

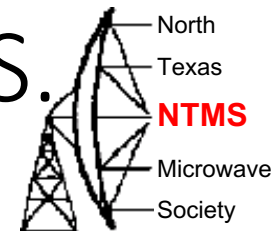
Getting Started with GNU Radio and a simple Beacon

1/18/20

N5BRG

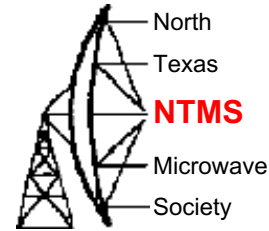
Gnuradio on Windows 10 64-bit OS.

NTMS.ORG



- Must be x86_64 type processor (not ARM).
- Prebuilt Windows Installer (MSI file) image.
 - You don't need to compile or build anything, just install.
- From MUD-workshop supplied USB stick.
- Latest version available at:
<http://www.gcndevelopment.com/gnuradio/downloads.htm>
- Limitation: Pre-built image only supports radios that the maintainer chose to include.
 - Several widely popular radios are included.
 - You cannot (easily) add new modules or radios.

The GRC Main Window



The screenshot shows the GNU Radio Companion (GRC) main window. At the top is a menu bar (File, Edit, View, Run, Tools, Help) and a toolbar with various icons. Red arrows point to specific icons: 'New' (a folder icon), 'Open' (a document icon), 'Save' (a floppy disk icon), 'Run' (a play button icon), and 'Block Search' (a magnifying glass icon). Below these are the labels 'New', 'Open', 'Save', 'Run', and 'Block Search' in red text. A note '(+Compile first if out-of-date)' is placed near the Run icon.

The main workspace contains a signal flow graph with the following blocks:

- Variable**: ID: samp_rate, Value: 32k
- Signal Source**: Sample Rate: 32k, Waveform: Cosine, Frequency: 1k, Amplitude: 1, Offset: 0
- Noise Source**: Noise Type: Gaussian, Amplitude: 1, Seed: 0
- Throttle**: Sample Rate: 32k
- Low Pass Filter**: Interpolation: 1, Gain: 1, Sample Rate: 32k, Cutoff Freq: 2k, Transition Width: 1k, Window: Hamming, Beta: 6.76
- QT GUI Frequency Sink**: FFT Size: 1.024k, Center Frequency (Hz): 0, Bandwidth (Hz): 32k

On the right side, there is a 'Blocks' panel with a tree view of available blocks, including Core, Audio, Boolean Operators, Byte Operators, Channel Models, Channelizers, Coding, Control Port, Debug Tools, Deprecated, Digital Television, Equalizers, Error Coding, FCD, File Operators, Filters, Fourier Analysis, GUI Widgets, Impairment Models, Instrumentation, Level Controllers, Math Operators, Measurement Tools, Message Tools, Misc, Modulators, Networking Tools, NOAA, OFDM, Packet Operators, Pager, Peak Detectors, Resamplers, Stream Operators, Stream Tag Tools, Symbol Coding, Synchronizers, Trellis Coding, Type Converters, and UHD.

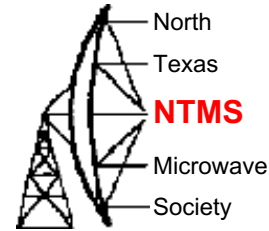
At the bottom, there is a 'Console' window showing the following text:


```
<<< Welcome to GNU Radio Companion 3.7.13.4 >>>
Block paths:
C:\Program Files\GNURadio-3.7\share\gnuradio\grc\blocks
Loading: "C:\Users\nonAdmin\Desktop\exercise 2a.grc"
>>> Done
```

 To the right of the console is a table with columns 'id' and 'Value':

id	Value
Imports	
Variables	
samp_rat	32000

The GRC Main Window



The screenshot shows the GNU Radio Companion (GRC) main window. At the top is a menu bar (File, Edit, View, Run, Tools, Help) and a toolbar with various icons. A red arrow points to the 'Compile' icon (a blue circle with a white 'C') in the toolbar, with the word "Compile" written in red text next to it.

The main workspace contains a signal flow graph with the following blocks:

- Signal Source**: Sample Rate: 32k, Waveform: Cosine, Frequency: 1k, Amplitude: 1, Offset: 0.
- Noise Source**: Noise Type: Gaussian, Amplitude: 1, Seed: 0.
- Throttle**: Sample Rate: 32k.
- Low Pass Filter**: Interpolation: 1, Gain: 1, Sample Rate: 32k, Cutoff Freq: 2k, Transition Width: 1k, Window: Hamming, Beta: 6.76.
- QT GUI Frequency Sink**: FFT Size: 1.024k, Center Frequency (Hz): 0, Bandwidth (Hz): 32k.

