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BODY OF REVOLUTION CONICAL VIVALDI ANTENNA FOR PHASED ARRAY APPLICATIONS

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ABSTRACT

A Conical Body of Revolution (BOR) 5x5 element planar antenna array for electronic warfare phased array applications in the frequency range of 5-19 GHz is designed, analysed and Simulated. The proposed antenna array can scan up to±45º from broadside. The return loss, gain and radiation patterns in E-H planes are measured through simulation (Ansys HFSS-15.0 software). It is checked that the antenna provides moderate gain of 6 dB at 18 GHz frequency and radiation patterns are unidirectional and satisfactory. The primary advantage of the proposed antenna is its miniaturized size and simple structure.

KEYWORDS: Broadband Antennas, Phased Array Antennas and BOR Antenna

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Original Article

INTRODUCTION

UWB (Ultra Wide Band) antennas are designed for the purpose of operating over wide range of frequencies. The most commonly used antennas in the wideband technology are Vivaldi antennas. This type of antennas are belongs to the surface wave travelling wave antennas and also known as Tapered slot antenna and Vivaldi Notch antenna. The surface wave antennas are classified in to two categories: propagating section and radiating section. In propagating section, the separation between the conductors is smaller than the one-half free space wavelength and then the waves are travelling down the flared curve path along the antenna. Where the separation between the conductors is greater than the one-half wavelength then the energy gets radiated away from the antenna in the radiating section.

Vivaldi antennas have more advantages in terms of efficiency, high gain and wide bandwidth. So that these antennas are used in the rapidly developing wireless communications, satellite, remote sensing and radars due to low weight, easy to fabricate and compact size. In order to overcome the Grating lobes the spacing between the adjacent elements in an array restricted to less than 9.5mm over the frequency 5-19 GHz to scan the array beam ±45º. Frequency Independent antennas such as Ridged Horns, Log Periodic, Equiangular spiral, Archimedean spiral, loaded Printed antennas and Tapered slot antennas (TSA) covers multi-octave bandwidths. This type of antennas gives the symmetrical patterns in both co-polarization and cross-polarization and these are used for Electronic warfare applications [1-6]. Many phased array antennas are designed and realized hardware in ultra wide band of 1-18 GHz [7-10]. A Phased array with 3:1 bandwidth has described in the literature over the frequency range of 6-18 GHz with ±45º[11]. A Novel, small aperture tapered slot antenna covering a frequency 7.2-18.0 GHz with a return of less than -7.5dB in the simulation and observed the results over 7.7-18.0 GHz frequency range in hardware having aperture size of 9.5mm [12]. TSA are widely used in EW applications [13]. The printed antennas have some serious drawbacks related to the fabrication and maintenance when it used in a dual polarized arrays. Maintenance of the good electrical contact between the polarized array elements is difficult. Soldering is difficult in such arrays operating at high frequencies at which the spacing between the elements is small. There is a considerable risk if one manages to attach the adjacent element also. It is difficult to connect the elements to the feed network and there may electromagnetic resonances in the dielectric part of the element. In order to overcome these drawbacks all metal Vivaldi antenna have been introduced [14-18]. The parametric study of this antenna has not been reported so far. As above mentioned the antenna [15] has taking the reference to design the required 5x5 planar array antenna using HFSS Tool.

ANTENNA GEOMETRY

The simulation diagram of the 5x5 dual polarized BOR phased array antenna is as shown in the Fig.1.

