POLISH ACADEMY OF SCIENCES - COMMITTEE OF MATERIALS SCIENCE
SILESIAN UNIVERSITY OF TECHNOLOGY OF GLIWICE
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS
ASSOCIATION OF ALUMNI OF SILESIAN UNIVERSITY OF TECHNOLOGY

Conference Proceedings

12th INTERNATIONAL SCIENTIFIC CONFERENCE
ACHIEVEMENTS IN MECHANICAL & MATERIALS ENGINEERING

Example of the system prepared to be controlled by the controller based on microcontroller *

J. Swider[a], G. Wszolek[a], W. Carvalho[b]

[a] Silesian University of Technology, Department of Mechanical Engineering,
44 –100 - 18a Konarskiego St, Gliwice, Poland

[b] Polytechnic School from the University of São Paulo,
Avenue Prof. Luciano Gualberto,
street 3, n. 380 - 05508-900 - São Paulo/SP, Brazil

This study is about how to elaborate and analyse complete pneumatic system, using a systematic method that allows in an easy and clean way to create the circuit with the logic components, moreover it includes components to guarantee the stability and the rely of a real application. System that has been shown in this article is used as an example of the electro-pneumatic system being controlled by the controller based on microcontroller PIC 16f877 with external peripherals [4].

1. INTRODUCTION

The pneumatic energy, together with hydraulic and electric, are the three most used kinds of energy for industrial automation. On an automation system one can find three families of components which are sensors, controllers and actuators, that can be joined together and allow to make all kinds of movements and sequences. An adequate technique is needed to project the logic circuit to integrate all the necessary components and realise the sequence of movements properly.

For a simple direct sequence of movement an intuitive method can be used [1], but for indirect or more complex sequence the intuition can generate a very complicated circuit and signal mistakes. It is necessary than to use another method that can save time of the project, make a clean circuit and can eliminate occasional signal overlapping and redundant circuits.

The present method is called step by step or algorithmic and it was used as a base in this work to design the circuit of a system with actuators that have various kinds of movement and can be used in most common applications.

* This work has been conducted as a part of the research project No. 5 T07C 02923 supported by the Committee of Scientific Research in years 2002-2005.

2. DESIGNING THE SYSTEM

It is very important to remember that this article does not take into account the calculation of the size of actuators or the tabulation of the circuit, or even other things as the pressure used, air treatment, flowing, compressor or the integration with one "machine". It applies to design and execution the logic circuit based on the movement sequence that is required.

For the correct operation of the system, the designer must pay attention in all the characteristics using the requirements of each specific application and international rules [3].

The step of the sequence is defined as the change of the state of the actuators of the system, but only when is generated by changing of a line supply (pneumatic) or the change of the supply to other relay (electropneumatic). Movements that must start together are in the same step. It will be possible to see on the example how other kinds of movement of actuators can be made in one step.

The process consists of the design of systems based on small circuits made for each step. The first part is to design those kinds of generic circuits for each step. The next task is to link the small circuits and the last part is to connect the control elements that receive signals from sensors, switches and the previous movements, and give the air to the supply line or the energy to the relay of the step. The final result with a complete circuit of the example described bellow can be checked in figs. 4, 5.

In Figs 1a and 1b the standard circuits are drawn for pneumatic and electropneumatic system. It is possible to see the relations with the previous and the next steps.

