Efficient High Gain Elliptically Polarized Phased MIMO Antenna

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Abstract: A phased MIMO antenna with a coaxial feed is designed to operate in the electromagnetic spectrum with the frequency range of 8 GHz to 12 GHz, which resonates at 9 GHz, is used in military and satellite communication. The ability of phased MIMO antennas to change the form and orientation of the radiation pattern without constantly moving the antenna is unique. The proposed approach can also improve radiation efficiency by maximizing array unit size. To validate the proposed method, an elliptical polarization phased antenna has been constructed as a planar array. A 2 to 2 planar dual polarized MIMO antenna is intended to improve the efficiency. The obtained return loss for 2x2 planar MIMO is -19.34 dB. The proposed 2x2 MIMO antenna is projected on a teflon material with dielectric constant of 2.25 and the thickness of the substrate is 7mm. The efficiency for two port MIMO antenna is97.7%.

Key-Words: - Phased MIMO antenna, dual-polarized antenna, radiation efficiency, Polarization, MIMO Antenna, Omini-directional, Gain, Planar array.

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1 Introduction

Broad-angle scanning is fast evolving, and it has been utilized by phased arrays in an assortment of applications in order to circumvent the vast coverage constraints of high gain arrays. [1], because polarized capacitance can improve system capacity without raising the system size, this technology can be used to obtained resistance to multipath fading. Many radio stations used phased MIMO to improve the signal strength and hence coverage in the license city will decrease the interference in other areas. Because of differences in ionospheric propagation at mediumwave frequencies between day and night, it is similar for all broadcast stations to switch between groundwave and skywave radiation patterns daily at sunrise and sunset by transitioning the level of power delivered to each antenna elements. Many stations use horizontal dipole arrays for shortwave broadcasts. [2], a single-polarization method is complicate to satisfy the requirements of communication in some fields, such as satellite communications and 5G communication systems. In the above fields, the dual-polarization method has been used. [3], for dual-polarization, the following antenna types should be investigated: dipole antennas and microstrip antennas. This type of antennas have numerous pros, including cross- polarization, a forward/backward (F/B) radiation ratio, and a broad frequency band, [4]. Advanced array techniques have invented for emerging technologies such as satellite, military, etc... However, the intricately intertwined array is not applicable for 5G systems (MIMO). [5], the phased MIMO's polarization is defined by the placement of side by side located, perpendicularly polarized radiating elements. This antenna can be accomplished by changing the magnitude and time of the individual racecourse to obtain the perpendicular performance of polarization at the peak of the beam. Aspiration for two input-polarized weather radar systems derived from attributes that lead to raindrops to become flat in their upward direction if they fall on the atmosphere. [6], radar Cross Section or brightness differs for radar beams with electric fields which gets polarized perpendicularly or parallelly to the symmetrical axis. Since this MIMO antenna has

complex structure, it is composed of two feed lines which is made of metal. [7], a Phased MIMO radar offers a transmitted antenna arrays which is split into imbricate subarrays with similar elements to manipulate the coherent gain and waveform diversification. [8], a multi feed antenna is regulated by altering the phase and amplitude inside the different feeds.

2 Proposed Design

Many emitters are used in MIMO arrays for formation of beams in microwave devices which is having high frequency. The goal of using a phased array antenna is to direct an emitted beam by utilizing two or more waves having a equal amplitude and phase to generate the signal waves among two or more transmitted signal. This will be referred to as "formation of beam".

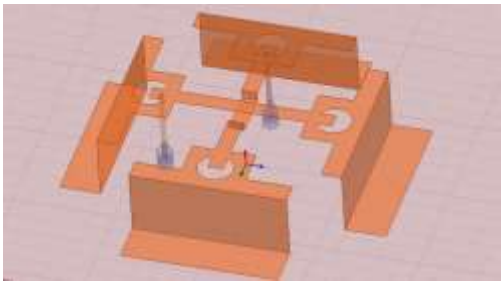

Fig. 1: Single phased antenna

A single phased antenna is first designed in Figure 1 and the current distribution is analyzed using HFSS software. The proposed MIMO antenna is compact and comprised of a ground plane, four coiled metal plates with four circular grooves, four slates, and two L-shaped line feeds. The metal sheet is displayed on a Teflon substrate with a dielectric of 2.1 and a depth of 7mm. The dimension is 60mm x 60mm. Table 1 shows the specifications for the suggested polarized antenna unit.

Table 1. Dimensions of proposed antenna

Lg	**Lo**	**L1**	**Lf**	**W1**	**W2**	**Wf**
50	13.5	8	16	2.5	3	1.2

All dimension units are in mm.

