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Remote control of pneumatic circular manipulator using CompactRIO controller[1]

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Abstract: Pneumatic circular manipulator is a new experimental facility developed for testing different control methods and energy efficiency of automated systems with compressed air as a working medium. Also, the manipulator has the ability of remote control, via the Internet and thereby it is an important didactic tool for teaching in the field of pneumatic control with multiple actuators. In this paper, the realization of control is presented using the CompactRIO controller, which eliminates the need for a server computer.

Keywords: circular manipulator; remote control; CompactRIO

1. INTRODUCTION

The latest researches in the field of remote control of real physical experiments confirms the hypothesis that remote laboratories are of great importance for a growing number of educational institutions, especially those that teach students in the field of mechatronics (Gadzhanov et al., 2014). For a certain time such laboratories and experimental facilities are being developed at the Faculty of Technical Sciences in Novi Sad, primarily in order to strengthen cooperation between universities and vocational schools in order to exchange valuable experience but also equipment that is not available for them. Examples of this are remotely controlled pneumatic spring (Reljić et al., 2015), remote laboratory for measurement tolerance of linear dimensions (Šulc et al., 2015), remote system for measuring geometric tolerances - roundness (Bajči et al., 2016) and remotely controlled pneumatic circular manipulator (Reljic et al., 2016). The practical realization of each of these devices brings with it its own specifics and what is typical for pneumatic circular manipulator is that, so far, for the remote control it has to be used, in addition to the client computer a server computer it was enabling only the connection between the client and the main controller - a programmable logic controller (PLC). That was the main drawback of the existing system.

This paper presents the implementation of remote control with the mentioned experimental facility using CompactRIO controller thus eliminating the need for using additional server

computers, because the controller, in addition to their base purpose, control of the system, takes over that role too.

2. MECHANICAL DESIGN AND OPERATION MODES OF THE MANIPULATOR

Pneumatic circular manipulator is a new experimental facility consisting of multiple pneumatic actuators - 3 pneumatic double acting cylinder (one of which is a multi-position cylinder, and is realized by using two pneumatic double acting cylinder, identical characteristics, which provided three different positions) and a pneumatic gripper which is used for gripping and releasing of the workpieces. Practical realization of the manipulator is shown in Fig. 1. The supporting structure is a rectangular plate, dimensions 1300x1200x15 and made of PVC. Using screw connections the plate is connected with profiles, made by the manufacturer Bosch Rexroth and with the cross section area of 50x50, and thereby is achieved a stable equilibrium. Cylinders and the storage with workpieces are placed on the supporting plate using aliminum profiles and screw connections.
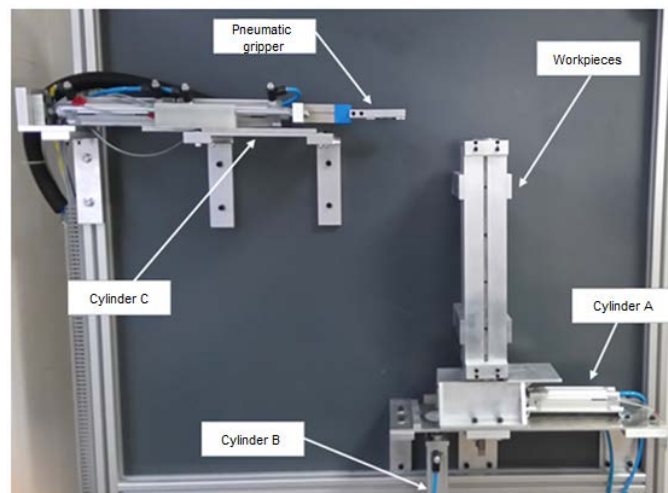

Figure 1. *Pneumatic circular manipulator*

Workpieces, with dimensions Ø80x100, are placed in the vertical storage unit. At the lowest point of storage unit, one horizontally mounted cylinder – cylinder A, pushes workpiece forward and places it above the vertically mounted cylinder – cylinder B. Cylinder B than raises it upwards, up to the level of the second horizontally mounted cylinder – cylinder C. Cylinder C is a multi-position cylinder, consisted of two cylinders mounted in series and enable realisation of several positions. At the end of cylinder C is mounted pneumatic gripper. Finally, cylinder C grasps the workpiece with the pneumatic gripper and moves it forward to the top of the vertical storage unit. Workpiece is sliding down through the storage unit with the help of gravity. When workpiece comes down to the initial position, one working cycle is ended. All pneumatic cylinders are from Festo manufacturer, where cylinders A and C have designation DNC-32-100-PPV-A, and the cylinder B has designation DNC-32-600-PPV-A. For easier explanation of manipulator operating mode, in Fig. 2 is shown the travel-step diagram, wherein the left and right cylinder of multi-position cylinder labeled C in the diagram respectively marks C and D. The detection of indented and drawn-out pneumatic

