CONTROL SYSTEM FOR BEAM DIAGNOSTIC SYSTEM OF INDUS-2

Amit Chauhan#, Bhavna Merh, Pravin Fatnani, Sampa Gangopadhaya
Raja Ramanna Centre for Advanced Technology, Indore-452013, India.

Abstract

This paper presents the Beam Diagnostics Control System for Indus-2 that monitors and controls the parameters related to Beam Profile Monitors (BPM), Beam Position Indicators (BPI), Direct Current Transformer (DCCT) and XZ-selection for strip-lines. The system has three-layered architecture. The middle and lower layer have VME stations with CPU cards having RTOS OS-9. The lowest layer has nine stations that house various Analog and Digital I/O boards connected to the actual devices in the field. The boards include 4-channel 16-bit ADC cards developed for BPI interfacing. The middle layer collects the data from lower layer and passes to top layer and passes the commands from top layer to the lower layer. The top layer has the GUI for operator control built using a SCADA software PVSS. It provides various features to the user for graphical display, trending, configuring, controlling, data-logging and selective data monitoring of the parameters. This system finds use right from the beam injection stage to the Orbit correction stage in addition to the normal operation stage of the machine.

CONTROL SYSTEM OVERVIEW

The control system of Indus-2 has a three-layered architecture as shown in figure-1.

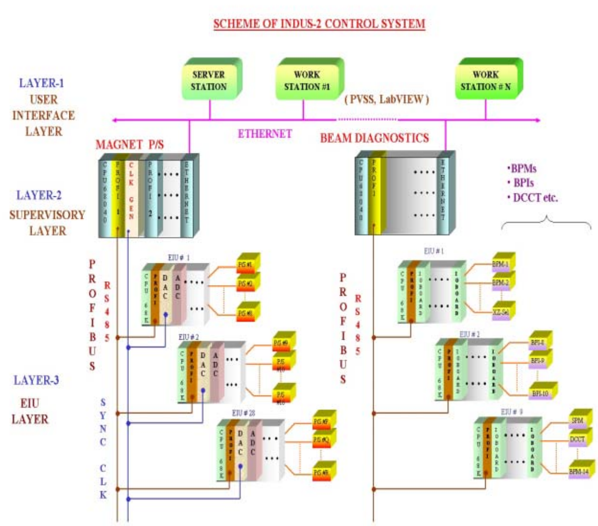

Figure 1: Scheme of Indus-2 Control system

At the lowest layer, Layer-3, known as Equipment Interface Unit (EIU) Layer there are VME stations that have various analog and digital I/O cards. These cards are interfaced with the devices in the field. The middle layer, Layer-2, is the Supervisory Layer where there are separate VME station controlling each sub-system of Indus-2 like Magnet Power supply system, beam diagnostic system, RF system, vacuum system etc. The top layer, Layer-1, is the User Interface Layer that provides the Graphical interface to the users for operating the machine.

The communication between Layer-1 and Layer-2 is on TCP/IP network using socket-based communication. Layer-2 and Layer-3 communicate using ProfiBus field-bus protocol where Layer-2 acts as the Profi Master and Layer-3 acts as Profi slave. Second and third layers make use of in-house developed Profi controller cards configured as master and slave respectively.

BEAM DIAGNOSTICS CONTROL SYSTEM

As the name suggests the Beam Diagnostics system is used for measuring the various parameters of the electron beam like its profile, position and the average current. For this various devices like BPIs, BPMs, DCCT etc. have been developed and installed in the machine by the Beam Diagnostic group at RRCAT. All the signals for controlling and monitoring of these devices are interfaced to the control system of Indus-2.

Like the control system for all other sub-system, the one for Beam Diagnostic system also has three-layer architecture as shown in Figure1.

Layer-3 has nine VME stations. Each station house a CPU card, a Profi salve card and the various digital and analog Input/output cards that are interfaced with the actual devices in the field. The OS-9 software at this layer implements Profi slave protocol, collects data from input cards and sets data on output cards.

Layer-2 has a single VME station that has one CPU card and one Profi master card. Layer-2 OS-9 software implements Profi master protocol and has socket programs for communication with Layer-1.It also holds the mapping of the various parameters of all the devices to the specific Layer-3 station, the I/O card and the channel number. So whenever a command from Layer-1 software is received, Layer-2 maps the command for the device at Layer-3 and sends it down.

