NEW INDUSTRIAL AUTOMATION LABORATORY & COURSES ECET TECHONOLOGY PROGRAM ADVANCEMENT

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1. INTRODUCTION

A combination of special Minnesota state funding, industry contributions, and curriculum planning efforts resulted in a significant addition to ECET's technology programs at Minnesota State University, Mankato in the College of Science, Engineering and Technology. A new industrial automation laboratory was recently assembled and seven stations of automation and electronics equipment provide the basis for new courses in technology and engineering. The first use involves applying technology in two 4-credit courses for roughly 15 senior year Electronics Engineering Technology (EET) and Computer Engineering Technology (CET) students. Then, laboratory experiments and lecture material can be adapted to train electrical and computer engineering students.

The addition was made possible through a combination of funding from the Minnesota Center for Excellence in Manufacturing & Engineering, a Minnesota State Colleges and Universities program, and a very significant contribution through Rockwell Automation's education discount program. Established in 2005, Minnesota's Center for Excellence in Engineering & Manufacturing is made up of seven institutions: Alexandria, Anoka, and Hennepin Technical colleges, Normandale Community College, Northeast Higher Education District, South Central College, and Minnesota State University, Mankato which serves as lead university and headquarters for the Center. All are acknowledged educational leaders in either engineering or manufacturing and members of the Minnesota State Colleges and Universities System. Automation programs in the partner institutions will share strengths and capabilities.

The funding opportunity coincided with faculty desires to improve technology programs through increased hands-on training and increased differentiation from engineering programs. Fluke and National Instruments electronics equipments obtained through education discounts are part of the seven stations. Over two hundred high school students toured the lab recently as part of a state-wide initiative to promote STEM education. This paper describes use of PLC control, motors, and sensors in laboratory experiments, lectures, and capstone student projects.

COURSE DESCRIPTION

A two-semester sequence of four-credit courses was started in Fall 2006 for senior-year technology students that had completed electronics and microprocessor courses. The brief course description was as follows: Automation components and subsystems involving sensors, transistors, logic, amplifiers, software, microprocessors, PLCs, actuators, encoders, stages, motors, controllers and drives. Students design, simulate, build, test and document automation systems for Capstone projects.

Course material was drawn from Rockwell Automation training material[1-5], websites, other publications, Jon Stenerson's Fundamentals of Programmable Logic Controllers, Sensors, and Communications), and Irving Gottlieb's Electric Motors and Control Techniques.

Twelve students were in the first class (Figure 1a&b).

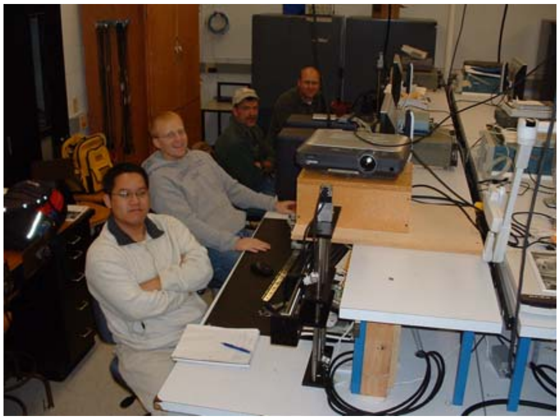

Fig. 1a. Left Side of Lab – 2 stations

Fig. 1b. Middle of Lab – 4 stations

Several outcomes were drafted for the course and are summarized below,

1. Use PLC's, servo drives, controllers, motors, actuators, encoders, sensors, and PID loops in automation systems.
2. Characterize performance of automation equipment.
3. Measure vibration and power-line harmonic distortion.
4. Effectively identify, formulate and implement a control system.
5. Participate in a group atmosphere for the defining, planning, and execution of an open-ended automation problem.
6. Develop an understanding of ethical and professional responsibilities in industrial automation.
7. Communicate effectively both verbally and in written form through the preparation of project report and a class presentation.
8. Study and implement appropriate project documentation standards.
9. Develop an understanding of economic issues related to industrial automation systems.

Weekly lectures and labs consisted of three one-hour and one two-hour sessions. Most classes were held in the laboratory which was equipped with a white board and a computer projector. In the Spring term the class will meet twice each week in three-hour sessions.

