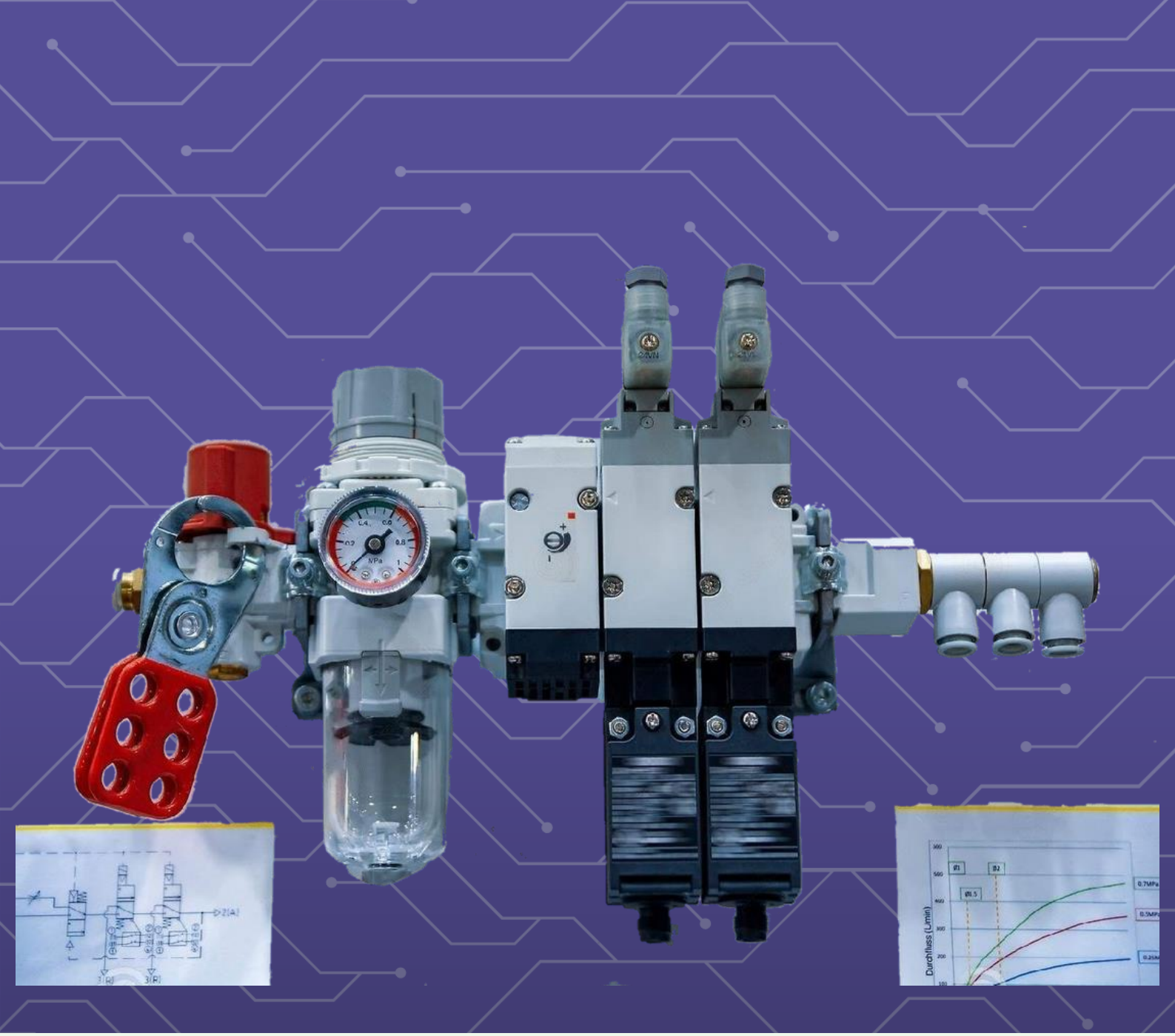

ELECTRO PNEUMATIC

MOHD ELIAS BIN DAUD
ZETTY ROHAIZA BINTI MOHD SAHAK @ ISHAK

JABATAN KEJURUTERAAN MEKANIKAL
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

ELECTRO PNEUMATIC

JABATAN KEJURUTERAAN MEKANIKAL
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

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Electro-Pneumatic

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Preface

Pneumatics technology is one of the important part in automation system. It can be divided into two; fully pneumatic and electro-pneumatic control. The learning system is therefore broken down in this chapter focuses only **electro-pneumatic** system as follows:

- The components of the electro-pneumatic
- Basic control in electro-pneumatic system
- Relays
- Electro-pneumatic circuit

The learning system for electro-pneumatic technology is continuously updated and expanded in accordance with developments in the field of education, as well as actual professional practice. This training packages deal with various component and circuit design of electro-pneumatic and very helpful for engineering technician for maintenance of the machine part.

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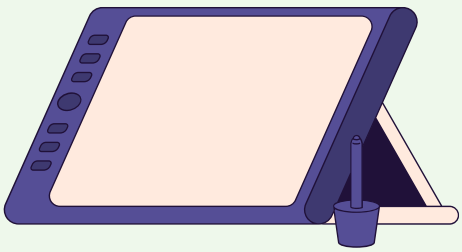
LEARNING OUTCOMES

Analyze the basic concept and function of electro-pneumatic system.

Construct pneumatic circuit according to assigned tasks.



Demonstrate understandings of pneumatics during practical work sessions.

1.0 Introduction to Electro-Pneumatic

- In Electro-pneumatic control systems, involved electrical control then converted into mechanical devices for pneumatic control system, it consist of two main circuit diagrams, one for the pneumatic section and one for the electrical components.

- The following of the Electro-Pneumatic control system explain a detailed for the operation of the circuit diagram.

1.1 Electropneumatic Controls

- The electrical energy used to actuated DCV (Directional Control Valve) valve called solenoid valve.

- The power supply called compressed air, which supplied directly to DCV for extension and retraction of the actuators.

- A proximity switches signal indicate at the position of the piston rods (Figure 1) send an electrical signal as fed back to the control unit for mechanical action.

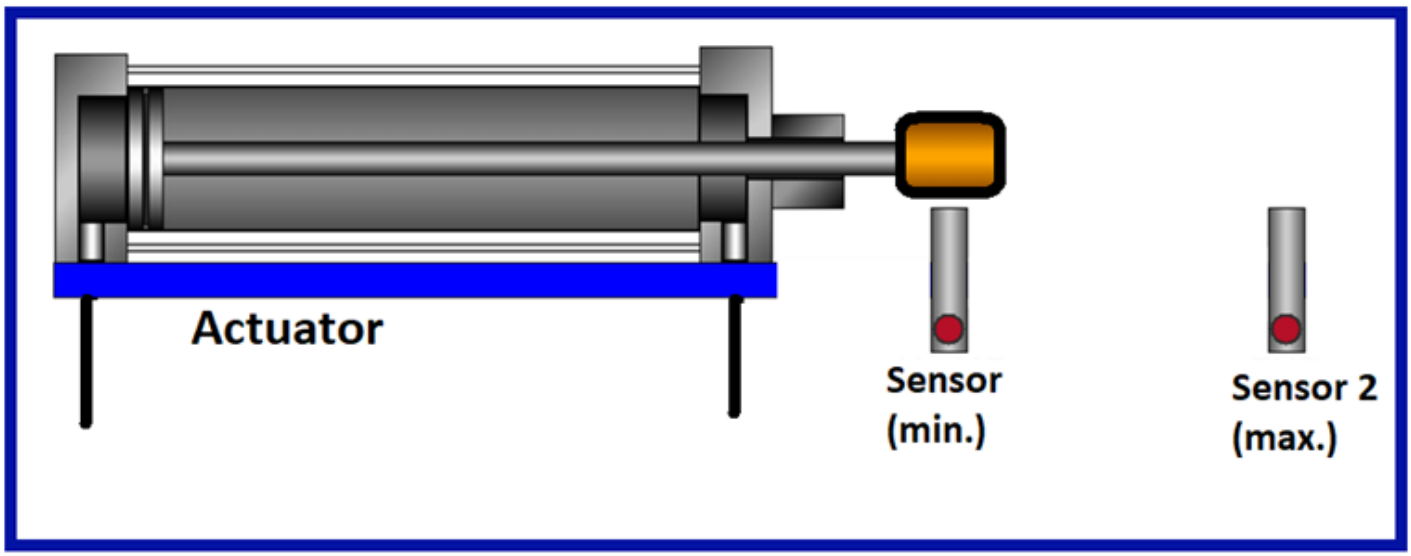
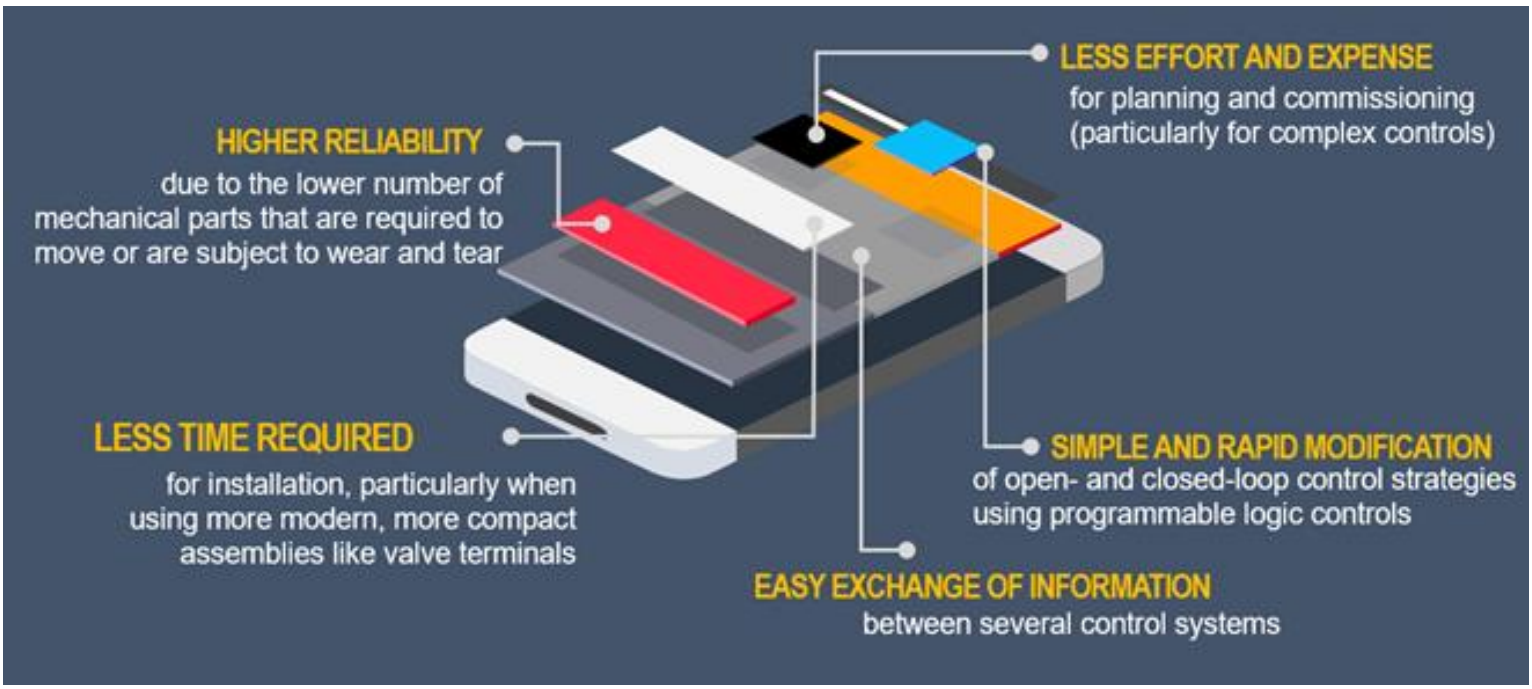
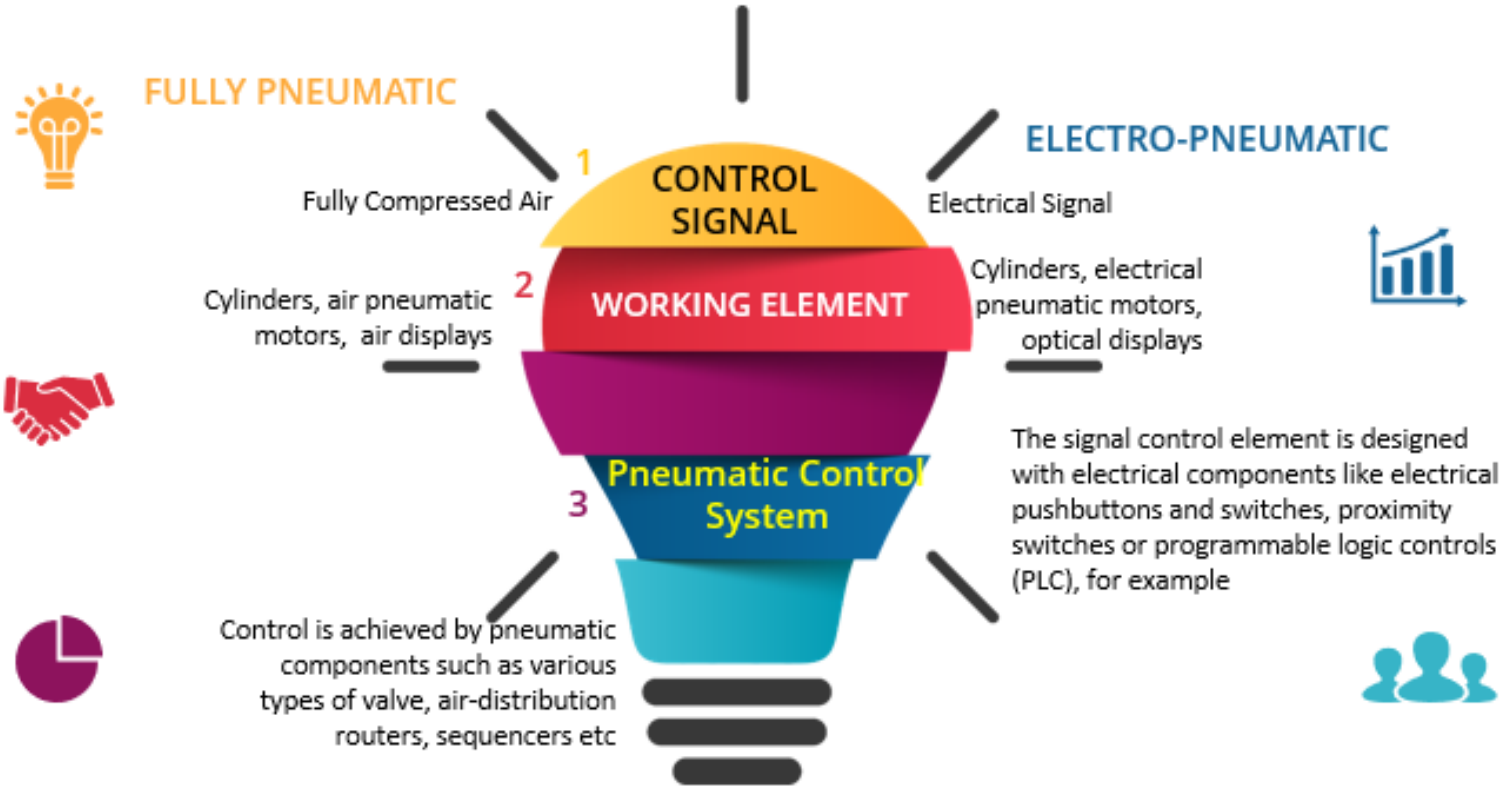


Figure 1 : Actuator

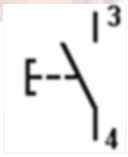
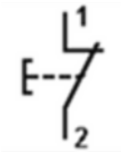
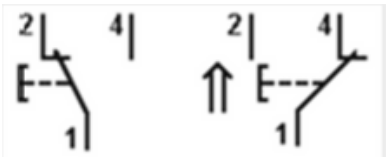
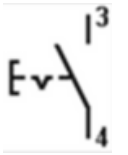
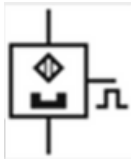
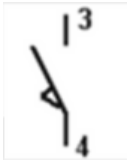
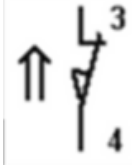
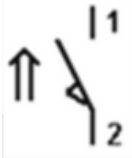
1.2 Electropneumatic Controls Advantages



1.3 Pneumatic Vs Electro-Pneumatic Controls



1.4 Electro-Pneumatics Symbols Electrical Symbols - DIN EN 60617

Push-Button (Normally open contact)	
Push-Button (Normally close contact)	
Changeover switch, (left – no 1-2 in activated and – n0 1 – 4 in deactivated state – (origin position) **Right – no 1-2 in deactivated and – n0 1 – 4 in activated state (as indicated by double arrow).**	
Normally open switch (Switch latches in position/hold in position)	
Reed switch/ magnetic switch	
Limit switch (normally open) / Roller switch NO	
Limit switch (normally closed) / Roller switch NC	
Limit switch (normally open,in activated state)	
Limit switch (normally close,in activated state)	

