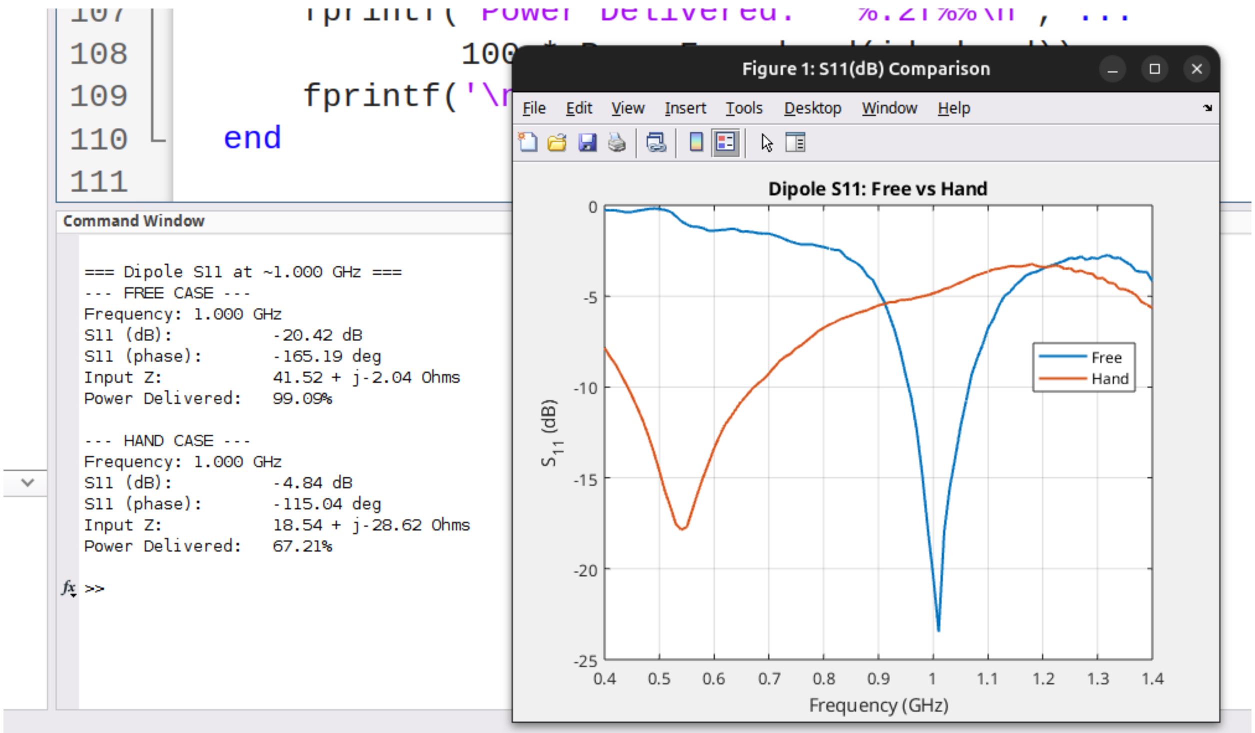
Lab 3:

Measuring your antenna:

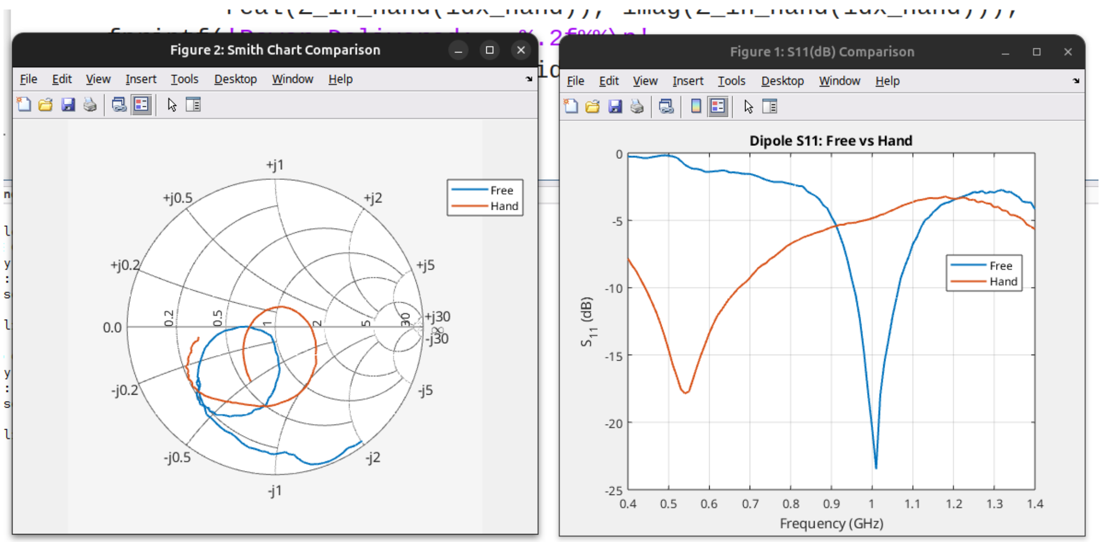
Only Port 1:

