SQUARE SLOT MIMO ANTENNA ARRAY FOR MILLIMETER-WAVE COMMUNICATION

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Abstract: *This article presents the design and simulation of a 3.89 dBi gain, quarter-wavelength impedance matching feed, square-shaped slot conventional microstrip antenna that operates in the ka-band at 30.18 GHz. High gain characteristic is needed for millimeter-wave applications. Therefore, the slotted microstrip antenna array that leads to an increase in the gain to 7.12 dBi at 30.36 GHz (ka-band) has been proposed. Due to this novel characteristic the proposed design best suitable for 5G communication systems. The proposed square-shaped slot antenna is embedded in the FR-4 substrate and a ground plane. Ansys-HFSS has simulated the structure. The simulation's output illustrates the antenna's gain, field pattern, and voltage standing wave ratio (VSWR).*

Keywords: **Microstrip, mm-wave antenna array, Square-shaped, VSWR, Radiation pattern**

1. INTRODUCTION

Today Wireless communication systems have expanded exponentially in terms of technology, wireless communication networks range from 1G through 5G. and infrastructure that have improved in providing transfer of voice, data, text, video, and GPS (Global Positioning System) between the transmitting and receiving devices. In contrast, millimeter-wave frequency bands are being used more and more for high-speed data links [1]. Fifth-Generation (5G) wireless communication systems are a recent development in mobile communications that aim to outperform their predecessors in terms of data throughput, capability, latency, and energy consumption. To achieve the aforementioned goals, the network must increase bandwidths through carrier aggregation using millimeter-wave spectrum. In particular, base station identification, Multiple Large Input Beam-forming antenna arrays and multi - output antenna technology will enhance the system's spatial capability [2]. The wireless communication systems' underlying RF front-end components will face increased demands as a result of these supporting technologies. [3].

In the current context, the unique requirement for quick wireless communication has assumed a central role. Consequently, Index for Visual Networking which predicts that traffic on mobile data will have surged by over 74% and that LTE traffic will surpass for the first time in 2015, 3G traffic, there will be M2M (Machine to Machine) modules and 11.6 billion mobile devices connected by 2020. [4]. Therefore, in this context, smart antenna is crucial to the creation of the upcoming communications infrastructure. To this purpose, a key component of millimeter-wave system design is the advancement of antenna design technology. The advantages of microstrip patch antennas are particularly noteworthy since they can be made to work with a range of surfaces that can support devices and components of any structure and size [5]. The main drawback of this architecture is its constrained bandwidth. This drawback can be remedied using a variety of design technology techniques, such as the introduction of feeding or the introduction of various slots to the DGS research of the efficacy of an antenna's ground plane with minimal reflection coefficient in wideband applications by the introduction of circular or diamond-shaped slots on the patch. [6]. The essay is set up like follows: Section II presents the antenna setup. Results have been discussed in Section III. Finally, section IV's recommended work has been completed.