1.4 Electro-Pneumatics Symbols Electrical Symbols - DIN EN 60617

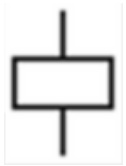
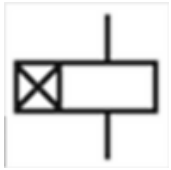
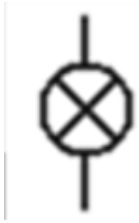
Relay / contactor	
Relay Timer (delayed "ON" activation)	
Relay Timer (delayed "OFF"release)	
Light Indicator	

Table 1.1 : Electro-pneumatic components and symbols

1.4 Electro-Pneumatics Symbols Electrical Symbols - DIN EN 60617

Logic functions

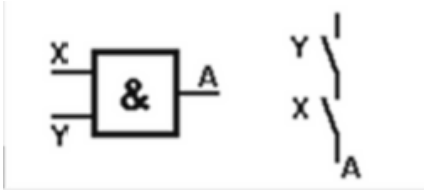
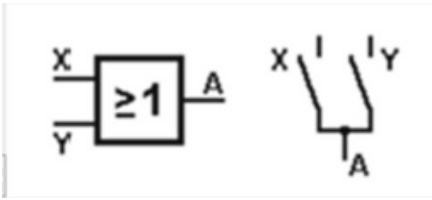
Logic Function	Name	Mathematical Formula	Logic symbol as per DIN 40700 or circuit symbol as per DIN 40713
Reverse Function	NOT	$A = \overline{X}$	
Two Component Function	AND	$A = X \wedge Y$	
Either One Function	OR	$A = X \vee Y$	

Table 1.2 : Logic Functions

Topic 2

Electro-Pneumatics Components

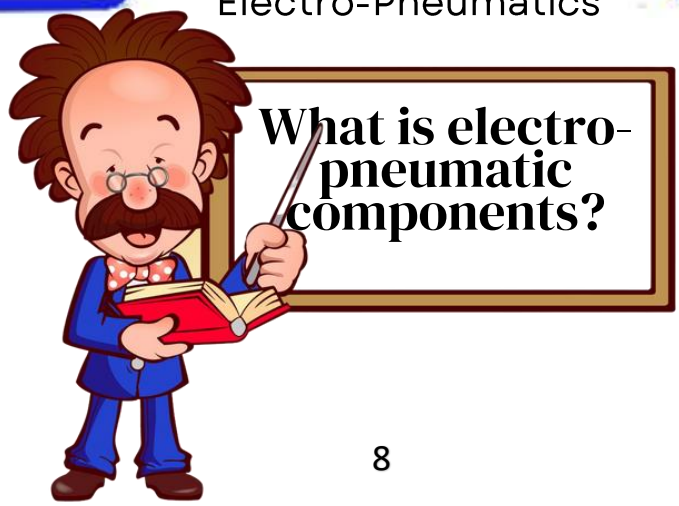
2.0 Introduction to Electro-Pneumatics Component

Electro-pneumatic control consists of electrical control systems operating pneumatic power systems. In this solenoid valves are used as interface between the electrical and pneumatic systems. Devices like limit switches and proximity sensors are used as feedback elements

Electro pneumatics is now commonly used in many areas of Industrial low cost automation control system. The application normally involved in production, assembly, pharmaceutical, chemical, automotive and packaging systems. The used of relays is a basic control for automation system as a basic knowledge for automatic control system. Currently, relays have increasingly been replaced by the programmable logic controllers in order to meet the growing demand for more flexible automation.

Electro Pneumatic control integrates pneumatic and electrical technologies, is more widely used for large applications. In Electro Pneumatics, the signal medium is the electrical signal either AC or DC source is used. Working medium is compressed air. Operating voltages from around 12 V to 220 Volts are often used. The final control valve is activated by solenoid actuation

Figure 2.1 : Introduction of Electro-Pneumatics



2.1 Momentary-Contact Switches

- *In figure 2.2* shows a momentary or push button-normally open (NO) contact switch regarding a circuit symbol according to DIN EN 60617-7 (right - switch operated by manual pushbutton).
- If the Push-Button is actuated, the circuit is closed. After releasing the button a spring restores the switch to its rest setting and the circuit is opened again.
- *The number* 3 and 4 normally used to indicate the contact number of the switch and it's a standardised number.

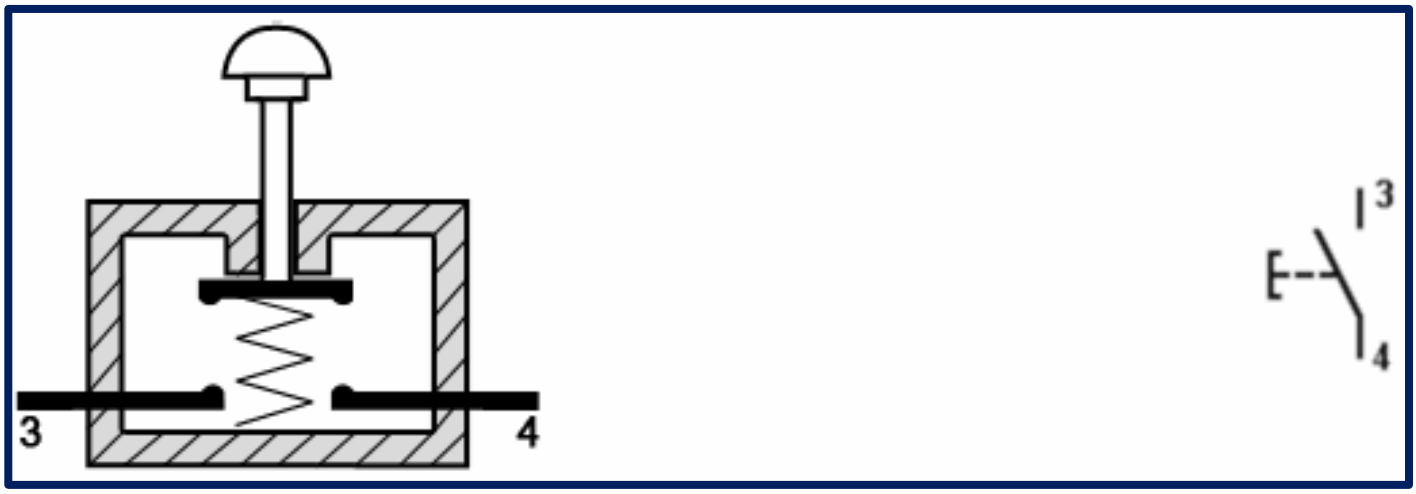


Figure 2.2 : momentary-contact switch in the form of a normally open (NO)

2.1 Momentary-Contact Switches

- *The Graphics* show the design of a momentary-contact switch in the form of a normally closed (NC) contactor with the relevant circuit symbol.
- *The NC contactor* (indicate a non-actuated state) the NC contactor of the circuit is closed as normal. If the pushbutton is activated, the switching contacts are separated thus opening the circuit. After releasing the pushbutton the spring restores the switch to the rest state and the circuit is closed again.
- *NC contact*, Normally used for example, to ensure that the interior light in a car goes off when the doors of the vehicle are closed.

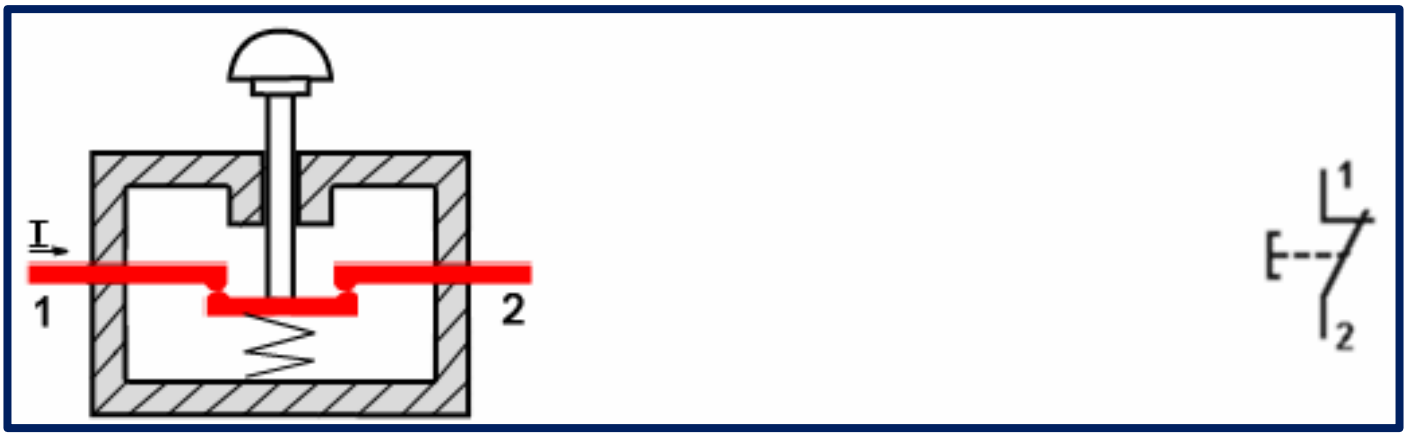


Figure 2.3 : momentary / push button - contact switch in the form of a normally closed (NC)

2.1 Momentary-Contact Switches

- ***A changeover switch*** **normally is** the combination of NO and NC contact (Figure 2.4). By operating the momentary-contact switch is a circuit (from contact 1 to contact 2) is opened contact, while at the same time another circuit (the one from contact 1 to 4) is closed.
- ***The switching action*** can be either when switch over through 1 to 2, or 1 to 4 a shows the changeover contact in the actuated operating state and break in the circuits occurs (if only momentarily).

Figure 2.4 : combination of NO and NC contactors

2.1 Momentary-Contact Switches

Latching Switches:

- For the switch operation of the momentary-contact , in a latching switch the switch setting assumed is also maintained after release. This type of switch can also be designed with NO, NC or changeover contactors.
- There are several operating method of the switch such as a pushbutton, rocker or rotary switch. In Figure 2.5 shows a symbol of a switch in the form of a normally open contact of the pushbutton.

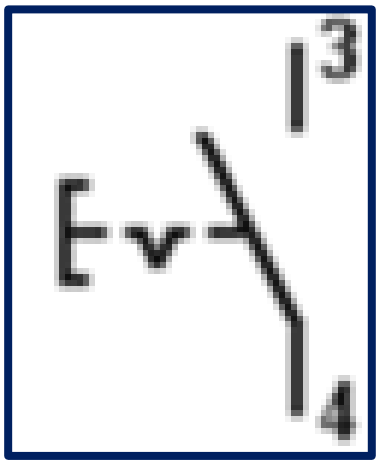


Figure 2.5 : latching switch

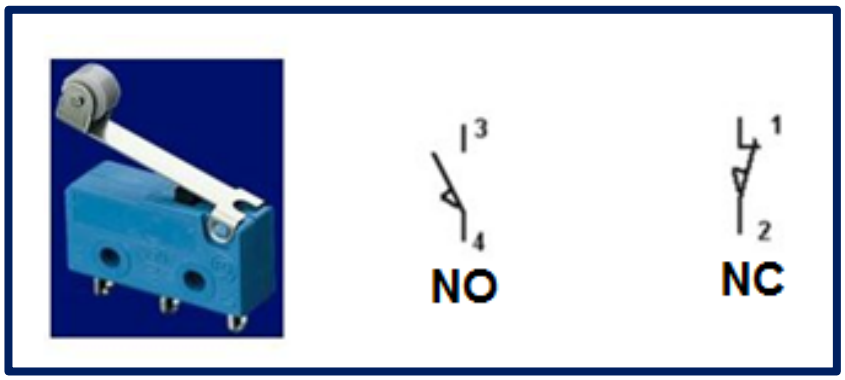


Figure 2.6 : Limit switch

- Limit Switches (momentary-contact limit switches):
- The Limit switches in figure shows a particular variation on the momentary-contact switch. A limit switch is actuated by a machine component or a tool assuming a particular position (e.g. a cylinder piston reaching its end position). As a rule this is performed by cams. Limit switches can also be designed with NO, NC or changeover contactors.
- *In Figure 2.6 illustrate* the design of a limit switch (left) as well as the circuit symbols for an NO contactor (centre) or an NC contactor (right). We can see that the limit switch is depicted with an inverted arrow in the shape of a right-angled triangle drawn directly onto the switch contacts of the circuit symbol ***(http://iamtechnical.com/).***
- ***The symbols*** of the limit switch represent here do not provide any information as to switch actuation, which, if needed may require additional depiction ***(http://iamtechnical.com/).***

2.2 Reed switch

Reed switch:

- Reed switches are magnetically actuated proximity switches designed of a pair pf contacts on ferrous metal reeds in a sealed glass tube filles with inert gas.
- The contacts consist of normally open (NO) contact or, normally closed(NC) contact and opening when a magnetic field is applied. Reed switches are fitted on the cylinder body.

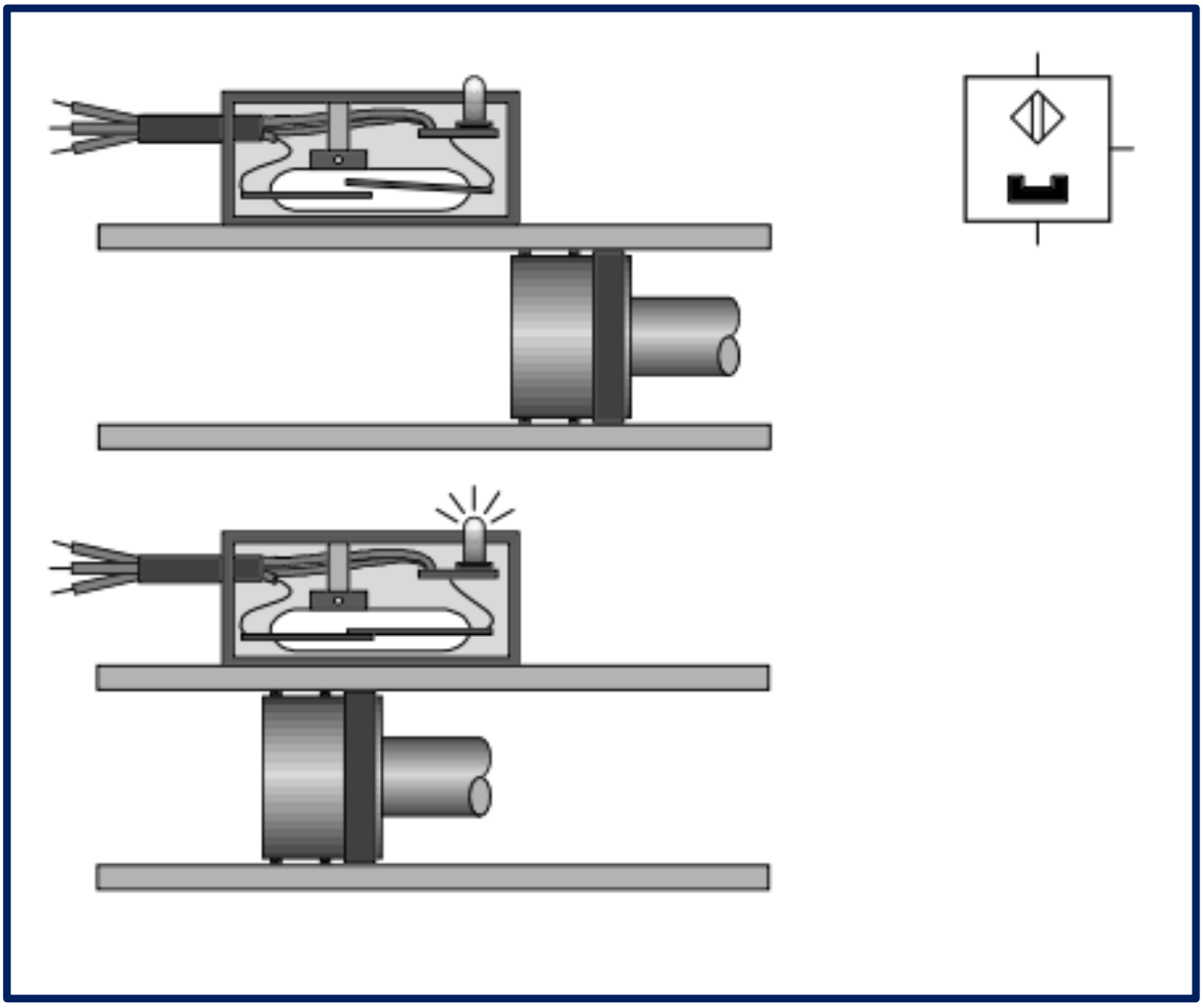


Figure 2.7 : Proximity Reed Switch

2.3 Proximity Sensor – Inductive Sensor

Inductive Proximity sensor:

- Are used for non-contact sensing purposes for metal part only and Being contactless sensors there can be used for position sensing, speed measurement, counting, etc.
- It can be used in extreme conditions, such as oily, dusty, corrosive environment.
- Widely used in electronic, automobile, Food industries, especially in robotic, automation, CNC machines to material handling equipment, process automation, conveyor systems, packaging machines.

