TAFTCOLLEGE

Prepared by: K. Olson
Revised by: J. Carrithers
Reviewed by: K. Bandy
Reviewed by: D. Layne
Date prepared: Fall 2016
C&GE approved: May 8, 2017
Board approved: June 14, 2017
Semester effective: Spring 2018

Energy (ENER) 1540 Fundamentals of Programmable Logic Controllers (3 Units) CSU

Prerequisite: Successful completion of ENER 1530 with a grade "C" or better

Prerequisite knowledge/skills: Before entering the course the student should be able to:

1. Demonstrate knowledge of the three things required any completed circuit,
2. Demonstrate understanding what is meant by open and closed circuits and short (including "short" and "ground"),
3. Demonstrate understanding of the direction and speed of electron flow in a completed circuit,
4. Demonstrate understanding in how electricity is produced,
5. Demonstrate understanding of how wire size is measured, the different gauges of wire, and their practical applications),
6. Demonstrate understanding why fuses are used to protect circuits, the different types of fuses (homes, industrial machinery, lab devices),
7. Demonstrate understanding of the process of soldering wire and the use of a heat sink,
8. Demonstrate understanding of how a resistor works and what it does,
9. Demonstrate understanding of how a capacitor works and what it does,
10. Demonstrate understanding of the two basic principles of magnetism,
11. Demonstrate understanding of the concept of a P-N junction,
12. Demonstrate the understanding of how a multimeter is used to measure current, voltage and resistance in circuits,
13. Apply circuit and analysis methods for DC and AC circuits with various components using Ohm's Law, Watt's Law, and Kirchoff's Laws, and
14. Demonstrate proper safety principles

Advisory**:** Eligibility for Math 1060 and English 1500 strongly recommended

Total Hours: 40 hours lecture; 32 hours lab (72 hours total)

Catalog Description: This course is a comprehensive introduction to the Programmable Logic Controller (PLC), the basic parts of a PLC, how a PLC is used to control a process, the different kinds of PLCs their applications, and troubleshooting. The course covers bit-level input and output instructions, timers, counters, latches, and introduces the ladder logic language developed to simplify the task of programming PLCs. Fieldtrips may be required.

Type of Class/Course: Degree Credit

Text: Petruzella, Frank D. *Programmable Logic Controllers.* 5th ed. New York: McGraw-Hill, 2017.

209:AC Control Equipment: TPC Training Systems, Buffalo Grove, Illinois, 2013.

TAFTCOLLEGE

Course Objectives:

By the end of the course a successful student will be able to:

1. Demonstrate understanding of the Allen Bradley PLC programming
2. Explain history and development of the programmable logic controller (PLC)
3. List advantages of the PLC over relay systems
4. Explain the basic sequence of operations of a PLC
5. Explain the components of a PLC and their functions
6. Create basic circuitry and applications for discrete and analog I/O modules
7. Demonstrate understanding of the different types of PLC peripheral support devices available
8. Use decimal, binary, octal, and hexadecimal systems in PLC
9. Explore timer and counter registers and functions
10. Convert relay ladder schematics to ladder logic programs
11. Write program instructions that perform logical operations
12. Demonstrate understanding how to read the input and output image table files and types of data files
13. Identify the function of internal relay instructions
14. Write and enter ladder logic programs
15. Debug, test and verify proper functions of programs

Course Scope and Content (Lecture):

Unit I Motor Starters
- A. Manual and Magnetic Starters
- B. Effects of Low Voltage on a Starter
- C. Reverse the Shaft Rotation of a 3-Phase Motor

Unit II Switches and Controls
- A. Industrial Switches and Controls
- B. Commonly used NEMA Pushbutton Stations
- C. Standard and Press-To-Test Indicating Lights
- D. Three-Wire Motor Control Circuits

Unit III Limit Switches
- A. Parts of a Snap-Action Limit Switch
- B. Actuators Used in Limit Switches
- C. Proper Design and Applications of Limit Switch Cams
- D. Mercury Switch Operations

Unit IV Timers and Counters
- A. Reset Timers

B. Types and Applications of Timers
C. Control Device for Non-Time Controlled Machine
D. Registers and Functions of Counters and Timers