During the 1st semester course students were introduced to basic control tools, sensors, I/O devices and ControlLogix hardware[1-5]. A first pass was through selected topics so that students could tackle a project based of use X-Y stages driven by servo motors. Topics covered in the first term included,

ControlLogix PLC, digital I/O modules and analog I/O modules
Logix5000 and Linx software tools
RS-232 and Ethernet connection between computer and PLC
Photoelectric sensors, LEDs and switches
Ladder logic instructions - switches, counters, timers, math, motion, subroutines
Servo motors

LABORATORY HARDWARE

Seven sets automation equipment were set up on lab benches,

Rockwell Automation ControlLogix PLC 17-slot chassis
1756-L60M03SE 3-axes ControlLogix controller with SERCOS
Kinetix 6000 Servo Drive, 2094-AC05-MP5
X-Y stage and 2 servo motors, TL-A120P-BJ32-AA
Digital and Analog Input & Output DC & AC modules & connector cables
EtherNet/IP network, ControlNet network & DeviceNet network
PanelVIEW touch panel, Switch input and LED display panel
Photoelectric sensor
Fluke portable oscilloscope & multi-meter

The Rockwell Automation ControlLogix Programmable Logic Controller (PLC) and I/O modules where configured in a 17-slot chassis (Figure 2).

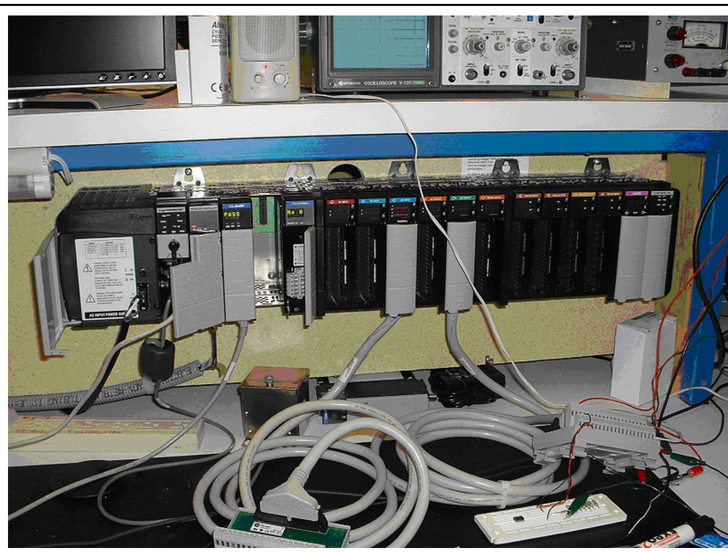

Figure 2. ControlLogix PLC & I/O Modules

The X-Y stage (Figure 4) had two servo motors with incremental position feedback, one for each axis. This enabled control of the vertical and horizontal motion of the stage. The X-Y stages were designed and built by a senior student, Matt Mueller. Kinetics 6000 servo drive (right-hand side of Hoffman cabinet (Figure 5) controlled the servo motors.

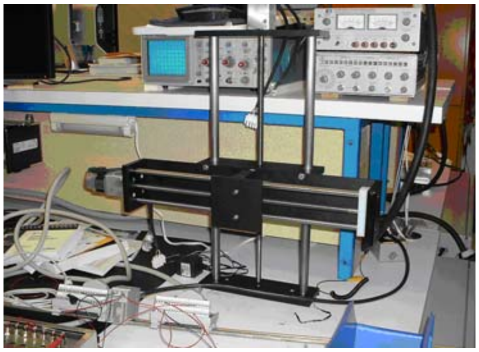
Figure 4. X-Y Stage


Figure 5. Servo Drives & Power Supply

Input/output devices included switches and LEDs (Figure 6), photoelectric sensor (Figure 7), and limit switch (Figure 8).


Figure 6. I/O Panel


Figure 7.
Photoelectric Sensor


Figure 8.
Limit Switch

Other lab equipment which was installed in the lab included Rockwell Automation AC & DC motors (Figure 9), National Instruments LabVIEW data acquisition and instrument control equipment, accelerometers, proximity sensors, temperature sensors, and pressure sensors.

