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SKEM3742

SCHOOL OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNOLOGI MALAYSIA
SKUDAI CAMPUS JOHOR

MECHATRONICS LABORATORY

ELECTRO-HYDRAULICS
&
ELECTRO-PNEUMATICS
(THEORY)

Prepared By :	Verified by : Director
Assoc. Prof. Dr. Salinda Buyamin Ir. Dr. Kumeresan Dr. Mohd Ariffanan Mohd Basri Assoc.Prof. Dr.Rosbi Mamat	Assoc Prof. Ir. Dr. Norhaliza Abdul Wahab
Signature :	Signature :
Official Stamp : Dr. Salinda Buyamin Associate Professor School of Electrical Engineering, Faculty of Engineering Universiti Teknologi Malaysia, 81310 Skudai Johor	Official Stamp :
Date :26 April 2020	Date : 26 April 2020

1. THEORY

i. ***Definition***

Electro-hydraulic (electro-pneumatic) term is defined from words of electro, which mean electrical and hydraulic (pneumatic) which mean hydro/liquid (air) pressure. The electro-hydraulic (electro-pneumatic) equipment and system is an integration of electrical and mechanical components with compressed liquid (air) source.

ii. ***Components***

Electro-hydraulic (electro-pneumatic) controllers have a hydraulic (pneumatic) power section. In an electro-hydraulic (electro-pneumatic) control, the signal control section is made up of electrical components, for example, the proximity switches, and relays. The directional control valves behaves as a medium between the electrical signal control section and the hydraulic (pneumatic) power section in the controller (refer **Figure 1.1**).

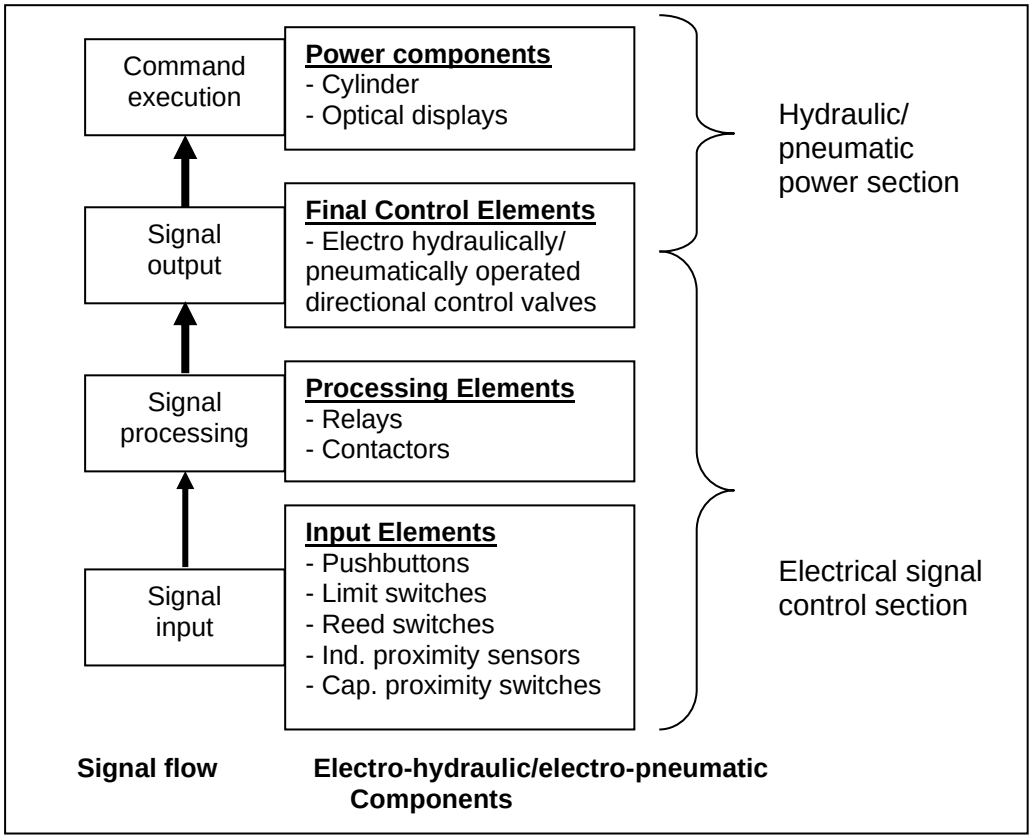

Figure 1.1: Signal flow and components of an electro-hydraulic/electro-pneumatic control system

iii. ***Switch***

There are 3 types of electrical switches used in the design of electro-hydraulic (electro-pneumatic) circuit. They are:

i) Normally-opened (NO) contact switch (refer **Figure 1.2(a)**).
ii) Normally-closed (NC) contact switch (refer **Figure 1.2(b)**).
iii) Changeover contact switch (refer **Figure 1.2(c)**).

