Industrial Maintenance

Programmable Logic Controller

Courseware Sample

39436-F0

Order no.: 39436-10
First Edition
Revision level: 09/2015

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Printed in Canada

ISBN 978-2-89640-129-1 (Printed version)
Legal Deposit – Bibliothèque et Archives nationales du Québec, 2007
Legal Deposit – Library and Archives Canada, 2007

Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal

Safety and Common Symbols

Symbol	Description
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

Table of Contents

To the Instructor

- Before a student begins an exercise, ensure that the equipment is in good condition and does not represent any risk when used.
- This guide provides you with the answers to questions.
- Make sure that the students understand the objectives of the work to do.

Sample Exercise

Extracted from

Student Manual

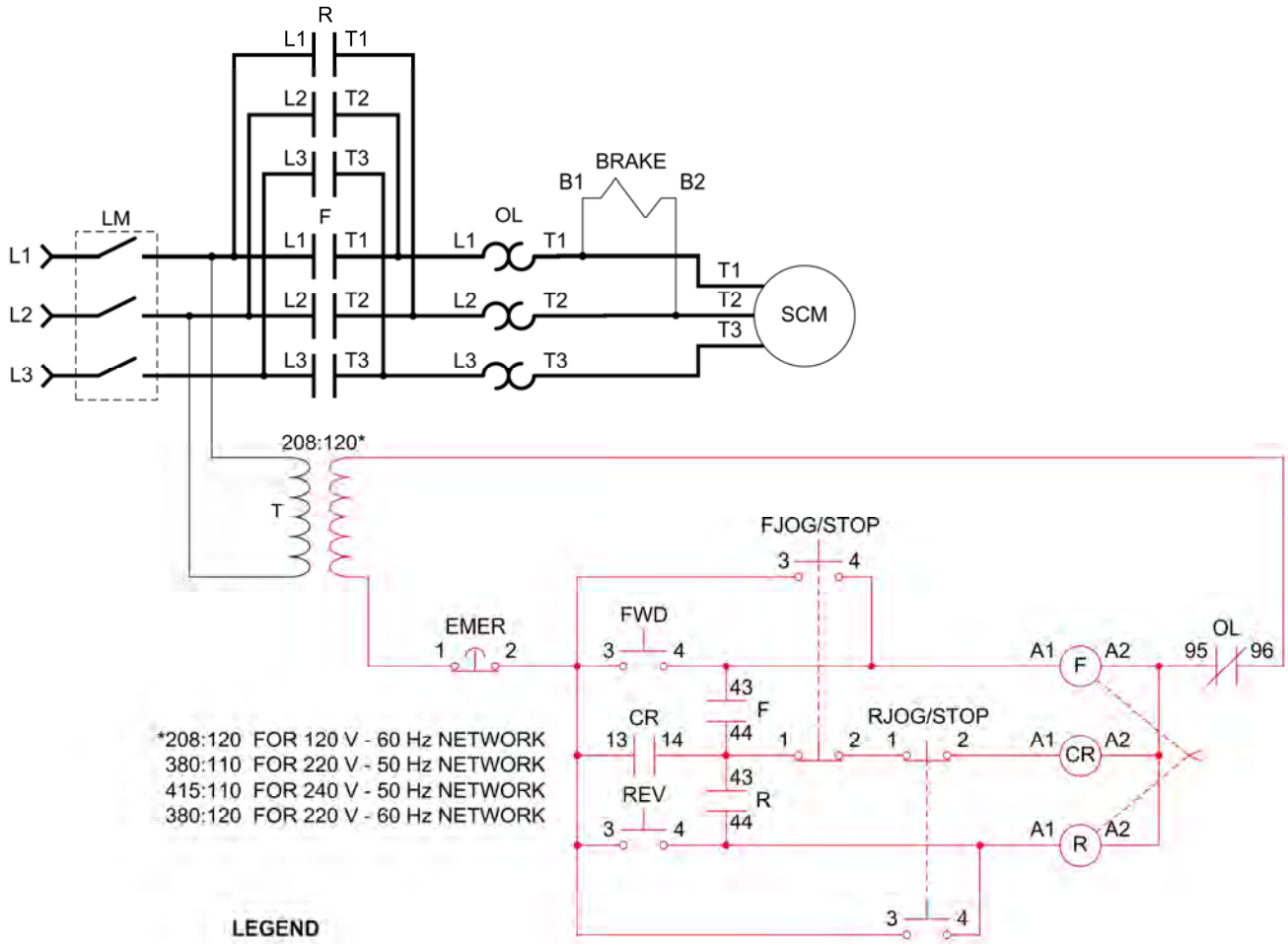
Reversing Motor Starters with Jogging

EXERCISE OBJECTIVE

- Implement a PLC reversing motor starter.
- Add a tripped overload relay light indicator to a circuit.

