Modular transmit / receive station control

Barry Duggan KV4FV

based on
https://github.com/duggabe/gr-control

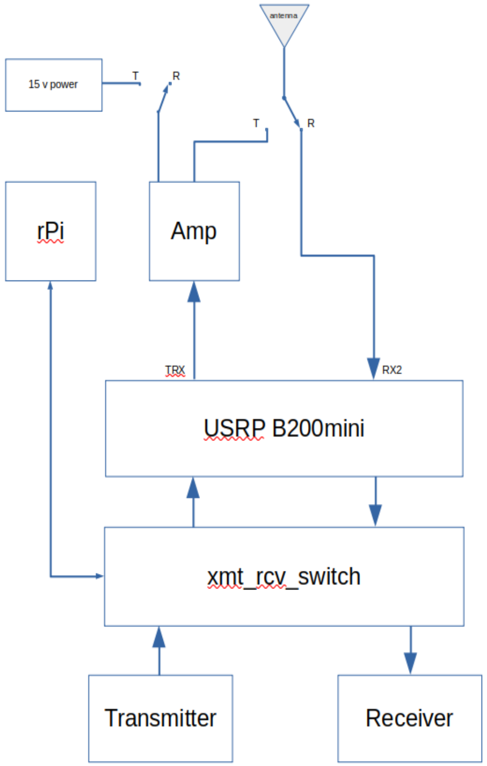
Design criteria

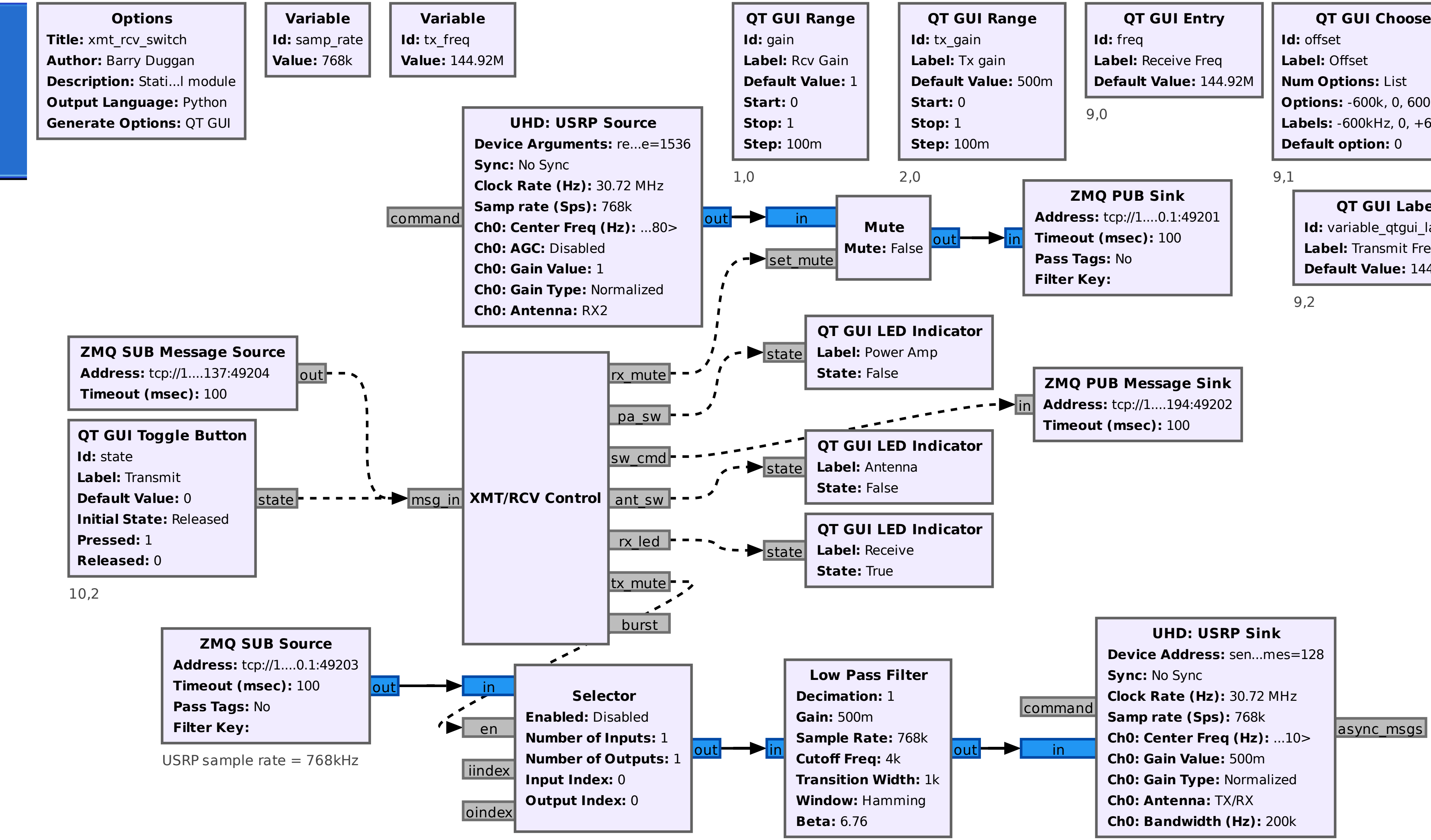
- “Plug and Play” design
- Four separate modules working together: control, transmit, receive, and relay driver
- USRP Source and Sink blocks must be in the same process (flowgraph)
- All transmit and receive modules must have the same interface to the control module
- To allow GUI presentation on the same display screen, the control module, transmitter, and receiver should be in the same computer
- No hardware modifications should be required

