Seminar

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Institute for Plasma Research

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Title: Design and Development of Liquid Stub Tuner and Liquid Phase Shifter for Antenna-Plasma Coupling Impedance Matching for High Power RF Experiments.

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Date: 04th September 2023 (Monday)

Time: 3:30 PM

Venue: Seminar Hall, IPR

Abstract

Impedance of plasma consists of resistive as well as inductive part. Resistance varies in the range of 0.5 to 5 Ohm while susceptance part varies from 10 to 50 Ohm. The impedance of RF generator is normally 50 Ohm. This necessitates the matching of plasma impedance with the source impedance for maximum power transfer. In this study the research and development activity was performed for the impedance matching by liquid stub tuner technique. The matching network consist of rigid transmission line, phase shifter and stub tuner. Both conventional phase shifter and stub tuner use the concept of finger contact (also termed as plunger) for the variation of impedance and admittance, respectively. However, it is risky to move the finger sliding joint of phase shifter or shortened finger joint of plunger for stub during the high power ICRF heating. These finger contacts can cause the breakdown due to kilo-amperes of RF current flowing through them during MW level of RF heating. Consequently, the liquid stub tuner presents itself as a superior alternative to conventional tuners since it mitigates the risks associated with moving the stub tuner's short-end or the phase shifter's sliding joint during high-power ICRF heating. Also, the absence of sliding contact makes it as a best option for matching during the long pulse operation of high RF voltages. Its functionality is based on the difference between the RF wavelengths in the liquid and air, which arises due to their differing relative dielectric constants.

The proposed work focuses on the development of a 1-5/8" liquid stub tuner and phase shifter with impedance matching for transmission of radio frequency (RF) signal at the ion cyclotron range of frequencies. The main objective is to transfer maximum power from the transmitter to antenna for Steady-State Superconducting and Aditya Tokamak system. The liquid stub tuner is connected to the coaxial transmission line to sustain impedance matching. The design and characterization of liquid stub tuner specifically focusing on induced susceptance over a wide frequency range of 10 MHz to 100 MHz has been presented. The concept relies on exploiting the different relative dielectric constants of liquids and air, which causes RF wavelengths to travel differently in these media. Experimentally achieved susceptance of the developed liquid stub tuner is validated through CST simulation and numerical analysis. The verified approach is applied to the single stub matching technique. The theoretical analysis shows the mechanical advantages of the liquid stub tuner over conventional stub tuners. Additionally, the liquid stub tuner eliminates the need of finger contact-based sliding mechanisms by utilizing liquid height movement, which prevents development of spark caused by flow of high current in finger contacts used in moving plungers in conventional air dielectric stub tuners.

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