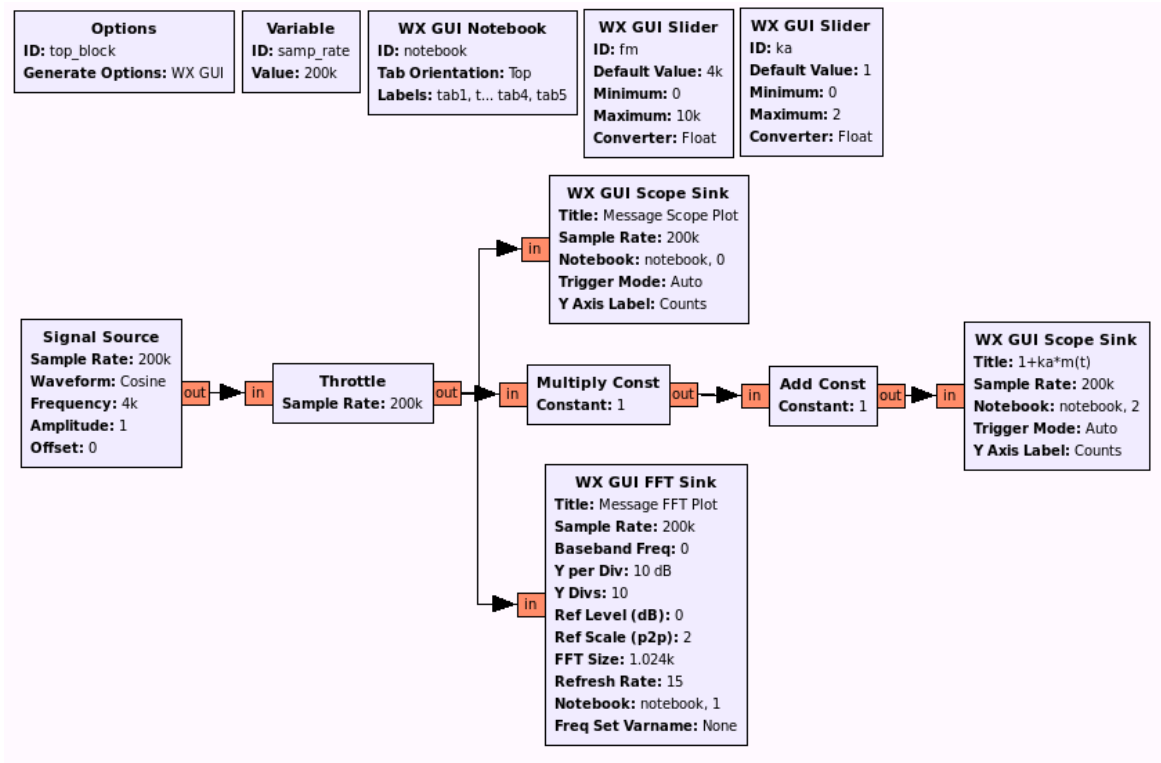


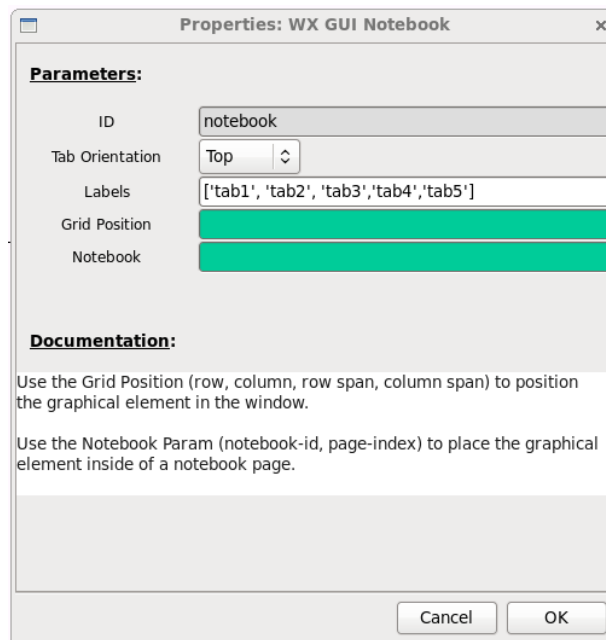
AM Transmission procedure steps

I. Amplitude Modulation

1- Construct the flow graph shown below consisting of a Signal Source, Throttle, Multiply Const and Add Const blocks.

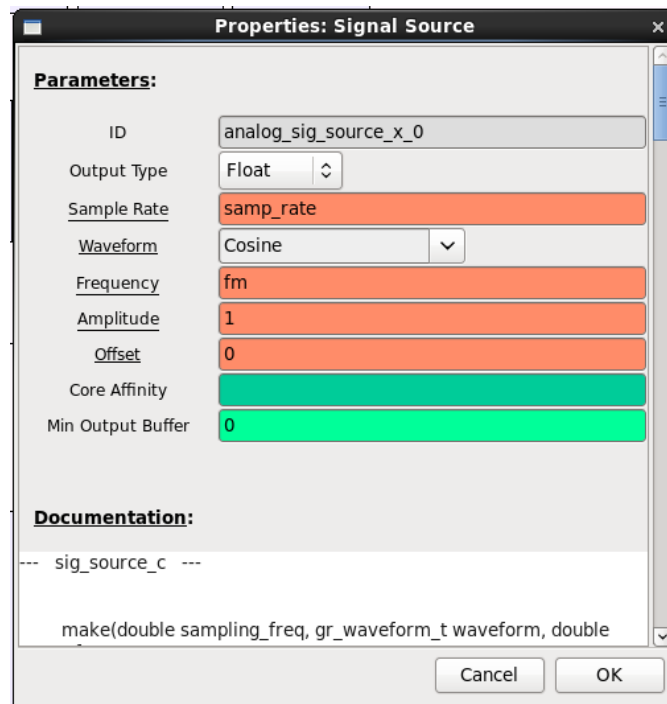


2- The WX GUI notebook block enables to show several plots in a single window using different tabs. Set the block as following so that you can see 5 different plots in a single display window.



3- Set the Sample Rate in the variable block to 200 KHz.

4- Double-click on the Signal Source block. Set the parameters as below.



The 'Properties: Signal Source' dialog box contains the following parameters:

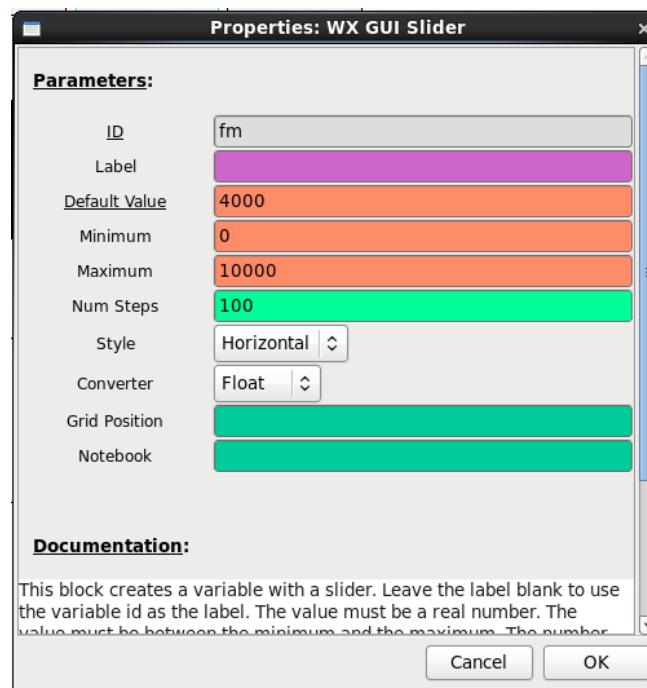
Parameter	Value
ID	analog_sig_source_x_0
Output Type	Float
Sample Rate	samp_rate
Waveform	Cosine
Frequency	fm
Amplitude	1
Offset	0
Core Affinity	
Min Output Buffer	0

Documentation:

```
--- sig_source_c ---  
  
make(double sampling_freq, gr_waveform_t waveform, double
```

Buttons: Cancel, OK

5- fm is the signal frequency which is controlled by the WX GUI Slider block with the following properties:



The 'Properties: WX GUI Slider' dialog box contains the following parameters:

Parameter	Value
ID	fm
Label	
Default Value	4000
Minimum	0
Maximum	10000
Num Steps	100
Style	Horizontal
Converter	Float
Grid Position	
Notebook	

Documentation:

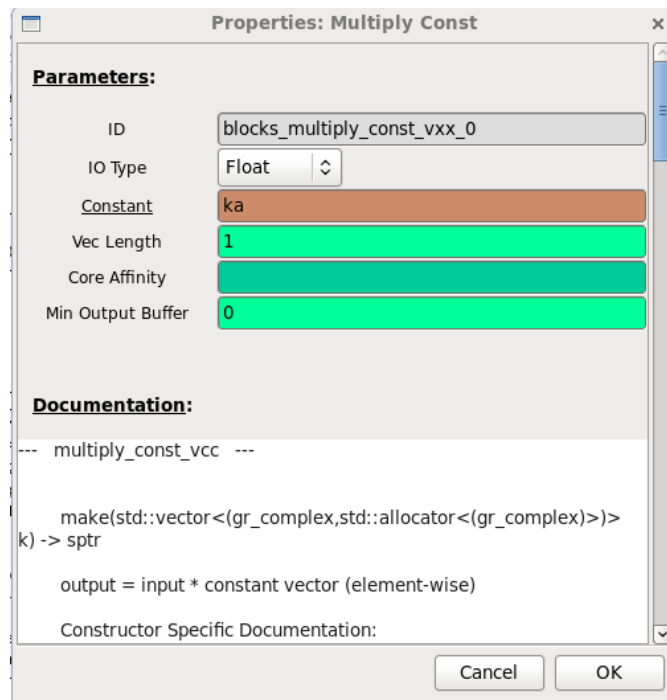
This block creates a variable with a slider. Leave the label blank to use the variable id as the label. The value must be a real number. The value must be between the minimum and the maximum. The number