DISCUSSION

Some applications, in particular in position control, require a motor to run and jog in both forward and reverse directions. To meet these requirements a jogging control circuit with a reversing motor starter can be implemented. Figure 2-12 is an example of a hardwired motor reversing circuit with jogging. This setup includes a control relay to form the holding circuits.



LEGEND

BRAKE	=	SOLENOID ACTUATED BRAKE COIL
CR	=	CONTROL RELAY
EMER	=	EMERGENCY PUSH BUTTON (MAINTAINED CONTACT)
F	=	FORWARD DIRECTION CONTACTOR
FJOG/STOP	=	FORWARD JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
FWD	=	FORWARD PUSH BUTTON (MOMENTARY CONTACT)
OL	=	OVERLOAD RELAY
R	=	REVERSE DIRECTION CONTACTOR
REV	=	REVERSE PUSH BUTTON (MOMENTARY CONTACT)
RJOG/STOP	=	REVERSE JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
SCM	=	SQUIRREL CAGE MOTOR
T	=	CONTROL VOLTAGE TRANSFORMER
LM	=	LOCKOUT MODULE

Figure 2-12. Reversing motor starter circuit with jogging.

Tripped overload indicator

An electric overload occurs when a motor draws a current that is above its nominal value. Standard motor starters include an overload relay that detects sustained, abnormally high currents to prevent damage to the motor. Under these irregular conditions, the overload relay trips, causing the motor to be de-energized.

The motor stopping and its origin might not be readily apparent to the operator. Therefore, a pilot light can be added into the motor control circuit to display the overload condition. Also, the overload signal can be used to keep the PLC from restarting the motor as soon as the overload relay is reset.

Procedure Summary

In this exercise, you will set up a PLC motor reversing circuit with jogging capabilities. You will test that the ladder program, shown in Figure 2-13, functions like the hardwired circuit in Figure 2-12.

