Pulse Reflectometer and Doppler back-scattering diagnostics in the TCV Tokamak

P. Molina Cabrera, S. Coda, L. Porte, N. Offeddu, and the TCV team[1]

Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland.

Both profile pulse reflectometer and Doppler back-scattering (DBS) diagnostics have been developed for the TCV Tokamak[1] using a steerable quasi-optical launcher and universal polarizers.

A pulse reflectometer is being developed to complement Thomson Scattering measurements of electron density, greatly increasing temporal resolution and also effectively enabling fluctuation measurements. Pulse reflectometry consists of sending short pulses (<1ns) of varying frequency and measuring the roundtrip group-delay with precise chronometers. To improve resolution and flexibility, a fast arbitrary waveform generator (AWG - 65GSa/s, analog BW up to 20GHz) is used as a microwave pulse source to commercial frequency multipliers that bring 8-12GHz pulses up to the V-band (50-75GHz). Two different timing techniques have been tested: direct digital sampling and traditional analog detection featuring constant-fraction-discriminators (CFD) and time-to-analog converters (TAC). AWG-driven pulse reflectometry has the potential to remain competitive when compared to other profile reflectometry techniques and may provide a new perspective in the study of density fluctuations. The design and progress in construction will be presented along with preliminary data from plasma discharges. The characterization of profiles and fluctuations in the pedestal region would be the focus of these first experiments.

A variable configuration V-band heterodyne Doppler back-scattering diagnostic has been recently made operational in TCV. The diagnostic uses a fast AWG as the main oscillator and a commercial vector network analyzer extension module as the main mm-wave hardware. It allows sweepable single or multi-frequency operation, leveraging on the flexibility of the AWG source and fast digital sampling in the receiver. A flexible launcher antenna inherited from TCV's electron cyclotron heating launchers allows 3D toroidal (+/-180°) and poloidal (10-58°). Sweeping of the poloidal angle may be done inside the shot. A pair of fast HE11 miter-bend polarizers allow flexible coupling to either O or X mode and programmable polarization changes during the shot. These have been used to measure the magnetic-field pitch angle in the edge of the plasma by monitoring the backscattered signal power. Ray-tracing simulations reveal an available k_{perp} range between 3-16 cm^{-1} with a resolution of 2-4 cm^{-1}. Perpendicular rotation velocity estimates compare well against ExB plasma poloidal rotation estimates from charge exchange recombination spectroscopy.

[1] See author list of S. Coda et al 2017 Nucl. Fusion 57 102011