Progress of computerisation in VEC modernisation

Sarbajit Pal, Tanushyam Bhattacharjee, Anindya Roy, R.B. Bhole, Manoranjan Das, Biswajit Sarkar, Lekha Chowdhury and Subrata Dasgupta

Variable Energy Cyclotron Centre, 1/AF Bidhannagar, Kolkata 700 064, India

Email : sarbajit@veccal.ernet.in

ABSTRACT

Retro-fitted computerization of several systems and sub-systems, are in progress under the progress of modernization of VEC technical system. Console computer as client and front end/device computer as server sitting on a dedicated LAN controls main magnet power supply, Trim Coil power supplies and other power supplies having serial interface. Laboratory developed serially interfaced softknobs (encoder driven software controlled assignable knobs) are used on central console for operator use. A number of web based environmental temperature and LCW temperature, flow and conductivity monitoring system have been implemented and some are at various stages of implementation at Vault, Pit and Cave area of VEC using various sensors and WEB enabled ADAM modules.

The power supplies, vacuum gauges, various Low Conductivity Water (LCW) parameters, radiation monitors and card readers of the access control system are interfaced to the computer over RS485 serial link. VI based IA servers and OPC servers are working as device server for the different distributed system. Device servers communicate with the devices through appropriate device driver developed in-house or procured with the devices. Servers work to log historical data, process and log alarm information and events for all systems. A multithreaded process running on Linux server has been developed for realtime monitoring of thirty-eight variable current control magnet power supplies. The suitable allocation protocol between console clients with device control server manages monitoring of all power supplies while controlling two of them simultaneously for beam tuning using softknobs. The event driven engine of the Labview DSC module implementation is being done for realtime data logging of various power-supply parameters at the Citadel database. The distributed data logging implementation would facilitate realtime data archiving and SQL query handling. The 3-finger beam current profiler has also been modified using more compact C-V Converter and ADAM analog module. The VB based DAQ program enhances on-line visualization of internal beam current profile. As for services automation the conductivity, temperature and storage tank level monitoring for LCW system is being implemented using DAQ module having LAN connectivity.

INTRODUCTION

The control scheme was designed considering the following aspects i.e. independence from specific hardware vendors and software codes or instruction sets and the incremental upgradation across the layers to take advantage of new equipment/hardware and s/w. The hardware of the control scheme is being implemented in two layer architecture with IPCs (Industrial Personal Computers) connected through a Ethernet control-lan (local area network) [1].

The most of the feature is fully distributed i.e. it does not require any central device or software entity at any layer. The FECs (Front End Controllers) are embedded device controller of the instruments, power supplies developed in-house or Danfysik power supplies. The micro-controller based I/O boards drive RS232/485 bus and Ethernet through a converter. The middle layer is implemented by Advantech IPC. This physical back-end layer is connected by Ethernet and isolated from the office-lan by a serial link to restrict any unauthorized access.

Special consideration is given for selection of control-lan which is separated from office-lan as the control-lan passes through radiation, EMI & RF noise inside the critical zone. Although immunity to EMI RF noise, having large bandwidth and electrical isolation are the major advantages of fiber optic cable over copper cable, but later is chosen for its less radiation hardening property. CAT6 UTP (Unshielded Twisted Pair) cabling provides 100 mbps and capable of supporting 1Gbps to each node. Copper cabling having flame retardant property (UL, 1666, CMR) is selected for control-lan [2].

The existing manual potentiometer control and DPM (Digital Panel Meter) type monitoring facilities are replaced by LCD monitors with some having touch-screen facilities. The requirement of several monitors on the existing control console are for monitoring of following parameters and system like i) beam view, position and external and internal beam current ii) Radiation levels iii) vacuum pressure

iv) temperatures at vault, pit and cave areas and for monitoring and controlling of several parameters of v)Low Conductivity Water (LCW) System vi) Access Control system etc. The progress in centralize control and monitoring of these systems are described in this paper.

CONTROL AND MONITORING OF MAGNET POWER SUPPLIES (MPS's)

The two-layered power supply control system for main magnet, trim coil, valley coil and other beam-line magnets (i.e. steering, quadrupole, analyzing and switching magnets) is installed using LabView (LV) and LV-DSC (Data-logging and Supervisory Control) module. The transaction at device/server layer is implemented with ASCII standard command-response and Modbus protocol [3] working on multi-drop RS485 link. After receiving command/configuration message via serial link, all related internal tasks for power supply is managed at the device level by the embedded controller of the power supply. The communication at client/server layer is based on TCP/IP protocol through control-lan and dedicated for the front-end GUI and Database server. The implementation of device/server and client/server (Figure 1) communication, caters 38 numbers of MPS's is successfully completed.

