CONTROL SYSTEM PROGRESS FOR K500 SUPERCONDUCTING CYCLOTRON

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Abstract

Construction of the K500 Super-conducting cyclotron facility at VECC, Kolkata, has progressed to the extent that the building, the Magnet yoke, the Helium-plant, the super-conducting coil winding on bobbin, the trim coils are in their advanced stages of completion. Requirement analysis of the control system is under continued development, based on a document depicting detailed specifications of the sub-systems, prepared after multi level and multi loop interactions with other subsystem implementing groups. The hardware of the control system is being implemented in a two layer architecture with PC's / Workstations connected through a Gigabit Control system Ethernet optical fibre LAN. The front-end computers are industrial PC's communicating through serial bus of the RS 232, RS 422, RS 485 multi-drop for device controllers or through GPIB bus for instruments. Commercial Data acquisition and Control modules equipped with serial connectivity are being used in cases of distributed I/O control and data acquisition. Plug-in PC modules are used in cases of parallel transfer needed in shorter distance and for faster communications. Windows 98, 2000 and NT are the OS choices in the FEC's. In console level PC's Linux is under strong consideration although presently Windows OS's are being chiefly used. Database with ODBC connectivity on Linux is being preferred.

Commissioning of hardware & infra-structures for the control system are progressing. A first system utilizing part of the resources will be put to use in the automated Magnet Field Mapping and Logging System. As planned, development and integration of variety of modules of software to control Subsystems and Instruments, being commissioned for the SCC cyclotron, are proceeding steadily. The products, in most of the cases, are being tested and updated successfully in the existing room temperature cyclotron, for later porting into the SCC control system. Some of such modules are Universal MMI [2] & Generic Components for its use [3], Generic multi-type Serial port driver, Main magnet (alpha & beta) Controller [4], Trim Coil Controllers [5], Beam view Collector-cum-Distributor, Vacuum line-controller, ECR Ion-Species Identifier, Alarm Panel Monitor & Logger, Micro-based power supply controllers etc.

INTRODUCTION

A Superconducting Cyclotron (SCC) with $K_{bend} = 520$ is under construction at the VEC Centre, Kolkata [1]. It will accelerate a variety of heavy ion beams for nuclear physics and allied experiments. Maximum beam energy for fully stripped ions will be 80 MeV/A. Experiments in the fields of radiochemistry, material sciences, radiation damage, analytical chemistry etc. are also planned. Fabrication and development of various systems of the cyclotron are currently at an advanced stage. The cyclotron, being constructed as a national facility, is scheduled to be commissioned towards the end of the year 2006.

Expectations from its control system include centralised monitoring, configurable parameter-groups, alarm annunciation and logging, multiple general purpose consoles and mini-consoles, protected access to industrial PLC controlled system e.g. Cryogenics, RF, Vacuum, Low Conductivity Water, etc. Other user-level facilities aimed are easier and faster beam-tuning, automated extraction and beam transportation, creating facilities for higher level automated controls, logging of machine and beam characteristics for improvement and extension of functionality, in stages

Over time, implementing of many subsystem computerisation are being undertaken to retro-fit in an existing room temperature cyclotron (RTC) with hardwired controls of early seventies. We work to use such control developments with a view to porting to the SCC control systems also. Many newer developments can be tested and improved with the user feedback Such pieces of control h/w and s/w are employed as building block components for SCC control developments as if some times in a bottom-up development.

OVERVIEW

In the first phase of the machine, a dedicated 100Mbit/sec (upgradable to 1 Gbit/sec) optical fibre Ethernet LAN connects about 20 FEC PC's, 5 Console PC's, 2 control room Instruments server PCs, of the distributed control system [2]. Since most of the devices and device controllers are intelligent, having RS 232 / 422 / 485 / GPIB serial connectivity, the field bus downstream to FEC is mostly of this type. Among the sub system devices, many of the power supplies, the ECR ion-source, the cryogenic plant, the cryogen distribution system, the cryostat instrumentation, the LCW system are vendor supplied with in-built intelligent controllers. Several other systems e.g. RF, the liquid nitrogen & helium gas distribution, Vacuum, Beam diagnostic, Extraction, Beam-transport, 9 Beamline power supplies etc. are being built and assembled in-house with micro-controllers / PLC's as controllers. All sub-systems will have provision for connecting to corresponding FEC's via the above said field bus. Needs of real time response will be mitigated by the embedded controllers in various sub systems. Many of the analog / digital i/o's will be managed through ADAM

/ FIELD POINT modules which are hooked to the local FEC through RS485 Field bus. Some of the instruments of Beam-diagnostic system will be directly connected through parallel bus as well.

