GNU Radio for Exploring Signals Talk Hard

A technical, historical, political, and cultural look at FM

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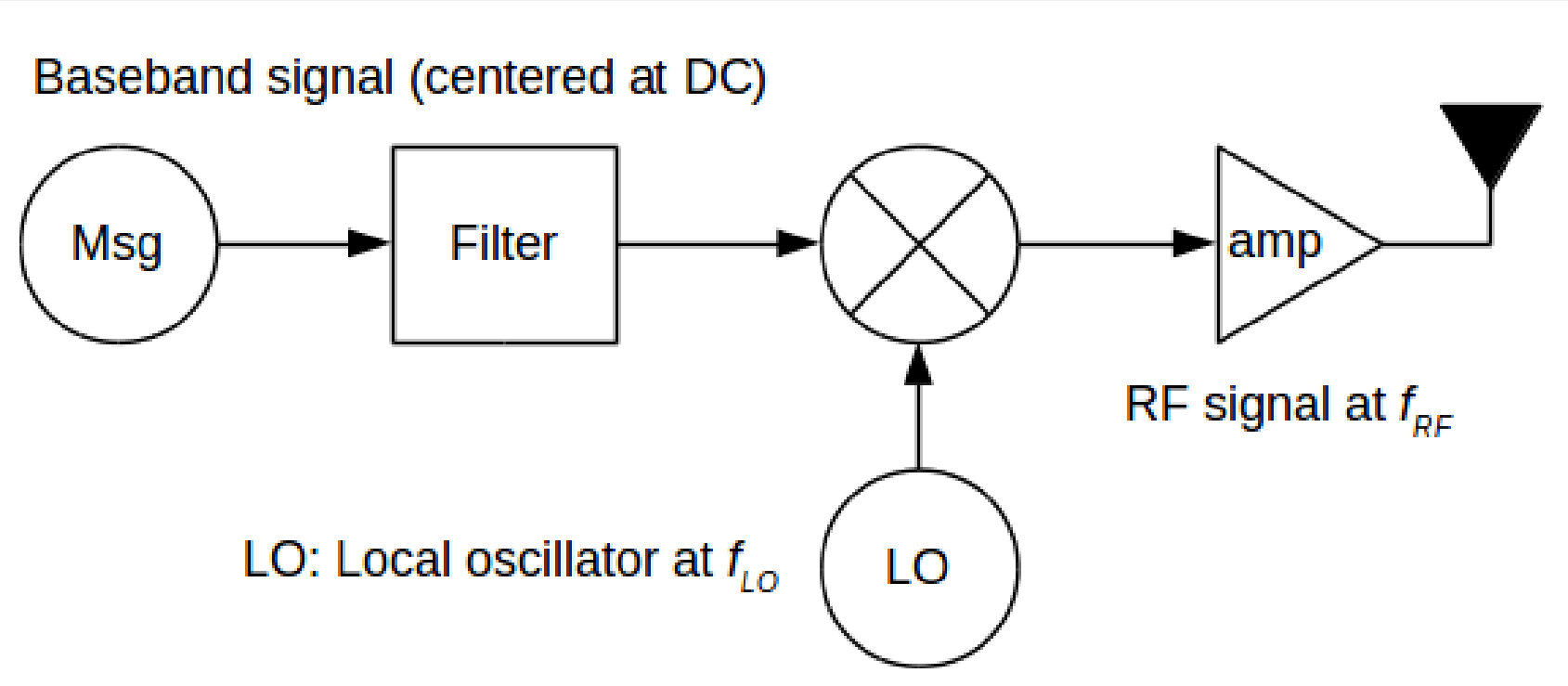
"It is proved that the frequency modulation system using a spacing or compensating wave is inferior to the amplitude variation system both as to the width of the frequency band occupied and as to distortion of signal wave form."

- John R. Carson, "Notes on the Theory of Modulation"

