Western Technical College

10605200 Industrial Control Systems

Course Outcome Summary

Course Information

Description	This course covers fundamental wiring concepts, relay ladder logic, sensors, timers, motor fundamentals, motor starters and Variable Frequency Drives. It also includes an introduction to PLC hardware/programming along with Touch Screen/HMI applications.
Career Cluster	Science, Technology, Engineering and Mathematics
Instructional Level	Associate Degree Courses
Total Credits	4
Total Hours	108

Pre/Corequisites

Prerequisite	10660125 Electronic Devices
Prerequisite	10662137 Digital Electronic Concepts

Textbooks

Electric Motors and Control Systems. 3rd Edition. Copyright 2020. Petruzella, Frank D. Publisher: McGraw-Hill Publishing Company. **ISBN-13:** 978-1-260-43939-7. Required.

Programmable Logic Controllers. 6th Edition. Copyright 2023. Petruzella, Frank D. Publisher: McGraw-Hill. **ISBN-13:** 978-1-264-16334-2. Required.

Logixpro PLC Simulator 500 CD-ROM. Publisher: The Learning Pit. Required.

Success Abilities

1. Cultivate Passion: Expand a Growth-Mindset
2. Live Responsibly: Embrace Sustainability
3. Refine Professionalism: Improve Critical Thinking
4. Refine Professionalism: Participate Collaboratively

High Impact Practices

1. Community Engagement - in this course, you will explore and reflect on opportunities presented by the college and the program to become more involved in the community (ex: Employer Spotlights, Volunteerism, Professional Associations, and Community Action Boards)

Course Competencies

1. Compare basic types of circuit protection devices.

Assessment Strategies

1.1. written objective test

Criteria

Your performance will be successful when:

1.1. you explain the various ratings of circuit protection devices.
1.2. you utilize appropriate terminology relative to circuit protection.
1.3. you describe the basic operating characteristics of fuses and circuit breakers.

Learning Objectives

1.a. Utilize appropriate terminology relative to circuit protection.
1.b. Describe the basic operating characteristics of fuses and circuit breakers.
1.c. Examine the various ratings of circuit protection devices.

2. Devise control circuits for various applications using control relays and pilot devices.

Assessment Strategies

2.1. skill demonstration
2.2. written objective test

Criteria

Your performance will be successful when:

2.1. you categorize pilot devices in terms of their function.
2.2. you develop practical control circuits using various pilot devices.
2.3. you classify control relays according to type and function.
2.4. you develop practical control circuits by selecting required control relays.
2.5. you assemble and test control circuits using control relays.
2.6. you build circuits containing photoelectric and proximity switches.
2.7. you develop and verify the operation of non-timed sequence control circuits for motors.
2.8. you develop and verify the operation of jogging and reversing control circuits for motors.

Learning Objectives

2.a. Classify control relays according to type and function.
2.b. Evaluate the electrical properties of control relays.
2.c. Develop practical control circuits by selecting required control relays.
2.d. Assemble and test control circuits using control relays.
2.e. Categorize pilot devices in terms of their function.
2.f. Evaluate the electrical and mechanical properties of pilot devices.
2.g. Develop practical control circuits using various pilot devices.
2.h. Develop and verify the operation of non-timed sequence control circuits for motors.
2.i. Develop and verify the operation of jogging and reversing control circuits for motors.

3. Devise control circuits utilizing time delay relays.

Assessment Strategies

3.1. skill demonstration
3.2. written objective test

Criteria

Your performance will be successful when:

3.1. you classify time delay relays according to type and function.
3.2. you develop practical control circuits by selecting required time delay relays.
3.3. you assemble and test control circuits using time delay relays.

Learning Objectives

3.a. Classify time delay relays according to type and function.
3.b. Evaluate the electrical properties of control time delay relays.
3.c. Develop practical control circuits by selecting required time delay relays.
3.d. Assemble and test control circuits using time delay relays.

