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Advances in Technology, Performance, and Power and Polarization Measurements for the ECH System on DIII-D

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The DIII-D electron cyclotron heating system (ECH) has six gyrotrons installed at this time and is operated for injection into the plasma of rf power up to 3.6MW at 110GHz frequency. The rf power injected at the tokamak is measured on a shot to shot basis with a calibration based on the heat deposition in the gyrotron water cooling circuits.

A technique for calibrated ECH power measurement using both orthogonal polarizations of the transmitted rf wave at the last miter bend in the line was tested. Polarization scans for each system show H-plane and E-plane rf waveforms can be combined using square law detectors to provide a reliable calibrated power signal at the closest access point near the tokamak. Previous attempts to calibrate the power at this location were limited by the detection of only one polarization component at the last miter bend.

The elliptical polarization of the injected rf wave was measured for all the transmission lines. Final wave polarization is controlled using a pair of corrugated mirrors installed in miter bends. This allows for the launching of the extraordinary mode that is absorbed at the second resonance for different plasma configurations and injection angles for heating or current drive. Two types of corrugated mirrors with different power handling capability were investigated. The smaller size mirrors performed better in terms of ellipticity control than the larger size mirrors with tapered mode convertor.

System upgrades include a new operating frequency, a new upgraded collector map measurement system better adapted to different configurations of collector RTDs, 4-port power monitors for reflected power and polarization measurements, and robust beam refraction protection using a density interlock, visible cameras, visible light monitors, and reflected power monitors used as sniffers. Increased levels of reflected power can indicate low absorption in the plasma or arcing in the launcher. Updates of the protection circuits to allow recovery after faults such as rf dropouts are included in the future plans for the system.

A newly designed depressed collector gyrotron in the 1.5 MW class, operating at 117.5 GHz, will be added to the ECH system. This new gyrotron has achieved 1.8 MW for short pulses during factory testing and is expected to be installed and operated in the spring of 2017. The system expansion is expected to reach a total installed power of over 11 MW and a total injected power of 8 MW with ten gyrotrons, some operating at 117.5 GHz and some at 110 GHz.

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Eligible for student paper award?

No

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