

Mechatronics

PLC Applications

Electro-Pneumatics

Job Sheets - Courseware Sample

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Internet: www.festo-didactic.com

e-mail: did@de.festo.com

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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 indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
	WARNING indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
	CAUTION indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
	CAUTION used without the <i>Caution, risk of danger</i> 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

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

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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 Electro-Pneumatic System, Model 8075-2. Throughout the manual, students will learn how to program, connect, operate, and troubleshoot different pneumatic configurations. For optimum operating conditions, the incoming air pressure should be set between 550 kPa (80 psi) and 690 kPa (100 psi).

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.

Pneumatic devices 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.

Also, shut off the compressed air source before disconnecting any pneumatic tubing. 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).

About This Manual

Appendices

- Appendix A: *List of Equipment Required*, gives the list of equipment needed to perform the exercises.
- 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 the 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.
- Appendix G: *Hydraulics and Pneumatics Graphic Symbols*, depicts the main symbols related to the hydraulic and pneumatic application fields.

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 Electro-Pneumatic System

Pneumatic systems (single cylinder control)

In day-to-day life, compressed air can be used to inflate a bike or car tire or to clean an area. But compressed air can also be used as a driving force that gives motion to pneumatic tools. For example, a pneumatic drill or a nailgun (see Figure 1) can be operated with compressed air.



Figure 1. Air nailer.

The term pneumatics implies the use of the force of compressed air to induce movement. Here are a few industrial applications of pneumatics:

- Pick up and move items
- Apply force
- Screw, drill, or nail

Advantages of pneumatic systems:

- Air is easy to find, store and dispose of
- Easy to install
- No need for return piping
- Not messy (as opposed to hydraulic oil)
- Safe (no fire and explosion hazards, controlled pressure)
- Reliable

Disadvantages of pneumatic systems:

- Noisy (although dampers help reduce the noise)
- Higher cost in energy than electricity and hydraulics
- Speed control is difficult due to air compressibility
- Need of air filtering, humidity control, and lubrication

The Electro-Pneumatic System

The Electro-Pneumatic System includes three modules:

- Station Control Valve (P/N 3217)
- Electro Pneumatic Module (P/N 3292)
- Pressure Regulator (P/N 3216)

Figure 2 shows the Station Control Valve. This module contains two 4-way/2-position directional valves with common input and exhaust ports. One valve is operated by two solenoids and the other one is operated by a single solenoid with spring return.

