Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

Development and Performance Evaluation of Supervisory Control for Proto -Type Cryoline Test Facility using CODAC Core System

Payyappilly Priti Jeejo, Ravin Sardhara
V.V.P Engineering College,
Rajkot, India.

Ritendra Nath Bhattacharya, Anuj Garg
ITER- India Institute for Plasma Research,
Ahemadabad, India

***Abstract*— Communication Data Access Control (CODAC) is software to develop Supervisory Control and Data Acquisition (SCADA) System to monitor, control and store data of process variables. The development of a SCADA System using CODAC Core software for the ITER Proto-type Cryoline (PTCL) experimental work is the main objective. The cryogenic test facility for PTCL is composed of helium compressor station, 80 K Cold Box, Test Box-A, Test Box-B and Test Box-C, Liquid helium storage tank and Liquid nitrogen storage tank. The developed SCADA using CODAC Core System along with two Programmable Logic Controller units and five Remote Input output units is responsible to execute experimental work of PTCL in a controlled manner. The project has been split into three phases as configuration & development, troubleshooting and performance evaluation of the developed SCADA System. The first phase focuses on developing mimic page, alarm page, X-Y graph plot and implementing proportional, integral, derivative (PID) control block for automation. Second phase encompasses analyzing, monitoring and troubleshooting the developed SCADA for the cryogenic test facility. Thereafter in third stage performance evaluation of developed SCADA by comparison with industrial SCADA system. All three phases have been completed demonstrating the capability of developed SCADA System.**

Key Words:- Cryogenic, Supervisory Control and Data Acquisition (SCADA), Prototype Cryoline (PTCL), Programmable Logic Controller (PLC) ITER-India

I . INTRODUCTION

ITER is a step towards future production of electricity from fusion energy. The ITER partners are presently the People's Republic of China, the European Union, India, Japan, the Republic of Korea, the Russian Federation and the United States of America. ITER-India is the Indian Domestic Agency (INIDA) responsible for delivering India's contributions to the ITER Project. Cryogenic test facility at ITER-India laboratory has been developed in order to execute the performance test of proto-type cryoline (PTCL), which is a 1:1 scale representative Cryoline for the ITER 'Torus and Cryostat Cryoline' .Cryogenic test facility for PTCL consists of helium screw-compressor station including oil removal system, 80 K Cold Box, Test Box-A, Test Box-B and Test Box-C, liquid helium (LHe) storage tank , liquid nitrogen (LN_2) storage tank and helium buffer tank as per block diagram in Figure.1 [1]. Cryogenic test infrastructure along with the PTCL consists of several process sensors for the measurement of temperatures, pressures, mass flow rates, liquid level, strains and displacements, which are connected to the respective process signal transmitters.

Fig.1 shows the system architecture which consists of CODAC Core SCADA System and PLC-1 and PLC-2 connected to the cryogenic facility for PTCL via an Ethernet switch.

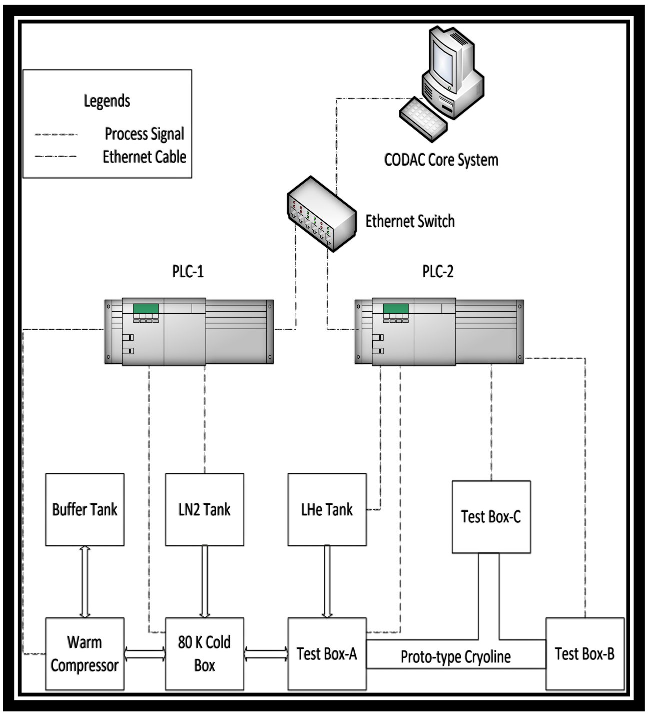

Fig 1 System Architecture

Programmable Logic Controller (PLC) of SIEMENS S7-300 series has been used to control the complete cryogenic process based on the data collected during the operation[2]. Supervisory Control and Data Acquisition System (SCADA) is necessary for the process command-based control and visualization for the operators as well as for the data storages to support the future analysis of the complete PTCL experimental work.

II. THEORY WORK

A. *Hardware's And Software's*

To implement this work it requires two PLC which are CC001, CC002 and five remote input output terminals (RIO 1-5) CODAC Core software package with Self

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

descriptive Data (SDD) for process variable declaration, Control System Studio (CSS) to develop mimic page[2], Alarm page and X-Y plot for cryogenics test facility as well as SIMATIC Manager  for PLC[3].

