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High Gain Vivaldi Antenna for Radar and Wi-Fi Application

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***Abstract* – In RADAR,WIFI and many other applications a variety of antennas has been used for various range frequencies. The antenna should also have a directional radiation pattern .Vivaldi antenna is a type of antenna in which the frequency range can be made very wide and hence a single antenna can be used for various applications The designed vivaldi antenna is operating for a frequency of 2.2GHz to 5GHz and 6GHz to 11GHz with below - 10dB impedance bandwidth and is designed on low cost FR4 substrate of thickness 1.6mm. The length and width of the antenna is about 20X20 mm and radius of the curve is 11 mm. Further, the Vivaldi antenna is modified at its edges which results in improvement in gain significantly along with increased directivity. The proposed antenna shows nearly stable radiation patterns throughout this frequency. A high gain compact Vivaldi antenna is with its reduced construction and wide bandwidth is presented for RADAR and WIFI applications.**

1. INTRODUCTION

Vivaldi antennas can be made for linear polarized waves or – using two devices arranged in orthogonal direction – for transmitting / receiving both polarization orientations. If fed with 90-degree phase-shifted signals, orthogonal devices can transmit/receive circular-oriented electromagnetic waves with Vivaldi antennas are useful for any frequency, as all antennas are scalable in size for use at any frequency. Printed circuit technology makes this type antenna cost effective at microwave frequencies exceeding 1 GHz.

Now a days various frequency range has been utilized by various applications . High frequency signals ranges between 3 MHz and 30 MHz . It also gets reflected by earth’s ionosphere and it is one of the suitable band fo long distance communication. High frequency band is mostly used by aviation industry, near field communication (NFC), government systems, amateur radio operators and weather broadcasting stations.

Very high frequency is one of the most commonly used bands which has an operating range from 30 MHz to 300 MHz . VHF frequency is widely used in analog TV broadcasting since it has started few decades back. FM radio broadcasting at 88 MHz to 108 MHz operates in VHF frequency band. Some advantages are higher directivity and produce symmetrical radiation pattern in H-plane and E-plane.

Ultra high frequency is the most important frequency bands for modern wireless communication systems. It begins from 300 MHz to 3 GHz and extremely complicated to design and implement the system. It has many sub frequency bands , some are restricted and assigned only for particular applications. It is used in GPS navigation systems, satellites, pagers, Wi-Fi, Bluetooth, television broadcasting, and most importantly GSM, CDMA and LTE mobile transmission. Super high frequency is in the range of 3 GHz to 30 GHz. It can only operate in line of sight path since any obstruction in between the transmitter and receiving station will break the communication.

It is commonly used in point to point communication, satellite systems, digital TV broadcasting in Ku band (DTH service – direct to home), Extremely high frequency band is the highest in RF frequency spectrum which range between 30 GHz and 300 GHz. EHF is only used in advanced communication systems due to its complex nature and line of sight requirement. EHF is used in radio astronomy and remote sensing (weather analysis).For the utilization of these frequencies various antennas has been designed for all these applications .Various antennas for various frequencies increases the complication in its size

II. ANTENNA DESIGN

The Vivaldi antenna is made of thin copper sheets or simple double-laminated printed circuit board material

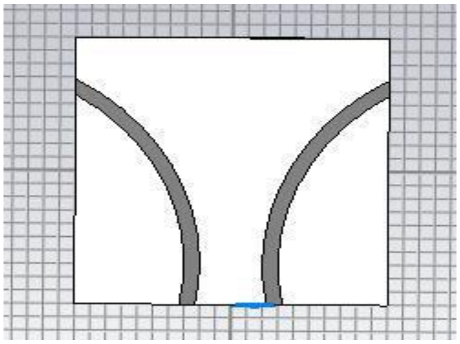

Fig 1.1Design of Vivaldi antenna

Its properties, such as the thickness of the carrier material and its dielectric constant have an influence on the properties of the antenna. The copper sheet at the bottom acts the ground with the thickness of 0.0165 mm and the patch above it is made of Fr4 substrate with the thickness of 0.8mm and relative permittivity of 4.4 with the size of 20mmx20mm and the patch is etched over it . The proposed Vivaldi antennas consist of a microstrip feed line, and the radiating structure. . The continuous scaling and gradual curvature of the radiating structure ensures theoretically unlimited bandwidth .The feed is given by SMA connector .