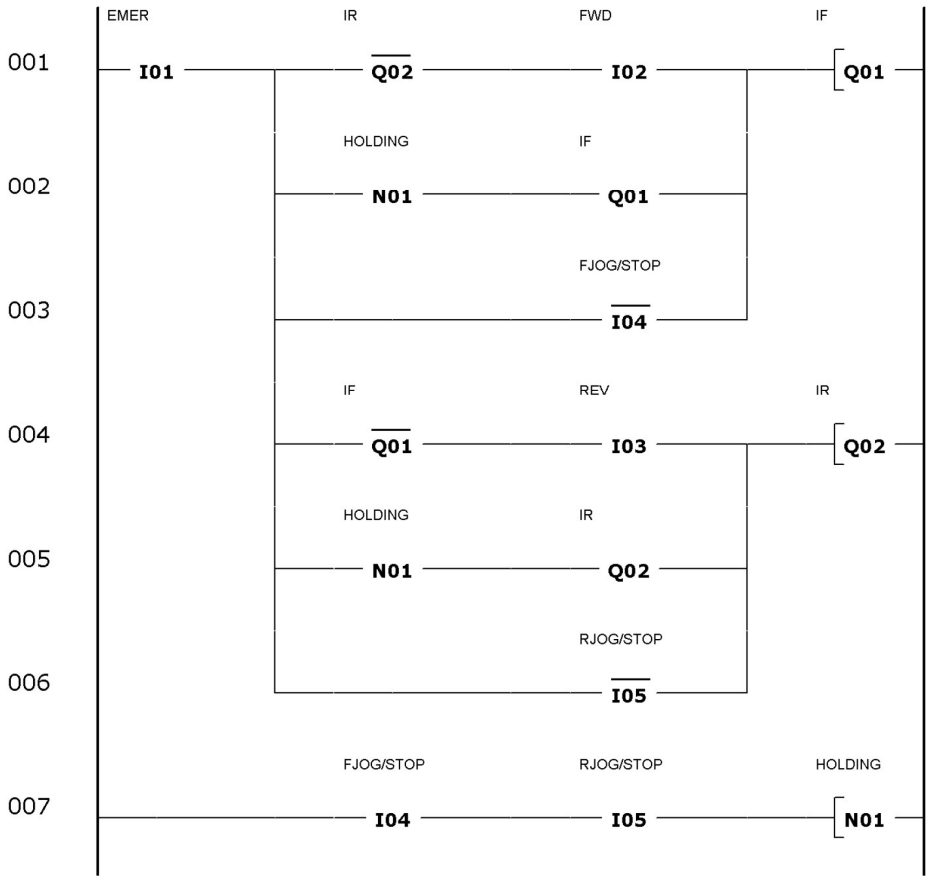


Figure 2-13. Reversing motor starter with jogging ladder program.

In the second part of the exercise, you will add a pilot light that uses the NO contact of the Overload Relay module to indicate the overload condition of the circuit. Figure 2-14 represents the new ladder program including an input for the NO contact of the Overload Relay module and an output for the pilot light. A timing relay is added to the program to make the pilot light flash.

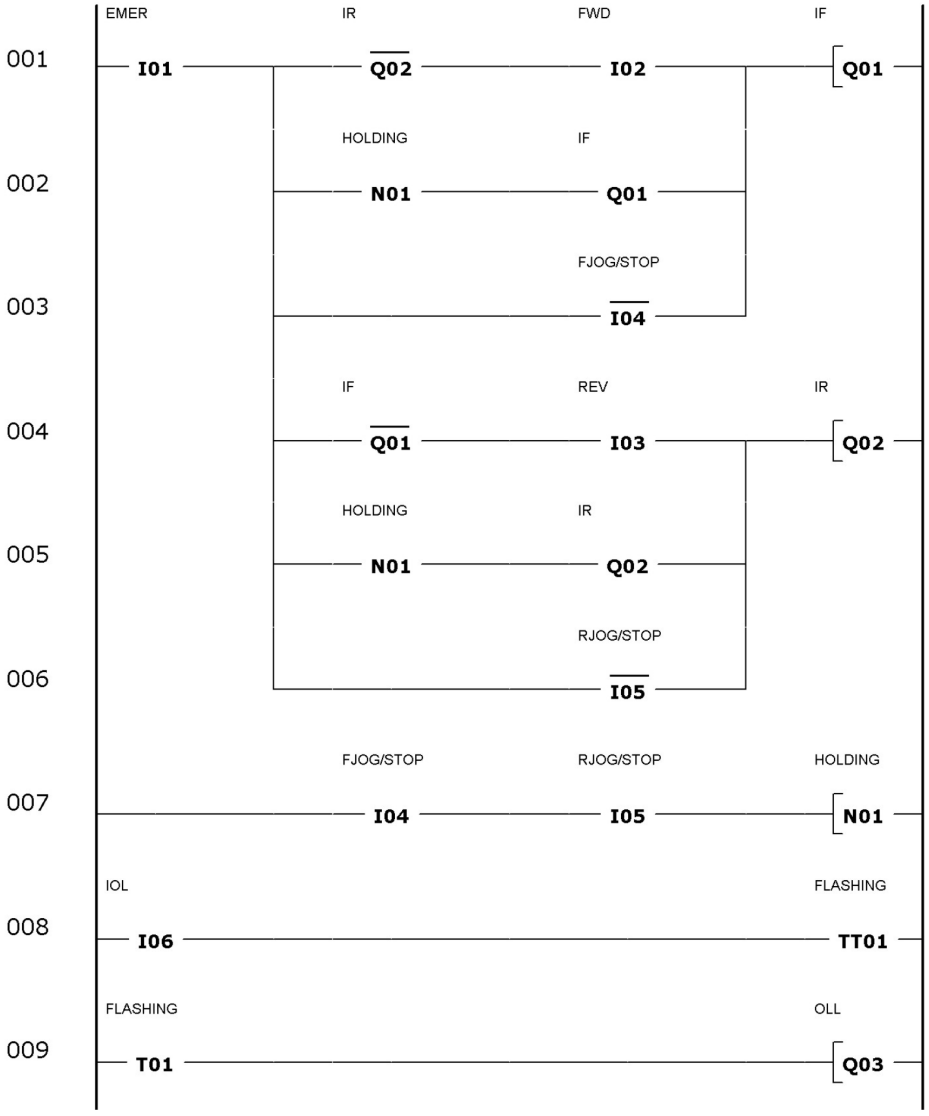


Figure 2-14. Reversing motor starter with jogging and overload indicator ladder program.

