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International Journal of Recent Advances in Engineering and Technology

ISSN: 2347 - 2812
Volume 14 Issue 01s, 2025

Patch with Rectangular Slit

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Peer Review Information

Submission: 1 Sept 2025

Revision: 28 Sept 2025

Acceptance: 12 Oct 2025

Keywords

Patch, Gain, Slit.

Abstract

This paper presents an enhancement in performance of a patch antenna using Slit structure. The Slit structure is applied to improve the antenna again. The antenna design is developed using HFSS (High Frequency Structure Simulator) software. Initially, a reference model is developed using single patch antenna. In simulation, this reference The antenna functions at a frequencyof2.45GHz,with again of 2.92dB, a band width of218MHz, and a VSWR of 1.58. To improve the antenna's gain the Slit structure is incorporated. The simulation of this modified antenna shows that it operates at the same frequencyof2.45GHzbutwith againof3.03dB,a bandwidth of 233 MHz, and a VSWR of 1.32 Consequently, the gain is improved from 2.92dB to 3.031dBbyemployingtheSlit structure.

INTRODUCTION

The micro strip antenna is one of many antenna designs extensively used and researched in various engineering fields [1]. Micro strip antenna are often used in many wireless systems because they are small, have a low profile, and are easy to integrate [2]. These structures enhance antenna performance by reducing surface waves, which leads to improvements such as reduced back-lobe radiation, and increased antenna gain and bandwidth. [3] This study focuses on designing a rectangular patch antenna with a microstrip line feed and evaluating its performance based on return loss, power loss, efficiency, gain, bandwidth, and radiation pattern at a frequency of 2.4GHZ. The antenna is designed using an FR4 substrate and a rectangular split micro strip patch at different frequencies. [4]Among them, the suspended micro strip is the most basic and commonly used structure, offering enhanced efficiency due to the air gap adjacent to the ground plane.

METHODOLOGY

The first step in the design of patch antenna is to determine the operating frequency or frequency band based on the specific wireless communication application.

The selection of substrate material plays a crucial role in the antenna's performance, especially regarding of dielectric constant **loss tangent**, and **thickness**. Materials such as FR4, Rogers RT/ duroid, and Teflonare commonly used in microstrip antennas. The dielectric constant determines the size of the antenna and affects its bandwidth and efficiency. A higher dielectric constant lead to a smaller antenna, but it may also result in lower efficiency and bandwidth. The patch shape is generally rectangular, circular, orelliptical, though other configurations such as triangular and fractal patches may also be used for specific applications. For a rectangular patch antenna, The patch dimensions are derived using the following key equations:

Width (W) Calculation

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Effective Dielectric Constant Calculation

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Effective Length Calculation

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

Length Extension Calculation

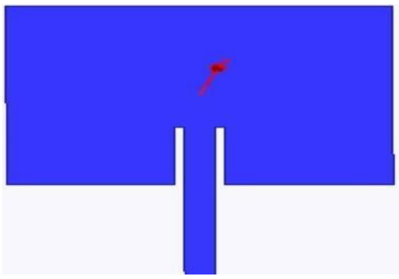
$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Actual Length Calculation

$$L = L_{eff} - 2\Delta L$$

Ground Plane Dimension Calculation

Wg=6h+W Lg= 6h+L



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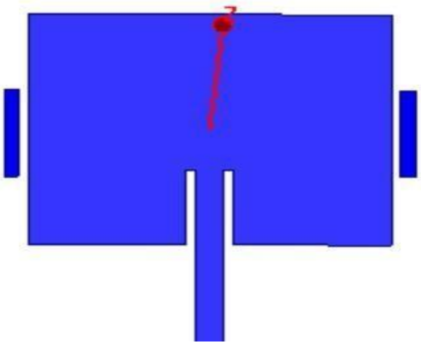
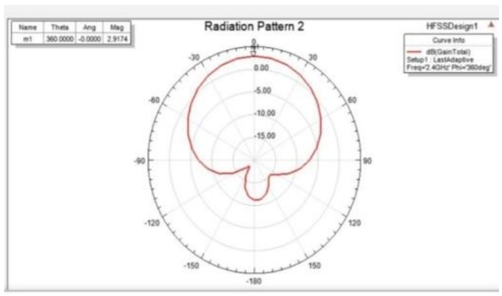


(b)

Figure1.a) Single patch without rectangular Slit and b) Single patch with rectangular slit

RESULTS AND DISCUSSION

This study design and simulate a single patch with slit. The bandwidth of the patch enhanced by using slit technique from 218 MHZ to 233 MHZ.



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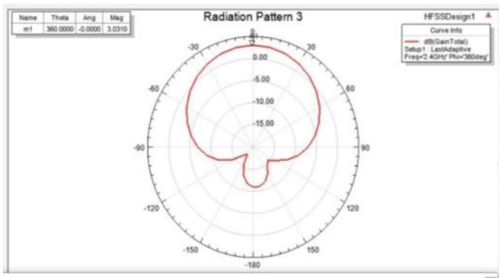
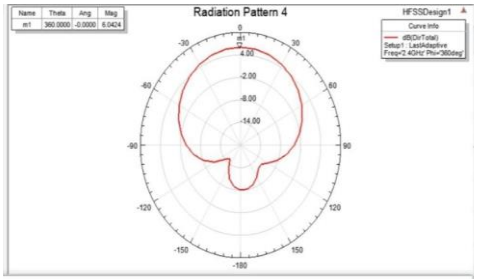


(b)

Figure 2: Simulation Result for Gain of single patch a) without & b) with rectangular slit

In the above figure 2 the gain of patch (a) without rectangular slit is 2.92dB and the patch(b) with rectangular slit gain is increased 3.03dB.



