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Design and Analysis of Square Microstrip Patch Antenna for Super Wide Band

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***Abstract*— For wideband transmission, a square microstrip patch antenna has to be lightweight, compact, and simple to construct. The current concept is to design a square microstrip patch antenna with a straightforward geometric form and a respectable bandwidth. The design study for a microstrip patch antenna with a rectangular or square form is presented in this article. Compared to the square microstrip, the square microstrip patch antenna has a greater bandwidth and adequate return loss. The little antenna is meant to be used with the X-bands of frequencies. The suggested square microstrip patch antenna provides a broad bandwidth, gain, directivity, and return loss.**

Keywords*— *Return Loss, Bandwidth Patch, Square microstrip, gain, Directivity, Voltage Standing Wave Ratio.

I. INTRODUCTION

While 4G is the fastest that existing wireless networks can achieve, 5G is on the horizon. These days, fourth-generation communication technologies support a lot of programmes. The field of 5G communications research is still in its infancy. Research on square microstrip antennas is crucial due to its potential applications.

In addition to enhancing user experience, 5G paves the way for previously unheard-of degrees of machine-to-human communication. It may be used to develop cutting-edge applications like virtual and augmented reality in healthcare, driverless cars, and more as it permits low-latency communications. In their attempts to alleviate the global bandwidth shortage, wireless service providers are facing previously unheard-of difficulties due to the widespread use of smartphones and the expansion of mobile data [1].

The perimeter of material inside a given total surface area or volume that may receive or transmit electromagnetic radiation, either on interior components or the exterior structure, is maximised by an antenna with a patch, self-similar design. Patch antennas have the feature of pattern repetition over two or more scale sizes, referred to as "iterations." Despite their small size, microstrip antennas are wideband or multiband, which makes them perfect for use in wireless networks such as those found in mobile phones and microwaves. Patch antennas have the ability to operate well to well over a wide range of frequencies simultaneously, in contrast to classic antennas. Because they need to be "cut" to match the operational frequency, conventional antennas can only be utilised effectively on that frequency [3].

The 2.4 GHz frequency band is used for Wi-Fi communication, which is made possible using square microstrip patch antennas. The design and performance study of a square microstrip patch antenna for a Wi-Fi communication system are covered in this research article. The main goal of this study is to construct a square microstrip patch antenna and evaluate its performance using various dielectric materials. With FR4, performance is enhanced. With an S11 of -31.13 dB at 11.408 GHz, FR4's return loss is substantially lower than that of the other dielectric materials utilised in this investigation. Additionally, a desirable VSWR of 1.057 was noted.

Serving consumers with more advanced, contemporary smartphones as well as legacy users with outdated, less effective mobile phones requires managing many technologies concurrently in the same band-limited spectrum. Currently, spectrum allotments to operators are divided into discrete frequency bands, and each of these bands employs a unique set of radio networks with unique propagation and building penetration loss characteristics. Since many base stations are deployed at each location (one for each frequency or technological application, such as 3G, 4G, and LTE-A), base station designs must support a wide range of frequencies across a vast diversity of cell sites [5].

It might take up to ten years to purchase more spectrum through agencies like the Federal Communications Commission of the United States (FCC) and the International Telecommunications Union (ITU). After licencing is completed, current users must be relocated off the spectrum, which prolongs the process and increases costs [6].

