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A 28 GHz 5G High Gain MIMO Antenna Array System for Human Body Communication

[1]N Sheshaprasad, [2]Kiran K N, [3]Sumathi A

[1]Associate Professor, [2]Assistant Professor, [3] Associate Professor
[1,2,3] Department of ECE,
[1,2,3]BNMIT, Bangalore, Affiliated to VTU, Karnataka, India

Abstract: This study presents a design for a linearly polarised MIMO antenna array that operates in the millimetre wave (mm) band. It is a small antenna with a high gain and a wide band. In particular, this 2-port MIMO antenna array operates with superior ECC at a 28 GHz centre frequency because of optimal element spacing. The intended MIMO antenna is built on FR-4 substrate, which has a 4.3 relative dielectric permittivity and 1.6mm thickness. The planned antenna measures 26×25.6×1.6 mm3 in total. The simulation findings indicate that the device's return loss in the frequency range of 25.92 to 30.92 GHz is less than -10 dB, and it offers a broad bandwidth of 5 GHz. It emits radiation in a single direction and has a high gain of 4.168 dBi. Each element has a mutual coupling value that is less than -25dB. The SAR measured is also below the IEEE standard making the designed antenna suitable for human body communication.

***Index Terms* - 5G, Antenna array, Multiple Input and Multiple Output (MIMO), ECC, SAR.**

1. INTRODUCTION

The excessive demand for higher data rates in mobile communication has brought an in-depth studies on fifth generation (5G) systems that are much quicker than cutting edge technology. The FCC (Federal Communications Commission) has proposed licensed frequency spectrum for 5G communication at 28 GHz, 37 GHz, and 39 GHz, along with unlicensed frequency spectrum for various application [1- 2]. Due higher path loss at high frequencies, an array of antenna or adaptive beam forming technique is required. For achieving higher data rates, a wide band antenna is needed. [3-4].

Massive Multi-Input and Multi-Output (MIMO) is one of the 5G technologies that has received a lot of attention since it has the potential to increase data transmission speed and become resilient to multiple routes fading. The transmitter or receiver must have two or more antenna elements to qualify as a MIMO system [5]. Although adding more antennas increases the system's size and worsens the isolation between them, which leads to altered radiation patterns and reduced channel capacity [6]. The MIMO antenna design must consider and maintain all necessary parameters.

In this paper, a layout of 1X2 S shaped microstrip patch array that's organized as MIMO for 5G framework is proposed, so that gain is enhanced. Antenna is designed for 28 GHz centre frequency, that could produce wider bandwidth.

2. ANTENNA DESIGN

The suggested patch 1X2 array MIMO antenna is built on the FR-4 substrate material, which has a 1.6 mm thickness, 0.025 loss tangent and 4.3 relative permittivity. The antenna system has dimension of 26 x 25.6 x 1.6 mm3 in total. It has complete ground plane in the bottom layer and an antenna array of 1x2 with ports feeding at the edge in the top layer.

2.1 1X2 Array Antenna System

The array's basic component is a single edge-fed S-shaped patch, and its dimensions were adjusted to operate at a frequency of 28 GHz. A 1X2 antenna array system is created with an impedance matching feed that includes microstrip line after its design is finalised. Each fundamental component of the array is positioned to provide greater gain with the fewest grating lobes possible [7]. Figure 1 depicts its precise design dimensions and geometry.

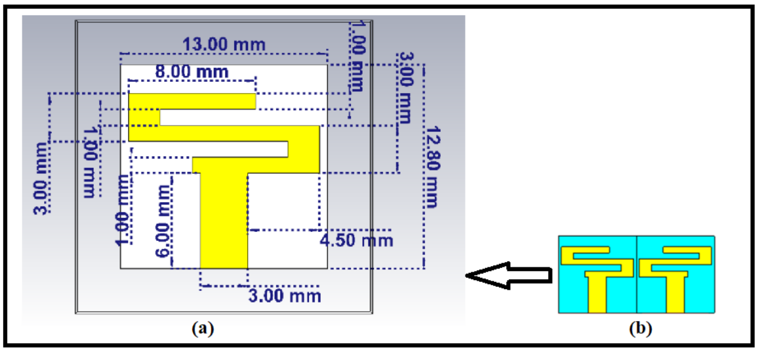

Figure 1. (a) S Shaped Microstrip patch antenna (b) 2-port MIMO antenna

2.2 2-Port MIMO Antenna

The next step is to combine two of these antenna systems to create a MIMO antenna, as shown in Figure. 1(b). Both the S-parameters and the radiation pattern consists of mutual coupling. The most critical MIMO antenna characteristics, which examine the power communicated between the ports, are mutual coupling. Therefore, it is important to arrange the elements in a way that minimizes the impacts of reciprocal coupling. In order to maintain better performance in antenna, the mutual coupling value should be less than -20 dB. Here, the S-parameters are used to determine the Envelop Correlation Coefficient (ECC).

