Ultra-Fast Langmuir Probe in Magnetised Plasma

C. J. Hickling[1,2], S. Hall[2], R. Sharples[3], R. Seath[2], J. Harrison[2] and J. W. Bradley[1]

[1] *Department of Electrical Engineering and Electronics, University of Liverpool, Liverpool, L69 3GL, United Kingdom*

[2] *UKAEA/CCFE, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, United Kingdom*

[3] *Department of Physics, Durham University, South Road, Durham, DH1 3LE, UK*

Conventional Langmuir probes are powerful diagnostics for measuring plasma temperature, ion saturation current, and floating potential and are widely used to diagnose the Scrape-Off Layer (SOL) and divertor of magnetic confinement fusion devices. Plasma in these regions is known to contain fast moving filamentary structures that require highly resolved measurements (typically order of 100 kHz in time and 1mm in space) to fully characterise. A triple probe provides real-time voltage dependent currents at the cost of sampling different regions of plasma. Conversely a single probe provides high spatial resolution at the cost of the time required to sweep the power supply, which also induces currents in the cables, limiting the temporal resolution, typically to the order of 10KHz. Conventional probes therefore are limited in either temporal or spatial resolutions for studies of fast events such as filaments.

By utilising Field Programmable Gate Arrays (FPGA), in a configuration similar to that of the Mirror Langmuir Probe[1], it is possible to bias a single probe at 3 precise voltages in sequence. These voltages can be dynamically adjusted in real-time based on the measured plasma temperature to ensure the transition region is always sampled. By utilising this method, real time outputs of plasma temperature, ion saturation current, and floating potential have been achieved on a low temperature DC magnetron. This probe is designed with intentions to be implemented onto MAST-U at 1MHz to aid in the study of exhaust physics and enable further investigation into filamentary behaviour.

References

[1] Labombard, B., Lyons, L. (2007). Mirror Langmuir probe: A technique for real-time measurement of magnetized plasma conditions using a single Langmuir electrode. Review of Scientific Instruments.