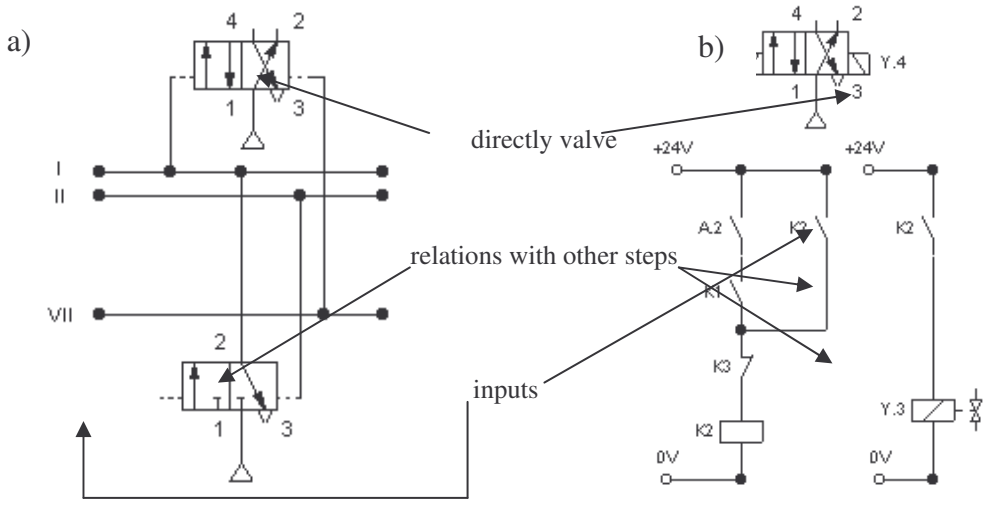

Fig. 1. Standard circuits for the system: a) pneumatic, b) electropneumatic

3. AN EXAMPLE OF THE REAL APPLICATION

The system is not a representation of a specific machine, but it is made with some common movements and components found in a real one. The system is composed of four actuators. The actuators A, B and C are double acting ones and D, single acting. Actuator A advances and stays in specified position till the end of the cycle, it could work fixing an object to the next action for example (Fig. 2), it is the first step. When A reaches the end position, actuator C starts his work together with B, making as many cycles as possible during the advancing of B. It depends on how fast actuator B is advancing; the speed is regulated by a flowing control valve. It was the second step. B and C are examples of actuators working together, while B pushes an object slowly, C repeats its work for some time.

When B reaches the final position, C stops immediately its cycle and comes back to the initial position. The actuator D is a single acting one with spring return and works together with the back of C, it is the third step. D works making very fast forward and backward movement, just one time. Its backward movement is the fourth step. D could be a tool to make a hole on the object.

When D reaches the initial position, A and B return too, it is the fifth step.

Fig. 3 shows the first part of the designing process where all the movements of each step should be defined [2]. (A+) means that the actuator A moves to the advanced position and (A-) - to the initial position. The movements that happen at the same time are joined together in the same cycle. The system has 5 steps.