Buttons: Cancel, OK

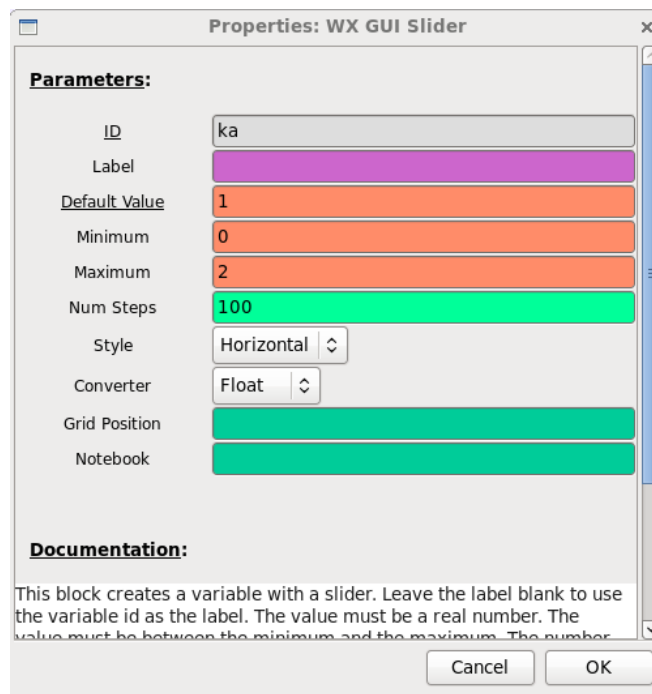
The fm slider enables you to change the signal frequency from 0 Hz to 10 KHz considering the default value of 4KHz and with step size equal to $(10\text{KHz}-0)/100=100$.

6- Set the Throttle sample rate to `samp_rate`.

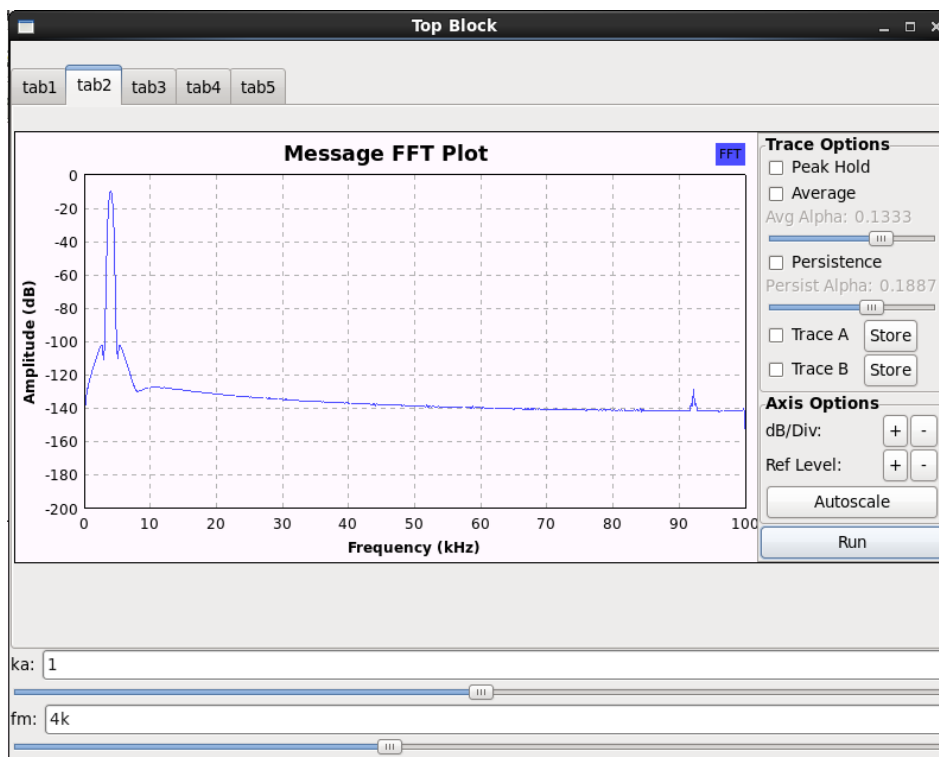
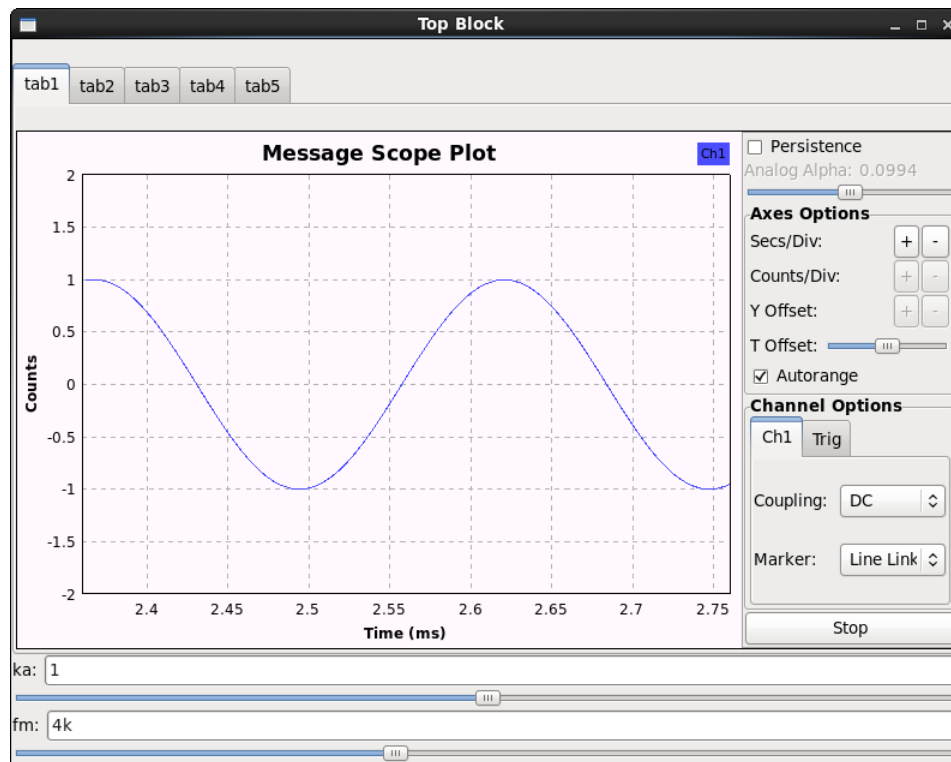
7- Double click on the multiply const block. This block controls the modulation index k_a .