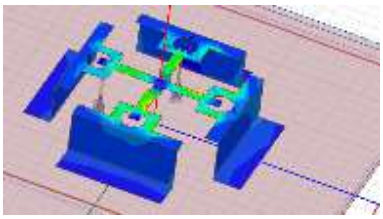

Fig. 2: Current distribution of single phased antenna

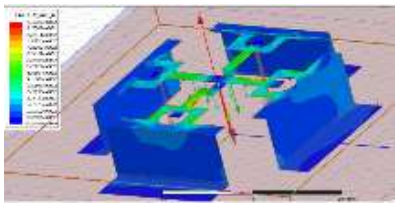

Fig. 3: E-field representation

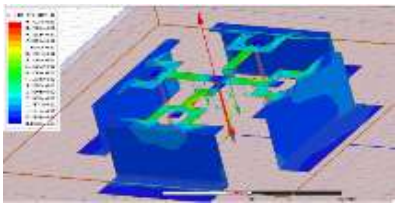

Fig. 4: H-field representation

[9], the bent frame can stimulate a longitudinal load in the elated unit, altering the dispersion in the patch. In Figure 3 and Figure 4, the E-field and H-field were also investigated. The sheet which is made of metal is used to boost the vertical current, resulting in a stronger opposite horizontal current. As a result, better current cancellation is seen in Figure 2. As given in Table 2, the return loss at 9 GHz is estimated to be -18.62 dB, VSWR obtained for the resonating frequency of **9 GHz** is **1.26**.and the maximum gain obtained is **8.5 dB.** This radiation pattern suggests that the antenna is omnidirectional and it radiates in all directions. [10], an Omni-Directional radiation pattern for an antenna emits and receives sufficient proportions of Radio Frequency, achieves in a 360-degree radiation pattern which enables connectivity in all directions. The obtained efficiency is **95.07%.**

3 Antenna Analysis and Result

3.1 Result and Analysis of 2 x 2 MIMO Antenna

To actually accomplish the proposed antenna's efficiency, a 2x2 MIMO was designed as in Figure 5

and its performance is evaluated. The same Teflon with a dielectric permittivity of 2.1 and a substrate depth of 7mm is used, with an ability to operate in the frequency of 9 GHz and a frequency band of 8GHz to 12GHz. The same Teflon with a dielectric permittivity of 2.1 and a substrate depth of 7mm is used, with an ability to operate in the frequency of 9 GHz and a frequency band of 8GHz to 12GHz.

The metal plates are ready to bend to form the vertical plates, which are then encased with the metal sheet. The proposed dual polarized antenna has a compact and elementary structure. The array antenna measures 81mm * 81mm.

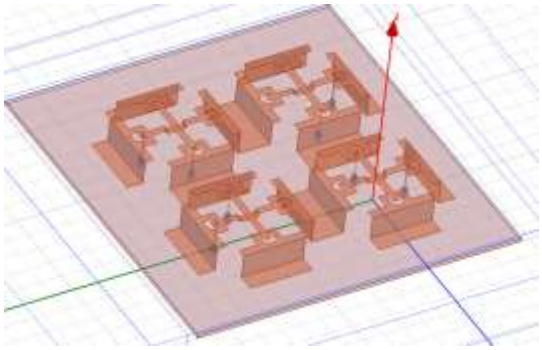

Fig. 5: Design of 2x2 phased MIMO antenna using HFSS software

At the resonant frequency of 9 GHz, the return loss is **-19.34 dB** as shown in Figure 6. This criterion indicates that minimum power is reflected from the load. If the gain is greater, the signal strength is greater in that direction. The resulting gain is **10.7 dB** as shown in Figure 7. The ideal VSWR value is 1, which means that no power is evidenced from the antenna. At a frequency of 9 GHz, this antenna has a VSWR of **1.24** as shown in Figure 8. This radiation pattern indicates that the antenna is omnidirectional, radiating in every direction which is shown in Figure 9. An Omni-Directional antenna emits and receives equal amounts of RF energy, resulting in a 360-degree radiation pattern that allows connectivity in all directions. The designed antenna has a efficiency of **97.79%** as shown in Figure 10**.** High efficiency indicates that the antenna delivers the output effectively with less losses in the transmission lines. If an antenna was flawlessly and clearly circular polarized, this ratio would be one. This would be larger than one if an antenna had perfect elliptical polarization.

The axial ratio obtained for the proposed antenna design is **1.18 dB** as shown in Figure 11. The proposed antenna is elliptically polarized, as illustrated in Figure 12. Similarly same elliptical polarization is observed for E_x and $-E_x$ plane which is polarized at 90 deg.

