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OPERATIONAL LIMITS AND SIGNAL-TO-NOISE RATIO OF THE HIGH MAGETIC FIELD SIDE REFLECTOMETER FOR ELECTRON DENSITY PROFILE MEASUREMENTS ON TOKAMAK T-15MD DEVICE *)

[1]Shelukhin D.A., [1]Vershkov V.A., [1]Molchanov D.S., [1]Lukyanov V.V., [1,2]Vladimirov I.A., [1,2]Loginov A.A.

[1]National Research Center "Kurchatov Institute", Moscow, Russia
[2]Moscow Institute of Physics and Technology, Dolgoprudnyi, Russia

Reflectometry diagnostic is widely used to measure the density profile at existing and developing thermonuclear machines (see references in [1]). The advantages of reflectometry include high temporal resolution and spatial resolution. In 2022, Frequency Modulation Continuous Wave (FMCW) reflectometry was proposed for the electron density measurements on the T-15MD tokamak [1]. It was proposed to use the same measurement scheme as for ITER, namely, a combination of a high magnetic field probing and utilizing the lower extraordinary (X) mode cutoff [2].

In this work, we assessed the possibility of measurements in the T-15MD machine in a wide range of densities and toroidal field values. Due to difficulties in integration of the in-vessel part of the transmission line into the environment, it was decided to use rectangular waveguides with an inner cross-section of 16 × 8 mm for the transmission line instead of the planned waveguides with a cross-section of 23 × 10 mm. This led to the mandatory use of devoted line in the diagnostics to measure the profile from a high magnetic field with an ordinary (O) mode. The range of measurements on O and X waves in the frequency range from 12 to 66 GHz ensures correct initialization of the profile reconstruction in discharges with a density on the separatrix above $4\cdot10^{18}$ m^{-3}.

It is shown that in discharges with a magnetic field on the axis B_T = 2 T, diagnostics can perform the measurements in the plasma core to the densities about $7\cdot10^{19}$ m^{-3} using microwave sources with a frequency of up to 66 GHz. The limitation of the maximum measurable density is associated with the absorption of the probing wave at the fundamental frequency of electron cyclotron resonance. Measurements in the outer half of the plasma column are possible up to a density about $1\cdot10^{20}$ m^{-3}. It should be noted that in modes with a lower value of the toroidal magnetic field, the range of measured densities is expected to decrease to ~$4\cdot10^{19}$ m^{-3}.

An analysis of the influence of small-scale density disturbances on measurements was performed using analytical estimates given in [3]. It has been shown that measurements of the electron density profile are possible when fluctuation level not exceeds 0.2–0.4% in the plasma core column, which is approximately 20%–30% lower than the observed level of fluctuations in thermonuclear devices.

An analysis of the microwave power balance and signal-to-noise ratio was carried out for diagnostics. It is shown that in the expected operation scenarios of the T-15MD, the signal-to-noise ratio for diagnostics will be 35–45 dB.

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