Programmable Logic Controller Standardization

1. Introduction

The Spallation Neutron Source (SNS) project will employ numerous types of control equipment for both technical subsystems (accelerator and target equipment) and conventional facilities (electrical; heating, ventilation, and air conditioning; etc.). A significant number of these control systems will be programmable logic controllers (PLCs). These are specialized industrial computers used primarily for discrete (on-off) and sequential control. In accordance with SNS Project Office directions on standardization of SNS components, the Controls Section has been investigating standardizing project use of PLC manufacturers and models.

The Controls Section has conducted informal market surveys and has been in contact with PLC users at the other consortium laboratories. A considerable amount of time has been spent to ensure that the selected manufacturer can meet SNS project requirements. We recommend that the SNS project standardize on Rockwell Allen-Bradley (A-B) PLCs. Exceptions will be required in some cases based on cost, schedules, or specialized technical objectives, but we propose that the Project Office mandate the use of the selected PLC manufacturer unless an exception is obtained.

2. Considerations

Considerations on PLC standardization are similar to those required for desktop personal computer (PC) standardization. These issues involve support of hardware and software, as well as training issues and continuity of operations.

2.1 Hardware

Despite industry efforts toward open standards, PLC hardware from different vendors is generally not compatible. Application of this hardware requires design engineers to wade through volumes of technical literature. A considerable learning curve is required to apply and maintain PLC equipment, and this process must be repeated for different models and manufacturers of PLCs.

- **Standardize on one manufacturer and a limited number of products. Selecting the manufacturer that the majority of the SNS control engineering staff has used in the past will maximize engineering and maintenance productivity.**
- ***Allen-Bradley Equipment is in use at all of the collaborating laboratories, and is already in use on two SNS Systems – the Front End and the Target Test Facility.***

Unlike desktop computers, industrial control systems are intended to operate for decades. This means that replacement parts and product support must be available even though rapid technological development makes current products obsolete after a relatively short period. Replacing or retrofitting a control system is expensive and requires processes to be taken out of service during the refit.

- **The selected manufacturer must have a proven track record in supporting legacy equipment.**
- ***Allen-Bradley has a strong record in supporting legacy equipment. Their PLC-5 family has been in widespread use for ten years, and continues to be well supported.***

Even the best manufacturers cannot cover all of the required technical information in their product literature. Manufacturers' field engineer support is often required to resolve problems

that develop, often during the critical startup phase. If this support is not readily available, commissioning and thus project schedules can be delayed. As these products grow increasing complicated (with connections to networks, third-party products, and software), plant engineering cannot maintain sufficient expertise in-house to solve all of the problems that will arise during installation, commissioning, and operation.

- **The selected manufacturer should have strong factory and local engineering support.**
- ***Allen-Bradley has local Support in Oak Ridge as well as Long Island and Berkeley.***

2.2 Software

PLCs are programmed using specialized software generally (but not always) supplied by the PLC manufacturer. The programming methods (usually ladder-logic) are similar between different manufacturers, but each manufacturer uses different implementations. These software packages are used by thousands of engineers and technicians (versus million of users for PC desktop software). The result is that these software packages are even more idiosyncratic than desktop PC software because these low-volume software packages have undergone much less testing and debugging. Because of the relatively low number of users, support for solving software problems is much harder to obtain (i.e., you cannot just run down the hall and ask a coworker for help).

- **Standardizing on one manufacturer will reduce the learning curve required for programming software.**
- ***The collaborating laboratories already have experience in the use of Allen-Bradley tools for PLC programming.***

2.3 Networking

PLC equipment is assembled from various types of modules [processor, power supply, communications, and input/output (I/O)]. Many times the I/O modules are mounted remotely from the main processor to reduce wiring costs. Network protocols are used to communicate information between the remote devices and the main processor. Historically, these networking protocols have been proprietary, such that devices from other manufacturers could not be added to the network.

Market pressure has forced PLC manufacturers to develop “open” networking standards. The intent is to allow mixing of different manufacturers’ components on the same network. Currently, several competing standards are vying for market dominance. The Controls Section conducted a separate effort to select standards for SNS control networks. Selection of a viable control networking standard will allow the expansion of SNS control capability based on cost and performance issues, instead of being locked into a single manufacturer.

- **The selected manufacturer must support SNS standards for control networks.**
- ***Allen-Bradley supports interfaces to Ethernet, the backbone network protocol of the EPICS-based SNS Control System. In addition, Allen-Bradley supports more recent open control networks (ControlNet, DeviceNet) which have been selected for use on the SNS Target control system.***

2.4 External Interfaces

The majority of PLC users integrate their various PLCs using “human-machine interface” (HMI) software. Third parties or the PLC vendor supplies the vast majority of this software. These software vendors supply software drivers that allow the HMI software to communicate to the PLCs. The HMI software extracts data from the PLC and displays it on a graphics workstation (often a desktop PC).