3 SIMULATION RESULTS AND ANALYSIS

This section provides the simulation findings of the parameters of antenna for the 1X2 antenna array system.

3.1 Single Antenna System

In this proposed design of antenna system, the frequency range of the antenna was first analyzed by simulation and it is shown in the Fig 2. Its center frequency is resonating at 28GHz. Simulated -10dB bandwidth of 4.55 GHz was obtained (operating from 26.23 to 30.78 GHz).

Simulation was conducted to investigate on efficiency and gain. A gain of 3.42dBi at 0^0 with efficiency of 92% was observed for the proposed array system. Its E plane, H plane and 3D radiation pattern are shown in the Figure.3.

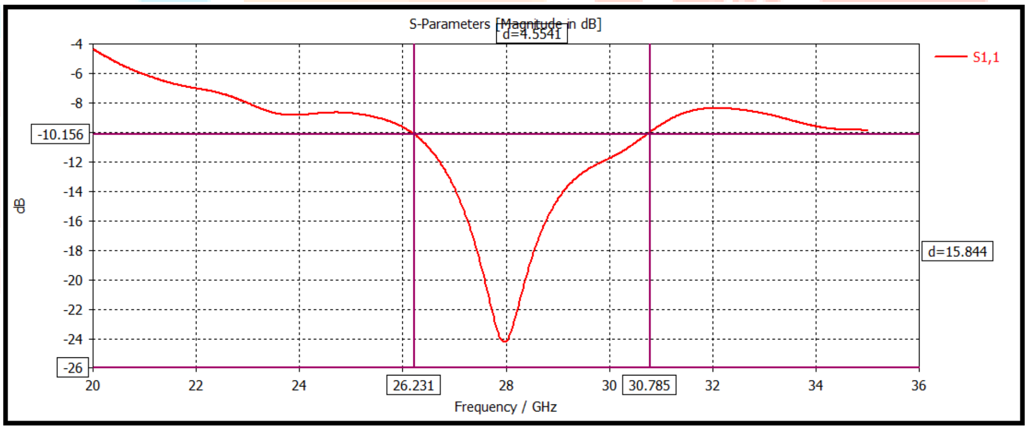

Figure 2. Single S shaped antenna’s Return loss

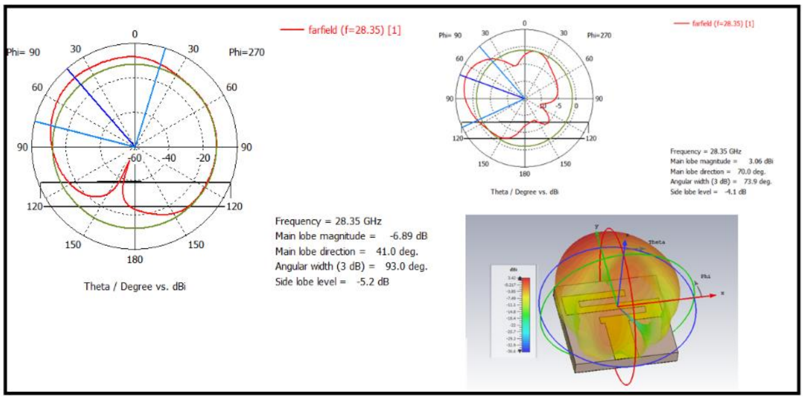

Figure 3. (a) E plane (b) H Plane (c) 3D Radiation pattern for single antenna

3.2 2-Port MIMO Antenna

Figure 4 displays the reflection coefficients (S_{11}, S_{22}) of each antenna system component on the MIMO structure. According to the simulation's findings, all antenna elements with return loss values lower than -10 dB have frequency ranges between 25 and 31.73 GHz and bandwidths of 6.73 GHz. The achieved center frequency is 28.35 GHz.

When all ports are activated, the proposed array system's gain is 3.724dBi at 0^0 with a 96 percent efficiency. The E plane, H plane, and 3D radiation pattern are depicted in Figure. 5. As a result, stimulation all ports improve the suggested antenna's gain and directivity, increasing the radiation efficiency.

