A.5: Development of power supplies for IRFEL beam transport line magnets

The Infrared Free Electron Laser (IRFEL) is being developed at RRCAT. Current regulated, dc power supplies are required for various electromagnets in its beam transport line. These are rated for 13 A and 15 V (max.) with output current stability of ±100 ppm. In all, 60 power supplies have been developed, including the spare ones. In order to facilitate timely development of these power supplies, uniform power converter scheme for all power supplies has been followed and all associated low-power electronics, e.g. sensing, fault handling, auxiliary power sources, handling remote interface have been standardized. Involvement of industry for production and testing was also foreseen.

The topology used in these power supplies is two-switch forward converter (Fig. A.5.1) operating with variable frequency PWM (VFPWM) control in the range from 20 kHz to 100 kHz. Maximum switching frequency of 100 kHz is chosen as a good trade-off between size of the power supply and switching loses. Besides, the two-switch forward converter is a reliable power converter topology since it is inherently free from shoot-through failures. Switch voltage ratings are limited to the supply voltage, allowing lower-voltage switches to be used. Transformer leakage energy is circulated back to the source, avoiding the use of snubbers. In the power supply, a zeranin shunt is used to sense the output current. The feedback control scheme consists of two loops: the inner fast voltage loop that corrects input line variations, and outer slow current loop that regulates output current against slow varying causes, such as temperature. Bandwidth of voltage loop and current loop is approx. 1 kHz and 10 Hz, respectively. The VFPWM helps to increase the conversion range of the power supply, which with the conventional PWM, is constrained on the lower side.

The power supplies were designed, simulated and prototyped at PSIAD, RRCAT. After the successful development and evaluation of a prototype power supply, 60 nos. of such power supplies have been developed with the help of industry, wherein production, assembly, testing and evaluation was carried out. Each power supply is standardized on a 6U card and five such power supplies are housed in one 6U, 19-inch sub-rack as shown in Fig. A.5.2.

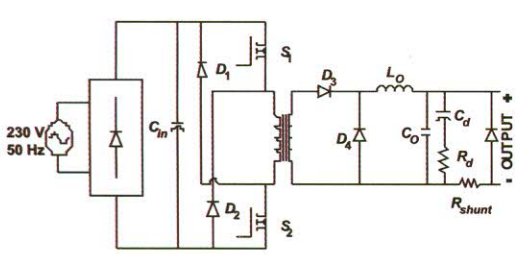

Fig. A.5.1: Two-switch forward converter schematic

Three sub-racks are mounted inside a 36 U cabinet. In each cabinet, provision is also made to house the control racks for the remote interface of these power supplies. The overall system, therefore, consists of four cabinets as shown in Fig. A.5.3.

(a) (b)

Fig. A.5.2: Photographs of the (a) power supply card and (b) sub-rack

Fig. A.5.3: Photograph of developed power supplies

The power supplies have been subjected to extensive testing at the manufacturer's premises including, functional tests comprising of open loop test and closed loop test, local/remote operation test, 48 hours heat run test at maximum rating, environmental tests and measurement of conducted electromagnetic interference (EMI). Figure A.5.4 shows the measured conducted EMI. The functional testing of power supplies has also been carried out at RRCAT.

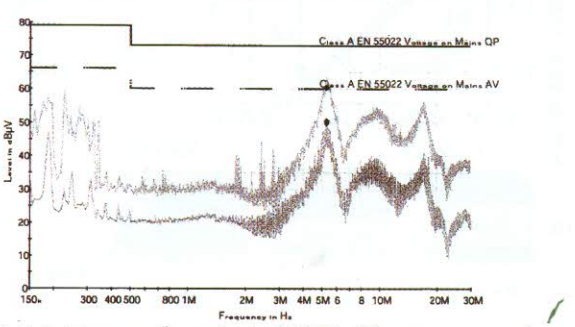

Fig. A.5.4: Measured conducted EMI of the power supply.

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