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X-Band Multi-Beam Klystron Design and Progress Report

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Abstract: *Progress on the development of a 5MW 16 beam x-band multi-beam klystron is presented. The power from each of the 16 klystrons is combined using a matched waveguide network. Mechanical and electric models and simulations are discussed. The status of procuring and assembling parts is presented.*

Keywords: klystron; multi-beam; modular;

Introduction

Combining the power of several single beam klystrons is an attractive option for scaling power. It reduces the design of multi-beam klystrons (MBK) to the design of a combining network and a single beam klystron [1]. This approach was used to design a 5MW X-band klystron with the design specifications summarized in Table 1.

Table 1. Klystron Design Specification

Beam Voltage (kV)	60
Beam Current (A)	8.8
Frequency (GHz)	11.424
Output Power (MW)	5
Beamlets	16
Beam Focusing	PPM
Cathode Loading (A/cm^2)	< 10
Efficiency (%)	60+

A 16 port combining network is shown in Figure 1. This design was optimized in HFSS to match all 16 ports and sum them into one common output waveguide. This process was used to combine the power from 16 independent output cavities.

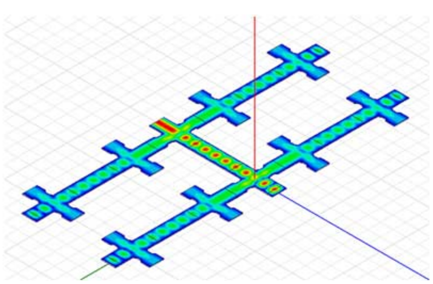

Figure 1. Waveguide Combining Network for 16 Klystrons.

Mechanical and RF Design

The mechanical design for the MBK has been completed and the long lead items have been ordered. Assembly of the klystron is expected to commence in mid-2015 starting with the construction of a single beam klystron, followed by a 4 beam MBK and finally the full 5MW 16 beam MBK. A preliminary version of the mechanical model is shown in Figure 2 (in later versions of the design the copper waveguide combining scheme has been modified mechanically to provide more structural support).

Figure 2. Mechanical Model of an Individual Klystron and Four Klystron MBK.

The potentials and gradients in the gun were evaluated and are shown in Figure 3. For the required beam pulse lengths, the gradients in the gun and ceramic are within acceptable limits.

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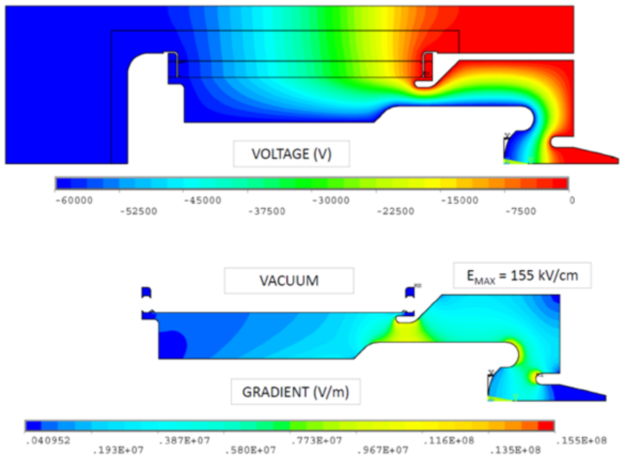

Figure 3. Gun Potentials and Gradients.

The periodic permanent magnetic (PPM) stack was simulated in both 2D and 3D. The 2D Superfish simulation is shown in Figure 4. In this stack the pole pieces are extended radially to shunt the field in the entrance region. This produces a magnetic field that gets stronger with distance to counteract the space charge in the beam as it bunches.

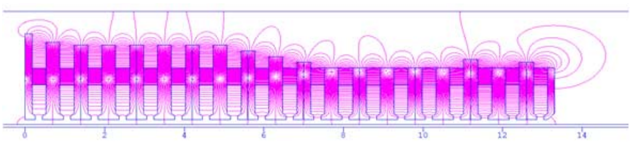

Figure 4. Periodic Permanent Magnetic Stack.

Figure 5 shows the behavior of the beam as it bunches and propagates through the circuit, collector and PPM stack. The beam is well behaved and maintains a nearly constant beam envelope throughout the circuit. The beam ultimately expands into the collector with little interception on the circuit walls.

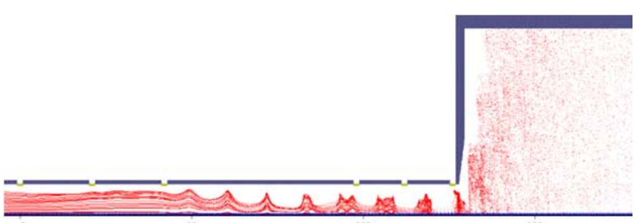

Figure 5. Circuit and Collector Simulation in MAGIC2D with RF.

The power densities in the collector were evaluated and found to be within acceptable limits. Figure 6 shows the power density on the collector wall as a function of distance. The power density was evaluated for both the DC beam and the RF beam.

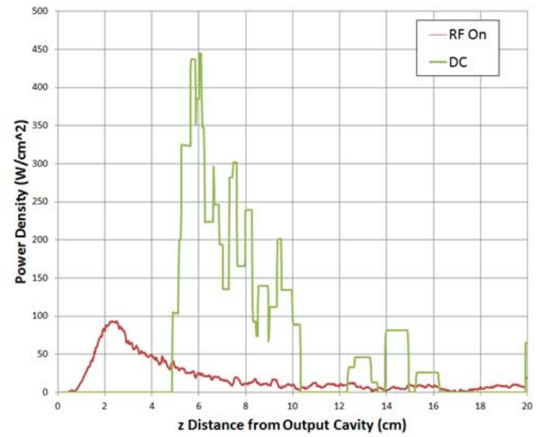

Figure 6. Power Densities in the Collector

Summary

The mechanical and electrical design for a 5MW x-band MBK using a waveguide combining network have been completed. Parts for the MBK have been ordered and are expected in mid-2015 at which point assembly of the device will begin.

Acknowledgements

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References

1. Jensen, A. J., S. Tantawi, and J. Neilson, “A Modular 5MW X-Band Multi-Beam Klystron,” *IEEE International Vacuum Electronics*, April 22-24, 2014.