Using gr-control branches

- \`main\` (the default) is the development branch for software not yet put into the maint branches. It contains flowgraphs for GNU Radio 3.9+. It includes relay control using a Raspberry Pi computer.
- \`maint-3.9\` contains flowgraphs for GNU Radio 3.9 and uses a USRP device. The sample rate is set to 768kHz.
- \`maint-3.8\` contains flowgraphs for GNU Radio 3.8 and uses an ADALM-Pluto. The sample rate is set to 576kHz to minimize the processing load if used on a Raspberry Pi computer.
- Note that the \`maint-3.8\` and \`maint-3.9\` branches simulate the relay switching.

Overview / Data Flow Diagram





Options
Title: xmt_rcv_switch
Author: Barry Duggan
Description: Stati...l module
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 768k

Variable
Id: tx_freq
Value: 144.92M

QT GUI Range
Id: gain
Label: Rcv Gain
Default Value: 1
Start: 0
Stop: 1
Step: 100m

1,0

QT GUI Range
Id: tx_gain
Label: Tx gain
Default Value: 500m
Start: 0
Stop: 1
Step: 100m

2,0

QT GUI Entry
Id: freq
Label: Receive Freq
Default Value: 144.92M

9,0

QT GUI Chooser
Id: offset
Label: Offset
Num Options: List
Options: -600k, 0, 600k
Labels: -600kHz, 0, +600kHz
Default option: 0

9,1

UHD: USRP Source
Device Arguments: re...e=1536
Sync: No Sync
Clock Rate (Hz): 30.72 MHz
Samp rate (Sps): 768k
Ch0: Center Freq (Hz): ...80>
Ch0: AGC: Disabled
Ch0: Gain Value: 1
Ch0: Gain Type: Normalized
Ch0: Antenna: RX2

Mute
Mute: False

ZMQ PUB Sink
Address: tcp://1....0.1:49201
Timeout (msec): 100
Pass Tags: No
Filter Key:

QT GUI Label
Id: variable_qtgui_label_0
Label: Transmit Freq
Default Value: 144.92M

9,2

ZMQ SUB Message Source
Address: tcp://1....137:49204
Timeout (msec): 100

QT GUI Toggle Button
Id: state
Label: Transmit
Default Value: 0
Initial State: Released
Pressed: 1
Released: 0

10,2

XMT/RCV Control

QT GUI LED Indicator
Label: Power Amp
State: False

ZMQ PUB Message Sink
Address: tcp://1....194:49202
Timeout (msec): 100

QT GUI LED Indicator
Label: Antenna
State: False

QT GUI LED Indicator
Label: Receive
State: True

ZMQ SUB Source
Address: tcp://1....0.1:49203
Timeout (msec): 100
Pass Tags: No
Filter Key:

USRP sample rate = 768kHz

Selector
Enabled: Disabled
Number of Inputs: 1
Number of Outputs: 1
Input Index: 0
Output Index: 0

Low Pass Filter
Decimation: 1
Gain: 500m
Sample Rate: 768k
Cutoff Freq: 4k
Transition Width: 1k
Window: Hamming
Beta: 6.76

UHD: USRP Sink
Device Address: sen...mes=128
Sync: No Sync
Clock Rate (Hz): 30.72 MHz
Samp rate (Sps): 768k
Ch0: Center Freq (Hz): ...10>
Ch0: Gain Value: 500m
Ch0: Gain Type: Normalized
Ch0: Antenna: TX/RX
Ch0: Bandwidth (Hz): 200k

