Development of a servo-pneumatic system in distant learning

András Czmerk, Károly Széll, Péter Korondi
Budapest University of Technology and Economics, Mechanical Engineering Faculty,
Department of Mechatronics, Optics and Engineering Informatics

***Abstract* —.**
The identification of a nonlinear system is a great challenge. This paper presents a servo-pneumatic experimental set-up available via internet. The advent of the Internet and other information technologies make teaching and research readily available to scholars and students across the globe. There are already many international distance learning programs with the aim to provide students with scientific materials that are easy to understand even alone at home. The specialty of this system, that most of the nowadays used programming languages and higher technology might be applied.

***Index Terms* — Pnetumatic cylinder, FPGA environment, Measurement**

I. Introduction

Modern technology is providing a broad foundation for a revolution in higher education worldwide. The advent of the Internet and other information technologies make teaching and research readily available to scholars and students across the globe. There are already many international distance learning programs with the aim to provide students with scientific materials that are easy to understand even alone at home. In recent years there are more and more students who choose distant learning instead of the common way to learn in classrooms. The new way of thinking, "learn during your whole life", also means that you have to learn even when you are already working. In this case people don't have the time to attend classes, hardly even at the weekend.

Nowadays, it is a trend to study abroad. Foreign students can be found all over the world in the universities. For them it may be a real challenge to get along with the language of the given country or only to find a good curriculum from which they could learn the given subject. For this purpose universities use nowadays English language materials.

For these students it would be really beneficial to create such an educational program, in which they can find all the materials they need for their scientific progress, which is accessible anytime, for the sake of simplicity, through the internet. For this purpose we continued an earlier project with animated learning material about simulating a DC servo system. The used language of the presented papers and software tools is English as it is getting common all over the world. Being the most popular communication tool it is sensible to use English in the field of e-learning.

In the next section the basic conception of the set-up is explained. The third section gives a brief introduction of the servo-pneumatic system. The fourth section describes the safety considerations. The fifth section introduces the control and measurement part of the system. In the sixth section the educational utilization of the set-up is discussed.

II. Basic conception

The system is based on four main parts. The Panda-board is responsible for the stable internet connection. The Atmel microcontroller is dedicated to the safety critical parts of the measurement setup. The cRIO is the "brain" of the system taking care of the measurements and control. The fourth part is the controlled pneumatic cylinder itself.

The measurement setup offers a lot of possibilities to try different control methods, to see the used algorithm line by line for example in C program on the lowest level and to watch the reaction of the system in the reality via a webcam. How is it possible for an average student to take these measurements without significant knowledge in controlling and programming? For this purpose a program was designed which operates like a frame for the control part. The students don't have to be able to program, they only have to handle the variables on the basis of an example for every task.

In the original framework program we can set every parameter for the operation of the system from which the most important is the output voltage for the magnet valves of the servo-pneumatic cylinder. For the tutor it is useful to know the construction of the complete system but confusing for a student who is not talented yet in programming or sees the remote laboratory for the first time. The remote laboratory is web based. This reduces network traffic overload, which can be caused by a Remote Desktop Control protocol. Only the controller instructions are transmitted from the client browser to the server. The controller is added to the same framework mentioned previously. After the controller has finished running on the servo-pneumatic system, the measurement results are available for download on the website. The result of the measurement can be downloaded in various types, to suit the needs. Priority levels are introduced in measurement execution to handle the possibility when more people want to use the system at the same time.

