Experiments with real-time controlled ECW on the TCV Tokamak

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The ECW system on the TCV tokamak consists of six gyrotrons (82.7GHz/0.5MW/2s) used for X2-ECH/ECCD and three gyrotrons (118GHz/0.5MW/2s) used for X3-ECH in a top-launch configuration. The X3 system broadens the operational space on TCV with the possibility of heating plasmas at high density, well above the cutoff density of the X2 system (X2 cutoff at $n_e = 4.2\ 10^{19} m^{-3}$). From its inception the ECW system has been designed to allow real-time control (RTC) on a variety of actuators such as the inclination of the last mirror on each launcher and/or the injected RF power. Some of these RTC actuators of the ECW system have been used with the TCV hybrid (digitally controlled) analogue controller based on matrix multiplication of signals and PID controllers.

In this paper three different experiments using the RTC capabilities of the ECW system are reported. The first experiment is related to the RTC of the X3 mirror angle in the top-launch configuration aimed at maximising the single-pass absorption of the X3 wave. Secondly, using X2-ECCD in a fully non-inductive current scenario with no external loop voltage a feedback control loop has been successfully implemented to control the plasma current in real time using the ECW power actuator. Finally, using a real time plasma elongation observer and both the ECW power and the deposition radius (via the mirror angles) as actuators, the plasma elongation has been varied in a controlled way without any change in the shaping magnetic fields; in particular, this has allowed the stable sustainment of highly-elongated, low-current plasmas that are vertically unstable in Ohmic conditions. An Advanced Digital Plasma Control System replacing the hybrid analogue controller is presently being installed and commissioned on TCV. The main features of this system will be outlined.