# Assignment-2

B M Manohara, RV College of Engineering

## Abstract

Microstrip patch antennas have become integral in modern communication systems owing to their compact size, planar configuration, and ease of integration with printed circuit boards. This report outlines the design of a rectangular microstrip patch antenna resonating at 6 GHz using FR4 substrate and simulated using ANSYS HFSS.

## Design Specifications

*Table 1: Design Specifications of Patch Antenna*

| Parameter | Value |
| --- | --- |
| Operating Frequency | 6 GHz |
| Dielectric Material | FR4 |
| Dielectric Constant | 4.4 |
| Substrate Height | 1.6 mm |
| Loss Tangent | 0.02 (typical for FR4) |

## Calculated Values

The design parameters were computed using standard equations found in *Antenna Theory: Analysis and Design* by Constantine A. Balanis:

*Table 2: Calculated Values of Patch Antenna*

| Parameter | Value |
|---|---|
| Width of Patch (mm) | 15.126 |
| Length of Patch (mm) | 11.32 |
| Approximate Feed Location from Edge (mm) | 3.614 |
| Width of Feed Line (mm) | 2.99 |
| Inset width (mm) | 4.6 |
| Inset depth (mm) | 3.8 |
| Effective Permittivity | 3.830 |
| Fringing Length (mm) | 0.723 |
| Effective Length (mm) | 12.774 |
| Edge Impedance (Ω) | 284.130 |

## Design Methodology

The patch dimensions were determined by:

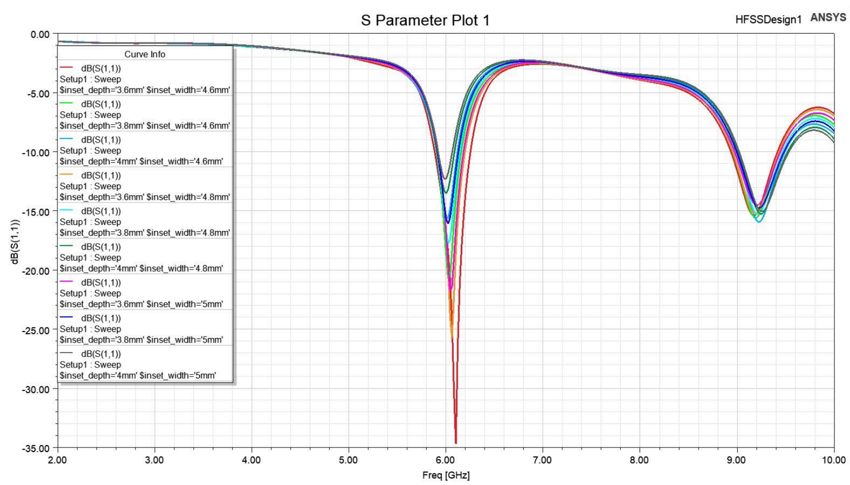
- Calculating the patch width to optimize the radiation efficiency.
- Adjusting the patch length based on fringing effects.
- Selecting an appropriate feed point to match the input impedance to 50 Ω.
- Designing the microstrip feed line with the calculated width for impedance matching.

## Substrate Selection

FR4 substrate was chosen for its low cost and wide availability. Though not ideal for high-frequency performance due to higher dielectric loss, it provides a good balance between cost and performance for prototyping and short-range communication devices.

## Simulation Using ANSYS HFSS

The designed antenna was modeled and simulated using **ANSYS HFSS**, a leading tool for 3D electromagnetic simulation. The simulation setup involved defining the patch geometry, applying appropriate boundary conditions, and exciting the antenna through a microstrip feed line.



