A New Configuration of Axial Vircator with Reflectors to Maximize the Power Efficiency

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Abstract— **The classical architecture of an axial Vircator is modified by introducing reflectors in the cylindrical waveguide. Behaviour of this new type of vircator is numerically analyzed using CST particle Studio® PIC 3D simulations. Decreasing reflectors radius is shown to be crucial in maximizing the power conversion efficiency. This new design enables to deliver up to 2 GW output power in S-band on TM_{01} mode only with a total efficiency close to 21%.**

Keywords-component; High power microwave, virtual cathode oscillator, Particle-in-cell, open drift tube

I. INTRODUCTION

Virtual cathode oscillators (so-called Vircator designs) are one of the most important classes of High-Power Microwave (HPM) generators. Axial Vircators are rather simple microwave (MW) devices which consist of two parts: a diode responsible for an electron beam emission, followed beyond the anode by a cylindrical waveguide in charge of shaping MW fields. Their operation requires an electron beam current exceeding the space charge limiting current in order that a virtual cathode (VK) builds up beyond the anode at a distance from the real cathode roughly twice the anode-cathode spacing d_{AK}. The electron cloud oscillation, both in location and potential, generates a powerful MW emission. Appreciated for their conceptual simplicity and robustness, Vircators unfortunately exhibit low power conversion efficiency (~ 1%). To overcome this severe drawback, reflectors consisting of thin anodic foils are introduced in the cylindrical waveguide [1].

II. AXIAL VIRCATORS WITH REFLECTORS

The axial Vircator under consideration is designed to operate in S-band, delivering a MW emission in TM_{01} mode. The electrons are emitted from a 4.5 cm radius cathode. Beyond the anode, the beam propagates through a cylindrical waveguide of radius R_G = 7.6 cm. The d_{AK} spacing is equal to 2.1 cm. The applied diode voltage is about 500 kV with a rise time of 5 ns. This design gives an input power of roughly 9.5 GW.

Following [1], 5 reflectors of 6-cm radius are placed in the waveguide. A spacing of 6 cm separates two successive reflectors. Reflectors are thin anodic foils 100 % transparent for the electrons and totally reflecting electromagnetic waves. As a result, a virtual cathode formation process gets duplicated beyond each reflector where MW created by VKs are trapped in pseudo-cavities. The power conversion efficiency is found maximum, roughly 13 %, when 3 reflectors are used. The averaged ouput power is about 1.26 GW and transmitted in the TM_{01} mode at 2.88 GHz (Figure 1). Adding more reflectors in the device weakens performances since the MW emission can also propagate in the TE_{11} mode at 1.4 GHz, creating a mode competition with the TM_{01} mode excited.

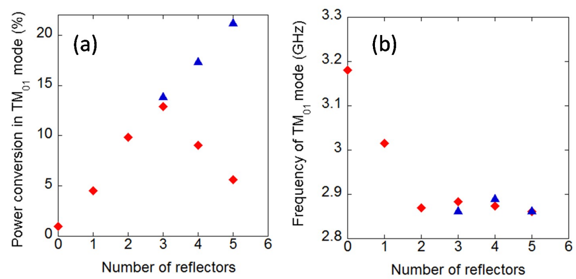

Figure 1. Power conversion efficiency in TM_{01} mode (%) (a) operating frequency in TM_{01} mode (b): comparison between devices with 6-cm constant radius reflectors (red diamonds) and devices with reflectors of decreasing radii (blue triangle).

To further increase the device performances when using more than two reflectors, it is shown that, despite [1], the reflectors radii have to be decreased below the threshold of $0.75R_G$, as claimed in [2]. Following [2], the radii of the third, fourth and fifth reflectors are respectively reduced down to 50, 50 and 40 mm. Figure 1 illustrates the increasing power conversion efficiency while the operating frequency remains roughly unchanged.

III. CONCLUSION

Compared to conventional axial Vircators, this novel architecture, based on a series of virtual cathodes, located in the center of adjacent pseudo-cavities, achieves higher output powers. A power conversion efficiency up to 21% is obtained with 5 reflectors of decreasing radii, yielding an averaged power of 2 GW at 2.86 GHz in TM_{01} mode only.

REFERENCES

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