SNS, like all modern accelerator facilities, will use a U.S. Department of Energy-sponsored software system called EPICS[1] to provide control system integration. A great deal of accelerator control equipment is based on highly specialized control hardware. This specialized equipment precludes the use of standard HMI software. Software drivers for control equipment like PLCs must be developed by the EPICS consortium and cannot be purchased from third parties. This means that EPICS communications software ("drivers") must be developed for each type of PLC. If SNS uses many disparate PLCs, a significant effort will be required just for developing the software drivers for each type of PLC. This typically requires that a PLC system be purchased and set up in a hardware lab to support the software development and testing. After these software drivers are developed, considerable effort is required to install and maintain the drivers in the EPICS control system.

- **Standardization of PLCs will minimize the effort required to develop EPICS software.**
- ***EPICS drivers already exist for a number of Allen-Bradley products and interfaces, and are currently under development in the SNS PLC lab at BNL for their newer products.***

3. Other Factors

Rockwell A-B PLCs have been widely used at other accelerator facilities, including the Relativistic Heavy Ion Collider and the Advanced Photon Source (APS). The front-end group at Lawrence Berkeley National Laboratory (LBNL) has already purchased Rockwell A-B equipment for front-end control. LANL successfully used Allen-Bradley PLCs for control of the LEDA High Power RF supplies. The same basic design is planned for SNS. Rockwell A-B PLCs are widely used in the Oak Ridge complex, including the Target Test Facility (part of the SNS target research and development effort). Although other PLCs from other manufacturers are also in use at the collaborating labs (GE Fanuc at APS; Modicon at CEBAF and LANL), Allen-Bradley is by far the most commonly used.

The majority of PLCs used for SNS will support major subsystems such as vacuum, klystron, and magnet power supply systems. As a result, these PLCs will be ordered as needed to support the schedule of the subsystems, instead of placing one large, project-wide order.

Several of the collaborating laboratories (BNL, LBNL, LANL) already have discount arrangements with Allen-Bradley. Oak Ridge National Laboratory (ORNL) has set up Rockwell A-B PLCs in the Accelerated Vendor Inventory Delivery (AVID) system. These PLCs are sold at a 40% discount of the list price. If the project were to set up an AVID-like ordering system for PLCs, this would confer several benefits on the project:

- A project-wide discount could be negotiated that would be applied to all SNS PLC procurements.
- Project participants could order PLC equipment as needed.

A desirable additional feature of this arrangement would be to extend the ordering agreement to SNS subcontractors who supply PLCs as a part of major equipment (such as the linac RF high voltage power supplies).

- **Set up an AVID-like ordering agreement to maximize price discounts and flexibility in ordering. Extend the agreement to cover subcontractors providing embedded PLCs.**

4. Market Overview

A recent magazine article on PLCs listed 42 different PLC manufacturers. Rockwell A-B is the number one domestic supplier with 40% of the market. Siemens is the number one supplier worldwide, with a strong presence in Europe. Several companies claim the second and third domestic spots, including GE-Fanuc, Siemens, and Schneider Automation (Modicon). Distribution models include local area distributors, direct factory sales, and even e-commerce models similar to amazon.com.

[1] Experimental Physics and Industrial Control System.

5. Recommended Manufacturer

We recommend that the project standardize on Rockwell A-B PLCs. Summarizing, this manufacturer was selected for the following reasons:

- Rockwell Allen-Bradley PLCs are already in use on the SNS injector at LBNL, and the Mercury Target Test Facility at ORNL.
- ORNL, Los Alamos National Laboratory, Brookhaven National Laboratory (BNL), and LBNL all have a long history of using Rockwell A-B PLCs. All of these labs have a considerable investment in training and development tools for these PLCs.
- ROCKWELL A-B has extensive local support personnel in the Oak Ridge–Knoxville area (five field engineers are located in this area).
- ROCKWELL A-B is the number one domestic supplier; therefore, it is reasonable to assume that this company will continue to supply PLC products for many years.
- ROCKWELL A-B has a broad product line and is an industry leader in developing innovative new product lines to improve performance and reduce hardware and installation cost. We proposes that the ROCKWELL A-B product set used for SNS be limited to a subset of this equipment to reduce engineering and support costs.
- This company has a long track record of supporting legacy equipment (ROCKWELL A-B's 20-year-old model PLC 2 is still supported).
- AVID-like ordering agreements are already in place at ORNL and BNL (both laboratories receive a ~40% discount on PLC products).
- ROCKWELL A-B not only supports but also originated the selected open-control networking standards for SNS (DeviceNet and ControlNet).
- The SNS Controls laboratory located at BNL has already begun work developing EPICS drivers for the selected ROCKWELL A-B products. Moreover, the EPICS community already has a large investment in drivers for Rockwell A-B PLCs.