ثانويــة التكنولوجيــا التطبيقيــة
Applied Technology High School

Electro-Pneumatics

Module 4: Sensors in Electro-pneumatics (Limit Switches)

PREPARED BY

Academic Services

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Module 4: Sensors in Electro-pneumatics (Limit switches)

Module Objectives

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

1. Explain and use the limit switch as position sensors.

2. Explain and use limit switches.

3. Configure various connections of limit switches.

4. Explain different applications of limit switches.

Module Contents

Introduction to sensors

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

- To detect the advanced and retracted end position of the piston rod in cylinder drives.

- To detect the presence and position of a work piece.

- To measure and monitor pressure and flow.

The following sensors are widely used in the industry:

1. Limit switches

2. Proximity switches

    a. Reed switches

    b. Inductive proximity switch

    c. Capacitive proximity switch

    d. Optical proximity switch

3. Pressure switches

Limit Switches

A limit switch interlocks a mechanical motion or position with an electrical circuit. Limit switch can be classified to several types according to the contacts arrangements. It is actuated when a machine part, work-piece or a piston rod is in a certain position. Normally, actuation is affected by a cam or cylinder piston. Figure 4.1.a shows the internal construction of the limit switch. Fig4.1.b shows the picture of the limit switch. Fig4.1.c shows the ISO symbol of the limit switch.
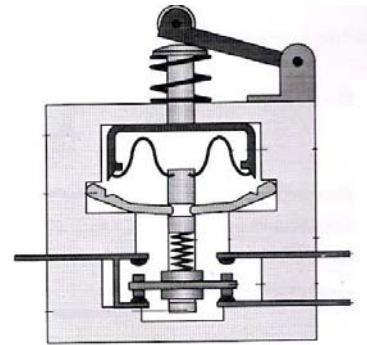
(a)

(b)

(c)

Fig. 4.1:
(a): internal structure
(b): Picture of the limit switch
(c): ISO Symbol

Various connections of a limit switch

A limit switch provides two distinct events, the making of one contact and the breaking of the other. Limit switches are normally changeover contacts and can be used in three connection forms as shown in Fig. 4.2 (a), (b) and (c)

(a)

- A normally closed contact (N/C) as shown in Fig. 4.2.a.
- A normally open contact (N/O) as shown in Fig. 4.2.b
- A changeover contact as shown in Fig. 4.2.c.
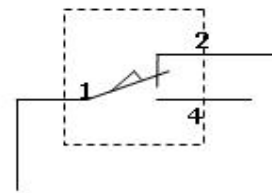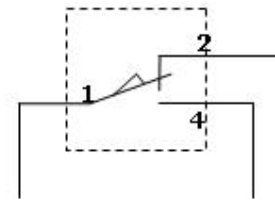
(b)

(C)

Fig.4.2:

(a): N/O limit switch

(b): N/C limit switch

(c): Changeover switch

Practical task 1

Title: Operating feeding machine.

Objectives:

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

- Use and configure the limit switch as position sensor.
- Control the stroke length and piston displacement automatically.

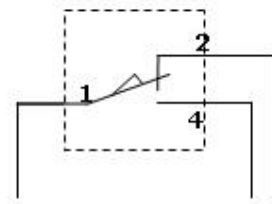**Problem description:**

The double acting cylinder in Fig.4.3 below is used to push a plank of wood under a sanding (polishing) belt. By pressing a pushbutton switch the sliding table with the plank of wood is positioned under the belt. Another pushbutton switch is used to return back the sliding table to its start position but after the cylinder rod has reached its full extended position.
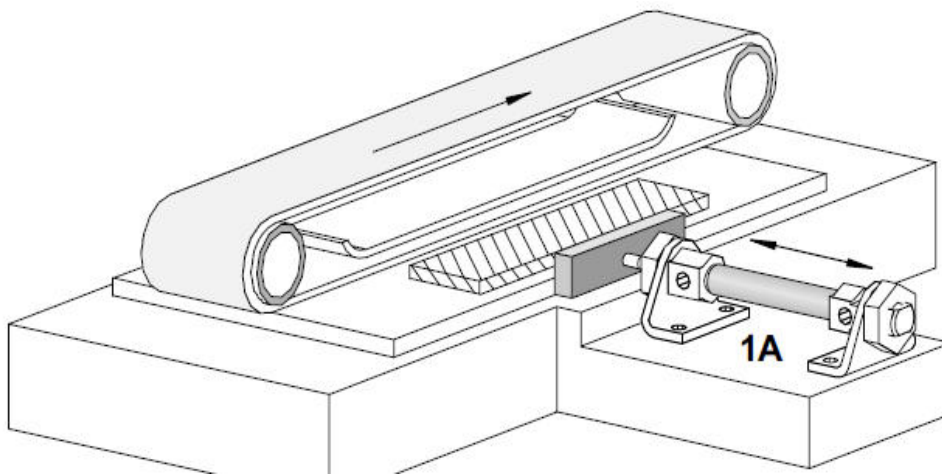
Fig.4.3