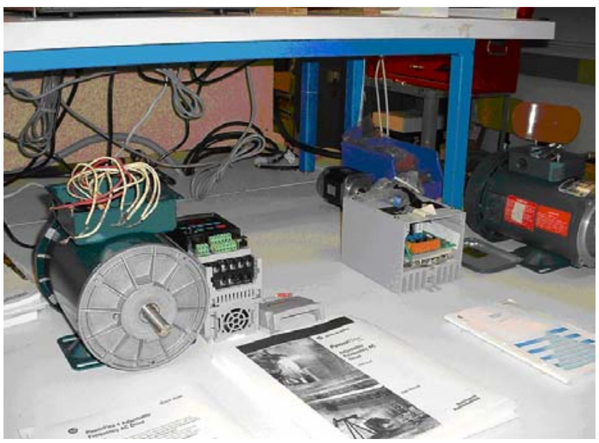
Figure 9. AC & DC Motors

The PLC was programmed using ladder logic (Figure 10).

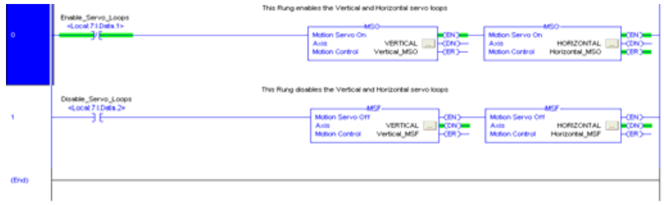

Figure 10. Ladder Logic Subroutine

STUDENT PROJECTS

Three teams of four students each completed capstone projects during the second of the half of the Fall semester. These were a car wash, an elevator and an escalator. The carwash simulator shown in Figure 11 had the following features;

Selectable wash cycles
Rotating sprayer assembly
Spraying wands and tire scrubbers
Moveable carriage & a rotating wash arm
Dryer fan
LED status indicators for start position, wet, soap, rinse, exit

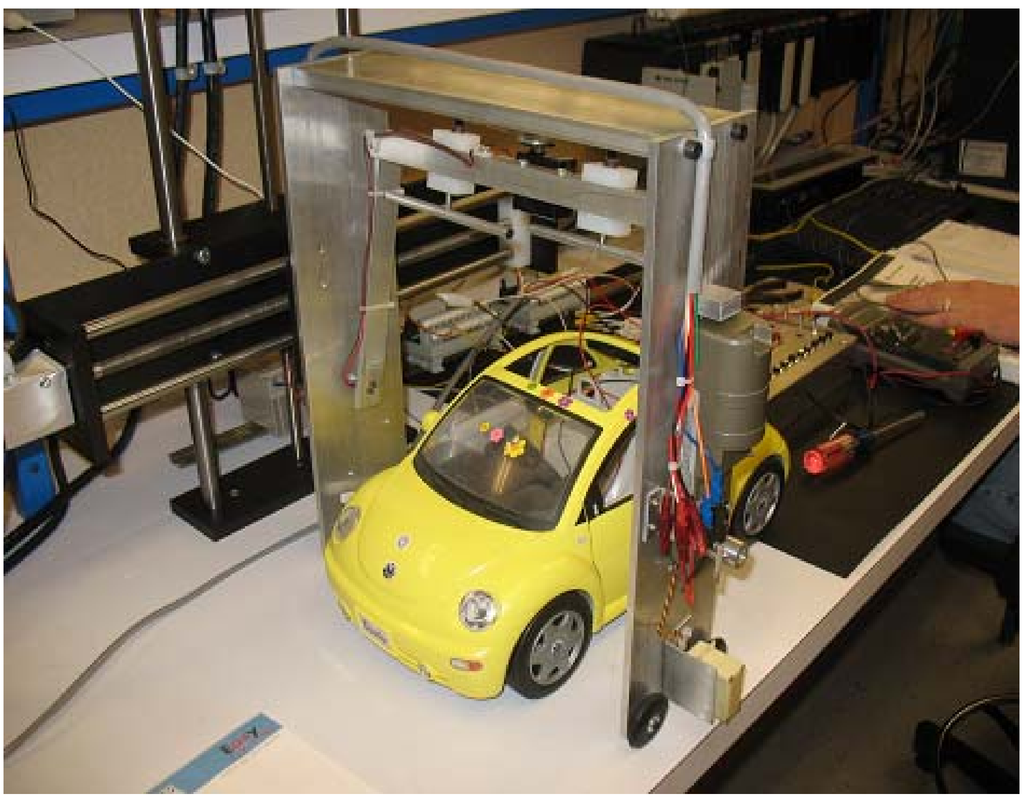
Figure 11. Car Wash Project

The elevator simulator (Figure 12) had the following features,

Elevator car vertical movement with limit switches.
Elevator car door open-and-close horizontal movement.
Elecvator car door interference detector (photoelectric sensor).
Call buttons and LED indicators.