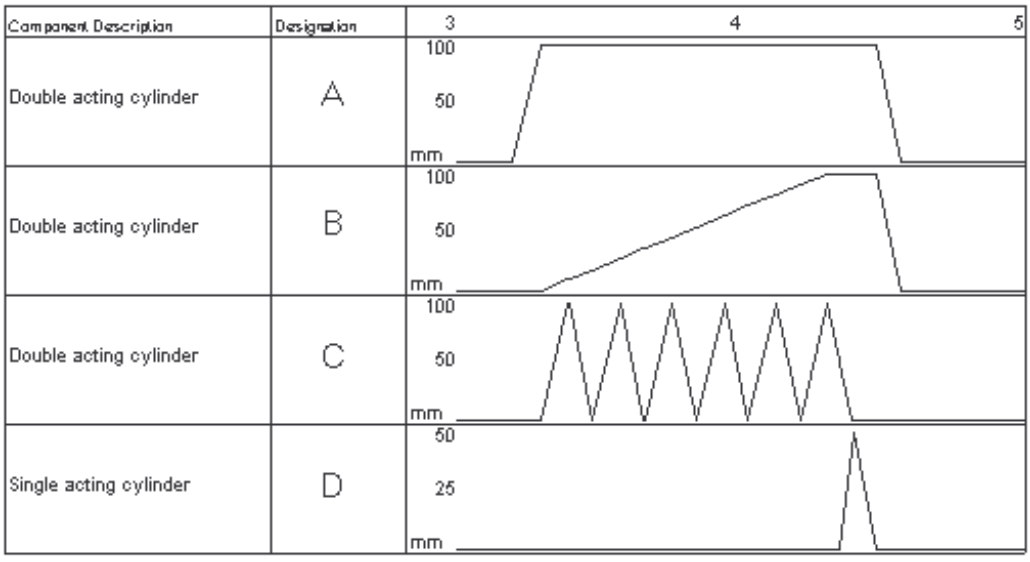

Fig. 2. Time diagram of actuators A, B, C and D movements

This drawing alone is not enough to describe the whole circuit, because the representation of the flow control on actuator B for example is not done, but it is enough to see the order of the movements and which movements must be together.

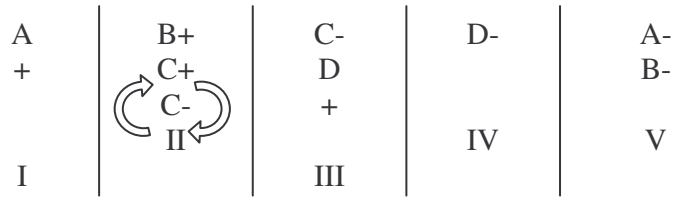

Fig. 3. Steps sequence of actuators A, B, C and D movements

These two representations of the system together are enough to describe correctly all the sequence. With them is possible to design the whole circuit with the necessary logic components. But till this time it is not a complete circuit, because it is missing some auxiliary elements that are not included in this draws because they work in parallel with the main sequence.

These auxiliary elements give more function to the circuit and are very important to the final application; the most important of them is the parallel circuit linked with all the others steps. That circuit should be able to stop the sequence at any time and change the state of the actuators to a specific position. This kind of circuit can be used as a reset or emergency buttons.

In additional to this important one, other auxiliary elements can be included, like the automatic/ manual switcher that permit a continuos work and the two start buttons that make the operator of a machine use their two hands to start the process, reducing the risk of accidents.

4. THE RESULTS

In figs 4 and 5a,b it is possible to check the actuators and all the necessary components needed for suitable work of the system. It is possible to see the flow control valve, that can be regulated and then make the actuator C do more cycles. Together with actuator D there is a quick exhaust valve to make a fast return.

Together with the circuit for the sequence of movements there are three functionality components, two start buttons, the switcher between manual and automatic work and the auxiliary reset circuit.

The two buttons were included in a very simple way where they just make an AND logic operation to give the signal to start the sequence.

The auto/manual switcher permits that the supply from the last step is used as a signal to the first step to start the sequence again.

In this example the parallel circuit is used as a reset button, and here it is used to return the system to the initial position, but it could be changed to return the system to any position. This circuit can stop the sequence at any moment, activating the last step and disactivating the automatic mode of work. In the figs 4 and 5b it is possible to see the component named RES and how it is included to the main circuit to disable the steps I to IV. RES activates the last step and gives a signal to actuator C in order to make it come back to the initial position. In fig. 4 the extra supply line reset is connected with all the other steps and in fig. 5 the extra relay changes the estate of all the others.

