Improvement of Antipodal Vivaldi Antenna Performance for Wireless Application

B.M.S. Sreenivasa Rao, B. Rajasekar

Abstract: This paper discusses about miniaturized size of the antipodal Vivaldi antenna by using triangular and circular slots on the Vivaldi antenna. A normal antipodal Vivaldi antenna using FR4 epoxy substrate with a dielectric constant of 4.4 and thickness 1.6mm has been designed. Then, the triangular and the circular slots are added at the upper layer of the miniaturized size of the antenna, the triangular slot plays a major role in reduction of size of the antenna and also results in the better improvement of return loss, gain and bandwidth operated at a frequency in the range of 3GHz to 25GHz and the circular slot placed at the exponential part of the antenna helps to reduce excessive mutual coupling between different slots of the antenna. The feeding technique used for designing of this antenna is micro strip feedline. The proposed antenna results in different applications by incrementing the frequency. The results of simulation are been realized using HFSS 13.0, a high frequency simulator structure program. The structured antipodal Vivaldi radio wire and the triangular and round openings antipodal Vivaldi receiving wire are manufactured. The arrival misfortune reaction and the increase of the manufactured radio wires are estimated and contrasted and the re-enactment results.

Keywords: Antipodal, Bandwidth, Gain, Micro strip field line, Return losses, VSWR

I. INTRODUCTION

As there is a colossal increment in versatile information arrange prompting lack of transfer speed. So as to give high caliber of administration, low dormancy video and sight and sound applications for remote applications the serious issue is that there is a constrained range extend between 700Mhz to 2.6 GHz where every one of the specialist organizations have allotted 200MHz over all extraordinary cell groups of the accessible range. This can be overwhelmed by utilizing higher frequencies. Inside the ITU areas, the recurrence range between 3 GHz and 300GHz has endless administrations and applications, for example fixed, aeronautical, satellites and space [1]. The real administrations are separated into applications in which the usable recurrence ranges are characterized for the end clients. Instances of use incorporate WLAN/WPAN, Wi-Fi, WiPro, WiMax, radar(civil, military), radio telecom and TV (satellite) just as traffic telematics.

Vivaldi reception apparatus is the appropriate contenders for these applications as it gives expansive data transfer capacity, simple creation, minimal effort and low cross polarization. Vivaldi receiving wire was first presented by GIBSON in the year 1979[2]. As an individual from the class of decreased space radio wire, Vivaldi reception apparatus GIBSON's Vivaldi receiving wire with a topsy-turvy one side microstrip to slot line progress was built on alumina utilizing microwave photolithographic flimsy film procedures. The improvement to the Gibson configuration has been presented in later years by E.Gazit in 1988 where he presented an antipodal structure and pursued by adjusted antipodal structure by Langley. Vivaldi reception apparatuses are broadly utilized in the flame control framework, little physical measurements and numerous airborne applications. The nourishing system utilized for the Vivaldi reception apparatus is the microstrip sustaining line [3]. In this sort of encouraging system, a leading strip is associated straightforwardly to the fix. This is invaluable because of its straightforward planar structure.

The fundamental issue of the antipodal Vivaldi receiving wire is its expansive size [4] [5]. The measure of the reception apparatus develops with lower frequencies because of longer wavelength. It likewise relies upon the radio recurrence because of the region of the reception apparatus which scales with the wavelength. The lower the recurrence, the bigger the receiving wire ought to be to accomplish a similar increase. So, for better execution at high frequencies, radio wire ought to be little in size. Consequently, extraordinary arrangements have been proposed to diminish the span of the reception apparatus. So in this paper two sorts of spaces have been utilized to diminish the measure of the receiving wire in order to upgrade the transfer speed.

II. ANTENNA DESIGN

The customary receiving wire Vivaldi radio wire is structured with length and width 110mm and 80mm. The receiving wire is structured utilizing HFSS 13.0 programming.

HFSS represents high recurrence test system structure used to utilize limited component technique and profound understanding electromagnetic issues. It is utilized to figures parameters, gain and numerous other receiving wire parameters. The substrate utilized for the plan of customary Vivaldi receiving wire is FR4 epoxy with dielectric steady 4.4 and thickness 1.6mm with misfortune digression 0.02. The fix and ground of the Vivaldi reception apparatus i.e. above and underneath the FR4 substrate is metalized utilizing copper as a metal. The geometry of the reception apparatus is appeared in Fig 1. The radiation box ought to be in the scope of $\lambda/2$ to $\lambda/4$. On the off chance that we

