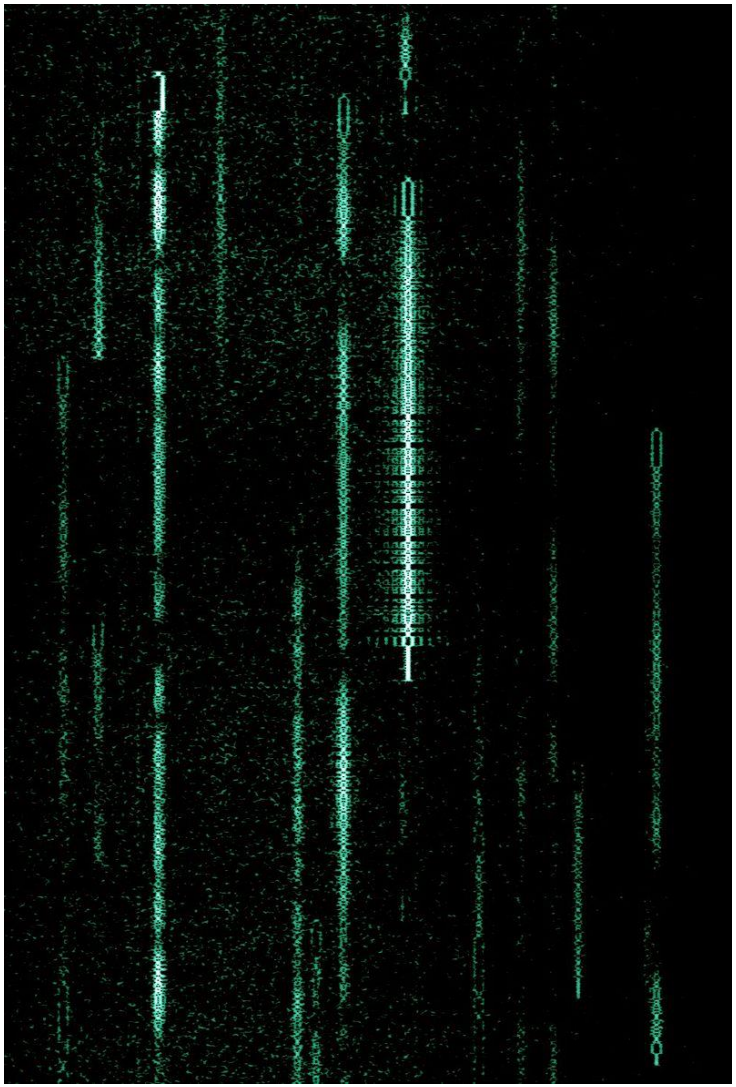
10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111

PSK31

11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 110111
11011111 101111 111 1111 10101 110111 11011111 101111 111
1111 10101 110111 11011111 101111 111 1111 10101 1101
11011111 101111 111 1111 10101 110111 11011111 101111
1111 10101 110111 11011111 101111 111 1111 10101 1101

Pamela O'Shea - @0xsh_ - Ruxcon – 23rd Oct 2016

PSK31 looks like…



PSK31 sounds like…

PSK31_sample.ogg

Amateur Radio Frequencies (RTLSDR Ranges)

- RTLSDR dongle frequency range of 24 – 1766 MHz (frequencies above 1.2 GHz may require cooling/heatsinking)

- PSK31 typical transmit frequencies (in range of RTLSDR dongle):
  - 24.920 MHz 12 meters
  - 28.120 MHz 10 meters
  - 50.290 MHz 6 meters

Some terms

- **Bit rate (bps):** Speed of data in bits per second. With PSK31 where 1 bit per symbol, baud & bit rates are the same.
- **Baud rate (Bd)**: number of symbols transmitted over a line per second.
- **Bandwidth (Hz):** difference between upper and lower frequencies of a given spectrum e.g. can have multiple channels within a bandwidth.
- **Baseband**: signal transmitted without modulation i.e. no shift in the range of frequencies of the signal, and is a low frequency - contained within the band of frequencies from close to 0 hertz up to a higher cut-off frequency or maximum bandwidth.

What is PSK31?

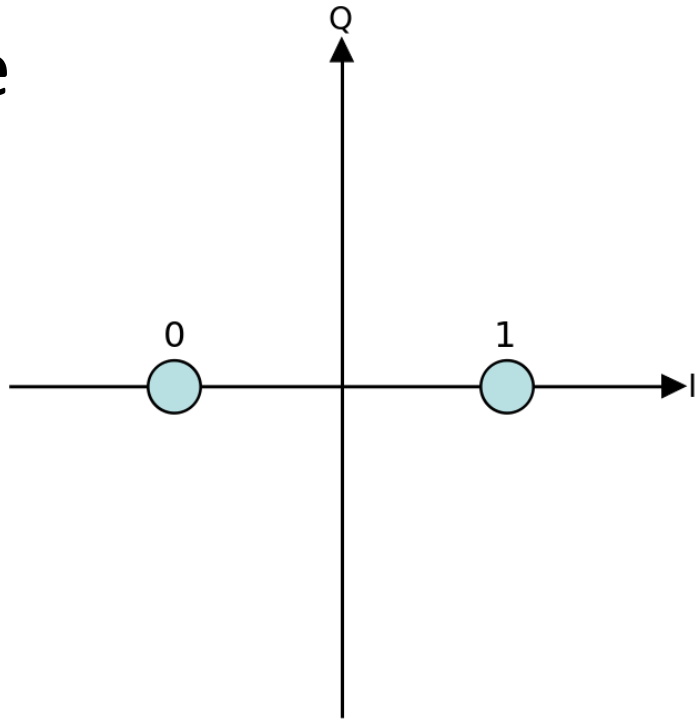
- Created by Peter Martinez (G3PLX)
- Released in 1998
- Used by amateur radio operators for real time chat
- Phase Shift Keying
- 31.25 baud rate & bits per second
- Baud rate matches a typical typing speed of 50 wpm approx.

What is PSK31?

- Phase modulated
- Remember the three main types of modulation are:
  - Amplitude-shift keying (ASK)
  - Frequency-shift keying (FSK)
  - Phase-shift keying (PSK)

What is PSK31?

- Uses binary phase-shift keying (BPSK/2-PSK)
- Two phases
- 180 degrees apart (anywhere on plane)
- BPSK is most tolerant to noise



What is PSK31?

- Not packet based
- Modulates in phase an audio signal
- Audio signal then modulates in amplitude a carrier sent over the air
- Can be used by equipment designed for audio

What is PSK31?

- 0 = phase shift of π radians
- 1 = no phase shift
- Characters = varicode
- Start of character = 00
- Data rate = 31.25 baud

Varicode

- Includes most of 7-bit ASCII characters
- Start with: 1
- End with: 1
- Never: have 00
- Break between characters: 00
- Prefix with long string of 000s

Varicode

- ruxcon:
- 10101 110111 11011111 101111 111 1111

```
'a':'1011',
'b':'1011111',
'c':'101111',
'd':'101101',
'e':'11',
'f':'111101',
'g':'1011011',
'h':'101011',
'i':'1101',
'j':'111101011',
'k':'10111111',
'l':'11011',
'm':'111011',
'n':'1111',
'o':'111',
'p':'111111',
'q':'110111111',
'r':'10101',
's':'10111',
't':'101',
'u':'110111',
'v':'1111011',
'w':'1101011',
'x':'11011111',
'y':'1011101',
'z':'111010101',
```

