Mechatronics

PLC Applications

Electromechanical Systems Using DC Motors

Job Sheets - Courseware Sample

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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
$\overline{\sim}$	Both direct and alternating current
3∿	Three-phase alternating current

Safety and Common Symbols

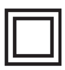
Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

Table of Contents

Preface

The *Programmable Logic Controller, Basic Programming* student manual (P/N 88270) allowed the reader to become familiar with PLCs and ladder programming. This was accomplished with the help of the Programmable Logic Controller Training System (Model 3240).

The aim of the present series of PLC applications is to integrate the basic principles previously acquired by designing small-scale systems that can be found in the real world. Through practical examples, students will gain a strong knowledge of the PLC field of study.

Each manual of the PLC applications series concentrates on a specific example of PLC application that evolves along a path of increasing complexity. With each manual, new components are added to the PLC module to create different opportunities to learn.

We hope that your learning experience with the PLC Training System will be the first step of a successful career.

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.

About This Manual

Programmable Logic Controllers (PLC's) represent state-of-the-art microprocessor-based electronics that make up technologically advanced control systems with applications in virtually every segment of industry where automation is required.

The present manual includes five Job Sheets that introduce students to PLC control of the Electromechanical – DC Motor System, Model 8075-3. Throughout the manual, students will learn how to program, connect, operate, and troubleshoot different configurations.

Prerequisite

Before performing the Job Sheets in this manual, it is recommended to review the *Programmable Logic Controller, Basic Programming* student manual (P/N 88270), which explains how to use the programming software and the most common PLC instructions. If any difficulty is encountered while performing the exercises, the programming software's user guide and help menu can assist students in problem solving.

Safety considerations

Safety symbols that may be used in this manual and on the equipment are listed in the Safety Symbols table at the beginning of the manual.

Safety procedures related to the tasks that you will be asked to perform are indicated in each exercise.

Electromechanical systems can be harmful when not used properly. Before performing any of the exercises in this manual, make sure that you respect the following general guidelines:

- Put your safety glasses on.
- Avoid wearing any loose clothing (e.g. tie, long sleeves, jewelry).
- Have your hair tied out of the way if it is long.
- Clean your work area if necessary.

Remember that you should never perform an exercise if you have any reason to think that a manipulation could be dangerous to you or your teammates.

Systems of units

Units are expressed using the International System of Units (SI) followed by the units expressed in the U.S. customary system of units (between parentheses).

Appendices

Appendix A: *List of Equipment Required*, gives the list of equipment needed to perform the exercices.

Appendix B: *Ladder Program Design*, presents two different methods that can be employed to program a PLC ladder program.

Appendix C: *Boolean Algebra and Digital Logic*, shows the logical relationships that can be employed with normally-open (NO) and normally-closed (NC) contacts.

Appendix D: *Troubleshooting Procedures*, is a set of guidelines permitting athe student to locate and correct PLC system failures.

Appendix E: *Glossary of Terms*, defines technical words and expressions contained in this manual.

Appendix F: *Ladder Diagram Graphic Symbols*, depicts the main symbols used in ladder diagrams.

To the Instructor

You will find in this Instructor Guide all the elements included in the Student Manual together with the answers to all questions, results of measurements, graphs, explanations, suggestions, and, in some cases, instructions to help you guide the students through their learning process. All the information that applies to you is placed between markers and appears in red.

Accuracy of measurements

The numerical results of the hands-on exercises may differ from one student to another. For this reason, the results and answers given in this manual should be considered as a guide. Students who correctly performed the exercises should expect to demonstrate the principles involved and make observations and measurements similar to those given as answers.

The instructor should be familiar with PLCs to recognize erroneous results. It is advised that a complete runthrough of each job sheet be included in the instructor's preparation for class. Each Job Sheet has several performance objectives. The instructor should ensure that each student understands them.

