PROGRAMMING PLCS UNDER EPICS AT THE SNS PROJECT: FURTHER EXPERIENCES IN COLLABORATION*

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Abstract

The Spallation Neutron Source (SNS) is an accelerator-based neutron source being built in Tennessee by a partnership of six national laboratories. The control system components for the SNS were produced by personnel at the collaborating laboratories, by vendors of the equipment, and by commercial contractors. A number of different approaches were used to provide the programming for both the programmable logic controllers (PLCs) and the input-output controllers (IOCs) which were all based on the Experimental Physics and Industrial Control System (EPICS). For conventional facilities, both the PLCs and the IOCs were programmed under a commercial contract. The PLCs for the high power radio frequency system (HPRF) were programmed by the vendors of the equipment, while the IOCs were programmed by the collaborating laboratory. Finally, while the IOCs for the cryogenic systems were programmed at Oak Ridge, three different approaches were used to produce the PLC programming: some were programmed at Oak Ridge, some at TJNAF, and some at vendor sites. This paper discusses the status of the PLCs in the control system and the integration challenges encountered in the various approaches.

PROJECT DESCRIPTION

The SNS project is a partnership involving six DOE national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge. The status of the project is described in more detail on the web [1] and elsewhere in these proceedings. [2]

STANDARD SNS PLC IMPLEMENTATION

Standard PLC implementation at the SNS consists of an Allen Bradley PLC interfaced to the equipment via ControlLogix. Equipment is also interfaced to PLCs using FlexIO and Group3. All of the high power RF systems and some of the cryogenic systems have local PanelView displays. The PLCs and the IOCs communicate using the EtherNet/IP driver written by Kay-Uwe Kasemir. [3] The IOCs are MVME2101 power PCs running EPICS under vxWorks in VME crates.

The control room operator workstations run the extensible display manager (edm) under Linux. SNS also specifies device symbols, color schemes and color rules. SNS specifies the device naming standard as well as guidelines for PLC programming.

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PLC DEPLOYMENT IN THE SNS CONTROL SYSTEM

PLCs are used extensively in the SNS control system to interface with many different kinds of equipment, including conventional facilities and protection systems.

Table 1: PLC Usage in the SNS Control System

System	PLC Count	IOC Count
Conventional Facilities	11	4
Front End	2	5
Resonance Control	13	4
Vacuum	14	13
HPRF Transmitters	27	12
HVCMs	15	(included in HPRF IOCs)
Cryogenics	18	10
Equipment Protection	1	
Machine Protection	1	1
Personnel Protection	15	2 (monitoring only)
Target	4	2

There are no PLCs in the power supply, low level RF or timing systems.

IOC AND PLC PROGRAMMING

Table 2 summarizes the entities that produced the programming for the components of the SNS control system.

Table 2: SNS Control System Programming

System	PLC	IOC
Conventional Facilities	Commercial Contract	Commercial Contract
Resonance Control	Collaborating Lab Controls	Collaborating Lab Controls
Vacuum	Collaborating Lab Controls	Collaborating Lab Controls

High Power RF	Vendor	Collaborating Lab Controls
Cryogenics - 4K Cold Box	SNS Controls	SNS Controls
Cryogenics - 2K Cold Box	Collaborating Lab	SNS Controls
Cryogenics - Warm Compressors	Vendor	SNS Controls
Machine Protection	SNS Controls	SNS Controls

More details about the implementation of the vacuum system can be obtained elsewhere in these proceedings. [4]

Conventional facilities

The programming for conventional facilities was provided by an outside contractor (Sverdrup) based on standards specified by SNS. SNS provided EPICS training for the engineers working on the contract.

High Power RF

The vendors of the transmitters and the modulators (Titan and ZTec respectively) supplied the PLC programming with the equipment. The collaborating laboratory in charge of procuring the equipment, the Los Alamos National Laboratory (LANL) produced the EPICS engineering screens for the for the high power radio frequency systems. The engineering screens are, for the most part, simple mimics of the PLC PanelView screens. As required by equipment engineers and operators in Oak Ridge, SNS is producing more operations-focused controls and displays.

