

Design and Electromagnetic Analysis of an Input Cavity for 648MHz Inductive Output Tubes



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Abstract

Inductive Output Tubes (IOTs) are high-power RF amplifiers that require efficient electron bunching and stable RF coupling. This work presents the design and electromagnetic analysis of a 648 MHz IOT input cavity using CST Studio Suite. With a -70 kV cathode potential and 350 V grid bias, the cavity achieved an S_{11} of -30.11 dB at 648 MHz, while the simulated RF voltages reached 54.83 V and 59.02 V at two monitoring positions. The results demonstrate effective impedance matching and a suitable RF field distribution for beam modulation.

Introduction

Inductive output tubes are highly efficient and compact microwave power amplifiers for applications that require high efficiency and linearity in the UHF to L-band range. The input cavity is the critical component that couples RF power into the device while maintaining precise field control for optimal beam modulation. At 648 MHz, the cavity must achieve low reflection, stable resonance, and sufficient RF voltage across the small cathode-grid gap. This study presents a re-entrant input cavity design and evaluates it through electromagnetic and beam-dynamics simulation for high-power IOT development.

Cavity Design & Methodology

The 648 MHz input cavity was designed with an anode attached to the cavity shell and integrated with a loop coupler, 5 mm Al_2O_3 insulator, cathode, window, focus electrode, and grid. The cavity was optimized using CST Studio Suite under a cathode potential of -70 kV and a grid bias of 350 V, with sinusoidal excitation at 648 MHz. Electromagnetic and particle-tracking simulations were used to evaluate RF coupling, field distribution, and beam interaction within the cavity.

