# ACCELERATOR PROGRAM

## A.1 Commissioning of Indus-2

The synchrotron radiation source, Indus-2 is a 2.5GeV electron storage ring consisting of 8 unit cells of an expanded Chasman Green lattice, each cell of which has 2 dipole magnets, 9 quadrupoles and 4 sextupoles. Besides, there are 48 horizontal steering magnets, 40 vertical steering magnets. Four RF cavities placed in one of the long straight sections are for providing the energy required for the acceleration of electron beam to 2.5GeV and also for replenishing the energy lost due to synchrotron radiation. For beam injection in Indus-2, two septa (thick and thin) and four kicker magnets are used. The beam injection is carried out in the horizontal plane. There are 11 beam profile monitors (BPMs) to observe the beam profiles and 56 beam position indicators (BPIs) to measure the closed orbit distortion (COD), one wall current monitor (WCM) to measure the pulsed beam current and one DCCT to measure the circulating beam current.

To facilitate beam injection and storage in Indus-2, dipoles and quadrupoles were arranged in the ring such that the closed orbit distortion (COD) and beta beat are minimum. Initially, a 450MeV beam was transported from the booster synchrotron to the mouth of injection septum of Indus-2 through a 68m long transport line-3 (TL-3) by optimising the parameters of TL-3 magnets, which include 3 dipole magnets, 18 quadrupoles and 23 steering magnets. Trials for beam injection in Indus-2 were started in August 05. Since the injection kicker power supplies were not ready at that time, it was decided to circulate electrons in the ring without using the kicker magnets. In order to make this task easier, injection septa were moved 8mm inwards so that the beam could be viewed on all beam profile monitors and more space was available for the beam motion. A beam of energy 450MeV was injected through the septa at working point (10.3,6.2). One turn beam circulation was confirmed by observing the beam spot at all 11 beam profile monitors placed at different places all around the ring. By optimising dipole and quadrupole currents, four turns beam circulation was achieved.

The kicker magnet power supplies were ready for operation in November, 05. By energising the kicker currents and optimising time delays, a beam circulation lasting 2.1 ms was achieved on November 28, 05. On the same day one RF station was switched on at 70kV gap voltage and with phase optimisation, a beam circulation staying up to 200ms was observed. Under those conditions, intense synchrotron light was seen on the synchrotron light monitor (SLM) of the sighting beamline.

By that time, the booster synchrotron was operated at frequency 31.619MHz, the operating frequency of Indus-1. As Indus-2 RF is always locked to the booster RF and the RF frequency of Indus-2 is 16 times of the booster RF, the Indus-2 RF was being operated at 505.904MHz. When Indus-2 RF frequency was changed to its design value i.e.. 505.812MHz, the beam circulation surviving 1 second was achieved. By optimising kicker time delays, the beam survival time became more than 1 second.

In order to increase the beam survival time and beam accumulation in Indus-2, the injection energy was increased from 450MeV to 550MeV because the radial damping time at 550MeV is 443ms, whereas it is 810 ms at 450MeV. A 550MeV beam was injected into Indus-2 at design tune (9.2,5.2), by energising focusing and defocusing sextupoles, 2 mA beam current was stored in it on February 17, 2006 shown in fig. A.1.1

Betatron tunes in both horizontal and vertical planes during ramp were measured on June16, 2006; the results are shown in Table A.1.1. The ramping of the beam current on the same day is illustrated in the fig. A.1.2. The measured tune in horizontal plane is close to the theoretical value whereas in vertical plane it differs by 0.075 at 550MeV and by -0.03 at 2GeV.

The exercise of closed orbit distortion measurement and its correction is in progress.

