

## IND220: Lab 4.2: AS Continuous Operation with Electrical/PLC Control

Upon completion of this lab procedure, the student should be able to:

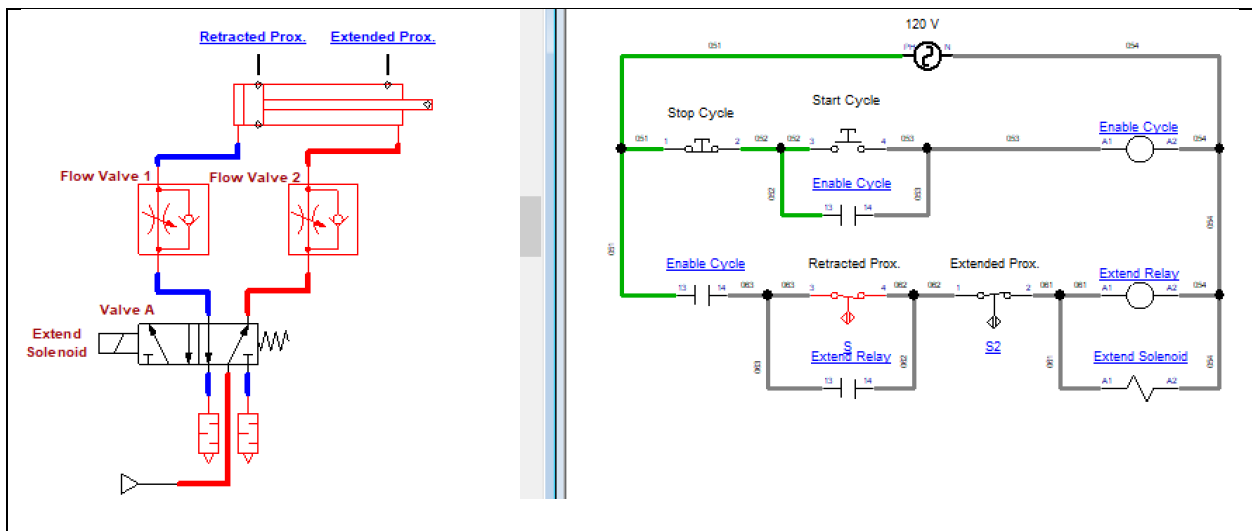
1. Explain how a flow control valve varies the speed of a cylinder
2. Explain how proximity switches in a circuit is used to monitor a cylinder rod
3. Explain how an electrical control circuit controls the operation of a pneumatic circuit
4. Identify the sections of a PLC used in Automation Studio
5. Determine what signals are coming into and going out of a PLC based on indicator lights
6. Interpret the PLC I/O addressing of a PLC in Automation Studio
7. Determine what input and output instructions should be highlighted in a PLC program

*\*This lab should be performed on the student's virtual machine. Automation Studio is a simulation software that will allow the users to build pneumatic and electrical circuits, then simulate the circuits running.*

### Part 1: Go into the Virtual Machine to access Sakai.

\*Log into the Virtual Machine, then open Sakai, then navigate to the IND220 course (sites).