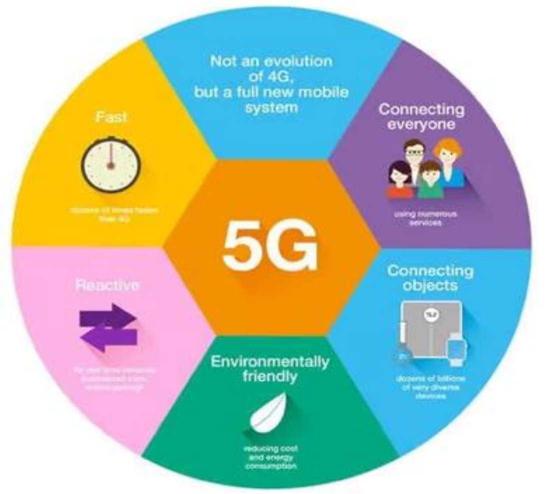

Figure 1: 5G service models

Figure 1 illustrates that 5G networks will require 1000 times more capacity and 10 to 100 times greater data rates in order to deliver 5G services. An antenna with a patch, self-similar design maximises the perimeter, or effective length, of material that can receive or transmit electromagnetic radiation within a given total surface area or volume (on inner sections or the exterior structure). The motif's recurrence over two or more scale factors is what sets these Microstrip antennas apart. [7], also known as "iterations." Despite their small size, microstrip antennas are wideband or multiband, which makes them perfect for use in wireless networks such as those found in mobile phones and microwaves.

Microstrip antennas have the ability to operate well to well over a wide range of frequencies simultaneously, in contrast to typical antennas. Conventional antennas can only work properly on that frequency since they have to be "cut" to match the operating frequency. Microstrip antennas are hence ideal for wideband and multiband applications [8].

This research is composed of four primary parts. The study's purpose, justification, and context are presented in Section I. The research technique and mathematical investigations are covered in Section II. The findings of the study's simulation are described in Section III. Suggestions for further investigation are provided at the end of Section IV.

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) in the Ku-band.
- To expand data transfer rates and minimise reflected interference.
- To derive new parameters and evaluate them against preexisting design outcomes.

II. PROPOSED ANENNA DESIGN

The proposed antenna was designed using the CST software. The suggested square microstrip patch antenna is seen in top view in Figure 2, where an emission patch and a ground plane are respectively formed by two sides of a dielectric substrate. Figure 2 shows top views of a square patch radio wire with thin rectangular microstrip feed. The surrounding fields formed by the patch and ground plane together produce the radiation from the antenna.

The introduction of the square microstip patch receiving equipment is attributed to its compact size and enhanced reference. The recommended receiving apparatus has a resonance frequency of 11.408 GHz, which is well within the X-band frequency range. Once these three factors are modified, the size of the radiating patch may be determined.

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, ε_0 = free space permittivity and ε_r = relative permittivity.

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

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

Step 3: Calculation of the Effective Length (L_{eff})

The effective length is

Step 4: Calculation of the Length Extension (ΔL)

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3}{(\varepsilon_{rff}-0.2}$$

Step 5: Calculation of the actual Length of Patch (L)

The actual length of radiating patch is obtained by

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

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

Only infinite ground planes are compatible with the transmission line model. But minimising carbon effect is essential for practical reasons. If the ground plane is larger than the patch dimensions by a factor of several times the substrate thickness throughout the perimeter, results that are comparable to those for a finite ground plane can be achieved, as demonstrated by:

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

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

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

With a little knowledge of circuit theory, you can calculate the patch's input impedance as follows: j The frequency ratio is defined as fR= f/f0, where f0 is the patch hole resonance frequency (the resonance frequency of the RLC circuit).

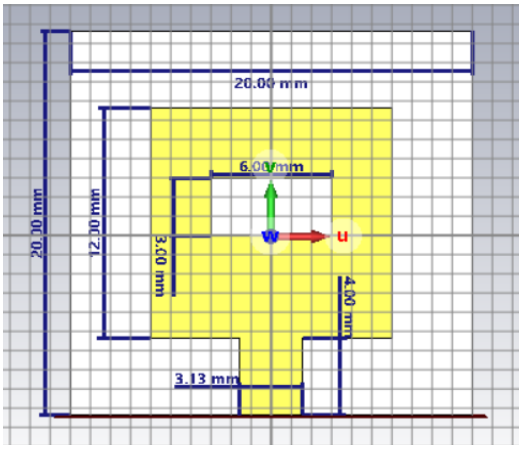

Figure 2: Antenna Design Top view

Figure 2 depicts the design for the suggested microstip patch antenna. The substrate is made of the FR4 substance, which has a dielectric steady worth of 4.4, while the top and bottom layers are made of the lossy copper material.

