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5G Microstrip Patch Antenna Design and Performance Improvement Methods

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Abstract

There is a necessity for continuous, high-quality distance learning globally, particularly in emerging nations, which necessitates elevated data rates and substantial bandwidth. In the study work, the researchers have developed a Microstrip Patch Antenna (MPA) for high-quality distance learning and various applications involving 5G utilizing 5G millimeter wave bands at a resonance frequency of 26 GHz. The proposed design features a circular patch with a dielectric value 2.4 and a tangential dielectric loss of 0.0012. The design is modeled and evaluated utilizing FEKO software. The simulation writers have identified a return loss of -31.5 dB, a bandwidth of 3.42 GHz, a VSWR of less than 2, a high gain of 12 dB, and an antenna radiation effectiveness of 95.2%. This suggested layout offers advantages under the current global lockdown circumstances.

Keywords: Fifth Generation, Patch Antenna, Millimeter Wave, Microstrip.

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Introduction

The advent of new Internet of Things (IoT) technologies has led to an increase in wireless data transmission traffic, driven by the proliferation of users of smartphones (Zikria et al., 2021). These users request an enhancement in download speeds, particularly for watching and downloading ultra-high-definition movies. The current 4G wireless connectivity cannot accommodate downloading ultra-high definition movies due to their vast data rates and low delay requirements. 5G wireless mobile networks are engineered to fulfill the demands of consumers with smartphones at millimeter wave (mmw) frequencies (Hong et al., 2017). The mmw technology seeks to enhance the available data capacity. This type of network offers significantly superior and broader bandwidth compared to 3G/4G. The mmw band represents the most sophisticated technology in wireless communications; nonetheless, various obstacles associated with its application have arisen. It results in significant signal attenuation. The research employed a Microstrip Patch Antenna (MPA) resonant at 28.5 GHz, providing excellent bandwidth, gain, and outstanding effectiveness. Significant demands for 5G apps have highlighted key service categories, including media, virtual experiences, and enormous connections for machine-type interaction. This service encompasses high-quality 8K Ultra-High-Definition (UHD) distribution (Khan et al., 2015), security cameras, broadcasting offerings, projects related to smart cities, smart home technologies, innovative office solutions, smart metering for electricity and gas, e-health, and online real-time education. 5G technological requirements include a higher speed of data (1 Gbps capacity per user), better connectivity, greater accessibility, and improved efficiency. All these requirements will be beneficial when situations such as COVID-19 or lockdowns emerge (López & Rodó, 2020). These antennas are created in many configurations, with certain limitations like the dielectric strength of the base, substrate thickness, ground plane dimensions, and feeder point, among others. These variables influence the electrical characteristics of antennae, including gain, return loss, and radiation patterns (Kamran Shereen et al., 2019). A crucial aspect of this layout is the selection of the optimal dielectric substrates. Substrates suitable for antennas typically possess dielectric constants within the range of 2.3 to 12. Substances with greater thickness and lower dielectric coefficients are chosen due to their enhancement of efficiency and bandwidth. The drawbacks of thicker boards include increased size and loss of dielectric property (Sebastian et al., 2015). A reduced value of & will augment the fringing field, increasing the radiated beams. The RT/Duroid 5880 base, with a dielectric constant (Er) of 2.3, was utilized in the design due to its slight dielectric loss, making it suitable for high-energy and wideband operations. When integrated with various shaped microstrip areas, the MPA is intended for a frequency of 13.2 GHz, exhibiting a lower gain of 5.28 dB and a reduced return loss compared to the suggested circular patch antennae (Shah et al., 2019). The present research examines the design of an MPA that utilizes microstrip line feeding. It analyzes the outcomes of return loss, loss of electricity, effectiveness, gain, connectivity, and radiation pattern at a frequency of 26.2 GHz for 5G use cases. An annular split circle MPA has been built using an FR4 base at various frequencies (Ameen & Chaudhary, 2020).

Background

Theory

MPA comprises a substrate plane, a ground flat, a microstrip supply, and a patch with different geometries, including elliptical, recurrent, and circular forms. The patches consist of conductive substances, including gold and copper. The MPA features a circular configuration, with a grounding plane and a dielectric substrate interposed between the surfaces. It is an alternative prevalent shape of MPA after the circular patch antennae. It is comparatively smaller than the MPA. In Fig. 1, h denotes the substrate's width, while b represents the diameter of the circular patches. The diameter of the circular patch antennae is calculated using the provided formula.

$$b = \frac{F}{\sqrt{1+\frac{2}{\pi\varepsilon_2 F}\left(\log\left(\frac{\pi F}{2h}\right)+1.78\right)}} \quad (1)$$

$$F = \frac{8.6\times10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

In this communication, f_r denotes the resonant frequency in GHz, ε_r signifies the relative permeability of the underlying substance, and F indicates the exponential constant.