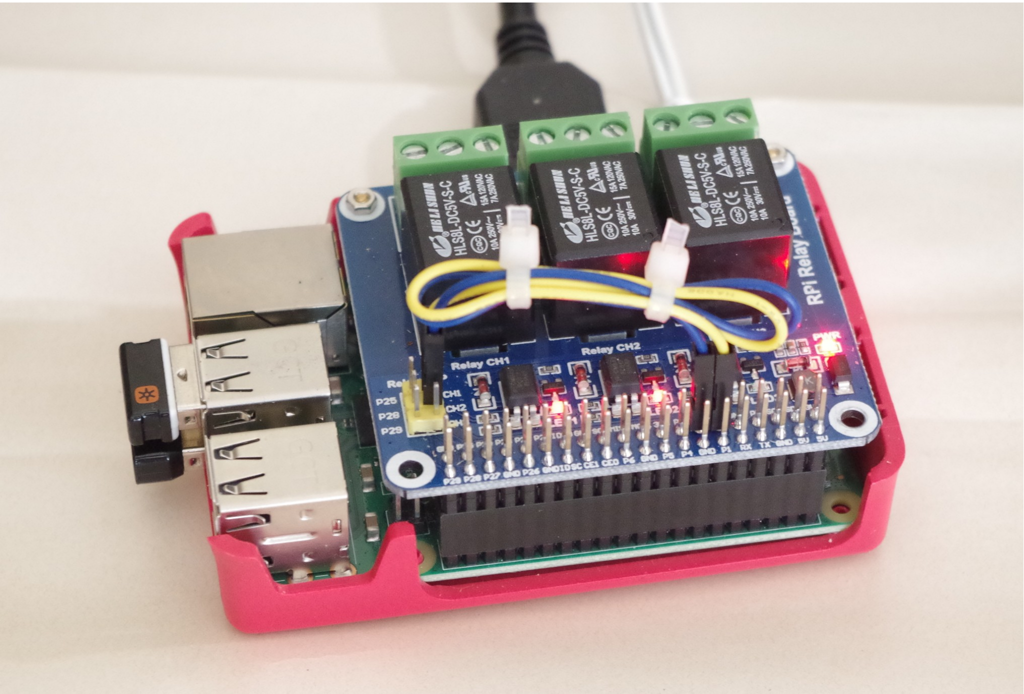
Station Control Module

- Python transmit switching sequence
    - mute receiver
    - turn off rcv LED
    - turn on Antenna LED
    - send message to relay controller
    - wait for reply message
    - delay 10 ms
    - unmute transmitter

