A Historical Introduction to GNU Radio

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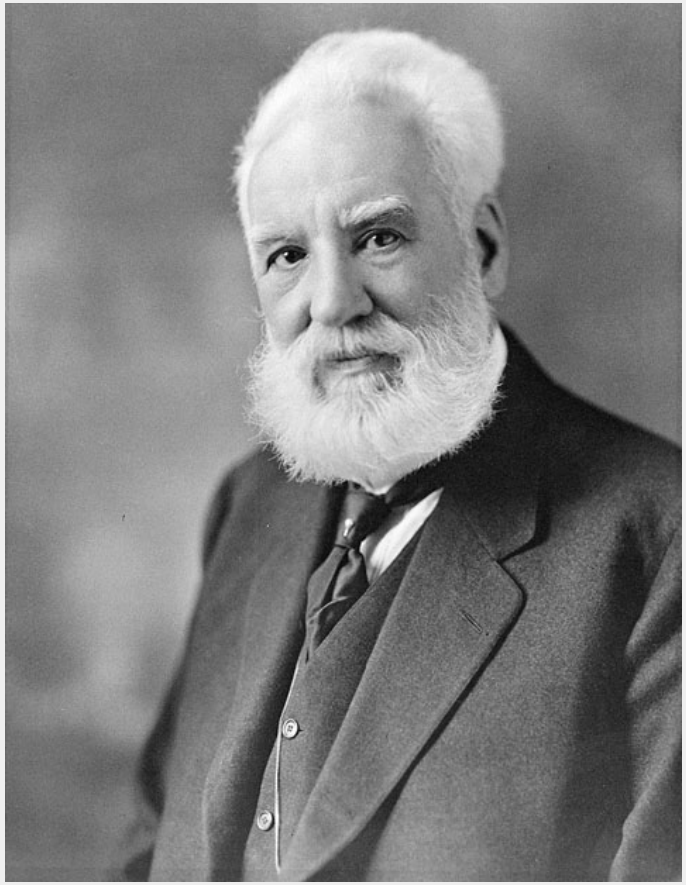
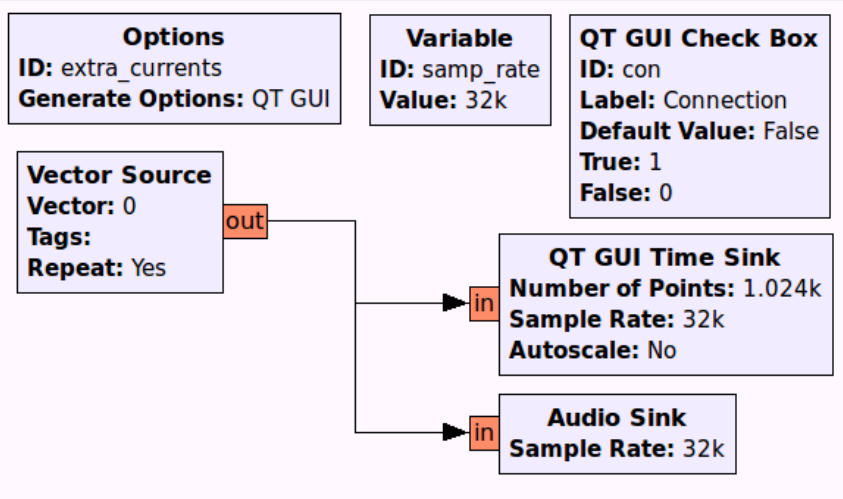
"Mr. Watson – Come here – I want to see you."

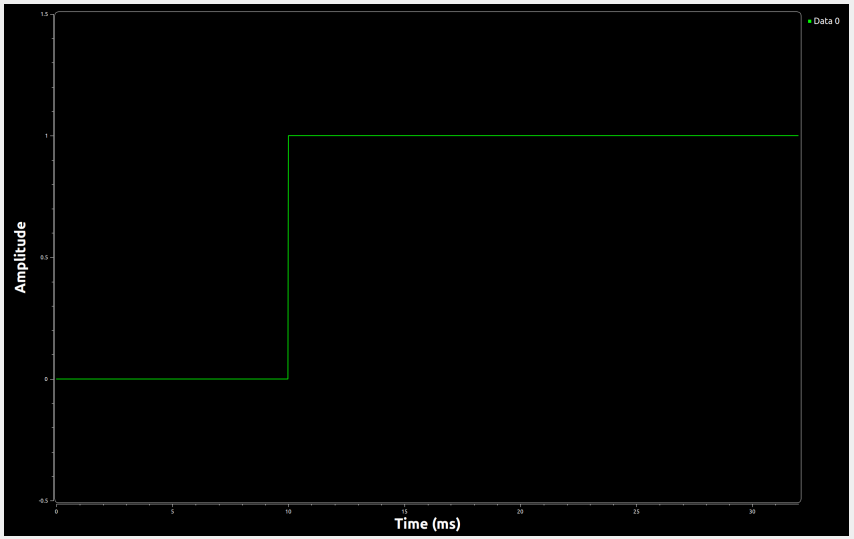
- Alexander Graham Bell



Some Early Inspiration: Circuit-switching "extra currents"

