Industrial Controls Training System

Basic Controls

Courseware Sample
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INDUSTRIAL CONTROLS TRAINING SYSTEM

BASIC CONTROLS

by
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of
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Foreword

Control systems for electric motors are vital to the proper performance and protection of modern equipment. They are essentially the link in every complex industrial process. These systems may range from the simple starting and stopping of an electric motor to directing energy flow in a completely automated factory. Between these extremes, we find semiautomatic controllers in which a human operator must fill some of the required functions.

The Industrial Controls Training System, Model 8036, and the related modules and manuals, provide a thorough understanding of the theory and operation of electric motor controllers. Many genuine industrial components are included in the system to familiarize the student with the way they actually operate and special emphasis is put on safety.

Training starts with the basic fundamentals, and proceeds step by step, through various types of controls encountered in industry. The student manual explains what kinds of controls are available, how they operate, where they are used, and why they are used in a particular application.

The multiplicity of modules makes it possible to implement setups that fit a large number of needs. Control equipment and components are panel mounted with hidden fault insertion switches in each module to develop the troubleshooting skills of the students.

This program is fully compatible with existing modular components from Lab-Volt.

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Sample Exercise

Extracted from

Student Manual

REVERSING STARTERS

EXERCISE OBJECTIVE

- Implement magnetic reversing starters.
- Understand the principles of mechanical and electrical interlocking.

DISCUSSION

As you have seen in the previous exercise, reversing rotation direction of a three-phase motor is usually done by interchanging any two power lines. When the equipment is sufficiently rugged, motor line reversal can be accomplished while the motor is running at full speed. This has a major advantage: a counter torque is developed and the motor stops faster. This motor braking method is called **plugging**.

When phase reversal is executed in magnetic circuits, one contactor is used for each direction. But a short-circuit can occur if the two contactors are energized at the same time. Look at the Figure 3-9 power circuit, for example. If all contacts of the F and R contactors close, lines 1 and 2 will be short-circuited. That is the reason why forward and reverse contactors are usually electrically and/or mechanically interlocked together.

