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Performance Evaluation of a Conformal Tapered Slot Antenna on Cylindrical Surfaces

Aparna C B[1], Vennila R[2], Vigneshram R[3]

1 Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Kuniyamuthur, Coimbatore, India
2 Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Kuniyamuthur, Coimbatore, India
3 Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Kuniyamuthur,Coimbatore,India

Abstract- **High gain, wide bandwidth, linear phase center and end fire pattern are the various notable parameters for Ultra-wideband (UWB) communications. Tapered Slot Antenna is an apt dart to the UWB applications as the antenna shows a wide bandwidth and good directional radiation pattern. In this paper, a tapered slot antenna (TSA) is conformed on cylindrical surfaces with various diameters and the characteristics are evaluated. Antennas on cylindrical structures play considerable roles in modern communication systems such as spatial domain multiple access (SDMA), smart antennas, beam-steering array antennas and aerospace applications. The simulated results for the TSA on cylindrical surface show a good impedance matching with low return loss but poor gain at high frequencies.**

Keywords— TSA,UWB, gain, return loss

I.INTRODUCTION

The tapered slot antennas (TSA) are the best candidates for use in Ultra-wideband (UWB) technology. These antennas offer a wide bandwidth, significant gain and symmetric patterns in both co-polarization and cross-polarization. This type of antenna has been employed in satellite communications, ground penetrating radar (GPR) and etc [1]. The most commonly used class of TSA in UWB technology is Vivaldi antenna.By changing the shape, length, dielectric thickness and dielectric constant, a symmetrical beam in the E-and H-plane or controlling the beam width along the axis of symmetry [2]. The tapered slot antenna, such as Vivaldi, has been widely used due to its ultra-wideband, high gain, simple feed structure, and easy fabrication [3-4-5]. A tapered slot antenna uses a slot line etched on a dielectric material, which is widening through its length to produce an end fire radiation. An Electro-Magnetic (EM) wave propagates through the surface of antenna substrate with a velocity less than the speed of light, which aids TSAs to gain slow wave antenna properties. TSA finds lot of applications in present day satellite, wireless and mobile communications. The dual exponentially tapered slot antenna (DETSA) is a modified form of the Vivaldi radiator.

Tapered slot antennas (TSA) are travelling wave antennas. In general, all antennas whose voltage or current distribution can be modeled by one or more travelling waves are called travelling wave (non-resonant) antennas. TSAs have moderately high directivity (on the order of 10-17 dB) and narrow beamwidth because of the traveling wave properties and almost symmetric E-plane and H-plane radiation patterns over a wide frequency band as long as antenna parameters like shape, total length, dielectric thickness and dielectric constant are chosen properly. Other important advantages of TSAs are that they exhibit broadband operation, low sidelobes, planar footprints and ease of fabrication. A TSA can have large bandwidth if it exhibits a good match both at the input side (transition from the feed line to slot line) and the radiation side (transition from the antenna to free space) of the antenna .The gain of a TSA is proportional to the length of the antenna in terms of wavelength. Tapered slot antennas are also suitable to be used at high operating frequencies (greater than 10 GHz), where a long electrical length corresponds to a considerably short geometrical length. The main disadvantage of the TSA is that, only linear polarization can be obtained with conventional geometries.

In this paper, the characteristics of tapered slot antenna are observed when it is made conformal over cylindrical structures of different diameters. Conformed antennas on cylindrical structures are being used as smart antennas, beam-steering array antennas and for aerospace applications [7]. The varying diameters of the cylinders changes the geometry of TSA which in-turn has significant effects on the return loss and the radiation pattern. Experimentation was done through simulation and the results were analyzed.

II.ANTENNA DESIGN

A conventional TSA is designed using CST Microwave Studio. Fig.1(a) show the top view of designed TSA. Further, the cylindrically mounted form of proposed antenna is shown in Fig.1(b). The antenna is designed over an FR4 substrate with $\varepsilon_r = 4.4$ and thickness of 0.8mm. The dimensions of the antenna are L= 150 mm,W=120.5mm. The typical TSA is mounted on a cylinder whose diameter ranges from 100mm to 200mm. The use of metallic cylinder is neglected as the two slots of TSA corresponds to opposite charges. Hence an FR4 dielectric cylinder is used.

