

A MAGNETRON INJECTION GUN WITH INVERTED GEOMETRY FOR AN 80 MW GYROKLYSTRON

M.E. Read, R.L. Ives and G. Miram, Calabazas Creek Research Inc., Saratoga, CA 95070-3753
 G. Nusinovich, W. Lawson and V.L. Granatstein, IREAP, University of Maryland, College Park, Maryland

Abstract

A 500 kV, 500 A magnetron injection gun (MIG) is being developed for the University of Maryland Ku-band, coaxial gyrokyklystron. The gun will have three electrodes, with the cathode at a larger diameter than the intermediate electrode, thus being an inverted form of the normal geometry. This allows the gyrokyklystron's inner conductor to be supported through the electron gun, eliminating the need for the beam-intercepting supports and facilitating cooling. It also allows for adjustment of the coax position external to the vacuum. Details of the design, including modeling of the beam trajectories, are discussed.

GEOMETRY

The gun is a replacement for the MIG used in the University of Maryland Gyrokyklystron[1] shown in Figure 1. With a conventional MIG, the inner conductor must be supported from the collector and/or beam-intercepting pins in the cavity region. Due to the use of the collector as the output waveguide, pins are the only supports in the existing experimental device. This limits the pulse repetition rate. Even if this restriction is removed by extracting the RF via the side of the gyrokyklystron, supporting the inner conductor from only the collector

requires an undesirable reversal of the cooling flow. Replacing the gun with the cathode on the outside, in an inverted geometry as shown in Figure 2, allows the inner

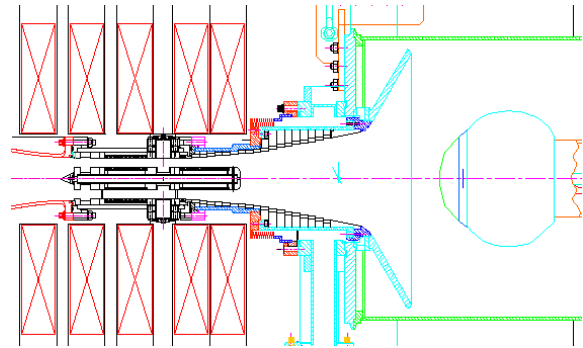


Figure 1. University of Maryland gyrokyklystron with a conventional MIG

conductor to be supported by the "modulating anode" of the gun. The mod anode is at ground potential, allowing it to be supported from the outer, grounded shell by two posts. This arrangement allows for coolant for the inner conductor to flow in one direction. The posts can be sealed to the vacuum envelope by bellows, allowing fine

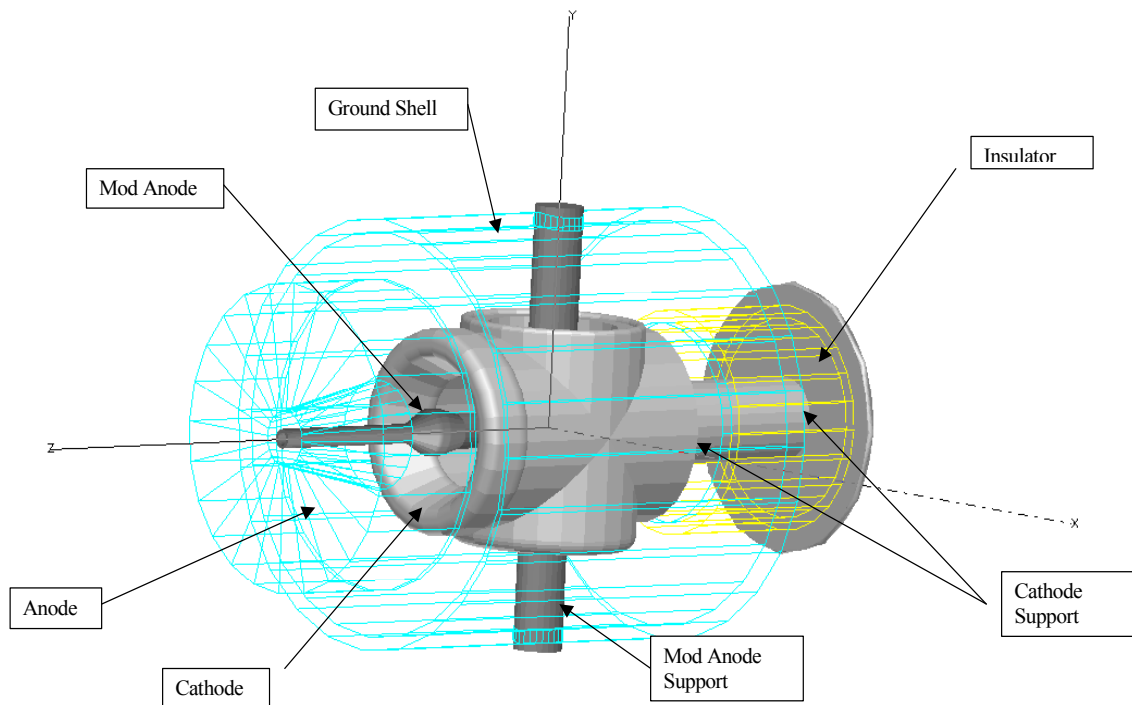


Figure 2. Geometry of the inverted MIG.