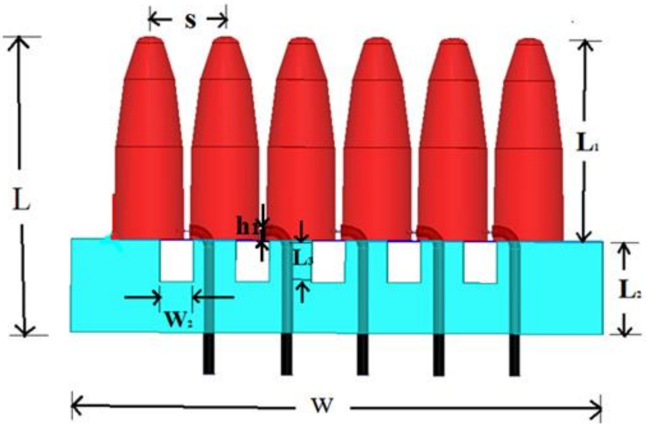

Figure 1: Dual Polarized 5x5 BOR Antenna. a). Front View

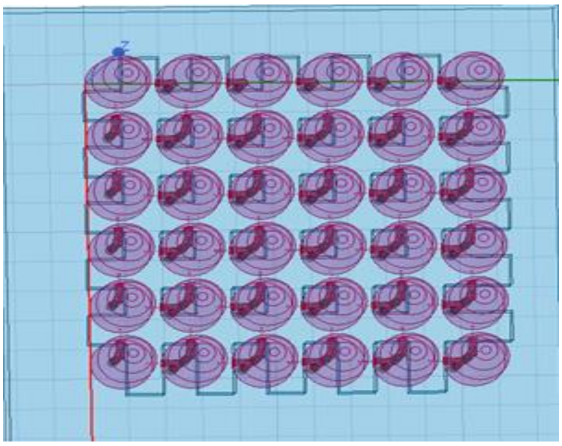

Figure 1: b).Top View.

The antenna is made up of entirely aluminium material. Because, all metal Vivaldi is completely made up by conducting material. Each single antenna element gets excited by two co-axial line feed orthogonal to each other. Therefore, no dielectric losses are present in this case. The inner conductor of the co-axial feed is at a height h1 from the rectangular slab having dimensions (L2, W, h2), to which conical BOR elements are attached though a screw. Spacing between the elements are denoted by‘s’ and the height of the element is L1.

PARAMETRIC STUDIES

Parametric studies have been performed on different parameters with the help of HFSS Tool and return loss of -7.5dB over 4-20 GHz is achieved. The following parameters raise an important role in the design of BOR antenna with a single central slot excited in the planar array.

Element Length ‘L1’

The frequency Vs Return loss plot with ‘L1’ is shown in Fig.2. Element length ‘L1’ is varied from 24mm to 50mm.

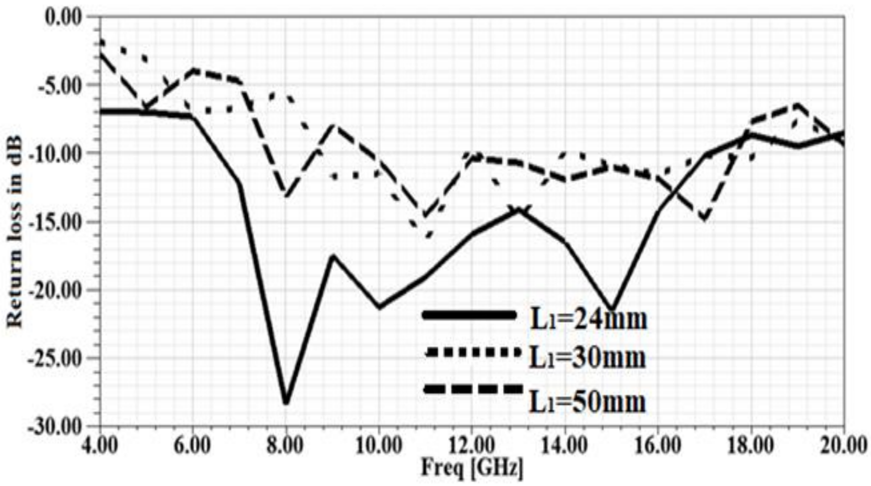

Figure 2: Frequency Vs. Return Loss with ‘L1’.

From the Fig.2, L1 = 24 mm have a return loss of -7.5dB over the frequency 6 -18 GHz. Hence, the value of ‘L1’ is considered as optimised value.

Cavity Width ‘W2’

The cavity width is varied from 2mm to 6mm and corresponding return loss plot is shown in Fig.3.

