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Research Paper

Performance Analysis of Microstrip Antenna Using Slotted Patch

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ABSTRACT
The microstrip patch antennas are very popular in communication applications, and they area low cost and compact size.Regardless of how these antennas are used, their bandwidth and efficiency are restricted and must be increased. This research intends to increase a microstrip antenna's antenna bandwidth and performance by introducing slotted patch designs. The dielectric substrate is made of Copper Annealed, and a microstrip line supplies power to the antenna.Efforts are made to maximize the antenna's performance by experimenting with lengths of feedlines, slot sizes and positions,dimensionsof the ground plane. Computer Simulation Technology (CST) is used to produce the results, and the research closes by demonstrating that the slot improves antenna performance. Various patch sizes and substrate materials are initially explored to achieve ideal antenna characteristics. After that, single, double, and more slots designs are included in the patch to improve the antenna performance further.The antenna is made to work in the X band.

CCS CONCEPTS
• Computer Simulation Technology • Microstrip Patch Antenna • X band
KEYWORDS
Microstrip, Patch, Slot, Antenna, VSWR, Antenna Gain.

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I. INTRODUCTION

In wireless communications, microstrip patch antennas are becoming more prevalent. A ground plane on the bottom and a radiating patch on the top are standard features of a microstrip patch antenna. Between the ground plane and patch, a dielectric substrate is utilized.Annular, rectangular, square, circular, semicircular,diamond, hexagonal, triangular, and bowtie are patch shapes that can be employed [1].Microstrip antennas have several appealing characteristics, including ease of manufacturing and integration with RF equipment and lightweight, a low profile, and cheap [2, 3].As a result, these are suited for various applications, including cellular phones, satellites, the Global Positioning System (GPS)and radar [4, 5].

Despite their widespread use, microstrip antennas have limited bandwidth andlow efficiency for the value of VSWR (Voltage Standing Wave Ratio) [1].For example, the typical microstrip antenna has a bandwidth of 2-5 percent and a maximum gain of 7dB when using a single patch. The value of impedance mismatch between the transmission line and antenna by determining Voltage Standing Wave Ratio (VSWR) should be less than two [5]. Different antenna characteristics may be responsible for improving fringing and, therefore, radiation. The antenna bandwidth can be increased by increasing the substrate thickness or decreasing the dielectric constant [6]. The substrate thickness must not cross 0.05λ, or the proposed antenna would supply power in surface waves rather than transverse waves and, hence, cease to radiate. Another issue arises due to reciprocal coupling, which affects the antenna's efficiency [7].

In general, the patch shape has a significant impact on the efficiency of a microstrip patch antenna. As a result, many patch shapes such as diamond, triangular, hexagonal, bowtie, circular, U-shaped, and others can be used [8-12]. Many researchers work with microstrip antennas, but they run into issues with VSWR and bandwidth. The effects of different substrates, patches, and ground thicknesses are critical for achieving the desired results. For the microstrip antenna, the thickness of different slots of the patch is particularly effective. The patch is a crucial component of an antenna for expanding the radiation region. Patch width is a key element for enhancing an antenna's bandwidth. 2G, 3G, and LTE networks have grown in popularity due to the advancement of the microstrip antenna. Microstrip antennas are widely used in satellite communication because they cover many frequency bands. This antenna has created a new chapter in wireless communications history by utilizing its valuable property. For higher efficiency, the majority of communication relies on slotted microstrip antennas. In order to extend the frequency bands in which the antenna may work, many alternative antenna structures have been constructed with many layers of resonators. All of the strategies mentioned above, or a combination of two or more, can expand the number of bands in which a microstrip antenna can function or raise the bandwidth of frequency bands of interest.

The following paper proposes a microstrip antenna design with patch slots, a radiator, and a ground plane. Unlike a few other microstrip antennas that have been designed, this one is compact. It can operate with a VSWR of less than two and have large bandwidth. The proposed antenna's working frequency is in the X Band, which is extremely useful in modern technologies, such as satellite communications, RADAR and wireless computer networks [9].

The proposed paper is described in the following sections: Section 2 presents the design of the proposed antenna, geometry and optimization. Section 3 deals with simulation results and analysis obtained from CST Studio Suite. In Section 4, a conclusion of this work is represented.

II.

III. Antenna Design

Fig.1illustrate the design of a microstrip patch antennain 3D.

