

# 4/15/2025 Comparing Simulated and Measured Results for Microstrip Patch Antenna designed for 8.5GHz

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# Outline

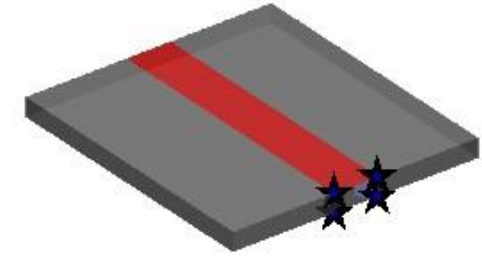
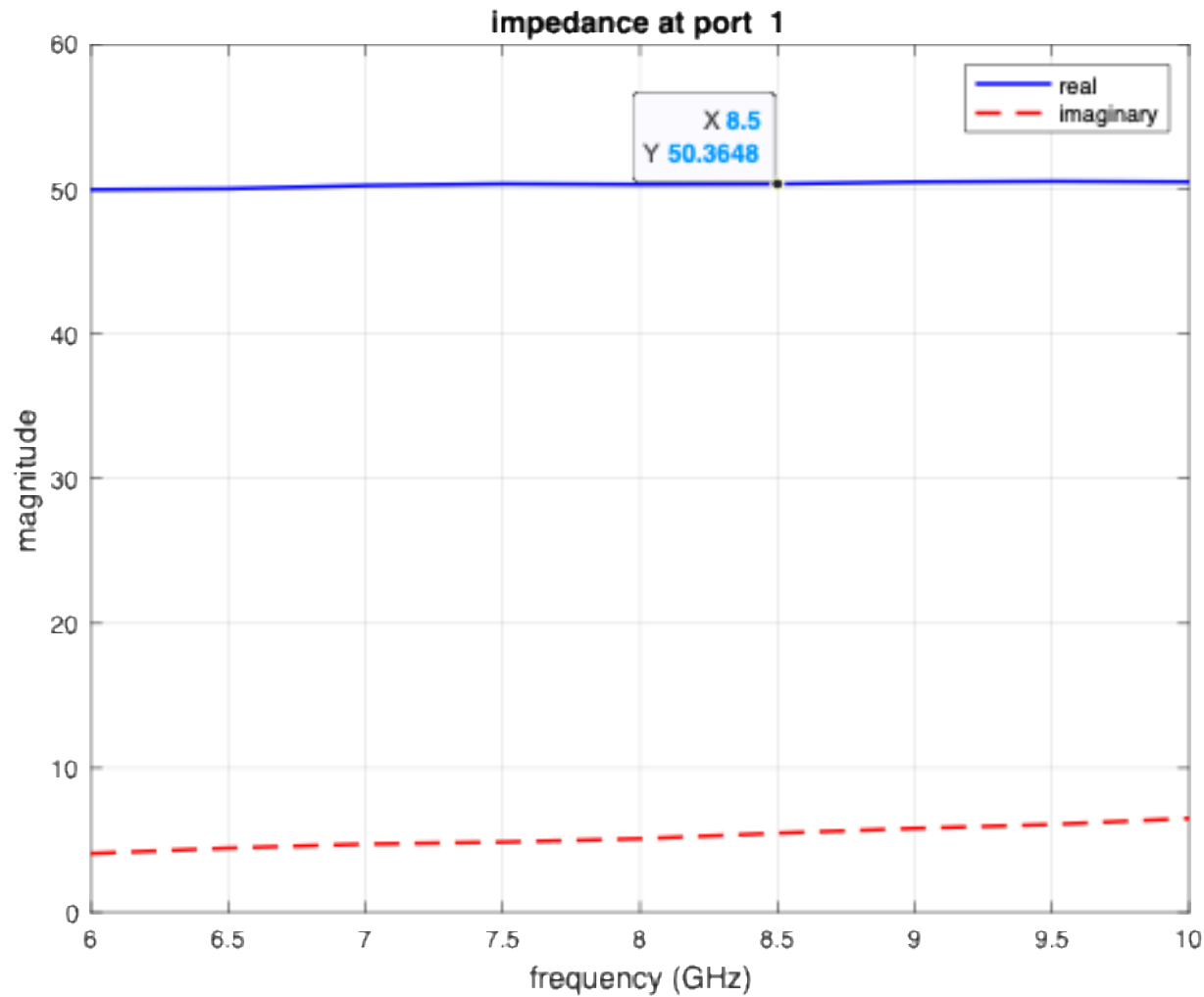
- Objectives
- Simulation
  - Design
  - Results
- Fabrication
- Measurement
- Comparison
  - S parameter
  - Comments

# Objectives

Fabricate an inset-fed patch antenna

Compare measured and simulated results

# Microstrip Line Simulation Results



## ■ Simulation Results:

- When the microstrip line width was 3.6mm, the impedance was very close to 50 ohms.

