Experimental Plan For 70% Efficient Relativistic Magnetron With Diffraction Output (MDO)

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***Abstract*— It was demonstrated via MAGIC [1] simulation that a relativistic magnetron with axial diffractive output (MDO) could operate at 70% efficiency [2]. In order to experimentally verify this, UNM's PULSERAD PI-110 electron accelerator was modified to provide a 350 kV, 30 ns flattop pulse with <4 ns rise time [3]. The MDO was characterized with a B-field scan at this voltage, where 6, 4, and 2 cavities are used to excite the downstream microwaves modes to be radiated. Behavior was predicted for a variety of cathode endcaps used to suppress the downstream drift of electrons; these endcaps include spherical, spherical dielectric coated, spherical magnetic, spherical magnetic dielectric coated, and conical. A diagnostic plan was made in order to capture power and microwave pulse shape/length for several potentially co-existing radiated modes using a calorimeter and microwave diagnostics, as well as measuring the microwave diode's voltage and current waveforms via D-dot and Rogowski probes. Finally, a pulsed insulating electromagnet system was recently finished.**

Keywords-magnetron; diffraction; diffractive; MDO; axial; MAGIC

I. Introduction

Preparations for the experimental verification of a 70% efficient MDO are in the final phase at UNM. Following a rebuild and redesign of the PULSERAD PI-110 to provide a 350 kV, 30 ns flattop, <4 ns rise time voltage pulse, a number of peripheral systems were constructed, including a pulsed electromagnet system and a high power microwave calorimeter capable of measuring energy depositions of less than 1 J. A variety of other diagnostics were also put into place. In addition, MAGIC simulations were performed in order to predict the power output with 6, 4, and 2 (of the magnetron's 6 cavities) used to excite the desired output mode and to predict the efficacy of a number of cathode endcaps that are to be used to block leakage current.

II. Experimental setup

A. Physical system highlights

The PULSERAD PI-110 accelerator's fast rise time is attributed to a low-inductance oil-breakdown switch that separates the pulse forming line from the final transmission line that feeds the magnetron. This will be the first-ever experiment to verify what is observed in simulations, that when the rise time of the applied voltage pulse is less than the cavity fill time for any mode in a vacuum HPM device, there is higher saturated output power. Furthermore, the MDO source will be very compact and quickly output a Gaussian-like antenna profile. This experiment will also be the first test of a variety of cathode endcaps in an MDO system, some which are to be coated with a thin layer of Rexolite dielectric and which are magnetic.

B. Diagnostics

Two D-dot probes will monitor the voltage waves on the PFL and final transmission line. A self-integrating Rogowski coil will monitor the diode current. To measure microwave power, a calorimeter with <1 J sensitivity was built, that would absorb ~70% of the incident power and allow the transmission of a fraction to an open waveguide so that the pulse profile and a time-frequency analysis could be captured and calculated. This open waveguide will also be swept in front of the antenna to calculate an integrated power.

In particular, the calorimeter employs an Arduino Uno microcontroller that measures the change in resistance in a changing volume of ethanol in a 2 mm inner diameter capillary tube, which is output to an LCD display and serial port. The microcontroller uses a nichrome heating coil and PID algorithm to heat the alcohol to just above room temperature and to pre-set the meniscus shape. A calibration coil is used to simulate the deposition of microwave energy.

III. Simulations

Simulations indicate 69% efficiency for an MDO when using 6 cavities to excite a TE_{21} output mode and greater than 50% efficiency when using 4 cavities to excite a TE_{11} Gaussian-like output mode.

References

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