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PLC Laboratories – The Next Generation

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Abstract

Programmable Logic Controllers (PLCs) were a novelty in the automotive industry after their introduction in the early 1970s. Thirty years after their debut, PLCs are the default industrial controller used in a broad range of control applications from simple machines to entire production facilities. In the last ten years, PLC development followed the computer industry trend toward networked devices and shared databases. In the last three years, however, vendor products that integrate the PLCs with other networks, smart sensors and smart actuators have increased significantly. Courses and laboratories covering PLC programming and interfacing started to appear in colleges and universities teaching engineering technology programs in the mid 1970s. Today PLC courses and a PLC laboratory are found in almost every engineering technology curriculum. In many institutions, however, the level of PLC technology taught has not progressed beyond simple discrete control using basic ladder logic programming on a stand-alone PLC. Engineering technology laboratories must include exercises using PLC and smart device networks to prepare graduates to work on the robust automation solutions adopted by manufacturing. This paper describes how PLC laboratories need to change to be aligned with current industrial usage.

PLC History – Three Distinct Periods

Programmable logic controllers (PLCs) were born in 1972 when the Oldsmobile division of General Motors asked a small company to develop a software-driven solid state replacement for racks of relays used to control production lines. Modicon, the first PLC company, designed a special purpose industrial computer that would translate discrete switch an sensor inputs into discrete outputs based on Boolean logical combinations of the inputs. The new device also had solid-state counters and timers for more complex control problems. From a beginning with one PLC company, the industry grew to a point today where over 50 companies offer PLC devices, and a robust industry of application development companies for PLC users exist.

For the first decade the PLC was actually called a PC, which was short for programmable controller. During this period, PLCs were used primarily as replacements for relay ladder logic, with inputs and outputs limited primarily to discrete control of manufacturing automation. Programming was usually done with dedicated hand held programmers or special purpose desktop programming systems. PLC use was primarily confined to the larger manufacturers in the automotive industry and major appliance areas. Near the end of the 1970s, the personal computer or PC appeared. The term logic was added to programmable controller and term used today, PLC, was adopted.

The 1980s saw increased PLC programming capability that included the addition of analog inputs and outputs, a much more robust command sequence, and use of the new personal computer technology as a universal programming device. The development of better programming software and less expensive stand-alone PLC models caused PLC adoption to spread to small production facilities and to be used as embedded machine controllers.

The 1990s witnessed an explosive growth in PLC technology that focused on integration and networking. PLCs can now have an IP address like other devices on a LAN. Programming is performed with powerful Windows-based programs. Systems are linked across the network with PLC systems, cell control software, and enterprise control software applications sharing databases and control algorithms. True distributed control became a reality with the development of sub-network technologies, like Devicenet, Controlnet, and Foundation Field Bus.

Corporate versus College Adoptions

A review of PLC adoption trends over the last thirty years indicates the level of training that college laboratories must deliver for consistency with the skill sets expected by industry. To put these changes into perspective the common characteristics of current college PLC laboratories are compared with the characteristics of industrial uses of PLCs. The status of college laboratories was determined by feedback to a web-based survey, and representatives of major PLC vendors provided the industry data. While there are exceptions, many college PLC laboratories exhibit the following characteristics:

- PLCs are not integrated with other industrial machines, and students receive a limited exposure to the problems associated with the integration of the PLC in an industrial machine control environment.

- PLCs are present in most technology program laboratories, but engineering curriculums still offer little PLC exposure to their students.

- Two or more PLC vendors are represented with an insufficient number of machines from a single manufacturer for all student stations. The use of multiple vendors supports diversity in the instruction but limits the level of control problems to the commands common across all of the different PLC models in use.

- The size of the PLCs varies widely from micro-logic devices to large system models, with an insufficient number of larger machines from a single manufacturer for all student stations. Again, diversity is supported, but the level of applications and command sets covered is often limited to the capability of the smallest machine.

- The primary focus is teaching programming using a variety of programming devices and software, with less emphasis on machine interfacing and use of network functions.

- Few networked systems are present. This is probably due to the number of different vendors present and the lack of a common networking standard at the PLC level.

- Use of other manufacturing network standards like Devicenet, Controlnet, and Profibus are usually not present.

- Teaching basic program commands in discrete control applications is the primary focus of the course and laboratories, using switches and lights for input/output devices with few real manufacturing problems.

- Students receive little exposure to PLC languages defined by the EIC1131 (International Electrotechnical Commission) standard, other than ladder logic programming.