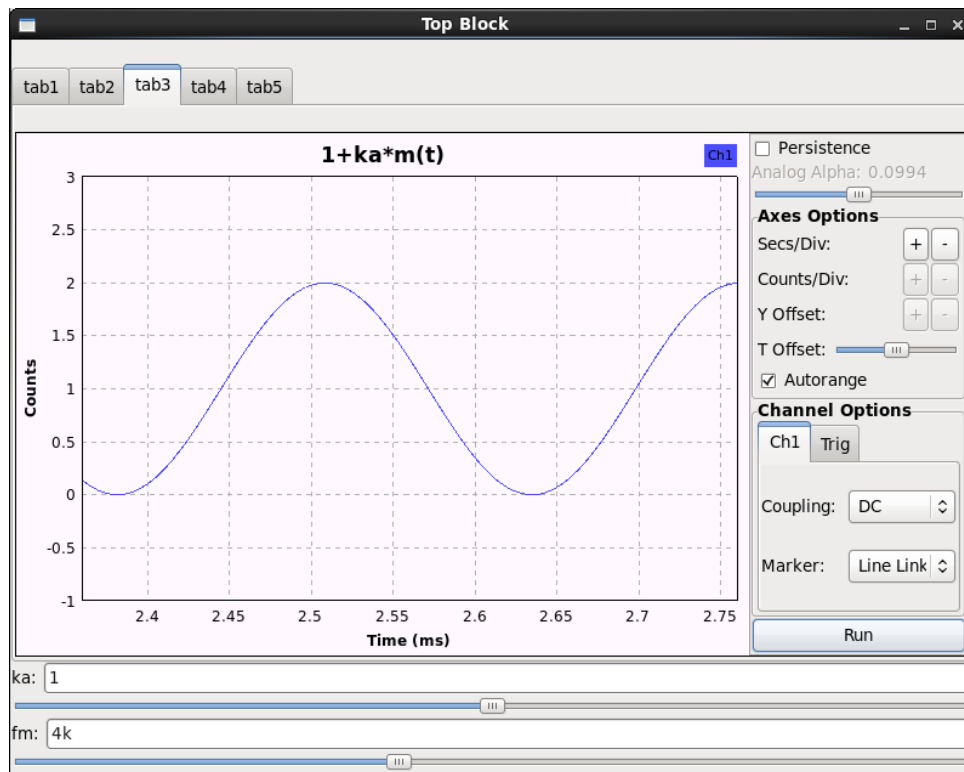


8- Use another WX GUI Slider to change the value of k_a in the interval $[0,2]$

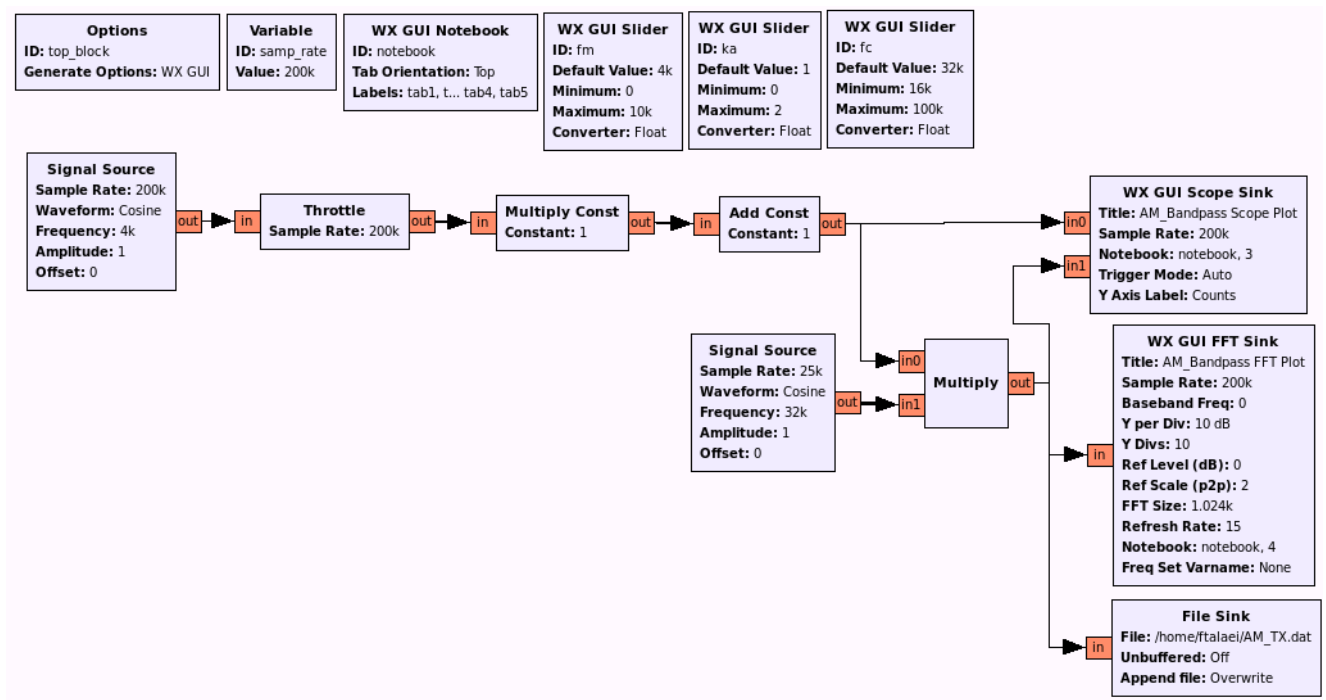


9-Use WX GUI Scop Sink and WX GUI FFT Sink to see the properties of the message signal $m(t)$ and modulation waveform $1+k_a m(t)$ when changing the modulation index and the signal frequency. Following figures these signals.

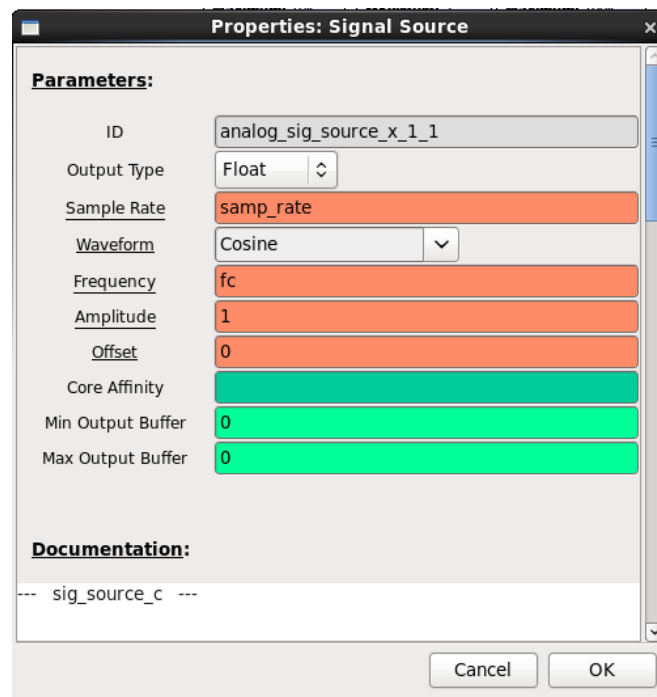




10- Expand the flow graph by multiplying the modulation waveform with the carrier signal to obtain the AM modulated waveform.



11- The carrier waveform is a cosine waveform with the following properties:



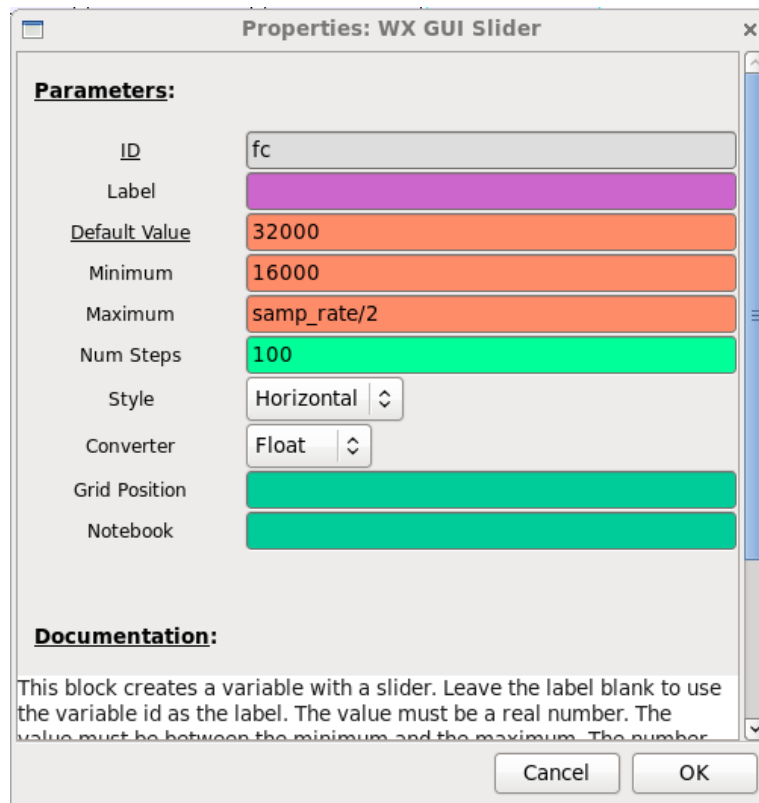
The 'Properties: Signal Source' dialog box contains the following parameters:

Parameter	Value
ID	analog_sig_source_x_1_1
Output Type	Float
Sample Rate	samp_rate
Waveform	Cosine
Frequency	fc
Amplitude	1
Offset	0
Core Affinity	
Min Output Buffer	0
Max Output Buffer	0

Documentation: --- sig_source_c ---

Buttons: Cancel, OK

12- f_c is the carrier frequency whose value is controlled by the WX GUI Slider.



The 'Properties: WX GUI Slider' dialog box contains the following parameters:

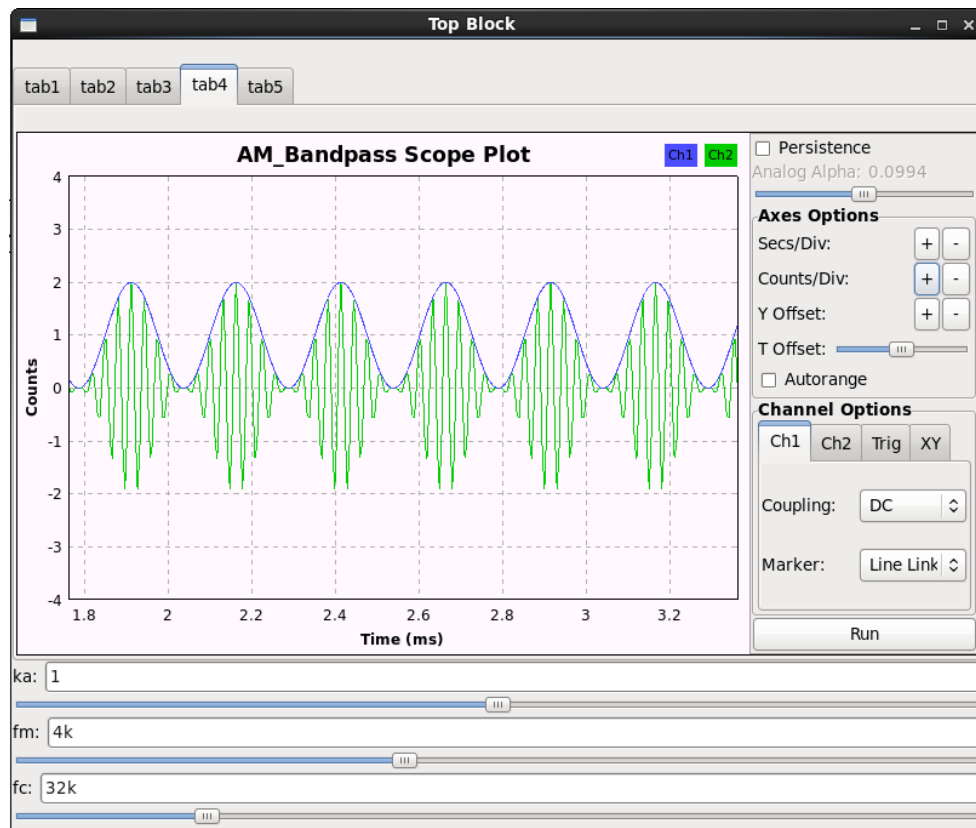
Parameter	Value
ID	fc
Label	
Default Value	32000
Minimum	16000
Maximum	samp_rate/2
Num Steps	100
Style	Horizontal
Converter	Float
Grid Position	
Notebook	