As an outcome, the correlation between two antennas is zero if one is entirely horizontally polarized and the other is fully vertically polarized. For a microstrip MIMO antenna, the ECC value obtained is **0.003** as shown in Figure 13. Performance analysis is given in Table 2.

3.2 Performance & Designed Analysis in HFSS

Table 2. Performance Analysis

PHASED MIMO ANTENNA	RETURN LOSS (dB)	VSWR	GAIN (dB)	EFFICIENCY	ECC
Single element	-18.62	1.26	8.5	95.07%	-
2x2 MIMO	-19.34	1.24	10.9	97.79%	0.003

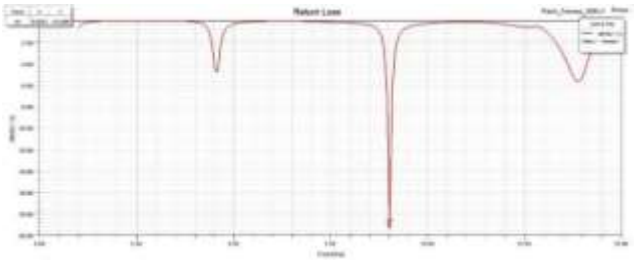

Fig. 6: Return loss vs frequency

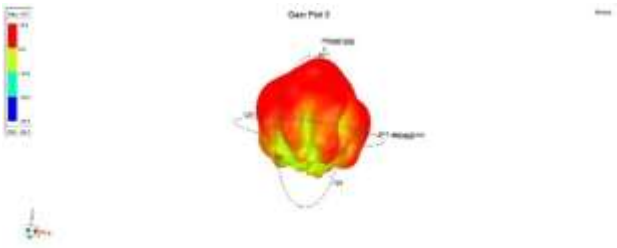

Fig. 7: Gain

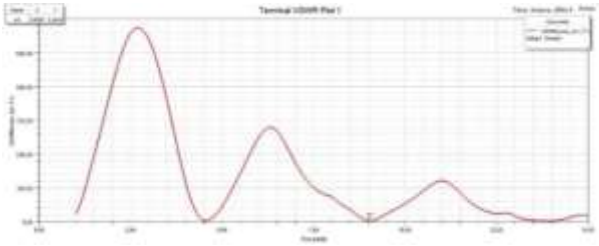

Fig. 8: VSWR vs Frequency

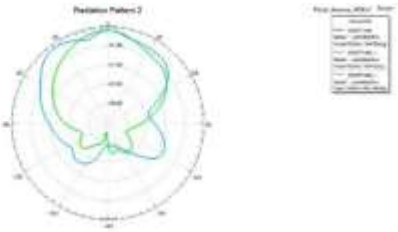

Fig. 9: Radiation Pattern

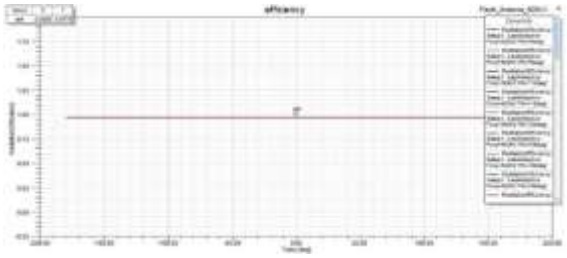

Fig. 10: Radiation Efficiency

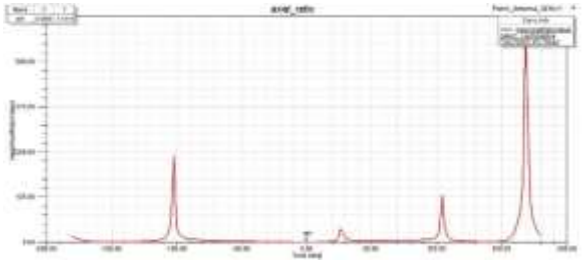

Fig. 11: Axial ratio

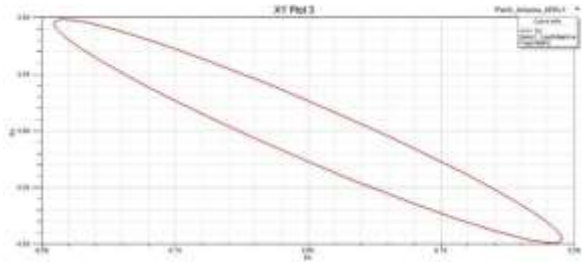

Fig. 12: Ey Plane polarised at 90 deg

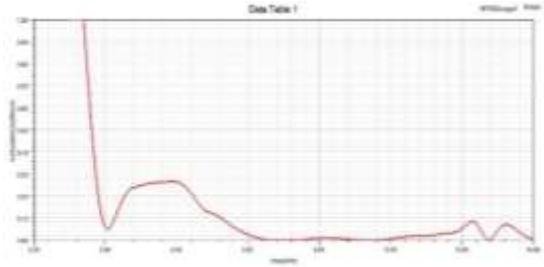

Fig. 13: Correlation Coefficient vs Frequency

4 Conclusion

The proposed antenna gives maximum efficiency which shows that the antenna delivers the output effectively with minimum losses while transmission. The use of a elementary and effectual feeding technique, coaxial feed, led to a higher impedance of more than 50% at a resonance frequencies of 9 GHz. While comparing with a single element, the proposed antenna with 2x2 MIMO has a radiation efficiency of 97.79%. The measured return loss is -19.34 dB, and the measured VSWR is 1.24. Using the simulation software Ansys HFSS, the simulation and analytical values were analyzed and validated. Satellite communication, radar systems, 5G, and WiFi are instances of applications. They are employed by the Electronic Warfare System. Based on the analysis, the best results for return loss, VSWR, gain, and radiation efficiency demonstrated that this antenna design is applicable for satellite technology.

References:

[1] Yang Guang-Wei and Zhang Shuai, Dual Polarized Wide-Angle Scanning Phased Array Antenna for 5G Communication System, *IEEE Antennas Wireless Propag,,* vol:70,Issue:9,September 2022.