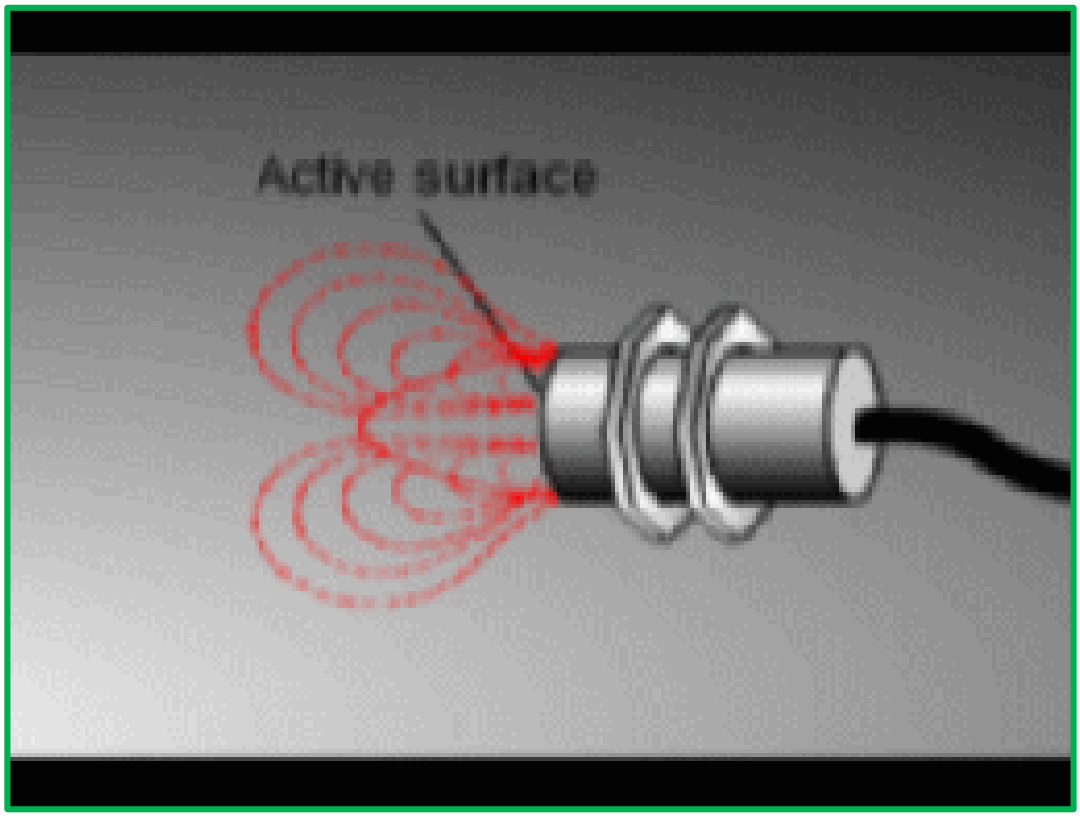


Figure 2.8 : Proximity Sensor – Inductive Sensor

2.3.1 Video Proximity Sensor – Inductive Sensor

Link of video:
https://youtu.be/RO1P8jGYU78

2.3.2 Proximity Sensor Circuit– Inductive Sensor

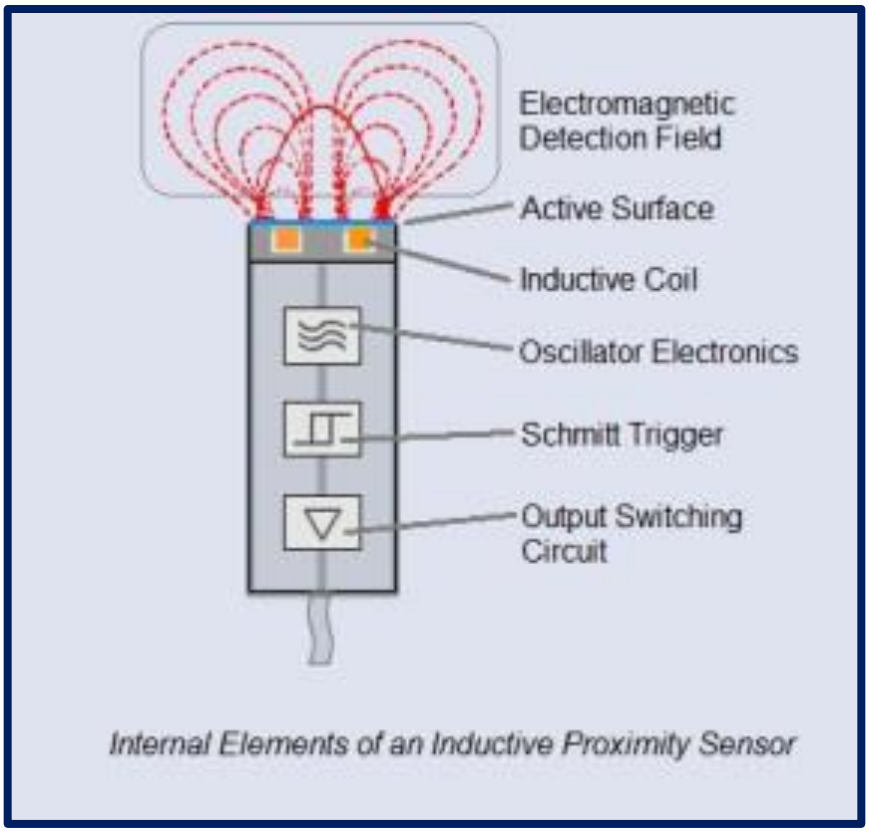


Figure 2.9: Internal elements of Inductive Proximity Sensor

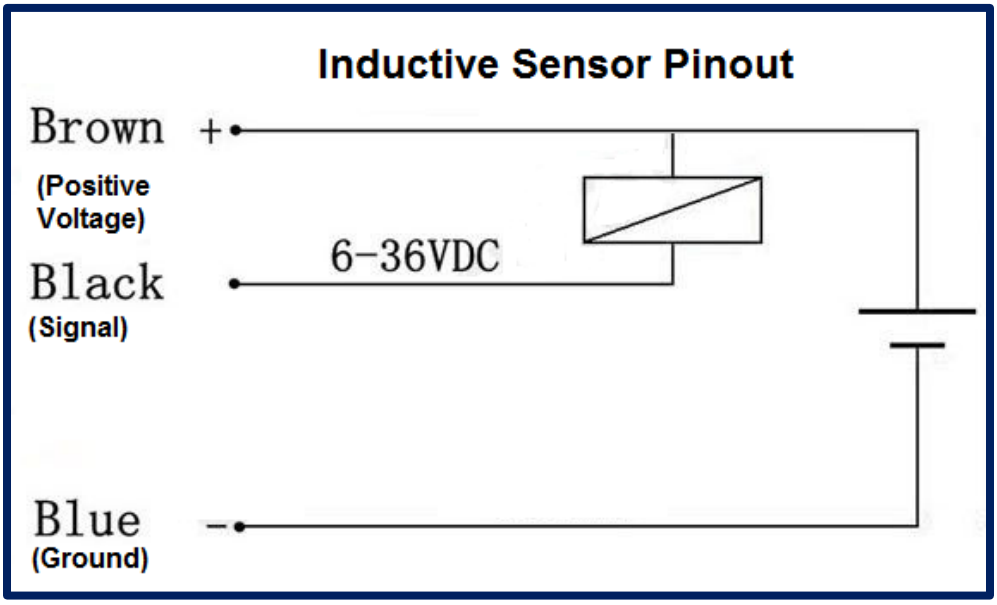


Figure 2.10: Pinout of Inductive Proximity Sensor

2.4 Proximity Sensor – Capacitive Sensor

Capacitive Proximity :

- ***Sensor*** is designed to detect, and react to any object which moves into the operating zone.
- ***Operating*** . The sensor contains an oscillator, The capacitance of this oscillator is linked with the sensing face and when any object moves into the operating zone; its capacitance activates the oscillator.
- ***Detection*** . The sensor can detect conductive as well as non conductive material. It is advisable to have an object with permittivity more than one, the conductive objects are generally to be earthed for better results.

Figure 2.11 : Sensor

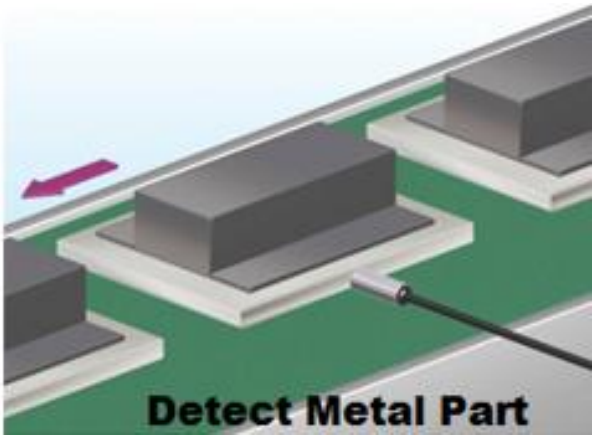
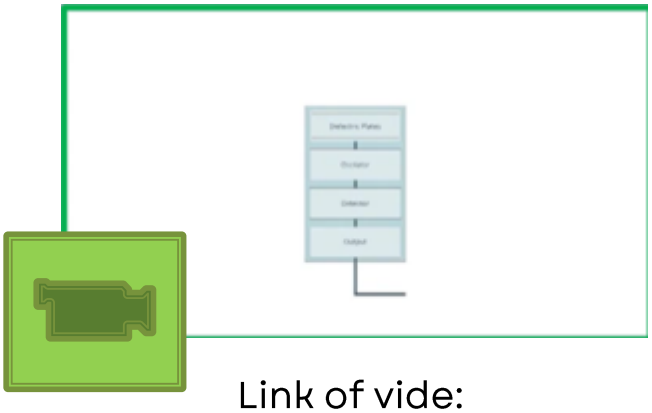


Figure 2.12 : Detection of metal part



Link of vide:
https://youtu.be/Y1mA50tEmLQ

2.5 Solenoid Valve

SOLENOID VALVE

- A 5/2 directional valve has five channels and two switch positions. It is particularly suitable for controlling double-action cylinders.
- The graphic below shows the schematic symbol for such a valve operated on one or both side
- For one side, an electromagnet with a spring operated return. This type of valve behaves in a monostable fashion since when the power is off the spring returns the valve to its rest position.
- A 5/2 directional valve operated by electromagnets on both sides, where, each of the solenoids is assigned to one of the two switching states.
- If the power fails, the valve remains in its current position and no further movement of the machinery takes place.

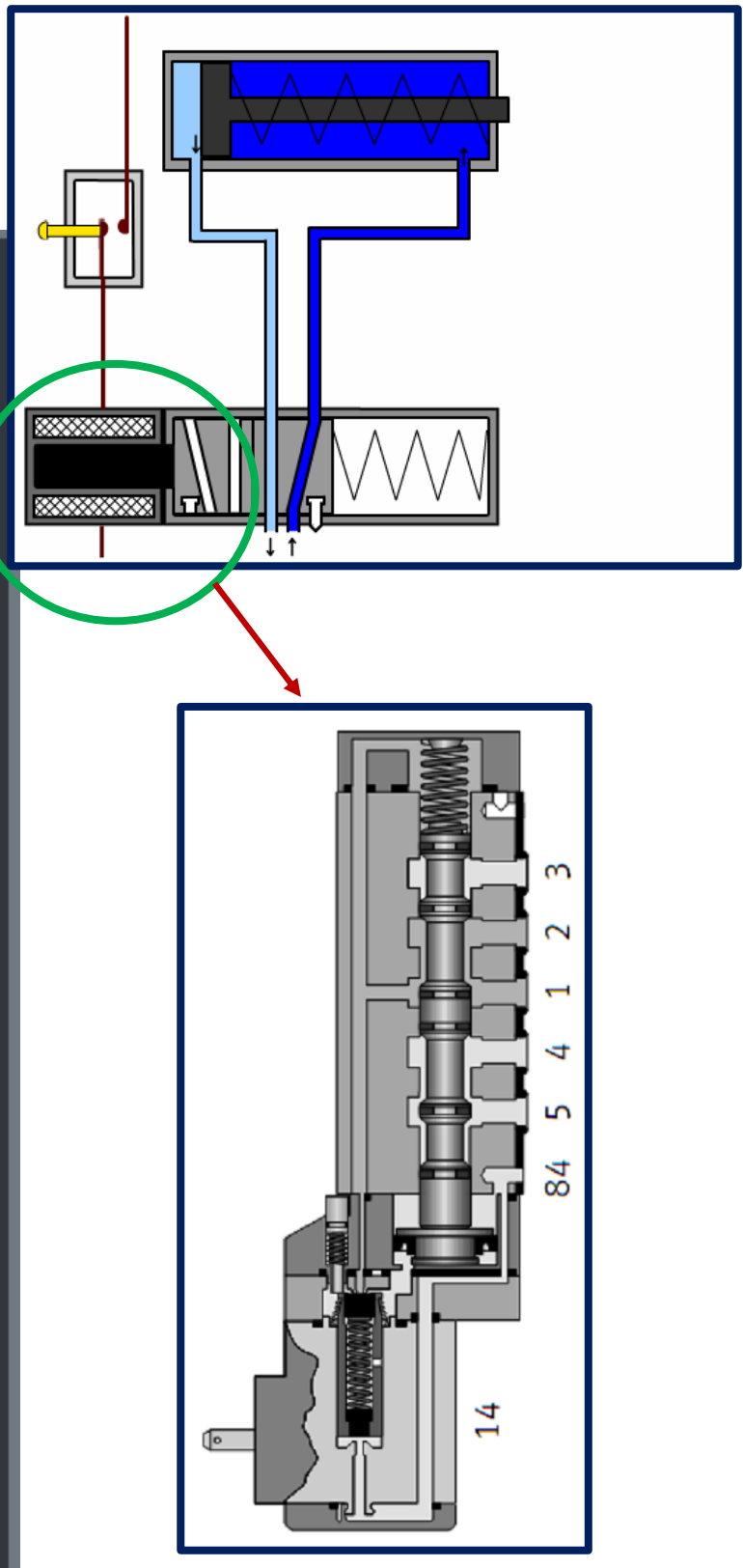


Figure 2.13: Solenoid valve

2.6 How Relays and Contactors Work

- The construction of the Relays or contactors are designed electromagnetically actuated switches with spring-operated return. When a voltage is applied to the coil of the electromagnet an electromagnetic field is induced by the flow of current.
- The armature inside of the relay coil are attracted by the coil core so that the relay contacts are closed or opened depending on how they are arranged. If the current flowing through the coil is interrupted, a spring ensures that the armature is restored to its rest position.
- The figure show the illustrates how relay works.

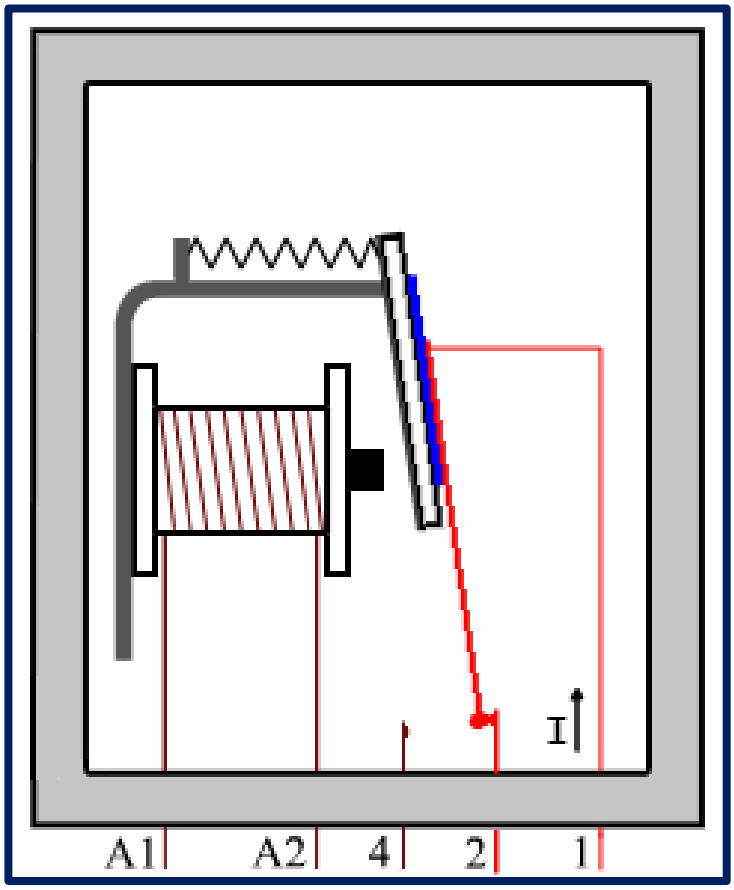


Figure 2.14 : Working principle of relays and contactors

How Relays and Contactors Work

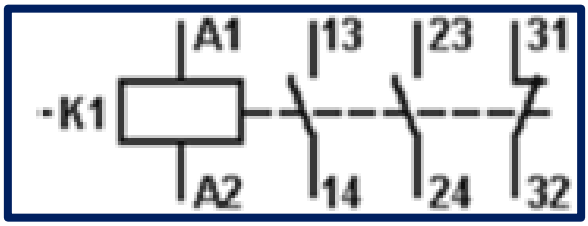


Figure 2.15 : relays and contactors

How Relays and Contactors Work

Your great subtitle in this line

1 **COIL**

➢One or more contacts can be switched by a single relay coil.

