THE RESISTIVE WALL MODE FEEDBACK CONTROL SYSTEM ON DIII–D*

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One of the primary instabilities limiting the performance of the plasma in advanced tokamak operating regimes is the resistive wall mode (RWM).[1] The most common RWM seen in the DIII–D tokamak is originated by an n=1 ideal external kink mode which arises as the plasma pressure exceeds the stability limit defined in the absence of a conductive wall near the plasma boundary. In the presence of a resistive wall, the kink mode is converted to a slowly growing RWM. The mode causes a reduction in plasma rotation, a loss of stored energy, and sometimes leads to plasma disruption. It limits the performance of a tokamak operating near high performance levels. A system designed to actively control the RWM has recently been installed on the DIII–D tokamak for the control of then n=1 mode with low m. Several control algorithms, designed either to maintain a constant radial magnetic flux through the resistive wall or to directly suppress the instability, were tested. In initial experiments, the control system has been capable of delaying the onset of RWMs in energetic discharges for several hundred milliseconds.

The feedback control system consists of detector coils connected via control software to high power current amplifiers driving the excitation coils. The excitation coils consist of a set of six 0.6 m by 2.0 m picture frame coils surrounding the tokamak midplane with diametrically opposed coils connected in series with opposite polarity.[2] The excitation coils and DC power supplies were previously used for error field correction, a function now incorporated into the operation of the new system. The three pairs of excitation coils are each driven by a current amplifier and a DC power supply. The control signal is derived from a set of six sensor coils similar to the excitation coils but nearer to the vacuum vessel (resistive wall). These sensor coils measure radial flux as low as one Gauss and are connected in diametrically opposite pairs. The signals are digitally processed and the control signal is sent to the current amplifier. Real-time software incorporated into the DIII–D Plasma Control System (PCS) responds in approximately 100 µs. Each amplifier, capable of ±5 kA at 300 V, is connected between a DC supply and a pair of coil sections configured to produce an n=1 field. The amplifiers have an operating bandwidth of approximately 800 Hz (–3 dB) and four quadrant capability.

Future experiments will be aimed at optimizing the feedback algorithm, guided by detailed modeling of the controls, amplifier, and coil system and the plasma response, in order to allow reliable feedback-stabilized operation for extended durations.

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