

ECE 6324: Antenna Design and Simulation Final Project

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Introduction

This report details the design and simulation of a corporate-fed patch antenna array for the ECE 6324 Spring 2025 project. The antenna was designed and simulated using CST Studio Suite. Due to time constraints, the antenna was unable to be fabricated and measured before the grading deadline. Therefore, this report will present the simulation data alone.

The designed antenna is a corporate-fed microstrip patch array intended to operate around 5 GHz. The design philosophy focuses on achieving good impedance matching and directive radiation characteristics.

Antenna Design

The antenna is a 1x4 corporate-fed patch array. The input impedance is 50 Ohms. This input is matched using a quarter-wave transformer with a characteristic impedance of approximately 36 Ohms. This transformer steps down the impedance to feed two parallel 50 Ohm microstrip lines, which present an equivalent impedance of 25 Ohms at the junction. Each of these 25 Ohm equivalent points is then split again using a similar T-junction structure to feed two individual patch antennas.

Each patch antenna element is sized to be approximately a quarter of a wavelength within the dielectric material at the target frequency, which corresponds to a dimension of around 14 mm. The patch elements are spaced approximately a quarter of a wavelength in free space apart, which is around 30 mm, to achieve constructive interference in the desired radiation direction and manage mutual coupling.

Simulated S11 Parameter

The S11 parameter, or return loss, indicates how well the antenna is matched to the 50 Ohm source. A lower S11 value (more negative in dB) signifies better matching. The simulation was run from 0 to 6 GHz. Figure 1 shows the simulated S11 parameter. A distinct dip is observed around the target frequency of 5 GHz, with the lowest point reaching -10.97 dB. This indicates a reasonably good impedance match at this frequency. This frequency (5 GHz) is chosen as the operating frequency for subsequent pattern analysis.

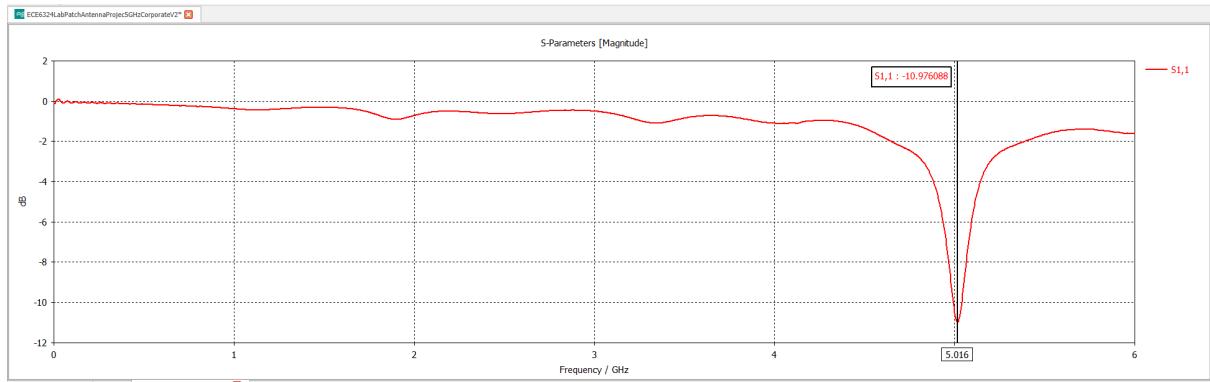


Figure 1: Simulated S11 parameter (return loss) of the corporate patch array, showing a dip at 5 GHz to -10.97 dB.

Antenna Geometry in CST

The geometry of the designed corporate patch array antenna as modeled in CST Studio Suite is shown in Figure ???. Both a front view and a perspective view are provided to illustrate the layout of the patches and the feed network.

