**Week 1 – Familiarization with simple pneumatics**

Learning Objectives

The student who successfully completes this lab will be able to:

* Identify and explain the function of a lubricator in the conditioning stage of a pneumatic system
* Identify and explain the function of a filter
* Identify and explain the function of a regulator
* Identify the types of pneumatic actuators from their schematic symbols
* Explain the difference between single-acting and double-acting cylinders
* Identify and explain the function of manual, air piloted, and solenoid-actuated valves
* Draw schematic symbols for pneumatic components
* Draw the schematic diagram of a simple pneumatic circuit
* Build simple pneumatic circuits based on given schematic
* Describe the function of air logic circuits
* Identify applications for air logic circuits
* Explain the direction of air flow within a pneumatic circuit
* Troubleshoot any faults that occur in the construction or operation of a pneumatic circuit

Equipment (typical example components from SMC are listed in parentheses)

* Manual switch (VHK2-04F-04F)
* Shuttle valve (VR1210F-04)
* T-valve (KQ2T04-00A)
* Two 3/2 NC single solenoid valves (SYJ512-5LZD-M5)
* 5/2 NC single solenoid valve (SYJ5220-5LZD-C4)
* Speed controller (AS20002F-04)
* Double acting cylinder
* 4 mm diameter pneumatic tubing (TU0604BU-100)
* 5, 12, or 24 V power supply
* ULN2803 Octal driver
* Solderless breadboard

Procedure

This manual is intended as guide for the exploration of some basic concepts in pneumatics. The experiment is divided into three sections to help students become familiar with simple pneumatics circuits and pneumatic components.

Pneumatic systems operate with pressurized air and they require safe and responsible handling in the laboratory. Careless handling may result in injuries and damage to components. BE CAREFUL, and follow instructions in constructing and operating your pneumatic circuits.

When you are doing this lab, build the pneumatic circuits following the steps below and make observations on how the components react to input signals. Take notes where needed for your post-lab report.

**Part 1 – Pneumatic Circuit for a Double Acting Cylinder**

1. Build the pneumatic circuit.
	1. Get five, 10-inch lengths of 4 mm OD pneumatic tubing
	2. Verify that your bench air manifold (the pipe with quick connect female fittings that is mounted to the bench) has air pressure and that the gate valve supplying its regulator is open. If the gate valve is not open, *stand to the side[[1]](#footnote-1)* of the pressure gage, and slowly open the gate valve, until the pressure gage reads about 60 psi.
	3. Look for the short section of ¼ in. tubing with a quick connect male fitting on one end and a ¼ in.-to-4 mm adapter on the other. Connect one of the 10 in. lengths of 4 mm OD tubing to the female end of the 4 mm adapter, and connect a manual finger valve to the other end of the 4 mm tubing. Pay attention to the arrows on the body of the finger valve, so you get the flow direction correct! Turn the finger valve, so that the knob is perpendicular to the flow arrow (as shown in Figure 1 below). This is the ‘off ‘ position. The finger valve will be your main ‘shut-off’ in case something goes haywire and you need to cut the air feed quickly.



Figure 1. Finger valve shown in the **OFF** state. Note that the arrows molded into the valve body show the direction for how air should flow through the valve.

* 1. Connect the finger valve assembly from the previous step to the air manifold that is mounted on the lab bench.
	2. Follow the piping and instrumentation diagram (PID) shown in Figure 2 to build the rest of the pneumatic circuit. You will need a T-connector after the finger valve to supply air to the two 3/2 solenoid valves. Note that the branch of the circuit that supplies air to the extension port on the double-acting cylinder output has *speed controller* between the solenoid valve and the extension port. Pay close attention to the markings on the body of the speed controller, so you get it in the orientation shown in the diagram. (Is this ‘metering in’ or ‘metering out’? What is your guess as to how it will affect the operation of the cylinder?) Make sure all of the tubing is inserted deeply enough into the fittings.
	3. Open the finger valve, and test the operation of the system using the manual override buttons on the solenoid valves. If you are satisfied that the system operates correctly, then you can move on to the next part of the experiment, where you will interface the PSoC to your system and use it to control the valves and cylinder.



Valve B

Valve A

Figure 2. First pneumatic circuit.

1. Interface your PSoC to the solenoid valves using the ULN2803 octal driver chip.
[**Be careful with your wiring in this part of the experiment**. The solenoid valves operate on 24 VDC, and this voltage will easily damage your PSoC if you are careless!!] See the diagram shown in Figure 3 below.
	1. Wire 24 V power (V+ and V-) from the power supply to the solderless breadboard power busses. Verify with a multimeter that you have 24 VDC between these busses.
	2. Insert the ULN2803 octal driver into the breadboard
	3. Connect available pins on the PSoC to the inputs of the ULN2803 octal driver
	4. Connect the black wires of the solenoid valves to two outputs of the ULN2803 octal driver
	5. Connect the red wires of the solenoid valves to +24 V on the breadboard
	6. **IMPORTANT**!!! Also connect pin 10 of the ULN2803 octal driver to +24 V on the breadboard. Do not proceed until you verify that this step has been done properly.
	7. Connect the PSoC GND, the ULN2803 GND (pin 9), and V- from the power supply at one location on the breadboard.