Device layer Communication Protocol

The communication protocol in device layer is divided into two parts *(i)* RS485 Modbus – the in-house developed power supply controller provides ASCII-Modbus protocol. It establishes the format for the master's query by placing the device address, a function code for requested action, data to be sent, and an error-checking field. The slave's response also contains fields confirming the action taken, any data to be returned, and an error-checking field (Figure 2). An erroneous reception of a message or unperformed requested action is responded back by the device. It is attractive to use within a real-time control environment [4]. (ii) RS485 Ack/Nack - is simple command/response protocol supported by several procured MPS's. This protocol checks for a particular response character in master side to manage the error, less reliable than Modbus. It is easy to use/maintain and supported by some of our vendors e.g. Danfysik PS [5].

Server Client

VI-based server is designed using VI-Based Server Development Toolkit. It communicates with tag engine which operates as OPC server. The real time Citadel database reliably logs critical process data. The server also communicates with an oracle database server by SQL queries to store historical data for future use. The client provides a high end GUI (Figure 3) to the operator for easier beam tuning. It communicates with PS server according to operator's instruction. Two optical encoder soft knobs simultaneously set the current of two MPS during beam-tuning operation.

INTERNAL BEAM VIEWING

The objective of the internal beam viewing using 3-finger probe is the visualization of beam current profile along Dee radius. The current signal and the position signal from the probe are fed to a lab-made four channel, variable gain Current to Voltage converter (CVC) module and a buffer respectively. The DAQ hardware is upgraded from PC Add-on card to Analog Input module (ADAM 4017) with RS-485 interface. Windows based VB GUI is shown in Figure 4, displays on-line current and profile plot for each finger in different color along the radius.

LOW CONDUCTIVITY WATER SYSTEM

The raw water is de-mineralized to produce LCW for cooling vacuum system, RF systems, Magnet power supplies, beam transport systems and ECR system. The system presently operates by monitoring the distributed process parameters without centralized monitoring facility. A plant up-gradation project has been taken up to provide TCP/Ethernet based on-line distributed monitoring of process parameters in the first phase of modernization and to implement control to automate total operation in subsequent phases.

Instrumentation scheme

The parameters are chosen to optimize the requirement from operation point of view. The scheme is shown in Figure 5. The sensors are selected to optimize the system requirement and installation time. The water levels in Raw water storage tank, Main LCW Storage tank, ECR LCW Storage tank and Cooling tower sump are to be measured by gauge pressure type smart level transmitter (LT). The capacitance type level switches (LS) are used to provide high-low level indications to initiate alarms. The temperatures are measured at inlet and outlet headers of each subsystem by RTD (Pt-100). The conductivity is measured and displayed at two points (CG) in the LCW system. The process parameter selection is done to operate the system in semi-automatic mode in second phase of up-gradation. The installation of the sensors is in progress.

Computerisation & GUI

The goal is to provide centralized monitoring facility and that will be utilized for semi-automatic control of the plant, later. Three types of web based data acquisition modules e.g. analog input modules for 4-20mA signals, RTD input modules for temperature signals and digital input modules for level switch signals are used. These modules are connected to TCP/Ethernet based VEC Control-lan and communicate with operator interface application program (GUI) with Modbus/TCP protocol. The GUI is under development in-house using Windows SDK, NI ActiveX embedded VB (Visual Basic). The GUI is designed to provide continuous monitoring of level, temperature and conductivity and data-logging in Excel database for off-line analysis. The GUI provides acknowledgeable audio-visual alarm for abnormal LCW levels and conductivity.

RADIATION SAFETY MONITORING

Total 29 monitors (i.e. 13 Neutron and 16 Gamma monitors) are planned to be placed at various critical zones and monitored from a central location. The complete scheme was considered depending on available interfaces of the monitors and location to be monitored.

As very high neutron flux is likely to exist, automatic protection is provided by inhibiting the H.V. supply to the Neutron detector to conserve detector life. The range of the monitor covers a three decade logarithmic scale with full scale corresponding to 5000 N/sq. cm./sec. The time constant of the instrument is approximately 10 seconds. Three decade logarithmic scale local panel and 4-20 mA current loop / 0-5V analog output are available for remote indication. Alarm/Status monitoring and set/reset facilities are available in both local and remote location (i.e. control room) simultaneously. The neutron monitors also have additional facility for high voltage reconnection to the detector in case of the presence of excess neutron flux, remote terminations for quick disconnection and maintenance and serial interface (RS485/RS232) for centralized monitoring.