- Little integration exists with other manufacturing technologies, such as vision systems, human machine interface (HMI) panels like Panel View, analog sensors and controls, and cell control software like Wonderware.

- Only one course focusing on PLC concepts typically is offered in the program.

In order to compare these college laboratory characteristics with actual industrial PLC usage, a look at the current state in industry is required. Again, exceptions exist, but the following characteristics are generally present:

- Industries generally adopt one vendor for all plant solutions to minimize the training and maintenance issues. However, companies cannot control the brand of PLC used in productions machines that are purchased for process applications. With a PLC from a different vendor embedded in the machine for discrete control, the goal of a single PLC vendor is compromised.

- Users of Allen Bradley PLC hardware are using the new Controllogix processors and programming language to integrate older systems into a common control system.

- Networked PLC solutions are becoming common with the use of Ethernet, proprietary PLC networks, and Devicenet the most common solutions.

- The focus is on support and control of a manufacturing operation with minimum down time.

- Integration with server-side databases is becoming common.

- Integration with multiple technologies including, robotics, inspection/quality system, CNC machines, sensors, control devices, vision systems, SQL data bases, enterprise production control software, and cell control software are common.

- Use of PLCs for closed-loop process control is increasing.

- A greater emphasis on structured programming like Sequential Function Charts in the U.S. and Instruction List in Europe exists.

- System development companies are frequently used for application development and installation, but maintenance is still the primary responsibility of the end user. However, two- and four-year technology graduates are being used in application development roles at both system development companies and at end users.

The difference between collegiate and corporate use of PLCs is quite marked and requires answers to the following questions: Should colleges teach a new technology just because it is widely adopted in industry? What options do colleges have to align PLC courses more closely with the current trends followed by industry?

Recommendations for Change

Technology curriculums have long felt an obligation to include instruction in any technology that graduates were likely to encounter on the job. The widespread adoption of PLC usage required the introduction of PLC classes in many technology curriculums. The growth in PLC technology and its subsequent adoption by a broad manufacturing base again demands a change in curriculum content. There are a number of options open to technology programs that want to align PLC program content with current industry use, and several are outlined below:

- Add a sufficient number of PLCs from a single vendor, so that the following technologies can be added to the PLC laboratory.

    - ♦ Place all PLCs on a common network, along with microcomputers for programming.

    - ♦ Add examples of other manufacturing networks, especially Devicenet.

- ♦ Include programming software for PLC program development.

- ♦ Include HMI and cell control software like Wonderware or Fix Dmacs that are available for almost no cost to colleges, or use PLC vendor-specific software like RS View from Allen Bradley or Factory Link from Group Schneider.

- Include programming exercises for real manufacturing applications with either real or virtual systems. It is possible to develop a virtual manufacturing system at each student station using the current HMI software, and then have just one actual target system for the final test of each student groups program.

- Add a closed-loop PLC programming exercise to the controls course and laboratory.

- Expand the programming structures to include sequential function charts or another of the new program language standards.

- Add exercises that require knowledge of network functions, like use of server-side database or remote network devices, such as motor controllers.

- Add an advanced PLC course as an elective.

Changes Planned at Penn State Altoona

The Automation Laboratory at Penn State Altoona will add the following technologies to bring the laboratory experience closer to current industrial practices.

- A student station with a PLC with Controllogix will be added that controls a pneumatic robot using Devicenet capable sensors. Student groups will be rotated through the station so they get experience working with Controllogix programming and systems with Devicenet capability.

- A student station will be added that uses a PLC to control two remote ac motors over either an Ethernet or proprietary type LAN network. Student groups will be rotated through the station so they get experience programming motor performance characteristics (i.e. speed, torque, acceleration, deceleration, and duty cycle) using a PLC and LAN compatible motor and speed control.

- Block I/O will be added to an existing PLC student station so students can gain experience working with this popular type of discrete control device.

- All of the PLC will connected to either an Ethernet LAN or have their proprietary PLC LAN connected to the laboratory Ethernet LAN.

Conclusion

The changes in programmable logic controller technology over the last 30 years have been far-reaching. Most of the change has been driven by industry's need for greater productivity, higher reliability and quality, and larger profits. College PLC laboratories have not adopted the new technology at the same rate as industry; as a result, many graduates of technology programs do not have the skill set needed to work on current state-of-the-art control systems used in manufacturing. A number of options are discussed that colleges can follow to move to the next level in PLC instruction. Some involve additional equipment and may be limited by capital budget issues; however, others, like including other program language standards, would only require a change in the course or laboratory syllabus.

References

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BIOGRAPHY

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