4. Analyze Photoelectric and Proximity controls.

Assessment Strategies

4.1. skill demonstration
4.2. written objective test

Criteria

Your performance will be successful when:

4.1. you construct circuits to verify the operation of through-beam photoelectric devices.
4.2. you build circuitry necessary to test the operation of retroreflective photoelectric devices.
4.3. you construct circuits to verify the operation of diffuse scan photoelectric devices.
4.4. you explain the term "modulated light source."
4.5. you compare "2-wire" and "3-wire" control configurations.
4.6. you construct circuits to test the operation of Inductive and Capacitive proximity switches.
4.7. you contrast "Sinking" and "Sourcing" outputs for proximity switches.
4.8. you construct circuits to test the operation of discrete and analog ultrasonic sensors.

Learning Objectives

4.a. Investigate the operation of through-beam photoelectric devices.
4.b. Investigate the operation of retroreflective photoelectric devices.
4.c. Investigate the operation of diffuse scan photoelectric devices.
4.d. Discuss the term "modulated light source."
4.e. Compare "2-wire" and "3-wire" control configurations.
4.f. Examine the operation of Inductive and Capacitive proximity switches.
4.g. Examine "Sinking" and "Sourcing" outputs for proximity switches.
4.h. Examine the operation of discrete and analog ultrasonic sensors.

5. Explain magnetic principles as related to electromechanical equipment

Assessment Strategies

5.1. Written Objective Test

Criteria

Your performance will be successful when:

5.1. you define magnetic characteristics and units
5.2. you describe a simple magnetic circuit in terms of magnetic flux, magnetomotive force, and reluctance.
5.3. you describe magnetic saturation as it relates to the B-H curve.
5.4. you explain Faraday's and Lenz's laws as applied to rotating equipment
5.5. you define Faraday’s and Lenz’s laws as applied to transformers
5.6. you define rotor and stator magnetics

Learning Objectives

5.a. Define magnetic characteristics and units
5.b. Describe a simple magnetic circuit in terms of magnetic flux, magnetomotive force, and reluctance.
5.c. Describe magnetic saturation as it relates to the B-H curve.

5.d. Explain Faraday's and Lenz's laws as applied to rotating equipment
5.e. Define Faraday’s and Lenz’s laws as applied to transformers
5.f. Define rotor and stator magnetics

6. Analyze power transformers

Assessment Strategies

6.1. Skill Demonstration
6.2. Written Objective Test

Criteria

Your performance will be successful when:

6.1. you explain transformer ratings
6.2. you explain the operation of an ideal single phase transformer
6.3. you describe transformer losses both fixed and variable
6.4. you determine transformer losses from models
6.5. you measure transformer parameters (such as short-circuit and open-circuit tests)
6.6. you compare transformer measurements to models
6.7. you calculate primary, secondary and load line and phase voltages, currents and power for a given three phase balanced transformer circuit
6.8. you explain typical three- phase transformer configurations (delta and wye)
6.9. you calculate three phase circuit line and phase parameters (voltage, current and power)
6.10. you measure three phase circuit line and phase parameters (voltage, current and power)
6.11. you describe the effects of an unbalanced three-phase load connected to a balanced three-phase source on the line and phase currents

Learning Objectives

6.a. Explain transformer ratings
6.b. Explain the operation of an ideal single phase transformer
6.c. Describe transformer losses both fixed and variable
6.d. Determine transformer losses from models
6.e. Measure transformer parameters (such as short-circuit and open-circuit tests)
6.f. Compare transformer measurements to models
6.g. Calculate primary, secondary and load line and phase voltages, currents and power for a given three phase balanced transformer circuit
6.h. Explain typical three- phase transformer configurations (delta and wye)
6.i. Calculate three phase circuit line and phase parameters (voltage, current and power)
6.j. Measure three phase circuit line and phase parameters (voltage, current and power)
6.k. Describe the effects of an unbalanced three-phase load connected to a balanced three-phase source on the line and phase currents

7. Examine the operation of DC machines.

Assessment Strategies

7.1. written objective test

Criteria

Your performance will be successful when:

7.1. you describe the construction of a DC motor and generator.
7.2. you distinguish the differences between the field and the armature of a DC machine.
7.3. you compare the operation of a DC Motor and a DC generator.
7.4. you calculate and measure voltage, current, power, torque and efficiency for a DC machine.
7.5. you explain the electrical ratings of a DC machine.
7.6. you wire DC motors and generators to run properly.
7.7. you measure rotational velocity of a shaft with a strob-tac.
7.8. you explain saturation as it relates to a DC machine.