Generating a message

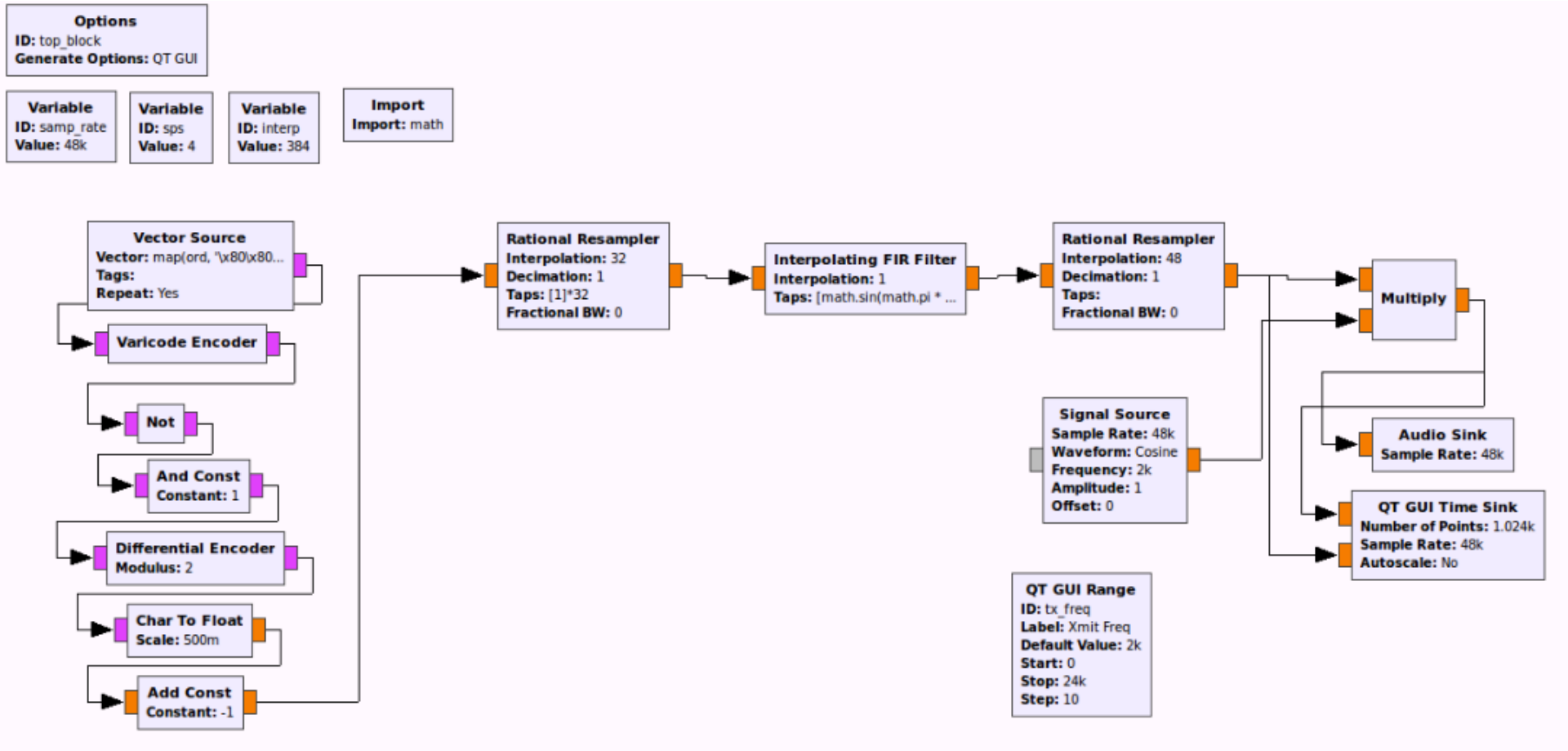
- Sample rate = 48,000Hz (audio rate)
- 1 channel
- 2 bytes per sample

Materials

- Using this PSK31 example as a base: https://github.com/tkuester/gr-psk31/

- All files, install instructions and modifications are described here: https://github.com/0xsh

Transmit PSK31 with an audio card

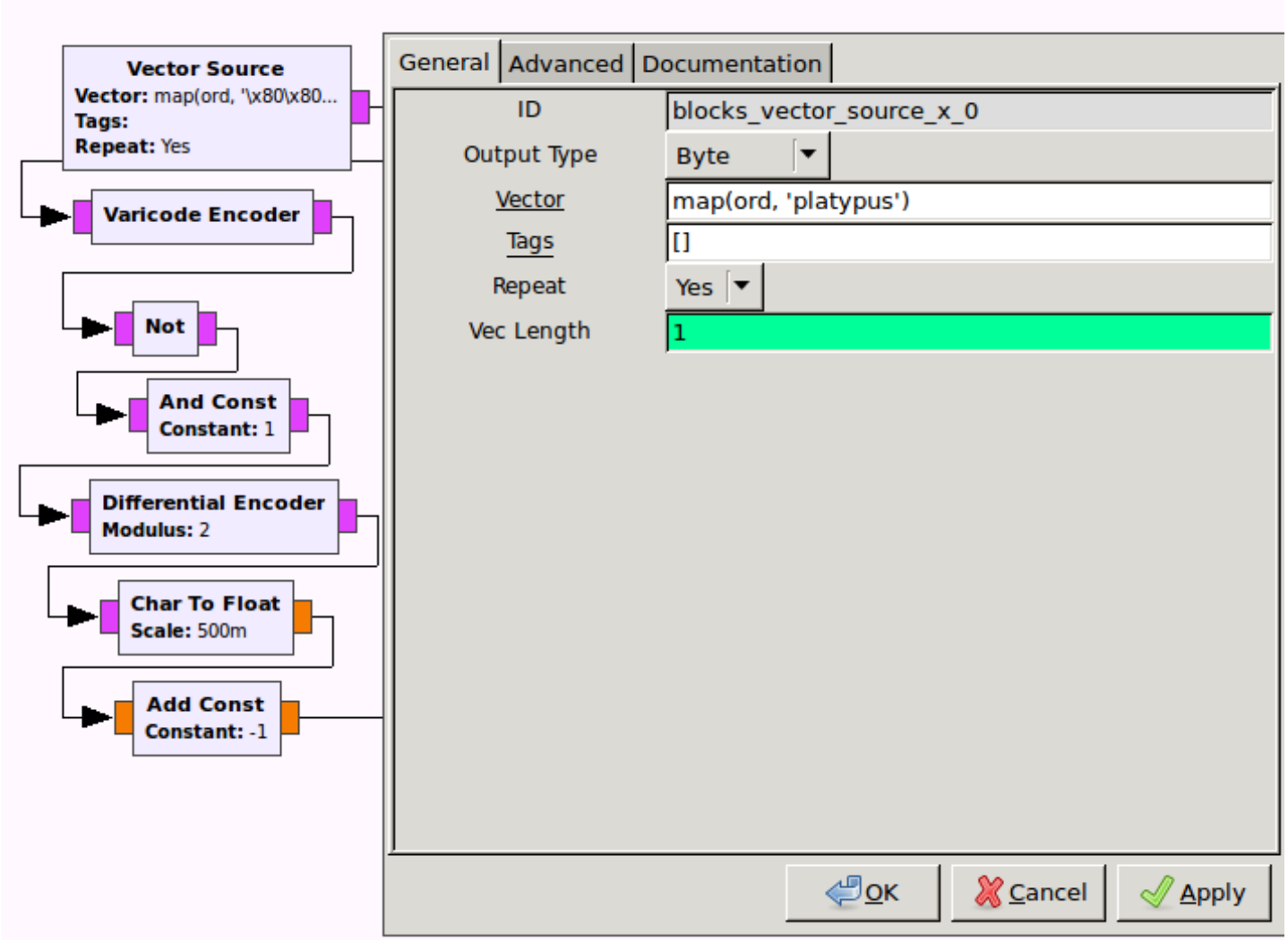


Transmit Graph: Vector Source

Vector source

- A vector is a dynamically sized sequence of objects (compared to a fixed array)
- Interpreted as list of integers
- Truncated to bytes when output
- Vector: “map(ord, ‘ruxcon’)”
- Repeat: Yes

