# DATA ACQUISITION PROCESSING SYSTEM BASED ON PXI

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## ABSTRACT

*An architecture model for fast data acquisition and processing system is developed in LabVIEW. The system monitors and controls the various components of Reflectivity Beamline of Indus-2. The system is based on PXI (PCI extension for instrumentation) Express and runs under real time operating system.*

***Index Terms: PXI Express, Real-time, LabVIEW RT, Shared Variable.***

## I INTRODUCTION

Indus-2 [1] is a 2.5GeV, 300mA synchrotron radiation source which is now working at 150mA current. There are 27 proposed beamline out of which 10 are functional. The upcoming beamline is Reflectivity Beamline. X-Ray Reflectivity [2] is a tool for the investigation of surfaces and interfaces in thin films and multi-layers. The beamline consists of Vacuum Gauges to measure the vacuum inside the beamline, Gate Valves to regulate the vacuum within the beamline, K-type thermocouple to measure the temperature of the beamline, flow sensors and flow switches to measure waterflow and airflow.

Beamline control system is a data acquisition and control system. The system facilitates the beamline user to remotely control and monitor the various beamline components from a centralized zone i.e. from the experimental hutch for acquiring and storing experimental data. Interlocking scheme has been implemented for the beamline operation. The main function of Interlock is to protect the beamline from the vacuum degradation and ensuring the safe operation of the components.

## II OBJECTIVE

The primary motive for developing the system is to control various components, to provide the fail-safe operation of the beamline. The system controls the component like Gauges, Gate Valve, flow switches and flow sensors with a user authentication. A proper interlocking scheme has been employed in the system for the fail-safe operation of the Beamline. The data acquisition software has been developed in LabVIEW which provide user friendly control interface. Different modules of LabVIEW have been used to develop the required system.

PXI has been used as a DAQ interface. The motivation behind the rapid adoption of PXI platform are its high embedded controller and its synchronization mechanism that helps in architecting fast and precise data acquisition system.



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## III PXI Express

PXI Express [3][4] has ended standard data acquisition platform in industrial market. PXI Express platform uses high speed PCI Express data communication bus. By incorporating the high speed PCI Express [5] data bus technology into the PXI platform, drastically expand the data bandwidth. PXI/PXI Express provide the compatibility with all major and significant operating system which offer a great deal of software that can run on PXI/PXI Express. PXI Express is completely compatible with PCI, PCI Express, Compact PCI and PXI slots. PXI is a synchronous bus. PXI utilizes different timing and synchronization features [6].

### 3.1 Using PXI for Real Time System

Real time system is often utilized for superior performance system obliging deterministic handling. A real-time system is required when it is expected to run the program more reliably for long time and run continuously without intrusion.

Real time processing is possible by exploiting powerful tool of Laboratory Virtual Instrumentation Engineering Workbench Real Time (LabVIEW RT) combined with a high performance Pentium based PXI Express embedded controller. LabVIEW RT satisfies the need of deterministic real time performance utilizing LabVIEW.

Real time (RT) system [7] comprises of hardware and software components as shown in Fig.1. The hardware components include host machine and RT target. The software components comprise LabVIEW with RT module, RT engine and LabVIEW VI.

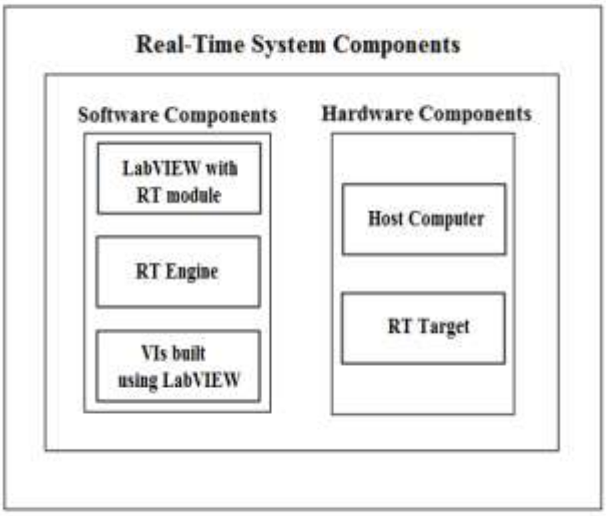


**Figure 1: Real Time System Components**

The host machine is the computer where the VIs is created. LabVIEW is graphical programming language with the help of which VIs is developed. RT module provides LabVIEW the capabilities to run the VIs on the RT target. RT engine run the VIs deployed to the RT target from the LabVIEW on the PC. It run on the real time operation system (RTOS) and gives deterministic real time performance. The RT target is the RT hardware i.e. PXI that run RT Engine and VIs created utilizing LabVIEW.