Design Procedure of Vivaldi Antenna

Calculations:

Calculation of the Width (W):

The width of the Vivaldi Antenna is given by the equation as

$$W = \frac{Co}{2fr}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Substituting f_r = 2GHz, ε_r = 4.4 and C0 = 3 × 108

The width is W = 37.26 mm.

Calculation of Effective Dielectric Constant ($\varepsilon_{r_{eff}}$):

The effective dielectric constant is calculated as

$$\varepsilon_{r_{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{\frac{-1}{2}}, \text{ W/h} > 1$$

Substituting ε_r = 4.4, h =1.6925 mm and W = 37.26 mm, $\varepsilon_{r_{eff}}$ is 4.8.

Calculation of the Length Extension (ΔL):

The length extension is calculated as

$$\Delta L = 0.412h\frac{\left(\varepsilon_{r_{eff}}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_{r_{eff}}-0.258\right)\left(\frac{W}{h}+0.8\right)}$$

Substituting for h = 1.6925mm, $\varepsilon_{r_{eff}}$ = 4.8 and W = 37.26 mm, ΔL is 0.8837 mm.

Calculation of Actual Length of Patch (L):

The actual length of patch is calculated as

$$L = \frac{Co}{2f_r\sqrt{\varepsilon_{r_{eff}}}} - 2\Delta L$$

Substituting ΔL = 0.8837 mm and f_r = 2GHz and C0 = 3 × 108 , L is 17.5 mm.

Calculation of the Ground Plane Dimensions (Lg & Wg):

Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane ( ) and the width of a ground plane (Wg) are calculated using the following equations

$$L_g = 6h + L$$

$$W_g = 6h + W$$

Substituting L = 1.6925 mm &W = 37.2 mm, is 47.355mm and is 64.8mm

III . RESULTS

The radiation pattern for Vivaldi antenna for the various frequencies are listed below:

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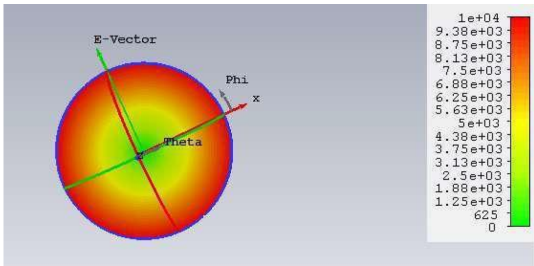