Figure 3. PSoC and power interface to the pneumatic system

1. Write a program for the PSoC that will let you control the operation of the system from the user button on the -044 board. You can modify the Blinking LED example from the recent PSoC lab session or if you run into trouble using the PSoC, you can use the sample code attached in the Appendix for the Arduino.
2. Investigate the possible combinations of valve states (ON if solenoid is activated or OFF if solenoid is not activated) and their effect on the cylinder piston. Fill out Table 1 below. Indicate whether the piston is extended or retracted, and note any observations about operation of the system.
3. Change the setting of the speed controller, and notice changes made to the movement of the cylinder piston.
4. When you are finished with the circuit close the finger valve

Table 1. Valve states (ON or OFF) and their effects on system operation for Part 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Valve A | Valve B | Piston | Observations/Comments on Operation |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |

**Part 2 – Pneumatic Logic Circuit 1**

1. Build the pneumatic system shown in Figure 4 below.
	1. Get five, 10-inch pieces of pneumatic tubing
	2. Connect the input to a manual finger valve
	3. Connect the manual valve to a 3/2 valve or to a manifold that has a 3/2 valve mounted on it.
	4. Connect an output of the 3/2 solenoid valve to the input of a portable 5/2 solenoid valve
	5. Connect the two outputs of the 5/2 solenoid valve to the double-acting cylinder



Valve B

Valve A

Figure 4. Pneumatic system for Part 2.

1. Investigate the possible combinations of valve states (ON if solenoid is activated or OFF if solenoid is not activated) and their effect on the cylinder piston. Fill out Table 2 below. Indicate whether the piston is extended or retracted, and note any observations about operation of the system.

Table 2. Valve states (ON or OFF) and their effects on system operation for Part 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Valve A | Valve B | Piston | Observations/Comments on Operation |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |

**Part 3 – Pneumatic Logic Circuit 2**

1. Build the pneumatic system shown in Figure 5 below.
	1. Get seven, 10-inch pneumatic tubing
	2. Connect the air input to a manual finger valve
	3. Connect the manual valve to a 3/2 valve or a manifold with 3/2 valves.
	4. Connect the outputs of the two 3/2 solenoid valves to the input of a shuttle valve
	5. Connect the output of the shuttle valve to the input of a 5/2 solenoid valve that has 4 mm ID female tubing connectors connected to it.
	6. Connect the two outputs of the 5/2 solenoid valve to the double acting cylinder



Valve C

Valve B

Valve A

Figure 5. Pneumatic system for Part 3.

1. Investigate the possible combinations of valve states (ON if solenoid is activated or OFF if solenoid is not activated) and their effect on the cylinder piston. Fill out Table 3 below. Indicate whether the piston is extended or retracted, and note any observations about operation of the system.

Table 3. Valve states (ON or OFF) and their effects on system operation for Part 3.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Valve A | Valve B | Valve C | Piston | Observations/Comments on Operation |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |

Deliverables

Document your findings from this lab experiment. Include in your report the following items:

* Circuit diagrams with formal ISO symbols. Visio and other programs have these symbols.
* Questions to be answered
	+ What is the function of a filter?
	+ What is the function of a regulator?
	+ What is the function of a dryer?
	+ What is difference between a single-acting cylinder and a double-acting cylinder?
	+ What is the function of a solenoid valve?
	+ What logical functions did the circuits execute?
	+ What does a speed controller do, and how does it affect operation of a cylinder?
	+ What does a shuttle valve do, and what can it be used for?
	+ What are some applications for these circuits?
* A truth table for each of the circuits (Tables 1-3)
* Fully documented code and circuit schematic.
* A Summary describing what was done, how it was done, and what was learned
* Conclusions and reflections on your observations

Appendix- Arduino code for driving solenoid valves

const int solenoid = 13;

// the setup routine runs once when you press reset:

void setup() {

 // initialize the digital pin as an output.

 pinMode(solenoid, OUTPUT);

}

// the loop routine runs over and over again forever:

void loop() {

 digitalWrite(solenoid, HIGH); // turn on

 delay(1000); // the delay before it turns off

 digitalWrite(solenoid, LOW); // turn off

 delay(1000); // the delay before it turns back on

}

1. You never want to directly face a glass covered pressure gage when you first apply pressure to it, so in the event of it blowing out, you don’t get a face full of glass shards. [↑](#footnote-ref-1)