TEACHING ENGINEERING MATERIAL TO INDUSTRY TECHNICIANS AND ENGINEERS

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Abstract

Today's skilled worker shortages are extremely broad and deep, cutting across industry sectors and impacting more than 80 percent of companies surveyed. This human capital performance gap threatens our nation's ability to compete and is emerging as our nation's most critical business issue. Teaching engineering course materials to regular students has an established record. Students learn the theory and then during the laboratory and projects the theoretical principles are applied. Students usually spend one or more semesters to learn the subject and apply them in the practice. However, teaching a new subject to technicians from industry has its own specific challenges. All this suggests that technician education is more difficult than the education of scientists and engineers. However, the technician is expected also to be highly skilled in acquiring data, caring for instruments, and producing error-free results. Unless technician education is designed very carefully so that real needs are determined and addressed, it will be packed with so much science and mathematics that technician skills will never be learned. These factors explain why so many technicians complain that their academic study was useless for their work. Purdue University Calumet College of Technology in collaboration with one of the leading manufacturers of the automation systems has established a training center to teach automation hardware and software to technicians and engineers from the industry. This paper presents the collaboration and the challenges of the center. The student recruitment, teaching environment, material updating, student feedback, collaborative industry response, reaction and accommodation, student assessment and current status of the center also will be presented in this paper.

1. INTRODUCTION

As technology changes, the technicians and workers must be trained and retooled. The role of the technology resource instructors and university professors must be more versatile to meet the growing teaching demands. The role of university teaching has been changed to adopt their operation for training workers and technicians.

Automation industry is one of the fastest growing industries worldwide. Most industries are trying to automate their production and manufacturing. Advantages commonly attributed to automation include higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, and reduced factory lead times. Higher output and increased productivity have been two of the biggest reasons in justifying the use of automation. Despite the claims of high quality from good workmanship by humans, automated systems typically perform the manufacturing process with less variability than human workers, resulting in greater control and consistency of product quality. Also, increased process control makes more efficient use of materials, resulting in less scrap. Worker safety is an important reason for automating an industrial operation. Automated systems often remove workers from the workplace, thus safeguarding them against the hazards of the factory environment. In the United States the Occupational Safety and Health Act of 1970 (OSHA) was enacted with the national objective of making work safer and protecting the physical well-being of the worker. OSHA has had the effect of promoting the use of automation and robotics in the factory [1].

Automation system mostly takes advantage of Programmable Logic Controller (PLC). A programmable logic controller is a specialized computer used to control machines and processes. It therefore shares common terms with typical PCs like central processing unit, memory, software and communications. Unlike a personal computer though the PLC is designed to survive in a rugged industrial atmosphere and to be very flexible in how it interfaces with inputs and outputs to the real world.

The components that make a PLC work can be divided into three core areas.

- The power supply and rack
- The central processing unit (CPU)
- The input/output (I/O) section

PLCs come in many shapes and sizes. They can be so small as to fit in your shirt pocket while more involved controls systems require large PLC racks. Smaller PLCs are typically designed with fixed I/O points. For our consideration, we'll look at the more modular rack based systems. It's called "modular" because the rack can accept many different types of I/O modules that simply slide into the rack and plug in [2]. To operate PLCs, one must have basic understanding of electrical circuits theory and power, programming, logics, digital and analog systems, and computer interfacing. Most technicians prefer hands-on learning methods rather than proof of concepts through math and formulae. A course developed for college program rarely can serve as a teaching course for technicians in the industry.

To address the increasing demands for teaching technicians, several modules have been developed. A brief list of these modules is as follows:

- DC/AC Electrical Systems
- Analog/Digital Electronics
- Programmable Logic Controllers (PLC)
- Basic Process Control, Elements & Systems

The complete list of these modules is available at [3].