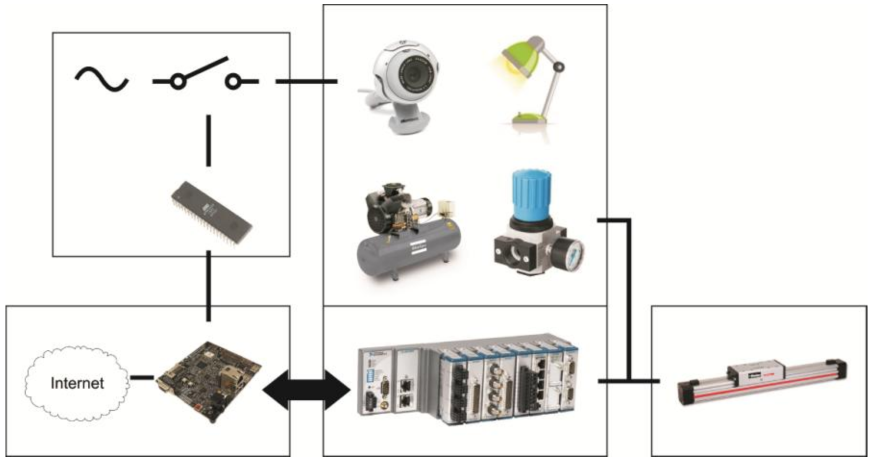

Fig. 1. Basic conception

III. SERVOPNEUMATIC

The pneumatic actuator is applied widespread because of its durability, long life, as well as its wet-strength operation and low price. It should not be neglected, that compressed air is serving as the energy transfer in most plants. Disadvantage is their strong nonlinearity.

The pneumatic motion has been used for the actuation only between the two ends of the stroke for a long time. The aimed positioning was realizable first in the 90's by the PID controller which is widely used in the industry.

This solution for the control of the pneumatic cylinder can be limitedly applied because of the varying parameters, and significant dead time. It is a great challenge to create a control algorithm that can handle the behavior of the pneumatic system for every expected case. The first step is to design such a model that describes the experimental setup. For this process a lot of measurements have to be taken in the case of such a nonlinear system. Let us investigate some parts of the cylinder to see how challenging it might be.

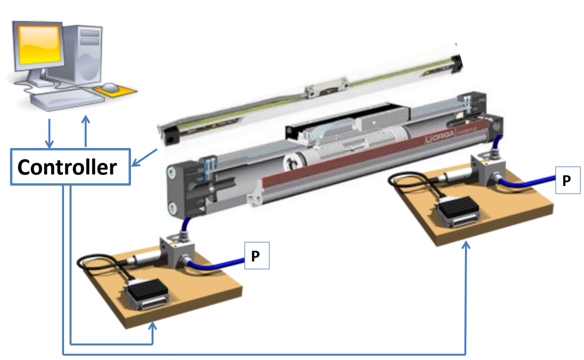

Fig. 2. Basic structure of a servopneumatic system

The piston is actuated by magnet valves which can switch the supply pressure p_S or the return pressure p_R to the chambers.

According to the requirements the compressed air q can flow according to the flow of the control edge 2 respectively 3 in the cylinder and 4 respectively 1 back to the return pipeline. The mass flows over the control edges 1, 2, 3, 4 of the servo valve must be calculated.

The dynamic behavior of pneumatic cylinders is characterized by significant nonlinearities. The setup gives the opportunity to make measurements via internet making the identification process much easier.