III. SIMULATION AND RESULTS

Figure 3 illustrates the suggested square microstrip patch form for Ku-band applications. The structure is etched on fire resistant 4 (FR4), measures 20 mm by 20 mm by 1.6 mm overall, has an overall permittivity of 4.4, and a loss digression of 0.024. The antenna parts utilised in this proposal are listed in Table 1. A simple connection or a 50 Ω and 0.5W micro thin link takes care of the antenna.

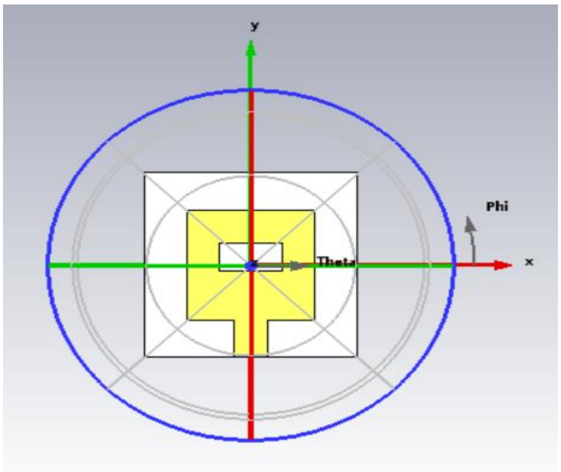

Figure 3: Simulation and fields of proposed antenna

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	Substrate & Ground Length	20mm
2	Substrate & Ground Width	20mm
3	Tangent Loss	0.06
4	Feed patch length	4mm
5	Feed patch width	3.13mm
6	Feed patch height	0.035mm
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
12	Patch Length	12mm
13	Patch Width	12mm

Return loss

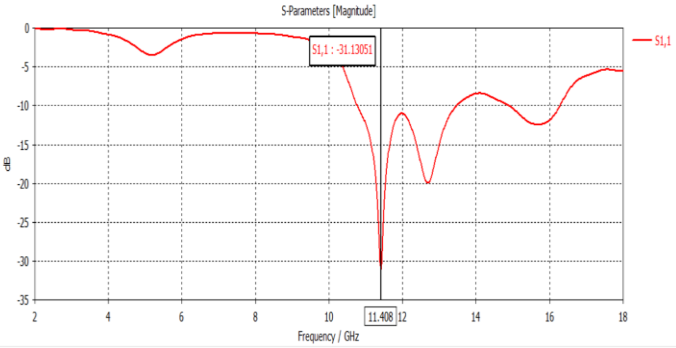

Figure 4: Return loss

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 -31.13 dB at a resonant frequency of 11.408 GHz.

Bandwidth

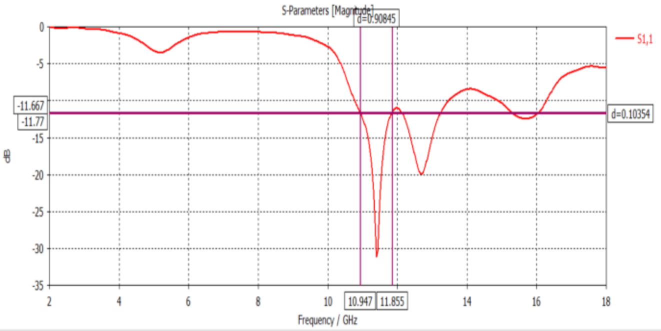

Figure 5: Bandwidth

The bandwidth of a broadband antenna is often represented as a fraction of the difference between the highest and lowest frequencies relative to the bandwidth's fundamental frequency. In this case, 0.91 GHz is the bandwidth of the proposed antenna (10.947GHz – 11.855GHz).