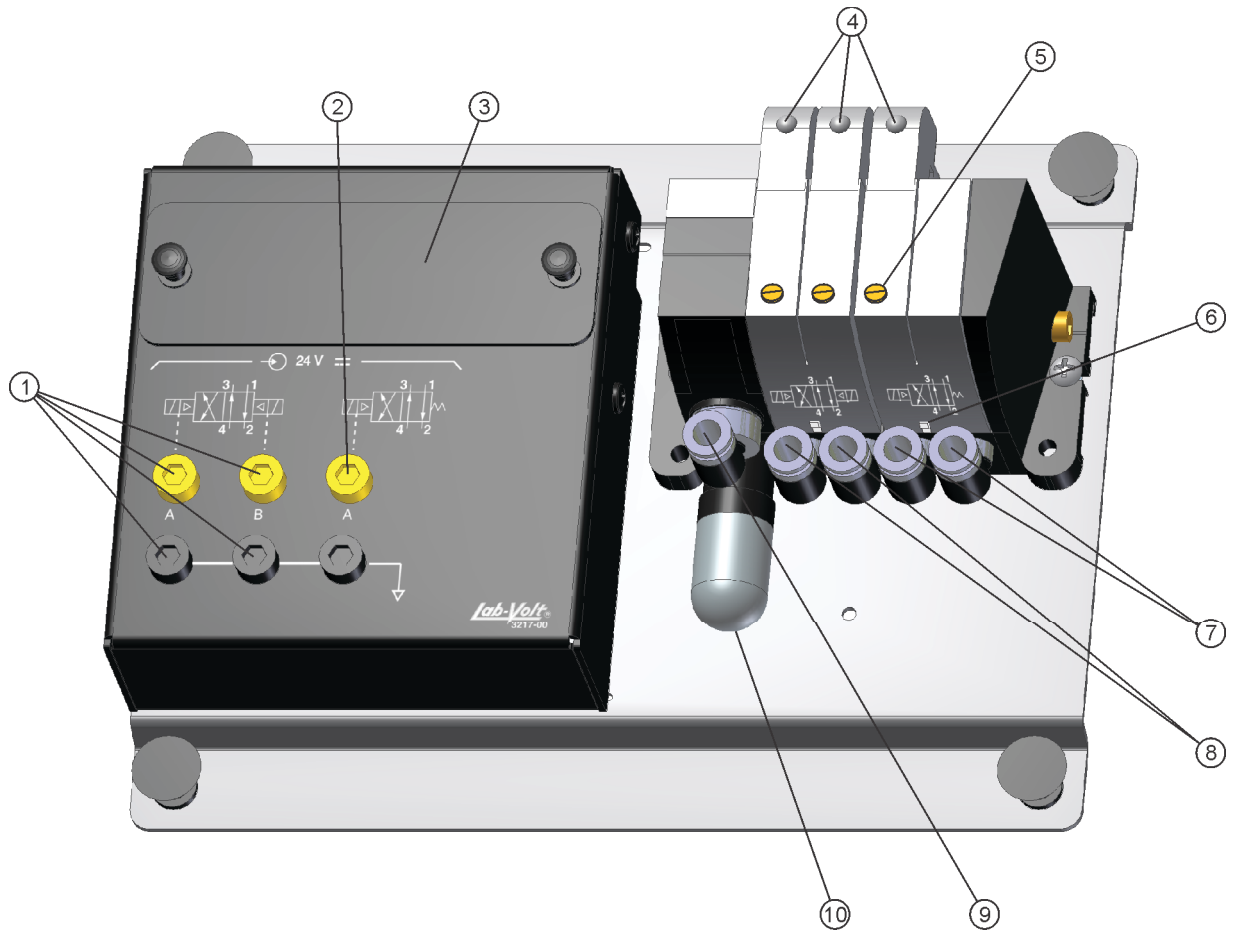


Figure 2. Station Control Valve, Model 3217.

1. Double solenoid valve terminals
2. Single solenoid valve terminals
3. Fault panel
4. Indicating LEDs
5. Manual override
6. Pneumatic connector lock/unlock
7. Single solenoid valve ports (2 and 4)
8. Double solenoid valve ports (2 and 4)
9. Input port (1) for both valves
10. Exhaust port (3) with a muffer for both valves

A solenoid-operated control valve uses low-voltage control signals to actuate a coil directing air flow into a pneumatic circuit. Figure 3 shows how a control valve works.

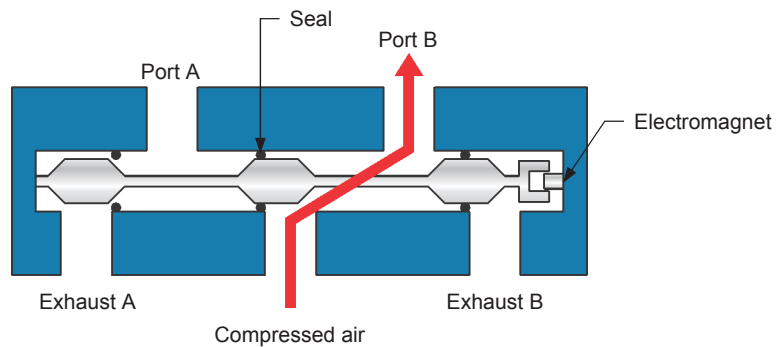


Figure 3. Control relay and control valve operation.

