Dheeraj Kumar, 2024, 12:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Analysis of Microstrip Rectangular Patch Anteena for 5G Communication

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Abstract- Wireless networks can now only function at 4G, although 5G is being developed. These days, a lot of software run on fourth-generation communication technologies. Research on 5G communications is still in its infancy. Because microstrip antennas may be used in cutting-edge 5G technology, research into them is crucial. The micro strip Patch antenna's large bandwidth is crucial for meeting 5G requirements. A microstrip patch antenna with an imperfect ground structure is proposed for usage in 5G wireless communication systems in this study. The resonance frequency of this antenna is 5.4 GHz. The whole bandwidth of the suggested antenna is 0.78 GHz.

Keywords- Return Loss, Bandwidth Patch, Microstrip, gain, Directivity, Voltage Standing Wave Ratio.

I. INTRODUCTION

Although current wireless networks can only reach a maximum of 4G speeds, 5G is soon to arrive. Many programmes are now supported by fourth-generation communication systems. Research on 5G communications is a relatively young field. The prospective uses of microstrip antennas make their research extremely important.

Apart from improving the user experience, 5G opens the door to unprecedented levels of communication between humans and machines. Since it allows low-latency transmissions, it may be utilised to create cutting-edge applications like virtual reality and augmented reality in medicine, autonomous vehicles, and more. The proliferation of smartphones and the growth of mobile data are posing unprecedented challenges for wireless service providers in their efforts to address the worldwide bandwidth crunch [1].

An antenna that has a patch, self-similar design maximises the perimeter of material inside a specific total surface area or volume that may receive or transmit electromagnetic radiation, either on internal components or the external structure.

A common characteristic of these patch antennas is the recurrence of a pattern over two or more scale sizes, which is known as "iterations." Fractal antennas are multiband or wideband in spite of their tiny size, which makes them ideal for usage in wireless networks like microwaves and mobile phones. Unlike traditional antennas, patch antennas can potentially perform well to well over a wide variety of frequencies concurrently. Conventional antennas can only be used efficiently on the operating frequency since they must be "cut" to match it [3].
Microstrip patch antennas provide Wi-Fi communication, which operates in the 2.4 GHz frequency range. This research paper describes the design and performance analysis of a microstrip patch antenna for a Wi-Fi communication system. The main objective of this article is to construct a microstrip patch antenna and assess its performance using different types of dielectric materials. Performance is improved with FR4. The return loss for FR4 is significantly smaller than that of the other dielectric materials used in this study, measuring S

11 at -6.31 dB at 5.4 GHz. Additionally, a satisfactory 2.89 VSWR was observed. [4].

Managing various technologies simultaneously in the same band-limited spectrum is necessary to serve both legacy users with older, less functional mobile phones and customers with more modern, sophisticated smart phones. At the moment, operators' spectrum allotments are separated into discrete frequency bands, each of which uses a different set of radio networks with different characteristics related to building penetration loss and propagation. Base station designs must accommodate a wide range of frequencies across a huge variety of cell sites, since many base stations are installed at each location (one for each frequency or technology application, such as 3G, 4G, and LTE-A) [5].

Purchasing more spectrum through organisations like the International Telecommunications Union (ITU) and the Federal Communications Commission of the United States (FCC) may take up to 10 years. Existing users have to be moved off the spectrum after licencing is finished, which adds time and expense to the procedure [6].

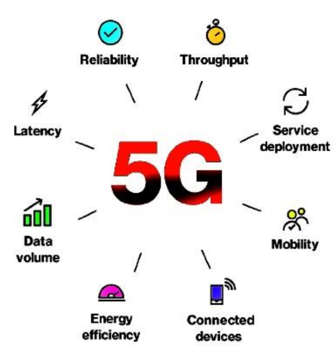

Figure 1: 5G service models

Figure 1 shows that in order to support 5G services, 5G networks would need 1000 times more capacity and 10 to 100 times higher data rates. The perimeter, or effective length, of material that can receive or transmit electromagnetic radiation within a specific total surface area or volume is maximised by an antenna with a patch, self-similar design (on inner parts or the external construction). The distinctive feature of these fractal antennas is the motif's repetition over two or more scale factors. [7], typically referred to as "iterations."