Gamma Area Monitors (GMs) have a built in detector (halogen quenched GM tube range (0.1-100 mR/hr), indicate dose rate on a digital display and have a visual and audio alarm. The units have local/remote configurable alarm-levels, auto/manual reset mode, self diagnostics features for possible failures with RS485 interface.

In addition of the above scheme, direct analog signals from the monitors are also brought to radiation monitoring panels of the control room as per the requirement of redundant monitoring of radiation. There will be around 40 monitors which will be continuously monitored during cyclotron operation as proposed by AERB (Atomic Energy Regulatory Board).

AMBIENT TEMPERATURE MONITORING

The temperature monitoring system using RTD sensors (PT100) at Vault, Pit and Cave area is installed and functioning satisfactorily. The GUI is developed in-house, which communicates with thermocouple input module (ADAM 6015) using Modbus/TCP protocol. The GUI uses color coding to indicate three levels of ambient temperature provides indication of any abnormal temperature raise to cyclotron operators and Air-conditioning system personnel.

ACCESS CONTROL SYSTEM AT CYCLOTRON ADJOINING AREAS

An access control system (ACS) is installed in the cyclotron-adjoining areas with a view to restrict the entry of unauthorized personnel in the cyclotron-adjoining areas and to keep record of authorized entry. The ACS is constituted by two subsystems. One subsystem is used only to allow the entry of authorized personnel in the cyclotron-adjoining areas (like the cyclotron control room) with the help of *proximity-type entry card (Smart Card)*. The card reader is equipped with a local memory that saves the ID of the card being flashed along with a timestamp. In order to determine an authorized entry into a designated area, the card reader tallies the card ID on-the-fly with a centralized database holding the authorized card IDs. The authorizations (allow/deny entry) are changed centrally as and when required by the administrator.

The other sub-system with wider scope is installed in potential radiation areas namely cyclotron-vault, pit and high-bay. Prior to entry into these areas, access control card for entry is enabled and subsequently disabled just after the exit from these areas. The recording of the exit time of an individual in a database, updated periodically, in addition to allow ones authorized entry determines the total duration of stay in the radiation area within the pre-specified days.

All the card readers (at Health Physics Unit, Electrical Substation, Radio-pharmaceutical laboratory and Basement) are interfaced to the computer located at Health Physics Unit over RS-485 interface. The entry-data stored in the individual card readers are refreshed periodically and saved in a database. The card readers are so configured for emergency exit facility i.e. in case of accidental conditions like power failure, fire hazard etc.

CONCLUSION

Most of the above computerized systems and sub-systems described here are working satisfactorily and few are in various phases of implementation. The improvement and modifications are continuously being executed to ease the operational difficulties. Although Windows OS are being chiefly used, Database with ODBC connectivity with Linux is being tested to provide redundancy, reliability and reduced access time [1]. The simputer is considered to be an alternative of IPC servers in the middle layer. The use of simputer is preferred for its serial, USB, lan and smartcard connectivity, apart from the advantages it has for the embedded Linux kernel and C libraries. The use of 'Ethernet to Serial converter' modules are also being considered to replace serial connectivity to Ethernet-lan for few magnet power supplies and beam line instruments in apprehension to achieve faster responses from the devices.

ACKNOWLEDGEMENT

REFERENCES

[1] S. Dasgupta, Control System progress for K500 Superconducting Cyclotron, Proc. Of ICALEPCS 2003, Gyeongiu, Korea

[2] N.C.Samanta et. al., Control lan for superconducting cyclotron building, VECC Progrss Report, 2003

[3] http://www.modicon.com/TECHPUBS/intr7.html

[4] Jinhong Zhang et. al., Distributed power supply control for SSRF, PCaPAC99, Japan

[5] Danphysik Magnet power supply 853 System 8500 Manual

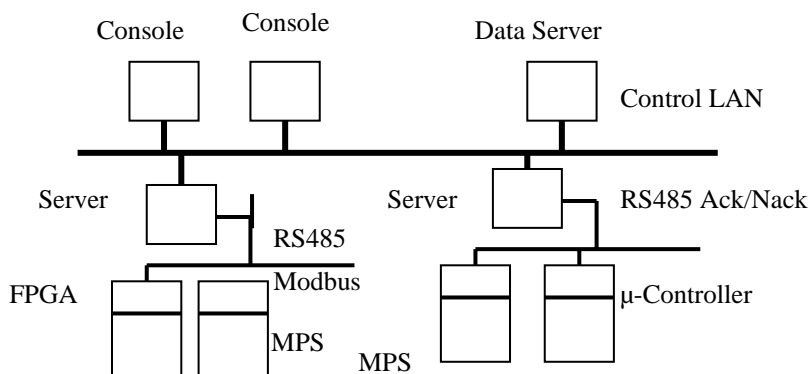Figure 1. Device level architecture for MPS control