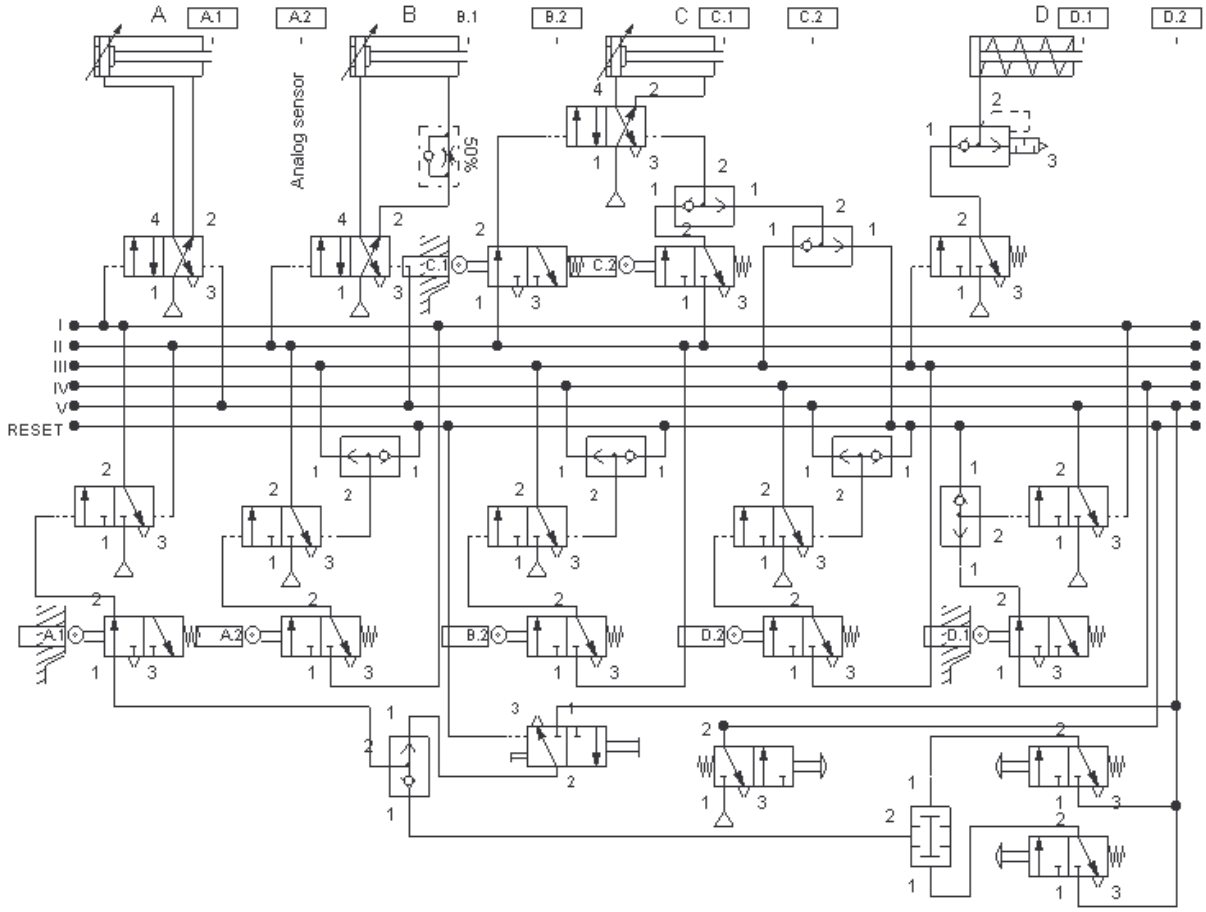

Fig. 4. The pneumatic system diagram

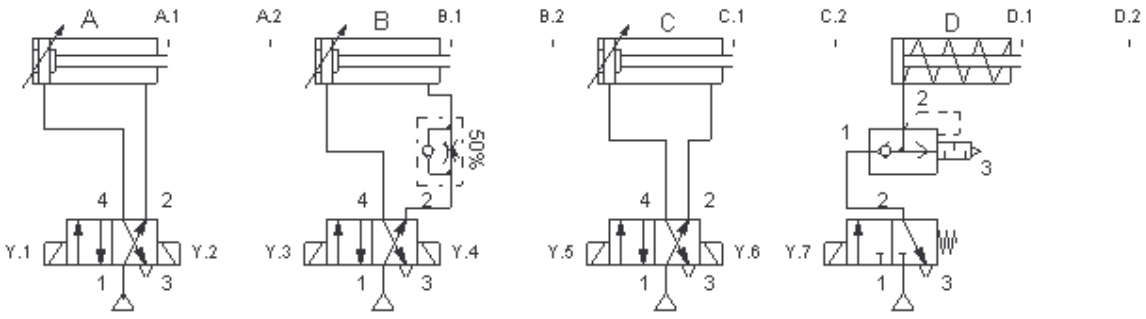

Fig. 5a. The electropneumatic system – actuators with electric directly control valves