Beginning to Understand Radio Waves

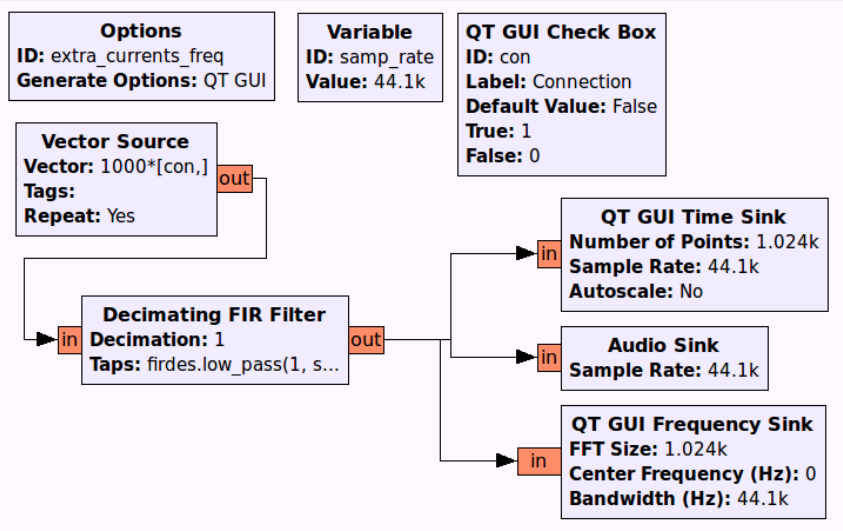


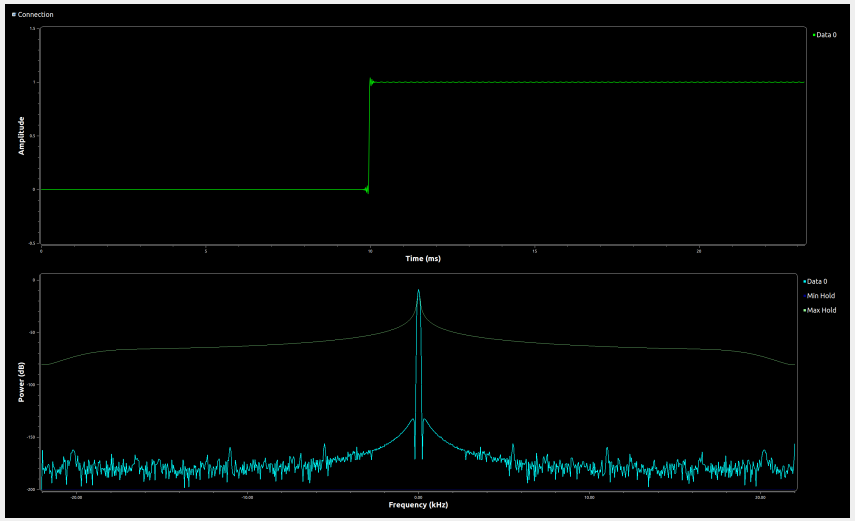


$$G(f) = \int_{-\infty}^{\infty} g(t)e^{-j2\pi ft}$$

- Joseph Fourier

Knowing the Frequency Domain

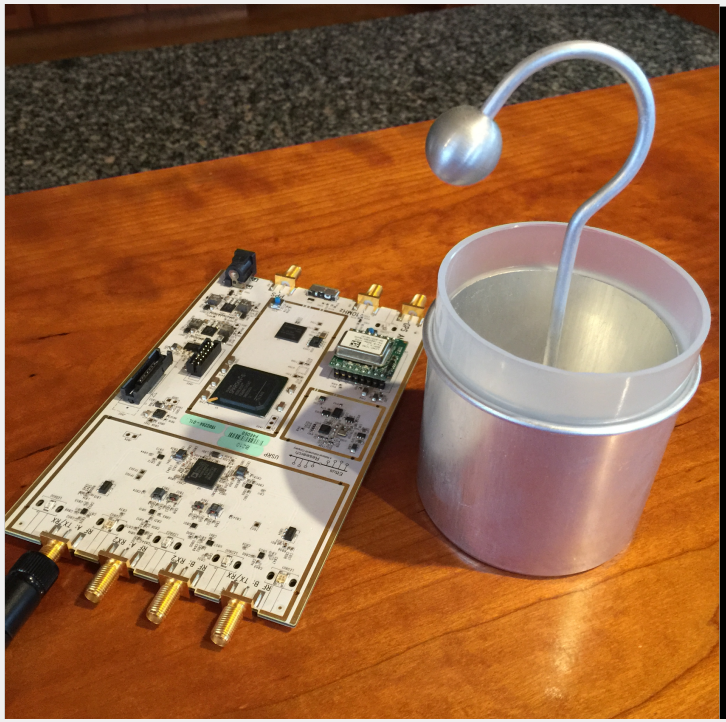


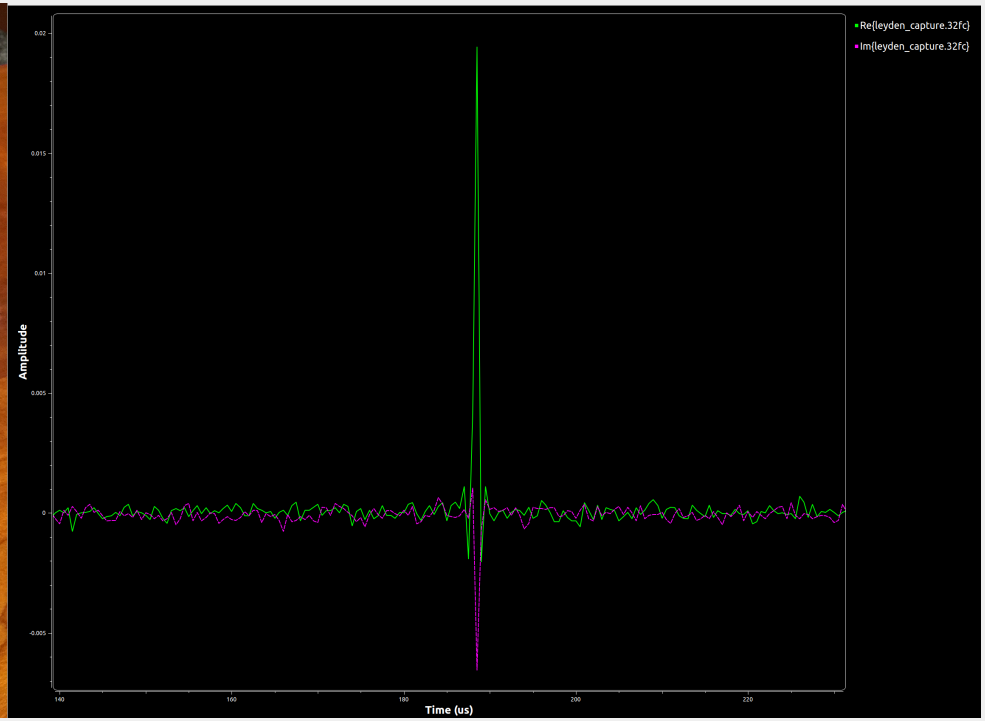


