Experimental Demonstration of Higher Order Dispersion in Inhomogeneous Slow Wave Structures for Backward Wave Oscillators

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Backward wave oscillators (BWO) are Cerenkov radiation type devices used to generate high power microwaves. These devices find applications in plasma science, radar and electronic susceptance and vulnerabilities testing among others. BWOs have been developed across many bands from S-band to terahertz frequencies. However the typical conversion efficiencies of BWOs using homogeneous SWSs are of the order of 20-30%. Therefore, there is need to improve the conversion efficiency of BWOs as it allows for device miniaturization and higher output powers. One approach to improve efficiency is to use SWSs consisting of two sections. By varying the interaction impedance and phase velocity between the two SWS sections, high efficiencies of 40-50% can be achieved. However, very little has been done to investigate the efficiency and frequency tunability of multi-section SWSs with more than 2 sections. In addition, the actual efficiency enhancement mechanism of inhomogeneous SWSs has not yet been characterized and experimentally demonstrated.

In this paper, we present a comprehensive study of multi-section SWSs whose inhomogeneity profiles are characterized by mathematical functions. Using PIC simulations, the efficiencies of these SWSs are obtained along with their oscillation frequency response to variations in beam voltage. This study is aimed at predicting the optimum SWS profiles for high efficiency and their corresponding tunability. The profile with the highest possible efficiency is fabricated and cold tested to experimentally determine and validate the underlying efficiency enhancement mechanisms. To our knowledge, this cold test experiment is the first demonstration of a guided structure whose dispersion has Multiple Secondary Inflection Points (MSIPs). Particle in cell simulations using this design predict an output power of 8.25 MW at 2.62 GHz corresponding to a conversion efficiency of 70%