PASSIVE PROTECTIONS AGAINST BREAKDOWNS BETWEEN ACCELERATING GRIDS IN SPIDER EXPERIMENT

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In the PRIMA test facility, under realization in Padova, a full size plasma source prototype for ITER (SPIDER**:** Source for the Production of Ions of Deuterium Extracted from RadioFrequency plasma) will be realized with the target to extract up to 12 keV a D^- beam of ~70 A and then electrostatically accelerate it to 100 keV energy. A crucial goal for this device is the reduction of the effects due to the frequent breakdowns between the accelerating grids.

The paper presents the solutions proposed to minimize these effects consisting in the implementation of components for passive protection. In order to assess the validity of these countermeasures, a detailed model of the circuit has been developed, in which all the magnetic and capacitive couplings between components are modeled. The evaluation of transient overcurrents and overvoltages occurring along the circuit for different cases was carried out. A parametric study for all the passive components implemented has been done in order to optimize the overall circuit design and to define the components requirements.

The first effect of breakdown is the grids damage due to energy deposition by arcing. Both the total energy transferred to the grids and the current peak have to be limited. The solution proposed is to install two passive components in the circuit: a damping resistor (connecting the last accelerating grid to the grounded vessel) and a magnetic snubber in series to the power supplies output.

The second effect is the strong electromagnetic noise (EMI) caused by the breakdown. To mitigate this effect, the electrical circuit design foresees two solutions.

The first solution is the adoption of a tri-axial structure of the 25 m long – 100 kV Transmission Line TL, which connects the Ion Source and Acceleration Power Supplies to the Ion Source for the Source electrical services (e.g. Radio Frequency coils, Extraction Grid, Grids biasing, magnetic filters and measurement cables) and for the beam acceleration. In particular, the acceleration current is carried by a low-resistance wire while a doubled screened structure acts during transients. The inner screen, along which transient currents are expected to flow, is in parallel to the return wire and is connected to the cold electrode of the 100 kV power supply at one side and to the reference ground (vessel) by a resistive link at the other. Instead, the outer screen, along which fastest transient currents are expected to flow, acts as a low-impedance ground being directly connected to the vessel.

The second solution consists in the installation of a Distributed Core Snubber DCS, aimed at increasing the damping of the oscillations due to the TL stray inductances and capacitances. The DCS is based on 10 magnetic cores, made of ferrite magnetic alloy Finemet® and evenly distributed along the TL length. As the DCS would be polarized by the accelerating during stationary phase, the available flux swing during the breakdown would be decreased, so reducing the effectiveness of the DCS; for this reason a biasing circuit has been designed and implemented in the SPIDER circuit to double the flux swing during breakdown.