pneumatics, pneumatic circuit,
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LOGICAL FUNCTIONS AS EXEMPLIFIED BY PNEUMATIC CIRCUITS

The article presents possibilities of using Pneumatics TP101 laboratory workstation and FluidSim P programme for research and testing pneumatic circuits during laboratory classes carried out in the Mechatronics Laboratory of the Faculty of Transport and Electrical Engineering at the Technical University of Radom.

Examples of laboratory experiments of systems performing logic functions are given.

UKŁADY PNEUMATYCZNE REALIZUJĄCE FUNKCJE LOGICZNE

Artykuł jest prezentacją możliwości stanowiska laboratoryjnego Pneumatyka TP10 oraz oprogramowania FluidSim P firmy FESTO DIDACTIC do badania i testowania elementów i układów pneumatyki. Stanowiska zostały uruchomione w Laboratorium Mechatroniki, Wydziału Transportu i Elektrotechniki Politechniki Radomskiej i są wykorzystywane do zajęć laboratoryjnych.

Podano przykłady realizacji ćwiczeń laboratoryjnych z wykorzystaniem elementów logicznych.

1. INTRODUCTION

Pneumatic systems play a very important role in modern machines. A large number of presently manufactured machines incorporate more or less complicated pneumatic control or actuation systems. What is more, in many of them these systems are their most crucial element. One can distinguish two principal sources of external energy used in modern control and automatic systems: electrical energy and the energy of the medium (air, oil) being under a specific pressure. The use of the energy of the medium enables application of pneumatic and hydraulic control systems, in particular measurement and logical systems.

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The commonly used pneumatic drives are the result of the advantages of the working medium and the equipment driven by this medium:

- air is widely available (energy)
- it is easy to store and transport at long distances; after the air-contained energy has been used it does not have to be replaced
- air is safe and clean in maintenance, it does not pose the electrocution risk and does not pollute the environment
- compressed air is resistant to temperature fluctuations and for this reason it guarantees problem-free work even in most extreme conditions
- compressed air (usually of 0.4 to 0.7 Mpa in pressure) is a very good source of energy to generate forces of up to a dozen kN

Air energy based equipment is widely applicable. One can mention here sorting and fastening machines in food industry, textile, footwear and food industry machines (e.g. plastic bottle manufacturing), injection moulding machines, bottle filling machines, welding and heat sealing machines, vulcanizing presses, road and railway vehicle suspension systems, systems for opening and closing bus, railway car and tramway doors, manipulators used for integrated circuit assembly on mounting plates, systems for conveying heavy objects, mechanisation of manually performed activities, pneumatic manipulators in biomedicine, pneumatic engines in hand tools like hammers, drills or spanners. [1], [2], [3], [7]

The article presents possibilities of using the *FluidSim P* software and work station TP 101 produced by *FESTO DIDACTIS* in laboratory classes focusing on the issue of pneumatic control.

2. GENERAL CHARACTERISTICS OF LABORATORY WORKSTATION

The set enables to conduct both basic and more advanced level classes concerning pneumatics. It also allows students to get familiarised with the basic components of pneumatic systems used in the actual industrial production plants. The set consists of brand-new industrial components tailored to the needs of didactic classes.

The set allows students to get acquainted with:

- structure, function and application of single-acting and double-acting cylinders,
- calculation methods of basic parameters of the elements used,
- direct and indirect actuation,
- application and function of 3/2 and 5/2-way valves,
- actuation methods of directional control valves,
- pneumatic circuit analysis,
- options for pressure measurement,
- flow control methods,
- structure of pneumatic control systems,
- logical elements (AND/OR/NOT) and combining logic operations,
- function and application of limit switches,
- time delay valves,
- continuous operation systems (oscillating systems).

Fig.1. Laboratory station TP 101

The station equipment is made of different sets of industrial elements (Fig.1.) for fast and convenient assembling and dismantling of various pneumatic (TP101, TP102) and electropneumatic (TP201, TP202) systems and their flexible arrangement. Owing to extra fastening clamps, these elements can be easily assembled on special profiled panels meant for this purpose.