2. Proposed Antenna Configuration

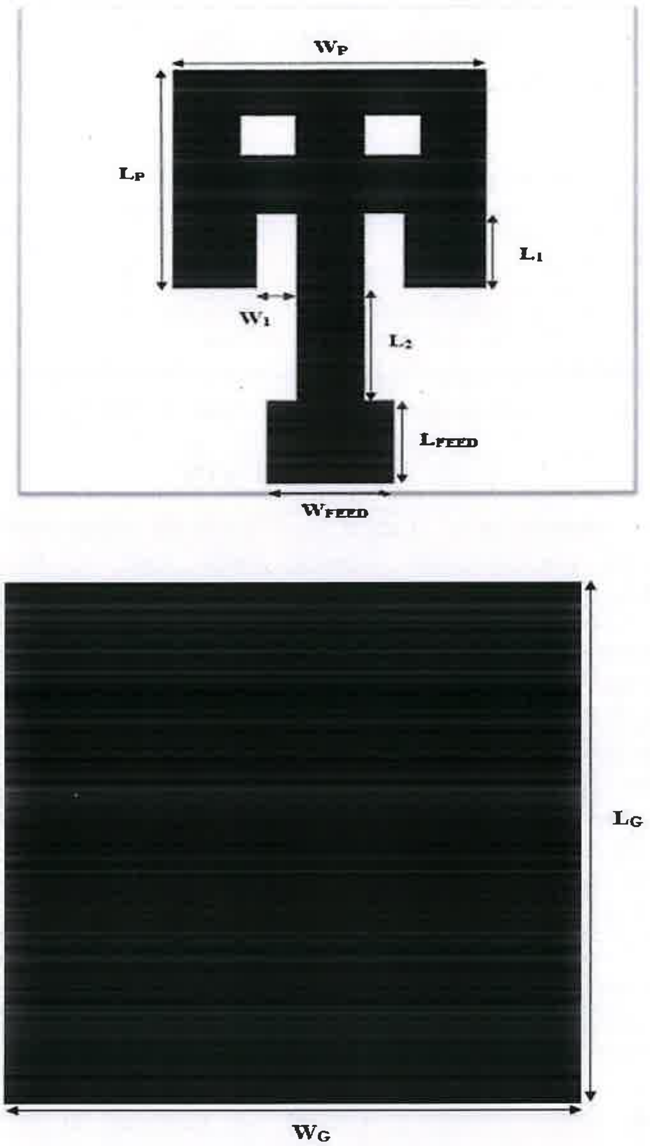

Figure 1. Single Element Square-Slot Microstrip Patch Antenna

Fig. 1 depicts the single element square-shaped slot microstrip patch antenna's geometrical layout. The square slot's edge measurement is 0.424 mm. The single element is 4.6 × 5.2 × 0.3 mm3. A microstrip line of 50 Ω with dimensions of WFEED = 0.955 mm and LFEED = 1 mm feeds the antenna. For impedance matching, the quarter wave transformer is attached to the patch. The antenna has 0.3 mm in height, 4.4 relative permittivity, and 0.02 dielectric loss tangent over a FR-4 substrate. The effective frequencies and yield deficit level of such antenna are determined by the effect of the slots and the dimensions of the slot edges. The antenna array was built and simulated using HFSS software. To boost the surface currents, slots were added to the patch [7]. Table 1 provides a summary of the proposed single element square-shaped slot patch antenna's dimensions. The two-element square-shaped slot patch antenna is suggested to accomplish the high gain property. The suggested square-shaped slot patch antenna array has the following measurements: 8.962 x 5.2 x 0.3 mm3. The distance (D) between the two elements is 4 mm. The square-shaped slot patch antenna array is a component of the proposed uniform-linear array concept. Figure 2 shows the geometry of the suggested square-shaped slot MIMO antenna array.

Table 1. Dimensions of Single Element and Array Slot Antenna

Dimension	L_P	W_P	L_1	W_1
Value (mm)	2.362	2.362	0.800	0.300
Dimension	LFEED	WFEED	LG	WG
Value (mm)	1.000	0.955	2.362	2.362

