Document Intent:

The intent of this document is to provide an example of how a subject matter expert might teach Relay Control Logic. This approach is what Idaho State University College of Technology is using to teach its Energy Systems Instrumentation and Control curriculum for Relay Control Logic. The approach is based on a Systematic Approach to Training where training is developed and delivered in a two step process. This document depicts the two step approach with knowledge objectives being presented first followed by skill objectives. Step one teaches essential knowledge objectives to prepare students for the application of that knowledge. Step two is to let students apply what they have learned with actual hands on experiences in a controlled laboratory setting.

Examples used are equivalent to equipment and resources available to instructional staff members at Idaho State University.

Fundamentals of Relay Control Logic Introduction:

This module covers fundamental aspects of Relay Control Logic as essential knowledge necessary to perform work safely according to national and local standards on or around electrical power sources that are associated with motors and controls. Students will be taught the fundamentals of Relay Control Logic using classroom instruction, demonstration, and laboratory exercises to demonstrate knowledge and skill mastery of Relay Control Logic. Completion of this module will allow students to demonstrate mastery of knowledge and skill objectives by
completing a series of tasks demonstrating safe work practices on or around electrical power sources.

References

This document includes knowledge and skill sections with objectives, information, and examples of how Motors and Control could be taught in a vocational or industry setting. This document has been developed by Idaho State University’s College of Technology. Reference material used includes information from:


STEP ONE

Relay Control Logic Course Knowledge Objectives

Knowledge Terminal Objective (KTO)

KTO 6.1. ANALYZE circuits and devices associated with Relay Logic Control for a variety of electrical control applications.

Knowledge Enabling Objectives (KEO)

Knowledge Enabling Objectives (Chapter 5):

KEO 6.1. DESCRIBE the Basic Rules of Line Diagrams to address: (pgs 91-96)
- One Load Per Line (Figure 5-1 & 5-2 pgs 91 & 92)
- Load Connections (Figure 5-3 & 5-4 pg 92)
- Control Device Connections (Figure 5-5 & 5-6 pg 93)
- Line Number Reference (Figure 5-7 pg 93)
- Numerical Cross-Reference Systems (Figures 5-8 & 5-9 pgs 94-95)
- Wire Reference Numbers (Figure 5-10 pg 95)
- Manufacturer’s Terminal Numbers (Figure 5-11 pg 96)
- Cross-Referencing Mechanically Connected Contacts (Figure 5-12 pgs 96-97)

KEO 6.2. EXPLAIN Line Diagrams to include Signals, Decisions, and Actions (Figure 5-13 pg 97)

KEO 6.3. DESCRIBE Logic Functions to include AND, OR, AND/OR, NOT, NOR, NAND, and Memory (Figures 5-14 through 5-21 pgs 97-100)
KEO 6.4. **EXPLAIN** Common Control Circuits to include: (Figures 5-22 through 5-29 pgs 100-103)
- Start/Stop Stations Controlling Magnetic Starters
- Two Magnetic Starters Operated by Two Start/Stop Stations with Common Emergency stop
- Start/Stop Stations Controlling Two or More Magnetic Starters
- Pressure Switch with Pilot Light Indicating Device Activation
- Start/Stop Station with Pilot Light Indicating NO Device Activation
- Pushbutton Sequence Control
- Jogging with a Selector Switch

KEO 6.5. **ANALYZE** Control Circuit Troubleshooting Techniques to include: (Figures 5-30 through 5-36 pgs 103-107)
- Tie-Down Troubleshooting Method
- Troubleshooting Open Circuits
- Troubleshooting Short Circuits

**Knowledge Enabling Objectives (Chapter 12):**

KEO 6.6. **DESCRIBE** Rectification of Alternating Currents to include: (Figures 12-11 through 12-16 pgs 316-319)
- Single Phase Rectifiers
- Three Phase Rectifiers
- Zener Diodes

KEO 6.7. **EXPLAIN** Amplification to include: (Figures 12-31 through 12-37 pgs 326-330)
- Amplifier Gain
- Transistors as AC Amplifiers
- Transistor Terminal Arrangements
- Biasing Transistor Junctions
- Transistor Current Flow
- Control of Base Current
- Transistors as DC Switches
KEO 6.8. **DESCRIBE** Switching Devices to include: (Figures 12-49 through 12-55 pgs 336-340)
- Silicon Controlled Rectifiers (SCRs)
- SCR Applications
- Triacs
- Uni-Junction Transistors (UJTs)
- Diacs

KEO 6.9. **DESCRIBE** Techniques for Troubleshooting Solid-State Devices to include:
(Figures 12-69 through 12-78 pgs 346-352)
- Testing Diodes
- Testing Zener Diodes
- Testing Thermistors
- Pressure Sensors
- Testing Photocells
- Testing Transistors
- Testing SCRs
- Testing Diacs
- Testing Triacs

