Unit 24: Applications of Pneumatics and Hydraulics

Unit code: J/601/1496 QCF level: 4 Credit value: 15

OUTCOME 2

TUTORIAL 1 – PNEUMATIC CIRCUTS

The material needed for outcome 3 is very extensive and the time required to study it in detail is more than that normally allowed for a single module. This tutorial looks at the design requirements for pneumatic circuits. This series of tutorials extends the work from outcome 2 to the construction of complete circuits. You can complete more of this outcome by doing the assignments.

3 Be able to design pneumatic and hydraulic circuits

Pneumatic circuits: e.g. directional control, piloted control, reciprocating control, logic, memory, multi-actuator circuits with sequential operation, cascading techniques, stepper circuits, pulsed signals, latching circuits, direction and speed control of rotary actuators and air motors

Hydraulic circuit: e.g. sequential operation of multi-actuator circuits, regenerative circuits, counterbalance circuits, 'meter-in' and 'meter-out' circuits, bleed-off circuits, direction and speed control of hydraulic motors

Electro-pneumatic and electro-hydraulic circuit: use of electronic logic devices and systems and their interface with fluid power circuits; solenoid valve arrangements

Emergency 'fail safe' circuit: use of emergency stop circuits to give predictable 'parking' positions for linear actuators, emergency stopping circuits for rotary actuators and motors, thermal and pressure relief circuits, 'fail safe' circuit arrangements

- Describe further elements needed for controlling pneumatic circuits.
- Explain the advantages of pneumatics compared to other systems.
- Explain the classification of pneumatic components.
- Explain some of the basic principles of control systems.

1. ADVANTAGES OF PNEUMATICS

Pneumatics is used in preference to hydraulics for the following reasons.

1. Easily connected to an air supply and needs no separate power pack.
2. The operation of actuators is fast.
3. No return piping is required; the air is vented to atmosphere.
4. Clean medium with no mess when it leaks.
5. No fire hazard as with oil.

Pneumatics is used in preference to electrics for the following reasons.

1. Will not start a fire through electric fault (Intrinsically safe).
2. Air motors are safe when over loaded and does not overheat.
3. Safer for operators (no risk of electrocution).

2. COMPONENT CLASSIFICATION

Pneumatic circuit elements are classed into four primary groups. These are

1. AIR SUPPLY AND CONDITIONING ELEMENTS such as
   - Compressor
   - Receiver
   - Pressure regulator,
   - Filter
   - Dryer
   - Lubricator

2. INPUT ELEMENTS (electrical or pneumatic) such as
   - On/off devices (switches)
   - Position sensors
   - Trip valves
   - Air jet sensors

Note many pneumatic sensing and switching devices are directional control valves such as a 3/2 plunger operated valve for detecting a cylinder position.

3. PROCESSING ELEMENTS such as
   - Logic valves (And Or and so on)
   - Time delay valves
   - Pressure switches
   - Directional control valves of many types.

4. ACTUATING DEVICES such as
   - Cylinders
   - Motors
   - Semi-rotary actuators

Some elements are MONOSTABLE or BISTABLE.

A monostable element only has one stable position and automatically returns to it when the switching signal is removed. Examples of these are

Directional valves with spring return
Pressure switches
Reed relays
Proximity detectors
Spring loaded switches.
Logic valves

A bistable element has two stable positions and requires a switching signal to change it from one to the other. Examples are

Directional valves with no spring return such as
Pilot/pilot operation
Solenoid/solenoid operation
Valves with detents
Switches with no spring return
Latching relays
Fluidic logic elements (AND, OR and so on can be bistable)

Bistable elements are also memory devices since they retain their status until switched and so their status indicates the last thing that happened to them.

3. ELECTRO-PNEUMATICS - SENSORS

The principles and symbols for electrically operated solenoid valves is covered in Outcome 2. In a circuit using electric control, sensors are needed for elements of automatic control. In order to control the movement of cylinders and mechanisms, sensors are fitted to provide a switching voltage when they are at the operated position. These might be simple mechanically operated switches or micro switches.

