An upgrade of the magnetic diagnostic system of the DIII-D tokamak for non-axisymmetric measurements

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Abstract. The DIII-D tokamak magnetic diagnostic system [E.J. Strait, Rev. Sci. Instrum. 77, 023502 (2006)] has been upgraded to significantly expand the measurement of the plasma response to intrinsic and applied non-axisymmetric “3D” fields. The placement and design of 101 additional sensors allow resolution of toroidal mode numbers $1 \leq n \leq 3$, and poloidal wavelengths smaller than MARS-F, IPEC, and VMEC magnetohydrodynamic (MHD) model predictions. Small 3D perturbations, relative to the equilibrium field $\left(10^{-5} < \delta B / B_0 < 10^{-4}\right)$, require sub-millimeter fabrication and installation tolerances. This high precision is achieved using electrical discharge machined components, and alignment techniques employing rotary laser levels and a coordinate measurement machine. A 16-bit data acquisition system is used in conjunction with analog signal-processing to recover non-axisymmetric perturbations. Co-located radial and poloidal field measurements allow up to 14.2 cm spatial resolution of poloidal structures (plasma poloidal circumference is ~ 500 cm). The function of the new system is verified by comparing the rotating tearing mode structure, measured by 31 $B_p$ fluctuation sensors, with that measured by the upgraded $B_r$ saddle loop sensors after the mode locks to the vessel wall. The result is a nearly identical 2/1 helical eigenstructure in both cases.

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