B. Methodology

The *Fig.2* shows the step wise method of system implementation

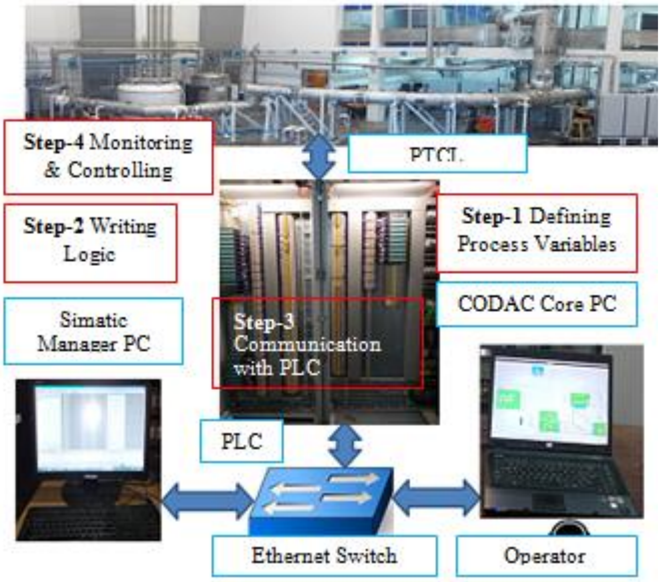

Fig.2 Methodology

- *Step-1*

The CODAC Core has two software's SDD and CSS. The process variables of the cryogenics test facility have been declared in SDD and the different parameters like alarm, archiving, data type deployment target etc have to been defined in Experimental Physics and Industrial control system(EPICS) detail. Then the mimic pages, alarm pages and complete human machine interface screen can be developed in CSS[3].

- *Step-2*

Import/Export the source file and symbol table for communication into SIMATIC Manager, the scripting is written in Functional Block Diagram (FBD) language[3].

- *Step-3*

Connecting PLC and CODAC Core system in one network via an Ethernet switch to control cryogenics test facility for PTCL.

- *Step-4*

Testing CODAC Core SCADA System by controlling and monitoring the cryogenics test facility infrastructure.

III. DEVELOPMENT AND TESTING WITH REAL TIME SYSTEM

After designing the mimic page in CODAC Core Software for cryogenic test facility for PTCL has to be tested and verified with the real time cryogenics test facility.The overall system of cryogenic test facility has been divided into two segments namely System-A and System-B which are deployed on two number of PLC namely PLC000 and PLC001 as shown in *Fig.3*

A. Communication with PLC

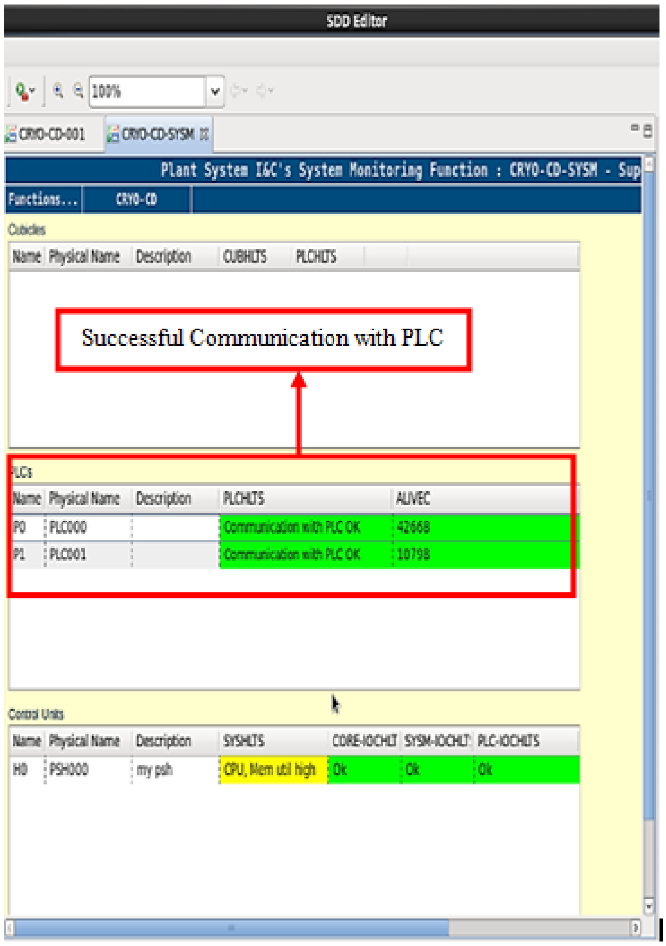

Fig.3 Successful Communication with PLC

On PLC-1 System-A is deployed and on PLC-0 System-B is deployed ,the figure.3 indicates the successful communication of CODAC Core with both the PLC.It also shows the input output controls (IOC),PLC and plant system host PSH status are in OK conditin and mentions centeral processing unit memory utilization is high.Fig.3 indicates that the over all IOC are in OK condition.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

A. Working With Real time System

Fig.4 shows the developed mimic page of PTCL test facility infrastructure using CSS.