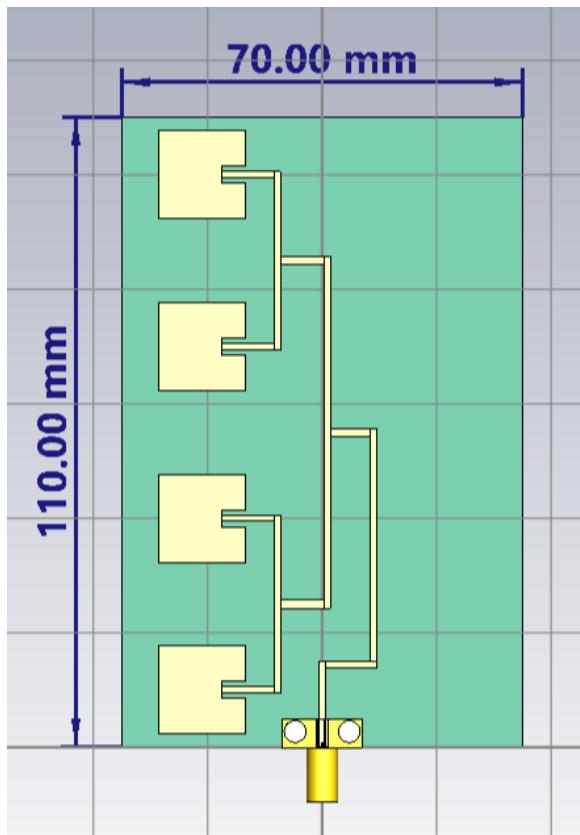


Figure 2: Front view of the corporate patch array antenna model in CST.

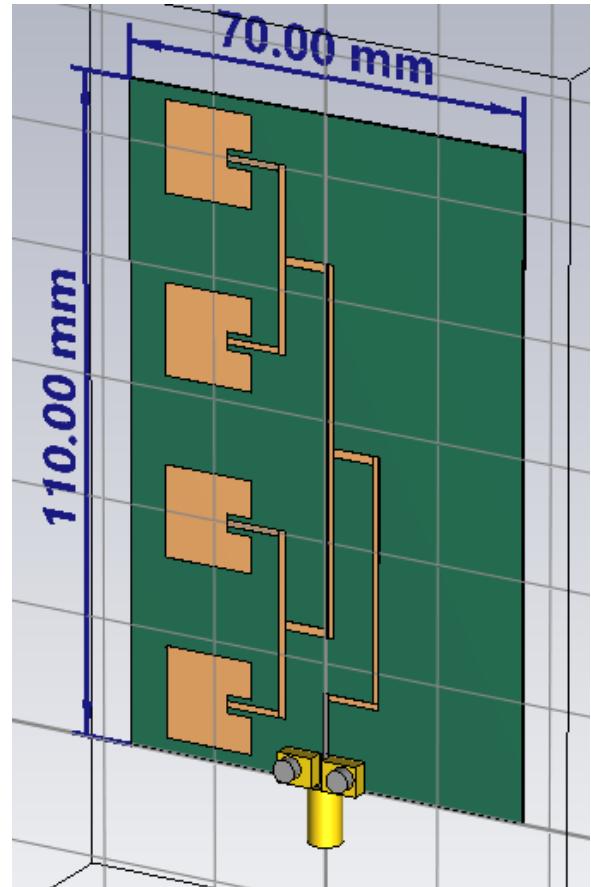


Figure 3: Perspective view of the corporate patch array antenna model in CST.

Figure 2 and 3: CST views of the antenna.

Simulated Radiation Patterns

The far-field radiation patterns were simulated at the operating frequency of 5 GHz. Two principal plane cuts are presented: $\phi = 0^\circ$ (E-plane for this orientation) and $\phi = 90^\circ$ (H-plane for this orientation).