The solenoid operated valves supplied with your trainer are of the solenoid-pilot operated type. In this type of valve, the electric current flowing through the solenoid coil produces a magnetic field that moves a plunger. Moving the plunger opens a flow path and allows the pilot pressure to act on the valve spool. Note that the spool of the valve will not move if compressed air is not supplied to the valve even though an electric current flows through the solenoid.

Figure 4 shows the Electro-Pneumatic module. This module features two pneumatic cylinders and three proximity detectors arranged so as to:

- deliver marbles from two tubes to a box, or
- perform a clamp and work operation on a plane surface.

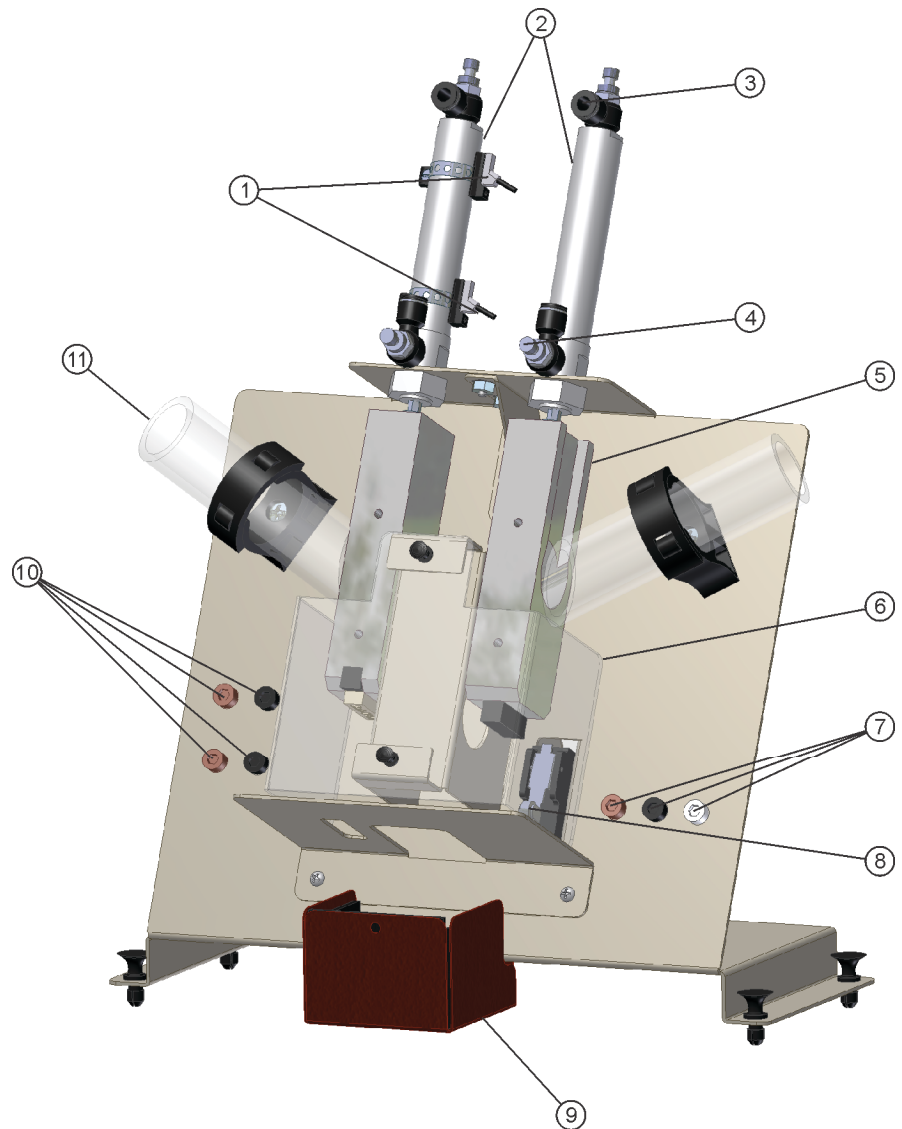


Figure 4. Electro-Pneumatic module, Model 3292.