Connections: The Signal Source and Noise Source both connect to the Throttle block. The output of the Throttle block connects to the Low Pass Filter block. The output of the Low Pass Filter block connects to the QT GUI Frequency Sink block.

On the right side, there is a tree view showing a hierarchy of modules:

- (no module specified)
- Core
 - Audio
 - Boolean Operators
 - Byte Operators
 - Channel Models
 - Channelizers
 - Coding
 - Control Port
 - Debug Tools
 - Deprecated
 - Digital Television
 - Equalizers
 - Error Coding
 - FCD
 - File Operators
 - Filters
 - Fourier Analysis
 - GUI Widgets
 - Impairment Models
 - Instrumentation
 - Level Controllers
 - Math Operators
 - Measurement Tools
 - Message Tools
 - Misc
 - Modulators
 - Networking Tools
 - NOAA
 - OFDM
 - Packet Operators
 - Pager
 - Peak Detectors
 - Resamplers
 - Stream Operators
 - Stream Tag Tools
 - Symbol Coding
 - Synchronizers
 - Trellis Coding
 - Type Converters
 - UHD

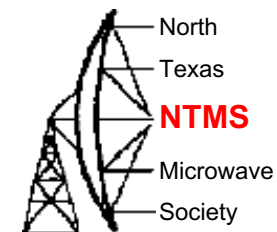
At the bottom left, there is a terminal window showing the following text:

```
<<< Welcome to GNU Radio Companion 3.7.13.4 >>>
Block paths:
C:\Program Files\GNURadio-3.7\share\gnuradio\grc\blocks
Loading: "C:\Users\nonAdmin\Desktop\exercise 2a.grc"
>>> Done
```

At the bottom right, there is a table with the following data:

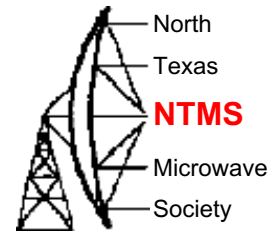
id	Value
Imports	
Variables	
samp_rat	32000

Gnuradio Core Concepts



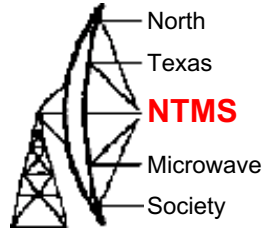
- Each block must know about the sample rate of the samples coming into it.
- Some blocks can change the sample rate.
 - For example 'decimation'. 'Keep one-in-N'
 - Make sure you low pass filter before decimation or you violate Nyquist !
- Gnuradio creates a default variable `samp_rate`.
 - If you have interpolation or decimation, you may need multiple sample rate variables because you have several different sample rates at the same time in your flowgraph.
 - Many gnuradio blocks combine some function with decimation.
 - For example Low-Pass-Filter has adjustable decimation.
- Tip: Reduce the sample close to the source in your flowgraph to reduce CPU workload.

Some Key Gnuradio Modules

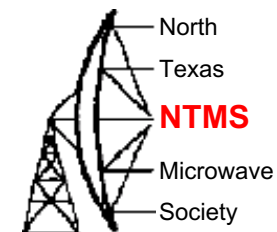


- Filters. General types: Lowpass, Bandpass, Highpass.
 - Pre-made filter types available.
 - Can make custom filters if necessary.
- Transfer function defined by the taps.
 - Pre-defined filters use pre-created taps. Fast & easy way to implement standard filters.
 - GRC includes a filter designer GUI. Use it to create taps.
 - Tools → Filter Design Tool
 - Large # taps substantially increases computational resources.
 - Real taps → both positive and negative frequency response.
 - Complex taps → single-sided frequency response.