Patch antennas are single band or wideband in spite of their tiny size, which makes them ideal for usage in wireless networks like microwaves and mobile phones. Unlike conventional antennas, fractal antennas have the ability to work well to well over a wide range of frequencies concurrently. Since they must be "cut" to fit the operating frequency, conventional antennas can only function well on that frequency. Because of this, Patch antennas are perfect for single band and wideband applications [8].

There are four main components to this study. Section I presents the study's background, rationale, and goals. Section II describes the research methodology and mathematical studies. Section III discusses the study's simulation results. Section IV concludes with recommendations for additional research.

These issues with preexisting antennas have been identified after reviewing:

- Inadequate bandwidth.
- Low productivity.
- Reduced gain.
- The feeds and connectors emit additional radiation.
- Antenna length and width.

The following is a objective of the planned study:

- As part of the development of 5G wireless networking, it is necessary to create ultra-wideband (UWB) fractal defective ground structures operating in the C-band.
- To expand data transfer rates and minimise reflected interference.
- To derive new parameters and evaluate them against preexisting design outcomes.

II. PROPOSED ANTENNA DESIGN

The CST programme was used to create the proposed antenna's layout. Figure 2 shows the proposed microstrip patch antenna in top view, with one side of a dielectric substrate acting as a ground plane and the other as an emitting patch. Figure 2 shows top views of a rectangular patch radio wire with thin microstrip feed. The patch and ground plane together create surrounding fields, and it is this field that provides the radiation from the antenna. Because of its compact size and improved reference, the microstip patch receiving equipment is introduced. The suggested receiver device is well inside the C-band frequency range, with a resonance frequency of 5.4 GHz.The radiating patch's size may be ascertained once these three parameters have been tuned.

Step 1: Estimate of dimension in term of width (W)
Practical width for an effective radiator that results in good radiation efficiency is:

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where, μ_0 = free permeability, = free space permittivity and = relative permittivity.

Step 2: Assuming a dielectric constant of, the second step is to calculate the effective dielectric coefficient.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{1/2}$$

Step 3: Calculation of the Effective Length (Leff)
The effective length is

Step 4: Calculation of the Length Extension (ΔL)

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

Step 5: Calculation of the actual Length of Patch (L)
The actual length of radiating patch is obtained by

L=L_eff -2ΔL

Step 6: Calculation of the Ground Dimensions (Lg, Wg)

The transmission line model can only work on infinite ground planes. But for pragmatic reasons, it's imperative to leave a minimal carbon impact. Results similar to those for a finite ground plane may be obtained if the ground plane is bigger than the patch dimensions by a factor of many times the substrate thickness across the perimeter, as shown by:

$$L_g = 6h + L \ , \ W_g = 6h + W$$

The simulation results are obtained by treating the ground plane as infinite.

$$\boldsymbol{Z_{in}} = j\omega L_p + \frac{R}{1 + jQ(f_R - \frac{1}{f_R})}$$

If you have a basic understanding of circuit theory, you can compute the input impedance of the patch as follows: j Where f0 is the resonance frequency of the patch hole (the resonance frequency of the RLC circuit), the frequency ratio is defined as fR= f/f0.