Unit V Control Relays
A. Definition of a Relay
B. Advantages of a Reed Relay
C. Double-Break Contacts

Unit VI Motor Control Centers
A. Define Motor Control Center
B. Advantages of Back-To-Back MCC Construction
C. How to Install an MCC

Unit VII Control Panel Wiring
A. Function of Terminal Blocks
B. Make a Terminal Connection
C. Use of Connectors
D. Use of a Wiring Duct

Unit VIII Programmable Logic Controllers (PLCs), an Overview
A. Introduction to Programmable Logic Controllers
B. Parts of the PLC
C. Principles of Operation
D. Modifying the Operation
E. PLCs versus Computers
F. PLC Size and Application

Unit IX PLC Hardware Components
A. The I/O Section
B. Discrete I/O Modules
C. Analog I/O Modules
D. Special I/O Modules
E. I/O Specifications
F. The Central Processing Unit (CPU)
G. Memory Design
H. Memory Types
I. Programming Terminal Devices
J. Recording and Retrieving Data
K. Human Machine Interfaces (HMIs)

Unit X Number Systems and Codes
A. Decimal System
B. Binary System
C. Negative Numbers
D. Octal System
E. Hexadecimal System
F. Binary Coded Decimal (BCD) System
G. Gray Code
H. ASCII Code

I. Parity Bit
J. Binary Arithmetic

Unit XI Fundamentals of Logic
A. The Binary Concept
B. AND, OR, and NOT Functions
C. Boolean Algebra
D. Developing Logic Gate Circuits from Boolean Expressions
E. Producing the Boolean Equation for a Given Logic Gate Circuit
F. Hardwired Logic versus Programmed Logic
G. Programming Word Level Logic Instructions

Unit XII Basics of PLC Programming
A. Processor Memory Organization
B. Program Scan
C. PLC Programming Languages
D. Relay-Type Instructions
E. Instruction Addressing
F. Branch Instructions
G. Internal Relay Instructions
H. Programming Examine If Closed and Examine If Open Instructions
I. Entering the Ladder Diagram
J. Modes of Operation

Unit XIII Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs
A. Electromagnetic Control Relays
B. Contactors
C. Motor Starters
D. Manually Operated Switches
E. Mechanically Operated Switches
F. Sensors
G. Output Control Devices
H. Seal-In Circuits
I. Latching Relays
J. Converting Relay Schematics into PLC Ladder Programs
K. Writing a Ladder Logic Program Directly from a Narrative Description

Unit XIV Programming Timers
A. Mechanical Timing Relays
B. Timer Instructions
C. On-Delay Timer Instruction
D. Off-Delay Timer Instruction
E. Retentive Timer
F. Cascading Timers

Unit XV Programming Counters
A. Counter Instructions
B. Up-Counter
C. Down-Counter
D. Cascading Counters
E. Incremental Encoder-Counter Applications

F. Combining Counter and Timer Functions

Unit XVI Program Control Instructions
- A. Master Control Reset Instruction
- B. Jump Instruction
- C. Subroutine Functions
- D. Immediate Input and Immediate Output Instructions
- E. Forcing External I/O Addresses
- F. Safety Circuitry
- G. Selectable Timed Interrupt
- H. Fault Routine
- I. Temporary End Instruction
- J. Suspend Instruction

Unit XVII Data Manipulation Instructions
- A. Data Manipulation
- B. Data Transfer Operations
- C. Data Compare Instructions
- D. Data Manipulation Programs
- E. Numerical Data I/O Interfaces
- F. Closed-Loop Control

Unit XVIII Math Instructions
- A. Math Instructions
- B. Addition Instruction
- C. Subtraction Instruction
- D. Multiplication Instruction
- E. Division Instruction
- F. Other Word-Level Math Instructions
- G. File Arithmetic Operations

Unit XIX Sequencer and Shift Register Instructions
- A. Mechanical Sequencers
- B. Sequencer Instructions
- C. Sequencer Programs
- D. Bit Shift Registers
- E. Word Shift Operations