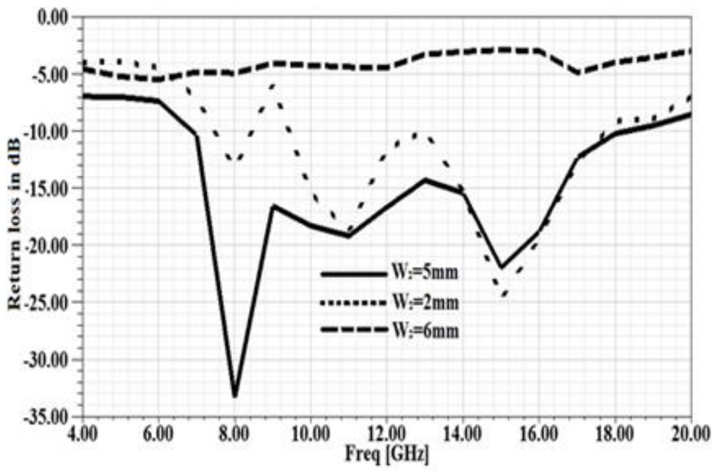

Figure 3: Frequency Vs. Return loss with ‘W2’.

Bandwidth is most affected with ‘W2’ parameter, which is as shown in Fig.3. Return loss of -7.5dB is achieved over 6-18 GHz for W2=5mm

Cavity Height 'L3'

The cavity height is varied from the 1mm to 7mm and corresponding return loss is shown in Fig.4.

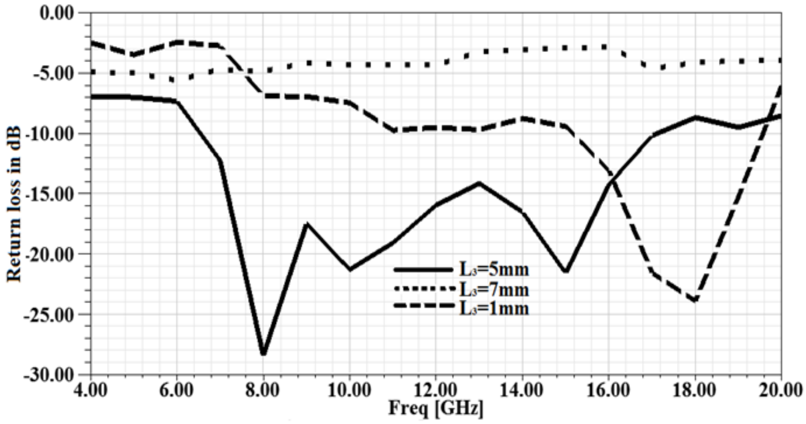

Figure 4: Frequency Vs. Return Loss with 'L3'.

It indicates the plot between Frequency Vs. Return loss with 'L3'.From the plot it is observed that cavity height have a significant effect on return loss.For L3=5mm, a return loss of -7.5dB isachieved over the frequency 6-18 GHz.

Feed Position above the Slab 'h1'

The feed positions above the rectangular slab are varied from 1mm to 5mm and the corresponding return loss is shown in Fig.5.

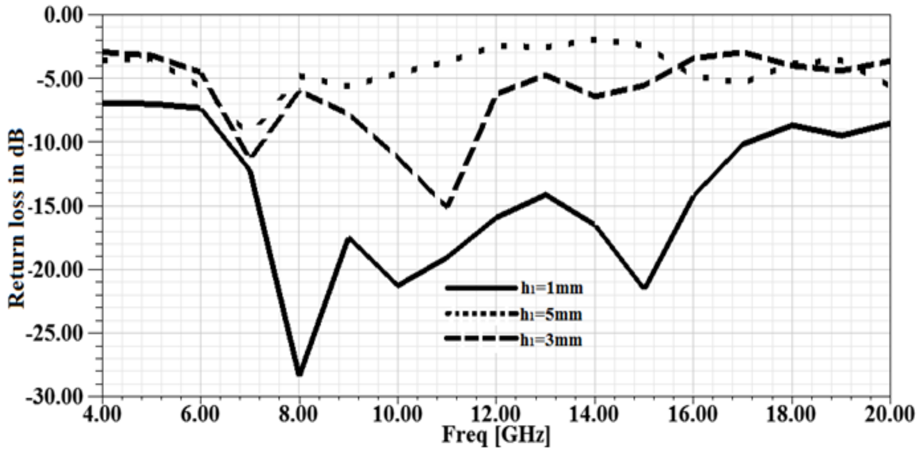

Figure 5: Frequency Vs. Return Loss with 'h1'.