Sample
Extracted from
the Job Sheets Student
and the Job Sheets Instructor

Familiarization with the Electromechanical – DC Motor System

Motion control

The sub-field of automation pertaining to position and/or speed regulation is called motion control. Motion control is widely used in the packaging, printing, textile and assembly industries. It also plays an important role in robotics and CNC (computer numerical control) machine tools.

A typical motion control system contains:

- A motion controller (e.g. a PLC).
- A drive or amplifier to transform the control signal (often desired velocity or torque signal) into a higher power output.
- An actuator such as a hydraulic pump, air cylinder, linear actuator, or electric motor for output motion.
- A feedback sensor such as an optical encoder, or proximity switch to return the position of the actuator to the motion controller.
- Mechanical components (gears, bearings, lead screw, etc.) to transform the motion of the actuator into the desired motion.

Electromechanical systems

The Electromechanical System – DC Motor is designed to study PLC programming in the context of a motion control application. Figure 1 shows the PLC and the DC Motor drive used to control the position and the velocity of a sliding block moving on a lead screw driven by a DC motor.

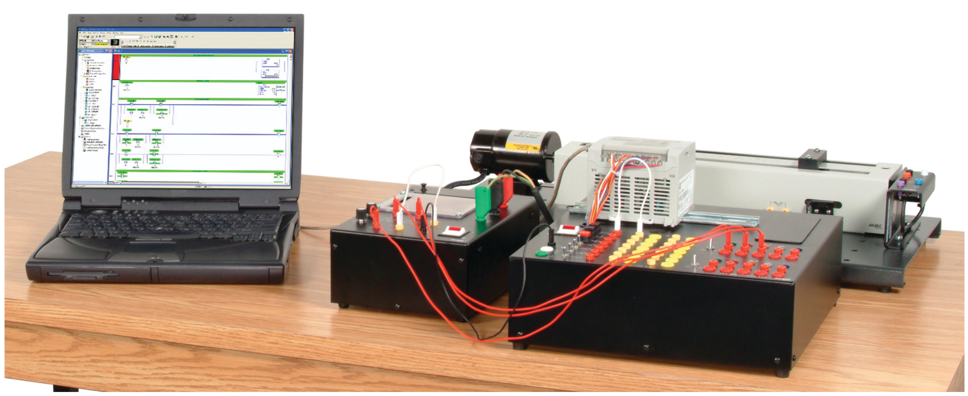


Figure 1. The Electromechanical System – DC Motor.

The Electromechanical – DC Motor System

The Electromechanical – DC Motor System includes two modules:

- DC Motor Drive (P/N 3209)
- Electromechanical – DC Motor Module (P/N 3293)

Figure 2 shows the DC Motor Drive. The DC Motor Drive output voltage is used to control motor speed (which is proportional to the armature voltage). The output voltage is proportional to the discrete (0-±10 V) dc signal applied to the SIG terminal when the EN (enable) terminal is powered. This signal can be provided by an external device or by the SP terminal located on the module. Two knobs permit the setting of two different motor speeds (SP1 and SP2). The signal at the SP terminal can be either SP1 or SP2 in forward (+) or reverse (-) mode, depending on the speed and direction terminals state.

