*International Journal on Recent and Innovation Trends in Computing and Communication*
*ISSN: 2321-8169 Volume: 11 Issue: 9*
*Article Received: 25 July 2023 Revised: 12 September 2023 Accepted: 30 September 2023*

# Comparative Study of Rectangular Patch Antenna using FR4 and RT Duroid Substrates

**Thingbaijam Rajkumari Chanu[1,2*], N. Basanta Singh[2]**
[1*]Manipur Technical University
[2]Manipur Institute of Technology
***Corresponding Author:-** Thingbaijam Rajkumari Chanu
***Manipur Technical University**

**Abstract**
This research presents a comparative analysis between RT Duroid and FR4 substrates for microstrip patch antennas using Zealand IE3D software. Spanning 3 GHz to 5 GHz, the study assesses parameters like return loss, VSWR, Axia, Antenna Efficiency, Radiation Efficiency, Gain, Directivity and Bandwidth. Results obtained through simulation are scrutinized to understand how substrate selection influences the antenna's behaviour and physical dimensions across the specified frequency range. This research provides valuable insights for microwave engineers, facilitating the informed selection of substrate materials based on application-specific requirements and optimizing the design of microstrip patch antennas for high-frequency communication systems.

**Key Words** - Return Loss, VSWR, Antenna Efficiency, Radiation Pattern, Gain, Directivity, Bandwidth, Zealand IE3D Software.

## Introduction

In the realm of microwave engineering, the choice of substrate material plays a pivotal role in determining the performance of microstrip patch antennas. This research endeavours to provide a comprehensive comparative analysis between two widely utilized substrates, RT Duroid and FR4, with a focus on the design and simulation of microstrip patch antennas. The study addresses resonating frequencies ranging from 3 GHz to 5 GHz, covering a significant spectrum relevant to contemporary communication systems. Leveraging the capabilities of Zealand IE3D software, known for its precision in simulating intricate microwave structures, our investigation delves into key performance parameters such as return loss, bandwidth, radiation pattern, and gain. By systematically exploring the impact of substrate selection on these parameters, we aim to uncover the strengths and weaknesses of RT Duroid and FR4 substrates, providing engineers and designers with valuable insights for optimizing the design of microstrip patch antennas tailored to the specific demands of high-frequency communication applications [3] [5]. This research contributes to the ongoing discourse in microwave engineering, offering practical guidance for substrate material selection and antenna design in the pursuit of enhanced performance and efficiency.

## Antenna Design

In conducting a comparative analysis between RT Duroid and FR4 substrates for rectangular patch antennas within the frequency range of 3 GHz to 5 GHz, the antenna design parameters are carefully considered. For both substrates, with FR4 having a height ($h$) of 1.6 mm, dielectric constant ($\varepsilon_r$) of 4.4, and a loss tangent of 0.0025, and RT Duroid with its unique properties, the dimensions are optimized for resonating frequencies across the specified spectrum. The probe radius is assumed to be 0.625 mm. The width ($W$)= $\frac{c}{2f_0\sqrt{\varepsilon_r+1}}$ [1]of the rectangular patch antenna is determined using the formula , and the length ($L$) is calculated as $L$=Leff−2ΔL
[1]. This comparative design approach enables a thorough examination of the performance characteristics of rectangular patch antennas utilizing RT Duroid and FR4 substrates. Critical parameters, including return loss, VSWR, axial ratio, antenna efficiency, radiation pattern, and bandwidth, are systematically evaluated for both substrates. The antenna dimensions and characteristics are analysed to discern nuanced trade-offs associated with substrate selection, providing valuable insights for optimizing antenna designs within the 3 GHz to 5 GHz frequency range.

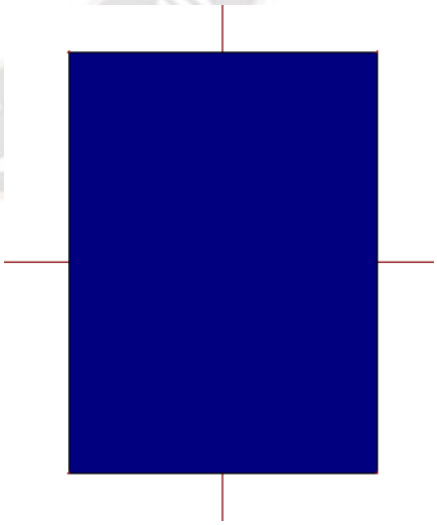

**Figure 1:** Rectangular Patch Antenna designed in IE3D software

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## SIMULATION RESULTS:

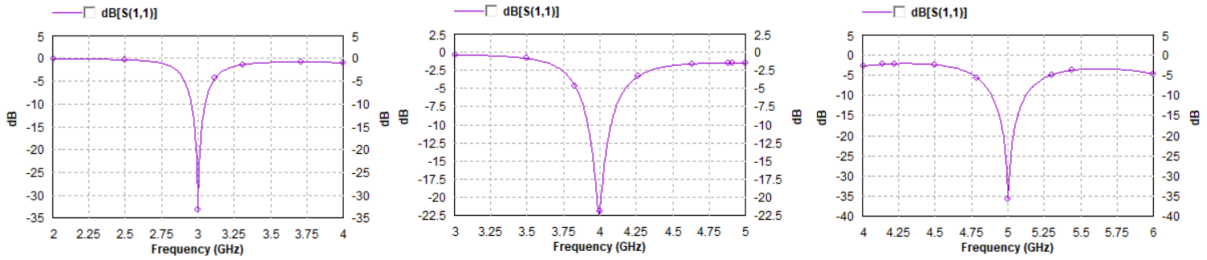


**Figure 2:** Return Loss graph for FR4 substrate for 1 GHz, 2 GHz & 3 GHz

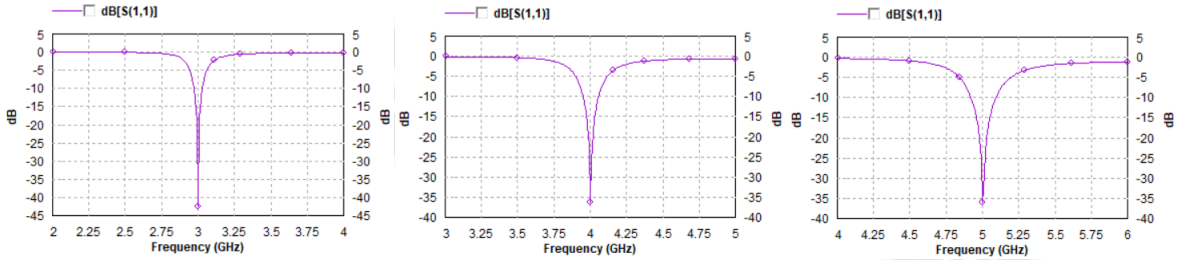


**Figure 3:** Return Loss graph for FR4 substrate for 1 GHz, 2 GHz & 3 GHz

### Comparison Table I

| Substrate | Dielectric constant ($\varepsilon_r$) | Loss tangent ($\frac{1}{tan\,\delta}$) | Height of the substrate (mm) | Resonating Frequency (GHz) | Length (mm) | Width (mm) | Return Loss (dB) | Antenna Efficiency (%) | Radiation Efficiency | Gain (dBi) | Directivity (dBi) | Bandwidth (GHz) | VSWR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FR4 | 4.4 | 0.025 | 1.6 | 3 | 22.7 | 30.41 | -33.043 | 40.089 | 40.109 | 3.252 | 6.497 | 3.06 | 1.07 |
| | | | | 4 | 16.7 | 22.81 | -21.640 | 44.563 | 44.870 | 3.081 | 6.591 | 3.75 | 1.19 |
| | | | | 5 | 12.8 | 18.25 | 36.443 | 45.823 | 45.833 | 3.302 | 6.691 | 4.4 | 1.04 |
| RT Duroid | 2.2 | 0.0009 | 1.588 | 3 | 32.16 | 39.52 | -41.58 | 88.061 | 88.067 | 7.098 | 7.650 | 1.8 | 1.10 |
| | | | | 4 | 23.74 | 29.7 | -36.715 | 87.995 | 88.031 | 7.129 | 7.685 | 2.5 | 1.05 |
| | | | | 5 | 18.7 | 23.71 | -35.863 | 86.702 | 86.724 | 7.104 | 7.724 | 3.2 | 1.03 |

Comparative study of FR4 and RT Duroid has been shown above table. Most of the parameters of the antenna have been shown in Table I and it can be compared easily.

## Conclusion:

In this paper, we have studied the rectangular microstrip patch antenna by using FR4 and RT Duroid. The simulation was done with the helped of Zealand IE3D software. From the results, it was found that RT Duroid is better than FR4 with respect to the parameters compared. By increasing the operating frequency also, RT Duroid was found to be more advantageous than FR4. However, the bandwidth is very low. In future, it can be enhanced by cutting slot. As of cost, FR4 is cheaper than RT Duroid. Different substrates are available like foam, bakelite, quartz, nylon fabric, roger 4350, etc may be studied for microstrip patch antenna.

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