Design of Metamaterial/metasurface based on efficient antenna for RF energy harvesting and wireless energy transmission

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Abstract

This study presents the design of an efficient metamaterial/metasurface based antenna for RF energy harvesting and wireless power transmission. The antenna operates at **2.45 GHz (linear polarization)** for efficient energy harvesting in Wi-Fi and ISM bands and **3 GHz (circular polarization)** for improved omnidirectional wireless power transmission.Metasurface/metamaterials are integrated to enhance impedance matching, bandwidth, and radiation performance. The design and simulations are carried out using HFSS software. The results show improved energy harvesting efficiency and wireless power transfer, making the antenna suitable for advanced wireless energy applications.

Background

Wireless power transfer and energy harvesting are key for powering IoT devices. This project designs a **dual-band antenna** that works at **2.45 GHz** (linear) and **3 GHz** (circular polarization) to improve energy harvesting and power transfer.

Using **metamaterials**, the antenna's performance is enhanced for better energy absorption and transmission. Simulations show the antenna works well in both polarization modes, making it ideal for wireless energy use.

Key References:

1.Vijay Gokul et al. (2020), *RF Energy Harvesting Antenna using Optimization Techniques*

2.Microstrip Patch Antenna Design

3.Circularly Polarized Antenna for Energy Harvesting

Methods

•**Ground Plane**:
A metallic sheet at the bottom to reflect signals and enhance performance.

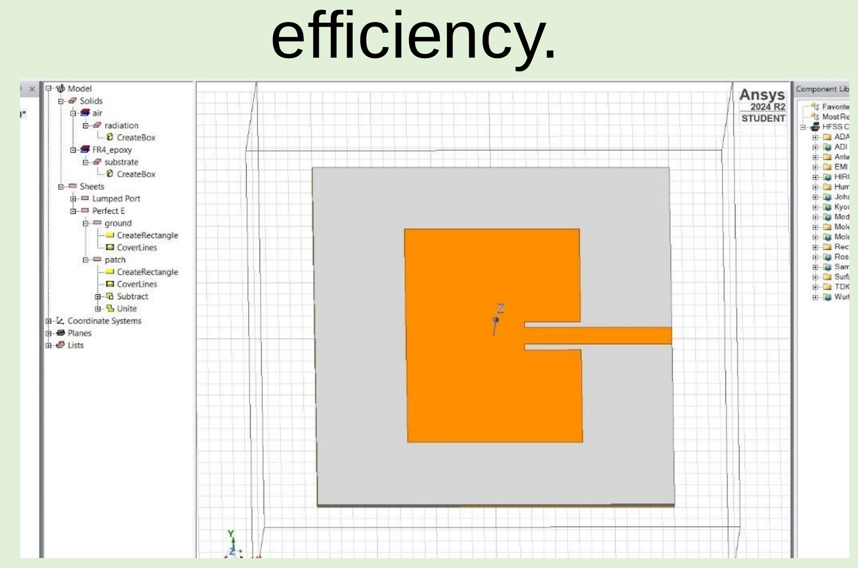
•**Substrate**:
A dielectric material between the patch and the ground plane to control frequency.

•**Patch**:
The main radiating element designed for 2.45 GHz and 3 GHz operation.

•**Feedline & Wave Port**:
Provides power to the antenna for testing and impedance matching.

•**Radiation Box**:
A virtual air enclosure around the antenna for accurate signal simulation.

•**HFSS Simulation**:
Optimizes performance by analyzing impedance (S11 < -10 dB), gain, and efficiency.