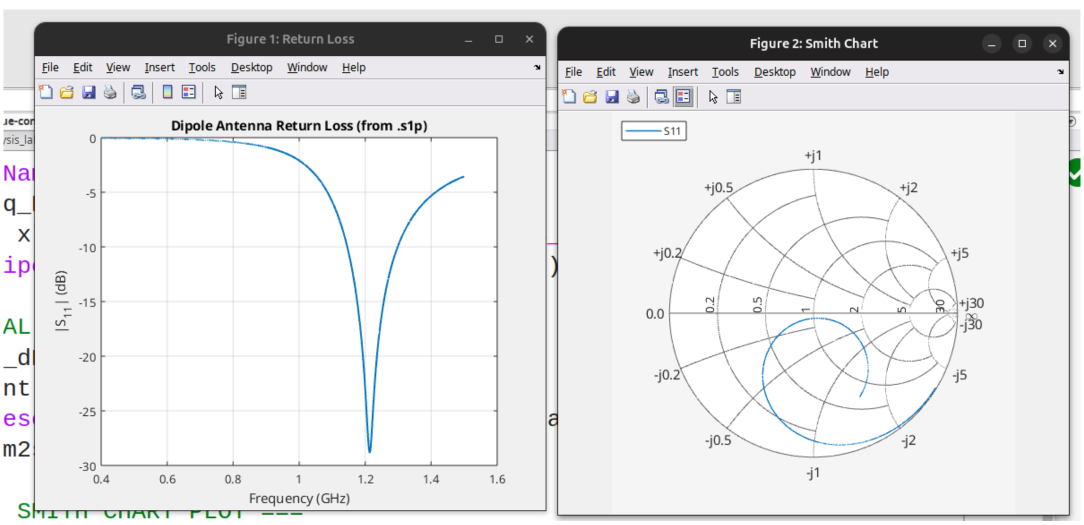
1. **Check the S11, what is the percentage of the power transferred from the NanoVNA to the antenna?**
2. **Bring one of your hands close to the antenna, do the results change? Why?**



Without hand covering the dipole the power delivered is much higher at 1GHZ. As the reflection dB increases from –20 to –5, as the near field environment is altered, the antenna does not match to 50 Ohms at 1Ghz which is what increased reflection and decreased power delivered.

3. **Compare your measured results with your simulated results. Are there differences? Why?**



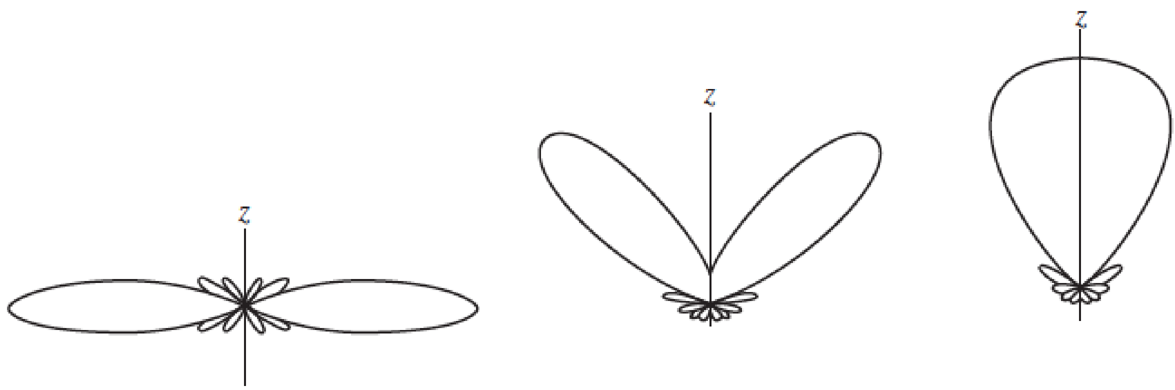


The simulated results of CST are relatively close, the differences could be caused by environmental effects, physical dimensions etc. Just in CST it's configured to 1.2Ghz.

