Symmetric Vlasov-type antenna for High Power Microwave applications

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***Abstract*—We present a novel Vlasov-type antenna operating at 2.5 GHz and composed of a circular waveguide with a double bevel-cut. Simulation results show that the proposed antenna is capable of providing a wider emission angle if compared to standard Vlasov configurations, while still maintaining an adequate gain level. For this reason, it could be of interest for those High-Power Microwave (HPM) applications in which a larger area need to be covered by the EM field.**

***Index Terms*—HPM; mode converter; Vlasov antenna.**

I. Introduction

Devices capable of generating high power pulses have attracted a broad interest in recent years [1], [2] , thanks to their several applications ranging from the medical field to defense. Usually, these devices produce guided signals in the transverse magnetic TM_{0n} or transverse electric TE_{0n} modes [3], that are not suitable for free space propagation. For this reason, antennas capable of also working as mode converters are generally employed at the output of HPM devices and the Vlasov antenna [4] is one of the most used worldwide. Vlasov antenna has two main configurations: the step-cut and the bevel-cut [5].

Both configurations are widely used, thanks to their ability in performing mode conversion without the need of any other module and their performance can be further improved, in terms of gain and directivity, through the use of external reflectors.

Vlasov antennas typically show a very high gain, but they usually have a small angular aperture. This is an advantage in those applications in which the EM power must be radiated along a single direction. On the other hand, modern HPM devices often need to reach multiple targets (e.g. in the case of a drone swarm attack) and, for this reason, antennas able to irradiate microwave power with a considerable gain over a wider angle are highly demanded. In this paper, we present a novel Vlasov-type antenna geometry capable of providing a wider emission angle with respect to its classical configurations, while still maintaining an adequate gain level.

II. Antenna Design and Performance Analysis

Fig. 1 shows the geometry for the proposed Vlasov-type antenna. In order to work at 2.5GHz the diameter of the circular waveguide has been set to 126mm. Unlike the classical Vlasov configuration, our antenna presents a double cut, which allows to generate a beam capable of covering a wider area.

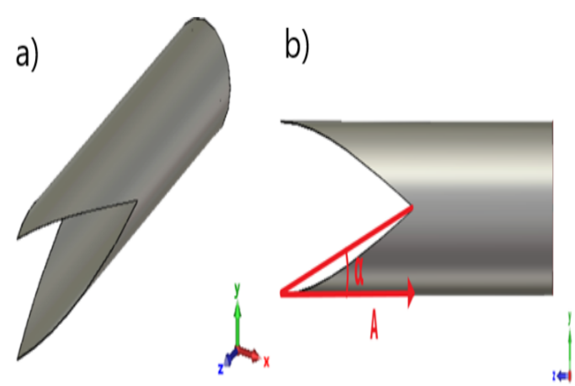

Fig. 1. Geometry of the proposed Vlasov-type antenna: (a) perspective view and (b) side view with indication of the geometric parameters (A and α).

In Fig. 1(b), the main design parameters of the antenna are presented: the length of the cut along the waveguide axis (A) and the angle of the cut itself (α). We have studied the dependence of both the maximum gain and gain pattern of the antenna at the varying of these two geometrical parameters, that are obviously linked one to another since the diamater of the waveguide is fixed. The optimization process was carried out by sweeping A from 200mm to 600mm and, consequentially, (α) from 17.5° to 6°. In Fig. 2 the gain patterns for Phi=90° and Phi=0° for three different values of A are shown.