Learning Objectives

7.a. Explain the electrical ratings of a DC machine.
7.b. Discuss magnetic saturation as it relates to a DC machine.
7.c. Distinguish the differences between the field and the armature of a DC machine.
7.d. Contrast the operation of a DC Motor and a DC generator.

7.e. Describe the construction of a DC motor and generator.
7.f. Calculate voltage, current, power, torque and efficiency for a DC machine.
7.g. Connect DC motors and generators to run properly.
7.h. Employ a strob-tac to measure rotational velocity of a motor/generator shaft.
7.i. Measure voltage, current, and power for a DC machine.

8. Analyze the operation of an AC induction motor.

Assessment Strategies

8.1. skill demonstration
8.2. written objective test

Criteria

Your performance will be successful when:

8.1. you identify the significance of nameplate data for a three-phase motor.
8.2. you apply induction motor principles to the operation of three phase motors.
8.3. you describe the construction of a three-phase induction motor.
8.4. you wire a three-phase induction motor for correct operation.
8.5. you measure voltage, current, power consumption and power factor for a three-phase induction motor.
8.6. you explain the need for power factor correction with regard to the operation of three-phase induction motors.
8.7. you describe the construction and operating characteristics of single-phase split-phase and capacitor start induction motors
8.8. you connect various single-phase motors for correct operation.

Learning Objectives

8.a. Discuss the significance of nameplate data for a three-phase motor.
8.b. Apply induction motor principles to three phase induction motors.
8.c. Describe the construction of a three-phase induction motor.
8.d. Wire a three-phase induction motor for correct operation.
8.e. Determine the number of poles for a given motor and relate this to operating speed.
8.f. Employ measuring instruments to determine voltage, current, power consumption and power factor for a three-phase induction motor.
8.g. Evaluate the operating characteristics of induction motors from experimental data.
8.h. Discuss horsepower, torque, speed and efficiency characteristics of three-phase motors.
8.i. Relate the need for power factor correction to the operation of three-phase induction motors.
8.j. Identify the significance of nameplate data for a single-phase motor.
8.k. Describe the construction of single-phase split-phase and capacitor start induction motors.
8.l. Describe the basic operating characteristics of split-phase and capacitor start induction motors.
8.m. Connect a single-phase motors for correct operation.

9. Apply manual and magnetic motor starters to control a three-phase motor.

Assessment Strategies

9.1. skill demonstration
9.2. written objective test

Criteria

Your performance will be successful when:

9.1. you identify the parts and connections of a magnetic motor starter
9.2. you apply a magnetic motor starter to control a three-phase motor.
9.3. you investigate the operation of a multi-station start/stop control.
9.4. you apply a reversing starter to control a three-phase motor in forward and reverse.
9.5. you investigate overload protection of a magnetic motor starter.
9.6. you relate the differences between NEMA and IEC starters.

Learning Objectives

9.a. Identify the parts and connections of a magnetic motor starter.
9.b. Apply a magnetic motor starter to control a three-phase motor.
9.c. Investigate the operation of a multi-station start/stop control.
9.d. Apply a reversing starter to control a three-phase motor in forward and reverse.
9.e. Investigate overload protection of a magnetic motor starter.

9.f. Relate the differences between NEMA and IEC starters.

10. Apply solid state overload protection to an AC motor.

Assessment Strategies

10.1. Skill Demonstration
10.2. Written Objective Test

Criteria

Your performance will be successful when:

10.1. you interpret equipment installation and operation manuals.
10.2. you identify the functional characteristics of a solid state overload relay.
10.3. you connect and test a solid state overload relay to protect a motor.
10.4. you ascertain the range of capabilities of a solid state overload relay.

Learning Objectives

10.a. Interpret equipment installation and operation manuals.
10.b. Identify the functional characteristics of a solid state overload relay.
10.c. Connect and test a solid state overload relay to protect a motor.
10.d. Ascertain the range of capabilities of a solid state overload relay.

