Seminar

Institute for Plasma Research

Title : Thermo-Mechanical Analysis and Simulation of Helix TWTs

Speaker : Dr. Vishant Gahlaut

Asstt. Prof., Banasthali Vidyapith University, Rajasthan

Date : 16th April 2021 (Friday)

Time : 03:30 PM

Venue : Online- Join the talk:

https://meet.ipr.res.in/Dr.VishantGahlaut_PDFTALK

Abstract:

Travelling Wave Tubes (TWTs) find wide applications in defense, ground and satellite communication due to its wide bandwidth and unique combination of power, gain and efficiency (Fig. 1). With the modern technologies and design concepts, this device is being designed successfully but a lacuna remains for proper thermal management. Proper thermal management of helix TWT enhances its average power handling capabilities. Interception current along with other losses, namely resistive loss, circuit loss, reflection of RF power due to mismatch of the helix with couplers, etc., enhances power loss in the helix and also increase the helix temperature which can lead to the damage of TWT. Also, poor thermal management of the helix restricts the average power handling capability of the TWT. With the increase in helix temperature, the helical pitch may get deformed which leads to the alteration of impedance and decrement in efficiency of the device. Change of impedance (characteristic) enhances the mismatch of helix with the coupler causing oscillations and generation of more heat in the helix that ultimately can damage the TWT. Hence, for efficient heat dissipation from helix, thermal contact resistance (TCRs) at different joints of dissimilar metals must be very less. The thermal management problem of TWT becomes mandatory if it is to be used for space application where reliability, weight and cooling of the heat sink are critical concerns [1-9]. Thus, TWTs for space applications demand efficient heat dissipation from the helix without deterioration of its performance over a long operational period. TWTs, for space applications, need intensive thermal and structural analysis before putting it into the space because in case of any failure, they cannot be replaced unlike the ones installed for ground applications.

This motivates us to take-up the thermal management of helix TWT and the establishment of an experimental setup for measuring the helix temperature practically, as the proposed work. The aim is to develop analytical and simulation models of slow-wave structure (SWS) for TWT for space applications operating in fixed ambient temperature as well as typical custom-made environment conditions. Heat-dissipation capability of SWS in TWT is one of the influencing factors that can contribute to obtain high average output power. The thermal performance of SWS can also affect the stability and reliability of the TWT. Hence, the main goal of this work is to develop a thermal model for SWS, that is the most important and critical part of the tube, as it plays a significant role in performance and efficiency of satellite transponder (Fig.2). In fact, TWT operating conditions are exposed to high temperatures, which can influence their reliability. Therefore, the methodology has been developed and implemented at the design stage and would lead to better outcomes related to improved thermal properties and corresponding performance along with the reliability parameters. One of the advantages of practical modeling over the analytical design is the ability to analyze the performance of the device under real boundary conditions without seeking the need of simplifying the physical phenomena or neglecting any geometrical details. An experimental measurement setup has been inculcated for validating the analytical model for measuring the temperature distribution in helix for TWTs to be used in space applications in typical working conditions.