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Physics Studies for assessment of requirement of Displacement Compensation System for ITER ECE Diagnostic

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The Electron Cyclotron Emission (ECE) diagnostic has the key function of measuring the core electron temperature profile and electron temperature fluctuation, from the intensity of electron cyclotron radiation emitted from the plasma along the major radius. Other roles of this diagnostic include the measurement of plasma energy, radiated power, runaway electron behaviour, edge electron temperature profile, and measurement of the ELM temperature transient. The ECE diagnostic consists of three main systems: (1) front-end optics, which collects the radiation from the plasma, (2) transmission lines including polarizer splitter unit, which transports the ordinary and extraordinary ECE emission modes separately from the front-end and distributes it to the instrumentation, and (3) detection and analysis instrumentation which is housed at a distance from the tokamak, in the diagnostics building [1].
With its high electron temperatures and harsh environment, ITER presents various challenges for the diagnostic system. One of the most insidious is the misalignment between the in-vessel front-end optics and the ex-vessel transmission line which is caused by vibration of the vacuum vessel due to plasma phenomena including vertical displacement events. Since the electron temperature is inferred from the intensity of the ECE, transient misalignment may lead to poor accuracy in this critical measurement. These displacements are expected to be ˜ 15 mm in vertical (z) and horizontal (x) directions, and ˜ 5 mm in the toroidal (y) direction. It is important to minimize the effect of these displacements, so that the system maintains alignment during operation, and reliable temperature information is attained. Our objective is to first study the coupling losses due to imperfect coupling of Gaussian beams owing to port plug displacements. These studies will serve as the basis to assess the requirement of the displacement compensation system. In this paper, different types of Gaussian beam misalignments are discussed and the power loss due to coupling of offset beams is estimated analytically. Measurements are done to determine the power loss due to coupling of offset beams experimentally. The measured value for coupling loss is ˜2.9 dB at 130 GHz, which is quite high, and it is therefore concluded that a system is needed to compensate for the displacements. This conclusion is supported by performance analysis which simulates the effect of displacements on ECE measurements. Comparison to the ITER requirements for the ECE diagnostic yields the acceptable limits on displacements.

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