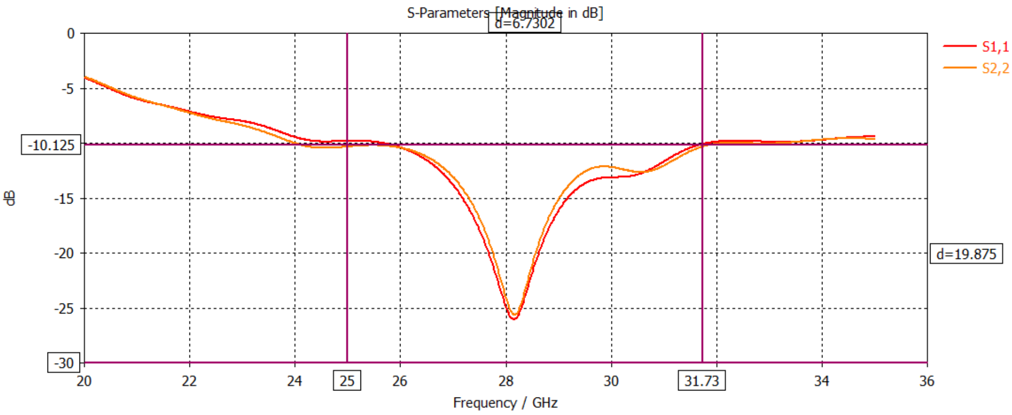

Figure 4. Return loss of Single S shaped antenna

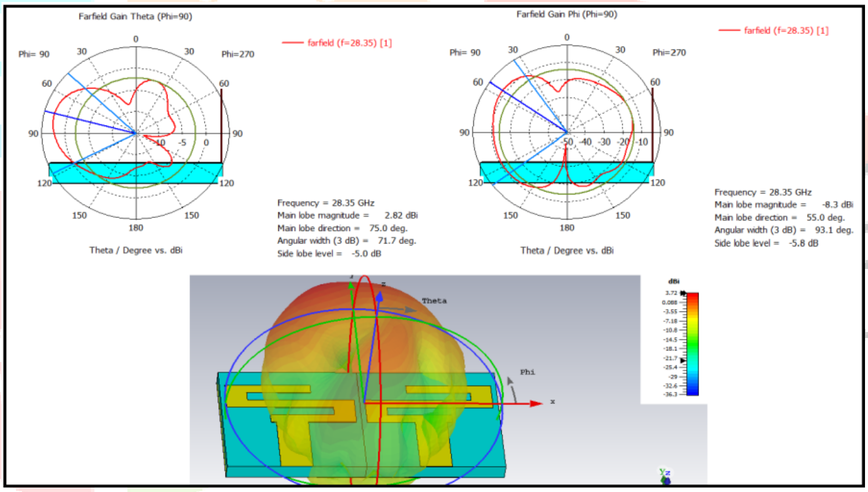

Figure 5. Radiation pattern for an array of 1x2 antenna (a) E plane (b) H Plane (c) 3D

The correlation between antennas in a MIMO system is measured by the correlation coefficient. The mutual coupling is inversely correlated with the correlation value. Finding the inter-element spacing is one of the important techniques to lower the correlation coefficient. A very good ECC (Envelop Correlation Coefficient) was attained for the band width that was accomplished, as shown in Figure 6 for the specified optimized inter element spacing. Here, the correlation coefficient [8] between antennas 1 and 2 is determined using equation (1). Acceptable ECC values [9] are less than 0.5.

$$\rho = \frac{|S11\times S12+S21\times S22|^2}{(1-(|S11|^2+|S21|^2))(1-(|S22|^2+|S12|^2))} \qquad (1)$$

The mutual coupling performance of a MIMO antenna is represented by the forward transmission coefficient (S_{12}) and the reverse transmission coefficient (S_{21}) [10, 11]. The outcome of electromagnetic interactions between nearby antenna elements is known as mutual coupling. Radiation efficiency increases as mutual coupling decreases, and vice versa [10]. A simulated reflection coefficient and all forward transmission coefficients are displayed in Figure 7. It demonstrates that a good mutual coupling reduction is made (-30dB).