Amplitude Modulation

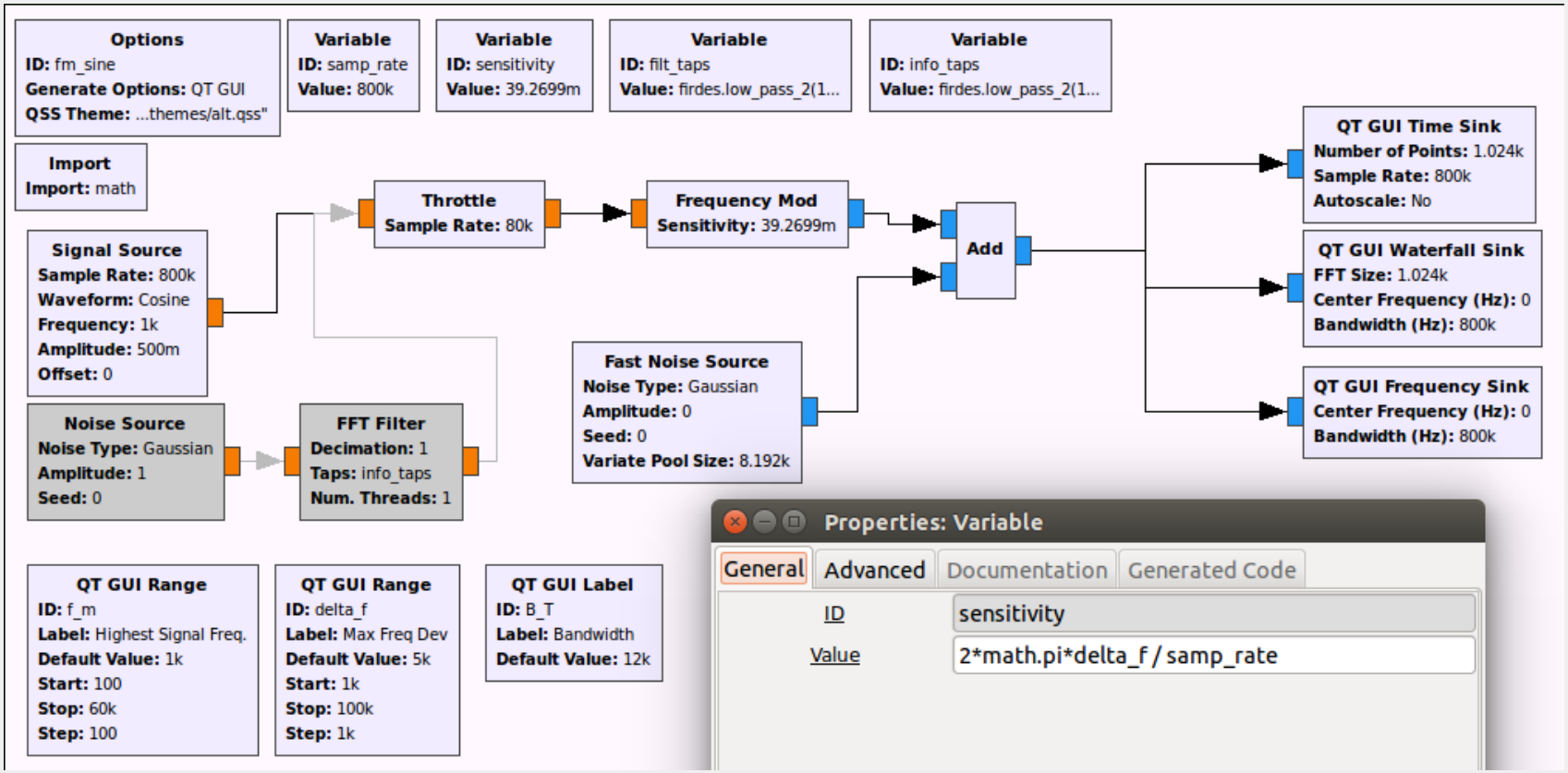


"This superiority will increase as methods of dealing with ignition noise, either at its source or at the receiver, are improved"

- Edwin H. Armstrong, "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation"

E. H. ARMSTRONG
The discoverer of the "feed-back" circuit, in the uniform of a major in the Signal Corps during the war

FMing a Sine Wave



Frequency Modulation:

Continuous Time

$$y(t) = cos\left(2\pi f_\Delta \int_0^t x(\tau)d\tau\right)$$

Discrete Time

$$y[n] = cos\left(2\pi \frac{f_\Delta}{f_s} \sum x[n]\right)$$

$$y[n] = cos\left(\eta \sum x[n]\right), \quad \eta = 2\pi \frac{f_\Delta}{f_s}$$

We call η the *sensativity*.

Bessel Functions!

WAT!

No, let's skip that.

Ok, good.

More practically speaking, what's the signal bandwidth?

Definitions – Assumes sinusoid input

- f_Δ: maximum frequency deviation from the carrier
- f_m: the highest frequency component in the original signal