# Patch Antenna Design Computations

## ■ Computing initial dimensions

- Substrate: Rodger 4003C
  - $\epsilon_r = 3.38$  and  $\sigma_c = 0.0051$
  - Substrate height = 1.52mm using 1.5mm for simulation
  - Center Frequency = 8.5 GHz
- MATLAB script to perform computations on the right
  - Initial dimensions are noted to be modified in full-wave simulation

$$W = \frac{c}{2f\sqrt{\frac{\epsilon_r+1}{2}}}$$

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ \frac{1}{\sqrt{1 + 12\frac{h}{W}}} \right]$$

$$\Delta L = 0.412h \frac{(\epsilon_{\text{reff}} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{\text{reff}} + 0.258)(\frac{W}{h} + 0.8)}$$

$$L = \frac{\lambda}{2} - 2\Delta L = \frac{c}{2f\sqrt{\epsilon_{\text{reff}}}} - 2\Delta L$$

$$R_{\text{edge}} = 90 \frac{\epsilon_r^2}{\epsilon_r - 1} \left( \frac{L}{W} \right)^2$$

$$R_{\text{in}}(y = y_0) = R_{\text{edge}} \cos^2\left(\frac{\pi}{L}y_0\right)$$

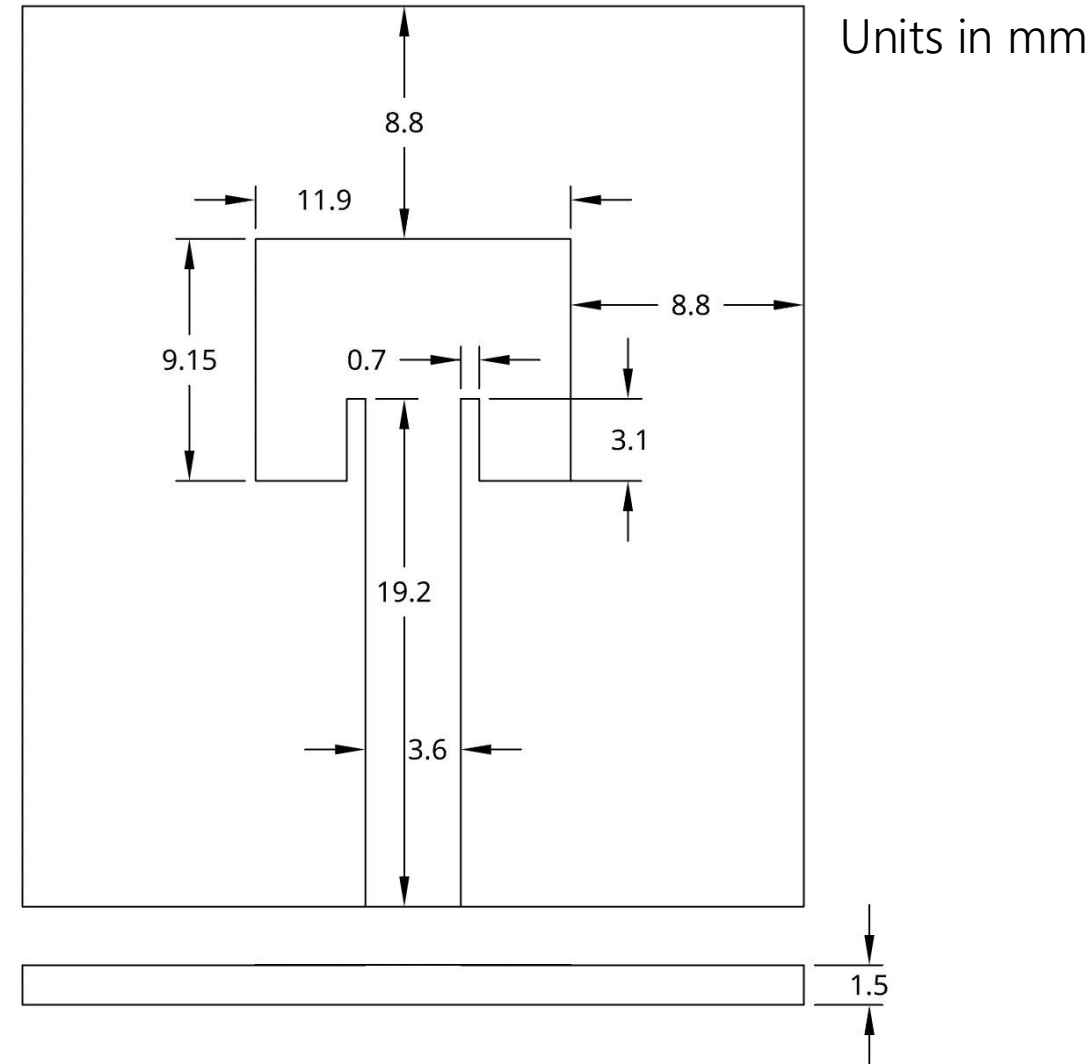
$$W = 11.9165$$

$$L = 8.8815$$

$$y_0 = 3.1007$$

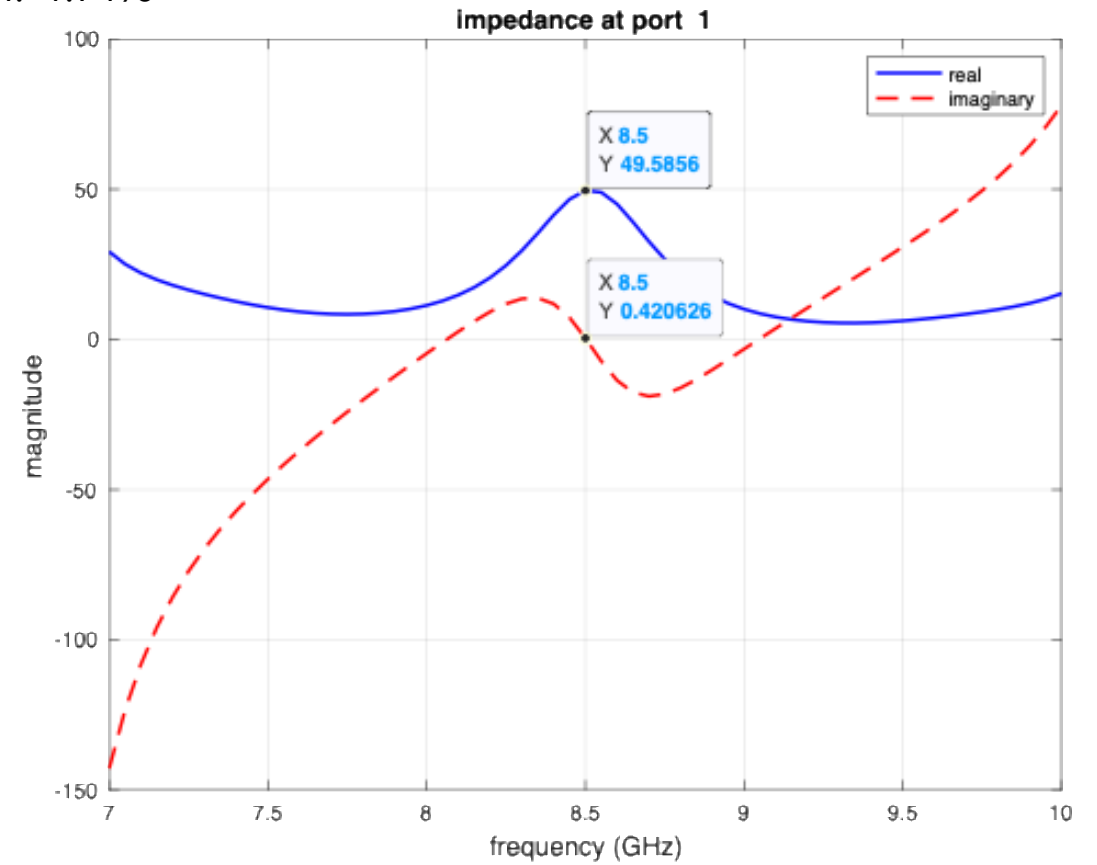
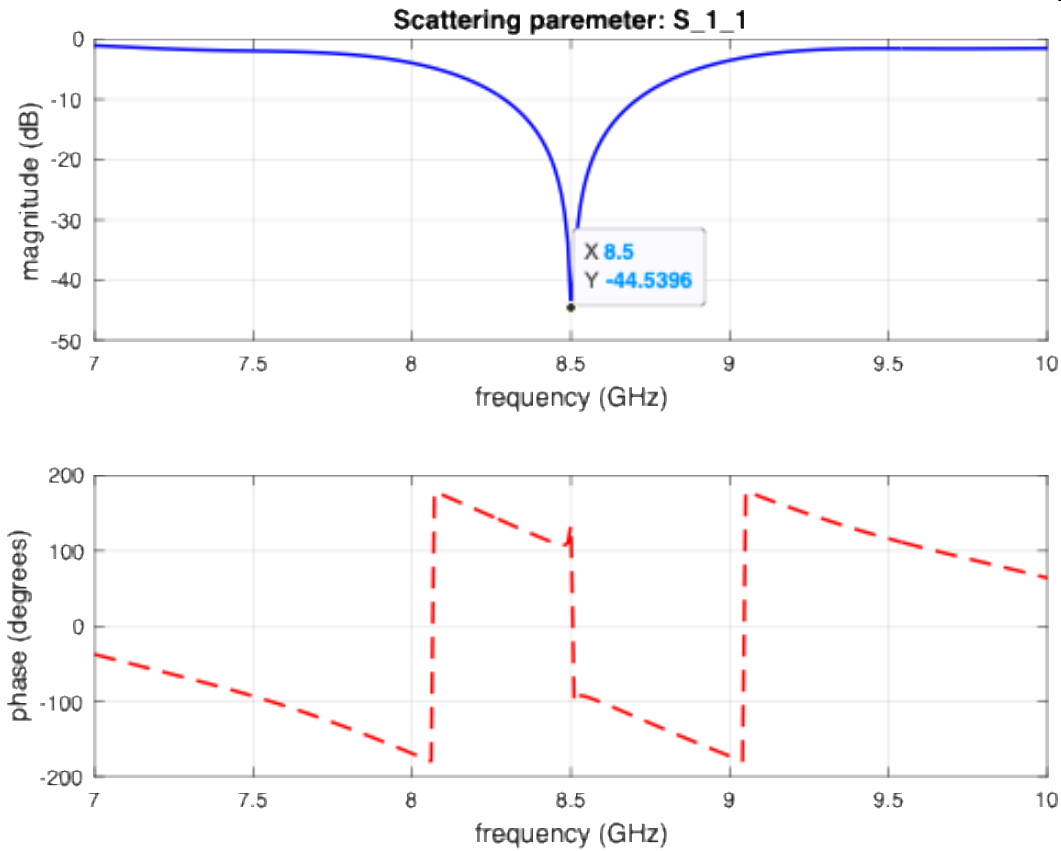
# Patch Antenna dimensions