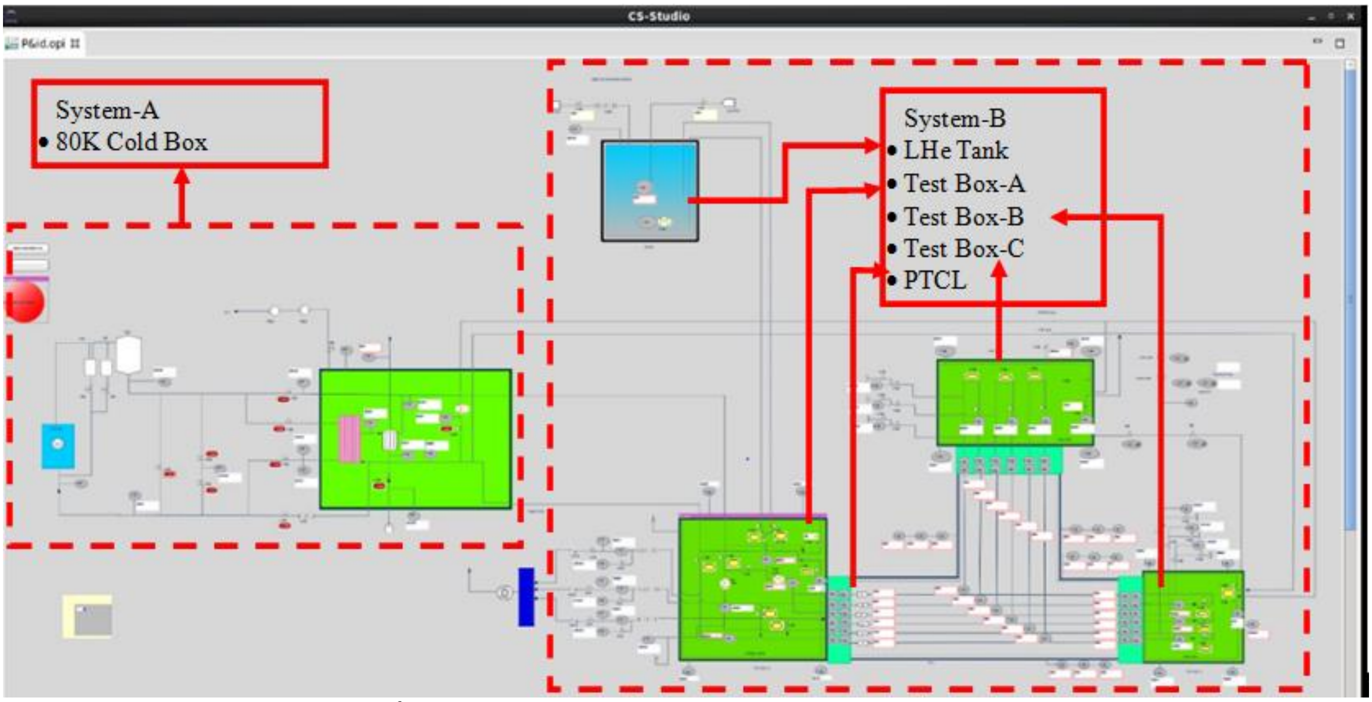

Fig.4 Mimic page of PTCL

Mimic page of cryogenics test facility has two segments System-A and System-B.System-A consists of 80K cold box.The 80K cold box is ment for 80K gaseous helium generation. System-B consists of (LHe) Storage tank,Test Box-A,Test Box-B and Test Box-C which are connected at three ends of PTCL which channels the required flow through valves mounted on them [5]. The value displayed on mimic page is the real time values of pressure transmitters,temperature transmitters,control valves and heater.