Carson's Rule

$$B_T = 2(f_\Delta + f_m)$$

Generally assumed to under-represent the signal bandwidth

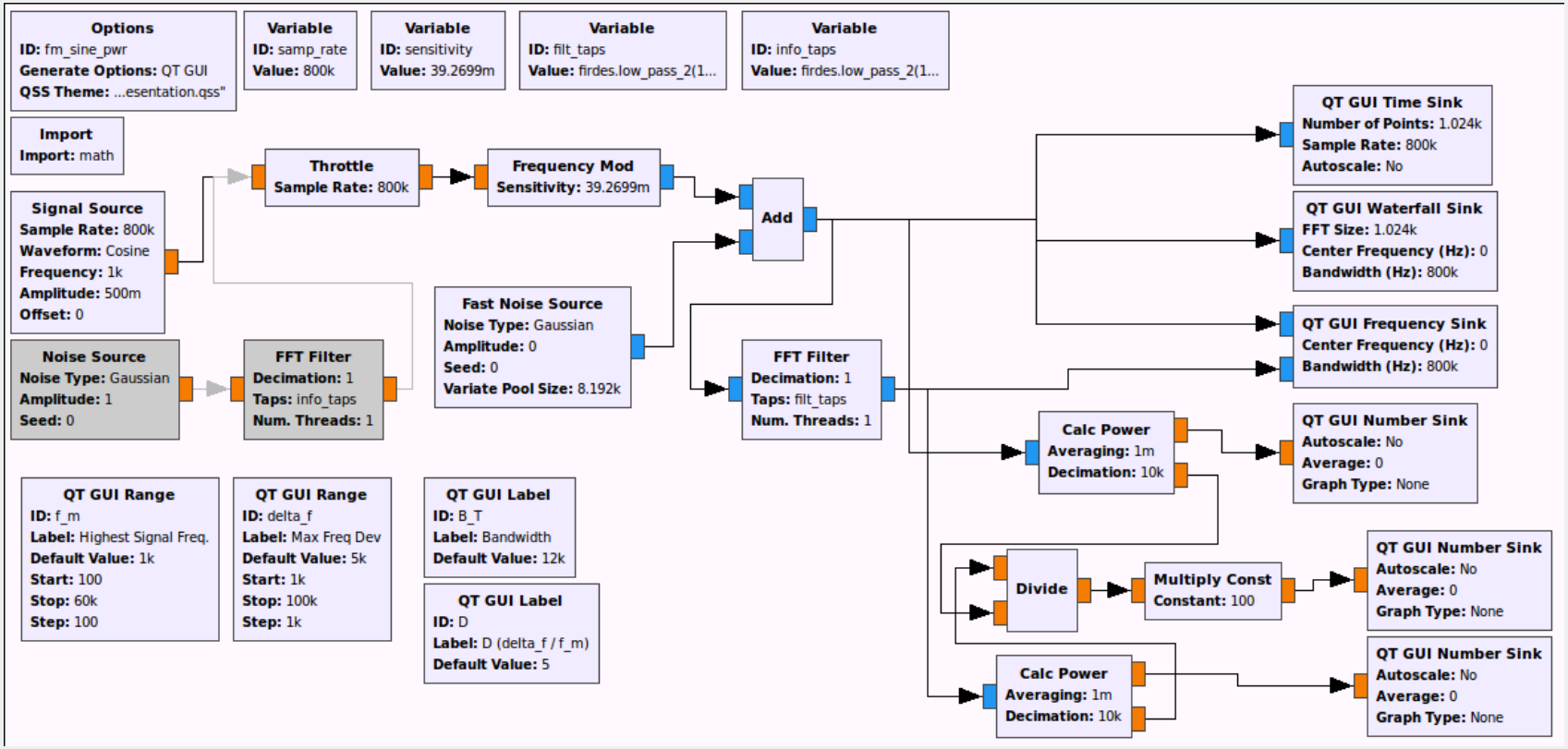
Carlson's Rule

$$B_T = 2(f_\Delta + 2f_m)$$

More realistic calculation of the bandwidth

What's the practical difference?

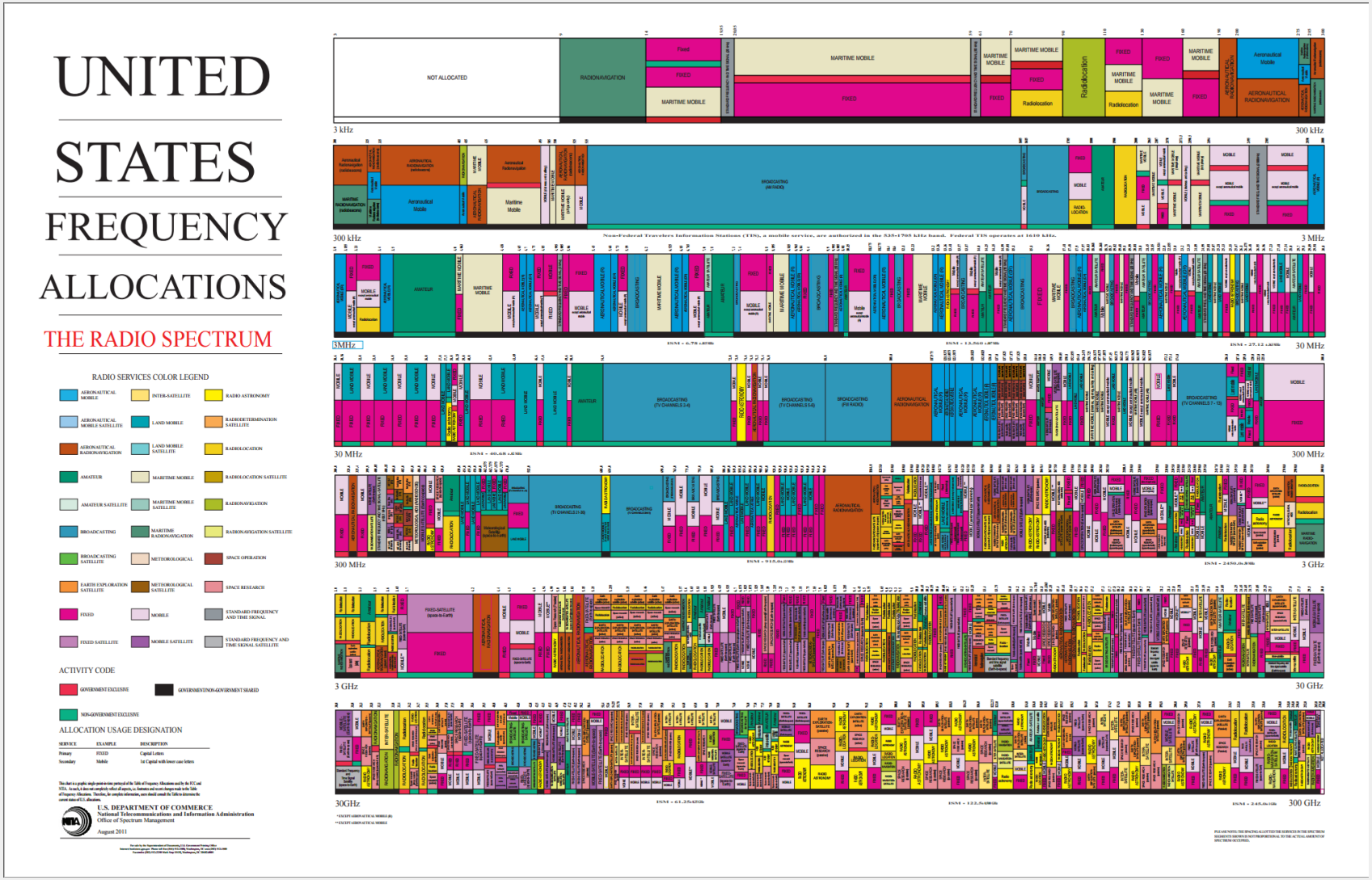
Filter to the bandwidth of the different rules



