Design and Study of Hydraulic Systems

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Abstract: *In this paper, the electro-hydraulic schemes are made with the FluidSim software from Festo. Electro-hydraulic circuits are used in transport, construction, research, etc. It is very important that in some emergencies, people's lives depend on some electro-hydraulic systems (e.g., launching systems from lifeboats). We present at the beginning the main components that are used in electrical (switches, relays) and hydraulic circuits (compressors, hydraulic cylinders, distributors, etc.). Next, the electrical and hydraulic circuits are made and studied separately. At the end of the paper, we designed and studied simple and complex electro-hydraulic schemes. These electro-hydraulic systems can be used in unfavourable weather conditions, for example, some cranes on a fishing vessel that use electro-hydraulic systems. These cranes can be used in cold, strong wind or storm fishing conditions.*

Keywords: *FluidSim, hydraulic, electrical, scheme, circuit, valve*

1. Introduction

In practice, electro-hydraulic systems are generally used for lifting or lowering heavy materials.
The transmission of hydraulic energy in the electro-hydraulic circuit is done through mineral oils. The mineral oils used are: without additive, with additives and with additional additives.

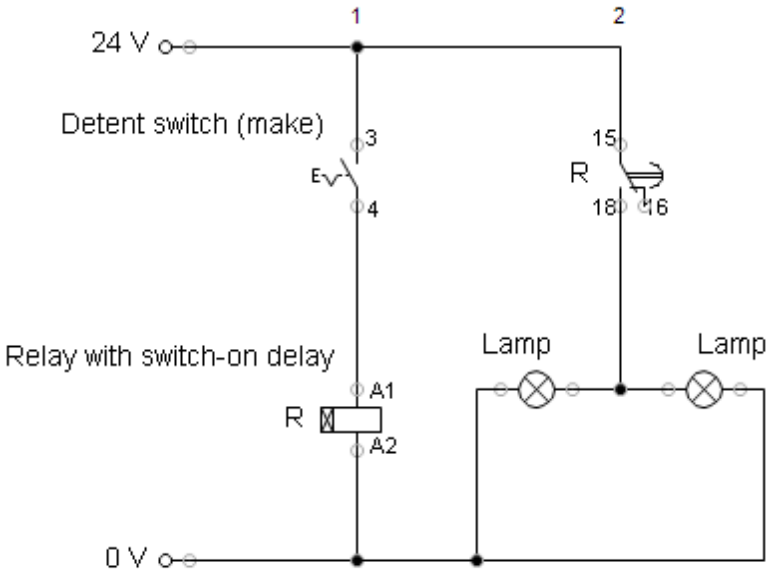


Fig. 1. Simple electrical scheme

The most important properties of oils are viscosity and density.
The oils of type H19, H35 or H57 can be used for the electro-hydraulic circuits presented in the paper.
Electro-hydraulic systems are used for cranes, elevators, jacks, etc. The electro-hydraulic scheme is made of two parts:

- Electrical scheme.
- Hydraulic scheme.

Relays, pushbuttons, electrical connection, make switch, light bulbs (lamps), etc. are used for electrical schemes.
Pump unit, hydraulic cylinders, distributors, etc. are used for hydraulic schemes.
In the diagrams made in this article, parts manufactured by Festo can be, [1].
The simplest electrical diagram is made of a light bulb and a battery.
In this paper, the simple electrical circuit is connected to an alternating current source consisting of: detent switch (make), relay with switch-on delay and two lamps, Fig.1.
If we press the detent switch, the electric current enters through the simple circuit, Fig. 2.

