Using GRC to Build Radios

Kick Start: help the novice to use the flow graph in GNU Radio

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Major Topics

- Getting started with GRC
- Basic flow graph workspace organization
- Flow graph details
- Data flow problem solving
- Practical odds and ends for real radios
- Group discussion

Getting Started with GNU Radio

How to install GNU Radio

https://wiki.gnuradio.org/index.php/InstallingGR

Guided Tutorials

https://www.youtube.com/watch?v=N9SLAnGlGQs&list=PL618122BD66C8B3C4

(novice flowgraph techniques, an oldie but goodie)

https://wiki.gnuradio.org/index.php/Tutorials

(sophisticated and advanced techniques)

Workspace Organization
Why Important?

- Promotes an understanding of signal processing logic

- Makes flow graph modifications easier

- Facilitates trouble shooting and problem solving

- Reduces risk of workspace mistakes

Workspace Organization

Flow Graph Details

- Options or 'top block'
- Note blocks
- Block rotation
- Virtual Sources and Sinks
- Samp_rate logic and gain distribution
- Nested Python commands to control multiple functions

Options Block or 'top block'

Note Blocks

Keep track of your thinking

Note
Note: RECEIVER SECTION

Properties: Note

General | Advanced | Documentation

| ID | note_0 |
| Note | RECEIVER SECTION |
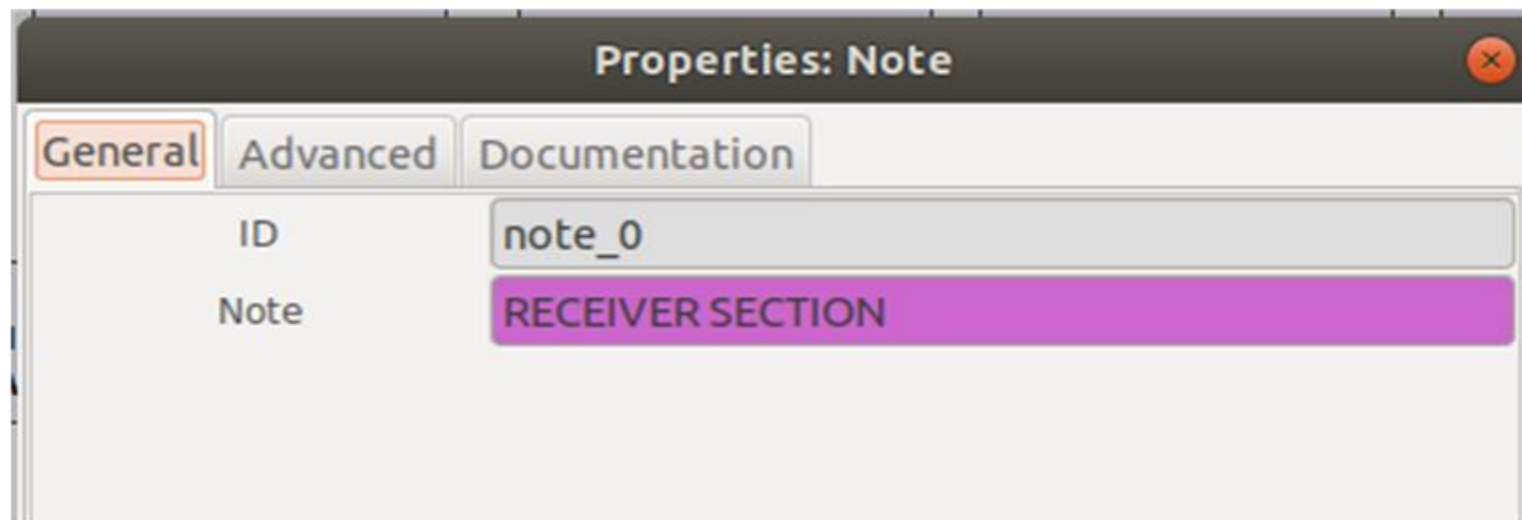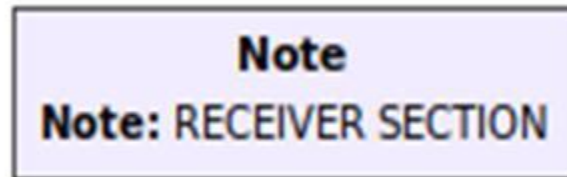
Block Rotation
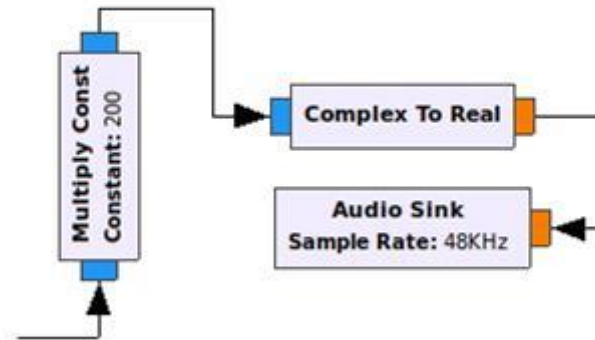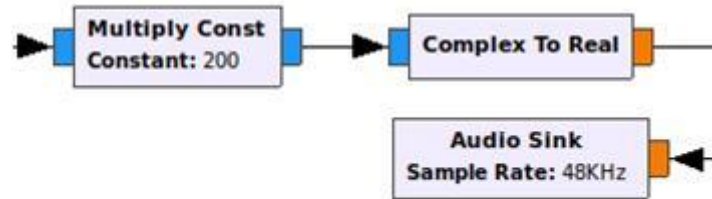
Notes and Virtual Sources and Sinks
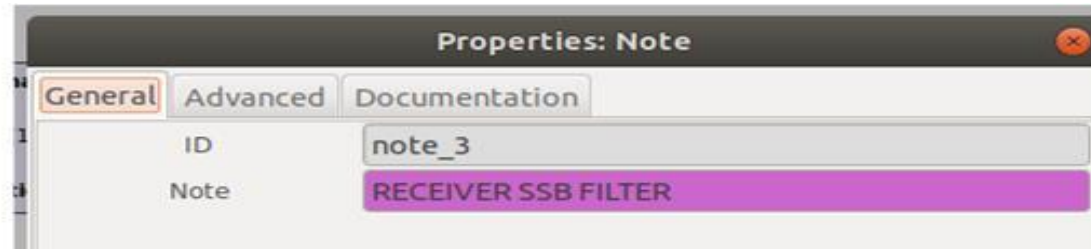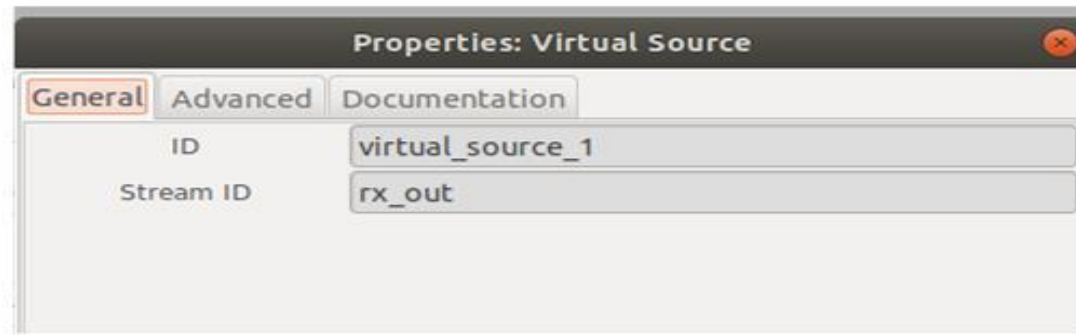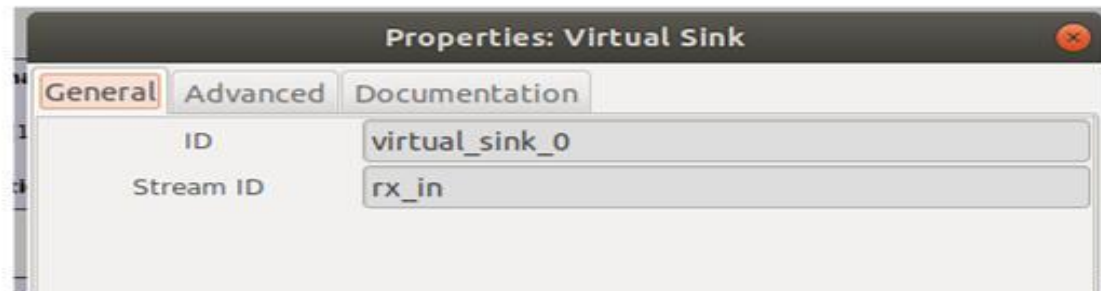
Samp_rate Logic and Gain Distribution
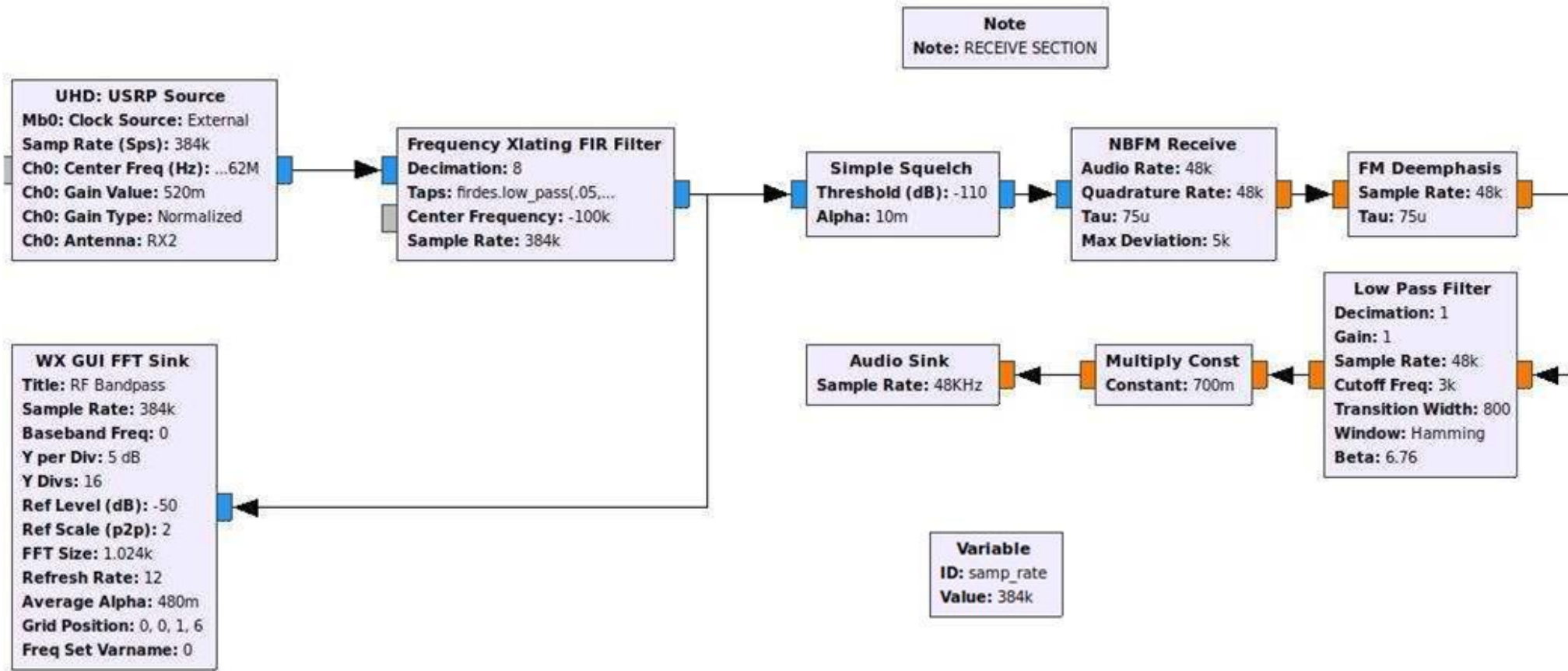
Nested Python Commands
Control Multiple Parameters

