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Modeling and Simulation of Dual Cavity based Tapered Slot Antenna

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ABSTRACT: In this work, a microstrip feedline based tapered slot antenna with a pair of cavities is simulated and studied. The proposed antenna is designed to evaluate the effect of cavities on both sides of the feedline. The proposed antenna is suitable for wireless and satellite communication applications simultaneously. The results obtained had showed satisfactory results in terms of return loss and radiation pattern as compared to the other existing antennas**.**

KEYWORDS: Finite Element Method, Microstrip feedline, Radiation Pattern, Return Loss, Tapered Slot Antenna

I.INTRODUCTION

Tapered slotted antennas have received considerable attention due to their high gain, relatively wide band, simple structure, facile fabrication, and wide use in UWB applications. Their minuscule lateral dimensions and simple integration make them excellent candidates to be applicable for wireless communication purposes [1]. The Vivaldi antenna is a affiliated with aperiodic perpetually scaled peregrinating-wave antenna structures [2]. This antenna is withal habituated with the terms “tapered-notch”, “flared-slot”, and “tapered slot” antennas that have been utilized by the researchers. These antennas consist of a tapered slot etched onto a thin film of metal. This is done either with or without a dielectric substrate on one side of the film. Some advantages of this antenna are being efficient and lightweight, and can work over a sizably voluminous frequency bandwidth [3]. The principle of operation of tapered slot antenna is predicated on the waves peregrinate down the curved path of the flare along the antenna. In the region where the disseverment between the conductors is diminutive when compared to the free-space wavelength, the waves are tightly bound and as the disunion increases, the bond becomes progressively more impuissant and the waves get radiated away from the antenna [4]. This transpires when the edge disunion becomes more preponderant than a moiety-radiation from high-dielectric substrates is very low and hence for antenna applications significantly low dielectric constant materials are culled [5].

In this paper, a change in cavity of the basic tapered slot antenna has been studied. The objective of this paper is to compute the far-field pattern and the insertion losses while changing the input cavity of the tapered slot antenna. The designs are modeled using finite element method (FEM) based Comsol Multiphysics software.[6] The details of proposed antenna designs have been presented in the next section. The methodology and results are discussed in the subsequent sections.

II.ANTENNA GEOMETRY

The peregrinating wave mode Vivaldi antenna provides a smooth transition between the guided wave peregrinating in the slot transmission line (slotline) and the plane wave, which is radiated [7]. This transition is achieved by a gradual tapering of the slotline. Since the slot-line is a balanced transmission line, a wide-band cavity is a paramount component in the antenna design. A Vivaldi antenna with a feedline is provided in Fig. 1.

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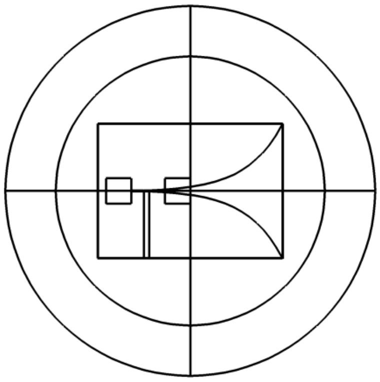

Fig. 1 Schematic layout of the tapered slot antenna design selected.

The microstrip line is printed on a substrate and the tapered slotline is etched on the ground plane below the microstrip. A few parameters are considered to be of great importance for satisfactory wideband performance[8]. The length and the width of the tapered slot line: to achieve the traveling wave mode of radiation, the slot length and width generally needs to be greater than λ_0 and $\frac{\lambda_0}{2}$, respectively. The opening rate of the tapered slot line: the Vivaldi antenna employs an exponential taper [9]. The coordinates of the tapered slot are defined by:

$$x = c_1 e^{Rz} + c_2$$

where, $c_1 = \frac{(x_2 - x_1)}{(e^{Rz_2} - e^{Rz_1})}$ (i)

and, $c_2 = \frac{(x_1 e^{Rz_2} - x_2 e^{Rz_1})}{(e^{Rz_2} - e^{Rz_1})}$

Given the highest frequency of operation, the width W of the tapered slot antenna should satisfy equation (ii) to circumvent the grating lobes of Vivaldi array.

$$W < \frac{c}{f_H \sqrt{\varepsilon_e}} \quad \text{(ii)}$$

where ε_e is the effective relative dielectric constant. In addition, the TSA has been designed to match at 100 Ω instead of 50 Ω. Therefore, the width of the microstrip line feeder should be defined to give the characteristic impedance of 100 Ω. Shin et al. [10] demonstrated that the wideband performance of the Vivaldi notch antenna arrays fed by microstrip line could be improved systematically. After defining the parameters cited above, all other parameters are optimized with Comsol Multiphysics software to get both the compact size and good performance at the operating band.[11] Yang et al. [12], employed two different types of Vivaldi antenna arrays for UWB see through wall applications. Here they fabricated two designs for Vivaldi antenna arrays suitable for see through wall applications were presented. Tapered slot antenna arrays for see through dry wall and concrete wall UWB applications, and miniaturization of antenna. In the traditional micro strip-to-slot line feed transition of a slot antenna was replaced with a micro strip-to-parallel strip line.[13]

