Design and Analysis of Micro strip Antenna for 5G Application

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Abstract —In order to keep up with the evolving technology, there's a growing need for communication antennas with higher bandwidth. One major solution for this demand is 5G technology. To address this, we've developed a 3.45GHz antenna. The antenna is constructed using FR4 material, a double-sided copper-coated PCB with a dielectric constant of 4.4 and a substrate height of 1.6mm. Our initial design involved simulating the antenna in Advanced Design System (ADS) and generating graphs for gain, directivity, frequency plot, radiation pattern, Electric field plane, and Magnetic field. Additionally, we utilized ADS software to create the equivalent circuit diagram and conducted simulations to calculate the S-parameters.

I. INTRODUCTION

Creating a seamless connection between two points requires a versatile antenna that can both transmit and receive signals. The recent developments in communication technology have paved the way for the implementation of 5G antennas. Presently in India, we rely on 4G with mobile antennas operating within the 800-900 MHz bandwidth. Transitioning to 5G demands a thoughtful antenna design that aligns with the specific requirements of the application. Given the continuous growth in population and the escalating need for a robust network, 5G endeavors to address these challenges by offering innovative solutions. To contribute to this, we developed a foundational3.45 GHz antenna. Beginning with simulation using ADS software, we progressed to the practical implementation in hardware, testing and refining the design. This antenna, built using a basic micro strip patch design for the 3.45 GHz frequency, serves as a stepping stone in our 5G journey. In our implementation, we printed the antenna pattern onto the PCB material, connected it with a connector, and linked It to a machine to generate the desired output. The advantages of a micro strip patch antenna, including being light weight, easy to implement, low-profile, and cost-effective, are notable. Despite these benefits, the design addresses drawbacks such as narrow bandwidth, low efficiency, and low power. Our approach focuses on maximizing performance and meeting the required parameters for antenna fabrication .Critical to the micro strip patch antenna is the impact of the printed pattern on the FR4 material substrate. Any alterations to this pattern can significantly affect the antenna's output, potentially leading to failure. Emphasizing the importance of maintaining the ground plane as a whole and avoiding antenna pattern designs on the ground plane side is a key consideration for a successful antenna design.

II. ANTENNA DESIGN

Absolutely, selecting the frequency is a pivotal initial step in antenna design. Once you've chosen 3.45 GHz, the next crucial aspect is determining the dimensions of the antenna patch. Calculating these dimensions is fundamental to achieving optimal performance. Could you share the formula or method you're using to calculate the length and width of the patch?

- Calculation of the Width (W)

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

- Calculation of the Effective Dielectric Constant

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

- Calculation of the Effective length

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

- Calculation of the length extension ΔL

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

- Calculation of actual length of the patch

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

- Calculation of Ground Plane

Wg = W + 6h

Lg = L + 6h

Using ADS software for the initial design is a sound approach. FR4 with a dielectric constant of 4.4 and a height of 1.6mm is a common choice for substrate material. It's great that you've provided a visual representation in Fig 1, as a side view of the dielectric can be instrumental in understanding the antenna's structure.

Fig.1. Side view of the micro strip antenna

Visualizing the pattern in Fig. 2 must be helpful in understanding the antenna design. Calculating the length and width of both the antenna and the feed is a crucial step in ensuring the desired performance.

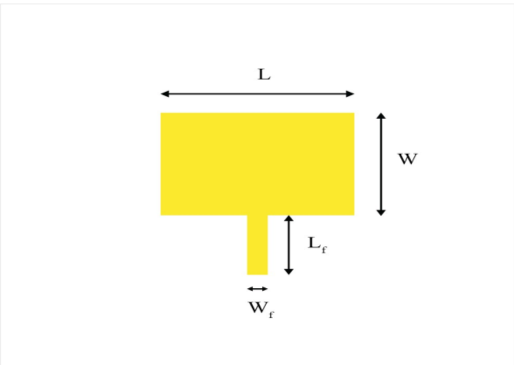

Fig.2. Top view of the micro strip antenna

While designing for the ground plane was also done by using formulas and view of ground plane is illustrated in Fig.3. as follows.