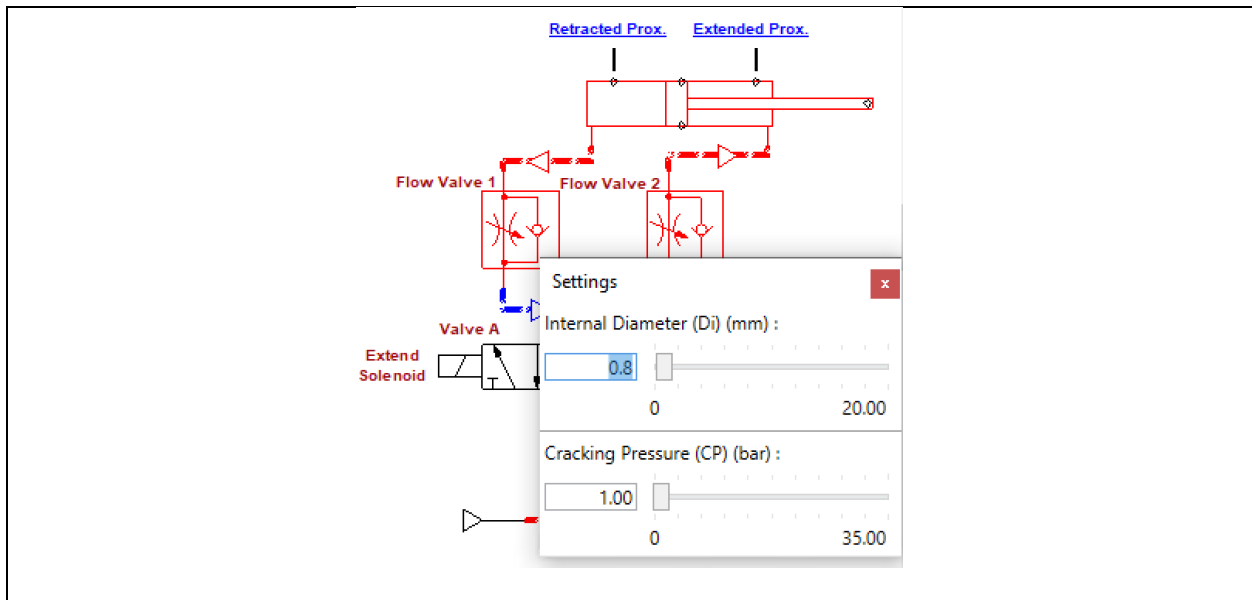
\*Go to Module 4 within Course Content. Click on the .PRX file: IND220 Lab 4.2 Circuit 1



**Figure 1. The pneumatic and electrical circuit in circuit 1 of this lab.**

1. The circuit shown in Figure 1 will be the circuit that will be run/simulated in Automation Studio.
2. The next step is to start the simulation. Click on the Start Simulation (Green) button in the top left corner of the Automation Studio screen to start the simulation.

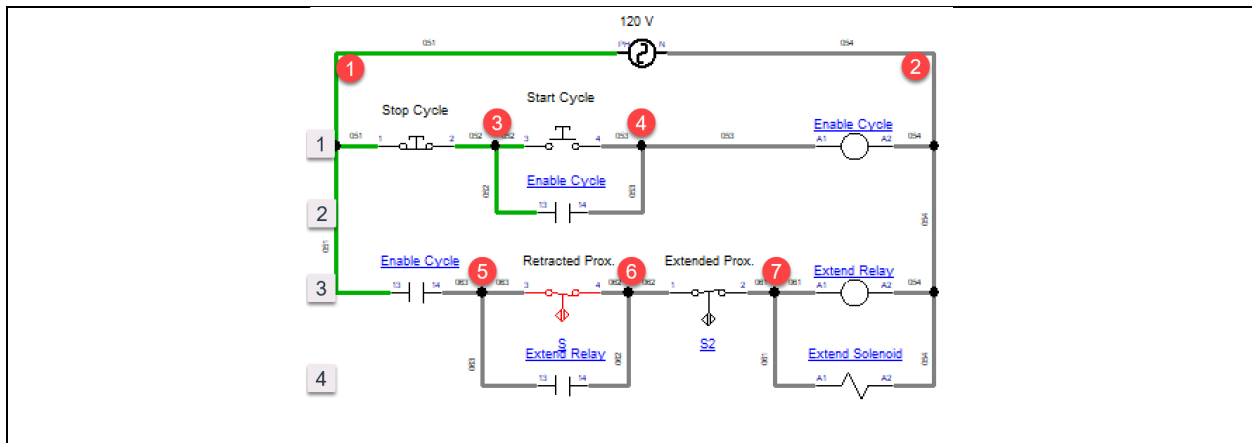
3. Click on the Start Cycle pushbutton to initiate the circuit:
  - a. Does the cylinder rod extend immediately? \_\_\_\_\_
  - b. When does the cylinder rod retract? \_\_\_\_\_
  - c. Does the cylinder automatically extend when Retracted Prox. is actuated? \_\_\_\_\_
  - d. Click the Stop Cycle pushbutton. How does the circuit respond? \_\_\_\_\_



**Figure 2. The proximity switch of Circuit 1.**

4. Notice in the pneumatic circuit Figure 2, that there is a flow control valve that controls the extension speed, and another flow control valve that controls the retraction speed. Click on the two valves to determine the internal diameters.
  - a. What is the Internal Diameter in Flow Valve 1? \_\_\_\_\_
  - b. What is the Internal Diameter in Flow Valve 2? \_\_\_\_\_
  - c. Click the Start Cycle to run the circuits.
  - d. Change the Internal Diameter of Flow Valve 1 to 0.5. How does the affect the operation of the circuit?