III. DESIGN PROCESS

The constructional layout of the proposed Vivaldi antenna that has been designed using Comsol Multiphysics software is shown in Fig. 2. After theoretical analysis, the dimension of the designed antenna is optimized and is set to radiate in the frequency range between 2 to 6.5 GHz. The designed structure is then enclosed in the spherical domain with diameter 90 mm. as shown in Fig. 2. The layer thickness of the sphere is selected as 15 mm. The material selected inside the sphere is air that acts as perfectly matched layer (PML) to avoid standing waves. Thus the antenna is designed and investigated to operate in the desired atmosphere containing air.

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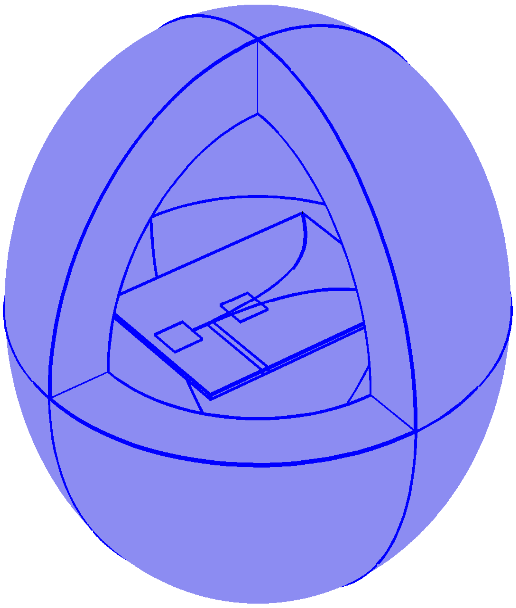

Fig. 2 Schematic the tapered slot antenna design enclosed in spherical domain.

The dimensions selected for the proposed designs are shown in Table I. This antenna consists of single material. The material selected is Epoxy Resin with value $\varepsilon_r = 3.38$. This material is chosen due to its low dielectric value. A properly tapered microstrip line was designed for 50Ω nominal input impedance. The output parameters were investigated for this design within the frequency domain in-between 2 and 6.5 GHz.

TABLE I. Dimensions for rectangular microstrip patch.

Parameters (mm)	*Substrate*	*Stripline*	*Square Cavities*	*Slot*	*Taper*
Length	110	3.2	15	20	70
Width	80	40.25	15	0.5	42
Thickness	1.5	1.5	1.5	1.5	1.5

IV. RESULT AND DISCUSSION

The design is simulated on the computational machine with 3.1 GHz processing speed. The virtual memory used while simulation was 2.1 GB. Normal meshing is selected to reduce the computational load. The electric field generated while computing the results is shown in Fig. 3.

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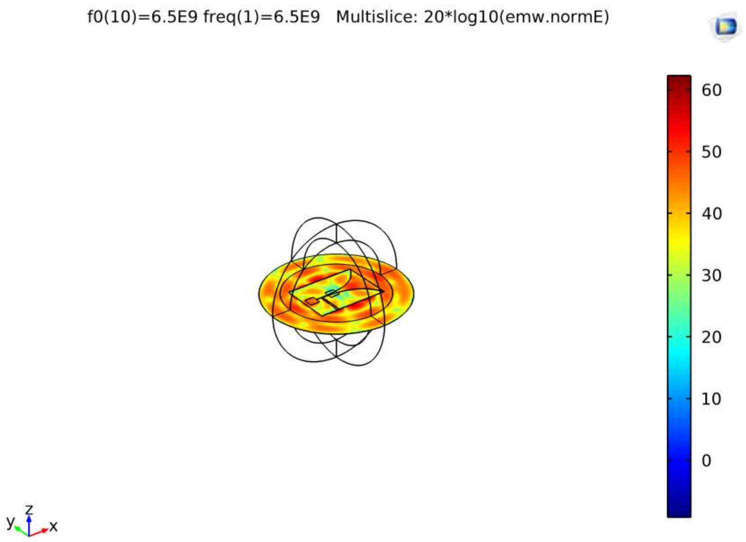

Fig. 3 Electric field for dual rectangular input cavity.

The maximum electric field observed for the designed tapered slotted antenna is 65 V/m while for antenna with circular input cavity, maximum value of 61 V/m. Fig. 4 shows the far field domain for the designed tapered slotted antenna.

