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UCD Ka-Band Harmonic Peniotron Status

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Abstract: *The UC Davis 34 GHz peniotron experiment is currently being prepared for test. The device is presently being operated in a "beamstick" configuration to characterize beam transmission and validate the magnetic design. Upon completion of this step the device will be reconfigured as the intended second-harmonic oscillator and tested for power output and efficiency (predicted values are 125 kW and 47% respectively).*

Keywords: peniotron; axis-encircling; gyro-device.

Introduction

The peniotron has previously achieved very high (75%) electronic conversion efficiencies in experiments performed at Tohoku University [1]. However, high output powers at mm-wave frequencies have not been reported. The UC Davis peniotron is designed to demonstrate high device efficiency at 100 kW power levels. The device is designed to operate in the second beam harmonic at 34 GHz as a first step toward operation at higher harmonics and frequencies. The goal is to develop high power mm-wave sources that do not require superconducting magnets.

Design parameters for the device have been previously reported [2]. The design is optimised for output power and device efficiency (125 kW and 47% predicted respectively) for the second-harmonic beam interaction with the fundamental mode of a four-vane slotted (magnetron-like) cavity, resonant at 34 GHz. The interaction B-field is 6.5 kG which is achieved with conventional coils. Key to the design is the 70 kV, 3.5 A axis-encircling electron beam produced by the Northrop Grumman cusp electron gun [3]. The device has been fabricated and assembled. Testing is underway at UCD.

Design and Fabrication

The copper interaction circuit (see Figure 1) incorporates four WR-28 diagnostic ports which are symmetrically coupled directly into the cavity. The cavity is coupled to the output circular waveguide through a replaceable iris which determines the cavity Q and hence, the device efficiency. The cavity output is connected to a short section of 4.5 mm radius circular waveguide.

The output waveguide length was selected to position the collector at the point where the axial B-field falls to zero and the beam diverges. The collector also passes RF power to an internal RF load which is the final internal element in the device. In this proof-of-principle test, the internal load will absorb almost all of the output power, thereby obviating the need for a high power RF vacuum window. Output power is measured at the diagnostic ports.

The device is assembled in standard 1.5 inch vacuum jacket and inserted in a conventional (i.e. copper) magnet comprised of four large pancake coils. Additional steel pole pieces shape the magnetic field to produce the required interaction field and also the complex field required by the cusp gun. An axial pole piece, critical to the design, shapes the field fall-off and determines the position of the collector. The axial pole piece was also designed to allow for tapering of the interaction field.

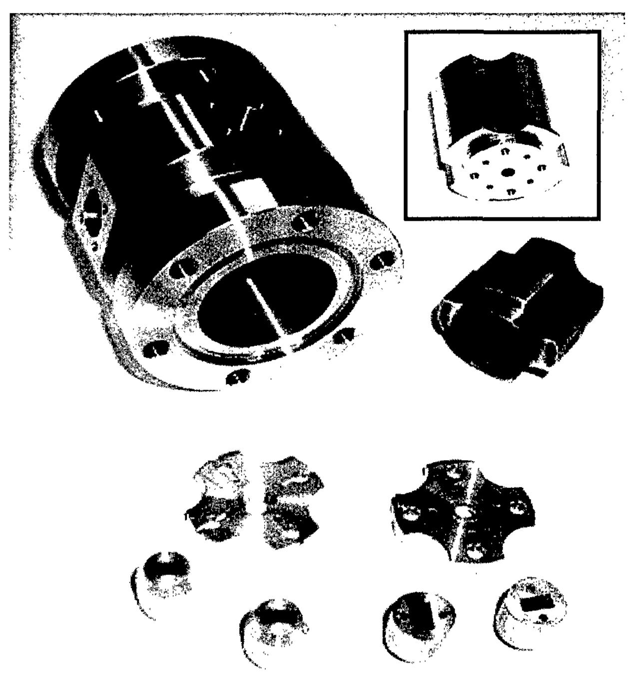

Figure 1. Major circuit components including the cavity, coupling irises, waveguide feed-throughs, vacuum nipple and beamstick (inset).

Present Status

The magnet has recently been re-tested with all of the associated pole pieces in place. Results showed almost perfect agreement with simulations performed using

Maxwell 2D® during the magnet design. The magnet power supplies were calibrated for the desired interaction field and several positions of the axial pole piece were tested to characterize tapering of the interaction field.

The device has been assembled with the beamstick in place of the circuit. The gun has been mounted and the entire device placed under vacuum. The cathode is currently being activated and initial beam transmission (at a reduced beam current) has been achieved. Successful beam transmission will lead to final assembly of the device with the circuit in place and RF testing.

The modulator intended for this experiment was recently completely re-designed and rebuilt. Operation of the modulator during a related W-band gyro-TWT experiment showed excellent pulse-to-pulse stability and reliable performance.

Problems discovered with the internal RF load have been temporarily addressed and a re-design of the load is in progress.

Conclusion

The UCD 34 GHz peniotron is being readied for testing with beamstick testing currently underway. Initial test results will be presented.

References

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