Voltage Standing Wave Ratio (VSWR)

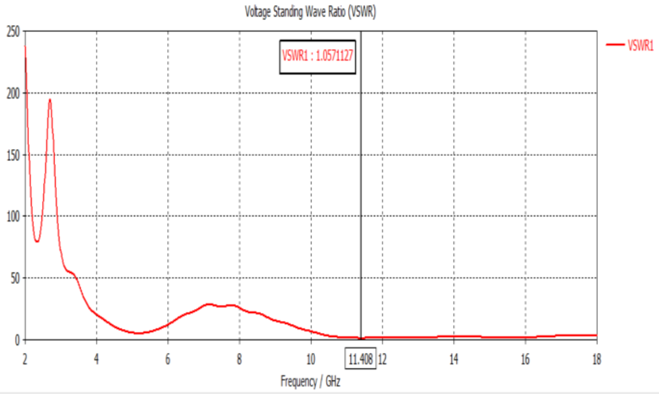

Figure 6: VSWR

The VSWR respect shown in Figure 6 has been attained at 11.408 GHz, The VSWR value is 1.057.

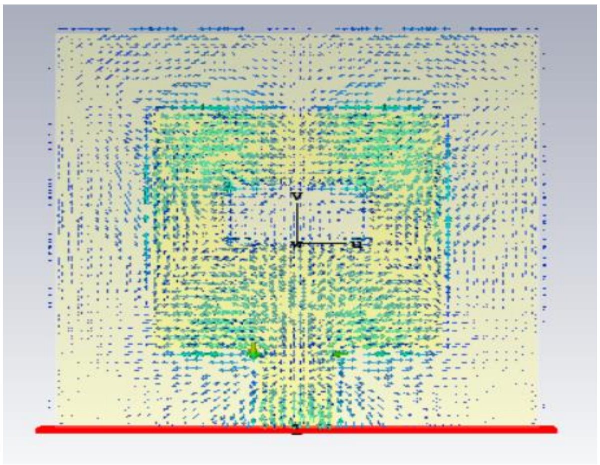

Figure 7: Surface current of proposed antenna

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.

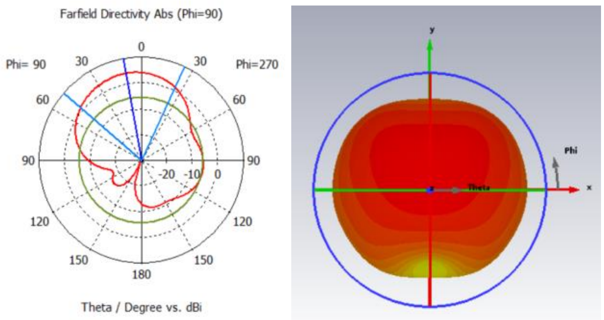

Figure 8: Radiation pattern

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.

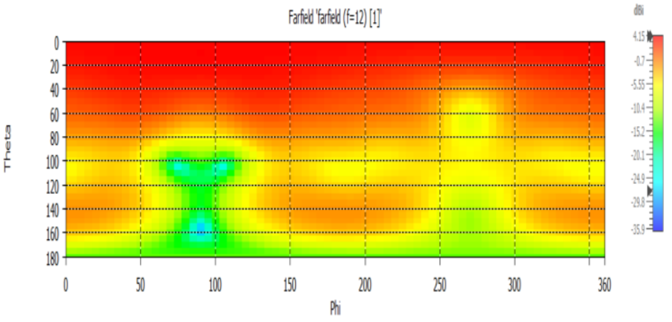

Figure 9: Directivity Analysis

An illustration of the proposed antenna's directional characteristics is shown in Figure 9. Value of directivity is 4.15 dBi.

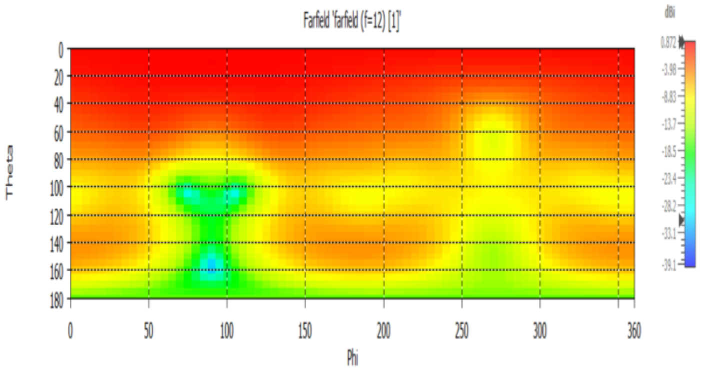

Figure 10: Gain Analysis

An illustration of the proposed antenna's directional characteristics is shown in Figure 10. Value of Gain is 0.872 dBi.