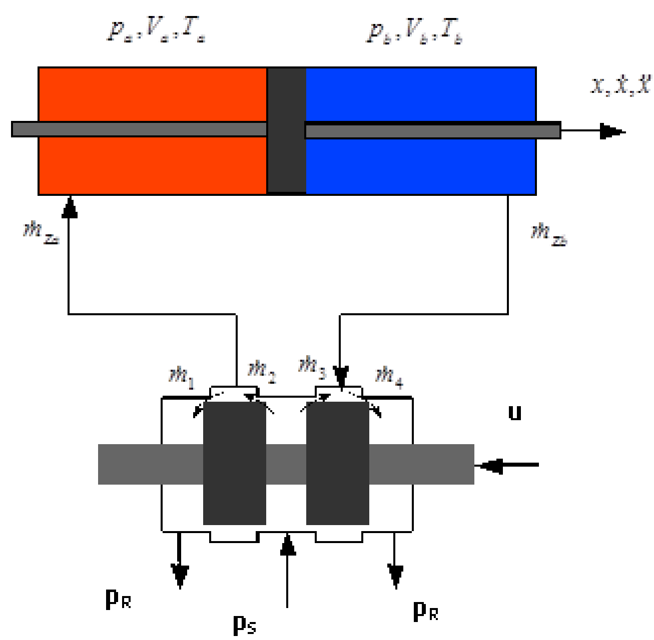

Fig. 3. Schematic mass flow diagram of cylinder and valve

IV. SAFETY

The system is designed to be such a setup which can be used 24/7 without control staff. Thus it is very important to elaborate a safety system to prevent the setup from a critical breakdown or the danger of fire.

A Panda-board works as the main interface for internet communication, data management and controls the safety critical issues. The safety critical part has a dedicated Atmel microcontroller, which switches on and off the main power supply. In the case of a microcontroller we do not have to fear that the operation system might crash. Using a watchdog-type supervision between the Panda-board and the microcontroller we can quickly switch our experimental setup off if the microcontroller senses the smallest trouble.

The system uses a webcam as well. In case of remote control it gives us much more supervisory possibilities. We can easily notice any safety critical problems during our measurements and additionally we can observe whether our program works according to our intentions. In the case of distant learning it also gives the so important practical part of the education. The students can implement their control, they can see the measurement data and they can also see how the real system moves. As the system is designed to give the opportunity to take measurements also in the night, we have built in a lamp as well.

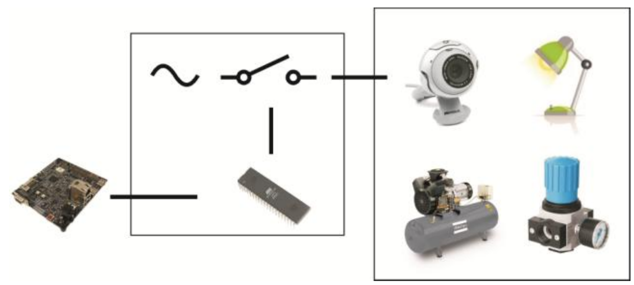

Fig. 4. Safety solution

V. Control and Measurement

We have chosen a National Instrument tool for the identification and control purposes. The main benefit of the cRIO-9073 that it makes a high-frequency real-time system available, using a relatively easy programming language. LabView is a graphical programming language with which GUIs are easy to implement, still it gives the opportunity to use deeper programming tools.

By the simulation beyond analyzing the basic control methods like Ziegler-Nichols or Kessler it is also possible to study or develop new types of controlling like sliding-mode control. As nowadays research activities usually mean cooperation between different universities of the world it is really beneficial that the laboratory equipment is accessible from anywhere in the world. This way the resources of the universities can be more effectively utilized. The members of the research team may stay anywhere in the world in any time zone they can work together on the same project effectively by using the same system for simulation and measurements. For analysis purposes TDMS and Excel format might be used (see Fig. 6-7.).

VI. Education

The students can watch the process through a webcam and make an analysis by the developed software tools for data process, simulation and comparison. Finally they can write their own controller in a program framework. This way they can easily understand the structure of the whole complex system starting from the fundamental model till the most complicated.

The experimental set-up makes it possible to use a wide range of tools applied in the industrial technology. The following topics might be encompassed in the educational materials using the proposed servo-pneumatic identification/control set-up:

- Measurement
- Identification
- Modelling
- Control (non-linear)
- LabView, MatLab and C programming
- FPGA resources
- Bistabil and proportional valves
- Potential and optic encoder
- Accelerometer
- Pressuresensor
- Volumeflowmeter