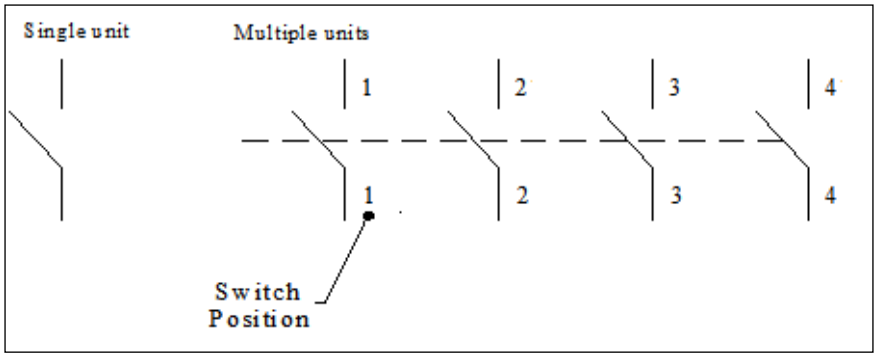

Figure 1.2(a): Normally-opened contact switches

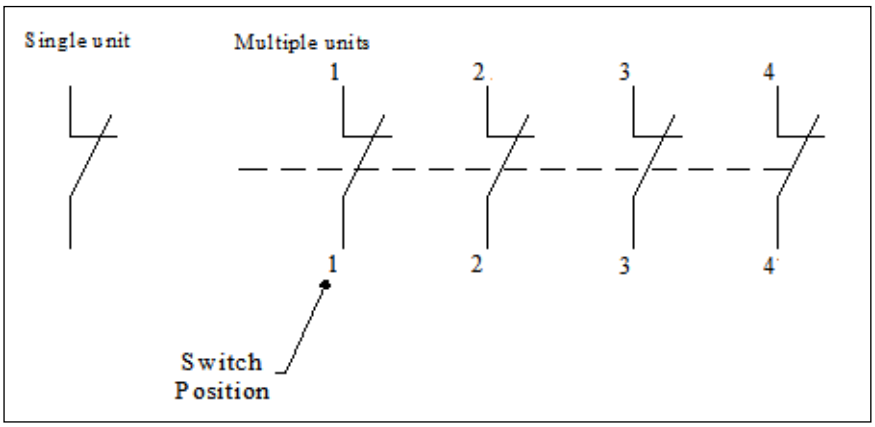

Figure 1.2(b): Normally-closed contact switches

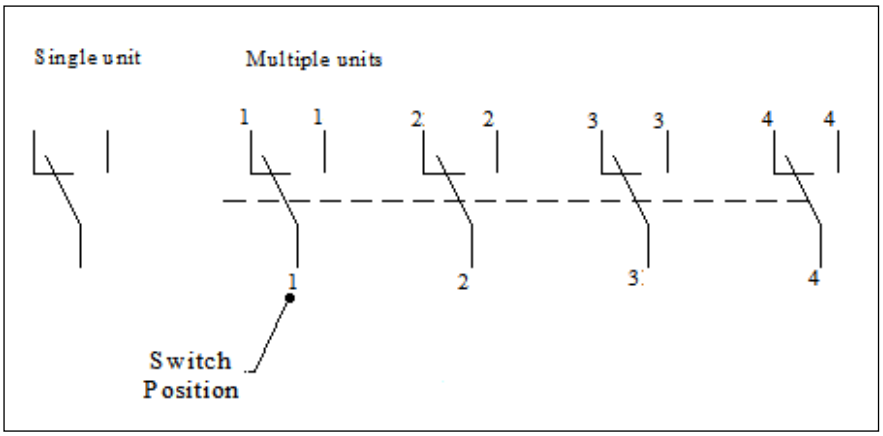

Figure 1.2(c): Changeover contact switches

iv. Relay

Relay is an electrical device that contains a coil and a contactor switch. Relay also can consist of a coil and multiple contactors. **Figure 1.3** shows a coil (K) with 4 contactor switches. If the coil is activated, the Changeover Contact will change its state. A NO switch will change its state from ON to OFF state.