Transmit Graph: Vector Source

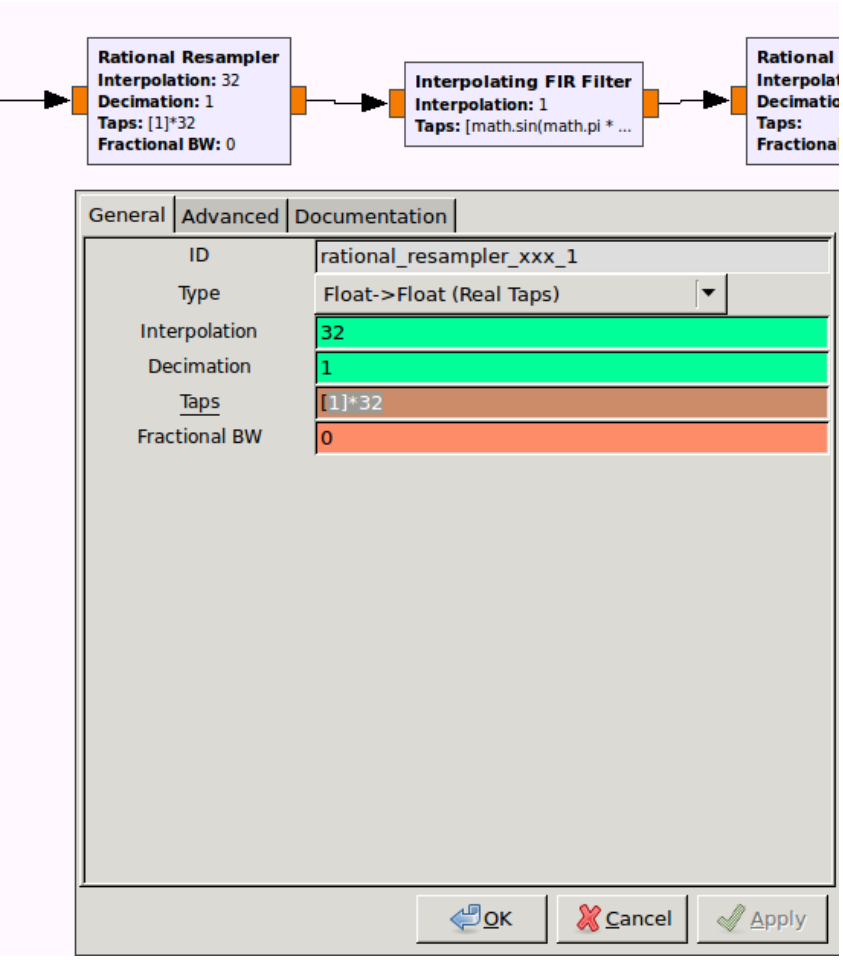


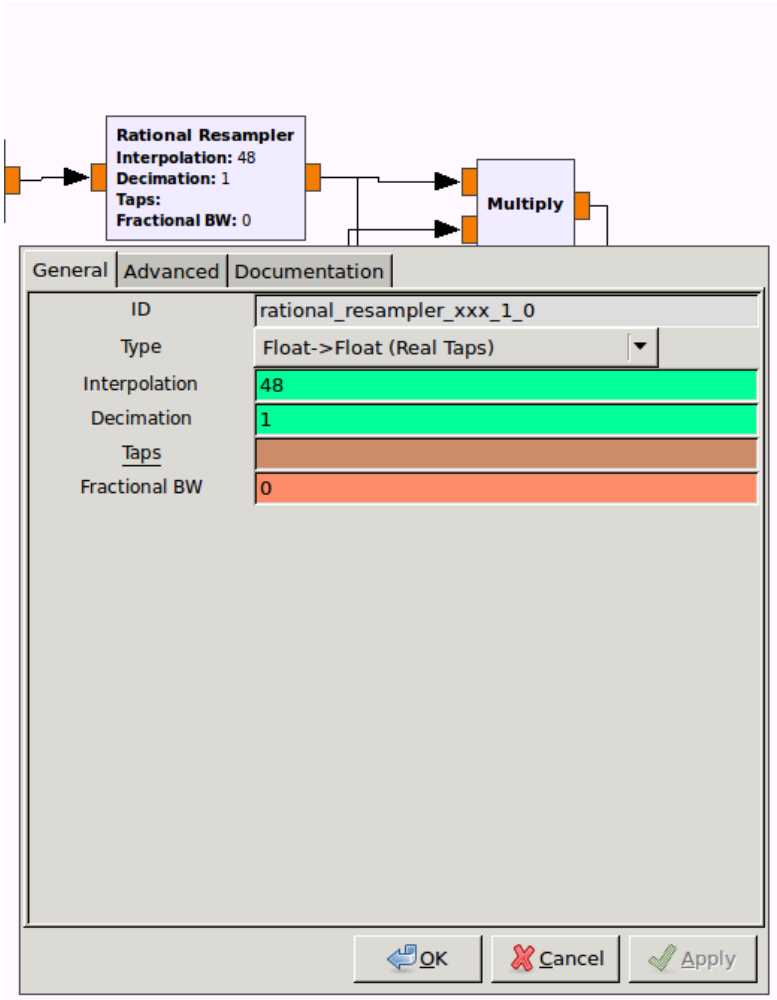
Transmit Graph: Rational Resampler

Rational Resampler

- Convert from one sample rate to another
- Combined interpolator (multiply by) & decimator (divide by)
- All following blocks should use newly set sample rate