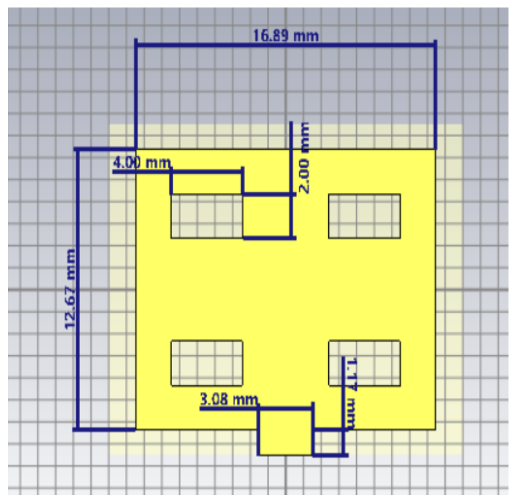

Figure 2: Antenna Design Top view

Figure 2 shows the proposed microstip patch antenna design. With a dielectric constant value of 4.4, the substrate is composed of the FR4 material, while the top and bottom layers are composed of the lossy copper material.

III. SIMULATION AND RESULTS

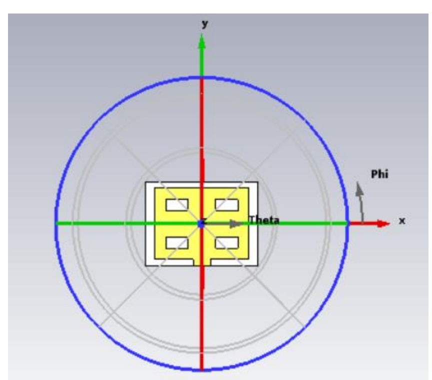

Figure 3: Simulation and fields of proposed antenna

Figure 2 depicts the suggested microstrip patch geometry for C-band applications. The construction is engraved on fire resistant 4 (FR4) and measures 16.89mm by 12.67mm by 1.64mm overall, with an overall permittivity of 4.4 and a loss digression of 0.024. This proposal's antenna components are listed in Table 1. A 50- and 0.5W micro thin link or a simple connection take care of the antenna.

CST microwave studio simulation and suggested antenna fields utilised to reproduce the design. Figure 3 depicts a circularly organised electric and attractive field simulation. "

"Table 1: Design parameters for proposed Antenna

Sr No.	Parameter	Value
1	Antenna Length	12.67 mm
2	Antenna Width	16.89 mm
3	Tangent Loss	0.06
4	Feed patch length	1.17 mm
5	Feed patch width	3.08 mm
6	Feed patch height	0.035 mm
7	Frequency (f_r)	5.4 GHz
8	Dielectric constant(ε_r)	4.4 / FR4
9	Ground Height	0.035mm
10	Substrate Height(Hs)	1.6 mm
11	Line Impedance	50 Ω

Optimized Band:"

Return Loss

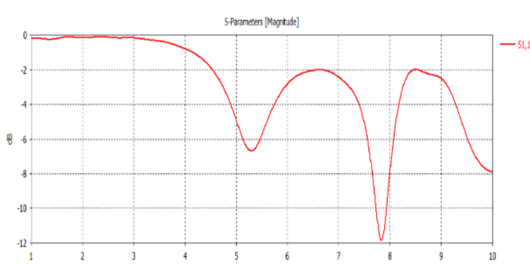

Figure 4: Return loss

The suggested structure's return loss is shown in Figure 4. By looking at this graph, we can easily deduce that the suggested antenna's return loss estimate is -6.31 dB at a resonant frequency of 5.4 GHz.

Bandwidth

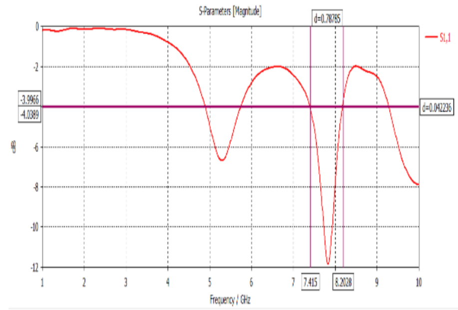

Figure 5: Bandwidth

A broadband antenna's bandwidth is sometimes expressed as a percentage of the difference between its fundamental frequency and the highest and lowest frequencies. In this instance, the suggested antenna's bandwidth is 0.78 GHz (7.41GHz – 8.20GHz).