2 **Relay Contact**

➢The contacts of the relay are depicted either separately or in relation to the electromagnetic drive, i.e. the coil.

3 **Relay Coil No.**

➢The following diagram shows the latter case for a relay coil (K1), indicate A1 and A2 with two NO contactors and one NC contactor.

4 **Contact No.**

➢Relay contacts are labelled according to a certain system: each first digit of a contact designation serves to number the existing contact paths or circuits.

5 **NO / NC**

➢The second digit specifies respectively whether we are dealing with an NO, NC or a changeover contactor.

2.7 Relays Construction

Figure 2.16 : Relays

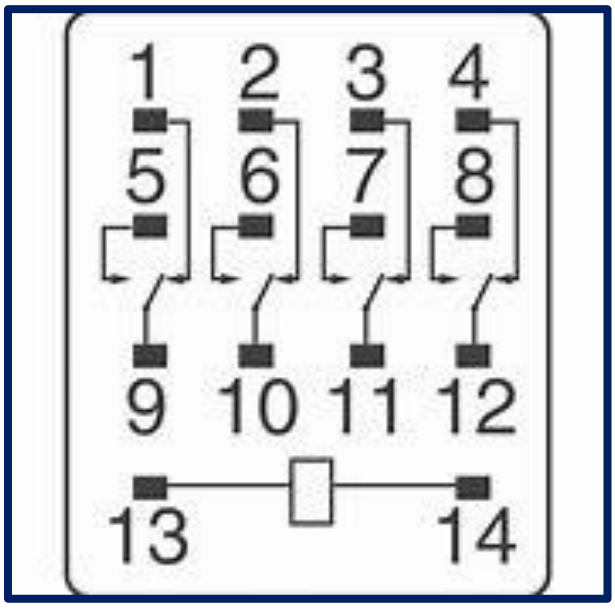


Figure 2.17 : Construction of Relays

4 Pole Relay

- No 13 & 14 – Relay coil
- No 1, 2, 3, 4 – Com.
- 5, 6, 7, 8 – NO contact
- 9, 10, 11, 12 – NC contact

2.8 How Relays and Contactors Work

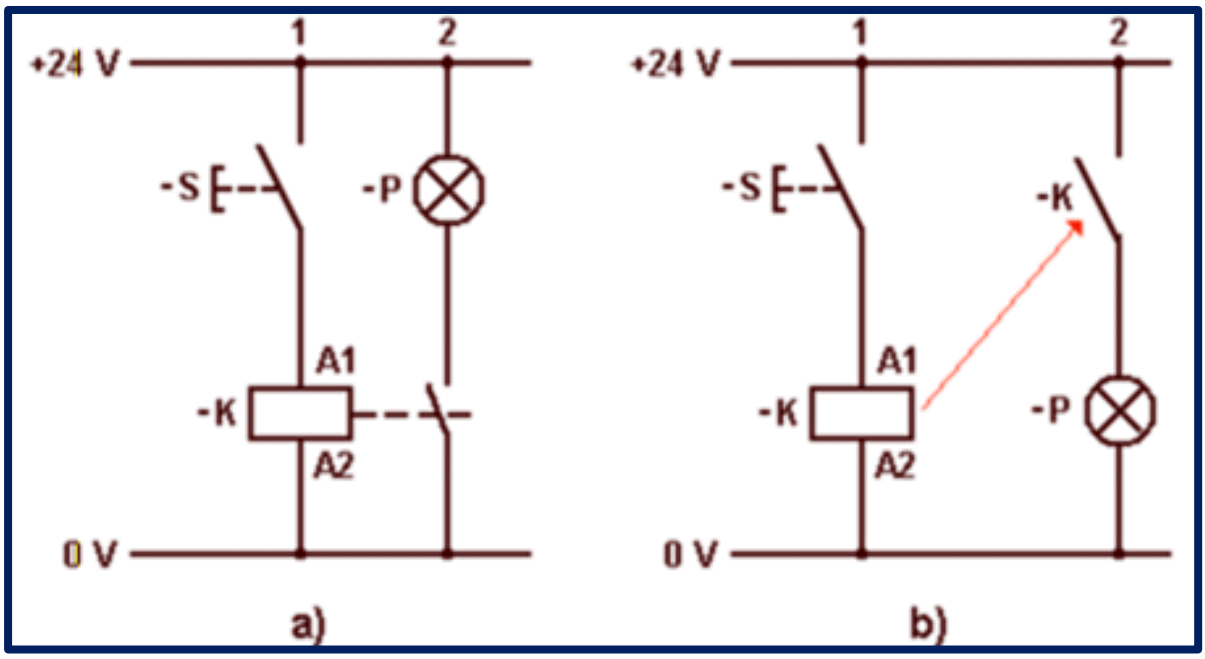


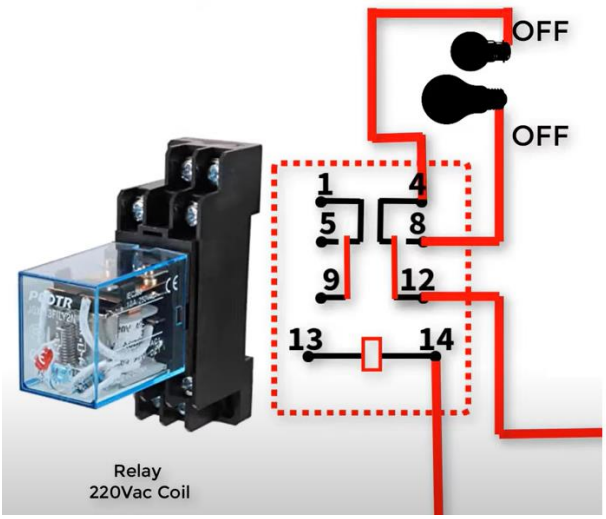
Figure 2.18 : Relays and contactors

- **Coils and relay contacts** are mostly drawn separate from each other, as this leads to more clarity in the drafting of circuit diagrams.
- Where, the lamp P that is indirectly switched on or off via a pushbutton S and a relay K.
- Figure a) shows the contacts depicted directly at the position of the coil, diagram b) shows a separated depiction (the red arrow serves here merely to illustrate the relationship and is not part of the circuit diagram!).
- **The circuit diagram** on the left (1) depicts the control circuit while the circuit diagram on the right (2) shows the main circuit.
- **Contactors** operate according to the same principle as relays, but they have *two* interruption points per contact as well as arc quenching chambers. For that reason they can switch higher currents than a relay.

Application in Pneumatics

- For signal multiplication (sequencing control circuit)
- As a signal conversion (switching circuits with higher voltage)
- For signal input and output for time delays and counters
- To form a logical switching operations using more than one relay)
- Used for various input and output through input contact.

2.9 Application of Relays

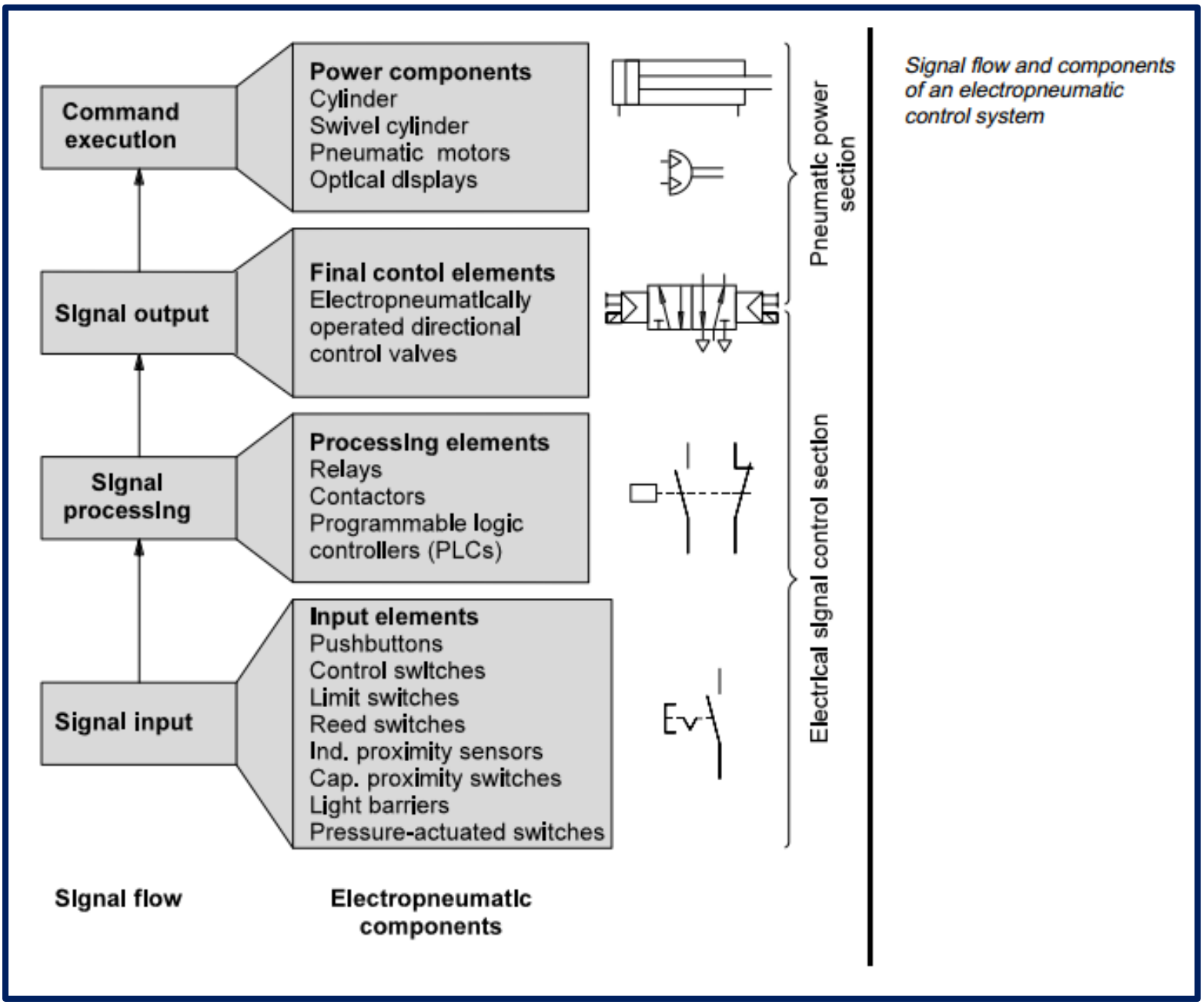


Link of video :
https://www.youtube.com/watch?v=GOg_TE5cfg8

Topic 3

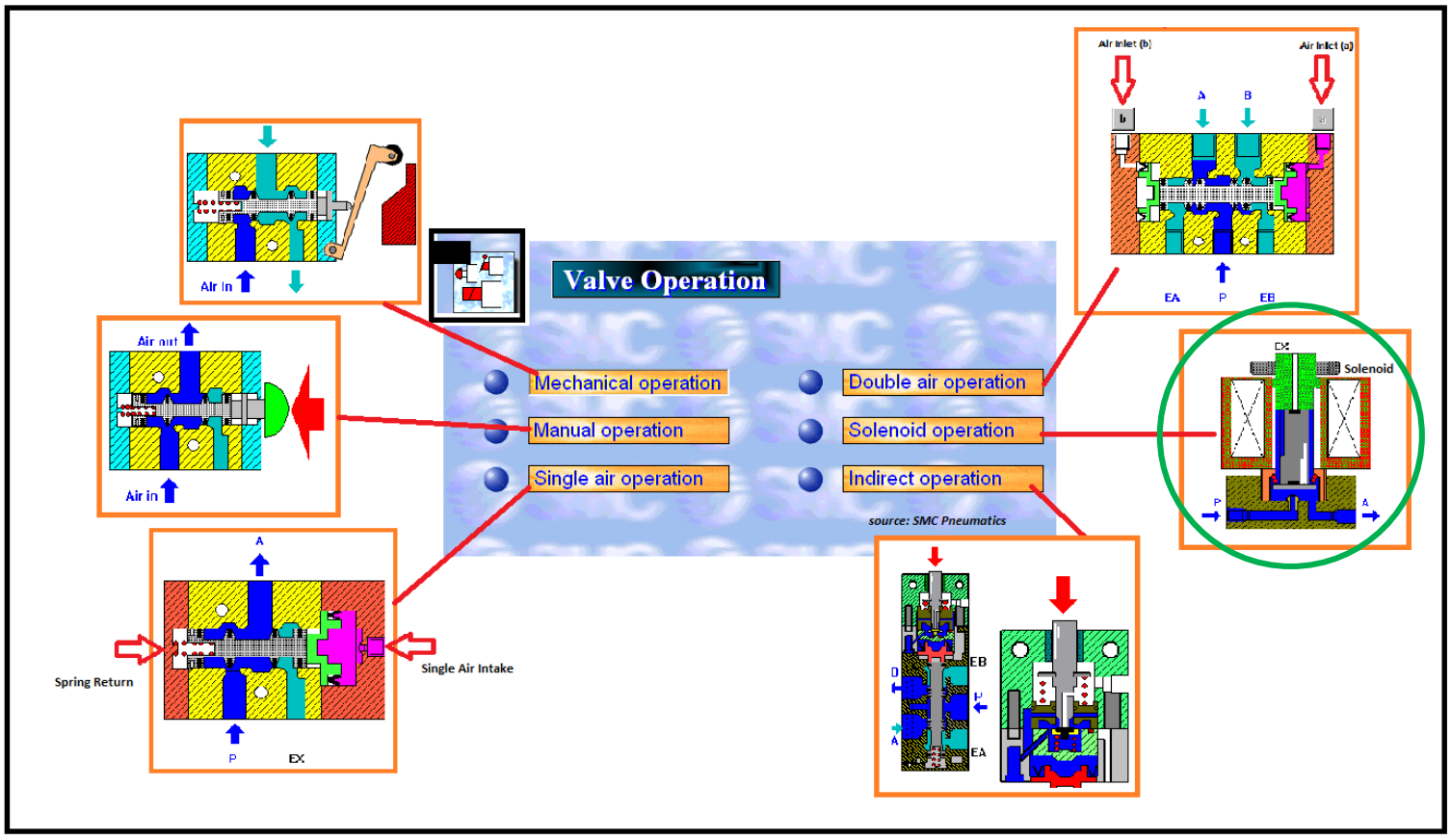
Electro-Pneumatics Circuit Design

3.1.1 Electro-Pneumatic Sequence



Signal flow and components of an electropneumatic control system

3.1.2 Electro-Pneumatic Valve Operation



- Directional control valve is represented by the number of controlled connections, the number of positions and the flow path. *(https://www.coursehero.com/file/12829684/PNEUMATIKA-labs-Festo-eng/)*
- Numbering system is used to designate directional control valves and is in accordance with DIN ISO 5599-3 . *(https://www.coursehero.com/file/12829684/PNEUMATIKA-labs-Festo-eng/)*

ISO 5599-3	Lettering System	Port or Connection
1	P	Pressure port
2, 4	A, B	Working lines
3, 5	R, S	Exhaust ports

Table 3.1: Directional Control Valve (DCV) Port

3.1.3 Electro-Pneumatic Application

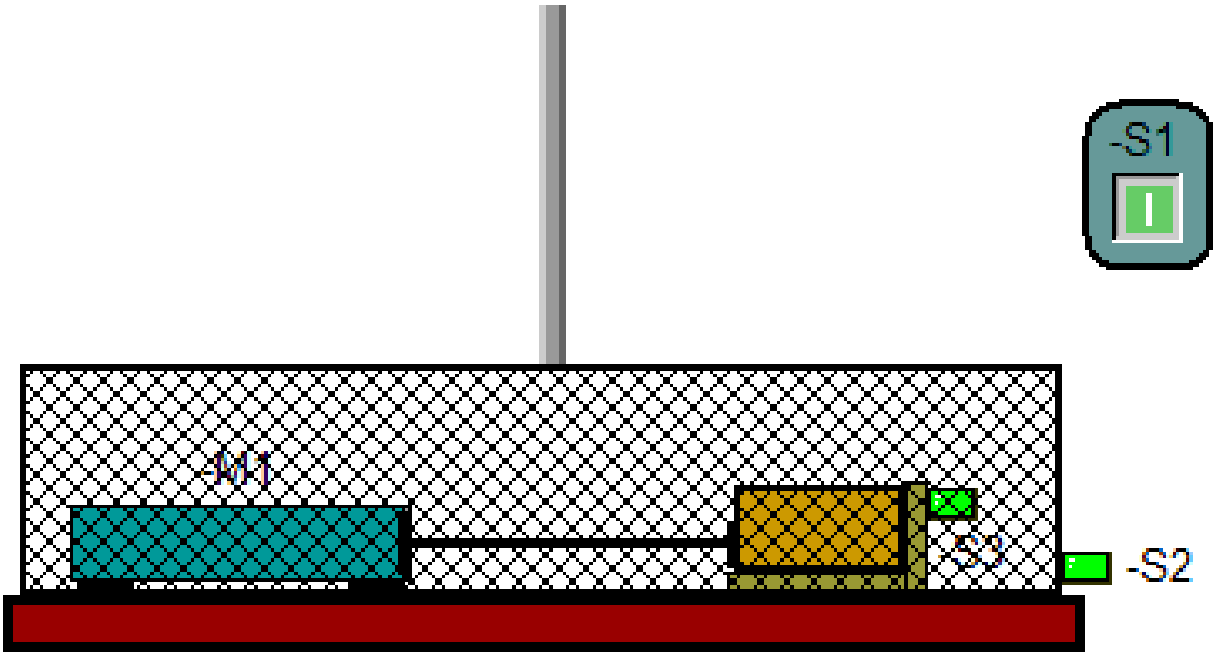


Figure 3.1: schematic for a clamping cylinder (M1) using a double acting cylinder with a spring return

- The **Figure** shows a schematic for a clamping cylinder (M1) using a double acting cylinder with a spring return
- It extends in order to clamp a piece of raw material to be worked on. The machinery is protected by a safety cover.
- **Switch S1** must switch on in order to start the sequence process.
- Then, the **protective cover** is lowered (detected by switch S2) and the piece to be worked on is in place (detected by switch S3).

