STATUS REPORT, FUTURE PLANS AND MAINTENANCE ISSUES OF VME BASED CRYOGENIC CONTROL SYSTEM AT IUAC

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Abstract

The Cryogenic Data Acquisition and Control system (CRYO-DACS) at IUAC was commissioned successfully in the year 2002 and has been continuously in operation since then with uptime better than 95%. The aim of CRY-DACS is to control and acquire many critical analogue and digital cryogenic parameters of super conducting LINAC and related equipments like beam-line cryostats, helium compressors, liquefier, cryogenic distribution line etc. from a central control room, without fail. The system monitors analog parameters like cryogenic temperature, pressure, vacuum and controls cryogenic fluid levels inside the cryostats and performs closed loop controls of cryogenic valves. The complete system is implemented using two distributed VME crates, housing I/O modules, placed far apart and interconnected using Ethernet. The entire system is still operational with a very few failure issues in last ten years due to high dust environment. The software implementation and maintenance have also been easy and trouble-free as we used some commercial software tools from m/s VMIC called IOWORKS for development. In summary, this paper will elaborate the implementation, use and related failures faced for last 10 years and the subsequent corrective actions taken to keep the system running for such a long time round the clock along with some future plans.

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 as shown in Fig. 1.

DEVELOPMENT TOOLS

IOWorks is a suite of PC-based software development and run-time tools for end-users and systems integrators to create affordable, scalable, and high-performance automation applications. IOWorks takes advantage of the PC platform and its wide range of supported software applications to provide an open system for automation and control environments. IOWorks board drivers are M/s VMIC (now GE) Intelligent Platform's data acquisition and control (DAQC) software driver. It is a hardware and operating system-independent driver designed to support the widest variety of I/O in the industry.

Figure 1: A view of Cryogenic control room at IUAC.

CRYO-DACS used VMIC's Intel-based VME CPUs (VMIVME-7698) using VMIC's VMISFT-package, which consists of a set of functions and utilities to easily develop, debug, and run standard VxWorks applications that access VMIC's broad line of I/O boards.

The VMISFT supported Visual Basic, C/C++, the IOWorks Soft Logic Link, and other languages that can call functions in a dynamic link library or connect to a DDE server. C function library provided a common interface to VMIC I/O products for reading, writing, and configuring.

VME H/W of CRYO-DACS

The hardware architecture of CRYO-DACS is single-host multi-crate distributed VME with CPU(VMIVME-7698) 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.

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Other I/O Parameters

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 using ladder-logic 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 main screen of CRYO-DACS is shown in Fig. 2.

The Microsofts 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 success-fully. The LLT and ULT settings of closed loop controls can be dynamically varied anytime online as shown in Fig.2. 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.

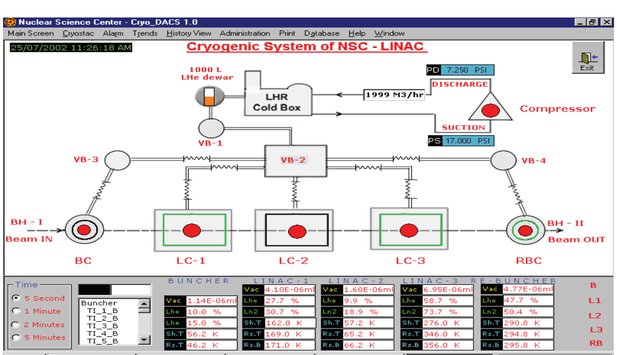

Figure 2: The main screen of CRYO_DACS.

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-rdeskTop 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.

FAILURES AND REMEDIES

Though VME is proven to be a rugged hardware, there were a few issues related to the hardware failures due to high dust environment. The dust accumulated in VME crates made the power supplies and I/O modules fail. Subsequently further action was taken for the routine maintenance in every three months and hence problems disappeared.

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 etc. The system has been working stable. 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.

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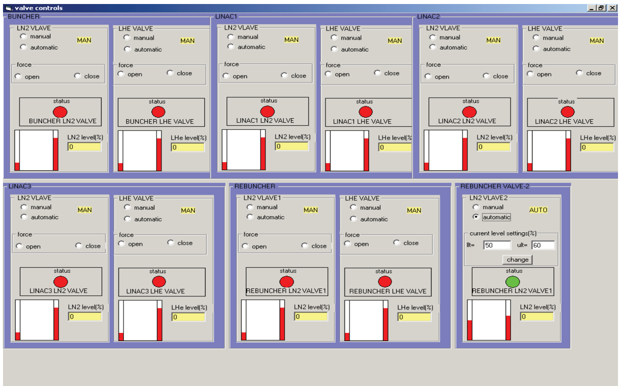

Figure 3: The valve control screen.

SUMMARY

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

FUTURE PLANS

Considering the past experiences of maintaining CRYO-DACS system and most components of the system is becoming obsolete like. Operating system, VME IOWORKS, VISUAL BASIC and VISUAL C++ tools, hardware VME CPU & Modules etc., we are working out plans to slowly replace the entire system by indigenous hardware, firmware and software being developed in-house.

Following are some design plans of the newly proposed system:

1. To reduce dependency on vendors
2. Distributed system should be preferred instead of centralized system to reduce cabling&easy trouble shooting.
3. Sensor transfer function should be embedded to device itself, control system PC should not worry about it.
4. Remote device reboot feature.
5. Inter bus communication between devices w/o any PC.
6. All control loops must run embedded in device level itself.
7. USB ports in each device for re-programming firmware
8. Multiple clients should be able to control and monitoring
9. Must support heterogeneous OS & languages like labview, c, c++, java,.NET, HTML, javascript etc.
10. Remote variables must be accessible across LAN.
11. Compact, low cost SMD design, RoHS, reflow soldered boards to be manufactured

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