Fig 1.2 Radiation pattern for 2 GHz

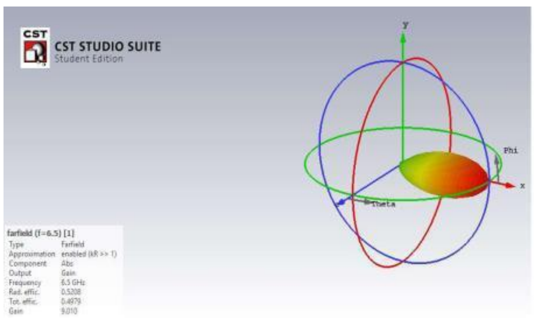


Fig 1.3 Radiation pattern for 6.5GHz

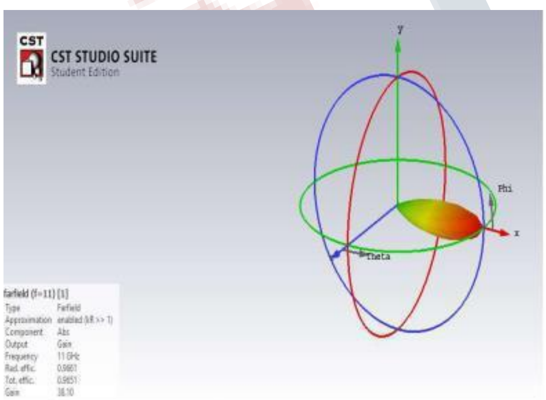
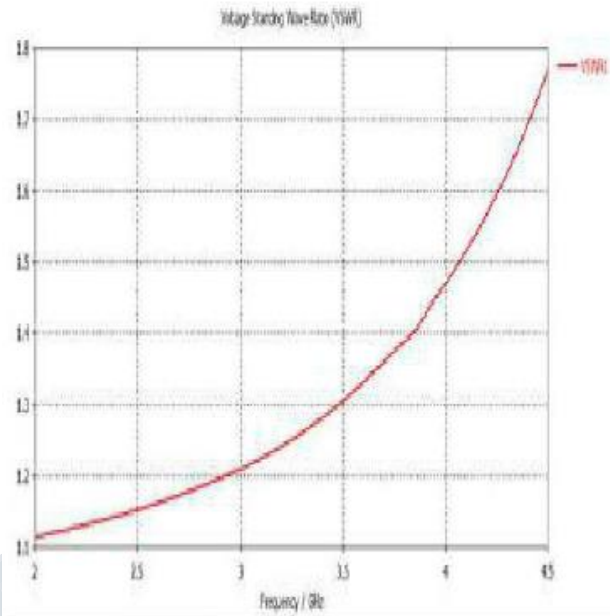
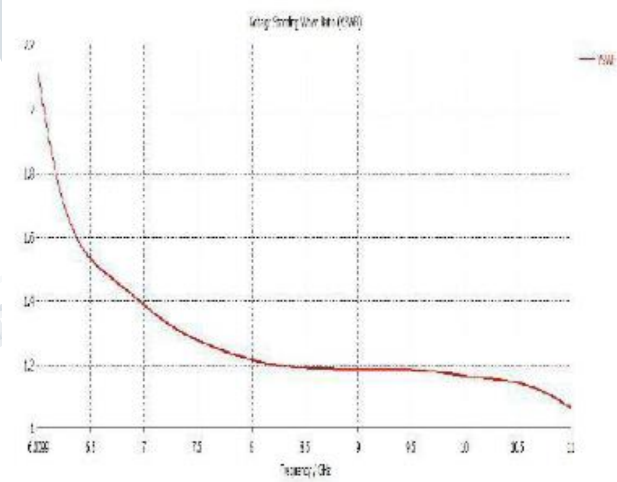


Fig 1.3 Radiation pattern for 6.5GHz





Reflection coefficient:

The variations of the reflection coefficient (S11) with frequency are shown . It is observed that the reflection coefficient is below -10dB for the frequency range from 2GHz to 4.5GHz and 6GHz to 11GHz.

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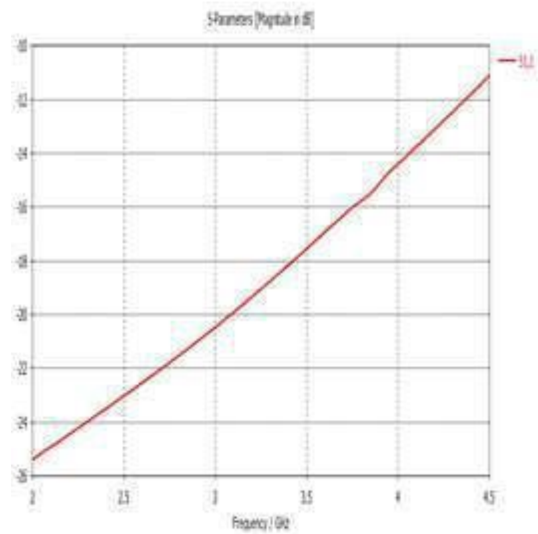

