ADVANCED COURSE IN PROGRAMMABLE CONTROLS FOR ENGINEERING TECHNOLOGY

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1. INTRODUCTION

Programmable Logic Controllers (PLCs) have been found in industry since the early 1970's and the application of PLCs has long been considered a required course for majors in Electrical Engineering Technology. A first course in PLCs is found in most 2 year programs, usually in the sophomore year. Content of a first course includes learning the PLCs instructions, some programming structures and the hardware one or more types of PLC. A second course, preferably taught in the senior year of a four-year technology program, should be structured to maximize the student's employability. The content of this course is the topic of this paper.

The content of the course should include applications of PLCs to both analog and digital processes. The analog portion should include an introduction to the PID algorithm from both from a theoretical and a practical point of view. Digital programs should include a number of more difficult programming applications.

Software should be introduced that familiarizes the student with an array of software types needed in the manufacturing environment. Software for Human-Machine-Interface (HMI) development should be included. Also, software to successfully implement a network should be introduced. A list of potential projects including hardware will be discussed. Hardware types will be discussed including recommendations of equipment to purchase.

2. COURSE DISTINCTIVES

After a first course, the emphasis of the material should change dramatically. Emphasis in the first course was to acquire the tools necessary to build a PLC program for control of real time applications. The second course will deal with the aspects of building a system. The second course is intended to build an attitude that very difficult systems problems can be broken down into more manageable parts, each of which can be solved. A basic programming skill level is assumed for success in the second course. What is significantly more difficult than PLC programming is integration of all the components including programming into a complete system. Smart devices such as the Allen-Bradley PanelView operator interface or servo drive are devices used to interface to the PLC instead of push buttons, pilot lights and switches. The

PID instruction and several other more complicated programming instructions are some of the more difficult instructions to master. Listed below are several of the exercises used in this course.

3. COMMUNICATIONA WITH PROCESSORS

A procedure for attaching to SLC processors using DF-1 and DH-485 is used to demonstrate the multi-faceted approach that most PLC vendors use to attach a computer to the PLC. Methods used are intended to attach and set up the PLC for use as networked device. Also discussed are data highway types, approaches to communicate peer-to- peer and other communication topics in PLC communications.

4. HUMAN-MACHINE-INTERFACE

The goal is to create an active interface between the PLC or group of PLCs and the operator. These are called Human-Machine-Interfaces or HMIs. Operators have been required to monitor and interpret much more information in the machine they operate than in the past. As a result, interfaces have become more complex. The operator may be called on to rapidly decide whether the machine is operating correctly or not. Alarms, machine modes, historical data, and real-time decision-making information are necessary to control many machines today.

HMIs are divided roughly into two main groups. First is the dedicated HMI, a push-button, numeric data entry replacement device with little capability of storing data-base information for the machine. Typically these HMIs are stand-alone. Second is the HMI that is part of the data-base package used to store and retrieve process information from the machine. These HMIs usually run on a network of computers.

Typical of the first group are products such as PanelView and PanelMate. Typical of the second group are products such as Fix Dynamics, Allen-Bradley RSView32 or WonderWare. For simpler applications, the PanelView will be selected. While it is not as sophisticated as the second, the process of building screens is similar. Also, the process of networking the processor to the HMI is similar.

5. MSG BLOCK

The Message (MSG) instruction is also studied. A lab was devised that allows the student to send and receive messages between two or more PLCs. Block Transfer instructions are also used in some PLCs to communicate between various devices. Up to 64 words may be transmitted at a time using the Block Transfer Read (BTR) or Block Transfer Write (BTW) instruction. The remote device, however, is a device communicated to through remote I/O and using Allen-Bradley's I/O files: M0 and M1 as opposed to the MSG instructions.

6. PID BLOCK

In its simplest form, the PID block is used as a single block with no input contacts and surrounded by only two Scaling Blocks (Scaling with Parameters – SCP) in the mid-level rack mount SLC 5/03 processor from Allen-Bradley. The SCP blocks are configured to retrieve a numerical value from the analog input channel, linearly scale the input and move the resultant value to the PID block.

HMI displays are used to allow the operator to run the process from the display. To run the PID successfully, several parameters should be displayed either to set the process in motion or to adjust the process once it is in motion.

A ramp block is a function block that is added in front of a PID block to change the setpoint (SP) over a period of time instead of immediately. It is constructed in the PLC diagram to increment from the old SP to the new SP in increments of 1. More sophisticated ramp blocks allow the ramp rate to be set by an operator or engineer.

When the PID block is switched from manual to auto, the function responds to the SP presently available to the block. If the process is sensitive to sudden changes in PID output, the program should include logic to give the output a signal matching the present flow when the block is in manual. This is commonly referred to as bumpless transfer.

Processes are described using flow diagrams. Symbols for diagrams are defined by the organization - Instrumentation, Systems, and Automation Society (ISA). Letter codes are written in circles representing various devices that control a process.