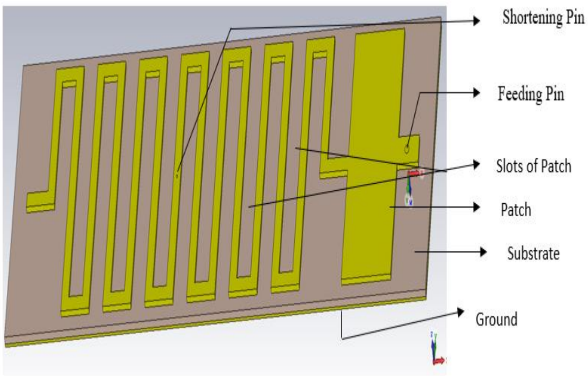

Figure 1: 3D view of proposed Microstrip Patch Antenna

A substrate of commercial chip FR-4 is used with a relative permittivity of 4.4, and thermal conductivity of 0.3[W/K/m] is used to imitate this antenna.For radiation, a copper patch and microstrip feed are utilized.On top of the substrate lies the radiating patch.The patch has some rectangular slots and is rectangular.The CST STUDIO SUITE program was used to simulate this proposed antenna.To examine the influence of radiating surface,the table shows the values of adequate length and width of the ground, substrate, and patch and the radius of shorting pin, feeding pin, cover, and dielectric coating.

A 50ohm microstrip feeding structure is used to feed the intended antenna, modified to achieve the best outcomes.The operating frequency is inversely related to the antenna's physical size, estimated using the following formula [10].

$$f = \frac{1}{4}\frac{c}{(L_p+W_p)} \quad (1)$$

The operating frequency is f, while the speed of light is c. Lp and Wp, respectively, represent the width and length of the patch element.

$$L_p \approx \frac{\lambda d}{4} = \frac{c}{4f\sqrt{\varepsilon_r}} (2)$$

$$W_p = \frac{c}{4f}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (3)$$

Where d is the wavelength substrate and r is the dielectric constant of the substrate. The total dimension of the proposed antenna can be calculated using Eqs. (2) and (3). During modelling, the length and width of the slotted microstrip antenna's radiating patch are optimised to increase the frequency band. Table 1 shows the antenna parameters.

Table 1:Antenna Parameters

Parameter Name	Length (mm)
Ground Length (Lg)	20
Ground Width (Wg)	60
Substrate Length (Ls)	20
Width of substrate (Ws)	60
Patch Length (Lp)	18
Width of patch (Wp)	56
Ground Thickness (Tg)	0.1
Substrate Thickness (Tsub)	0.5
Thickness of Patch (Tp)	0.4
Shortening Pin Radius (Rs)	0.09
Feeding Pin Radius (Rf)	0.3
Coating Radius (Rcot)	0.4
Cover Radius (Rcover)	0.45

IV. Simulation and Result Analysis

To identify the parameters and determine the covering bands, bandwidth, operating frequency and efficiency, this designed antenna is simulated in a soft's CST.

