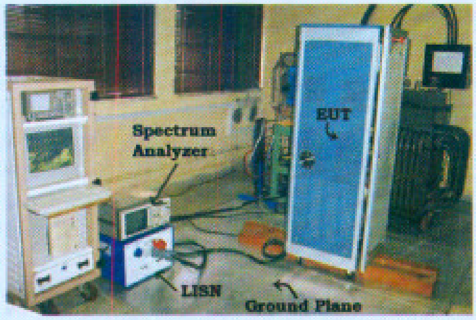


Fig.A.2.1 Photo of conducted EMI test set-up

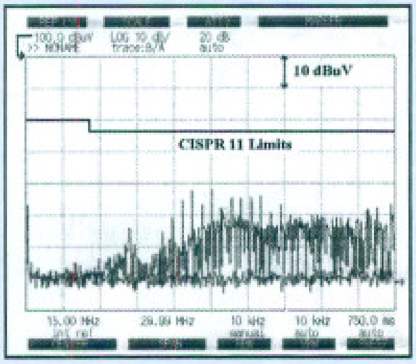


Fig.A.2.2 Measured conducted EMI spectrum

The LISN defines the line impedance to 50Ω as seen by the EUT for measurement frequency range of 150kHz to 30MHz. The power supplies are categorized as Group – 1, Class – A ISM equipment for which the limits for quasi-peak terminal disturbance voltage is 79dbμV for frequency band of 150kHz to 500kHz and 73dbμV for band of 500kHz to 30MHz. A 50μH / 50Ω, three-phase, four-wire LISN is installed at the setup for testing of EUTs powered from three-phase as well and single-phase AC mains. An attenuator inbuilt to LISN and additional transient pulse limiter are used for safe measurements on the spectrum analyzer. Fig. A.2.2 shows typical results obtained with the test set-up.

(Contributed by: Sunil Tiwari; sunil@cat.ernet.in)

A.3 Development of power supplies for Indus-2 quadrupole magnets

The specifications of the power supplies required for the quadrupole magnets type Q1, Q2, and Q3 are given in Table 1. The power supplies for Q1 and Q2 type are developed using transistor series pass scheme with twelve-pulse SCR rectifier as pre-regulator. Input three-phase supply is stepped down by a water-cooled delta/delta-star transformer, the secondary is rectified using a 12-pulse full bridge converter. The 600Hz ripple present in the DC output is attenuated with the help of a damped LC filter. The output is fed to a transistor bank, which controls the output current according to the set current. Q3 type power supplies are developed using high frequency resonant converter. Input three phase line is rectified using six-pulse SCR rectifier to get unregulated DC input. In resonant converter stage, an IGBT bridge converts input DC to high frequency square wave fed to a LCC network. The switching frequency of IGBT bridge is above the peak frequency of LCC network, this allows zero-voltage-switching of IGBTs and eliminates lossy snubbers. A switching frequency of 30 to 75kHz gives required variation in output current.

Power supplies have been tested on dummy load. The output current stability is found to be within specifications. Fig.A.3.1 shows typical long term stability measured on Q3 type magnet power supply at 150A output current. The maximum conversion efficiency of Q1 and Q2 type power supplies is 0.85 and that of Q3 type power supply is 0.92 as shown in fig. A.3.2. Output current sensing by DCCT and temperature controlled ambience for the front-end electronics of current feedback loop helps in achieving required output current stability. High frequency switching noise that is generated especially in Q3 magnet power supply can also degrade the stability and overall performance. Passive techniques for cancellation of common-mode (CM) noise reduce conducted electromagnetic interference (EMI) and consequently the requirement of additional EMI filters. Fig.A.3.3 shows the injected CM current before and after suggested passive noise cancellation techniques. Power supplies have been shifted to Indus-2 magnet power supply hall and pre-commissioning functional tests are in progress.

