

Transformerless Operation of DIII-D With High Bootstrap Fraction

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We have initiated an experimental program to address some of the questions associated with operation of a tokamak with high bootstrap current fraction under high performance conditions, without assistance from a transformer. In these discharges we can maintain nearly stationary conditions for >2 s at $\beta_N \approx \beta_p \approx 2.4$. Current overdrive, with positive dI/dt and zero or negative voltage, can be sustained for up to 0.5 s. The overdrive condition is ended with the appearance of MHD activity, which alters the profiles and reduces the bootstrap current. Characteristically these plasmas have 65%–80% bootstrap current with the remainder divided between NBCD and ECCD. These discharges are prepared using the transformer, NBI, and ECH to approximate the expected noninductive profiles. Then, to allow the plasma to relax noninductively, the transformer current is held constant or else a novel voltage feedback technique is used to maintain zero voltage at the plasma surface. Typically these plasmas operate in ELMy H-mode, with $I_p \sim 0.6$ – 1.0 MA, 4–8 MW of auxiliary heating, and $q_{min} \sim 2$ – 2.5 .

The key questions being addressed are the nature and stability of profiles assumed by the plasma consistent with transport, high beta, and a large bootstrap current fraction, and without transformer regulation of the total current. One effect on the profiles associated with transformerless operation is that the value of the density in the flat part of the profile at the top of the pedestal decreases somewhat, while the width of this region increases. The total current is very sensitive to profile changes resulting from brief MHD events. In one case (Fig. 1), improvement in confinement leads to a burst of $m=3/n=1$ activity. After recovery the total thermal energy exceeds its earlier value but the current is 8% lower.

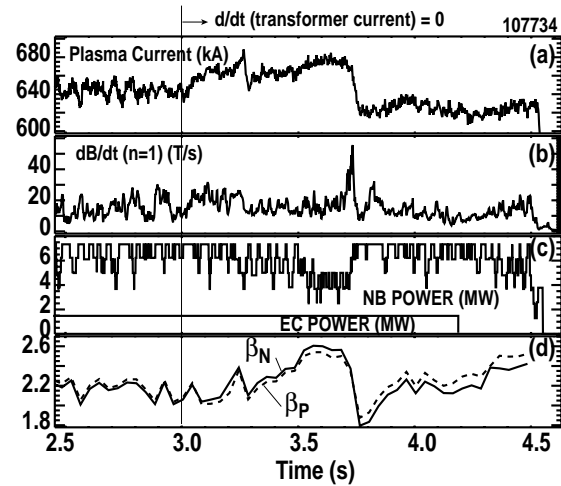


Fig. 1. A brief MHD event modifies the noninductive state. (a) Plasma current. The transformer current is fixed from 3.0 s onward. (b) Odd toroidal mode number component of the Mirnov signal. (c) NB and EC power levels. (d) β_N and β_p .

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