through the filter. Experiment with the High Pass Filter.





20. Open a file browser in Ubuntu (Places → Home Folder). Go to the directory that contains the GRC file that you have been working on. If you are unsure as to where this is, the path to this file is shown in the bottom portion of the GRC window. In addition to saving a ".grc" file with your flow graph, note that there is also a file titled "demo1py". Double click on this block. You will be given the option to Run or Display this file. Select Display. This is the Python file that is generated by GRC. It is this file that is being run when you execute the flow graph. You can modify this file and run it from the terminal window. This allows you to use features that are not included in GRC. Keep in mind that every time you run your flow graph in GRC, it will overwrite the Python script that is generated. So, if you make changes directly in the Python script that you want to keep, save it under another name.