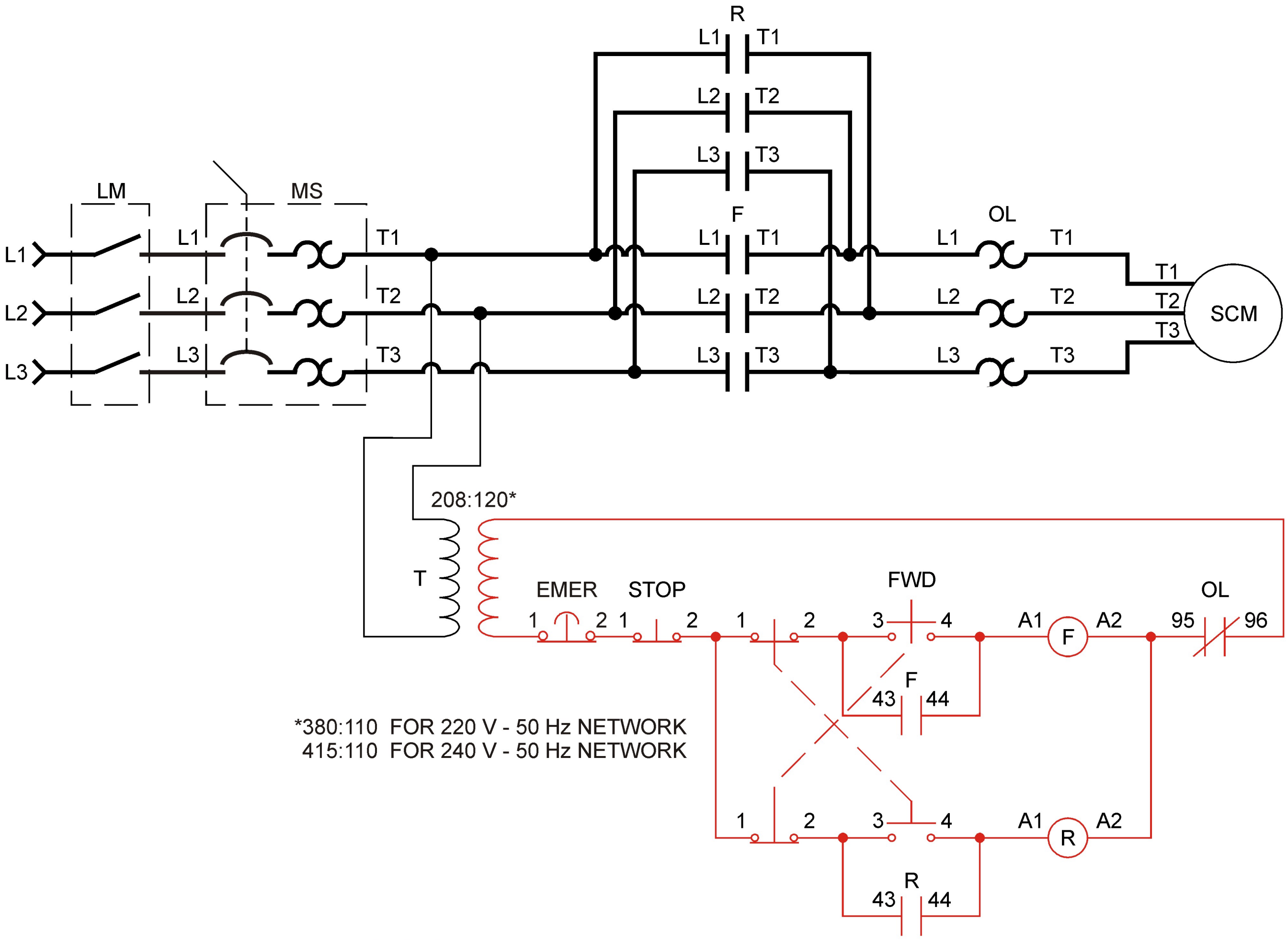
Push button interlocking

Avoiding simultaneous actuation of two contactors can be done electrically, by way of push button interlocking.

When the FWD push button in Figure 3-9 is pressed, the coil (F) is energized and the related holding contact closes. If the REV push button is pressed while the motor is running in the forward direction, the forward control circuit de-energizes. At the same time, the reverse contactor (R) is energized and held closed, making the motor run in the reverse direction. Note that it is not necessary to press the STOP push button to reverse direction. This fact facilitates plugging.

If the FWD and REV push buttons are simultaneously activated, both contactors will stay open. That is because push button NC contacts open the control circuit completely, thereby forcing contactor coils to de-energize.

However, if a contactor coil is stuck closed or does not open fast enough, there can still be a short-circuit when the other coil is activated.



LEGEND

F	=	FORWARD DIRECTION CONTACTOR
FWD	=	FORWARD PUSH BUTTON (MOMENTARY CONTACT)
OL	=	OVERLOAD RELAY
R	=	REVERSE DIRECTION CONTACTOR
REV	=	REVERSE PUSH BUTTON (MOMENTARY CONTACT)
SCM	=	SQUIRREL CAGE MOTOR
STOP	=	STOP PUSH BUTTON (MOMENTARY CONTACT)
T	=	CONTROL VOLTAGE TRANSFORMER
EMER	=	EMERGENCY PUSH BUTTON (MAINTAINED CONTACT)
LM	=	LOCKOUT MODULE
MS	=	MANUAL STARTER

Figure 3-9. Push button interlocking circuit.

Mechanical Interlocking

A mechanical lever is another manner of preventing both starter coils from being energized simultaneously. Figure 3-10 displays the mechanical interlock located between the two contactors of the Dual Contactors, Model 3119.