Layer-1 software has been developed using PVSS, SCADA software. This software has two components. First is the API-manager written for PVSS that connects to Layer-2 on TCP/IP network and exchanges data and commands. It resides on a specific server machine. The second component is the Graphical User Interface (GUI) in the form of PVSS panels. These panels can be run on any PC on the Control Room network. Various panels have been developed for the various sections of the Beam-diagnostic sub-system like BPM, BPI, DCCT, etc

#amit@cat.ernet.in

BPM CONTROL

Beam profile Monitors (BPMs) have been developed by the Beam Diagnostic group. These are used to monitor the profile of the electron beam in the ring. A BPM typically consists of a CCD camera and a movable assembly to move a florescent screen in and out of the accelerator assembly. When the beam falls on the screen, an image is generated which is captured and transmitted by the CCD camera. There are 23 such BPMs in the system.

For operation of every BPM six signals are interfaced with control system. Two are control signals – activate and deactivate BPM interfaced with Relay-output cards. Four are status signal – screen in, screen out, selection/deselection status and remote/local status interfaced with opto-input cards. The video signals from all the BPMs are connected to a pair of Video-multiplexer cards. For the operation of a particular BPM, the corresponding relay channels and the video multiplexer channels are activated by the control system.

Figure 2 shown the control panel for BPM control system developed using PVSS.

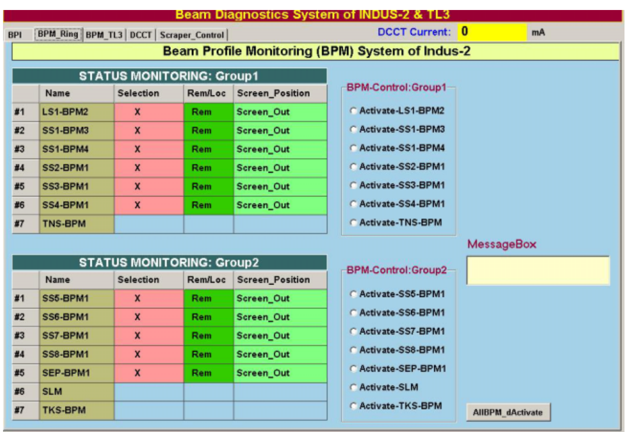

Figure 2: PVSS Panel for BPM control

BPI CONTROL

In Indus-2 the beam position is measured using Beam Position Indicators (BPI) that have 4-button electrodes each. There are a total of 56 BPI in the ring. Each BPI unit provided 4 analog signals and one digital signal. The analog signals are 0 to 10 volts corresponding to the charge induced on each button as per the beam position. The digital signal corresponds to the PLL status of the BPI unit.

The GUI panel shows all the individual readings as well as the calculated X-plane and Z-plane position of the beam under that particular BPI. The panel also shows the PLL and external trigger enable status for all BPIs.

Figure 3 shows the snapshot of the panel for BPI system.

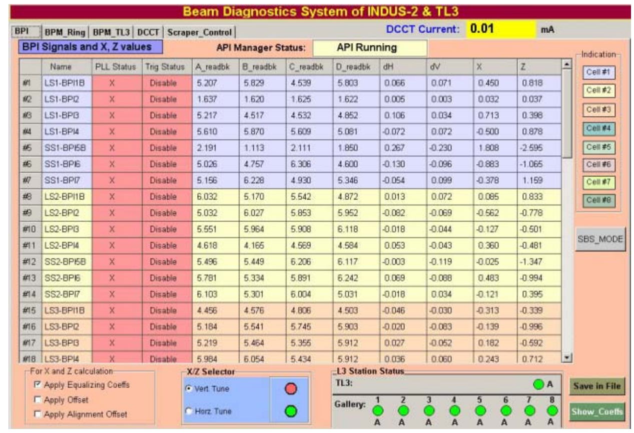

Figure 3: PVSS Panel for BPI control

4-channel 16-bit ADC card development

For the purpose of fast acquisition and conversion of the BPI signals, a VME based ADC card has been developed by the Controls group at RRCAT. The 4 analog signals from the BPI unit are connected to the 4 channels of this ADC card. The block diagram of this card is shown in figure 3.

The main features of this card are:

- 4-independent channels of 16-bit serial ADC with conversion time of 10 microseconds.
- 4- digital input channels
- Isolation between ADC front-end and VME logic circuit using DC-DC converters.
- Capable of interrupting VME controller on selectable level
- Full 24-bit selectable address
- 8-bit selectable interrupt vector
- External / Internal SOC selection by software. External SOC comes at the BNC connector and Internal SOC is generated by writing at an address location.
- Analog filters at the input with gain selection.
- ADC configuration has range selection through jumper setting (0 to 10 V or –10 to +10 V)
- Most of the logic implemented in CPLD

Presently there are 58 such cards used in the beam diagnostic control system

Features of Software

The Layer-2 API software for calculating the beam position uses various equations, offset data and calibration data to convert the button monitors readings into position values.

