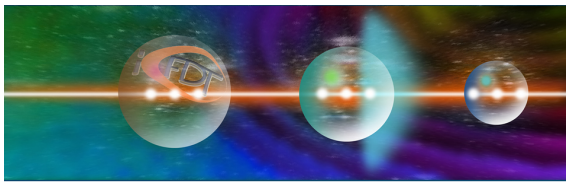

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Compact, Reconfigurable Millimeter-Wave Back-End for Next-Generation Fusion Reactors

Tuesday, 22 October 2024 18:05 (1 hour)

Diagnosing plasma parameters in next-generation fusion reactors like DEMO [1] poses a challenge due to limited in-vessel access and harsh environments. Millimeter-wave diagnostics offer a robust solution to measure electron density, but achieving comprehensive plasma coverage, essential for plasma position and shape control [2], requires large number of probing channels with wide frequency bandwidths and compact back-ends [3]. We present a redesigned compact, fast frequency-sweeping millimeter-wave back-end overcoming limitations of a previous prototype. The back-end utilizes commercially available Monolithic Microwave Integrated Circuits (MMICs) to achieve a base frequency range of 10-20 GHz. External frequency multipliers extend this range to ultra-wideband coverage up to 160 GHz, enabling detailed plasma characterization. Driven by component obsolescence, the back-end underwent a complete PCB redesign, incorporating key improvements: (1) a programmable function generator for variable tuned oscillator (VTO) sweeping, enhancing control and flexibility; (2) a novel frequency translator scheme based on a vectorial modulator, potentially improving system efficiency, flexibility and cost; and (3) a new programmable PLL for the in-phase/quadrature (I/Q) reference signal, enabling precise signal generation. This work details the new back-end design and its subsequent performance evaluation. This work has been carried out under EUROfusion Enabling Research Project (ENR-TEC.01.IST).

[1] F.P. Orsitto et al., “Diagnostics and control for the steady state and pulsed tokamak DEMO”, 2016 Nucl. Fusion 56 026009 DOI 10.1088/0029-5515/56/2/026009.
[2] J. Santos et al., “Reflectometry-based plasma position feedback control demonstration at ASDEX Upgrade” , 20212 Nucl. Fusion 52 032003 DOI 10.1088/0029-5515/52/3/032003.
[3] Raul Luís et al., “A diagnostics slim cassette for reflectometry measurements in DEMO: Design and simulation studies”, 2023 Fusion Engineering and Design 190 https://doi.org/10.1016/j.fusengdes.2023.113512.

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