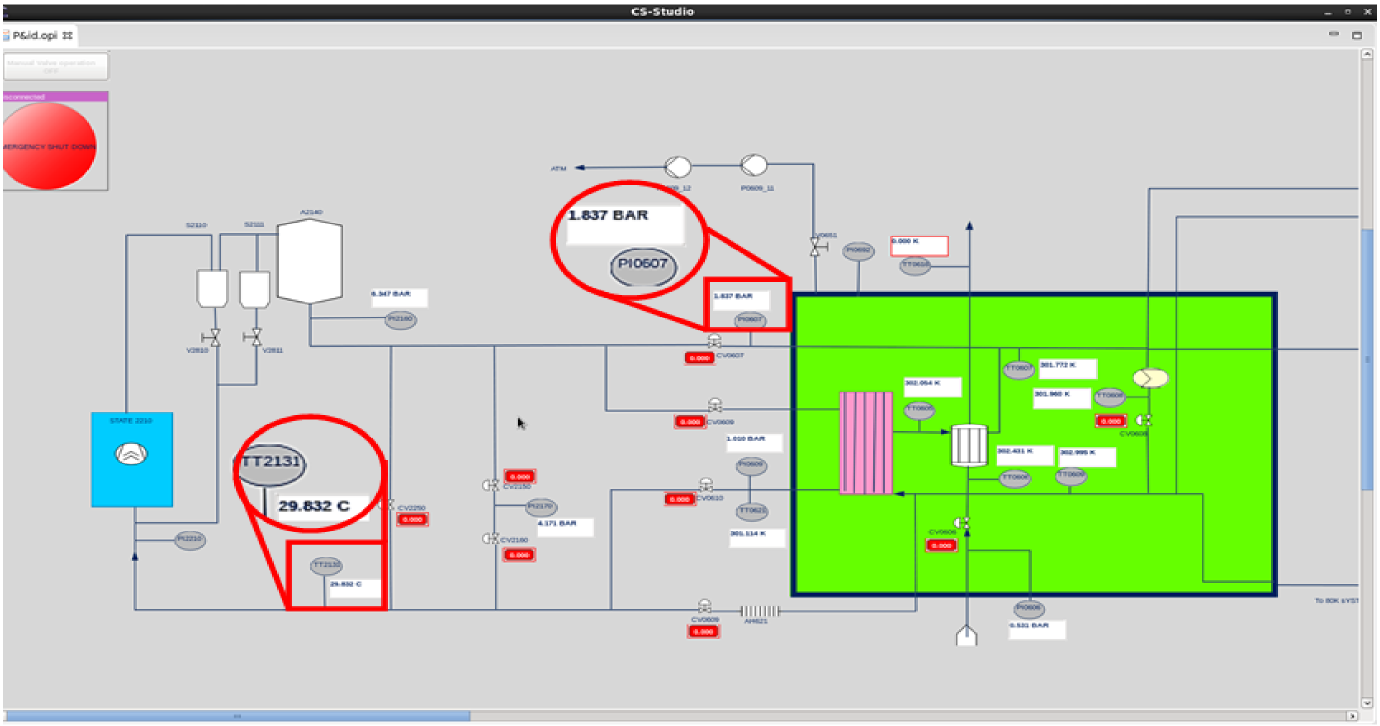

Fig.5 System-A

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

As per Fig.5 Compressor station in System-A has been used to compress helium gas at 300 K up to 7 bar. 80 K cold box, which has two process heat exchangers, is used to cool the compressed helium gas from 300 K to 80 K using LN_2 as coolant [5].

