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Antipodal Vivaldi Antenna with dielectric Director for UWB radar applications

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***Abstract*— this paper demonstrates an Antipodal Vivaldi Antenna with dielectric Director to be used for UWB radar applications. This configuration has the ability to produce good input match, high gain low dispersion, narrow beam width, small side lobe level and constant radiation pattern with a gain of 10±2 dB over the operating bandwidth. Addition of a director which consists of a rod portion of a higher dielectric constant material improved the antenna performance.**

Keywords-component; Antipodal Vivaldi Antenna (AVA), UWB, radar applications, dielectric Director.

I. Introduction

In recent years, many research interests have been attracted to compact ultra-wideband antenna radar sensor network. These antennas are used in diverse applications including see-through walls, active and passive imaging and precise localization [1].
Generally, in UWB radar applications directive antennas with almost constant radiation pattern, good input match and low insertion loss over a wide frequency range are preferable [2] [3]. In addition, the antenna has to be compact in order to ease its position.
Antipodal Vivaldi Antenna which has presented by Gazit [4], is a good candidate for radar applications, because of their compact structure, higher gain, broad bandwidth and radiation efficiency. Adding a dielectric Director is an excellent design to achieve a compact antenna with higher gain and narrow beamwidth [5] [6]. It operates as a wave guiding structure and direct most of the energy in the direction of aperture center. The shape of the director is designed to avoid reflections from its extremities [7].
In this paper, an Antipodal Vivaldi Antenna with dielectric Director is proposed in order to attain UWB antenna radar performances. The simulation results were performed with commercially CST MWS software.
In section II, the Antipodal Vivaldi Antenna design and the modified structure by including dielectric rod are presented. Section III study the simulation results and compares the AVA and AVA-D in order to demonstrate the performance of this contribution. Finally, section IV summarizes the findings of the antenna studies.

II. Antenna Design

In this section, the Antipodal Vivaldi Antenna design and loading director are given.

A. *Antipodal Vivaldi Antenna With Circular-shape-loaded*

Figure (1) shows the structure of simple Antipodal Vivaldi Antenna designed to operate over 2-15 GHz frequency range. This design follows conception described in [8]. It consists of two copper layers which show an exponential taper profile, is defined as:

$$Y = \pm(Ae^{rx} + B) \quad (1)$$

$$A = \frac{y_2 - y_1}{e^{rx_2} - e^{rx_1}} \quad (2)$$

$$B = \frac{y_1 e^{rx_2} - y_2 e^{rx_1}}{e^{rx_2} - e^{rx_1}} \quad (3)$$

The antenna is designed on a 0.76mm RF4 substrate with a dielectric constant of 3.5.

Where (x_1, y_1), (x_2, y_2), the peak and bottom point respectively of the exponential tapered curve, r is the exponential factor which determines the beam width of the antenna. Antipodal Vivaldi antenna accepts a simple micro strip feeding.
The circular- shape loaded, which is proposed in [9] in order to improve bandwidth by reaching the lower cutoff frequency, is presented in fig (2). This configuration is attained by adding a circular-shape- load on each arm of the conventional antenna.
Geometric parameters for the design antenna are listed in table1.

TABLE I: DIMENSIONS OF DESIGN ANTENNA

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a	b	c	d	L	g	w	l	r	f	r_0
20.5	24.5	44.7	15	71	1.73	24	3	15	35	25

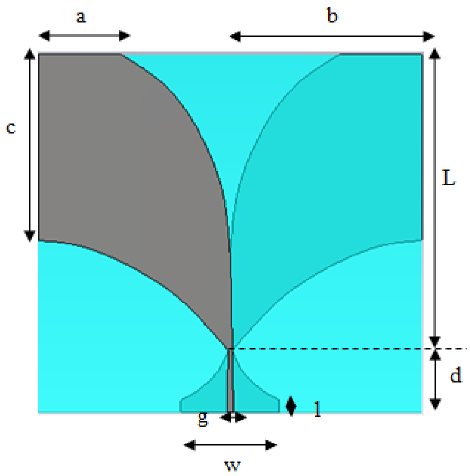


Fig.1: Simple Antipodal Vivaldi antenna

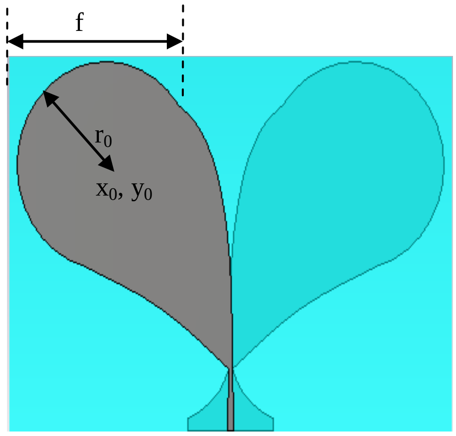


Fig.2: Antipodal Vivaldi antenna with circular shape- loaded

B. Antipodal Vivaldi Antenna with dielectric Director

Figure (3) presents the Antipodal Vivaldi Antenna with dielectric Director. The director consists of a shaped dielectric rod of higher permittivity, placed in the aperture of the antenna. The dielectric director length and permittivity are 43 mm and 6 respectively.