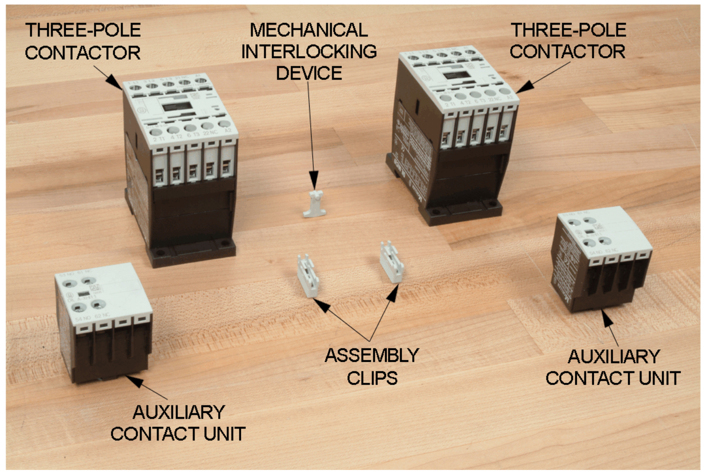
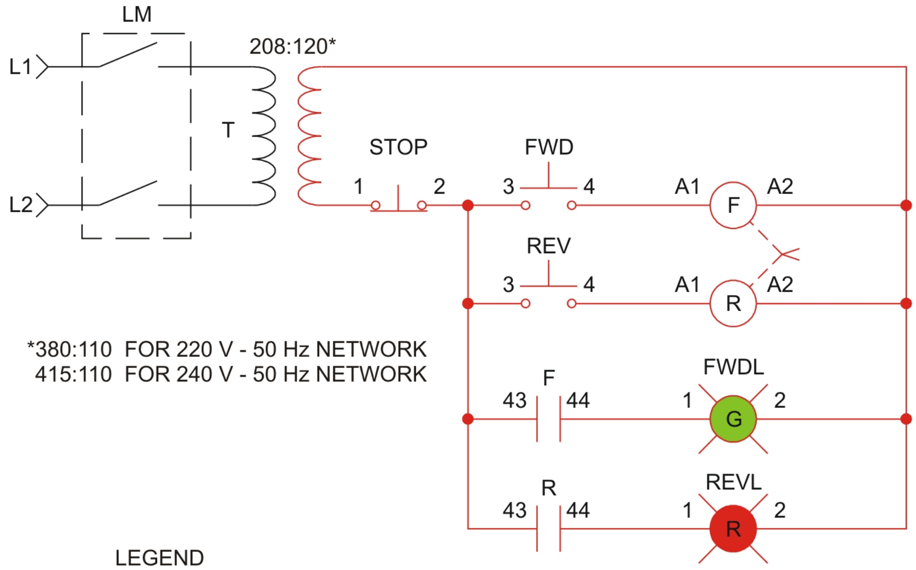


Figure 3-10. Mechanical interlocking.

If you refer to the Figure 3-11 circuit, a mechanical interlock (in dashed lines) is located between the two contactor coils. When one of the two contactors is energized, the contacts of the other contactor are mechanically maintained, even if the second coil is energized. This method provides a level of security against short-circuits resulting from stuck contactors. This explains why mechanical interlocks are so common in the industry.



LEGEND

F	=	FORWARD DIRECTION CONTACTOR
FWD	=	FORWARD PUSH BUTTON (MOMENTARY CONTACT)
FWDL	=	FORWARD PILOT LIGHT
R	=	REVERSE DIRECTION CONTACTOR
REV	=	REVERSE PUSH BUTTON (MOMENTARY CONTACT)
REVL	=	REVERSE PILOT LIGHT
STOP	=	STOP PUSH BUTTON (MOMENTARY CONTACT)
T	=	CONTROL VOLTAGE TRANSFORMER
LM	=	LOCKOUT MODULE

Figure 3-11. Dual contactors testing circuit.

Procedure Summary

In the first part of this exercise, you will set up a reversible starter circuit with push button interlocking and verify that this circuit enables changing of motor direction. You will also observe that motor direction reversing can be accomplished without having to press the STOP push button, to stop the motor faster. You will then verify that both contactors remain de-energized if the operator accidentally presses the two push buttons. Finally, you will simulate a stuck contactor to see that push button interlocking does not protect against short-circuits resulting from that type of trouble.

In the second part of this exercise, you will study, with the assistance of pilot lights, how a mechanical interlock operates. By manually applying pressure on the dual contactors plungers, you will check that it is not possible to activate both contactors at the same time. You will then visualize that, when both coils are powered, only the first contactor has its related contacts closed.

In the last part of this exercise, you will connect a reversing starter with push button and mechanical interlocks. You will see that this circuit, like the push button interlock circuit, enables motor direction reversal and opens completely when both push buttons are pressed. You will also discover that the mechanical interlock included adds protection against stuck contactors.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart in Appendix A to obtain the list of equipment required for this exercise.

PROCEDURE

WARNING!

The Power Supply provides high voltages. Do not change any AC connection with the power on.

Basic setup

☐ 1. Perform the Basic Setup and Lockout/Tagout procedures.

Push button interlocking

☐ 2. Install the Brake Motor and the Inertia Wheel.

Connect the circuit shown in Figure 3-9.

> **Note:** *Use one of the two contactors from the Dual Contactors, Model 3119, as the forward direction contactor, and the Contactor, Model 3127, as the reverse direction contactor, to make sure that there is no mechanical link between contactors.*

☐ 3. On the Manual Starter, set the overload potentiometer according to the motor FLA, and the O/I button to the I position.