Band Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 4k
Low Cutoff Freq: 100
High Cutoff Freq: 3.9k
Transition Width: rx...shape]
Window: Blackman
Beta: 6.76

Variable
ID: bpf_low
Value: 100, 100, 380, 580
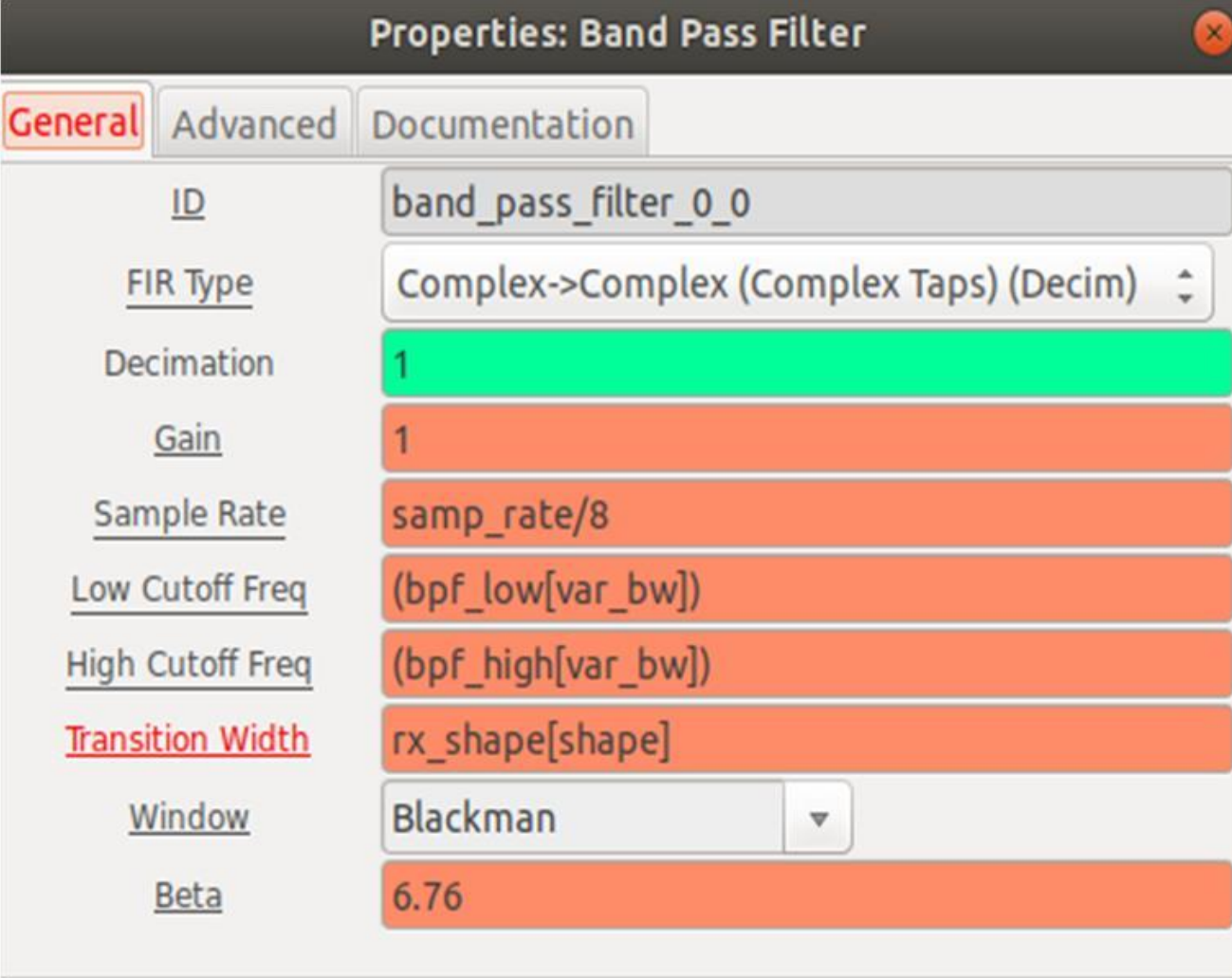
Variable
ID: bpf_high
Value: 3.9k, 2.7k, 880, 590

