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Analysis and design of a passive protection system for the High Voltage RadioFrequency Test Facility circuit components

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The inductively coupled radiofrequency plasma source of SPIDER and MITICA experiments for the ITER Neutral Beam Test Facility in Padova is designed with highly engineered device called “driver”responsible for the ignition and sustainment of the plasma in the source and delivering 100kW power at 1 MHz. In order to provide high reliability of the source, such a high operating power requires accurate analyses of the potential issues related to breakdowns occurrence in the driver region due to the high electric field present on its components.
Particular effort is given to support the study of the voltage hold off in radiofrequency regime in Consorzio RFX Padova developing a dedicated experimental arrangement: the High Voltage Radio Frequency Test Facility (HVRFTF). This facility is design to be a simple, accessible and flexible device and it aims in particular at the characterization of the voltage hold off of the RF components used for the plasma sources of SPIDER and MITICA. The facility is composed of a RF power amplifier (presently rated for 300 W but upgrade amplifier in the kW range is foreseen for the future) working at the frequency of 1 MHz, a resonant circuit to provide high RF voltage and a vacuum chamber to host the device under test (DUT). The full ratings of this facility comprises pressure range 10⁻³ −10⁵ Pa and a delivered testing voltage of up 17 kV rms (presently 10 kV rms are reached) at the frequency of 1 MHz.
In order to provide an electrical qualification of the DUT in terms of maximum operative voltage it is necessary to test the voltage hold off up to the breakdown event. A set of breakdown events are identified being either operational foreseen DUT breakdowns or possible fault condition on RF components and also studied by numerical simulation of an electrical model of the HVRFTF RF circuit. The electrical stresses were found not tolerable by the circuit components, thus a proper passive protection circuit (PPC) based on spark gaps and semiconductor devices is identified and developed considering the ratings of the RF circuit components. The analyses and design of the protection system and of its integration in the HVRFTF RF circuit will be presented and discussed.

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