1. Reed switches.
2. Pneumatic cylinders.
3. Pneumatic port.
4. Cylinder valve.
5. Distribution mechanism.
6. Protective shield.
7. Limit switch terminals.
8. Limit switch.
9. Marbles container.
10. Reed switches terminals.
11. Incoming marbles piping.

Figure 5 shows the Pressure Regulator module. This device offers two different air flow paths: one that is not regulated (labelled "2"), and one that is limited in pressure by a rotary knob (labelled "4").

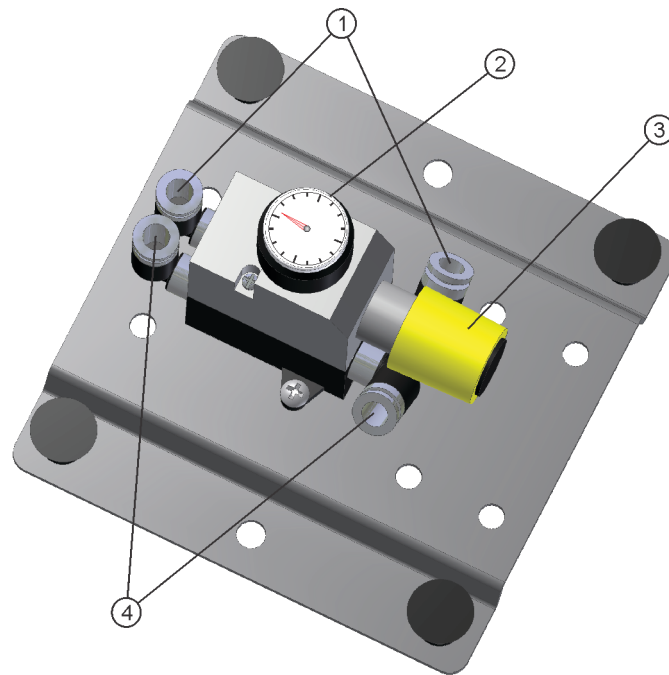


Figure 5. Pressure Regulator, Model 3216.

1. Pass-through port.
2. Regulated pressure gauge.
3. Pressure adjustment knob.
4. Regulated-pressure port.

The Electro-Pneumatic System requires a compressed air generator. An optional portable air compressor (P/N 6410-A0) and a Conditioning Unit (P/N 6411-A0) can be provided by our company for that purpose.

The system control section operates on low voltage provided by a 24 V dc power supply located inside the PLC module (P/N 3240). The PLC is programmed and monitored using a computer running a ladder programming software.

Familiarization with the Electro-Pneumatic System

OBJECTIVE Test the operation of some basic pneumatic components.

