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# 100mA Electron Gun for Ku-Band Helix TWT

**Manish Kumar Saini and Parikha Chawla**

*CBS Group of Institutions, Jhajjhar, Delhi (NCR)*
*E-mail: manishsaini9@yahoo.co.in, parikha.chawla@gmail.com,*
*Ph. No. 9468649504*

**Abstarct**

A dual anode electron gun has been designed using EGUN for Ku-band 140W short length space Traveling Wave Tube (TWT). Pierce type electron gun with an electrically isolated beam forming electrode (BFE), a control anode and an ion barrier anode (A0) in addition to ground has been opted. Due considerations have been given in the design of gun assembly to ensure the long life (>10 years) and high reliability. A PPM circuit with confined beam flow focusing has also been designed with Sm2Co17 magnets using inhouse developed code MAGFLD. A good beam laminarity and beam ripples (<5%) have been obtained. An electron gun assembly has been designed and developed with due considerations for high voltage and thermal considerations from space TWT point of view.

## Design of Electron Gun

Electron gun is an important part of any microwave tube devices which plays significant role in obtaining the desired performance of the device. In the TWTs for space applications, electron gun design needs due considerations for long life, high reliability, and linearity.

For the development of Ku-Band 140W short length space TWT, An M-type dispenser cathode with low cathode emission loading (~1.0 Amp/cm2), low cathode operating temperature ~950oC at heater power around 3.0 W with suitable heat shield and cathode support has been selected to ensure the desired long life of more than 10 years and high reliability. The control anode has been employed in order to regulate the beam perveance of the device without changing the accelerating ground voltage. The application of about +100 volts at the ion barrier anode with respect to ground anode (A1) protects the cathode surface from the ion bombardment and hence enhances the life and reliability of the tube. Application of BFE negative bias of the order of 10 to 20 volts with respect to the cathode is used to achieve the overall beam transmission in the tube of the order of 99%, which is an essential requirement for a

CW space TWT. Electron gun with above features as been designed to achieve beam current ~ 100 mA at 6.0kV anode potential (A0), 5.9kV at ground anode (A1) with respect to cathode, and ~ 0.27mm beam waist radius. The potential at control anode is 1.6kV with respect to cathode. Fig.1 shows the optimized electron gun simulation with the desired potentials, using EGUN code. The enlarged view of the same is shown in Fig.2.

Dependence of the beam current on various geometrical and electrical parameters has been simulated using EGUN code in order to determine the tolerances in the various critical parameters. Dependency of the beam current on the control anode voltage and control anode axial position with respect to cathode has been analysed. It has been observed that with the variation of ±50 V on the control anode there is a variation of ±4 mA in beam current(Fig.5) With the change in the axial position of the control anode by ± 0.05 mm, the current varies as ± 3.9 mA (Fig.6). The effect of BFE negative bias on beam current and on the beam waist radius has been studied. It has been observed that with the application of negative bias beam current has been reduced on an average by 4 mA/-10 V (Fig.7) and beam radius has been reduced by 40 micron on the application of -10 V.

**Design of PPM focusing**

The beam focusing is also a critical issue in order to ensure the beam transmission of the order of 99%. Confined flow with optimum magnetic flux linked to cathode (Buches theorem) is used for achieving the beam with good laminarity and least scalloping. The PPM focusing with RMS value of PPM field twice the Brillouin field is used. The gun adopter has been designed with two materials, inner portion with non-magnetic material and the outer portion with the magnetic material in order to achieve the desired magnetic flux coupled at the cathode for the confined beam flow focusing.

