INITIAL DESIGN STUDIES OF A > 200 kW, 30/60 GHz, DUAL-FREQUENCY GYROTRON

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ABSTRACT

Gyrotrons offer a variety of Industrial, Scientific, and Medical (ISM) applications in millimeter-wave and sub-terahertz regimes starting from plasma heating in tokamaks to medical spectroscopy and industrial heating [1]-[2]. To address specific industrial-heating and plasma-diagnostic requirements in India, the feasibility of dual-frequency gyrotrons operating at 30 GHz and 60 GHz with output powers exceeding 200 kW is investigated. Both frequencies correspond to operation at the fundamental cyclotron harmonic (s=1). These requirements motivate the initial design studies reported in this work.

In the calculations, suitable mode pairs supporting the same cavity radius and caustic radius, while simultaneously satisfying the window transparency condition, are identified [3]. Also, the modes selected should support the same magnetron injection gun, interaction cavity structure and output system. After a careful mode selection calculation for dual frequency operation at 30/60 GHz, two modes, $TE_{4,2}$ mode at 30 GHz and $TE_{9,3}$ mode at 60 GHz are chosen.

In the next step, starting currents and diffractive quality factor times coupling coefficients are computed considering the main mode and the probable competing modes, to study the mode competition for a suitable cavity geometry supporting dual-frequency operation. These studies ensure that the chosen modes are well separated from their competing modes. In the succeeding steps, cavity design and self-consistent (single mode and time-dependent multi-mode) computations are carried out to estimate the output power and efficiency. All the computations are carried out with the latest in-house computational code Gyrotron Design Studio (GDS.V.2024) [4]. The initial feasibility design studies indicate that such a dual-frequency fundamental harmonic operation is feasible for achieving output powers (200 kW) with electronic efficiency ≈ 42 % using the selected modes. Further studies on RF-behavioral aspects are currently in progress.

References

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