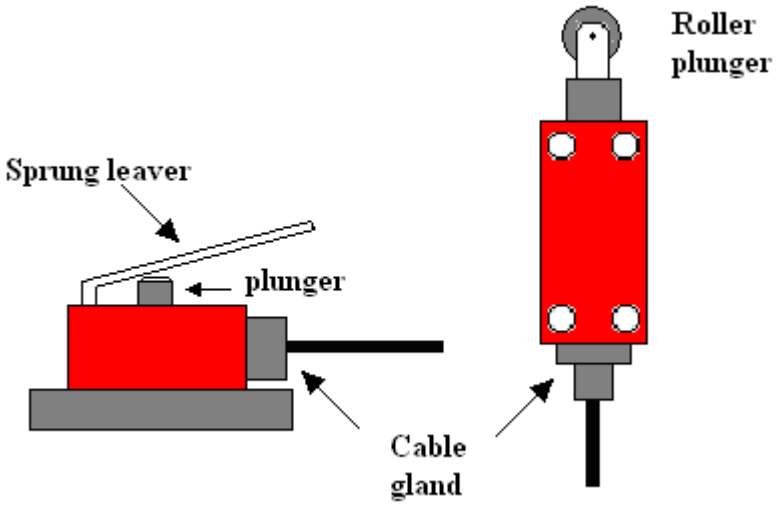


Figure 1

Another form of detector is the magnetically operated reed switch. These usually fit directly onto the cylinder with suitable clips. The piston of the cylinder has a magnet built into it and when the piston comes close to the reed switch, the contacts close. The contacts on reed switches can only take a small current so they are not suitable for directly switching solenoids. Additional electronics is needed to do this.

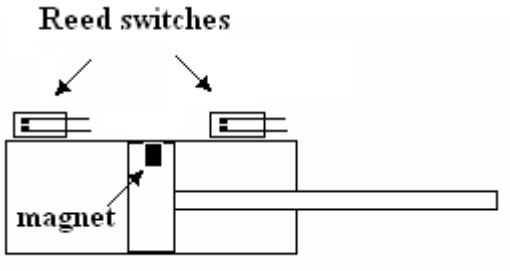


Figure 2

Another system uses proximity detectors. These contain a transistor which conducts and switches when something comes near them. Some only work with steel but others work with any material.

Another form uses light beams which are reflected back when something comes near the end and operates the transistor switch. The LED is a useful aid. It lights up when the proximity switch is activated. This helps when tracing faults.

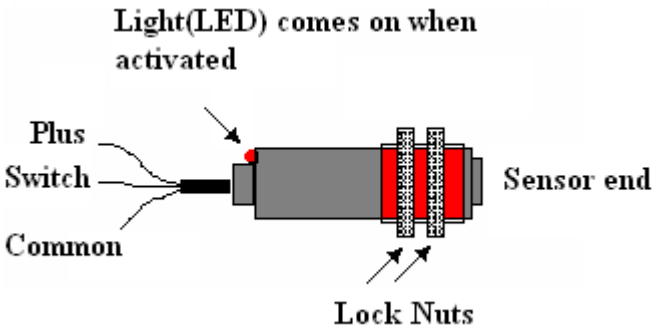


Figure 3

A similar sensor uses light beams and sensors. Often the light used in infrared. These sensors switch on or off when the light beam is interrupted. These might be used for detecting an item passing on a conveyor belt and activate a cylinder accordingly.

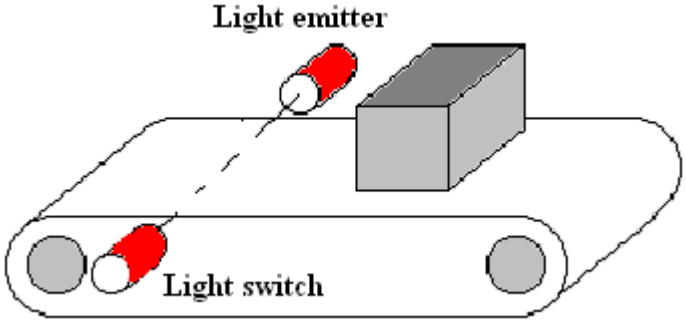


Figure 4

Switches and valves may be normally open (NO) or normally closed (NC).

