Analysis of Patch Antenna Array With Hexagonal Shaped Slots With DGS For Wireless Communications and IoT Applications

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Abstract: The design of rectangular micro strip patch antenna array with hexagonal shaped slots with DGS using inset line feeding technique has been presented in this paper. The antenna is designed and simulated by using CST software. FR-4 glass epoxy having dielectric constant 4.4 and thickness 1.6mm is used as a substrate material for the designing of proposed antenna. The different parameters of designed antenna are calculated and analyzed such as return loss, VSWR (voltage standing wave ratio), gain, radiation pattern and bandwidth. Simulation results show that the proposed antenna works on five different frequency bands. The value of return loss is -30.2 and VSWR is 1.06 at 11.2 GHz frequency bands respectively. It shows that all the values of return loss and VSWR is for X-band frequency bands are at excellent level. It shows that the results of antennas are in good agreement with results.

Keywords: Patch Antenna Array, DGS, Slots, 6, CST.

1. INTRODUCTION:

To meet the rising demand for data and connectivity, 4G wireless network is being replaced by the 5G network, which fixes issues brought on by previous network generations, including high energy consumption, lack of spectrum, inadequate coverage, and Quality of Service (QoS), increased capacity, global coverage, higher availability, and greater adaptability at multiple gigabits per second with a latency of one millisecond or less. For 5G to integrate existing communication technologies and utilize each to create a sizable heterogeneous network, it must deliver the performance necessary to satisfy regional and global market demands [1]. As a result, 5G will be able to deliver the necessary performance while meeting regional and global market demands. Mobile and satellite communication are examples of these technological developments. For 5G global connectivity to be possible, satellite communication networks are crucial because they make it possible to deploy networks quickly, eﬀ ectively, and eﬃ ciently. Utilizing these benefits will increase the network's ability to broadcast worldwide, reduce reliance on terrestrial infrastructure, and provide high security. More than terrestrial-only solutions, a 5G satellite-terrestrial network can enhance use cases. This can be accomplished by incorporating satellite communications into 5G. This covers private mobile and nomadic deployment, on-premises local networks, content acquisition and distribution, highly dispersed Internet of Things (IoT) networks, and on-premises local networks. Wireless devices must meet strict QoS requirements and transmit data at high rates over a variety of Wireless Communications Services (WCS) in IoT applications. These devices should be able to carry out several tasks at once and across WCS. Most often, reversible antennas are required. A wireless device demonstrates the capacity for dialogue in a range of contexts [2].

Traditional satellite architecture can be reduced, as demonstrated by nano satellites. Any spacecraft with a diameter under one meter is considered a satellite. Previously enormous, intricate, time- consuming, and expensive satellite systems can now be developed as smaller, less expensive satellite structures in less time thanks to improvements in miniaturization techniques for electrical and electronic components. CubSats make up most nano satellites [3]. Nano satellites are miniature satellites. CubeSats have a form factor of one Unit (1U). Depending on user requirements, this modular design can be scaled to 3U, 6U, 12U, or 24U. Commercially available Oﬀ -The-Shelf

(COTS) components make the construction of CubeSats less complicated. Traditional satellites offer security, ubiquity, and coverage for 5G. Traditional satellite development for 5G communication is costly and time-consuming. Specialized knowledge and infrastructure are needed for design, development, and testing [4]. Satellites in Low Earth Orbit (LEO) are necessary for the IoT and massive Machine-Type Communication (mMTC) in next-generation communication systems like 5G and 6G. They must also communicate in constellations to offer mobility and global coverage [5].

The deployment of 6G technology, which is anticipated to begin in 2030, may be delayed by the lengthy and expensive construction of these massive conventional satellite constellations. Due to their small size and affordable development and launch costs, nano satellites could be used to support satellite- terrestrial 5G networks in LEO. Their launch is reasonably priced because they can be launched from the International Space Station (ISS) or in "ride sharing" missions. To increase latency, robustness, security, and global coverage, nano satellite constellations can be created and launched [6]. Compared to larger satellites, nano satellites are simpler, less expensive, and easier to launch. The antenna was initially employed as a beam-emitting "slots and DGS" on a surface. A slot antenna's ability to function depends on its slots. When being connected, patch are metallic sub-wavelength sections that emit radiation and produce antenna impedance. The majority of currently used slot antennas have hexagonal slot and DGS. However. The slots can be non-square if a plane tessellation can be created by copying the fundamental shape. By fusing volumetric slots with DGS, slots antennas can create three-dimensional structures [7–10]. This study examines slots antenna arrays for IoT and wireless communication systems. Both the traditional and the proposed slot patch antenna configurations have been fabricated and measured. To illustrate the effectiveness of a new Driven-Shorting (DS) post strategy in antenna size reduction with lower-order mode, results of proposed antennas are shown. Such slot antennas' design parameters are carefully examined to increase gain and enhance radiation pattern and efficiency [11]. Reconfigurable antennas with adjustable gain and radiation patterns are essential for extending 5G and micro satellite coverage [12, 13]. Different radiation pattern setups and increased gain can be beneficial.