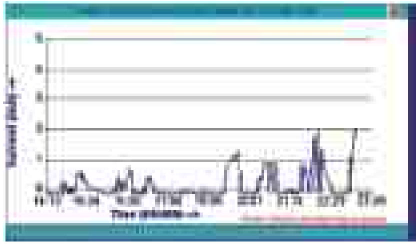

***Fig. A.1.1*** *DCCT signal of first time beam accumulation in Indus-2 on February17,2006.*

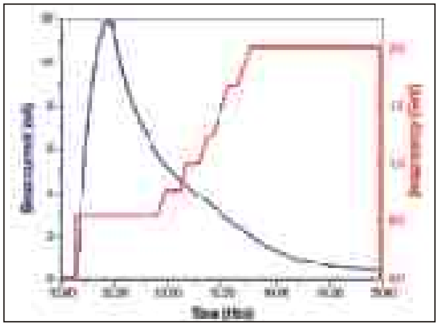

***Fig. A.1.2*** *DCCT signal during ramping of beam energy on June16, 2006.*

**Table A.1.1**:
Measured fractional betatron tunes with
beam current at different energy on 16th June, 2006

| E (GeV) | $I_{beam}$ (mA) | $\nu_x$ | $\nu_z$ |
|---|---|---|---|
| 0.550 | 4.3 | 0.3199 | 0.2152 |
| 1.0 | 3.4 | 0.298 | 0.1352 |
| 1.56 | 2.6 | 0.3026 | 0.1174 |
| 2.01 | 1.7 | 0.325 | 0.1099 |

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## A.2 Indus-2 control system during commissioning

The commissioning of the machine from control system's perspective may be categorized in phases like successful injection, build-up of required current, energy ramping, beam storage at final energy, orbit corrections and operation with predefined bunch filling patterns. So far, we have stepped in the injection, current build up, ramping and beam storage phases. Each phase has its typical requirements. Most of these have been already implemented. However, there are some eventual requirements as per the need of system diagnostics in the initial stages of each phase of commissioning. Many new features were also demanded and added to the control system. The modular design of control system has greatly facilitated the addition of new hardware and software components as per the commission requirements without much alteration in the system. Apart from these requirements, the regular operation of Indus-1 has to go on with minimum switch over time. The booster is the common entity for both Indus-1 and Indus-2 and switching the operation between Indus-1 and Indus-2 posed some timing related problems initially. The modular approach of the Indus-2 control system played a key role in combating these problems. Another issue in the commissioning was the augmentation of new hardware and software modules, their online testing and induction into the operation. The layered and modular approach made the online testing of the 'ramping scheme' an easy affair. Teething troubles were however faced with respect to high common mode conducted noise, data integrity across layers etc. but with more and more understanding of the behavior of system, such problems could be solved.

The database has played a vital role in the commissioning. Apart from providing the regular data of the system parameters, the database is made capable of serving the data for diagnosis of the faults at various layers. Most of the times the problems could be located and separated layer wise by a careful observation of the stored data. With every passing day, the usefulness of the history data in analyzing the machine performance and its easy access over intranet is appreciated more and more.

Controls for the first front end of the beam line 12 of Indus-2 were integrated successfully with the machine controls. This essentially caters to monitoring of the beam line front end status in the main control room and enabling use of beam lines by the users in a safe and secured manner The system presently includes all necessary signals for status and control, does the logging of all critical events in the central machine database and alarm handling and logging is done for all the signals. User authentication is enforced opening the safety shutter and for changing the alarm limits. The system has been made operational. Based on the operational experience and feedback, a common strategy would be evolved for applying to all the front ends on Indus2.

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## A.3 Interface characteristics of Fe/Si bilayers

Interface studies in metal/semiconductors systems are important due to their potential technological applications in microelectronics, spintronics, thermionic conversion devices, photodetectors etc. These studies become more interesting in transition metal/semiconductor systems, because of the presence of magnetic materials as Fe, Co, Ni. In transition metal/semiconductor systems, Fe/Si thin films shows abnormal magnetic and transport behaviours at low thickness of Fe and Si, as a function of Si layer thickness. For low thickness, interface characteristics become significant and play an important role in thin film properties. Interface characteristics in thin films are dictated by interdiffusion thickness, uniformity of interdiffusion parallel to interface and structural properties at interfaces

*[for details please see S. R. Naik, S. Rai, G. S. Lodha, R. Brajpuriya, J. Appl. Phys. 100, (2006), 013514.]*

Depth profile ultra violet photoelectron measurement of Fe/Si bilayer at energy 134eV, at synchrotron radiation source Indus-1 is shown in fig. A.3.1. In this spectra Si and Fe valence bands, and Oxygen peak are clearly distinguishable. In 20 min sputtered sample density of states corresponds to Si valence band is obtained. No density of states for Fe is obtained in this scan. 40 and 70min sputtered sample show density of states corresponds to Fe3d band. Density of states for Fe3d band (Peak at 0 .7eV) is broader for 40min sputtered sample, compared with 70min sputtered sample (inset of fig. A.3.1) shows the presence of iron silicide at Si/Fe interface. Figure A.3.2 shows GIXRR measurements results on bilayers, along with the model