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Design and Simulation of Circular Waveguide Elbows Applicable in High Power Microwave (HPM) Coupling to Plasma

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SYstem for Microwave PLasma Experiments (SYMPLE) is an experimental system set up at the Institute for Plasma Research (IPR), Gandhinagar, India, to investigate the physics of linear and nonlinear interaction of high-power microwave (HPM) with plasma. BWO based HPM source, proposed to be used for these studies, generates pulsed (˜50 ns) microwave power of ˜500MW at 3GHz frequency in TM01 mode. The BWO output power is extracted via an oversized circular waveguide of radius 15 cm. A transmission system is required between the HPM source and the plasma in order to couple the HPM power to plasma and to carry out measurements of forward and reflected microwave power. This transmission system will need a few elbows which can maintain same operating frequency, power level and propagating mode.

Understanding of HPM compatible waveguide elbows assumes further significance due to their applications in modern HPM systems in general. In the design of waveguide elbows, two considerations are of foremost significance. One is the minimization of the return loss as well as maintainability of mode purity in a frequency band as wide as possible and the other is the minimization of the size of the elbow.

Various configurations of elbows have been subject to analysis by the solver, CST Microwave Studio, for efficient transmission of power while maintaining the operating frequency and propagating mode. Irrespective of the shape of elbows used, those with gradual bends have been found to perform better compared to 90 elbows, in terms of power loss and frequency/mode shift. Further, of the various configurations studied, Z-shaped, L-shaped, U-shaped and Pi-shaped elbows are found to perform relatively better. Performance of circular waveguide elbows having configurations discussed above has been studied in detail in the present work. Observations show that, at 3 GHz frequency, U-shaped elbow shows good power transmission and reflection but not mode purity while others show either poor or average transmission. Pi-shaped elbows, however, maintains TM01 mode but not power. Choice of the elbow configuration for any particular application should therefore depend on the requirement, i.e. having the minimum power loss, or having the frequency or mode retained.

A detailed account of the design, simulation and analysis of various elbow configurations is presented in this report.

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