Manually disengage the friction brake.

Perform the Energizing procedure.

Determine the motor rotation direction as you press the FWD push button.

☐ Clockwise ☐ Counterclockwise

☐ 4. Press the STOP push button and observe the time taken by the motor to stop.

☐ 5. Determine the motor rotation direction as you press the REV push button.

☐ Clockwise ☐ Counterclockwise

☐ 6. Compared to the forward operation, does the motor turn in the other direction?

☐ Yes ☐ No

Note: *The contactors are all AC-4 rated. This class allows for plugging operation (reversing direction of rotation from other than off condition).*

☐ 7. While the motor is running in the reverse direction, press the FWD push button until the motor halts. Press the STOP push button before the motor starts rotating in the opposite (forward) direction. Repeat if necessary.

Note: *Repeated motor starts and stops may cause the Overload Relay to trip.*

Did the motor stop slower or faster than with the STOP push button only?

☐ Slower ☐ Faster

☐ 8. When the FWD push button was pressed, why were both contactors (F and R) not activated at the same time, thereby causing a short-circuit?

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☐ 9. What happens when you keep the FWD and REV push buttons pressed simultaneously?

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☐ 10. Describe how the circuit operates while you simultaneously keep the FWD and REV push buttons pressed.

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☐ 11. What happens if you do not release both push buttons simultaneously? Explain why.

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☐ 12. Press the FWD push button to start the motor.

To simulate a stuck contactor, manually hold the forward contactor plunger down (using the tip of a pen), then press the REV push button. What happens?

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☐ 13. Describe how the circuit operates while you simultaneously hold the forward contactor plunger down and press the REV push button.

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☐ 14. Does push button interlocking offer a good protection against stuck contactors?

☐ Yes ☐ No

☐ 15. Perform the Lockout/Tagout procedure.

Mechanical interlocking

☐ 16. Connect the circuit shown in Figure 3-11.

Note: *Use the two contactors from the Dual Contactors module.*

☐ 17. Perform the Energizing procedure.

☐ 18. Can you (manually) hold down completely the two contactor plungers simultaneously? Explain why.

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☐ 19. When you press the FWD push button alone, which contactor coil is energized? (refer to the respective pilot lights)

☐ F ☐ R

☐ 20. When you press the REV push button alone, which contactor coil is energized? (refer to the respective pilot lights)

☐ F ☐ R

☐ 21. Does pressing the FWD and REV push buttons energize both contactor coils simultaneously?

☐ Yes ☐ No

☐ 22. When both push buttons are pressed, which contactor coil(s) energize(s), in regard to the order in which the corresponding push buttons were pressed?

☐ The first ☐ The second ☐ Both ☐ None

☐ 23. Perform the Lockout/Tagout procedure.

Reversing starter with push button and mechanical interlock

☐ 24. Connect the circuit shown in Figure 3-9, this time using the two contactors from the Dual Contactors module.

☐ 25. Perform the Energizing procedure.

Determine the motor rotation direction as you press the FWD push button.

☐ Clockwise ☐ Counterclockwise

☐ 26. Press the STOP push button and wait for the motor to stop.

☐ 27. Determine the motor rotation direction as you press the REV push button.

☐ Clockwise ☐ Counterclockwise

☐ 28. While the motor is running in the reverse direction, press the FWD push button. Does the motor direction change? Explain what happens, considering that the circuit now contains a mechanical interlock.

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☐ 29. Press both push buttons simultaneously, and determine which contactor(s) energize(s), in regards to the order in which the corresponding push buttons were pressed.

☐ The first ☐ The second ☐ Both ☐ None

☐ 30. Press the FWD push button to start the motor. To simulate a stuck contactor, manually hold the forward contactor plunger down (using the tip of a pen). Press the REV push button.

Does the motor still run in the forward direction? Explain why.

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☐ 31. Does mechanical interlocking offer protection against stuck contactors?

☐ Yes ☐ No

☐ 32. Turn the Power Supply off, disconnect the circuit, remove the magnetic labels, and return the equipment to the storage location.

CONCLUSION

Reversing magnetic starters are built with two contactors, one per rotation direction. If both contactors are actuated at the same time, a short-circuit can occur. This is why electrical and/or mechanical interlocks are used.

Push button interlocking is an electrical means of disabling two contactors actuation. When a push button is pressed, the circuit controlling the other motor direction is automatically opened.

