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DESIGN AND ANALYSIS OF SLOT ARRAY ANTENNA FOR HIGH FREQUENCIES

Ritik Khatri[*1], Ritik Jain[*2]

[*1,2]Medicaps University, Indore, India.

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ABSTRACT

In this study, a Rectangular-shaped slot antenna is designed for the future wireless applications. The antenna has a compact size of 15.7988 x 7.8994 at 12.40 GHz to 18 GHz, which consists of rectangular shaped radiating slot array . A rectangle shaped slot is etched in the ground plane to enhance the antenna bandwidth. In order to obtain better impedance matching bandwidth of the antennas, some small rectangular radiating patches are added to the rectangular-shaped slot. Simulations show that the measured impedance bandwidth of the proposed antenna ranges from 12.40 to 18 GHz for a reflection coefficient of S11 less than −10 dB which is cover 5G bands (28/38 GHz). The proposed antenna provides almost omni-directional patterns, relatively flat gain, and high radiation efficiency through the frequency band. Basically it is an extension of the thesis made by Mr. Hare Ram, Jha in which he has designed a antenna which works well for the frequency range varying from 8 GHz to 12 GHz. **Methods/Statistical Analysis:** The Multiple Cavity Modeling Technique (MCMT) has been applied in both cases of structural antennas. The scattering parameters (i.e. |S11| and |S21|) data have been computed for both cases of 2-element shunt slotted array antenna. The MCMT |S11| and |S21| data graphs have been compared with Ansoft High Frequency Structure Simulator (HFSS) simulated data graphs. Comparison results signify that a slight difference between computed and simulated data. **Findings:** Subsequently, the HFSS simulated gains total of the both cases of design structures antenna are obtained. The outcome found in 2-element shunt slotted array with similar slot length gains higher total rather than dissimilar slot length 2-element shunt slotted array antenna. In order to achieve further increases in gain a 2-elements lotted array antenna up to optimal point was extended up to three slots. Analysis was done to compare the results with simulated HFSS results and are compared with the results obtained by the Hare Ram's Thesis. **Application /Improvement:** The antenna finds its application in high speed data communication system in the area of air crafts and wireless 5G communication.

I. INTRODUCTION

Antennas are basic components of any electric system and are connecting links between the transmitter and free space or free space and the receiver. In the world of communication basic need is an antenna. Antennas are employed in different systems in different forms. The antennas are used to radiate electromagnetic energy in an omnidirectional or finally in some systems for point-to-point communication purpose in which increased gain and reduced wave interference are required. Microstrip antennas have extensive applications in wireless communication system following to their advantages such as low profile conformability, low cost and ease of fabrication. However, conventional Microstrip antenna suffers from very narrow bandwidth with respect to the center frequency. To overcome this, slot antenna have been considered as a good source in conforming to these trends. In order to reduce antenna size, recent research has involved many miniaturization techniques for slot antennas. For compact slot antenna design, increasing the length of the slot or adjusting the shape of the slot is needed. By employing different shapes of the slots, the antenna size can be reduced for a given operating frequency.

Slotted waveguide antenna array is a good candidate for using in radar and communication systems due to its low power loss, low profile, low cross-polarization levels, high efficiency, high power capacity, and accurate control of amplitude and phase distributions. The radiating slots are commonly etched on the wide-wall or narrow-wall as shown in Fig. 1. The slotted waveguide antenna array can be designed by using analytical theories, numerical techniques and experimental methods. However, for the antenna array consist of narrow-wall inclined slots, the slot is difficult to represent by using equivalent magnetic currents . Over recent decades, the design methods of the slotted waveguide antenna have been developed. Furthermore, there are many

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electromagnetic simulation tools based on the numerical solution of Maxwell's equations allowing the user to analyze and design the inclined slot conveniently.