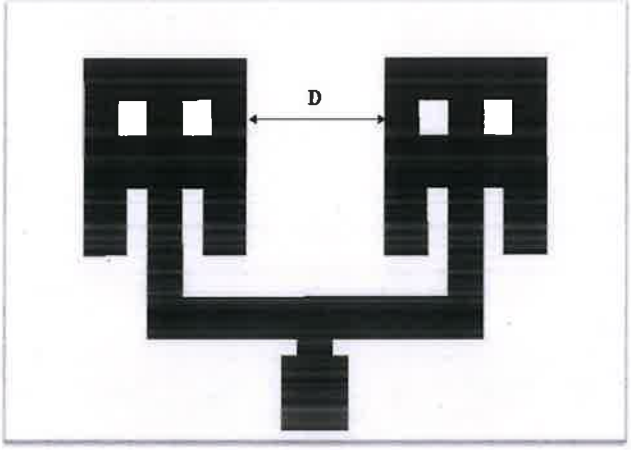

Figure 2. Square-Slot Microstrip Patch Antenna Array

3. RESULTS AND DISCUSSION

The single element square-shaped slot microstrip patch antenna's S11 characteristic is depicted in Fig. 3. At the resonant frequency of 30.42 GHz, the element's reflection coefficient is -42.24 dB. The Voltage Standing Wave Ratio (VSWR) measures how effectively an antenna transmits and receives electromagnetic waves in a certain frequency spectrum. According to Fig. 4, the VSWR is less than 2 at the antenna's working frequency, indicating acceptable impedance matching. Peak gain is described as the difference between the far-field power of the antenna and the power of the isotropic antenna. Fig. 5 illustrates the gain of the single element, which is calculated to be 3.98 dBi at the resonance frequency. The coverage area of an antenna in free space is determined by its radiation pattern. Fig. 6 depicts the element's three-dimensional (3-D) radiation pattern at its operating frequency. In Fig. 7, the element's E-plane and H-plane field pattern is displayed. In that, it is determined that the HPBW of the single element is 81.39° for the xz plane and 90.93° for the xy plane.