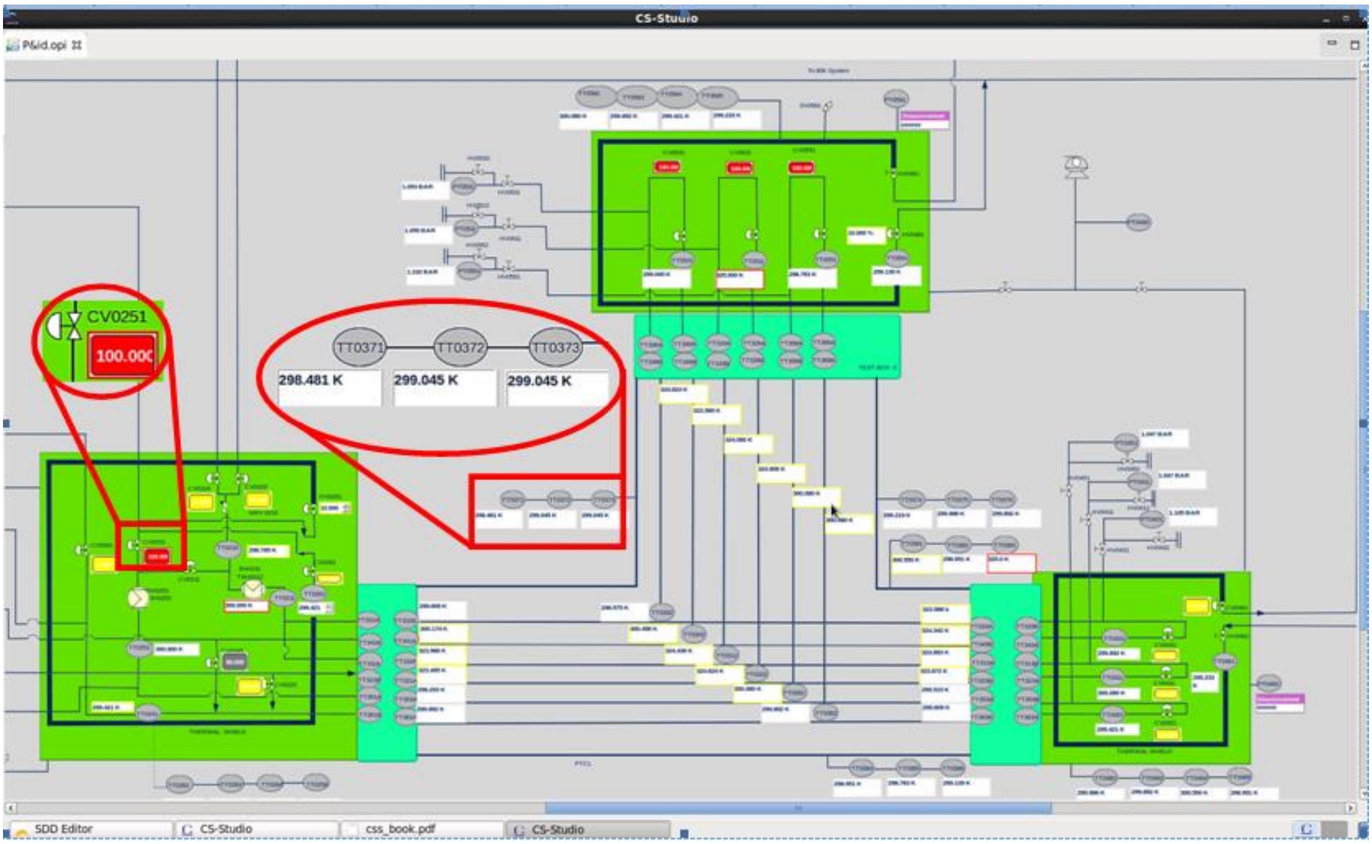

Fig.6 System-B

Test Box-A interfaces‘80 K Cold Box’ with the PTCL and liquid helium (LHe) storage tank [5]. Test Box-B and C provide the termination with control of flow split up between main Cryoline and branch Cryoline. The complete cryogenic test facility will be used to cool the PTCL from 300 K to 80 K using LN_2 and 80 K to 4.5 K by LHe from storage tank [5]. The values from the temperature transmitter of PTCL have been incorporated in the designed as shown in fig.6 which is at room temperature as 300K approximately.

C. Inputs and outputs

TABLE 1

Parameters	System-A	System-B	Total
Analogue Input	20	112	132
Analogue Output	18	10	28
Digital Input	-	5	5
Digital Output	1	-	1
Total Input Output	-	-	166

The above table describes about the number of inputs and outputs used in the cryoline test facility for PTCL it further bifurcates in detail about the analogue/digital input outputs used in System-A and System-B.

D.Operating a Valve

To operate a valve it has to be set to ON condition from the mimic page and this action will be reflected in the real time system when the valve is actually turned on with visible movement of valve stem.

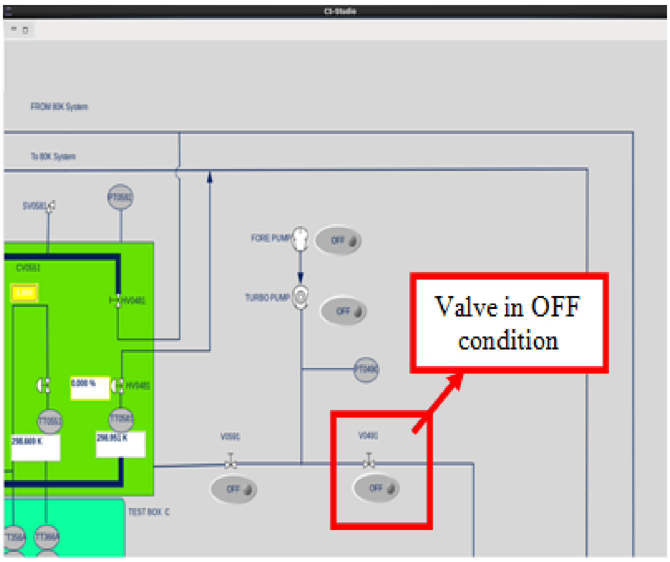

Fig.7 The Valve is in OFF condition.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

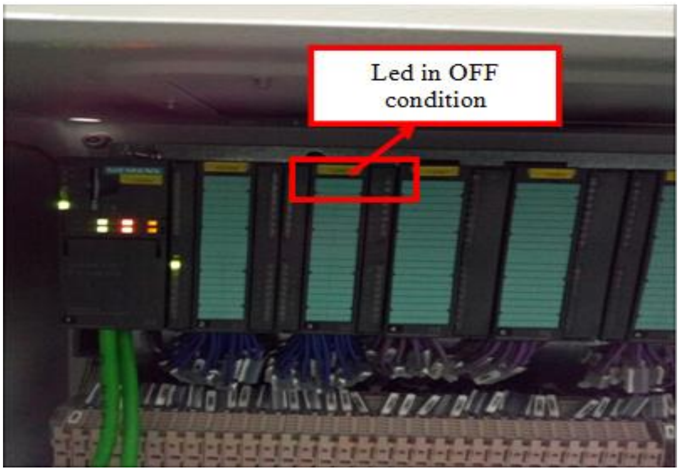

Fig.8 Output RIO-4 (Remote Input Output)

The Output is observed in PLC module the LED does not glow which indicates OFF condition.