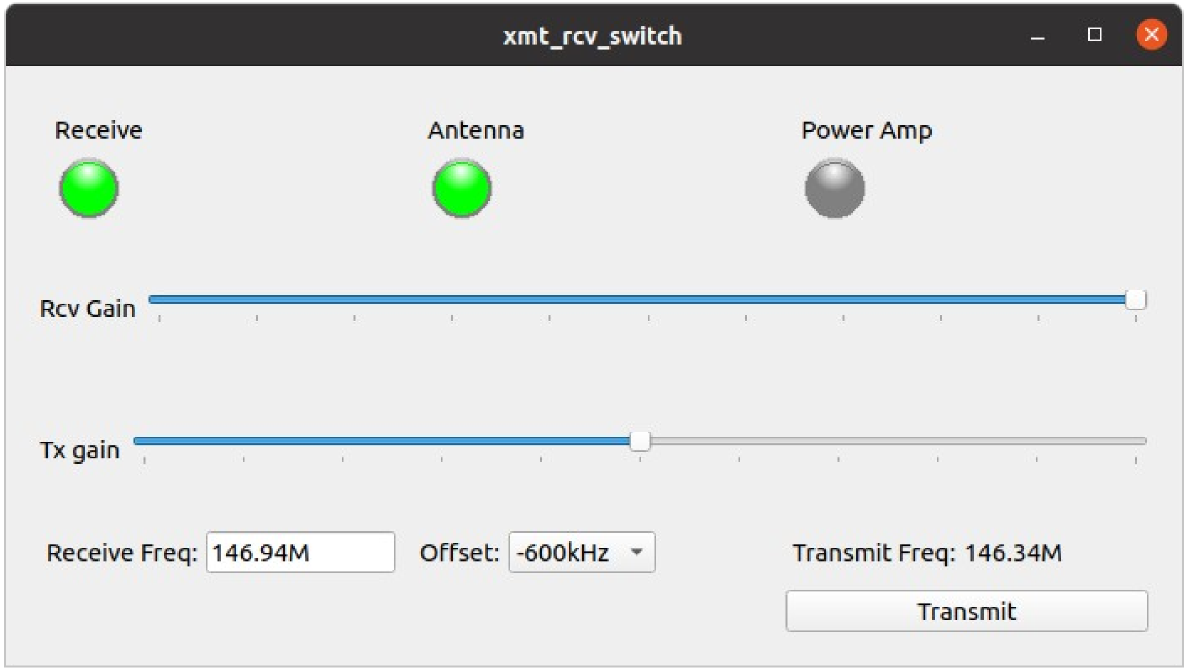
Raspberry Pi relay controller

- Python transmit sequence
  - wait for an input message
  - switch antenna from rcv to xmt
  - delay 100 ms
  - turn on power amp
  - delay 250 ms
  - send reply back to client