Radios for GNU Radio Use

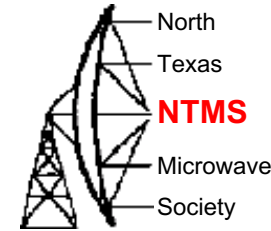


Some Key Gnuradio Modules

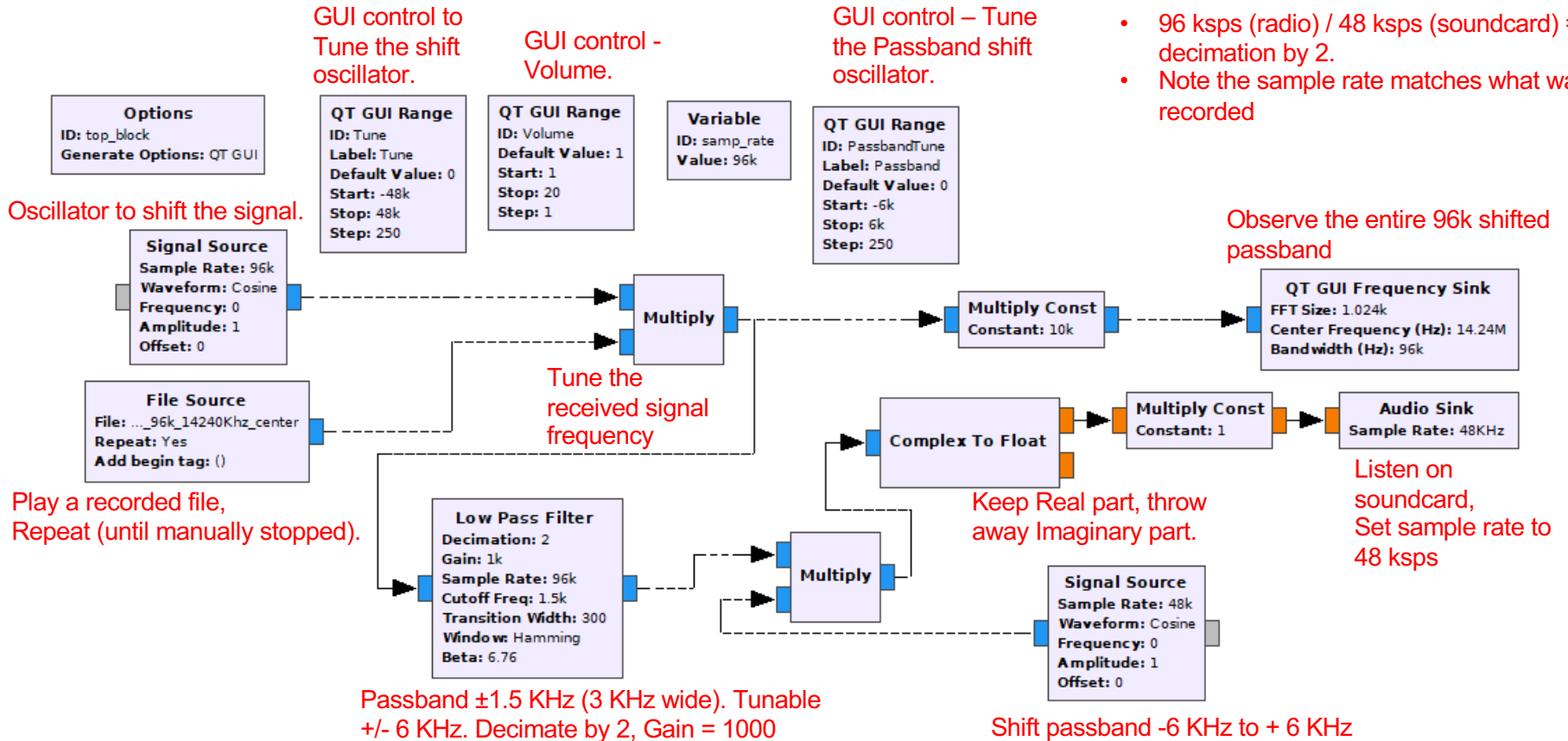


- Add
 - Adds two signals sample-by-sample.
- Multiply
 - Multiply two signals sample-by-sample.
 - Implements mixer (frequency shifter) or Gain / Attenuate.
- Convertors
 - Float → Complex
 - Complex → Float
 - Stream → Vector
- GUI : scope, spectrum analyzer, constellation, waterfall.
- Many more. Explore on your own.