From the Fig.5, it is clear that the parameter 'h1' have a most significant effect on the return loss. For h1=1mm, return loss of -7.5dB achieved over the frequency of 6-18 GHz.The return loss plot of BOR antenna with a single element excited in the planar array is as shown in Fig.6.

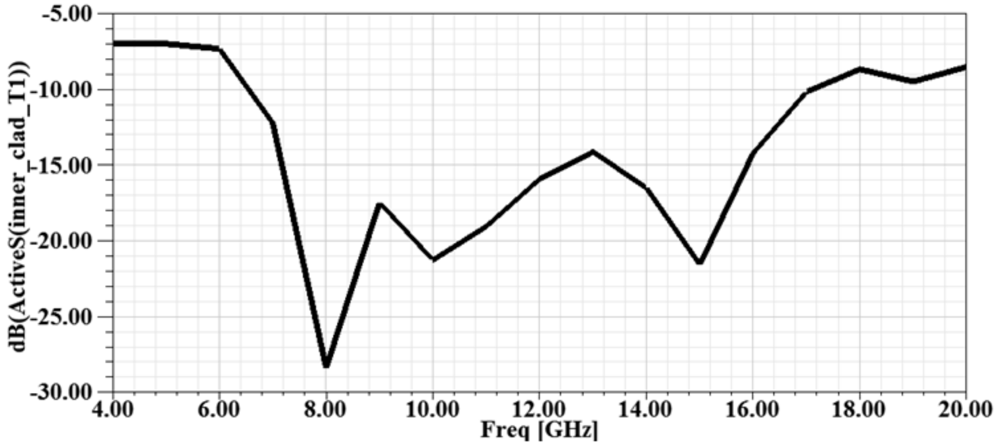

Figure 6: Frequency Vs. Return Loss.

RADIATION PATTERNS

The scanned simulated radiation patterns are taken at selected frequencies i.e. at 4GHz, 8GHz, 12GHz, 16GHz and 20GHz are shown in Fig.7. to Fig.11.

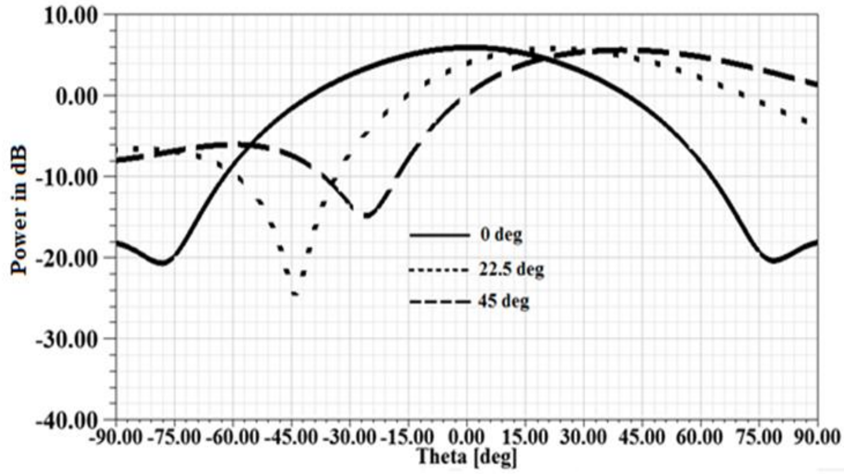

Figure 7: Scan Patterns at 4GHz (0°, 22.5°, 45°).