$$\nabla \times E = -\frac{\partial B}{\partial t}$$

- James Clerk Maxwell

Experimenting with Leyden jars to capture static electric sparks

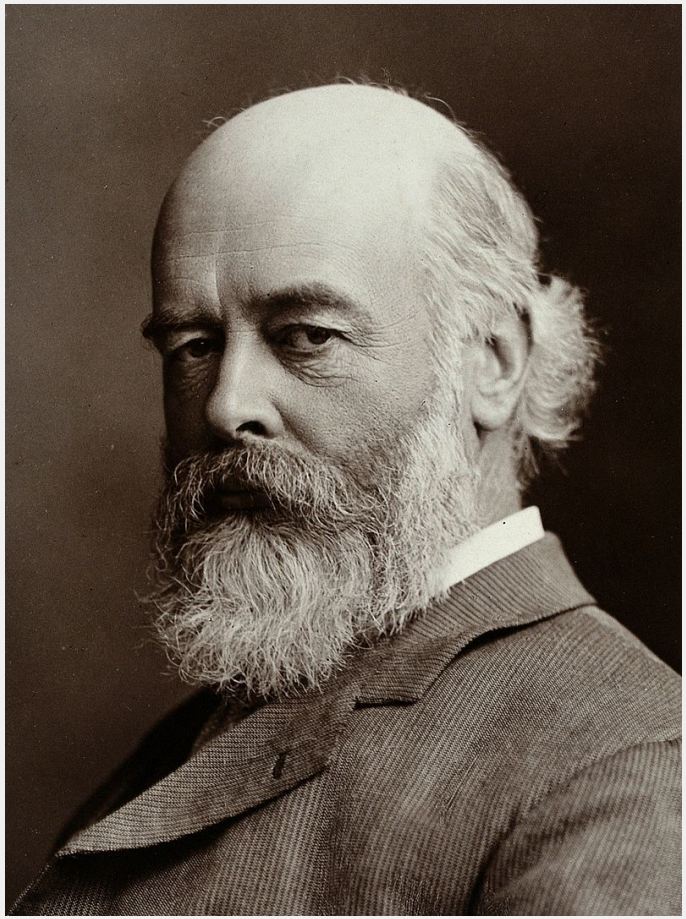




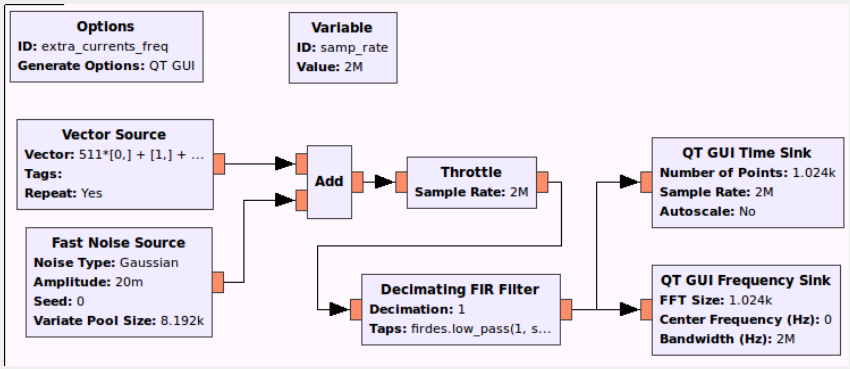
- Makes for a short impulse, captured here at 190 MHz with 2 MHz bandwidth.
- Too little energy to easily see in FFT.