- e. Which flow valve controls the speed of extension? \_\_\_\_\_
  - f. Which flow valve controls the speed of retraction? \_\_\_\_\_
5. It is important to understand how the electrical circuit operates as shown in Figure 3.
- a. When the Start Cycle pushbutton is actuated, the Enable Cycle coil is actuated and it latches up through the Enable Cycle hold-in contact.
  - b. This enables the rung on line 3, and when the cylinder rod is fully retracted (NO retracted proximity switch is actuated) it powers the Extend Relay (and also the Extend Solenoid) and latches up through the Extend Relay hold-in contact on line 4, which since the Extend Solenoid is energized, the cylinder starts extending.
  - c. When the cylinder rod is fully extended, the Extend Prox. switch is actuated, which opens the power going to the Extend Relay, thus the Extend Solenoid loses power, then the cylinder is retracting until it is fully retracted, and the cycle starts over automatically.
  - d. The circuit operation will stop if the Stop Cycle pushbutton is clicked.



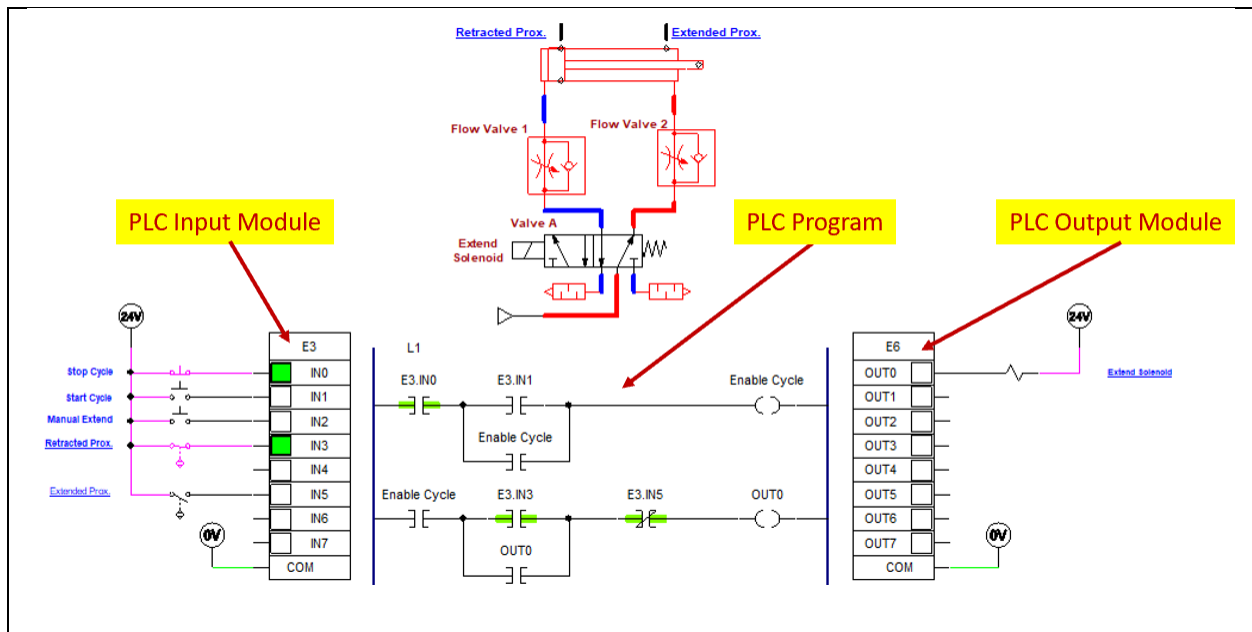
**Figure 3. The electrical control circuit for Circuit 1.**

6. Click the Start Cycle to initiate the circuit.
- a. What voltage is measured between wires 4 and 2? \_\_\_\_\_
  - b. What voltage is measured between wires 5 and 2? \_\_\_\_\_
  - c. When the cylinder is fully retracted, what is the voltage between 6 and 2?
  - d. When the cylinder is fully retracted, what is the voltage between 7 and 2?