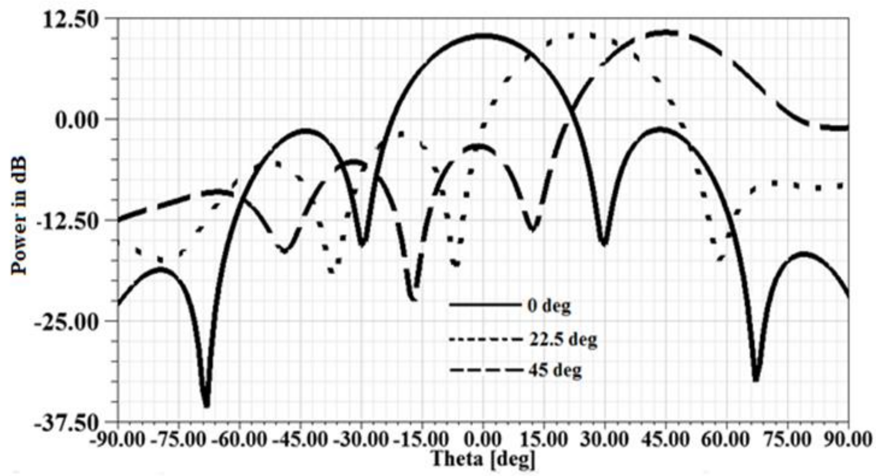

Figure 8: Scan Patterns at 8GHz (0°, 22.5°, 45°).

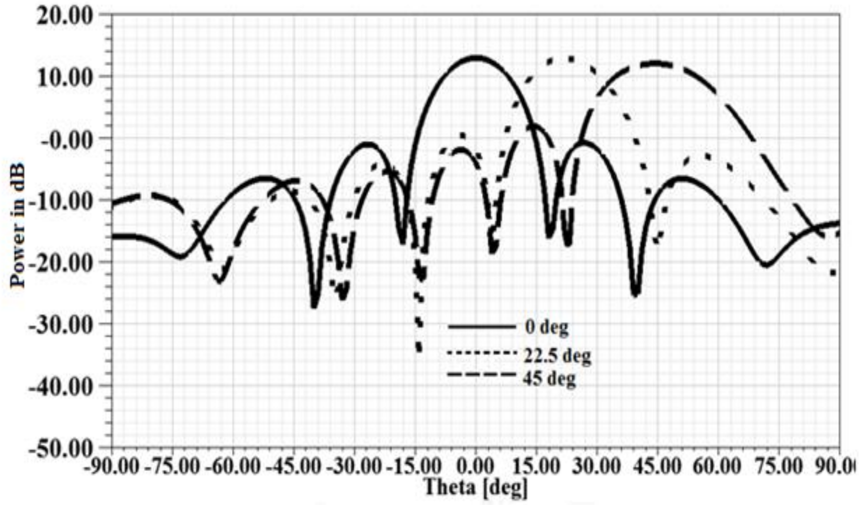

Figure 9: Scan Patterns at 12GHz (0°, 22.5°, 45°).

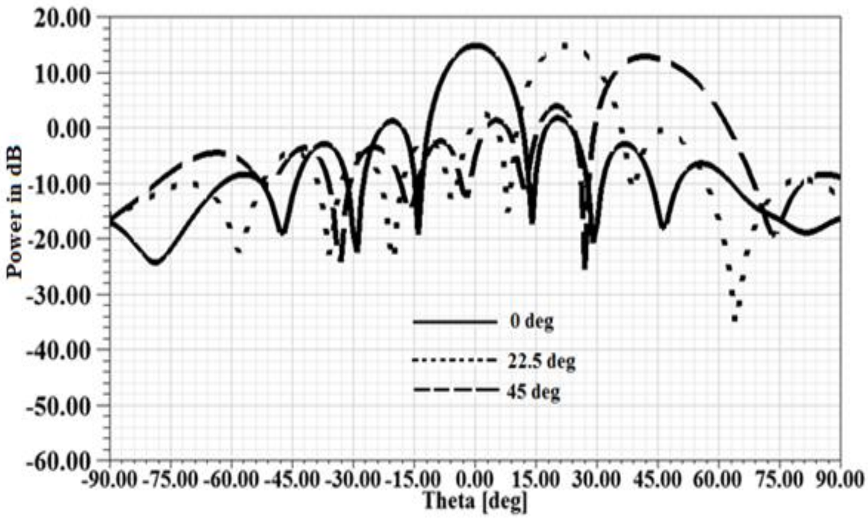

Figure 10: Scan Patterns at 16GHz (0°, 22.5°, 45°).