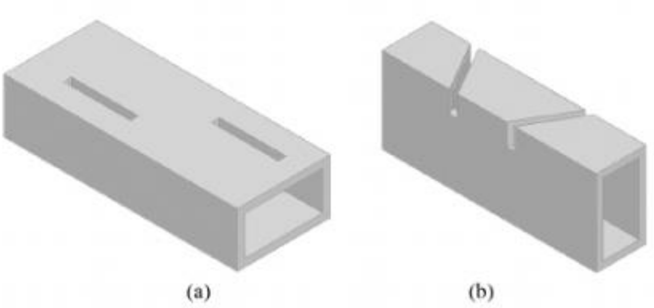


Fig. 1. Two types of radiating slots: (a) etched on the wide-wall; (b) etched on the narrow-wall.

Antenna Design-

Generally, rectangular waveguide comprises with two broad walls and two narrow walls. In fact, the waveguide is a hollow metal box that is made from perfect conduc-tor material as shown in Figure 2. In slotted waveguide antenna, longitudinal slots are cut on waveguide. These slots start discontinuities inside the conductor and stop the flow of current along the waveguide. In its place, the current must flow in the region of the edges of the slots, causing them to work as dipole antennas.

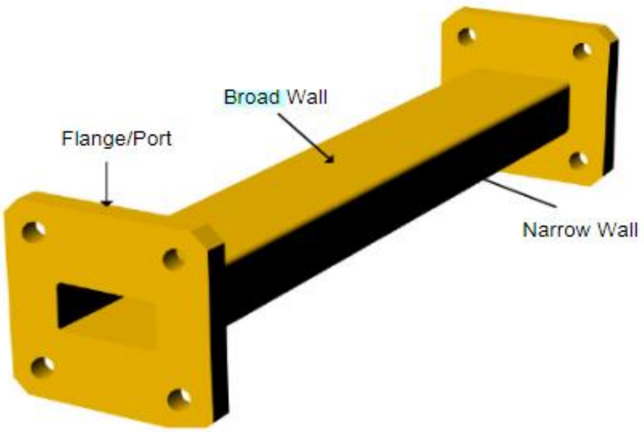
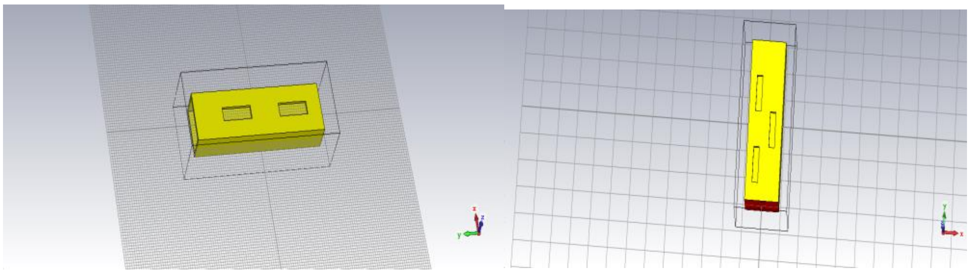


Fig 2:- waveguide

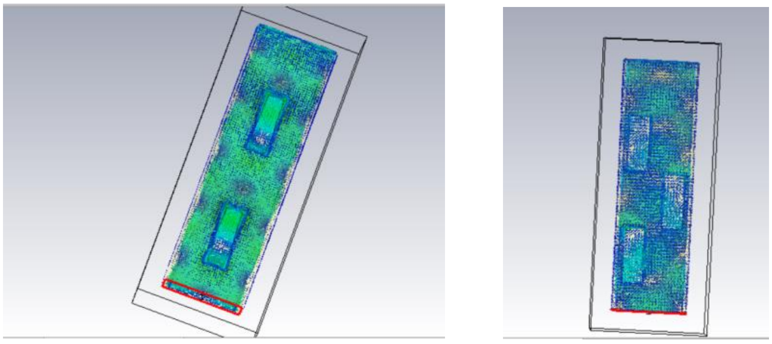
In this paper, we have designed an antenna which is based on Mr Hare Ram's thesis. According to his idea, the antenna was built to operate between 8 and 12 GHz. Initially two longitudinal slots with similar size lengths cut on one face of broad wall of a standard waveguide (WR-90) and also dissimilar size lengths cut on one face of broad wall of another WR-90 respectively for designing 2-element shunt slotted array antenna. Here, only two designs have been prepared as shown in Figure 3.