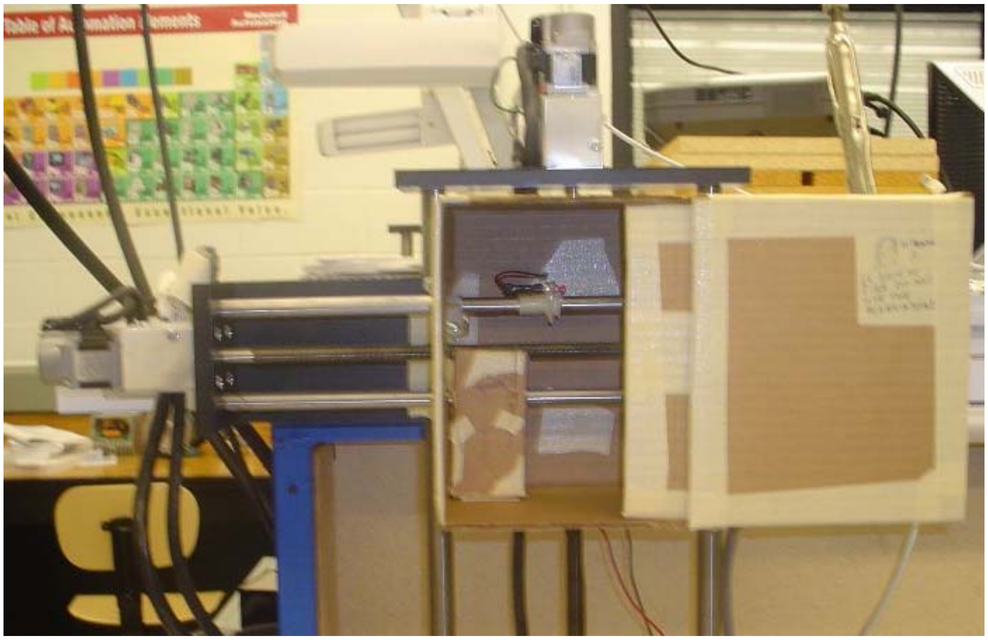

Figure 12. Elevator Project

The escalator simulator (Figures 13 &14) had control buttons, LED indicators and a display of UP and DN.

Figure 13. Escalator Project

Figure 14. Escalator Direction Indicator

The automation equipment was used by a graduate student, Anand Devatha, in his Master's project. Highlights of this work, Automation & Control of PLC Using LabVIEW, and other work with the laboratory equipment will be reported in 2007.

RESULTS & PLANS

The students said that in working towards a major goal in team project they gained a much better understanding of concepts covered earlier in the course. Many unexpected issues surfaced and many early ideas had to be discarded or revised. Time constraints and funding limitations were encountered. Troubleshooting problems in the design and implementation stages proved to be much more difficult and time consuming than expected. As a result they learned the value of breaking the project down into smaller tasks.

In the second course the class will dig deeper into topics introduced earlier and explore new areas. For example, they will work with other types of sensors and motors and they will use LabVIEW to control the automation system and acquire data from sensors. Use of the laboratory for training graduate students and students from other programs will be continued.

REFERENCES

1. Rockwell Automation, ControlLogix Controllers, Publication 1756-UM001F-EN-P - May 2005.

2. Rockwell Automation, ControlLogix Digital I/O Modules, Publication 1756-UM058C-EN-P - March 2001.

3. Rockwell Automation, ControlLogix Analog I/O Modules, Publication 1756-UM009B-EN-P - June 2003.

4. Rockwell Automation, Logix5000™ Controllers General Instructions, Publication 1756-RM003H-EN-P - May 2005.

5. Rockwell Automation, Logix5000™ Controllers Motion Instructions, Publication 1756-RM007G-EN-P - May 2005.

