Upgrade of the Data Acquisition and Control System of Microwave Reflectometry on the Experimental Advanced Superconducting Tokamak

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Abstract: Upgrade of reflectometry is ongoing on Experimental Advanced Superconducting Tokamak (EAST) for more comprehensive measurement of plasma density profile and fluctuation. The Data Acquisition and Control System (DACS) has been redeveloped to satisfy requirements of upgraded reflectometry. The PXIe-based DACS includes two 8-channel 14-bit 250MSPS digitizers and Ten 8-channel 14-bit 60MSPS digitizers. The data (1840MBytes/S) from digitizers is streamed to disk array (RAID 0) with data throughput capacity of 2.9 GB/S. Meanwhile, selected data is transported to a FPGA based real-time computing module, which utilizes a pre-trained neural network to invert raw data to plasma density profile. Now the new reflectometry is being installed on EAST, and its performance will be tested in experimental campaign of 2018.

EAST

The Experimental Advanced Superconducting Tokamak (EAST) is an experimental superconducting tokamak magnetic fusion device in Hefei, China. It is the first tokamak to employ superconducting toroidal and poloidal magnets. It aims for plasma pulses of up to 1000 seconds. On July 3, 2017, EAST became the first tokamak to successfully sustain H-Mode plasma for over 100 seconds at ~50 million Kelvin. (from Wikipedia)

Microwave Reflectometry

Fig. 1. Typical architecture of microwave reflectometry

The DACS is a COTS based system, and most of the devices are from National Instruments. All the modules including digitizers, timing module and disk array are connected to the controller via PXIe bus which provides 24GB/s total data bandwidth and 8GB/s data bandwidth for one slot. A dedicated arbitrary waveform generator outputs swept voltage (0-20V) to controls the VCO of reflectometry. There is a trigger and clock manager used for synchronizing the DACS with the central controller.

High-Speed Data Streaming

The DACS employs 12 digitizers to acquire data. The total data rate reaches a staggering 1840 MBytes/S. During a shoot of EAST, there are a lot of transient events that need to be recorded, like the ELMs, L-H transition. The DACS have to record all signals during the shoot. When a shoot lasts over 100 seconds, the amount of data will reach 184 GBBytes. The DACS will download the data to data warehouse via Gigabit Ethernet between the shoots, so it works well for the high data rate job. To satisfy the real-time control requirements, a FPGA based neural network module is applied to process selected data in real time.