2. HEXAGONAL SHAPED SLOT WITH DGS PATCH ANTENNA ARRAY DESIGN STRUCTURE

This 2x2 patch antenna array works at a frequency of about 11.2 GHz. The presentation and analysis of an electrically loaded hexagonal slot patch array design will be done around this frequency using a novel design strategy. The dielectric substrate used in the suggested element structure is FR4, which has a thickness of 0.635 mm, a relative permittivity of 4.4, and a loss tangent of 0.02. The size of the proposed patch is in the range of $\lambda/4q$, where q is a rational number related to the root of the substrate's dielectric constant ($q\sqrt{\varepsilon_r}$). A partially grounded, 1 mm-wide, 6 mm-long microstrip Transmission Line (TL) forms the bottom layer. q reduces the size of the pixel patch to highlight its importance and function. The patch measured about 5 mm, and q is roughly 3.2 [14]. Operating frequency differences can be eliminated during design by "matching." Fig. 1 and 2 depicts the proposed design of front and bottom geometry. In patches hexagonal shaped slots are added and in ground hexagonal shaped discontinuity inserted. These slots and discontinuity are not only cause of electrical variations but also alter the quality of antenna results.

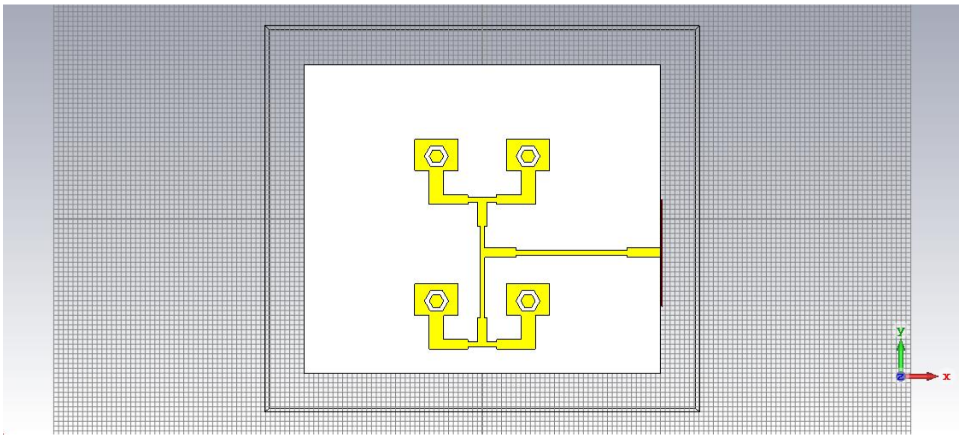

Fig.1 Geometry of top layer of 2×2 patch antenna array

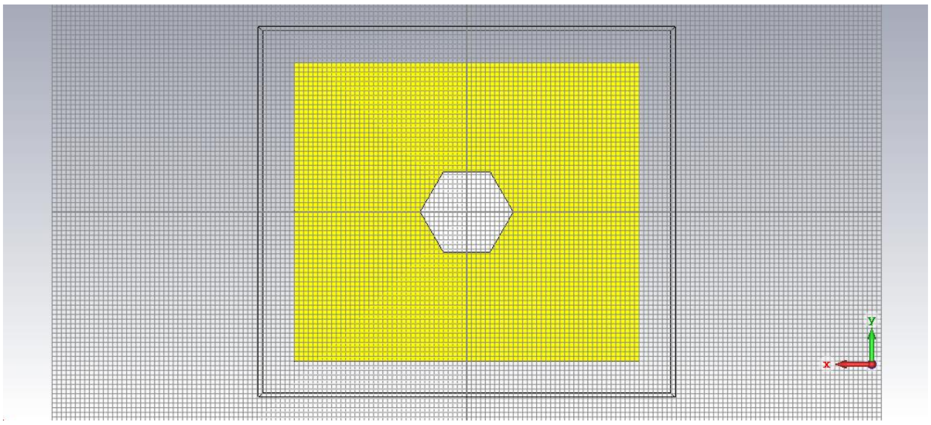

Fig.2 Geometry of 2×2 bottom layer (ground) of patch antenna array

3. **SIMULATION RESULTS:** The Return loss, the gain, the VSWR and the radiation pattern of the proposed models needs to be evaluated before one can conclude the proposed antennas to be practical.Return loss, VSWR, reference impedance, Efficiency, and directivity are shown in fig. 3, 4, 5, 6, and 7 respectively.