(a) (b)

Fig 3:- Antenna Design. (a) two similar size lengths of slots milled on a WR90 at a similar distance from centre and aligned in a line. (b) two similar size lengths of slots milled on aWR90 at a similar distance from centre but are in zig-zag direction from each other.

In this Case-(a) and Case-(b), we keep the distance between slots as $\lambda g/2$ such that the slots will be fed in the same phase (spacing between the slots at $\lambda g/2$ intervals in the waveguide is an equivalent electrical spacing of 1800. Therefore, each slot is exactly out of phase with its neighbours, so their radiation cancelled each other. On the other side, slots on opposite sides of the centre axis of the guide are out of phase (1800), so we can swap the slot displacement around the centre axis and have a total phase difference of 360° between slots, putting them back in phase) and the beam will not be inclined. From the position of the initial/last slot, the center of the slot is kept at guiding quarter wavelength away from the initial/closed end of the waveguide. The guided wavelength λg is calculated 26.72mm at 15 GHz cut off or central frequency. The Case-(a) and Case-(b) structures are made in CST Software separately. The perfect conductor material is used for designing the shunt slot array antenna. Simulated the structures and computed the electric field for Case-(a) and Case-(b) as shown in Figure 4. Subsequently, scattering parameters of Case-1 and Case-2 are obtained respectively, when both ports of the waveguide are excited by wave port.



(a) (b)

Fig 4:- Electric field distribution on Case-(a), Case-(b)

Table 1. Design constraint of similar and dissimilar 2-element shunt slotted array antenna:-

Case-#			Case-a	Case-b
Slot-#	Width (mm)	Offset (mm)	Length (mm)	Length (mm)
Slot-1	5	6.3994	13.36	13.36
Slot-2	3	7.3994	13.36	13.36

II. PROBLEM STATEMENT

The antenna built was working in the X-band frequencies, which was the problem mentioned in the hare ram's theory. To solve this issue, we updated the antenna and it is now capable of working well in both X-band and k-band frequencies. The following table shows the modifications.

Table 1. Design constraint of similar and dissimilar 2-element shunt slotted array antenna

Case-#			Case-1	Case-2
Slot- #	Width (mm)	*Offset (mm)*	*Length (mm)*	*Length (mm)*
Slot-1	2	+3.5	16	19.5
Slot-2	2	-3.5	16	13.5

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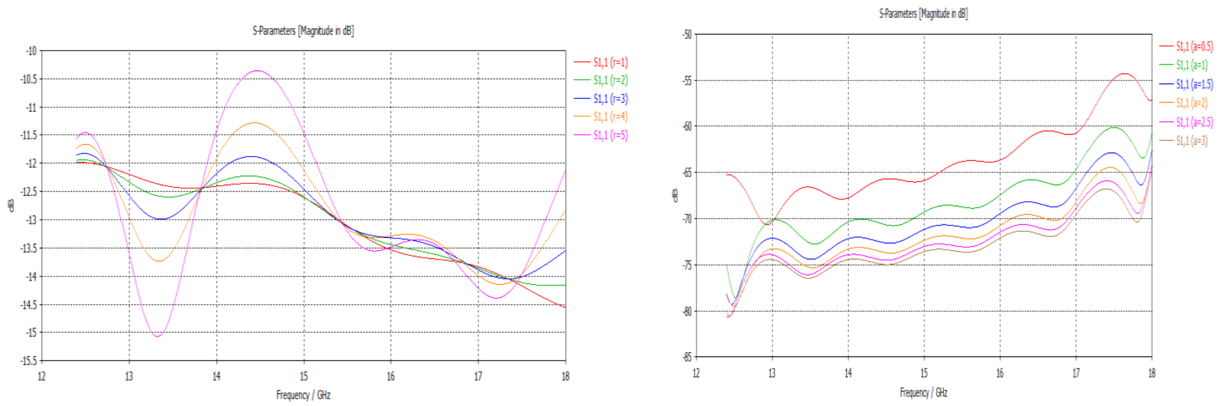
The tables above demonstrate the changes made to the design's parameters.

