

Modification of Vivaldi Tapered Slot Antenna with Square Shaped Slot

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Abstract

This paper offered the design of Vivaldi Tapered Slot Antenna(TSA) for the Ultra Band Applications using RT Duroid Substrate with relative permittivity of 2.2. The Vivaldi antenna has several applications like WLAN, air bone applications, Ultra wide band applications etc. The minimum and maximum frequency used are 2Ghz and 11Ghz respectively. It improves the Reflection coefficient, gain, directivity, bandwidth of the antenna. In this paper, the conventional antenna is modified by adding Square Slot in the Tapered Vivaldi Antenna. This proposed antenna had been designed and simulated using Comsol Multiphysics software.

Keywords - Ultra wide band, Tapered Slot Vivaldi Antenna, Square Slot, Comsol Multiphysics.

I. Introduction

A Vivaldi Antenna is a co-planar broadband antenna, which is made from a dielectric plate metalized on both sides. The feeding line through micro strip line, terminated with sector shaped area encircles the circular space. The Energy from the circular Resonant area reaches an Exponential pattern through symmetrical slot line.[1]

Vivaldi antenna can be made for linear polarization or for transmitting /receiving both polarization orientations. If the signal has 90° phase shifted, the orthogonal devices can transmit/receive circular oriented electromagnetic wave.[2]

Advantages of Vivaldi antenna are their broadband characteristic which is suitable for the ultra wide band signals, their simple structure and small size, their easy manufacturing process using common method for PCB production and their easy

impedance matching to the feeding line using micro strip line modeling.[3]

In recent decades, a great effort has been contributed to computational electromagnetic with the aim of developing new software tools to analyze and design microwave circuits and antennas. A lot of research has been carried out on full wave solvers based on numerical techniques such as finite element method (FEM), the finite difference time domain(FDTD), the method of moments(MOM) and the transmission line matrix method(TLM).

Finite element method has been extensively used in the simulation of electromagnetic problems because the computer simulation determines the optimal design of the structures to be analyzed. So, simulation through FEM is comparatively well suited over the other methods. The simulation and computational work is carried out with the help of FEM based COMSOL Multiphysics software.[4]

II Antenna Design and Configuration

The Vivaldi is kind of tapered slot antenna. It is exponential tapered slot. It consist of ground plane, dielectric substrate, microstrip transmission line as feed, taper curve design. The material used for ground plane having dielectric constant of 3.38 for conventional Vivaldi antenna .The Thickness of the substrate is 60 milli inch. A simple exponential function, $e^{0.044x}$ is used to create the tapered slot curves. The conventional antenna is modified by adding square shaped slot. The Dimensions used in Vivaldi antenna is shown table 1

Table 1. Antenna Dimensions

Name	Expression	Value	Description
thickness	60[mil]	0.0015240 m	Substrate thickness
w_slot	0.5[mm]	5.0000E-4 m	Slot width
f_min	2.0[GHz]	2.0000E9 Hz	Minimum frequency in sweep
f_max	11[GHz]	1.1000E10 Hz	Maximum frequency in sweep
fo	f_max	1.1000E10 Hz	current frequency in sweep
l_sub	110[mm]	0.11 m	Length of Substrate
b_sub	80[mm]	0.08 m	Breath of Substrate
D_cir	24[mm]	0.024m	Diameter of circle
l_rec	20[mm]	0.020 m	Length of rectangle

Here 'mil' refers to the unit milli inch .

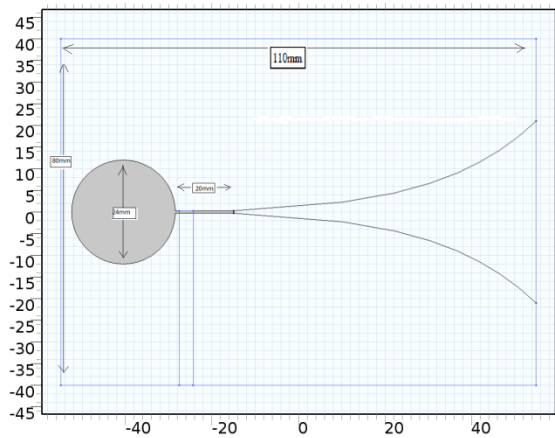


Figure1:Geometry of Conventional Vivaldi Antenna

basic model of conventional vivaldi antenna in above figure 1. One end of slot is open to air and the other end is finished with circular slot. The microstrip to slotline transition is used to feed the TSA. In this transition ,the slotline on the one side of the substrate and the microstrip is etched on the other side of the substrate. Now the square shaped slot has been

added at the upper layer of the tapered design as shown below in figure 2.