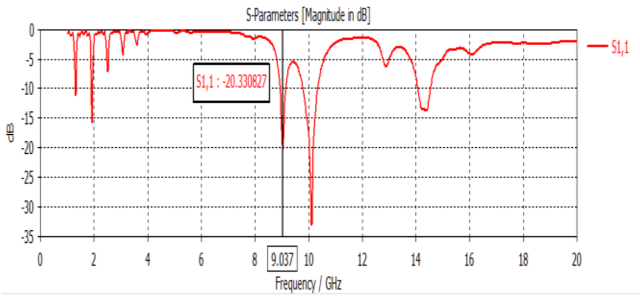

Figure 2: Simulated return loss of the antenna for 9.03GHz

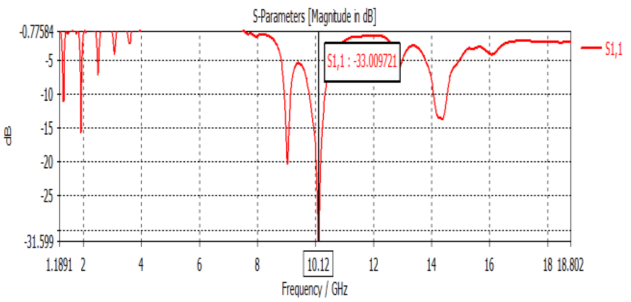

Figure 3:Simulated return loss of the antenna for 10.12GHz

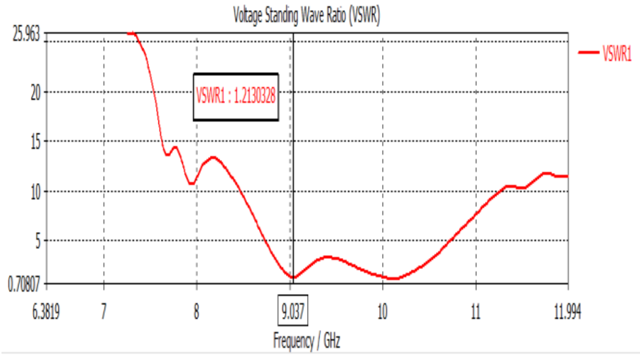

Figure 4:Simulated VSWR of the antenna for 9.03GHz

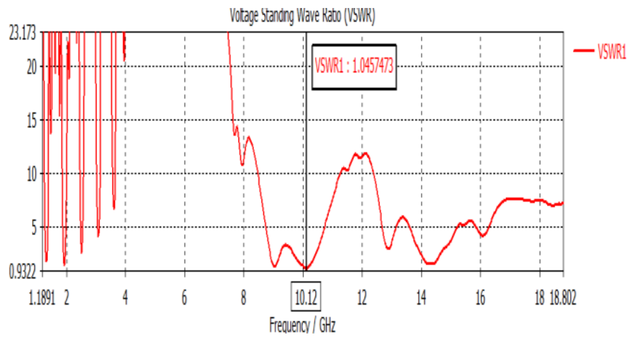

Figure 5:Simulated VSWR of the antenna for 10.12GHz

The voltage standing wave ratio (VSWR) determines the impedance mismatch between the transmission line and the antenna. This VSWR should always be less than two. Figure 2 and 4 show that the value of VSWR is 1.21with return loss -20.30dB at the operating frequency of 9.03GHz, according to the simulated data. On the other hand, Figure 3 and 5 also show that VSWR is 1.04 with return loss -33.01dB. The following diagrams demonstrate that the antenna can cover the X band. This antenna can be used for radar and satellite communication and a wireless computer network.

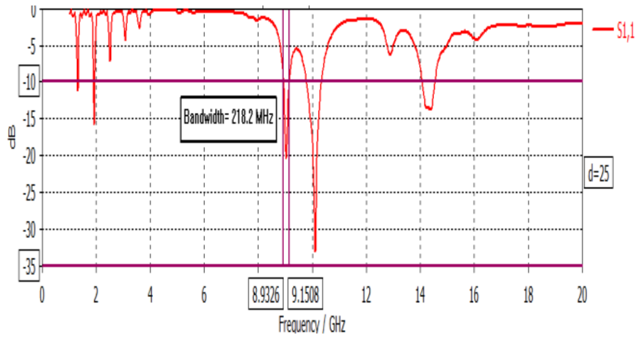

Figure 6: Bandwidth of the antenna for 218.2MHz

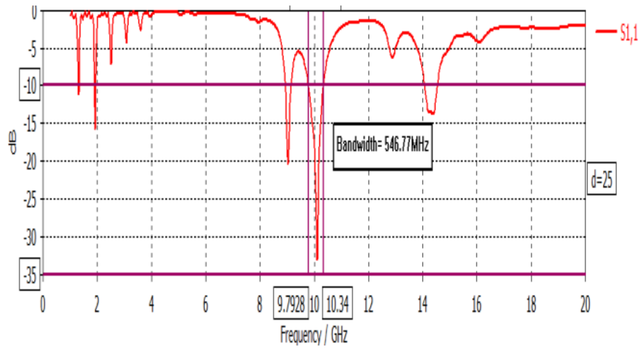

Figure 7: Bandwidth of the antenna for 546.7MHz

The return loss of -10dB is utilized as a reference for this suggested antenna. Figure 6 and 7 show the graphical illustration of bandwidth.

The term "directivity" refers to measuring the degree of emission from a single antenna direction. Antenna gain is determined by directivity. In Figure8, 9 and 10,the 3D radiation pattern is observed from the simulation result with directivity are determined from the simulated result for f=10.5GHZ, f=1GHZ and f=20GHZ.