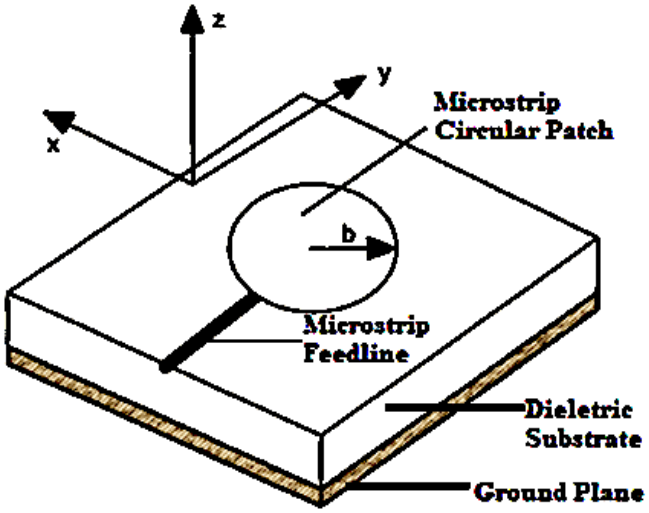


Fig. 1: Structure of the Antenna

Design

The initial step to constructing an MPA is to select an appropriate substrate with a lower dielectric constant than 0, as a shorter dielectric constant enhances radiation effectiveness. Thicker substrates provide an expanded bandwidth. The research utilized RT/Duroid 5880 platform material with a dielectric constant (Er) of 2.3, a substrate thickness of 0.6 mm, and a dielectric loss tangent of 0.0012. The second and most critical design phase is calculating the patched antenna's diameter. The third and most crucial phase in the development process is selecting the frequency that will resonate from the 5G radio range, which spans from 27.2 GHz to 28.2 GHz. The research has chosen 27.2 GHz since it is deemed superior and highly beneficial for wireless communication in 5G. With the aforementioned design variables, the study has computed the diameter of the patch at the resonance frequency of 27.2 GHz to be about 2.14 mm. Fig. 2 illustrates the shape of a circular patch of antennae.

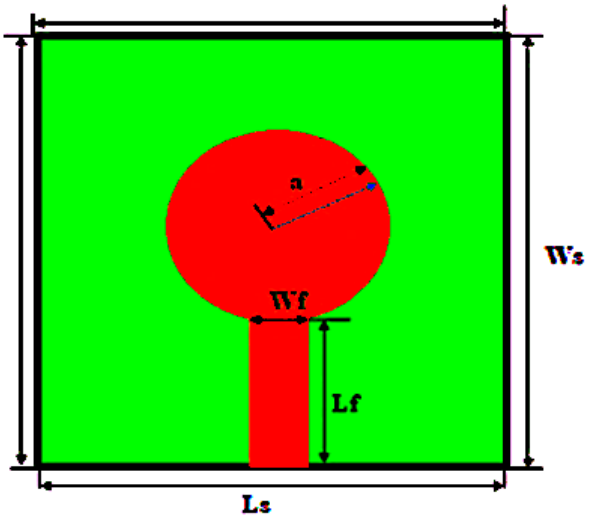


Fig. 2: Antenna Layout

Results

Reflection Coefficient

The reflection factor, commonly called return loss, is represented by (S11). The efficacy of an antenna typically relies on a reflecting coefficient or return loss of at least -10 dB or preferably greater than -14 dB, as return loss is the ratio of transmitted power to the reflection energy. If the reflection coefficient is 0 dB, then no power has been broadcast,

as the antennae have reflected all the power. Fig. 3 illustrates a return loss of -32.1 dB and an adequate bandwidth of 4.21 GHz. This substantial capacity and favorable return loss enable uninterrupted streaming of UHD data, such as 4K and 8K films, which is particularly advantageous for high-quality online courses.

