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The mega amp spherical tokamak real-time protection system

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The Mega Amp Spherical Tokamak (MAST) is currently being extensively upgraded to provide a system that will be able to add to the knowledge base for ITER as well as testing innovative reactor systems such as the Super-X divertor. MAST-U will have increased coil system and power supply capability. Therefore, to ensure operation of MAST-U within safe engineering limits, the machine protection system was also updated. The protection system is needed to protect against coil faults (such as flashovers) and monitor and calculate, in real-time, quantities such as coil currents, axial coil forces and the stored energy within the coils. Its aim is to be able to react within hundreds of microseconds if there were any inconsistencies that breach pre-defined thresholds. The Real-Time Protection System uses Field Programmable Gate Arrays (FPGAs) which monitors up to 89 different signals collected from 8 different locations around MAST-U at a rate of 0.5MS/s. It filters and calibrates the signals before calculating engineering parameters. The results of these calculations are then compared to thresholds, and events are registered if these are exceeded. These events are then mapped to actions such as disabling specific power supplies or requesting a more gradual stop from the plasma control system. In addition to stop requests, more intricate actions can also be performed, such as sending control parameters to the vertical stability system to shift the position of the plasma in the vessel. This bespoke FPGA-based system enables delivery of deterministic results with high bandwidth and with low latency, all within a highly configurable framework. Here, we will present an overview of system design and its interfaces, the results of the functional testing and commissioning of the system.

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