Several protection systems e.g. the main-coil quench, various level, pressure and flow interlocks for the Cryostat system etc. will work on hardwired logic, independent of the computer control system, for highest reliability and response speed.

DEVELOPMENT SITUATION

A number of stand-alone applications for monitoring, logging and doing higher level beam diagnostics and beam tuning aids have been developed by different working groups on Win98, Win2000 and WinNT based PCs and workstations, for the RTC. These are cases for upward porting to SCC controls. The server systems so far developed in house or provided by industrial sub system vendors, have some heterogeneous history. Stand alone developments for retro-fitting into RTC controls e.g. μp based 'Data acquisition and display systems', 'Trim coil settings programs' etc were written in assembly. 'Internal beam current profiler', 'Iconic representation for beam momentum'[3], 'Remote dosimetry and dose-viewing' etc. were on DOS and evolved from Win 3.1 through Win 9x, written in C and then some of them updated through several VB versions. Several accelerator MMI management procedures [4] [5] were developed in VB on Win98 and Win2000 platforms. 'Beam view acquisition and distribution' [6], 'Charge-state analysis in ECR', 'Control of α and β coils power supplies' [7], 'Control of 18 trim coil Power supplies' [8],

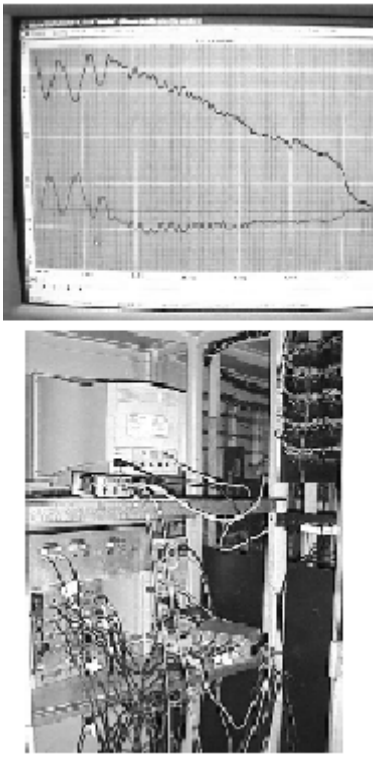

Fig.1 : Computerised Beam Current Profiler

'In-house Controller module for Danphisik Power Supplies', 'ECR source & injection line control', 'Multiple Vacuum gauge monitoring', 'Total Magnetic field mapping System', 'Mag. Channel drive', 'Operator's soft console' are several applications which have been written in Assembly, C, VB, LabView etc. on Win98, Win2000, WinNT.

Use of Linux for PCs , although in strong consideration, is comparatively lagging because of limited availability of ready made drivers for commercial devices in use.

HARDWARE RESOURCES

The FECs, each housed in a standard 19 inch Rack are distributed near to various subsystem equipment. The Racks will also house LAN hubs and other eletronics for direct serial and / or parallel connection to accelerator operating and diagnostics equipment. The Ethernet main switch and the Fibre back-bone is of 1000 Mbps capacity and branch networks are of 100 Mbps with Star topology. Some branch networks have expansion capacity to 1000 Mbps for future, if need be.

The FEC PC's are Pentium based industrial type boxes with facility for remote booting and the console PC's are higher end work station PC's. Few LCD panel and a cordless keyboard-mouse units will serve as cheaper portable consoles for the FEC's when needed. A PC with sufficient resources will work as the central Database server.

PRESENT STATUS

We have largely completed preparing a Sub System Requirement Document (SSRD) with an uniform format of specification for all the sub systems for the design of the central control system [9]. The SSRD contains the detail of the various subsystem parameters, required to be monitored and controlled from the control room. The document includes description of the subsystem, subsystem development platforms e.g h/w, s/w and network communication protocol, specifications of the parameter type - analog or digital, name, range of values, units, safe operating ranges, interlocks etc. This is expected to contribute towards a more engineered system development in the upcoming system integration phases.