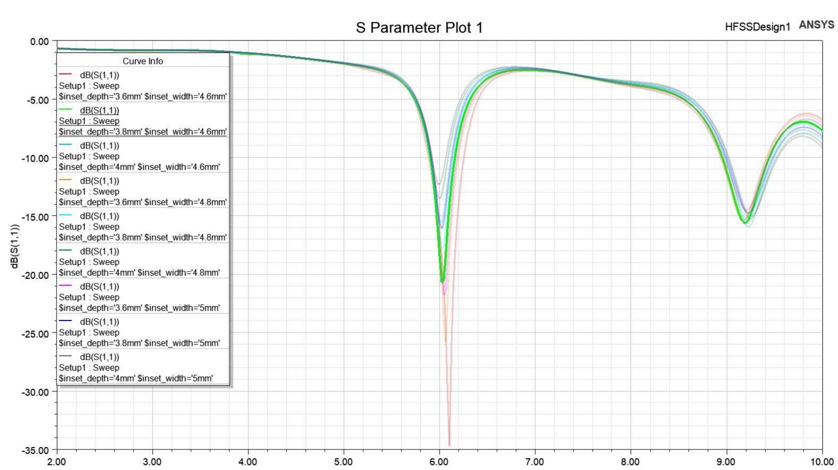




*Fig 1: Compares the return loss for various antenna dimensions, revealing how design changes affect performance.*

Both of these graphs are "S Parameter Plot 1" showing S11 (return loss) versus frequency. They illustrate the results of a parametric study. This means that one or more physical dimensions of the antenna (in this case, 'inset_depth' and 'inset_width') have been varied, and the S11 response has been plotted for each variation.

**Design Optimization:** This is crucial for optimizing the antenna's performance. By varying parameters, we can fine-tune the resonant frequency, bandwidth, and impedance matching.

**Sensitivity Analysis:** It also shows how sensitive the antenna's performance is to small changes in its dimensions.

## S11 Parameter (Return Loss)

The S11 parameter represents the reflection coefficient and is crucial in determining how much power is reflected back due to impedance mismatch.

**Expected Behavior**: S11 should be about-20 dB at 6 GHz, indicating good impedance matching.

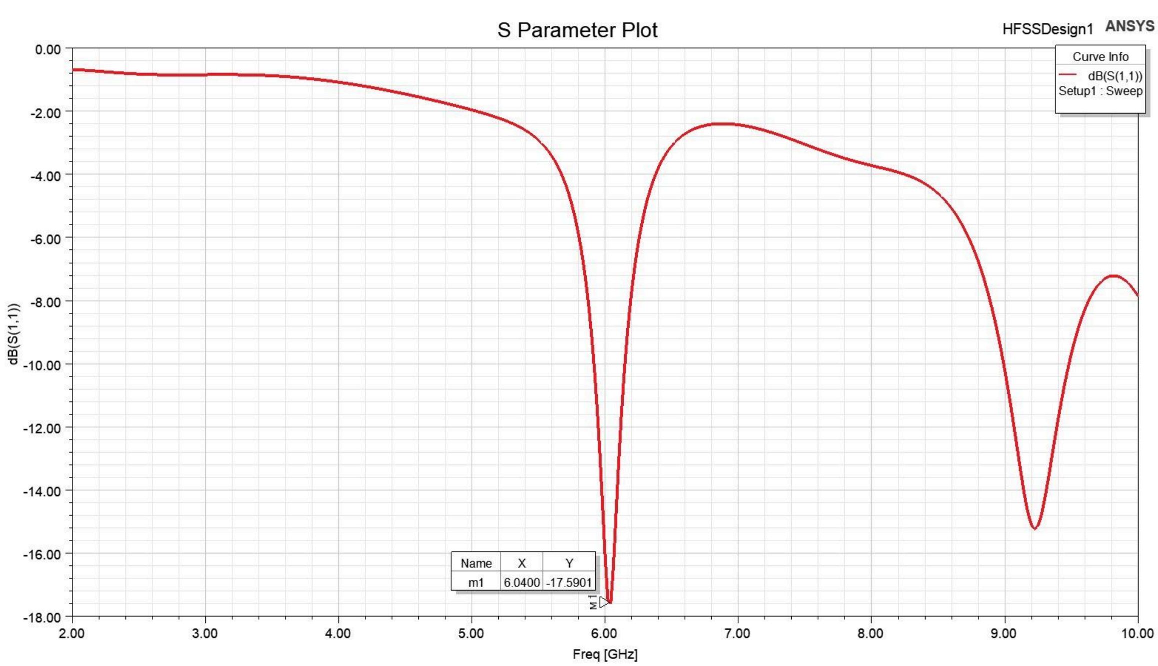
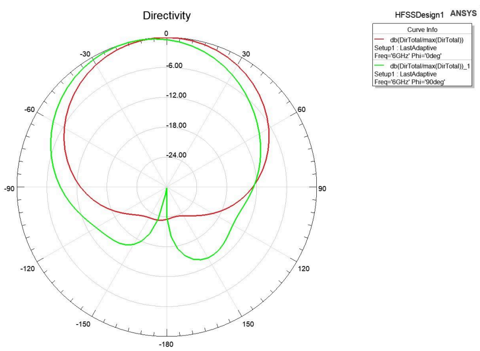