Results

Figure 1

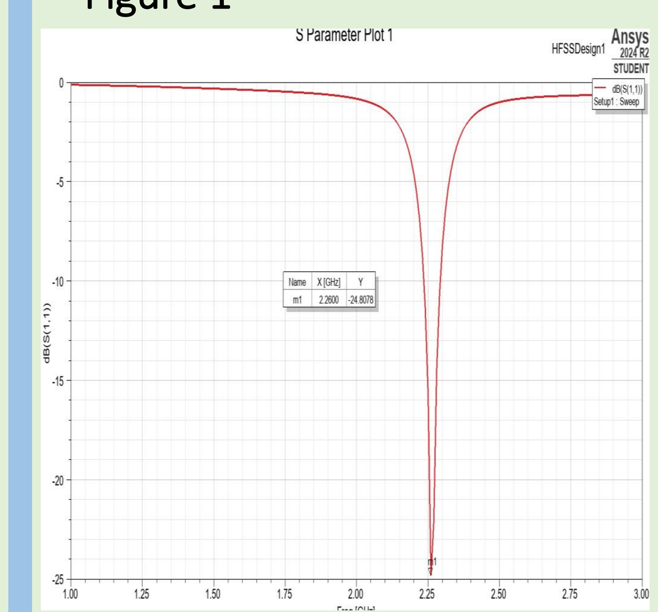


Figure 2

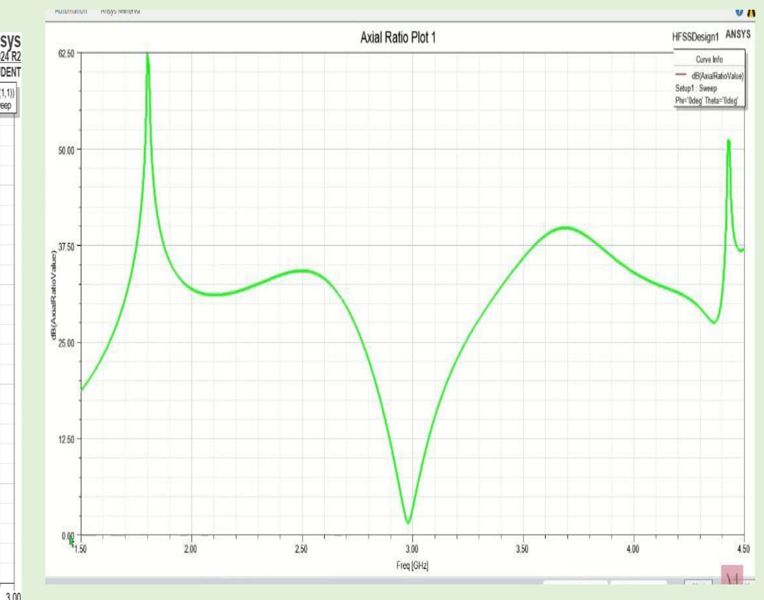
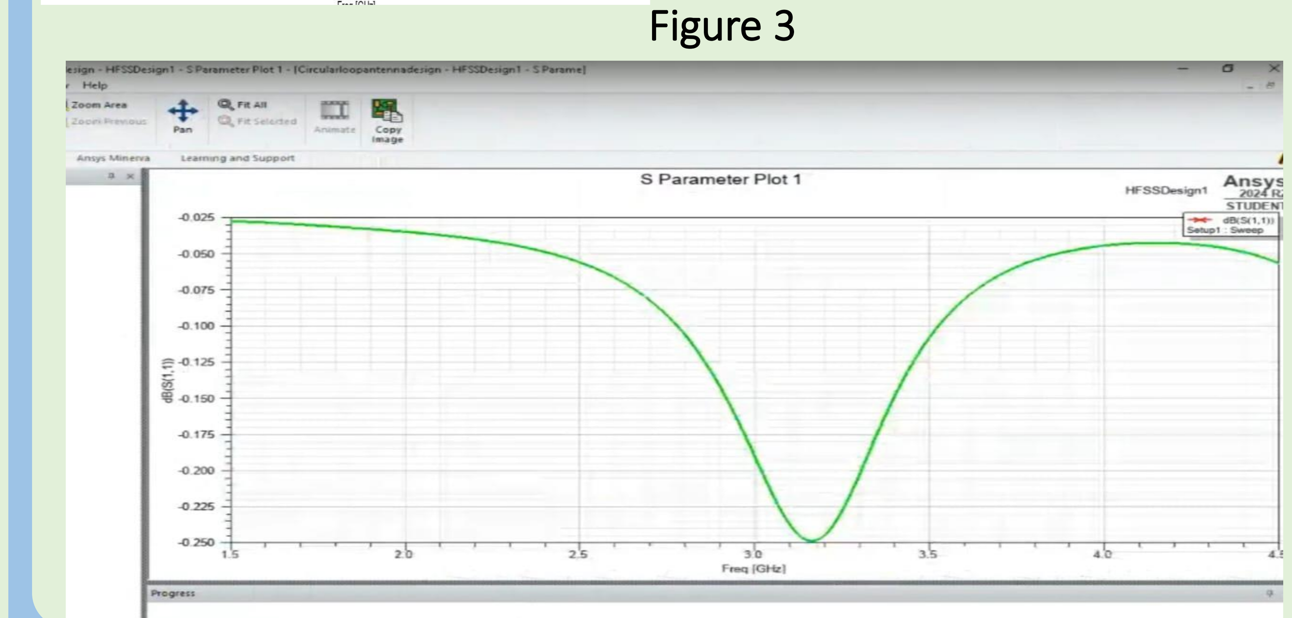


Figure 3



Conclusion

- Designed and simulated efficient antennas for RF energy harvesting and wireless energy transmission
- Successfully designed and simulated a **rectangular patch antenna** operating at **2.45 GHz** using **HFSS software**.
- Successfully designed and simulated a **circular patch antenna** operating at **3 GHz** using **HFSS software**.
- Ensured the availability of necessary tools and resources to meet project objectives.
- Achieved optimal antenna performance through rigorous design, simulation, and analysis.
- Completed the project with detailed documentation and performance evaluation.

Future Perspectives

Future advancements in **metasurfac-based antennas** can enhance RF energy harvesting through **tunable, miniaturized, and high-efficiency designs**. Key focus areas include:

•**Reconfigurable metasurfaces** for adaptive frequency control.
•**Compact and flexible designs** for IoT and wearable applications.
•**Multi-band and wideband operation** for broader energy harvesting.

Impact on Society

Metasurface-based antennas can improve **energy access and sustainability** by:

•**Reducing battery dependence** and wired power needs.
•**Powering smart cities & IoT** with self-sustaining devices.
•**Supporting healthcare** with wireless medical sensors.

To know more

GitHub link: https://bit.ly/4hIoM2v

Video link: drive.google.com