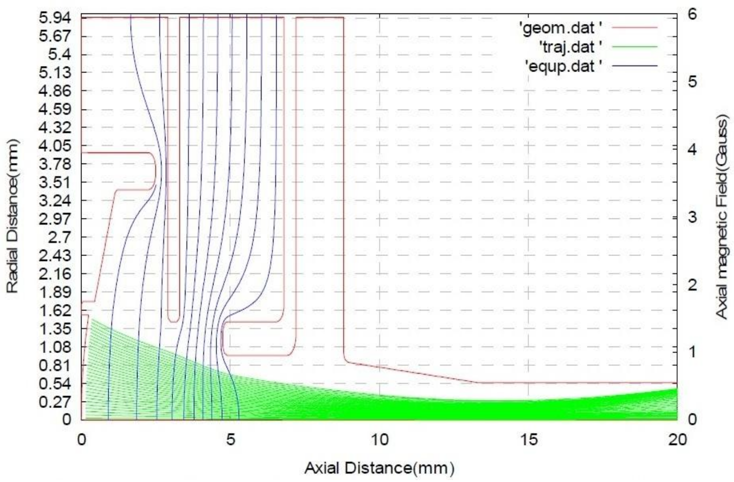


**Fig.1: EGUN Simulated electron beam flow**

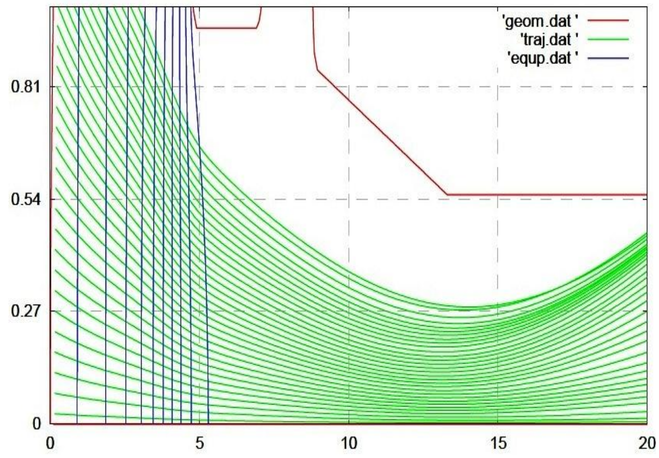


**Fig.2: Enlarged view showing beam laminarity**

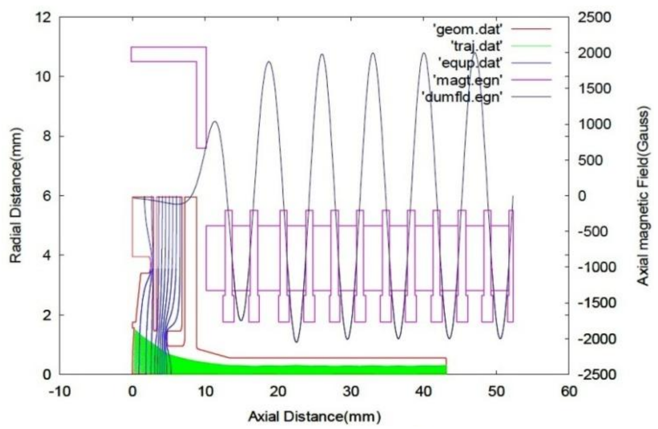


**Fig.3 Beam flow under MAGFLD designed magnetic field profile**

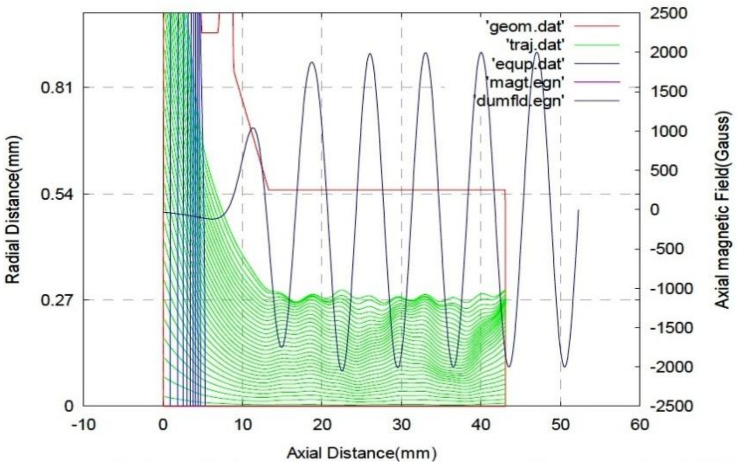


**Fig.4: Enlarged view of beam flow under PPM**

Design and optimization of PPM beam-focusing system has been accomplished through in-house developed code MAGFLD. The design of PPM beam focusing circuit includes the design of gun end pole piece, pole piece of magnetic circuit, Sm2Co17 magnets for the optimum axial magnetic field profile along with linkages of ~ 30 Gauss magnetic flux at the cathode. The EGUN simulated beam flow under the influence of MAGFLD designed PPM axial magnetic field profile is shown in Fig. 3. The beam scalloping is within 5% maintaining the beam laminarity as shown in Fig.4, an enlarged view of the beam simulation under optimized PPM profile.

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