Raspberry Pi with relay board



xmt_rcv_switch display

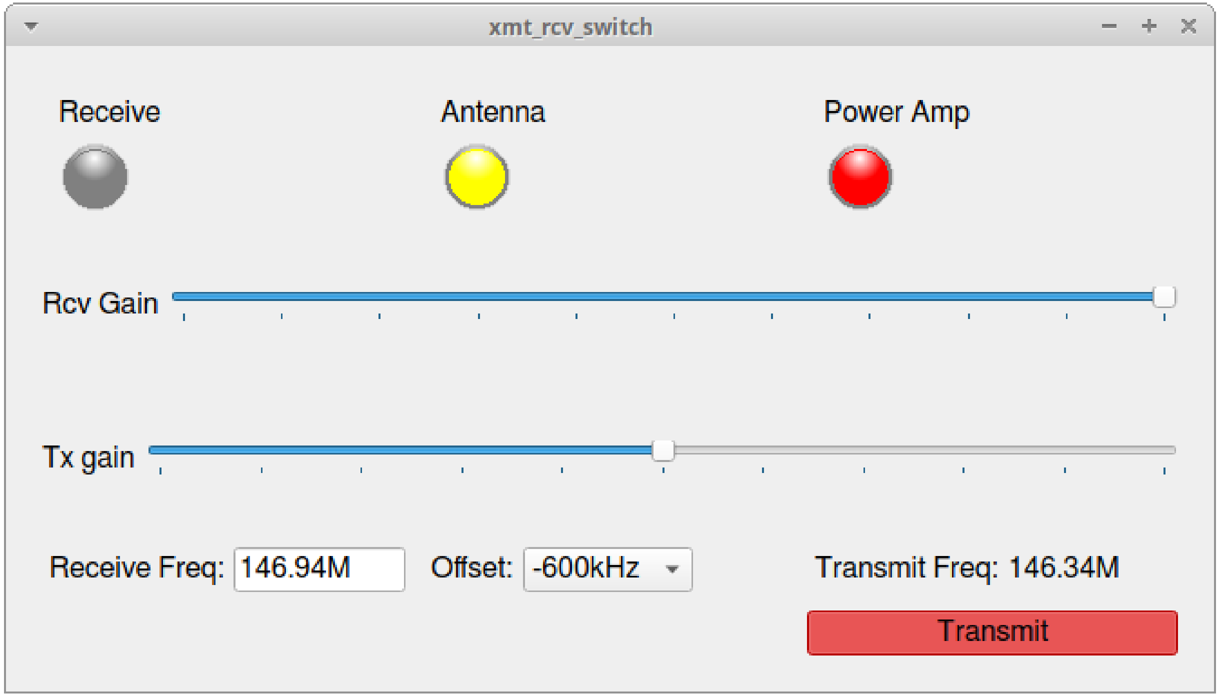


Receive Freq: 146.94M

Offset: -600kHz

Transmit Freq: 146.34M

xmt_rcv_switch display



Receive Freq: 146.94M

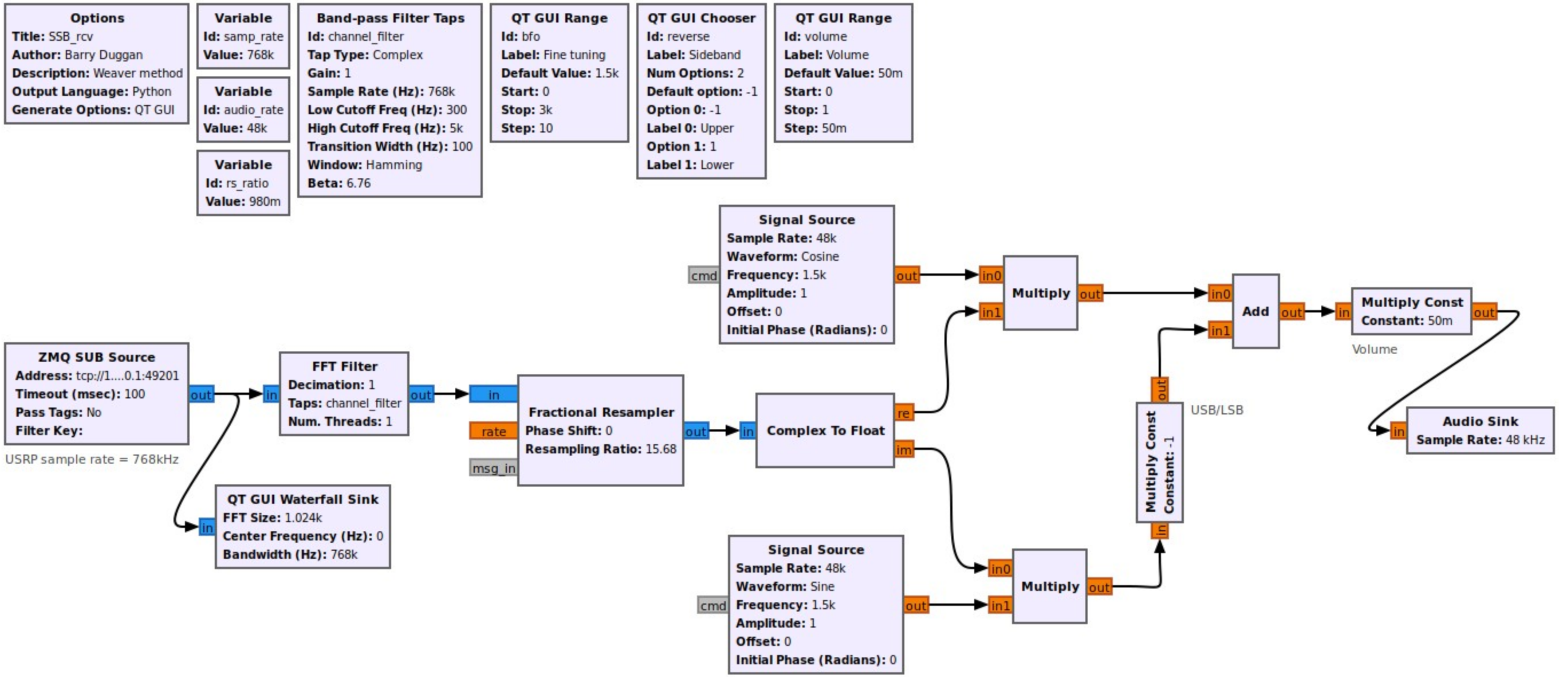
Offset: -600kHz

Transmit Freq: 146.34M

Receiver modules

- Narrow Band FM
- Single Sideband
- Broadcast Wide Band FM stereo

SSB receiver



Options
Title: SSB_rcv
Author: Barry Duggan
Description: Weaver method
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 768k

Variable
Id: audio_rate
Value: 48k

Variable
Id: rs_ratio
Value: 980m

Band-pass Filter Taps
Id: channel_filter
Tap Type: Complex
Gain: 1
Sample Rate (Hz): 768k
Low Cutoff Freq (Hz): 300
High Cutoff Freq (Hz): 5k
Transition Width (Hz): 100
Window: Hamming
Beta: 6.76

QT GUI Range
Id: bfo
Label: Fine tuning
Default Value: 1.5k
Start: 0
Stop: 3k
Step: 10

QT GUI Chooser
Id: reverse
Label: Sideband
Num Options: 2
Default option: -1
Option 0: -1
Label 0: Upper
Option 1: 1
Label 1: Lower

QT GUI Range
Id: volume
Label: Volume
Default Value: 50m
Start: 0
Stop: 1
Step: 50m

Signal Source
Sample Rate: 48k
Waveform: Cosine
Frequency: 1.5k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

ZMQ SUB Source
Address: tcp://1....0.1:49201
Timeout (msec): 100
Pass Tags: No
Filter Key:

USRP sample rate = 768kHz

FFT Filter
Decimation: 1
Taps: channel_filter
Num. Threads: 1

Fractional Resampler
Phase Shift: 0
Resampling Ratio: 15.68

Complex To Float

Multiply

Add

Multiply Const
Constant: 50m

Volume

Multiply Const
Constant: -1

USB/LSB

Audio Sink
Sample Rate: 48 kHz

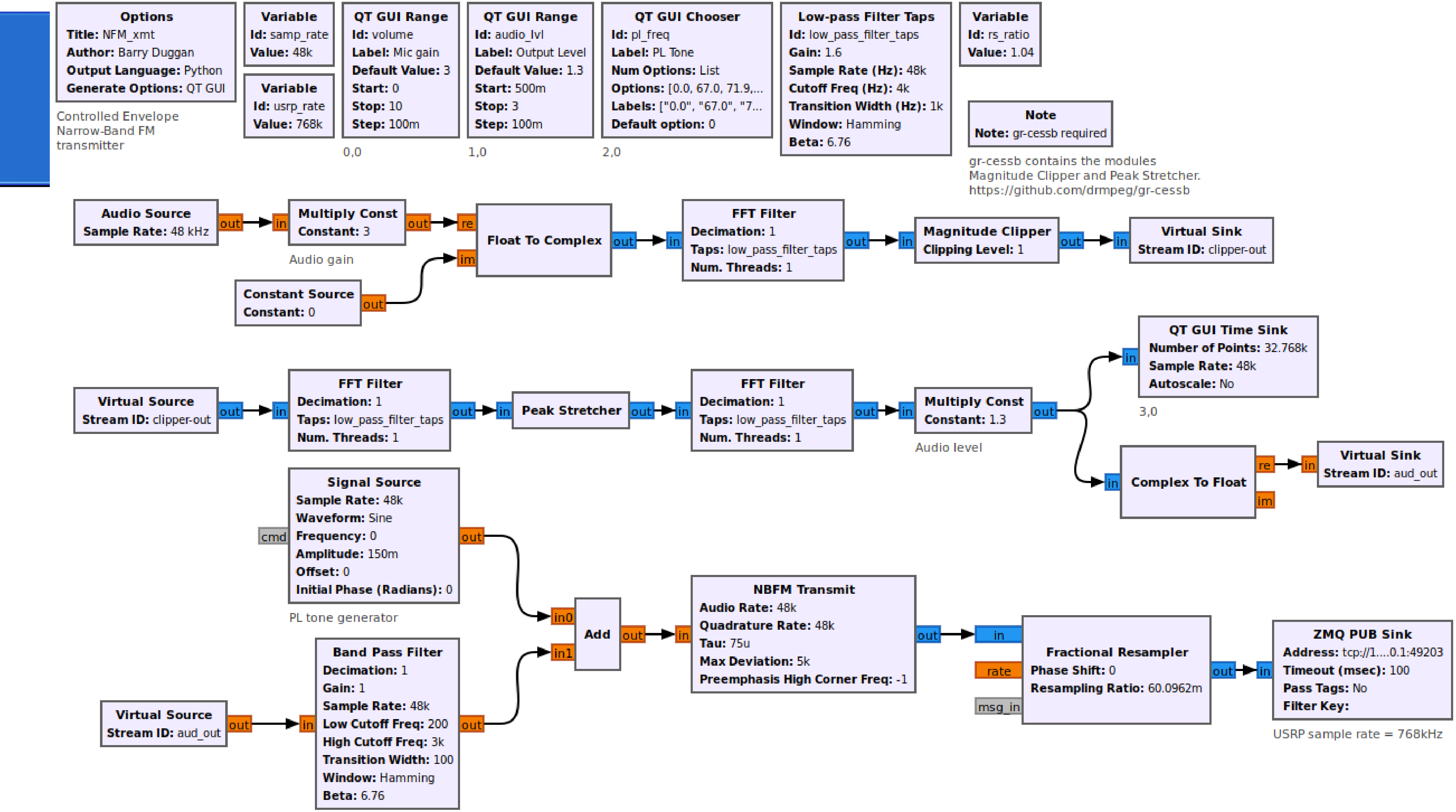
QT GUI Waterfall Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 768k

Signal Source
Sample Rate: 48k
Waveform: Sine
Frequency: 1.5k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Multiply

Transmitter modules

- Narrow Band FM
- Single Sideband



Options
Title: NFM_xmt
Author: Barry Duggan
Output Language: Python
Generate Options: QT GUI