Required components:

1- Double acting cylinder

2- 5/2 Directional control valve, double solenoid

3- Power supply

4- Switch blocks

5- Limit switch

6- Relay block

1- Required procedures – Direct control

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
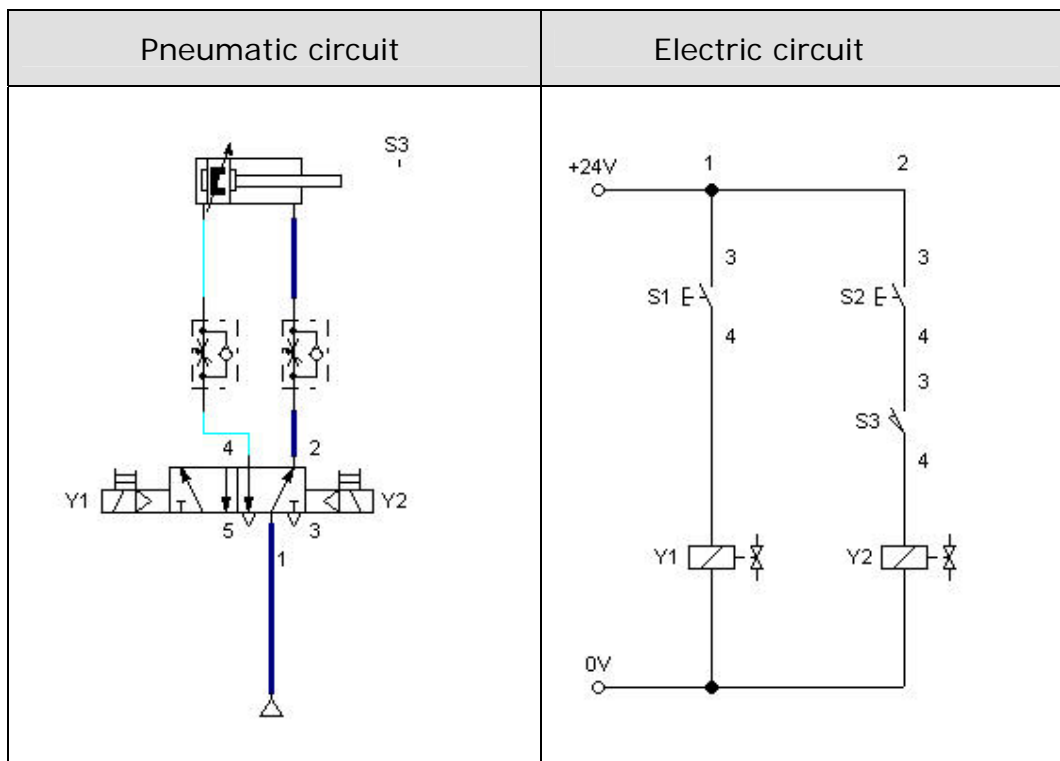
Observations and notes

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2- Required procedures – Indirect control

1. Draw the electro-pneumatic circuit (indirect 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
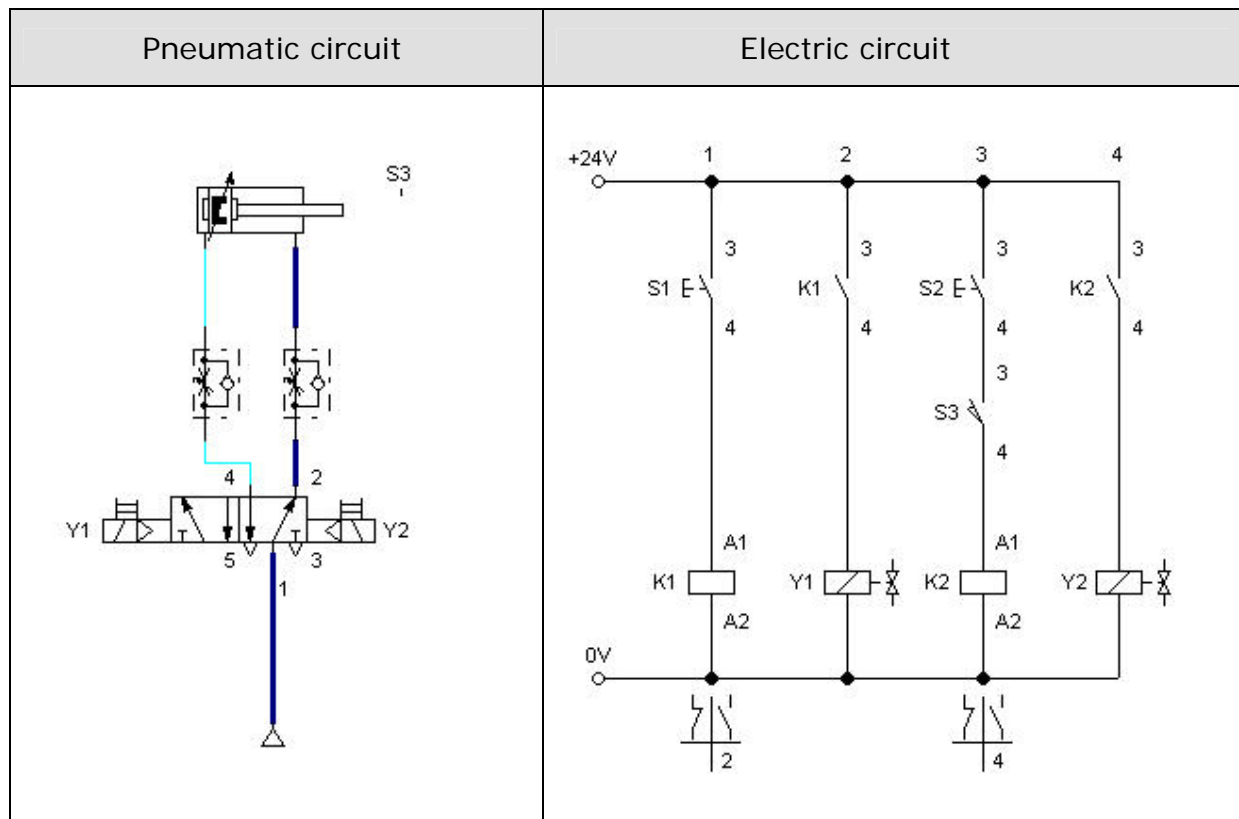
Observations and notes