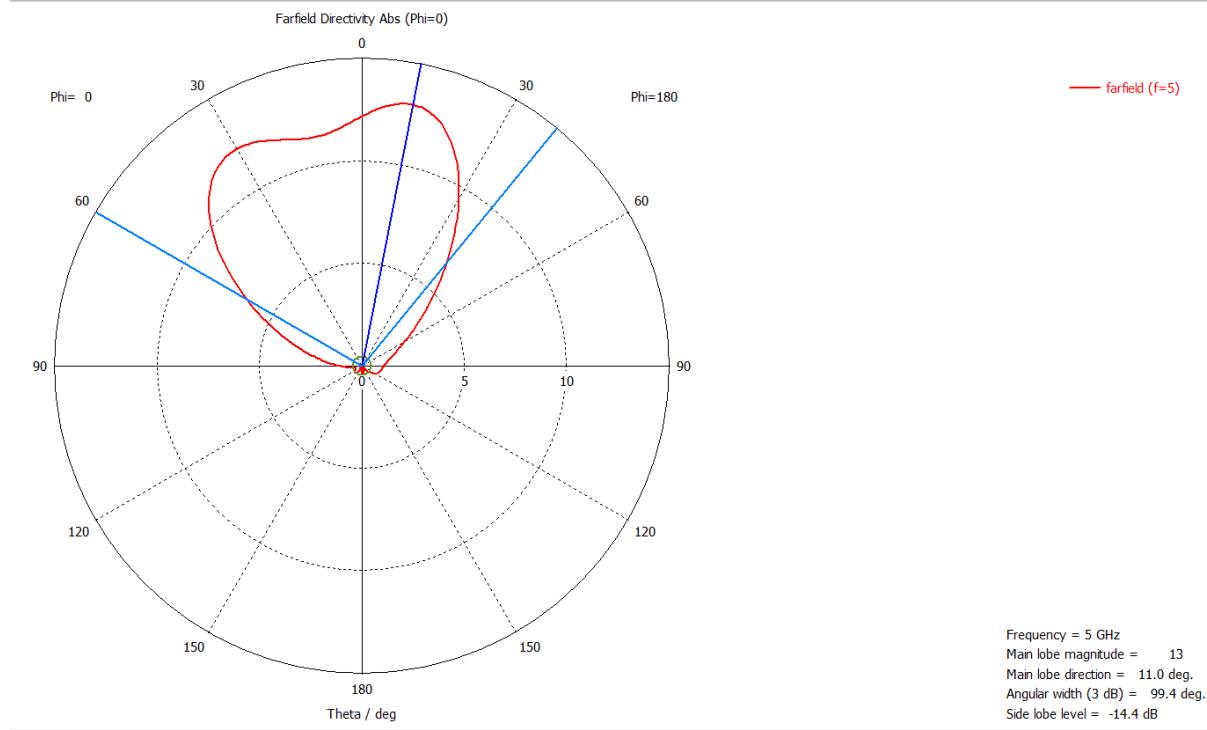


Figure 4: Simulated radiation pattern at 5 GHz for the $\phi = 0^\circ$ cut (E-plane). This plot shows a 3 dB beamwidth of approximately 99 degrees.

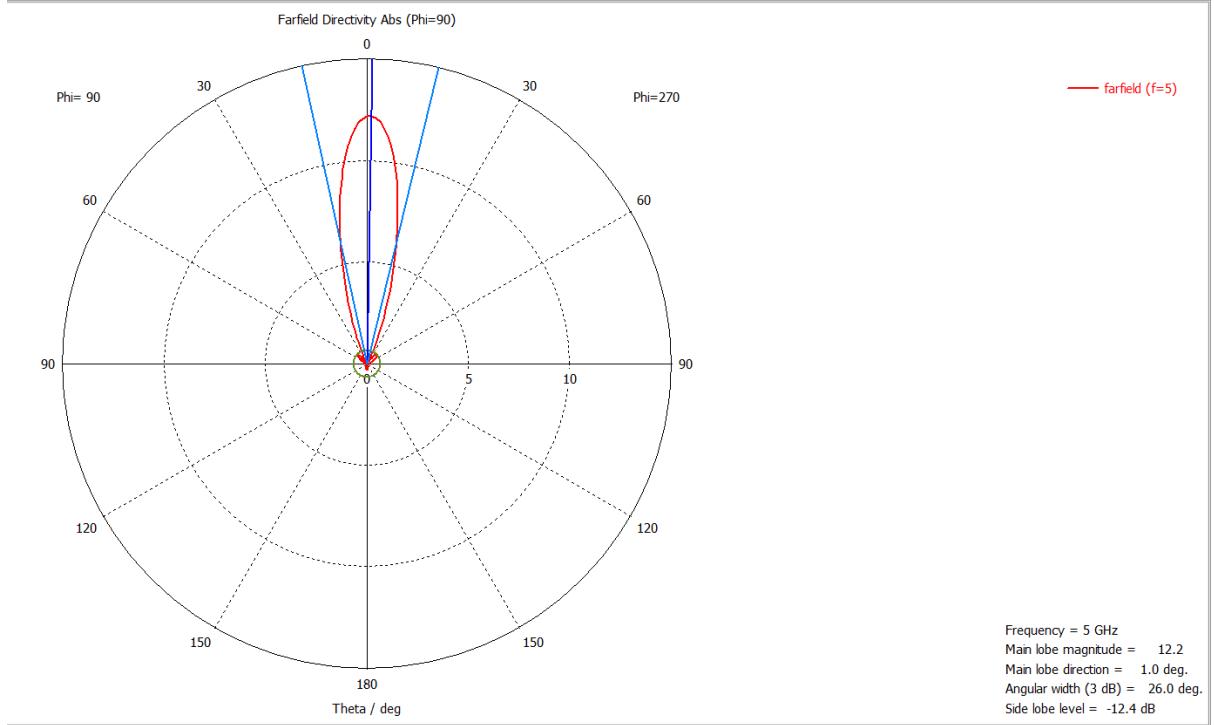


Figure 5: Simulated radiation pattern at 5 GHz for the $\phi = 90^\circ$ cut (H-plane). This plot shows a 3 dB beamwidth of approximately 26 degrees, which is narrower due to the array configuration along this axis.