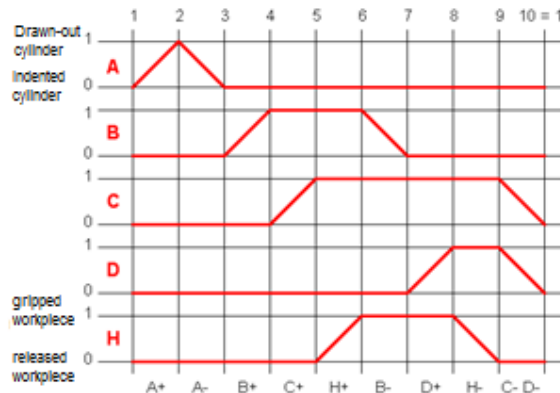cylinders piston rod positions was achieved using a magnetic reed relay.

Figure 2. *Travel-step diagram*

3. REMOTE CONTROL USING THE COMPACTRIO 9074 CONTROLLER

CompactRIO 9074 controller, manufactured by National Instruments, whose is shown in Fig. 3, was used to control the manipulator. It is a modular system that consists of three main parts: the real-time processor, chassis and I/O modules. The real time controller has high processing power and data processing what makes this system very suitable for advanced applications management and high-speed data transfer. It contains a processor speed of 400 MHz. In addition, it contains a network port that is used to provide communication between the controller and a computer. Network communication contains HTTP and FTP protocols. Modular systems operates with a software package for graphical programming LabVIEW, which is used during the control realization. The controller also contains RS232 port, and is powered by 19-30 VDC. In our case, a 24 VDC power supply is used.

Figure 3. *CompactRIO 9074*

During the realization of remote control, it was necessary to do 3 things - design and connect electropneumatics control scheme based on the travel-step diagram shown in Fig. 2, set the controller and connect its input and output modules (in this case they are used for digital

inputs and outputs) and make the client application for remote control and program the controller. Electropneumatic scheme is drawn in software package Fluid Draw and is shown in Fig. 4.
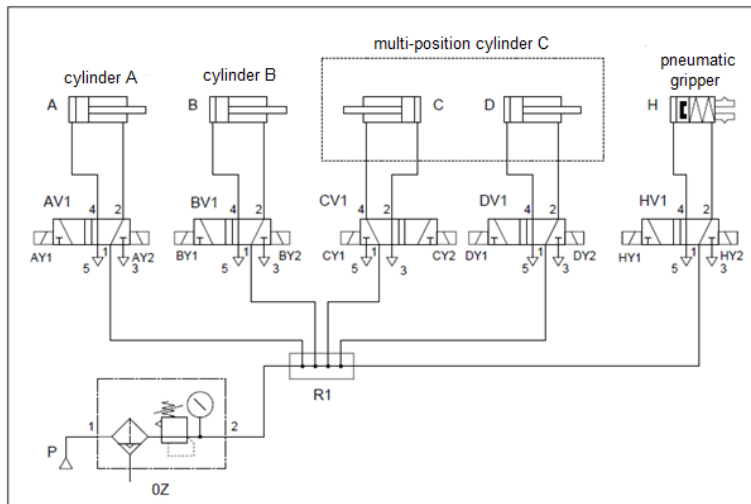

Figure 4. *Electropneumatic scheme*

Digital inputs and digital outputs are connected with I/O modules of the controller as shown in Fig. 5 and 6, respectively. It is important to note that under the symbol A+ (Figure 6) implies activation of coil AY1 (Fig. 4) and under the symbol A- (Fig. 6) activation of coil AY2 (Fig. 4), and so on.
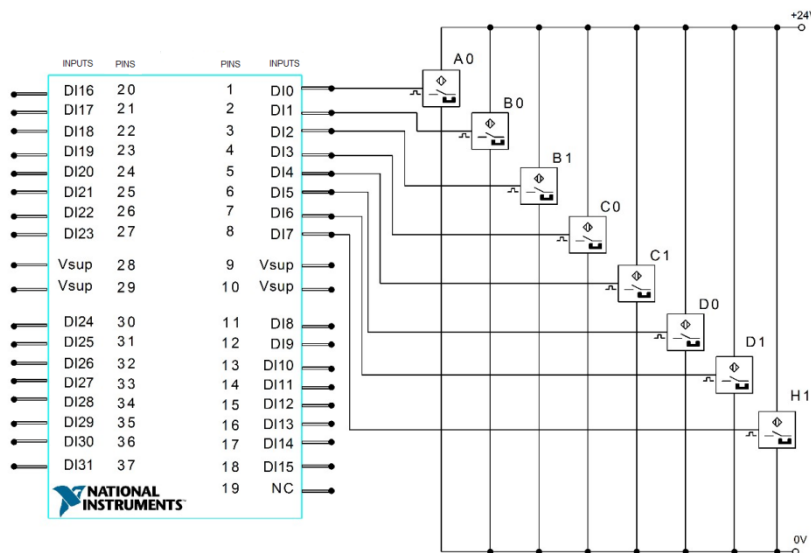