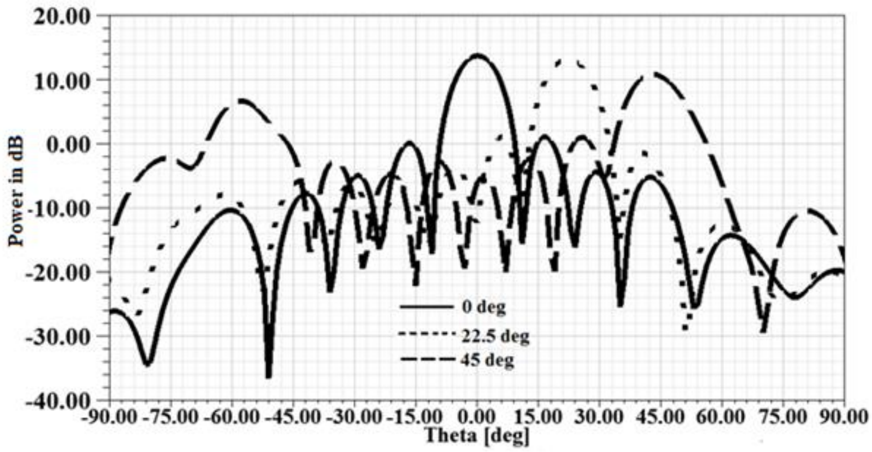

Figure 11: Scan Patterns at 20GHz (0°, 22.5°, 45°).

The simulated frequency Vs. Gain plot is shown in Fig.12. The gain of the antenna is increasing exponentially with respect to frequency.

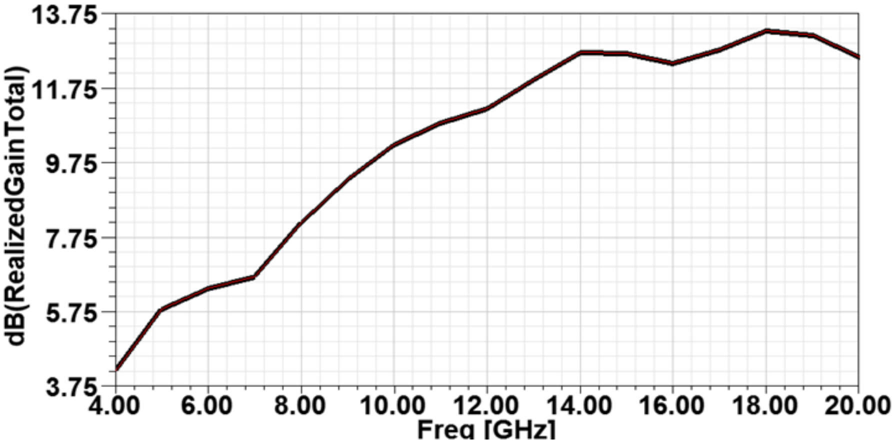

Figure 12: Frequency Vs. Gain Plot.

CONCLUSIONS

A 5x5 BOR antenna is proposed and parametric studies are carried out to make the antenna and simulated results are computed using HFSS software. The optimized dimensions of the antenna are determined through careful parametric study. The simulated return loss below -7.5dB is obtained over the entire operating frequency band of 5-19GHz. It is shown that the simulated radiation patterns in both E-Plane and H-Plane are uni-directional. The simulated gain valueof 5 dBat 5 GHz and is 12 dB at frequency 19 GHz. It is established that the measured results agree well with simulated results. The proposed antenna has ultra-wide bandwidth, wide beam width and satisfactory gain. Hence, it can be used as a phased array antenna element for electronic warfare applications and radar applications.

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