Extension of the 4C code to include the power supply model and analysis of a LOCA in the EU DEMO magnet system.

Introduction

The EU DEMO tokamak fusion reactor is a demonstration fusion power plant currently in its pre-conceptual design phase in Europe. As all recent tokamak experiments, it will use superconducting (SC) magnets to generate the strong magnetic field needed for plasma confinement; to maintain their SC state, such magnets are cooled with supercritical helium (SHe) at ~4.5 K and ~6 bar. The cryogenic and SC magnet systems are the most expensive single sub-system of a fusion reactor; therefore, their design must be carefully verified. One of the tools used for the thermal-hydraulic analyses with this aim is the 4C code [1], developed and validated [2], [3] at Politecnico di Torino, which has been applied successfully to the modelling of the SC magnet systems for different tokamaks worldwide [4]-[9], in nominal conditions but also considering Loss-Of-Flow Accident [10], [11].

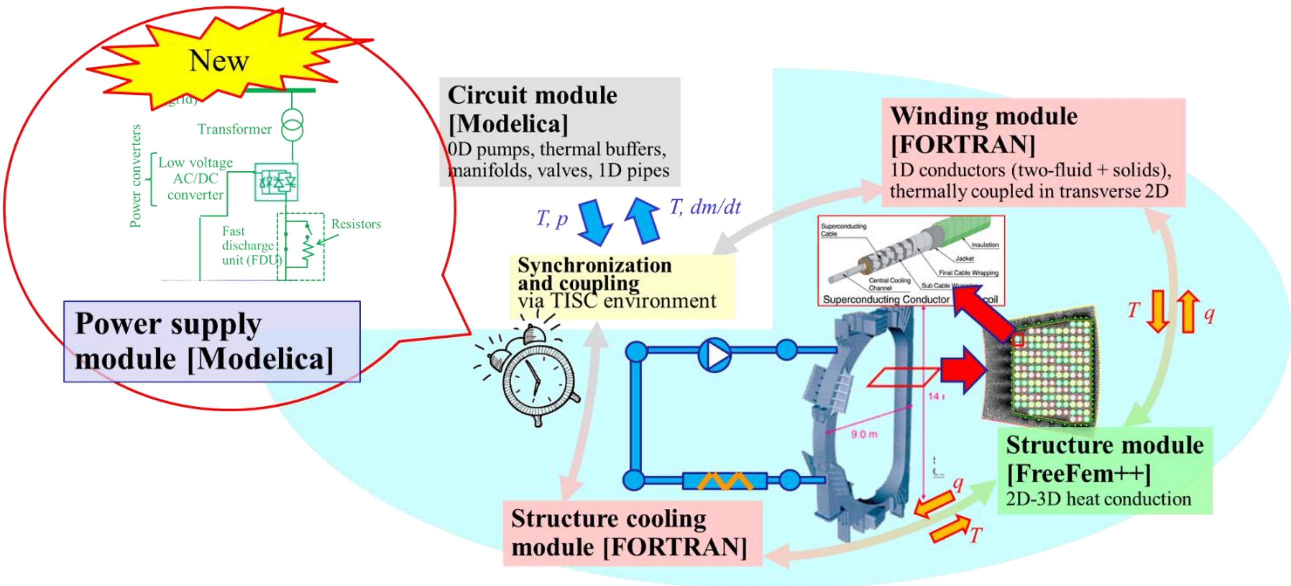

Figure 1: Current scheme of the 4C code with the new power supply module to be added in the frame of this PhD.

Aim of the work

Another accidental scenario to be considered is the Loss-Of-Coolant Accident (LOCA), which could take place either inside the cryostat or outside, causing different accidental sequences. On one hand, the loss-of-vacuum in the cryostat will reduce the maximum voltage needed to induce electrical arcs between different coils or between the coil and other components; on the other hand, the lack of active cooling may result in a quench of the coils, with the consequent sudden release of all the magnetic energy stored therein. This energy release can be controlled by means of a current discharge [4], inducing non-negligible voltage in the coils. Considering the increased electric permeability of the environment, the probability of an electrical arc rises, with possible break of the Vacuum Vessel, which is the first containment barrier for radioactive products.

The aim of the present proposal is to analyze different scenario of LOCAs in the EU DEMO magnet system, to investigate the effect on the magnet system itself and possibly the pressurization of the cryostat.

In order to capture the electrical implications of this transient, involving the power supply (the resistors for the fast current discharge and the current unbalance between the coils), the coil inductances and the electric permeability of the insulating materials in the magnet, a new, dedicated module must be developed in the 4C code. This electric module, to be written with the Modelica language [12], should then be carefully verified and validated or benchmarked against experimental data (whenever available) or other existing tools.

After that, the qualified code can be reliably applied to the analysis of the LOCA in the DEMO TF magnet system.

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