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IPSE DIXIT: A User-Friendly Software Tool for the Design and Operation of Tokamak Power Supplies

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The design and the operations of a tokamak often require to assess the feasibility of a desired experimental scenario with the available power supplies (PSs). After the definition of the evolution of the current waveforms in the supplied conductors (active elements, AEs) and in the plasma, it is necessary to verify if the PS equipment is able to produce them, also taking into account the conductive structures (mainly of the Vacuum Vessel) that are not directly fed by a PS (passive elements, PEs).
In an operating tokamak, this process aims to estimate, with a reasonable trade-off between computation time and accuracy, the achievable experiments, the consequent stress on the components and the power demanded from the external grid. In the design of a new facility, this is essential to identify the component ratings and specifications and the impact on the electrical distribution systems.
A user-friendly software tool was developed to answer the question "Is Power Supply Equipment Designed Implementing Current Scenario In Tokamak?"and was named IPSE DIXIT after the acronym of such a question.
The main input data (mutual inductance matrix, resistance vector, currents in the AEs) can be entered with any mesh and time resolution. The effect of the PEs can be obtained by including their inductances and resistances in the input data. A more refined simulation of the plasma and of the AEs can be implemented by modeling them as distributed axisymmetric current filaments. Worst-case or random waveforms can be selected to include the influence of the coils for the feedback control of the plasma position and instabilities.
Some functional models are available for the most common devices and system used in tokamaks, as AC/DC converters, thyristor bridges, switching network units (SNUs) and boosters. The current actually flowing in each thyristor of parallel and back-to-back bridge configurations can be estimated, also taking into account the limit firing angles and the circulation currents. The knowledge of the heatsink characteristics allows the calculation of the thyristors'power loss and junction temperature. The verification of the single SNU resistor elements is also possible.
The electrical contribution of the systems for plasma additional heating and of the plant auxiliary services can be estimated by simplified models.
The final result consists in the estimation of the active, reactive and apparent powers expected for each tokamak operation.
IPSE DIXIT was used to design the PSs of the Divertor Tokamak Test (DTT) facility moving from a reference single-null scenario. The results obtained considering only the AEs were compared to those obtained introducing the PEs by meshes of increasing complexity (at least 140 elements). A similar analysis was carried out also on JT-60SA, where the PS components are already defined. In this case, specific thresholds can be set to verify a selected scenario.
The target of the research is to provide a free environment that could be adopted independently of the considered tokamak, covering a wide set of PS topology and components with a possible interaction with existing tools for structural analysis of experimental scenarios.

Eligible for student paper award?

No

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