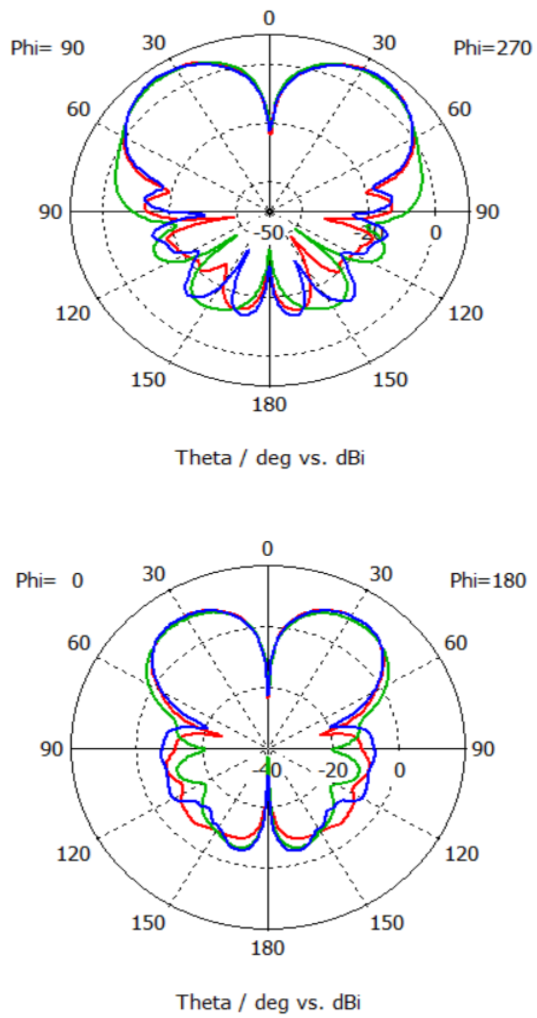

Fig. 2. Gain patterns for Phi=90° (top) and Phi=0° (bottom) of the antenna for different values of A: 200mm (green), 370mm (red) and 600mm (blue)

From this image we can deduce that best compromise in terms of gain and back/sides lobes is obtained for A=370mm and α=13.2°.

Scattering parameters and gain pattern have been simulated by means of CST time domain solver [6]. The reflection coefficient of the designed antenna shows a reflection coefficient below -15 dB in the 2.3 - 2.6 GHz range, as noticeable from the S_{11} parameter in Fig. 3.

The 3D farfield pattern, plotted in Fig. 4, shows the wide area covered by the EM field at the output of the antenna.

In greater detail, a gain of 10.4 dB and an aperture angle of 33.0° for each main lobe were attained at an elevation angle of Phi=0°, whereas a gain of 6.51 dB with an aperture angle of 36.0° for each main lobe was achieved for Phi=90°.

III. Conclusions

The novel proposed Vlasov-based antenna shows a radiation solid angle far exceeding the performance of its classic configuration, while maintaining a comparable gain. This makes this geometry suitable for several applications where multiple targets have to be reached at the same time. Ongoing activities are investigating further improvements, in terms of gain and directivity, through the use of external reflectors.

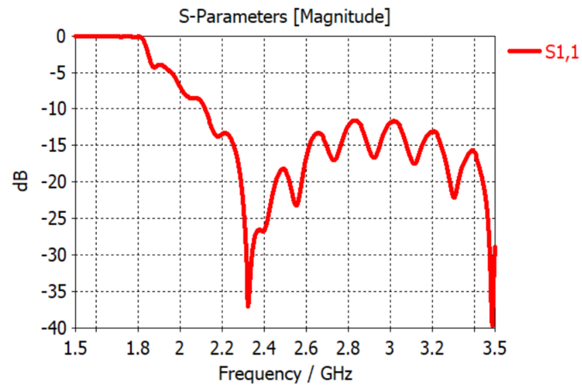

Fig. 3. S11-parameter of the proposed antenna.

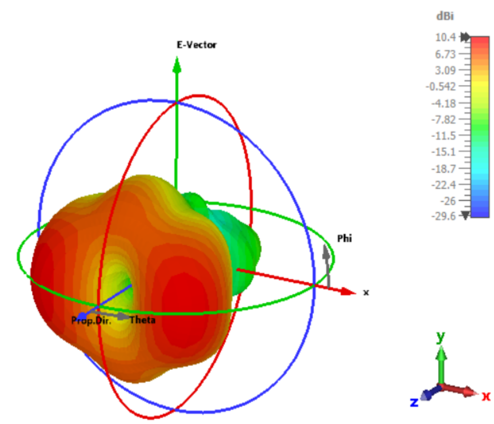

Fig. 4. 3D far-field pattern of the proposed antenna.

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