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Real-time vertical plasma position control using the heavy ion beam diagnostic

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ISTTOK is an iron core tokamak (R = 46 cm, a = 8.5 cm, BT = 0.5 T) which operates regularly in alternate current (AC) mode, extending the plasma duration up to 1 second by inverting the plasma current sequentially. However, during the current reversal process, the signal integrity of the magnetic diagnostics (Mirnov coils) is degraded due to low plasma current leading to wrong plasma position measurements. One alternative solution is the use of Langmuir Probes (LP) to measure the floating potential and inferring indirectly the plasma position. Nevertheless, in some cases, the LP diagnostics have limitations when measuring the plasma position leading to wrong measurements that eventually lead to a plasma disruption. Also, during edge biasing experiments, the floating potential is strongly affected and the LPs are not reliable to measure the plasma position.
The Heavy Ion Beam Diagnostic (HIBD) has been upgraded to measure fast neσ(Te) profiles to improve the signal to noise ratio in 12 sample volumes vertically distributed along the plasma minor radius (-0.7a < r < 0.7a). The neσ(Te) quantity (product of the density times the effective ionization cross-section for the Xe+ to Xe2+ ionization) can be regarded as a proxy for the plasma pressure which is a good indicator of the plasma position. Off-line HIBD data processing for the determination of the plasma vertical position has demonstrated promising results. The fast neσ(Te) profiles can be acquired up to 150 kHz which is more than 10 times faster than the ISTTOK real-time control cycle (100 µs). These characteristics bring up the HIBD as a promising diagnostic for the plasma vertical position measurements and feedback control using magnetic actuators.
This work presents the integration of the HIBD data for real-time plasma position measurement and control in a closed loop using a combined fast digital processing implemented in a FPGA (Field Programmable Gate Array) and MARTe (Multi-threaded Application Real-Time executor) software framework. The overall implementation and integration will be described and the first experimental results presented together with a comparison with the existing control schemes.

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