**Knowledge Enabling Objective (Chapter 13):**

KEO 6.10. **EXPLAIN** the role Timers and Counters provide to Relay Control Logic to include: (Figures 13-1 through 13-33 pgs 355-372)
- Dashpot Timers
- Synchronous Clock Timers
- Solid-State Timers
- Programmable Timers
- ON-Delay and OFF-Delay Timers
- One-Shot Timers
- Recycle Timers
- Multiple-Function Timers
- Up Counters
- Up/Down Counters

**Knowledge Enabling Objective (Chapter 14):**
KEO 6.11. **EXPLAIN** the role Relays and Solid-State Starters provide to Relay Control Logic to include: (Figures 14-1 through 14-46 pgs 375-409

- Relays
  - Reed Relays
  - General Purpose Relays
  - Machine Control Relays
  - Solid-State Relays
- Solid-State Starters
  - Wiring and Control Circuits
  - Setting Overload Protection
  - Programming Motor Starter Operating Functions
  - Motor Starting Modes
  - Motor Stopping Modes
- Troubleshooting Techniques for Relays and Starters

**Knowledge Enabling Objective (Chapter 15):**

KEO 6.12. **EXPLAIN** the role Sensing Devices and Controls provide to Relay Control Logic to include: (Figures 15-1 through 15-63 pgs 411-443)

- Photo-Electric Sensors
- Fiber Optics
- Photo-Electric control Applications
- Ultrasonic Sensors
- Proximity Sensors
- Flow Detection Sensors
- Troubleshooting Sensor Techniques
Knowledge Enabling Objectives (Chapter 5):

**KEO 6.1.** **DESCRIBE** the Basic Rules of Line Diagrams to address: (pgs 91-96)
- Load Per Line (Figure 5-1 & 5-2 pgs 91 & 92)
- Load Connections (Figure 5-3 & 5-4 pg 92)
- Control Device Connections (Figure 5-5 & 5-6 pg 93)
- Line Number Reference (Figure 5-7 pg 93)
- Numerical Cross-Reference Systems (Figures 5-8 & 5-9 pgs 94-95)
- Wire Reference Numbers (Figure 5-10 pg 95)
- Manufacturer’s Terminal Numbers (Figure 5-11 pg 96)
- Cross-Referencing Mechanically Connected Contacts (Figure 5-12 pgs 96-97)

**KEO 6.2.** **EXPLAIN** Line Diagrams to include Signals, Decisions, and Actions (Figure 5-13 pg 97).

**KEO 6.3.** **DESCRIBE** Diagrams to include Signals, Decisions, and Actions (Figure 5-13 pg 97)

**KEO 6.4.** **EXPLAIN** Common Control Circuits to include: (Figures 5-22 through 5-29 pgs 100-103)
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- Two Magnetic Starters Operated by Two Start/Stop Stations with Common Emergency stop
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**KEO 6.6.** **DESCRIBE** Rectification of Alternating Currents to include: (Figures 12-11 through 12-16 pgs 316-319)
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- Testing Zener Diodes
- Testing Thermistors
- Pressure Sensors
- Testing Photocells
- Testing Transistors
- Testing SCRs
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- Testing Diacs
- Testing Triacs

**Knowledge Enabling Objective (Chapter 13):**

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- One-Shot Timers
- Recycle Timers
- Multiple-Function Timers
- Up Counters
- Up/Down Counters

**Knowledge Enabling Objective (Chapter 14):**

**KEO 6.11.** **EXPLAIN** the role Relays and Solid-State Starters provide to Relay Control Logic to include: (Figures 14-1 through 14-46 pgs 375-409)
- Relays
  - Reed Relays
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  - Machine Control Relays
  - Solid-State Relays
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  - Motor Starting Modes
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- Proximity Sensors
- Flow Detection Sensors
- Troubleshooting Sensor Techniques

STEP TWO

Relay Control Logic

Skill/Performance Objectives

Skill Knowledge Introduction:

Below are the skill knowledge objectives. How these objectives are performed depend on equipment and laboratory resources available. With each skill objective it is assumed that a set of standard test equipment and tools be provided and safety procedures be implemented during each tasked being performed.

- Design and test relay control circuits to safely operate in compliance with instructor defined parameters
- Design and operationally test relay controls to interface with various voltage requirements operating simultaneously
- Identify faults in relay control circuits, isolate and correct the fault
- Design relay control schemes to interface with PLC and DCS controls
• Design and test relay controls systems with multiple control locations
• Design interlocks, permissive and protections into relay control schemes
• Interface electromechanical relays with solid state relay systems and power electronics application