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# 4P08 - Studies on power transfer efficiency in the drivers of the SPIDER inductively coupled RF ion source

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SPIDER is the full-size prototype of ITER Neutral Beam Injector ion source, in operation since June 2018 as a project of the ITER Neutral Beam Test Facility located at Padova, Italy. It consists of an inductively coupled plasma source and an extraction system to accelerate the produced negative ions up to 100 keV energy. The plasma source is composed of 8 drivers, operated in low hydrogen gas pressure (˜ 0.3 Pa) and maximum radio frequency (RF) power of 100 kW per driver at 1 MHz frequency.

A key parameter to qualify performances of the driver is the power transfer efficiency (PTE) which is defined as the ratio between the power absorbed by the plasma and the total RF input power. Experimentally it is not possible to measure the power absorbed by the plasma, which is found to depend on various parameters coupled together. Therefore a model is needed which can account for all the mechanisms to provide an estimation of this PTE.

A methodology was developed in this regard based on the integration of two main models: analytical, to account for different mechanisms of plasma particle dynamic; and electrical, accounting for coil, plasma and passive metallic structures present within the driver region. The methodology was then applied to two different ion sources.

This work highlights a further development of this methodology. Two main additions in analytical model are discussed: the estimation of average electron density as a function of RF power and gas pressure; and the influence of the magnetic field on the input parameters for the electrical model (for instance, plasma conductivity). The methodology is then applied to SPIDER drivers and the results in terms of equivalent electrical parameters and PTE are presented.

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