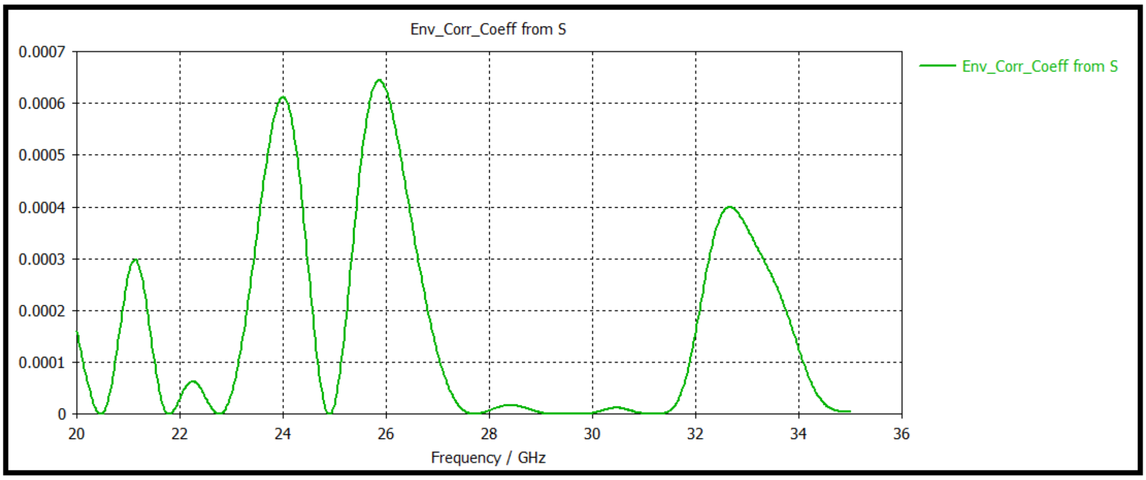

Figure 6. Envelop Correlation Coefficient

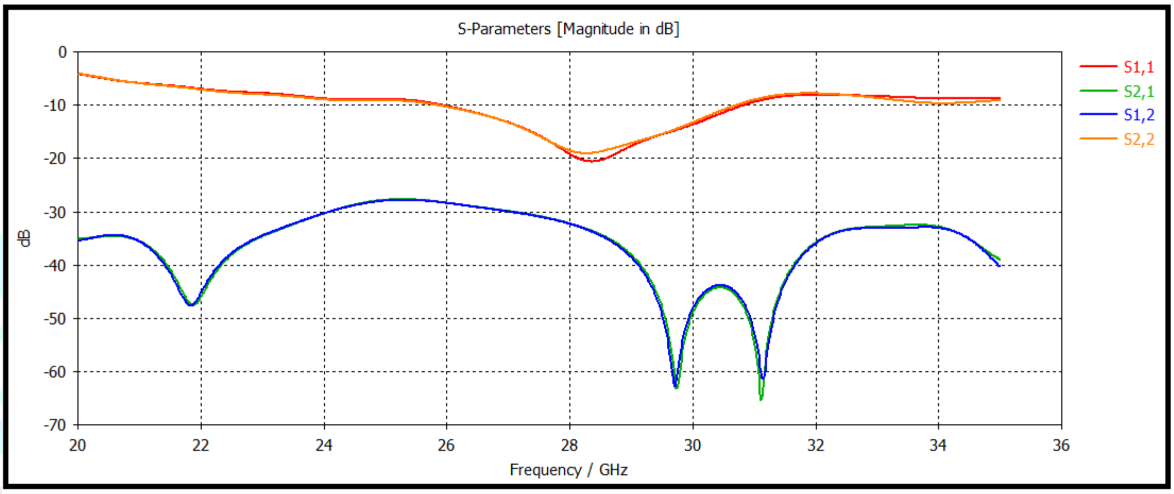

Figure 7. Return losses S11, S12, S21 and S22

3.3 Return loss, gain and efficiency on human tissue model.

Body tissue model consisting of flat muscle, fat, and skin is put 10mm away from the antenna. For the three layers of skin, fat and muscle with respective thicknesses of 2, 4, and 10 millimeters, the area is kept common at 50 x 50 mm^2. Table I, lists the dielectric characteristics and sizes of various tissue layers. The antenna recorded a gain of 4.168dBi with an efficiency of 67.34 percent at 28.35GHz when put on the 3-layer tissue model at a distance of 10mm above the skin with S_{11} of -20.60dB as shown in Figure 8, with bandwidth of 4.91GHz (from 25.90GHz to 30.81GHz)

Tissue	Conductivity (S/m) at 28GHz	Permittivity at 28GHz	Tissue dimension In mm^3
Skin	25.8	16.6	50x50x2
Fat	5.04	6.09	50x50x4
Muscle	33.6	24.4	50x50x10

TABLE I: TISSUE PROPERTIES [12].