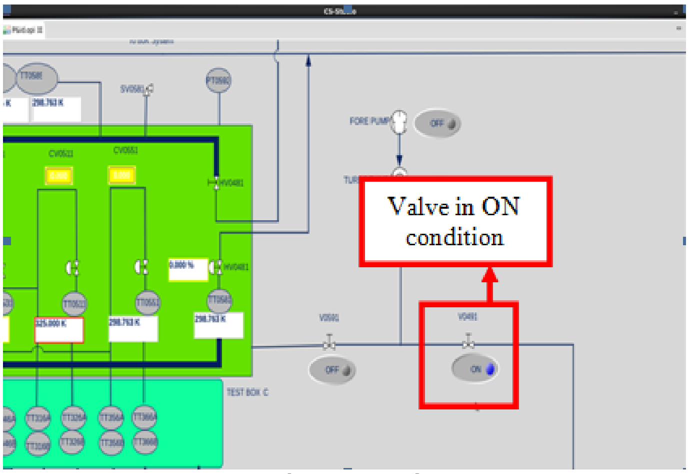

Fig.9 Valve in ON Condition

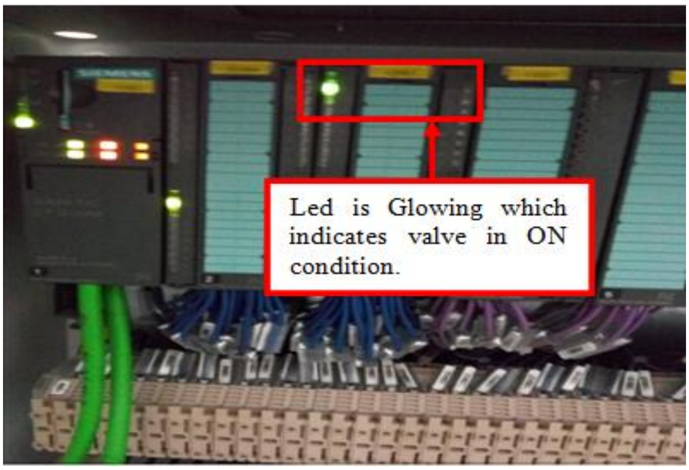

Fig.10 RIO-4(Remote Input Output) output

Fig.9 and *Fig.10* show the status when the Valve is in ON condition and the Output is observed in PLC module the LED glows which indicates that the valve is in ON condition.

IV.PERFORMANCE EVALUATION PARAMETERS

After the literature survey on CODAC CORE SCADA system, its performance evaluation can be done according to the following parameters:

- *Scalability:*

  Scalability is the possibility to extend the SCADA based control system by adding more process variables, more specialized servers or more clients.

- *Speed :*

  CODAC Core SCADA system gives optimized output as the time communication between the networks is faster hence any change in the values of the process variable is reflected faster in CODAC Core Software approx 50 TO 100 ns [3].

- *Trending:*

  Trending in a SCADA System refers to view the process variable data in real time graph and can save the data and view it in future. Trends play an important role in observing and analyzing the behavior of a process variable. The system should provide trending facilities and one can summaries the common capabilities as follows:

  - A graph may contain process variables with their tags
  - Real-time and historical trending are possible, Trending is possible for any archived process variable.
  - Zooming and scrolling functions are provided
  - Parameter values at the cursor position can be displayed
  - Staggering view removes the overlapping in the graph for a better view

All these trending feature are provided in a data browser window in CODAC Core system.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

- *Alarm Handling :*

Alarm handling is based on limit, checking status, checking severity which is performed by CODAC Core system. The information only exists in one place and all users see the same status. The alarm handling is done efficiently in CODAC Core software as there is a feature of annunciation when alarm is generated and can be acknowledged by the operator on the bases of its severity and status.Fig.11 shows the alarm page of CODAC Core system the green color indicates OK status, yellow color indicates minor status and red color indicates major status of alarm.

