Experimental Validation of Mode Dominance Reversal in Novel Slow Wave Structure for High Power Backward Wave Oscillator

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Vacuum electron devices (VEDs) are the sources of choice for high power (kW-GW) delivery in the microwave to millimeter wave frequency range. VEDs are used in satellite communication, electronic countermeasures, radar and energy beaming systems among other applications. Backward wave oscillators (BWOs) are robust, high power VED sources that generate RF power through the Cherenkov radiation mechanism. That is, BWOs generate power through energy exchange between a high power electron beam and an electromagnetic mode. Critical to BWO systems is a slow wave structure (SWS) which acts as the medium in which the energy exchange occurs. Specifically, SWSs slow down the TM_{01} mode to match the beam velocity while concurrently facilitating electron bunching through velocity modulation.

BWOs suffer from low beam-to-RF electronic conversion efficiency and poor mode purity. Specifically, the nominal electronic efficiency for BWOs is 20%. To address these challenges we present a novel, deeply corrugated, ring loaded SWS with cavity recessions. This design provides higher efficiency through a two-fold improvement in interaction impedance. Output mode purity is enhanced through mode dominance reversal. That is, the SWS makes the desired interacting TM_{01} mode dominant in the SWS. We present a fabricated version of the SWS at S band along with the results of a cold test. Mode dominance reversal, a key novelty of our SWS design is validated experimentally. Furthermore, the experimentally derived dispersion curve of the SWS shows excellent agreement with simulated results from CST and HFSS. Hot test simulations using the new SWS show output powers of 5.94 MW and 8 MW at 2.6 GHz. These output powers correspond to electronic efficiencies of 35% and 70% for homogeneous and inhomogeneous SWS's respectively.