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## IV LabVIEW RT

LabVIEW RT consists of three components: LabVIEW, RT Development System and the RT Engine as shown in fig.2 [8].

The RT Development System is a window application that runs on the host PC. It can be utilized to download the VIs to the RT Engine. LabVIEW and RT Development System are the different form of the labview.exe. LabVIEW RT extends the capability of LabVIEW to run on real time processor. When labview.exe is executed on host PC, then it is in the LabVIEW mode. When labview.exe is executed on RT hardware, then it is in the RT Development System mode.

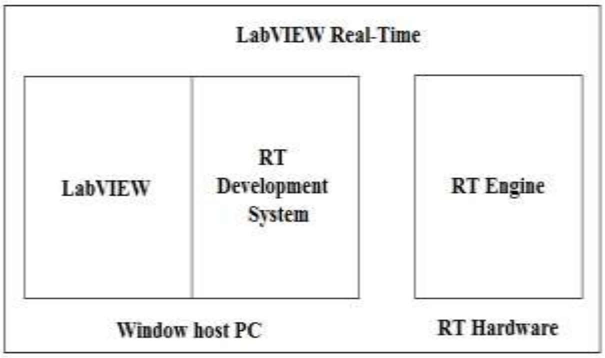


**Figure 2: LabVIEW RT Components**

## V SHARED VARIABLE

A host LabVIEW application can control the behavior of the RT Engine application programmatically and save and analyze data that an RT Engine VI produces. The host LabVIEW application likewise gives a user interface for communicating with RT Engine VI. The communication is given through network published shared variable as indicated in fig.3.

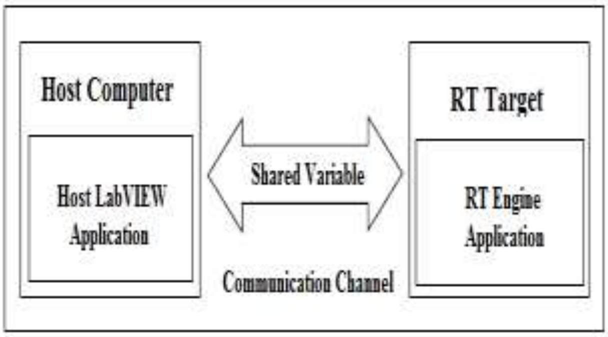


**Figure 3: Communication between Host and Target VI**

By utilizing network published shared variable, data can be read or written over the network through a software component called shared variable engine SVE. It manages shared variable updates using NI-PSP. NI PSP (NI Publish and subscribe Protocol) is a networking protocol implemented for the transportation of network published variable.

## VI GUI DEVELOPMENT

The Graphical User Interface (GUI) is developed using LabVIEW to monitor and control the different instrument such as Gate Valve (GV), cold cathode gauges, K-type thermocouple and flow switches. Based on various condition mentioned in Table 1, beam ready signal will be generated. GUI comprises three screens: Status, Login and Control Screen.

**Table 1: Important Parameters for Beam**

| **Parameters** | **Conditions** |
|---|---|
| Vacuum within the Beamline | < 2*E-9mbar |
| Waterflow | ≥2LPM |
| Temperature | < 40°C |
| Airflow | 6-7bar |

**6.1 Status Screen:** Status screen shows the status of the installed components such as gauges, gate valves, water flow, beam ready and temperature as shown in figure 4. Tri-color scheme, Green for OPEN, Red for CLOSE and Yellow for Intermediate has been used to show the status of gate valve.

**6.2 Login Screen:** Fig. 5 shows the login screen.


**Figure 4: Status Screen**


**Fig. 5: Login Screen**

The two type of authentication have been used: (1) Administrative (2) User. Administrator can modify, change the developed code if required by using password. User has to get register before he operates the beamline. The control screen is automatically popped-up after the successful authentication of the beamline user. Each successful access to login screen is stored in a database, which can be referred in future.

**6.3 Control Screen:** Gate valves (GV) can be opened only in a sequential fashion. An intermediate valve opening is forbidden. This sequential valve opening scheme is assured in the code via a logical coding, in which display of next valve to be open will be popped up only when its previous valve is opened and the associated condition to open meets. The conditions for the valves opening are mentioned in Table 2.