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Practical task 2

Title: Latching circuit with a limit switch

Objectives

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

- Use and test the electric relay.

- Use and configure the limit switch as position sensor.

- Control the stroke length automatically.

- Control indirectly the solenoid valves.

- Construct a latching circuit with a limit switch.

Problem description:

In this task the piston rod of a cylinder is to be advanced when pushbutton S1 is triggered and retract when pushbutton S2 is pressed. A relay with latching function is to be used in order to maintain the signal.

Required components:

1- Double acting cylinder

2- 5/2 Directional control valve, single solenoid

3- Power supply

4- Switch blocks

5- Limit switch

6- Relay block

1- 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
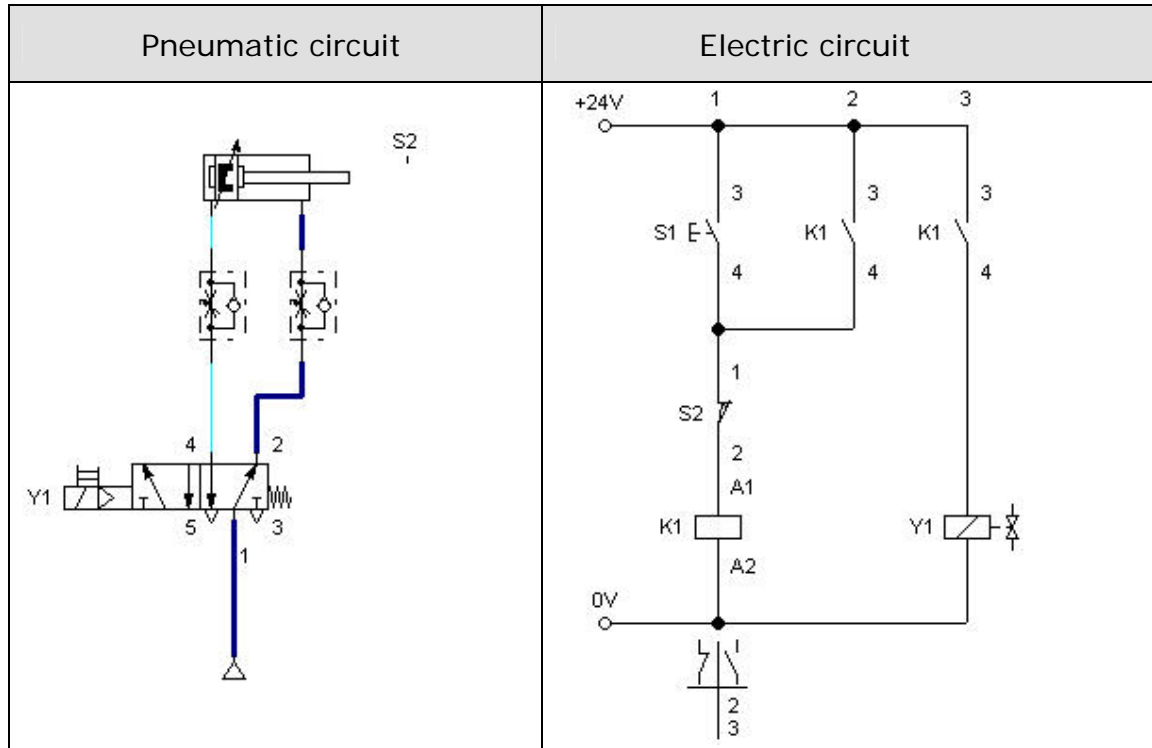
Observations and notes