The overall software also provides the feature for averaging a number of sample readings of all the BPI data at Layer-3 station. The sample count is selectable from 2 to 20 per reading.

There is facility to selectively enable/disable particular BPIs from the panel. The software has the feature of periodically or on-demand archiving of the values of all the BPIs readings.

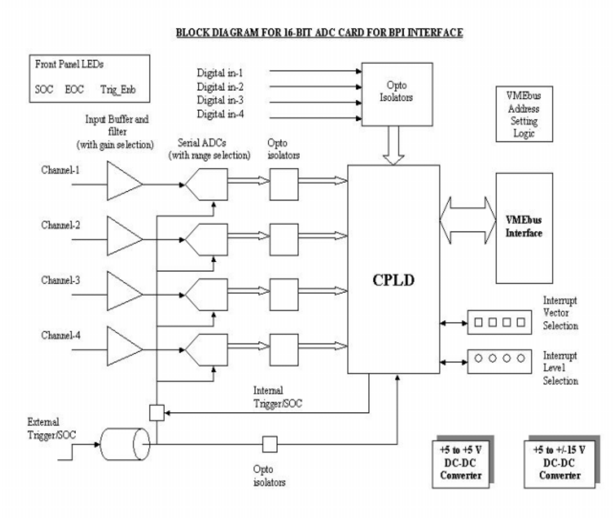

Figure 4: Block Diagram of ADC card

DCCT CONTROL

The Beam Diagnostic Group has installed a Direct Current Transformer (DCCT) in the Indus-2 ring to measure the average electron beam current.

The DCCT unit provides one analog signal to the control system that is digitised by the 16-bit ADC card (similar to the one used for BPIs). In addition to it there are five status-signals and five control-signals that are interfaced to the control system using opto-input and relay-output cards respectively. The status signals include calibration on/off, test on/off, Range A selection, Range B selection and temperature alarm. The control signals include test on/off, Range A/ Range B selection, put in calibration, Negative/positive calibration and temperature alarm reset.

Figure 5 shows the PVSS panel for DCCT. The panel has built in logic for automatically switching from Range A(0-1000 mA) to Range B(0-100 mA) and vice-versa depending on the present current value and the range limits. It also plots the current data and provided all the control and status information.

XZ-SELECTION CONTROL

There is a VME based XZ-selection card with RF-switch developed by Beam Diagnostic group. It is used to select the strip-lines in either X-plane (horizontal) or Z-plane (vertical). It is housed in one of the VME stations at layer-3 of control system. The logic to switch the plane and show the status of the presently selected plane has been incorporated in all the three layers of the control system. The PVSS panel for BPI system includes the XZ-selection control and display also as shown in Figure 3.

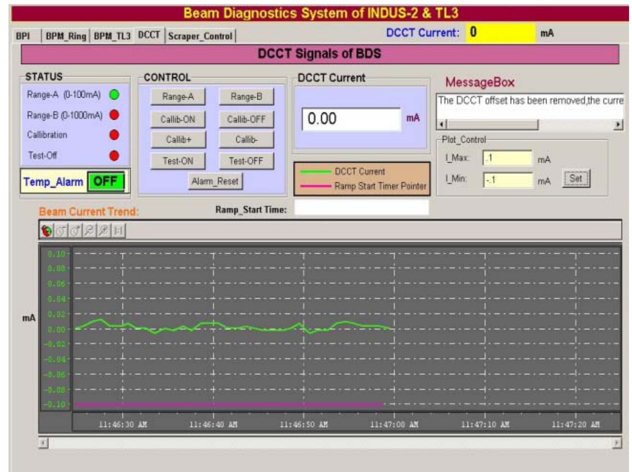

Figure 5: PVSS Panel for DCCT control

CONCLUSION

The control system for Beam Diagnostics is useful at all the stages of machine operation. During the injection process the various BPMs come in very handy to know the status of the electron beam. During the normal operation the DCCT data helps in knowing the beam current and BPIs data is used for displaying beam position. In near future during the orbit correction stage again the BPI data will be used to calculate the appropriate values to be applied to the various horizontal and vertical corrector magnets.

REFERENCES

[1] P.Fatnani et al, “Indus-2 Control System”, PCaPAC 1999, Tskuba Japan.

[2] T.A.Puntambekar et al, “Experiences of Beam Diagnostic System in commissioning stage of Indus-2”, APAC 2007, Indore, India.

[3] K.Saifee et al, “Profibus development for Indus-2 control system”, InPAC-2003, Indore, India

[4] Amit Chauhan et al, “Application of RTOS (OS-9) for Indus-2 Control System”, InPAC-2003, Indore, India