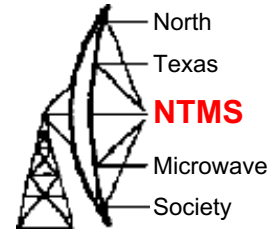
Exercise #4 Play pre-recorded file (SSB)



- 96 kpsps (radio) / 48 kpsps (soundcard) = decimation by 2.
- Note the sample rate matches what was recorded

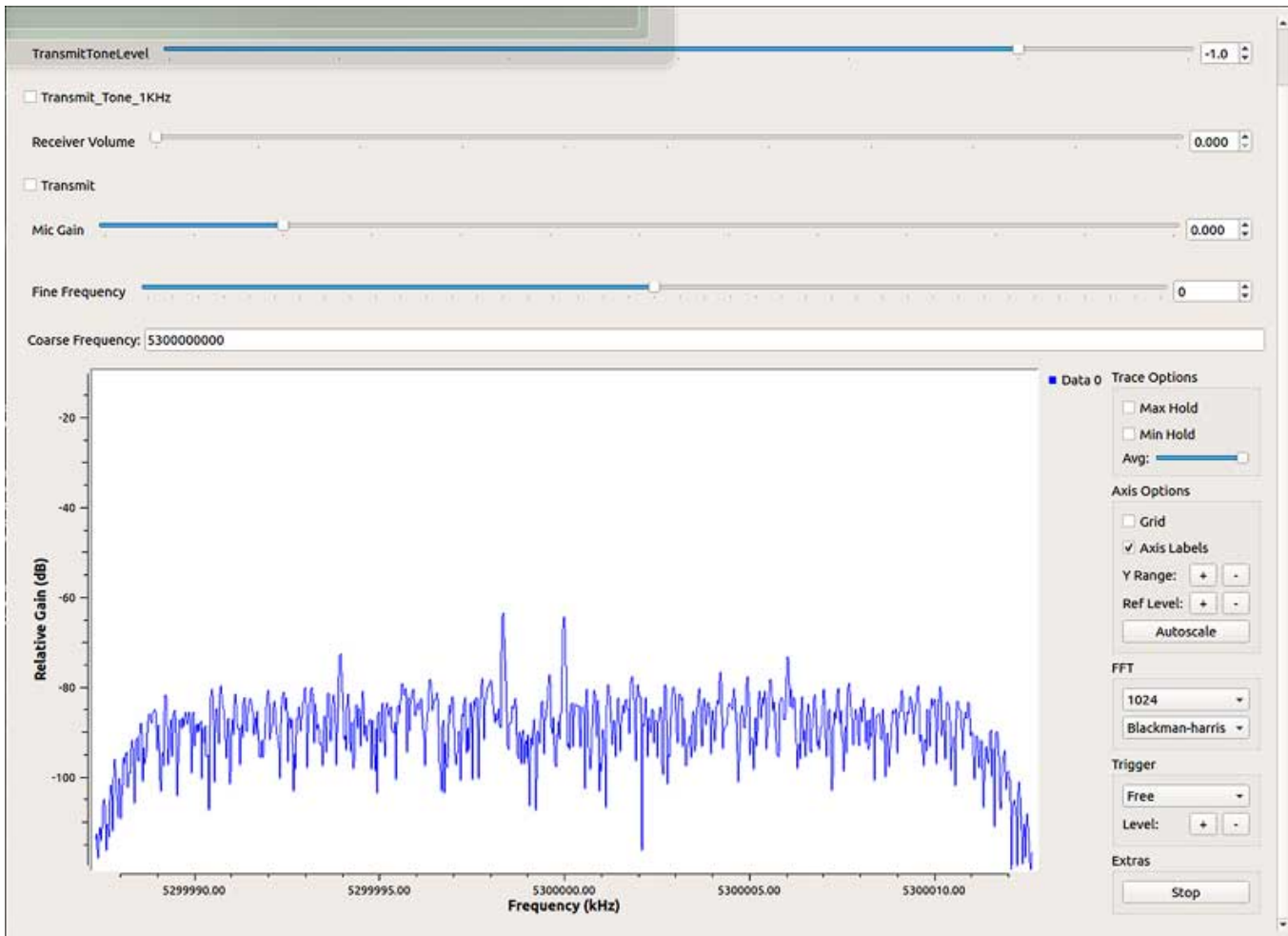
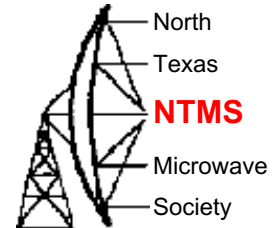