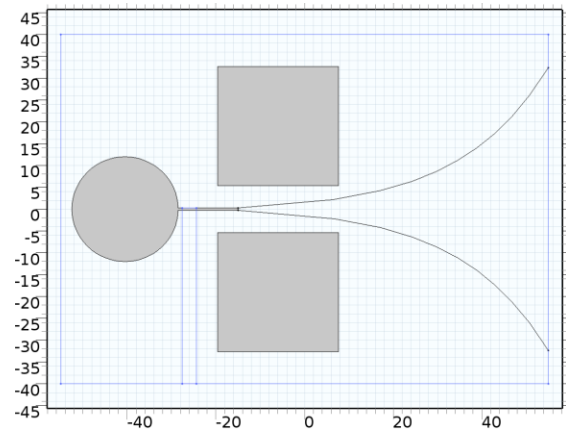


Figure 2: Geometry of Vivaldi Antenna with Square Shaped Slot

In the Square Shaped Slot Vivaldi Antenna, the material used for ground plane having dielectric constant of 3.38.The Thickness of the substrate is 60 milli inch. A simple exponential function, $e^{0.050x}$ is used to create the tapered slot curves. The size of the square in antenna is 27.27mm*27.27mm. It improve the bandwidth , gain and directivity of the antenna.

On the bottom of the substrate, the shorted 50 Ω micro strip feed line is modeled as PEC surfaces. The entire modeling domain is bounded by a perfectly matched layer (PML) which acts like an anechoic chamber absorbing all radiated energy. To excite the antenna, a lumped port is used. The model is meshed using a tetrahedral mesh with approximately five elements per wavelength in each material and simulation frequency as shown below in figure 4.

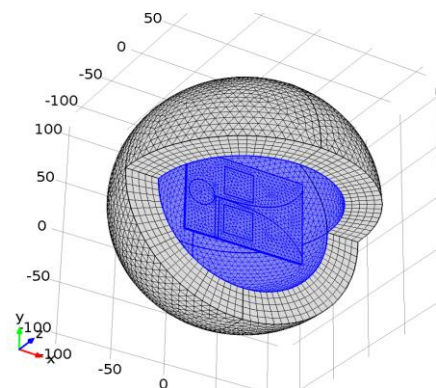


Figure 4: Tetrahedral Meshing of the Model

The Electric Field boundary condition specifies tangential component of the electric field. The commonly used special case of zero tangential electric field. The Electric field at the resonant frequency of 6.5 GHz shown below in figure 5.

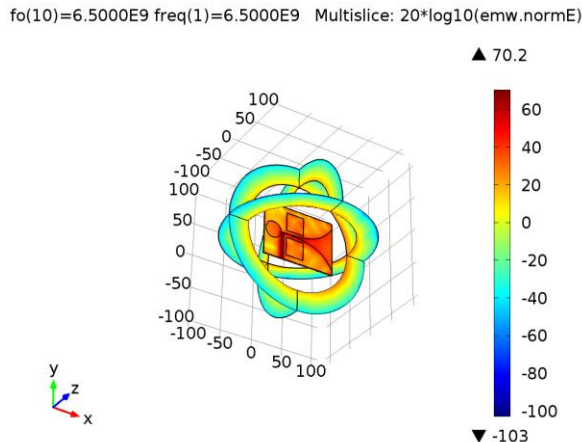


Figure 5: The Electric Field at the Resonant Frequency

III. Simulations and Result

The Designed Antenna has some parameters are:

A. Far Field

The Far field at resonant frequency of 6.5 GHz shown below:

1) 3D Polar Plot Of Conventional Antenna

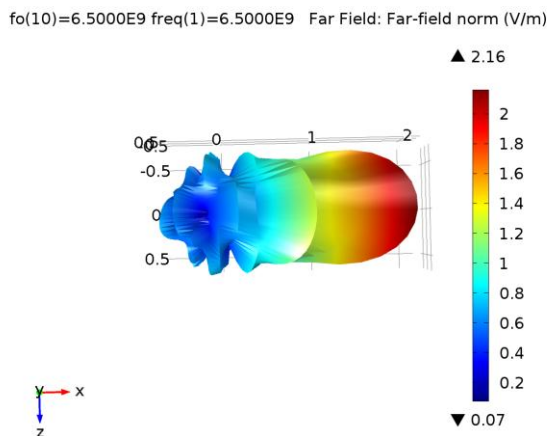


Figure 6: The Far Field of Conventional Antenna

The 3D polar plot of conventional antenna is shown in figure 6. The maximum far field is obtained at 2.16 V/m

2) 3D Polar Plot of Square Shaped Slot Antenna

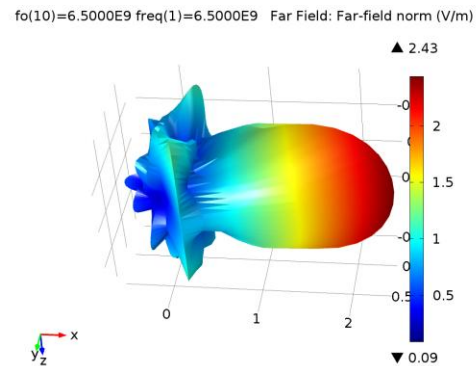


Figure 7: The Far Field of Square Shaped Slot Antenna

The 3D polar plot of the far field shown in figure 7. The maximum far field obtained at the 2.43 V/m.