Cryogenic Systems

The control system for the 2400-Watt cryogenic plant and the linac cryomodules was produced by Oak Ridge personnel based on specifications provided by the system designers at the Thomas Jefferson National Accelerator Facility (TJNAF). An EPICS-based control system is connected to the cryogenic devices via Allen-Bradley ControlLogix PLC standard input and output modules.

All of the EPICS programming of the IOCs and the operator interfaces were produced at SNS/Oak Ridge. Because the cryogenic equipment is very similar to the equipment in operation at TJNAF, SNS was able to copy the operating screens, translating from MEDM to edm and changing the device names, color schemes and drawing details as appropriate. This provides an enormous advantage in producing screens that will be useful to operations at the outset.

SNS is using a multifaceted approach to PLC programming. Like the high power RF systems, the vendor (PHPK) supplied the PLC programming for the warm compressor skids with the equipment. TJNAF, the collaborating laboratory in charge of procurement of the cryogenic equipment, programmed the PLC for the 2.1 K cold box. SNS controls provided the programming for the 4K cold box from logic specified by the vendor (Linde). Finally, SNS controls personnel are programming the gas management and cryomodules PLCs from logic specified by TJNAF. Our paper at the last conference gave more details about the cryogenic control system. [5]

LESSONS LEARNED

We have discovered to our chagrin that it is very important to ensure that there are no latched commands that get sent to the PLC. Every interface that sends to the PLC must be tested to make sure there is no way for commands to hang around to take effect when interlocks become okay.

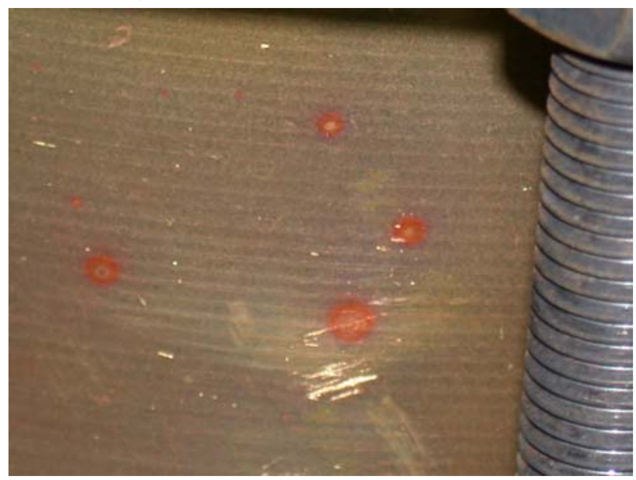

Figure 1: Klystron Damage after Modulator Turned on Inadvertently

ADVANTAGES OF THE PRESENT APPROACH

Where we have been able to impose standardization, we will reap benefits in the ease of maintenance in the future. The present approach allows a way to integrate diverse kinds of equipment provided by many different entities into one system. For example, the SNS cryogenic systems and conventional facilities are able to share signals: the Central Helium Liquifier (CHL) efficiency calculation uses the power into the warm compressors from the conventional facilities (CF) system, and CF uses pressure and flow signals from the CHL.

PID CONTROL LOOPS

The PID loops that run within the equipment controllers will not be considered here. The resonance cooling PID loops run in the PLCs. All except five of the cryogenic system PID loops run in the IOCs under EPICS control. Generally loops for which even momentary interruptions cannot be tolerated run in PLCs, and those for which short interruptions can be tolerated run in IOCs. Thus IOC reboots will be allowable for maintenance.

There are advantages to running PID loops in IOCs. The EPICS "cpid" record developed at TJNAF allows easy adjustment of loop constants and even changing loop parameters on the fly – otherwise, this would require going into the PLC logic to make changes. Figure 2 illustrates how this has led to our early success.