Six years ago, with the support of industries such OEM and machine builders the Mechatronic Engineering technology at Purdue Calumet was established. One of the industries with close collaboration with our program is Mitsubishi Electric Automation. As one of many Mitsubishi automation affiliates around the world, Mitsubishi Electric Automation, Inc., is part of a global company serving a wide variety of industrial markets with a family of automation products including programmable logic controllers, variable frequency drives, operator interfaces, motion control systems, computer numerical controls, industrial robots, servo amplifiers and motors, and industrial sewing machines. In order to provide training for end users, engineers, technicians, and students a training center has been established. Collaboration with universities can provide an avenue for technical problem solving and facilitate the trainings. The classes provide practical, hands-on training that can be used the moment the student walks out of the class. The facility is equipped with five racks with PLC, motion control and networking gears.

This collaboration provides benefits both Purdue University Calumet and Mitsubishi. Purdue University Calumet is able to obtain the state-of-the-art manufacturing automation products for student education, leverage industry professionals to provide real-world experiences to students, and gain training revenues and equipment. Mitsubishi also benefits greatly from this collaboration. The Mitsubishi training capability is expanded by utilizing a dedicated training center associated with a world class university, and a pipe-line of well trained and educated faculty and students with hands-on experience. The collaboration also allows Mitsubishi to leverage the university research and development capability.

2. LABORATORY DEVELOPMENT

Several laboratory experiments have been developed for teaching PLC structure, operation software, programming language, process components, servo motors, variable frequency drive (VFD), Human Machine Interface (HMI) and networking. A brief description of these laboratory experiments are given below.

PLC Structure: In this lab the student are introduced to the basic hardware selection in the use of series programmable logic controller(s) (PLC). Specifics for this lab are the familiarity with different families of PLCs. Familiarization with hardware that make programming solutions possible. Each component has its own function to perform but as demonstrated in the procedures ahead all components interconnect to perform the operations desired.

Basic Understanding of Programmable Logic Control (PLC): This experiment demonstrates the procedure for maneuvering around in the specific Mitsubishi software for the hardware configured. In this lab the students utilize the hardware configuration compiled and saved before, and program basic ladder logic tailored to the hardware configured.

Mitsubishi's iQ software offers programming for their wide range of PLC hardware. This lab concentrates on the Q-Series PLC hardware and software.

Interfacing with Operating Software: In this lab the student learn how to connect to PLC through different communication methods

Basic understanding of Human Machine Interface (HMI): In this lab the student will create an interfacing screen on the Human Machine Interface (HMI) through the iQ Development Software provided by Mitsubishi.

Introduction to Motion Control: One of the features of the iQ platform offered by Mitsubishi Electric is its ability to integrate various controls components. One of these components is motion control. In complex systems such as robotics or more industrialized use such as conveyors these systems have motors (servos and pulse) that constitute their basic movements. These motors can be systematically controlled through PLCs. The Q-Series PLCs offer motion modules that can control up to four axes each. These modules, once configured through MELSEC Navigator have the ability to control motors interconnected with them through motor controllers from the MR-J3 family. Standard controls of the motors are communicated through fiber optic SSCNETIII connections. For external controls, such as E-Stop and motion indication, the 40 pin connector on the face of the motion module is used. Special interface terminal blocks (MR-TB50) are used for these controls. The Q-Series PLC has a variety of motion modules. For the purposes of this lab experiment, the QD75MH2 will be used. This is a dual axis motion module for pulse controls of the connected motor(s). Fig. 1 shows a rack, a PLC, I/O, Analog to Digital, and Motion Control cards connection [4].