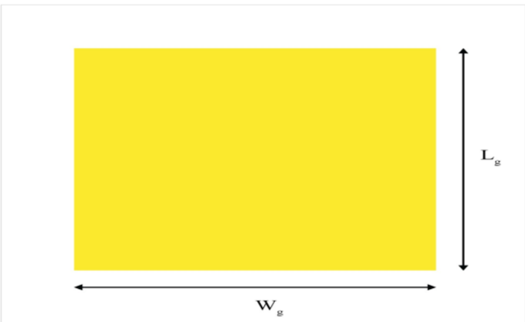

Fig.3. Ground view of the micro strip antenna

To make antenna work at frequency of 3.45Ghz we have done so many calculations and find the values by doing trial and error method. The values for different sides, patch and ground plane can be seen in the Table.1.

TABLE.1 ANTENNA DESIGN PARAMETERS

SR.NO.	PARAMETER	DIMENSION(mm)
1.	L	26.21
2.	W	20.20
3.	Lf	12
4.	Wf	3.11
5.	Lg	50
6.	Wg	50

The equivalent circuit of the antenna represent antenna in the from of the RLC components and it can be designed using the same in the project if someone want to make it from the passive component. For implementing it we also need the S parameters. In ADS software after simulating the pattern the antenna is designed automatically and that is shown below in Fig.4.

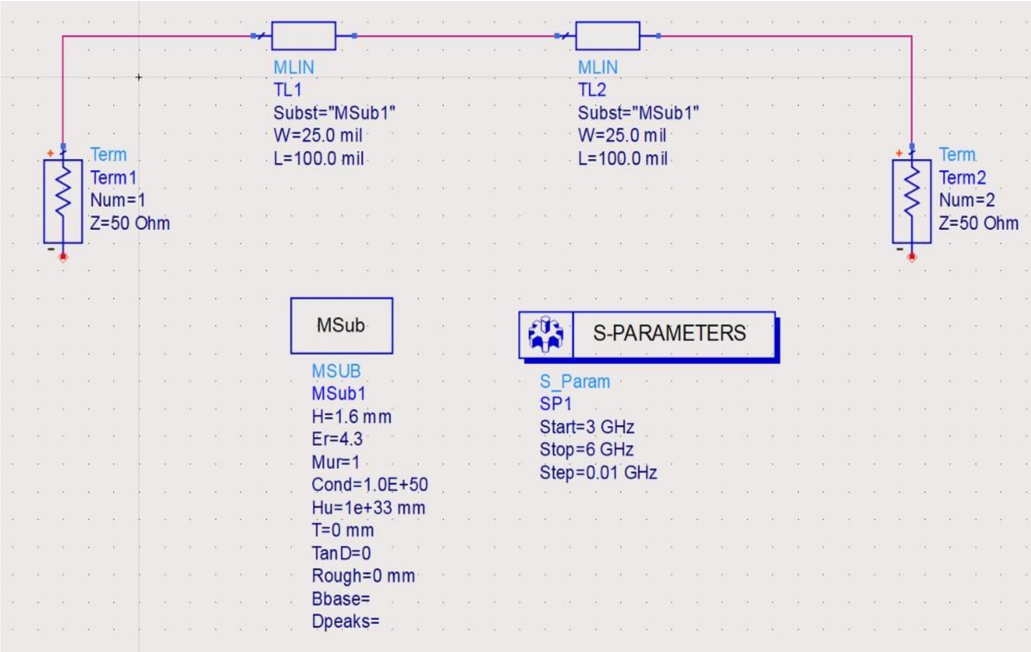

Fig.4. Equivalent circuit diagram for the antenna

III. SIMULATION RESULTS

Performing simulations in the frequency range from 3 GHz to 6 GHz with a step size of 0.1 GHz is a comprehensive way to analyze the antenna's behavior across a spectrum. Achieving a resonance frequency of 3.45 GHz is in line with your design objective. The return loss of -8.661 dB at the resonance frequency, as depicted in Fig. 5, provides valuable insight into the antenna's impedance matching.