S-Parameter display the input to output relation between ports. S11 is the most commonly quoted parameter in terms to antenna. Return loss plot represent the power reflect from the antenna which is known as reflected coefficient or return loss [15,16]. If S11 = 0 dB this implies entire power is reflected. If S11 = -10 dB that means 3dB of power is transfer to the antenna and -7 dB is the reflected power. Therefore the excellence performance of antenna should be S11 ≤ 10 dB. Below show the reflection coefficient of hexagonal Slots with DGS 2x2 patch antenna array.

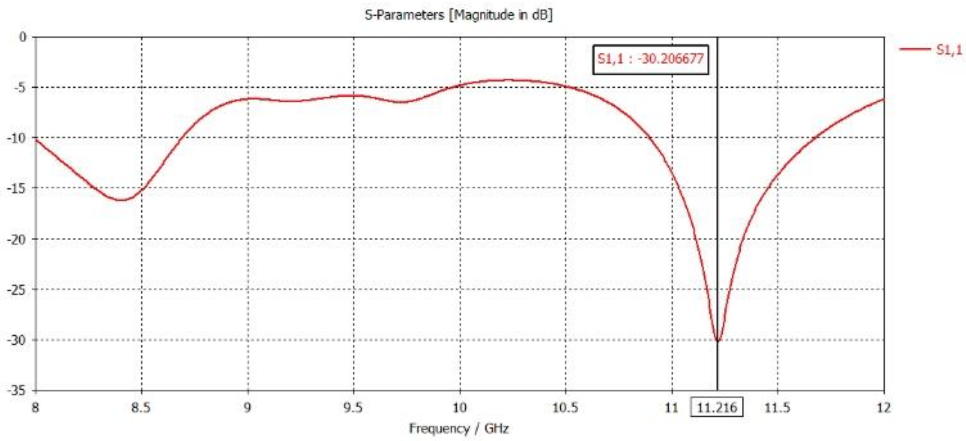

Fig. 3 Return loss of 2×2 patch antenna array

VSWR is a part of reflection coefficient, which explains the power reflection from antenna. VSWR must be a real and positive number. The smaller value of VSWR represent the excellent performance. It will demonstrate the antenna impedance match to the transmission line and also more power delivered to the antenna. Below show the VSWR of 2x2 patch antenna array.

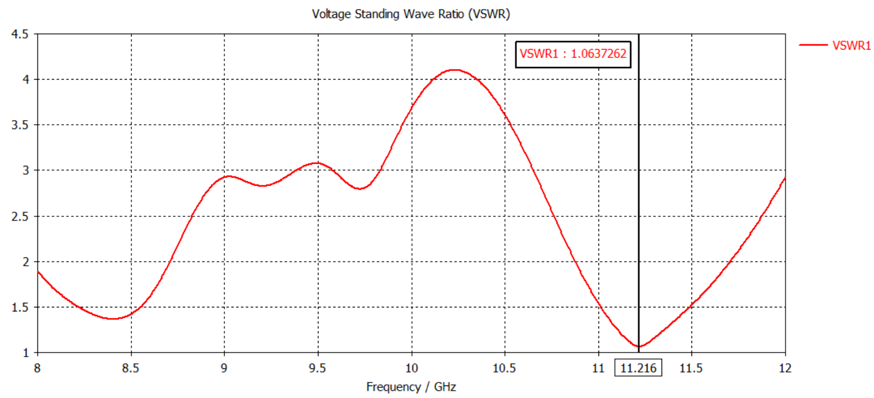

Fig. 4 VSWR of 2×2 patch antenna array

The theory of maximum power transfer states that for the transfer of maximum power from a source with fixed internal impedance to the load, the impedance of the load must be the same of the source. "Jacobi's low. In fact, the approximate impedance range for practical patch antenna is 100 □ ZA □ 40Ω which causes a mismatch if the patch is connected directly to a standard transmission line that has Z = 50Ω. Fig. 5 show the reference impedance of 2x2 patch antenna array