Mechanical interlocking uses a lever to artificially keep the second contactor de-energized, while the first coil is actuated. This method is more rugged in the way that it prevents short-circuits resulting from a stuck contactor.

Plugging is a method of making the motor brake faster. It is accomplished by reversing phases while the motor is running.

REVIEW QUESTIONS

1. What is the purpose of interlocking in reversing starters?

   a. Prevent any contactor from being energized
   b. Prevent any contactor from being de-energized
   c. Stop the motor in case of electrical overload
   d. Prevent two contactor coils from being energized at the same time

2. How many contactors are necessary for reversing starters?

   a. 2
   b. 3
   c. 4
   d. 5 or more

3. What is the motor braking method called that uses the counter torque produced by reversing connections?

   a. Inching
   b. Plugging
   c. Jogging
   d. DC injection

4. In mechanical interlocking, which item prevents both coils from being actuated simultaneously?

   a. Coil
   b. Lever
   c. Push button
   d. Diode

5. In the Figure 3-9 circuit, which lines have been interchanged in the reverse mode compared to the forward mode?

   a. Line 1 and line 2
   b. Line 1 and line 3
   c. Line 2 and line 3
   d. Line 1 and line N

Sample

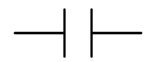
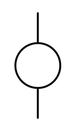
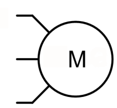
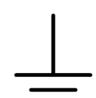
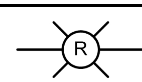
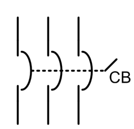
Extracted from

Instructor Guide

EX. 2-2 SYMBOLS, DESIGNATIONS, AND DIAGRAMS

ANSWERS TO PROCEDURE STEP QUESTIONS

☐ 1.

ITEMS	SYMBOLS
Normally open contact	
Single throw toggle switch	
Diode	
Normally closed contact (IEC)	
Fixed resistor	
Relay operating coil	
Three-phase induction motor	
Earth ground	
Red indicating light	
3-pole manual circuit breaker	

☐ 2.

a. Time-delay opening contacts: TO or TDO
b. Overload: OL
c. Diode: D
d. Circuit-breaker: CB
e. Push button: PB
f. Ammeter: AM
g. Fuse: FU
h. Capacitor: C or CAP
i. Pressure switch: PS
j. Transistor: Q

☐ 3.
a. General transformer (control)
b. Normally closed, push button contact (stop button)
c. Normally open, push button contact (start button)
d. Normally open, push button contact (jog button)
e. Normally open contact (relay contact)
f. Normally open contact (contactor contact)
g. Normally open contact (relay contact)
h. Relay coil (main contactor coil)
I. Relay coil (relay coil)
j. Normally closed contact (overload relay contact)
k. Normally open contacts (main contactor power contacts)
l. Thermal overload elements
m. Squirrel-cage induction motor

☐ 4.

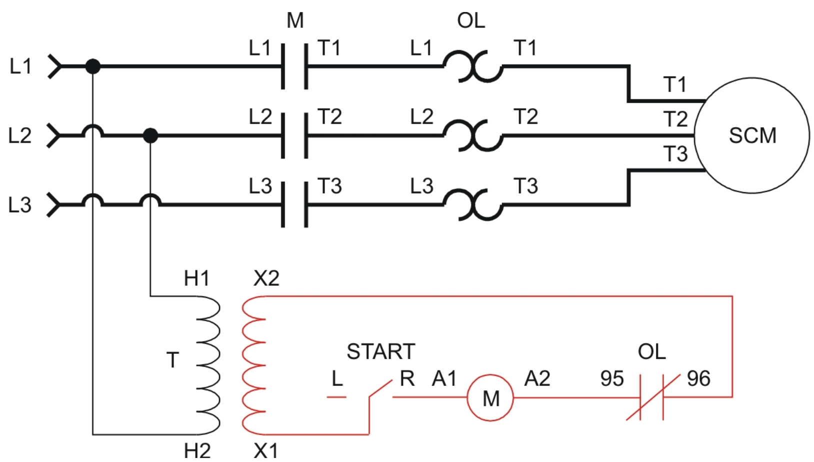


Figure 2-9. Schematic Diagram.

ANSWERS TO THE REVIEW QUESTIONS

1.a; 2.b; 3.d; 4.b; 5.d.

ANSWERS TO UNIT TEST

1.d; 2.c; 3.c; 4.a; 5.b; 6.d; 7.b; 8.d; 9.d; 10.c.

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