Unit XX PLC Installation Practices, Editing, and Troubleshooting
- A. PLC Enclosures
- B. Electrical Noise
- C. Leaky Inputs and Outputs
- D. Grounding
- E. Voltage Variations and Surges
- F. Program Editing and Commissioning
- G. Programming and Monitoring
- H. Preventive Maintenance
- I. Troubleshooting
- J. PLC Programming Software

Unit XXI Process Control, Network Systems, and SCADA

A. Types of Processes
B. Structure of Control Systems
C. On/Off Control
D. PID Control
E. Motion Control
F. Data Communications
G. Supervisory Control and Data Acquisition (SCADA)

Course Scope and Content (Laboratory):

Unit I Design, write, operate three PLC ladder logic programs
A. One input to control one output
B. Two inputs in series to control one output
C. Two inputs in parallel to control one output
D. Download the programs one at a time to the PLC and operate

Unit II Design, write, and operate a motor control PLC ladder logic program
A. 3-wire motor control to include an E-stop, stop, and start with latching control
B. 3-wire motor control with the addition of a jog control

Unit III Design, write, operate a PLC ladder logic program – Two Motors
A. 3-wire motor control with E-stop, start, stop, and jog controls to start motor #1 and then Motor #2 five seconds later (TON delay)
B. 3-wire motor control with E-stop, start, stop, and jog controls to start a pump motor with a ten second delay before a re-start can happen

Unit IV Design, write, and operate a PLC Ladder Logic Program
A. Control- Projector lamp to include a ten second off delay for the cooling fan
B. Control- Traffic intersection, two directions including red, yellow, and green lights
C. Control- Automobile Parking lot, 4 car limit, with vacancy and full lights
D. Control- Production conveyor with box counter and a limit of six boxes per case
E. Control- Fluid, temperature, or pressure control

Unit V Troubleshooting PLC Controls in industrial settings and safety standards
A. Industrial safety practices
B Troubleshooting in in industrial settings (e.g. oil & gas, manufacturing)

Learning Activities Required Outside of Class:

The students in this class will spend a minimum of 6 hours per week outside of the regular class time doing the following:

1. Studying assigned text, handout materials and class notes
2. Reviewing and preparing for quizzes, midterm and final exams
3. Completing group projects

Methods of Instruction:

1. Lecture and discussions
2. Group activities/projects
3. Field trips (industrial sites using PLCs)

4. Lab

Methods of Evaluation:

1. Quizzes
2. Exams
3. Class Participation
4. Individual and group exercises & projects
5. Practical Observation
6. Written reports based on field applications

Laboratory Category: Extensive Laboratory

Pre delivery criteria: All of the following criteria are met by this lab.
1. Curriculum development for each lab.
2. Published schedule of individual laboratory activities.
3. Published laboratory activity objectives.
4. Published methods of evaluation.
5. Supervision of equipment maintenance, laboratory setup, and acquisition of lab materials and supplies.

During laboratory activity of the laboratory: All of the following criteria are met by this lab.

1. Instructor is physically present in lab when students are performing lab activities.
2. Instructor is responsible for active facilitation of laboratory learning.
3. Instructor is responsible for active delivery of curriculum.
4. Instructor is required for safety and mentoring of lab activities.
5. Instructor is responsible for presentation of significant evaluation.

Post laboratory activity of the laboratory: All of the following criteria are met by this lab.

1. Instructor is responsible for personal evaluation of significant student outcomes (lab exercises, exams, practicals, notebooks, portfolios, etc.) that become a component of the student grade that cover the majority of lab exercises performed during the course.
2. Instructor is responsible for supervision of laboratory clean-up of equipment and materials.

Supplemental Data:

TOP Code:	093400: Electronics and Electric Techn
SAM Priority Code:	C: Clearly Occupational
Distance Education:	Not Applicable
Funding Agency:	Y: Not Applicable(funds not used)

Program Status:	1: Program Applicable
Noncredit Category:	Y: Not Applicable, Credit Course
Special Class Status:	N: Course is not a special class
Basic Skills Status:	N: Course is not a basic skills course
Prior to College Level:	Y: Not applicable
Cooperative Work Experience:	N: Is not part of a cooperative work experience education program
Eligible for Credit by Exam:	E: Credit By Exam
Eligible for Pass/No Pass:	NO
Taft College General Education:	NONE