WX GUI Chooser
ID: var_bw
Label: Receiver...width - kHz
Default Value: 0
Choices: 0, 1, 2, 3
Labels: 3.9, 2.7, 0.5, 0.05
Type: Radio Buttons
Grid Position: 4, 1, 1, 1

Nested Python Commands Control Multiple Parameters

Nested Python Commands Control Multiple Parameters

Flow Graph Problem Solving

- Source and Sink not in your DSP library

- Console data interpretation

- Version and subversion problems

- Signal tracing

- Fractional resampler - 'U' and 'aU' interruptions

- Bypass block option

- Undo button on task bar

Source and Sink Drivers not in DSP Library

Solution: Download and install driver for your hardware

Pluto SDR

Https://wiki.gnuradio.org/index.php/PlutoSDR_Source

Lime SDR

https://medium.com/bugbountywriteup/limesdr-setup-with-gnuradio-gr-limesdr-and-gqrx-on-ubuntu-20-04-4b275176d7cd

HackRF

https://github.com/mossmann/hackrf/wiki/Getting-Started-with-HackRF-and-GNU-Radio

Console Data – GRC version + samp_rate error

```
<<< Welcome to GNU Radio Companion 3.7.13.4 >>>

Block paths:
    /usr/local/share/gnuradio/grc/blocks

Loading: "/home/john/Desktop/presentation flow graph.grc"
>>> Done

Generating: '/home/john/Desktop/Multi_mode_HF_VHF_transceiver.py'

Executing: /usr/bin/python2 -u /home/john/Desktop/
Multi_mode_HF_VHF_transceiver.py

linux; GNU C++ version 7.5.0; Boost_106501; UHD_003.009.005-0-g32951af2

Error: failed to enable real-time scheduling.
– Opening a USRP2/N-Series device...
– Current recv frame size: 1472 bytes
– Current send frame size: 1472 bytes
– Detecting internal GPSDO.... No GPSDO found

UHD Warning:
  Unable to set the thread priority. Performance may be negatively affected.
  Please see the general application notes in the manual for instructions.
  EnvironmentError: OSError: error in pthread_setschedparam

UHD Warning:
  The hardware does not support the requested RX sample rate:
  Target sample rate: 0.384000 MSps
  Actual sample rate: 0.384615 MSps

UHD Warning:
  Setting IQ imbalance compensation is not possible on this device.

UHD Warning:
  The hardware does not support the requested TX sample rate:
  Target sample rate: 0.384000 MSps
  Actual sample rate: 0.384615 MSps
Warning: the blks2.selector block is deprecated.
Warning: the blks2.valve block is deprecated.
Warning: the blks2.selector block is deprecated.
Warning: the blks2.selector block is deprecated.
INFO: Audio source arch: alsa
INFO: Audio sink arch: alsa
```