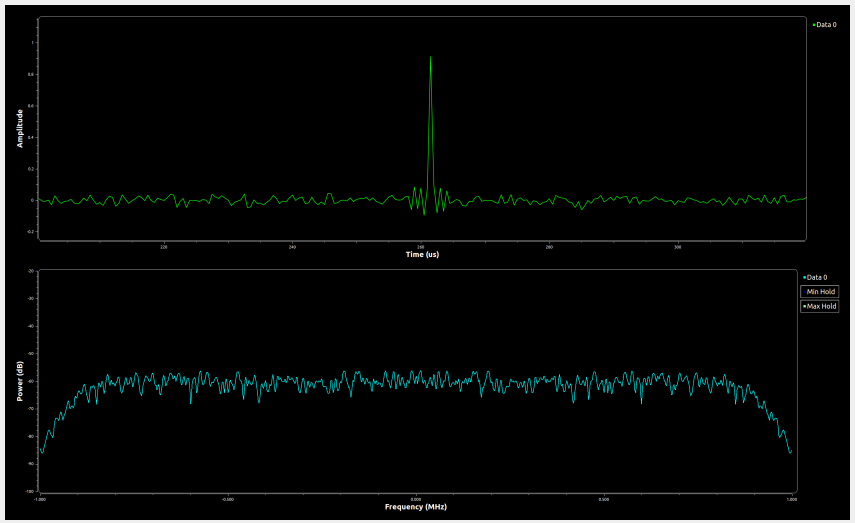
"It is, in fact, ridiculously easy to produce the waves; the difficulty was to find the evidence."

- Oliver Lodge



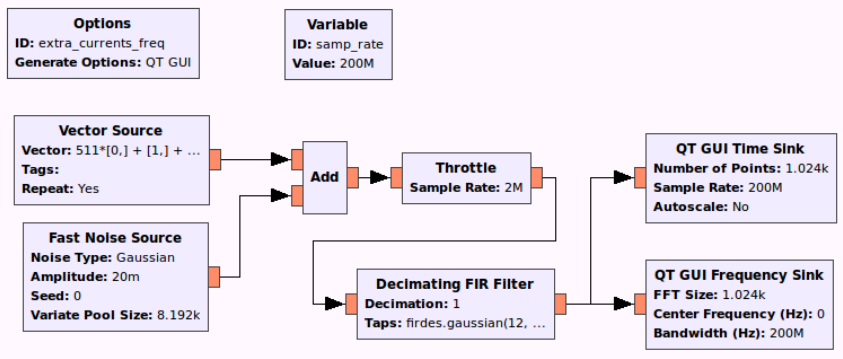
If we can create these impulses, how do we receive them?



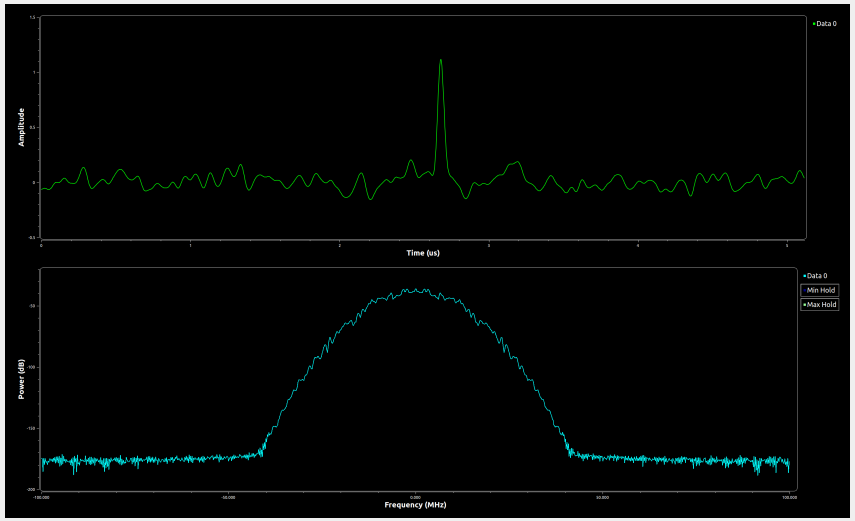


- Create a band-limited impulse via filtering.
- Because everything is band-limited.

Take a truly band-limited signal



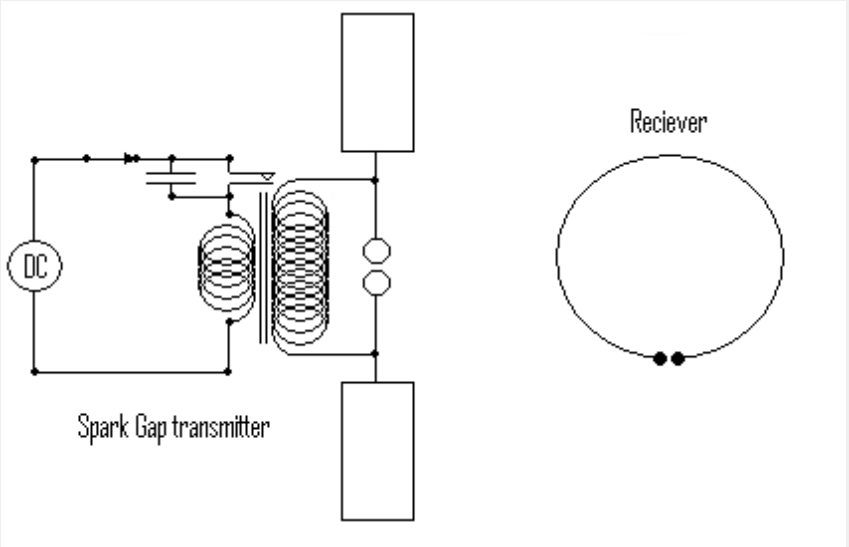
- 200 MHz spectrum
- Using Gaussian filter of 1/8 spectrum
- The “trick” is to sample this energy