Transmit Graph: Rational Resampler



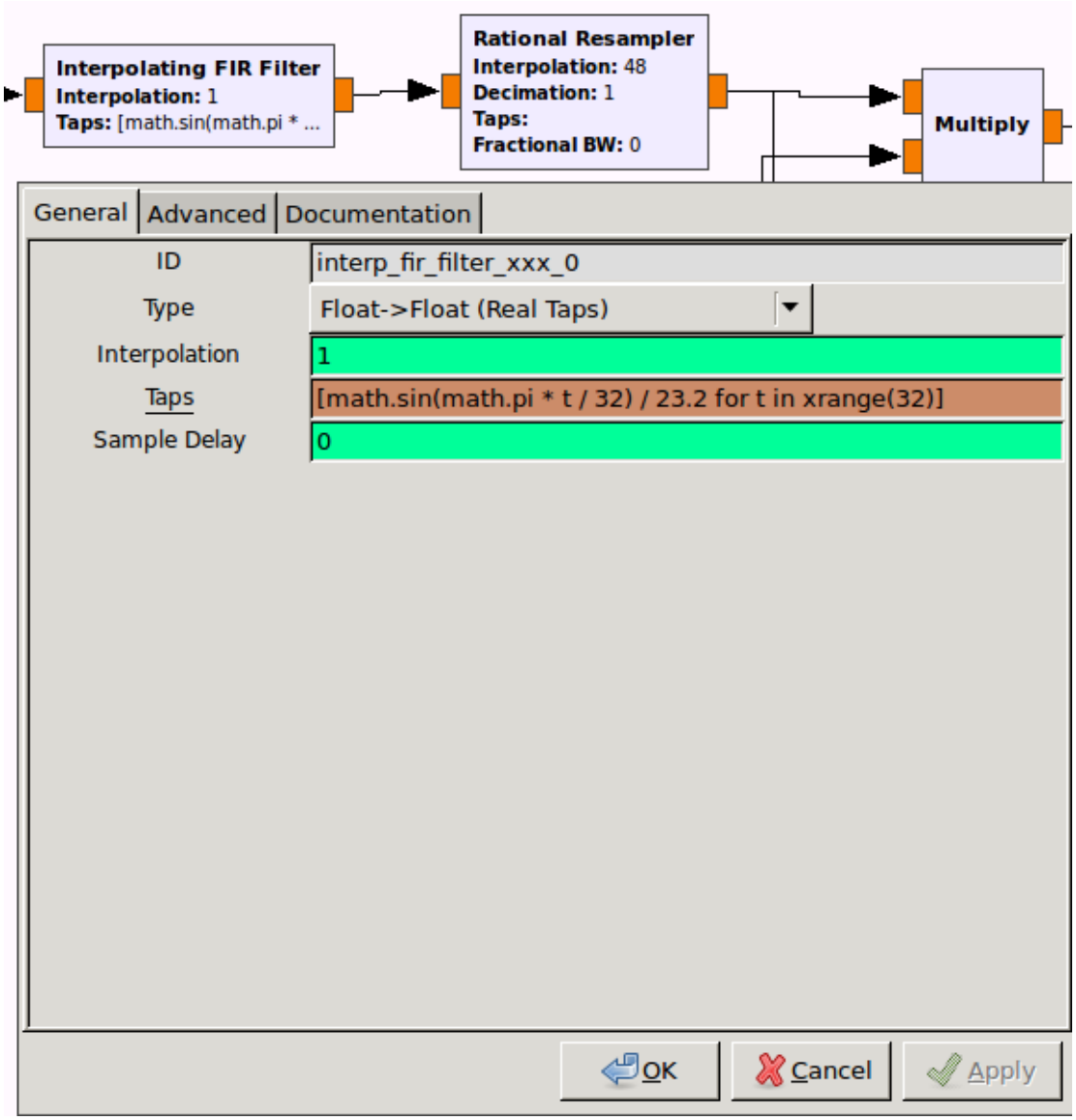


Transmit Graph: Interpolating FIR Filter

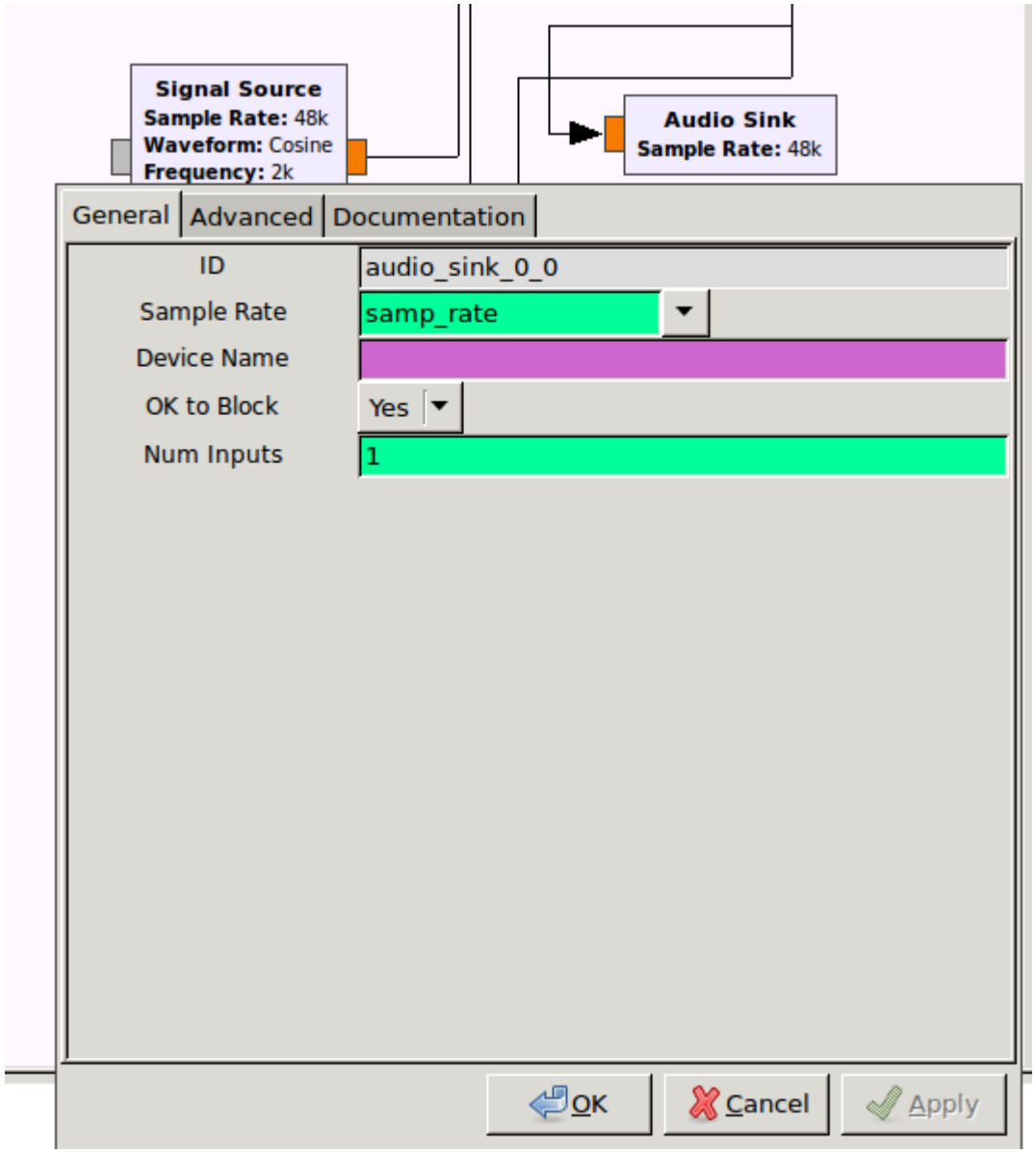
Interpolating FIR Filter

- FIR = Finite Impulse Response filter
- Settles to 0 in finite time
- Tap = a delay
- More taps = more stopband attenuation, less ripple, narrower filters

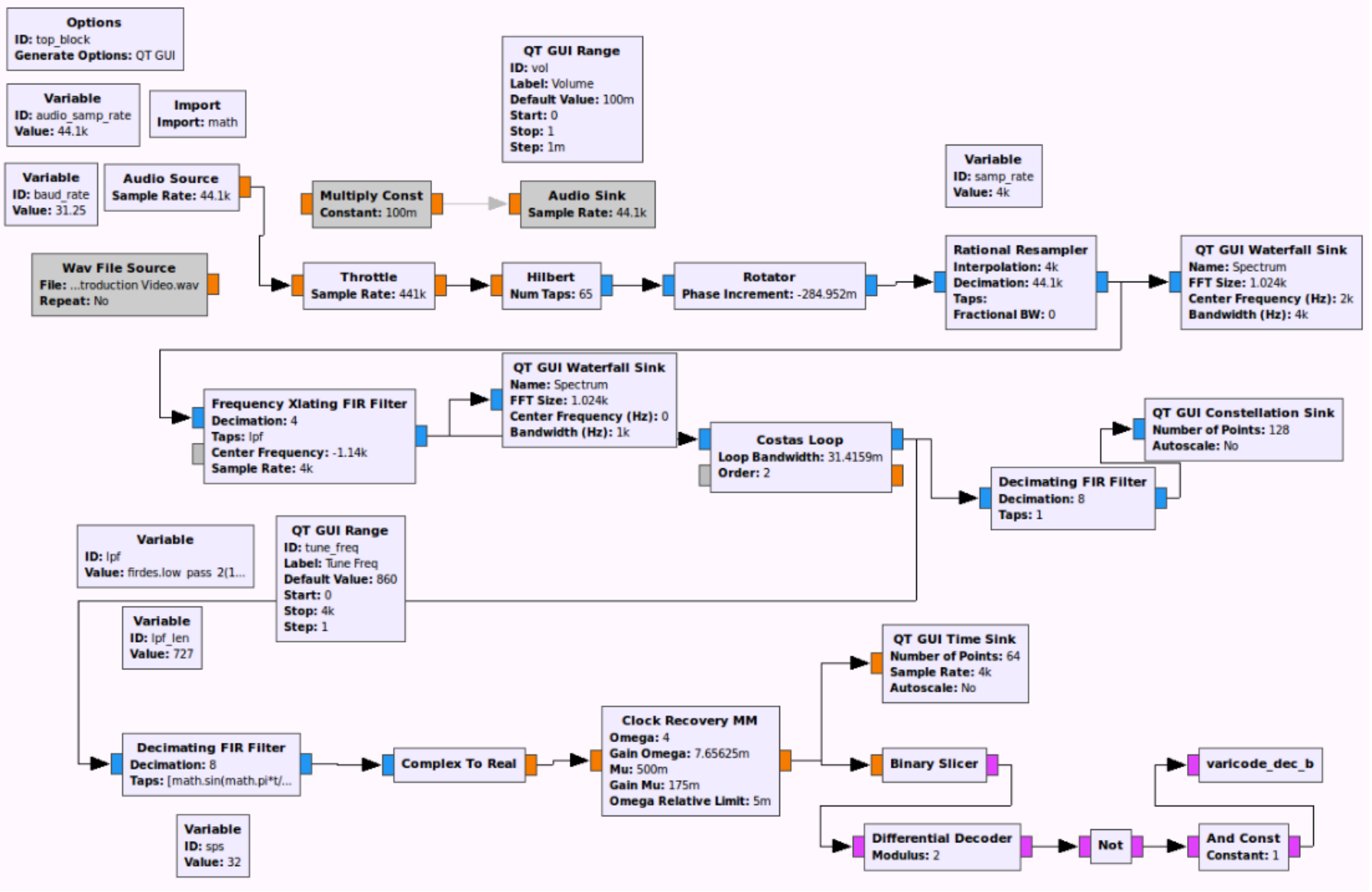
Transmit Graph: Interpolating FIR Filter