Controlled Envelope
Narrow-Band FM
transmitter

Variable
Id: samp_rate
Value: 48k

Variable
Id: usrp_rate
Value: 768k

QT GUI Range
Id: volume
Label: Mic gain
Default Value: 3
Start: 0
Stop: 10
Step: 100m

0,0

QT GUI Range
Id: audio_lvl
Label: Output Level
Default Value: 1.3
Start: 500m
Stop: 3
Step: 100m

1,0

QT GUI Chooser
Id: pl_freq
Label: PL Tone
Num Options: List
Options: [0.0, 67.0, 71.9,...
Labels: ["0.0", "67.0", "7...
Default option: 0

2,0

Low-pass Filter Taps
Id: low_pass_filter_taps
Gain: 1.6
Sample Rate (Hz): 48k
Cutoff Freq (Hz): 4k
Transition Width (Hz): 1k
Window: Hamming
Beta: 6.76

Variable
Id: rs_ratio
Value: 1.04

Note
Note: gr-cessb required

gr-cessb contains the modules
Magnitude Clipper and Peak Stretcher.
https://github.com/drmpeg/gr-cessb

Audio Source
Sample Rate: 48 kHz

Multiply Const
Constant: 3

Audio gain

Constant Source
Constant: 0

Float To Complex

FFT Filter
Decimation: 1
Taps: low_pass_filter_taps
Num. Threads: 1

Magnitude Clipper
Clipping Level: 1

Virtual Sink
Stream ID: clipper-out

Virtual Source
Stream ID: clipper-out

FFT Filter
Decimation: 1
Taps: low_pass_filter_taps
Num. Threads: 1

Peak Stretcher

FFT Filter
Decimation: 1
Taps: low_pass_filter_taps
Num. Threads: 1

Multiply Const
Constant: 1.3

Audio level

QT GUI Time Sink
Number of Points: 32.768k
Sample Rate: 48k
Autoscale: No

3,0

Complex To Float

Virtual Sink
Stream ID: aud_out

Signal Source
Sample Rate: 48k
Waveform: Sine
Frequency: 0
Amplitude: 150m
Offset: 0
Initial Phase (Radians): 0

PL tone generator

Virtual Source
Stream ID: aud_out

Band Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 48k
Low Cutoff Freq: 200
High Cutoff Freq: 3k
Transition Width: 100
Window: Hamming
Beta: 6.76

Add

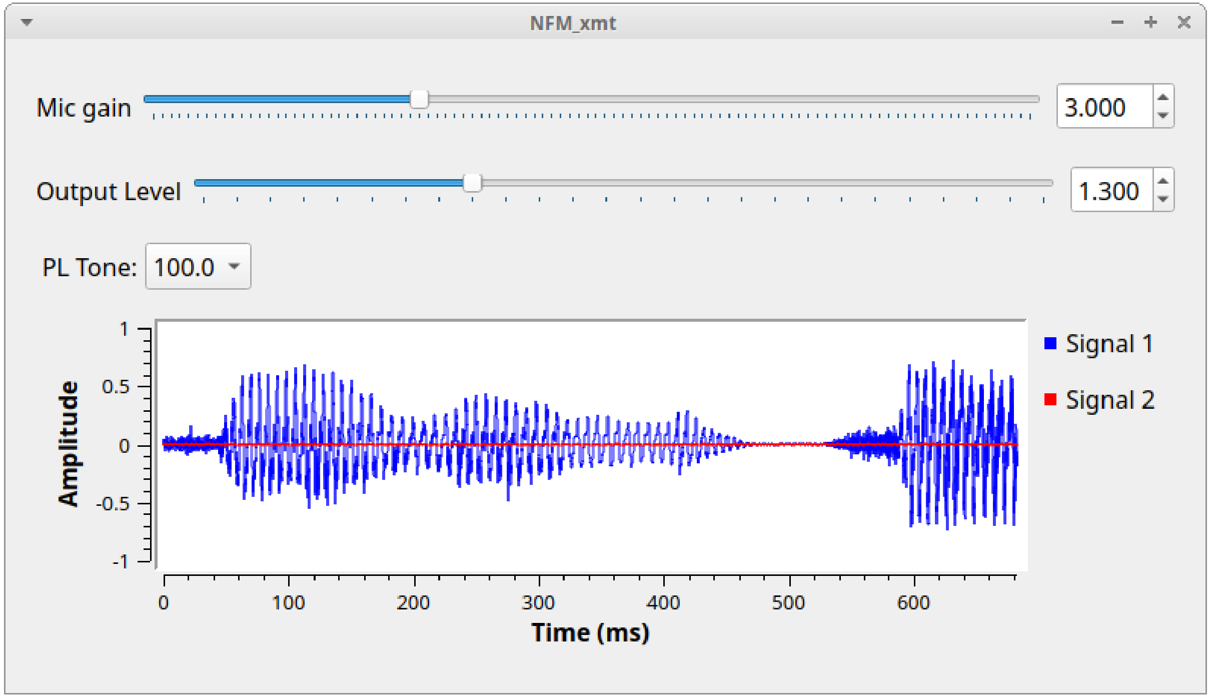
NBFM Transmit
Audio Rate: 48k
Quadrature Rate: 48k
Tau: 75u
Max Deviation: 5k
Preemphasis High Corner Freq: -1

