Design and Analysis of Tiny Microstrip Patch Antenna for 5G Applications

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Abstract - *Human existence has evolved dramatically in this evolving technological period, with transportation ranging from bull cart to aeroplane, land line phones to smartphones, CRT-based televisions to LED televisions, and so on. The human being has witnessed a massive transformation, particularly in the realm of communication. Due to significant advancements in wireless communication technology, the usage of tiny antennas has expanded dramatically. Not only is the antenna size important, but so are the cost, performance, and simplicity of use. Microstrip antennas are widely employed in a variety of applications due to their excellent radiation efficiency, high gain, small size, and wide bandwidth. The microstrip antennas are employed in this study for public safety communications because of its mobility and light weight. The antenna is intended for use as a wearable device. The microstrip antenna was modeled and simulated using CST Microwave Studio 2019. As a dielectric, a ROGERS RT5880(LOSSY) substrate will be employed. The simulated results match the intended parameters exactly. The antenna's size has been reduced to make it more compact and adaptable. The antenna's dimensions and overall thickness are 5.5 X 5.5 mm and 0.017mm, respectively. The resonance frequency is 33.4 GHz, and the effective bandwidth for these results is 28 GHz to 35 GHz.*

Key Words: Resonant Frequency, Substrate, Better return loss, Microstrip antenna, Size optimization

1.INTRODUCTION

In today's world of communication systems, wireless technology is one of the most significant disciplines of research, and a study of communication systems is incomplete without understanding of antenna operation and fabrication. This was the primary motivation for us to pursue a project in this area.

An antenna is a conductor or series of conductors that transmits electrical signals. Transmitter - A device that sends forth electromagnetic radiation into the universe. Receiver - A device that collects electromagnetic radiation from the environment. “A component of a transmitting or receiving system that emits or receives electromagnetic radiation. ,” is defined as Antenna according to the IEEE definition given by Stutzman and Thiele.

A microstrip patch antenna is planar resonating cavities that leak and emit energy from their edge. Antennas can be etched on soft substrates using printed circuit processes, resulting in low-cost, reproducible antennas with a low profile. The antennas constructed on flexible substrates can resist a lot of shock and vibration. Microstrip patch antennas are useful in wireless communication, particularly for Wi-Fi applications. Hardware like a personal laptop, mobile phone, media player, or GPS can connect or access internet inside the range offered by a high-performing transmitting antenna.
Due to its great performance, low cost, lightweight, compact size, acceptable shape, and ease of fabrication, antennas are extensively employed in wireless communication. Patch antenna design utilizing various software programs has grown increasingly common in recent years. This could be owing to their practical experience with a wide range of parameters, which play a critical role in the development of high-performance antennas.

In this paper, we design a 33.4 GHz microstrip antenna and its performance is measured in terms of relative data gain. The classic patch is the basis for our antenna design and was designed using CST microwave studio software. This antenna is implemented directly on the user's side. For our antenna, the results are promising over 33.4 GHz, return loss is less than −50dB. Our antenna has been subjected to a SAR study.

2. MICROSTRIP PATCH DESIGN

Microstrip antennas are made out of a small radiating patch on one side of a dielectric substrate with a ground plane on the other. On a dielectric substrate, the radiating patch and feed lines are normally photo etched. The patch is a resonant chamber composed of copper with short circuit walls on top and open circuit walls on the sides, and it is often square, triangular, round, or elliptical in form.

The suggested antenna will be made using textile technology and will operate in the range of frequencies of 28 GHz to 35GHz, and they are suited for public safety communication applications. Textile technology was chosen because it gives the necessary flexibility for the suggested antenna's wearable use as well as the creation of a proof-of-concept. The design process is largely the same as for a typical patch antenna, and the patch dimensions should be accurate in order to attain the appropriate resonance frequency.

Common felt with a thickness of 0.74 mm and a value of 2.2 dielectric constant was employed as the substrate, while PEC(Perfect Electrical Conductor) material was used for the conductive component.

The patch for the suggested antenna has dimensions of 5.5 X 5.5 X 0.017 mm. To attain a minimal reflection coefficient at the intended working frequency and adequate bandwidth, the antenna's original design parameters (patch size and thickness of the material used as substrate) have to be tuned. Given that a shift in the resonance frequency was noticed, most likely due to the bend effect and the presence of a lossy medium like human tissue, this optimization approach was required. Keeping in mind that this is just a proof-of-concept, the antenna's behavior has also been studied.

Simulated results with relation to the antenna radiation pattern and S-parameters are provided for the optimal design parameters. The calculated return loss of around –50.95 dB on the other hand, indicates that antenna is adequately matched at the operational frequency range of 28 GHz to 35 GHz.