Console Data – error corrected

```
Error: failed to enable real-time scheduling.
-- Opening a USRP2/N-Series device...
-- Current recv frame size: 1472 bytes
-- Current send frame size: 1472 bytes

UHD Warning:
    Unable to set the thread priority. Performance may be negatively affected.
    Please see the general application notes in the manual for instructions.
    EnvironmentError: OSError: error in pthread_setschedparam

UHD Warning:
    Setting IQ imbalance compensation is not possible on this device.
Warning: the blks2.selector block is deprecated.
Warning: the blks2.valve block is deprecated.
Warning: the blks2.selector block is deprecated.
Warning: the blks2.selector block is deprecated.
INFO: Audio source arch: alsa
INFO: Audio sink arch: alsa
```
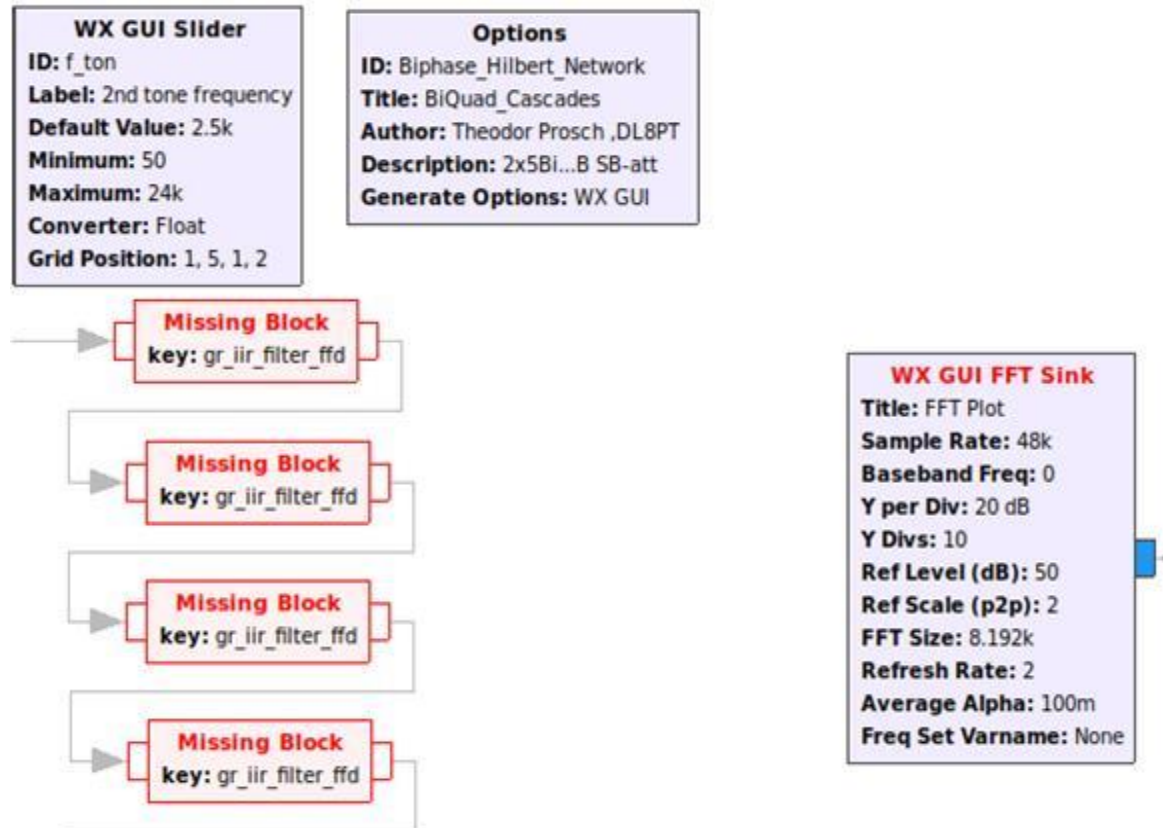
Version Problems: GRC v3.7 vs. v3.8

- Version 3.7 flow graphs will not run on a Version 3.8 installation: a blank workspace
- Version 3.8 flow graphs will not run on a Version 3.7 installation: missing blocks
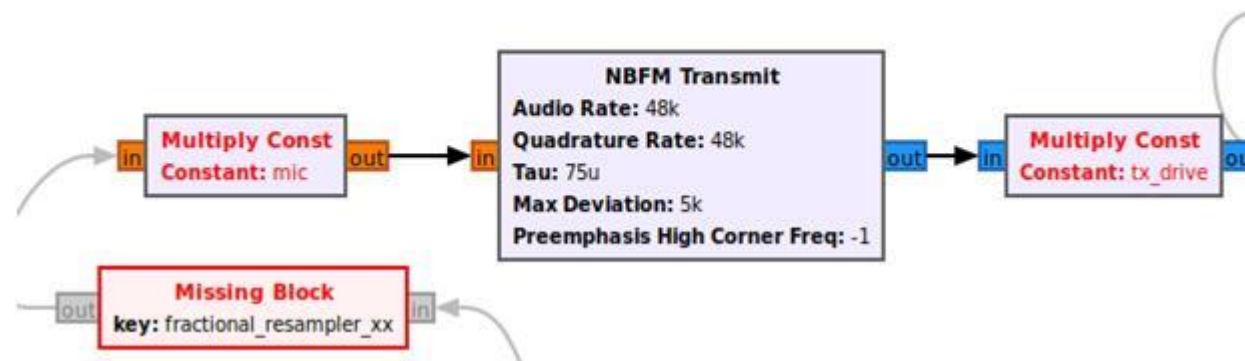
Solution: Hand build flow graph: block by block, parameter by parameter from your DSP library. Not a Copy and Paste solution