Fig 1.5 Reflection coefficient from 2GHz -4.5GHz

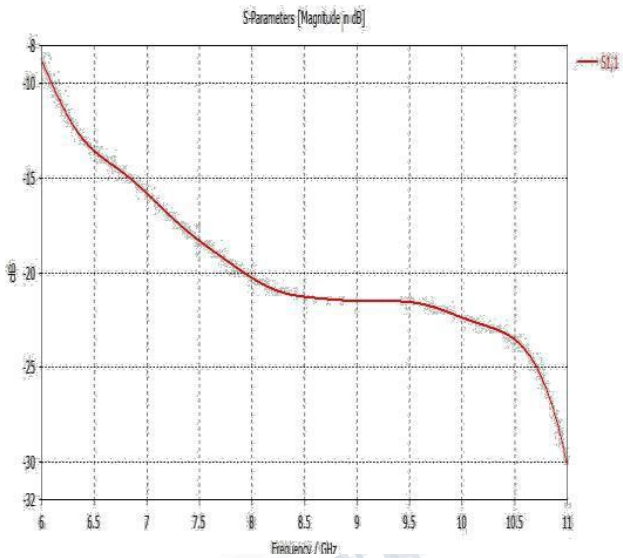

Fig1.6 Reflection coefficient from 6GHz to 11GHz

Smith Chart:
The impedance of a transmission line and antenna system as a function of frequency is observed in the smith chart. Smith Charts can be used to increase understanding of transmission lines and how they behave from an impedance viewpoint.

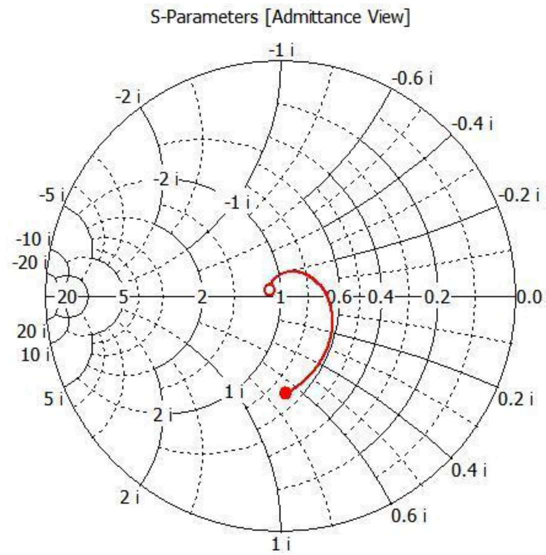

Fig 1.7 Smith Chart

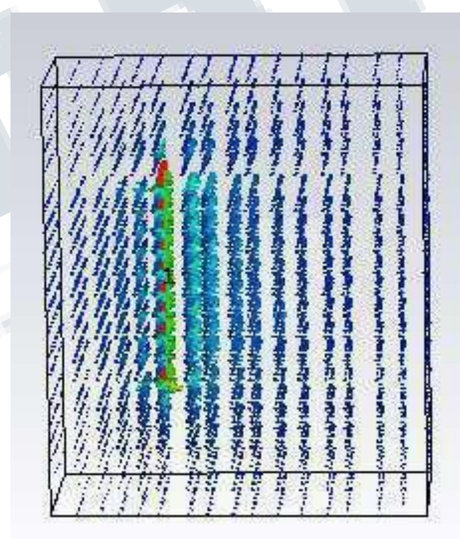

Fig1.8 Electric field pattern

IV.CONCULSION

A high gain Vivaldi antenna in the frequency range from 2GHz-5GHz and 6GHz -11GHz has been explained in this paper for Wi-Fi and radar applications. The input impedance and radiation patterns of the antennas have been plotted to understand the antennas operating principles. It offers wide bandwidth characteristics and hence used for wideband signals. It offers higher directivity.

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It can produce symmetrical radiation pattern in H-plane and E-plane. Bandwidth can be changed by varying antenna parameters such as shape, length, dielectric constant and dielectric thickness etc

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