- The dimensions that yielded good simulated results are shown on the right
- There is approximately  $\frac{\lambda_0}{4}$  distance from the patch to the edge substrate
- The notch is roughly the width of the line divided by 5
- The length of the microstrip line is  $\lambda_d = \lambda_0 / \sqrt{\epsilon_r}$ ,  $\epsilon_r = 3.38$

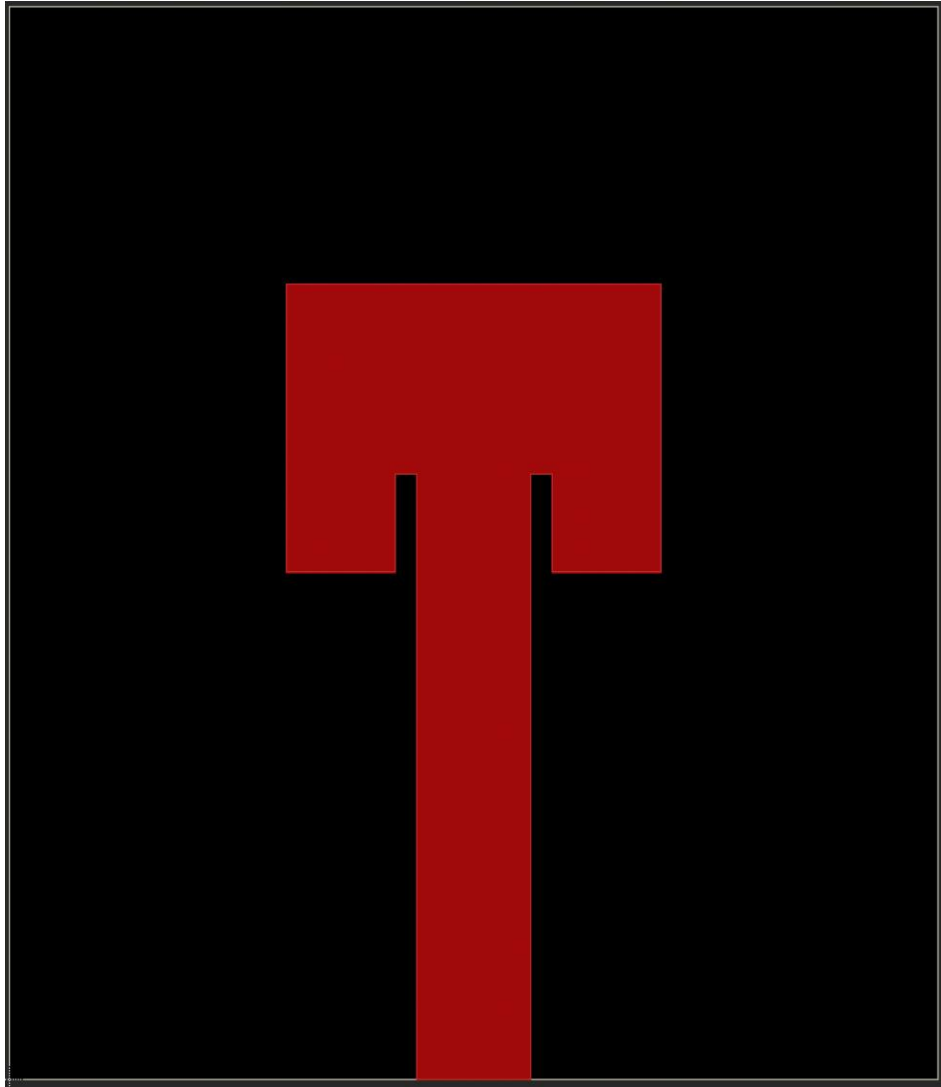


# Patch Antenna S11 and port impedance

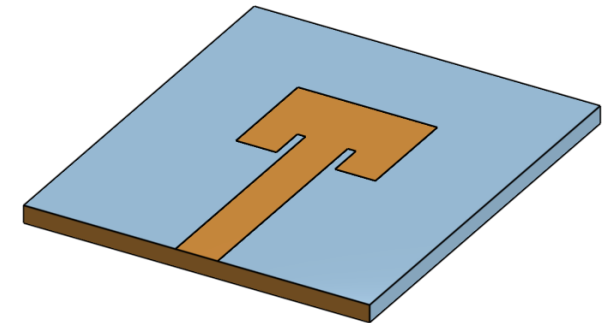
Impedance  
Bandwidth: 4.71%



# Fabrication Process

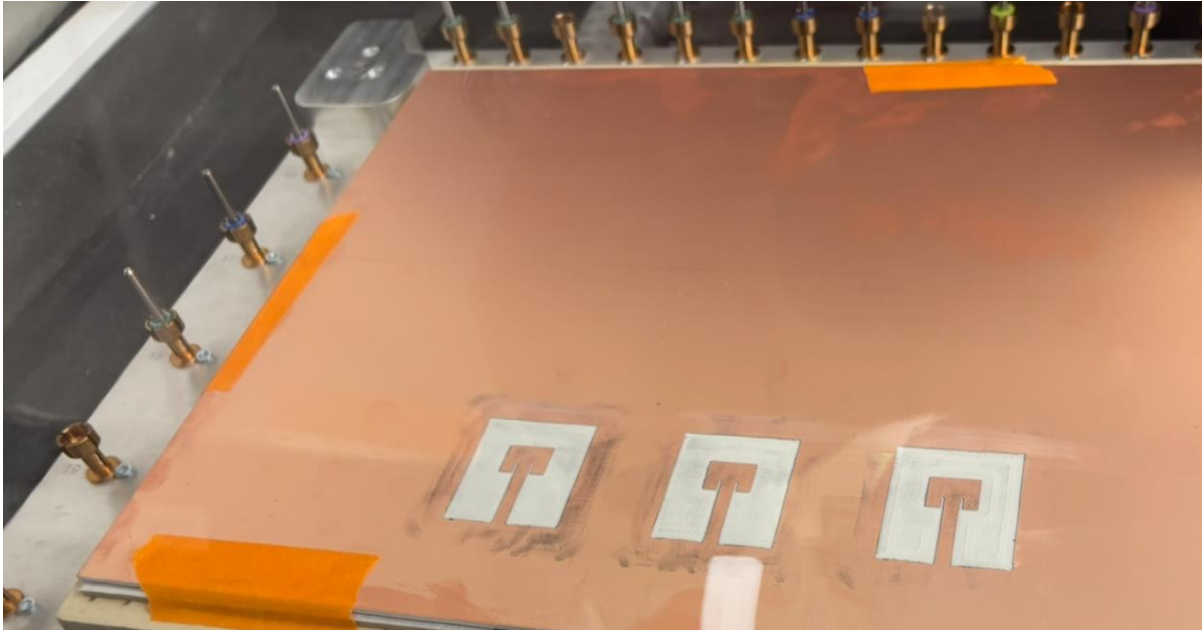


- The first step to fabricating the patch antenna was generating Gerber files using Eagle PCB.
- I imported a .dxf file from a free online CAD software called Onshape to get the board dimensions as a reference