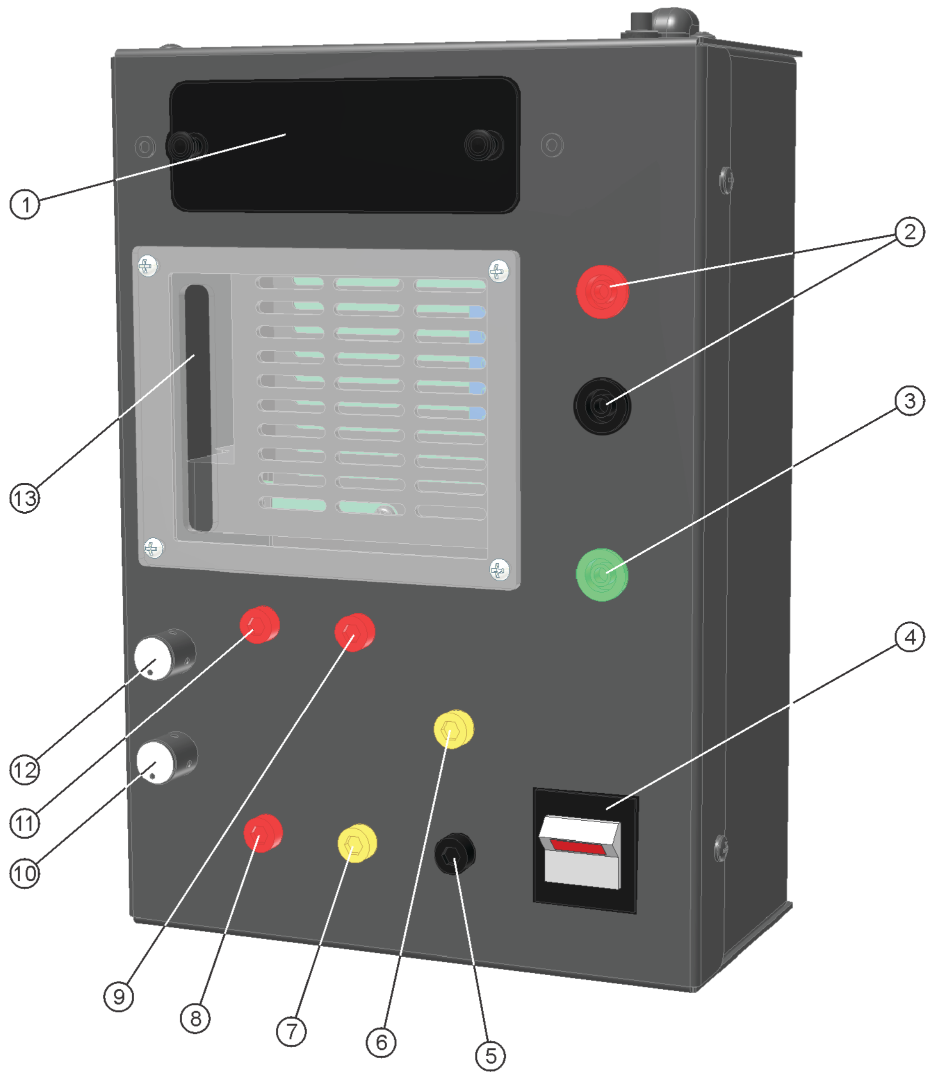


Figure 2. DC Motor Drive, Model 3209.

1. Fault Panel
2. DC Motor Power Supply Terminals
3. Ground Terminal
4. ON/OFF Switch
5. Common Terminal
6. Speed Signal Terminal (Out)
7. Speed Signal Terminal (In)
8. Enable Terminal
9. Direction Selection Terminal
10. Speed 2 Control
11. Speed Selection Terminal
12. Speed 1 Control
13. DC Motor Drive Tuning

Figure 3 details the tuning trimpots of the DC Motor Drive. The factory settings are shown. It is recommanded to keep these settings throughout the manual.

DB (Dead Band)	Sets the minimum speed level required to initiate control voltage output.
RESP (Response)	Determines the dynamic response of the control.
IR (Compensation)	Used to stabilize motor speed under varying loads. DC motors generally lose speed with greater loads. This is because larger currents (I) must fight the motor's armature resistance (R) of the motor, hence producing a greater voltage drop.
RCL (Reverse Current Limit)	Sets the maximum amount of DC current that the motor can draw in the reverse direction.
FCL (Forward Current Limit)	Sets the maximum amount of DC current that the motor can draw in the forward direction.
MAX (Maximum Speed)	Used to set the maximum output voltage of the control that is proportional to the motor speed.
FACC (Forward Acceleration)	Determines the amount of time (0.1 to 15 seconds) needed to go from zero to full output voltage in the forward direction or from full to zero output voltage in the reverse direction.
RACC (Reverse Acceleration)	Determines the amount of time (0.1 to 15 seconds) needed to go from zero to full output voltage in the reverse direction or from full to zero output voltage in the forward direction.