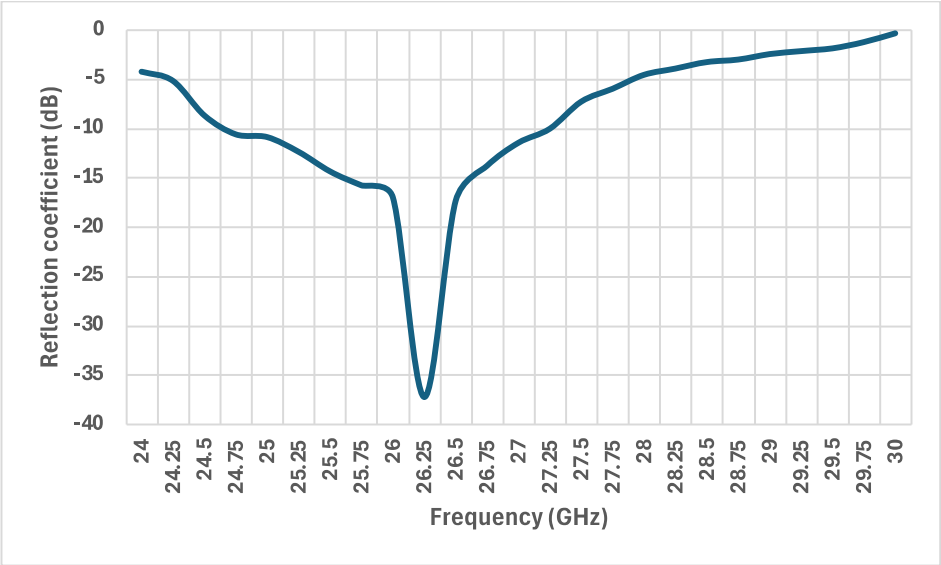


Fig. 3: Return Loss Analysis

Voltage Standing Wave Ratio (VSWR)

The VSWR are called the standing wave ratios. For the design of MPA intended for 5G uses, such as online education and teaching, the VSWR should be maintained within the 1 < VSWR < 2 range. This ratio is consistently regarded as a genuine and positive real integer. The higher the value of VSWR, the more significant the discrepancy. The MPA exhibits a value of 1.15 at 26.4 GHz, as illustrated in Fig. 4.

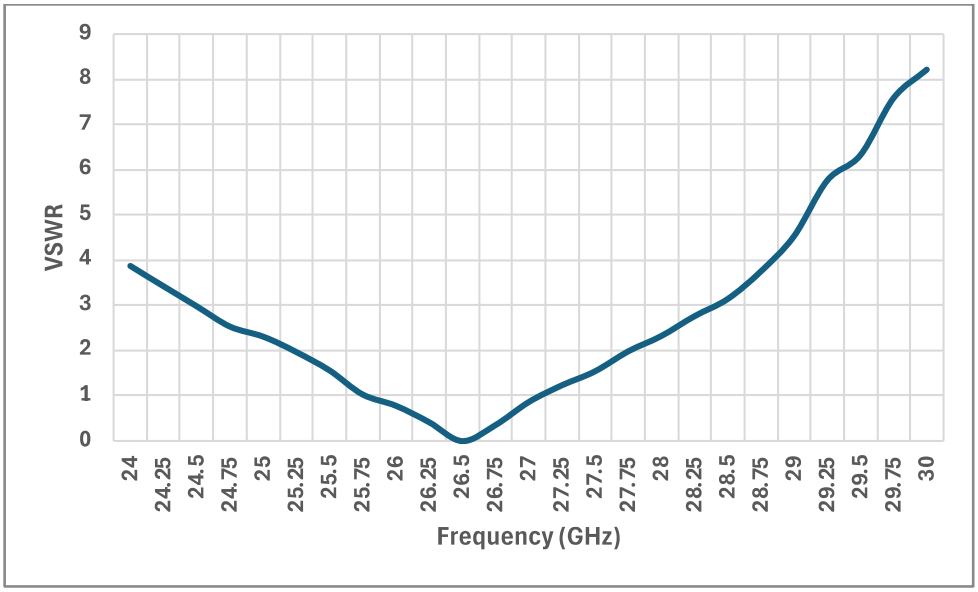


Fig. 4: VSWR Analysis

Antenna Radiation Efficacy

As illustrated in Fig. 5, the suggested antenna has a high radiation effectiveness of 98.2%, indicating that a significant portion of the received power is emitted.

