A COST EFFECTIVE UPGRADE TO THE DIII-D NEUTRAL BEAM MODULATOR CONTROL SYSTEMS

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(Conference Category: Power Modulator Configurations, and Systems)

ABSTRACT

The DIII-D National Fusion Facility at General Atomics in San Diego has eight neutral beam main power modulator systems, and four modulators running up to eight gyrotrons. Several improvements to these modulators have been under development, and one such upgrade pertains to the control system in four of the oldest modulator systems. This project is in the prototype test stage of development, and aims to significantly increase reliability and decrease troubleshooting issues while greatly enhancing the user experience and allowing for future upgrades.

The intended upgrade will be a "wholesale" drop-in replacement of the original Mod/Reg control system, using commercial off-the shelf components and open-source products to quickly and inexpensively integrate the much needed upgrade. The new control system is responsible for 61 I/O signals, five separate timers, interlock management, start-up and shut-down sequencing, as well as human interfacing. Many of these functions were originally handled with analog electronics and relay logic designed and implemented over 34 years ago. A portion of the original design also included cutting edge, at the time, microprocessor technology in the TRANSREX designed modulators, using the Intel 8080, and 8k UV EPROM chips. Technology has evolved in computing power and entire "systems on a chip" (SoC) have become commonplace and integrated into everyday items. Inexpensive commercial products using SoC's have huge resources of "open source" material and well developed on-line communities. We are able to use these to quickly develop a working prototype able to inexpensively replace the entire control system of the TREX Mod/Regs at DIII-D. We have chosen to use the AtMega2560 because it has enough I/O for the complex control system, and it is included on one of the most advanced Arduino boards. This board is still able to directly accept a 0-5Vdc input signal which is a great advantage in our application thanks to a greater signal-to-noise ratio, as the system will be installed in very close proximity to the High Voltage Tetrode based modulator. On our systems with more modern gyrotron modulators, PLC control has been used. PLC's are a simple and straightforward upgrade, but it is also generally a more costly solution, and can require more physical space.

The project discussed in this paper will present details of the chosen microcontroller design, install flexibility, testing, and cost benefit as compared to PLC's.

This work was supported by the US Department of Energy under DE-FC02-04ER54698.