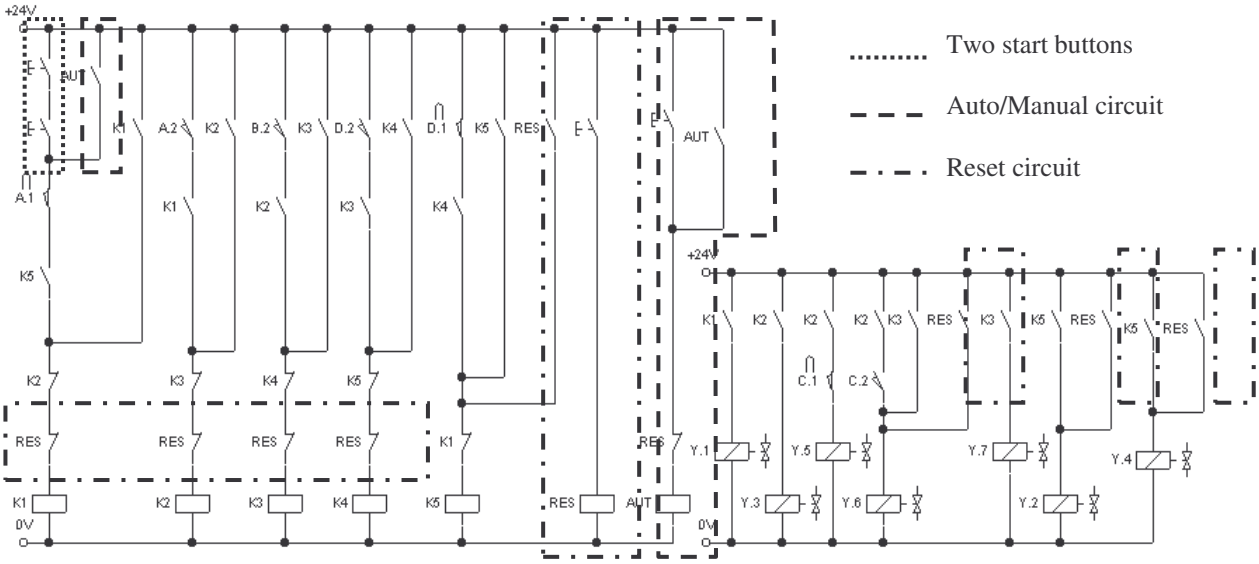

Fig. 5b. The electropneumatic system – electric diagram

6. COMMENTS

To project a real application does not mean to design only the sequence of movements but also to project auxiliary components, that can help the final application to be a reliable system and safety for the operator.

The step by step method helped to make a circuit only with the simple movement prepared to be complemented by the other auxiliary components, because each step is defined very clearly by the standard circuits. This characteristic gives possibility, for example, to choose exactly which steps must be stop with the reset button and which is the initial position of the actuators.

Finally this developed circuit is ready to be adapted with the auxiliary program to be designed and executed inside of a PLC or other specific controllers developed for pneumatic system that can execute all the logic of steps movements inside of the program.

REFERENCES

1. E. Nelli Silva, Fluid-mechanics systems Manual, Escola Politécnica-USP 2002 (in Portuguese)
2. Fundamental of Electropneumatic – FESTO Didatic (2000)
3. J. Swider (redaction), Control and Automation of Technological Process and Mechatronic systems, Silesian University Publishing Company, Gliwice 2002 (in Polish)
4. J. Swider, G. Wszolek, W. Carvalho, Controller based on microcontroller designed to execute the logic control of pneumatic systems, 12 International Scientific Conference – Achievements in Mechanical & Materials Engineering, Gliwice-Zakopane 2003, Poland