3 MW, 110 GHz ECH SYSTEM FOR THE DIII–D TOKAMAK*

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To support the Advanced Tokamak (AT) operating regimes in the DIII–D tokamak, methods need to be developed to control the current and pressure profiles across the plasma discharge. In particular, AT plasmas require substantial off-axis current in contrast to normal tokamak discharges where the current peaks on-axis. An effort is under way to use Electron Cyclotron Current Drive (ECCD) as a method of sustaining the off-axis current in AT plasmas. The first step in this campaign is the installation of three megawatts of electron cyclotron heating power. This involves the installation of three rf systems operating at 110 GHz, the second harmonic resonance frequency on DIII–D, with each system generating nominally 1 MW.

Two 110 GHz gyrotrons with nominal output power of 1 MW each have been installed on the DIII–D tokamak, and are operational. The first 110 GHz gyrotron built by Gycom has a nominal rating of 1 MW and a 2 s pulse length, with the pulse length being determined by the maximum temperature allowed on the edge cooled Boron Nitride window. This gyrotron was first operated into the DIII–D tokamak in late 1996. The second gyrotron was built by Communications and Power Industries (CPI) was commissioned during the spring of 1997. The CPI gyrotron uses a double disc FC-75 cooled sapphire window which has a pulse length rating of 0.8 s at 1 MW, 2 s at 0.5 MW and 10 s at 0.35 MW. A third gyrotron, being built by CPI, utilizes a single disc CVD (chemical-vapor-deposition) diamond window, that employs water cooling around the edge of the disc. Calculation predict that the CVD diamond window should be capable of full 1 MW cw operation. All gyrotrons are connected to the tokamak by a low-loss-windowless evacuated transmission line using circular corrugated waveguide for propagation in the HE_{11} mode. Using short pulse lengths to avoid breakdown inside the air filled waveguide, the microwave beam has been measured inside the DIII–D vacuum vessel using a paper target and an IR camera. The resultant microwave beam was found to be well focused with a spot size of approximately 8 cm. The beam can be steered poloidially from the center to the outer edge of the plasma. The initial operation of the Gycom gyrotron with about 0.5 MW delivered to a low density plasma for 0.5 s showed good central electron heating, with peak temperature in excess of 10 keV. Central current drive experiments with the two gyrotrons with 1.2 MW of injected power drove about 0.1 MA.

The initial phase of testing the 1 MW class 110 GHz gyrotrons has been completed, with plasma heating and current drive consistent with the theoretical predictions. A third gyrotron is in production that incorporates a CVD diamond window and promises to provide long pulse ECH capabilities. This system will now be routinely used to investigate the generation and maintaining AT plasma configurations.

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