GLOBAL COD CORRECTION FOR INDUS-2: SCHEME & IMPLEMENTATION

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Abstract

Orbit in a synchrotron or storage ring gets distorted due to factors like dipole field errors, magnet alignment errors, slow power supply drifts, ground settlements, vibrations etc. Such orbit distortion is routinely corrected in all accelerators by different schemes. Global orbit correction scheme helps to correct the orbit distortion by taking feedback from beam position indicators, calculating required correction strengths and applying them on corrector magnets. Such a scheme has been developed for Indus-2 also. An important part of this scheme is the interactive global orbit correction software to provide the facility from control room. The paper discusses the scheme, the software features, automatic generation of Response Matrix, the operating modes etc. to be implemented for Indus-2 storage ring.

INTRODUCTION

Indus-2 is a national facility with a 2.5 GeV synchrotron light source. Dipole field errors affect the e-beam orbit in both transverse planes resulting in closed orbit distortion (COD), which may affect the synchrotron radiation position and stability. Crucial to any synchrotron machine is the Global Orbit Correction[2] scheme, which helps to minimize the COD by taking beam position data from beam position indicators (BPIs) and calculating required steering magnet strengths and applying them to correct beam position globally or locally as desired by the users. Indus-2 employs 56 BPIs and 48 (horizontal) and 40 (vertical) steering (correction) magnets around the ring. The COD correction Software provides two modes of operations: 1) to operate on real machine and 2) to work with accelerator model for understanding the simulated COD and its correction. Software gives single user interface to correct the COD in both planes and many other features.

CONTROL ARCHITECTURE & SCHEME

Control architecture for data acquisition of Indus-2 parameters is implemented with three-layered control architecture. Out of the three layers, Layer-1 (L1) of the control architecture basically constitutes SCADA (Supervisory Control And Data Acquisition) functionality with API managers, event managers, database managers, and GUI applications. Layer-2 (L2) of the architecture is composed of Motorola 68040 processor based VME station which polls data from various Layer-3 (L3) stations through profi bus protocol over RS-485 based communication link. Communication link between L1 and L2 is Ethernet on restricted LAN (AccNet). SCADA at L1 polls data from

L2 at one second rate. L3 stations, based on Motorola 68000 CPU, are called Equipment Controllers (ECs) and they directly interact with field devices [3]. To service COD correction software, interface support is developed using VC++ which is the API manager for PVSS at L1. The COD correction software directly interacts with this API manager to poll BPI data and to apply predicted steering magnet strengths. L2 polls all data from L3 at the rate of one sec.

RESPONSE MATRIX GENERATION

The COD correction is based on prior knowledge of machine behaviour. Machine behaviour can be represented in terms of matrix called Response Matrix of dimension [mxn], here m is the number of steering magnets and n is the number of BPIs available in the ring. Generation of response matrix is a time taking process. To generate response matrix, known unit strength (in Amp) is applied on individual steering magnet and deviation in position of beam from previous orbit (before applying strength) is noted down. This forms one row of response matrix. Further, the unit strength is removed from this steering magnet and same unit strength is applied to next steering magnet, which then generates second row of the response matrix. This way all the steering magnets (48 in horizontal and 40 in vertical for Indus-2) are passed through same process to generate complete response matrix of dimension [48x56] in horizontal plane and [40x56] in vertical plane. Matlab based response matrix GUI Software is designed to automatically generate response matrix of selected plane. This software also displays relevant orbit data graphically. The response matrix generation software interacts with COD interface API manager at L1 to collect BPI data and operate on steering magnets. The response matrix is generated under stable conditions of the beam at
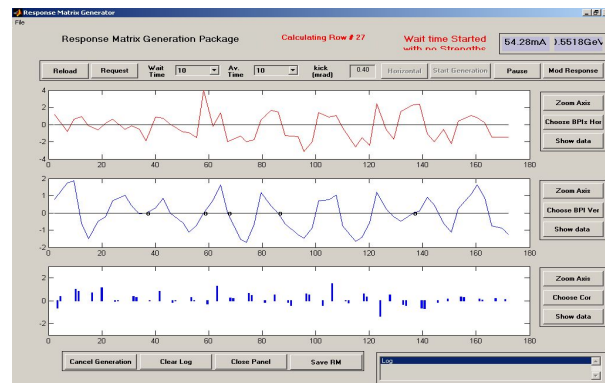

