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P4.031 New features of the ECH control system in DIII-D and impact of power modulation on collector loading

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The electron cyclotron heating system in DIII-D comprises four 110-GHz gyrotrons and one 117.5-GHz gyrotron able to inject more than 3 MW into the plasma for an administrative limit of 5 s during the 2018 experimental campaign. In a major controls upgrade, the gyrotron high voltage reference waveform is no longer generated by an obsolete pre-programmed waveform generator but by a newly developed adaptive FPGA-based generator. This new generator outputs 16-bit signals every microsecond and responds in real time, being able to detect, block faults, and restart full RF power within 10 ms during plasma or conditioning shots. Some gyrotron faults, such as excessive body current, can be detected and avoided within 10 μs by the new system.

In order to control plasma instabilities, gyrotrons are required to provide modulated power with frequencies up to a few kilohertz. Power modulation can be achieved by reducing the main cathode voltage while keeping the body deceleration voltage constant. The impact of modulating and operating with reduced interaction efficiency and lower electron beam power on collector loading has been quantified using a newly developed and improved collector mapping system.

A description of the mapping system along with collector loading results will be presented. The performance of the integrated real-time FPGA-based waveform generator during gyrotron faults and over-dense plasmas as well as upgrades to the ECH data acquisition system will also be presented.

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