STATUS OF INDUS-2 CONTROL SYSTEM

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Abstract

Indus-2 is a 2.5 GeV Synchrotron Radiation Source at Indore, India. With 8 beamlines operational, several more under installation & commissioning and 5 insertion devices planned, the machine is operated in round the clock mode for users. With implementation of orbit, tune and bunch feedback systems and many new systems in planning, machine is constantly evolving and so is the control system. The control system software is based on WINCCOA SCADA running on windows PCs and also integrates with other software modules in Labview and Matlab. The control hardware is a combination of VME based control stations interconnected over Ethernet and Profibus. Some recent system enhancements include parameter deviation alarms, transient data capture system, database improvements and web services. Paper takes a stock of the control system and its evolution along with new systems recently introduced.

INTRODUCTION

Over the years, Indus-2 has been consistently graduating to newer milestones. Among various other enhancements, these relate to addition of new front ends and beam lines, regular operation of various beam lines, round the clock operation of machine, improvement of orbit stability through implementation of orbit control systems, tune feedback system to stabilise the machine tune points, improvements in ramping and cycling procedures, faster data logging, automation and monitoring of various auxiliary systems like LCW, compressed air system, cavity precision chillers, solid state RF amplifiers, addition of vacuum chamber temperature alarms, bunch by bunch feedback system to counter instabilities at higher beam currents, addition and remote operation of diagnostic beamlines, machine and sub-system diagnostics etc. Now the machine operates with global slow orbit feedback (SOFB) system controlling the orbit to within 30 microns. With tune feedback system implemented, bunch by bunch feedback system integrated with the control system, both local and global fast orbit feedback (FOFB) systems demonstrated, the system is now being prepared for regular use of combined operation of SOFB along with FOFB. Average horizontal orbit drift correction using RF frequency correction will also be integrated. Two undulators will be received and installed soon.

The preparations for system integration of undulators and its control system with machine control system are on the anvil. The control system for Indus accelerators is designed, developed, and maintained by the Accelerator Control Section, RRCAT.

OVERVIEW

The control system works on client server model and enables functional and physical separation and placement of hardware and software modules across the entire range of control system components. Using WinCCOA [1] SCADA on Windows client and server machines interconnected over ethernet switched network to two layers of VME controllers via Profibus, the distributed Indus-2 control system (Fig.1) monitors about 10000 I/Os in all. User Interfaces are mostly built around the SCADA for managing the complex requirements in an integrated manner. The intermediate, supervisory layer and the lower equipment interface layers are based on VME controllers running a multitasking real time operating system. Ethernet (100 MBPS) and PROFI bus (750 K baud) communications are used between L1-L2 and L2-L3 respectively. The modular control system hardware is designed around VME bus.

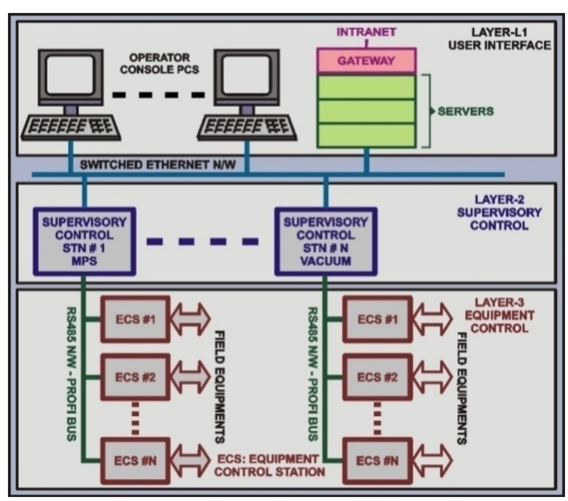

Figure 1: Indus-2 Control System Architecture.

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Various enhancements in the individual control systems leading to performance improvements in past few years and in recent times are briefly described below.