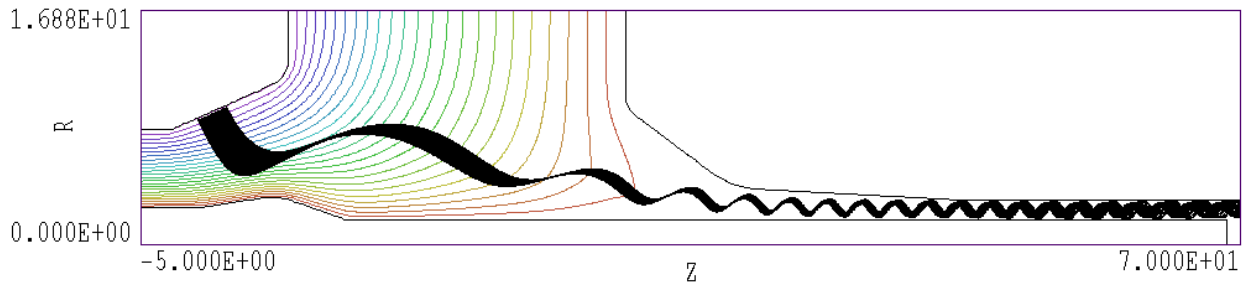


Figure 3. Trajectories of the inverted MIG as calculated using TRAK. Dimensions are in cm.

adjustment of the position of the mod anode, and hence the inner conductor, if needed.

BEAM SIMULATIONS

Simulations of the beam trajectories were done using TRAK[2]. This code is well documented and has been used for a number of gun simulations by the authors. It agrees very well with EGUN [3] and has the advantage of a variable mesh that allows modeling of the problem without continuations, as would be required in EGUN to handle the small orbits of the fully compressed beam. The results of a TRAK simulation are shown in Figure 3. For a beam current of 550 A, an average ratio of perpendicular to parallel velocities, alpha, of 1.49 was achieved with a spread in the perpendicular velocities of 0.6%. The spread in parallel velocities was 1.3%. These spreads are due to the optics only, and thermal and surface roughness contributions will decrease the beam quality. The optics-determined values are significantly lower than those achieved with the conventional design, where the spread in parallel velocities was about 7%.

The dependences of alpha and the velocity spreads on the beam current are shown in Figure 4. The design is clearly optimized for about 525 A, with the velocity spread rising for both lower and higher currents. The design could be optimized for another current. In this design, the parallel velocity spread is less than 2.1% over the range of 100 A – 600 A.

It is important to include not only space charge effects, but also self magnetic fields in the calculation. With inclusion of the latter, alpha rises to 1.7 and the parallel velocity spread is 1.5%.

A disadvantage of the inverted geometry is that the fields on the mod anode higher than normally found in gyrotrons to obtain the electric fields at the cathode required for proper beam formation. The fields for the current design are shown in Figure 5. The peak field on the mod anode is 150 kV/cm. This is high for a CW gun, but is not high for a ~1 microsecond pulse gun, particularly considering that mod anode is a positive electrode.

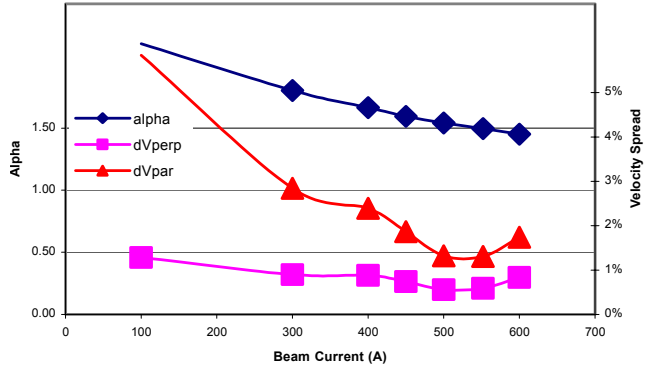


Figure 4. Ratio of perpendicular to parallel velocities, alpha and velocity spreads as functions of beam current.

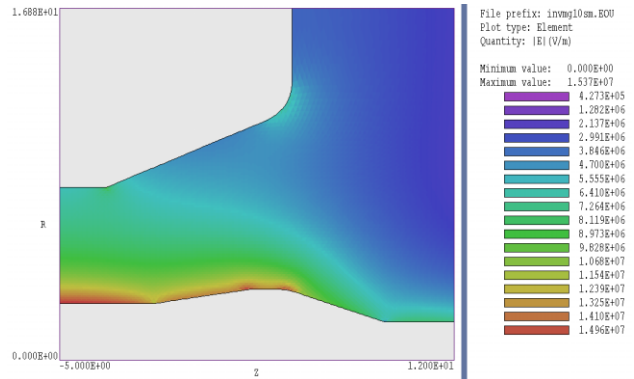


Figure 5. Electric field magnitudes.

ACKNOWLEDGEMENT

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1. V. L. Granatstein and W. Lawson, IEEE-PS, v. 24, p. 648, (1996).
2. S. Humphries, www.fieldp.com (2003).
3. W.B. Hermansfeldt, SLAC Report 226, Sanford, CA, Nov, 1979.