To verify that this new feature functions correctly, you will use the Overload Relay's TEST button to simulate a motor overload condition. You will notice that the system can restart automatically if the overload signal is not used to reset the PLC program. To increase the system safety, you will modify your program so that an operation is required from the operator to restart the motor, following an overload.

EQUIPMENT REQUIRED

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

PROCEDURE

⚠ WARNING

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

Basic setup

☐ 1. Perform the Basic Setup procedure.

Reversing motor starter with jogging

☐ 2. Connect the Programmable Logic Controller module as described in Exercise 1-1.

Perform the Energizing procedure.

Enter the ladder program shown in Figure 2-13.

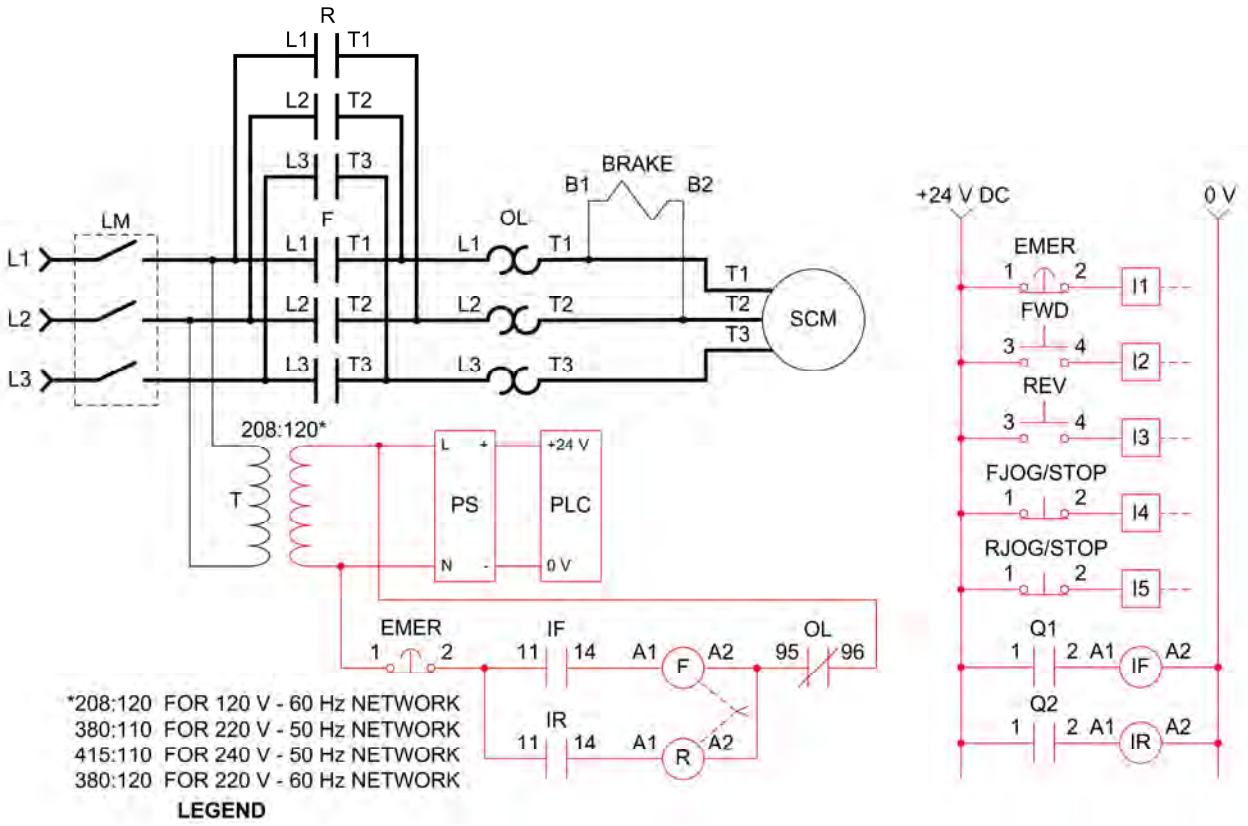
Perform the Lockout/Tagout procedure.