- e. When the cylinder is fully extended, what is the voltage between 7 and 2?
7. Click the Stop Cycle pushbutton to stop the circuit operation.
  - a. What voltage is measured between wires 4 and 2? \_\_\_\_\_
  - b. What voltage is measured between wires 5 and 2? \_\_\_\_\_
8. Stop the simulation.

**Part 2: Controlling the Circuit with a PLC:**

- \*Log into the Virtual Machine, then open Sakai, then navigate to the IND220 course (sites).
- \*Go to Module 4 within Course Content
- \*Click on the .PRX file named IND220 Lab 4.2 Circuit 2

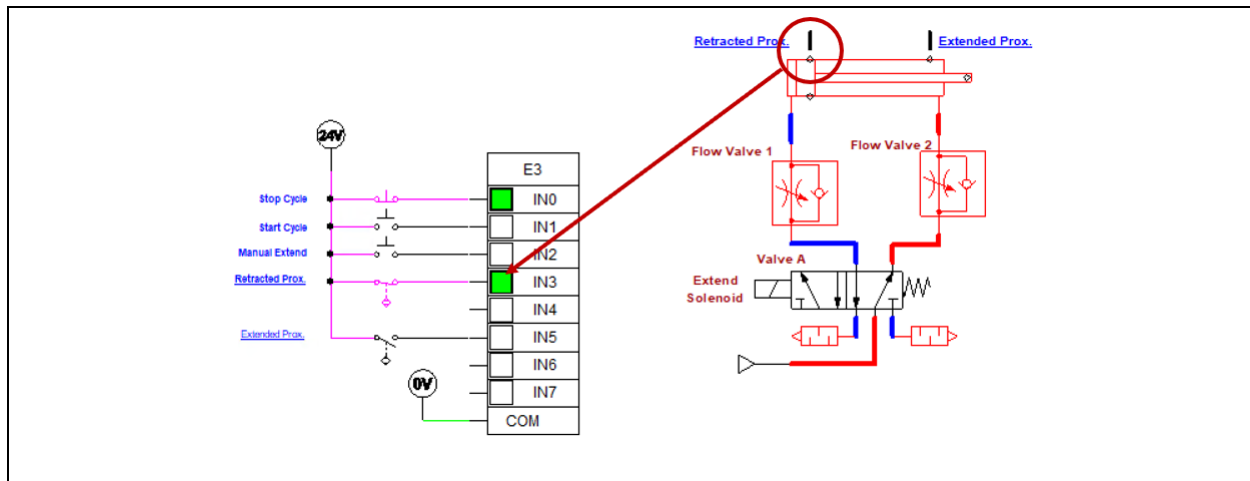


**Figure 4. A PLC circuit controlling the continuous operation circuit.**

9. Figure 4 shows circuit 2 of this lab. Notice that in this simulation a PLC is controlling the same pneumatic circuit as was in Circuit 1 of this lab. The PLC system consists of the PLC Input Module, the PLC Program and the PLC Output Module.
10. Figure 5 shows the input module and the input devices connected to it. It is important to note that the proximity switches are input devices, thus they connect to the input module. In this case the Retracted Prox. switch is actuated, since the cylinder is fully retracted.

Since this proximity switch is wired normally-open, it will send a signal into the PLC input module when actuated (IN3), thus turning on the input indicator light. Also, since the stop pushbutton (connected to IN0) is shown as normally-closed, the input indicator light will be on since the pushbutton is sending signal (24Vdc) into the input terminal of IN0.

The correlation between the status of the input and the input indicator light is important.



**Figure 5. The PLC input module.**

11. Click the Start Cycle PB.
  - a. Does the input indicator light for IN1 come on? \_\_\_\_\_
  - b. Does the cylinder rod extend immediately? \_\_\_\_\_
  - c. Does the input indicator light for IN1 shut off when the Start Cycle is released?
  
12. Figure 6 shows the PLC program that is controlling an output (Extend Solenoid) on the PLC output module. It is important to understand that real world outputs (solenoids, motor starter coils, indicator lights, etc.) are wired to the PLC output modules. These outputs are turned on by output instructions (typically termed coils in the PLC program). Notice that the OUT0 coil in the PLC program has highlight, which means the coil is turned on, thus the output indicator light is turned on, which should turn on the solenoid that is connected to it.
  