III. RESULTS

Accordance with formulation S11 and S21 codes have been written in Mat Lab of Case-1 and Case-2 respectively. On comparing the results after designing the antenna on CST software keeping theta and phi at 0 degree we get. When the gain is compared to the outcomes produced by the "Hare Ram," the gain that he attained was carrying on high gain (more than 5dB) across the entire X-band and gain total is acquired up to and around 8.14dB at 10.8 GHz. Furthermore, we were able to achieve a gain in the k-band that ranged from approximately 6.59 dB at 12.4 GHz to 8.14 dB at 18 GHz. When we compare the outcomes of our two alternative designs—a linear and an alternate antenna—we see the findings that are shown below in fig 5.



(a) (b)

Fig 5:- comparison of S11 parameters.

The S11 parameter findings for both linear and alternative slots are shown in the comparison above, which illustrates how much power is reflected off the antenna. Voltage Standing Wave Ratio (VSWR) is a measurement of the effectiveness with which radio-frequency power is transferred from a power source, through a transmission line, into a load (for instance, from a power amplifier, through a transmission line, to an antenna). Consequently, the VSWR results for each antenna are as shown in fig6.

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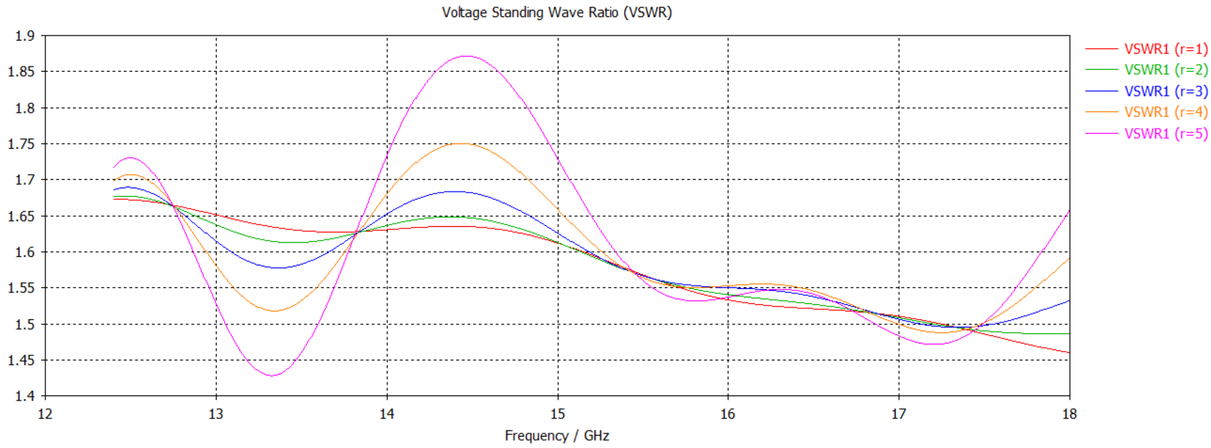
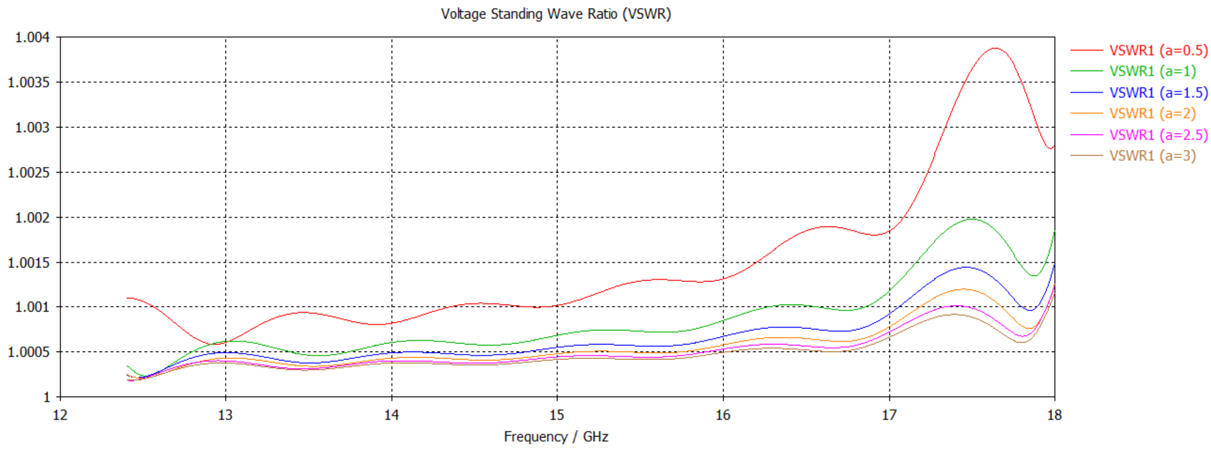