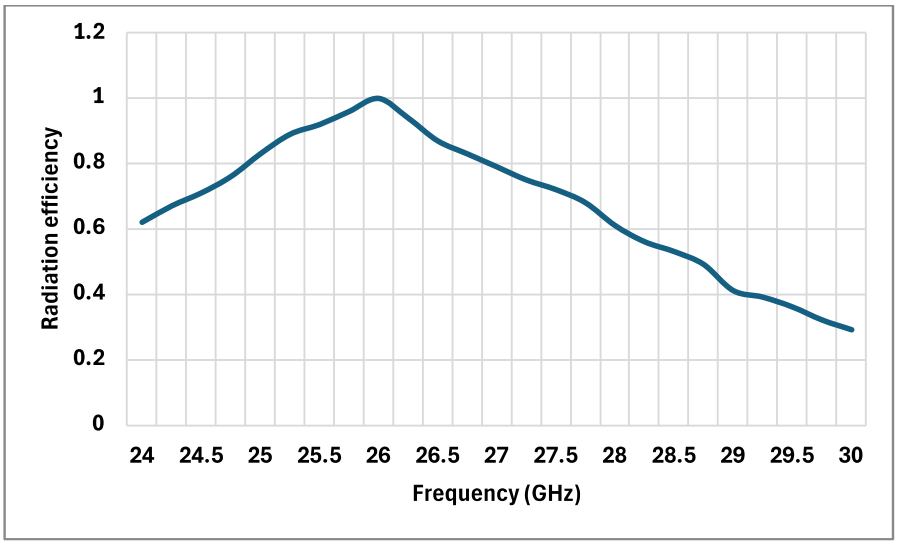


Fig. 5: Radiation Efficiency Analysis

Conclusion

The research has built and successfully executed an MPA with a frequency of resonance of 26 GHz utilizing programs that are more trustworthy for design and provide superior quality outcomes, particularly in 3D radiation patterns, compared to conventional antenna design tools. The simulation findings and comparison graph indicate that the suggested MPA design achieves a gain of 10 dB, ensuring robust signal strength. It features an expanded bandwidth of 3.62 GHz, facilitating high-quality e-learning and the capability of downloading and uploading 4K/8K UHD material, as well as support for various 5G services. It demonstrates a commendable return loss of -34.2 dB, a VSWR of 1.12, and an impressive antenna radiation effectiveness of 98.4%. The limitation of this suggested device is that the return loss and bandwidth are inferior. The future objective is to achieve enhanced bandwidth, improved return loss, and increased gain by constructing the antenna using array components.

References

Zikria, Y. B., Ali, R., Afzal, M. K., & Kim, S. W. (2021). Next-generation internet of things (iot): Opportunities, challenges, and solutions. *Sensors*, *21*(4), 1174. https://doi.org/10.3390/s21041174.

Hong, W., Baek, K. H., & Ko, S. (2017). Millimeter-wave 5G antennas for smartphones: Overview and experimental demonstration. *IEEE Transactions on Antennas and Propagation*, *65*(12), 6250-6261. https://doi.org/10.1109/TAP.2017.2740963.

Khan, M. U., Sharawi, M. S., & Mittra, R. (2015). Microstrip patch antenna miniaturisation techniques: a review. *IET Microwaves, Antennas & Propagation*, *9*(9), 913-922. https://doi.org/10.1049/iet-map.2014.0602.

López, L., & Rodó, X. (2020). The end of social confinement and COVID-19 re-emergence risk. *Nature Human Behaviour*, *4*(7), 746-755. https://doi.org/10.1038/s41562-020-0908-8.

Kamran Shereen, M., Khattak, M. I., & Witjaksono, G. (2019). A brief review of frequency, radiation pattern, polarization, and compound reconfigurable antennas for 5G applications. *Journal of Computational Electronics*, *18*(3), 1065-1102. https://doi.org/10.1007/s10825-019-01336-0.

Sebastian, M. T., Ubic, R., & Jantunen, H. J. I. M. R. (2015). Low-loss dielectric ceramic materials and their properties. *International Materials Reviews*, *60*(7), 392-412. https://doi.org/10.1179/1743280415Y.0000000.

Shah, I. A., Hayat, S., Basir, A., Zada, M., Shah, S. A. A., & Ullah, S. (2019). Design and analysis of a hexa-band frequency reconfigurable antenna for wireless communication. *AEU-International Journal of Electronics and Communications*, *98*, 80-88. https://doi.org/10.1016/j.aeue.2018.10.012.

Ameen, M., & Chaudhary, R. (2020). Metamaterial circularly polarized antennas: Integrating an epsilon negative transmission line and single split ring-type resonator. *IEEE Antennas and Propagation Magazine*, *63*(4), 60-77. https://doi.org/10.1109/MAP.2019.2950920.