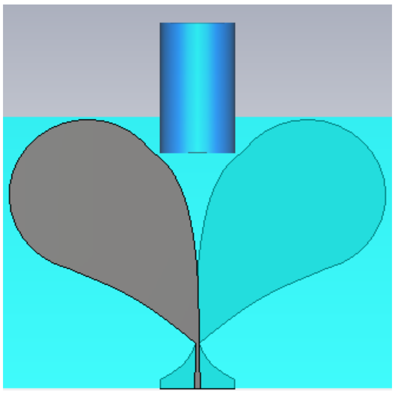


Fig.3: Antipodal Vivaldi antenna with dielectric Director

III. SIMULATION RESULTS

Figure 4 shows the simulation return loss of the conventional Antipodal Vivaldi antenna and the AVA with dielectric. It can be seen that adding the rod to the antenna did not significantly affect the return loss of the antenna. Both antennas operate over 2 to 15 GHz band and no considerable difference is observed between the two antennas besides a little amelioration reflections at lower frequencies for the AVA-D.

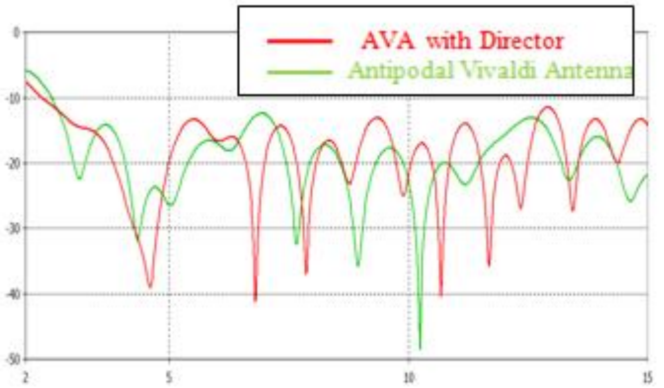


Fig.3: Simulated return loss of the simple antenna and the antipodal Vivaldi antenna with Director

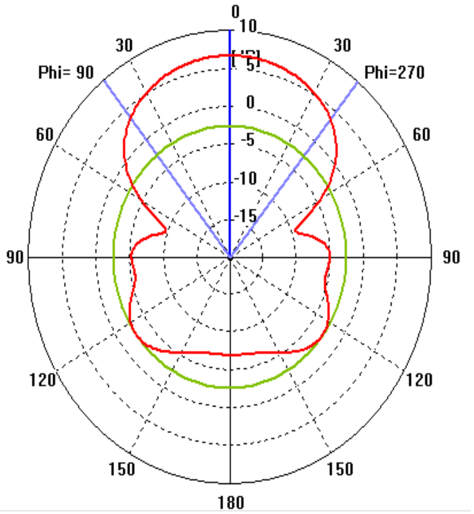
The simulated radiations patterns of the both antennas at 4 GHz, 7.5 GHz and 10 GHz are shown in fig. (5) and Fig. (6). It is indicating that adding dielectric director has increased the gain by more than 2 dB over 5- 10 GHz.

Moreover, the director affects the beamwidth is an overall narrowing. It can be observed when the director is present, the pulse energy stays concentrated inside the antenna structure. This demonstrates the waveguide effect produced by the director.

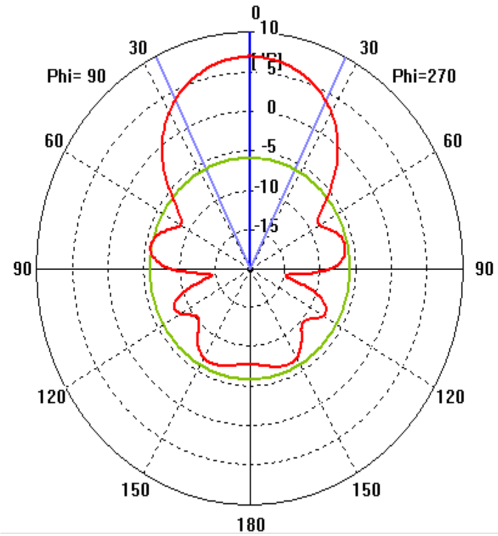
A quantitative comparison of the gain and the beamwidth for both antennas is contained in table II.