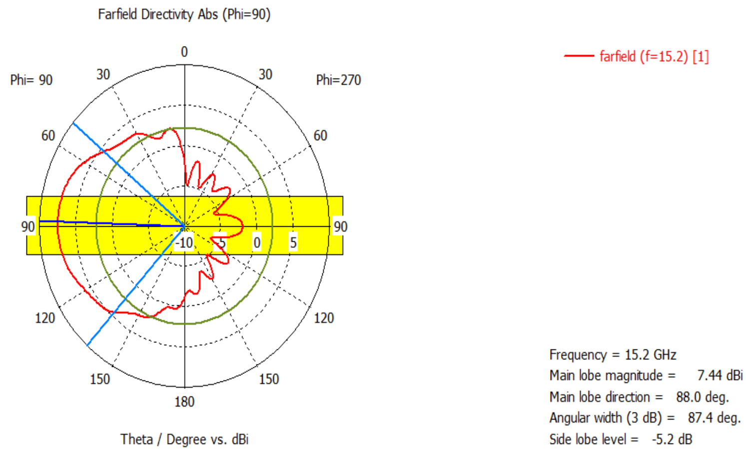
(a)



(b)

Fig 6:- VSWR results.

The ratio of an antenna's radiation strength in one direction to its radiation intensity on average in all directions is known as its directivity. Both antennas have extremely directional directivity, or as we can see from the fig 7, both are omnidirectional in nature.



(a)