GRC v3.7 Subversion Problems: missing blocks

WX GUI Slider
ID: f_ton
Label: 2nd tone frequency
Default Value: 2.5k
Minimum: 50
Maximum: 24k
Converter: Float
Grid Position: 1, 5, 1, 2

Options
ID: Biphase_Hilbert_Network
Title: BiQuad_Cascades
Author: Theodor Prosch ,DL8PT
Description: 2x5Bi...B SB-att
Generate Options: WX GUI

Missing Block
key: gr_iir_filter_ffd

Missing Block
key: gr_iir_filter_ffd

Missing Block
key: gr_iir_filter_ffd

Missing Block
key: gr_iir_filter_ffd

WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 48k
Baseband Freq: 0
Y per Div: 20 dB
Y Divs: 10
Ref Level (dB): 50
Ref Scale (p2p): 2
FFT Size: 8.192k
Refresh Rate: 2
Average Alpha: 100m
Freq Set Varname: None

Solution: Replace missing blocks with blocks from your DSP library

GRC v3.7 Subversion Problems: global failure

```
-- Asking for clock rate 16.000000 MHz...
-- Actually got clock rate 16.000000 MHz.
-- Performing timer loopback test... pass
-- Asking for clock rate 49.152000 MHz...
-- Actually got clock rate 49.152000 MHz.
-- Performing timer loopback test... pass
Traceback (most recent call last):
 File "/home/john/Desktop/NBFM_VHF_RX_TX.py", line 495, in <module>
   main()
 File "/home/john/Desktop/NBFM_VHF_RX_TX.py", line 489, in main
  tb = top_block_cls()
 File "/home/john/Desktop/NBFM_VHF_RX_TX.py", line 288, in __init__
   self.uhd_usrp_source_0.set_auto_dc_offset("", 0)
 File "/usr/lib/python2.7/dist-packages/gnuradio/uhd/uhd_swig.py", line 3464, in set_auto_dc_offset
   return _uhd_swig.usrp_source_sptr_set_auto_dc_offset(self, enb, chan)
TypeError: in method 'usrp_source_sptr_set_auto_dc_offset', argument 2 of type 'bool'
```

Solution: Try replacing Source and Sink blocks first. Otherwise, hand
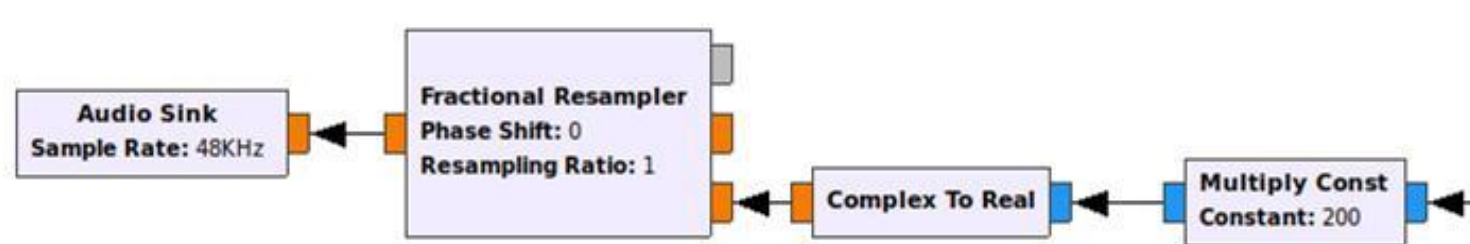Rebuild from your DSP library.

Signal Tracing and Stimulus Response Testing

- <u>Signal Tracing:</u> Output to an instrumentation GUI widget, e.g. FFT display to study data stream frequency components
- <u>Stimulus Response testing:</u> Use a Signal Source or Noise Source to study frequency response of filters, phase shifters, etc.

Noise Source
Noise Type: Gaussian
Amplitude: 100m
Seed: 0

Low Pass Filter
Decimation: 8
Gain: 1
Sample Rate: 48k
Cutoff Freq: 3k
Transition Width: 100
Window: Hamming
Beta: 6.76

QT GUI Frequency Sink
Name: LSB   ...   USB
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 6k

Fractional Resampler
'U' and 'aU' Interruptions

Adjust 'Ratio' GUI slider to reduce 'U' and 'aU' interruptions

Block 'Bypass' Option

A convenient means to functionally remove a block from a data stream.