3. EXPERIMENTAL ANTENNA CHARACTERIZATION

The proportions of the design are the same as previously stated. It can be seen that simulations and measurements have a reasonable level of agreement. The proposed 5G antenna resonates at 33.4 GHz, with a measured return loss of less than -50dB. The substrate was ROGERS RT5880(LOSSY) with a thickness of 0.74mm and a copper ground with a height of 0.017mm. It should be noted that minor discrepancies may be caused mostly by manufacturing inaccuracies. Figure 1 depicts the geometry of a 5G antenna. The planned 5G antenna's specs are listed in Table I.

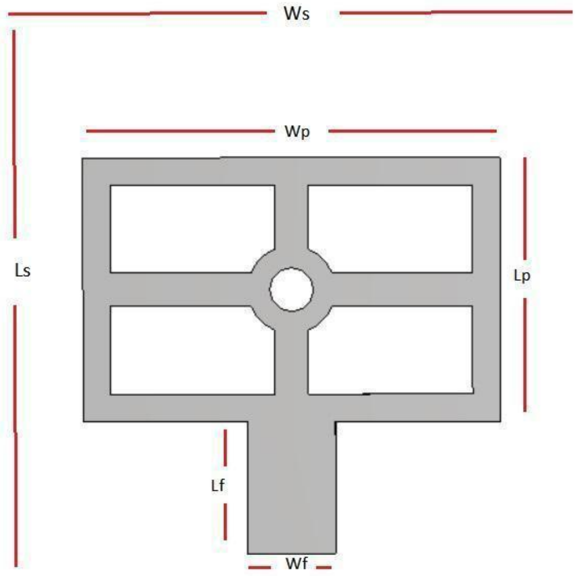

Fig -1: Microstrip patch antenna dimensions with feedline

Table -1: ANTENNA DIMENSIONS OF CONVENTIONAL MICROSTRIP PATCHES

Parameter	Description	Value (in mm)
Ls	Substrate length	5.5
Ws	Substrate-width	5.5
Lp	Patch length	2.4
Wp	Patch width	3.8
Lf	Feeding line length	1.4
Wf	Feeding line width	0.8
t	Ground height	0.017

4. RESULTS AND DISCUSSION

4.1 Return Loss Plot:

The reflected power from the antenna is measured by return loss. It provides a rough estimate of the magnitude of the reflection coefficient. The reflection coefficient's magnitude ranges from 0 to 1, with 0 denoting no reflected power and 1 denoting perfect matching. The bandwidth is determined by the frequency range for which S11< -10dBi is employed, i.e. the range of frequencies for which the antenna radiates at least 90% of the power and at least 10% of the power is reflected off the antenna. Over the 28 GHz to 35 GHz frequency range, we achieved a superior return loss of -50.95 dB in our design with resonance frequency of 33.4 GHz.

The return loss plot for our simulation is shown in Figure 2, and the data are listed in Table II.

Return loss is given as

$$RL = 10\log\frac{P_{incident}}{P_{reflected}}$$

Return loss measured in terms of reflection

$$RL(db) = -20\log|\gamma|$$

coefficient where,

$$\gamma = \frac{V^-}{V^+}$$

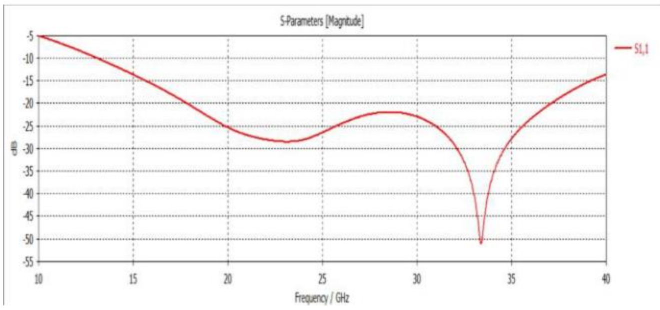

Fig -2: S11 parameter for a 5G microstrip patch

Table -2: RETURN LOSS OF PROPOSED 5G ANTENNA

Antenna	5GAntenna
Resonant Frequency(GHz)	33.4
Return Loss(dB)	-50.95
VSWR	1.0056

4.2 VSWR

The range of VSWR (Voltage Standing Wave Ratio) is [1 -]. If the antenna produces zero reflected power, the VSWR measurement is 1, whereas a significant VSWR number suggests increased miss matched. The plot of the VSWR for our simulation is given in Fig. 3 and the values are tabulated in Table II.

It is related to reflection coefficients:

$$VSWR = \frac{V_{max}}{V_{min}}$$

It is related to reflection coefficient as:

$$VSWR = \frac{1+|\gamma|}{1-|\gamma|}$$

The VSWR of a traditional 5G antenna is less than 2 only for single bands. The return loss, VSWR and bandwidth for 5G antennas are summarized in Table II.