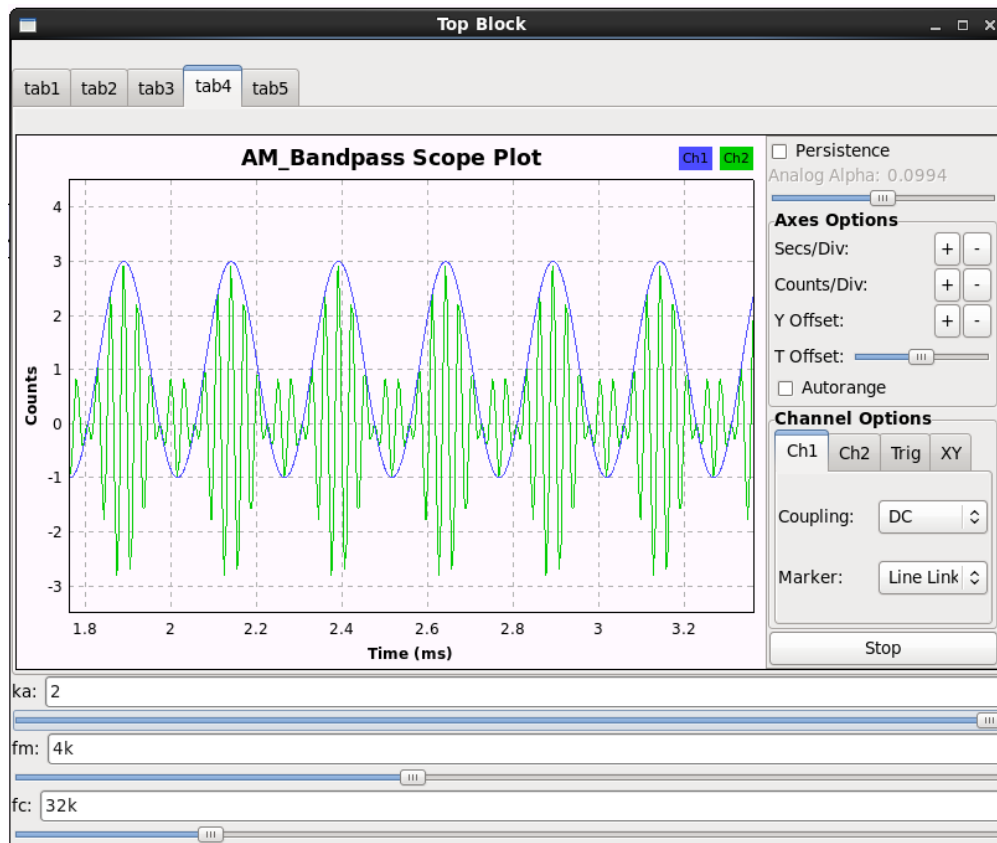
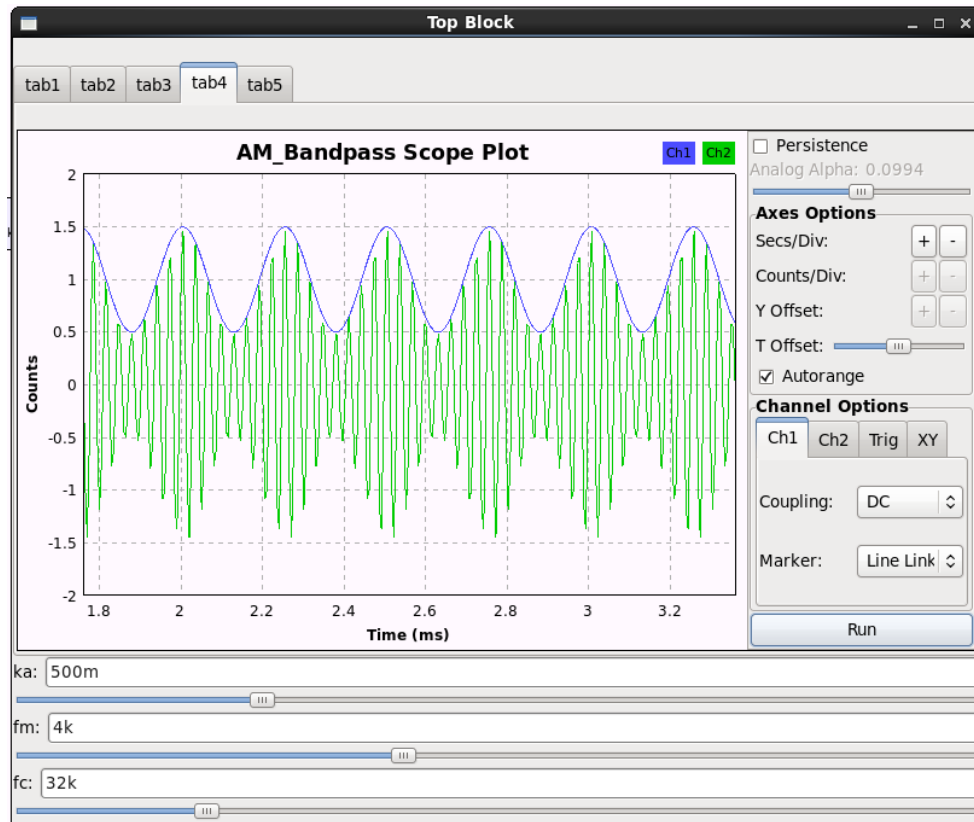
Documentation: This block creates a variable with a slider. Leave the label blank to use the variable id as the label. The value must be a real number. The value must be between the minimum and the maximum. The number

Buttons: Cancel, OK

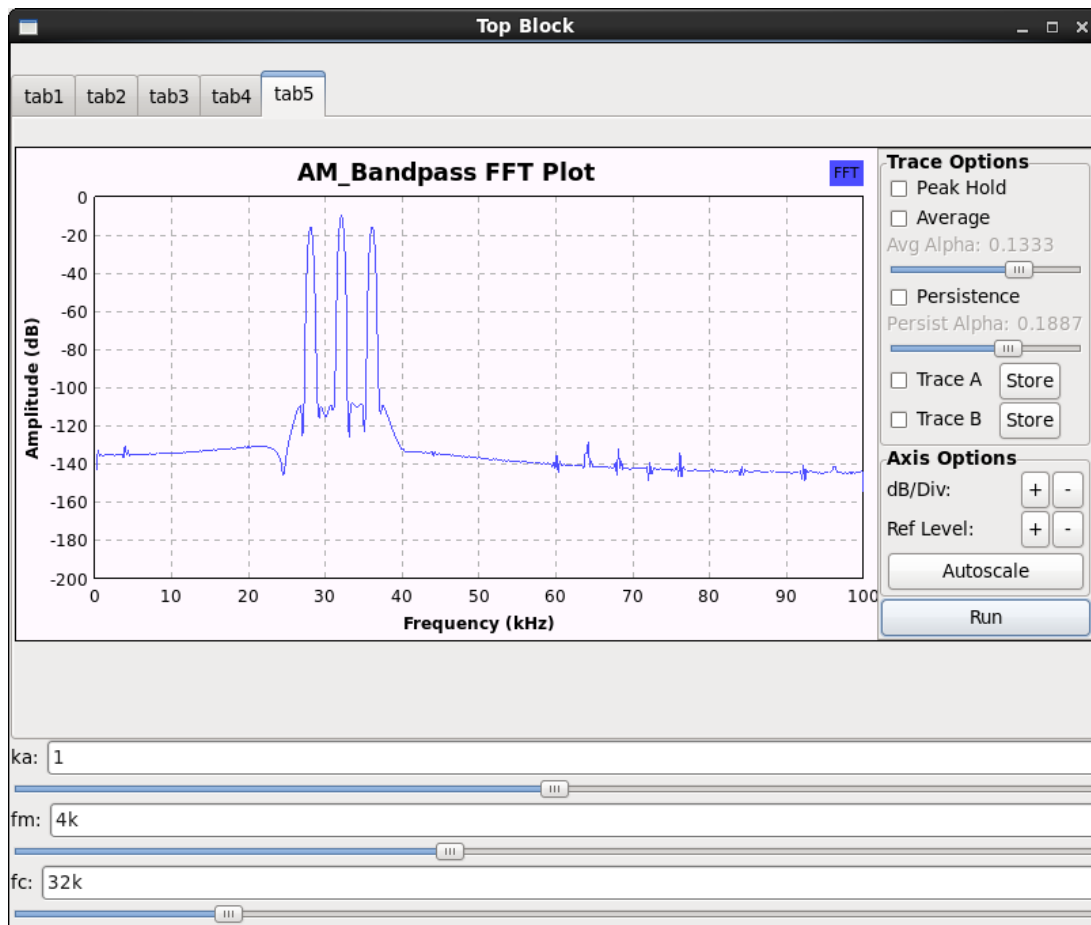
13- Use a WX GUI Scope Sink to observe the AM modulated signal and its correspondence message signal. Double click on the Scope Sink block and change the *Num Inputs* value to two. As it is shown in step ten, connect the first input to $(1+k_a*m(t))$ and the second input to $s(t)$.

You can change the modulation index k_a and see how its affect the AM signal. The following figures show the Scope plots of AM signals and their correspondence envelopes $(1+k_a*m(t))$ for three different values of k_a .





14- You can also use the FFT sink block to see how k_a , f_m and f_c affect the spectrum of the AM signal. Following figure shows the spectrum of AM signal for $k_a=1$, $f_m=4\text{KHz}$ and $f_c=32\text{KHz}$.

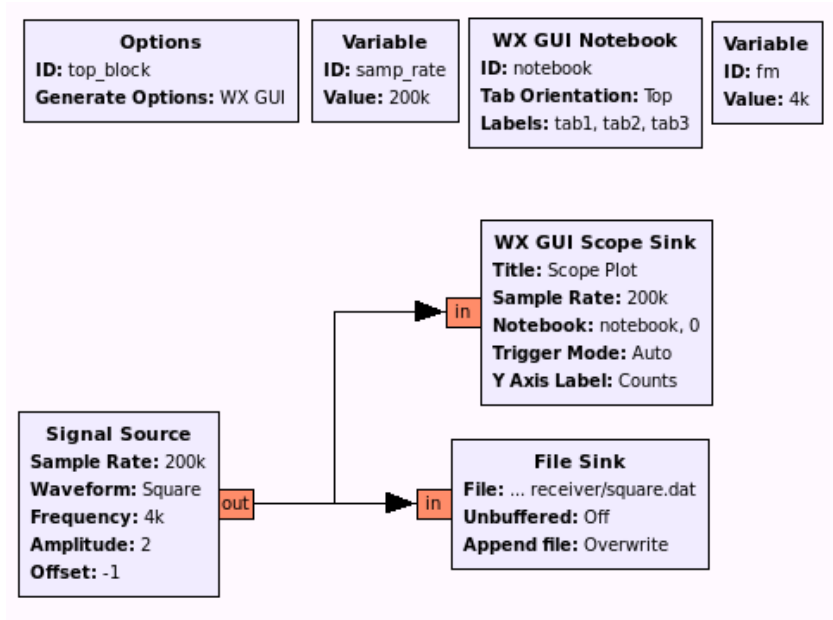


II. General Messages

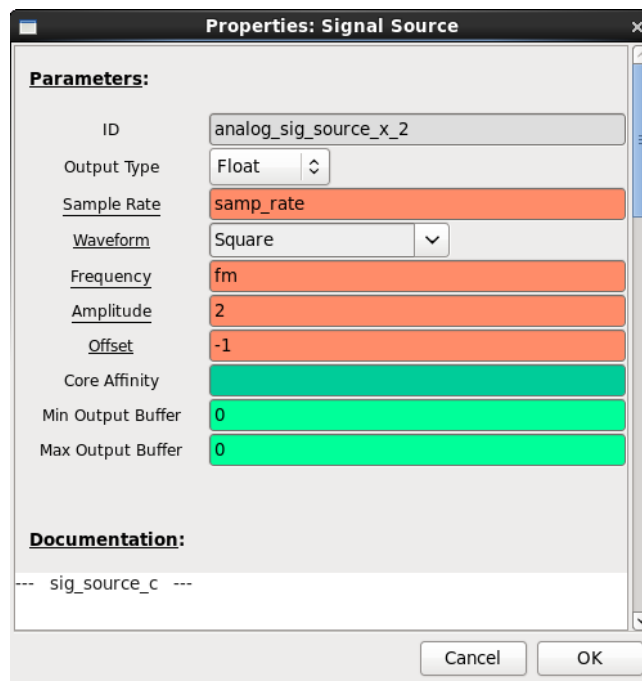
Until now, we have only used a sinusoidal message. In this part we want to create three other waveforms and modulating them using amplitude modulation.

a) Square wave with selectable frequency:

1) Use the following flowgraph to create a symmetric square waveform.

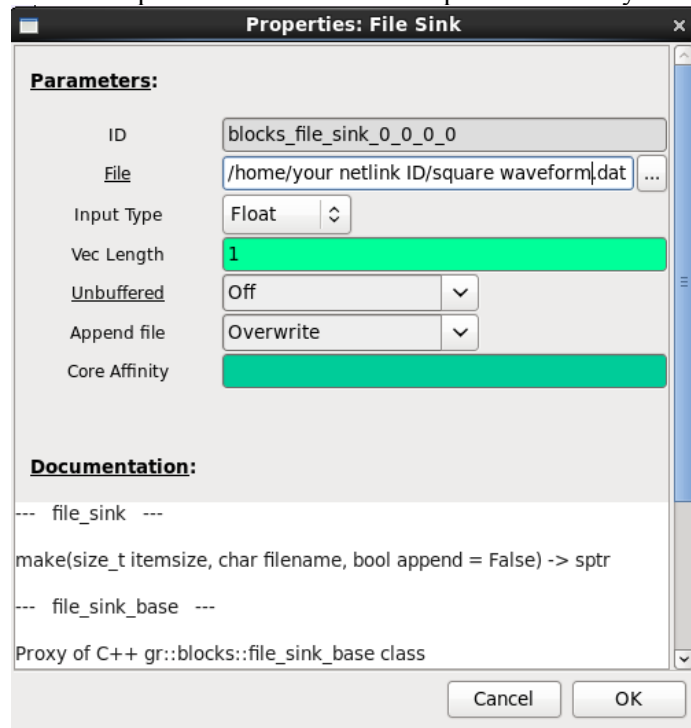


2) Set the parameters of the Signal Source block as below:

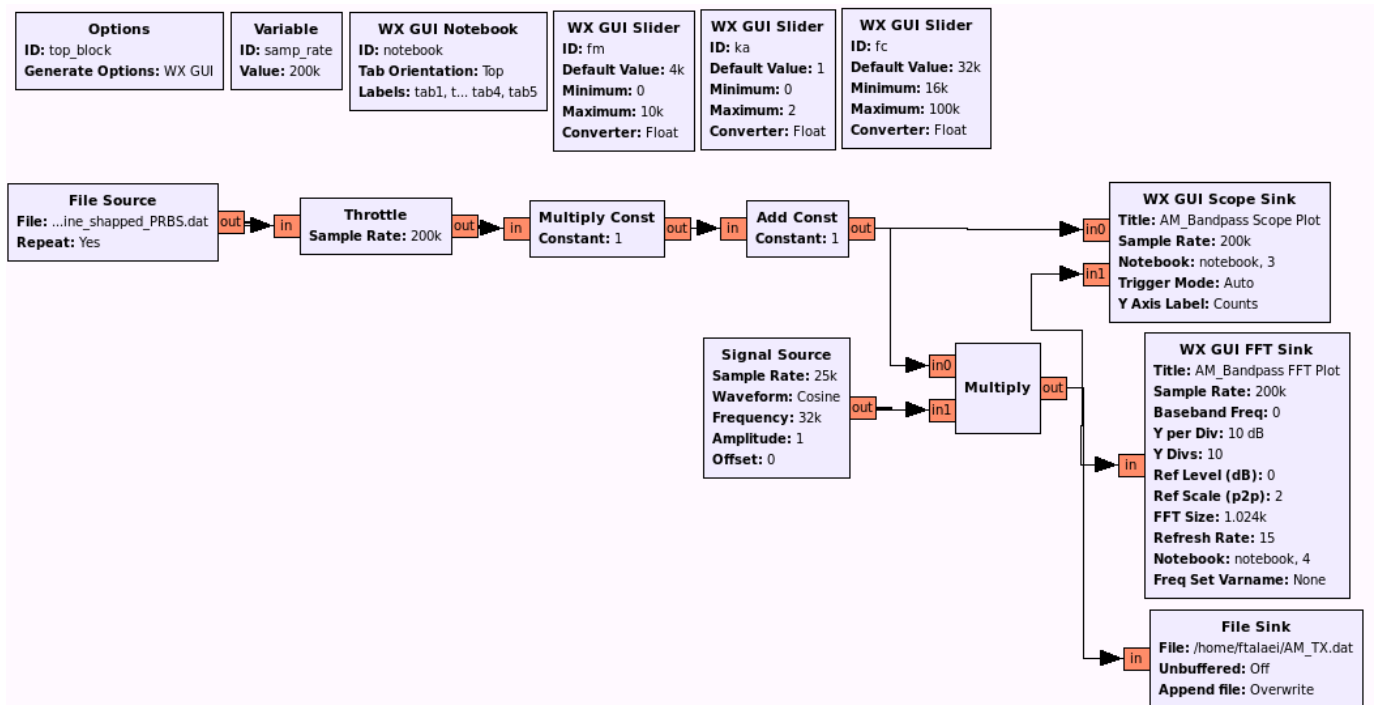


3) *fm* is the frequency of square waveform and its default value is set to 4KHz using a variable block with the same name.

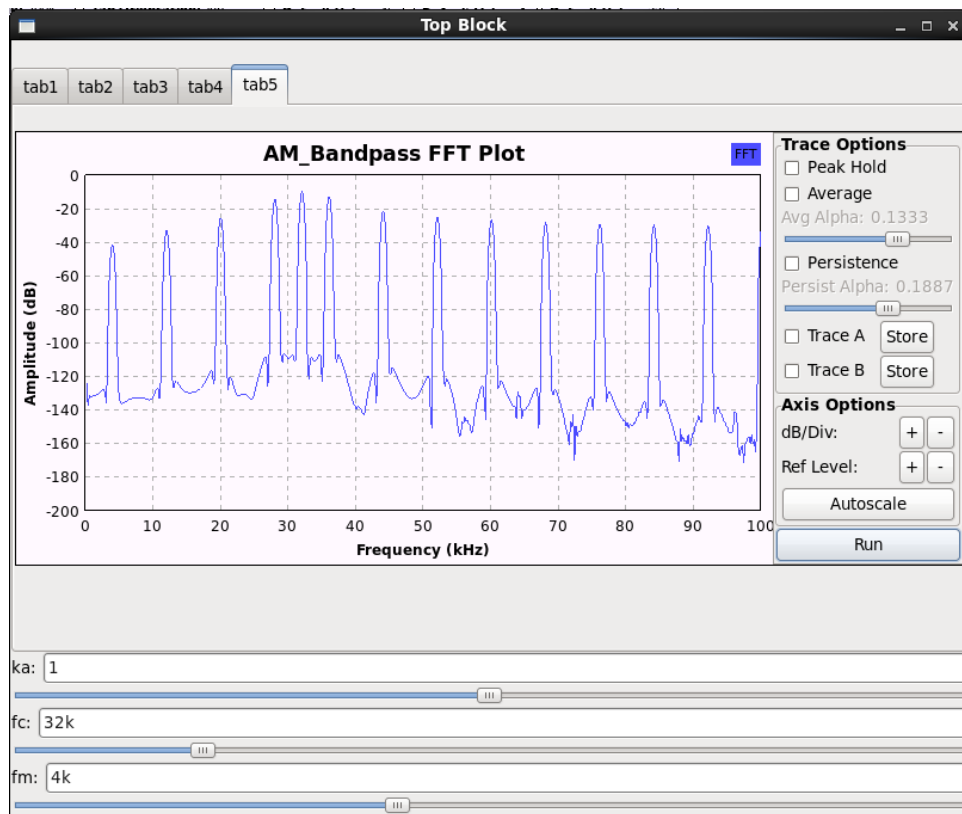
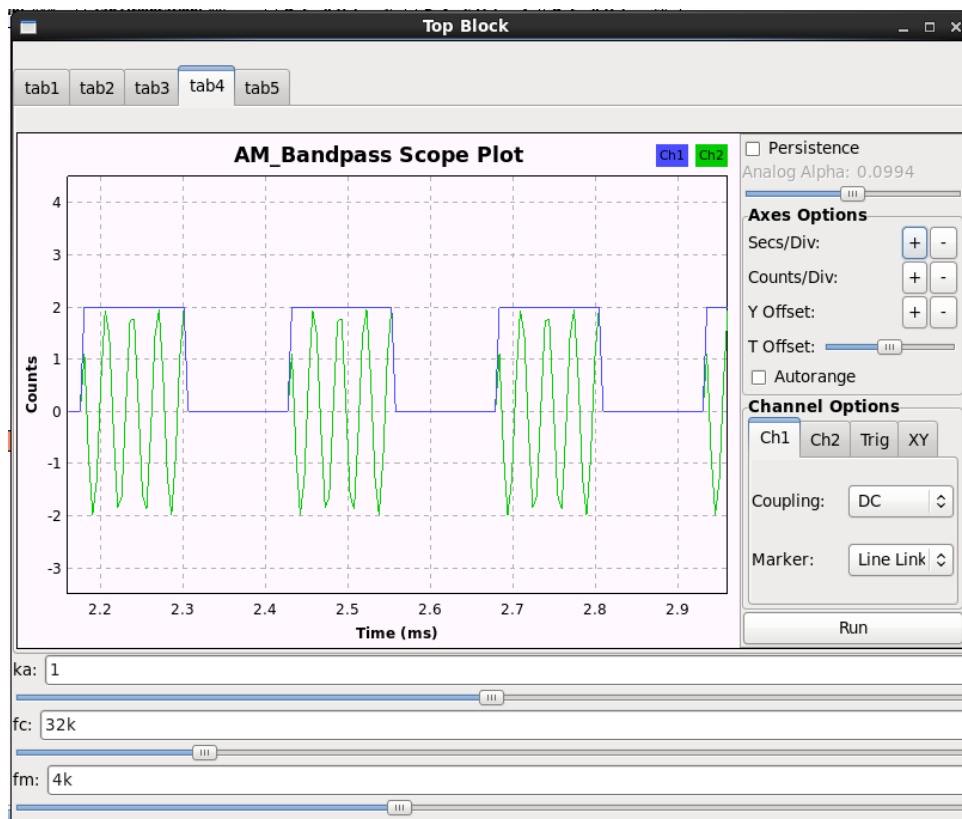
4) You can save the generated waveform using a File Sink. Double click on this block. Click on the ellipsis (...) next to the File parameter and choose the place in which you want to save your file.



5) Now replace the Signal Source with a File Source and upload the saved message in the previous step for AM modulation:

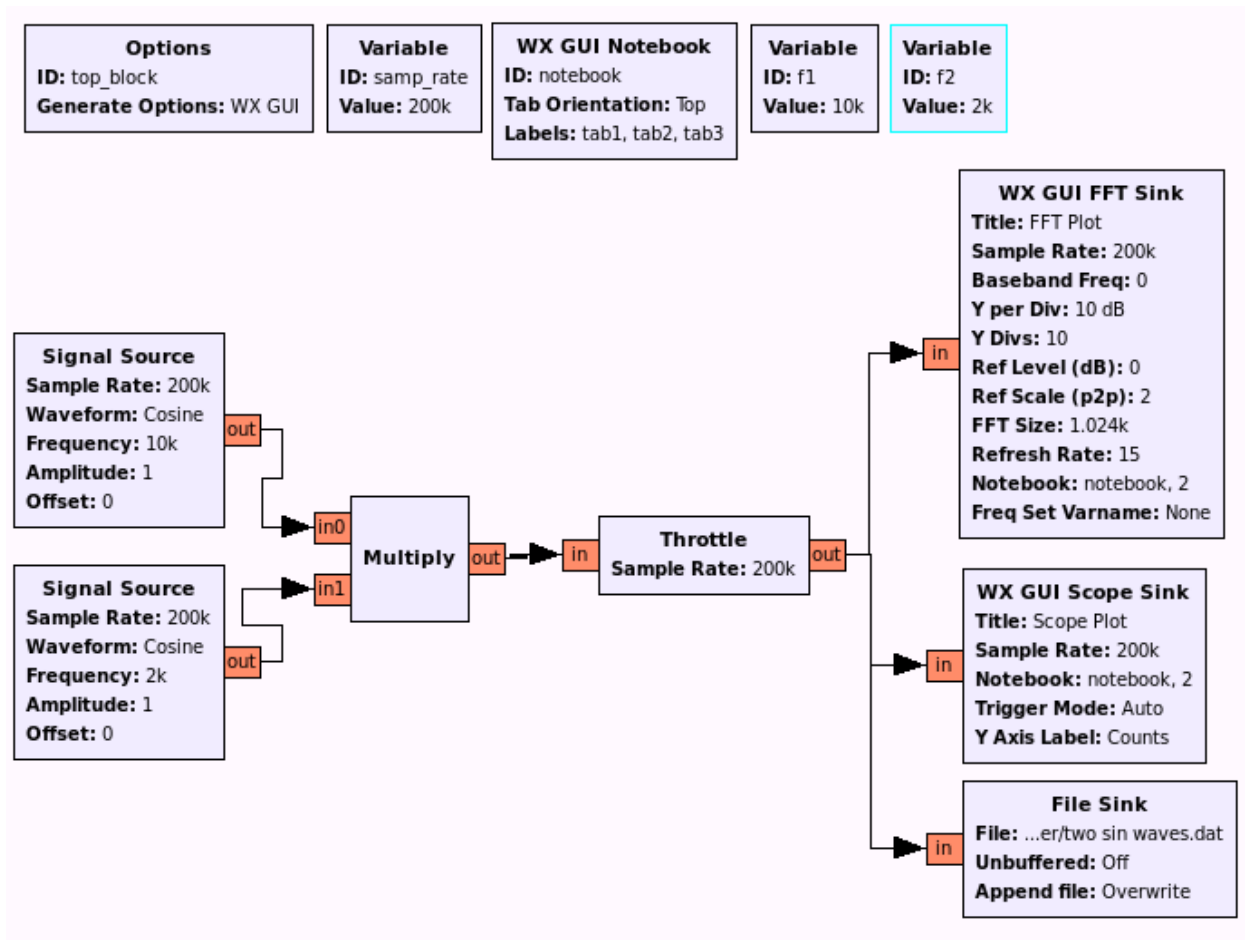


6) The following figures show the AM modulate signal and its spectrum.

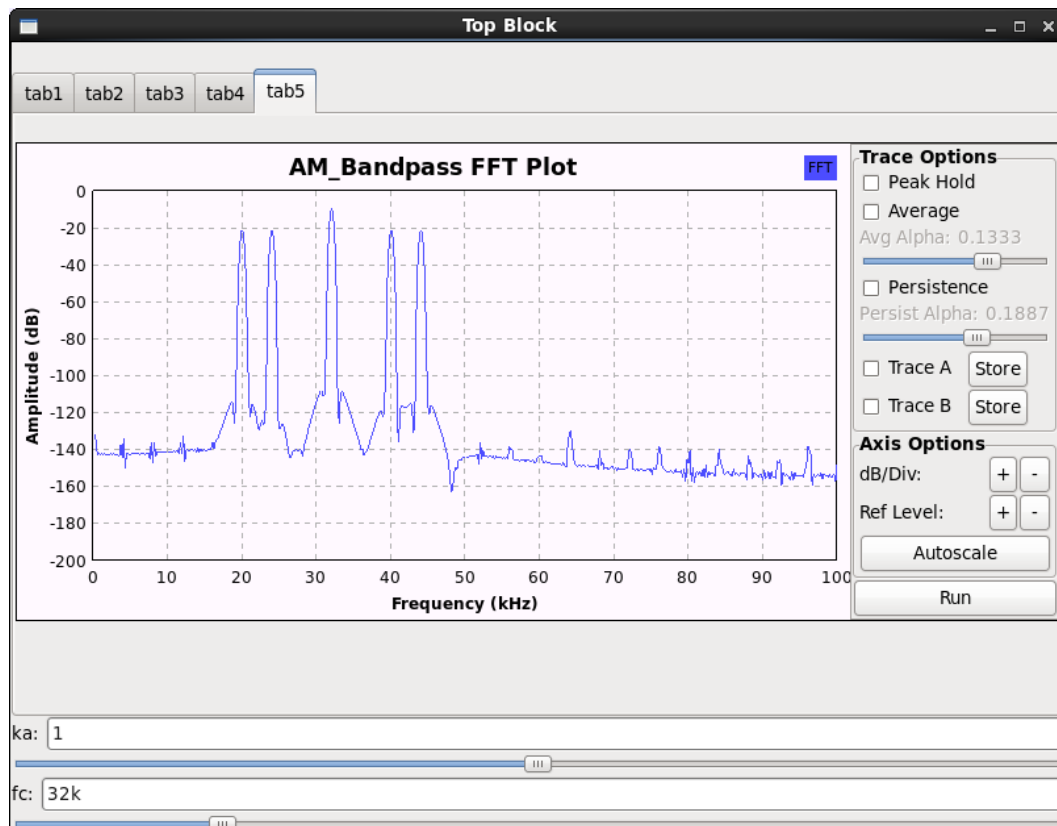
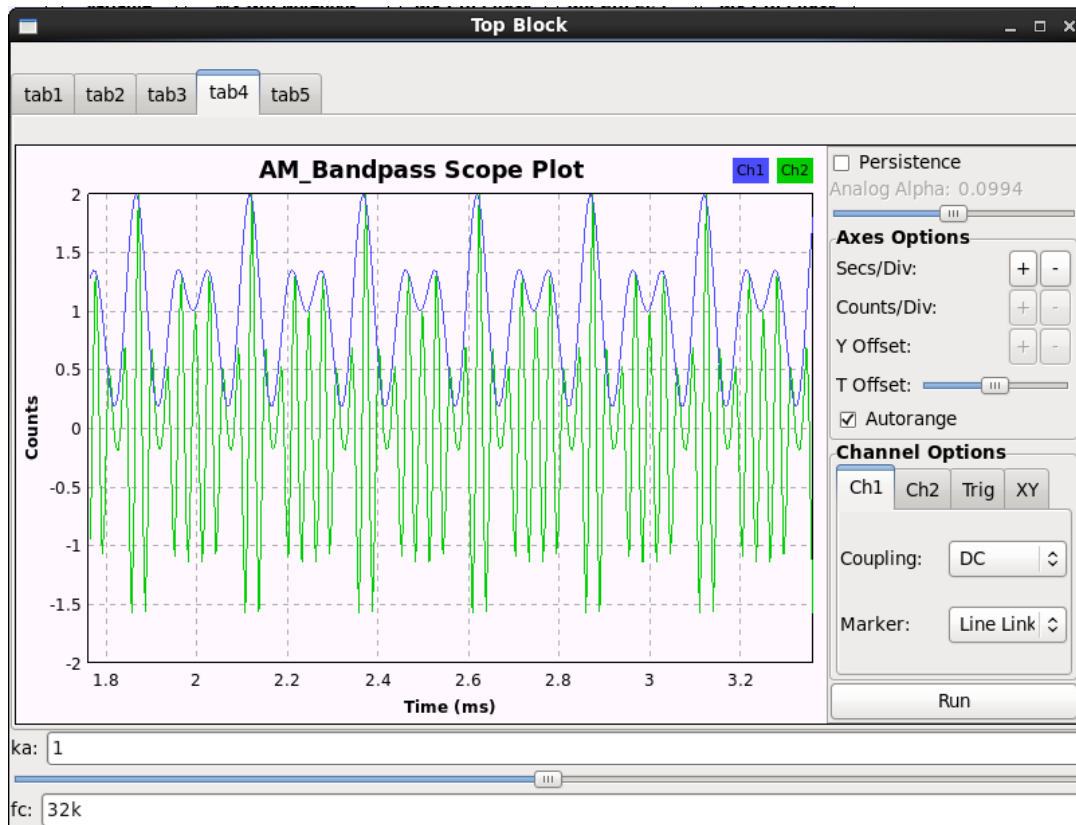


b) Two sine waves with selectable frequencies:

1) In the following graph, two sinusoidal signals with frequencies $f1$ and $f2$ are mixed together to create a two-tone signal with $(f1-f2)$ and $(f1+f2)$ tones. This signal is then saved using a File Sink.

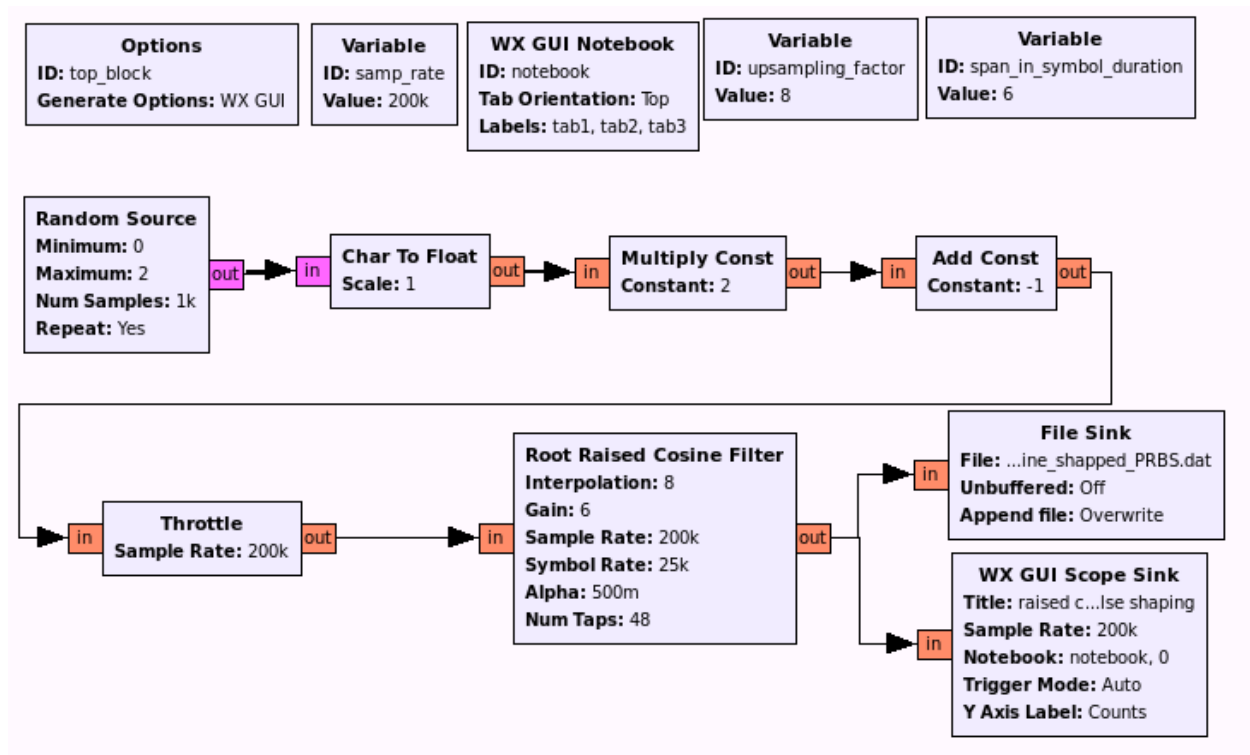


2) The following graph shows the AM signal and its correspondence two side spectrum.

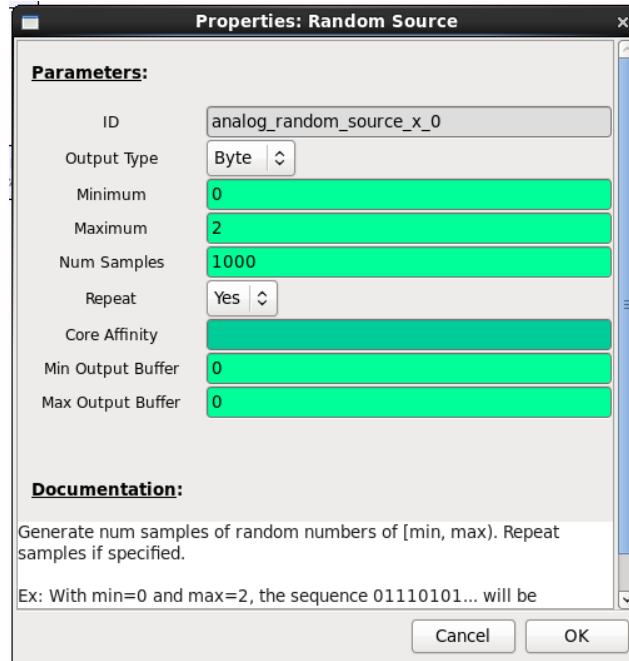


c) Baseband data waveform using Pseudo Random Binary Sequence (PRBS) for data and time domain raised cosine pulse shape over 6 symbols:

1) In the following flow graph a message signal is created from a sequence of random binary bits which is converted to a sequence of pulses using a raised cosine pulse shaping filter. This sequence is then modulated using the AM modulation scheme. The details will be discussed in the following.



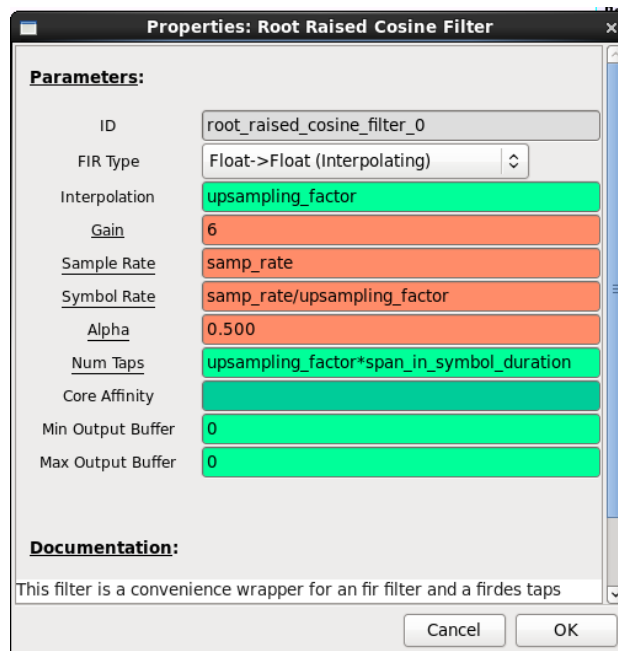
2) Set the parameters of Random Source as below. This block generates a sequence of 1000 random bits which is repeated by setting the Repeat option to “Yes”. The output type is “Byte” which is then converted to “Float” type using a Char to Float block. The sequence of $\{0,1\}$ bits are converted to $\{-1,1\}$, which is symmetric around zero, by setting the parameters of Multiply Const and Add Const blocks to 2 and -1 respectively.