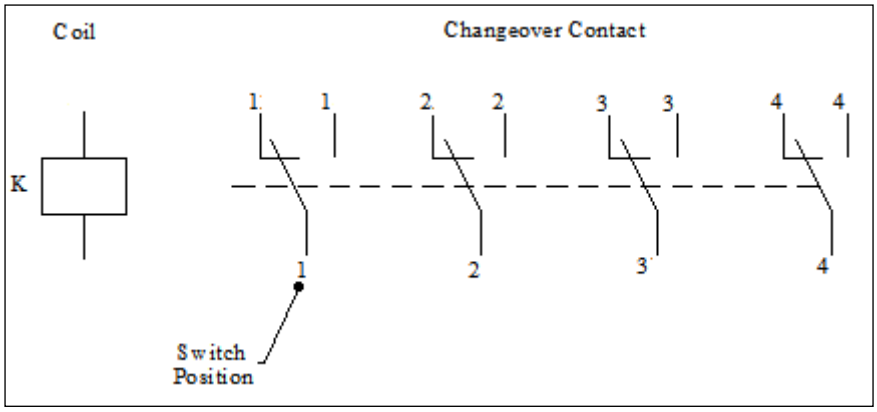

Figure 1.3: Relay with a coil and multiple contactor switches

v. Solenoid Valve

Solenoid valve is an electro-mechanical device that built-in with a coil (solenoid) and a hydraulic/pneumatic directional control valve (DCV). There are many types of built-in solenoid directional control valve. A few of them are:

- 4/2 Way DCV single solenoid with spring return
- 4/3 Way DCV double solenoid with spring return
- 2/2 Way DCV single solenoid with spring return
- 5/2 Way DCV double solenoid

a. Basic Electro-Hydraulic Operation Using the 4/2 Way DCV Single Solenoid

The 4/2 way DCV single solenoid or monostable valve consists of a built-in solenoid at the left hand side and a built-in spring at the right hand side of the valve. **Figure 1.4** shows the hydraulic and electrical circuits (electro-hydraulic circuits) for actuating a double acting cylinder using 4/2 DCV single solenoid.

When pushbutton S1 is pressed, coil R1 is activated. Activation of R1 will turn ON the NO K1switch. Once, K1 is ON, it will activate Y1. Solenoid Y1 will change the position of the valve from the original position (right dominant) to the new position (left dominant). The liquid will start to flow into the left side of the cylinder. This will cause the rod of the cylinder to extend.

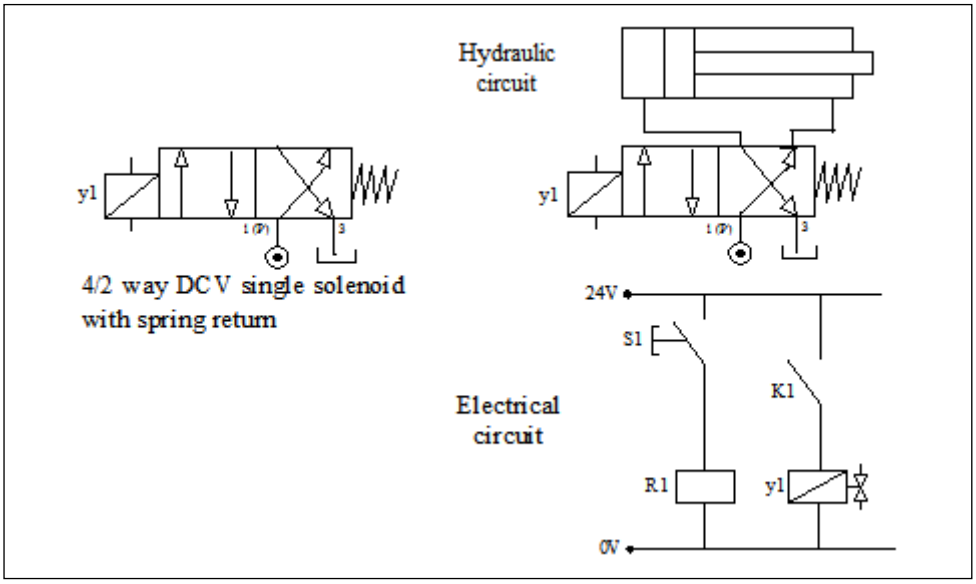

Figure 1.4: 4/2 DCV single solenoid is used for actuating a double acting cylinder