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Practical task 3

Title: Conveyor belt with Oscillation motion

Objectives:

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

- Use relays and limit switch
- Construct direct and indirect control.
- Control the stroke length and piston displacement automatically

Problem description:

The double acting cylinder shown in Fig.4.4 below is used to generate an oscillating movement in order to provide a belt timely movement. When the detent switch is turned on, the piston rod starts oscillating. Two limit switches should be used to control the length of the forward and backward strokes.
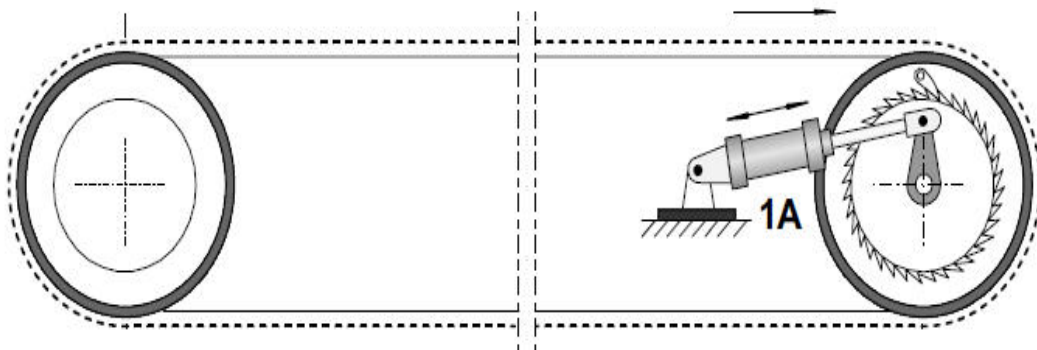
Fig.4.4

Required components:

1- Double acting cylinder

2- 5/2 Directional control valve, double solenoid

3- Power supply

4- Switch blocks

5- Limit switch

6- Relay block

1- Required procedures

1. Draw the electro-pneumatic circuit (indirect 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
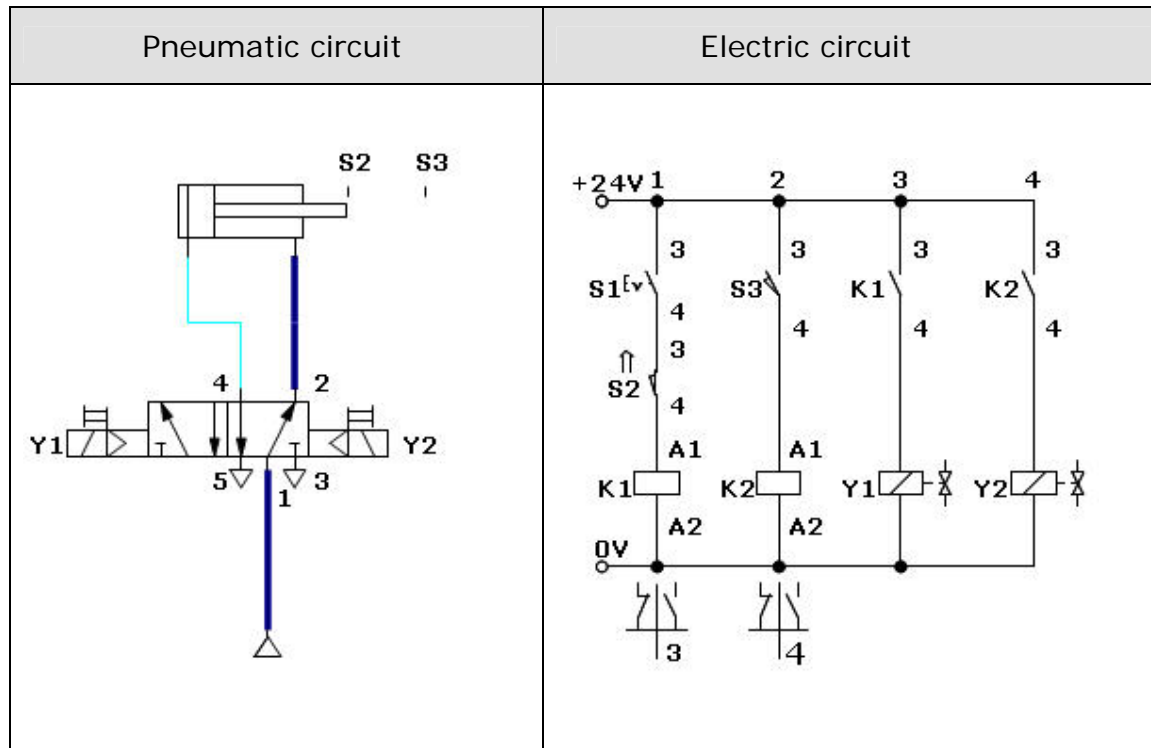
Observations and notes

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Class work (1)

1. List three types of sensors.

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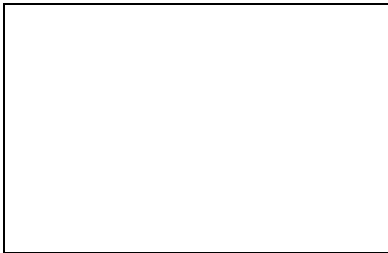
2. Explain the function of a limit switch? Give an industrial application of the limits switch

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3. Draw the ISO symbol of a limit switch.