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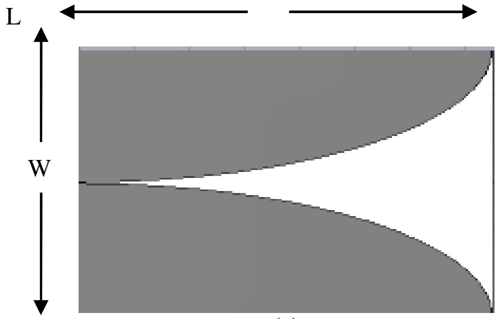
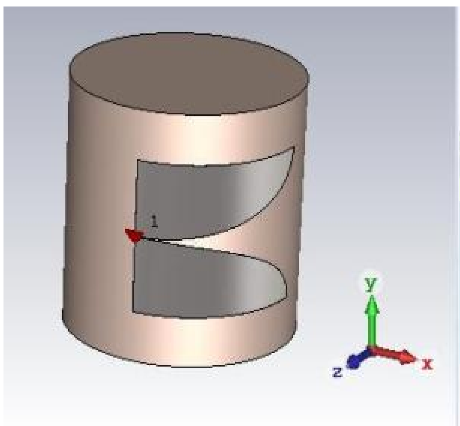


(a)

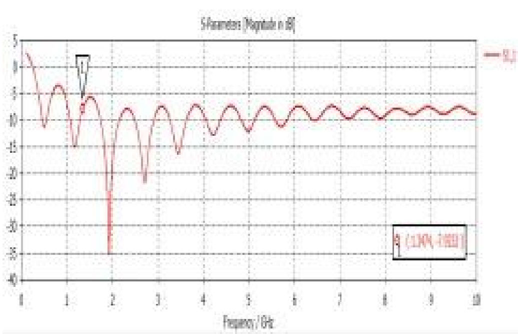


(b)

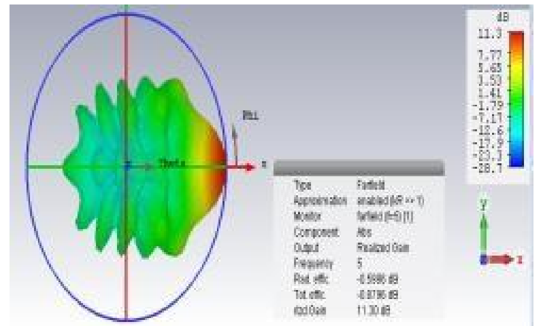
Fig. 1. (a) Simulated TSA, (b) TSA conformed on a dielectric cylinder

III.SIMULATION RESULTS AND ANALYSIS

The conventional TSA antenna operates in the 1-10GHz frequency range and for this impedance bandwidth, it is observed that the S11 is less than -5dB. The corresponding s-parameter graph is shown in Fig.2(a).The antenna pattern is observed and is seen that a maximum gain of 11dB is attained at a frequency of 5GHz as shown in Fig.2 (b). Gain Vs frequency characteristics is depicted in Fig.2(c), which shows a good performance for TSA.



(a)