11. Utilize a Variable Frequency Drive to control the velocity of an AC induction motor.

Assessment Strategies

11.1. Skill Demonstration
11.2. Written Objective Test

Criteria

Your performance will be successful when:

11.1. you identify the specifications of an Adjustable Frequency Drive (AFD).
11.2. you apply proper operational guidelines from the AFD manufacturer manuals.
11.3. you utilize manufacturer manuals to connect a AFD to operate an AC induction motor.
11.4. you perform the proper AFD start-up procedures utilizing manufacturer manuals.
11.5. you modify AFD operating parameters using the Human Interface Module (HIM).
11.6. you compare the operation of a loaded AC induction motor with and without the AFD connected.

Learning Objectives

11.a. Identify the specifications of an Adjustable Frequency Drive (AFD).
11.b. Apply proper operational guidelines from the AFD manufacturer manuals.
11.c. Utilize manufacturer manuals to connect a AFD to operate an AC induction motor.
11.d. Perform the proper AFD start-up procedures utilizing manufacturer manuals.
11.e. Modify AFD operating parameters using the Human Interface Module (HIM).
11.f. Compare the operation of a loaded AC induction motor with and without the AFD connected.

12. Explain the basic operation of a Programmable Logic Controller (PLC).

Assessment Strategies

12.1. Written Objective Test

Criteria

Your performance will be successful when:

12.1. you identify the basic components of a PLC.
12.2. you describe the function of each of the basic components of a PLC.
12.3. you explain the operation of a PLC in terms of one complete scan cycle.
12.4. you describe Input/Output (I/O) structure for the MicroLogix PLC.
12.5. you describe the Memory System Architecture of a MicroLogix PLC.
12.6. you identify types of PLC Input/Output devices.
12.7. you compare the different types of digital I/O interfaces.
12.8. you describe typical power distribution wiring to a PLC.
12.9. you compare Rack/Slot to Tag-Based addressing in a PLC system.
12.10. you compare standard PLC operation to that of a "Safety" PLC.

Learning Objectives

12.a. Identify the basic components of a PLC.
12.b. Describe the function of each of the basic components of a PLC.
12.c. Explain the operation of a PLC in terms of one complete scan cycle.
12.d. Describe Input/Output (I/O) structure for the MicroLogix PLC.
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12.f. Identify types of PLC Input/Output devices.
12.g. Compare the different types of digital I/O interfaces.
12.h. Describe typical power distribution wiring to a PLC.
12.i. Compare Rack/Slot to Tag-Based addressing in a PLC system.
12.j. Compare standard PLC operation to that of a "Safety" PLC.

13. Perform basic PLC programming activities utilizing Bit, Timing, Counting, and Data Handling instructions of RSLogix Software.

Assessment Strategies

13.1. Skill Demonstration
13.2. Written Objective Test

Criteria

Your performance will be successful when:

13.1. you apply basic relay type instructions such as examine-if-closed, examine-if-open and output in programming a PLC.
13.2. you utilize relay type instructions including latch, unlatch and one shot when programming a PLC.
13.3. you develop application programs using relay type instructions.
13.4. learner develops PLC programs utilizing TON, TOF and RTO timer instructions as directed utilizing LogixPro PLC simulation software.
13.5. learner develops PLC programs utilizing CU, CD and CU/CD instructions as directed utilizing LogixPro PLC simulation software.
13.6. learner lists applications of the Move , Masked Move and Clear PLC data transfer instructions.
13.7. learner properly programs the EQU, NEQ, GRT, GRQ, LES, LEQ and LIM comparison instructions in PLC applications as directed using LogixPro simulation software.

Learning Objectives

13.a. Apply basic relay type instructions such as examine-if-closed, examine-if-open and output in programming a PLC.
13.b. Utilize relay type instructions including latch, unlatch and one shot when programming a PLC.
13.c. Develop application programs using relay type instructions.
13.d. Apply timers in PLC programs using LogixPro PLC simulation software.
13.e. Apply counters in PLC programs using LogixPro PLC simulation software.
13.f. Apply PLC data transfer functions to common industrial control applications.
13.g. Apply PLC comparison functions to common industrial applications.

