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Multiband Vivaldi Antenna for X and Ku band Applications

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ABSTRACT

A Multiband vivaldi antenna is designed to operate in the X and Ku bands and simulational results are presented in this paper. Along with the ultrawide band, this particular vivaldi antenna is working in the range between 7 to 20 GHz at different resonent frequencies. Gain of more than 9dB and bandwidth enhancement of 0.92% can be achieved using this model. All the antenna parameters including design considerations and field distributions are presented in this paper.

Keywods: Multiband, Vivaldi, ku band, Ka band.

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I. Introduction:

Vivaldi antennas are preferable in many applications due to high gain, simple structure and easy fabrication. They are mostly used in ultra wideband and broadband applications. The Vivaldi antenna comes under the tapered slot antenna with exponential flare profile [1-4]. The flare radiates at different points along its length for different frequencies, determined by the flare width. This Vivaldi antenna consists of tapered slot etched on to a thin film of metal. The performance of antenna mainly depends on the aperture width. Generally the width of the antenna should be greater than λ/2 and width of the flare will increase with distance from the antenna feed [5-8].

The main characteristics of Vivaldi include greater bandwidth, high directivity, high gain and symmetric radiation pattern with low side lobes. A transition is required to feed the slot line of the Vivaldi antenna from a strip line or microstrip circuit. The Vivaldi antenna uses a stripline to balanced slot line transition [9-10]. The main objective of this paper is to produce a Multiband Vivaldi antenna with compact structured, light weight and has to give constant gain characteristics from 7-20 GHz. Printed Vivaldi antennas are a low-cost solution and relatively easy to manufacture on standard PCB substrate. The shape of the tapered slot is usually defined by an exponential function.

II.Antenna Model and Design Considerations

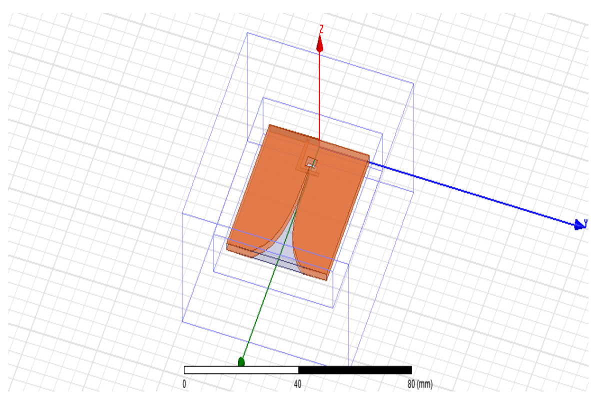

Figure (1) Vivaldi Antenna

S.No	Design Parameter	Value
1	Operating Range	7-20 GHz
2	Slot width	0.2049 mm
3	Taper width	18.75 mm
4	Taper length	37.5 mm
5	Balun width	3.49 mm
6	Balun length	3.49 mm

7	No. of points in curve	20
8	Strip width	1.3068 mm
9	Offset of strip length	3.49 mm
10	Strip length	5 mm
11	Total width	37.5 mm
12	Total length	48.49 mm

Table (1) Antenna Dimensions

III. Research Findings and Analysis:

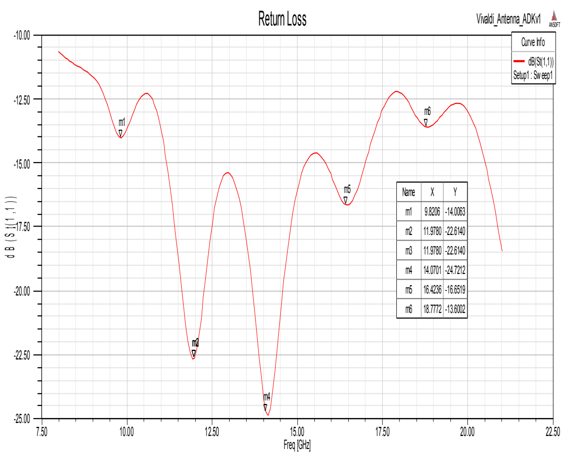

Figure (2) Return Loss Vs Frequency

Figure (2) shows the return loss Vs frequency curve for the proposed vivaldi antenna. This antenna is resonating at multiple frequencies and all the resonant frequencies are giving excellent reflection coefficient parameter values i.e., < -10dB in the entire range. The return loss obtained at 9.8,11.9, 14.07, 16.42 and 18.77 are -14.0, -22.6, -24.72,-16.65 and -13.60 respectively.