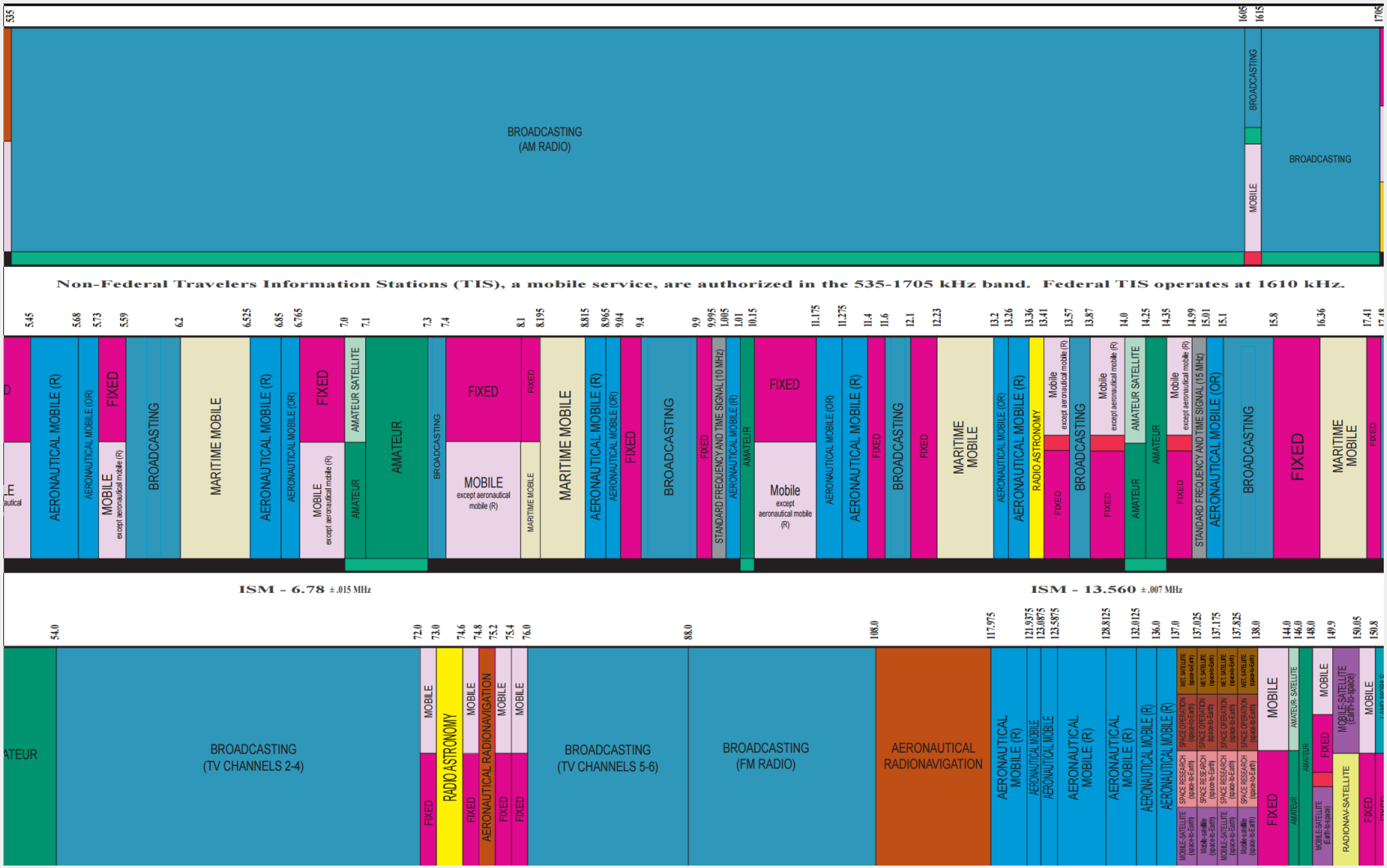
"The thrill, believe me, is as much in the battle as in the victory."