**Table 2: Interlocking Scheme for Reflectivity Beamline**

| Component | Signal | Action |
|---|---|---|
| GV1 | Open/Close | Open if G1< 2*E-10mbar |
| GV2 | Open/Close | Open if G2< 2*E-10mbar and GV1 is open |
| GV3 | Open/Close | manual |
| GV4 | Open/Close | Open if G4< 2*E-10mbar and (GV1, GV2 and GV3) are open |
| GV5 | Open/Close | Open if G5< 2*E-10mbar and (GV1, GV2, GV3 and GV4) are open |
| GV6 | Open/Close | manual |
| GV7 | Open/Close | Open if G8< 2*E-10mbar and (GV1, GV2, GV3, GV4, GV5 and GV6) are open |
| GV8 | Open/Close | Open if G9< 2*E-10mbar and (GV1, GV2, GV3, GV4, GV5, GV6 and GV7) are open |
| GV9 | Open/Close | Open if G10< 2*E-10mbar and (GV1, GV2, GV3, GV4, GV5, GV6, GV7 and GV8) are open |
| GV10 | Open/Close | Open if G11< 2*E-10mbar and (GV1, GV2, GV3, GV4, GV5, GV6, GV7, GV8 and GV9) are open |

The control screen is shown in fig. 6.

**6.4 Alarm: N**etwork-published shared variables hosted on Real-Time target are used to read temperature data. Comparing those values to limits specified by the user or as mentioned in table 1, and displays a warning if those values are exceeded by flashing and changing the color of the indicator as shown in Figure7.

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Fig. 6: Control Screen


Figure 7: Alarming Facility

**6.5 Data Logger:** Data logging means recording the critical parameters over a period of time. In our case vacuum and temperature are the most critical signals. Enabling logging in shared variable property, the user will be able to know the historical data of the beamline parameters from the database (MS Access) file of the shared variable on the real time environment. The trend of temperature and vacuum is displayed in the graph as shown in figure 8 and 9.

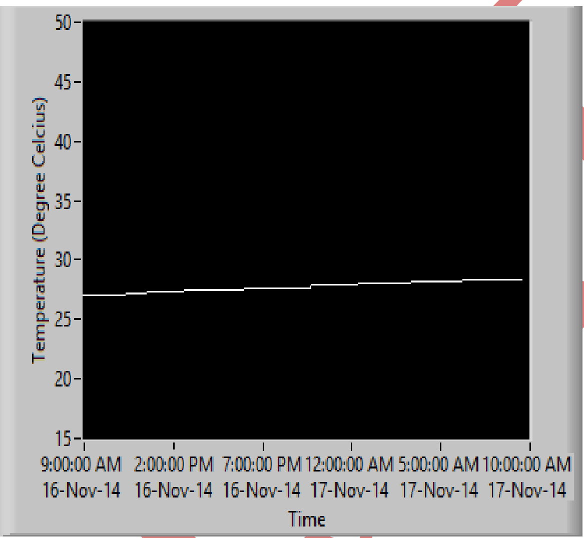


Figure 8: Temperature in the Beamline

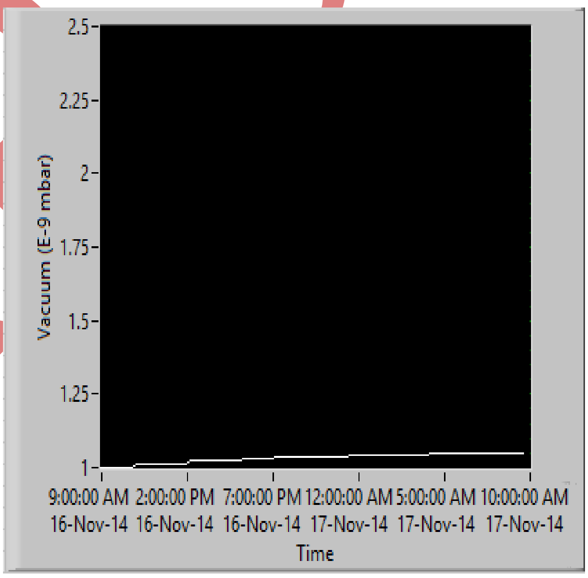


Figure 9: Vacuum in the Beamline

## VII CONCLUSION

The Data Acquisition System has successfully been developed using LabVIEW. The developed system has been tested at Reflectivity Beamline of Indus-2. All interlocks have also been tested and are working accordingly. Fault analysis such as observation of status and values of various beamline components can be performed via referring the stored data which are logged on MS Access database. The system also has the scope to be modified using other data acquisition system such as VME.

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