13. **Important:** In a PLC program, an input instruction (normally-open or normally-closed) that has highlight indicates the instruction has logic continuity. If an output instruction

(coil in the program) is highlighted it means that the address assigned to the output instruction (such as OUT0) is turned on.

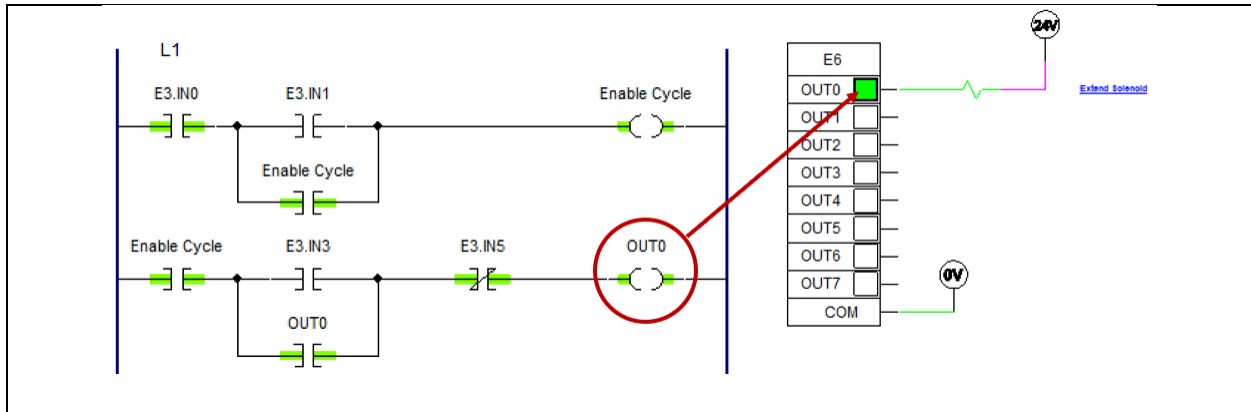


Figure 6. The PLC program turning on an output.

14. **Figure 7 shows an important correlation:** If an input indicator light is on, such as E3.IN3, any normally-open instructions with that address in the PLC program will be highlighted, which means they have logic continuity.