Table 1 Specifications of power supplies for quadrupole magnets type Q1, Q2 and Q3

Type	Q1	Q2	Q3
Maximum Output Voltage	82 V	113 V	92V
Maximum Output Current	170 A	170 A	170 A
Total Numbers	8	8	8
Output Current Stability	± 50ppm	± 50ppm	± 50ppm

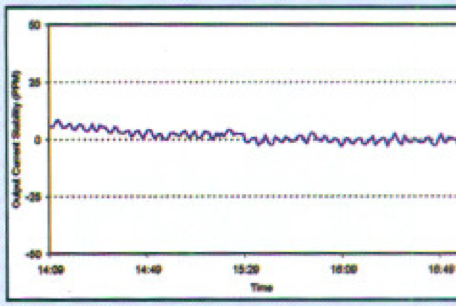


Fig.A.3.1 Stability of Indus-2 Q3 magnet power supply

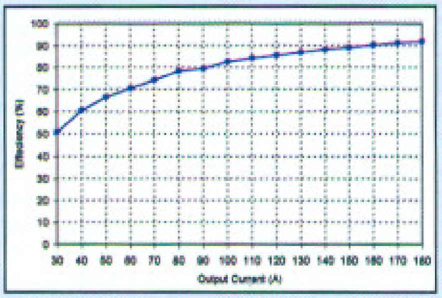
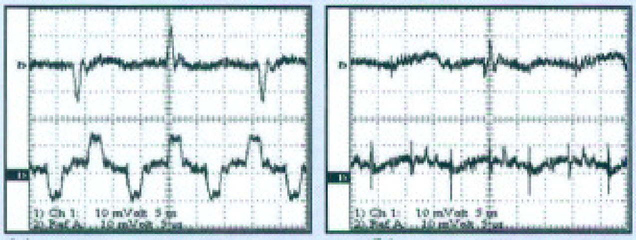


Fig.A.3.2 Conversion efficiency of Indus-2 Q3 magnet power supply



(a) (b)

Fig. A.3.3 CM current injection observed on (a) before, and, (b) after cancellation. Upper traces are for I_o=180A and Lower traces for I_o=40A

(Contributed by M.B.Borage.S.R.Tiwari; sunil@cat.ernet.in)

A.4 Laser profile cutting for quadrupole magnets of Indus-2

Particle accelerators utilize different types of magnets in limited number. Quite often prototype magnets have to be developed and tested before finalizing the design. It is not always practical to make die and punch for developing these magnets. High precision profile cutting of metal sheets could be exploited to have flexibility in magnet design and its prototype development. Indigenously developed high power CW CO_2 laser was utilized for profile cutting of 1200 numbers of 1.5mm thick steel sheets for the fabrication of Quadrupole magnets of Indus-2. Dimensional accuracy of dross-free profile cut was within ±50μm limited by the CNC workstation and the surface roughness of the cut edge was less than 5μm.

Fig.A.4.1 Laser cut-profile

(Contributed by: Dr. AK Nath; aknath@cat.ernet.in)

A.5 Open-type quadrupole magnets for Indus-2

The open-type quadrupole magnets for Indus-2 are slowly ramped from 3.84T/m to 16T/m in 300 seconds and require stringent magnetic field quality. In these magnets both of the outer vertical sections of the steel are removed in order to take out the emerging synchrotron radiation beam lines, in the region immediately adjacent to the main dipole magnets. In addition, a group of magnets, which are powered by a single power supply, need to be uniform. To meet these specifications, the critical features (pole aperture diameter and symmetry of poles) of the magnet geometry were precisely controlled. The magnet cores were made from 1.5mm thick decarburized steel sheets and their excitation coils were made from hollow oxygen free copper conductors. The core is an assembly of four pole pieces, which are made by laser-cut laminations, using 1kW-CO_2 laser and consolidated into laminated core by welding.

Fig. A.5.1 Open- type quadrupole magnet assembly

The pole tip profile was machined to finish by wire-EDM. The excitation coils were made using a semi-automatic coil-winding machine. The wound coils were consolidated with vacuum pressure impregnation followed by epoxy encapsulation for ground insulation. All open type quadrupole magnet cores and coils have been made successfully and the variation in magnet core geometries are within ± 0.05mm. The variation in the electrical parameters among the coils is within 3%. Few magnet assemblies (assembly of magnet core with coils) were completed and the balance magnet-assembly work is in progress.

(Contributed by: K. Sreeramulu; sreeram@cat.ernet.in)

A.6 Beam profile monitor for Indus-2

A fluorescent screen beam profile monitor (BPM) has been designed and fabricated for electron storage ring Indus-2. This monitor is an interceptive device, which serves as useful tuning aid during the initial commissioning stage or re-commissioning after a major shutdown of Indus-2 ring. Critical design features of the monitor are: minimum beam coupling impedance, UHV compatibility, uniform internal