By comparing the both far fields models, the square shaped slot antenna has very much sharp lobe. By adding the square shaped slot at the upper layer of antenna improves the radiation pattern and electric field of antenna.

B. Far Field Gain

The Far Field Gain at the resonant frequency of 6.5 GHz.

1) 1D Plot Gain of Conventional Antenna

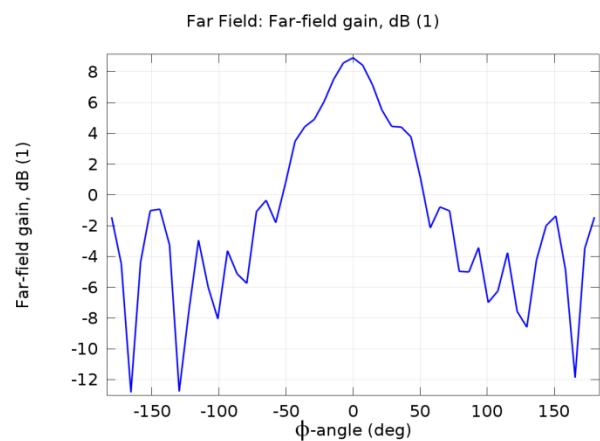


Figure 8: The Far Field Gain of Conventional Antenna

The Far Field Gain of conventional antenna is shown in figure 8. It shows the plot of radiation pattern on rectangular co-ordinates and gain is observed. The plot shown is gain in db versus angle in degrees. The Conventional antenna show the gain of 9db is obtained.

2) 1D Plot of Square Shaped Slot Antenna

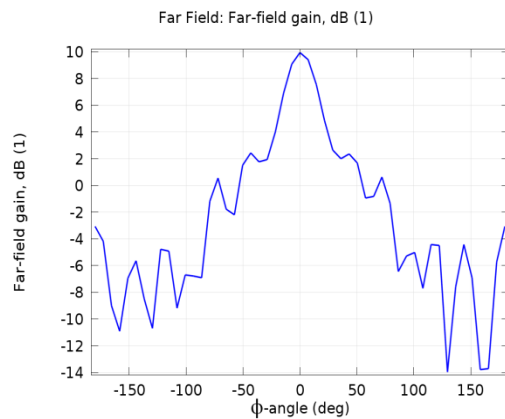


Figure 9: The Far Field Gain of Square Shaped Slot Antenna

The Far Field gain of the square shaped slot antenna is shown in figure 9. By adding square shaped slot in the design of the antenna, the gain is increased by 1 db.

By comparing far field of both the models, square shaped slot antenna has improved gain. The far field gain of the square shaped slot antenna is 10 db. The Gain of conventional antenna is about 9 db

C. Reflection Coefficient

The variation of the reflection coefficient (S_{11}) for both antenna is shown in figure. It is observed that reflection coefficient in conventional antenna is below -10db from 2 GHz to 5.9 GHz as shown in figure 10 and square shaped slot antenna is below -10 db from 2 GHz to 8 GHz as shown in figure 11.

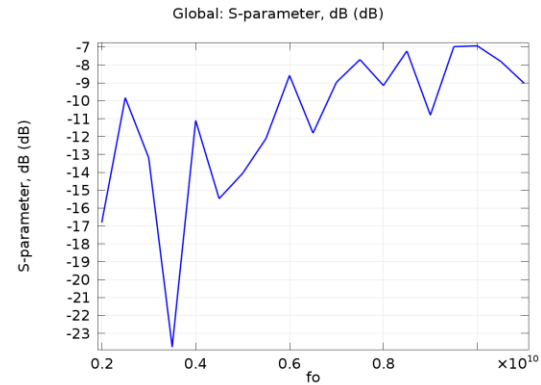


Figure 10: The Reflection Coefficient of Conventional Antenna

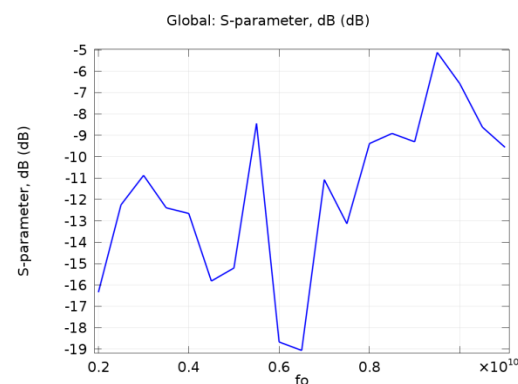


Figure 11: The Reflection Coefficient of Square Shaped Slot Antenna.

IV. Conclusions

A high gain and directivity with square shaped slot vivaldi antenna has been proposed in this paper for Ultra wide band applications. It works at the 2 - 11 GHz and reflection coefficient is below -10db from 2GHz to 8 GHz. Square shaped design antenna has the gain of 10 db which is more than conventional antenna.

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