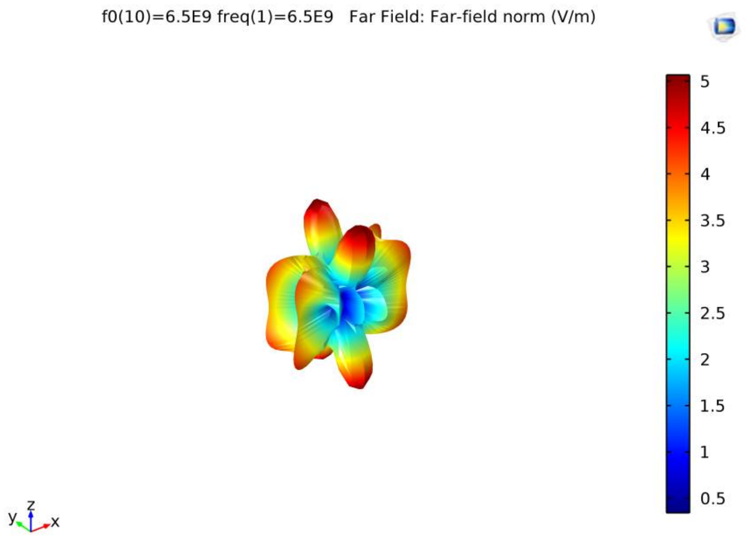

Fig. 4 Far field domain for dual rectangular input cavity at frequency 3.5 GHz.

This is clear that the maximum far field domain for the antenna with dual input cavities is 3 V/m at frequency 3.5 GHz. Figures 5 shows the plot of polar graph showing electric and magnetic field radiated in the surroundings.

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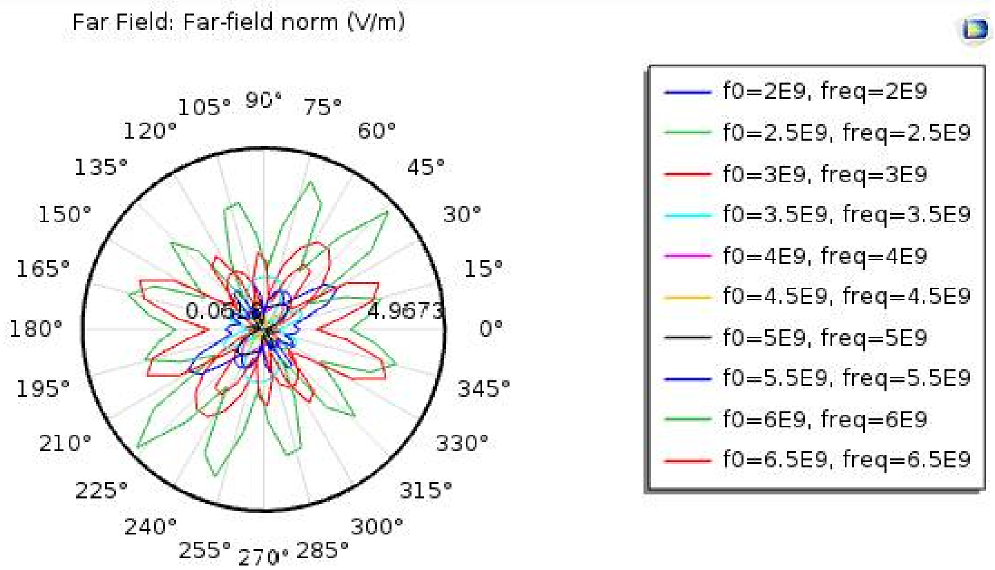

Fig. 5 Polar graph plot for dual rectangular input cavity based tapered slot antenna.

These polar plots show the signal radiated in all possible directions. Fig. 6 shows the variation in return losses to the domain of frequencies applied to the designed and simulated tapered slotted antenna respectively.