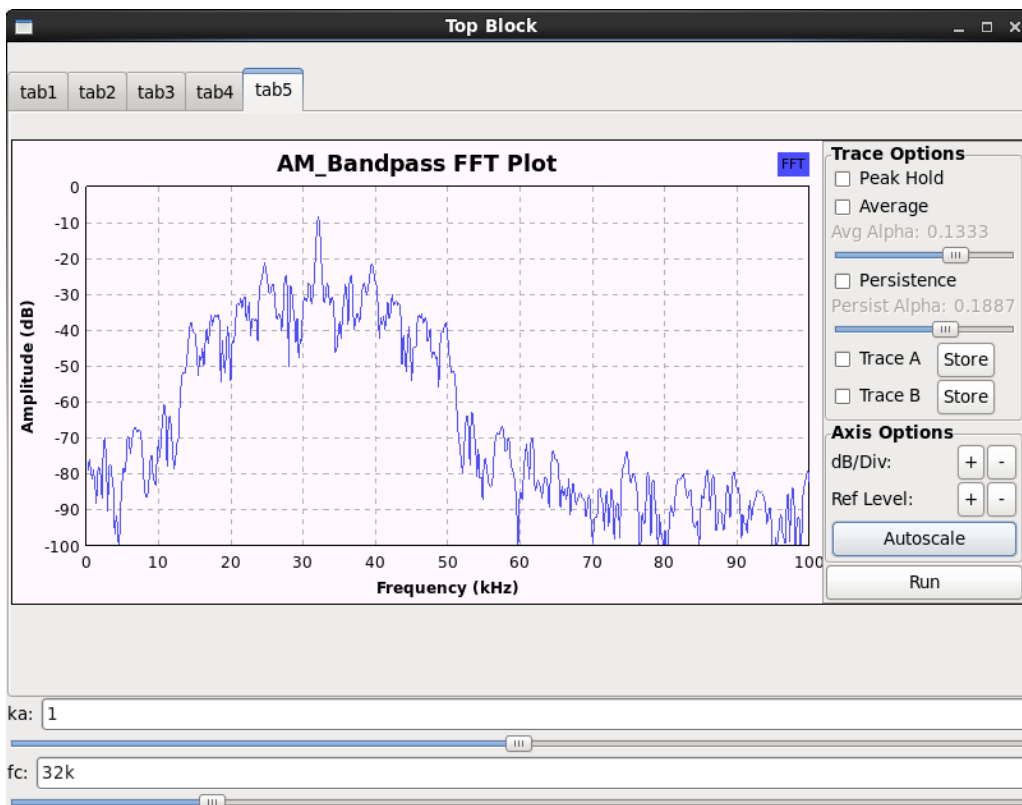
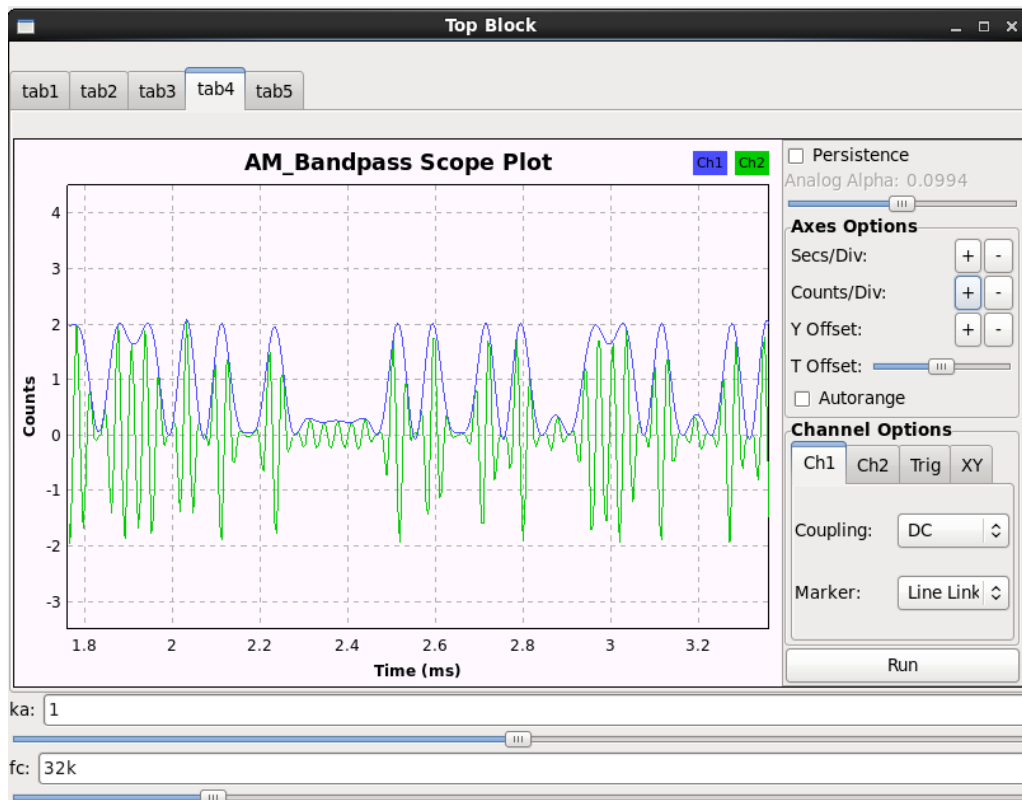
3) The sequence of $\{-1,1\}$ is converted to a sequence of pulses using the Root Raised Cosine Filter. The parameters of the filter are set as following:

The main parameter of a raised cosine filter is its roll-off factor (alfa), which indirectly specifies the bandwidth of the filter. Ideal raised cosine filters have an infinite number of taps. Therefore, practical raised cosine filters are windowed. The window length is controlled using the “span_in_symbol_duration” variable. In this example, we specify the window length as six symbol durations, i.e., the filter spans six symbol durations. Raised cosine filters are used for pulse shaping, where the signal is upsampled. Therefore, we also need to specify the upsampling factor. The “upsampling_factor” is set to eight.

Symbol rate is also equal to samp_rate divided by the upsampling_factor.

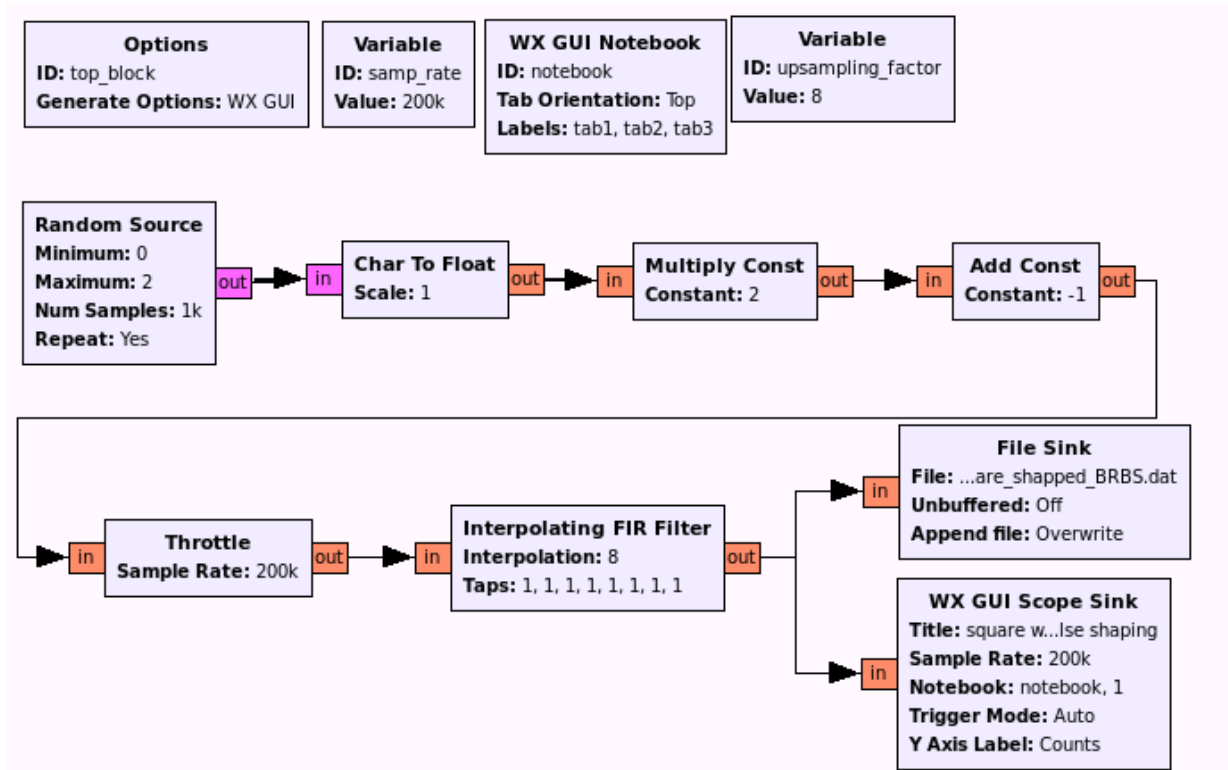


4) The following figures show the AM modulated signal and its spectrum.

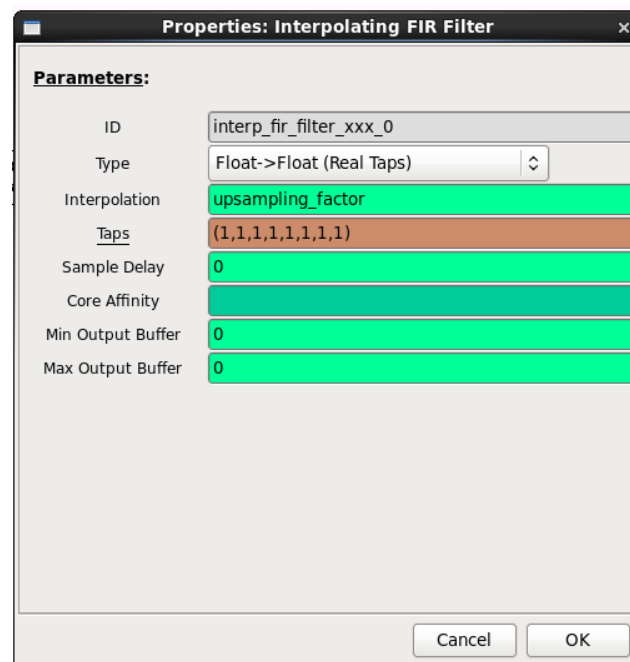


d) Baseband data waveform using PRBS for data and square pulse shape:

1) The following flowgraph uses the binary random sequence and square pulse shaping filter. Comparing to the flow graph of part c, in this figure the raised cosine filter is replaced by “Interpolating FIR Filter” .



2) The parameters of the Interpolating FIR Filter are determined as following



3) The following figures show the AM modulated signal and its correspondence Spectrum.