☐ 3. Install the Brake Motor, Inertia Wheel, and Security Guard.

Set up the circuit shown in Figure 2-15.

Perform the Energizing procedure.

Note: *Make sure that the PLC is set to the RUN mode.*



LEGEND

BRAKE	=	SOLENOID ACTUATED BRAKE COIL
EMER	=	EMERGENCY PUSH BUTTON (MAINTAINED CONTACT)
F	=	FORWARD DIRECTION CONTACTOR
FJOG/STOP	=	FORWARD JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
FWD	=	FORWARD PUSH BUTTON (MOMENTARY CONTACT)
Ix	=	PLC INPUT #x
IF	=	INTERPOSING RELAY FOR FORWARD CONTACTOR (24 V DC COIL)
IR	=	INTERPOSING RELAY FOR REVERSE CONTACTOR (24 V DC COIL)
M	=	MAIN CONTACTOR
OL	=	OVERLOAD RELAY
PLC	=	PROGRAMMABLE LOGIC CONTROLLER
PS	=	DC POWER SUPPLY
Qx	=	PLC OUTPUT RELAY #x
R	=	REVERSE DIRECTION CONTACTOR
REV	=	REVERSE PUSH BUTTON (MOMENTARY CONTACT)
RJOG/STOP	=	REVERSE JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
SCM	=	SQUIRREL CAGE MOTOR
T	=	CONTROL VOLTAGE TRANSFORMER
LM	=	LOCKOUT MODULE

Figure 2-15. PLC reversing motor starter with jogging circuit connection diagrams.

☐ 4. Which PLC's inputs/outputs are energized?

☐ I1 ☐ I2 ☐ I3 ☐ I4 ☐ I5 ☐ Q1 ☐ Q2

☐ 5. Test the PLC circuit and note in Table 2-1 if it has the same characteristics as the hardwired version in Figure 2-12.

CHARACTERISTICS OF THE HARDWIRED CIRCUIT	PLC circuit	
	Yes	No
FWD button makes the motor run continuously		
REV button makes motor run continuously in reverse direction		
FJOG/STOP can make a motor running continuously (F and R) stop		
RJOG/STOP can make a motor running continuously (F and R) stop		
FJOG/STOP makes motor run only as long as it is pressed		
RJOG/STOP makes motor run in reverse direction only as long as it is pressed		
The EMER button de-energizes the control circuit until it is reset		

Table 2-1. Characteristics of the hardwired circuit.

☐ 6. What are $\overline{Q1}$ and $\overline{Q2}$ contacts used for in the ladder program?

_____

_____

☐ 7. Do your observations confirm that the PLC version is equivalent to the hardwired version in terms of functionalities?