14. Utilize Bit Shift, Sequencer and Program Control PLC instructions utilizing RSLogix Software.

Assessment Strategies

14.1. Skill Demonstration
14.2. Written Objective Test

Criteria

Your performance will be successful when:

14.1. you explain the operation of a PLC Bit Shift instruction.
14.2. you program Bit Shift instructions using RSLogix 500 software.
14.3. you apply Bit Shifting to a PLC control application.
14.4. you explain the operation of a PLC Sequencer instruction.
14.5. you program Sequencer instructions using RSLogix 500 software.
14.6. you apply a Sequencer instruction to a PLC control application.
14.7. you properly apply Jump/Label and Subroutine instructions for program control functions in a PLC program.

Learning Objectives

14.a. Explain the operation of a PLC Bit Shift instruction.
14.b. Program Bit Shift instructions using RSLogix 500 software.

14.c. Apply Bit Shifting to a PLC control application.
14.d. Explain the operation of a PLC Sequencer instruction.
14.e. Program Sequencer instructions using RSLogix 500 software.
14.f. Apply a Sequencer instruction to a PLC control application.
14.g. Utilize Jump/Label and Subroutine instructions for program control functions in a PLC program.

15. Investigate PLC System Analog I/O applications.

Assessment Strategies

15.1. Skill Demonstration
15.2. Written Objective Test

Criteria

Your performance will be successful when:

15.1. you describe the difference between discrete and analog I/O devices.
15.2. you describe applications of analog input and output PLC control.
15.3. you properly connect discrete and analog ultrasonic sensors to a PLC to utilize sensor input as part of a PLC program.
15.4. you properly wire a VFD to a PLC for discrete operational control.
15.5. you correctly program the VFD and PLC for discrete operational control.
15.6. you properly wire a VFD to a PLC for analog input control and output monitoring.
15.7. you correctly program the VFD and PLC for analog input control and output monitoring.

Learning Objectives

15.a. Compare Digital and Analog PLC input and output devices.
15.b. Discuss PLC analog input/output applicaitons.
15.c. Connect discrete and analog ultrasonic sensors as inputs to a PLC.
15.d. Review installation and operational characteristics of Variable Frequency Drives(VFDs).
15.e. Investigate the discrete and analog I/O features of a VFD.
15.f. Interface a VFD to a PLC to demonstrate discrete and analog I/O control applications.

16. Explore Human Machine Interface (HMI) touch screen PLC applications.

Assessment Strategies

16.1. Skill Demonstration
16.2. Written Objective Test

Criteria

Your performance will be successful when:

16.1. you describe HMI features and applications.
16.2. you properly connect an HMI to a PLC to provide communication capability.
16.3. you perform the required wiring and programming functions to provide HMI input control and output status display of a standard start/stop 3-wire PLC control function.
16.4. you properly utilize the Tag-Based addressing scheme of an HMI/Touch Screen as opposed to the Rack/Slot addressing scheme of a MicroLogix PLC..
16.5. you describe the function of the PLC "Scale with Parameters" instruction for analog HMI/VFD I/O applications.
16.6. you perform the required wiring and programming functions to provide HMI input control and output status display of discrete start, stop and directional PLC control of a VFD.
16.7. you properly wire and program a HMI/PLC/VFD system to provide HMI input control and output status display of analog VFD speed control via the PLC.
16.8. you create a complete wiring diagram for an HMI/PLC/VFD system application including all elements as directed.

Learning Objectives

16.a. Discuss touch screen Human Machine Interface (HMI) features and applications.
16.b. Examine the process of connecting an HMI to a PLC to provide communication capability.
16.c. Compare the Rack/Slot addressing scheme of a MicroLogix PLC to the Tag-Based addressing scheme of an HMI/Touch Screen.
16.d. Explore the HMI/PLC programming elements required to provide HMI discrete and analog input control to a PLC.
16.e. Examine the required HMI/PLC programming to provide HMI display of discrete and analog output

status of a PLC.

16.f. Examine the interaction of a complete PLC system including an HMI, PLC and VFD.

16.g. Investigate the programming required to have a touchscreen provide discrete and analog control of a VFD via a PLC and display the VFD operational status.

16.h. Discuss the requirements of a properly drawn wiring diagram for an HMI/PLC/VFD system application.