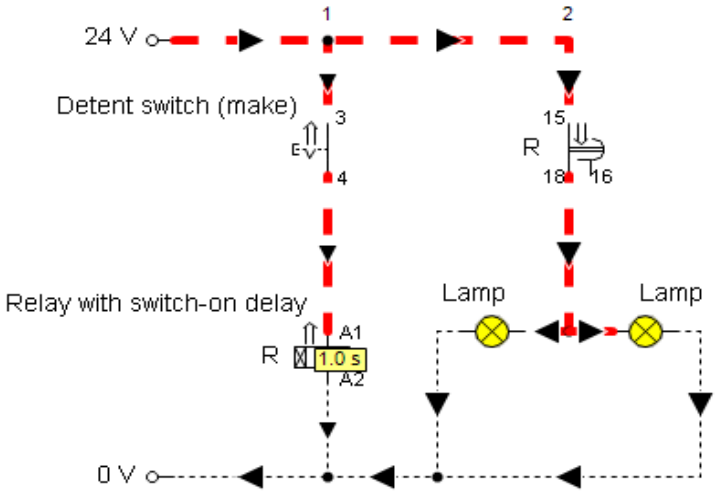


Fig. 2. Simple open electrical circuit

The electrical circuit is equipped with two lamps. These lamps light up simultaneously when current flows through the circuit, Fig. 2.

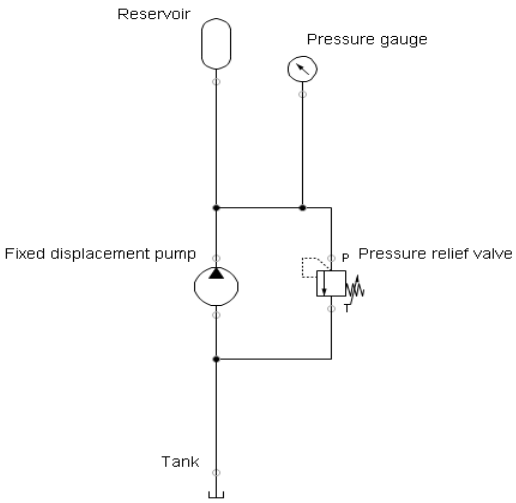


Fig. 3. Simple hydraulic scheme

The simple hydraulic circuit in the article is composed of tank, fixed displacement pump, reservoir, pressure gauge and pressure relief valve, Fig. 3.
If we start the pump, then the fluid in the tank moves into the tank and pressure relief valve.
Pressure gauge records the pressure in the hydraulic circuit. At this point, the circuit pressure is P_c = 3.46 MPa, Fig. 4.

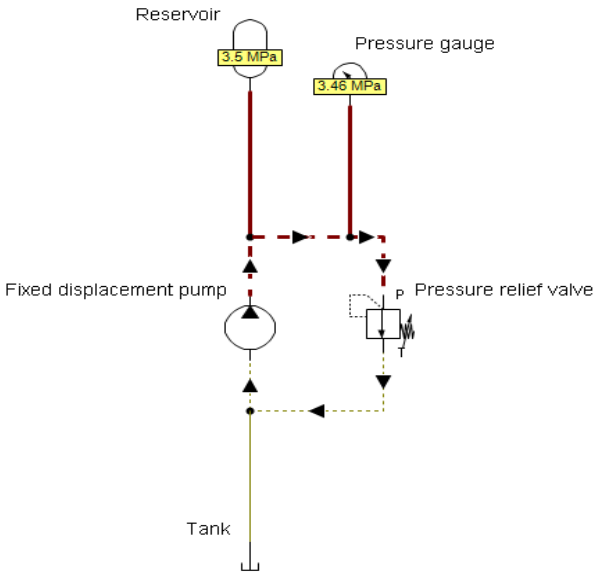


Fig. 4. Simple open hydraulic scheme

2. The main devices

All electrical and hydraulic circuits are made of main components. The electrical diagrams may contain the following basic components: pushbutton, make switch, pump unit and hydraulic reservoir.

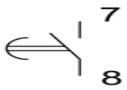
1) Pushbutton (make)

Fig. 5. Pushbutton

Description	Symbol
That switch closes when actuated and opens immediately when released.	

2) Make switch (switch-on delayed)

Fig. 6. Make switch

Description	Symbol
Switch that delayed closing after pickup. Switch-on delayed make switches are created by using a general make switch and setting a label.	

An electric current is a flow of electric charge. The equation in circuit is, [2]:

$$I = \frac{\Delta Q}{\Delta t} \quad (1)$$

Where:

- I – current flowing.
- ΔQ – the change in electrical charge.
- Δt – the change in time.

Pneumatic diagrams may contain the following basic components:

3) Pump unit (simplified)

Fig. 7. Pump unit

Description	Symbol
A pump unit is a device that moves liquid by mechanical action, typically converted from electrical energy into hydraulic energy.	