☐ Yes ☐ No

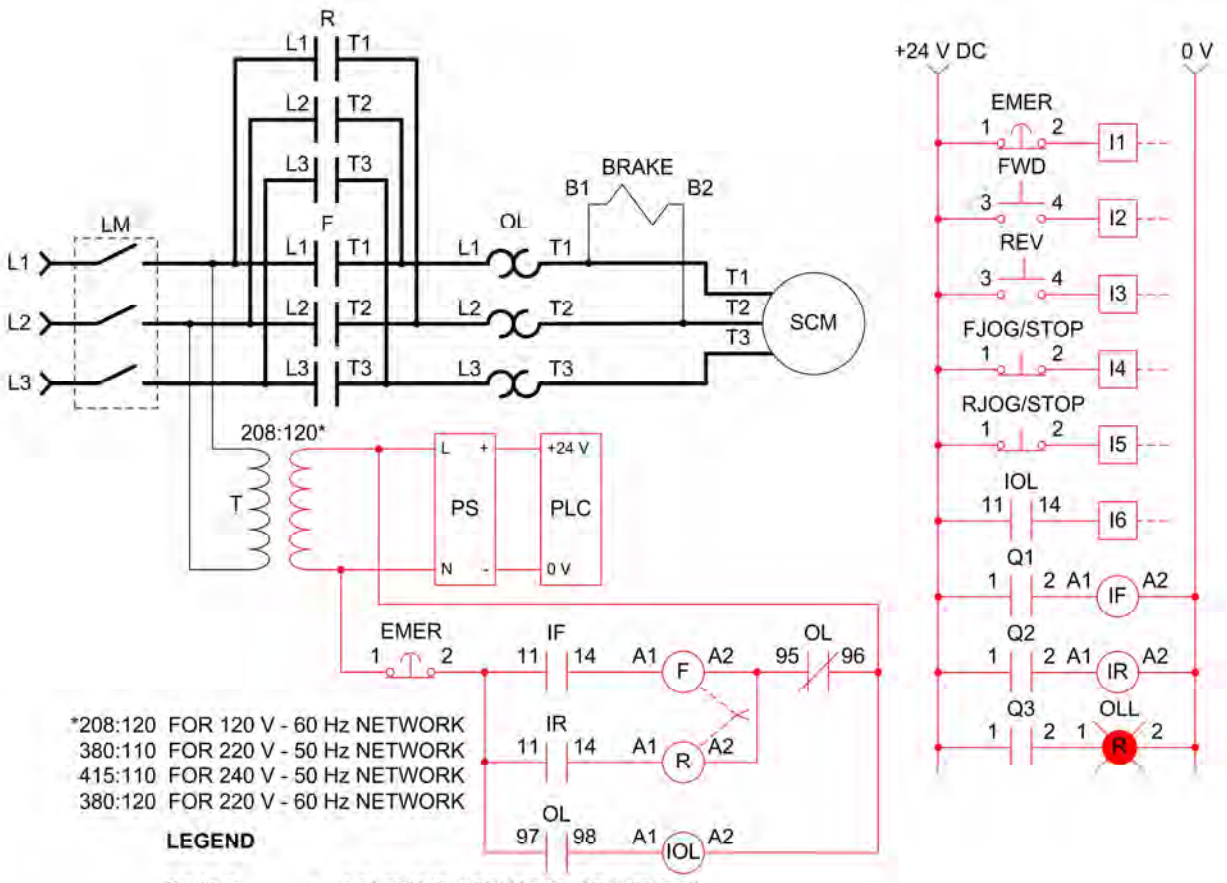
☐ 8. Set the Programmable Logic Controller module to the STOP mode.

Enter the program shown in Figure 2-14, with the following timing relay (T1) parameter values:

- Coil function: trigger
- Mode: flash switching
- Setpoint I1: 0.5 s
- Setpoint I2: 0.5 s

☐ 9. Perform the Lockout/Tagout procedure.

Set up the circuit according to Figure 2-16.



LEGEND

BRAKE	=	SOLENOID ACTUATED BRAKE COIL
EMER	=	EMERGENCY PUSH BUTTON (MAINTAINED CONTACT)
F	=	FORWARD DIRECTION CONTACTOR
FJOG/STOP	=	FORWARD JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
FWD	=	FORWARD PUSH BUTTON (MOMENTARY CONTACT)
Ix	=	PLC INPUT #x
IF	=	INTERPOSING RELAY FOR FORWARD CONTACTOR (24 V DC COIL)
IOL	=	INTERPOSING RELAY FOR OVERLOAD SIGNAL (110/120 V AC COIL)
IR	=	INTERPOSING RELAY FOR REVERSE CONTACTOR (24 V DC COIL)
M	=	MAIN CONTACTOR
OL	=	OVERLOAD RELAY
OLL	=	OVERLOAD PILOT LIGHT (RED)
PLC	=	PROGRAMMABLE LOGIC CONTROLLER
PS	=	DC POWER SUPPLY
Qx	=	PLC OUTPUT RELAY #x
R	=	REVERSE DIRECTION CONTACTOR
REV	=	REVERSE PUSH BUTTON (MOMENTARY CONTACT)
RJOG/STOP	=	REVERSE JOG/STOP PUSH BUTTON (MOMENTARY CONTACT)
SCM	=	SQUIRREL CAGE MOTOR
T	=	CONTROL VOLTAGE TRANSFORMER
LM	=	LOCKOUT MODULE

Figure 2-16. Reversing motor starter with jogging and overload indicator connection diagrams.