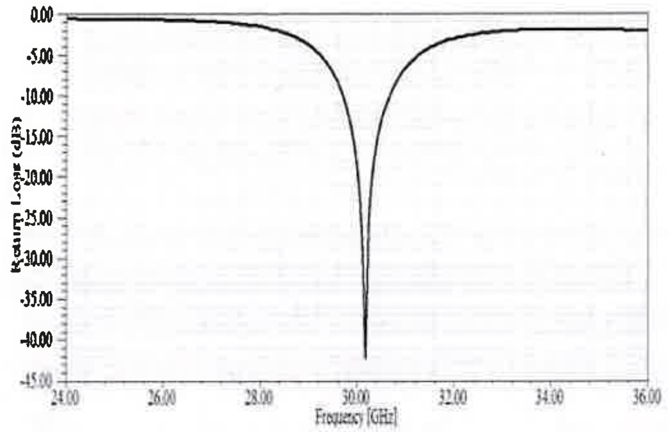

Figure 3. Return Loss of the Single Element Square-Shaped Slot Patch Antenna

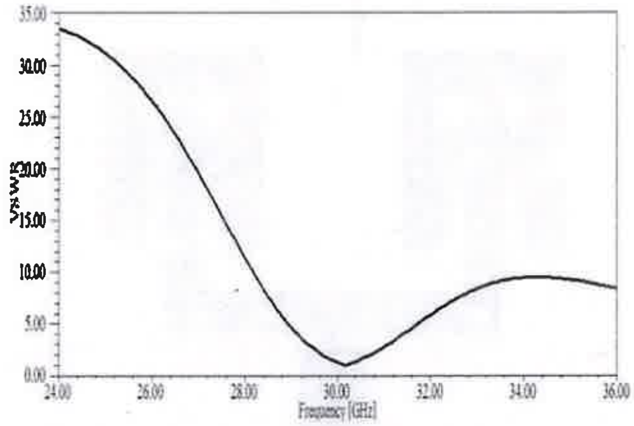

Figure 4. VSWR of the Single Element Square-Shaped Slot Patch Antenna

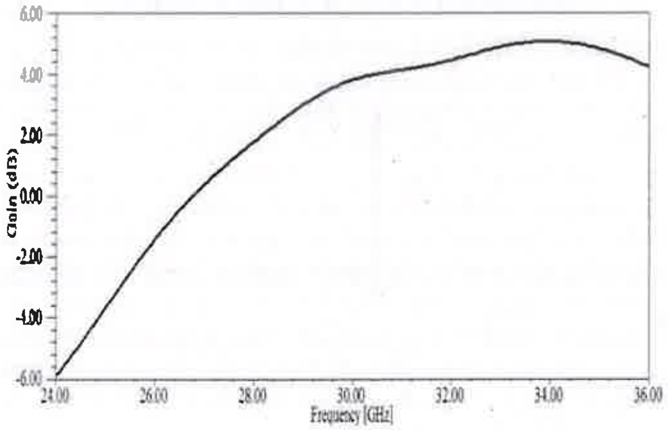

Figure 5. Gain of the Single Element Square-Shaped Slot Patch Antenna

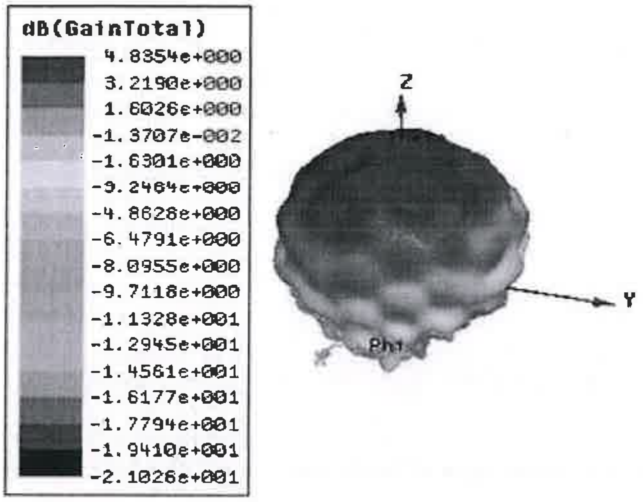

Figure 6. 3D Radiation Pattern of the Single Element Square-Shaped Slot Patch Antenna

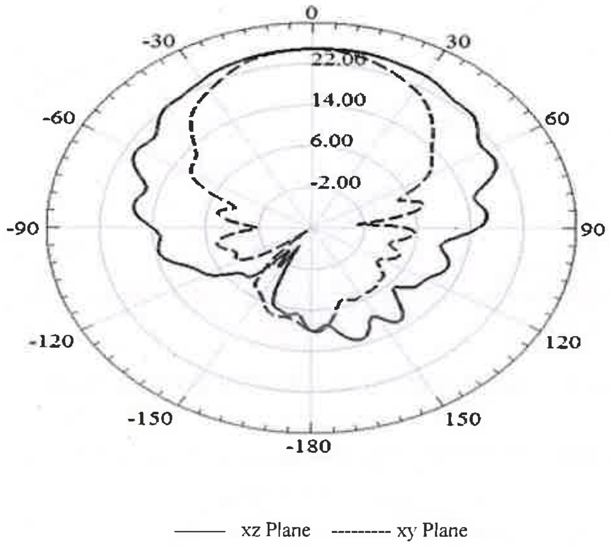

Figure 7. xz-Plane and xy-Plane Radiation Pattern of the Single Element With Slot

Fig. 8 depicts the square-shaped slot microstrip patch antenna array's return loss characteristics. At the operating frequency of 30.36 GHz, the return loss of the two elements is -27.05dB. In Fig. 9, There is evidence that the suggested antenna array works has a VSWR value of less than 2 at the resonance frequency. Fig. 10 depicts the two elements' gain characteristics. The gain value at the operational frequency is 7.12 dBi. Fig. 11 depicts the array's three-dimensional (3-D) field pattern at the effective frequency. The antenna array's E-plane and H-plane field pattern is depicted in Fig. 12. In that, it is determined that the HPBW of the proposed antenna is 95.46° for the xz plane and 51.81° for the xy plane.