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PARAMETERS	CONVENTIONAL VIVALDI DIMENSION	MODIFIED VIVALDI DIMENSION	NOTATION
Area	110mm × 80mm	60mm × 30mm	L×W
Dielectric substrate	FR4 epoxy Thickness-1.6mm Dielectric constant- 4.4	FR4 epoxy Thickness-1.6mm Dielectric constant- 4.4	ε
Patch	110mm × 80mm × 0mm	60mm × 30mm × 0mm	L×W
Ground	110mm × 70mm × 1.6mm	60mm × 30mm × 1.6mm	L×W
Feedline (microstrip feedline)	Position (30,0,0)	Position (18,0,0)	F_1
Antipodal Vivaldi antenna • Circle • Rectangle • Exponential length	Radius-12mm Position(20,40,0) Position(16,15,0) 62mm	Radius-8mm Position(14,15,0) Position(28,42,0) 33.75mm	R L_1×W_1 L_2
length of the triangular slot	-	2mm	TL
Radius of circular slot	-	0.8mm	

take not exactly λ/4 we will get wrong addition and on the off chance that we take more than λ/2 there is no issue, yet it will prompt increment in reenactment time. A radiation limit is utilized to truncate unbounded free space to limited count area.

As the ordinary receiving wire is substantial in size, an altered reception apparatus is plan with diminished size of length and width 60mm and 30mm. The triangular opening is put for the decrease of size of the reception apparatus and on the fix with 2mm length and dividing between each triangular space is 1.6mm and it ought to be done appropriately on the fix. The roundabout space is set on the exponential piece of the receiving wire to diminish common coupling of various openings of the reception apparatus. Cutting of the openings on the fix makes the Vivaldi radio wire a conservative reception apparatus. The substrate utilized for the altered radio wire is additionally FR4 epoxy.

The geometry of the changed plan is appeared in Fig 2. Both the receiving wires are then worked at a recurrence extend between 3GHz to 25GHz. The parameters for structuring both the reception apparatus is appeared in the Fig 3 and Fig 4

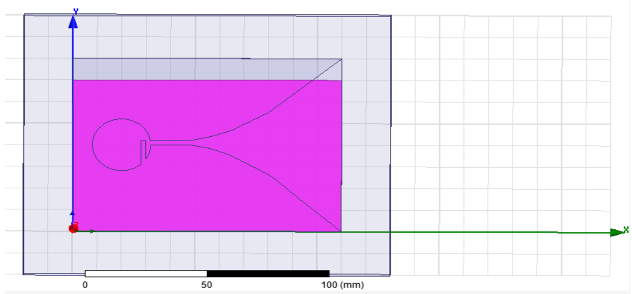

Fig 1: Conventional Antipodal Vivaldi Antenna

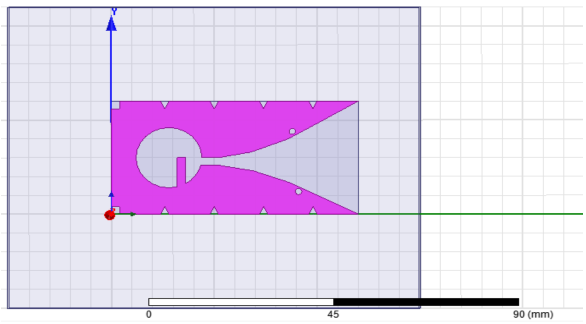

Fig 2: Modified Antipodal Vivaldi Antenna

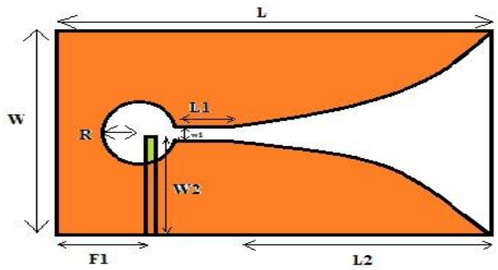

Fig 3: Design Parameters of conventional Antipodal Vivaldi antenna

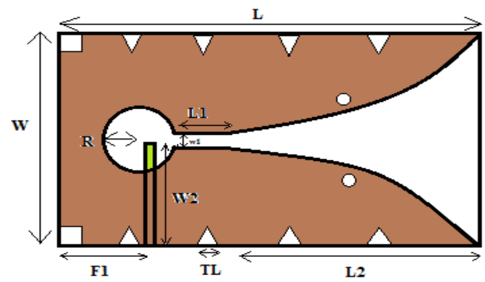

Fig 4: Design parameters of modified Antipodal Vivaldi antenna.

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The Table1 shows the parameters and the notations.

III. SIMULATION RESULTS

The conventional and modified antenna results are done using HFSS software. The frequency range for both conventional and modified antennas are taken between 3GHz to 25GHz. The center frequency is taken as 14GHz. The parameters calculated for the antenna are return loss(S_{11}), VSWR and gain.

1. *Return Loss:* The return loss is very important parameter as it represents how much the power is reflected from the antenna. The antenna radiates best at below -10dB.

$$\text{Return loss} = 20\log\frac{\text{vswr}-1}{\text{vswr}+1}$$

For the conventional Vivaldi antenna the return loss is found to be below -10dB in the frequency ranges of 12.6-13GHz, 14.6-14.8GHz, 15.7-16.18GHz shown in the Fig 5. This indicates that this antenna provides multi band application. But it has narrow bandwidth, so to obtain wider bandwidth we are going for modified design providing triangular and circular slots shown in the Fig 6.