Port 2 connected:

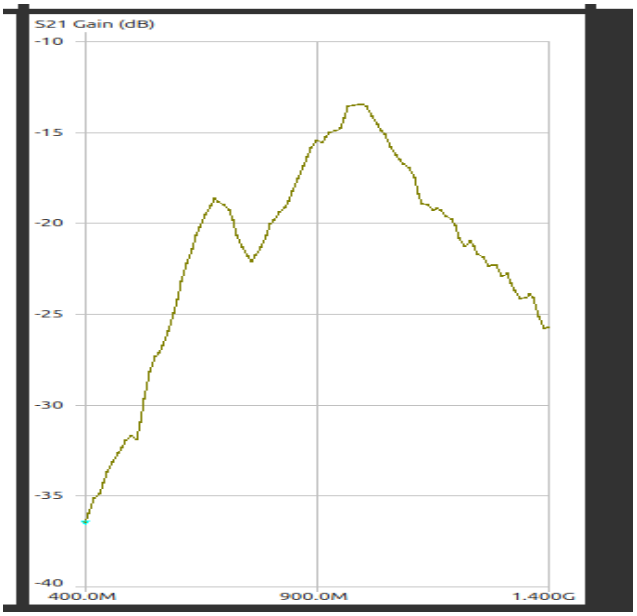
1. **Think in terms of antenna alignment. If you look at the simulated 3D radiation pattern, where does the antenna radiate the most and least energy? Can you think of a best and worst transmission in terms of antenna alignment? Verify this with measurements.**

   An ideal dipole radiates most energy broadside (perpendicular to the dipole axis) and least energy along its axis; the best transmission is when both dipoles face each other broadside with matching polarization, and the worst is when they are end-to-end or cross-polarized, which measurements confirm by showing higher S21 in the best case and lower S21 in the worst case.

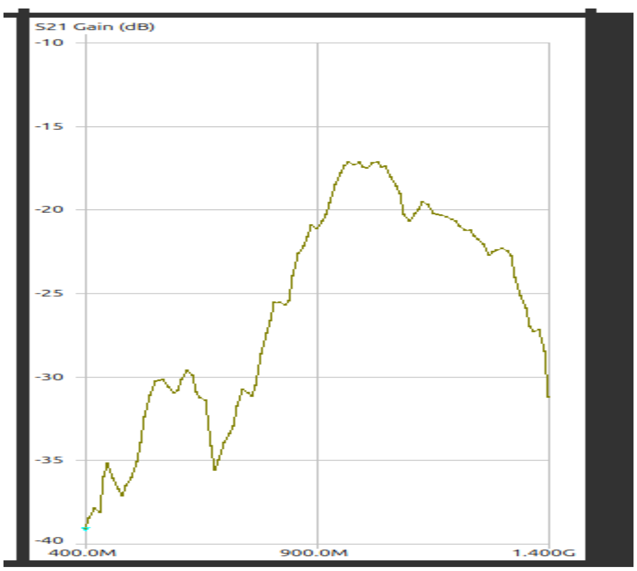


(a) Broadside (b) Intermediate (c) Endfire

Broadside facing dipoles:



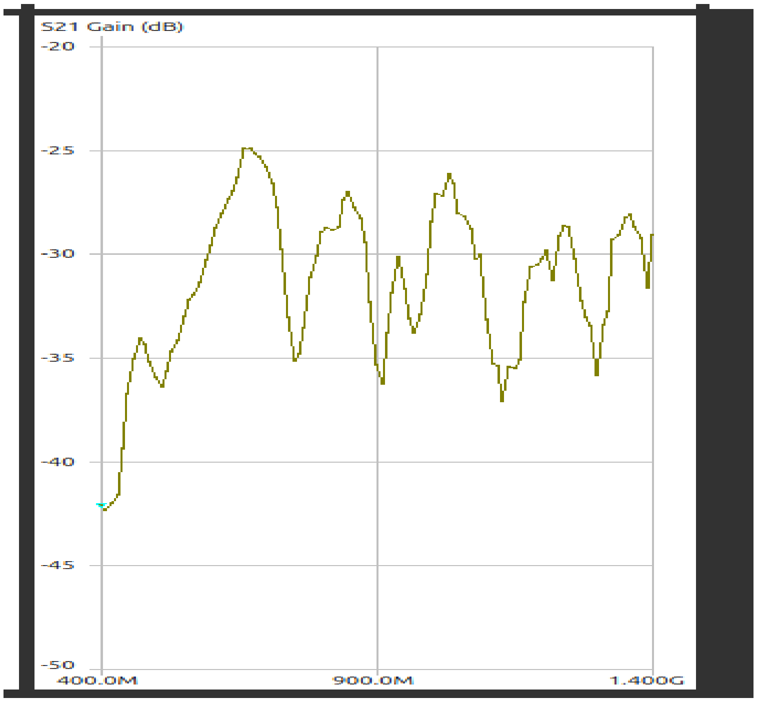
Endfire facing dipoles:



2. **Think in terms of the polarization, what configuration would be ideal and what configuration would be the worst in terms of maximum transmission? Verify this with measurements.**

   The ideal configuration is co-polarized alignment for maximum transmission, and the worst is cross-polarized orientation; measurements confirm that S21 is highest when antennas share the same polarization and lowest when they are orthogonal.