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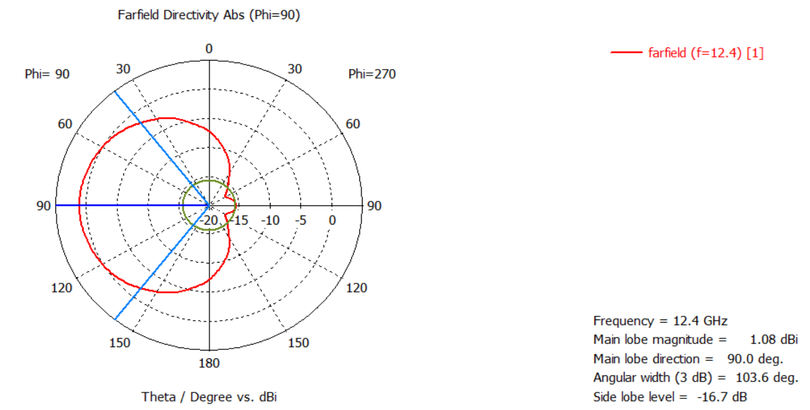
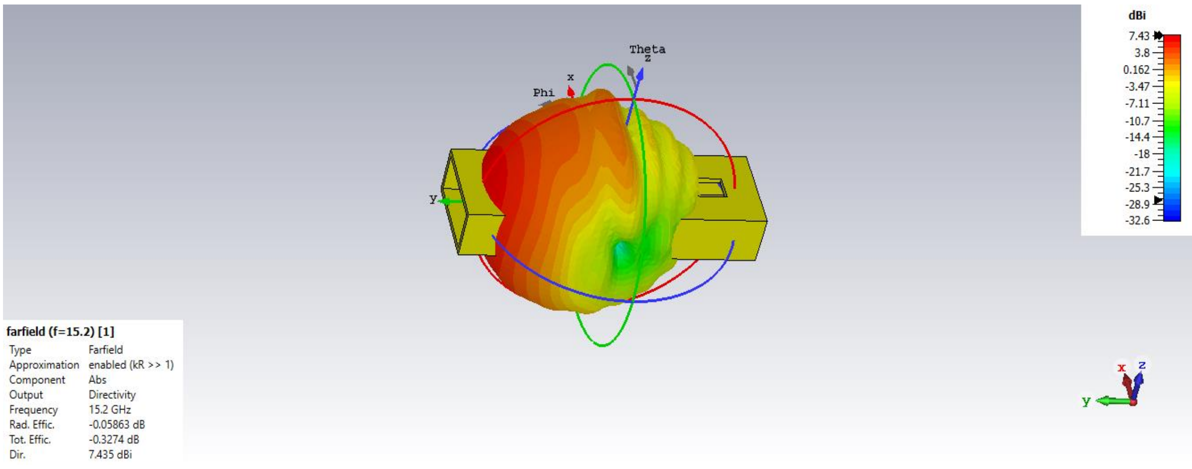
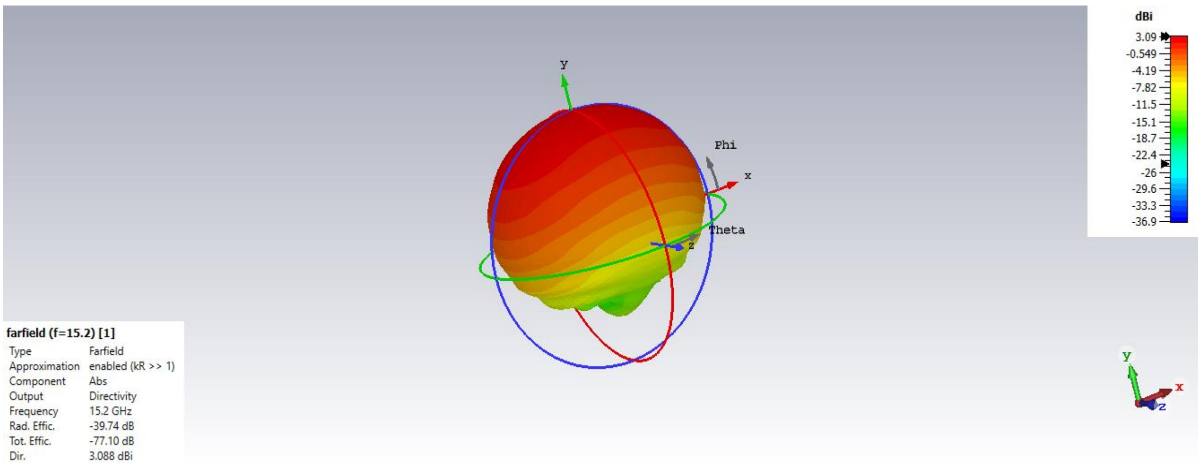


(b)



(c)



(d)

Fig 7:- (a)(b) shows the 2-D plot of farfield and (c)(d) shows the 3-D representation of the farfield achieved .

IV. CONCLUSION

In this study, a structure with two shunt symmetrical slots (similar slot length dimension) and two shunt unsymmetrical slots (dissimilar slot length dimension) machined on one broad wall face independently served as the basis for the development of a slotted waveguide antenna with high gain. The results from this antenna were then contrasted with those from an X-band antenna constructed by Hare Ram. The results from the two new antennas in terms of scattering parameters are different from one another. Although both the antennas offers a good k-band performance with the right gain and directivity.

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V. FUTURE SCOPE

By modifying the antenna's size and the slots, new band possibilities, such as ka-band and ku-band, can be investigated in the future.

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