TABLE II: COMPARATIVE TABLE CHARACTERISTICS ANTENNAS CONFIGURATIONS

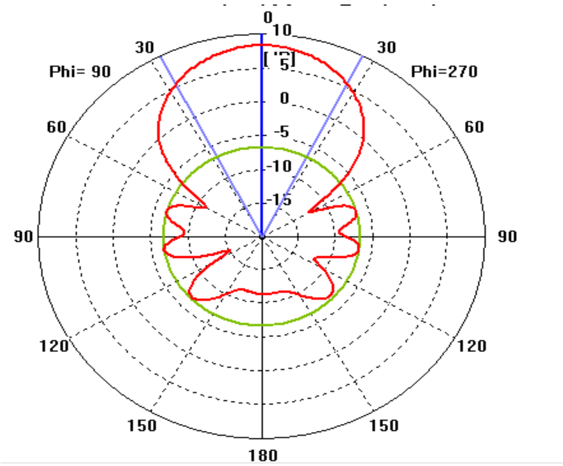
	Antennas	S_{11} (dB)	Gain (dB)	HPWB (deg)
4GHz	***Antipodal Vivaldi antenna***	-26.43	6.7	79.3
	Antipodal Vivaldi antenna with Director	-27.53	8	76
7.5 GHz	***Antipodal Vivaldi antenna***	-22.35	7.2	52.5
	Antipodal Vivaldi antenna with Director	-26.2	11.6	40.1
10 GHz	***Antipodal Vivaldi antenna***	-22.98	8.4	54.1
	Antipodal Vivaldi antenna with Director	-22.63	10.4	31.3



At 4 GHz:

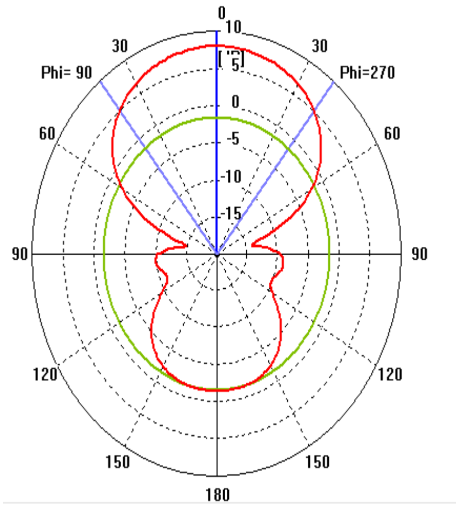


At 7.5 GHz:

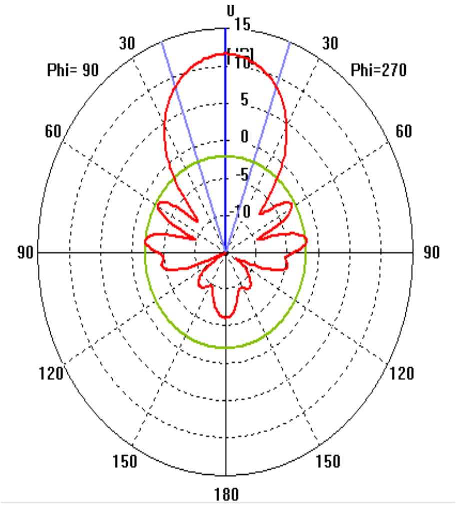


At 10 GHz:

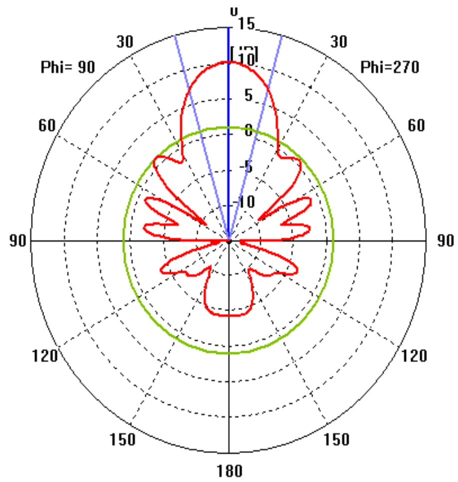
Fig. 5: Simulated radiation patterns at 4, 7.5, 10 GHz of the Antipodal Vivaldi antenna.



At 4 GHz:



At 7.5 GHz:



At 10 GHz:

Fig. 6: Simulated radiation patterns at 4, 7.5, 10 GHz of the Antipodal Vivaldi antenna with dielectric Director.

IV. CONCLUSION

In this paper, the directivity of the Antipodal Vivaldi antenna is improved by adding of a director with a higher permittivity in the aperture. In addition, the AVA-D antenna is characterized by a compact geometry and a constant radiation pattern over the operate range bandwidth. Finally, adding the dielectric director decreases the beamwidth in comparison to the Antipodal Vivaldi Antenna.

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