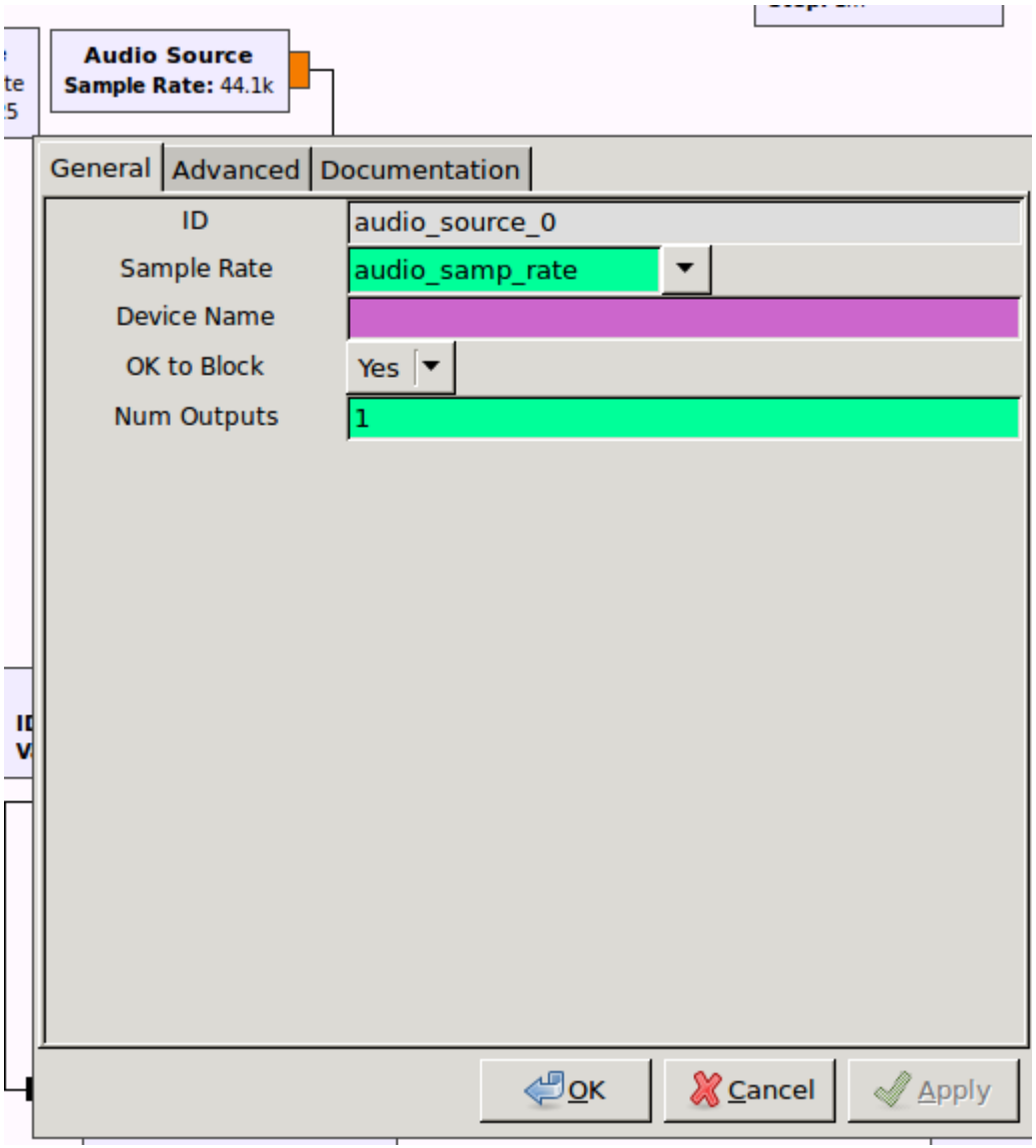
Transmit Graph: Audio Sink



Receive PSK31 with an audio card



Receive Graph: Audio Source



Receive Graph: Throttle

Throttle

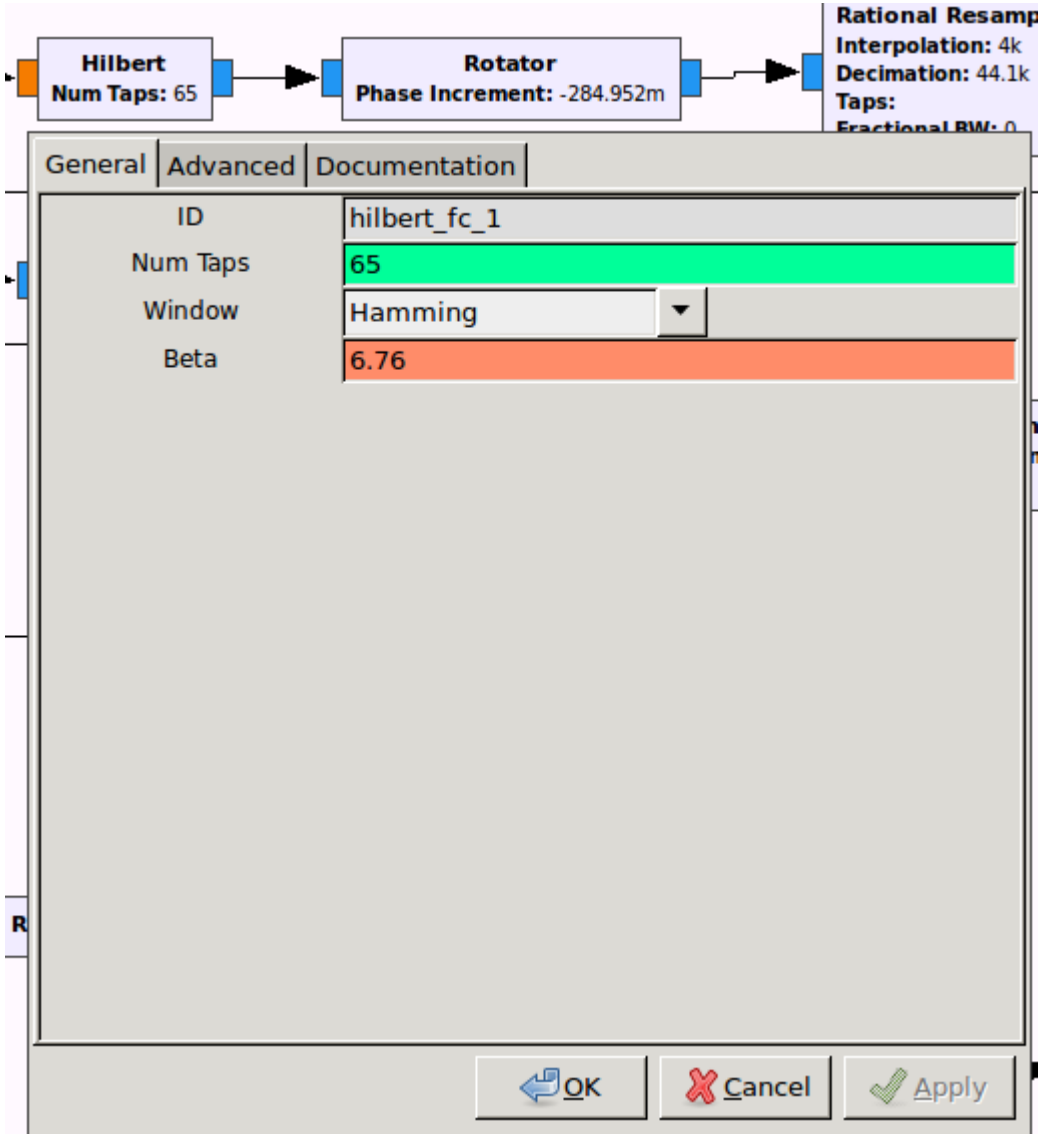
- Gnuradio operates at full speed (when no real hardware in way to slow down)
- Need throttle to control rate
- Don’t use with real hardware (throttle is a bad clock and will end up with timing issues)

Receive Graph: Hilbert Transform

Hilbert Transform

- Truncates the filter to the number of taps
- Introduces a delay into the signal