*Fig 2: Displays the antenna's return loss, with a strong -17.59 dB at 6.04 GHz, signifying minimal reflected power.*

## Radiation Pattern

This is a 2D polar plot showing the directivity of the antenna (in dB) as a function of the angle. Similar to the rE plot, it likely shows the directivity in two different planes ( ϕ=0 deg and ϕ=90 deg). Directivity is a measure of how concentrated the radiated power is in a specific direction, assuming a lossless antenna.



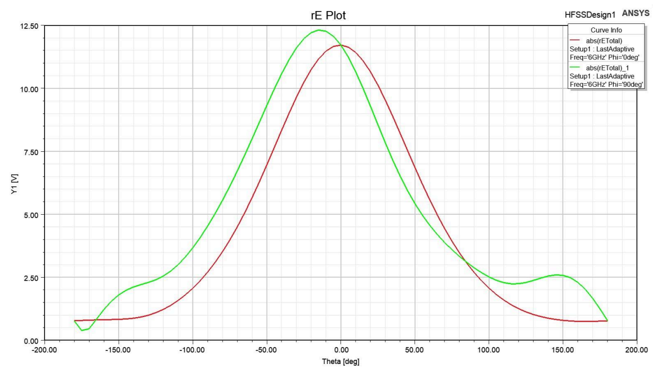




*Fig 3 (left): Shows the antenna's directional concentration of radiated power in specific planes, highlighting its beam shape.*

*Fig 4 (right): Illustrates the electric field radiation pattern in two planes at 6 GHz, showing the antenna's directional energy distribution.*

## Gain and Efficiency

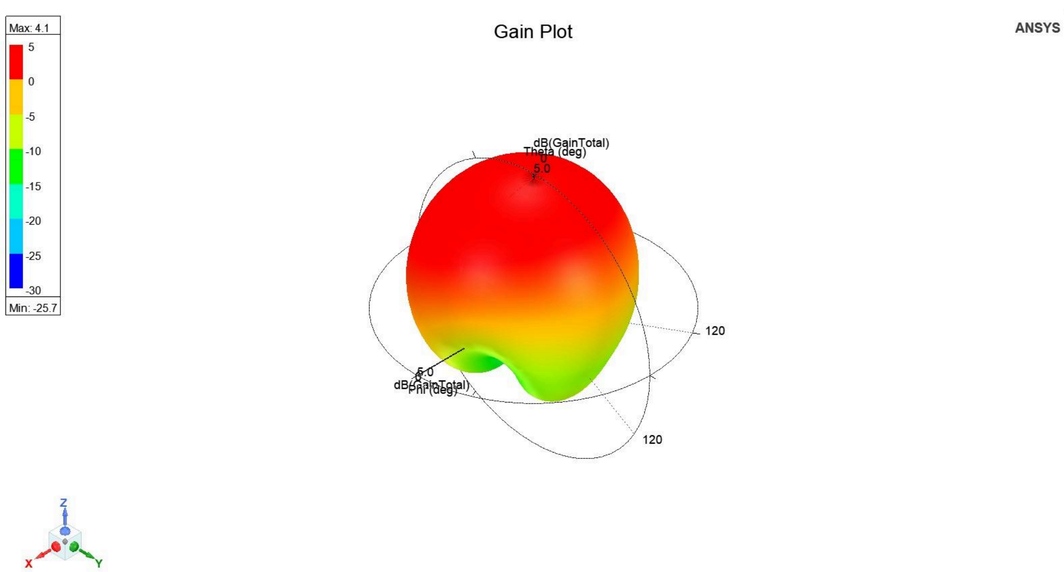



*Fig 5: Provides a 3D visualization of the antenna's total gain, peaking at 4.1 dBi, indicating its power focusing ability.*

This is a 3D polar plot showing the total gain of the antenna in dBi (decibels relative to an isotropic radiator). The color scale indicates the gain values. This plot provides a comprehensive view of how the antenna radiates power in all directions.