Example of Beacon + Echo

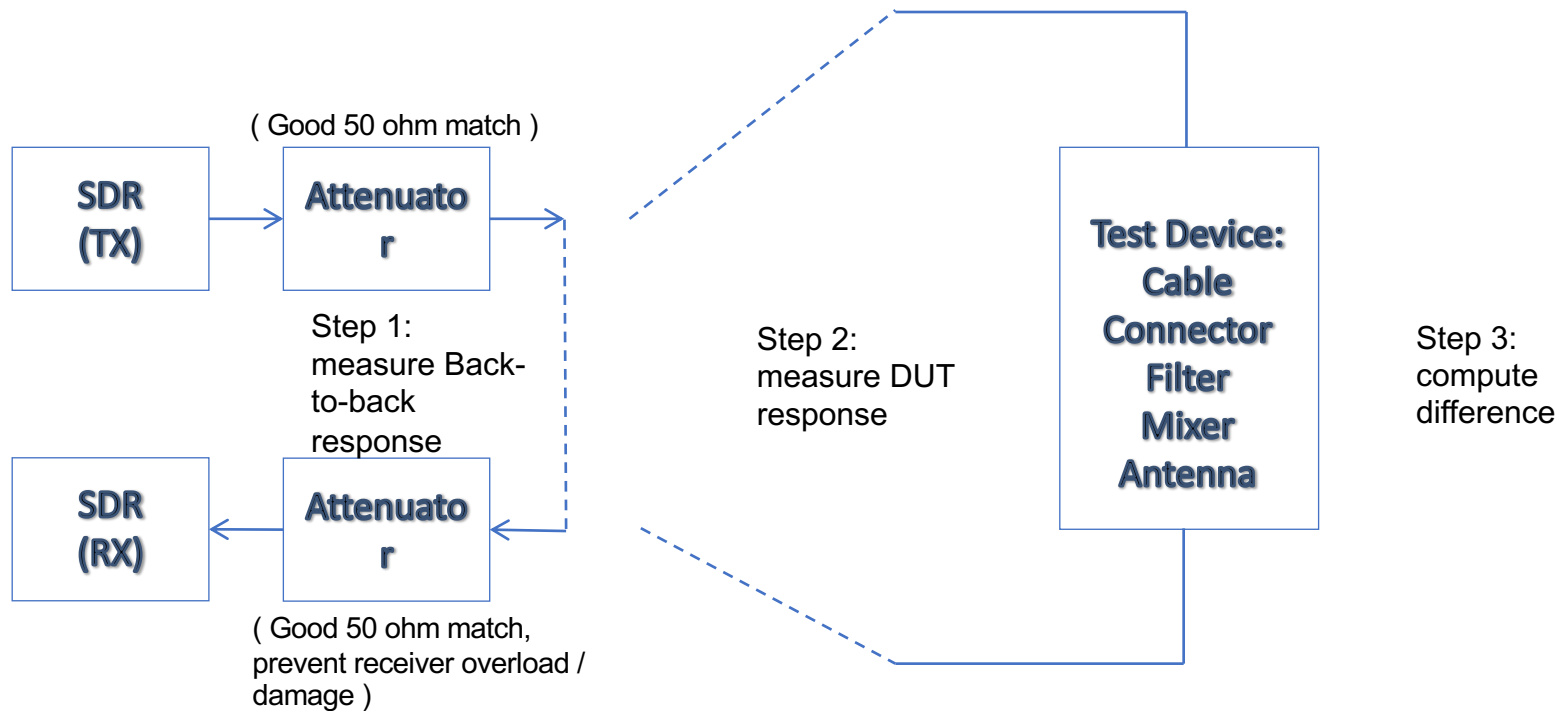
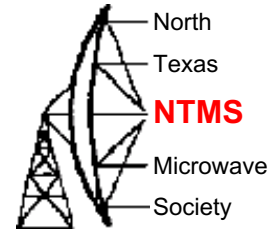


- Loop
 - Transmit Recorded File (Call Sign and Beacon Info)
 - Wait 2 Seconds
 - Receive Mode and Record to File for 20 Seconds
 - Wait 2 Seconds
 - Transmit Recorded File (Call Sign and Beacon Info)
 - Transmit Recorded File (Rx Recorded File)
 - Wait 2 Seconds