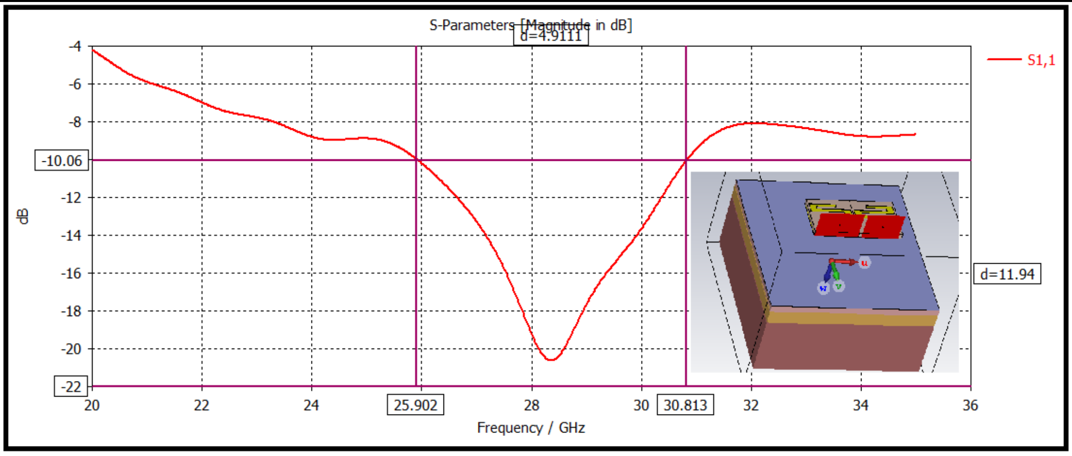

Figure 8. Return losses S_{11}, on human body tissue model

The SAR performance of the antenna on the human body tissue model was conducted. The measure SAR was 1.966W/Kg for an input power of 0.5W at a distance of 10mm from the tissue model. This SAR result was compared to the Federal Communications Commission's authorized limits of 2W/kg for 10g of human body. Hence the designed antenna array is well suited for the Human body communication applications.

4 CONCLUSION

This paper showcased the design and simulation of a linearly polarized MIMO antenna array with two ports operating at a center frequency of 28 GHz for various applications of 5G. A 1X2 basic antenna array system with an appropriate impedance stub has been demonstrated. With board dimensions of 26 X 25.6 X 1.6 mm^3, the design proposed is a straightforward, compact planar one that is ideal for human body communication. The findings demonstrate that the suggested antenna performs better and at its best in terms of SAR, mutual coupling, bandwidth, radiation pattern features, and reflection coefficient.

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REFERENCES

[1]. Qian Zhu, Kung Bo Ng, Chi Hou Chan, Kwai-Man Luk “Substrate-Integrated-Waveguide-Fed Array Antenna Covering 57–71 GHz Band for 5G Applications” *IEEE Transactions on Antennas and Propagation, vol. 65, no. 12, December 2017.*

[2]. S.Praveena, B. Murueshwari, U. Surendar, R..Kayalvizhi, “A review of antenna design for millimetre wave range” International conference on Electrical, Information and communication

[3]. F. Boccardi et al., “Five disruptive technology directions for 5G,” IEEE Communications Magazine, vol. 52, no. 2, Feb. 2014, pp. 74–80.

[4]. R. J. Weiler et al., “Environment Induced Shadowing of Urban Millimetre -Wave Access Links,” IEEE Wireless communications Letters, vol. 5, no. 4, Aug. 2016, pp. 440-443.

[5]. Zhang, L., T. Jiang, and Y. Li, “Design of a high isolation dual- band MIMO antenna for WLAN and WIMAX applications,” PIERS Proceedings, 593–1597, Prague, July 6–9, 2015.

[6]. Zulkifli, F. Y. and E. T. Rahardjo, “Compact MIMO microstrip antenna with defected ground for mutual coupling suppression,” PIERS Proceedings, 89–92, Marrakesh, Morocco, March 20–23, 2011.

[7]. Balanis, C. A., “Antenna Theory, Analysis and Design,” 3rd edition, John Wiley & Sons, New York, 2005.

[8]. S. Blanch, J. Romeu, and I. Corbella, “Exact representation of antenna system diversity performance from input parameter description,” Electron. Lett., vol. 39, no. 9, pp. 705–707, 2003.

[9]. M. S. Sharawi, “Printed MIMO Antenna Engineering.” Norwood, MA, USA: Artech House, 2014.

[10]. Zhou, X., R. Li, and M. M. Tentzeris, “A compact broad band MIMO antenna for mobile handset applications," Antennas and Propagation Society International Symposium (APSURSI), 2010.

[11]. Najam, A. I., Y. Duroc, and S. Tedjini, “Design & characterization of an antenna system for UWB-MIMO communications systems," Antennas and Propagation (EuCAP), Proceedings of the Fourth European Conference, 2010.

[12]. https://itis.swiss/virtual-population/tissue-properties/database/tissue-frequency-chart/