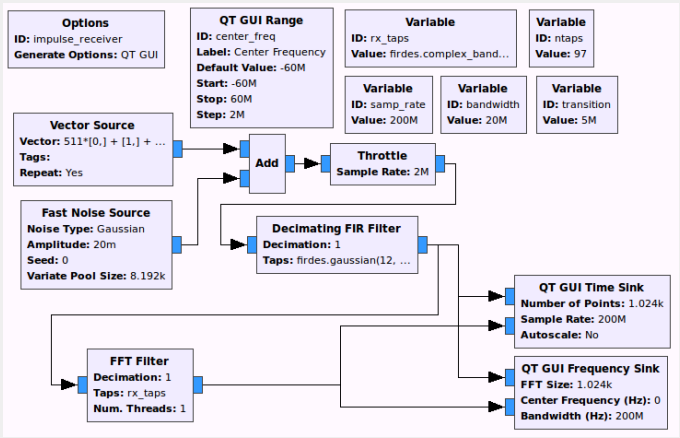
"Nothing, I guess."
- Heinrich Hertz

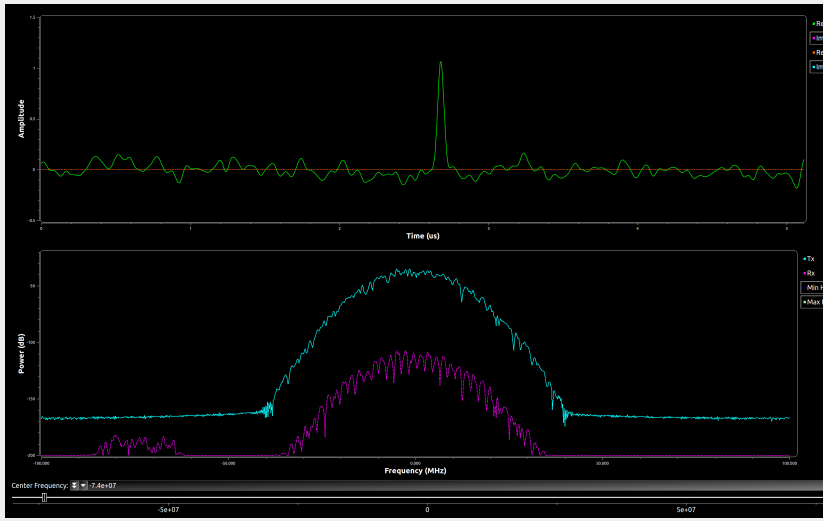
The Hertz setup: signals at ~ 100 MHz

- Wideband impulse... but...
- The transmission apparatus resonates and acts as a filter.
- The receiver loop antenna is also a filter with resonance at a certain frequency.



Let's receive our impulse by "tuning" our antenna

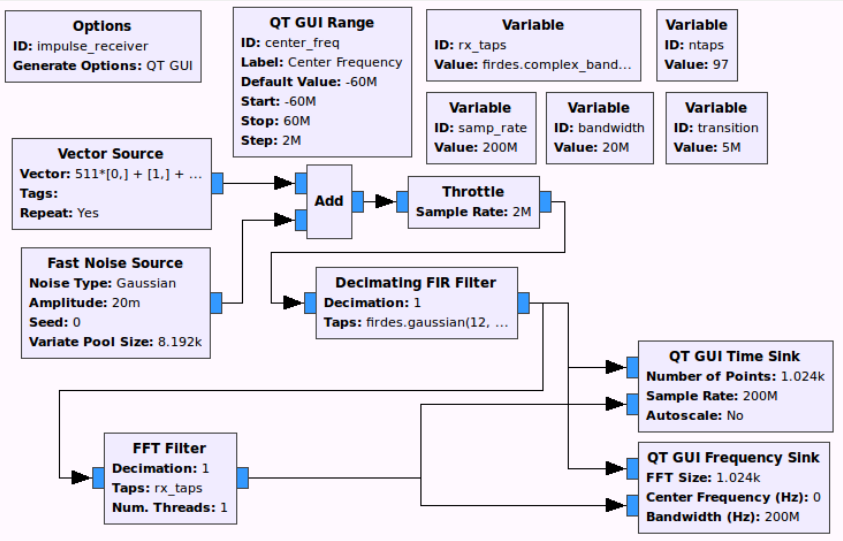


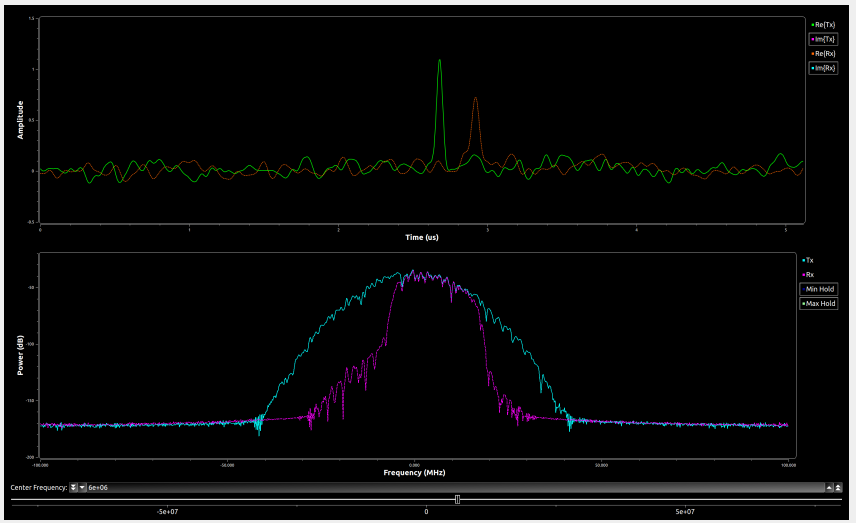


- QT GUI Range to adjust the filter's center frequency.
- Adjusting it across the band picks up more or less energy.
- The trick is to know what is being transmitted where.
- Mistuned, we receive nothing.