Table 2: Simulated Results of Proposed Antenna

Sr No.	Parameter	Value
1	Dimension	20 X 20 X 1.6 mm^3
2	No of band	1
3	Directivity	4.15 dBi
4	Gain	0.872 dBi
5	S11 or Return loss	-31.13 dB
6	Band Width	0.91GHz
7	VSWR	1.057
8	Resonant Frequency	11.408 GHz
9	Design type	Square

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

Using CST modelling software, we construct and test a square microstrip patch antenna for a single band. We demonstrate and talk about the simulation's findings. The present antenna has a straightforward and small design, measuring just around 12 x 12 x 1.64 mm3. The tiny size of the developed antenna makes it suitable for usage in portable devices. Based on the data, the frequency range is determined to be 1 to 20 GHz, with resonance frequencies of 11.408 GHz, VSWRs of less than 2, and S11s of -31.13dB. The results obtained fully conform to the current antenna standards. The designed antenna's good impedance matching and low return loss make it effective in any setting. The recommended antenna satisfies 5G wireless communication standards and is appropriate for X band applications.

REFERENCES

1. N.O. Porchan, Y.I.A. Al-Yasir, Ammar. H. Ali et al., "Eight element dual polarized MIMO slot antenna system for 5G smart phone applications", IEEE Access, vol. 7, pp. 15612-15622, 2019.
2. A.R. Checkatla and S. Ashtankar, "Compact microstrip antenna for 5G mobile phone application", International journal of Applied Engineering Research, vol. 14, no. 2, pp. 108-111, 2019.
3. T. Li and Z.N. Chen, "Shared surface dual band antenna for 5G application", IEEE Trans.Antennas and propagation(Early Access), pp. 1-1, September 2019.
4. Li-Yan Rao and Churng-Jou Tsai, "8 loop antenna array in the 5 inch size smart phone for 5G communication-3.4–3.6GHz Band MIMO operation", Progress in Electromagnetic research symposium (PIER-Toyoma), 1–4 August 2018.
5. Jingli Luo, Lun Chi, Chang Li and Baohua Sun, "Side Edge frame Printed Eight port dual band antenna array for 5G smart phone applications", IEEE Trans. Antennas and Propagation, vol. 66, no. 12, pp. 7412-7417, 2018.
6. Libin Sun, Haigang Fang, Y. LI and Z. Zhang, "Compact 5G mobile phone antennas with tightly arranged orthogonal mode pairs", IEEE Trans. Antennas and Propagation, vol. 66, no. 11, pp. 6364-6369, 2018.
7. Haitham Alsaif, Mohammad Usman, Mohammad T. Chughtai and Jamal Nasir, "Cross polarized 2×2 UWB-MIMO antenna system for 5G wireless applications", PIER-M, vol. 76, pp. 157-166, 2018.
8. Y. Wang, L. Zhu, H. Wang and G. Yang, "Design of compact wideband meandering loop antenna with a monopole feed for wireless applications", PIER Letters, vol. 73, pp. 1-8, 2018.
9. Rizwan Khan, A. Abdullah, Al-hadi, Ping Jack Soh et al., "User influence on mobile terminal antennas: A review of challenges and potential solutions for 5G antenna", IEEE Access, vol. 6, pp. 77695-77715, November 2018.
10. P. Ranjan, GS Tomar and R. Gowri, "Capacitive Coupled Rectangular microstrip patch antenna o Ku Band", 4th IEEE UP Electrical Compute and Electronics (UPCON), pp. 649-653, 2017.
11. Constantine A. Balanis, "Antenna Theory Analysis and design", Tohnwiley, 2016.