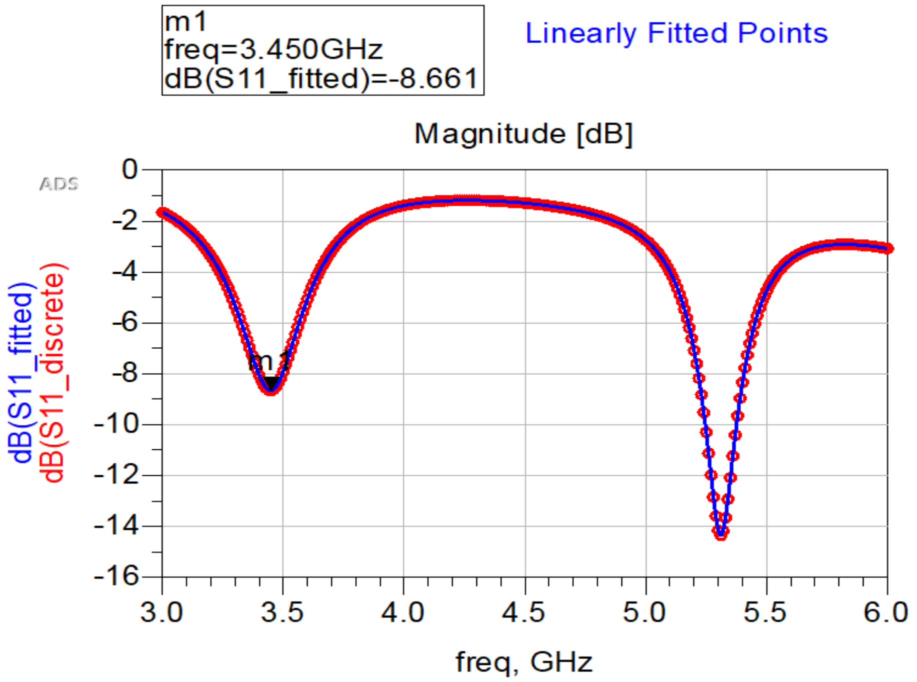

Fig.5. Return loss vs Frequency

While Fig.6. shows the far field radiation pattern and near field radiation pattern of the designed antenna. As it is clearly seen that both the patterns look similar in terms of the structure.

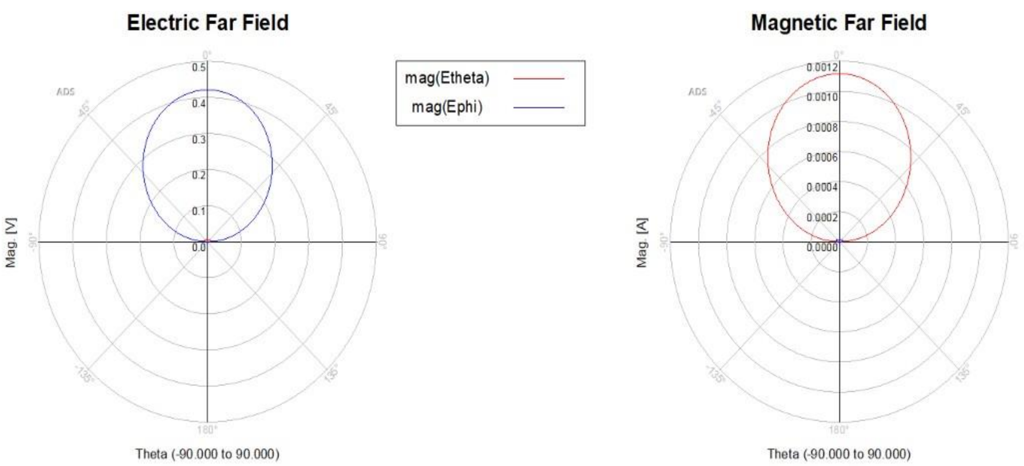

Fig.6. Electric far field and Magnetic far field

Whereas the output obtained for linear polarization and circular polarization is different in terms of the pattern. It is clearly seen from the following figure Fig.7.