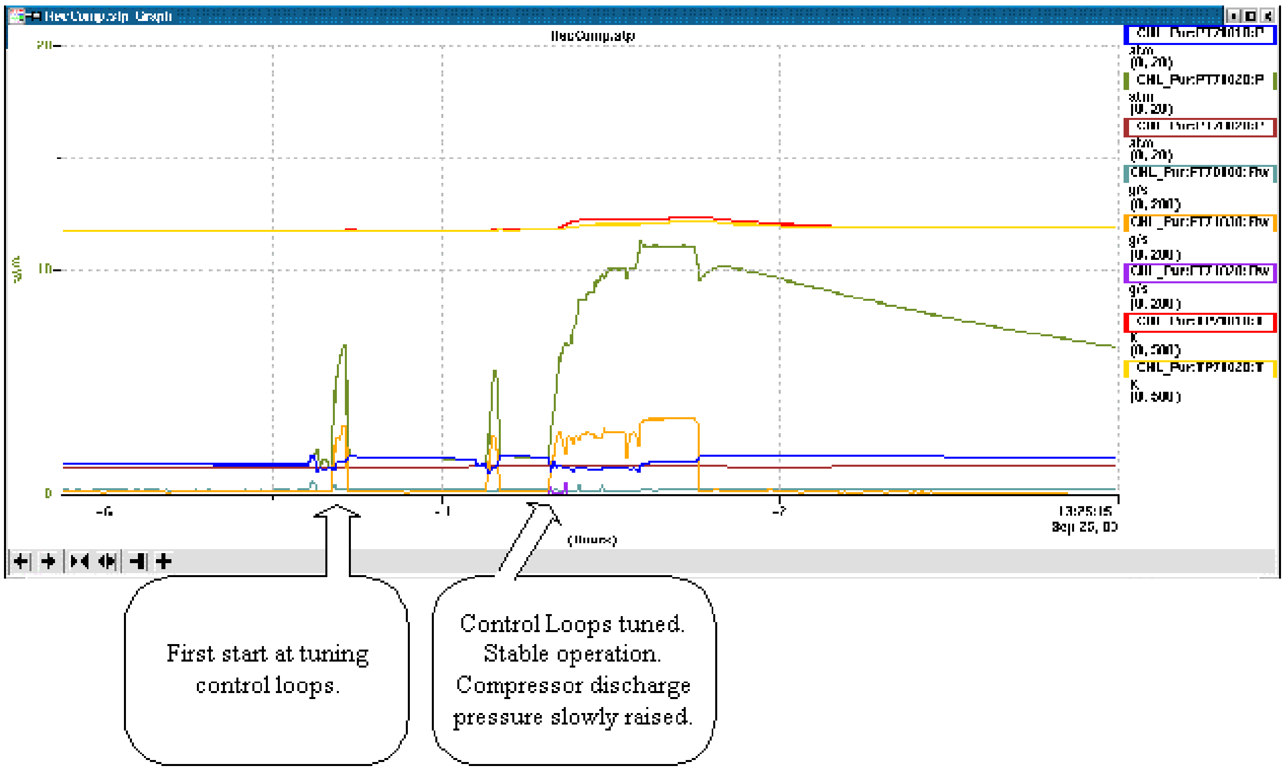

Figure 2: First Deployment of a PID Loop in the Cryogenic System

CONCLUSIONS

While it may be too early in the project to offer firm conclusions, the use of PLCs gives a clear interface separating the control system responsibilities and modularizing the controls. The use of EPICS affords an integrated way to bring together many different pieces and to use components created by others. The SNS control system integrates PLCs provided by a diverse collection of vendors and collaborating laboratories.

REFERENCES

[1] http://www.sns.gov

[2] D.P.Gurd, "First Experience with Handoff and Commissioning of the SNS Control System," ICALEPCS 2003, Gyeongju, Korea 13-17 October 2003.

[3] Kay-Uwe Kasemir and L.R. Dalesio, "Interfacing the ControlLogix PLC Over EtherNet/IP" ICALEPCS 2001, San Jose CA 27-30 November 2001.

[4] J. Tang, et al, "SNS Vacuum Control System: Software Design Strategy and Commissioning Experience," ICALEPCS 2003, Gyeongju, Korea 13-17 October 2003.

[5] W.H. Strong, et al, "The SNS Cryogenic Control System: Experiences in Collaboration," ICALEPCS 2001, San Jose CA 27-30 November 2001.