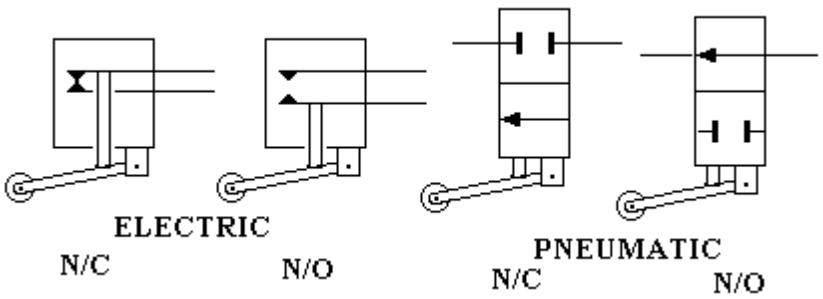


Figure 5

4. RELAYS

Some position sensors are able to switch high currents directly and may be hard wired to the solenoid of a directional control valve. Most sensors (e.g. reed relays) would be damaged by high currents so they have to be interfaced to the solenoids by relays. A relay is used to to allow a small switch to operate and heavy duty switch. The relay is mechanical switch and the contacts are moved by a solenoid.

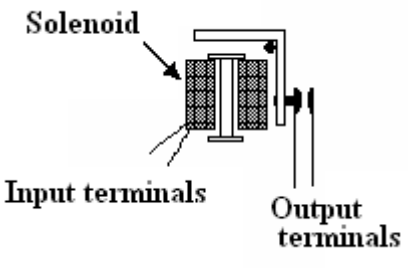


Figure 6

The output terminals may be normally open or normally closed. A typical circuit diagram would show the arrangement of a sensor, relay and output switch like this.

Proximity detectors may be connected directly to computerised controllers but to switch solenoids directly, it is safer to make them switch a relay unit and the relay switches the solenoids. The relay unit may use the following symbols.

K is the relay solenoid and relay contact, S is the sensor switch and Y is the valve solenoid. If something operates S1, k1 is energised and relay contact k1 is closed and the solenoid Y1 is energised thus operating the valve.

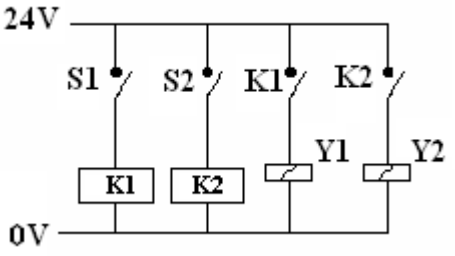
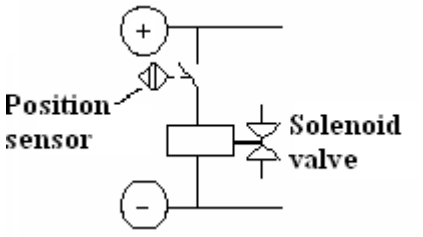


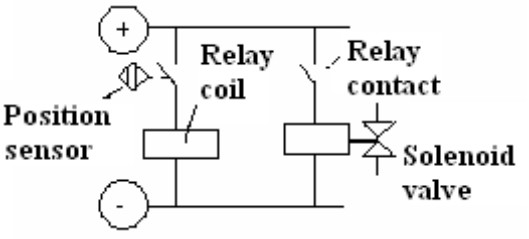
Figure 7

5. EUROPEAN LADDER LOGIC SYMBOLS



This diagram shows a solenoid operated directly by a sensor with no relay.

Figure 8



This diagram shows a solenoid valve operated by a relay. The relay is operated by the position sensor. The sensor contacts may be normally open or normally closed.

