

# Design and Performance Analysis of Microstrip Antenna with Frequency Selective Surface (FSS)

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## Abstract

This project presents the design, theoretical analysis, simulation, and performance evaluation of a microstrip antenna integrated with a Frequency Selective Surface (FSS). Microstrip antennas are widely used in wireless communication systems due to their compact size and ease of fabrication, but they suffer from limited bandwidth and impedance mismatch. To overcome these drawbacks, an FSS structure is incorporated. Comparative analysis between the antenna with and without FSS is carried out using S-parameter characteristics. The results demonstrate improved impedance matching and frequency selectivity around the 2.4 GHz ISM band, making the proposed antenna suitable for modern wireless applications.

## 1. Introduction

With the rapid growth of wireless communication technologies, antennas with compact size, low cost, and reliable performance are in high demand. Microstrip patch antennas fulfill these requirements and are extensively used in Wi-Fi, Bluetooth, WLAN, and IoT applications. However, conventional microstrip antennas exhibit narrow bandwidth and surface wave losses, which degrade performance.

Frequency Selective Surfaces (FSS) provide an effective solution to these limitations. By acting as spatial filters, FSS structures improve impedance matching, suppress surface waves, and enhance overall antenna performance. This project focuses on integrating an FSS with a microstrip antenna and analyzing its impact through simulation.

## 2. Literature Review

Several researchers have explored the use of Frequency Selective Surfaces in antenna engineering. Studies have shown that FSS structures can improve antenna gain, bandwidth, and radiation efficiency. Balanis discussed fundamental antenna theory and microstrip antenna behavior, while Garg et al. provided detailed design methodologies. Recent IEEE publications highlight the effectiveness of FSS in modern wireless systems.

### 3. Theory of Microstrip Antenna

A microstrip antenna consists of a radiating metallic patch printed on a dielectric substrate with a ground plane on the opposite side. Radiation occurs due to fringing fields at the patch edges. The resonant frequency depends on the patch dimensions, substrate height, and dielectric constant.

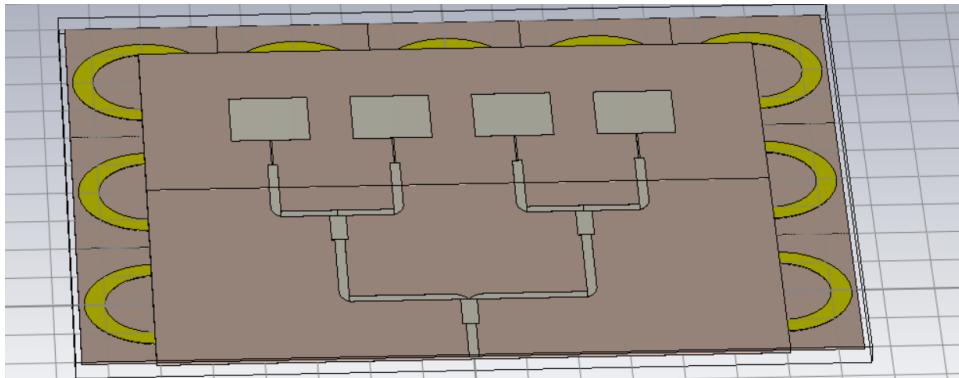
The approximate resonant frequency is given by:

$$f_r = c / (2L\sqrt{\epsilon_{eff}})$$

where  $c$  is the speed of light,  $L$  is the effective patch length, and  $\epsilon_{eff}$  is the effective dielectric constant.

### 4. Antenna Design Without FSS

The initial antenna design is implemented without the Frequency Selective Surface to evaluate baseline performance. A microstrip feed network excites multiple radiating patches. This configuration provides basic radiation characteristics but exhibits higher reflection loss and limited impedance matching.



### 5. Frequency Selective Surface (FSS) Theory

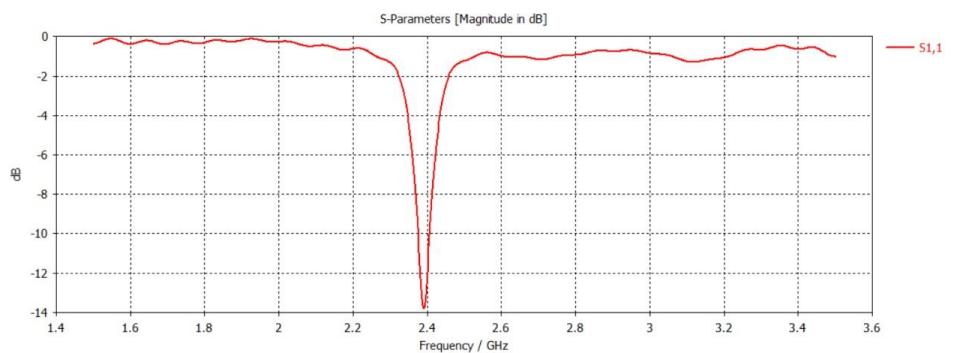
A Frequency Selective Surface is a periodic arrangement of conductive elements or apertures that controls the propagation of electromagnetic waves. Depending on its geometry, an FSS can act as a band-pass or band-stop filter. When placed near an antenna, it alters surface current distribution and improves radiation characteristics.

### 6. Antenna Design With FSS

After analyzing the antenna without FSS, the FSS structure is introduced around the radiating patches. The FSS enhances impedance matching, suppresses surface waves, and improves return loss at the desired operating frequency.

## 7. Simulation Results

The antenna is simulated using electromagnetic simulation software. S-parameter analysis is used to evaluate impedance matching. The S11 plot shows a deep resonance around 2.4 GHz with a return loss of approximately  $-14$  dB, indicating good matching.



## 8. Comparison: Antenna With FSS vs Without FSS

Parameter	Without FSS	With FSS
Return Loss (S11)	Moderate	Improved ( $\approx -14$ dB)
Impedance Matching	Poor to Moderate	Good
Bandwidth	Narrow	Enhanced
Surface Wave Loss	High	Reduced
Radiation Efficiency	Lower	Higher
Frequency Selectivity	Low	High

## 9. Applications

The proposed antenna is suitable for ISM band applications such as Wi-Fi, Bluetooth, WLAN, wireless sensor networks, and IoT systems.

## 10. Advantages and Limitations

Advantages include improved impedance matching, enhanced bandwidth, and compact size. Limitations involve increased design complexity and fabrication precision requirements.

## 11. Conclusion

This project successfully demonstrates the improvement in antenna performance using a Frequency Selective Surface. The comparative analysis confirms that the antenna with FSS

outperforms the conventional design, making it suitable for modern wireless communication systems.

## **12. Future Scope**

Future work may include optimizing FSS geometry, extending the design to multiband operation, and experimental validation through fabrication and measurement.

## **References**

1. C. A. Balanis, Antenna Theory: Analysis and Design.
2. R. Garg et al., Microstrip Antenna Design Handbook.
3. IEEE Transactions on Antennas and Propagation.