Receive Graph: Hilbert Transform

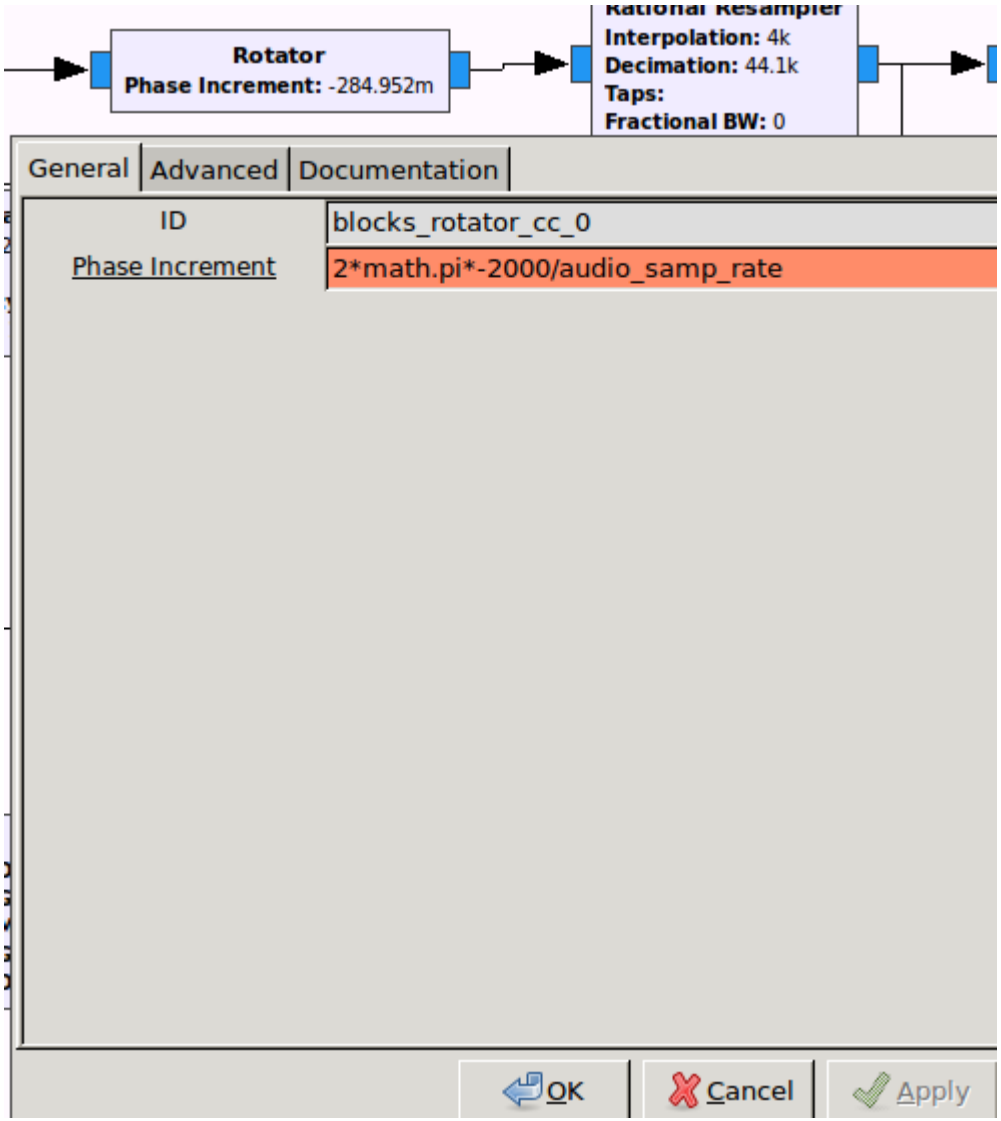


Receive Graph: Rotator

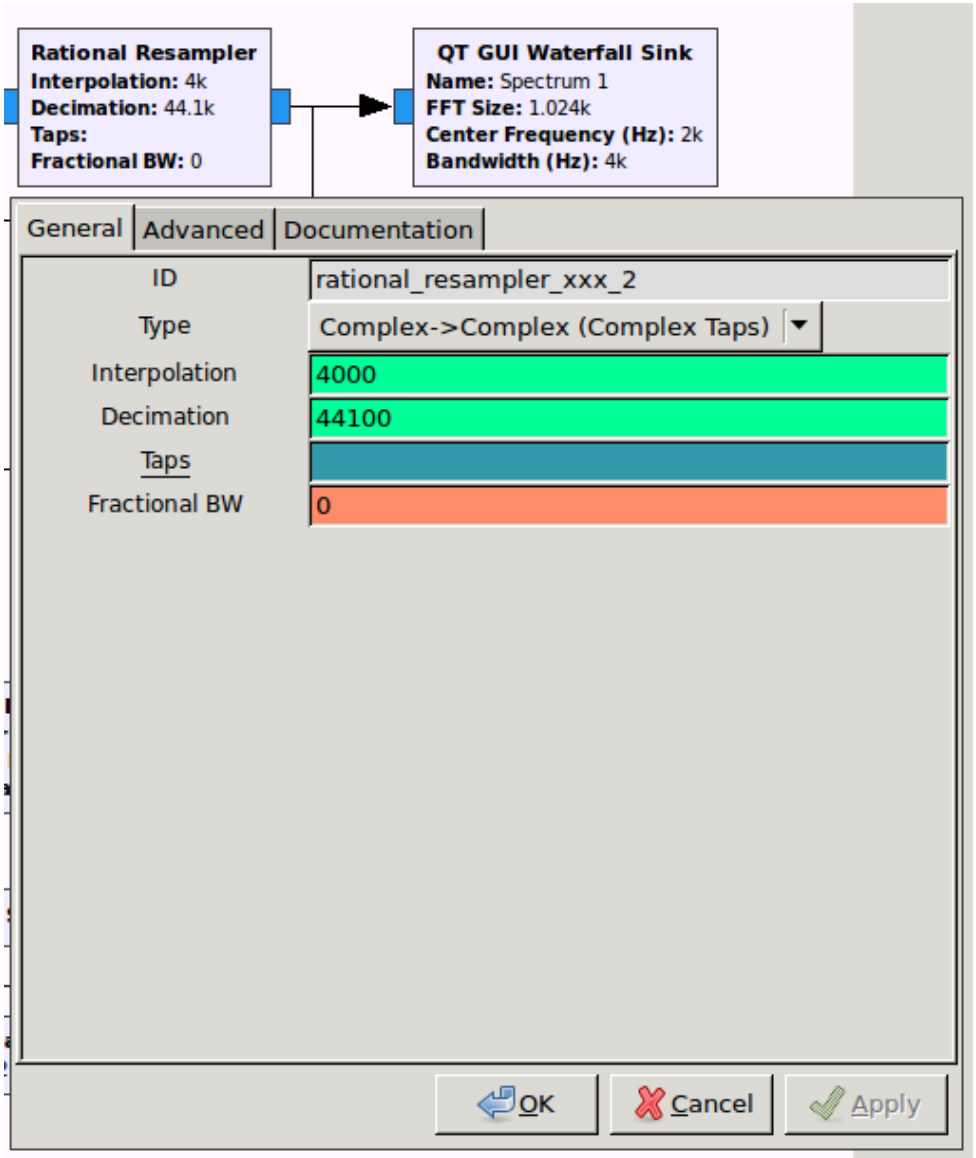
Rotator

- Frequency shifting
- Shift specified as a complex vector (amount of rotation per sample)