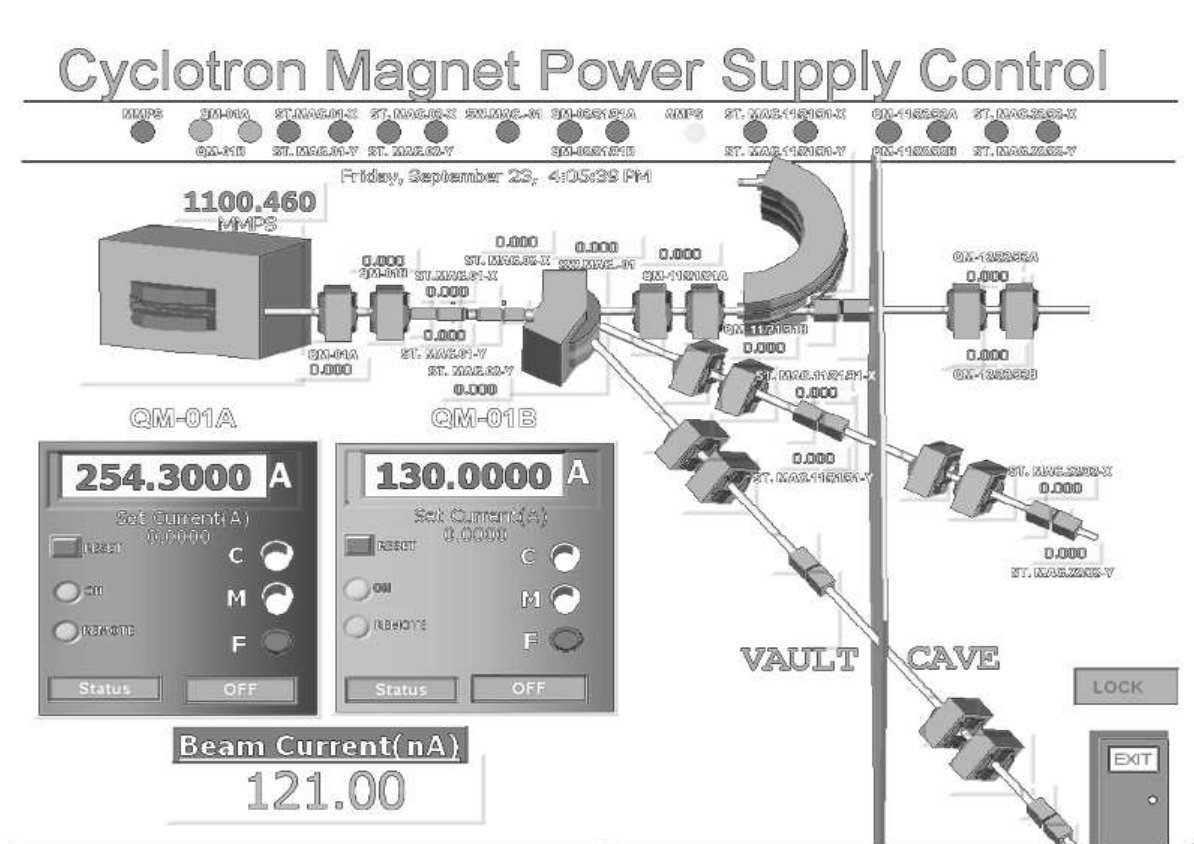| Start	Address	Function	Data	LRC	END
1 CHAR	2 CHARS	2 CHARS	N CHARS	2 CHARS	2 CHARS

