Keep-in-Touch meeting
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A compact FMCW reflectometer/interferometer design for the monitoring of atmospheric entry flows

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On the next experimental fusion reactors, the number of suitable diagnostics to measure relevant plasma quantities is very limited. Millimetre wave diagnostics are one of the obvious choice due to the limited in-vessel access requirements and front-end robustness. Frequency-Modulated Continuous-Wave (FMCW) reflectometry is a well-established technique to measure electron density profiles and to provide feedback for plasma position and shape control in such applications.

As the telecommunication industry is focused on the next network generation such as 5G, manufacturers are releasing high performance Monolithic Microwave Integrated Circuits (MMIC) in a large scale and at affordable prices. For such reasons a prototype of a coherent fast frequency sweeping RF back-end was developed at IPFN-IST using commercial MMICs. One of the design goals for the back-end prototype focuses on the flexibility of the system, so that it can be easily matched to the required frequency ranges. The back-end alone covers the NATO J-Band (10 GHz to 20 GHz) and it is designed to drive external full band frequency multipliers resulting in an ultra-wideband coverage up to 140 GHz.

Such diagnostic may be deployed for other plasma monitoring applications. One possible application is the atmospheric entry of a Spacecraft, where the knowledge of the properties for the plasma surrounding the vehicle, and namely the electron densities, is key for:

a) the validation of Computational Fluid Dynamic models with a comparison against predicted electronic densities; and

b) the validation of radiative transfer models, since the radiative properties of a plasma are highly dependent on the populations of the excited electronic states of the plasma species, and since these excited states are preferentially populated through electron-impact reactions.

The potential for this improved reflectometer architecture, as pertaining these applications which are also key to IPFN activities, have motivated the current investigation, wherein the reflectometer is expected to be firstly field-tested on the ESTHER shock-tube in interferometer mode, and then further validated in reflectometer mode on ground test facilities plasma plumes, and ultimately on entry demonstrators, which may be as small a cubesats (3U architectures).

This work presents the reflectometer architecture, discussing the main key design features and the prototype expected performance and valid test regions. Also, it compares its expected performance to previous similar experiments.