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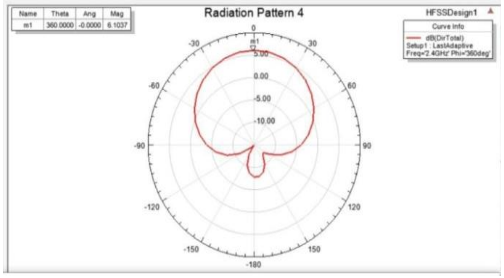
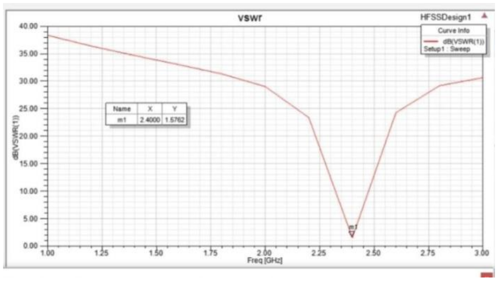


(b)

Figure3: Simulation Result for Directivity of single patch a) without & b)with rectangular slit

In the above figure3 the directivity of patch (a) without rectangularslitis6.0424dBand the patch(b) with rectangular slit is 6.1037dB.



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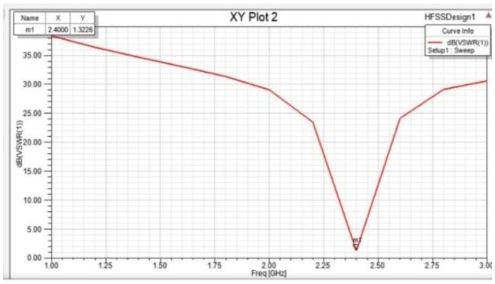
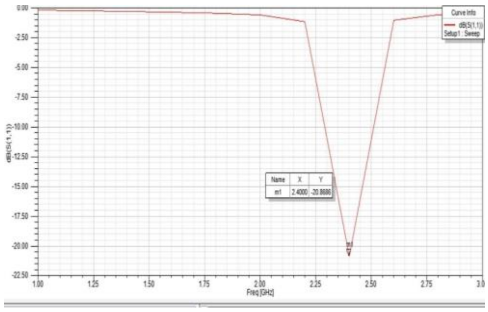


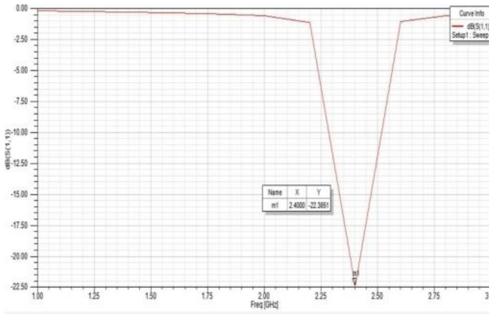
(b)

Figure4: Simulation Result for VSWR of single patch a) without & b) with rectangular slit

In the above figure 3 the VSWR of patch (a) without rectangular slit is 1.58dB and the patch (b) with rectangular slit VSWR is increased 1.32dB.



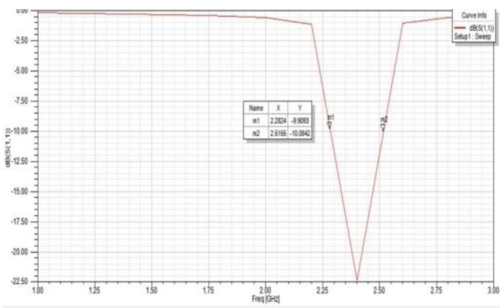
(a)



(b)

Figure 5: Simulation Result for S11 of single patch a) without &b) with rectangular slit

In the above figure 5 the S11 of patch (a) without rectangular slit is -20.86dB and the patch(b) with rectangular slit increased -22.38dB.



(b)

Figure6: Simulation Result for Band width of single patch a)without & b)with rectangular slit

In the above figure 6 the Band width of patch (a) without rectangular slit is 1.58dBandthe patch (b) with rectangular slit is increased 1.32dB.

Comparison Table of Simulation Result

Table1: Comparison of result

Parameter	Patch without rectangular slit	Patch with rectangular slit
Frequency(MHZ)	2.45	2.45
Gain(dB)	2.92	3.03
Directivity(dB)	6.042	6.103
VSWR	1.58	1.32
Bandwidth(MHZ)	218	233
S11(dB)	-20.86	-22.3851

CONCLUSION

From the above simulation result, the Gain of patch without rectangular slit is 2.92dB and with rectangular slit is 3.03 dB. The Directivity of patch without rectangular slit is 6.042dB and with slit is 6.103dB. VSWR of patch without rectangular slit is 1.58dB and with slit 1.32dB. Bandwidth of patch without rectangular slit is 18MHZ and with slit 233MHZ. The S11 of patch without rectangular slit -20.86d Band with slit-22.38dB.Therefore, antenna with slit show better performance.

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