Seminar

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Institute for Plasma Research

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Title: Design and Performance Improvement Studies of Millimeter Wave Gyro-Twystron Amplifiers

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Date: 21st July 2023 (Friday)

Time: 3.30 PM

Venue: Committee Room No. 3, IPR

Abstract

The desire to bridge the millimeter-wave and submillimeter-wave technology gap in the high-power regime, where numerous civilian and military applications exist, has led to significant research and development in fast-wave gyro sources and amplifiers. Although one such gyro-source, the gyrotron, is now commercially available for applications such as plasma heating and material processing, gyro-amplifiers such as the gyro-klystron and the gyro-TWT have emerged as successful amplifiers for millimetre radar systems, they each have their own set of drawbacks. To mitigate the issues and combine the advantages of both devices, a hybrid device known as a gyro-twystron is introduced.

The gyro-twystron amplifier is created from the gyroklystron and gyrotron travelling wave tube (gyro-TWT) amplifier. This hybrid amplifier integrates the merits of both amplifiers, resulting in a high power-bandwidth product and a gain-bandwidth product. Despite these aspects, the gyro-twystron is the gyrotron family's most undiscovered device. These benefits and uses have sparked the curiosity of research to improve the potential capabilities of a gyro-twystron for applications such as RADARs, Plasma Research, and Industrial application in the millimeter-wave frequency band.

Mainly focus on a different configuration of gyro-twystron, using various techniques to improve the performance of gyro-twystron for various aplications. The present work concentrates on the design, multimode beam wave interaction behavior, and simulation of *Ka*-band gyro-twystron amplifiers utilizing nonlinear theories and the 3-D Particle-In-Cell (PIC) simulation code. This work describes the many design challenges associated with gyro-twystron amplifiers and formulates the design methodology. One of the main challenges in achieving high-power operation with gyro-twystron is ensuring stability, as the output waveguide section is susceptible to parasitic instabilities and backward wave oscillations. To address this issue, a nonlinear multimode analysis is employed to study the growth of operating modes and competing modes in the RF interaction structure of a *Ka*-band gyro-twystron. This analysis predicts that unwanted spurious oscillating modes can cause instability in the amplifier's operation. To suppress these spurious modes, a short periodic dielectric loading (PDL) is introduced in the output waveguide section, effectively suppressing the unwanted oscillations. Additionally, a stability analysis of the PDL gyro-twystron is performed. The design process that determines the interaction structure dimensions and beam parameters of gyro-twystron is structured or composed. Simultaneously with the designing process, the modeling of interaction structures is carried out to present their 3D view. The design computation is validated by the 3D RF wave propagation investigation. Design, modeling, and simulation of subassemblies such as input coupler, Magnetron Injection Gun (MIG), collector, and RF window address the challenge of inclusion with an interaction structure.