Figure 9

Here is a set of symbols for switches.

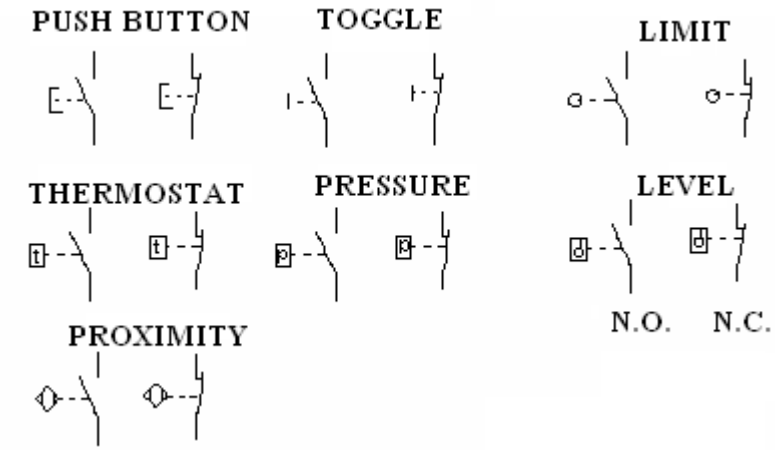
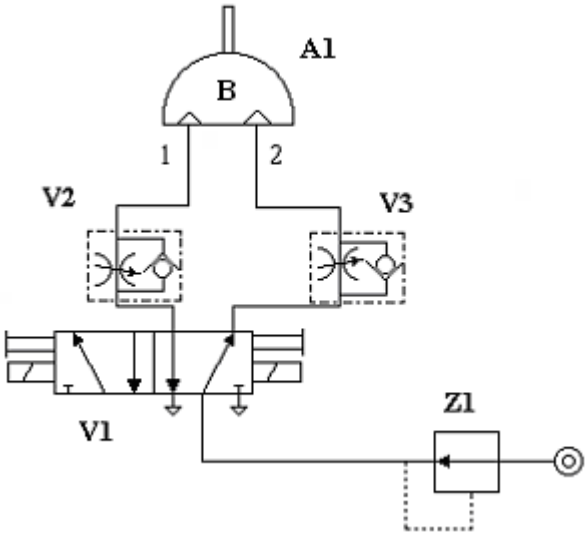


Figure 10

SELF ASSESSMENT EXERCISE No.1

Examine the pneumatic circuit below.



Circuit No.1

Write out an accurate description of each component.

A1. _____

V1. _____

Z1. _____

V2/3. _____

Items V1 and V3 are used to control the speed of the actuator. One uses "metering in" and one uses "metering out". Explain these terms and identify which does which.

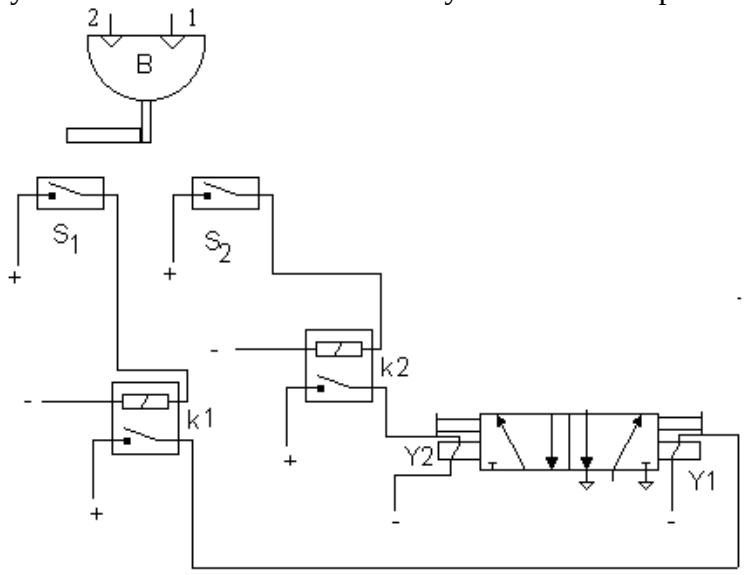
_____

_____

_____

_____

Study the electrical circuit No.2. This is the circuit that will control the pneumatic circuit No.1. S represents a switch, K represents a relay and Y represents a solenoid. If you have access to test ig or simulation software, you should construct circuit and test it. You will need to select the components correctly. You will need an electrical relay board and two proximity switches.



