A STABLE CRYOGENIC DATA ACQUISITION & CONTROL SYSTEM AT IUAC

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Abstract

A Cryogenic data acquisition and control system (Cryo-dacs) has been set-up at IUAC to control and acquire many analog and digital Cryogenic parameters from equipments like beam-line Cryostats, Helium Compressors, liquefier, Cryogenic distribution line etc. The system monitors analog parameters like Temperature, pressure, vacuum and Cryogenic fluid levels inside the cryostats and performs closed loop controls of cryogen valves. The majority of these sensors are interfaced to a VME based system. The front-end electronics for the low temperature thermometry sensors has been developed in-house. The emergency alarm management has been successfully implemented with Cryo-dacs sever to monitor the failures through mobile devices, sms and client PCs simultaneously.

INTRODUCTION

The Super conducting booster linac project[1] at Inter University Accelerator Centre (IUAC) uses niobium quarter wave resonators for the acceleration of heavy ions to high energies[2]. A cryogenic facility has been setup for maintaining the above system at helium temperatures during normal operations .This facility include five beam line cryostats namely Buncher,Linac1,Linac2,Linac3 & Re-buncher , Nitrogen & Helium plants and distribution lines etc. In order to monitor , control and analyze all the above system from a central control room , the Cryogenic data Control network has been setup. Fig.1 shows the Cryogenic control room commissioned at IUAC.

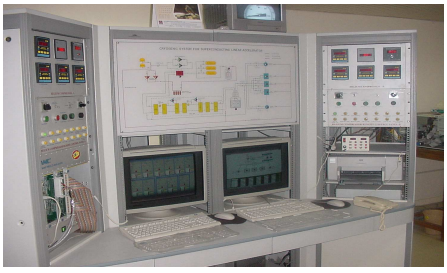

Figure1: Cryogenic control room at IUAC.

SYSTEM DETAILS

VME

The hardware architecture of CRYO-DACS is single-host multi-crate distributed VME with CPU running embedded VxWorks , all linked by workstation clients in 100 Mbps private LAN for distributed logging , historical trending , analysis , alarm management and control GUIs. The crates and modules are procured from M/s VMIC USA. The modules used are Analog inputs, Digital inputs and outputs. The AI modules used are VMIVME 3113-A & 3801 both 12 bit differential ADCs and VMIVME 2536 for digital input-outputs. The CPU used is INTEL based VMIVME 7698. Two windows PCs have been installed in the central cryogenic control room to act as development and operator consoles.

Front-end instrumentation

To accomplish the task of low temperature measurements, each cryostat is installed with several silicon diode sensors and are connected to one or more sixteen channel temperature linearizer units which have built-in current sources and 0 to 10V dc linear outputs. Cryogenic level meters with 4-20 mA outputs for level measurements are also developed in-house. Voltage outputs are processed using VME ADCs .

Web Server i/o

These are standalone low cost i/os which has small TCP/IP stack implemented within the sensor-electronics having Ethernet outputs. These i/os don't use VME hardware instead directly accessed through cryogenic LAN. Presently we have successfully installed i/os for LHe plant parameters like liquid helium tank level monitor, return temperature & pressure monitors and a heater ON/OFF control. The advantage of such an IP network is variety of options of remote client user interface.

Other i/o Parameter

The main cryostat analog parameters measured are Temperature [4.2 to 350 K], LN2 pressures [0-4 bar] , LHe pressures[-1 to +1 bar] , vacuum [mbar] ,LN2 levels[%] and LHe levels [%] whereas the digital inputs are status read backs from valves and vacuum systems. The main Helium compressor parameters acquired are suction & discharged pressures(-15 to +15 PSI), Oil temperatures (deg.C), Power (kWh), loading (%),unloading (%) etc. and a large number of digital input-outputs for loading , unloading , start, stop ,reset etc.

THE SOFTWARE

The Software development is done in two parts. The first part, i.e. IOWORKS MANAGER, a development center, has been used to configure an NT based host which acts as a development system for VxWorks based targets . The tool VISUAL IOWORKS has been used for the development of real-time VME bus access which supports a group of libraries for VxWorks target. The six logic modules, each specific to any one cryostat viz.

buncher, linac1, linac2, linac3, rebuncher and compressor are hot-swapped into the target online. The second part , a graphics package and OPC client, has been developed in VISUAL BASIC 6.0 for the real time trends, analysis and control GUIs.

The OPC (OLE for process control) server-client communication method is used to collect data from targets and record into an RDBMS backend (ACCESS-2000) and further retrieved using ADO for graphical analysis. The control GUIs to control valves in automatic and manual modes, remote controls of compressors etc. are done from control room consoles. Closed loop controls of LN2, LHe valves have been tested successfully. The LLT and ULT settings of closed loop controls can be dynamically varied anytime online. Many advanced software features are recently added to the system which include an alarm server, currently operated for emergency parameters, with the capability to generate SMS automatically.

Networking

A Windows-2000 server has been configured as a host and a gateway. This gateway separates local-cryogenic LAN (192.1.3.XX) from main IUAC-LAN (192.0.3.XX) using route and remote access service (RRAS). Another server running WIN-2000 is configured as a backup domain controller to the above Primary domain controller in CRYODACS-DOMAIN. Both servers run terminal services . Any user who wants to run experiment near to any cryostat can simply connect a LAPTOP/PC running WINDOWS or LINUX to the LAN port provided near to each cryostat and start logging and analyse data locally.

Signal Conditioning

Output signals from most transducers required conditioning in order to adjust the signal level to be compatible with the assigned 12 bit ADCs in the range of 0-10 V dc. The current signals in the form of 4-20 mA and 0-20 mA are converted to multiple isolated 0 -10 V dc using MTL make signal conditioners. Such 20 signal conditioners are installed in our system. All analog signals are filtered at 40 Hz prior to feeding into ADCs internally. A separate clean earth has been laid only for CRYO-DACS to isolate all electrical noises in the system. The cabling of all the signals (approximately 2000 terminations) are done using individual and overall shielded multicore instrumentation cables. All the VME digital input, outputs are optically isolated 24-28 volt standard.

RESULTS

The initial basic system was installed in the year 2002 and then several additions and modifications were carried out from time to time e.g. front end sensor electronics, alarm systems, heater interface, sms, mobile and web interfaces etc. The system has been working stable with almost 95% uptime. The hot swapping feature of software modules has been extremely useful, to modify the running system online. The Debug feature to debug or force the variables has also been useful. Maintaining the system needed virus free network as it is operated in windows environment but linux terminal server clients could run cryodacs clients virus free. The bought out VME hardware is always a bottle neck but we have been good as there are no major hardware failures for last 8 years except VME create power supply failures which needed emergency replacement.

SUMMARY

The development and operational experience of such a system is that, it is easily expandable and stable data acquisition and control system where users can quickly setup additional cryodacs clients without modifying any server parameter anywhere in the network. The front-end GUIs can be modified by operator himself as it is written in VB. The VME hardware has been proved very rugged. A separate private 100MBPS cryogenic LAN is setup only for CRYO-DACS server.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the electrical group of IUAC for their support in providing the electrical interfaces required for CRYO-DACS.

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