3.2 Electro-Pneumatic Circuit

Question

- **Develop** a Pneumatic and Electric Circuit
- **The electrical circuits** are constructed as in Figure.
- **Push button** is connected in series (AND Function).

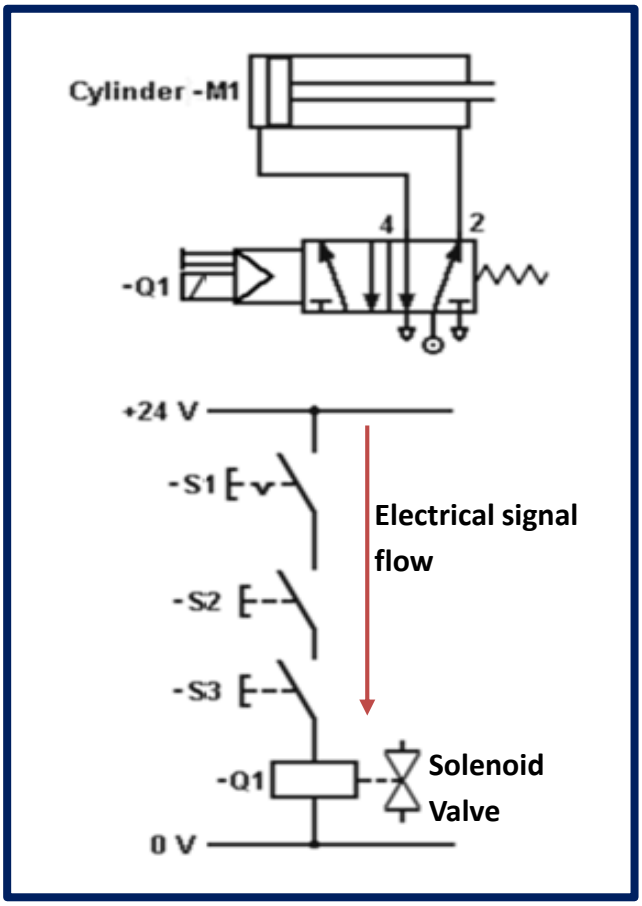


Figure 3.2: Electro-Pneumatic Circuit (answer)

3.3 Truth Table and AND function

Question

- A piece of material that has been worked on should be ejectable by a cylinder as a result of activating either of two switches (S3 and S4-OR function) but the retraction of the cylinder should occur as a response to only one switch (S2)
- The machinery is turned on by switch S1
- Circuit is connected in parallel.

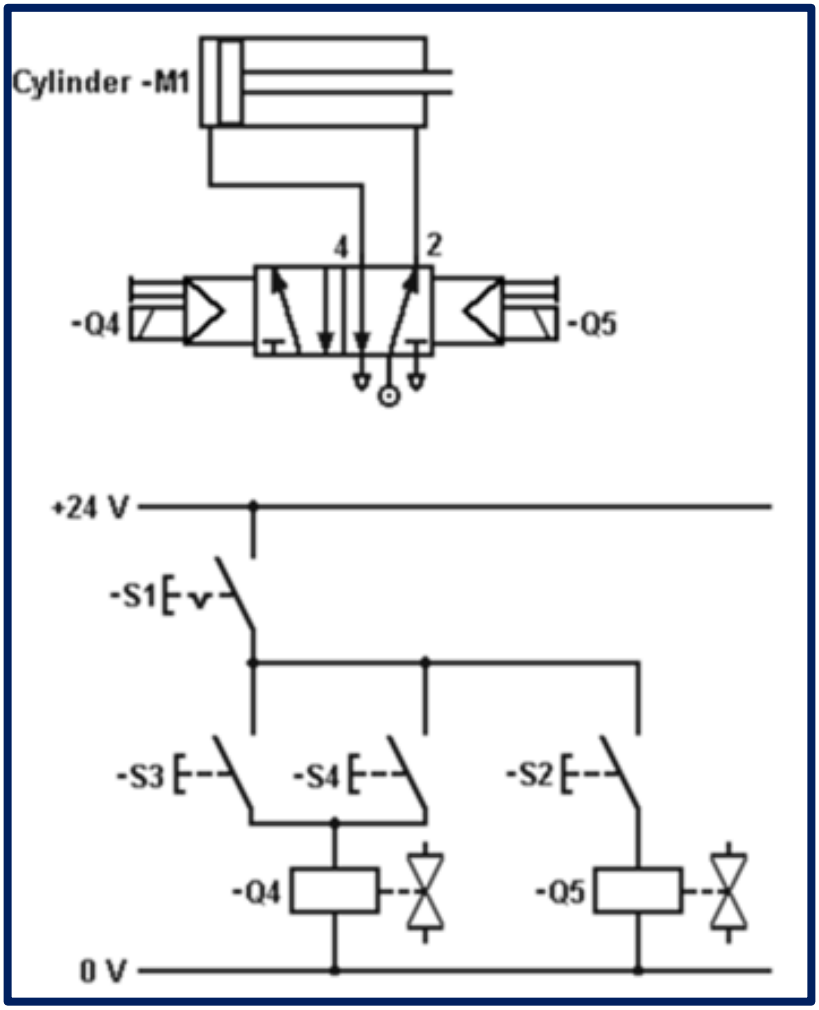


Figure 3.3 : Electro-Pneumatics Circuit (OR and AND function) answer

3.4 Electro-Pneumatics Circuit (OR and 'AND' Function)

Truth Table of AND function

- Used for parallel application
- Needs a two switches
- The OR valve is switched through to the output by applying compressed air to either one of two switches as in Table. *(https://vbook.pub/documents/lab-manual-of-pneumatics-control-mo80l077v6wn)*

AND Truth Table

X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

input		Output	
0	Deactivate	0	Off
1	activate	1	On

Table 3.2 : Truth table of AND function

Electro-Pneumatics Circuit (OR and 'AND' Function)

Truth Table of OR function

- Used for parallel application
- Needs a two switches
- The OR valve is switched through to the output by applying compressed air to either one of two switches as in Table. *(https://vbook.pub/documents/lab-manual-of-pneumatics-control-mo80l077v6wn)*

OR Truth Table

X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

input		Output	
0	Deactivate	0	Off
1	activate	1	On

Table 3.3 : Truth table of OR function

3.5 Electro-Pneumatics Circuit (Indirect)

The graphic shows an example of a circuit diagram for a pneumatic control system, consisting of a pneumatic diagram (top) and an electric circuit diagram (bottom). It can be seen that the solenoid Y1 of valve 1V1 appears in both diagrams and so it is labeled identically in both.

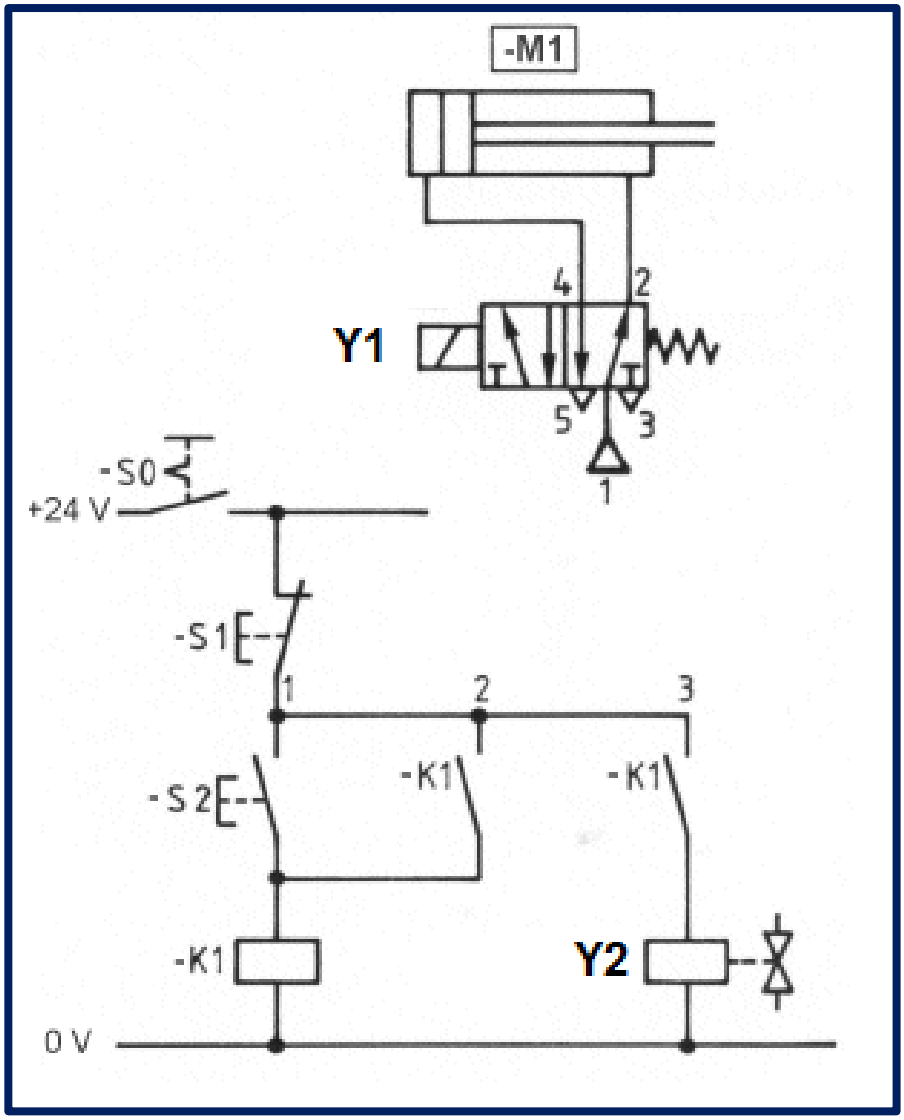


Figure 3.4 : Pneumatic control system

3.6 Direct circuit Vs Indirect Circuit

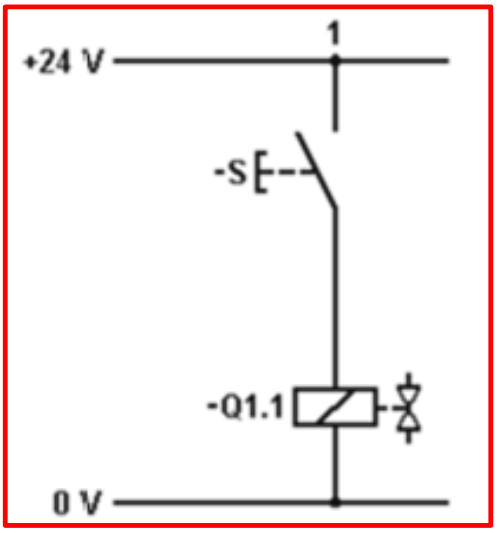


Figure 3.5 : Direct Control components

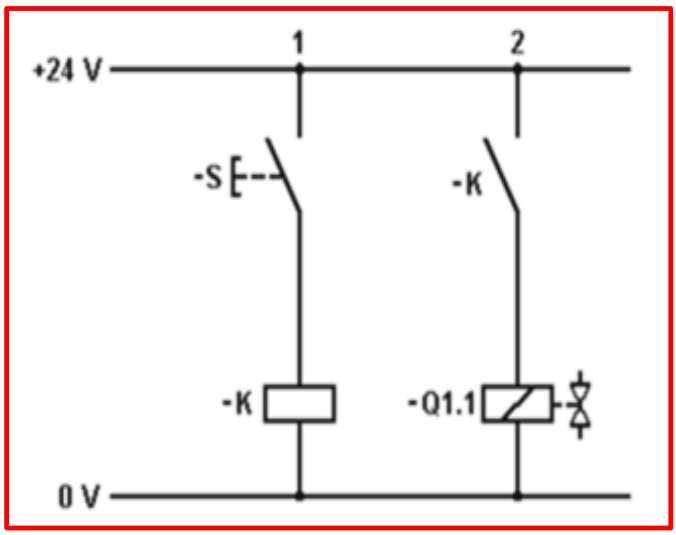
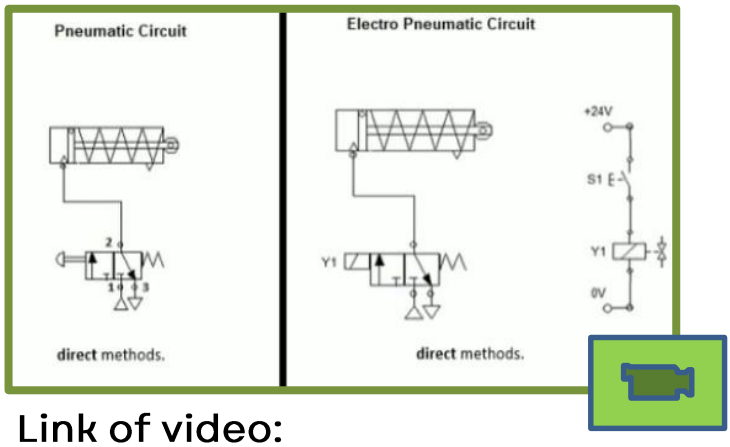