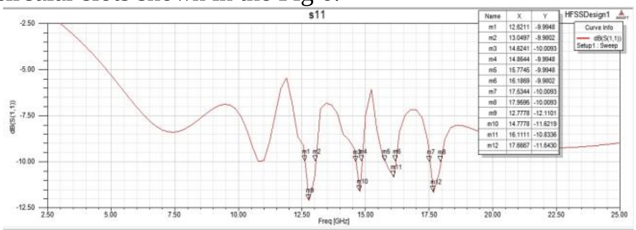

Fig 5: Return loss of conventional Antipodal Vivaldi antenna.

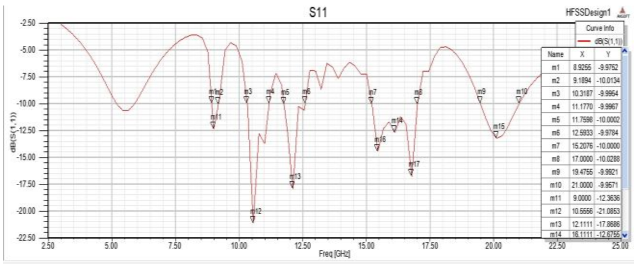

Fig 6: Return loss of Modified Antipodal Vivaldi antenna

In Fig 6, the modified antenna provides wide bandwidth at frequencies 15.2-17GHz and 19.47-21 GHz.

The circular part of the Vivaldi antenna is basically used for the impedance matching between feedline and the antenna [6] [7]. At the cut-off frequency of the antenna impedance is 50ohms and the impedance of the feedline is also kept as 50ohms. Thus we can see perfect impedance matching between feedline and antenna.

2. *VSWR:* VSWR describes the power reflected from the antenna. The littler the VSWR, the better the receiving wire is coordinated to the feedline and more power is conveyed to the radio wire.

$$\text{vswr} = \frac{1+\Gamma}{1-\Gamma}$$

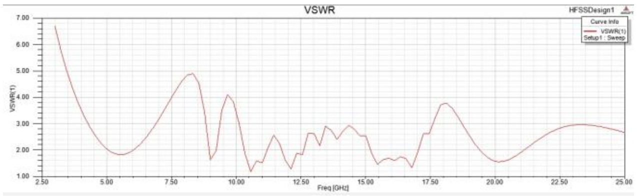

Fig 7:VSWR of conventional Antipodal Vivaldi Antenna

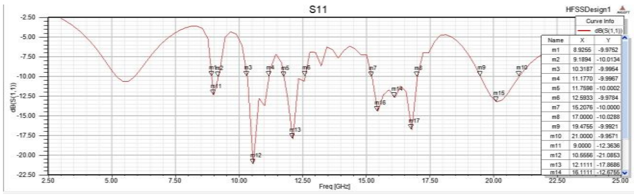

Fig 8: VSWR of modified Antipodal Vivaldi antenna

The VSWR for the modified antenna is found to be below 2. The enhanced results are found using these antenna parameters of the modified antenna.

3. Gain: The addition depicts how well the reception apparatus changes over information capacity to radio waves a predetermined way. The increase of the altered radio wire is observed to be 8 dB. and that of customary receiving wire is observed to be 4 dB.

Fig 9: Gain of Conventional Antipodal Vivaldi Antenna

CALCULATIONS:

a. Antenna Length and width:

$$f_{min} = 3\text{GHz}$$

$$f_{max} = 25\text{GHz}$$

$$\lambda = \frac{c}{f}, \quad \text{where } c = 3\times10^8\ \text{m/s}$$

$$\lambda_{max} = 12\,\text{mm}$$

$$\lambda_{min} = 100\,\text{mm}$$

$$L \geq \frac{(\lambda_{max}+\lambda_{min})}{2} = 56\,\text{mm}$$

$$W \geq \frac{(\lambda_{max}+\lambda_{min})}{4} = 28\,\text{mm}$$

Fig 10: Gain of Modified Antipodal Vivaldi Antenna

There is a condition for the length and width of the antenna i.e., the antenna length and width should be greater than the average value of the maximum and minimum operating frequency[8] [9]. Here the antenna length [10] should be greater than 56 mm and width should be greater than 28mm. So the conventional and modified antenna is taken as 110mm×80mm and 60mm×30mm.

IV. CONCLUSION

In this paper we designed two Antipodal Vivaldi antennas. The conventional antenna is large in size so we go for modified Vivaldi antenna where we use triangular and circular slots and minimized the area of the antenna. The usage of slots enhanced the antenna parameters and achieved better bandwidth, return loss, VSWR and gain and the circular slots placed at the exponential part of the antenna helps in reducing excessive mutual coupling. The frequency range of Vivaldi antenna helps to use it for different wireless applications.

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