At present, performance of a number of programs as mentioned above, for those implemented with PC Add-on modules, CAMAC, RS232 / RS 422 / RS485 using NI, Advantech, Kinetic and ADAM modules, are being investigated in terms of communication speed and response speed. Based on some available data, number of maximum devices that can be controlled from a PC has been finalised. This information in turn has been used to decide the number of Racks and also floor planning of the field Racks to be placed in the cyclotron vault, vault mezzanine, basement, basement mezzanine and first floor areas. Guiding structures for field bus cables and LAN cables for the SCC building are completed. Selection and

procurement of LAN system hardware and control cables are proceeding.

The Racks to work as nodes for the distributed control system and a number of Industrial PC's to work as FEC's and also a number of LCD monitors to work in the control room have been put to
use in several set-ups in the RTC control system for evaluation.

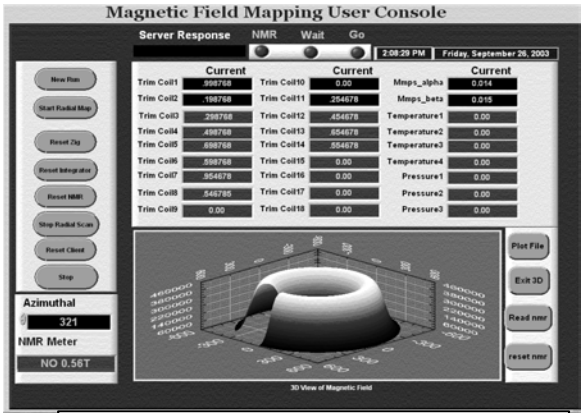

Fig. 2 : Mag. Field. Mapping Console

The automated Magnetic field mapping program for gathering hi-volume data for the SCC, will be taken up in an environment which has been planned to be a working sub-set of the SCC control system set-up. This includes remote client control of α & β power supplies and 18 trim coil power supplies, control of mapping Jig, control & operation of NMR Gaussmeter, Digital Integrator along with collection, logging and on-line preliminary analysis of magnetic field data. This will be conducted from the central control room of the SCC, with the devices stationed in the vault area. The developments for this

has been tested with actual equipment and a simulation to work as the jig which is not ready yet. Monitoring of other operational services like Cryogenics, LCW etc.. will also be taken care in the Control room PC's remotely through the ethernet.

The improvement / modifications of many of the RTC applications are now being worked up to make them compatible as OPC clients and OPC servers working anywhere on the LAN.

COMMENTS

The control system will start operating in phases at the SCC complex from April of 2004. Newer components of h/w, s/w and even newer modified architecture will be adopted as demanded by future and the commercial products to come. An example in order is the planned use of 'Ethernet to Serial modules', currently available, for certain cases of data collection in place of FEC PC's.

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REFERENCES

[1] R.K. Bhandari, "Status of the Calcutta K500 Superconducting Cyclotron Project", 16th International Conference on Cyclotrons and Their Applications, May 2001, East Lansing, Michigan, USA

[2] S..Dasgupta, "Guidelines for Design of the Computer-Control System for the Calcutta Super-conducting Cyclotron", CTDCA '91, VECC, Calcutta

[3] S.Dasgupta et.al., "Iconic Representation of Particle Beam Using Personal Computers." , ICALEPCS '91, KEK, Japan

[4] Sarbajit Pal et.al., , "Advancement Towards Development of Sharable Accelerator MMI"; PCaPAC '99, KEK, Japan

[5] Sarbajit Pal et.al., "Distributed Acquisition of Beam view property through Standard Video Components", PCaPAC'99, Jan.1999, KEK, Japan

[6] Tapas Samanta et.al, "Generic Component Class in Java For Cyclotron Control System" , PCaPAC '99, KEK, Tsukuba

[7] Biswajit Sarkar et al., "Supervisory software for operation of main magnet power supplies of superconducting cyclotron", DAE-BRNS Symp.on Nucl. Phys. Tirunelveli, India, December, 2002,Vol. 45B

[8] A. Goyal et.al., Power Supply Control and Monitoring System,VECC Progress Report (2000)

[9] Amitava Roy et.al., " Computerised control of superconducting cyclotron" , Indian Particle Accelerator Conference (InPAC), Feb. 2003