Let's receive our impulse by "tuning" our antenna

firdes.complex_band_pass(1, fs, fc-bw/2, fc+bw/2, tb)

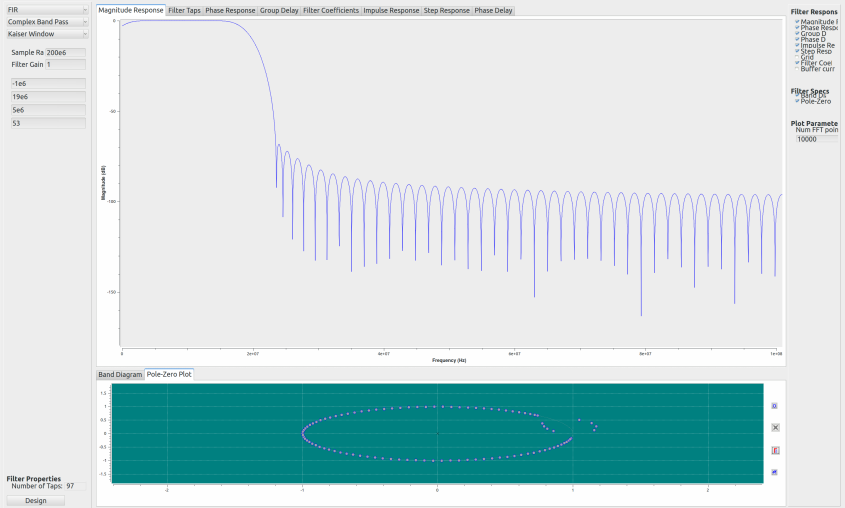




- GR's filter tools to create the filter.
- fc is adjusted by Range variable.
- bw (20 MHz) and tb (5 MHz) are constant in this application.
- Tuning near the right place gets us some energy.

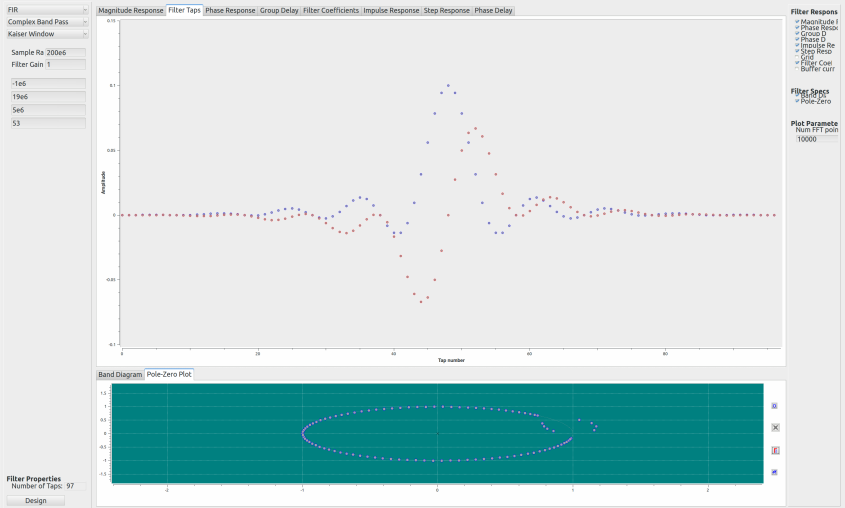
Experimenting with Filters

- GNU Radio's **gr_filter_design** tool.
- Or in GRC: Tools -> Filter Design Tool.
- Make standard filters for lowpass, high pass, bandpass, band reject, Gaussian, and RRC filters.
- Windowed filters or using PM method.
- Also limited support for IIR filter design.