In the hydraulic circuit, using pump unit and the Bernoulli's equation is valid, [3]:

$$P + \rho g h + \frac{\rho \vartheta^2}{2} = constant \quad (2)$$

Where:

- P – pressure
- ρ – density
- g – the acceleration due to gravity
- h – the elevation
- ϑ – velocity

4) Hydraulic reservoir

Fig. 8. Hydraulic reservoir

Description	Symbol
The reservoir enables the performance of a hydraulic system to be optimized. It can be used as an energy reservoir and for the absorbance of pressure surges or flow fluctuation.	

3. The electro-hydraulic systems

In this paper, we make two electro-pneumatic schemes. The controls in this circuit are electric. The pressure in the compressor is 0.6 MPa (6 bar). The first electro-hydraulic scheme in the paper aims to move a piston from the hydraulic cylinder. This piston is equipped with adjustable cushioning. [4].
The hydraulic cylinder (piston diameter-16mm, piston rod diameter-10mm, maximum stokes - 200 mm) is of type double acting cylinder, Fig. 9.

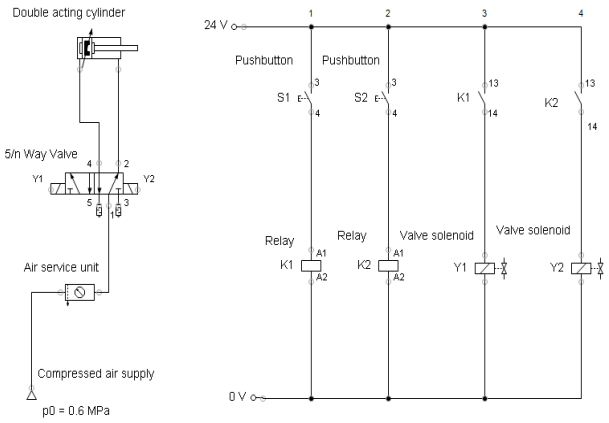


Fig. 9. Electro-hydraulic scheme – Case 1

To open the electro-hydraulic circuit we must press the S1 button. Then the piston moves to the right, Fig. 10.

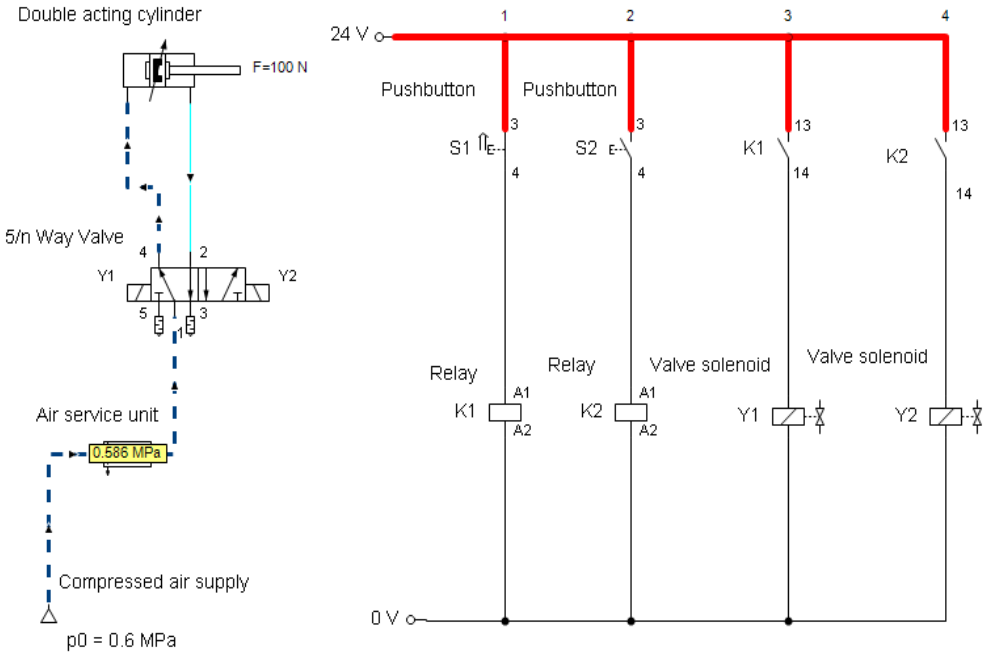


Fig. 10. Electro-hydraulic circuit opening – Case 1

To close the electro-hydraulic circuit, we must press the S2 button. Then the piston moves backwards, figure 11, [4].