[2] Haobo Wu, Junping Geng, Kun Wang, Han Zhou, Xiaonan Zhao, Chong He, Xian-Ling Liang, Weiren Zhu and Ronghong Jin, A Low-Profile Wideband Dual Polarized Antenna Based on an Improved HIS and Its Broad-Angle Beam-Scanning Array*, IEEE Antennas Wireless Propag. Lett.,* vol. 19, no. 3, pp. 383-387, March 2020

[3] Guo-Feng Gao, Xiao Ding, You-Feng Cheng and Wei Shao, Dual-Polarized Wide- Angle Scanning Phased Array Based on Multimode Patch Elements, *IEEE Antennas Wireless Propag. Lett.,* vol. 18, no. 3, pp. 546-550, March 2019

[4] Zhang P, Qu S and Yang S, Dual-Polarized Planar Phased Array Antenna with Cavity-Backed Elements, *IEEE Antennas Wireless Propag. Lett.,* vol. 18, no. 9, pp. 1736-1740, Sept 2019

[5] Hui Li, Le Kang, Feng Wei, Yuan-Ming Cai and Yong-Zeng Yin, A Low-Profile Dual Polarized Microstrip Antenna Array for Dual-

Mode OAM Applications, *IEEE Antennas Wireless Propag.* Lett., vol. 16, pp. 3022-3025, 2017

[6] Hangyu Zhang, Shiwen Yang, Yikai Chen, Jixin Guo and Zaiping Nie, Wideband Dual Polarized Linear Array of Tightly Coupled Elements, *IEEE Trans. Antennas Propag.,* vol. 66, no. 1, pp. 476-480, Jan. 2018

[7] Yang G W and Zhang S, A Dual-Band Shared-Aperture Antenna with Wide-Angle Scanning Capability for Mobile System Applications, *IEEE Transactions on Vehicular Technology,* vol. 70, no. 5, pp. 4088- 4097, May 2021

[8] Zhang Y M and Zhang S, A Novel Aperture Loaded Decoupling Concept for Patch Antenna Arrays, *IEEE Transactions on Microwave Theory and Techniques*, vol. 69, no. 9, pp. 4272-4283, Sept. 2021

[9] Boyuan Ma, Jin Pan, Shaode Huang, Suibin Liu, Tung Ngo, Zaw Thet Aung and Yong-Xin Guo, Compact Dual- Polarized Antenna With Enlarged Effective-to-Physical Aperture Ratio for Wireless Power Transfer and RFID, *IEEE Transactions on Antennas and Propagation*, vol. 69, no. 7, July 2021

[10] Amir Raeesi, Ardeshir Palizban, Ahmad Ehsandar, Hussam Al-Saedi , Suren Gigoyan , Wael M. Abdel-Wahab and Safieddin Safavi-Naeini, A Low-Profile 2D Passive Phased-Array Antenna-in-Package for Emerging Millimeter-Wave Applications , *IEEE Transcations on Antennas and Propagation,* vol. 71, no. 1, January 2023

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- Guruarchana. V and Guruatchaya. V, carried out the design, Simulation and Manuscript writing.
- Shantha Selva Kumar. R, guided in Problem formation, Trouble shooting and Manuscript organization.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.