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IMPLEMENTING OF A CONTROL SYSTEM FOR PNEUMATIC PROCESS

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ABSTRACT

Within the research and didactical activity implementing of a control system represent a first step. Rather difficult to fulfil when every component, both pneumatic process and digital controller is new. The effort of implementation is done for connecting the elements of the process, measurement, interfaces with digital controller, software. The result is a system that can be developed according to theory, increased in complexity, with minimal changes in structure.

KEYWORDS:

pneumatic elements, control systems, learning, LabView

INTRODUCTION

Pneumatic elements are wide spread in low power positioning systems. They are very advantageous because of flexibility, but not very performing regarding the precision. The control of these systems was improved in last years by introducing of proportional valves instead of on-off valves. This paper describes the steps of building a rather complex control system for 2 degrees of freedom pneumatic system plus a suction valve. The process is provided by FESTO Company, being a part of a full control system. Weren't used the FESTO controller and interfaces, but replaced with an acquisition board from National Instruments and consequently electronics. Unfortunately, the feedback from a pneumatic element was in CAN bus format and was not processed by the built control system. The software used was LabView 7 and MAX 2.0 from National Instruments.

EXPERIMENTAL PART

The experimental part consists of a control system with one closed loop and two open loops. The block diagram is presented in fig.1.

- process PC, detailed in fig.2, is formed of one linear pneumatic piston (1), with a sliding cursor (2), a rotating pneumatic motor (5) on whose shaft (6) is mounted an arm (4) with suction valve (3),
- y1, y2 and y3 represents position of linear piston, angular position of motor respectively the air volume absorbed by vacuum generator,
- actuators EE1 and EE2 are two identical proportional pneumatic valves, while EE3 is a vacuum generator,

- measurement element EM is a potentiometer that measures the angular position of rotating motor (for linear piston the feedback is in CAN bus format and couldn't be processed in actual version),
- controller RG consists of a computer and NI acquisition board together with the LabView and MAX software.

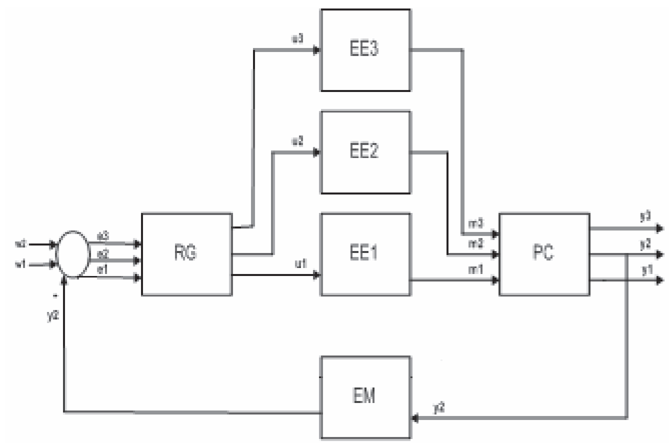


Fig.1

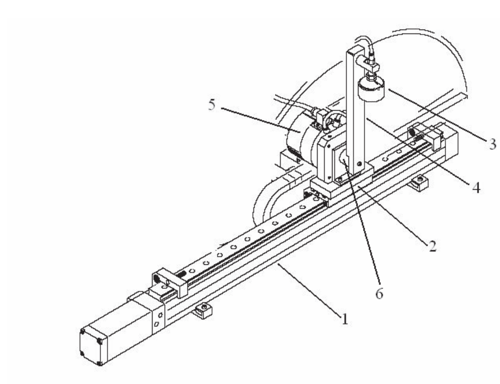


Fig.2

The whole pneumatic process is powered by a 3HP compressor that can issue 8 to 10 bars. The pressure of compressed air is regulated by a regulator that has the main task to maintain the pressure in circuit constant at 4 bars, but also the task to filter the air from impurities and humidity.

Vacuum generator. The task of this device is to generate vacuum when supplied with 4 bars air. The command signal is logic 0V for OFF and 24V for ON. Its efficiency is 85%, consumed power is 2.5W at an input impedance of 240 Ohms. It is connected through a pipe to the suction valve mounted on the arm of rotating motor.

Linear piston. (Fig.3) It consists of a metalic case (2), the piston with a mounting plate (1), the pneumatic circuit that has two inputs (3) and the measurement system with the corresponding electronics. The movement of the piston is realized by the differential pressure supplied at input 3, by the proportional valve. The ampltude of difference detremines the speed, while the sign of difference determines the direction. On the mounting plate of the piston is fixed the rotating motor.

Rotating motor. The principle is identical to that of the linear piston, but the displacement is angular. The air flow through two pipes from proportional valve determine the movement of the motor shaft.