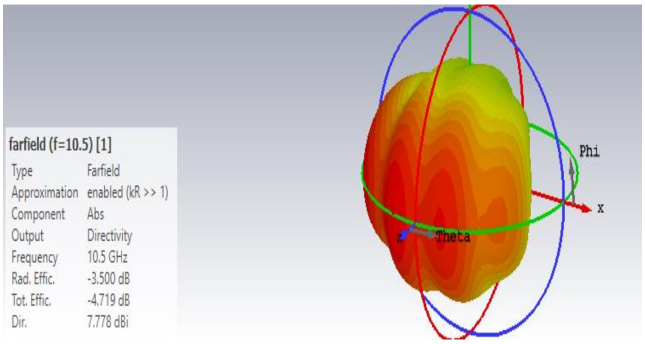

Figure 8:Radiation pattern (3D) and antenna directivity for 10.5GHZ

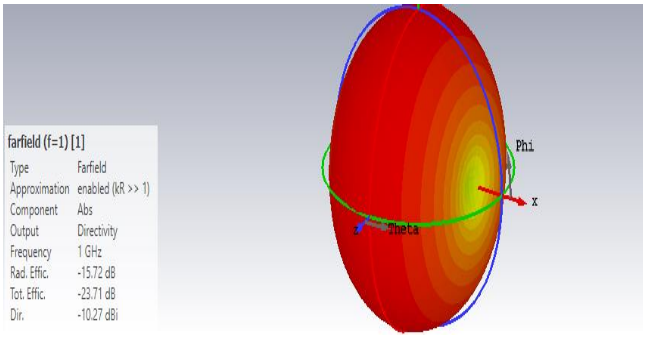

Figure 9:Radiation pattern (3D) and antenna directivity for 1GHZ

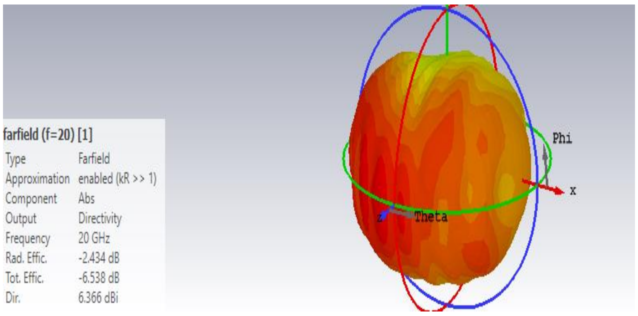

Figure 10:Radiation pattern (3D) and antenna directivity for 20GHZ

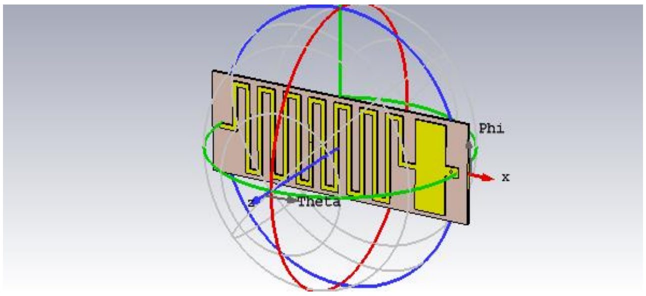

Figure 11:Farfield Excitation

There are two types of farfield: (I)electric farfield and (II)magnetic farfield. The distance between the source and the strength of farfield is inversely proportional. The term "directivity" refers to measuring the degree of emission from a single antenna direction. Antenna gain is determined by directivity. Directivity varies from 1.76dBi for an actual antenna. A dish antenna's maximum directivity value is 50dBi. The angular dependence of the strength of radio waves from the antenna is known as the radiation pattern. The field radiation pattern of an antenna creates farfield and near field. The near field pattern is always in front of the source of the enclosing cylindrical surface. Effective radiating efficiency and directivity are obtained in the accompanying figures, with 7.778dBi, -10.27dBi, and 6.366dBi for 10.5GHz, 1GHz, and 20GHz, respectively.

The efficiency of this slotted antenna is better, which is determined by figure 12.

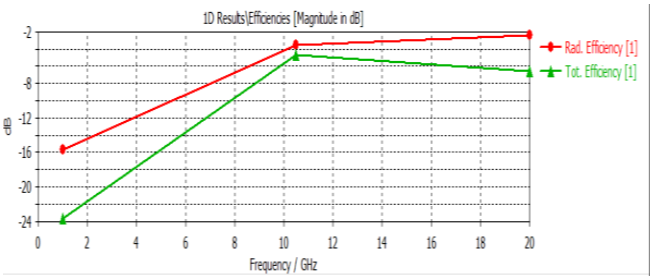

Figure12: 1D result of Efficiency

V. Conclusion

This research discussed how to improve a microstrip patch antenna's resonance characteristic in the X band. The research entailed inserting a slot into various patch shapes and relocating the ground plane to the antenna's front side. The CST software was employed, and in the majority of the examples investigated, slot insertion and front grounding significantly lowered the minimum power reflection. The antenna presented in this research is ideal for satellite and radar applications and several essential networking applications.The effects of slot width change on response frequency, different substrate materials, and ground are also investigated.For the variation of the patch and FR4 substrate slots, frequency responses are shifted.As a result, the developed antenna's performance is excellent, witha VSWR of 1.21, 1.04 and effective efficiency.

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