# THE INSTALLATION, TESTING AND PERFORMANCE ON THE JET COILS OF THE ENHANCED RADIAL FIELD AMPLIFIER (ERFA)

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The ERFA is a significant part of the upgrade to the plasma vertical stabilisation system for JET. As well as improvements to the plasma controller, there was a requirement for a new power supply with increased voltage and current capability over its predecessor the Fast Radial Field Amplifier (FRFA). This paper describes the ERFA installation on site, dummy load testing and operation on the modified JET radial field coils. It also covers the system performance and highlights its impressive capability. This includes a novel and complex high-speed control system for selecting units to switch on in order to distribute heating between the main power devices and to minimise dv/dt avoiding potentially damaging voltage overshoots on the JET coils.

The contract for ERFA was placed in July 2007 with delivery due in Spring 2009 [1]. It specified a voltage and current capability of ±12kV; ±5kA with a response time of better than 100μs. The ERFA design uses Insulated-Gate Bipolar Transistors as the main power device, which has significant performance advantages over the GTO-based FRFA.

A design in 6 transport-container-like modules allowed factory power testing to be completed with the minimal amount of disassembly prior to transportation to site. Dummy load testing started following four months of on-site installation work and was completed in late June 2009.

The site preparation and final installation was constrained by the need to allow continued JET operation with the FRFA followed by a short, 7 week, intervention to connect all power, control, interfacing and data acquisition needed to fully integrate ERFA with other JET systems. An additional constraint was that return to FRFA operation must be possible in two weeks in the event of a serious ERFA problem. This required the project to supply a dedicated ERFA connection box configuring all unit outputs as well as the design and installation of a patching cubicle for speed of signal cable reversal.

For the new amplifier to be effective it was necessary to allow for a reduced number of radial field coil turns with many more increments than were possible at the time. It was also necessary to have the possibility of changing the polarity of the connections or even leaving a complete winding (P2 or P3) out of circuit. For this new busbars, clamps and cooling manifolds were needed on the coils.

The first commissioning pulses showed an unacceptable drop in the ERFA output voltage on some of the more demanding pulses. A model study showed that this was due to eddy current losses in the JET structure being higher than expected [2]. Following an upgrade to each Unit's converter in August 2009, the outstanding pulses were successfully repeated.

The upgraded ERFA has been operated successfully on the modified coils for almost 1000 pulses. In terms of reliability, high-speed capability and response to complex reference waveforms, ERFA has shown that this is a significant power amplifier whose performance and selected technology makes it potentially suitable for use on other fusion machines.

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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.
[2] R. Albanese et al., this conference.