☐ 10. Perform the Energizing procedure.

Note: *Make sure that the PLC is set to the RUN mode.*

☐ 11. Which PLC's inputs/outputs are energized?

☐ I1 ☐ I2 ☐ I3 ☐ I4 ☐ I5 ☐ I6 ☐ Q1 ☐ Q2 ☐ Q3

☐ 12. Press the FWD push button. Does the motor start running continuously?

☐ Yes ☐ No

☐ 13. Pull the red TEST button located on the Overload Relay module. This will simulate an overload condition where the Overload Relay is triggered.

Does the motor stop?

☐ Yes ☐ No

☐ 14. Does the red OLL (overload) pilot light start flashing?

☐ Yes ☐ No

☐ 15. Release the TEST button. Does the red OLL (overload) pilot light keep on flashing?

☐ Yes ☐ No

☐ 16. Does the motor restart automatically?

☐ Yes ☐ No

☐ 17. Set the PLC to the STOP mode.

To increase the system safety, modify the program according to Figure 2-17. This modification prevents the motor from automatically restarting.

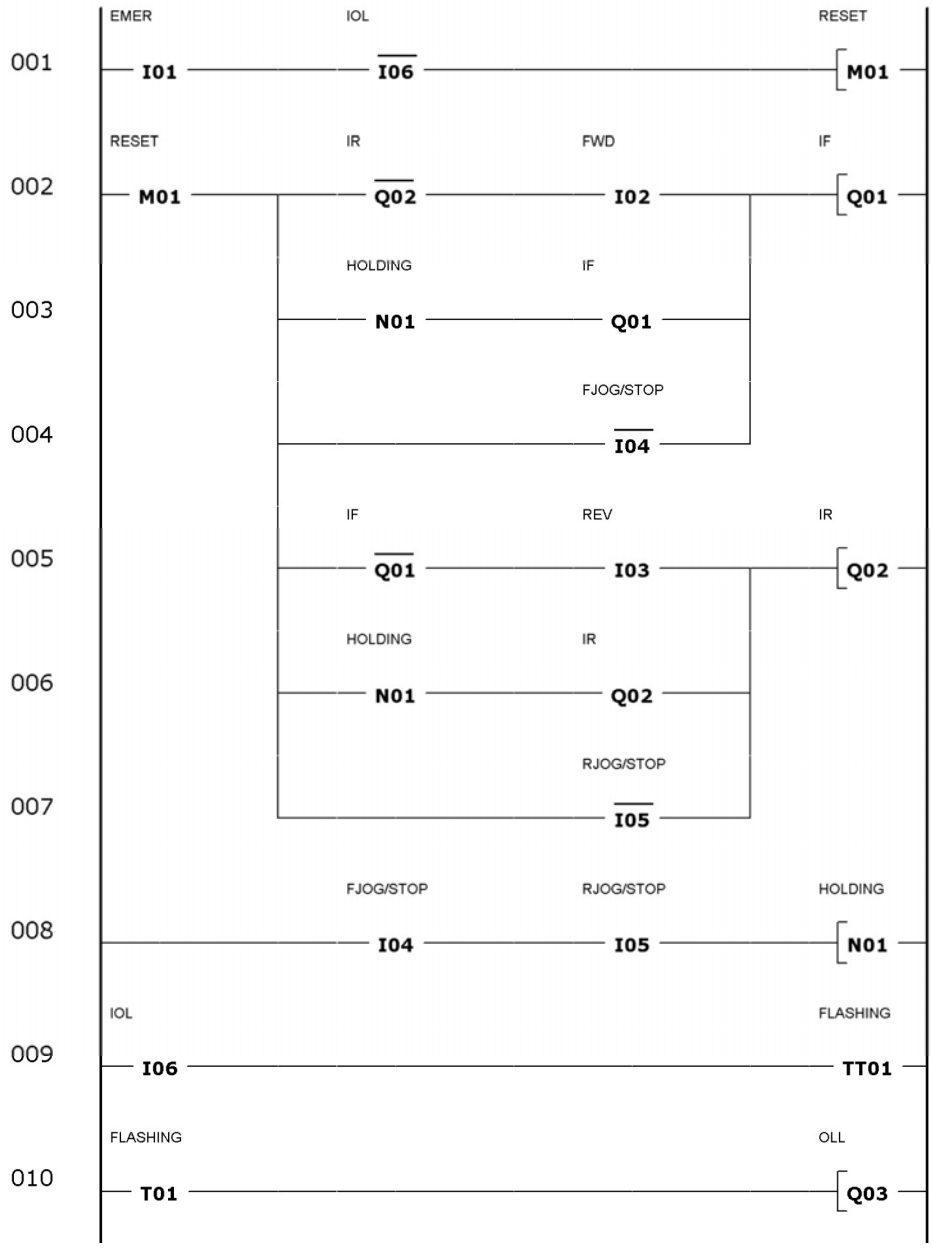


Figure 2-17. Reversing motor starter with jogging and overload indicator and reset connection diagrams.

☐ 18. Set the PLC to the RUN mode.

Press the FWD push button. Does the motor start running continuously?

☐ Yes ☐ No

☐ 19. Simulate an overload condition by pulling the red TEST button of the Overload Relay module.

Does the motor stop and the red OLL (overload) pilot light start flashing?

☐ Yes ☐ No

☐ 20. Release the TEST button. Does the red OLL (overload) pilot light keep on flashing?

☐ Yes ☐ No

☐ 21. Does the motor restart automatically? Explain why.

_____

_____

_____

☐ 22. Set the PLC to the STOP mode.

Turn the individual power switch of the AC Power Supply off, disconnect the circuit, and return the equipment to the storage location.

CONCLUSION

In this exercise, you programmed three different ladder programs to obtain a reversing motor starter with jogging. The first program could run and jog in both directions. However, it did not provide any feedback from the Overload Relay module.

The second program was similar to the first one, except that the PLC had an input connected to the Overload Relay module to make a pilot light flash in case of an overload. But this setup caused the motor to restart as soon as the Overload Relay module was reset.