4. List three types of connections for a limit switch. Support your answer with a sketch.

Home Work (1)

The circuit below illustrates an electro-pneumatic system. Answer the following questions.
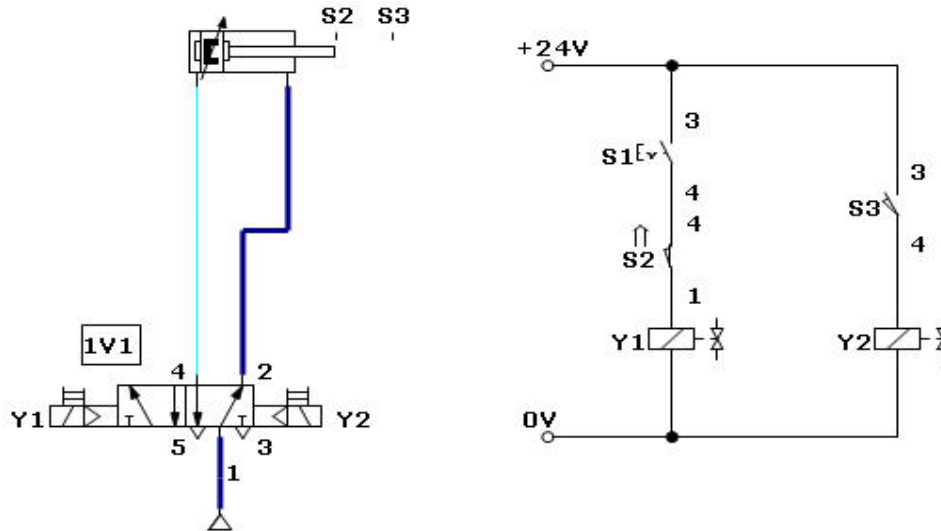
a) Is the above electric circuit representing a direct or indirect control? Justify your answer

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b) What is the type of the following switches? Indicate if the switch is N.O or N.C.

- S1: ....

- S2 ....

- S3: ....

a) Explain briefly how to extend and retract the piston of the above cylinder.

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Development of multiple actuator circuits

In practice, most of the machines have more than one actuator. Actuators can be cylinders, motors, or grippers. The motion of these actuators is either time-dependent or process-dependent. See Fig. 4.5.a and Fig. 4.5.b.

- **Time dependent process**

In this case the sequence control is obtained through a time-based control. Step enabling conditions are generated via timers, or camshaft controllers with constant speed. Timers can be hardware or software through a computer or a PLC program.

- **Event dependent process**

In the event dependent process, the control and the switching conditions are only based on signals from the system being controlled. These signals can be pneumatic signals from actuated valves, or electric signals from limit switches, proximity switches or other sensors. In other words, the control depends on the signal event with no relation to the time.

(a)

**(b)**

Fig.4.5
(a): Yogurt filling machine
(b): packaging machine.

Control system development

As mentioned previously, the actual industrial machines normally consist of several actuators and advanced control circuits. In the case of multiple actuator circuits, a clear definition of the problem is important. There are many ways to represent the problem in a descriptive or graphical form. Below are some methods and ways of representing the control problem

1. Positional sketch

It shows the relationship between the location of the actuators and the machine fixture as shown in Fig.4.6.a
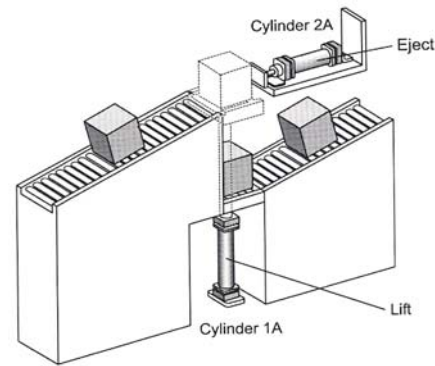
(a)

2. Displacement-step diagram

It represents the operating sequence of actuators in relation to the sequence step as shown in Fig4.6.b. In this case there are two cylinders 1A and 2A. In step 1 cylinder 1A extends and then cylinder 2A extends in step 2. In step 3 cylinder 1A retracts and in step 4 cylinder 2A retracts. Step 5 is equivalent to step 1.