EVOLUTION

Machine Safety Interlock System (MSIS)

MSIS monitors about 400 critical signals of machine components and takes action during abnormal and potentially harmful conditions to safeguard the machine. It takes decisions for allowing different power supplies to run, injection to happen, or trip the power supply or kill the beam by tripping the RF system. The system ensures that all safety shutters are closed at the time of injection, all valves are open, water flow is normal and temperatures at various locations are within range. It also takes action if any of the assigned beam line front end signals have abnormality. It also takes care for the conditional bypassing of any faulty status or device. It is built using home grown VME infrastructure and carefully designed to be reliable and fail-safe. It is a distributed system built using VME controllers but without the Profibus for interconnection on RS 485 bus. It rather uses specific custom communications for tighter performance and guaranteed reliability. Many signals from beam line front ends were later included with MSIS for improved safety of beam line components and machine. This system is runs in 24x7x365 mode.

Central Alarm Handling System

Alarm handling system for Indus-2 keeps watch on all machine parameters and raises alarms whenever abnormal conditions are detected. Alarms have been categorized into two categories, normal and critical which have distinctly different audio annunciation tones in the control room. Recently hysteresis has also been introduced to alarm values. Towards the policy of empowering the sub-system experts to themselves set and change the system parameter limits, an alarm configuration module is now made. System experts can now manage the parameter limits on their own.

Parameter Deviation Alarms

Proper machine operation depends on complex relation of a number of online alterable critical parameters which should remain within some tolerance limits. Therefore need was felt for a Parameter Deviation Alarm System which would raise alarms in such well defined cases. PDA has been implemented for magnet power supply parameters.

System Diagnostics

Extensive system and data diagnostics are made available which help to minimize the machine down time by quicker diagnostics of system malfunctions. System diagnostics built from the initial days are - L3 and L2 layer controller status, Bus-error status of L-3 CPU, L-3 CPU running state, L1-L2 communication status, API running status, DAC readback by ADC for end-to end reference signal confirmation (in MPS system) and board temperature info for high stability analog I/O boards. Later application level diagnostics facilities were also developed, like, cycling analysis and verification system, ramping data capture and analysis system (Fig.2)using fast data capture through onboard ADC and local data storage, transient data capture system using separate faster ADC modules and web based beam trip analyzer etc.

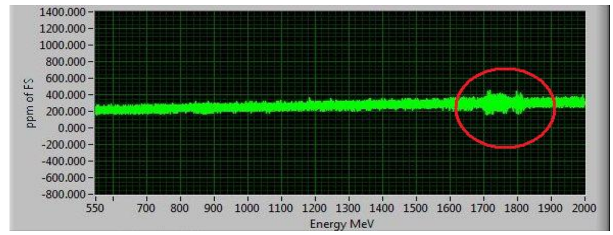

Figure 2: Ramping data capture system showing up malfunction at 100 PPM level in high accuracy power supply readback signal.

SCADA - WINCCOA

In the three-layered architecture of Indus control system, the WINCCOA API manager [2] plays a crucial and interacts with both the WINCCOA database and L2, the VME Supervisory layer. In order to access the PVSS database it uses the PVSS API, a C++ class library, whereas in order to access the L2, custom functions have been built. Any external software can be integrated in a PVSS System via class libraries provided by the API. API managers have been developed for various sub-systems of Indus-2. These cater to multiple clients by following a multi-threaded design. As the work progressed, the developed API managers were put to real test. The system did require changes and fine tuning to cater to new requirements and to remove some bugs. Some operations, like ramping clock generation, earlier done using panel scripts were later moved to API. For a special requirement like energy ramping, the magnet power supplies API manager code was modified such that it retains the state of the last operation. The various states maintained are INIT, RAMP-ON, RAMP-PAUSE, RAMP-RESUME and RAMP-OVER. So even if the API Manager is re-run during ramping process, it does not affect the clock generation and ramp operation.