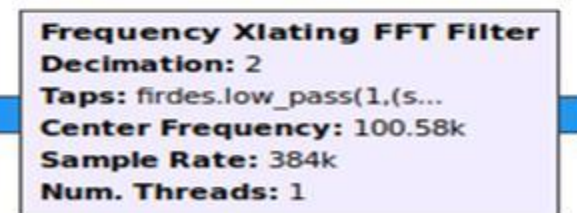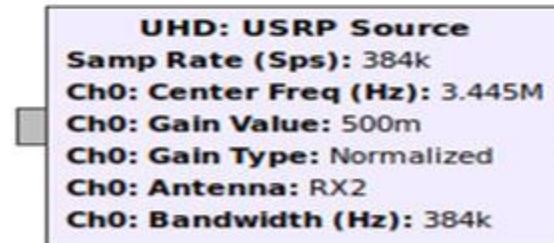<Right> click block and select <Bypass> from menu

Unbypassed block

Bypassed block

'Undo' Button on Task Bar

Easy way to undo workspace mistakes, especially common with congested flow graphs using computers with touch pads, small screens
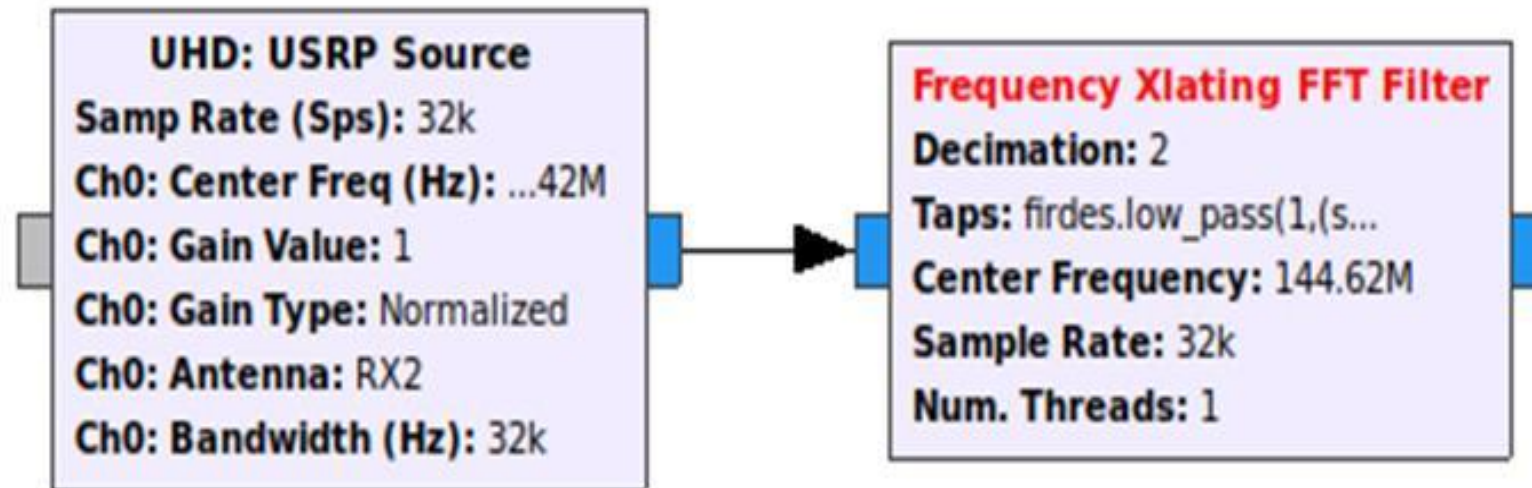
Odds and Ends

- Eliminate Receiver DC artifact

- Selector switch

- Analog TX/RX hardware logic control schematic

- Software TX/RX control using duplex mode

Eliminate Receiver DC Artifact

Solution: Offset Source center frequency and Freq Xlating filter center frequencies by the same amount in opposite directions, e.g. +/- 100e3 Hz

Eliminate Receiver DC Artifact

Properties Boxes

Properties: UHD: USRP Source

General | **RF Options** | FE Corrections | Advanced | Documentation

Ch0: Center Freq (Hz)	144.52e6-100e3
Ch0: Gain Value	1
Ch0: Gain Type	Normalized ▾
Ch0: Antenna	RX2 ▾
Ch0: Bandwidth (Hz)	samp_rate

Properties: Frequency Xlating FFT Filter

General | Advanced | Documentation

ID	freq_xlating_fft_filter_ccc_1
Decimation	2
Taps	firdes.low_pass(1,(samp_rate),(samp_rate/21),30
Center Frequency	144.52e6+100e3
Sample Rate	samp_rate
Sample Delay	0
Num. Threads	1

Selector Switch

Selector interrupts data flow and turns off Sink. Useful for hardware derived logic for TX/RX switching systems.