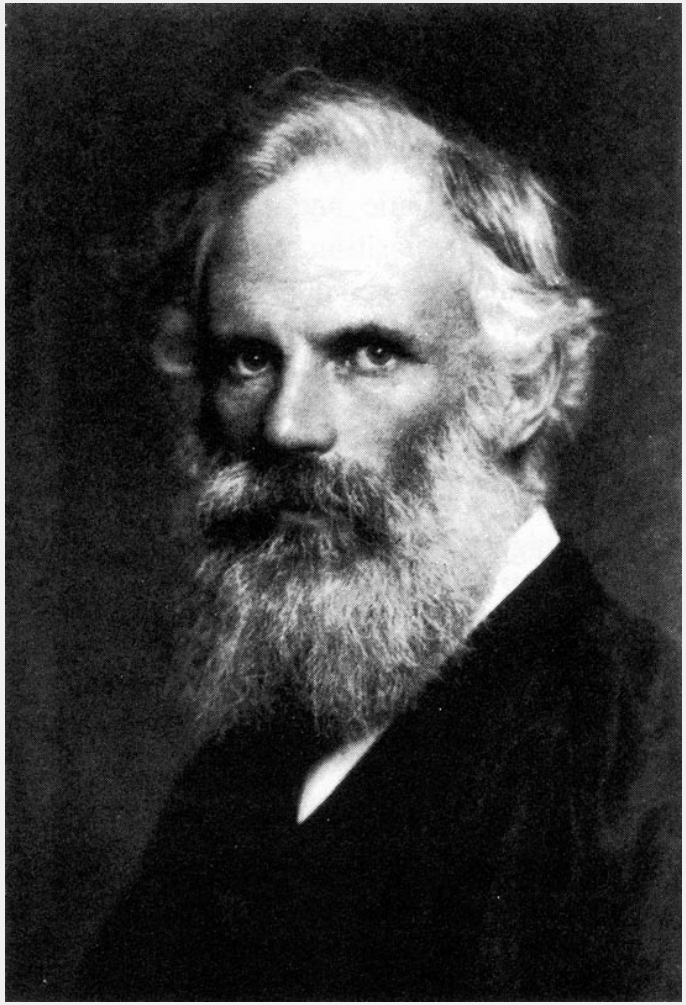
Experimenting with Filters

- Play around with different parameters.
- Optimize filter response for shape vs. number of taps.
- Change window and design methods for different behaviors.
- Observe the response in different domains (freq, time, phase, etc.).
- Save and open filters as CSV for easy storage and reuse.

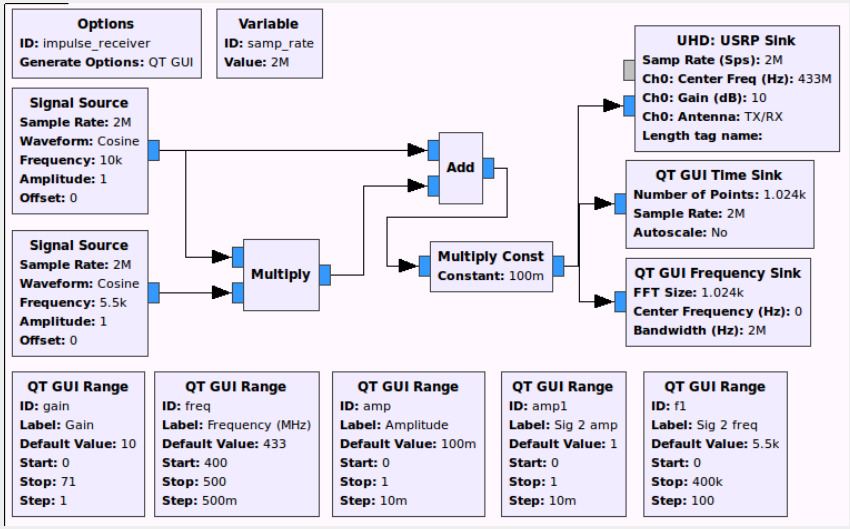


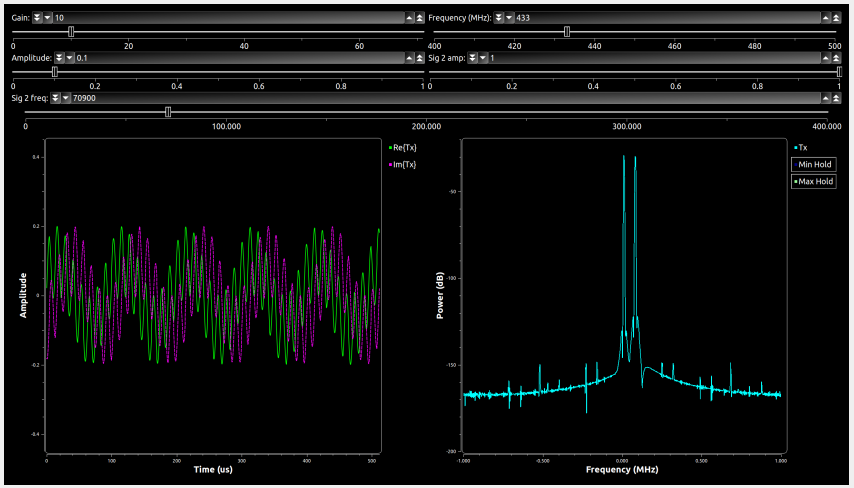
"The cultivation and training of the practical ability to do things and to learn from observation, experiment and measurement, is a part of education... which the doctor and the engineer can only neglect at their own peril and that of those who employ them."