b. Basic Electro-Hydraulic Operation Using the 4/3 Way DCV Double Solenoid

The 4/3 Way DCV double solenoids consists of two solenoids (Y1 and Y2) at the both sides of the valve. It is also called 'bistable valve' or 'memory valve'. Basically, the 4/3 Way DCV are identical with 4/2 way DCV. The difference is that a center section is added for 4/3 DCV. **Figure 1.5** shows the hydraulic and electrical circuits (electro-hydraulic circuits) for actuating a double acting cylinder using 4/3 DCV single solenoid. Initially, the 4/3 DCV single solenoid is at a stable state (center dominant).

When pushbutton S1 is pressed, coil R1 will be activated. Activation of R1 will turn ON the NO K1 switch. Once, K1 is ON, it will leads to activation of solenoid Y1. Solenoid Y1 will change the position of the valve from the original position (center dominant) to the new position (left dominant). On the other hand, if pushbutton S2 is pressed, coil R2 will be activated. Activation of R2 will turn ON the NO K2 switch. Once, K2 is ON, it will lead to activation of solenoid Y2. Solenoid Y2 will push the position of the valve from the original position (center dominant) to the new position (right dominant).

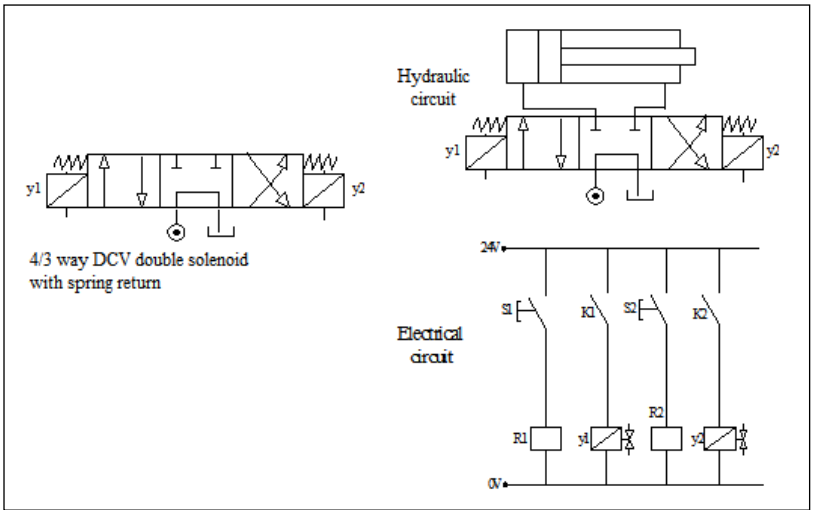

Figure 1.5: 4/3 DCV double solenoid is used for actuating a double acting cylinder

~End~

c. ***Basic Electro-Pneumatic Operation Using 2/2 Way DCV Single Solenoid***

The 2/2 way DCV single solenoid or monostable valve consists of a built-in solenoid at the left hand side and a built-in spring at the right hand side of the valve. It is used to control the actuation of double acting cylinder.

Figure 1.6 shows the electro-pneumatic circuit for actuating a single acting cylinder using 2/2 DCV single solenoid. When pushbutton S1 is pressed, coil R1 is activated. Activation of R1 will turn ON the NO K1 switch. Once K1 is ON, it will leads to activation of solenoid Y1. Solenoid Y1 will change the position of the valve from the original position (right dominant) to the new position (left dominant). The air will start to flow into the left side of the cylinder. This will cause the rod of the cylinder to extend.