- David Sarnoff

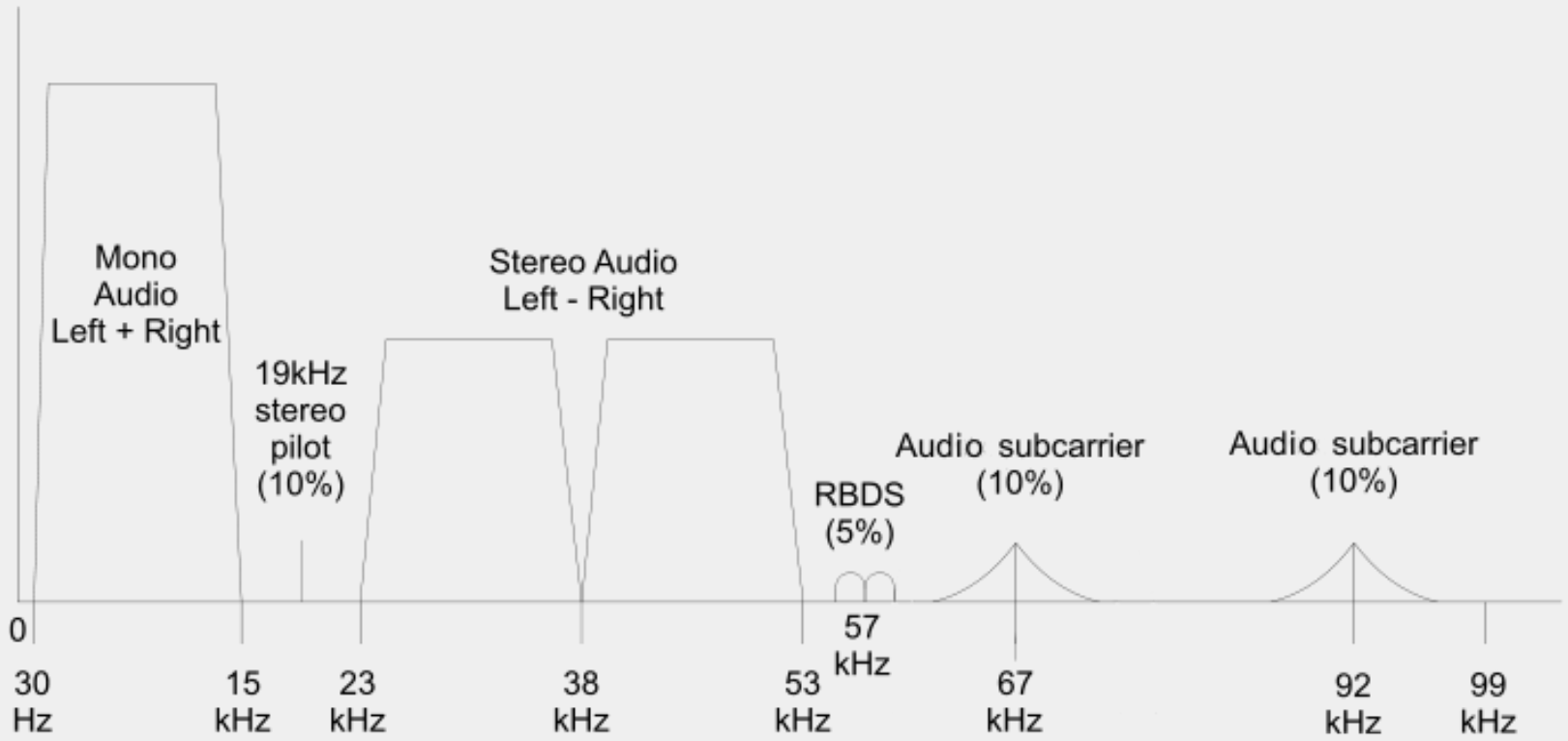
Spectrum Allocation



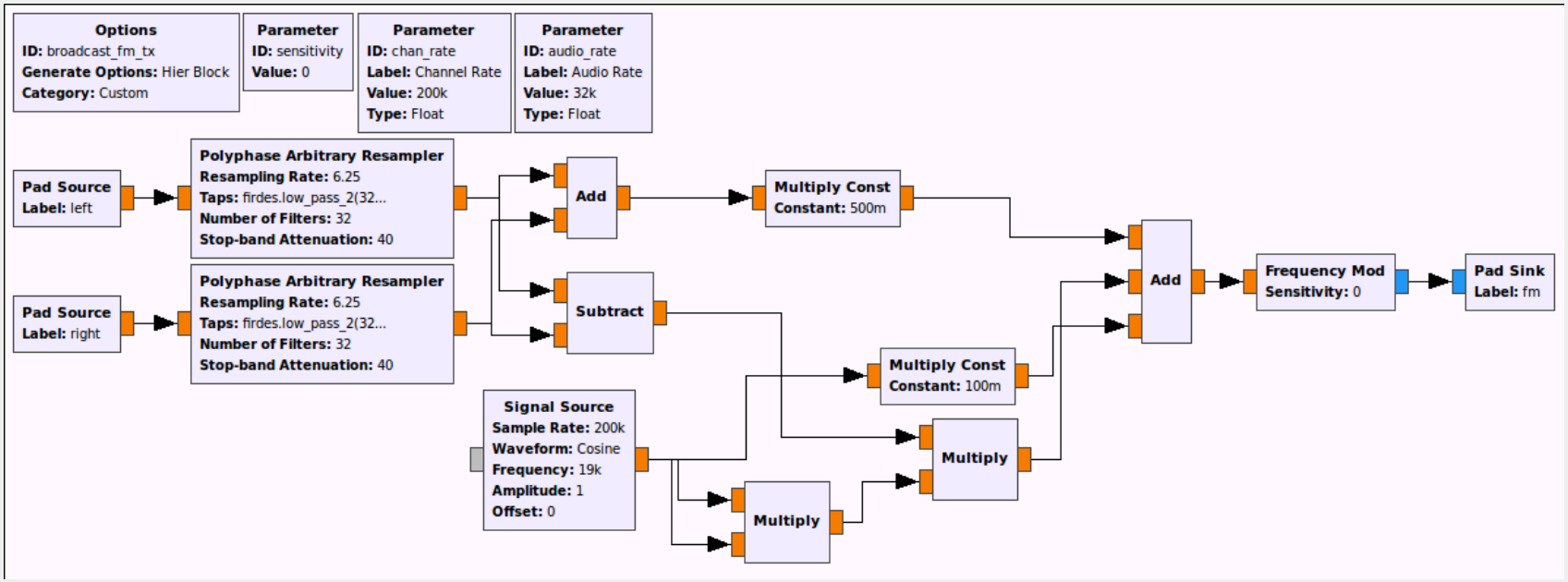
AM and FM Bands



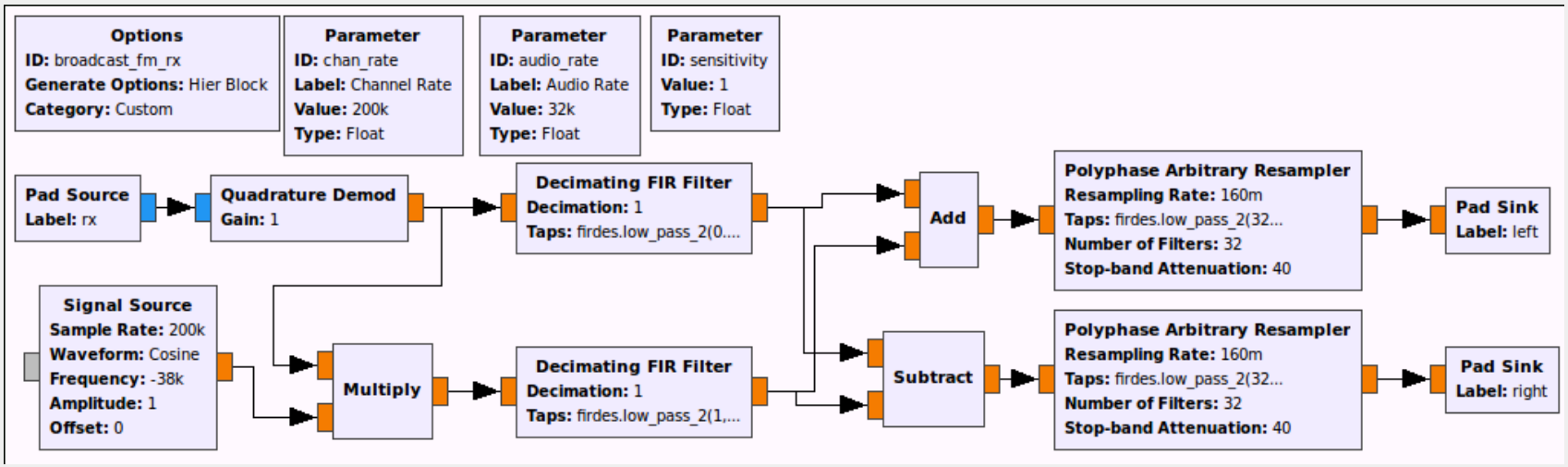
