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Trigger and Timing Control System Using FPGA and MicroBlaze Soft Processor for Plasma Operations of Aditya-U Tokamak

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Every discharge in Aditya-Upgrade tokamak[1] is initiated with starting of the toroidal field power supply (TFPS) which also generates a master trigger pulse time-stamped t = 0 for that particular discharge. Based on the rise-time of the toroidal field of ~ 2 seconds, the loop voltage is initiated ~ 2.4 seconds from this master trigger. Apart from this master trigger pulse two more trigger pulses are generated by the power supply at fixed time prior to the initiation of the loop voltage, one at ~ 40mS and another one at ~ 4mS before loop voltage. These three trigger pulses originating from the power supplies are the backbone of the whole discharge timing sequence and they operates/controls/initiates various sub-systems of Aditya Upgrade tokamak like gas puffing system, data acquisition system, radio frequency pre-ionization and heating system, plasma position control etc. However, different subsystems require triggers at different times and hence an appropriate trigger pulse from the three fixed time-stamped trigger pulses originating from the power supplies need to be chosen and manipulated according to the experimental requirements. As the power supplies are kept ~ 30 ï 40 m away from the machine, these trigger pulses need to be transported to the systems lying in the tokamak hall. Further, for feedback control of plasma, control signals from diagnostics etc. from the tokamak hall need to be sent to the power supplies. To facilitate the smooth communication among systems lying in tokamak hall and the power supplies an optical fiber based trigger transmitters and receivers system with programmable delay setting has been designed, developed and installed in ADITYA-U. The optical fibers have many advantages over the electrical cables, which are more prone to noise pickups and false-triggering. In FPGA based trigger system, input selection & time delay for various systems can be set remotely through Graphical user interface developed in Labview and hence is much more user friendly. The hardware and software are presently configured for triggering 16 subsystems with any of three input (generated by power supplies) triggers with a time delay from 1 microsecond to 4seconds. Special care has also been taken to avoid multi-triggering as the power supplies are prone to generate multiple triggers as well as noise pulses close to the main trigger. The system is successfully tested during first phase of ADITYA-U operation and worked without any fail as all the systems are fired at the set timings in all the discharges. Detailed design, development, testing and operation of the Trigger and Timing Control System for plasma operation in Aditya upgrade tokamak will be presented in this paper.

References:

[1] Ghosh J. et al 2016 Upgradation of ADITYA tokamak with limiter configuration to ADITYA upgrade tokamak with divertor configuration 2016 IAEA Fusion Energy Conf. (Kyoto), 17-22 October, 2016 (FIP/P4ï 46) Nucl. Fusion submitted. Pre-print: https://nucleus.iaea.org/sites/fusionportal/Shared%20Documents/FEC%202016/fec2016-preprints/preprint0720.pdf