Cavity geometry & Simulation

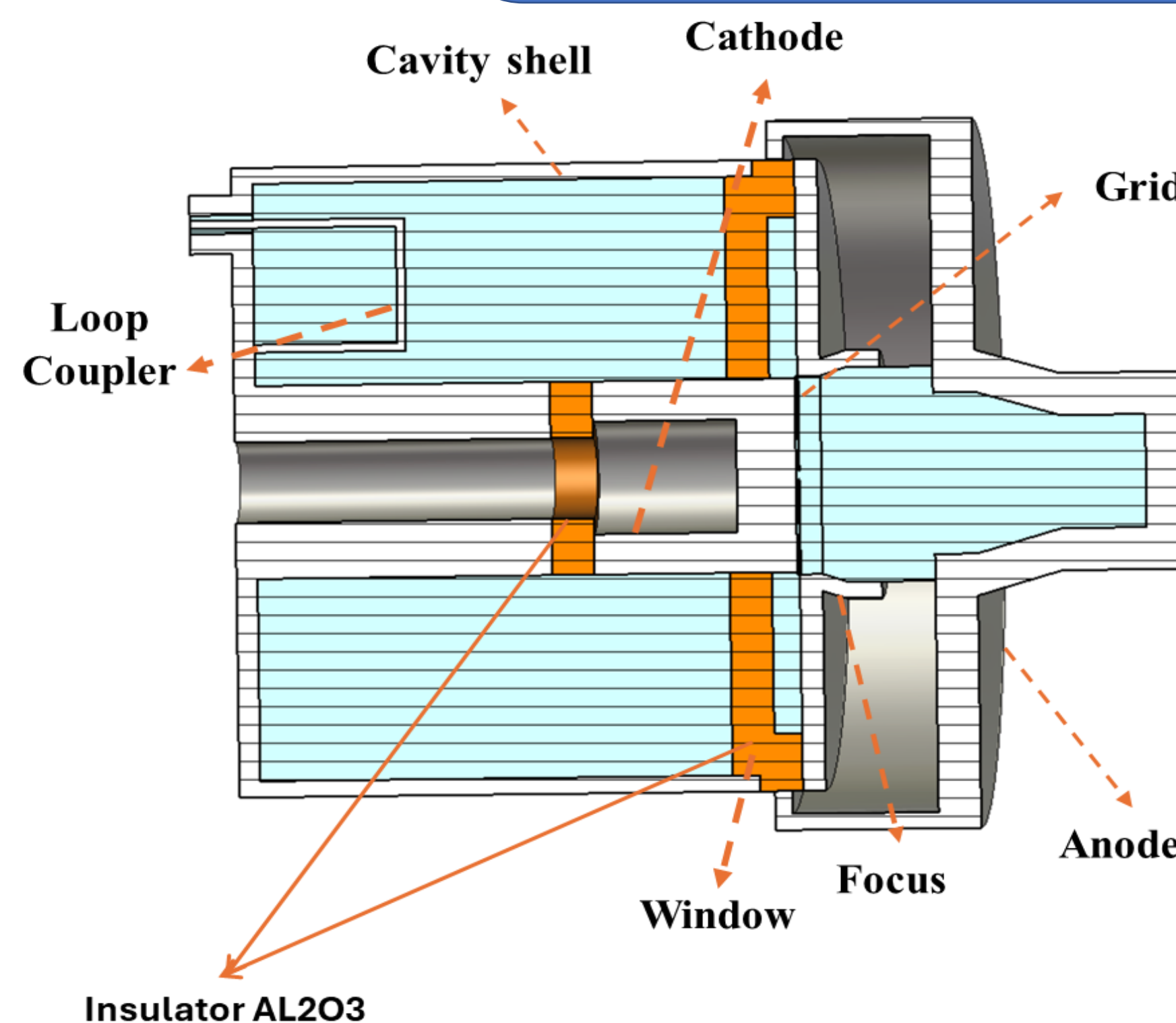


Fig.1. Proposed 648MHz input cavity

Simulation setup

- Target frequency: 648 MHz
- Cathode potential: -70 kV
- Grid bias: 350 V
- Sinusoidal RF excitation
- Al_2O_3 insulator: 5 mm
- Voltage monitors: center and 5 mm offset