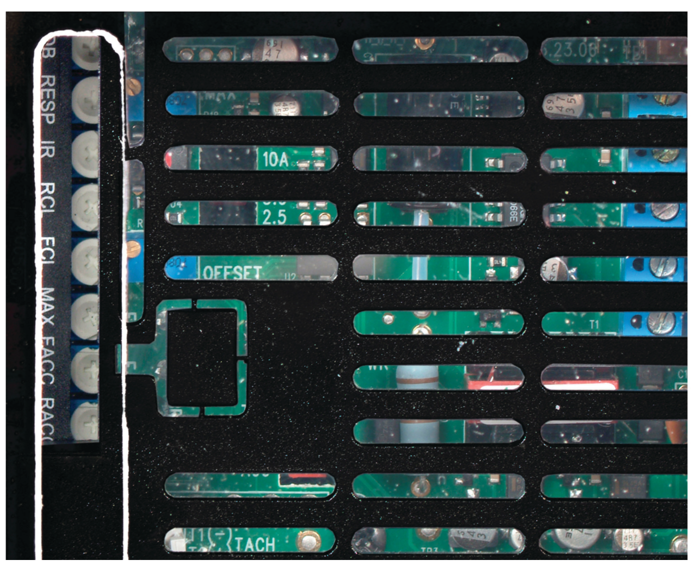


Figure 3. Trimpot adjustments (factory settings shown).

Figure 4 shows the Electromechanical – DC Motor module. It consists of a DC motor driving a lead screw on which a sliding block is installed. Two magnetic limit switches detect when the sliding block approaches the start or end position.

The Electromechanical – DC Motor is designed with a gap on both sides of the lead screw that lets the sliding block rest safely in case of overtravel.

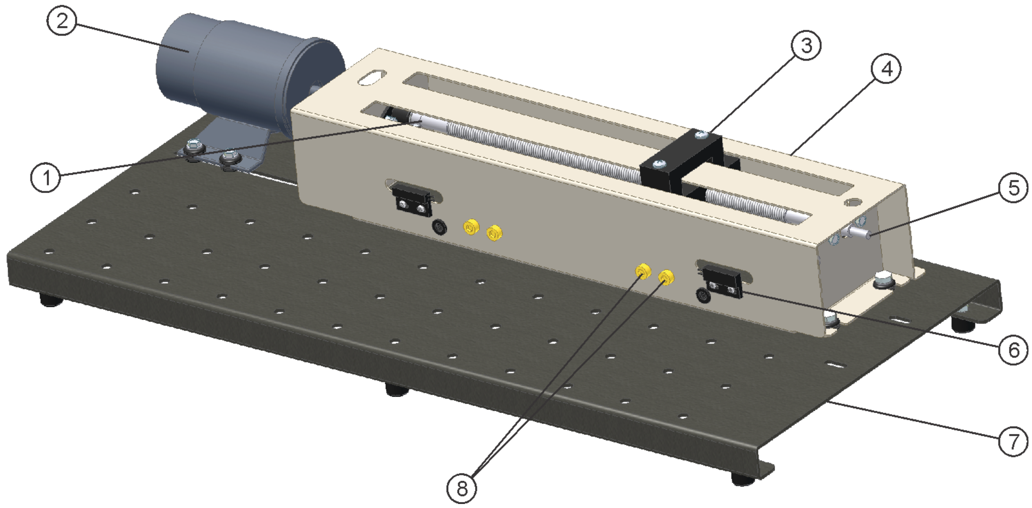


Figure 4. Electromechanical – DC Motor module.

1. Leadscrew
2. DC Motor
3. Sliding Block
4. Cover
5. Rod End
6. Magnetic Contact
7. Application Base
8. Magnetic Limit Switch Terminals

The system control section operates with low voltage signals (24 V dc). The PLC is programmed and monitored using a computer running a ladder programming software.