   Co-polorized can be observed above, and cross polarized can be seen below:



3. **Take a fixed antenna distance and extract the antenna gain by solving the Friis equation. Is this different from the simulated gain? Why?**
   Using the Friis equation at 1.0 GHz with S21 = -17.72 dB and free-space path loss = -26.42 dB (at R = 0.50 m), we calculate a single-antenna gain of 4.35 dBi, which differs from the simulated value because of real-world factors like cable losses, mismatches, measurement environment, and near-field effects.

Simulating your antenna:

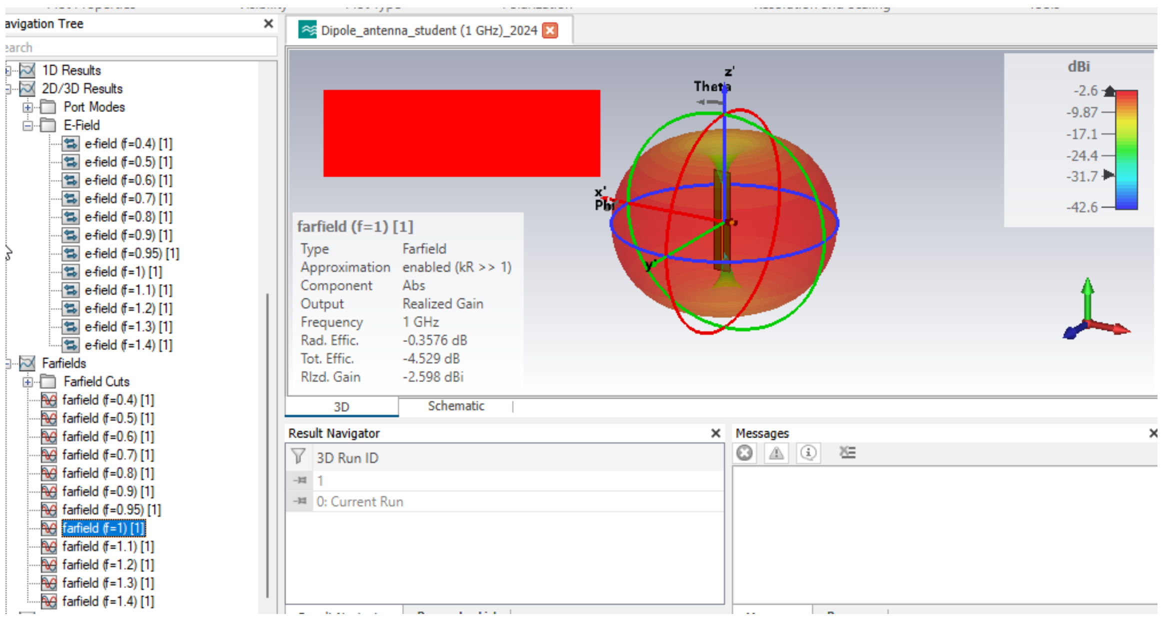
1. **Calculate the correct dipole length for a resonance at 1 GHz and simulate**

   Design frequency: 1 GHz

   Free-space wavelength: 300.000 mm

   Ideal dipole length: 150.000 mm (half-wave)

2. **S11 should have a minimum (< -10 dB) around your design frequency, is this the case? If not, why and how far off is your simulation from your desired value? Try to optimize until you have the correct value.**



   Number of freq. points: 1011

   Found resonance near: 1.214 GHz

   S11(dB) at resonance: -28.84 dB

   Offset from design (MHz): 214.00 MHz

3. **Check the radiation pattern. Is this what you would expect from a dipole? Why?**

   The classic dipole pattern is doughnut-shaped with max gain broadside. Directivity ~ 2.15 dBi.

4. **What about the gain? It that would you theoretically would expect?**

   Yes, a simple half-wave dipole in free space typically has about 2.15 dBi of gain, and the simulation result should be close to that if there are minimal losses.

5. **Is the radiation pattern symmetric? Why (not)?**

Yes, in an ideal dipole with symmetric geometry and a center feed, the pattern is symmetric because the current distribution.

6. **What is the polarization of this antenna (linear/circular)? Why?**

   It is linearly polarized because the dipole current flows along a single axis, producing an electric field in one predominant direction.

7. **CST: How did you verify that you used enough mesh cells?**

   By using adaptive mesh refinement and checking that the S-parameters and far-field results converged (i.e., they stopped changing significantly with each refinement iteration).

8. **Where do the least/most mesh cells occur after iterative meshing? Why?**

   The fewest cells appear in large, low-field regions (where the field does not vary rapidly). The most cells are concentrated around the feed and edges, where field gradients are highest and fine detail is required.