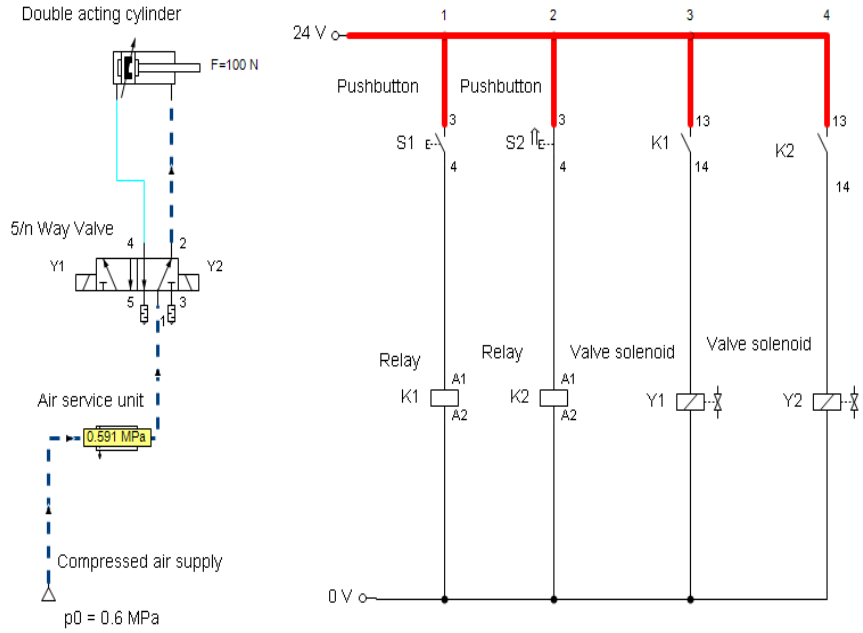


Fig. 11. Closing the electro-hydraulic circuit – Case 1

In the second case, we used an air tank, compressor, a hydraulic, a throttle and two distributors. For case 2, the piston has the same dimensions as in case 1. However, the piston has not adjustable type cushioning, Fig. 12.

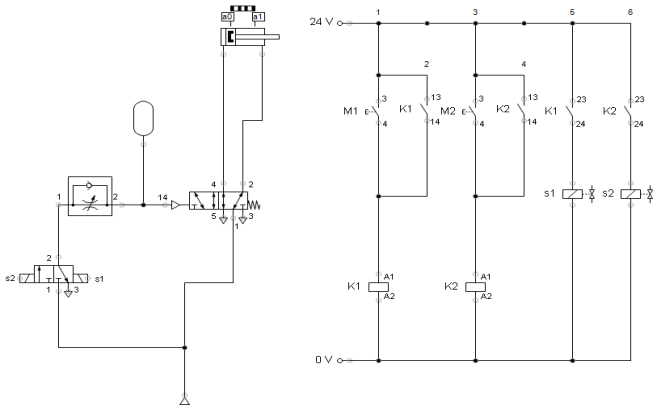


Fig. 12. Electro-hydraulic scheme – Case 2

In the case 2, at the hydraulic cylinder, the piston moves from a0 to a1. To do this, press the M1 button, Fig. 13.