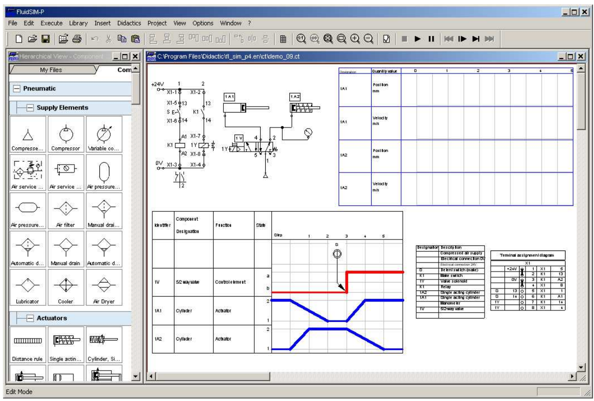

Fig.2. FluidSim P – design view

Software (Fig.2.) enables students to design control systems, simulate their operations and, in the case of electropneumatics, to connect them – via specialist EasyPort equipment – to actual elements of automatic systems or control devices. These functions are fulfilled by the

FluidSim P programme. Because software reproduces (simulates) the system operations faithfully, it is an inexpensive set for experiments aiming at practical aspects of control technique teaching. Communication solutions included in the software allow for wide co-operation with PLC controllers, which enables one to simulate many practical applications.

A laboratory workstation includes, among others, pneumatic logic valves: alternative valve (Fig.3.). The flow circulation switch is used in pneumatic systems which demand the output signal if one of two input signals has occurred. The flow circulation switch implements the logical alternative function – “OR”.

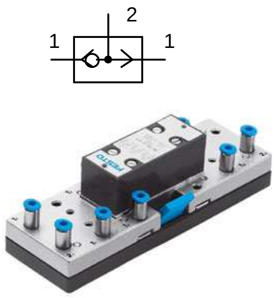

Fig.3. Pneumatic symbol of the alternative valve and laboratory element (3 “OR” elements)

The double signal valve (Fig.4.) is used in pneumatic systems where the output signal is demanded if two input signals have occurred simultaneously. The flow circulation valve implements the logical conjunction function – “AND”.

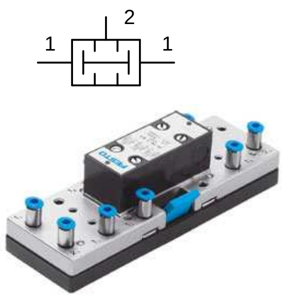

Fig.4. Pneumatic symbol of the conjunction valve and laboratory element (3 AND elements)

The logical valve of alternative is used when a signal transferred from two places is to trigger off the same action, whereas the conjunction valve is used in the systems where the output signal (2) is demanded when two input signals appear

3. EXAMPLES OF LABORATORY CLASSES WITH THE USE OF LOGICAL PNEUMATIC ELEMENTS

EXAMPLE 1

Design a pneumatic system controlling a double-acting cylinder according to the following assumptions:

a) the system is actuated only in the left extreme position of the cylinder, i.e. the cylinder is hidden
b) the cylinder returns after the 3/2-way valve pushbutton is pressed,
c) the piston rod movement is throttled in both directions.

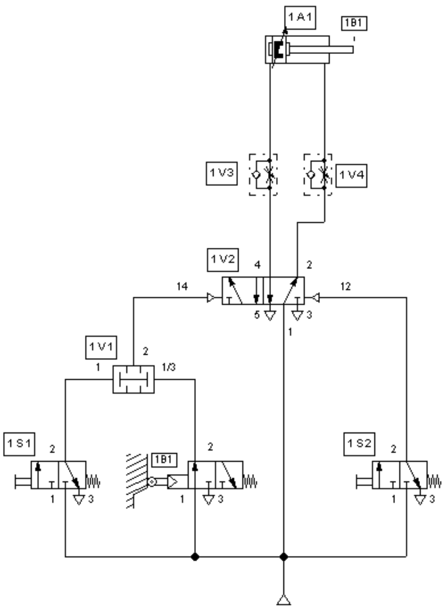

Fig.5. Pneumatic circuit (Example 1) executed in the FluidSim P programme

In order to achieve the start-up conditions, the 3/2-way NZ valve with a roller (the so called „road" valve 1B1) was applied which is mechanically coupled with the cylinder's piston rod in the left extreme position. Additionally the logical CONJUNCTION valve 1V1 ensures actuation of the system. The piston rod's return is effected by 1S2 valve controlling the monostable 5/2-way valve 1V2 pneumatically actuated on both sides. The one-way throttle-valves – 1V3 and 1V4 – ensure the throttle movement.

EXAMPLE 2

To design the pneumatic system controlling a single-acting cylinder with a spring using logical valves of alternative functioning according to the pressing any button actuates the cylinder's movement.