## VSWR

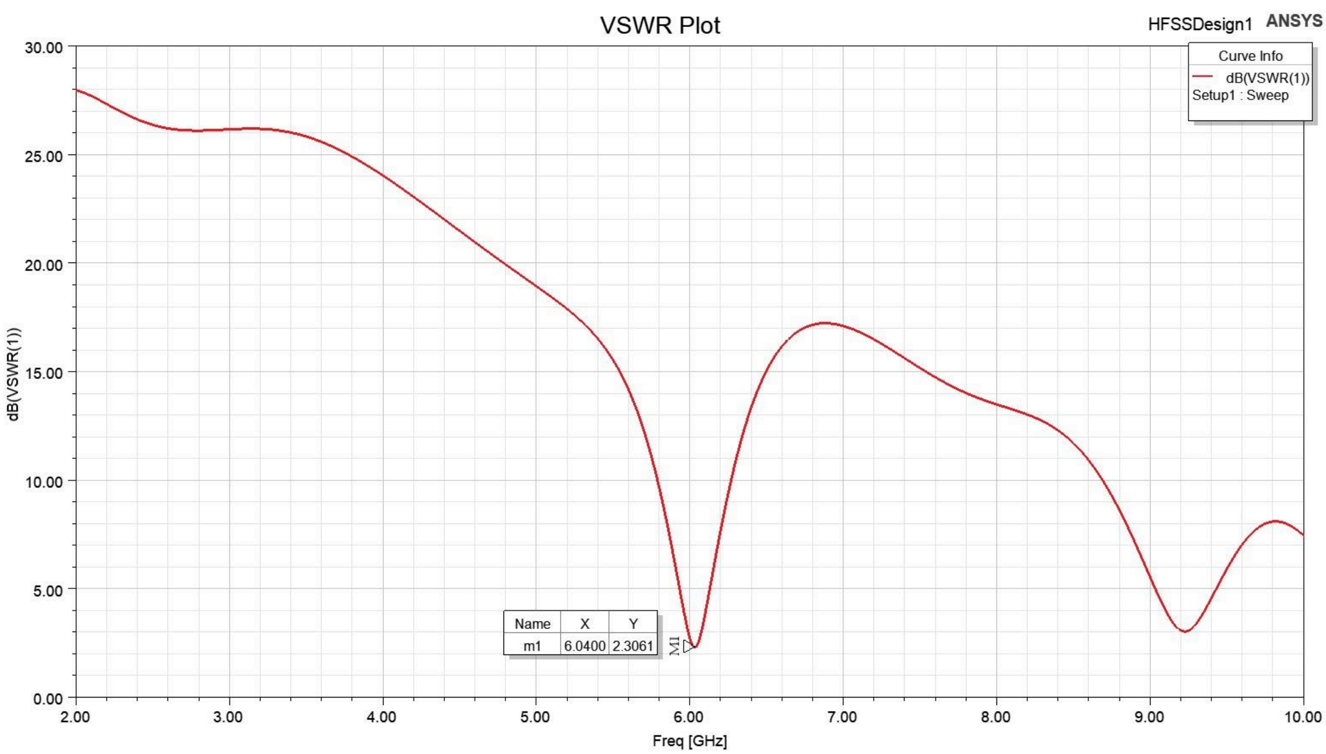



*fig 7: Shows the antenna's impedance match, with a minimum VSWR of 2.31 dB at 6.04 GHz, indicating good power transfer.*

This graph shows the Voltage Standing Wave Ratio (VSWR) in dB as a function of frequency. VSWR is a measure of how efficiently radio frequency power is transmitted from a power source, through a transmission line, into a load. A lower VSWR indicates better impedance matching between the antenna and the transmission line, meaning more power is delivered to the antenna and less is reflected back.

## Conclusion

The patch antenna designed for 6 GHz shows promising characteristics as verified by ANSYS HFSS simulations. The calculated parameters and simulation results demonstrate acceptable return loss, good radiation characteristics, and suitable impedance matching using FR4 substrate. This design can be extended to real-world prototyping and further optimized for better bandwidth or gain as needed.