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Protection of Superconducting Magnets in Fusion Experiments: the New Technological Solution for JT-60SA

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JT-60SA satellite tokamak is an experimental device, presently under construction, equipped with superconducting Toroidal Field (TF) and Poloidal Field (PF) magnets, capable of confining high temperature plasmas (current up to 5.5 MA) for 100 s [1]. The majority of the new power supplies are provided by Europe, and the Italian National Research Council (CNR), acting through Consorzio RFX, contributes in particular with two systems: the Quench Protection Circuits (QPC) for the superconducting (SC) magnets and the Power Supply System for RWM control.
The function of QPCs is to conduct the coil current in normal operation and commutate it into a dump resistor in case of quench or other faults by means of a dc Circuit Breaker (CB). In JT-60SA, the total number of QPC units is 13: 3 for the TF circuit and 10 for the PF circuits. The nominal currents to be interrupted and the maximum reapplied voltages are 25.7 kA and 2.8 kV for the TF QPCs and ±20 kA and ±5 kV for PF QPCs.
An R&D program has been carried out since 2007 to identify innovative solutions for the interruption of high dc current, able to improve the maintainability and availability of the protection systems for SC magnets. An advanced design was finally worked out for JT-60SA: it consists in a hybrid mechanical-static CB composed of a ByPass Switch (BPS) for conducting the continuous current, in parallel to a Static Circuit Breaker (SCB) based on Integrated Gate Commutated Thyristor (IGCT) for current interruption.
Dc circuit breakers based on this hybrid approach and at this level of power have never been realized before. Moreover, the JT-60SA QPC represents the first application of this technology for protection of SC magnets in fusion experiments. The contract for QPC procurement is now in a well advanced state: the final design was approved in 2011, the qualification of the full scale prototype was completed in 2012 and the manufacturing and routine testing of the units is being completed.
The paper will give an overview of the main R&D tasks for the development of this new technological approach, which has been developed for fusion experiments but can also be suitable for different applications. Then, the paper will describe in detail the progress and present status of the procurement of the JT-60SA QPCs, which are expected to be delivered in Japan within 2014.

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