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Newly designed Langmuir probe system at the tungsten lower divertors in KSTAR

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The present status of the newly designed Langmuir probe (LP) system installed in the upgraded tungsten lower divertors of KSTAR will be discussed [1]. The LP tip has a replaceable, one-sided roof-top shape (with a tip angle of 16° protruding 1 mm out to the divertor) to achieve insensitivity of the ion collection area to the incident angle. The LPs have been installed in numbers of 16, 18 and 18 on the inner, central and outer divertors respectively, at each of the D and L ports (located toroidally opposite to each other), total 104 LPs. Since the KSTAR 2023 campaign, temporal ion saturation currents have been measured in the D-port by applying a negatively DC-biased (-240 V) to the LP using batteries, with a DAQ sampling frequency of 200 kHz. As the ion saturation current alone is insufficient to determine plasma parameters such as density and temperature, we adopted a voltage sweeping method to obtain IV-characteristics over time. The waveform of the applied voltage is generated by an SDG1032X function generator and then amplified using a KEPCO BOP100-4D bipolar power supply. The corresponding current is measured across a 10 Ω shunt resistor placed between the LP tip and the power supply. Single voltage-sweeping LP data was successfully obtained during the KSTAR 2024 campaign by applying a 1 kHz triangular waveform voltage from -100V to 100V. The IV-characteristics over time were reconstructed by applying a 1 kHz comb filter to the raw data and cycle-averaging over designated time windows. For noise suppression, a comb filter passing the DC component and harmonic frequencies at multiples of 1 kHz was primarily used, and its result was compared with that of a conventional low-pass filter. Plasma parameters, such as density and temperature, were then extracted from the IV-characteristics using two approaches. In the first approach, the plasma potential was determined using the inflection point method, and the electron density was calculated from the conventional electron saturation current formula at the plasma potential, while the electron temperature was obtained from the slope of the logarithm of the IV-characteristics at that point. In the second approach, the reconstructed IV-characteristics were fitted using current-voltage models, with electron density and temperature treated as free parameters. For this fitting, both the conventional unmagnetized probe current equation and the Weinlich-Carson asymmetric double probe (WC-ADP) model were applied [2]. The results between these two methods will be compared and discussed with the tungsten optical emission spectroscopy (OES) diagnostics in the divertor region. Additionally, the impact of gas injection on the LP system measurements will be discussed.

References
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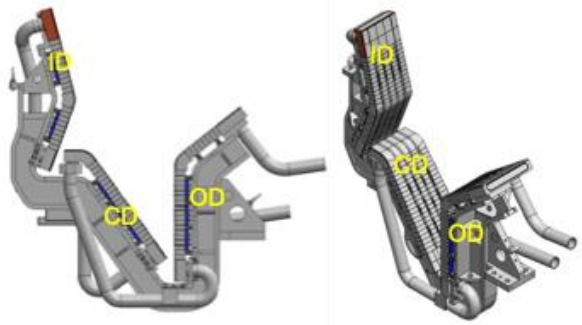

Figure 1. KSTAR lower tungsten divertor. A total of 16, 18 and 18 LP tips are installed in the inner divertor (ID), central divertor (CD), and outer divertor (OD), respectively.

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