Fractional Resampler
Phase Shift: 0
Resampling Ratio: 60.0962m

ZMQ PUB Sink
Address: tcp://1....0.1:49203
Timeout (msec): 100
Pass Tags: No
Filter Key:

USRP sample rate = 768kHz

Narrow Band FM transmit



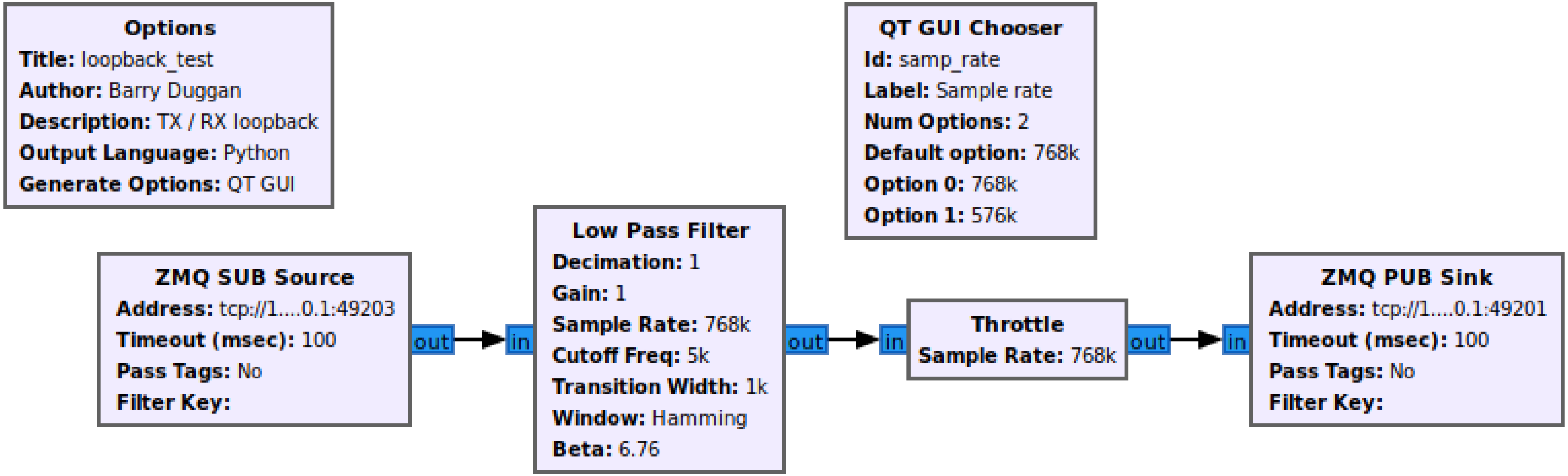
NFM_xmt

Mic gain 3.000

Output Level 1.300

PL Tone: 100.0

loopback_test



Options
Title: loopback_test
Author: Barry Duggan
Description: TX / RX loopback
Output Language: Python
Generate Options: QT GUI

QT GUI Chooser
Id: samp_rate
Label: Sample rate
Num Options: 2
Default option: 768k
Option 0: 768k
Option 1: 576k

ZMQ SUB Source
Address: tcp://1....0.1:49203
Timeout (msec): 100
Pass Tags: No
Filter Key:

Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 768k
Cutoff Freq: 5k
Transition Width: 1k
Window: Hamming
Beta: 6.76

Throttle
Sample Rate: 768k

ZMQ PUB Sink
Address: tcp://1....0.1:49201
Timeout (msec): 100
Pass Tags: No
Filter Key:

Modular transmit / receive station control

- Summary
  - Easy to add new modules
    - Radioteletype (RTTY) https://github.com/duggabe/gr-RTTY-basics
    - Morse Code https://github.com/duggabe/gr-morse-code-gen
  - Easy to test variations