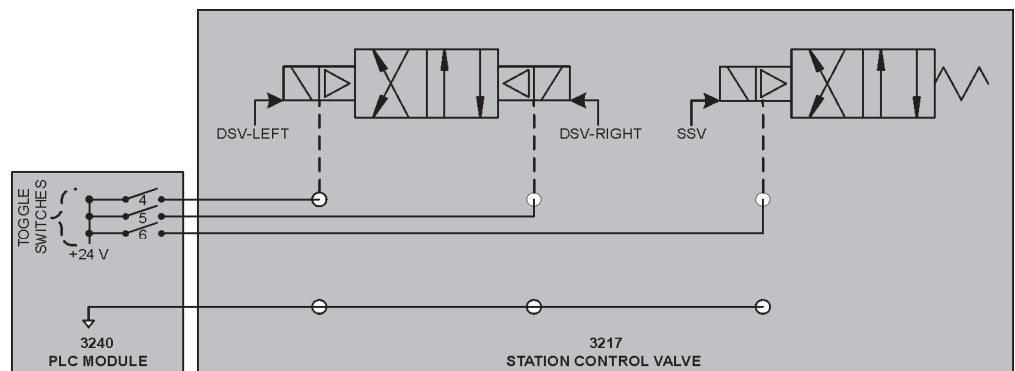
PROCEDURE



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 Station Control Valve

1. Connect the Station Control Valve to the PLC module, as shown in Figure 6.



DSV = DOUBLE-SOLENOID VALVE
SSV = SINGLE-SOLENOID VALVE

Figure 6. Station Control Valve test circuit.

Table 1. Job Sheet 1 electrical connections.

PLC module port	Connected to
Switch 4 (Toggle)	Double Solenoid Valve Left Terminal
Switch 5 (Toggle)	Double Solenoid Valve Right Terminal
Switch 6 (Toggle)	Single Solenoid Valve Terminal

2. Verify that each toggle switch turns on a specific LED on the Station Control Valve.



When an LED is on, this means that the corresponding valve solenoid is actuated. Refer to the symbols printed on the valve to determine how the pneumatic ports are now interconnected. Hydraulics and Pneumatics Graphic Symbols are presented in Appendix G.

Familiarization with the Electro-Pneumatic module

3. Take the Electro-Pneumatic module and remove the safety shield. No lead or pneumatic tubing is connected to the module and the compressed air source is closed.
4. What type of cylinders are present on the module (both cylinders are of the same type)?
 - a. Single acting, spring return
 - b. Single-end rod, double acting
 - c. Double-end rod, double acting

b. Single-end rod, double acting

5. Open (unscrew) the left cylinder valves to a maximum and close (screw) the right cylinder valves completely. Move both sides of the distribution mechanism with your hands (but do not use excessive force). Which arm moves the more easily?

The left cylinder with open valves.



The right cylinder hardly moves and should return to its original position by itself because the air is trapped inside the cylinder.

6. Open the right cylinder valves half way. Which cylinder rod moves faster if you apply with your hands the same force on both sides of the distribution mechanism?

The left cylinder with valves completely open moves faster for the same applied force.

7. Put back the safety shield on the Electro-Pneumatic module. Connect the pneumatic tubing on the Station Control Valve and the Electro-Pneumatic module as shown in Figure 7. Refer to Table 1 for the Station Control Valve electrical connections.



To avoid air leaking from the connectors, make sure that plastic tubes are cut clean and inserted deep enough into the connectors.

Plastic tubes are removed by pressing the release button towards the body of the connector before pulling out the tubing.

8. Open the compressed air source. Actuate one solenoid at a time with the help of the toggle switches. Do the cylinder rods on the Electro-Pneumatic module extend and retract according to the symbols printed on the front of the valves?

Yes No

Yes

Depress the yellow manual override controls located on top of the double solenoid valve. Does this make the cylinder rod extend and retract?