7. ASCII BLOCKS

Only the ASCII WRITE (AWT) and ASCII READ (ARD) will be used to demonstrate communication between serial devices. The AWT or AWA instruction is appropriate for the Write instruction. Since no appended characters need be appended to the string, the AWT instruction may be preferred. The ASCII blocks demonstrate communication between PLCs and devices such as bar code readers or weigh scales.

8. FAULT RECOVERY INSTRUCTIONS

Chapter 12 of the SLC 500 and MicroLogix 1000 Instruction Set Reference Manual is dedicated to understanding interrupts in the PLC. Four major types of routines are introduced. They are the User Fault, Selectable Timed Interrupt, Discrete Input Interrupt and I/O Interrupt.

The User Fault Routine is used to protect the processor from shutting down when a fault occurs. The other three routines interrupt the processor scan and run a program to accomplish a particular high priority task.

When a recoverable or non-recoverable user fault occurs, the processor goes to Status Table location S:29 and reads a number corresponding to a program file handling the fault. If the fault is a recoverable fault, the program in the file can correct the problem and clear the fault bit, allowing the processor to fully recover from the fault. Of course, if the problem occurs again, the fault will occur again.

9. STEPPER AND SERVO CONTROL

One SLC 5/03 was used to control an automatic storage and retrieval system of pallets. This is commonly referred to as an ASRS. Two different motion control cards were used to control the horizontal and vertical motion of the positioning belts used to move the pallet-extracting device. Although an engineer would not select two different types of control cards to install in such an installation, the two cards selected were a stepper control card and a servo control card. Specifically, the stepper control card was the SLC Stepper Controller Card (1746-HSTP) and the servo card was the SLC Servo Controller Card (1746-HSRV).

When starting the program development of the stepper motor, the first object should be to control the drive manually. If possible, the drive should be controlled with a simple test program to give the engineer simple control of the axis. In this case, no program is necessary. Entry of the configuration and command words is seen as all that is necessary to control the drive manually.

To configure the SLC Servo Module, data is written to the M0 file, not the Output Data File as was the case with the stepper controller card. Use a copy file to transfer data to the M0 file.

10. DEVICE-NET NETWORK

DeviceNet is a relatively easy I/O network to install and configure. It will be discussed in part by using a manual from Allen-Bradley, the DeviceNet Starter Kit Installation Manual. DeviceNet is an extension of CanBus. DeviceNet is an easy-to-implement network that uses CanBus as well as additional software drivers to implement industrial networks. The DeviceNet Starter Kit is a good point to introduce the capabilities of an industrial network to students.

11. CONTROLOGIX

The ControlLogix platform is suited for the high-end application while the CompactLogix platform is more suited for the lower-end application. Costs are also comparatively lower for the CompactLogix platform.

Each of these processor types uses RSLogix 5000 software and can be programmed in a similar manner. Assigning of tags and building of programs is similar through the product line. Creation of tags is one of the first differences found to be a major change from the SLC programming experience. As discussed in the Logix5000 Quick Start Manual, tags are no longer automatically assigned but given names only as the programmer (you) assign them. Tag data

bases are just that, a data base. With the creation of a new tag, the entire function of that tag is defined. The name is the name used above the contact. The type is a bit, integer, or other type used in the definition of how the data is actually stored.

12. SAFETY

Allen-Bradley, Jokab and Banner Engineering are only some of a long list of safety equipment manufacturers. Use of information from their catalogs gives an insight into proper design of a circuit as it pertains to safety in an industrial setting

13. OTHER PLCs

PLCs have moved in many different directions over the last few years. One direction is toward a standardization of languages of the various PLCs so projects can more easily be moved between different hardware platforms. This standardization has become the IEC 1131 specification.

14. NETWORKS AND PROTOCOLS

It is not enough to know that everything uses Ethernet and thus be able to 'get by' when implementing a modern control network using Ethernet. Knowledge of multitasking is needed as well as a background pertaining to proper configuration of each device on the network on the plant floor. The same Ethernet cable is now be able to transmit office or business data as well as process monitor and control data and embedded device data.

15. AUTOCADD ELECTRICAL

Generating of electrical schematic drawings can be a very manual task. Either AutoCAD or other graphic package is most often selected and the drawings are generated using a symbol library purchased from a source or created by the user.

16. SUMMARY

Today, PLC programming involves engineering hours and the money necessary to generate the engineering hours for the job. Companies do not have an infinite supply of either money or hours to appropriate to any project. Programming intelligently is a high priority in today's engineering environment.

Some of the projects listed in the paper are very difficult when studied thoroughly. Two or three weeks of intense work should be allowed to master various aspects of these projects. It is very humbling for some students to even be required to re-learn the basics of logging on to the PLC in order to be able to program on-line.

The goal of the second course in PLCs is to aid the student in the interview process to find a good job. In order to do this, the student must be informed and interested in the potential job. If the job includes PLC programming, courses such as the one outlined in this paper should aid in that task.

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