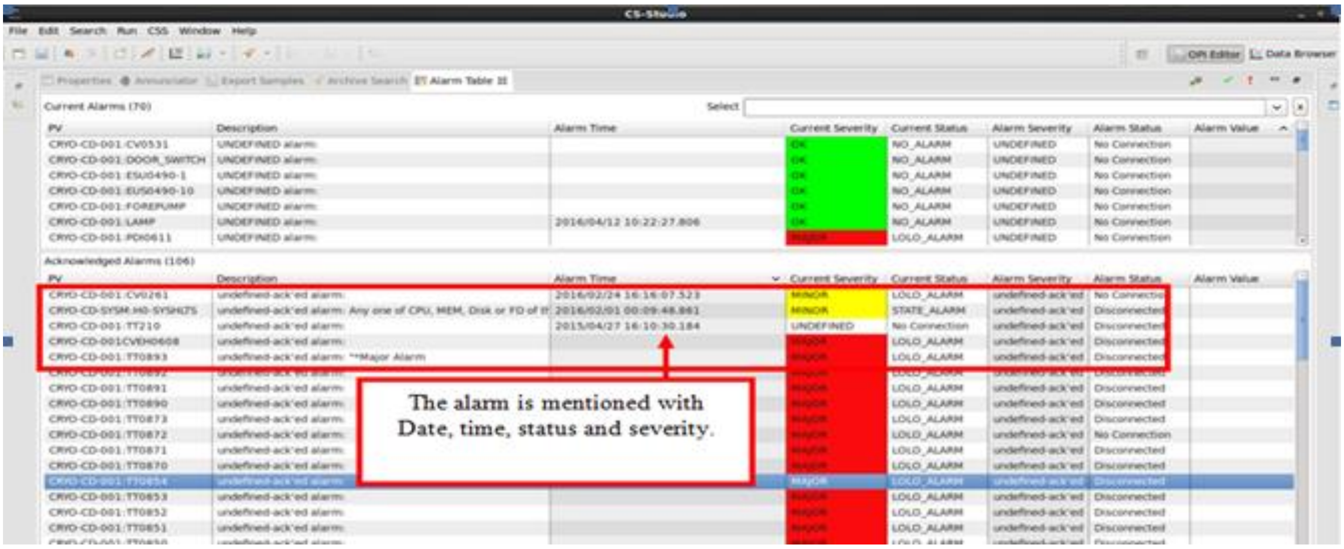

Fig.11 Alarm Page of CODAC Core SCADA

- *Automation:*

The majority of the systems allow actions to be automatically triggered by events. A scripting language provided by the CODAC Core SCADA allows these actions to be defined. In general, one can load a particular page, acknowledge an alarm by sending an Email, run a user defined application or script and write to the server PC. The minor alarms generated in CODAC Core System are acknowledged automatically when actions are defined. For automation of valves to open and close on the bases of temperature PID (Proportional Integral Derivative) tuning is performed. The graph in Fig.18 shows the PID tuning graph for valve CV0531 which should open and close according to the user defined set point temperature. If the temperature exceeds the value of 300K the valve will automatically open on the basis of PID tuning and the valve will close automatically when the temperature falls below 300K .This process is demonstrated in Fig.12

Fig.13 PID Tuning Graph

- *Archiving:*

The term archiving is a method to store the data of process variables. Archiving is long-term storage of data either on disk or on another permanent storage medium, a folder that contains copies of files for backup or future reference a computer file containing one or more files. In CODAC Core Data Archiving includes two types Monitor mode and Scanning mode in scanning mode the data is stored as per the fixed time and in monitor mode data is recorded at a random time when there is a change hence this saves disk space. As shown in fig the exported excel sheet of data acquisition contains time, date, alarm, severity and status as shown in fig14.