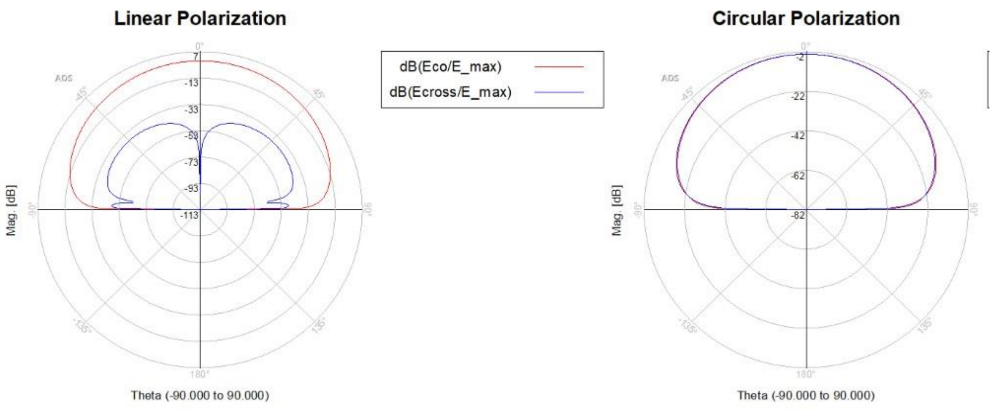

Fig.7. Linear polarization and Circular polarization

Simulated directional wave pattern of the antenna is shown in Fig.8. which is simulated in ADS software. It also gives the animated output for the antenna in the pattern format with green color.

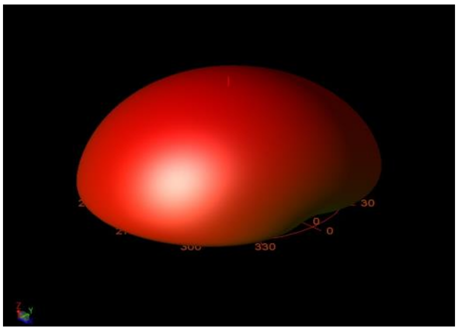

Fig.8. Radiation pattern for the antenna.

The designed antenna has gain of 1dBi and the radiation efficiency is 28.75%. Table.2 represents summary of the parameters obtained after simulation.

TABLE.2 SIMULATION RESULTS SUMMARY

Sr. No	*Antenna Parameter*	*Values*
1.	*Return Loss*	*-8.661dB*
2.	*Gain*	*1dBi*
3.	*Directivity*	*6.4dBi*
4.	*Radiation Efficiency*	*28.75%*

IV. CONCLUSIONS AND FUTURE WORKS

It's fantastic to hear that the proposed micro strip patch antenna for 5G communication has been successfully designed and implemented. The simplicity and ease of implementation are significant advantages, making it a practical solution for future 5G communication applications. Achieving resonance at 3.45 GHz with again of 1 dB and a return loss of -8.661 dB indicates a well-matched and functional antenna. The positive radiation characteristics further contribute to the antenna's effectiveness. The simplicity of the design structure, with dimensions of 50mm×50mm×1.6mm, not only makes it easily reproducible but also emphasizes efficiency.

That's a thoughtful approach to continuous improvement. Choosing a higher-quality substrate is an excellent idea as it can impact various aspects of the antenna's performance. The consideration of reducing dimensions to resonate at a higher frequency while consuming less space and power aligns with the ever-evolving demands of efficient communication systems. By optimizing dimensions, you not only address practical concerns but also potentially enhance radiation, efficiency, and directivity. It's a dynamic process where each adjustment contributes to the overall effectiveness of the antenna.

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