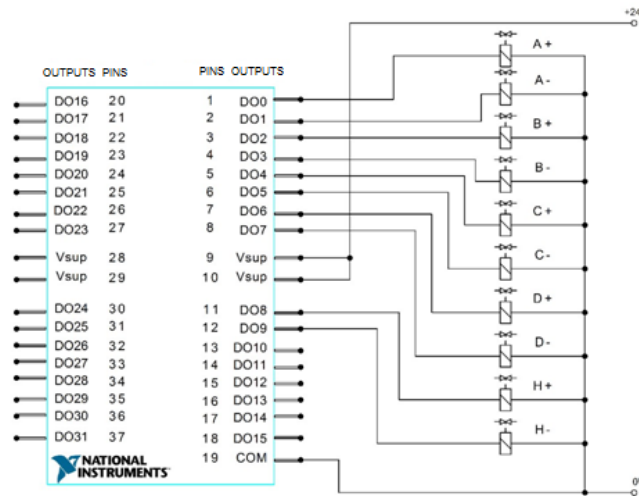**Figure 5.** *Connecting of the digital inputs*

Figure 6. *Connecting of the digital outputs*

To communicate with the controller, which also represents the server, it is necessary for the client to possess a client application in which, first of all, we need to define the IP address of the controller and communication port. The client, by sending the appropriate commands through the Internet, via the controller, indirectly controls the pneumatic circular manipulator because the control of the cylinders piston rod is done by the controller. The client application is shown in Fig. 7. There is three modes available for the client – start one cycle (Fig. 7, the START 1 CYCLE button), start five cycles (Fig. 7, the START 5 CYCLE button) and start automatic mode (Fig. 7, AUT switch). Termination of work in automatic mode can be performed by turning off the AUT switch. In order to secure the device in the application are placed a total stop switch (Fig. 7, the button TOTAL STOP), which allows the execution of the program and then sets the actuators of the device in the safest position for the operator and the environment, as well as a stop button (Fig. 7, button STOP), which interrupts the execution of the program but only after completing his cycle. If the client activates any of two types of management at the same time, the cycle will be performed only once.

4. CONCLUSION

This paper presents the practical realization of the new experimental facility called pneumatic circular manipulator which is a very suitable didactic tool for those who deal with pneumatic control with a number of actuators for practical training (if they do not have adequate equipment in its educational institution, or if they want to learn more about this area) since it has the ability of remote control, via the Internet. In addition, this paper presents the possibility of remote control using CompactRIO controller, thus eliminating the need for additional server computer what was the main drawback of the existing system. Using CompactRIO controller, the programming of the system is facilitated instead, so far used, PLC and serial communication. CompactRIO programming is performed in LabVIEW (which is used for creating the client application) and there is no need to use additional programming languages.

Figure 7. *Client application*

ACKNOWLEDGEMENTS

REFERENCES

[1] Gadzhanov, S.D., Nafalski, A., Nedic, Z. (2014). *LabVIEW Based Remote Laboratory for Advanced Motion Control*, 11th International Conference on Remote Engineering and Virtual Instrumentation, Polytechnic of Porto, REV 2014, Porto, pp. 130-136

[2] Reljić, V., Milenković, I., Šešlija, D., Dudić, S., Šulc, J. (2015). *Development of Remote Controlled Pneumatic Spring,* 12th International Scientific Conference "Flexible Technologies" – MMA, Andrevlje: Fakultet tehničkih nauka, Novi Sad, pp. 195-198

[3] Šulc J., Šešlija D., Dudić S., Milenković I. (2014). *Implementation of Remote Laboratory for Measuring Linear Dimensions in the Process of e-Learning, The* 3rd Experiment@International Conference – Exp. at '15, Azores, pp. 65

[4] Bajči B., Dudić S., Šulc J., Milenković I., Šešlija D., Reljić V. (2016). *Remote System for Measuring Geometric Tolerances: Roundness,* 13. International Conference on Remote Engineering and Virtual Instrumentation – REV, Madrid: UNED Madrid, pp. 279-280

[5] Reljić V., Šešlija D., Dudić S., Milenković I., Šulc J., Bajči B. (2016). *Upravljanje na daljinu pneumatskim kružnim manipulatorom,* 22. Trendovi razvoja – TREND, Zlatibor: Fakultet tehničkih nauka, Novi Sad, pp. 103-106