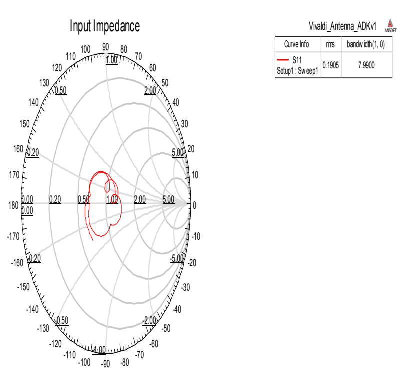

Figure (3) Input Impedance Smith Chart

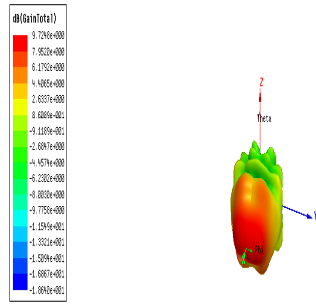

Figure (4) 3D gain of the antenna

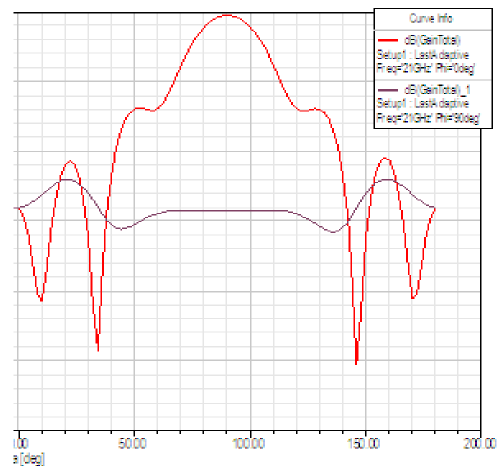

Figure (5) 2D gain of the antenna

The input impedance at the feed of the antenna is represented with Z=R+jX, which is equal to the ratio of voltage to the total current of the antenna. The figure (3) indicates the input impedance smithchart for the proposed antenna with bandwidth enhancement of 0.92% and r.m.s of 0.190.

Figure (4) & Figure (5) indicates 3D and 2D gain curves with respect to the degrees in position. The proposed multiband vivaldi antenna is producing a maximum gain of 9dB at the desired operation.

Figure (6) & Figure (7) are showing the radiation pattern of the proposed antenna in the contour plot representation. Actually there must be two orthogonal planes in the far-field region namely E-plane and H-plane. The far zone electric field lies in the E-plane and it is represented with rE Phi which is shown in figure (6). The far zone magentic field lies in the H-plane and it is represented with rE Theta which is shown in figure (7).

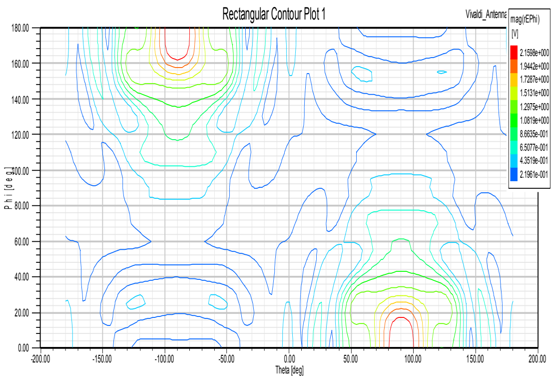

Figure (6) Rectangular contour plot (rE Phi)

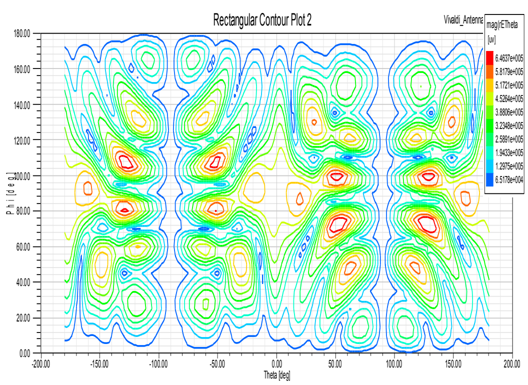

Figure (7) Rectangular contour plot (rE Theta)