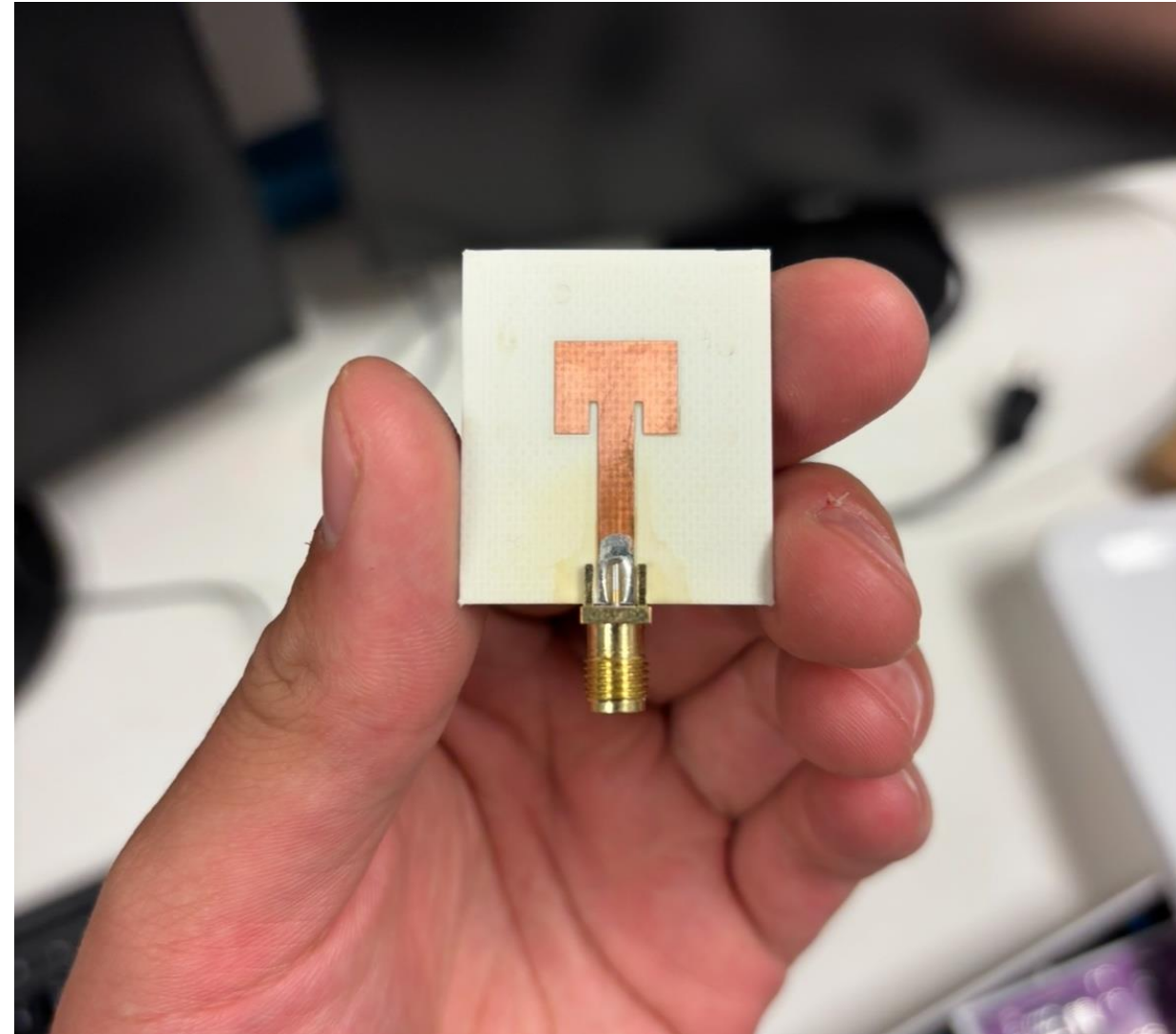
# Fabrication Process Continued

- Then I used the LPKF milling machine to etch away the copper on the top layer and cut the patch out to the specifications in the gerber file



