Improved Antennas for High Power Microwave Applications

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Abstract: **This paper presents antenna designs with improved performance and characteristics for applications requiring high levels of microwave power. One such application is in the remote neutralization of landmines and unexploded ordnance, which is part of a wide research program on Humanitarian Demining. A description of this program is included in this paper. Two types of antennas are dealt with in this work: Vlasov and the slotted waveguide antennas. A Vlasov antenna with a curved cut is first introduced. This novel cut shape is more suitable for high power microwave (HPM) applications and results in increased antenna gain and good sidelobe level and half-power beamwidth. Bevel-cut and step-cut Vlasov antennas with optimized reflector position and angle are also reported. The optimized reflector is directly attached to the waveguide making the Vlasov antenna, which gives a simpler design. It also offers the advantages of a better control over the direction of maximum radiation, an increased antenna gain and a reduced half-power beamwidth. Corrugations are used inside slotted waveguide antennas in two configurations: one leading to a much smaller reflection coefficient at the antenna input, which is essential for HPM, and the second resulting in antenna size reduction by shifting down its operational frequency.**

***Index Terms*— High Power Microwaves; Slotted Waveguide Antennas; Vlasov Antennas**

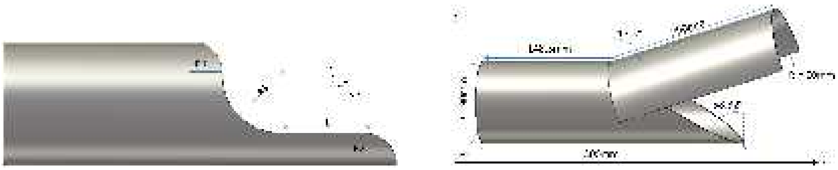
I. INTRODUCTION

A research program on Humanitarian Demining has been established at the Beirut Research and Innovation Center (BRIC). The program involves researchers from BRIC, the American University of Beirut, the Lebanese University, and Notre Dame University, and is done in close collaboration with the Lebanon Mine Action Center. The aim of this Humanitarian Demining Research Program (HDRP) is to develop advanced methods for the safer, faster and less expensive detection and cleaning of the landmines and unexploded ordnance, which pose a serious problem to the Lebanese population. Part of HDRP is a project on the remote neutralization of landmines using high power microwave pulses. This project involves the implementation of a high power microwave source, for the generation of the needed high power pulses, and antennas to radiate these pulses in the direction of a detected landmine. Vlasov antennas [1] and slotted waveguide antennas (SWAs) [2] are two antenna types known for their support of high power energy. This paper reports results of research work done to improve these two antenna types in terms of their size, ease of fabrication, performance and radiation characteristics.

II. VLASOV ANTENNAS

A Vlasov antenna is a cylindrical waveguide with a shaped end, either a step cut or a bevel cut [1]. The proposed antenna, shown in Fig. 1(a), has an improved curved cut with no sharp edges or corners, better suitable for HPM applications [3]. Antennas based on the step, bevel, and the proposed curved cut are designed for the same angle of maximum radiation given by $\Theta=32^o$ and $\Phi=90^o$. The obtained results show that the proposed cut gives a higher gain, a smaller HPBW and a better sidelobe level (SLL).

Although considerable work has been done on increasing the gain of the Vlasov antenna, mainly by adding a reflector to it, none of the previous studies considered bringing back the maximum radiation along the axis of the waveguide, for example from $\Theta=32^o$ to $\Theta=0^o$. By attaching a reflector made of a half hollow cylinder at the start of the Vlasov antenna cut, and optimizing the length, radius and angle of this reflector, the generated waves are oriented back along the +Z direction ($\Theta=0^o$, $\Phi=90^o$) [4]. The resulting structure is shown in Fig. 1(b) for a bevel-cut Vlasov antenna. This new geometry also increases the gain by 10.3% (in dB), decreases the HPBW and reduces the antenna overall volume.



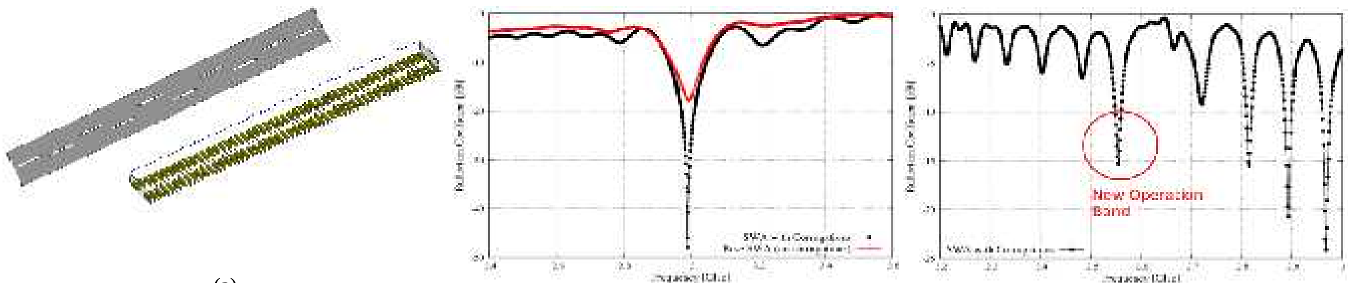
(a) (b)

Fig. 1. Improved Vlasov antennas: (a) new cut with curve edges, (b) improved reflector position

III. SLOTTED WAVEGUIDE ANTENNAS WITH CORRUGATIONS

Slotted waveguide antenna arrays [2] radiate energy through slots cut in a broad or narrow wall of a rectangular waveguide. They are attractive due to their design simplicity and their significant advantages in terms of high power handling, high efficiency and good reflection coefficient. Starting with an *S*-band SWA having 10 elliptical slots on one broadwall and designed for 3 GHz and an SSL of less than -30 dB, two identical sets of metallic corrugations are added inside, on the non-slotted broadwall, as indicated in Fig. 2(a). The corrugations are first optimized (their count and dimensions) to maintain the antenna resonance at 3 GHz while decreasing the reflection coefficient S_{11}. This is important in HPM applications since we would be dealing with high levels of EM power, and any reflected amount will be considerable. For a relatively small corrugation height (equal to $b/4$ where b is the waveguide's internal height), an S_{11} value of about -48 dB is achieved, compared to a value of -18 dB without the corrugations. The corresponding S_{11} plots are compared in Fig. 2(b). An improvement of about 30 dB in S_{11} is achieved.

Keeping the same number and inter-spacing of the corrugations as in the first case, while increasing their height to $b/1.5$ and optimizing the spacing between their two sets, the S_{11} plot in Fig. 2(c) is obtained. It shows a decrease in the resonance frequency from 3 GHz to 2.55 GHz. At this new frequency, the SWA keeps its desired radiation characteristics. This frequency down-shift signifies an antenna volume reduction of 46.75% if it were to be designed for 2.55 GHz without the corrugations.



(a) (b) (c)

Fig. 2: (a) SWA with corrugations; (b) Corrugations optimized for better S_{11}; (c) Corrugations optimized for frequency down-sift (size reduction)

IV. CONCLUSION

In this work, improved designs of Vlasov and slotted waveguide antennas have been reported. These two high-power-capable antennas can be used in a project on the remote neutralization of landmines and unexploded ordnance. Improvements to the Vlasov antenna are done using a novel cut shape, or by optimizing the position and angle of a connected reflector. Corrugations are used with SWAs to either improve their S_{11} or reduce their size.

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