Receive Graph: Rotator



Receive Graph: Rational Resampler

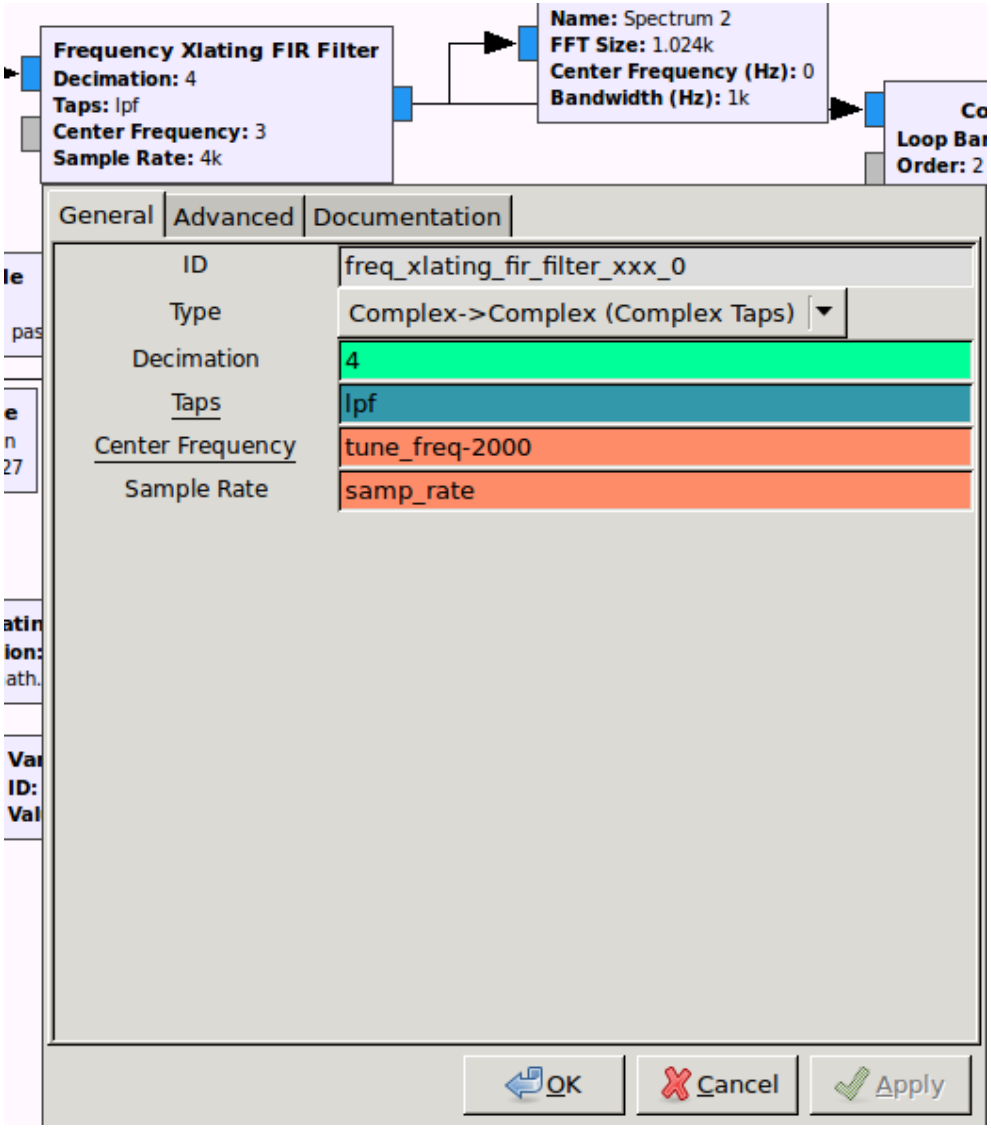


Receive Graph: Frequency Xlating FIR Filter

Frequency Xlating FIR Filter

- Frequency-translating FIR filter
- Often used for channel selection block
- Performs frequency translation, channel selection and decimation in one step