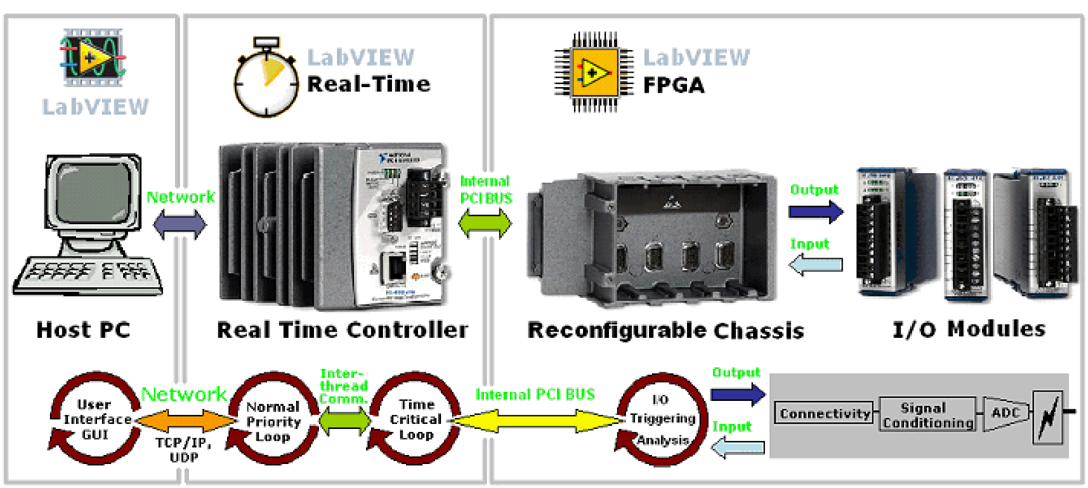

Fig. 5. FPGA environment

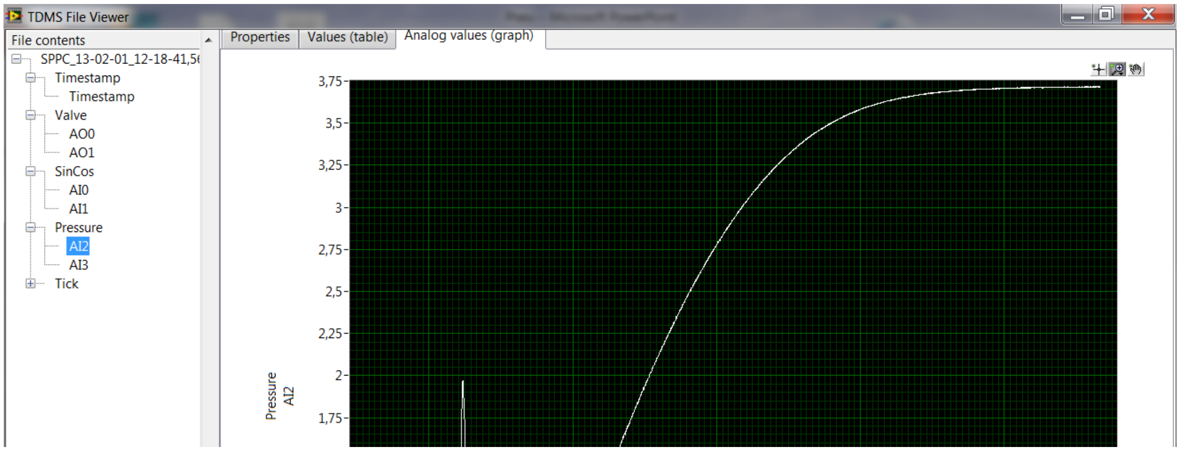

Fig. 6. Analysis using TDMS format

VII. CONCLUSION

The main contribution of this paper was to present a solution for R&D and distant learning using higher technology and theory. This experimental setup gives the opportunity for researchers to use a broad variety of tools for their studies disregarding where they are and which time they need a new measurement result. For educational purpose it is a good connection between theory and practice. The students can watch the process via a webcam, make their own control system, gaining the practical essence of the learnt theory.

VIII. ACKNOWLEDGEMENT

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23	**AI1**	DT_DOUBLE		5800				1	
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Fig. 7. Analysis using Excel format