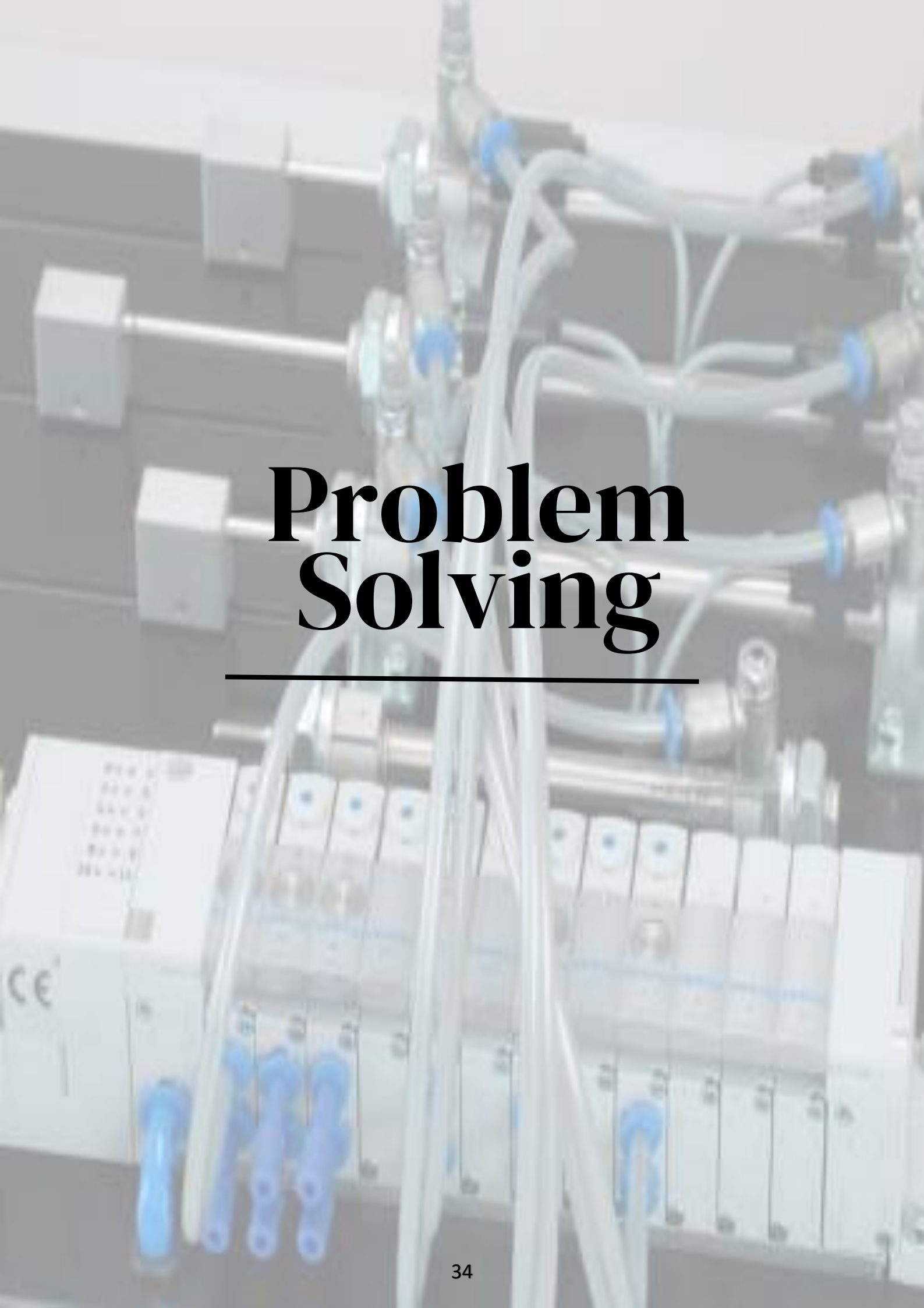
Figure 3.6 : Indirect Control components

The graphic shows the electrical component of an electro-pneumatic control system that directly controls a cylinder (the pneumatic component of the system is not illustrated). Pressing the button S closes circuit 1 and solenoid Q1.1 of the directional control valve is supplied with power. When the button is released, the circuit opens, the electromagnet releases and the valve returns to its rest position. ***(http://iamtechnical.com/direct-and-indirect-control-single-action-cylinder)***

The circuit illustrates indirect control of a cylinder (with its more complex circuitry). The current to the coil of the solenoid is not directly applied via the switch but indirectly via an intermediate **Relay K.** ***(http://iamtechnical.com/direct-and-indirect-control-single-action-cylinder***



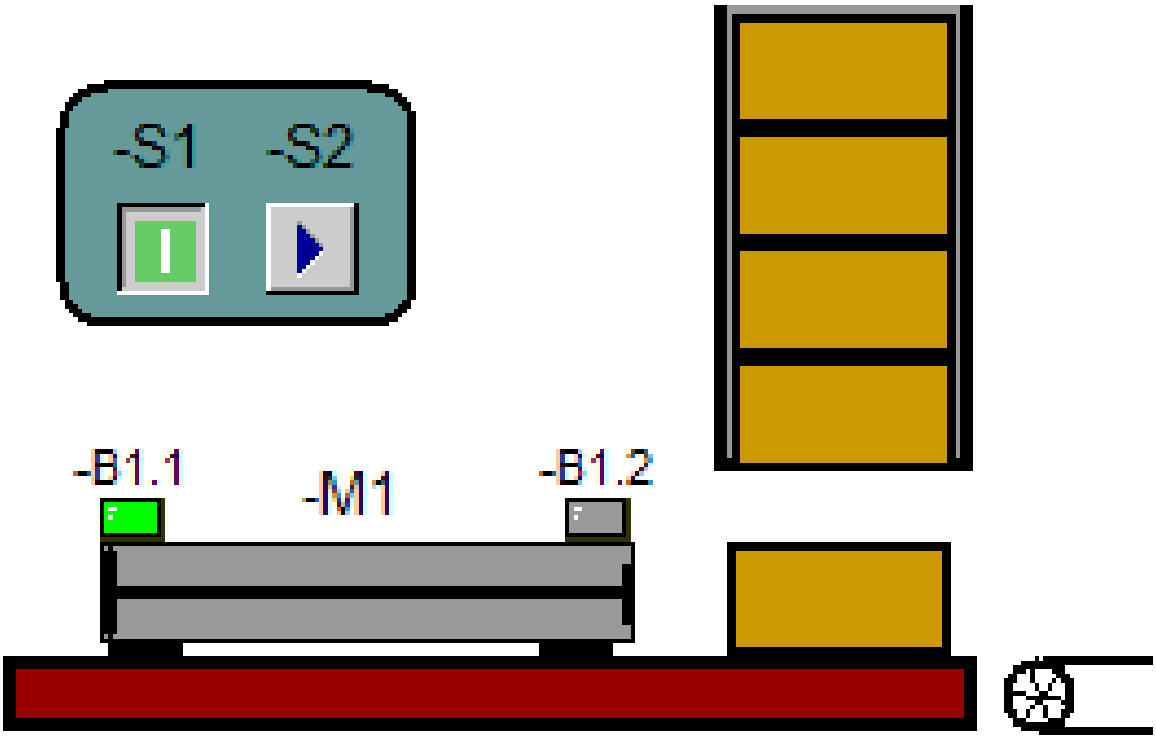
Link of video:
https://youtu.be/7x3s8ipEU5E



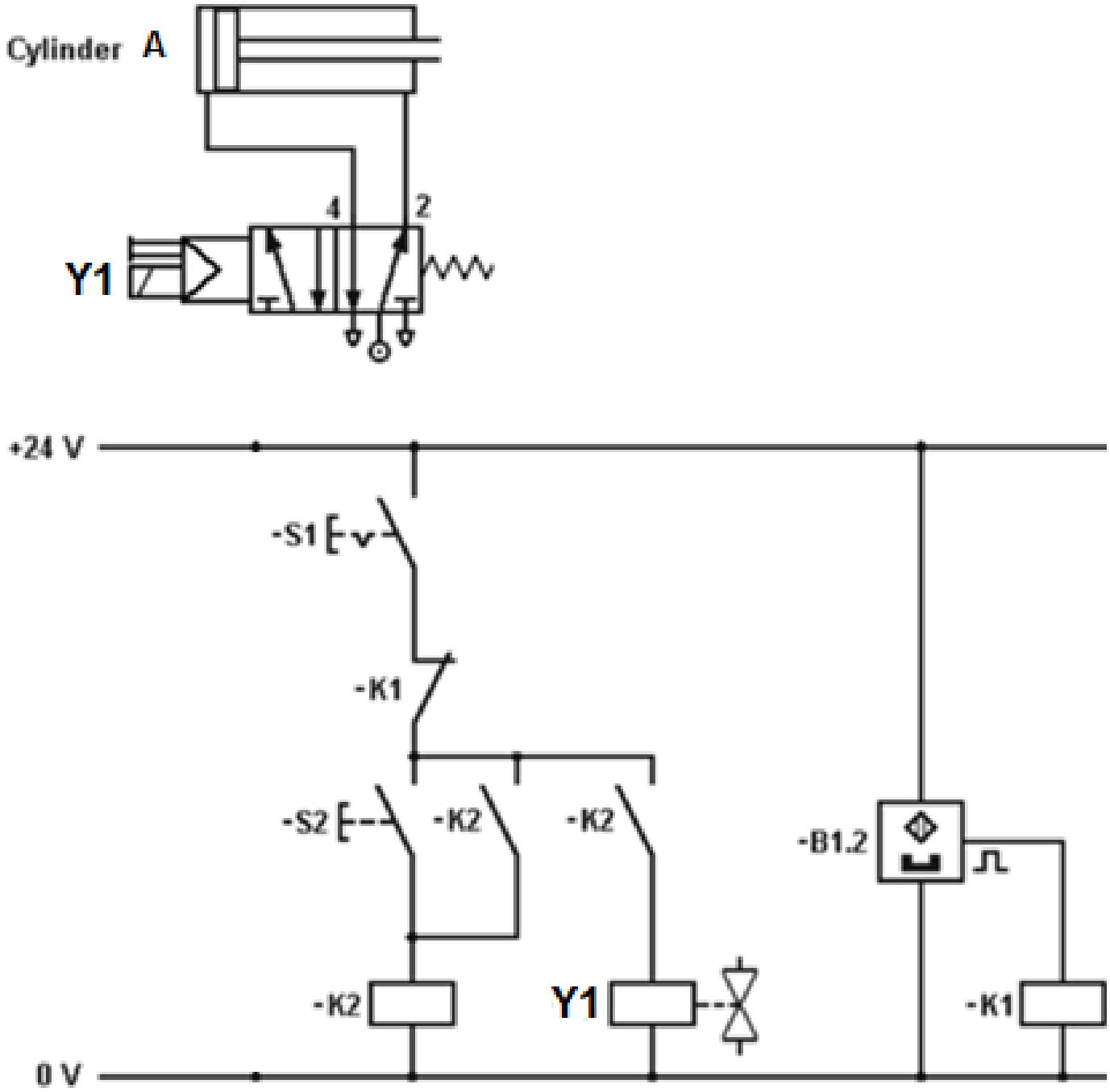
Problem Solving

3.7 Problem 1

- A double-acting cylinder (M1) with a directional control valve with single solenoid, spring-operated return is intended to push components from a magazine onto a conveyor belt.
- The cylinder is extend after a brief press of button S2 and automatically return to its original position after reaching a limit position detected by switch B1.2.
- The system is switched on and off via switch S1.

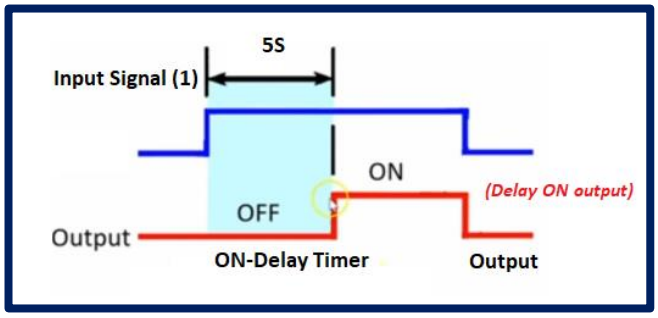


Solution 1

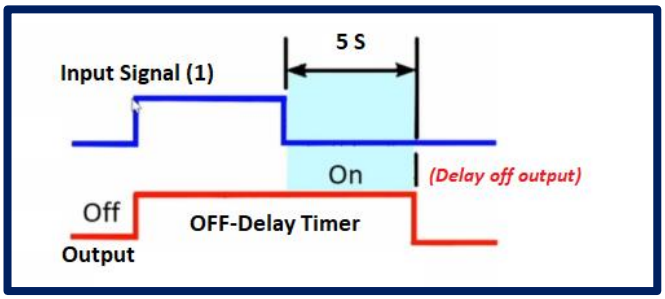


3.8 Timer

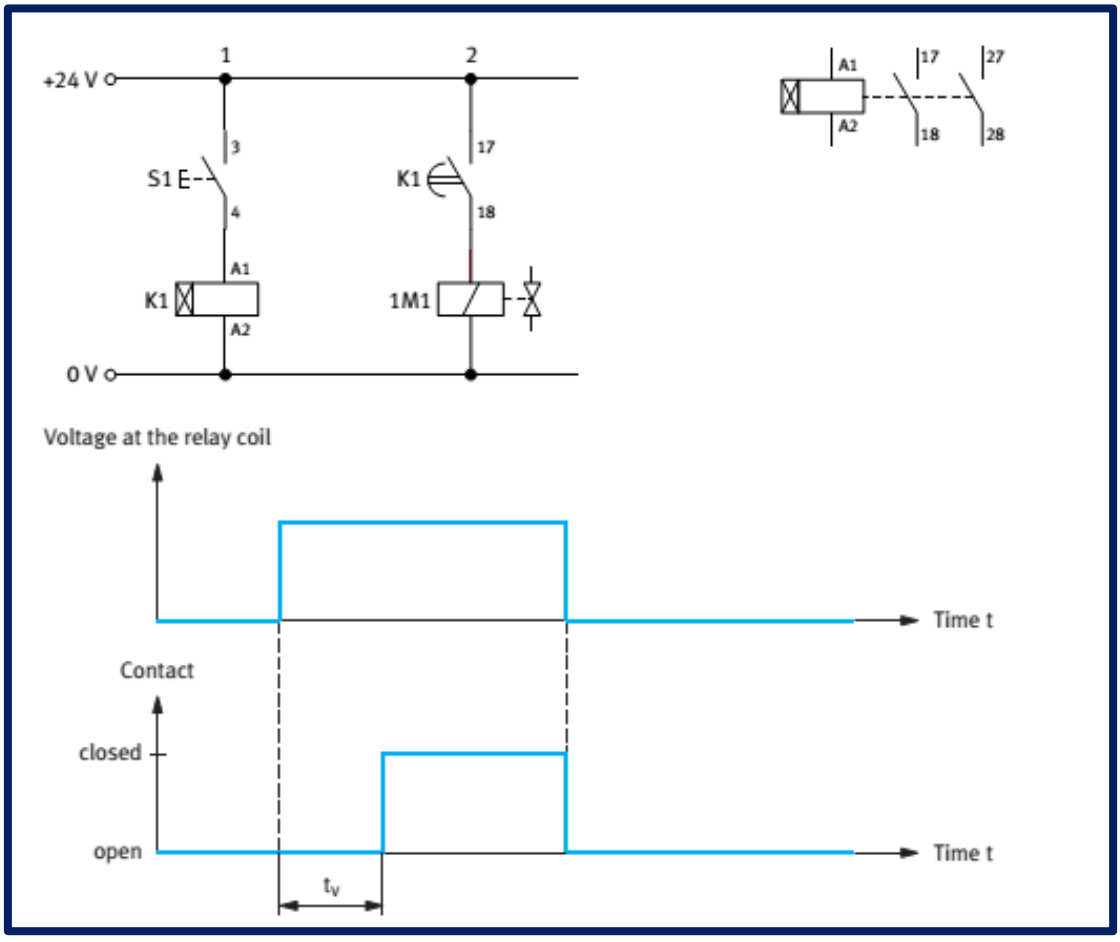
- With time delay relays, it has a coil that acts either to delay ON operation or delay OFF operation; There are two types of timer, namely:
  - On-Delay Timer
  - Off-Delay Timer



- On-Delay Timer, where it will delay the moment an operation starts.



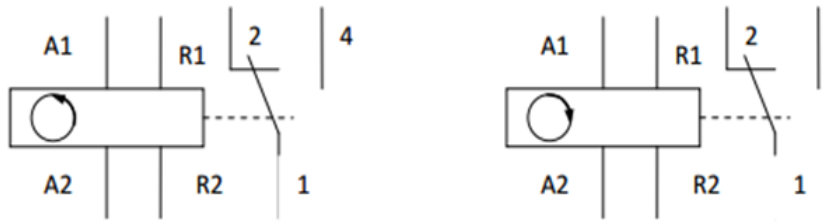
- In Off-Delay Timer , the output is reverse is true, where it will delay Off signal and the delay time can be set.