Abbreviated notation is another way of representing motion sequences. If considering '+' for advancing and '-' for retracting then the above sequence is represented as :

(b)

$1A^+$ $2A^+$ $1A^-$ $2A^-$

(c)
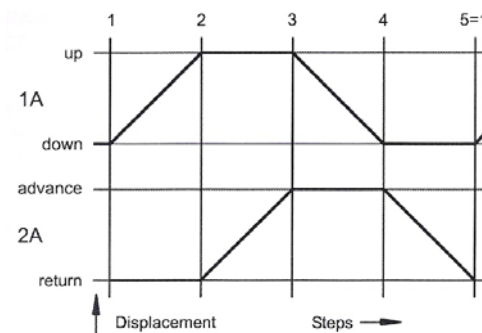
3. Displacement-time diagram

The displacement is plotted in relation to time. In this case, the time of each stroke should be known in order to create the displacement time diagram. As shown in Fig.4.6.c, the time of the stroke **1A⁺** and **2A⁺** is 5 seconds each. While the time of the backward stroke **1A⁻** and **2A⁻** is 3 seconds each.

The total cycle time = 5+5+3+3 = 16 seconds.

4. Circuit diagram

It shows the signal flow and the relationship between components and the air connections. There is no mechanical representation with the circuit diagram, Fig.4.6.d. The circuit is prepared with the energy flow from the bottom to top. The various levels include the energy source, signal inputs, and signal processing, control elements and actuators. The position of the limit valves and limit switches are at the actuators also.
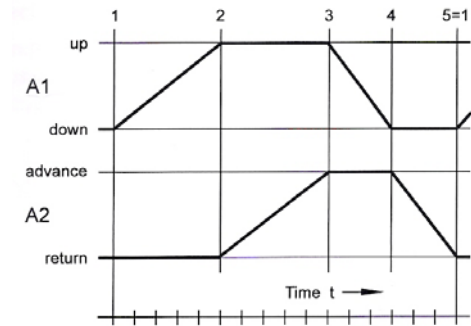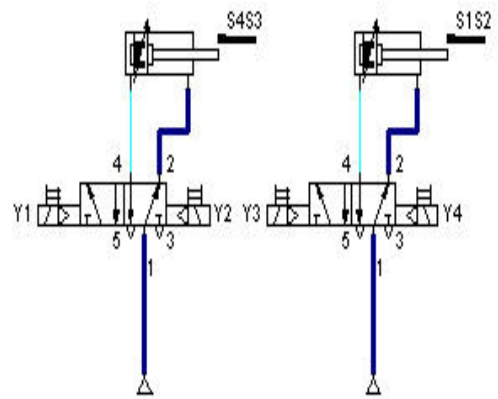
(d)

Fig.4.6

(a): Positional sketch

(b): Displacement- step diagram.

(c): Displacement- time diagram

(d): Pneumatic circuit

Practical Task 4

Title: Multiple actuator circuit with direct control circuit.

Objectives:

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

- Explain the displacement step diagrams
- Use the limit switch as position sensor.
- Control of the stroke length and piston displacement automatically.

Problem description:

As explained previously in event dependent process, the control and the switching conditions are only based on signals from the system being controlled. These signals can be pneumatic signals from actuated valves, limit switches, proximity switches or other sensors. In this task, the two cylinders are linked and their motion is dependent on each other as illustrated in the cylinders sequence $1A^+$ $2A^+$ $1A^-$ $2A^-$

Required components:

SR.	Name	Qty.
1	Double acting cylinder	1
2	DC power supply	1
3	5/2 DCV, double solenoid	2
4	Switch block	1
5	Limit switch	4

Required procedure:

1. Connect the pneumatic circuit according to the pneumatic circuit as in Fig 4.7.a

2. Connect the electric circuit according to the electric circuit Fig 4.7.b

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

4. Switch the power supply on and open the service unit.

5. Adjust the air flow via the one way flow control valves.

6. Press switch S and explain what happens to the two cylinders in steps.

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7. Replace the pushbutton switch S, with a detent switch and see what happens to both cylinders motion.

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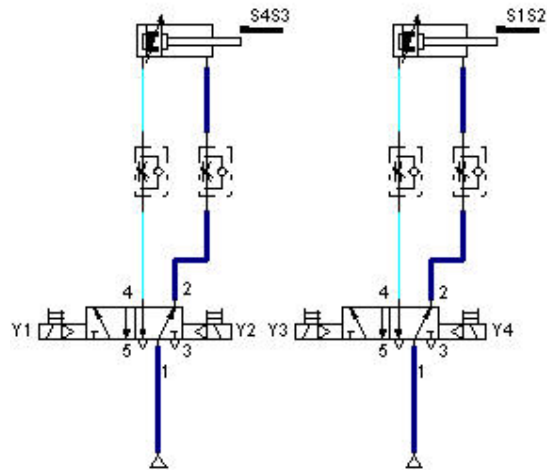
(a)
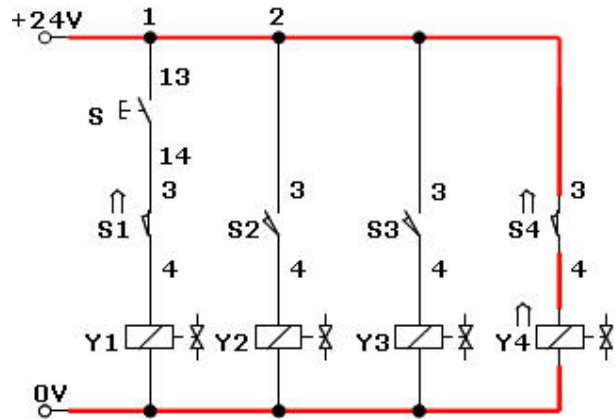
(b)