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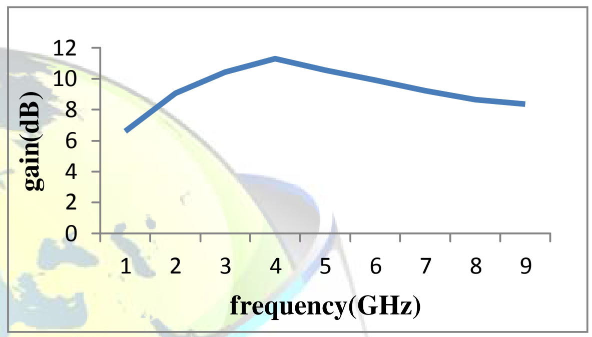
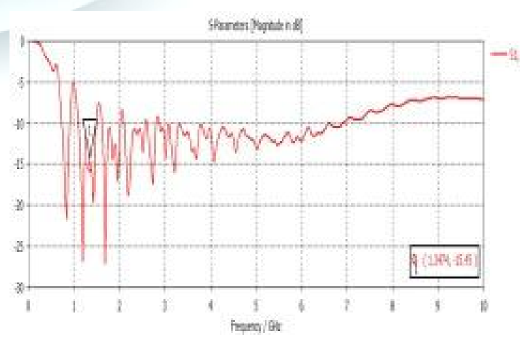


(c)

Fig. 2(a) Return loss of conventional TSA, (b) 3D Radiation Pattern at 5 GHz, (c) Gain Vs frequency plot of conventional TSA.

Fig. 3(a) shows the s-parameters of the same TSA conformed on a cylindrical surface. The simulated results shows that there is a significant improvement in return loss. The return loss has still got reduced to less than -10 dB for an impedance bandwidth of 7 GHz, i.e. from 1 GHz to 7 GHz.



(a)

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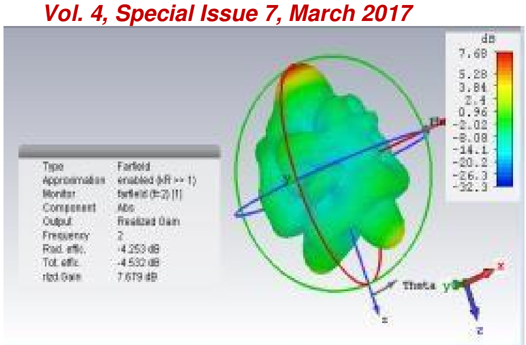

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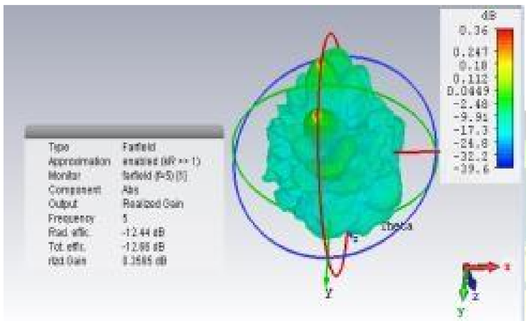

(c)

Fig. 3. (a) Return loss of TSA conformed over dielectric cylinder, (b) Radiation pattern of conformed TSA at 2 GHz, (c) Radiation pattern of conformed TSA at 5 GHz

It is noted that for higher frequencies, the desirable gain is not achieved. The simulated gains are only 0.35dB at 5GHz and a maximum of 7.67dB at 2GHz. Poor gain characteristics is shown at high frequency in Fig. 4 shows the gain vs frequency characteristics of conformal TSA. It is observed that the gain decreases with increase in frequency. [6] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

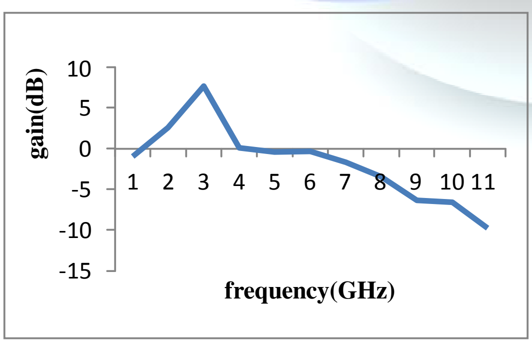

Fig. 4. Gain Vs frequency plot of conformed TSA

IV. CONCLUSION

This paper presents the simulated results for the radiation characteristics of TSA mounted on the surface of a dielectric cylinder. The experimental results show that the antenna has improved return loss but poor gain characteristics at high frequencies.The study can be referred in implementation of TSAover a cylindrical body which may find applications on smart antennas, beam-steering array antennas and aerospace.

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