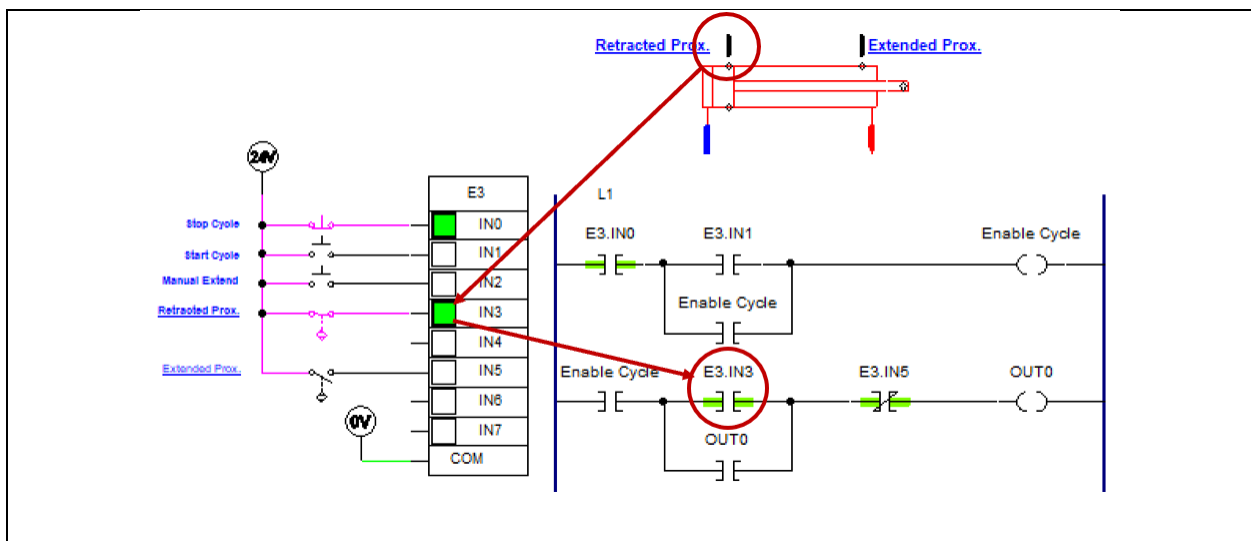
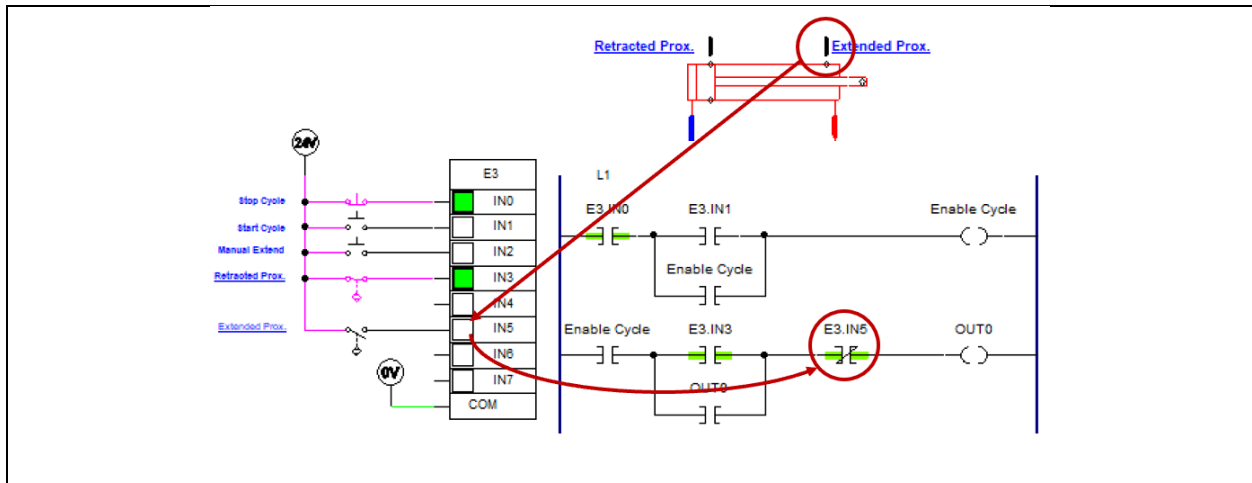


Figure 7. Normally-open instruction has highlight if input is on.

15. **Figure 8 shows an important correlation:** If an input indicator light is off, such as E3.IN5, any normally-closed instructions with that address in the PLC program will be highlighted, which means the instruction has logic continuity.

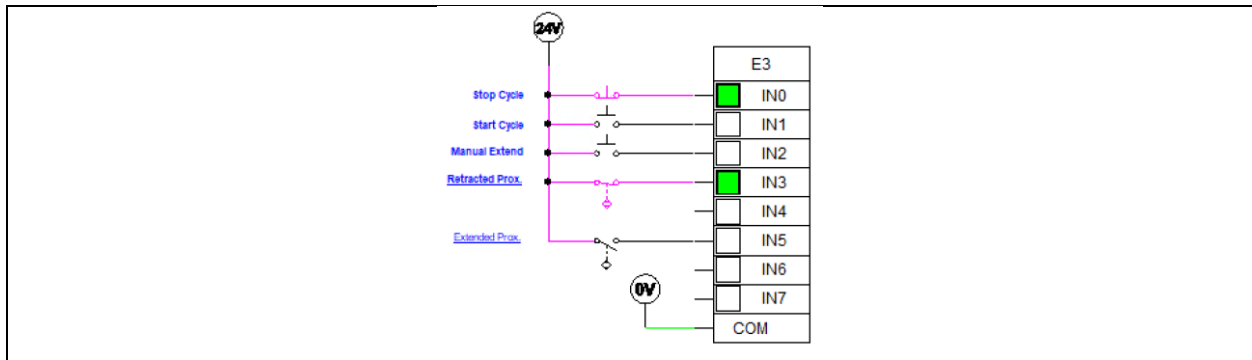


**Figure 8. Normally-closed instruction has highlight if input is off.**

16. Start the program by initiating the Start Cycle input. Verify the operation of the system by observing the input indicator lights and the PLC program.