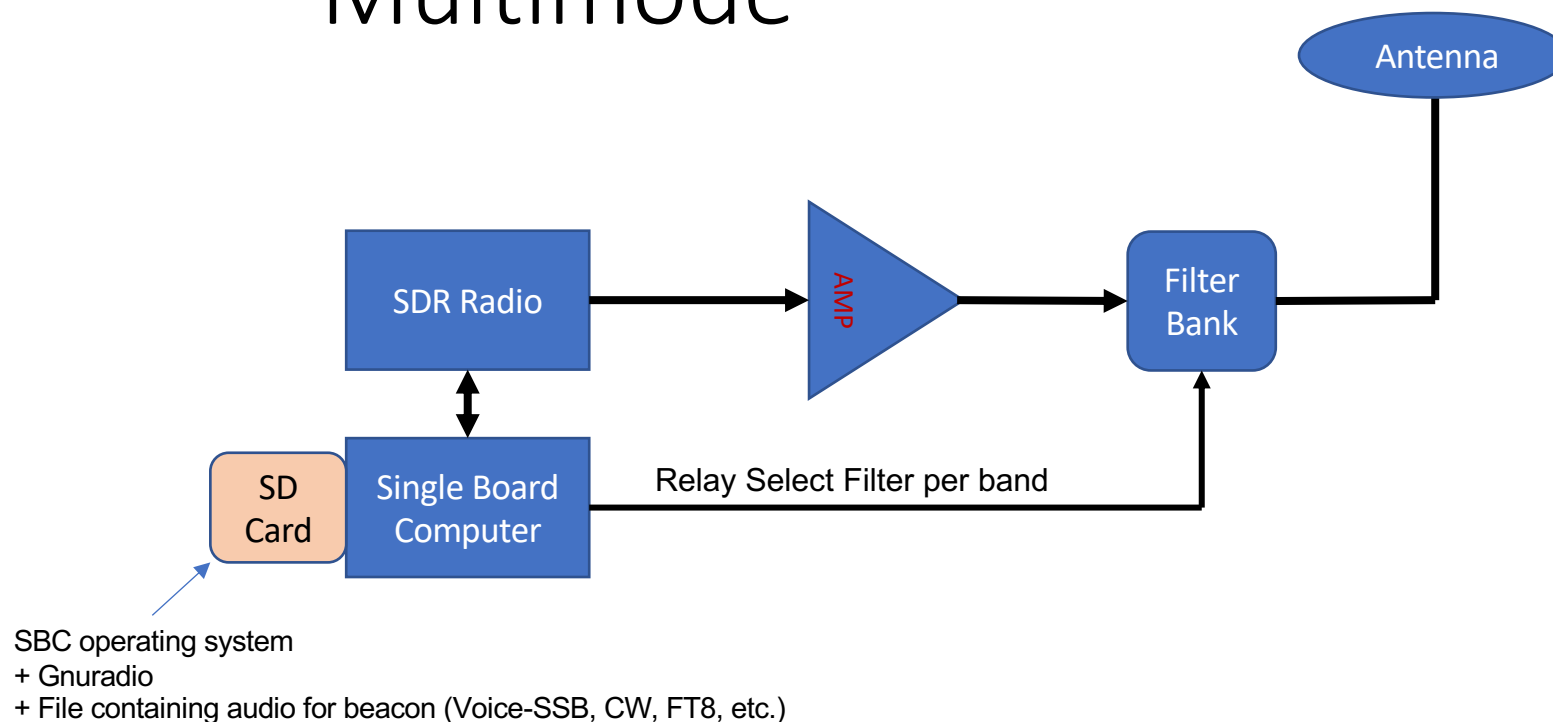
GNU Radio GUI Example:



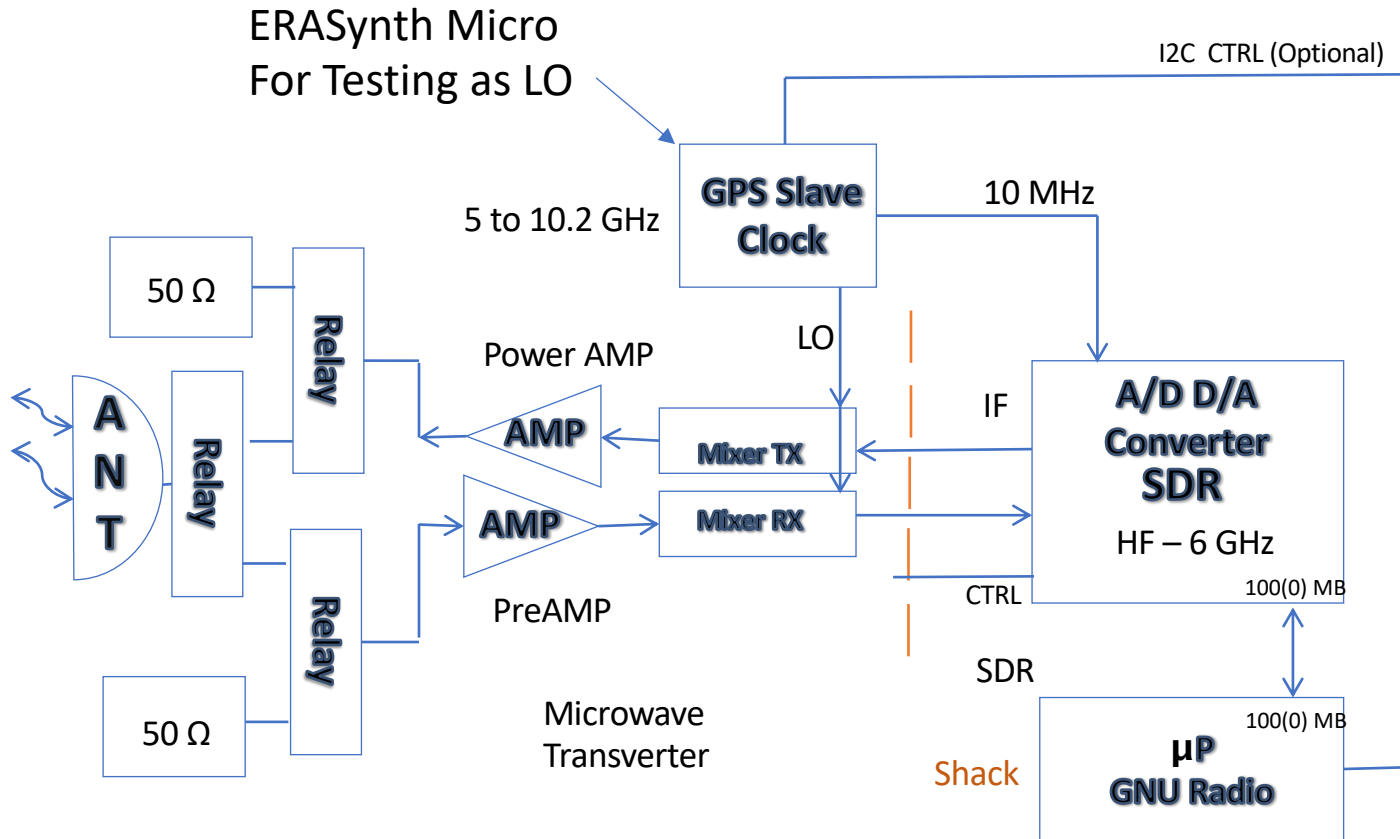
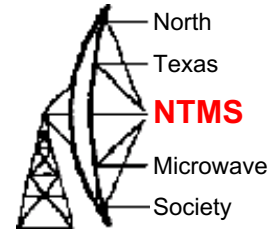
Measuring Loss vs. Frequency