Figure 2 : Message frame format for ASCII Modbus

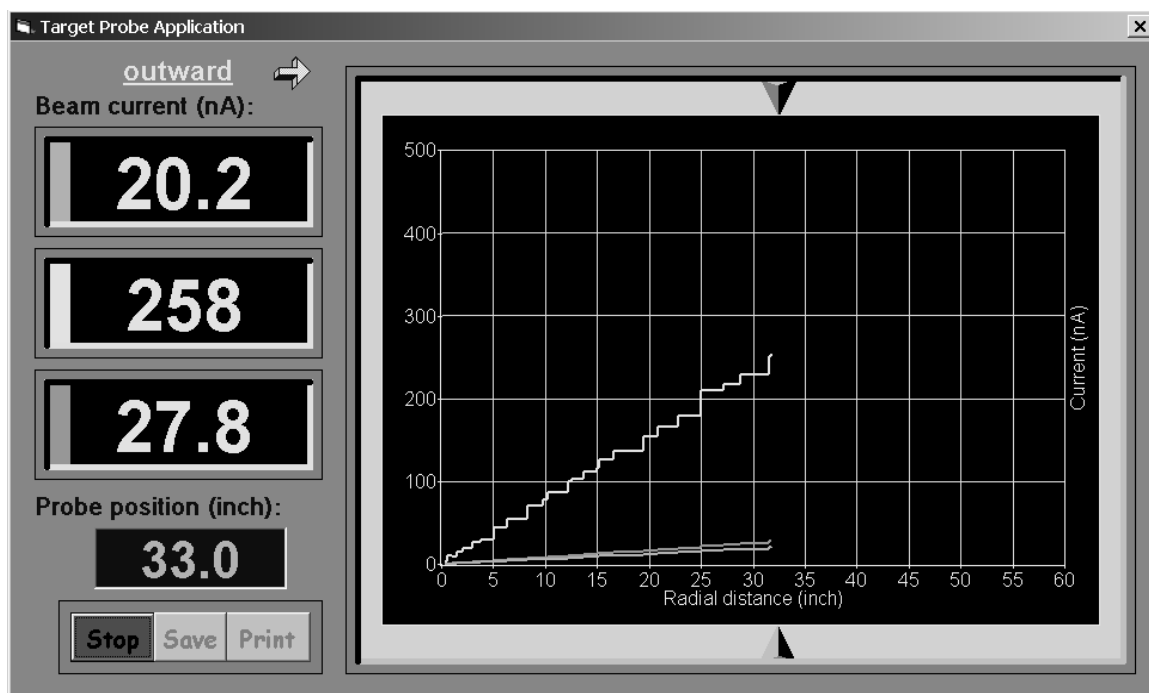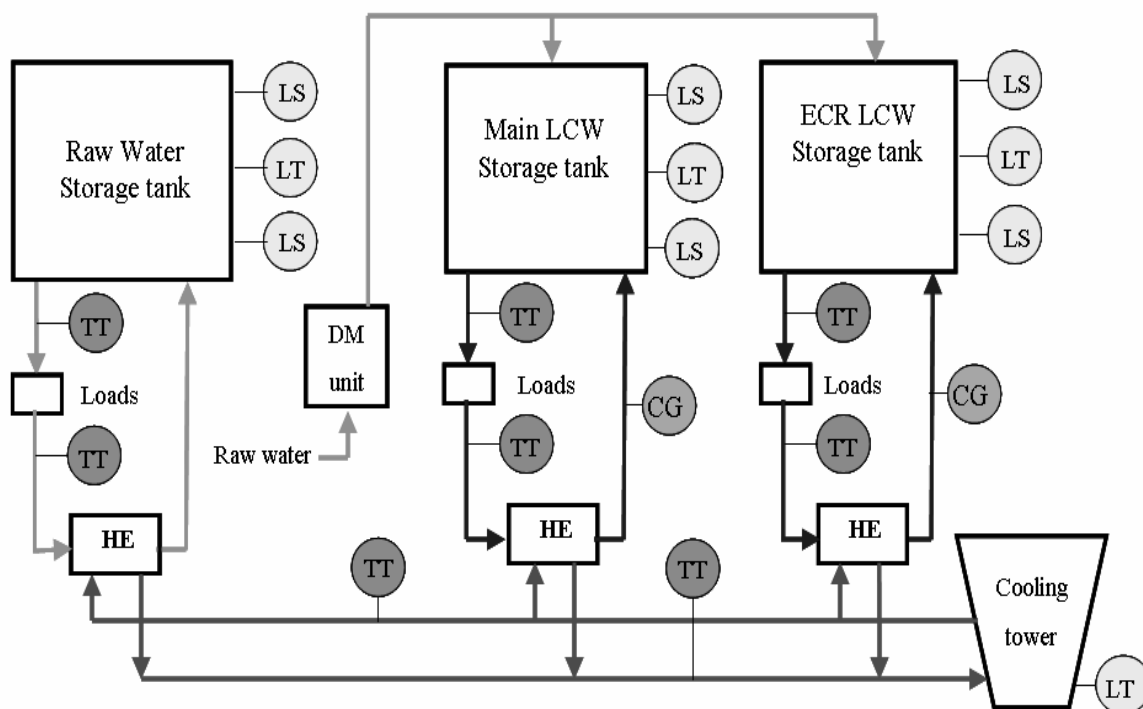Figure 3. GUI for MPS control at control console

Figure 4. GUI for Internal Beam Profile Monitoring System

Figure 5. The schematic of LCW instrumentation