Voltage Standing Wave Ratio (VSWR)

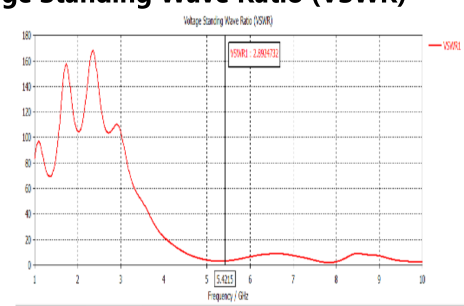

Figure 6: VSWR

The VSWR respect shown in Figure 6 has been attained at 5.4 GHz, The VSWR value is 2.89.

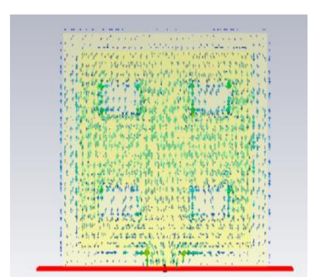

Figure 7: Surface current of proposed antenna

Surface current of the proposed antenna is shown in Figure 7. The proposed antenna's electric and magnetic fields are also shown, with electric field shown by blue dots and magnetic field shown by green dots.

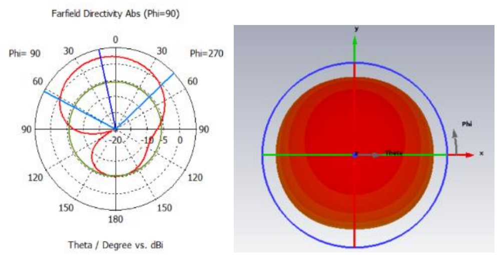

Figure 8: Radiation pattern

As can be seen in Figure 8, the suggested antenna bands have a certain radiation pattern. It's a twist on the force an antenna always sends out as part of the direction of the signal it receives.

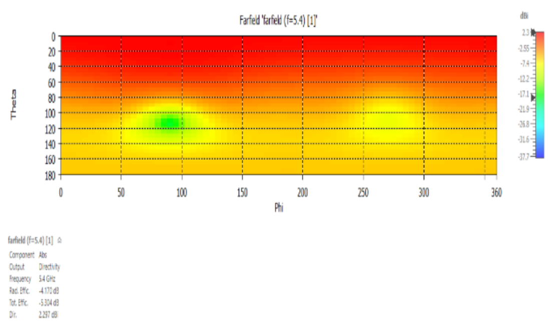

Figure 9: Directivity Analysis

An illustration of the proposed antenna's directional characteristics is shown in Figure 9. Value of directivity is 4.468dBi. "

Table 2: Simulated Results of Proposed Antenna

Sr No.	Parameter	Value
1	Dimension	16.89 X 12.67 X 1.6 mm3
2	No of band	1
3	Directivity	2.297 dBi
4	Gain	-1.873 dBi
5	S11 or Return loss	-6.31 dB
6	Band Width	0.78 GHz
7	VSWR	2.89
8	Resonant Frequency	5.4 GHz
9	Design type	Rectangular

Parameters such as return loss, bandwidth, VSWR, and resounding recurrence are summarized in Table 2. Table 2's recalculated data show that the proposed antenna produces a significant improvement over the status quo.

IV. CONCLUSION

We build and test a single-band microstrip patch antenna using CST modelling software. We present and discuss the results of the simulation. The current antenna is compact and simple in design, with dimensions of around 16.89 by 12.67 by 1.64 mm3. The created antenna may be used in portable devices because to its small size. The frequency range is found to be between 1 and 10 GHz, with resonance frequencies at 5.4 GHz, VSWRs less than 3, and S11s of -6.31dB, according to the data. The obtained findings are in full compliance with the existing antenna specifications.

The constructed antenna works well in any environment because of its minimal return loss and strong impedance matching. The suggested antenna is suitable for C band applications and meets 5G wireless communication standards.

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