Receive Graph: Frequency Xlating FIR Filter

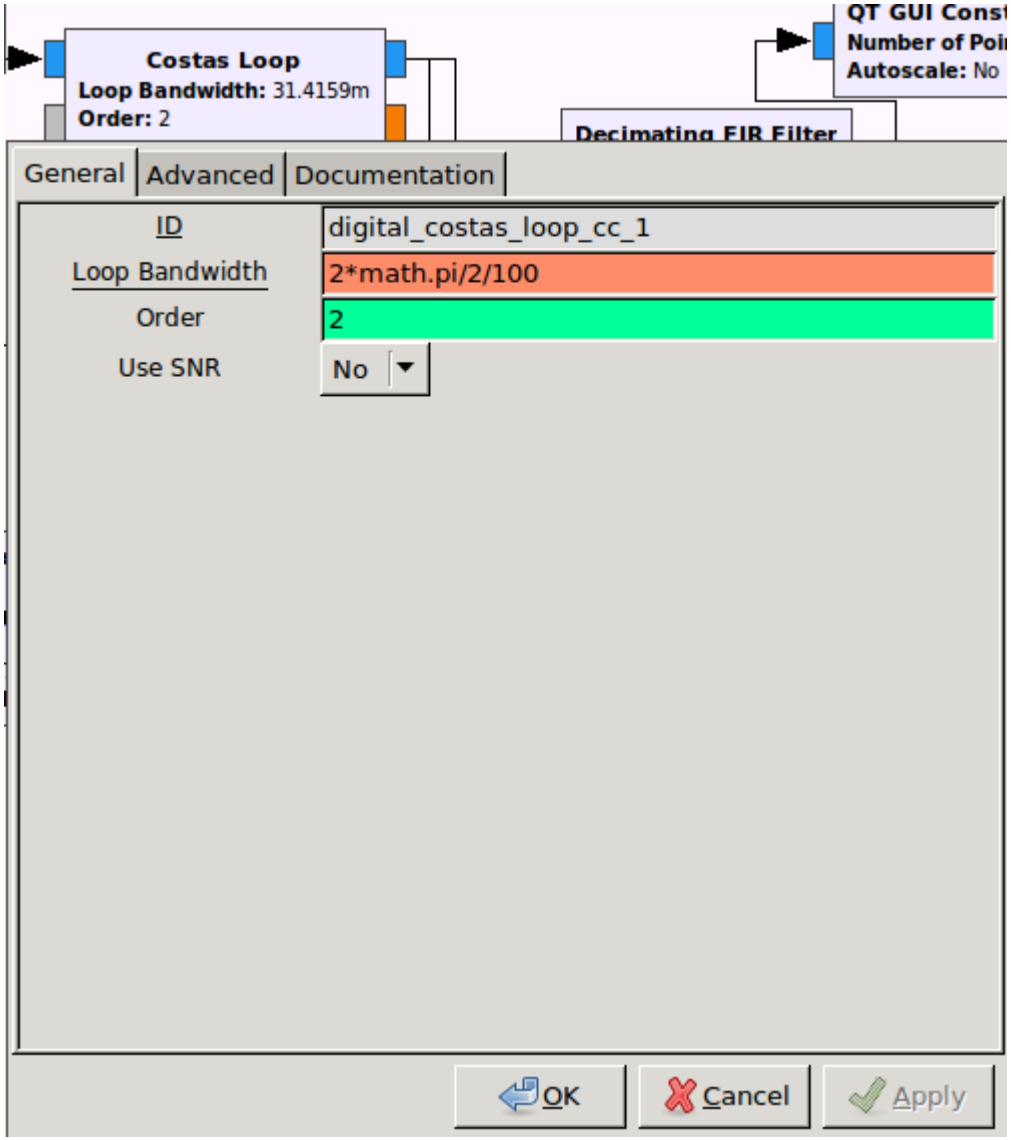


Receive Graph: Costas Loop

Costas Loop

- Locks to the centre frequency of a signal and downconverts it to baseband

Receive Graph: Costas Loop

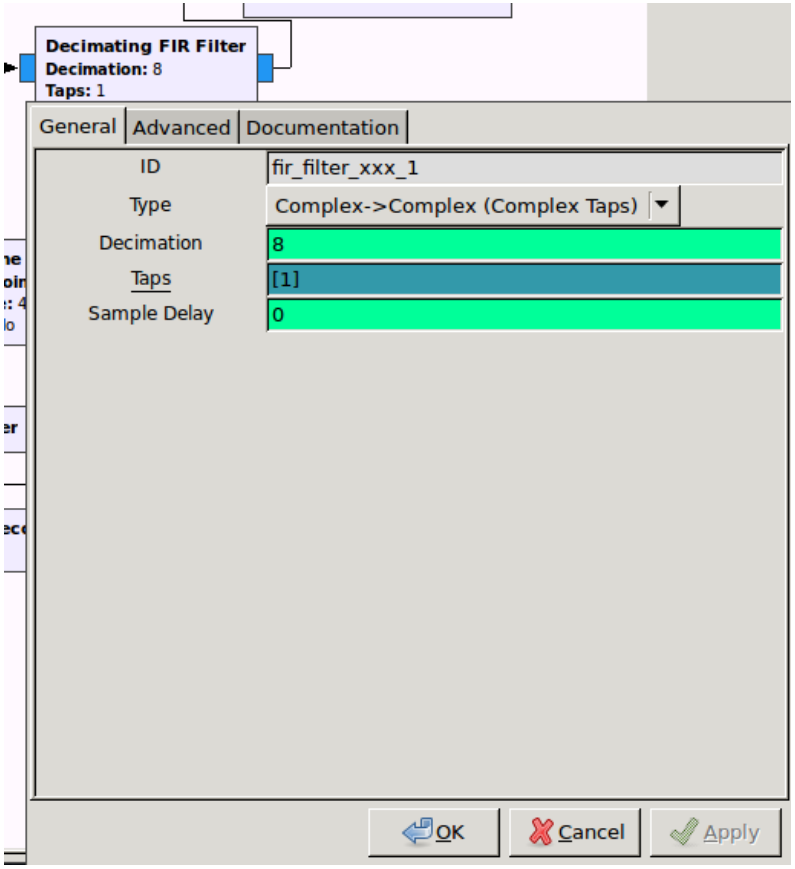


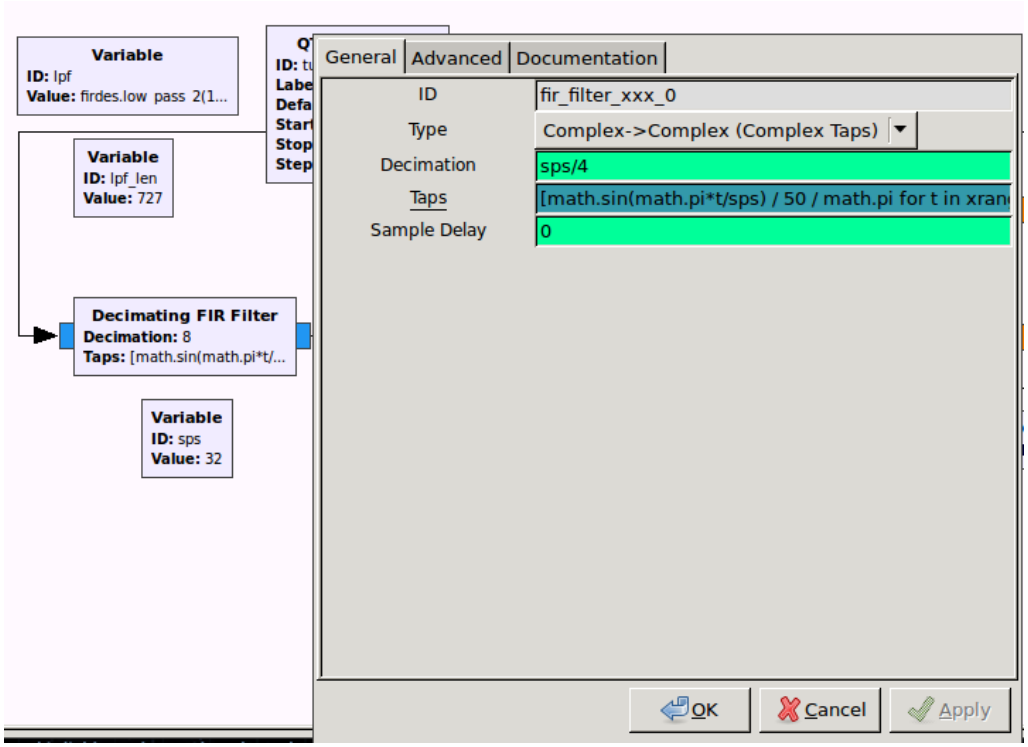
Receive Graph: Decimating FIR Filters

Decimating FIR Filters

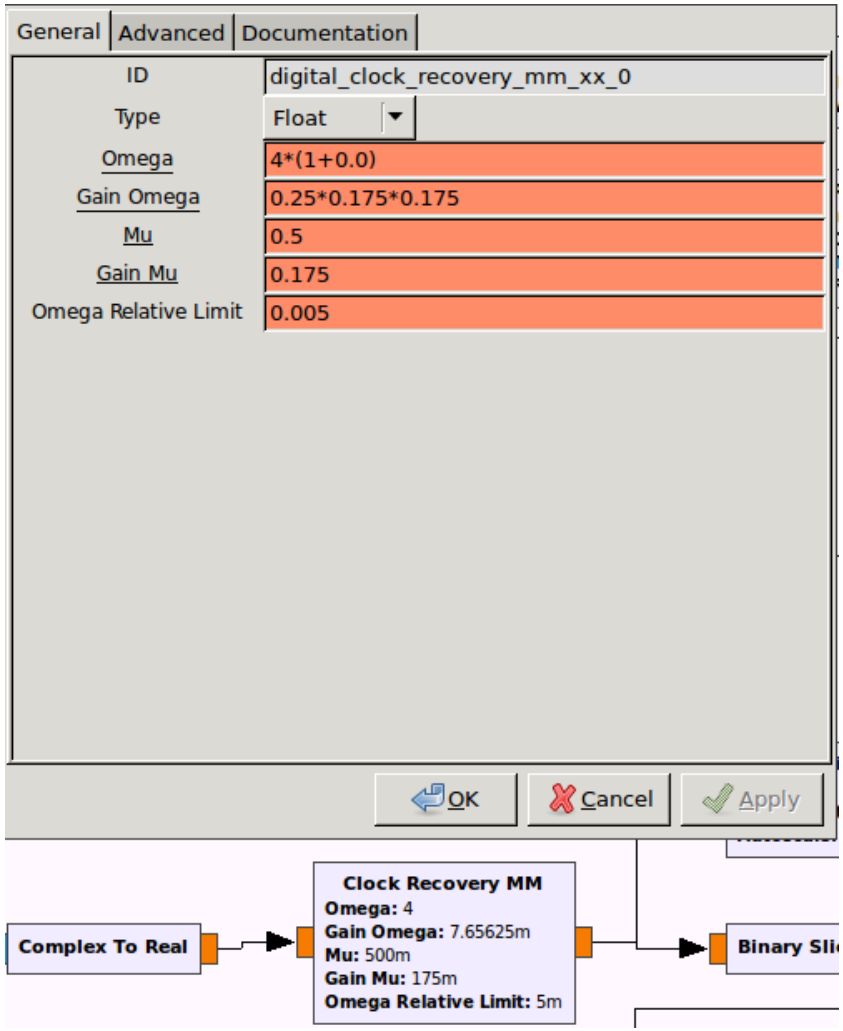
- Decimation is reducing the output sampling rate by ignoring all but every Nth sample

Receive Graph: Decimating FIR Filters





Receive Graph: Clock Recovery



Materials

- Next, follow the Step1, Step2 & Step 3 instructions here: https://github.com/0xsh

Other work you can play with…

- **GoodPSK** “is a tool for generating PSK31 audio recordings, sometimes with strange or clever attributes” & check out the lectures!: https://github.com/travisgoodspeed/goodpsk
- https://sdradventure.wordpress.com/2011/10/15/gnuradio-psk31-decoder-part-1
- https://sdradventure.wordpress.com/2011/10/15/gnuradio-psk31-decoder-part-2/
- https://github.com/JasonBens/PSK31-transceiver
- https://github.com/tkuester/gr-psk31
- https://github.com/christophL/gr-digimodes
- https://github.com/argilo/sdr-examples

References

- http://aintel.bi.ehu.es/psk31theory.html
- http://www.arrl.org/digital-data-modes
- https://en.wikipedia.org/wiki/Phase-shift_keying
- https://en.wikipedia.org/wiki/PSK31
- https://en.wikipedia.org/wiki/Baud
- http://people.scs.carleton.ca/~barbeau/SDRCRBook/Content/chapter09.pdf
- https://github.com/travisgoodspeed/goodpsk
- https://github.com/tkuester/gr-psk31
- http://www.w1hkj.com/FldigiHelp/index.html

Glossary

- FIR Filter: Finite Impulse Response Filter
- PSK: phase shift keying
- SPS: samples per second

Questions…


IT'S A
WOMAN'S WAR
TOO!
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