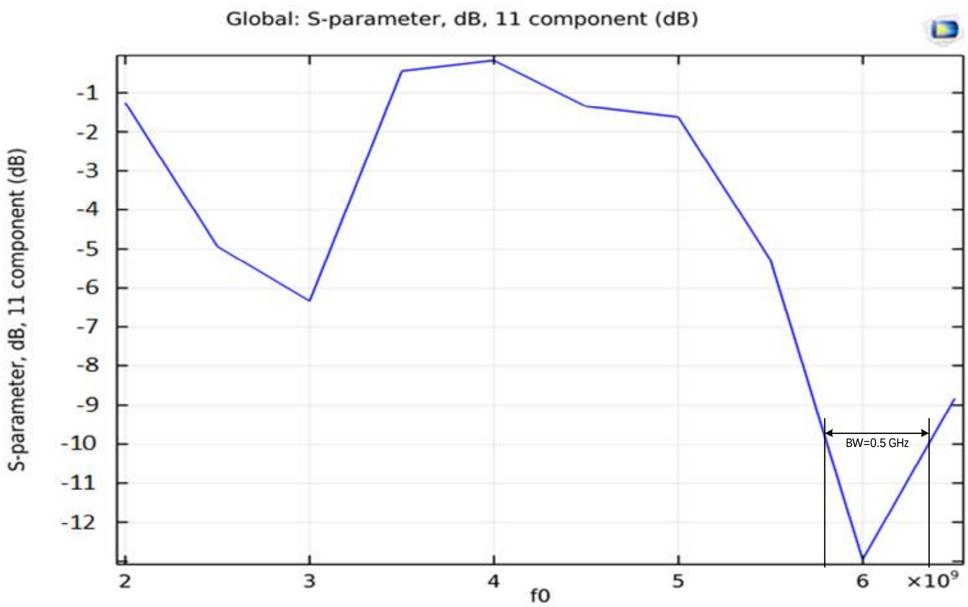

Fig. 6 Return loss versus frequency for rectangular input cavity based tapered slot antenna**.**

From the results, it is observed that the designed antenna can operate well for a limited frequency band in-between 5.75 GHz to 6.35 GHz, having bandwidth 0.5 GHz. This antenna posses comparative insertion loss with omni-directional radiation pattern. Hence, the amount of radiation power is significant. The gain and the radiation pattern parameters also support the proposed design for wireless communication systems.

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V. CONCLUSION

This paper proposes a dual cavity based tapered slot antenna with input cavities on both sides of the feed line. The design is simulated and the results were obtained for far-field radiations, polar plots and the insertions losses (s-parameters). The output parameters show promising features for wireless communication purposes within the frequency domain 5.75 GHz to 6.35 GHz.

REFERENCES

[1] P.J. Gibson, The Vivaldi aerial, *in Proc. 9th Eur. Microw. Conf.*, 1979, 101–105, 1979.

[2] E.W. Reid, L. Ortiz-Balbuena, A. Ghadiri, et al., A 324-element Vivaldi antenna array for radio astronomy instrumentation, *IEEE Transactions on Antennas and Propagation*, *61(1)*, 2012, 241–249.

[3] N.Vignesh, G.A. Sathish Kumar, and R.Brindha, Design and Development of a Tapered Slot Vivaldi Antenna for Ultra-Wide Band Application, *International Journal of Advanced Research in Computer Science and Software Engineering*, *4(5)*, 2014, 174-178.

[4] R. Janaswamy and D.H. Schaubert, Analysis of a Tapered Slot Antenna, *IEEE Transactions on Antennas and Propagation*, *35(9)*, 1987, 1058-1065.

[5] N. Jastram, and D. S. Filipovic, Wideband millimeter-wave surface micromachined tapered slot antenna, *IEEE Antennas Wireless Propag. Lett.*, *13*, 2014, 285–288.

[6] Faranak Mahmoudian and Gary F. Margrave, A review of the finite-element method in seismic wave modelling,15,2003.

[7] Richard C Johnson, *Antenna Engineering Handbook* (3rd Edition, Tata McGraw-Hill, 1993).

[8] Yao Yuan , Chen Wenhua ,Huang Bin Feng Zhenghe , Zhang Zhijun , Analysis and Design of Tapered Slot Antenna for Ultra-Wideband Applications, 14, 2009,1-6

[9] R. Janaswamy, D.H. Schaubert, *Characteristic Impedance of a Wide Slot Line on Low Permittivity Substrates*, Thesis, Department of Electrical and Computer Engineering University of Massachusetts Amherst, MA 01003.

[10] Schaubert and Shin, A parameter study of stripline-fed Vivaldi notch-antenna arrays, *IEEE Trans. on Antennas and Propagation*, V *47(5)*, 1999, 879-886.

[11] Feng-Chao Ren, Fu-Shun Zhang, Bo Chen, Qing-Chen Zhou, Compact Tapered Slot Antenna for Wideband Applications, National Laboratory of Antennas and Microwave Technology Xidian University Xi'an, Shaanxi 710071, China.

[12] Yao Yuan , Chen Wenhua ,Huang Bin Feng Zhenghe , Zhang Zhijun , Analysis and Design of Tapered Slot Antenna for Ultra-Wideband Applications, 14, 2009,1-6

[13] Y. Yang, Y. Wang, and A. E. Fathy, Design of Compact Vivaldi Antenna Arrays for UWB See Through Wall Applications, *Progress In Electromagnetics Research*, 2008, 401-418.