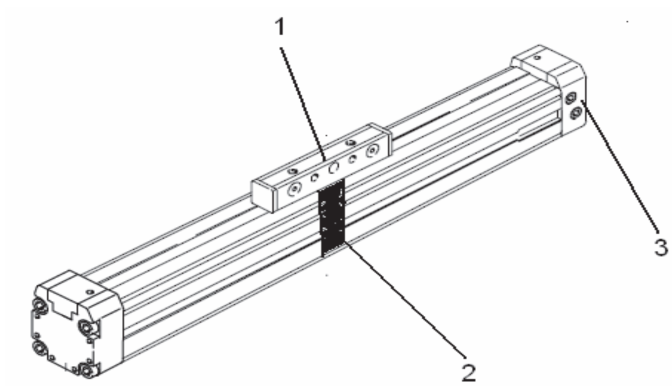


Fig.3

Proportional valves. These devices have the task to generate differential pressure to actuate the linear piston and rotating motor. The structure is presented in fig.4, where 1 is the electric converter that transforms the input voltage into the displacement of the shaft 2. The consequence is that the input air flow in 3 is distributed towards outputs 4 or 5, the excess being evacuated in atmosphere through 6 or 7. They are controlled in voltage as in fig.5. When in equilibrum status, at 5 V, the air flow on both output is null. When voltage is different from 5 V the air flow is guided towards one or another output from 0% to 100%.

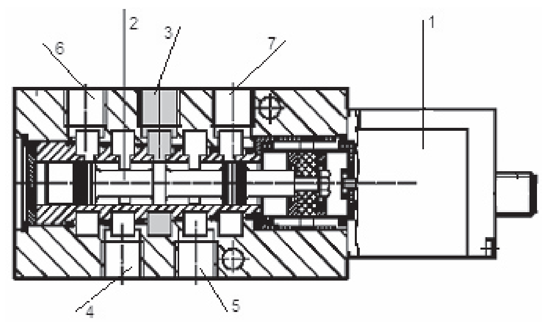


Fig. 4

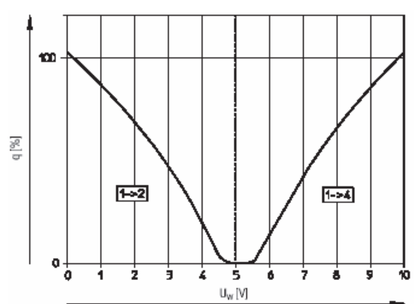


Fig. 5

Controller. It is performed by a personal computer with NI PCI-6024E data acquisition board. The software used for development is LabView 6.0 and MAX 2.0 of National Instruments.

Control System implementation. From the hardware point of view there are 4 connection between controller and actuators and measurement elements.

- 1 analog signal from position sensor of rotating motor (voltage in range 0V- 8.2V) towards Analog Input of PCI 6024E board,
- 2 analog signals to proportional valves (voltage in range 0V-10V) from Analog Output of PCI 6024E board,
- 1 logical signal to vacuum generator (voltage with TTL levels) from Digital Output of PCI 6024E board, through a 24V relay.

From the software point of view there are three modules that deals with the three pneumatic actuators:

- *rotating motor control module* (fig. 6), has the following functions:
  - analog signal acquisition from position sensor on Analog Input,
  - generation of reference (w2),
  - computing the comand using control law (in this case was a simple proportional controller),
  - limitation and generation of the analog signal towards valve through Analog Output.

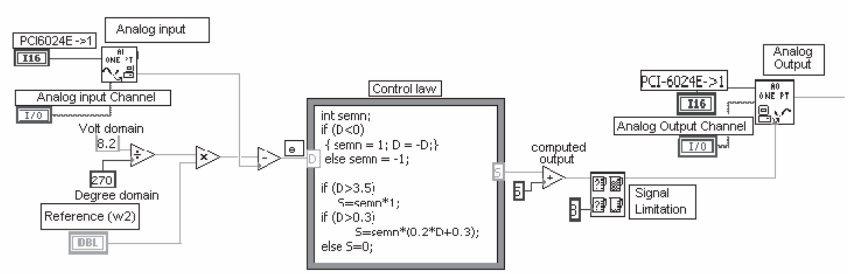


Fig.6

- *vacuum generator module* (fig. 7), has the following functions:

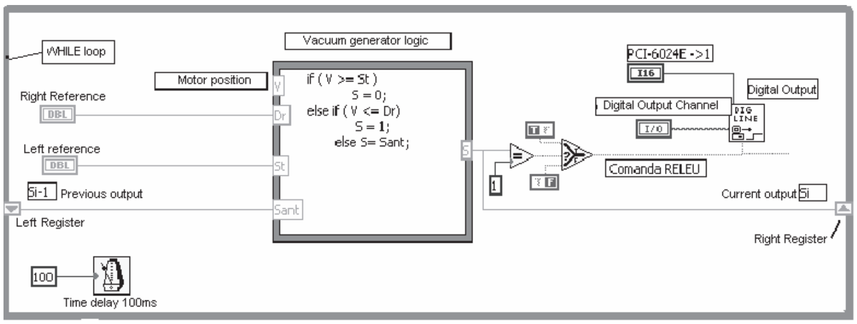


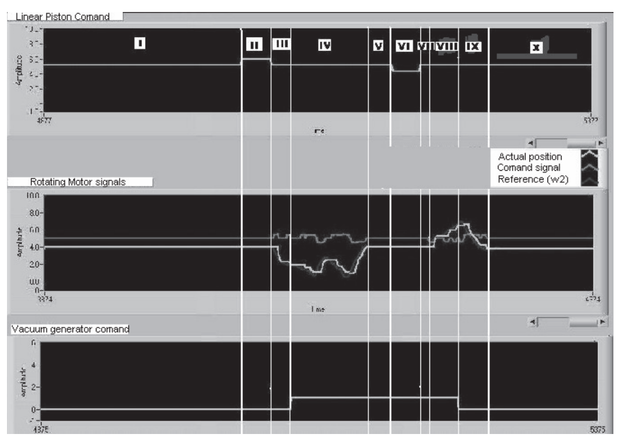
Fig.7

- reading the position of motor, aquired by previous module,
- comparing with two limits (left and right),
- generating a proper logic signal if the position is on a certain relation with these limits

- *linear piston module*, has the following functions:
  - reading of comand signal from a user interface,
  - generating an analog signal towards proportional valve through Analog Output (open loop control).

The time diagram in fig.8 shows all the signals involved in this control system:

Fig.8



- diagram 1 – comand signal for linear piston

- diagram 2 – motor blue (reference signal w2), green (actual position),red (comand signal),
- diagram 3 – comand signal for vacuum generator.

Zone I- initial state, Zone II- movement of linear piston towards a desired position (manual comand), Zone III- start of rotating, Zone IV- when reaching a certain position, start of vacuum, continuing rotation (getting an object), reverse rotation (lifting the object), Zone V- stop movement (pause), Zone VI- start linear movement backwards, Zone VII- stop movement (pause), Zone VIII- start rotating (lowering object), Zone IX- when reaching a certain position, stop vacuum (release object), reverse rotating, Zone X- stop.

For this application there is a user interface that allows to set the variables, and to visualize the signals. In fig.9 is presented the whole system (on the monitor screen can be seen the signals from process).

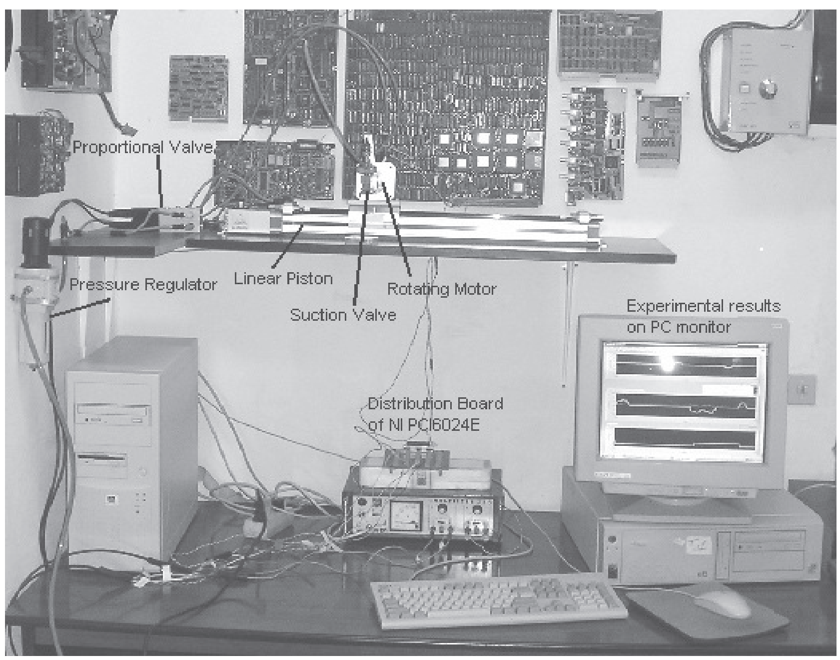


Fig.9

CONCLUSION

This application was designed and started up to create a base for future development for Control Systems design and research. From this point, with minor interventions the application can be changed. The linear piston loop has to be added by processing the can BUS signals.

REFERENCES

Cottet F., Ciobanu O. *Bazele programării în LabView,* Matrix Rom, Bucureşti, 1998
Bishop R.H., *LabVIEW Student Edition 6,* Prentice-Hall, 2001
Festo AG & Co.KG *Assembly instructions* , 2004.
SMC, *Electropneumatica practic*a, 2004
SMC, *Introducere în pneumatica practică,* 2004