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Type Tests of JT-60SA Central Solenoid / Equilibrium Field (CS/EF) Super-Conducting Magnet Power Supplies

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JT-60SA is a Superconducting Tokamak in the framework of the Broader Approach Agreement between Europe and Japan. For this International Project among its various procurements, the Italian National Agency for New Technology Energy and Sustainable Economic Development (ENEA) is providing: four AC/DC converters for the central solenoid superconducting magnets (CS1, CS2, CS3 and CS4 PSs rated ±20 kA and ±1 kV); two AC/DC converters for the Equilibrium Field superconducting magnets (EF1 and EF6 PSs rated in the range +10 kA -20 kA and ±1 kV); and two AC/DC converters Fast Plasma Position Control Coils (rated ±5 kA and ±1 kV). Furthermore, ENEA is also providing six converter transformers of which: four dry type for FPPCC PSs and two oil type for CS PSs. These systems, being procured by ENEA through a contract signed in August 2013 with Industrial Suppliers (Poseico and Jema in Join-Venture), have been already constructed and they are in advanced testing phase.

The basic devices of a CS/EF PS consist in: a thyristors rectifier or base PS, a converter transformer, a crowbar (to protect by over-voltages and/or over-currents); whereas the load of the CS/EF PS is a Super-Conducting Magnet, whose purpose is the generation of strong magnetic fields able to induce and confine the plasma current in a prefixed geometrical configuration. This requires that the control system of CS/EF PSs is able to reproduce in real-time a reference current or voltage profile, known as "scenario". The scenarios are particularly critical in these systems for the high currents required and hence for the high magnetic energy stored in the load. The main characteristics of CS/EF base thyristor rectifier procured by ENEA are: 4-quadrant AC/DC converter 12-pulses with circulating current in back-to-back configuration, with a DC current of ± 20 kA (+10 kA/-20 kA for EF1 and EF6), a DC voltage of ± 1 kV and an accuracy of $\pm 1\%$. After the design phase, completed in 2015, the construction and the factory tests of all EF/CS PSs were completed in 2016, except EF1 and EF6 PSs, whose tests are currently ongoing.

All performed type tests were carried out both in closed loop feedback current control and in open loop feed forward voltage control and in accordance to the IEC60146 Standards. The electric load used for these tests consists of three inductances connected in series, and the whole resulting values of 3.3mH and 3m Ω represented a worst condition for the current derivative compared to the actual load. The testing facility is fed by the 30kV electric power grid and by an autotransformer, that allows the possibility to increase or decrease the voltage at the primary side of the converter transformers, that power the EF/CS PS. These tests, made at full current, pointed out a good dynamic behaviour of the control system both for forward and for reverse rectifier bridges, assuring the smooth transitions between different operating modes: single mode, circulating current mode and dual mode. This is the focus of the paper. The complete systems will be delivered to Japan by 2017.

Eligible for student paper award?

No

Authors: Dr ZITO, Pietro (ENEA); Dr LAMPASI, Alessandro (ENEA); Dr NOVELLO, Luca (F4E); Dr MAT-SUKAWA, Makoto (QST); Dr SHIMADA, Katsuhiro (QST); Dr HATAKEYAMA, Shoichi (QST); Mr PORTESINE,

Marco (POSEICO Ltd); Mr DORRONSORO, Ander (JEMA Ltd); Mr VIAN, Dionisio (JEMA Ltd); Mr CELAYA, Koldo (JEMA Ltd)

Presenter: Dr ZITO, Pietro (ENEA)

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