Yes No

Yes

9. Shut off the compressed air source.

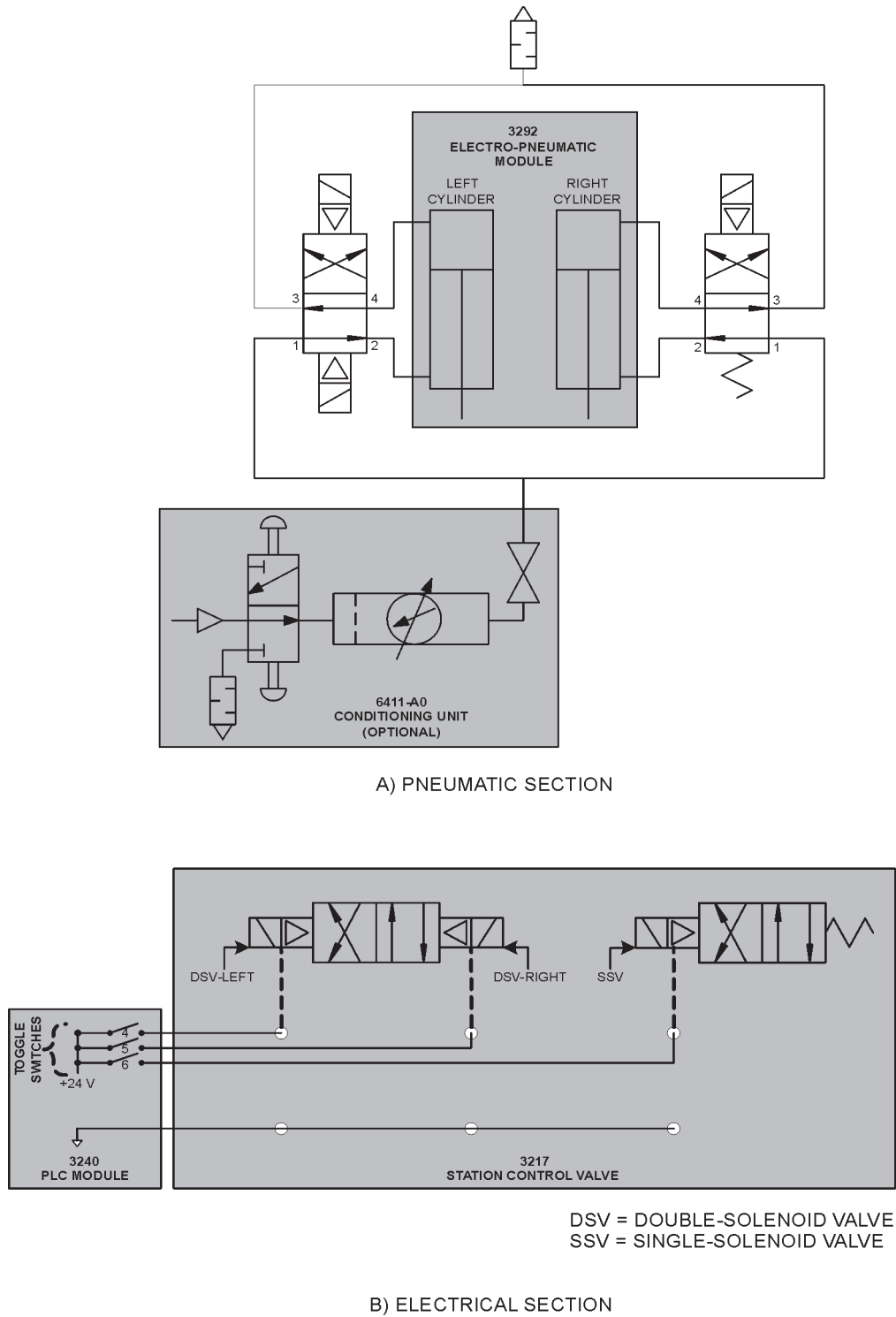


Figure 7. Electro-Pneumatic module test circuit.

Familiarization with the Pressure Regulator

10. Install the Pressure Regulator and connect it to the pneumatic circuit according to Figure 8. Refer to Table 1 for the Station Control Valve electrical connections.