17. Stop the simulation.

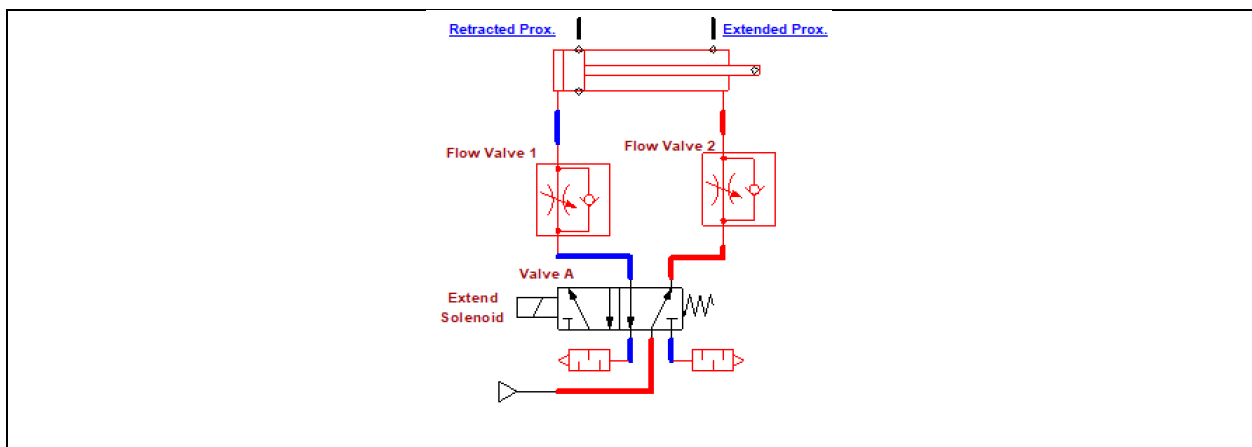
**Review Questions:**



**Figure 9. Automation Studio PLC Input Module.**

1. What is the input address for the Extended Prox. switch in Figure 9?
  - a. E1.IN5
  - b. E3.IN5
  - c. E3.IN3
  - d. E1.IN3
  
2. Based on the status of the input indicators shown in Figure 9, what is the location of the cylinder rod in the pneumatic circuit?

- a. Cylinder rod is extending
  - b. Cylinder rod is retracting
  - c. Cylinder rod is fully extended
  - d. Cylinder rod is fully retracted
3. T F If the Extend Relay is energized in Figure 3 (control circuit for circuit 1) the Extend Solenoid should also be on, extending the cylinder rod.
4. In an actual PLC controlled machine in an industrial environment, where is the PLC program located that is controlling a machine?
- a. In the PLC input module
  - b. In the PLC processor
  - c. In the PLC output module
  - d. In the PLC power supply