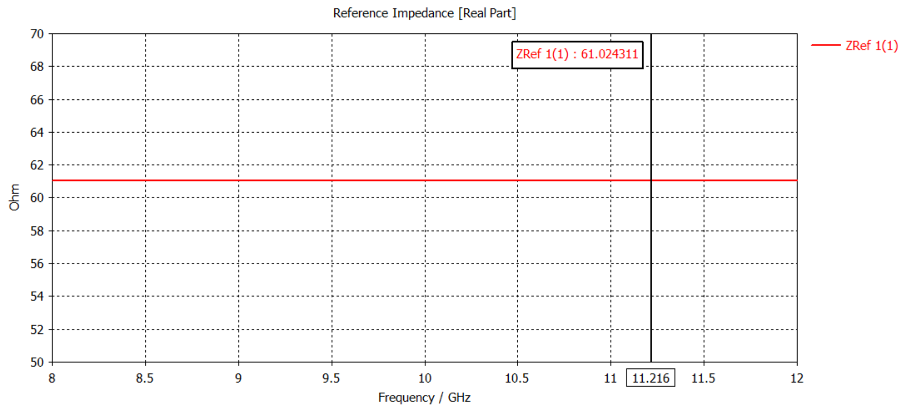

Fig.5 Reference Impedance of 2×2 patch antenna array

For a microstrip patch antenna, efficiency can be defined as the power radiated from the microstrip element divided by the power received by the input to the element. Factors that affect the efficiency of the antenna and make it high or low are the dielectric loss, the conductor loss, the reflected power, the cross polarized loss, and power dissipated in any loads in the element. Below show the fig.6 of effeciency of 2x2 patch antenna array.

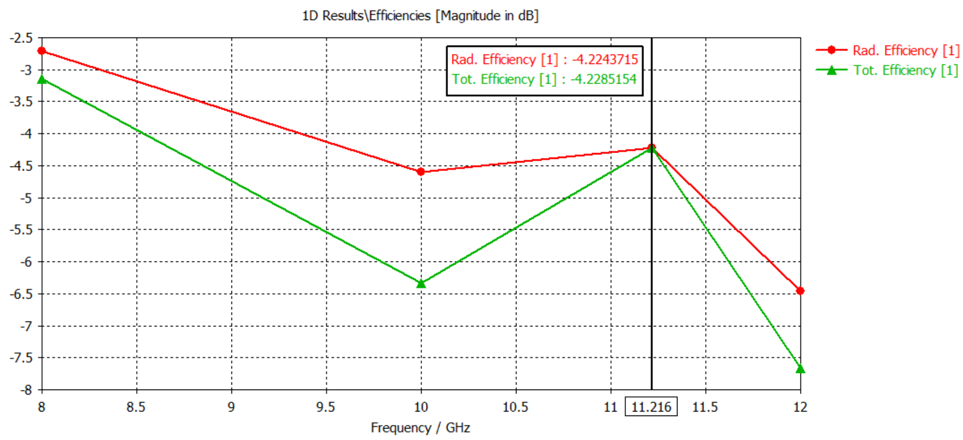

Fig. 6 Efficiency of 2×2 patch antenna array

In concept of antenna, Directivity is a figure of merit (FOM). Directivity also defined by gain and efficiency. Most of the emissions are intended to go in a particular direction (Vertical or Horizontal) [10]. Directivity is defined as the ratio of radiated energy in particular direction to radiated energy in entire direction. Results of S Directivity Hexagonal slot with DGS antenna are shown in fig. 7.

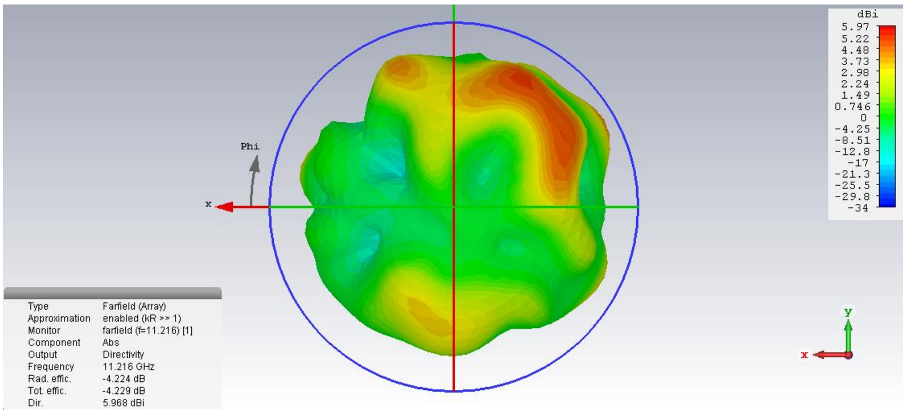

Fig. 7 Directivity of 2×2 patch antenna array

Conclusion :

Some of the expanding activities in the field of wireless communication is mobile cellular and satellite , wireless sensor, local area network, remote control and identification and global positioning system. .Wireless communication was study in this . Many application of wireless communication, Wi-max, WLAN, are studied. In this research paper show 2x2 patch antenna array design for x-band application like IoT, radar, satellite, Wi-max and WLAN etc. Return loss of array antenna is -30.2dB at centre frequency 11.2 GHz voltage standing wave ratio is 1.05 which very near to 1 that indicate the antenna is working great. Star shaped slots inserted in every patch and also star shaped discontinuity in inserted in antenna ground. This discontinuity is not only changing the electrical path in antenna but also alter the good response of Antenna.

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