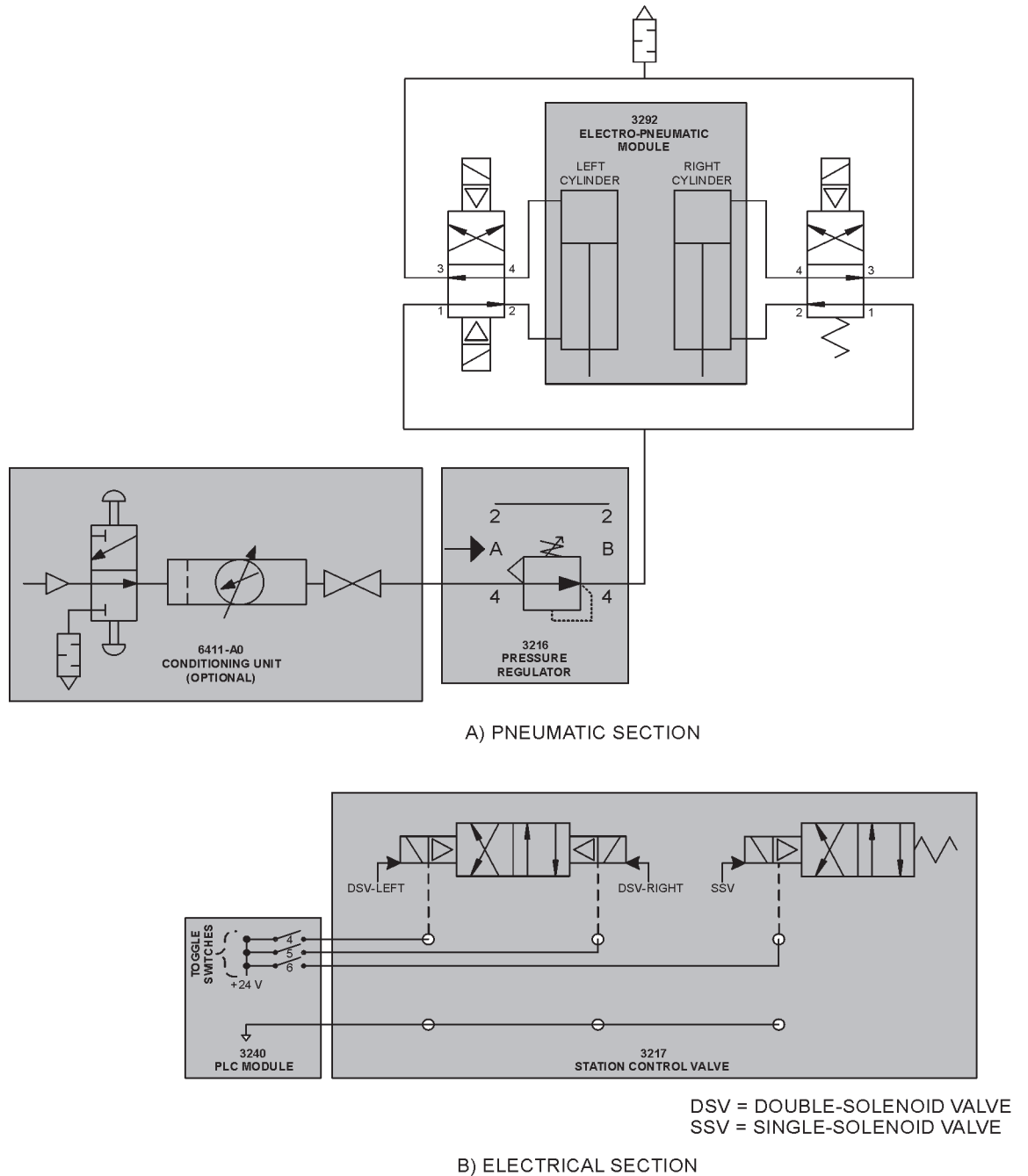


Figure 8. Pressure Regulator test circuit.

11. Open the compressed air source. Can you obtain air pressure greater than that of the compressed air source by turning the manual knob?

Yes No

No

12. Adjust the pressure knob to obtain a pressure of 80 psi. Actuate the single solenoid valve.

13. Adjust the pressure knob to obtain a pressure of 40 psi. Does the cylinder rod move faster when the single-solenoid valve is actuated with this new pressure setting?

Yes No

No

14. Shut off the compressed air source.

15. Disconnect and store all leads and components.

Name: _____ Date: _____

Instructor's approval: _____