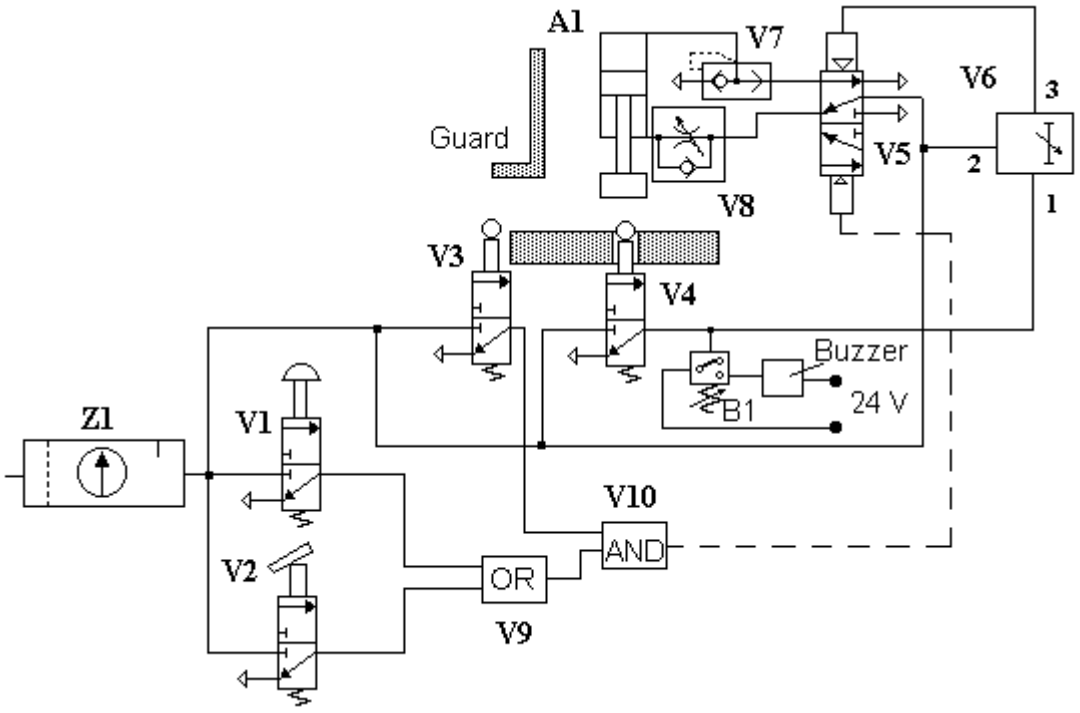
Circuit No.2

Explain the train of events that will occur after the 24 V supply is switched on.

Explain why the valve does not switch when the actuator is at half its rotation.

SELF ASSESSMENT EXERCISE No.2

The circuit below is designed for a press tool. When the guard is pulled down V3 is operated. If V1 or item V2 is operated and V4 is not operated, the pressing operation is achieved by operation of the cylinder (A1). When the press is fully operated, item V4 is pressed and the buzzer must sound. After a small time delay the press is automatically raised.



Refer to the list of symbols and complete the identification chart below.

Item	Name/Description	Primary level 1,2, 3 or 4
Z1		

Item	Complete description	Primary level 1,2 ,3 or 4.	Memory Device Yes or No
A1			
B1			

Item	Name/Ports/ positions/ operation/ return	Primary level 1,2 ,3 or 4.	Normally Open or Normally Closed	Memory Device Yes or No
V1				
V2				
V3				
V4				
V5				
V6				