The $\phi = 0^\circ$ cut (Figure 4) exhibits a relatively wide 3 dB beamwidth of approximately 99 degrees. This is characteristic of the radiation from the individual patch elements in this plane. The $\phi = 90^\circ$ cut (Figure 5) shows a significantly narrower 3 dB beamwidth of approximately 26 degrees. This narrowing is expected due to the array factor of the four elements aligned along the axis corresponding to this plane, leading to increased directivity.

3D Radiation Pattern

A 3D representation of the simulated far-field radiation pattern at 5 GHz is shown in Figure 6. This visualizes the overall directional characteristics of the antenna array, showing the main lobe directed broadside to the array.

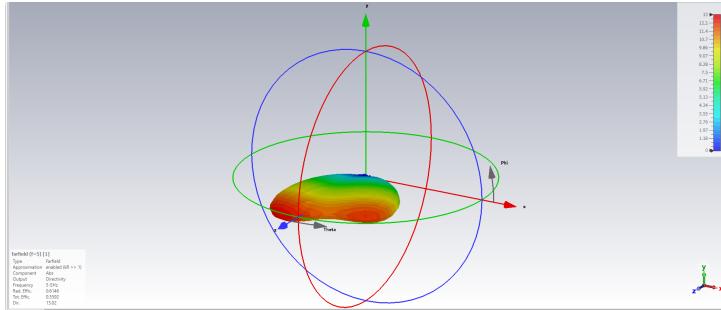


Figure 6: Simulated 3D far-field radiation pattern of the corporate patch array antenna at 5 GHz.

Surface Current Distribution

The surface current distribution on the antenna elements and feed network provides insight into its operation. Figure 7 shows a contour plot of the current magnitude (amperage), and Figure 8 shows an arrow plot indicating the direction and relative magnitude of the currents at a specific phase.