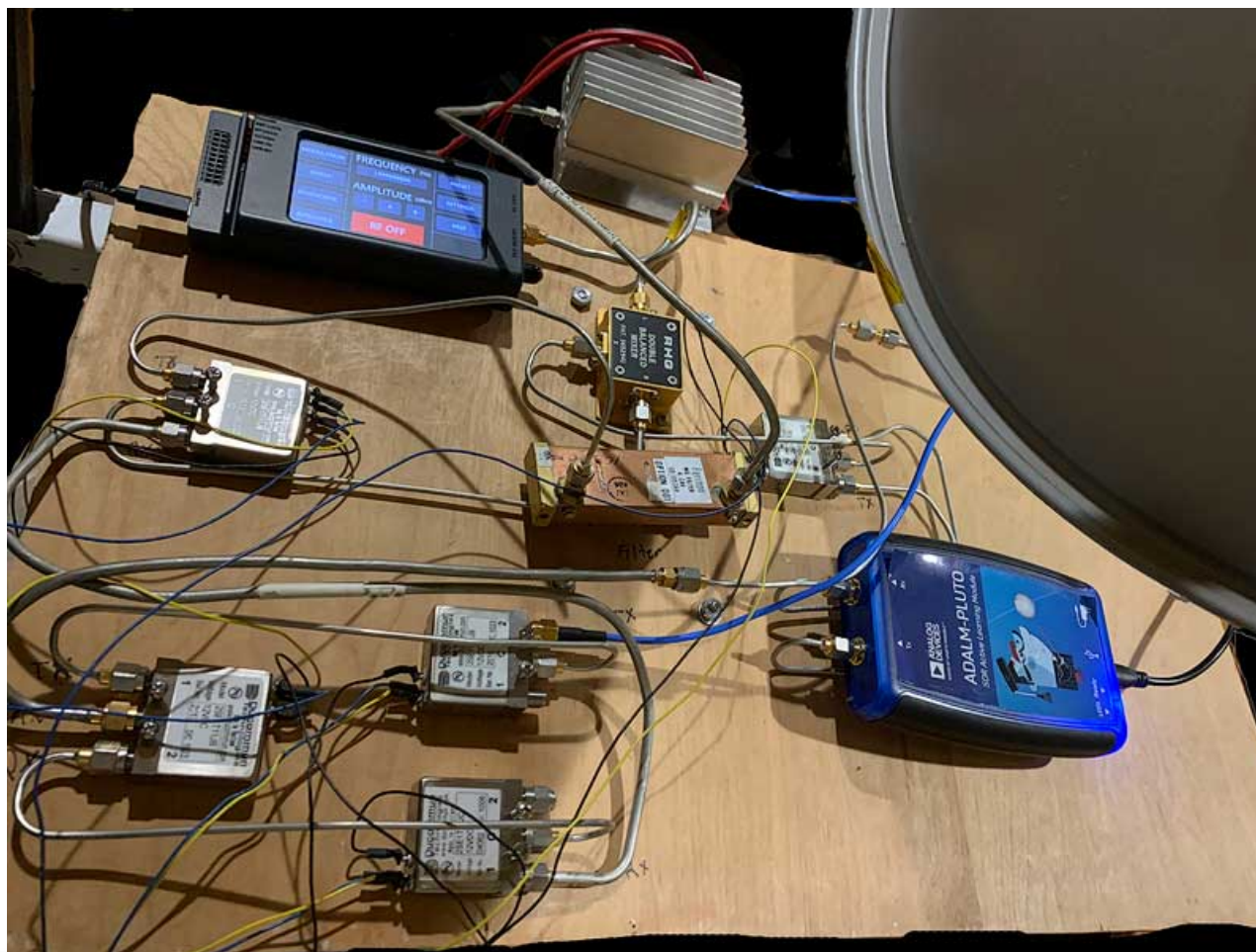
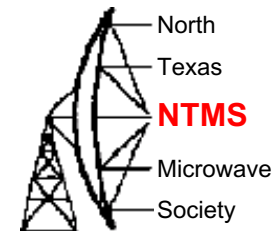
Automated Low Cost Beacon: Multiband, Multimode



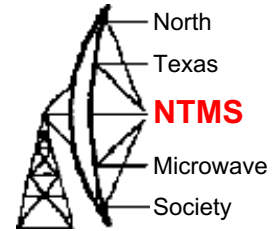
Extending Frequency Range – Microwave Applications



10 GHz Transverter Testbed Pluto Requires Linux



QRadioLink

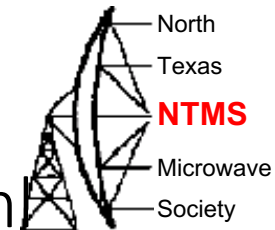


The screenshot shows the QRadioLink software interface. At the top, there are tabs for Spectrum, Base station, Link services, Geo services, Setup, and Logs. The main display area is split into two sections: a spectrum analyzer at the top and a waterfall plot below it. The spectrum analyzer shows a frequency range from 10489.540 to 10489.780 MHz with a vertical green line at 10489.720 MHz. The waterfall plot shows a signal centered at 10489.720 MHz. Below the plots are various controls: Sample rate (1000000), FFT size (131072), Peak hold, FFT Averaging, EFT (checked), Peak detect, FPS (15), AutoSq, and Mem. At the bottom, there are five knobs for Squelch (-74), Volume (50), TX gain (51), RX gain (30), and Clarifier. A central frequency display shows 10.489.720 338 MHz. To the right of the frequency display are buttons for Rev, Duplex, CTCSS, USB, FM, RX, and TX. A Last heard and Scan section is also visible.

Adrian Musceac YO8RZZ

FT8 on 2M with GNU Radio

<http://qradiolink.org/ft8-plutosdr-2meters.html>



A screenshot of a website article. The background is a dark red, textured image of a spectrum analyzer. At the top, there is a navigation menu with the following items: ARTICLES, ABOUT, DEVELOPMENT, CREDITS, DOWNLOADS, SCREENSHOTS, and SUPPORT. The main title of the article is 'FT8 with the PlutoSDR on the 2 meters band' in large white font. Below the title, it says 'By Adrian, Sun 13 January 2020, in category Amateur radio'. In the bottom right corner, there is a small icon of a speech bubble with the text 'FT8, digital modes'.

FT8 with the PlutoSDR on the 2 meters band