Progress on Design and Testing of ITER ECH&CD Transmission Line Components

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***Abstract*— The performance requirement of 1 (possibly 2) MW cw at 170 GHz for ITER Electron Cyclotron Heating and Current Drive transmission line components is much more demanding than the performance that has been demonstrated on present devices. The high ITER heat loads will require enhanced cooling and, for some components, new or modified designs. In addition to thermal management issues, the components must be designed to have very low losses in order to meet the ITER transmission line efficiency requirements. Testing at representative ITER conditions of some components (waveguide switch, waveguides, miter bends, gate valve, and waveguide window) has been initiated at the JAEA 170 GHz gyrotron test stand at Naka, Japan [1]. Results obtained on additional tests of GA components at JAEA will be presented. These additional components include a DC break, polarizer miter bends, arc detector miter bend, very low loss miter bends, and a waveguide switch. In addition, the US ITER Project Office (USIPO) plans to test a complete prototype ITER transmission line in order to validate the designs for use on ITER, and GA is providing some components to the USIPO for initial tests.**

I. Introduction and Background

The theoretical thermal and stress performance of various transmission line components will be presented based on finite element analyses performed at GA. A new code was recently written to estimate the microwave absorption at the mirrors in polarizer miter bends versus input polarization and mirror rotation angle. The calculated ohmic losses at polarizer mirrors will be compared with calorimetric measurements made in tests at the JAEA gyrotron test stand. This paper will also address the design changes that are being made for the various components to assure low loss transmission and acceptable component temperatures for operation at up to 2 MW cw. A new component that is being prepared for testing at JAEA is a very low loss miter bend that has a calculated diffraction loss one-third that of a standard miter bend and has essentially no generation of higher order modes near cutoff. As a result, heating in the miter bend arms and waveguides adjacent to this new component is expected to be very low. Tests at JAEA should verify the calculated performance of this new component.

The ITER Base Line Design requires that the Electron Cyclotron Heating and Current Drive System (ECH&CD) deliver 20 MW of rf power to the ITER plasma. The ECH&CD system consists of twenty-four 1 MW 170 GHz gyrotron systems, upper and equatorial launchers, and low loss transmission lines connecting the microwave sources to the launchers. To achieve the desired power delivery the transmission lines must have a transmission efficiency no less than 90%, when the inherent losses associated with connecting the gyrotron systems to the transmission lines (~3%) and losses in the launchers (~4%) are taken into account. This 90% transmission efficiency appears to be achievable based on the ITER Base Line Design. Calculated and transmission line efficiency measured at JAEA will be presented and extrapolated to the ITER Base Line transmission line configuration, as well as to modified ITER transmission line layouts that may become available mid-2008.

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References

[1] K. Takahashi, K. Kajiwara, A. Kasugai, N. Kobayashi, K. Sakamoto, "Investigation of Transmission Characteristic in Corrugated Waveguide Transmission Lines for Fusion Application," Proc. 8th IEEE International Vacuum Electronics Conf., Kitakyushu, Japan, 2007.