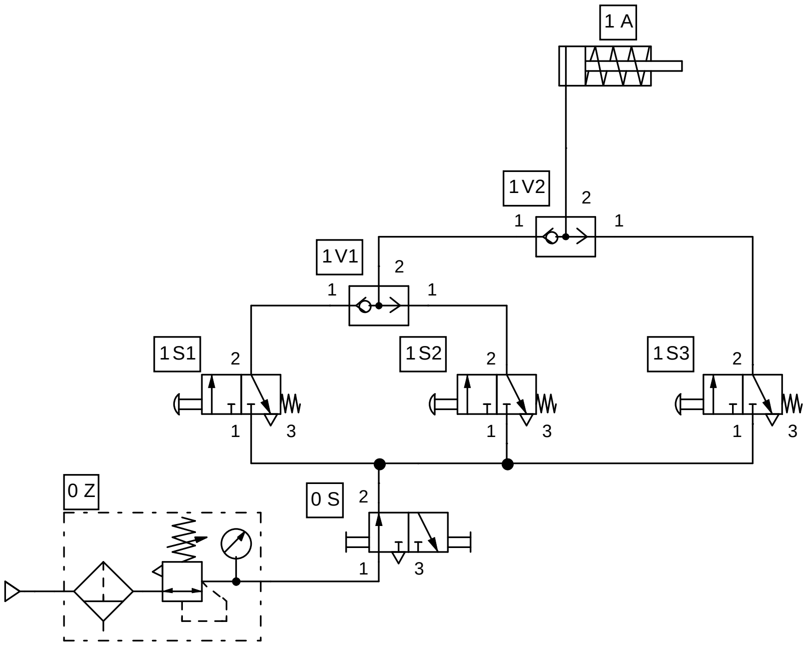

Fig.6. Pneumatic circuit (Example 2) executed in the FluidSim P programme

Two logical valves of alternative are used in the system. When connected in cascade, they enable controlling of the single-acting cylinder by means of three different valves: 1S1 or 1S2 or 1S3

EXAMPLE 3

To design a pneumatic system controlling the single-acting cylinder with a spring with the use of logical conjunction valves functioning according to the 3 of 3 principle, i.e. pressing three buttons actuates the cylinder's motion.

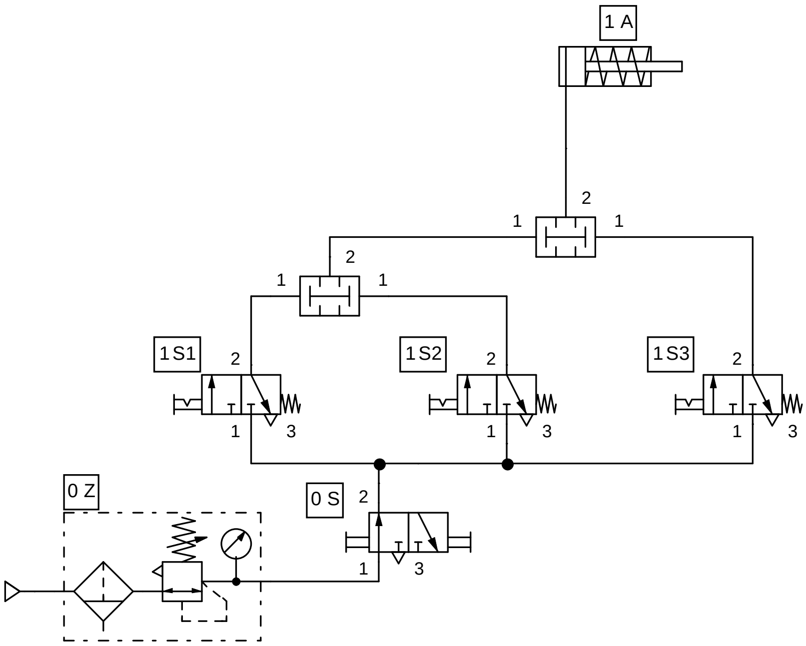

Fig.7. Pneumatic circuit (Example 3) executed in the FluidSim P programme

Two logical conjunction valves were used in the system. When connected in cascade, they can control the single-acting cylinder by means of three different valves 1S1 or 1S2 or 1S3. [1], [4], [6]

4. CONCLUSIONS

The *Festo Didactic* offered furniture, software and equipment allow one to equip laboratory with many things from the virtual design laboratory to the actual, complete laboratory.

Classes carried out in the Mechatronics Laboratory with the use of the *FluidSim P* package and *Festo Didactic* pneumatic components allow students to get acquainted with the structure and function of the pneumatic control and actuation components and systems. The programme enables them to create standardised control circuits and offers a possibility of simulating the operations of the designed systems.

One of the tasks developed by the employees of the Department of Automatics and Measurement Engineering is application of pneumatic logical elements in the control systems with the use of the above presented specialist software and the assembly table manufactured by *Festo Didactic*.

5. REFERENCES

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