NEXT-GENERATION PLASMA CONTROL IN THE DIII–D TOKAMAK*

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The advanced tokamak (AT) operating mode which is the principal focus of the DIII–D tokamak will require highly integrated and complex plasma control. Simultaneous and high performance regulation of the plasma boundary and internal profiles will require multivariable control techniques in order to take into account the highly coupled influences of equilibrium shape, profile, and stability control. This paper describes progress towards the DIII–D AT mission goal through both significantly improved real-time computational hardware and control algorithm capability.

Routine operational plasma control requires providing algorithms which operate with all normal experimental plasma configurations as well as dealing with a number of operational constraints. In the course of normal experimental operations at DIII–D, a large range of plasma shapes, currents, and fields are used, requiring design and implementation of controllers covering this large range, as well as methods for switching between these controllers as the plasma regime changes. Operational constraints include sometimes severe limits on coil currents and voltages, an extremely nonlinear set of shaping power supplies, actuators which are shared by both vertical position stabilization and shape control, a linearized X–point response which changes sign during an experimental discharge, and a hard constraint on achievable combinations of shaping coil currents.

When multivariable controllers replace the current PID control, a number of different control methods will be used to deal with the various constraints and nonlinearities. Gain-scheduling of multivariable linear controllers will be used to accommodate the range of plasma regimes. Anti-windup and bumpless transfer methods will be used to ensure smoothly varying performance during and between transfers of controllers. Several novel nonlinear control methods will be used in conjunction with the multivariable linear controllers in order to handle the constraints and nonlinearities imposed by operational hardware and real-time changes in plasma response.

A major enabling aspect of DIII–D PCS development is the next-generation plasma control system (PCS) hardware and network configuration upgrade which has been underway for the last two years. This upgrade extends the architecture of the PCS to much higher performance and flexibility, producing a factor of 10 or more increase in processor speed and adding a scalable network which can accommodate a large number of real time cpus and peripherals. Phase I of the upgrade plan is complete with all implementation scheduled for completion in 2004. Three of the previous six VME based i860 real-time processors have been replaced with new PCI based computers and the current hybrid VME/PCI system is currently in use in experimental operations. A new 2 Gigabits per second Myrinet network is in use and pre-integration testing of new 32 channel simultaneous sampling PCI form digitizers has begun.

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