Design of a 1420 MHz Bandpass Filter for Radio Astronomy

By: Logan Spooner, Shantanu Chakraborty

Outline

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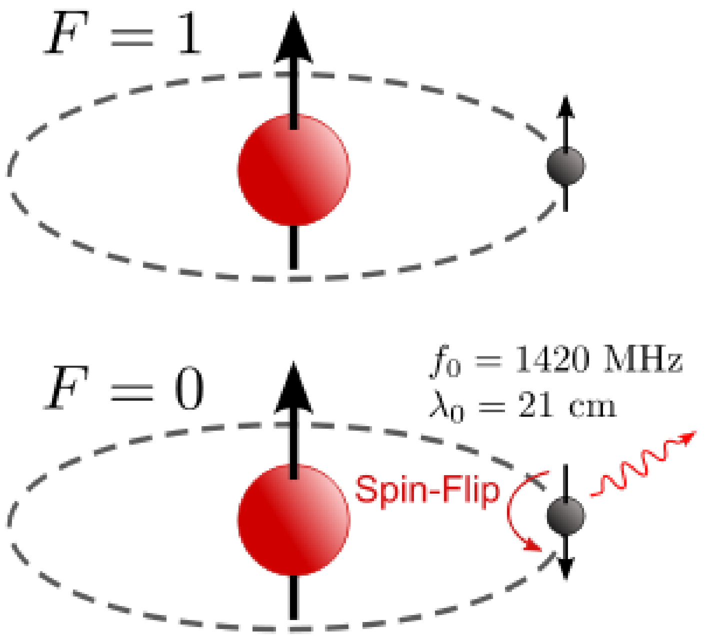
- Methods
- Design and Simulation
- Construction
- Testing and Results
- Use in Software Defined Radio

Background and Premise

- 21 cm wavelength radiation emitted by cold Hydrogen Clouds
  - Cold Hydrogen is that which makes up most of the Inter Stellar Medium (ISM)
- Background noise can hinder the detection of this signal, especially for amateur astronomers.
- Our goal was to create an efficient bandpass filter to reduce this background noise using a microstrip structure.



Methods

- Design: Sonnet EM Simulation Software
- Material:
  - FR-4 (PCB material)
  - Copper Tape
  - Precision knife
- Analysis:
  - Used Sonnet to analyze designed BPF
  - Used VNA to analyze constructed BPF

Effective Dielectric Constant:

[1] $\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{10h}{w}\right)^{-1/2} + 0.468\frac{\varepsilon_r+0.5}{1.5}\sqrt{\frac{t}{w}}$

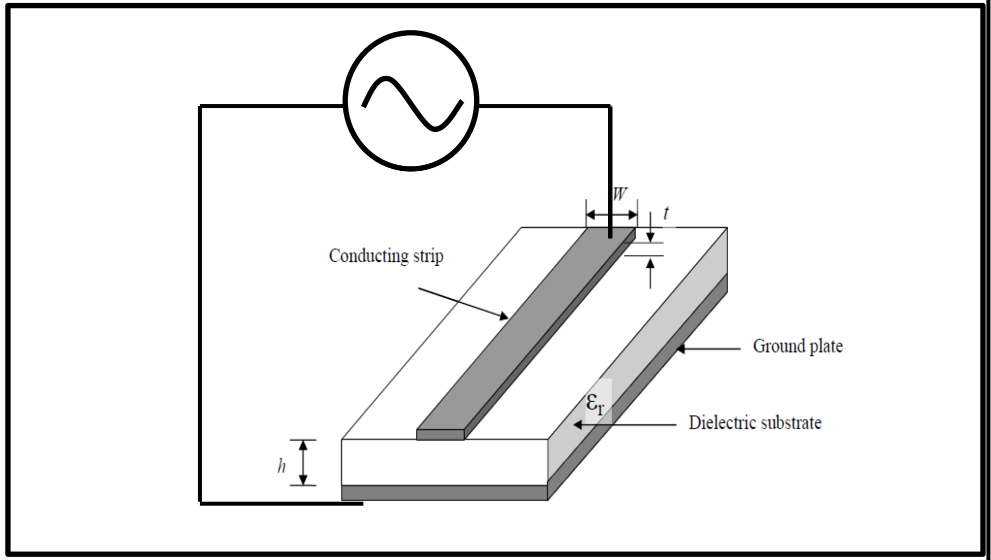
w= 1.3mm

t=0.03mm

h=1.6mm

$\varepsilon_r \approx 4.4$

$\varepsilon_{eff} \approx 3.4$



Effective Wavelength:

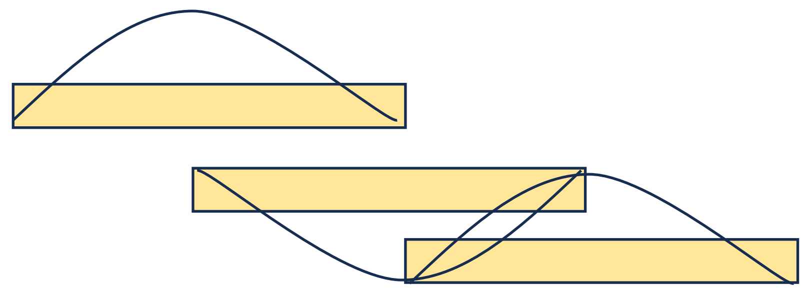
C=λ_0f → λ_0=C/f

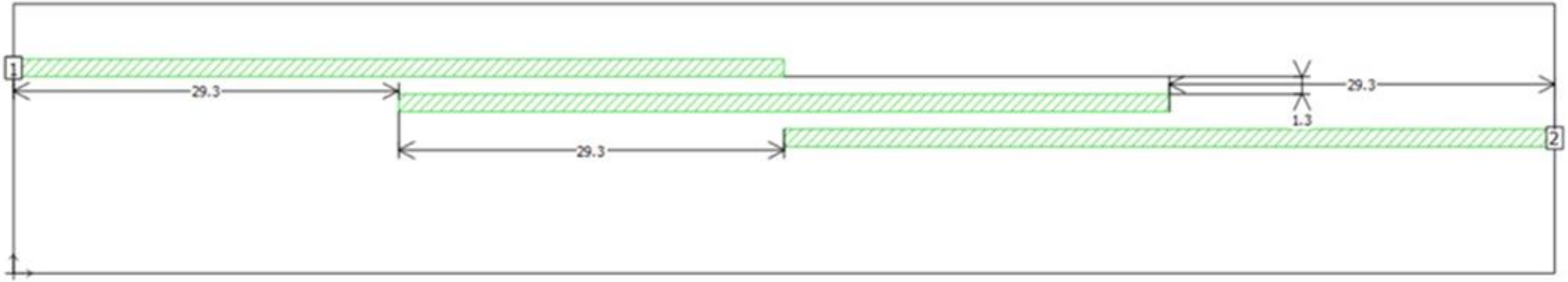
Then: $\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_{eff}}}$ → $\lambda_g = 114\ mm$

Design and Simulation

- Started with quarter of the guided wavelength
  - $\lambda_g \cong 28.5\ mm$
- Used a coupled resonator design.
- Adjusted measurements until simulation resulted in desired efficiency.

EM Wave representation of Line-Coupled resonator:



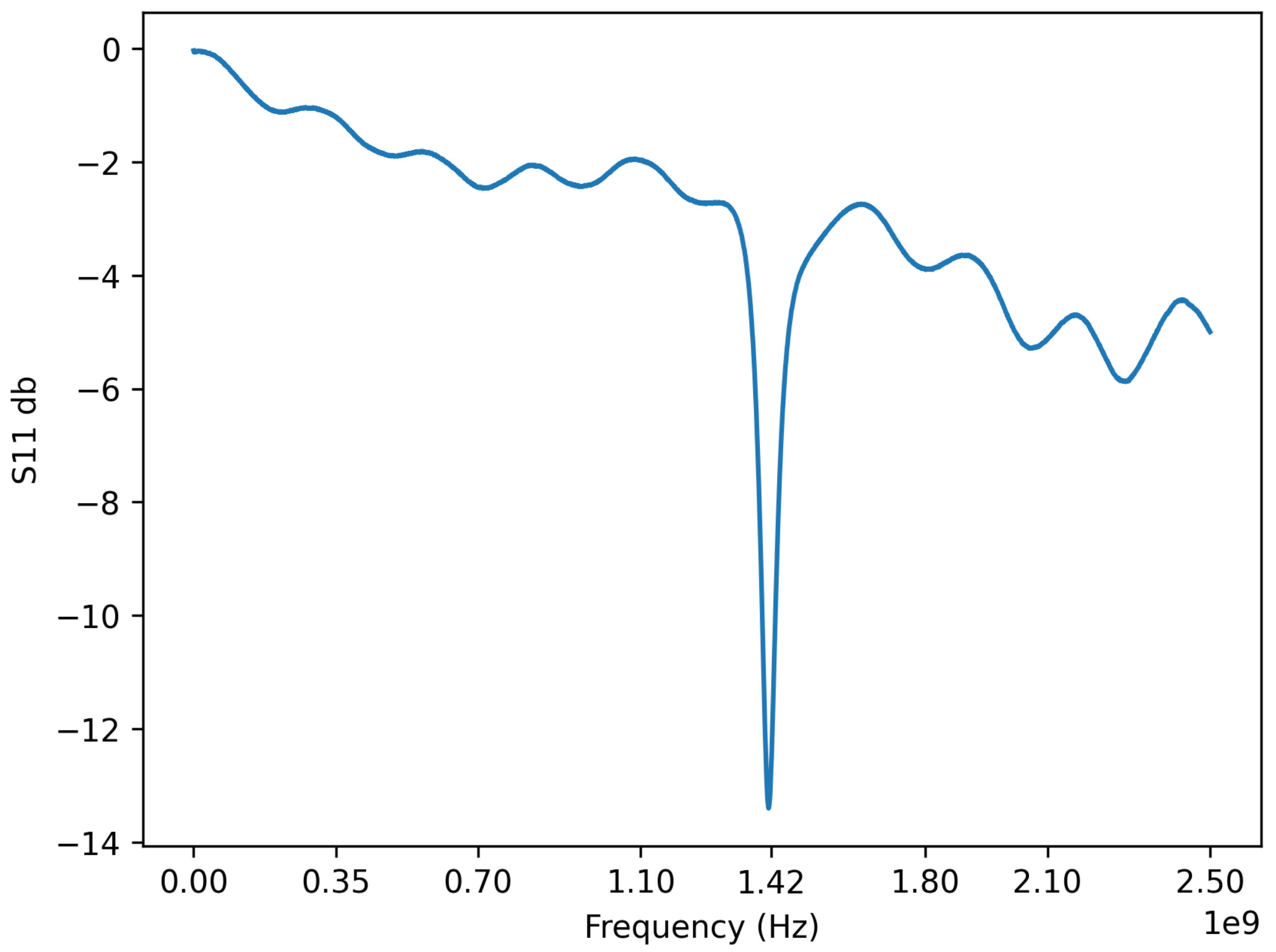


Construction

- FR-4 PCB utilized as dielectric and copper tape for microstrip circuit design.
- Cost efficient and widely available materials.
- Easily implemented design using Calipers and a Precision Knife.
- Soldered 50ohm SMA connectors.

Testing and Results

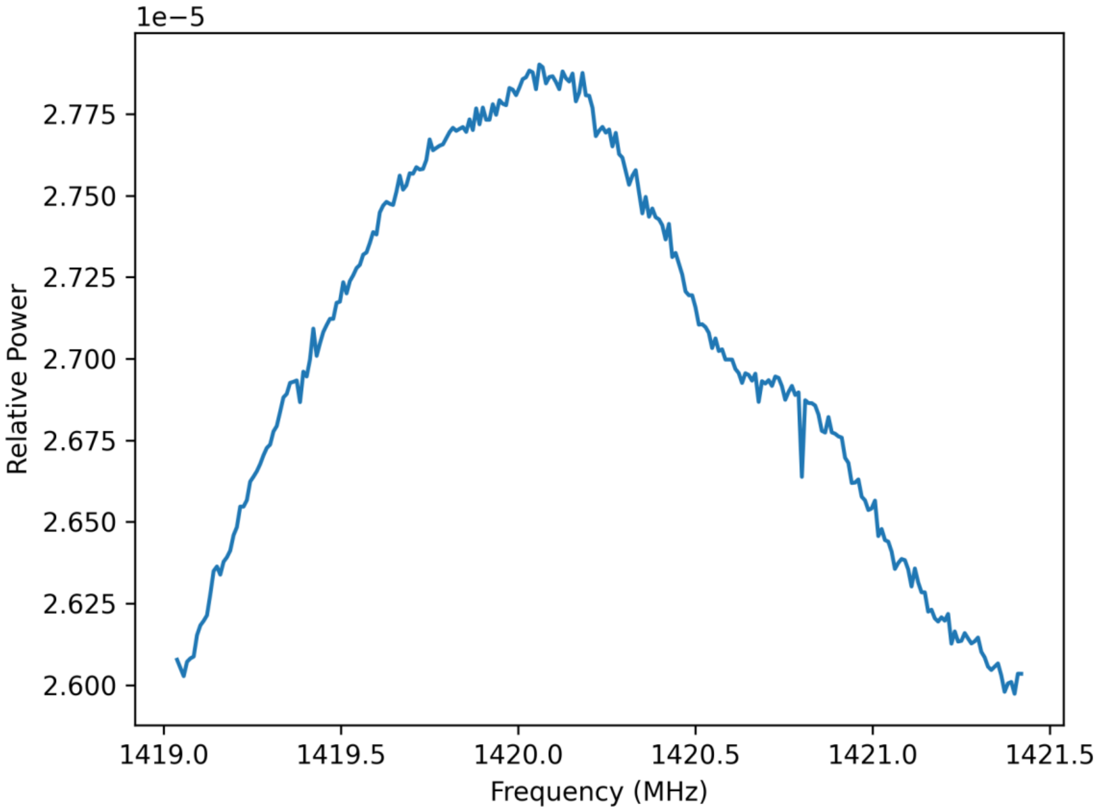
- Vector Network Analyzer (VNA) used to test BPF.
- Collected data from VNA and converted to db scale.
  - $P_{db} = 10Log_{10}\left((Re)^2 + (Im)^2\right)$
- Converted and plotted the data using Python.



Sharp peak at 1.42 GHz shows a high S11 (reflection) loss at our desired frequency. This suggests a high transmission of signal across the BPF for target frequency and high reflection for other signals.

Use in Software Defined Radio Telescope

- Connected in series with horn antenna, Low noise amplifier, and RTL-SDR to collect 1420 MHz signal near Cygnus.
- Used SDR# and IFAve plugin to compute FFT
- Analyzed 8 data sets taken over 6 minutes each.



Acknowledgements

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Sources

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