FM Spectrum and Information Composition



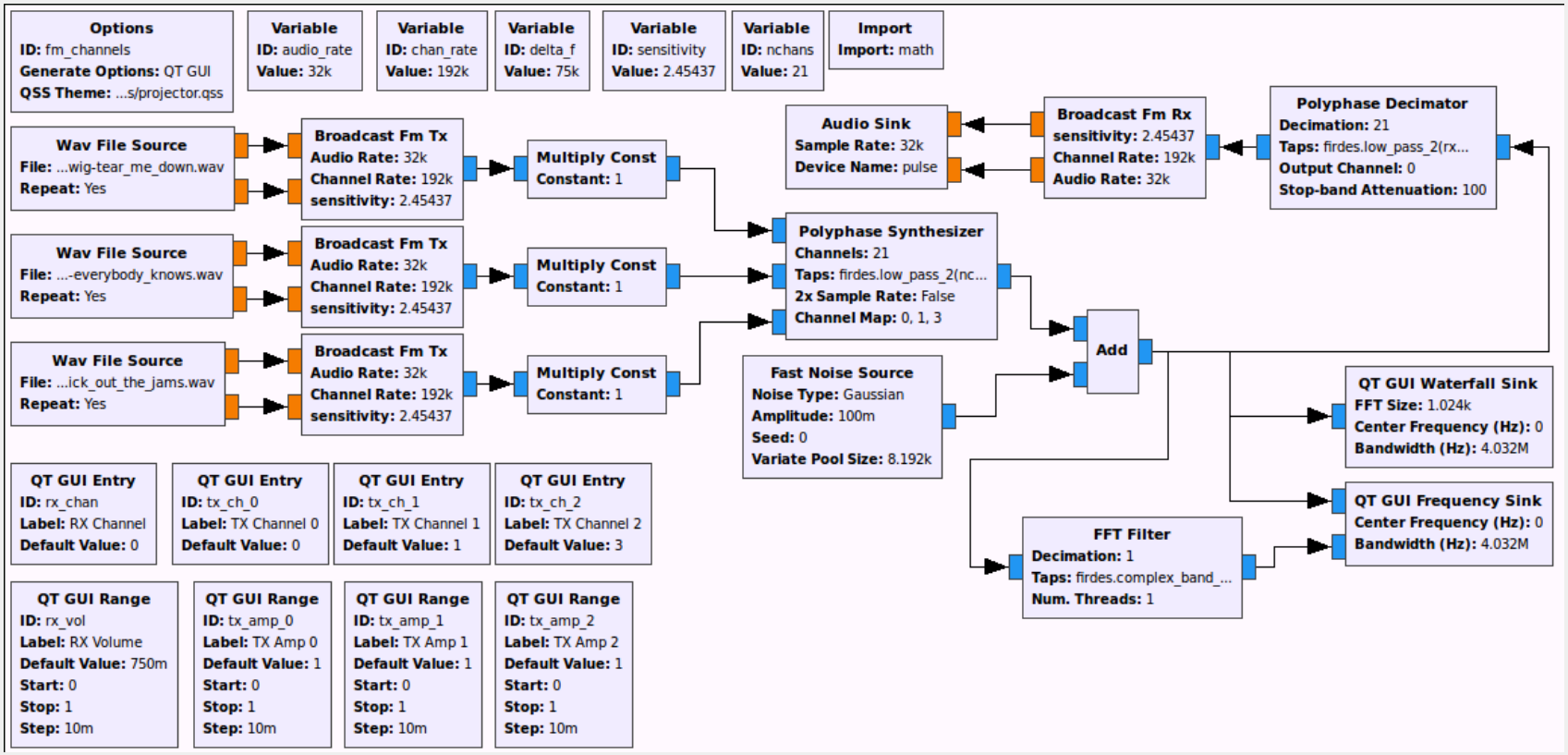
Modulating Stereo FM



Demodulating Stereo FM