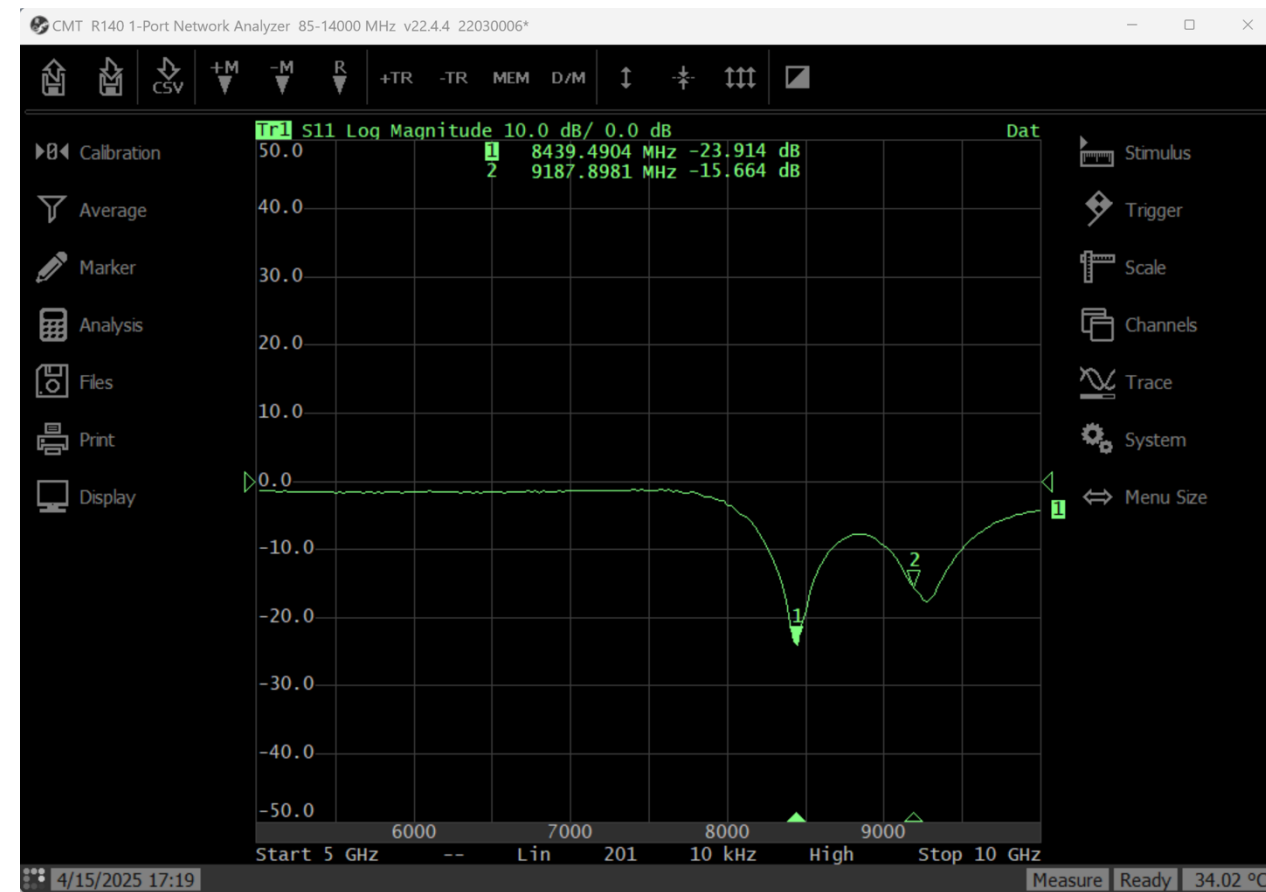
# Fabrication Process Continued

- Finally, I soldered the SMA connector to the patch using solder paste and a heat gun.



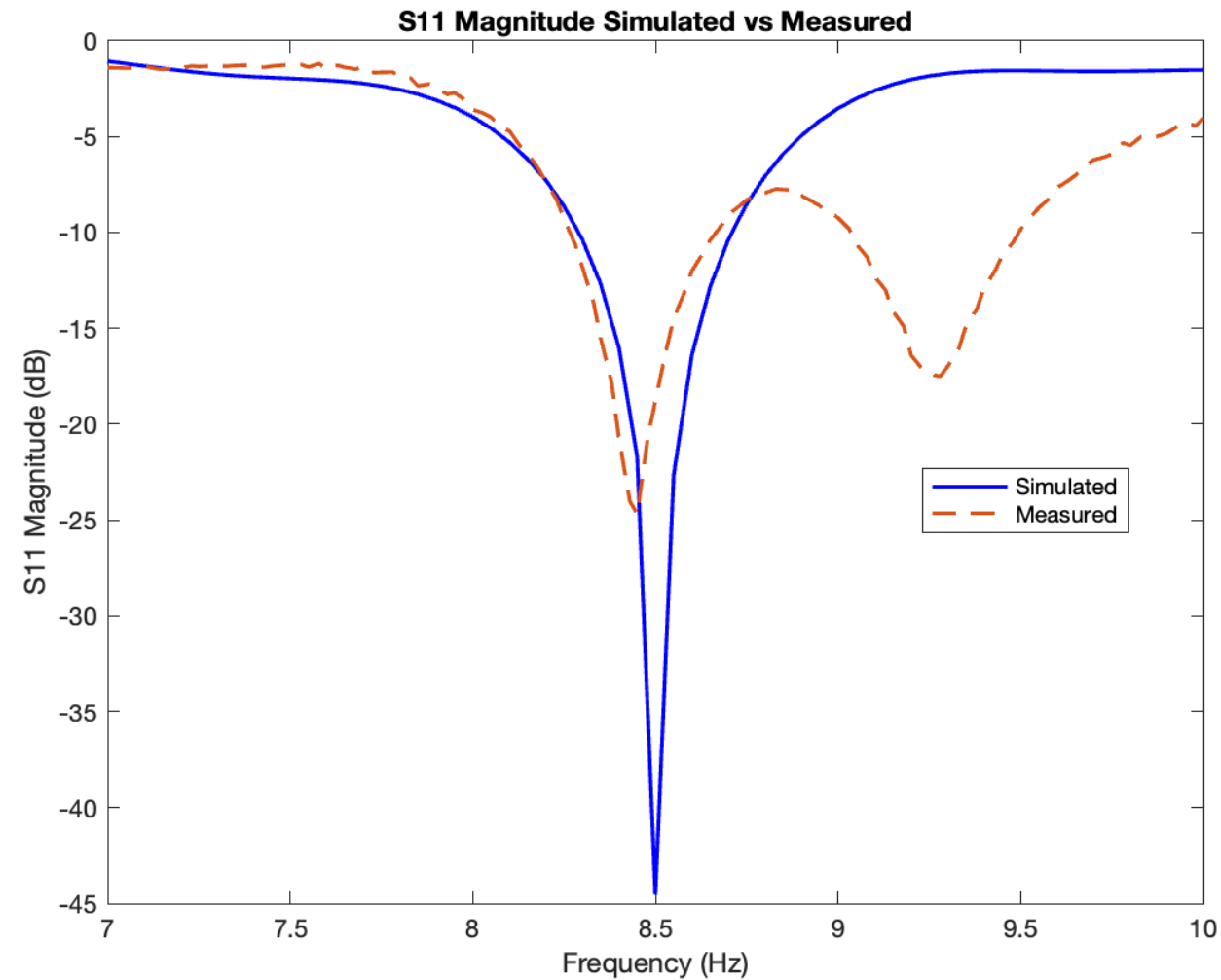
# Measurement

- Using a single port vector network analyser (VNA), I measured the S11 scattering parameter which shows how much reflection is present at the input port with respect to frequency.
- As depicted to the right it resonates well at 8.44 GHz, very close to the desired operating frequency.



