Programmable Logic Controller II

PEIMS Code: N1303690
Abbreviation: PROLGCNT2
Grade Level(s): 11–12
Award of Credit: 1.0

Approved Innovative Course

- Districts must have local board approval to implement innovative courses.
- In accordance with Texas Administrative Code (TAC) §74.27, school districts must provide instruction in all essential knowledge and skills identified in this innovative course.
- Innovative courses may only satisfy elective credit toward graduation requirements.
- Please refer to TAC §74.13 for guidance on endorsements.

Course Description:

The purpose of the Programmable Logic Controllers (PLC) II course is to demonstrate advanced knowledge of programming of programmable logic controllers (PLC) by incorporating the use of timers, counters, and other advanced functions. The students that complete the PLC II course will gain hands-on experience in the use of PLCs in industry and be able to troubleshoot the PLCs in common industrial applications. Additionally, the course includes an introduction to human machine interfaces (HMI) and networking. The PLC II course aligns to industry standards for various brand PLCs, and the outcomes from this course will prepare the students for postsecondary education and career readiness in the industrial maintenance/manufacturing industry.

Essential Knowledge and Skills:

(a) General Requirements. This course is recommended for students in grades 11th & 12th. Recommended prerequisites: Principles of Applied Engineering or Principles of Manufacturing and Programmable Logic Controllers (PLC) I. Students shall be awarded once credit for successful completion of this course.

(b) Introduction.

(1) Career and technical education instruction provides content aligned with challenging academic standards and relevant technical knowledge and skills for students to further their education and succeed in current or emerging professions.

(2) The Manufacturing Career Cluster focuses on planning, managing, and performing the processing of materials into intermediate or final products and related professional and technical support activities such as production planning and control, maintenance, and manufacturing/process engineering.

(3) The Programmable Logic Controllers (PLC) II course is designed to demonstrate advanced knowledge of programming of programmable logic controllers (PLC) by

incorporating the use of timers, counters, and other advanced functions. The students that complete the PLC II course will gain hands-on experience in the use of PLCs in industry and be able to troubleshoot the PLCs in common industrial applications. Additionally, the course includes an introduction to human machine interfaces (HMI) and networking. The PLC II course aligns to industry standards for various brand PLCs, and the outcomes from this course will prepare the students for postsecondary education and career readiness in the industrial maintenance/manufacturing industry.

(4) Students are encouraged to participate in extended learning experiences such as career and technical student organizations and other leadership or extracurricular organizations.

(5) Statements that contain the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and Skills.

(1) The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:

(A) research career development and entrepreneurship opportunities by understanding of the use of programmable logic controllers (PLC)s;

(B) identify and research careers in industries which use PLCs;

(C) apply competencies related to resources, information, interpersonal skills, problem solving, critical thinking, and systems of operation in PLC systems;

(D) research and present on available industry certifications and internship/employment opportunities;

(E) identify and exhibit employers' expectations, appropriate work habits, ethical conduct, legal responsibilities, and good citizenship skills; and

(F) establish career goals, objectives, and strategies as part of a plan for future career opportunities.

(2) The student understands timer and counter instructions and can apply them within PLC applications. The student is expected to:

(A) differentiate between on-delay timers and off-delay timers;

(B) apply the use of a timer to cause a delay in the action of an output;

(C) apply the use of a counter to determine the number of input occurrences; and

(D) integrate timers and counters within event sequencing applications.

(3) The student explains, and demonstrates, and evaluates advanced program control instructions. The student is expected to:

(A) analyze and perform the operation of a master control reset instruction;

(B) evaluate the purpose of master control reset (MCR) zones in PLC applications;

(C) implement subroutines such as jump to subroutine (JSR), subroutine (SBR), return (RET) within a main program;

(D) analyze the functionality of immediate input and output instructions in time-critical applications; and

(E) demonstrate performance of nested subroutine functions.

(4) The student evaluates the function of data manipulation within PLC applications. The student is expected to:

(A) evaluate the function of controller mathematical instructions such as add, subtract, divide, multiply (ADD, SUB, DIV, MUL) and referenced memory stored in each instruction;

(B) apply mathematical operations such as: square root, negate, clear, structured control language (SQR, NEG, CLR, SCL) to transform data in PLC programs;

(C) analyze how word data and file data are implemented into PLC programs;

(D) analyze and differentiate between data-transfer instructions such as move (MOV), masked moved instructions (MVM) and data-comparison instructions such as equal (EQU), less than (LES), and greater than (GRT);

(E) evaluate data-transfer instructions and mathematical instructions to achieve a desired outcome;

(F) evaluate open-loop and closed-loop systems in PLC applications; and

(G) evaluate the different point control schemes such as proportional control (P), proportional integral control (PI), or proportional integral derivative Control (PID) used to optimize performance of closed-loop systems.