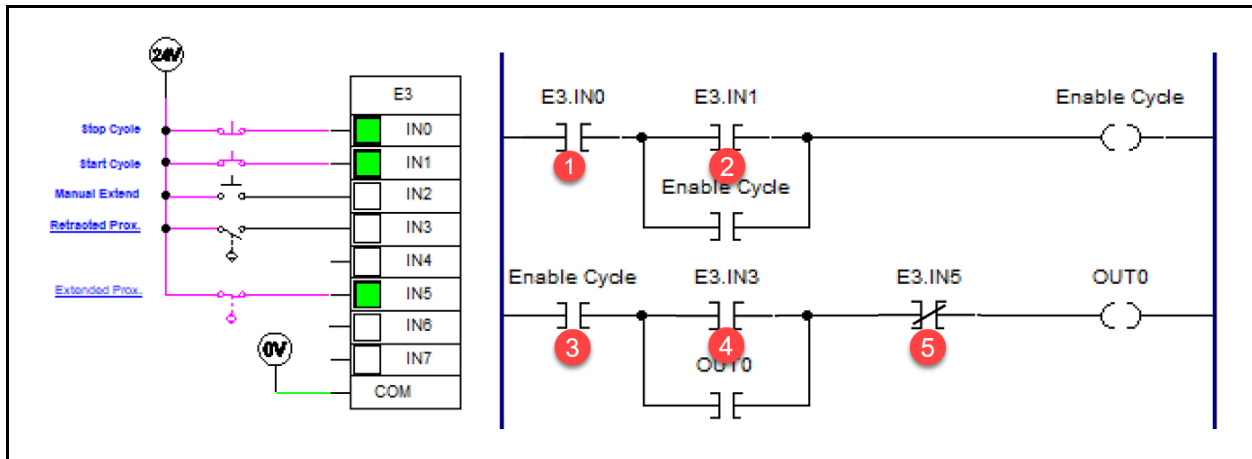


**Figure 10. The pneumatic circuit in Lab 4.2.**

5. Which flow control valve in Figure 10 controls the speed of the cylinder rod during retraction?
- a. Flow Valve 1
  - b. Flow Valve 2
  - c. Neither, the extension speed is controlled by the 5/2 directional control valve
6. T F Flow Valve 1 in Figure 10 will control the air flow in both directions with the needle valve.
7. What could be wrong if in Figure 1, the cylinder is fully retracted, but will not extend when the Start Cycle pushbutton is actuated, yet the Enable Cycle relay pulls in, but the Extend Relay does not? (Choose all that apply)
- a. The Extended Prox. switch is faulty

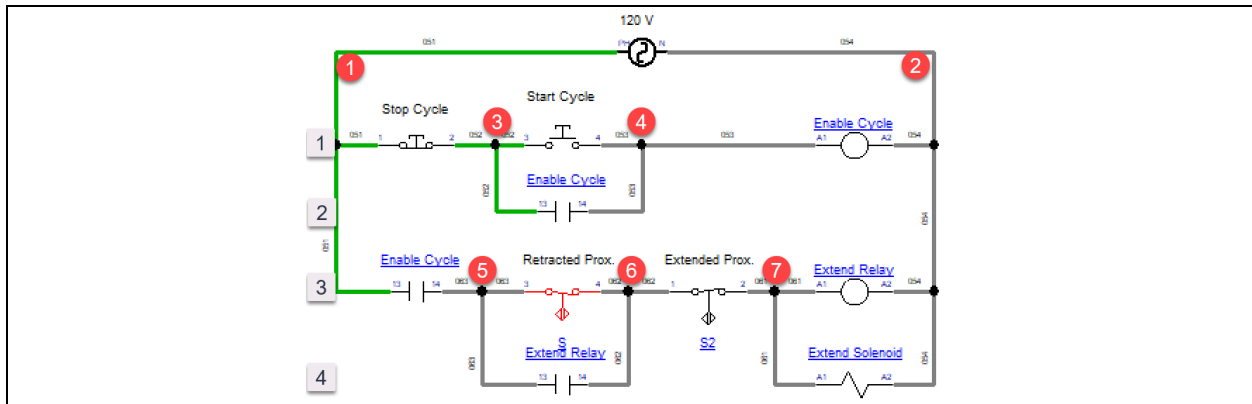


- b. The Retracted Prox. switch is faulty
- c. The 120 Vac input power is lost
- d. The Extend Solenoid is bad



**Figure 11. Control circuit for circuit 2.**

8. Which input instructions (identified by a number) in Figure 8 are highlighted based on the inputs and the program?
  - a. 1, 2, 3, 4 and 5
  - b. Only 1, 2 and 3
  - c. Only 1, 2, 3 and 4
  - d. Only 2, 3, 4 and 5
  
9. What will happen to the extension speed of the cylinder rod if the internal diameter of the flow control valve controlling extension speed is reduced?
  - a. Cylinder rod speed increases
  - b. Cylinder rod speed decreases
  - c. Nothing, the flow control valves do not affect the speed of a cylinder rod
  - d. The internal diameter does not affect the speed of the cylinder rod



**Figure 12. The electrical circuit from circuit 1.**

10. What type of proximity switch is located between wires 5 and 6 in Figure 12?
  - a. Normally-open proximity switch
  - b. Normally-closed proximity switch
  - c. Cannot determine from this graphic
  
11. What will the voltage measure between wires 7 and 2 in Figure 12, if the cylinder rod is fully extended?
  - a. 0 V
  - b. 120 Vac
  
12. What part of the PLC system will determine the sequence of operation of a machine that is controlled by the PLC?
  - a. PLC Input Module
  - b. PLC Output Module
  - c. PLC Program
  - d. All of the listed options