Results

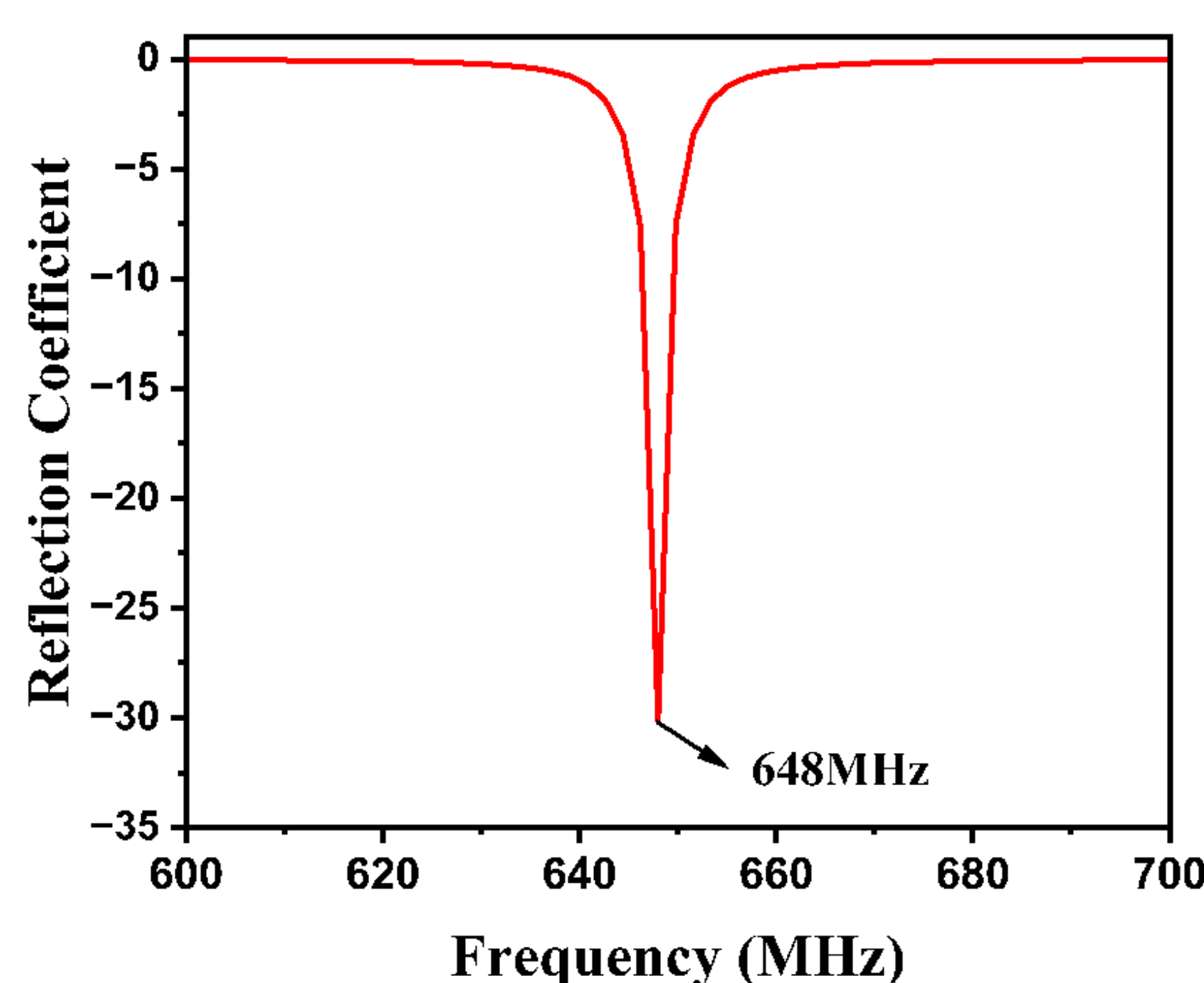


Fig. 2. Reflection Coefficient

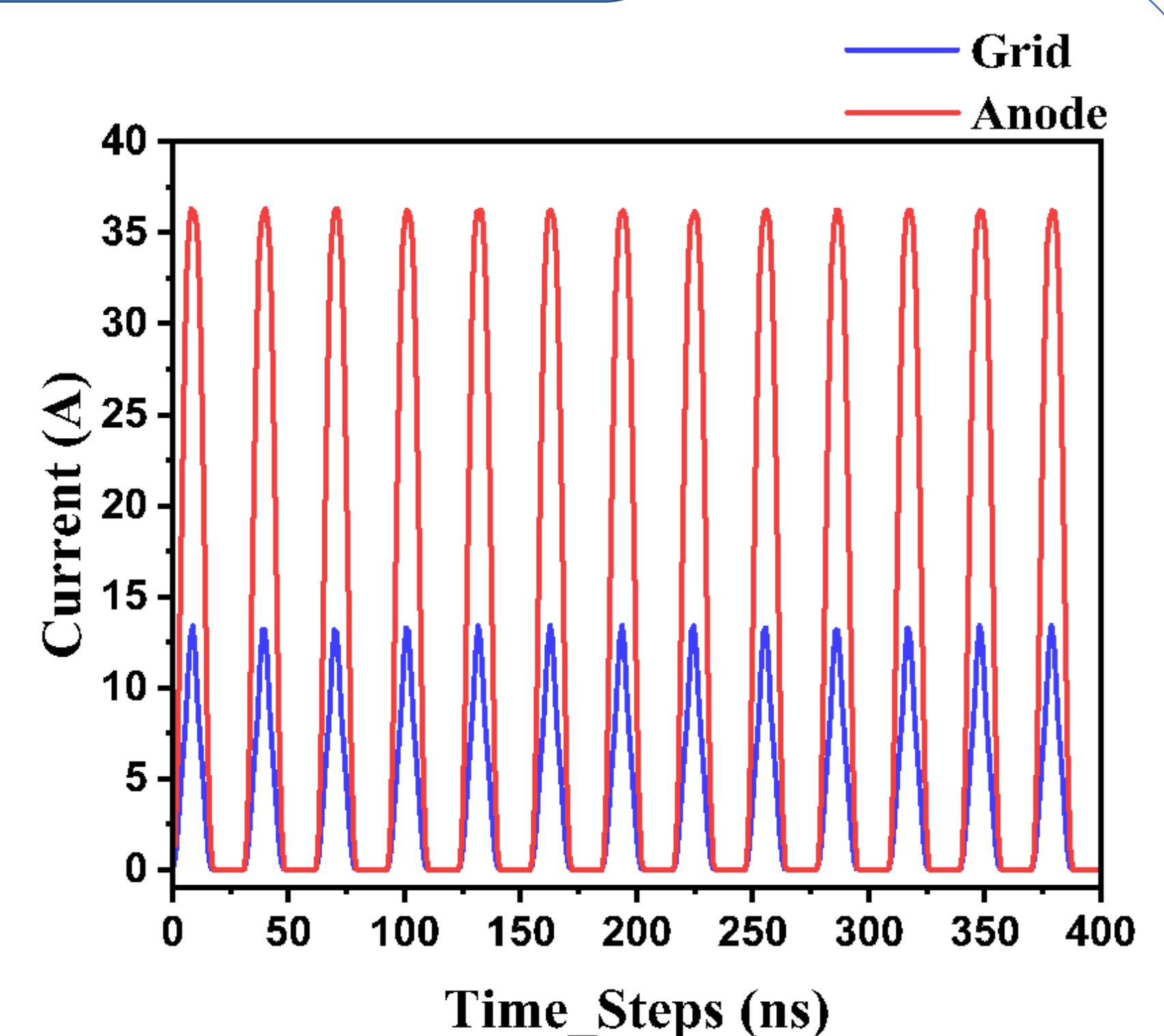


Figure 3. Current Collision on anode and grid

Results Discussion

The electromagnetic simulation achieved an S_{11} of -30.11 dB at 648 MHz, indicating excellent impedance matching and effective RF power transfer. The simulated peak voltages were 54.83 V at the cavity center and 59.02 V at a 5 mm offset, demonstrating a suitable RF field distribution for beam modulation. Particle-tracking results also showed current collision behavior on the anode and grid, supporting the feasibility of the proposed cavity for IOT operation.

Reference

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- [2] R. L. Ives et al., "Inductive output tube development," IEEE Transactions on Electron Devices, vol. 52, p. 673, 2005.