CONTROL ALGORITHMS DEVELOPED FOR THE ENHANCED RADIAL FIELD AMPLIFIER (ERFA) FOR JET

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The company JEMA has delivered to the Joint European Torus (JET facility in Culham) the Enhanced Radial Field Amplifier (ERFA). This device is a high frequency, high power amplifier aimed at correcting instabilities due to fast plasma disturbances.
The system is composed of four identical units connected in series through a connection box delivering up to 12kV 5kA (60MVA) in four quadrant operation [1]. Every unit is composed of an input converter stage, a DC link energy storage stage, an output inverter and an output bypass (for continuing operation in case of a unit failure). ERFA works as an energy exchanger between the DC link capacitors bank and the JET radial field coils. The input converter compensates for power losses in the JET coils and the ERFA during operation.
This paper will cover the control architecture of ERFA, the real-time evaluation and high speed response to the system requirements, and the fast exchange rate of data among ERFA units.
The four quadrant operation is performed by 10 'H' bridge IGBT modules per unit. This so called ‘inverter stage’ is responsible for amplifying the reference signal with minimum delay. A demanding requirement of the design is that the voltage reference generated by JET is virtually unpredictable. Real-time evaluation of the system capabilities is necessary not only for optimum use of ERFA but also for self protection of the power supply.
Since four identical units are used for ERFA, there are a number of operating points in which different unit switching combinations are possible. The real-time control checks the availability status of the units at every instant in terms of tolerable temperature of the most critical components (IGBT’s and output filter resistors) and limits the stored energy (DC link capacitor voltage), so that the optimum switching combination can be selected. The bulk of the paper is dedicated to the description and discussion of the complex algorithms developed to this purpose
A novel 'staggered switching' technique is also discussed. This technique is used in particular for reducing the output voltage overshoot and dV/dt, as requested by the operating limits of the JET coils.
The converter regulation in current, the PLC based overall control, the JET interface, the SCADA and data acquisition systems are also briefly described in this paper.

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[1] D.Ganuza et al, ‘The design and manufacture of the enhanced radial field amplifier (ERFA) for the JET Project’, Fusion Engineering and Design, Volume 84 (Part A), 2009, page 810 to 814