DESIGN STUDIES OF A TRIODE MIG AND OUTPUT WINDOW FOR A 30/60 GHz DUAL-FREQUENCY GYROTRON

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ABSTRACT

This study presents a Triode Magnetron Injection Gun (TMIG) for a dual-frequency gyrotron, targeting operation at 30 GHz and 60 GHz, each with output power exceeding 200 kW. To achieve the gyrotron's specifications under various technological constraints, the $TE_{4,2}$ and $TE_{9,3}$ modes are chosen for operation. The selection of a TMIG is based on its effectiveness in controlling the beam parameters [1]. In the context of a dual-frequency gyrotron, while the physical dimensions of components designed for one frequency remain unchanged, parameters like beam radius and compression ratio vary with the frequency. Achieving the required beam conditions involves modifying the magnetic field strength and profile in the device, necessitating changes in currents applied to the solenoid coils. Precise optimization of both the TMIG and the magnetic field distribution is crucial to produce a high-quality beam with minimal electron velocity spread, thereby enabling efficient beam–wave interaction and power transfer to the desired operating modes. Initial determination of T-MIG parameters is carried out using the latest version of in-house code GDS.V.2024 [2]. Subsequent optimization is conducted through particle trajectory commercial code EGUN, ensuring accurate prediction of beam parameters while integrating the required magnetic field profile [3]. A four-solenoid magnet system is employed to generate the required magnetic field distribution, comprising a central main coil with two auxiliary coils to establish the required static magnetic field along the interaction cavity and a dedicated gun coil positioned in the emitter region for the initial formation of the quasi-laminar electron beam. The operating magnetic fields are 1.07 T and 2.14 T. Assuming a device efficiency of around 40 %, the required electron beam radii are estimated to be 4.98 mm and 7.68 mm to excite modes $TE_{4,2}$ and $TE_{9,3}$ in the cavity for this dual-frequency operation at 30/60 GHz, respectively. In addition, window design studies are carried out considering both sapphire and SiN as candidate window materials [4]. The window design is performed for a Gaussian beam with radial output coupling and an estimated window aperture radius of 50 mm.

References

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