3.9 Counter

- An electric counter consist of a coil, associated circuits and contacts, a reset coil, manual reset,
- release button and a display window. Pressure the release button of the counter and entering the
- desired count valve set the pre-determining counter. The pre-determined count valve is displayed in the window *(http://docplayer.net/23993521-Lecture-41-electro-pneumatic-control.html)*
- It consists of two main types of counters:
  - Counter-Up
  - Counter-Down

Type of Counter

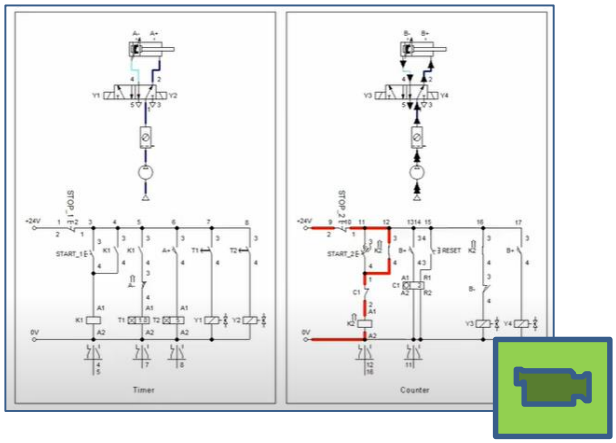


a) up counter

- **Up Counter**: An up counter counts electrical signal upwards from zero. For each electrical counting
- pulse input to an up-counter coil, the counter value is incremented by 1. When the predetermined
- valve has been reached, the relay picks up and the contact set is actuated.

b) down counter

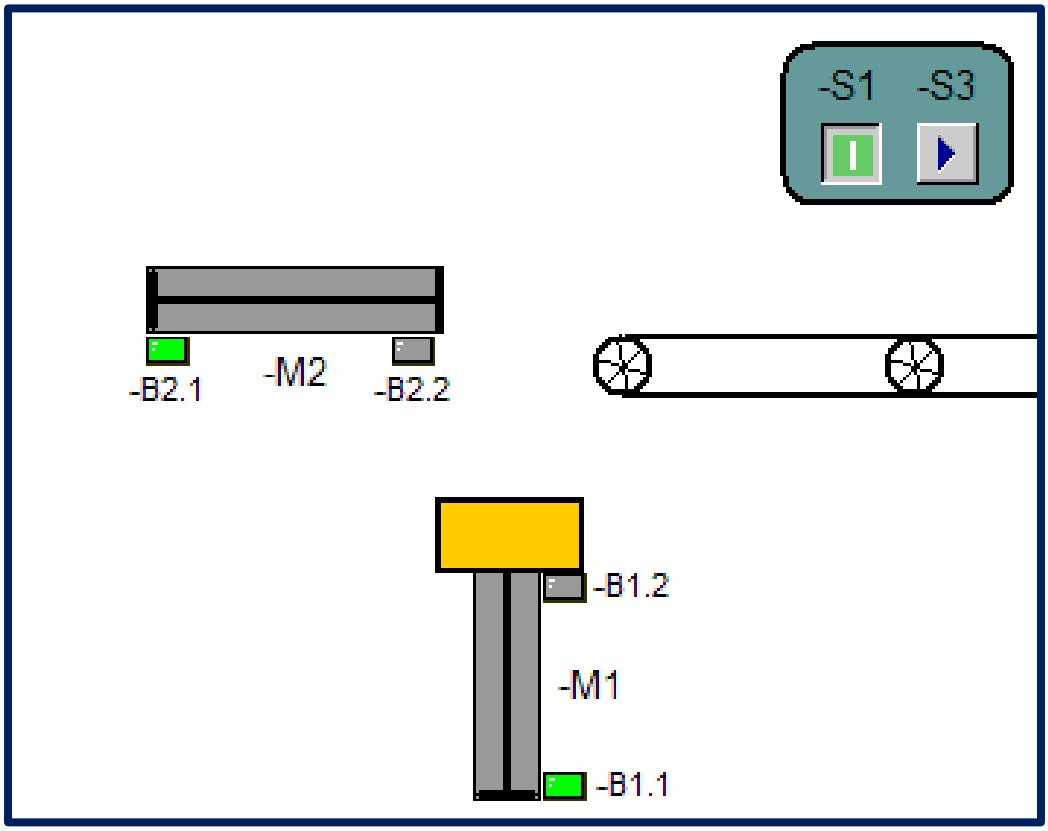
- An down counter counts electrical signal downwards An down counter counts electrical signal downwards from preset valve.
- If the count valves of zero is reached the relay picks up and the contact set is actuated.
- The counter can be reset manually by pressing the reset button or electrically by applying a reset pulse to the reset coil.
- The pre-determined value is maintained when the counter is reset



Link of video: https://youtu.be/PGC21Wxlf-Q

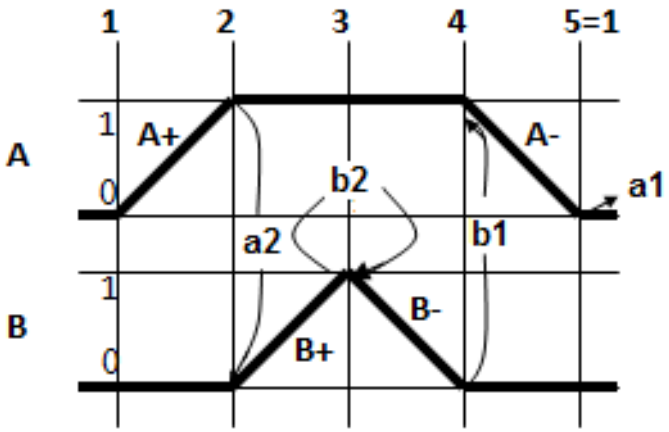
3.10 Problem 2

- Boxes are to be transported to a conveyor belt by means of two dual-action cylinders controlled by bi-stable 5/2 directional control valves.
- **Pressing S3** causes the first cylinder **(M1)** to lift the box and when it has reached its limit, the second cylinder **(M2)** pushes the box onto the conveyor belt, returning thereafter to its rest position.
- Once it has reached its rest position, the first cylinder also retracts back to its initial state.
- The machinery is switched on using **switch S1** (as main switch).

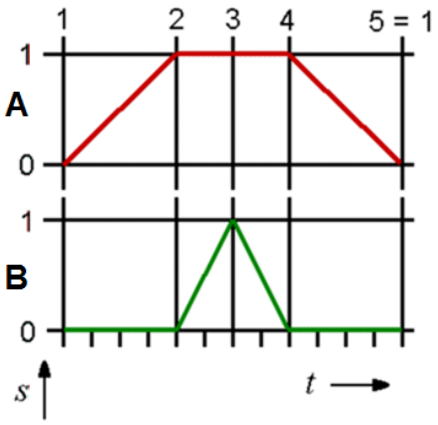


Solution 2

Draw a displacement-step diagram or timing diagram



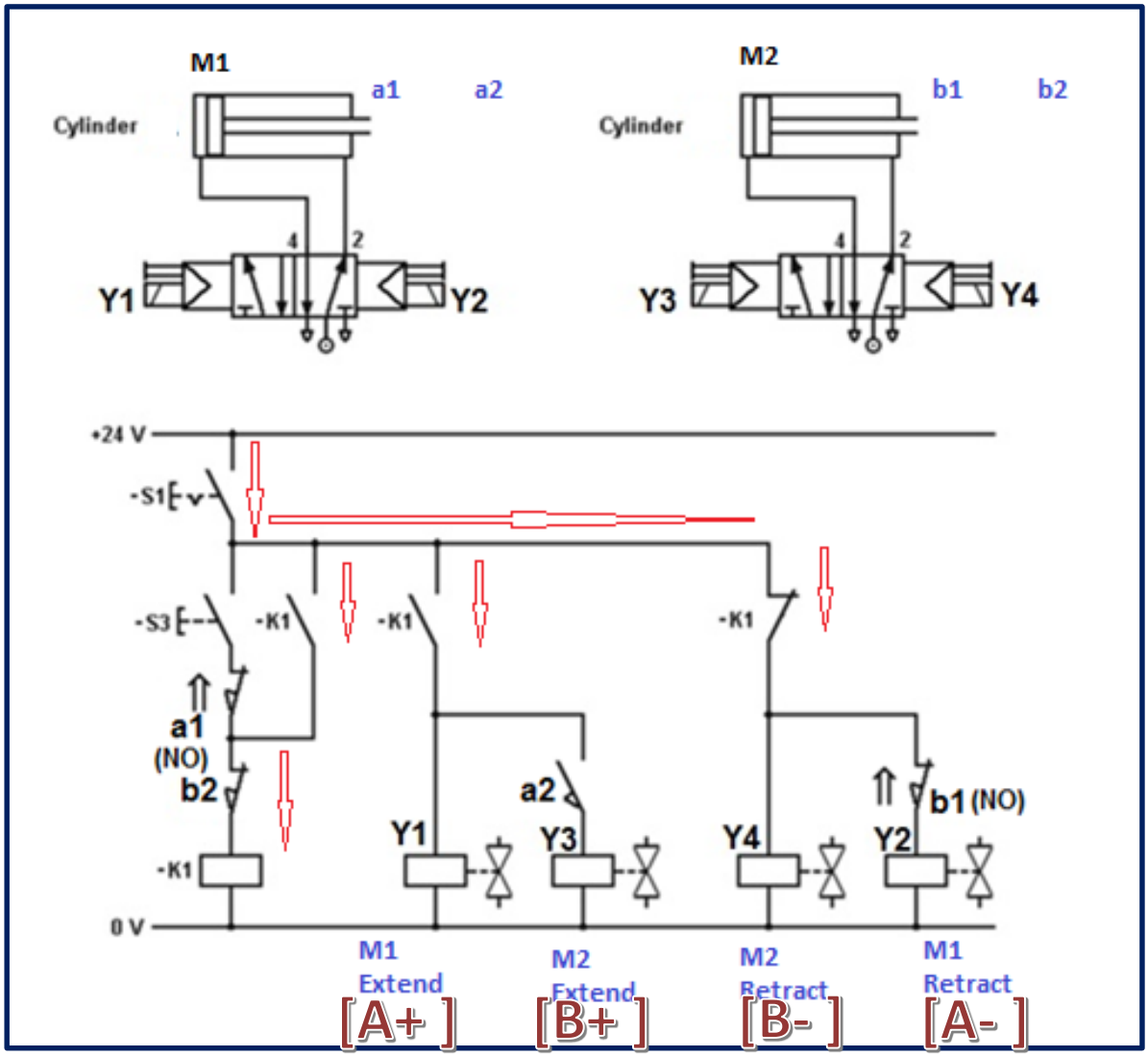
Displacement step-Diagram



Timing diagram

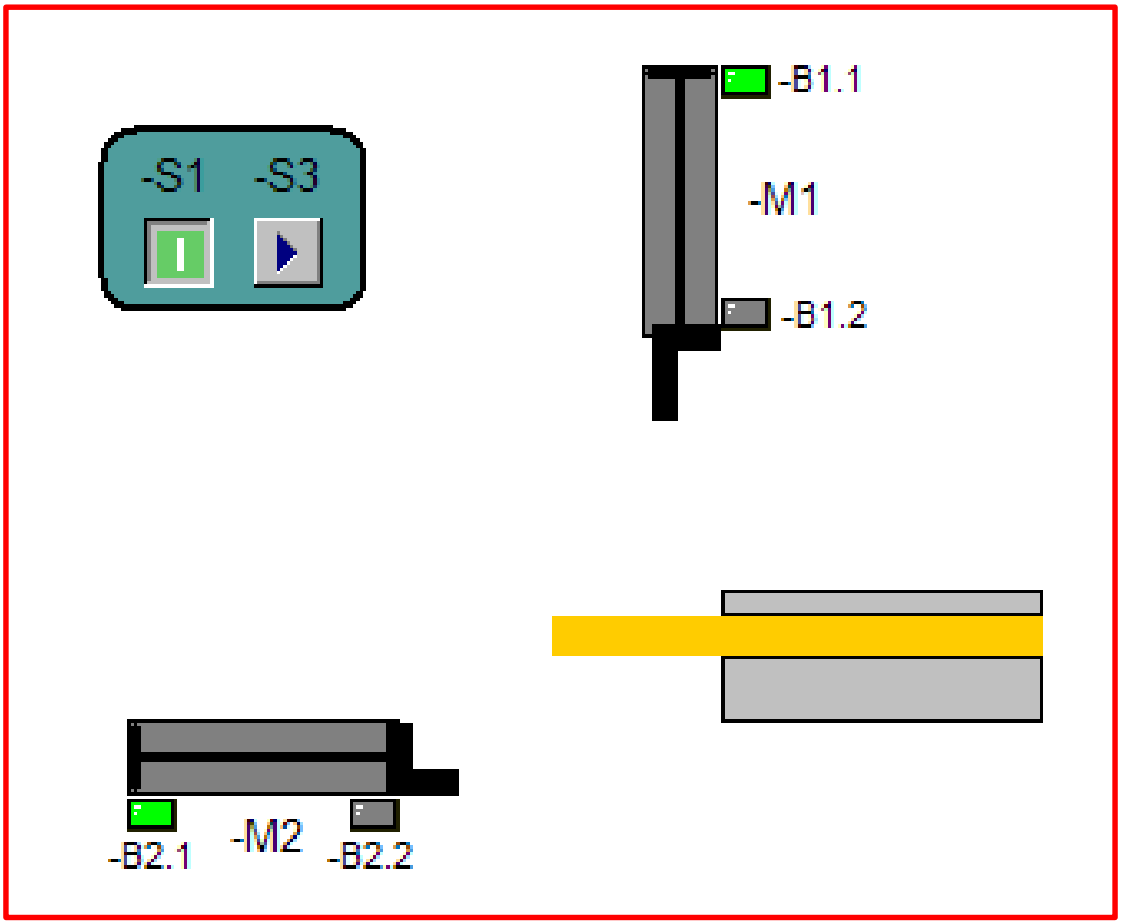
[A+ B+ B- A-]

Construct a pneumatic and electrical diagram

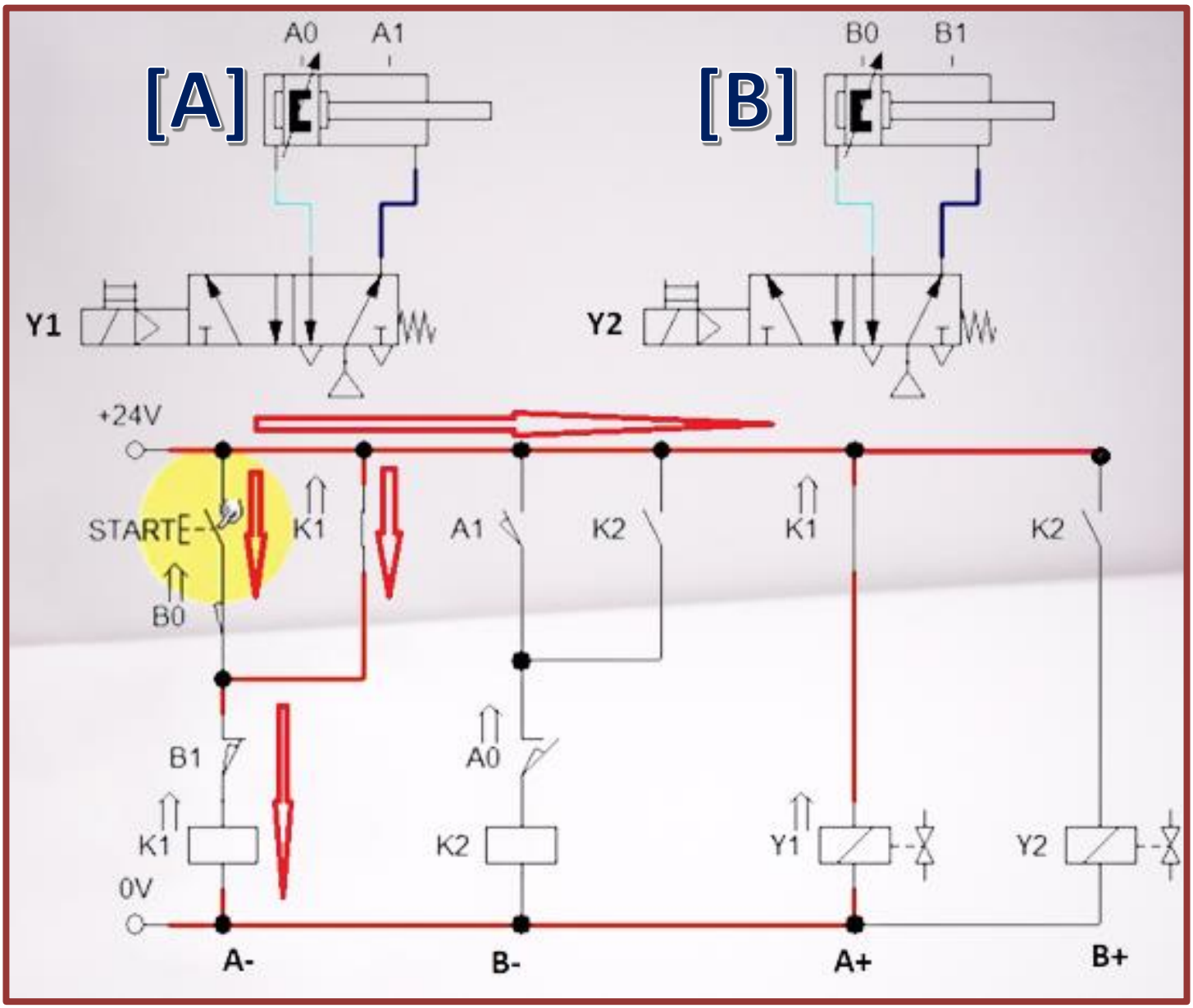


3.11 Problem 3

- The control system built for the previous experiment can also be designed using a monostable 5/2 directional control valve, to control a bending tool, for instance.
- In that case, the first cylinder would be used to put one bend a workpiece that had previously been clamped, then the second cylinder would put in a second bend.
- In this case the control circuitry for each cylinder needs to include latching capability.
- Equipment used:
  - Single Solenoid with spring return (2)
  - Double Acting Cylinder (2)
  - Limit Switch (4)
- The Sequence Follow, A+, B+, A-, B-