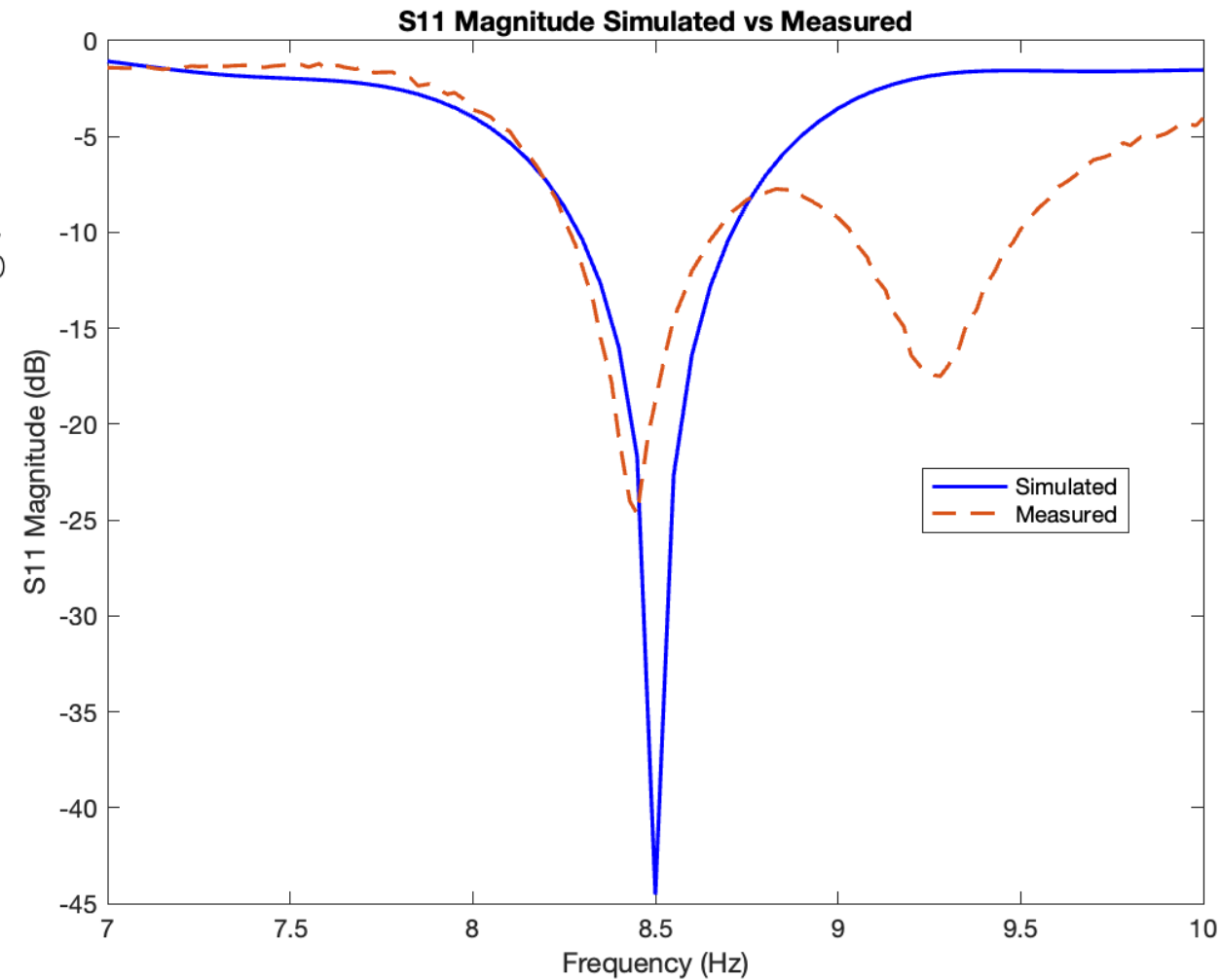
# S11 Comparison

- An overlay to the right compares the measured S11 scattering parameter with simulated results.
- Simulation indicates better resonance at -44dB compared to the measured resonance at -23.9dB.



# S11 Comparison

- Despite the measured value being -23.9dB, which reflects approximately 6.4% of the power, it still indicates good performance  
$$-23.9dB = 10^{\frac{-23.9}{20}} = 6.4\%$$
- The manufactured patch resonates at a slightly lower frequency.
- The manufactured patch also exhibits a second resonance around 9.3 GHz



# Comments

- The differences in simulated results can be explained by the following:
  - Fabrication tolerances: small differences in dimensions leading to changes in antenna characteristics
  - Modeling assumptions: the port that excited the patch in the simulation spanned the whole feedline whereas only some of the feed line was electrically connected to the port via solder
  - Small differences in substrate permittivity
  - The copper was modeled as a perfect electric conductor with 0 thickness

