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Ka-Band Reflectometer System for measuring Radial Electron Density Profile at IPR.

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The determination of electron density and its fluctuations are essential in understanding the physical principles that determine the confinement in tokamaks. Aditya tokamak at IPR is routinely operated with a peak density of ~ 3 x 1019 m-3 and a typical magnetic field of 0.75T. We present and describe the bench test calibration and its results and the designed FMCW Reflectometer which is capable of measuring the electron density profile (ne(r)) in the range (0.84 to 1.98) x 1019 m-3 with minimal access requirements.
We assume a parabolic density profile and plot the resultant variation in plasma frequency and thus Ka-band from 26.5 to 40GHz is selected. A Ka-Band Frequency Modulated Continuous Wave (FMCW) Reflectometer has been designed and developed to measure the electron density profile. It is to be operated in O-mode due to its simplicity. The super heterodyne detection scheme in conjunction with quadrature down conversion is used for unambiguous phase determination. To overcome the deleterious effects of plasma density fluctuations, the implemented Reflectometry system is capable of ultra-fast sweep over the entire Ka-Band in 5µs and has high data acquisition rates of 200MSps. The Voltage Controlled Oscillator (VCO) used as the frequency source was linearized by nonlinear tuning voltage as input which resulted in only 5% variation in the output beat frequency. Oversized waveguides in the X band (WR-90) have been used to minimize the waveguide dispersion over the swept frequency range. The complete system is controlled by a master trigger received from the tokamak control room which is fed to a trigger pattern generator which triggers the microwave circuit and the data acquisition system at predetermined times.
The reflectometer has been calibrated in lab and in-situ in tokamak hall using a custom coaxial delay line for circuit delay as well as the waveguide delay for a length of 9.6m. The dispersion in delay was found by placing metallic mirrors at different locations and finding the internal circuit delay while the dispersion in waveguide is calculated for rectangular waveguides. Multiple (>25) sweeps were done for each position of the mirror (Fig1a) and the results obtained showed very good repeatability (Fig1b).

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