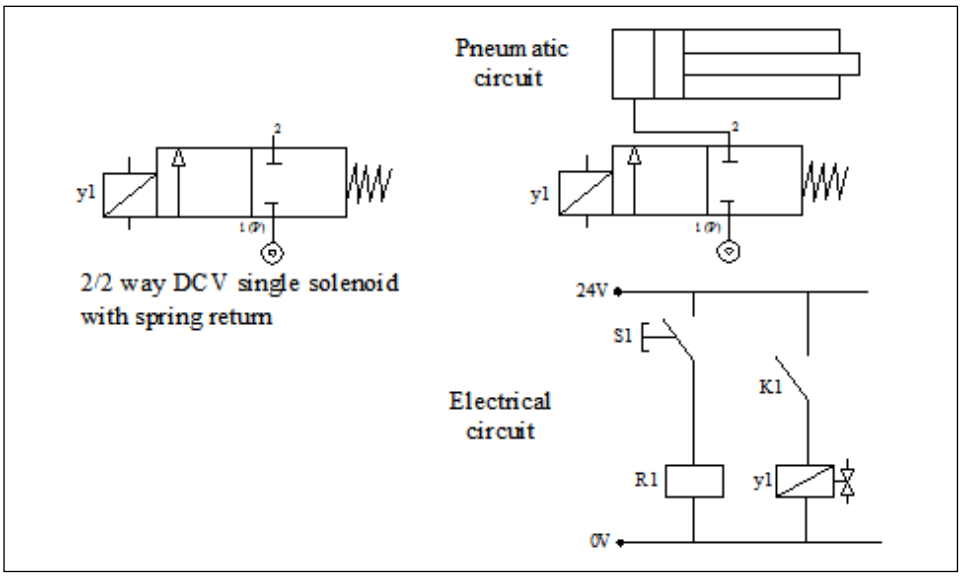

Figure 1.6: Electro-pneumatic circuit for actuating a single acting cylinder

d. ***Basic Electro-Pneumatic Operation Using 5/2 Way DCV Double Solenoid***

The 5/2 way DCV double solenoid consists of two solenoids (Y1 and Y2) at both sides of the valve. It is also called 'bistable valve' or 'memory valve'. The 5/2 way DCV is used to control the actuation of double acting cylinder. **Figure 1.7** shows the electro-pneumatic circuit for actuating a double acting cylinder using the 5/2 DCV double solenoids.

Initially, the 5/2 DCV double solenoid is at the initial state (right dominant). When pushbutton S1 is pressed, coil R1 is activated. Activation of R1 will turn ON the NO K1 switch. Once K1 is ON, it will leads to activation of solenoid Y1. Solenoid Y1 will change the position of the valve from the original position (right dominant) to the new position (left dominant). The air will start to flow into the left side of the cylinder. This will cause the rod of the cylinder to extend.

Then, if the pushbutton S1 is released and the pushbutton S2 is pressed, coil R2 is activated. Activation of R2 will turn ON the NO K2 switch. Once, K2 is ON, it will lead to activation of solenoid Y2. Solenoid Y2 will push the position of the valve from the current position (left dominant) to the new position (right dominant). The air will start to flow into the right side of the cylinder. This will cause the rod of the cylinder to retract.