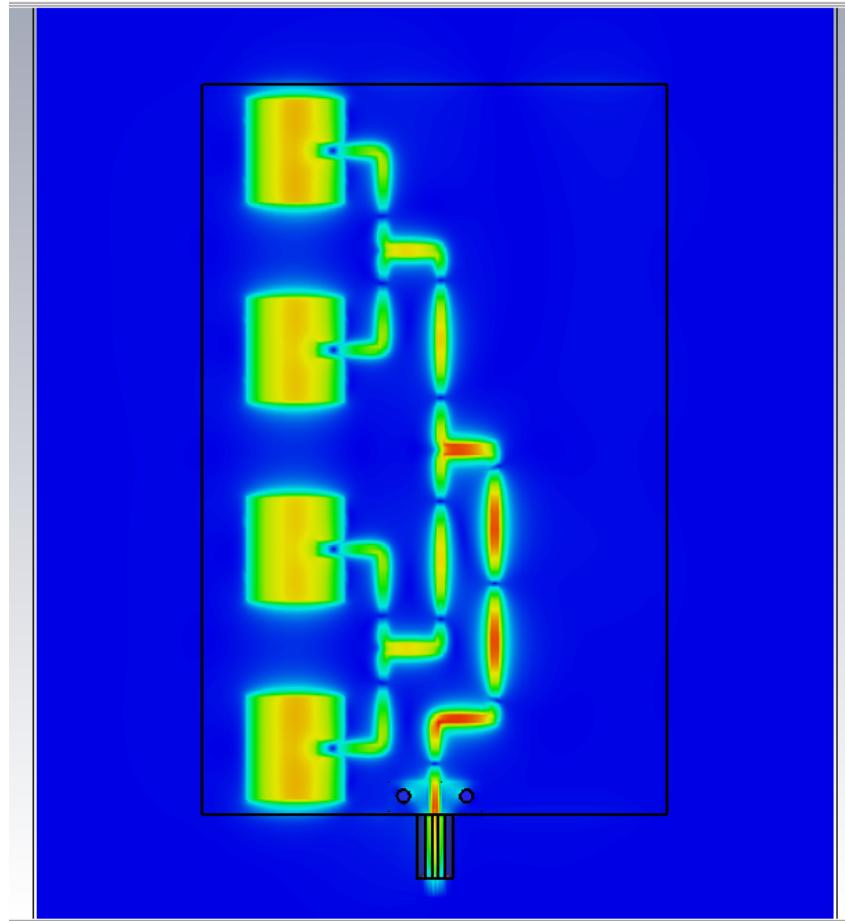


Figure 7: Contour plot of the simulated surface current magnitude (amperage) on the antenna at 5 GHz.

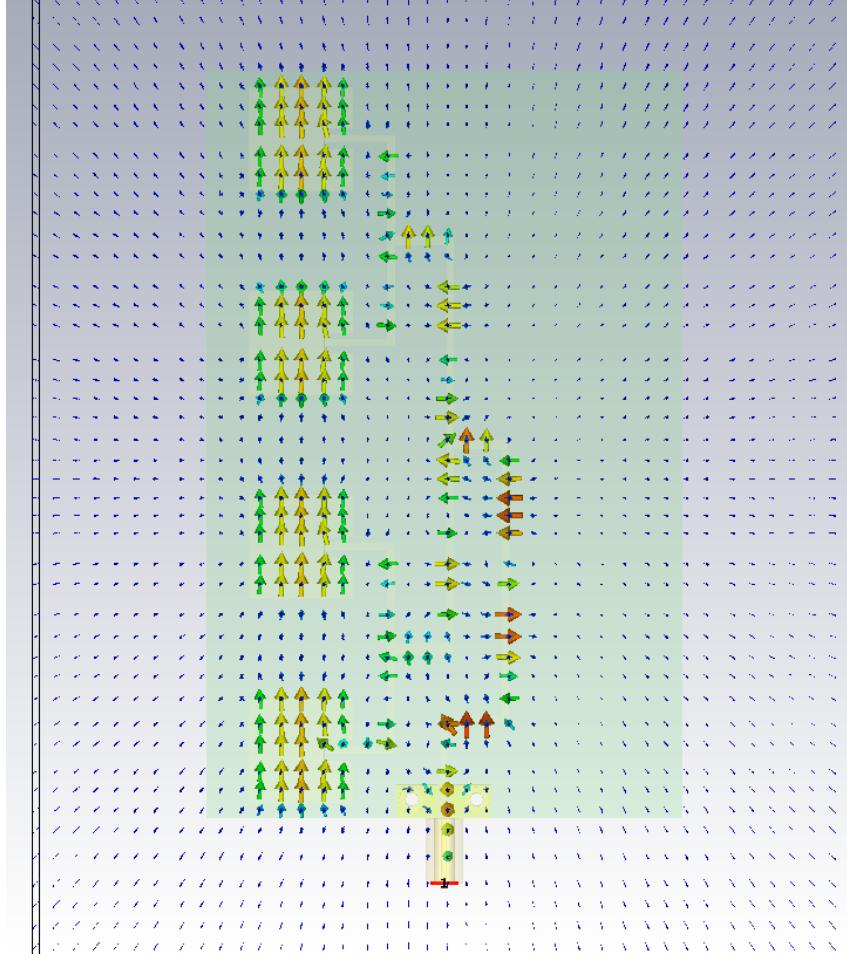


Figure 8: Arrow plot of the simulated surface current distribution on the antenna at 5 GHz. It is interesting to note that the current arrows on all patch elements are predominantly pointing in the same direction, indicating in-phase excitation which is crucial for broadside radiation.

The arrow plot in Figure 8 is particularly insightful as it shows that the currents on all four patch elements are largely in-phase and pointing in the same direction. This coherent excitation is essential for achieving the desired constructive interference in the main beam and confirms the proper functioning of the corporate feed network.

Conclusion

A 1x4 corporate-fed microstrip patch antenna array was designed and simulated for operation at 5 GHz. The simulation results show a good impedance match at the target frequency, with an S₁₁ of -10.97 dB. The radiation patterns exhibit expected characteristics, with a narrower beamwidth in the plane of the array (26 degrees) compared to the plane of the individual element (99 degrees). Surface current plots confirm the in-phase excitation of the patch elements. While fabrication and measurement were not possible, the simulation results suggest a viable antenna design. With further optimization the design could be improved further.