

Initial Operation of a High Power Cusp Gun*

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A cusp gun, designed to generate an axis encircling beam with low velocity spread for high harmonic, high power (70 kV, 3.5 A) operation in gyrotrons and peniotrons, has been successfully fabricated and hot tested at reduced voltage, in a beam tester designed to measure beam perveance, size, thickness, velocity ratio (beam alpha), and later, beam ripple and velocity spread. The correct beam perveance was observed, and a relatively thin, round, hollow beam, with approximately the correct dimensions, was imaged on the Cerium glass witness plate. The data indicated, however, that there was substantial current intercepted on the anode and excessively high beam alpha measured through the capacitive probes. Maxwell magnetic field simulations and EGUN trajectory simulations showed these results to be consistent with a substantial fraction of the electrons incident on the glass probe generating reflecting secondaries and/or re-reflected primaries, which back-stream through the capacitive probes and then are intercepted at the anode.

The design of the beam tester was therefore modified so that back-streaming from the glass probe would be removed. Beam transmission through the anode could then be accurately determined, and capacitive probe data could provide an accurate determination of the beam alpha. The modification was completed and hot testing continued. At normal operation of the gun at 10 kV, the beam transmission was as high as 98.5%. Furthermore, the beam alpha, calculated from the capacitive probes, was 1.42 to 1.48, compared to the EGUN prediction of 1.37 to 1.41 at the probes (and 1.49 to 1.53 in the circuit region). In another test, the polarity of the heater coil was reversed, and the measured drop in beam alpha was found to range between 0.07 and 0.14, compared to 0.14 in the EGUN simulation. In other tests, the beam transmission and beam alpha were measured and plotted over a full range of gun coil current and focus electrode voltage. In the next iteration, the beam tester will be modified to make it possible to measure beam ripple and velocity spread.

Many exciting opportunities exist for fast wave devices employing an axis encircling electron beam including slow wave cyclotron masers, broadband frequency multipliers and high harmonic gyrotrons and peniotrons. Two Cusp guns are currently being fabricated for the University of California - Davis for joint experiments with Northrop Grumman on fourth harmonic, 50 kW, gyrotrons and peniotrons operating at 94 GHz. Development of a higher perveance Cusp gun has also been proposed for use on an eighth harmonic 25 kW, 94 GHz gyrotron. The eighth harmonic W-Band gyrotron would be compatible with the use of a permanent magnet focusing structure, thereby offering the potential for small size and light weight.

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