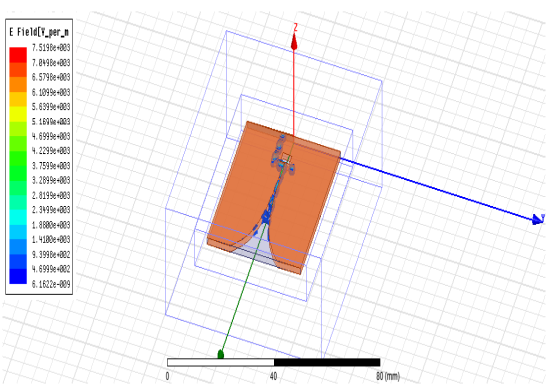

Figure (8) E-field distribution of the antenna

Figure (8) & Figure (9) shows the E-field and H-field distributions of the proposed vivaldi antenna. For the TM_{01} mode the contributions to the far field are from the magnetic surface current densities on the side walls containing the radiating edges.

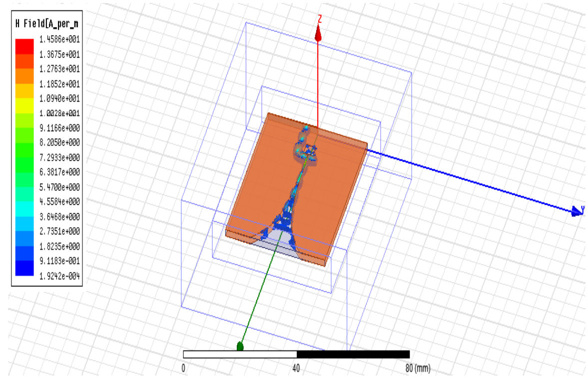

Figure (9) H-field distribution of the antenna

The directions of the magnetic currents that are in the E-field is shown in figure (8) and the directions of the magnetic currents in the H-field shown in figure (9).

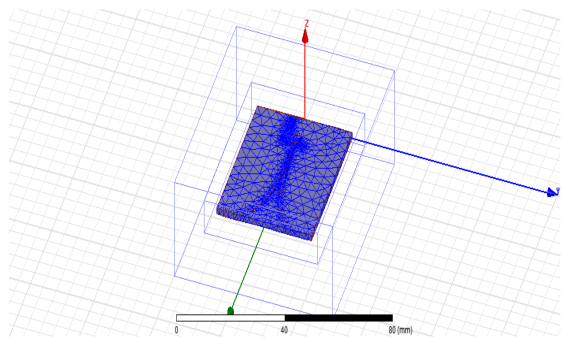

Figure (9) Current distribution of the antenna

Figure (10) indicates the current distribution with triangular gridding on the surface of the antenna. The patch containing the closer gridding of triangular zones which indicates the flow of current density is more on the patch and the lesser concentration when moving from patch to surface of the substrate.

Antenna parameters:

QUANTITIY	VALUE	UNITS
Max U	0.0074835	w/sr
Peak directivity	9.3329	
Peak gain	9.386	
Peak realized gain	9.2339	
Radiated power	0.010076	w
Accepted power	0.01002	w
Incident power	1.0057	w
Front-to-back ratio	106.38	

Table (1) Antenna parameters of the proposed Vivaldi antenna

Maximum field data:

rE field	VALUE	UNITS	At Phi (degrees)	At Theta (degrees)
Total	2.3754	V	175	-90
X	0.79037	V	120	-90
Y	2.376	V	0	90
Z	0.58229	V	75	124
Phi	2.3754	V	175	-90
Theta	0.71094	V	75	126
LHCP	1.6861	V	175	-88
RHCP	1.6841	V	175	-92
Ludwig3/x dominant	0.96282	V	35	120
Ludwig3/y dominant	2.3736	V	0	90

Table (2) Maximum field data of the proposed Vivaldi antenna

Table (1) and (2) shows the Antenna additional parameters and maximum field data of the Vivaldi antenna.

Conclusion: We designed and simulated broadband antenna which operates in the frequency range from 8-20 GHz. This antenna is resonating at five different frequencies and all the results obtained for this model is showing good agreement with the standard parameters in this range of specific frequencies. This antenna covers both X and Ku bands with excellent output characteristics in the entire range. Gain of 9dB and bandwidth of 0.92% enhancement cab be obtained from this current model.

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