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

J.D. King[1], E.J. Strait[2], R.L. Boivin[2], D. Taussig[2], M.G. Watkins[2], J.M. Hanson[3], N.C. Logan[4], C. Paz-Soldan[1], D.C. Pace[2], D. Shiraki[3], M.J. Lanctot[2], R.J. La Haye[2], L.L. Lao[2], D.J. Battaglia[4], A.C. Sontag[5], S.R. Haskey[6], and J.G. Bak[7]

[1]*Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee 378300-8050, USA*

[2]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*

[3]*Columbia University, 116th and Broadway, New York, New York 10027, USA*

[4]*Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, NJ 08543-0451, USA*

[5]*Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831, USA*

[6]*Plasma Research Laboratory, Research School of Physical Sciences and Engineering, The Australia National University, Canberra, ACT 0200, Australia*

[7]*Research and Development Division, National Fusion Research Center, Daejeon, Korea*

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 $1 \le n \le 3$, 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.

PACS Numbers: 52.70.-m, 52.70.Ds, 52.55.-s, 52.55.Fa, 52.55.Hc