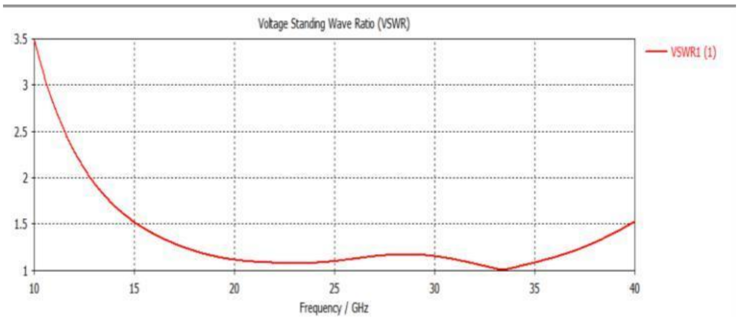

Fig -3: VSWR plot for 5G microstrip patch antenna

4.3 Current Distribution

Figure 4 shows the surface current distribution for a traditional 5G microstrip antenna. The standard 5G patch antenna has the majority of the radiation from the patch at resonant frequency, as can be shown.

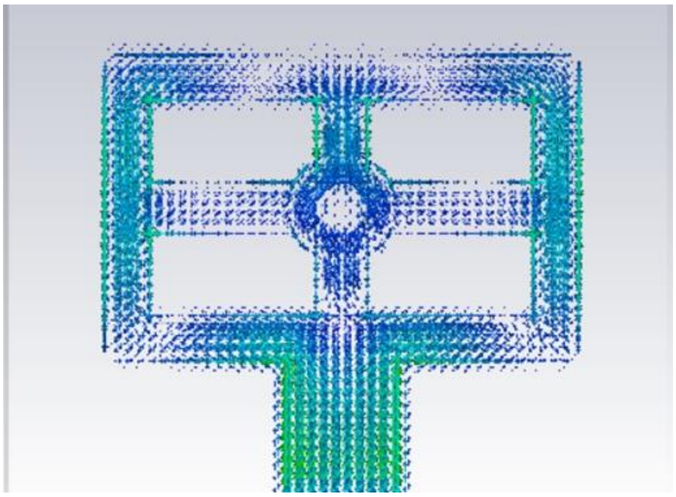

Fig -4: Current distribution map for 5G antenna is shown at 33.4GHz.

4.4 Radiation Pattern

The radiation pattern, often known as the antenna pattern, is a graphical depiction of the antenna's radiation qualities as a function of space.

Figure 5 shows the Radiation Pattern for a traditional 5G microstrip antenna.

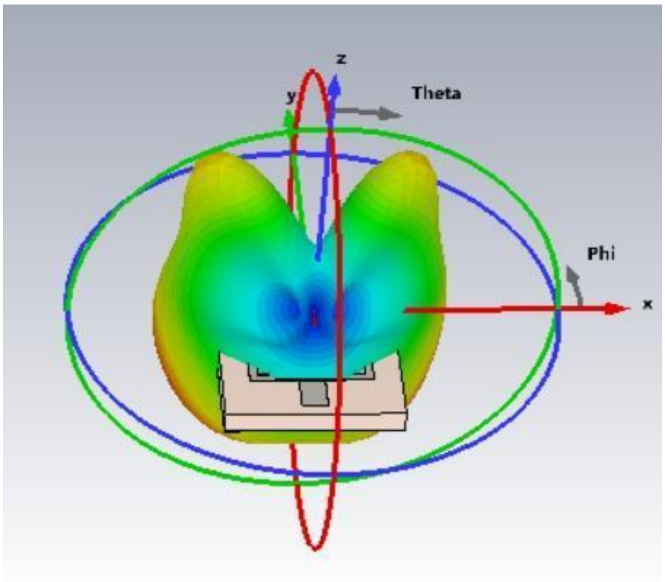

Fig -5: Radiation Pattern for a 5G microstrip patch.

5. CONCLUSION

Design of a tiny microstrip antenna for 33.4 GHz public safety communications is presented in proposed paper. The microstrip antenna is developed directly at the rescuer end as part of an improved user equipment proposition. The proposed design's practicality is demonstrated by simulation and experimental findings, such as appropriate gain and lowered back radiation levels, proper bandwidth, and SAR values below the specified levels. In terms of data rate gain, we demonstrate that a user terminal fitted with our microstrip antenna may utilize future 5G multimedia services in emergency conditions. In light of this, we believe the suggested antenna design is feasible and can provide a big opportunity for next-generation public safety communications based on 5G.

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