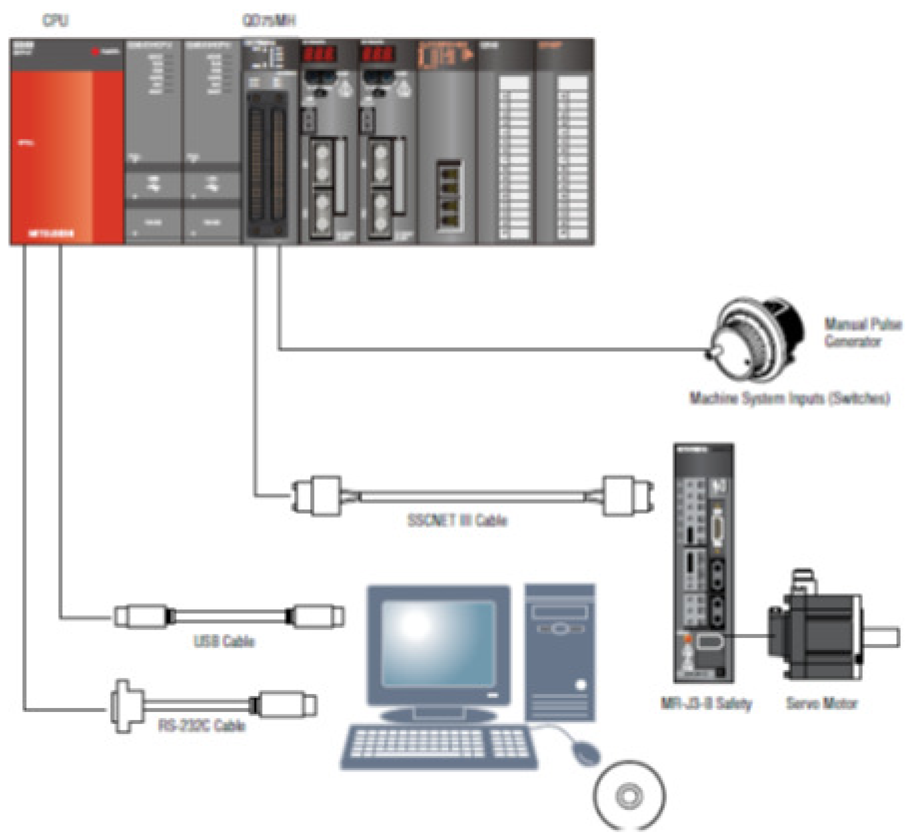

Figure 1 Control of Motors via PLC connection

This motion module will connect to a motion controller with an SSCNET III cable. This cable connects on the bottom of the QD75MH2 module to the CN1A plug in the front of the MR-J3-10B motion controller. Two controllers will be needed for two axis controls. Interconnect Axis 1 motion controller from CN1B on its face to Axis 2 motion controller's CN1A socket with a second SSCNET III fiber optic cable. Once the hardware has been configured as shown modifications to the configuration must be made to accommodate. The PLC logic must be modified as well to include the software configuration and motions controls required for this setup. And finally an HMI screen can be created to interface the motions controls with the user.

Variable Frequency Drive: This expriment explores the speed and torque control of induction motors using VFDs. The students have to describe the relationship between motor speed and applied frequency, show the relationship between applied voltage magnitude and frequency, and to explain how the inverter provides a soft start capability for the motor.

3. ASSESSMENT

In order to assess the student's acquired knowledge, several in class quizzes and small projects are conducted. The student's backgrounds vary from little knowledge to several years of experience in the field. Instructor must walk through the class and help each student individually. The lecture and explanation must be tailor-made to the need of each class. There is no "One Size Fit All". Students with many years of field experience can challenge the instructor. The instructor must be willing to find the answer to student's questions quickly by contacting expert in the field. The first few class instruction could an uphill battle for the instructor. However, by going through two or three sets of teaching sessions, the instructor will gain adequate confidence to successfully teach the classes. There are several national agencies that independently conduct tests for technicians in the area of electrical circuit and control systems. Packaging Machinery Manufacturers Institute (PMMI) conducts tests through a series of assessments that are based on industry-developed competencies [5]. The available PMMI tests are:

- Fluid Power 1
- Industrial Electricity 1
- Industrial Electricity 2
- Mechanical Components 1
- Programmable Logic Controllers (PLCs) 1

These tests allow both entry-level and skilled technicians to assess their skills needed for technology intensive manufacturing jobs.

The International Society of Arboriculture (ISA) is another independent agency conducting tests for technicians in the area of process control [6]. These tests are as follows:

- Certified Automation Professional (CAP) Program
- ISA Certified Control Systems Technician (CCST) Programs
- Certified Industrial Maintenance Mechanics (CIMM) Program

The above tests are performed by independent agencies and students may register through their websites [5, 6] and schedule their test location and time.

4. SUMMARY

A training center with industry collaboration is established. With donated equipment from industry several relevant laboratory experiments were developed. These experiments can be used for both engineering technology students as well as industry technician. Assessment is performed through quizzes and short projects. Students can take nationally accepted test to receive certification.

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