CIRCUIT ANALYSES OF THE FILAMENT ION SOURCE POWER SUPPLIES FOR THE ITER NEUTRAL BEAM TEST FACILITY

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The reference design for the ion source of the International Thermonuclear Experimental Reactor (ITER) includes tungsten filaments heated by ac and dc voltage to drive a high current arc. Electrically the filaments are configured as a three-phase load and matching transformers, located near the ion source, are provided to reduce the length of high current cabling. The heating circuit also provides the return path for the arc direct current, with connection of the matching transformer via diodes to the cathode of the arc power supply.

This design significantly reduces the conductor count, as compared to a solution with monophase ac or dc heating of the filaments and separate cabling for the return of the arc current.

The reference scheme is novel, as none of the existing neutral beam systems employs three-phase filaments. In the paper results are presented of the analysis of the electrical behaviour of the ITER filament circuit, from the prospective of power supply specification and control.

A circuit model was developed in PSIM, to simulate normal operation and fault conditions. The arc current distribution in the matching transformer windings, with the potential to lead to saturation of the iron core, was addressed first. A flexible transformer block was developed, featuring three-phase magnetic circuit and non linear magneto motive force (m.m.f.)-flux characteristic. Net dc m.m.f. due to the arc current was quantified and the impact on transformer operation evaluated.

Various fault scenarios were identified - also based on the operating experience of existing injectors - and reproduced in the model, with the aim of providing indications on instrumentation and control of the supply voltage to ensure source uniformity. The voltage-current characteristic of the ion source arc was extrapolated from published literature and implemented in the model. The role of passive components in series to the arc circuit was investigated, in relation to the need of limiting the fault current and, more importantly, of stabilising and controlling the arc current.

The results give confidence that the proposed circuit will give the required performance and quantify several aspects of the technical specification for the ITER neutral beam test facility.