- George Fitzgerald



Connecting GNU Radio to Hardware

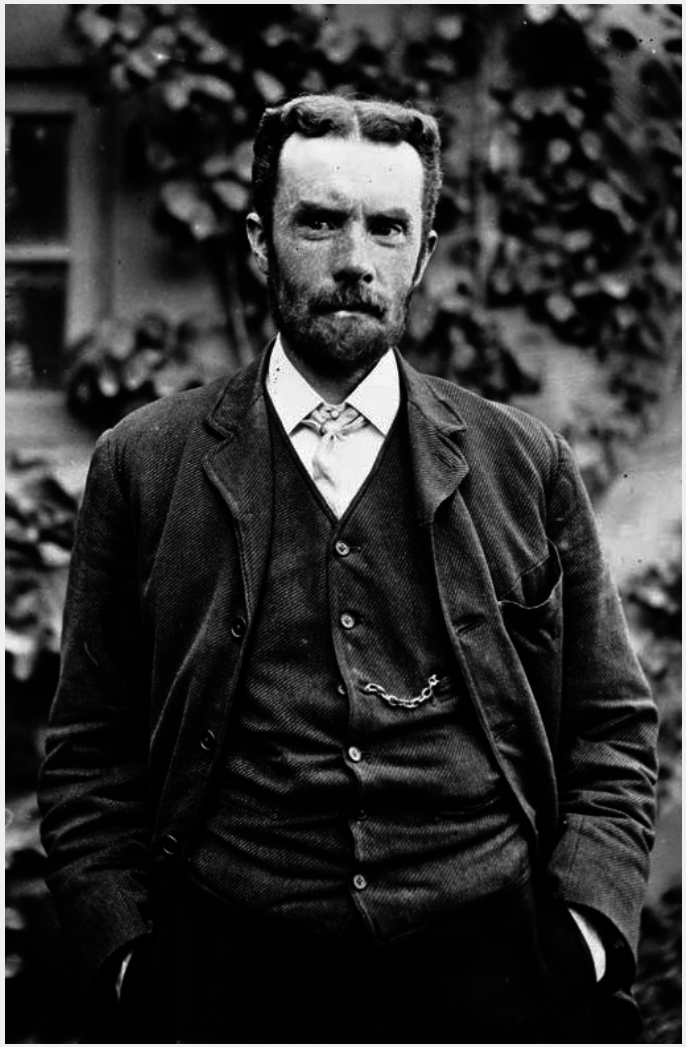




- Connect the hardware sink (UHD here).
- Added QT Range sliders to adjust frequency and gain.
- Removed throttle – already have rate control!

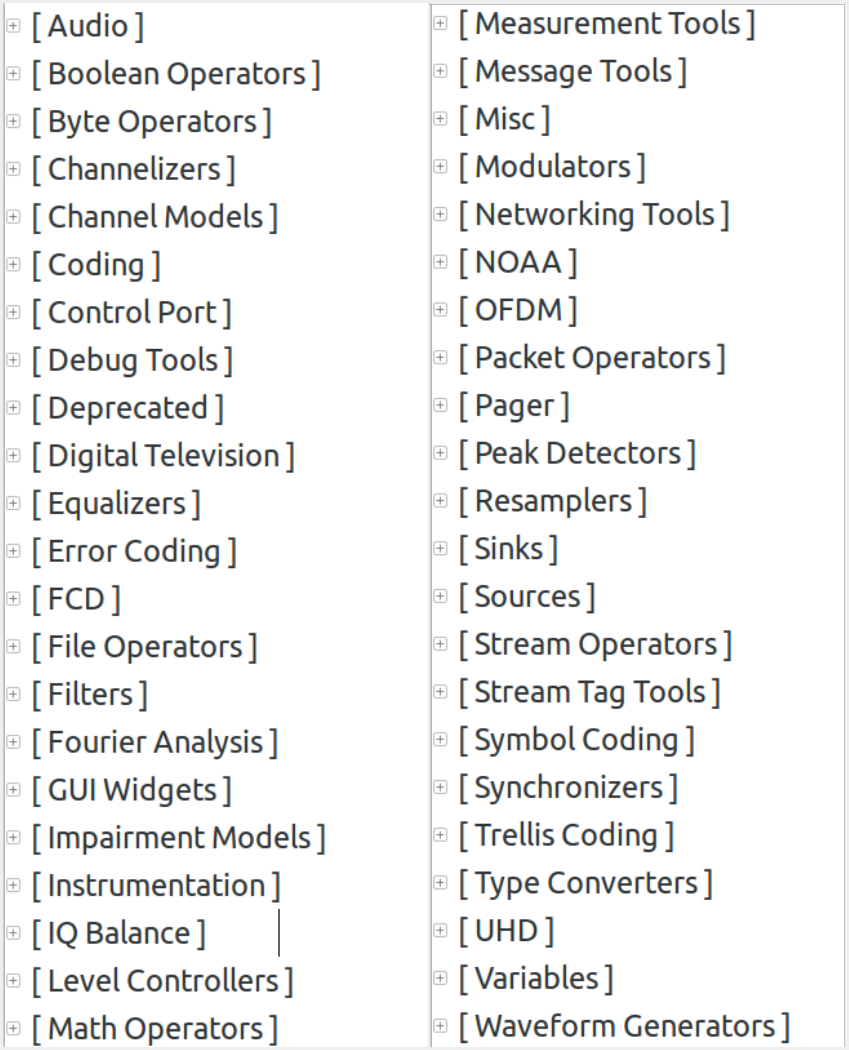
"Am I to refuse to eat because I do not fully understand the mechanism of digestion?"

- Oliver Heaviside



The scope of GNU Radio is rather large

- Many blocks for fundamental signal processing algorithms.
- Highly-tuned performance.
- not all algorithms available.
- Out-of-Tree project model is very important.
- Develop your own set of blocks.
- Standard model for building OOT projects.
- PyBOMBS: gnuradio.org/pybombs



For more, follow our Tutorials

- Tutorials on gnuradio.org
- Guided tutorials for basics and building our own blocks.
- Guides for how to set up and configure an OOT module.
- Working with advanced features like VOLK and stream tags.
- Other topics for helping you work with the project.
- gnuradio.org/doc/doxygen