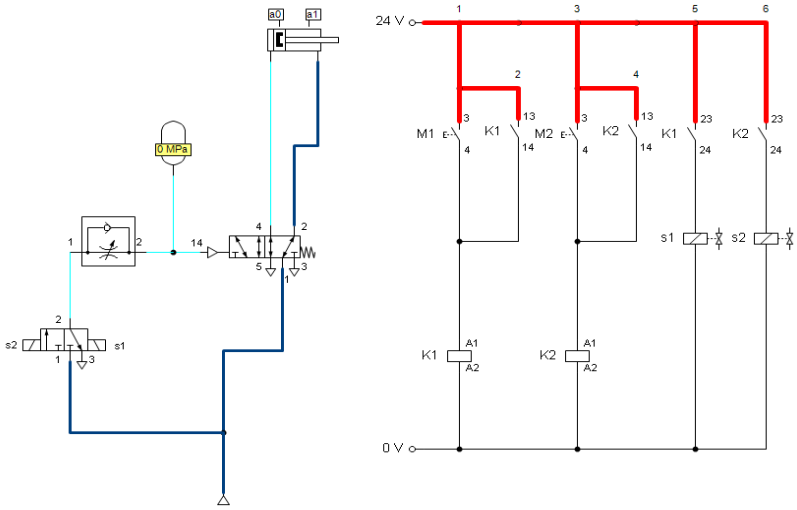


Fig. 13. Electro-hydraulic circuit (press M1 button) – Case 2

To move the piston from a1 the a0, press the M2 button, Fig. 14, [5].

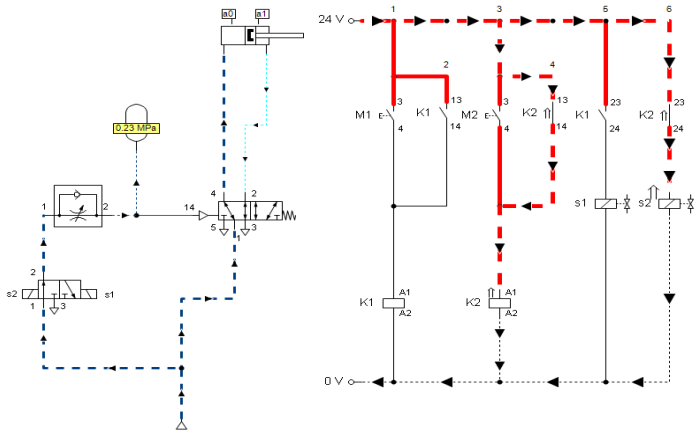


Fig. 14. Electro-hydraulic circuit (press M2 button) – Case 2

The parameters of the cylinder from the case 2: position (x) and velocity (v), Fig. 15.

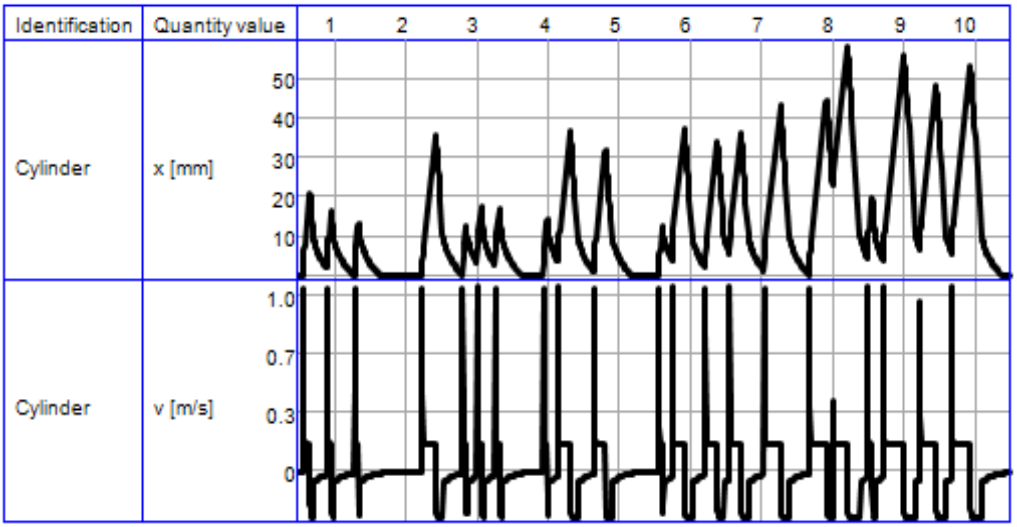


Fig. 15. Diagrams from cylinder – Case 2

3. Conclusions

Regarding the schemes presented in this paper the complex electro-hydraulic circuits can be developed. From these electro-hydraulic schemes other electrical or hydraulic schemes can be further developed. The advantage of electro-hydraulic schemes made in the FluidSim software is that circuits with good quality electrical and hydraulic devices (e.g. Festo products) can be used in practice. The advantage is the electro-hydraulic schemes that are made in a timely manner. Changing the schemes to achieve optimal circuits can be done in a short time.
In the future, we would like to develop electro-hydraulic schemes in the FluidSim Software that will work at better yields.

References

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