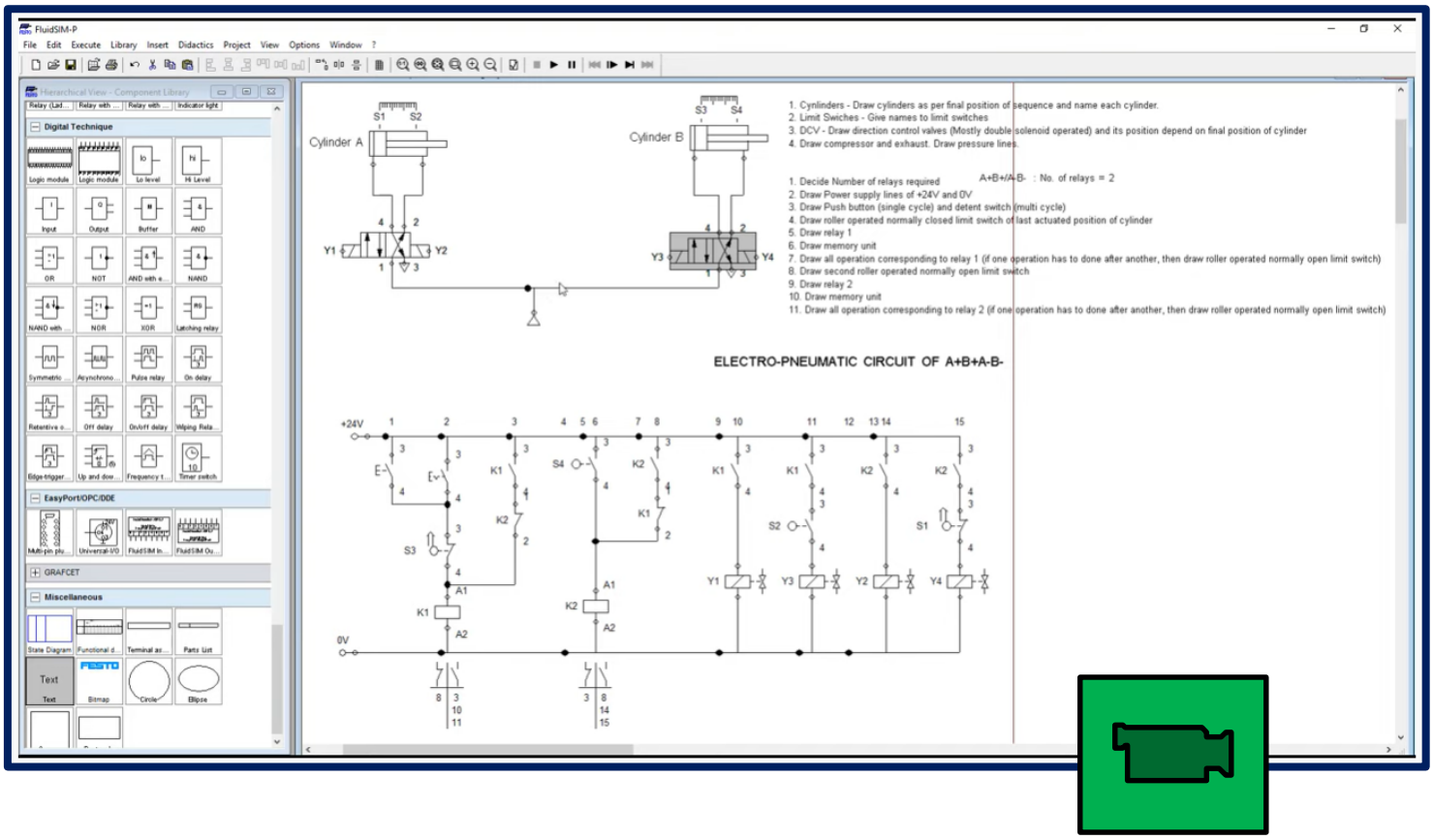


Solution 3



[A+ B+ A- B-]

Circuit Explanation



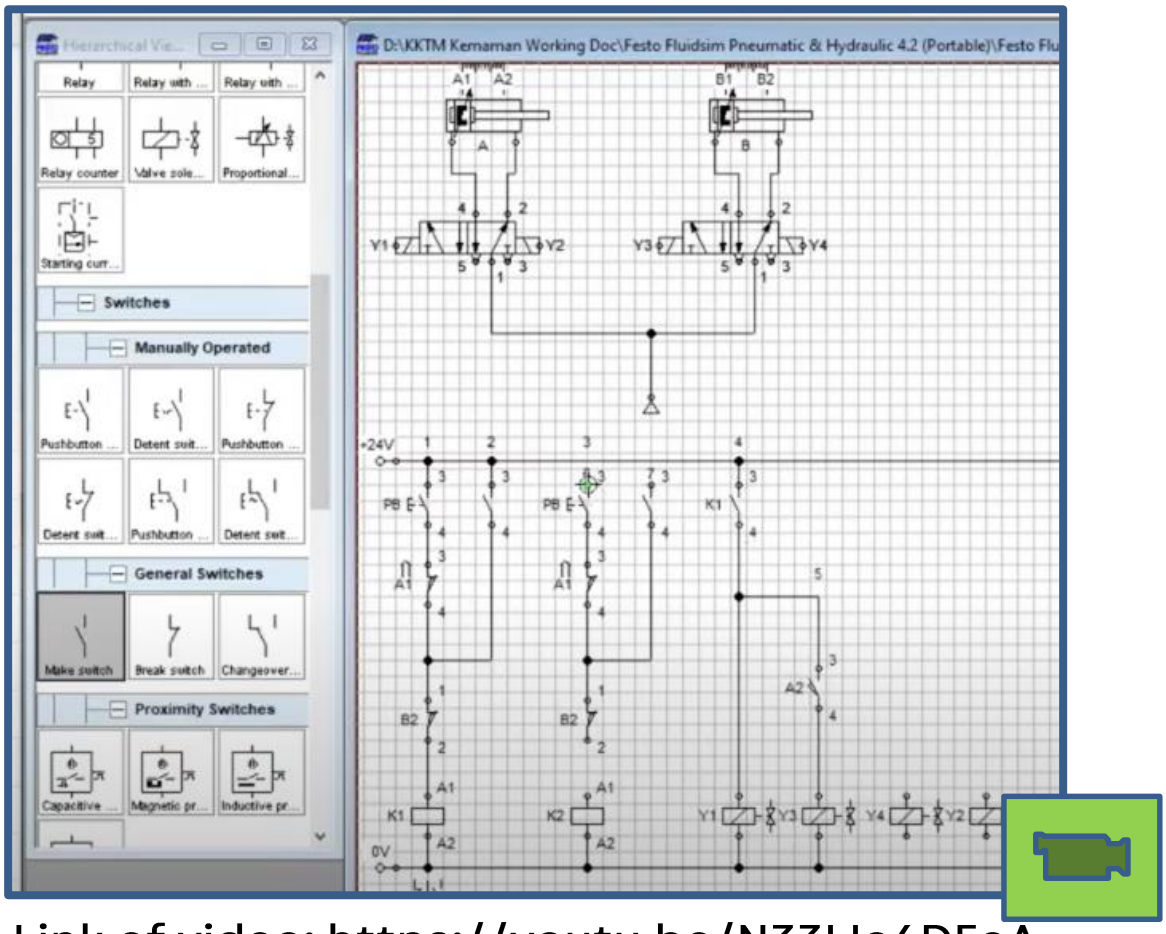
Link of video:
https://youtu.be/faow2qJ0YdU

3.12 Problem 4

Problem Condition:

- Base on Video, write a sequence notation (A+, ……..) https://youtu.be/N33LIo6DFoA
- - *(Link Video)*
- Construct a Displacement-Step Diagram
- Develop a Pneumatic dan Electrical Diagram

Solution 4



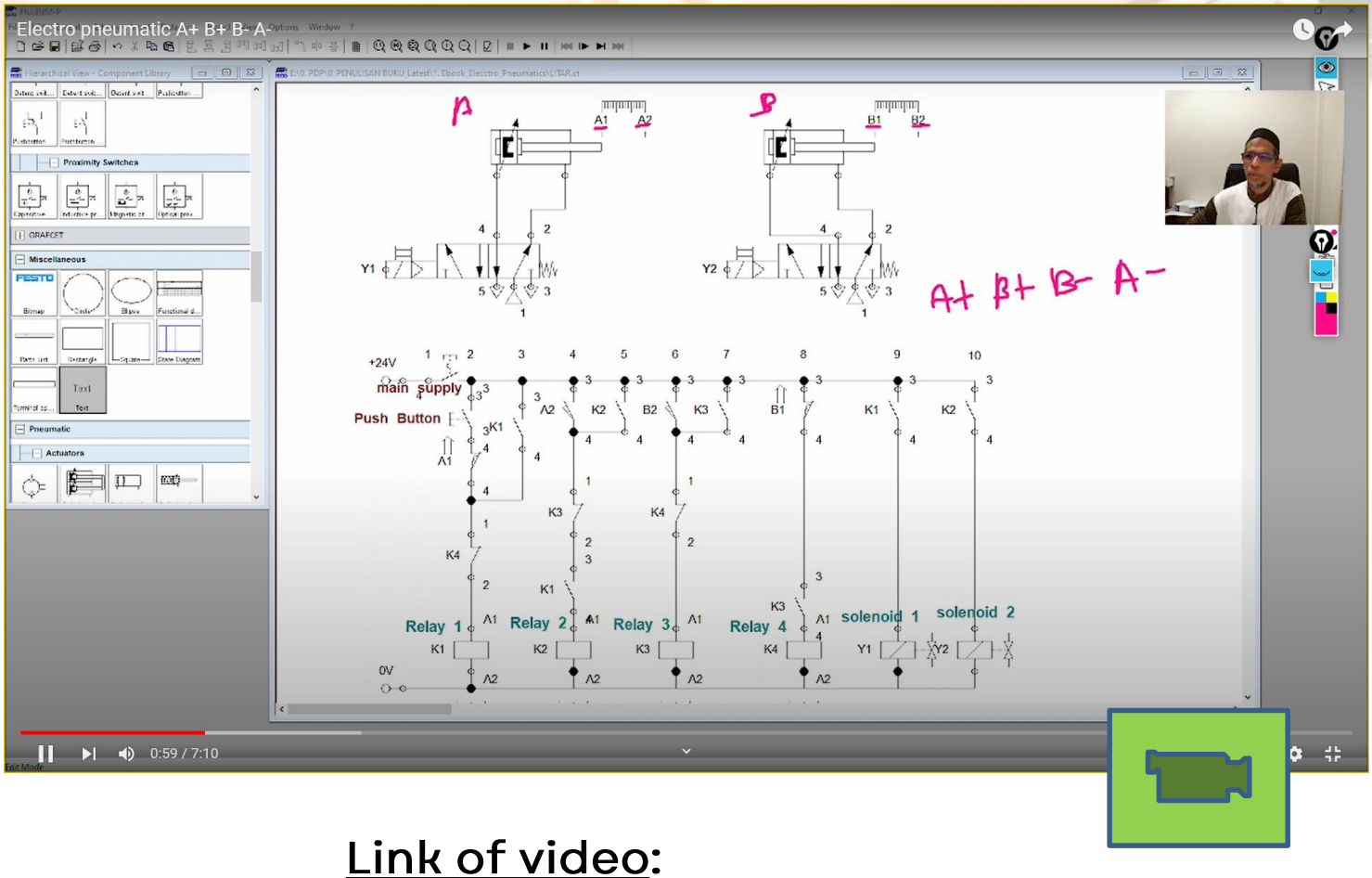
Link of video: https://youtu.be/N33LIo6DFoA

3.13 Problem 5

Problem Condition:

- Base on Video, write a sequence notation **(A+, B+, B-, A-)**
- Construct a Displacement-Step Diagram
- Develop a Pneumatic dan Electrical Diagram

Solution 5



Link of video:
https://www.youtube.com/watch?v=blw9FR-IzmI

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3. SMC Pneumatic (Hongkong) Limited. SMCT. C.A.T. P1, SMC Training Software.
4. https://youtu.be/RO1P8jGYU78
5. https://www.youtube.com/watch?v=GOg_TE5cfg8
6. https://www.coursehero.com/file/12829684/PNEUMATIKA-labs-Festo-eng/
7. https://www.coursehero.com/file/12829684/PNEUMATIKA-labs-Festo-eng/
8. https://vbook.pub/documents/lab-manual-of-pneumatics-control-mo80l077v6wn
9. http://iamtechnical.com/direct-and-indirect-control-single-action-cylinder
10. http://docplayer.net/23993521-Lecture-41-electro-pneumatic-control.html
11. https://www.youtube.com/watch?app=desktop&v=Y1mA50tEmLQ
12. https://youtu.be/N33LIo6DFoA

Biography

MOHD ELIAS BIN DAUD

He started his career as a lecturer in Mechanical Engineering since the year of 1999 at Polytechnic Sultan Salahuddin Abdul Aziz Shah. He finished his Bachelor Degree of Electro Mechanical from UTM and his PhD in Manufacturing System at UTHM. He have 20 years of experience in teaching Automation System, Pneumatic and Hydraulic Technology. Thus he is also actively involved in Curriculum Development of Mechatronic Engineering.

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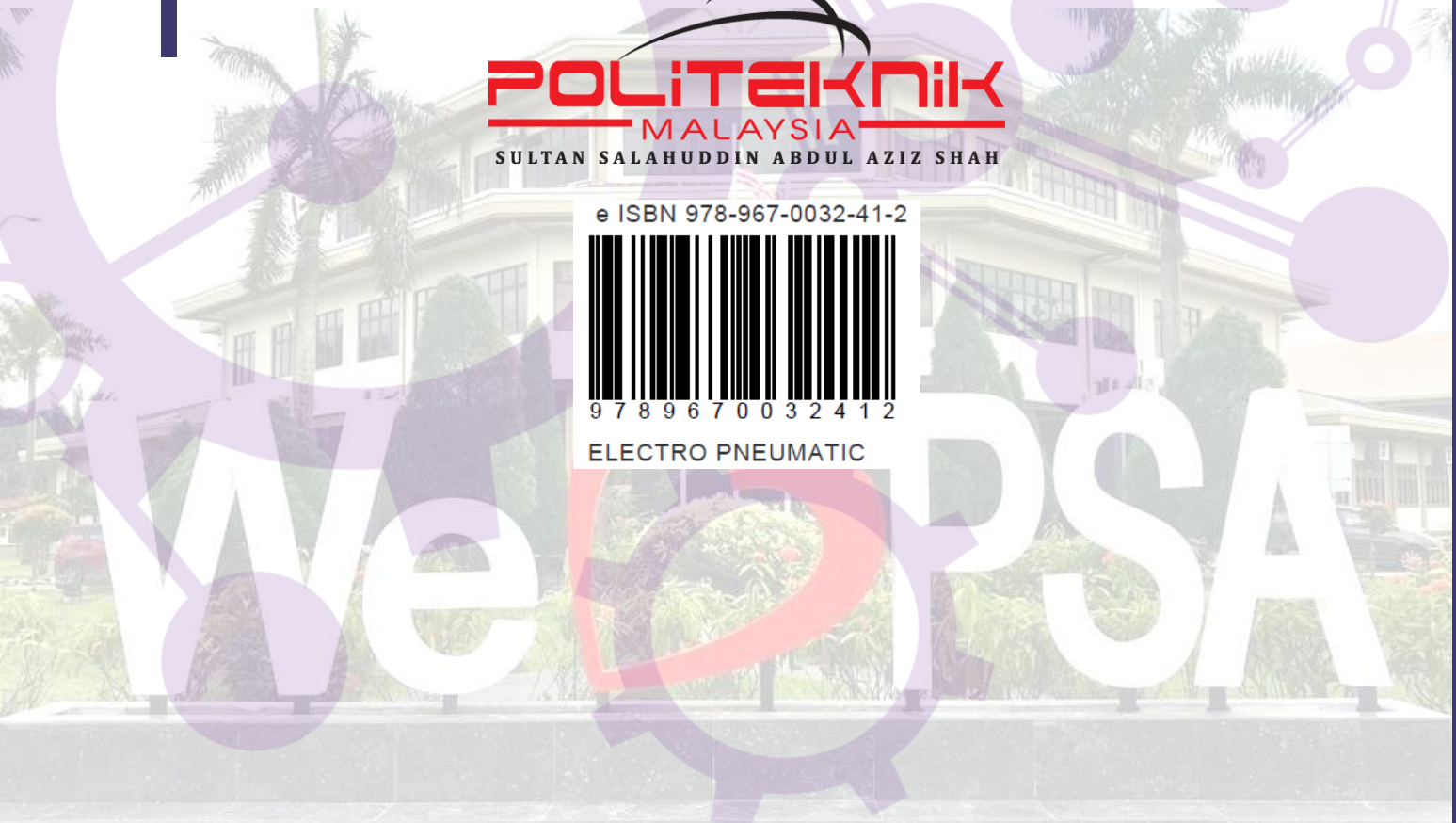
ELECTRO PNEUMATIC



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