Fig.4.7

(a): Pneumatic circuit

(b): Electric circuit

8. Draw the displacement step diagram for the above system.

	1	2	3	4
1A				
2A				

Observations and notes

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Practical task 5 (For high achievers)

Title: Transfer station

Objectives:

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

- Explain the displacement step diagrams
- Use the limit switch as position sensor.
- Construct the control circuit based on a given cylinders sequence.

Problem description:

In the transfer station shown below in Fig. 4.7, the blocks are to be transferred from a magazine to a processing station. The blocks are pushed out of the magazine by cylinder 1A and transferred to the processing station by cylinder 2A. The piston rod of cylinder 1A may only return when the piston rod of cylinder 2A has reached the retracted end position. Limit switches are used to control the cylinders movements achieving the following sequence:

$$1A^+ \quad 2A^+ \quad 2A^- \quad 1A^-$$
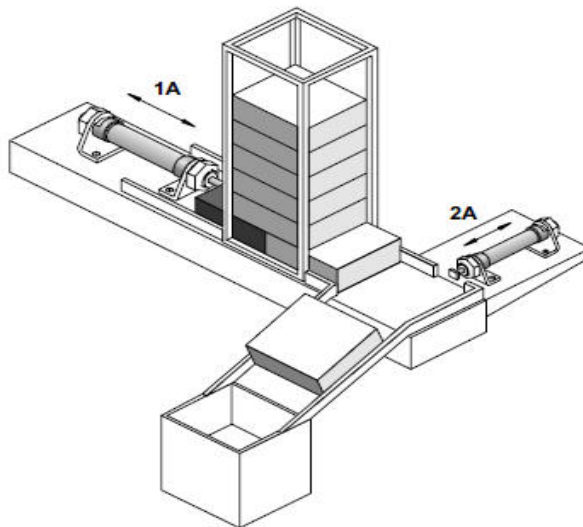
Fig.4.7

Required components:

SR.	Name	Qty.
1	Double acting cylinder	1
2	DC power supply	1
3	5/2 DCV, double solenoid	2
4	Switch block	1
5	Limit switch	4

Required Procedures:

1. Draw the electro-pneumatic circuit using the FluidSim software

2. Draw the displacement step diagram of the transfer station

3. The speed of the forward and backward stroke of the cylinder rod is adjustable

4. Test the circuit functions against any errors or mistakes.

5. Construct the circuit on the workstation

6. Write down your notes and observations.

Displacement step diagram

Pneumatic and electric circuit
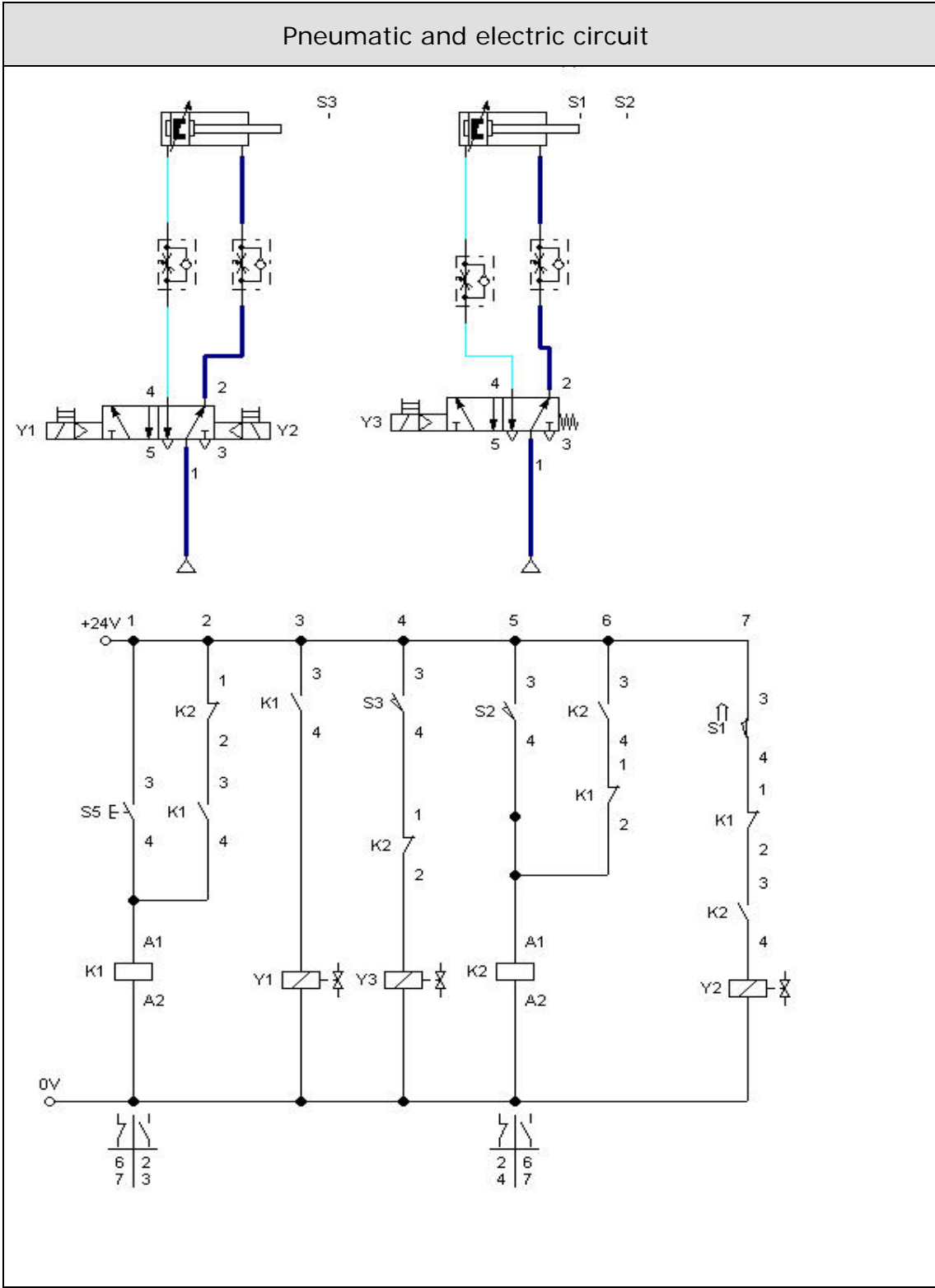
Observations and notes

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Class work

1. What are the types of sequence control?

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2. List the steps that should be followed during the control system development.

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3. What is the difference between step-displacement diagram and step-time diagram?

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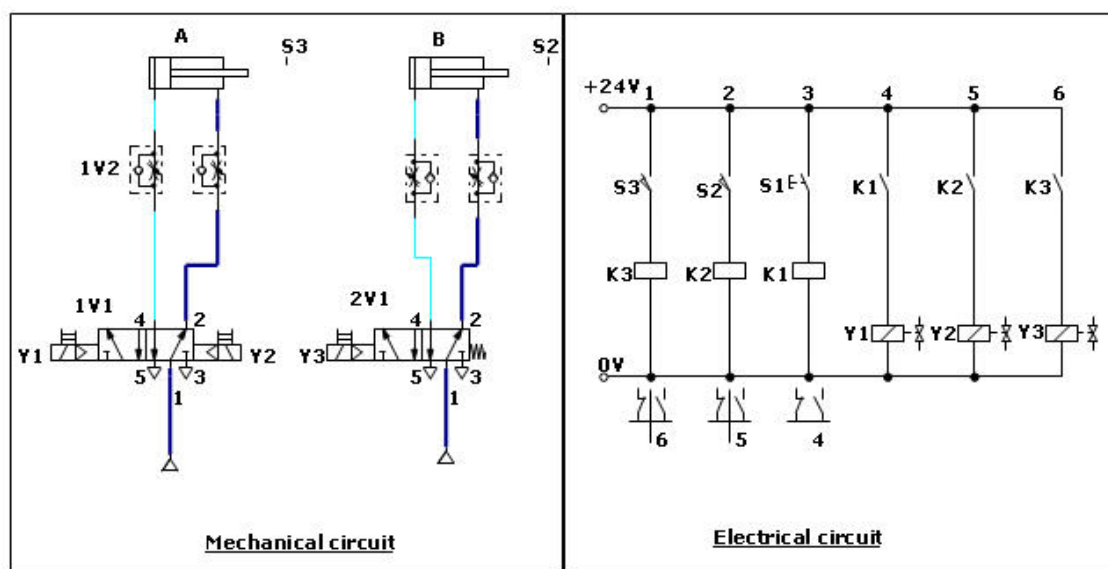
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4. Draw the step-displacement diagram for the following sequence:

A+ A- B+ B-.

Home Work

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

Mechanical circuit | Electrical circuit

a) Name the components in the table below

K1	
S2	
1V1	
2V1	
Y1	

b) Explain briefly what happens after actuating the switch S1?

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c) Write down the cylinders sequence and draw the displacement-step diagram.

Cylinders sequence

Displacement

step diagram

	1	2	3	4
A				
B				

References

- Electro-pneumatic text book TP 201 2005 – Festo

- Electro-pneumatic work book TP201 2005 – Festo

- Electro-pneumatic work book TP202 advanced level – Festo