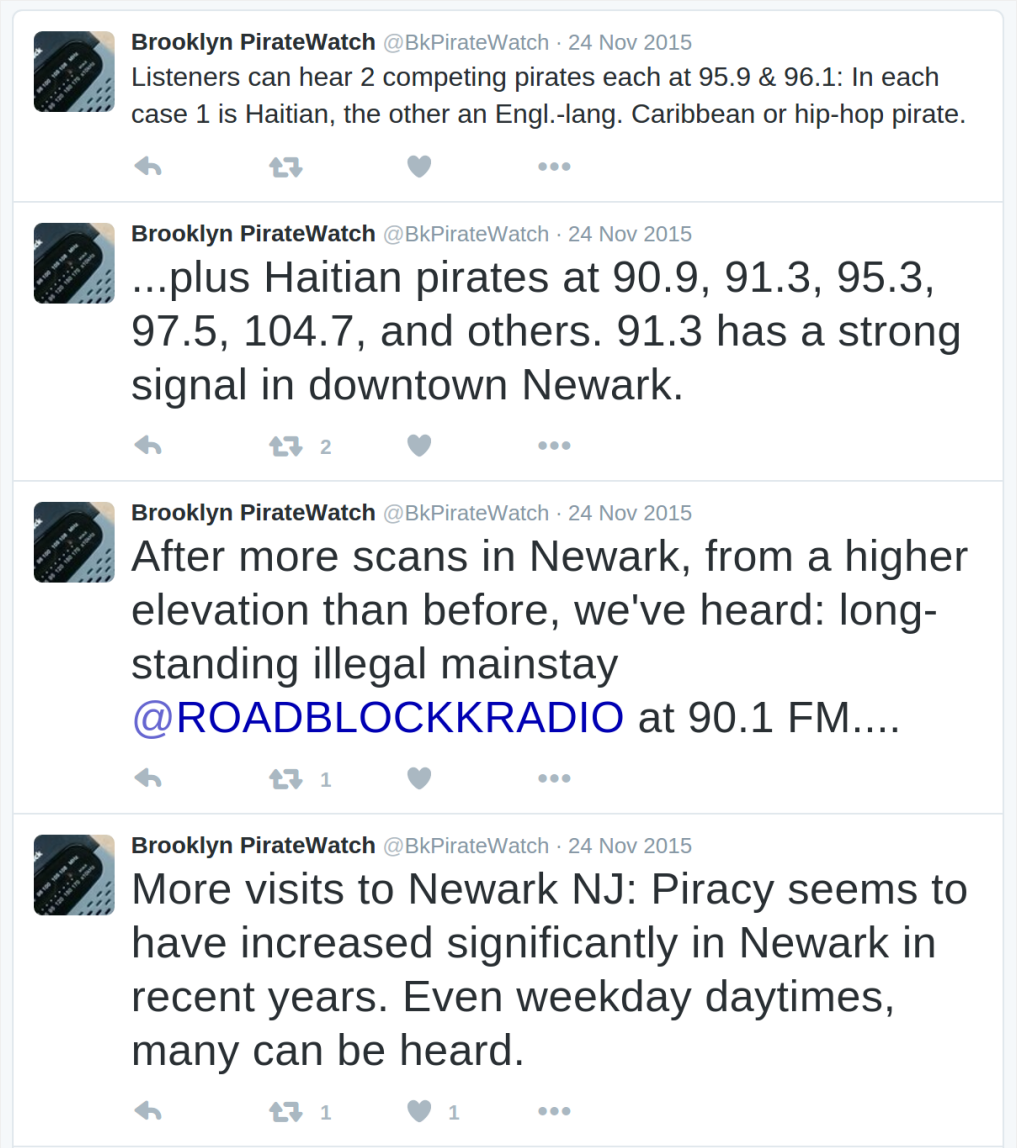


Channelizing FM



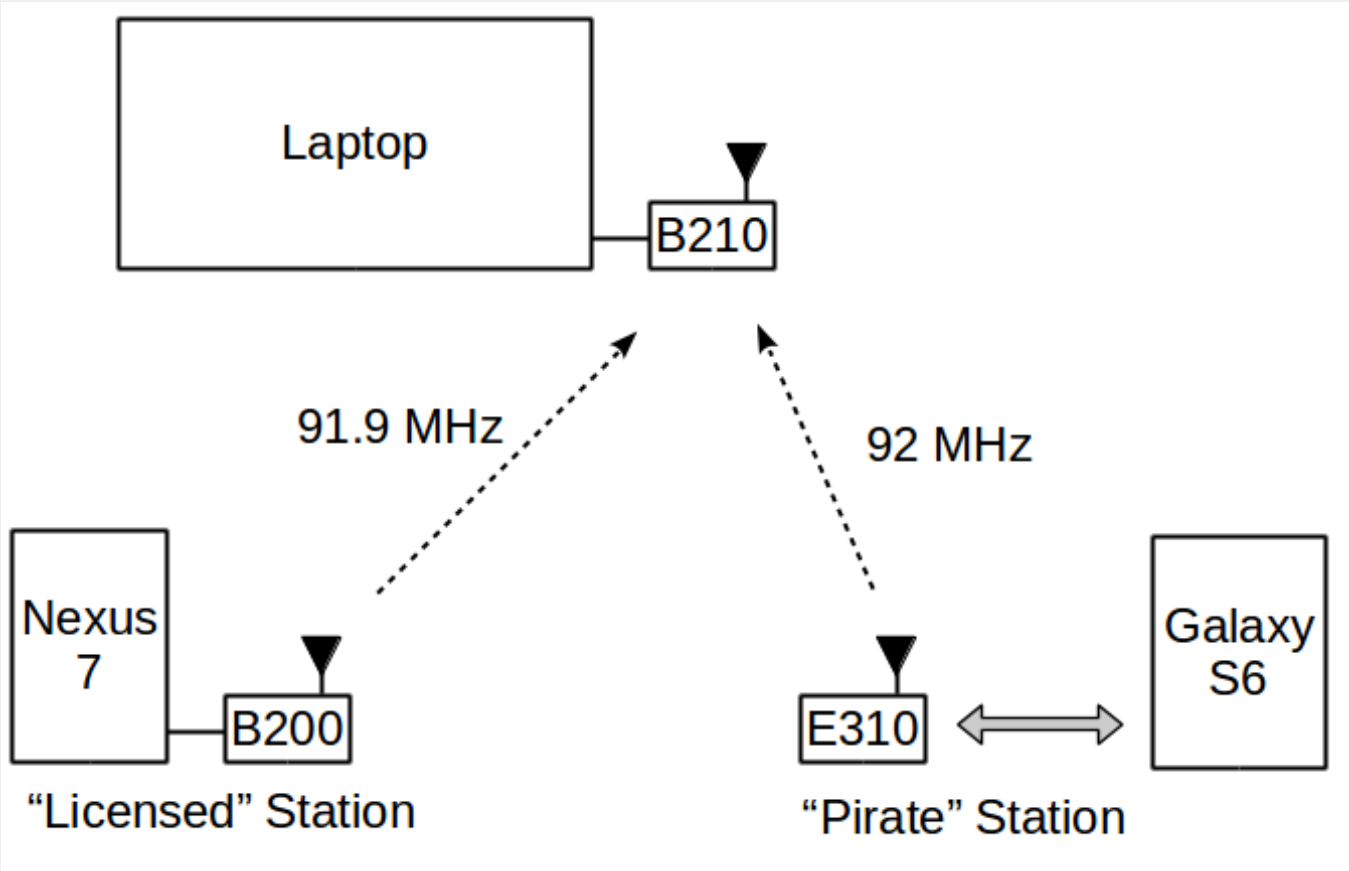
"Welcome to radio free America."
- Happy Harry Hardon (Christian Slater), *Pump Up the Volume*

Pirates on the airwaves



What's the issue?

- High demand for spectrum.
- Interference and the FM Capture Effect.



Questions?

So be it.