Timing System

Timing system controls every phase of the electron beam extraction and injection through various machine components, like Microtron, Transport line-1, Booster, Transport lines 2 & 3 and Indus-2. It provides for proper bunch filling modes, control of various trigger pulses, generating the required delays and amplitudes of pulsed power supplies etc. Since booster (31.613 MHz) and Indus-2 (505.6 MHz) rf frequencies are different, a coincidence generator board was designed and used for proper injection into Indus-2. The bucket separation in Indus-2 ring is 1.99 ns and delays are generated with sub-nano second resolution and jitter less than 2 ns. Noise issues initially faced with the timing system were

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overcome by re-design of some boards and avoiding ground loops through use of optical fiber based analog reference signal delivery system. Initially three bunch filling modes were built but recently new bunch filling patterns were required and these have been provided now.

Data Logging

About 10,000 machine parameters are continuously logged in the central database. Logging of all operator interactions and system events is also done, which helps in correlating the information that is crucial in case of system malfunction. The data logging system in use till recently made SCADA write directly to MS SQL database. It supported logging at varying time intervals of one second to one minute. Although this strategy worked satisfactorily till some time back, it did not scale up well as the number of control parameters increased and began to strain network and storage capabilities. So the data logging system has been upgraded [3] and now it supports logging of all the machine parameters at the same rate at which all the parameters are acquired from the field i.e. at 1Hz.

The new data logging scheme adopts '*data table per data type'* approach [4] i.e. same data-type parameters values are stored in a single table. Besides this, in this new data logging scheme [5], the time series data are first put into text files by the SCADA and later bulk inserted into the data base using Java programe and stored procedures. Table partitioning using sliding window scenario concept [6] is an important ingredient.The Java application also manages temporal synchronization and serve as watchdog for any application failure. With these and associated major modifications at software level, the system achieves fast data logging of all the parameters at 1 Hz.

Web Based Information Management Tools

Some very useful and convenient web based tools have been developed and deployed. Indus Online provides the live, historical and statistical data to users and system experts, Fault Information System allows tracking and emailing the faults occurring in sub-systems, Machine Status Information System is used to display the live machine status at various locations of Indus Complex, Flogbook [7] helps logging and emailing the machine faults by shift crew and solutions and comments by system experts. Elogbook allows recording of shift operation details in electronic form. Eplanner is a package extensively used for machine activities management.

Orbit Feedback Correction Systems

Two orbit correction schemes are being implemented. The *global Slow Orbit Correction (SOFB) Scheme* has been implemented. It brings down the natural occurring beam variations in both horizontal and vertical planes to within ± 30µm. The global Fast Orbit Feedback (FOFB) system is being implemented in phases. In its first phase the FOFB system with 16 BPIs and 16 fast correctors is developed for both the planes. In the second phase this scheme will be extended to the full 56 BPI and 32 corrector version for both the planes. FigureXX gives the block diagram for global FOFB system at Indus-2. The system successfully brings down the natural occurring beam variations up to 50Hz in Vertical plane to ≈ ± 3µm (Fig.3).

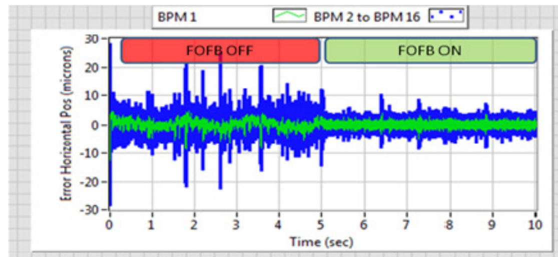

Figure 3: Measured beam position on different BPIs with Global FOFB system OFF and ON for vertical plane.

SUMMARY AND FUTURE PLANS

Indus 2 control system continues to evolve to support the ever growing new requirements and enhancements and thereby support the evolution of this national facility. API managers have been running with no crash events being reported. The load of the over all SCADA system has been nearly constant and lies between 17-21% with API manager load being maximum 2%. Possible extensions to the API are developing a generic API which caters to all future up-gradations of the Indus control system. In near future, the system will see development and integration of controls for insertion devices and beam based alignment systems.

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