200 KW CW, 350 MHZ MULTIPLE BEAM INDUCTIVE OUTPUT TUBE

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Abstract

Assembly is nearing completion of a 350 MHz, 200 kW CW, multiple beam, inductive output tube. The device incorporates seven electron beams interacting in a single, fundamental mode, output cavity. A single collector dissipates the spent beam power, and input and output power is transmitted in coaxial waveguide. Simulations predict 70 % efficiency with 23 dB gain. The tube is targeted for ion accelerators.

INTRODUCTION

Calabazas Creek Research, Inc. (CCR), in collaboration with Communications & Power Industries, LLC (CPI), is nearing completion of a 350 MHz, 200 kW CW, multiple beam, inductive output tube (MBIOT). This device is targeted for upgrade of the Advanced Photon Source (APS) at Argonne National Laboratory but will be applicable for a broad range of accelerator systems requiring RF power from 300 to 800 MHz. The MBIOT provides efficiencies higher than klystrons in a dramatically smaller device. The gain is limited to less than 24 dB; however, solid state drivers are commercially available providing several kilowatts of RF power. The principal challenge is designing an input cavity that will drive all electron guns at the same power and phase. This paper describes the design of the MBIOT and status of the assembly.

DESIGN

The MBIOT incorporates a single, coaxial input cavity to drive the seven electron guns. The tube uses electron guns produced by CPI for their single beam IOTs. The gun design is well established, and the performance has been verified through years of operation. Figure 1 shows the gun support plate and two of the guns.

Figure 1: Gun support plate with two guns.

Figure 2 shows an HFSS simulation of the input cavity electric fields. The axis of the device is the Y-axis. Input power enters through a coax waveguide from the right. Heater power is provided by the leads emerging from the back of the gun and coupling to the top wall in the image.

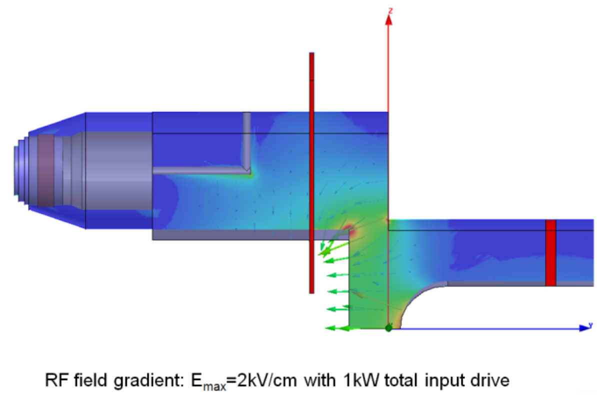

Figure 2: HFSS Simulation of MBIOT input cavity.

Figure 3 shows an HFSS simulation of the output cavity, with the beams entering from the left and the RF output power coupled to a coaxial waveguide on the axis. The external Q is determined by the penetration depth of the coax center conductor, which will be set during cold testing. The seven electron beams exit toward the right into a common collector that surrounds the output waveguide and window.

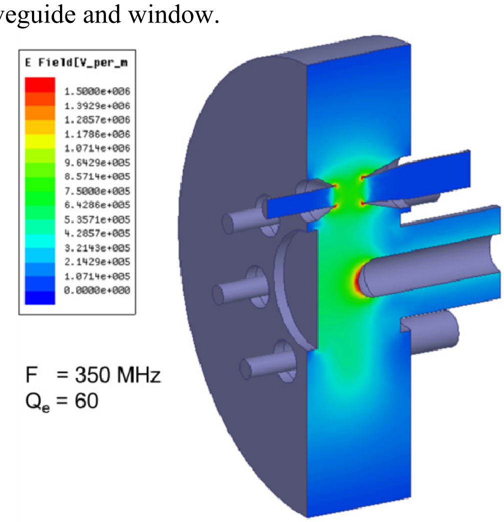

Figure 3: HFSS simulation of the output cavity.

Table 1 provides the performance specifications based on computer simulations. These satisfy the requirements for the APS upgrade and a number of anticipated accelerator systems.

Table 1: MBIOT performance specifications.

Parameter	Value
Frequency	350 MHz
Bandwidth	4 MHz
Output Power	200 kW CW
Gain	23 dB
Operating Voltage	30 kV
Efficiency	70%
Total Current	9.5 A
Number of Beams	7
Average current per beam	1.4 A

FABRICATION

Fabrication is almost complete with only a few assembly steps remaining. The seven guns are complete, as are the input cavity assembly, HV ceramic assembly, collector, and output window. Figure 4 shows a photograph of the input cavity assembly. Tuners behind each electron gun should provide some adjustment of the fields to balance emission from the seven guns. Figure 5 shows a photograph of the collector and output window and waveguide assembly.

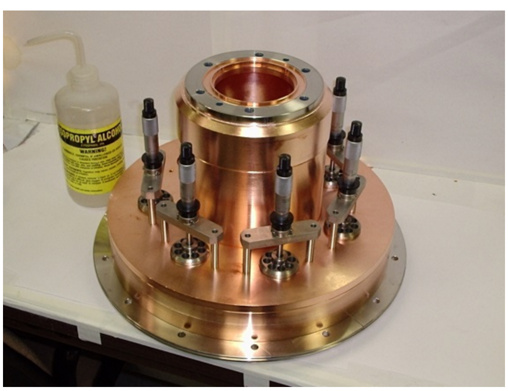

Figure 4: Input cavity assembly.

Several issues arose during assembly of the output cavity. Because of the presence of iron and numerous braze joints associated with the electron beams, brazing was a significant challenge. The differential expansion between copper and iron caused significant distortion of the large plates. Sufficient material was incorporated for subassembly machining; however, the distortion also impacted braze alloy flow. Consequently, numerous braze cycles were required before vacuum tight assemblies were achieved. These assemblies are now complete, and final assembly of the output cavity will begin when cold tests are completed. Figure 6 shows a solid model of the completed MBIOT.

Figure 5: Collector and output window and waveguide assembly.

SUMMARY

A multiple beam inductive output tube for accelerator applications is nearing completion. The device is designed to produce 200 KW CW at 350 MHz. The IOT incorporates seven electron beams driven by a single, coaxial input cavity and excites a fundamental mode output cavity. The tube is targeted for ion and proton accelerators and colliders.

ACKNOWLEDGEMENT

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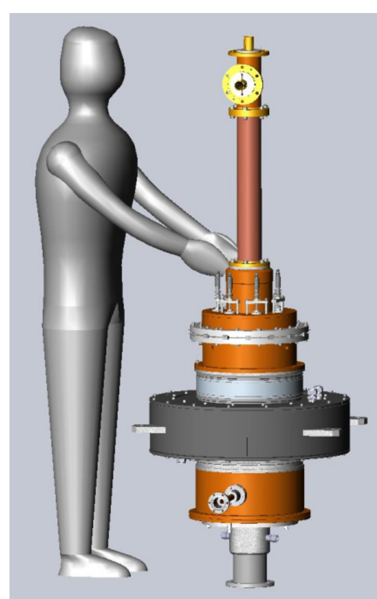

Figure 6: Solid model of completed MBIOT.

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