Figure 1: Snapshot of response matrix generation software in operation

different energy levels of beam starting from injection energy to final energy of 2.5 GeV. To avoid any change in machine operating condition all setting options for power supplies of main magnets like dipole, quadruple and sextuple from Magnet Power Supply (MPS) panel are disabled. Figure 1 shows the snapshot of response matrix generation software in operation. First plot shows the current orbit of the beam, second plot shows difference orbit with persistence mode to show change in orbit clearly. Third plot shows the bar chart of measured strengths and presently applied unit strength. Operator can pause the process any time and resume the operation from same point. Operator can also choose desired set of BPIs (say k) and steering magnets (say l) to generate reduced response matrix of dimension [lxk]. Once complete response matrix is calculated, it is saved in an excel file format and it can be stored in desired location by operator on local machine. This can be loaded in COD correction software during online mode of operation.

COD CORRECTION SOFTWARE

The COD correction software is available to be used either in real machine mode or accelerator model (using Accelerator Toolbox) of Indus-2. These modes will be helpful to learn, understand and compare the real machine orbit behaviour with accelerator model. Developed by Accelerator Physics Group at Stanford Synchrotron Radiation Laboratory, Accelerator Toolbox [4] is a collection of tools to model particle accelerators and beam transport lines in MATLAB environment. Snapshot of COD correction software is shown in Figure 2. The COD correction software provides numerous features like:

- Displays all orbit and strength data graphically,
- Option to select correction algorithms like Singular Value Decomposition (SVD) and Least Square Minimization (LSM),
- Database save and browse operation,
- Detailed view, orbit & strength statistics (max, rms) of data display,
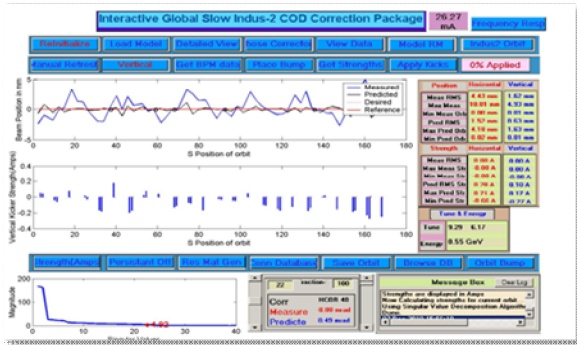

Figure 2: Snapshot of COD Correction Software showing measured and predicted COD data in vertical plane at injection energy

- Option to save all orbit & strength data locally,
- Orbit bump operation, persistent mode display of orbit option, option to display strength in mrad or Amp,
- Option to apply strengths in wanted fractions,
- Option to enter the desired SVD value to optimize rms steering magnet current.

RESULTS & CONCLUSION

The initial trials of COD correction using the global orbit correction software are performed recently. The results were encouraging. In these trials using model response matrix, the rms COD in horizontal plane was brought down from 4.20 mm to 1.30 mm at injection energy and from 4.50 mm to 1.20 mm at 2 GeV. Similarly in the vertical plane the rms COD was reduced from 1.67 mm to 0.60 mm at injection energy and from 2.83 mm to 0.60 mm at 2.0 GeV. The uncorrected and corrected horizontal COD at energy of 2GeV is shown in Figure 3. For further reduction in COD the measured response matrices in both the planes are required. The trials are going on to measure these response matrices.
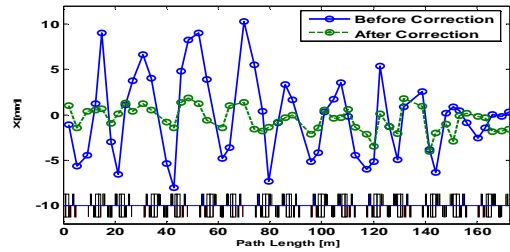

Figure 3: COD correction performed in horizontal plane at 2.0 GeV.

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