The third program prevents the motor from restarting automatically by unlatching the motor output (forward or reverse) when an overload condition is detected.

REVIEW QUESTIONS

1. Which PLC programming unit in Figure 2-13 is logically equivalent to the control relay in Figure 2-12?

   a. Q1
   b. N1
   c. Q2
   d. I1

2. For what reason would a tripped overload pilot light be implemented in a motor control circuit?

   a. To suggest the operator to stop the motor manually.
   b. To make use of the overload relay NO contact.
   c. Because the motor overload might not be readily apparent.
   d. None of the above are correct.

3. Why is the circuit of Figures 2-14 and 2-15 likely to restart automatically, following an overload?

   a. The PLC is powered continuously.
   b. The signal from the overload relay NO contact does not reset the PLC program.
   c. The overload relay can be reset automatically.
   d. All of the above are correct.

4. In Figure 2-14, which PLC input triggers the flashing timing relay?

   a. I1
   b. I4
   c. I5
   d. I6

5. In Figure 2-17, which conditions cause the program to reset?

   a. False (make) I1
   b. True (break) I6
   c. True (make) T1
   d. None of the above is correct.

Sample

Extracted from

Instructor Guide

Interfacing Voltages

ANSWERS TO PROCEDURE STEP QUESTIONS

☐ 5.

CONTACT/COIL DESCRIPTION		ANTICIPATED STATUS			
		RUNNING MODE (no push button pressed, motor on)		STOPPED MODE (no push button pressed, motor off)	
		ON	OFF	ON	OFF
I1	Start make contact		✔		✔
I2	Stop brake contact	✔		✔	
I3	Motor run input	✔			✔
Q1	Run pilot light	✔			✔
Q2	Stop pilot light		✔	✔	
Q3	Motor output	✔			✔

Table 2-1. Status of the contacts and coils in running and stopped modes.

☐ 6. Yes

☐ 7. Yes

☐ 8. Yes

☐ 9. The holding contact is the PLC input I3, connected to the NO contact of the contactor via the AC to DC interposing relay.

☐ 10. Keeping the motor running continuously.

☐ 11. No

☐ 12. Yes

☐ 13. Yes

☐ 14. The PLC output Q3 is connected to the DC interposing relay coil (IM), whose NO contact is controlling the actuation of the contactor coil (M).

ANSWERS TO REVIEW QUESTIONS

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

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