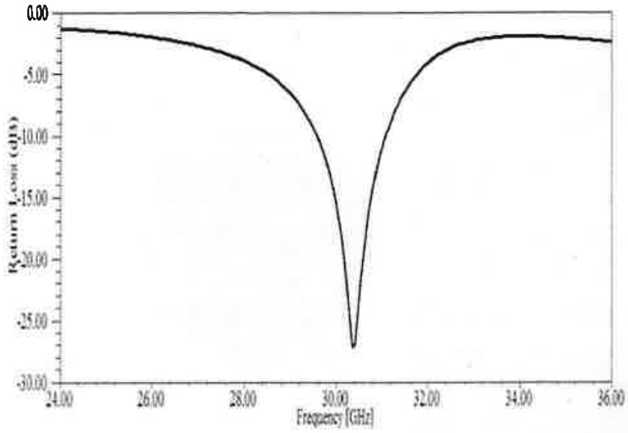

Figure 8. Return Loss of the Square-Shaped Slot Antenna Array

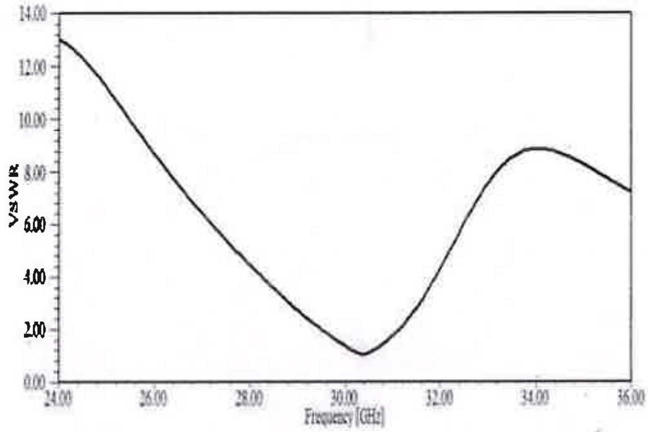

Figure 9. VSWR of the Square-Shaped Slot Antenna Array

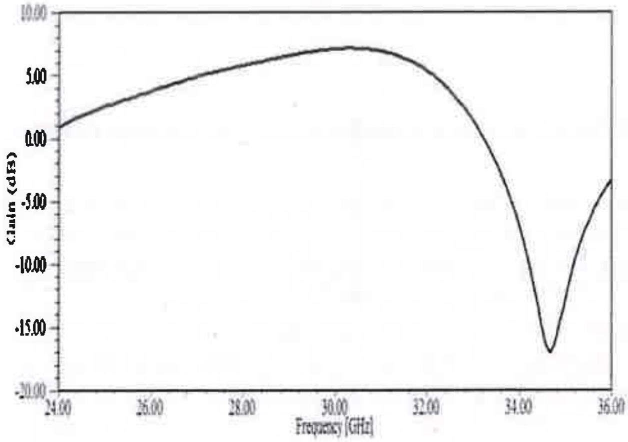

Figure 10. Gain of the Square-Shaped Slot Antenna Array

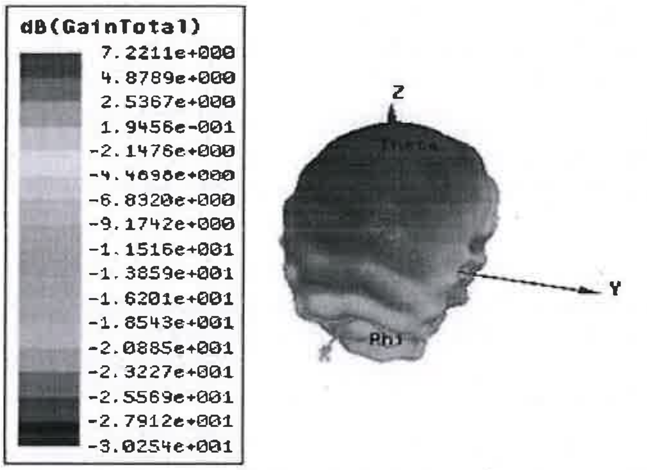

Figure 11. 3D Radiation Pattern of the Square-Shaped Slot Antenna Array

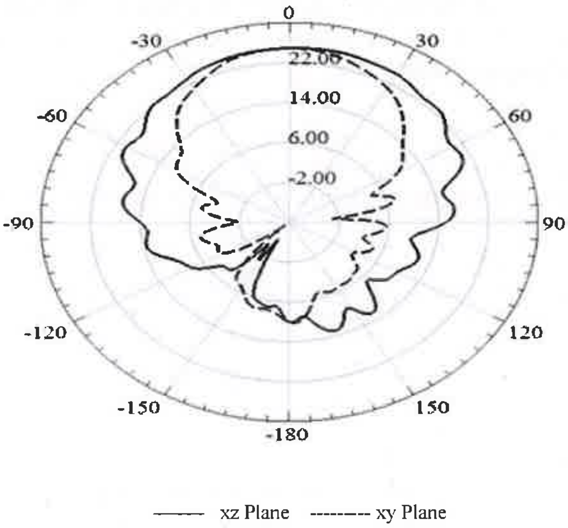

Figure 12. xz-Plane And xy-Plane Radiation Pattern of the Square-Shaped Slot Antenna Array

4. CONCLUSION

This work proposes a tiny microstrip patch antenna array that performs well and can be easily installed on a FR-4 substrate. For VSWR 2, At a certain frequency, the antenna array resonates. of 30.36 GHz. In comparison to a single square-shaped slot patch antenna, the gain of the antenna array is high. characteristic. For applications using millimeter waves, it is more suitable. It makes use of the ka-band frequency range. Radar, cellular communications, and huge data transmission are just a few of the numerous uses it may serve.

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