(5) The student explains the function of sequencers and shift registers to control PLC applications. The student is expected to:

(A) differentiate and evaluate between mechanical sequencers and PLC sequencer instructions;

(B) evaluate and apply event-driven and time-driven operations;

(C) analyze and perform the combination of sequencer input (SQI) and sequencer output (SQO) instructions;

(D) analyze and perform bit-shift registers to track the flow of information within a PLC application;

(E) differentiate and evaluate between bit-shift registers and word-shift operations; and

(F) analyze the combination of first-in-first-out (FIFO) and last-in-first-out (LIFO) instructions in PLC applications.

(6) The student analyzes the implementation of non-PLC hardware and the communication required for their integration. The student is expected to:

(A) evaluate the functionality and integration of various Human Machine Interfaces (HMI);

(B) analyze and perform basic PLC networking fundamentals and the associated communication protocols;

(C) describe and perform the communication process between the PLC and field devices such as Motion Control System (servo drive, motion module), sensors, and other hardware applications; and

(D) explain the integration of supervisory control and data acquisition (SCADA) systems within PLC applications.

(7) The student understands the installation and connections of PLC-controlled systems. The student is expected to:

(A) analyze the wiring configuration used for input and output devices; and

(B) explain how power is delivered to the PLC module and its exits points.

(8) The student executes proper safety protocols and techniques when operating equipment. The student is expected to:

(A) evaluate and perform grounding methods, color coding systems, and conductor types adopted by industrial safety standards;

(B) employ appropriate wiring techniques described by the PLC manufacturer;

(C) demonstrate and evaluate proper techniques used to reduce or eliminate electrical noise and leaky inputs and outputs; and

(D) evaluate and perform essential emergency circuit shutdown implementations required in PLC installations, including emergency stop button and switches.

Recommended Resources and Materials:

Rabiee, M. *Programmable Logic Controllers.* 4th ed. Tinley Park, IL: Goodheart Wilcox, 2017.

Borden, Terry and Richard A. Cox *Technicians Guide to Programmable Controllers.* 6th ed. Clifton Park, NY; Delmar Cengage Learning, 2013.

- PLC module and software
- Inputs such as sensors or switches
- Outputs such as lights or fans

Recommended Course Activities:

- Write a ladder logic program that uses an AND, OR, Buffer, XOR (gate logic when either input is 1 but not both), NAND (AND Gate with a NOT gate), NOR (OR Gate by a NOT Gate), NOT/Inverter, and (Exclusive NOR) XNOR logic gates.
- Write a ladder combinational logic program that uses an AND, OR, Buffer, XOR, NAND, NOR, NOT/Inverter, and XNOR logic gates.
- Write a ladder logic program that uses momentary start, latching start, and latching start with interrupts.
- Write a ladder logic program that uses TON (timer on), TOF (timer off), and TP (pulse timer) timers with comparators.
- Write a ladder logic program that uses CTU (up counter), CTD (down counter), and CTUD (up down counter) counters and comparators.
- Write a ladder logic program that combines timers and counters.
- Write a ladder logic program that creates a flasher circuit using two timers.

- Write a ladder logic program to create a conveyor system that uses sensors.
- Use a multimeter to troubleshoot input/output malfunctions.
- Visit a site to view how PLCs are used in local industries

Suggested methods for evaluating student outcomes:

- Written exams
- Projects, presentations, and group participation
- Evaluation of oral and written communication skills
- Completion of class assignments
- Portfolio of all class assignments
- Participation in a work-based learning program

Teacher qualifications:

An assignment for Programmable Logic Controller II is allowed with one of the following certificates.

- Secondary Industrial Arts: Grades 6-12
- Secondary Industrial Technology: Grades 6-12
- Technology Education: Grades 6-12
- Trade and Industrial Education: Grades 6-12 with appropriate work approval as identified on the certificate
- Trade and Industrial Education: Grades 8-12 with appropriate work approval as identified on the certificate
- Vocational Trades and Industry. This assignment requires appropriate work approval.

Additional information: