ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

Electro-Pneumatics

Module 5: Sensors in Electro-Pneumatics

(Proximity switches and pressure switches)

PREPARED BY

Academic Services

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Module 5: Sensors in Electro-Pneumatics (Proximity switches and pressure switches)

Module Objectives

After the completion of this module, the student will be able to:

1. Differentiate between different types of sensors.
2. Explain the function and applications of reed proximity switches.
3. Explain the function and applications of optical proximity switches and sensors.
4. Explain the function and applications of pressure switches and sensors.

Module Contents

Introduction to Sensors

Sensors have the task of measuring information and passing this on to the signal processing unit of the control system in a form that can easily be processed. In electro-pneumatic controlling systems, sensors are primarily used for the following purposes:

1. To detect the advanced and retracted end position of the piston rod in cylinder drives.
2. To detect the presence and position of work piece.
3. To measure and monitor pressure.

The following sensors are widely used in the industry:

1. Limit switches
2. Proximity switches
    a. Reed switch
    b. Inductive proximity switch
    c. Capacitive proximity switch
    d. Optical proximity switch
3. Pressure switches

5.1 Proximity Switches

In contrast to the limit switches, proximity switches operated contactless (non-contact switching) and without an external mechanical actuating force.

As a result, proximity switches have a long service life and high switching reliability.

The following types of proximity switches are widely used in industry:

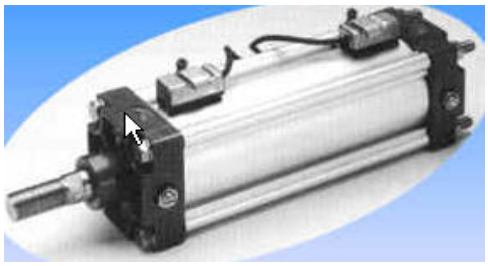
1. Reed switches
2. Inductive proximity switches
3. Capacitive proximity switches
4. Optical proximity switches.

5.1.1 Proximity reed switches (magnetic switches).

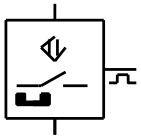
Proximity reed switches are magnetically actuated proximity switches and consist of a pair of contacts on ferrous metal reeds in a sealed glass tube filled with inert gas. The contacts may be normally open, closing when a magnetic field is present, or normally closed and opening when a magnetic field is applied. Proximity switches are fitted on the cylinder body as shown in (Fig.5.1.a) and as shown in this link: http://www.ifm.com/obj/gb_mk5101.swf

Reed switches have a long service life and a very short switching time. They are maintenance-free. Fig.5.1.b shows the ISO symbol of the proximity reed switch while Fig.5.1.c shown the internal construction and the operating status (before and after operation).

This link shows also a nice animation of the function of the reed switch:http://www.ifm.com/obj/gb_gm504s.swf

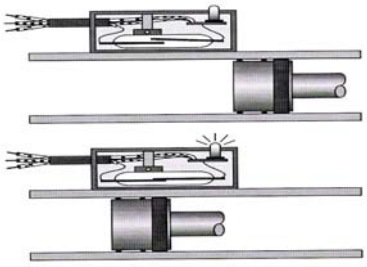


(a)



(b) I

(c)



(d) Reed switch fitted to

Fig. 5.1:

(a): Reed switch on a cylinder

(b): ISO of proximity reed switch

(c): picture of reed switch

(d): internal construction

5.1.2 Proximity optical sensors

Proximity optical sensors use optical and electronic means for object detection. Red or infra red light is used. Semiconductor light emitting diodes (LEDs) are particularly reliable sources of red or infra red light. They are small and rugged have a long service life and can be simply modulated. Photodiodes or phototransistors are used as receivers. Red light has the advantage that the light can be seen during the adjustment of the optical axes of the proximity switch. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets require different sensors. For example, a capacitive sensor is suitable for a plastic target while an inductive proximity sensor is suitable a metal target.

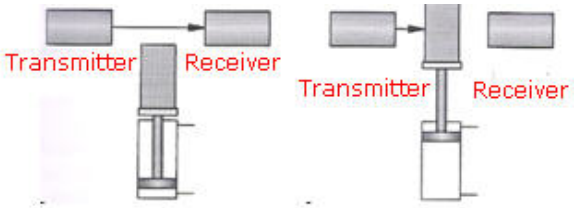
Proximity sensors have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Optical proximity switches can be divided to three different types:

1. One-way light barrier.
2. Receiver light barrier.
3. Diffuse reflective optical sensor.

5.1.2.1 One-way light barrier.

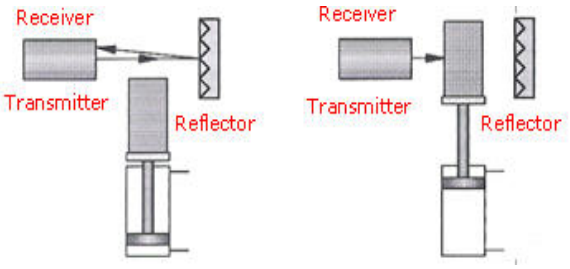
The one-way light barrier has spatially separate transmitter and receiver units. The parts are mounted in such a way that the transmitter beam is directed at the receiver. The output is switched if the beam is interrupted as illustrated in Fig.5.2.a.



(a)

5.1.2.2 Reflective light barrier.

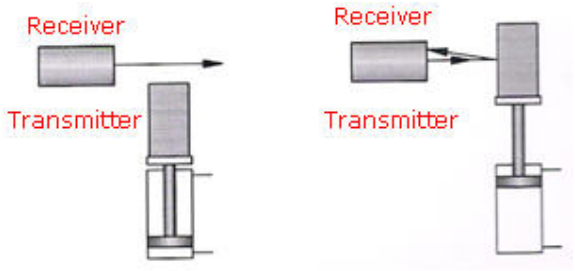
In the reflective light barrier the transmitter and receiver are mounted together in single housing. The reflector is mounted in such a way that the light beam transmitted by the transmitter is completely reflected to the receiver. The output is switched if the beam is interrupted as illustrated in Fig.5.2.b.



(b)

5.1.2.3 Diffuse reflective optical sensor.

In the diffuse reflective optical sensor, the transmitter and receiver are mounted together in one unit. If the light hits the reflective object. It is redirected to the receiver and causes the output of the sensor to switch interrupted



(c)

(d)

as illustrated in Fig.5.2.c.

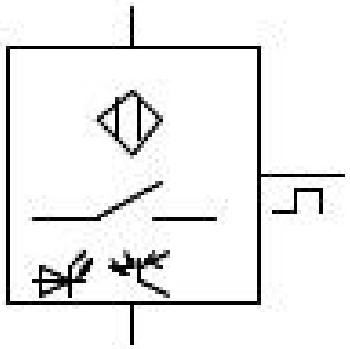
Fig.5.2.d shows the picture of the optical sensor while Fig.5.2.e shows the ISO symbol of the same.

Because the function principle, the diffuse reflective optical sensor can only be used if the material or machine part to be detected is highly reflective (for example polished metal surface, bright paint.

These two links show nice animations of the function of the diffuse reflective optical sensor:

http://www.ifm.com/obj/gb_oj5048.swf

http://www.ifm.com/obj/gb_o5h500.swf



(e)

Fig. 5.2

(a): One -way light barrier

(b): Reflective light barrier

(c): Diffuse reflective optical sensor

(d): picture of optical sensor

(e): ISO symbol of optical sensor

Practical Task 1

Title: Controlling (directly and indirectly) the oscillating movement of double acting cylinder using two magnetic reed switches.

Objectives:

Upon the completion of this task, the student should be able to

- Use electric relays.
- Use the magnetic reed switch as position sensor.
- Design an electric circuit that controls the stroke length and piston displacement.

Problem description:

The double acting cylinder shown in Fig.5.3 is used to generate an oscillating movement in order to provide a belt timely movement. When the pushbutton switch is triggered the piston rod starts oscillating. Two magnetic reed switches should be used to control the length of the forward and backward strokes.

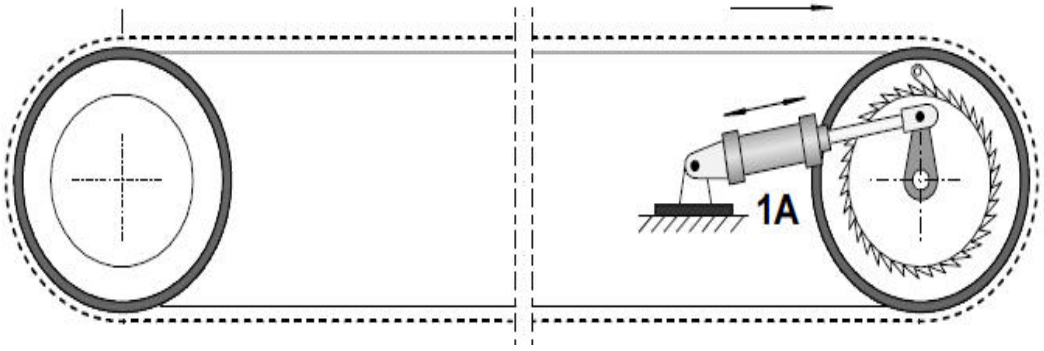


Fig.5.3

Required components:

1- Double acting cylinder

2- 5/2 Directional control valve, double solenoid

3- DC power supply

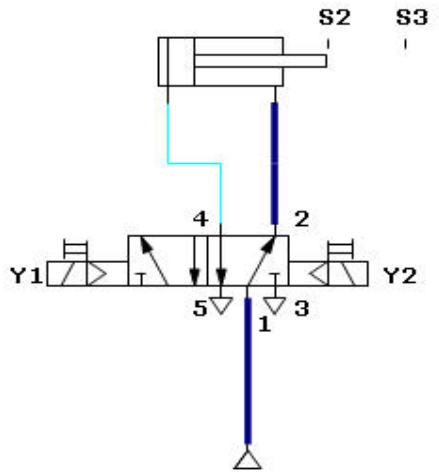
4- Switch blocks

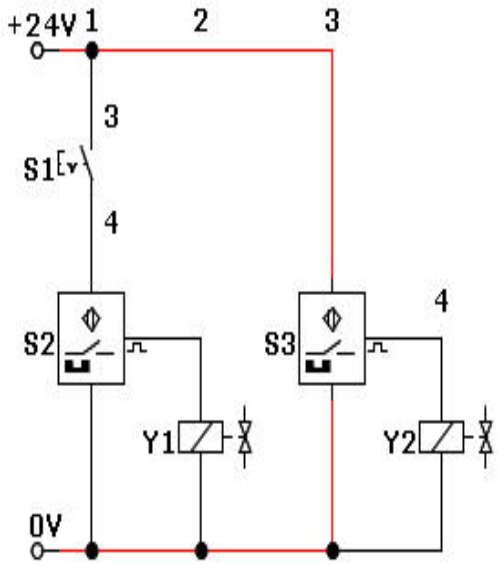
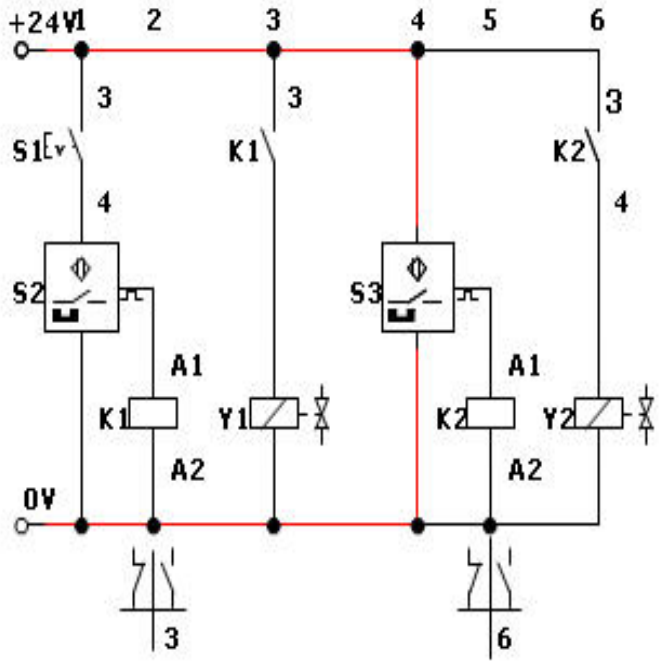
5- Magnetic reed switch

6- Relay block

Required procedures

1. Draw the electro-pneumatic circuit (direct control) using the FluidSim software and then convert the direct control circuit to indirect control circuit.
2. The speed of the forward and backward stroke of the cylinder rod is adjustable
3. Test the circuit functions against any errors or mistakes.
4. Construct the circuit on the workstation
5. Write down your notes and observations.

Pneumatic circuit


Electric circuit (direct control)	Electric circuit (indirect control)
	

Observations and notes

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Practical Task 2

Title: Controlling (directly and indirectly) the oscillating movement of double acting cylinder using magnetic reed switch and optical sensor

Objectives:

Upon the completion of this task, the student should be able to

- Use electric relays.
- Use the magnetic reed switch as position sensor.
- Use the optical sensor
- Design an electric circuit that controls the stroke length and piston displacement.

Problem description:

Use the same problem on task 1 above and instead of using two magnetic reed switches use one magnetic reed switch and one optical sensor.

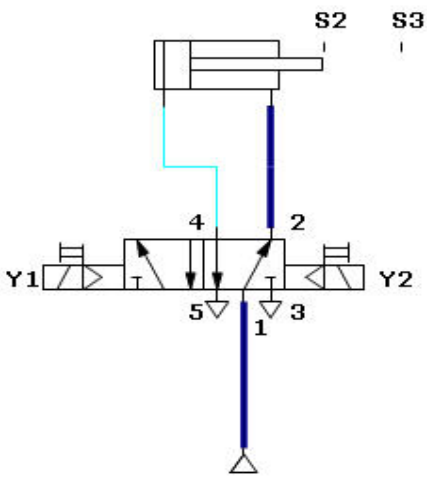
Required components:

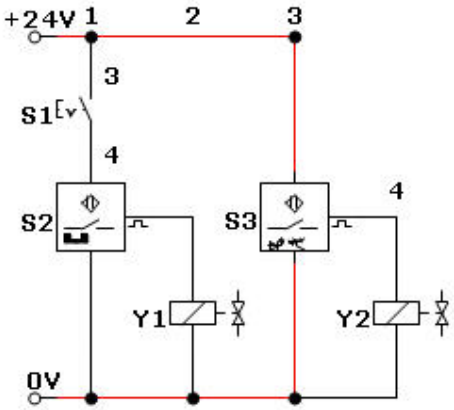
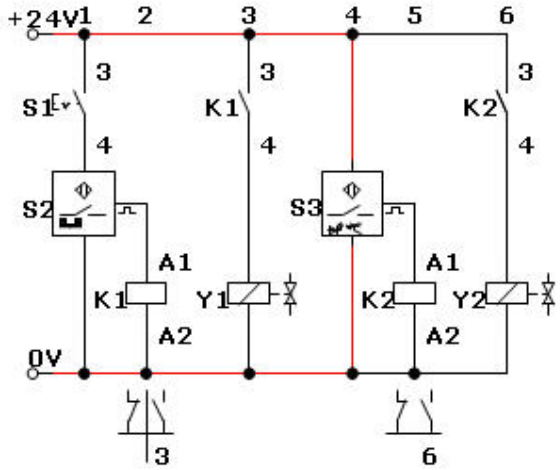
1. Double acting cylinder
2. 5/2 Directional control valve, double solenoid
3. DC power supply
4. Switch blocks
5. Magnetic reed switch
6. Optical sensor
7. Relay block

Required procedures

1. Draw the electro-pneumatic circuit (direct control) using the FluidSim software and then convert the direct control circuit to indirect control circuit.
2. The speed of the forward and backward stroke of the cylinder rod is adjustable
3. Test the circuit functions against any errors or mistakes.
4. Construct the circuit on the workstation

5. Write down your notes and observations.

Pneumatic circuit


Electric circuit (direct control)	Electric circuit (indirect control)
	

Observations and notes

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Practical Task 3

Title: Constructing a circuit that controls (indirectly) a double acting cylinder by using a magnetic reed switch and an optical sensor.

Objectives:

Upon the completion of this task, the student should be able to

- Use electric relays.
- Use the magnetic reed switch as position sensor.
- Use the optical sensor
- Design a latching circuit that controls the stroke length and piston displacement.

Problem description:

In a sorting machine, the single acting cylinder is used to feed different colored work pieces. Construct an electro-pneumatic circuit that controls the movement of the single acting cylinder according to the following conditions:

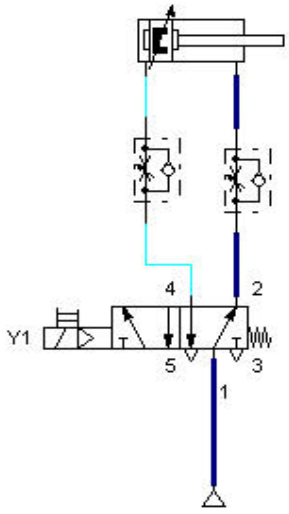
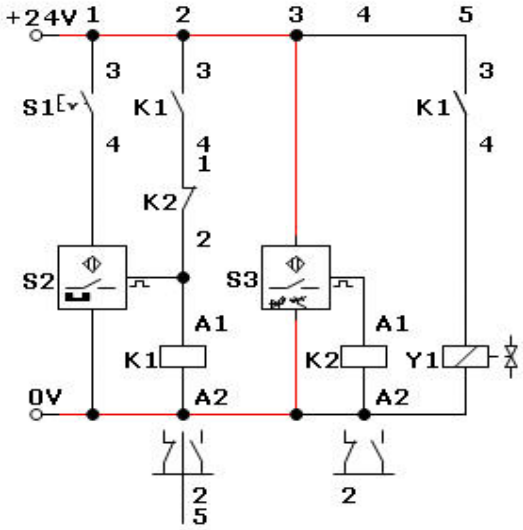
1- The cylinder rod has to be advanced only if it is fully retracted (initial position) by triggering a pushbutton switch
2- The cylinder retracts when it reaches its end position using an optical sensor

Required components:

1- Double acting cylinder
2- 5/2 Directional control valve, single solenoid
3- DC power supply
4- Switch blocks
5- Magnetic reed switch
6- Optical sensor
7- Relay block

Required procedures:

1. Draw the electro-pneumatic circuit (direct control) using the FluidSim software.
2. The speed of the forward and backward stroke of the cylinder rod is adjustable
3. Test the circuit functions against any errors or mistakes.
4. Construct the circuit on the workstation
5. Write down your notes and observations.

Pneumatic circuit	Electric circuit (indirect control)
	

Observations and notes

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Class work (1)

1. List two types of proximity sensor.

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2. Explain the function of an optical sensor? Give an application example.

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3. Draw the ISO symbol of a reed switch and an optical switch.

4. Compare between the reed switches and normal switches

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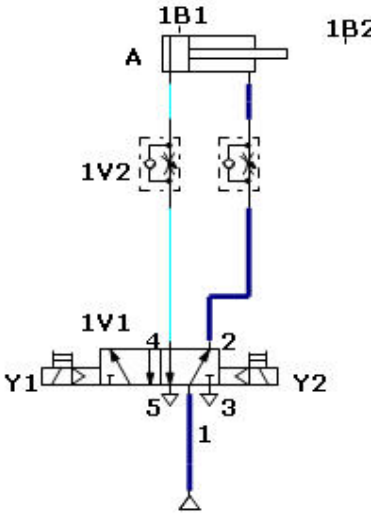
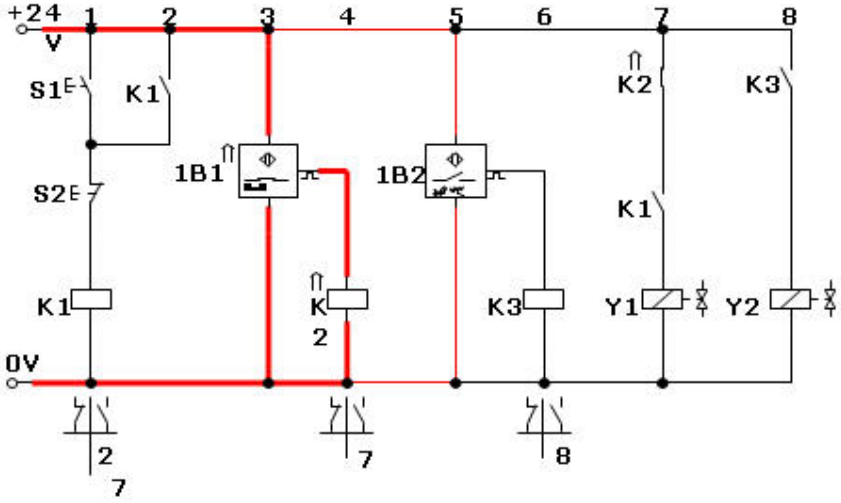
5. List three types of an optical sensor. Provide a sketch of each one.

Optical sensor	Sketch

Home Work (1)

The two circuits below represent an electro-pneumatic system. Answer the following:

Pneumatic circuit	Electric circuit
	

1. Name the listed items in the table below

1B1	
1B2	
S1	
S2	

2. What is the number of the branch that represents the latching circuit?

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3. What is the function of the switch S2?

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4. Referring to the electric circuit above, state the purpose of the symbol below circuits, 1, 4 and 6?

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5. The electric circuit above is <u>indirect control</u>. Convert this circuit to a direct control by eliminating all the relays from the circuit. *<u>Hint</u>: To obtain the same function use a detent switch instead of the push button switch S1.*

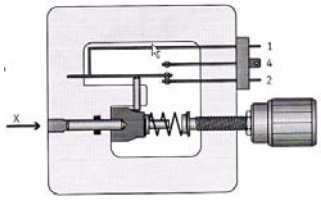
5.2 Pressure switches

A pressure switch is a form of switches that causes electrical contact when a certain preset pressure has been reached on its input. This is used to provide on/off switching from a pneumatic source. The switch may be designed to make contact either on pressure rise or on pressure fall. There are various types of pressure sensitive sensors and switches:

1- Pressure switch with mechanical contact.
2- Pressure switch with electronic switching.
3- Electronic pressure sensor with analogue output signal

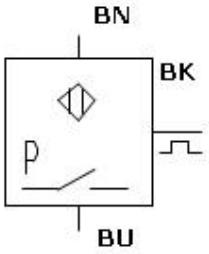
5.2.1 Mechanical pressure switch

In the mechanically actuated pressure switch, the pressure acts on a cylinder surface. If the exerted pressure exceeds the spring force of the spring, the piston moves and operates the electric contact as shown in Fig. 5.3.a



(a)

(b)



(c)

5.2.2 Electronic pressure switch

The pressure acts on a highly flexible diaphragm, whose deflection is measured by a sensitive electronic circuit. Instead of actuating a mechanical contact, the output

is switched electronically. The sensor signal is evaluated by the electronic circuit and as soon as the pressure exceeds the preset value, the output is switched on.

5.2.3 Electronic pressure sensor with analogue output signal.

It is used to provide an analogue output signal (the actual value of the working pressure)

(d)

Fig 5.4

(a): Piston-actuated pressure switch

(b): pressure sensor-ISO symbol

(c): pressure switch-ISO symbol

(d): Pressure sensor and switch

Practical Task 4

Title: Protecting a pneumatic system from the high pressure

Objectives:

Upon the completion of this task, the student should be able to

- Understand and use a pressure sensor.
- Understand and use a pressure switch.
- Use an electric relay.

Problem description:

The pneumatic systems are subjected to unexpected malfunctions (blockage or a compressor fault) that cause a severe raise in the pressure value. It is very crucial to protect the system against the high pressure by designing a suitable protection circuit. The pressure in the circuit is monitored using the pressure sensor. If the pressure in the circuit increases, the pressure switch will switch off the electric circuit and thus stops the pressure.

Required components:

1. Double acting cylinder
2. DC power supply
3. 5/2 DCV, single solenoid
4. Switch block
5. Pressure switch
6. Relays block

Procedures

1- Build the pneumatic circuit according to the pneumatic circuit as shown in Fig.5.5.a.

2- Connect the electric circuit according to the electric circuit as shown in Fig.5.5.b.

3- Check that all the parts are connected firmly with each other.

4- Switch the power supply on and open the service unit. Make sure that that the pressure in the circuit is adjusted to 6 bars.

5- Adjust the pressure sensor to 7 bars, or any value greater than the system pressure.

6- Press the switch S1 and note what happens to the cylinder piston. Does it extend?

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7- Adjust the pressure switch S2 to 5 bars or less than the system pressure and then press S1. Does the cylinder extend? Explain why.

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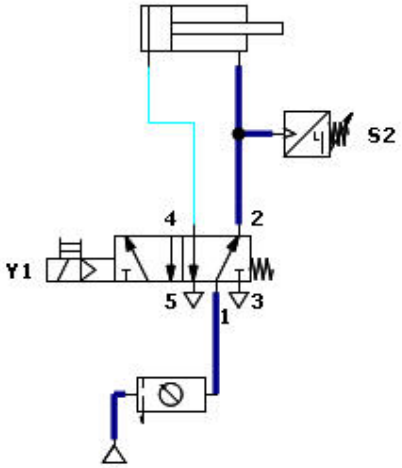
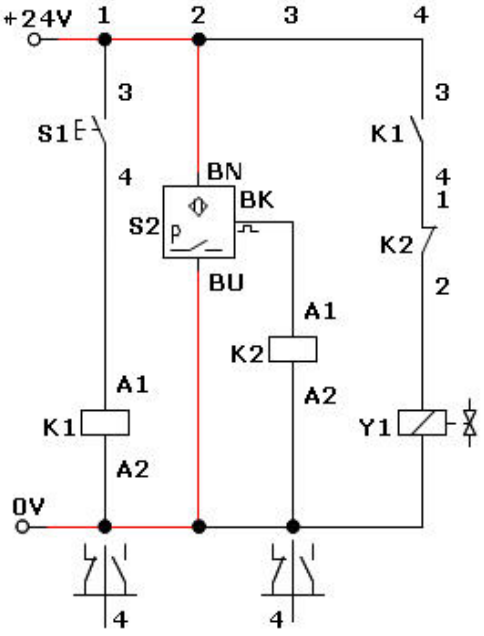


(a)



(b)

Fig.5.5

(a): Pneumatic circuit

(b): Electric circuit

8- Switch off the power supply. Disconnect the power from S3. Reconnect the power and press S1. Does the cylinder piston extend? Why?

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9- Switch of the power and the air supply and dismantle the circuit.

Observations and notes

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Practical Task 5

Title: Circuit protection against high pressure and low pressure

Objectives:

Upon the completion of this task, the student should be able to

- Understand and use a pressure sensor.
- Understand and use a pressure switch.
- Configure the pressure switch
- Use an electric relay.

Problem description:

In some pneumatic applications, the pressure should remain in a certain range. In order to achieve this, an electric circuit has to be designed in which the pressure should be monitored using the pressure sensors. If the pressure in the circuit increases due to any reason (tube blockage), the circuit should be terminated. If the pressure in the circuit also goes below the preset value of the pressure switch, the circuit has to be terminated.

Required components:

1. Double acting cylinder
2. DC power supply
3. 5/2 DCV, double solenoid
4. Switch block
5. Pressure switch magnetic reed switch
6. Relays block

Required Procedure:

1- Build the pneumatic circuit according to the pneumatic circuit as shown in Fig.5.6.a.

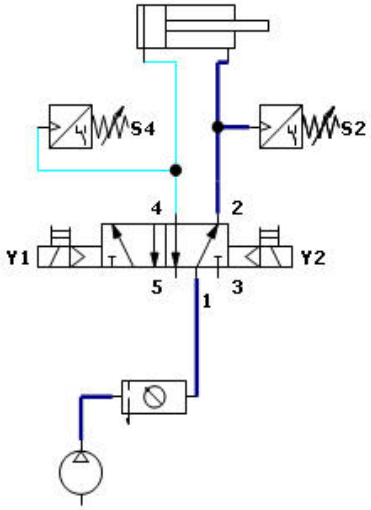
2- Connect the electric circuit according to the electric circuit as shown in Fig.5.6.b.

3- Check that all the parts are connected properly with each other.

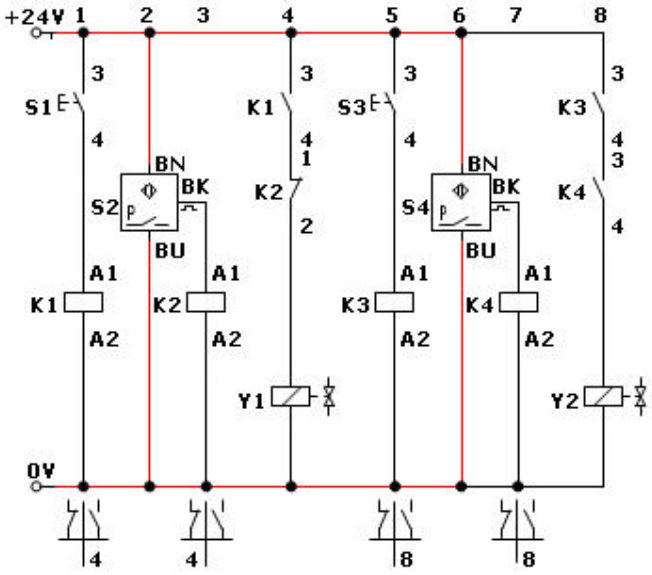
4- Switch the power supply on and open the service unit. Make sure that that the pressure in the circuit is adjusted to 6 bars.

5- Adjust the pressure sensor S2 to 7 bars, or any value greater than the system pressure.

   Adjust the pressure sensor S4 to 4 bars or any value less than the system pressure.



(a)



(c)

Fig.5.6

(a): Pneumatic circuit

(b): Electric circuit

6- Press the switch S1, and see what happen to the cylinder piston. Does it extend?

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7- Press the switch S3. What happen to cylinder piston? Does it retract?

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8- Adjust back S2 pressure to 7 bars and then press S1. Does the cylinder piston extend?

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9- Adjust the system pressure to 3.5 bars or to any value less than the adjusted pressure of S4.Press the switch S3, and see the piston movement. Does the piston retract?

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10- Return back the system pressure to 6 bars and press the S3. Does the piston retract?

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Observations and notes

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Practical Task 6

Title: Sealing machine

Objectives:

Upon the completion of this task, the student should be able to

- Understand and use a pressure switch.
- Configure the pressure switch
- Use an electric relay.

Problem description:

Using a hot pressing die, packing material is to be sealed by application of heat and pressure as shown below in Fig.5.7. By pressing a pushbutton switch the heating rail is advanced and the packaging material is heated along the adhesive strip. After the adhesion pressure (7 bar) has been reached, the heating rail is returned automatically to its start position.

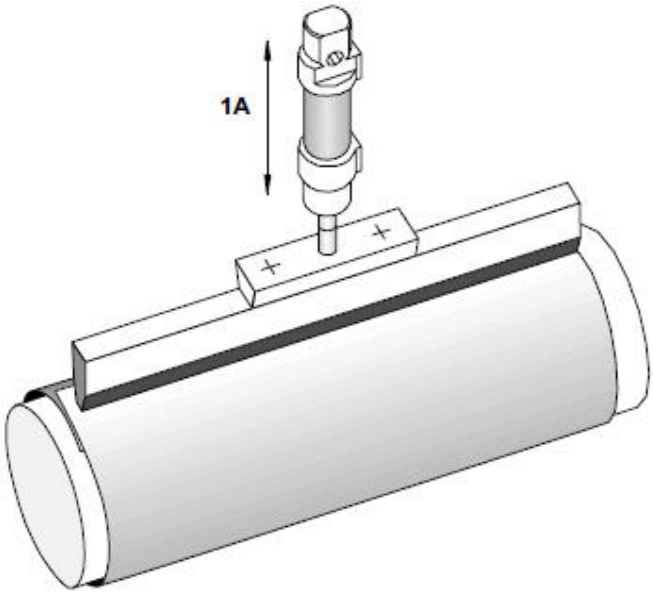


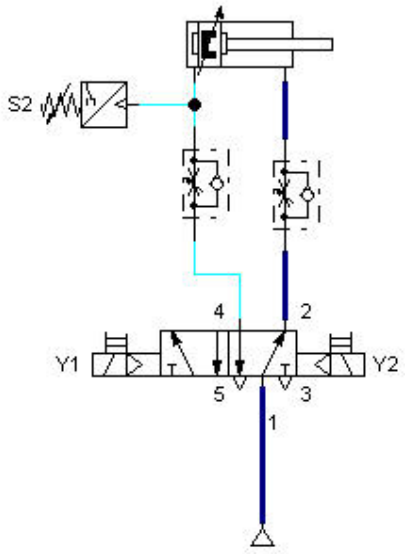
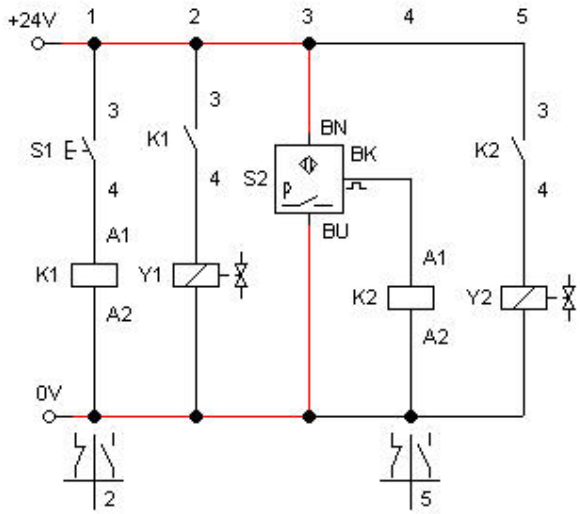
Fig5.7

Required components:

1. Double acting cylinder
2. DC power supply
3. 5/2 DCV, double solenoid
4. Switch block
5. Pressure switch magnetic reed switch
6. Relays block

Required procedures

1. Draw the electro-pneumatic circuit using the FluidSim software.
2. The speed of the forward and backward stroke of the cylinder rod is adjustable
3. Test the circuit functions against any errors or mistakes.
4. Construct the circuit on the workstation
5. Write down your notes and observations.

Pneumatic circuit	Electric circuit
	

Observations and notes

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Class work (2)

1. List two types of pressure switch.

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2. Explain the function of a pressure switch. Give example of an application

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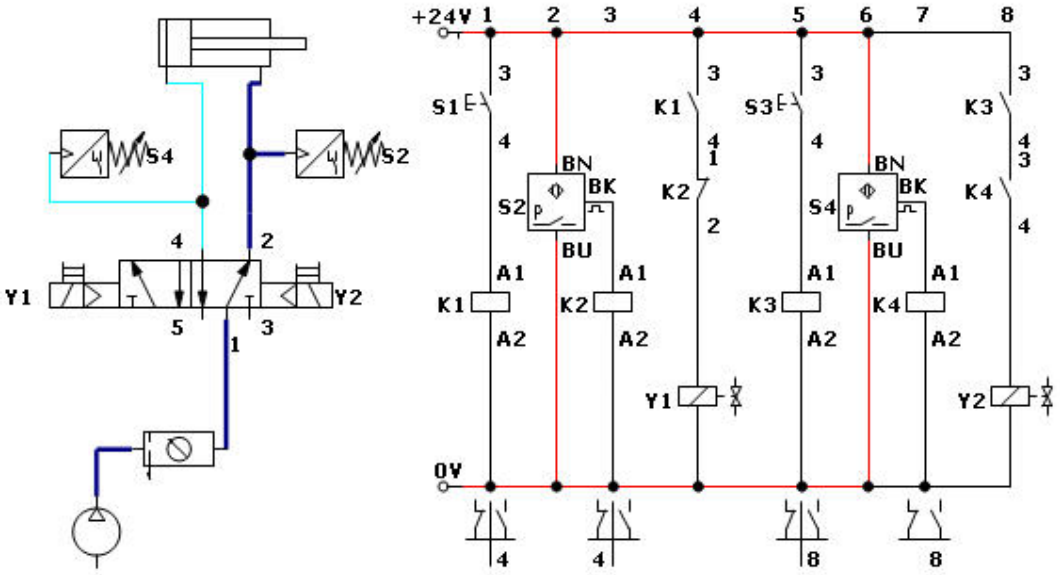
3. Draw the ISO symbol of a pressure sensor and a pressure switch.

4. What is the difference between a pressure switch and the following components?

pressure switch	Pressure regulator	Pressure relief valve	Pressure sequence valve

Home Work (2)

The two circuits below illustrate an electro-pneumatic system. Answer the following questions:



1- Name the listed items in the table below

S1	
S2	
S3	
S4	
K1	
K2	
Y1	

a) What is the meaning of the symbol below circuit 1, 3, 5, 7?

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b) What is the function of the switch S2?

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c) What is the function of the switch S4?

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d) Explain how to extend and retract the cylinder piston.

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e) If the pressure source is 8 bars and the pressure switch S2 is set to 5 bars, does the cylinder extend if the switch S1 is activated? Justify your answers.

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Student's notes

References

- Electro-pneumatic text book TP 201 2005 – Festo
- Electro-pneumatic work book TP201 2005 – Festo
- Electro-pneumatic work book TP202 advanced level – Festo