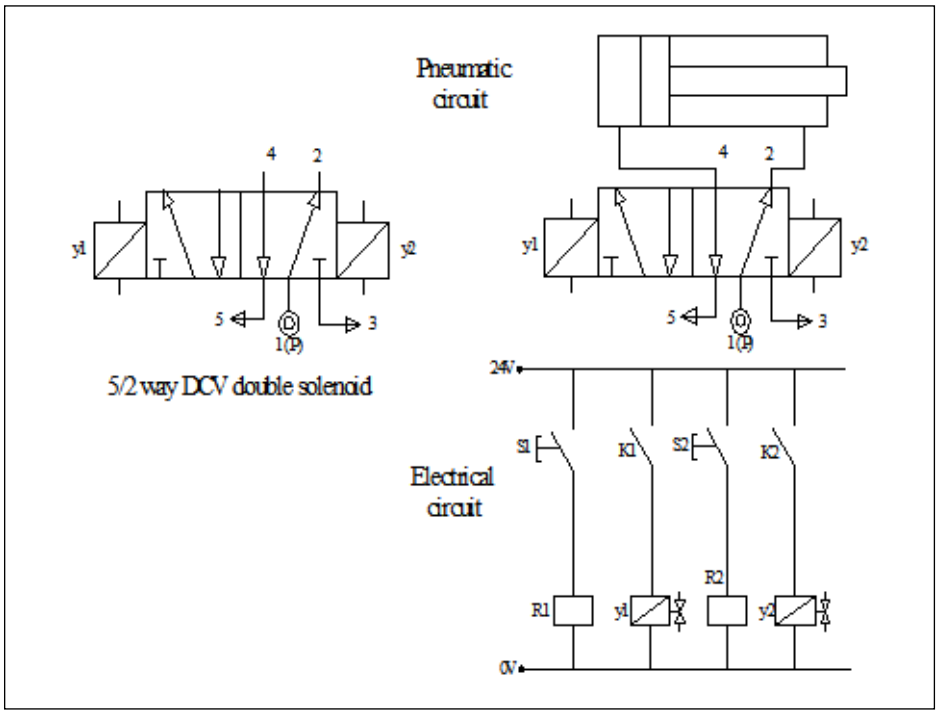

Figure 1.7: 5/2 DCV double solenoid is used for actuating a double acting cylinder

vi. Proximity Sensor

Proximity sensors, **Figure 1.8**, are commonly used to monitor a process condition in a machine. For instance, sensor is used to ensure the raw part was placed on a fixture, height of raw material within control, etc. There are three types of proximity sensors:

- Inductive sensor – able to detect metal, especially mild steel
- Capacitive sensor – able to detect most parts except low-density product
- Optical sensor – able to detect bright surface reflectively except black / rough surface

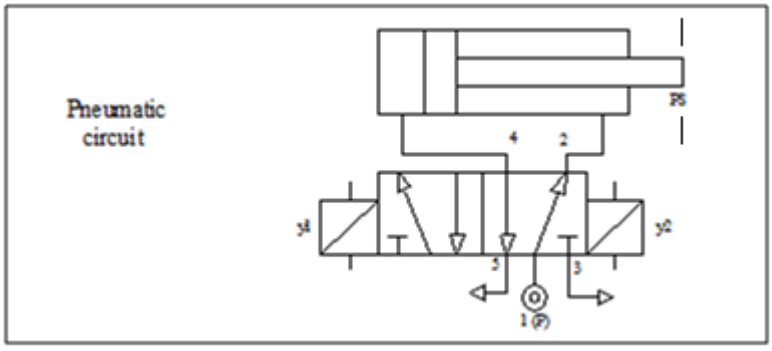

Figure 1.8: Proximity sensor (PS) is placed at the beginning of the actuator movement

a. Operation of the self-holding (memory) electrical circuit for Electro-Hydraulic and Electro Pneumatic

The self-holding electrical circuit is as shown in **Figure 1.9**. The function of this circuit is to provide continuous electrical signal to the circuit even after the pushbutton S1 is released.

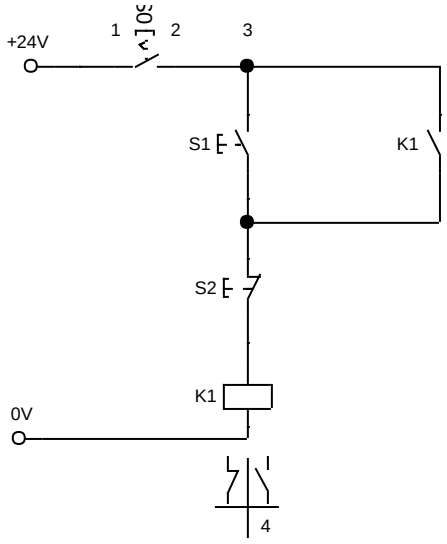

Figure 1.9: The self-holding electrical circuit

It is made up of:

1. A NO detent switch, S0.
2. A NO pushbutton, S1.
3. A NC pushbutton, S2.
4. A relay, K1 (with a NO changeover contact switch K1).

The operation of the self-holding circuit is as follows: when the pushbutton S1 is pressed for a short period of time, the coil of relay K1 is activated. The (changeover contact) switch K1 closes and relay K1 remains activated even after the pushbutton, S1 is released. Pushbutton S2 is pressed to cancel the self-holding effect. Detent switch S0 is use as a safety switch.