Familiarization with the Electromechanical – DC Motor System

OBJECTIVE

Test the operation of some basic system components.

PROCEDURE

⚠ CAUTION

Make sure you are wearing appropriate protective equipment when performing the jobs. You should never perform a job if you have any reason to think that a manipulation could be dangerous for you or your teammates.

Familiarization with the DC Motor Drive

1. Connect the DC Motor Drive to the PLC module, as shown in Figure 5. All toggle switches must be turned off (down position).

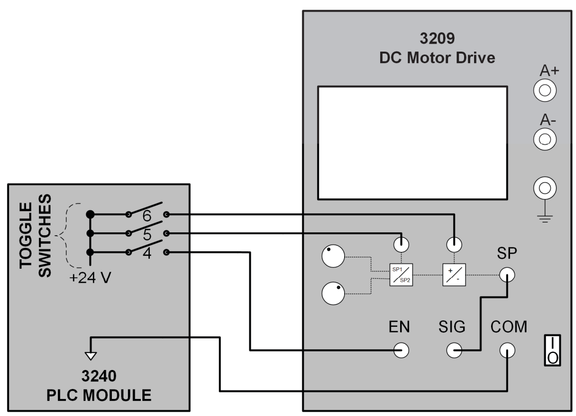


Figure 5. DC Motor Drive test circuit.

Table 1. Job Sheet 1 electrical connections.

PLC module port	Connected to
Switch 4 (Toggle)	Enable (EN)
Switch 5 (Toggle)	Speed (SP1/SP2)
Switch 6 (Toggle)	Direction (+/-)

2. Connect your voltmeter between the speed (SP) and the common terminal. Turn on the DC Motor Drive. Does the voltage change when you turn the SP1 knob?

❑ Yes ❑ No

Yes

Does the voltage change when you turn the SP2 knob?

❑ Yes ❑ No

No

3. Turn on the Speed (SP1/SP2) toggle switch to activate speed 2. Does the voltage change when you turn the SP1 knob?

❑ Yes ❑ No

No

Does the voltage change when you turn the SP2 knob?

❑ Yes ❑ No

Yes

4. Turn on the direction (+/-) toggle switch to activate the reverse direction. What happens to the voltage?

A negative voltage is produced.

5. Connect the voltmeter to the DC Motor Power Supply Terminals. Do you observe an output voltage?

❑ Yes ❑ No

A cable must be installed between the SP and the SIG terminals to act as a jumper.

No

⚠ CAUTION

High voltage can be present at the DC Motor Drive output terminals.

Turn on the enable (EN) toggle switch. Do you observe an output voltage now?

❑ Yes ❑ No

Yes

6. Set the DC Motor Drive to different configurations and measure the voltage both at the SP and at the output terminals. Is the output voltage proportional to the SP voltage?

❑ Yes ❑ No

Yes

7. Turn off all toggle switches.

Familiarization with the Electromechanical – DC Motor module

8. Connect the Electromechanical – DC Motor module to the DC Motor Drive output terminals. Set the two speed knobs to different values.

When the sliding block overtravels and leaves the lead screw threads, you can gently push it back on the threads while the DC motor is turning in the opposite direction at a reduced speed.

Turn on the enable switch. The motor should start to rotate, initiating the sliding block movement in the forward direction (following the markings on the scale.) Turn on the direction switch. Does this make the sliding block move in the reverse direction?

❑ Yes ❑ No

Yes

Turn on the direction switch. Do you perceive a change in the speed at which the sliding block is moving?

❑ Yes ❑ No

Yes

9. Connect the multimeter to the magnetic limit switch terminals located close to the DC motor. Set the multimeter to check contact continuity. Energize the motor in the reverse direction until the magnet attached to the sliding block actuates the switch.

Next, connect the multimeter to the other magnetic limit switch. Energize the motor in the forward direction until actuation of the magnetic switch.

10. Disconnect and store all leads and components.

Name: ______________________________ Date: ____________________

Instructor's approval: ____