Analog TX/RX Hardware Control

Solution: Use a small amount of current from the SDR RX or TX LED as a logic source. Use the current to drive a high gain transistor switch array. The transistor switch then controls other system switches and relays, i.e. PA's, preamplifiers, antenna relays, etc.

Analog TX/RX Hardware Control Schematic Diagram
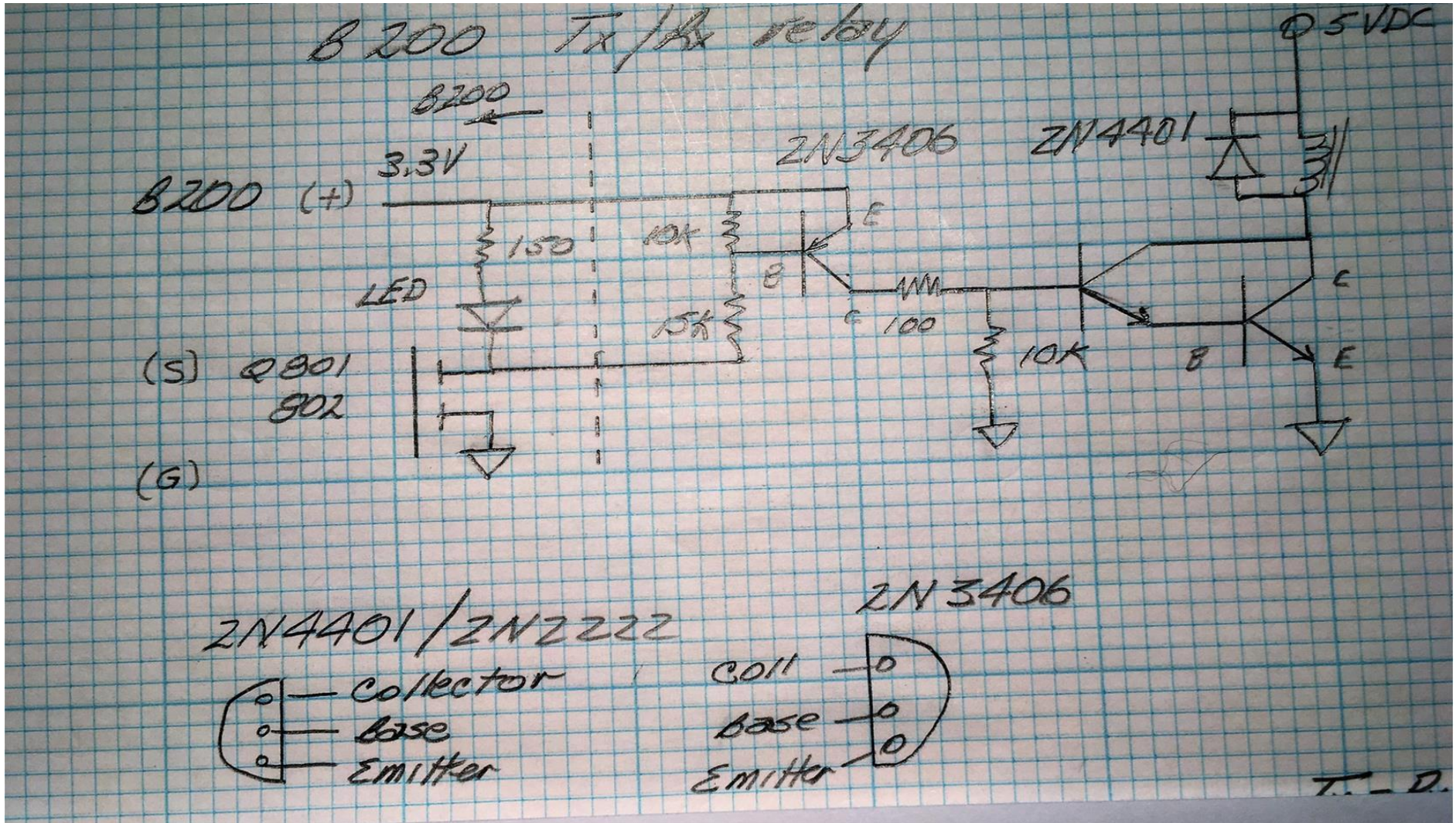
Software TX/RX Control: Duplex Mode

Solution: Use nested commands

Receive mode: The Source center frequency is selected for the desired operating frequency. The Sink center frequency is selected to "0" frequency. (or some out-of-bounds frequency)

Transmit mode: The Sink center frequency is selected for the desired operating frequency. The Source center frequency is selected to "0" frequency. (or some out-of-bounds frequency)

Software TX/RX Control: Duplex Mode

Group Discussion

- What additional flow graph techniques do you want to share?

- What are your current GRC projects or problems?