A.9: High Stability DC Power Supply for Field Mapping of Electromagnets

A high stability current-controlled dc power supply has been developed to characterize the field quality of electromagnets. The power supply, which operates on 415 V - 50 Hz three-phase ac mains, is rated for 300 A, 60 V output with ± 20 ppm stability of the output current including ripple, regulation and drift.

The power supply is based on full-bridge zero-voltage-switching (FBZVS) converter operating with phase-shifted pulse-width-modulation (PSPWM) at 25 kHz. Conventional FBZVS converters suffer from non-ZVS operation at low output current levels. Since the power supply developed for the present application needs to be operated from very low to full rated output current, this technique is not suitable. The techniques earlier reported in the literature to increase the ZVS range, and therefore reduce the switching loss, of the converter mostly results in increased conduction loss. Methods have been proposed [1] to optimally resolve this trade-off and achieve ZVS operation over the entire conversion range without significant increase in the conduction loss. In the present application, a modified version of the technique reported in [1] has been effectively used to achieve the objective.

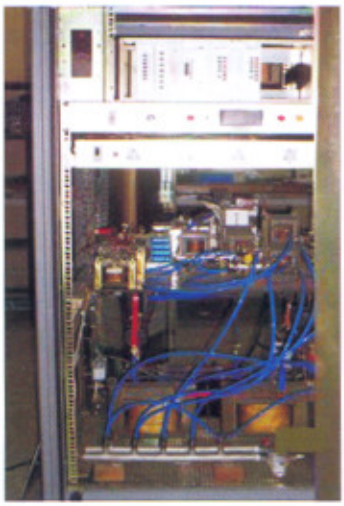

Fig. A.9.1: A photograph of the power supply.

The power supply is housed in 0.8 m x 1 m X 32 U cabinet. Three-phase ac mains is rectified by a bridge rectifier and filtered with damped LC filter to get an unregulated dc input for FBZVS converter using IGBTs. All semiconductors and high-frequency magnetic components are water-cooled to reduce the heat loss to the ambient. An on-board oven is used to maintain temperature of the important electronic components within ± 0.2 °C. Zeranin shunt is used as current sensing element and the required stability has been achieved without using costly DCCT. Figure A.9.1 shows a photograph of the power supply. The developed power supply operates satisfactorily in the output current range from 1 A to 300 A. Figure A.9.2 shows the stability of the output current measured independently using a 300 A DCCT at two current levels after one hour warm-up, which is seen to be well within the specified limits. Figure A.9.3 shows the measured conversion efficiency of the dc-dc converter stage of the power supply at different output power levels. The efficiency is measured to be about 90% maximum and it remains above 80% till 30% of the maximum power rating. Since ZVS of IGBTs is maintained over the entire conversion range, the voltage stress on IGBTs has been observed to be minimum and conducted EMI has been measured to be well within the CISPR-11 Group 1, Class A limits.

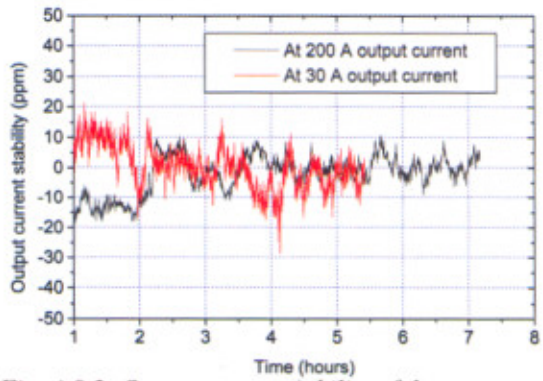

Fig. A.9.2: Output current stability of the power supply

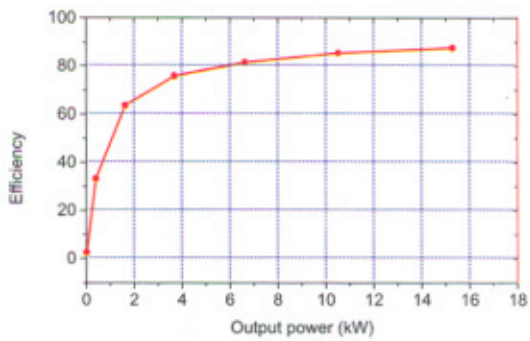

Fig. A.9.3: Measured efficiency of the FBZVS converter

References

[1] M. Borage, S. R. Tiwari and S. Kotaiah, "A Passive Auxiliary Circuit Achieves Zero-Voltage-Switching in Full-Bridge Converter over Entire Conversion Range", IEEE Power Electronics Letters, Vol. 3, No. 4, pp. 141-143, December 2005.

Reported by:
Manohar Koli(manohar@rrcat.gov.in), Mangesh Borage and Sunil Tiwari