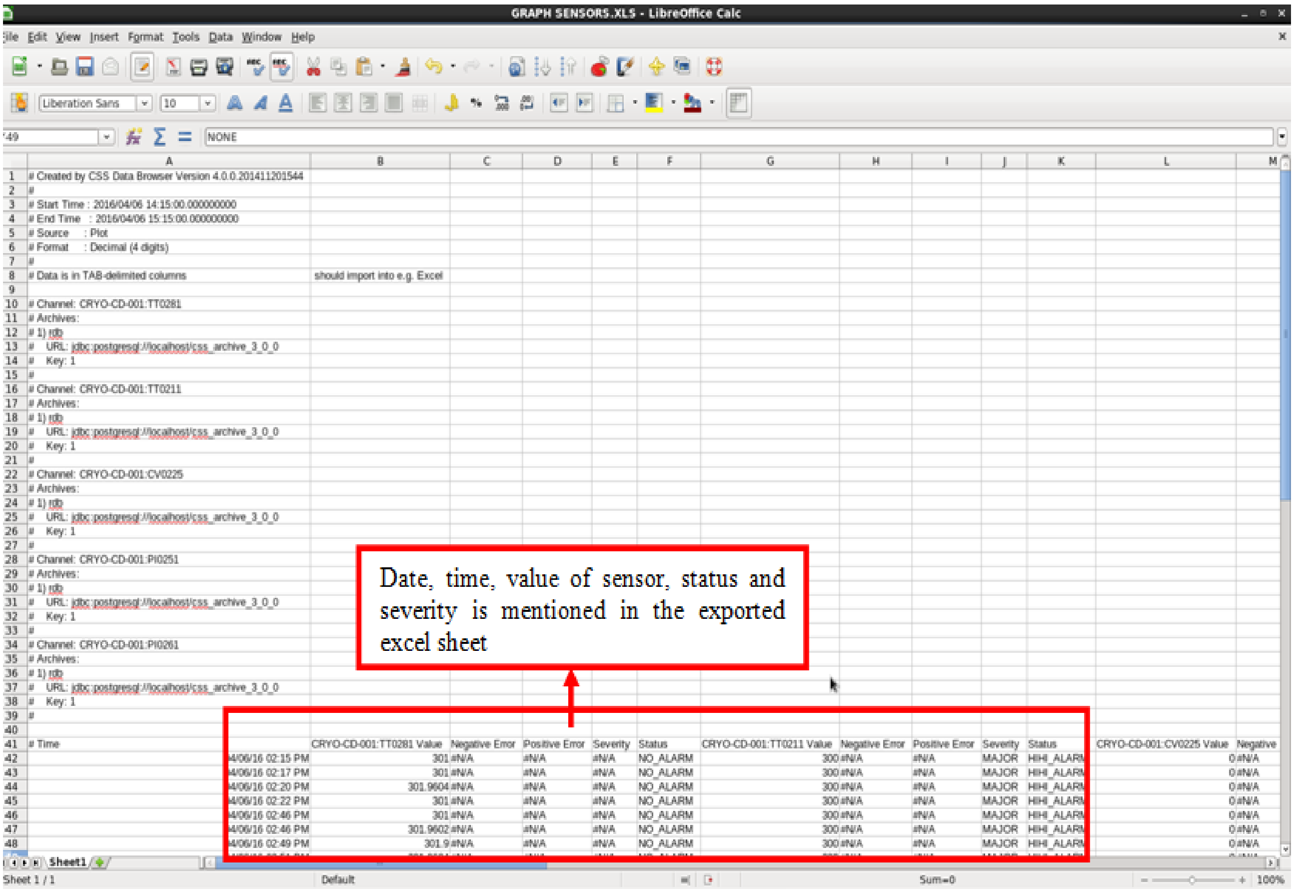

Fig.14 Exported Excel Sheet of CODAC Core System

V. COMPARISION WITH INDUSTRIAL SCADA

TABLE 2

PARAMETERS	INDUSTRIAL SCADA SYSTEM	CODAC CORE SCADA SYSTEM
• ***Scalability***	160 Plant System Approx	160 Plant System Approx
• ***Operating System***	Windows	Red hat Linux
• ***Speed***	30ms approx	50 to 100ns approx
• ***Graph***	Similar values	Similar values
• ***Data Archiving***	Value of sensor is mentioned but alarm is not mentioned in the exported sheet	Value of sensor, Alarm severity is mentioned in the exported excel sheet.
• ***Scripting***	C language, VB,	C,C++,SNL
• ***Coding Software***	Simatic Manager	Simatic Manager, SNL(State Notation Language)
• ***Log book entry with screen shot***	Not available	Available
• ***Security For valve operation***	Available	Available
• ***Alarm Handling***	Similar	Similar
• ***Cost***	Not Cost Effective	Cost effective

CONCLUSION

This paper deals with the theoretical and practical concepts to develop a SCADA System using CODAC Core Software. The work has been focused on developing the complete human machine interface The final application has been successfully developed to control the cryogenic test facility for PTCL to show the process variables values, alarms and trends in the data browser and has been exported in an MS excel sheet to perform the experimental data analysis. The operation of control valve is tested with the actual system in real time and the outputs are observed in PLC module. The analysis and results confirm that the objective of developing SCADA using CODAC Core software for the cryogenic test facility has been fulfilled is ready for actual experimental work.

ACKNOWLEGEMENT

Authors would like to thank the colleagues/teachers from ITER-India and V.V.P Engineering College for their guidance/contribution to the project with specific gratitude to the Project Director, ITER-India and Director, IPR. Special thank is extended to the CODAC Support team at ITER Organization in southern France.

REFERENCES

[1] Bhattacharya R., Srinivasa M., Shah N., Badgujar S., Sarkar B., “Detailed Design of Control System for Proto-type Cryoline Test” Indian Journal of Cryogenics, Volume – 36, page-173-178, 2011.

[2] Christina Anita Bejan et al.“SCADA automation system laboratory elements and applications” “Politehnica” University of Timisoara, Dept. of Automation and Applied Informatics, Timisoara, Romania IEEE 2012.

[3] Nadine Utzel, W. D. Klotz, A. Wallander, H. Dave, F. Di Maio, H. K. Gulati, C. Hansalia, D. Joonekindt, J. Y. Journeaux, K. Mahajan, P. Makijarvi, L. Scibile, D. Stepanov, and I. Yonekawa “ITER CODAC Status and Implementation Plan” IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 57, NO. 2, APRIL 2010.

[4] F.DI Maio, L.Abadie, C. Kim, K. Mahajan et all, “ITER CODAC Status and Implementation Plan” Proceedings of ICALEPCS2011 Grenoble, France.

[5] N.Shah ,R Bhattachraya, B Sarkar et al “Preliminary System Design And Analysis Of An Optimized Infrastructure For ITER Prototype Cryoline Test” Advances In Cryogenics Engineering, AIP Conference Proceedings 2012.

[6] Duo Li, Yoshizumi Serizawa, Senior Member, IEEE, and Mai Kiuchi.“Concept Design for a Web-based Supervisory Control and Data-Acquisition (SCADA) System.” Central Research Institute of Electric Power Industry, lwado Kita, Komae-shi, Tokyo 201-851 1 JAPAN 2002 IEEE.

[7] Alan M. Barker, Stephen M. Killough, Timothy S. Bigelow, John A. White, John K. Munro “A Case Study of Modern PLC and LabVIEW Controls: Power Supply Controls for the ORNL ITER ECH Test Stand”.Oak Ridge National Laboratory ,Oak Ridge, TN, USA 2011 IEEE.

[8] Rajkumar Bansal,Ashok Kumar Goel, Manoj Kumar Sharma “Matlab and its applications in engineering” Oak Ridge National Laboratory Oak Ridge, TN, USA 2011 IEEE.

[9] Joseph Mathew* , Shankar s st , Pratheesh H+ , Raja Singh B § , Lajitha C S and Muhammed Irshad “Implementation of High Availability S CADA System for Superheater Steam Temperature Control in a 2 1 0 MW Thermal Power Plant” A l l Control and Instrumentation Group Centre for Development of Advance Computing 2014 Vellayambalam, Thiruvananthapuram.

[10] Pramod T C N R Sunitha “An Approach to Detect Malicious Activities in SCADA Systems”Department of Computer Science & Engg. Department of Computer Scienc & Engg Siddaganga Institute of Technology,Siddaganga Institute of Technology, Tumkur, Karnataka ,India Tumkur, Karnataka,India 4th ICCCNT 2013July 4-6, 2013, Tiruchengode, India.

[11] Rajkumar Bansal,Ashok Kumar Goel, Manoj Kumar Sharma “Matlab and its applications in engineering” Oak Ridge National Laboratory Oak Ridge, TN, USA 2011 IEEE.