ISSN 1453 – 7303 **"HIDRAULICA" (No. 4/2015)**
Magazine *of Hydraulics, Pneumatics, Tribology, Ecology, Sensorics, Mechatronics*

Experimental Model of Pneumatic Tracking System for Photovoltaic Panel

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Abstract: *Because conventional energy production resources are limited, mankind headed for using other sources of energy, alternative, inexhaustible. Solar energy is an alternative to traditional sources. However, the conversion of solar energy into electricity using photovoltaic effect is achieved with low yield (15-18% when using monocrystalline silicon). A method for increasing the yield is based on the use of tracking systems for photovoltaic panels. The paper aims to experimentally validate the theory presented in the paper ˝Pneumatic Tracking System for Photovoltaic Panel˝ [2].*

Keywords: *pneumatic drive, tracking system, photovoltaic (PV) panel, programmable logic controller (PLC)*

1. Introduction

To increase photovoltaic yield and electricity production photovoltaic tracking systems are sometimes used. The photovoltaic tracking system is a device capable of turning after the Sun, which means following the Sun's track from its rising in the east to its setting in the west. The photovoltaic tracking system is a mechanical construction and the photovoltaic panels are attached to this construction. Because the tracking system turns after the Sun all day long, the solar panels are set to face the Sun directly all day long, and so is their performance substantially enhanced.
This process allows the energy usually generated using static photovoltaic panels to be increased by as much as 45% [19]. Optimal alignment is made possible by a precise astronomical control mechanism which can plot the course of the sun from any geographical location at a given time of the year. The most of photovoltaic tracking systems uses the electric drive. In the paper ˝Pneumatic Tracking System for Photovoltaic Panel˝ [2] is shown another type of tracking system based on a pneumatic drive. Of the existing tracking systems in literature [8], the pseudo-equatorial system was adopted. This tracking system was particularized for Craiova location.

2. Structure of mechanical part of tracking system

The tracking systems contain controlled mechanisms that allow maximization of direct normal radiation received on PV panel [9]. As specified in [2], a pseudo-equatorial tracking system type has been adopted for reason of savings in terms of energy efficiency and material consumption.
Pneumatic drive was chosen due to the following advantages [2], [10], [17]:
- their structures are simple and suited for mass production;
- the forces, moments and engine speeds can be adjusted easily using simple devices;
- pneumatic motor overload does not introduce risk of damage;
- pneumatic transmissions allow starts, stops, frequent and sudden changes of direction without risk of damage;
- compressed air is relatively easy to produce and transport network is environmentally friendly non-flammable;
- can be stored in high quantity;
- risk of injury is reduced;
- easy maintenance.

The structure of the mechanical part of a tracking system is shown in Figure 1.
As shown in the figure, a single pneumatic cylinder was used for orientation of a photovoltaic panel after E-W (azimuth) axis. For S-N axis (elevation) a screw-nut mechanism of orientation was used.
According to schematic diagram in Figure 1, it was started the effective realization of an experimental tracking system. The experimental model achieved is shown in Figure 2.

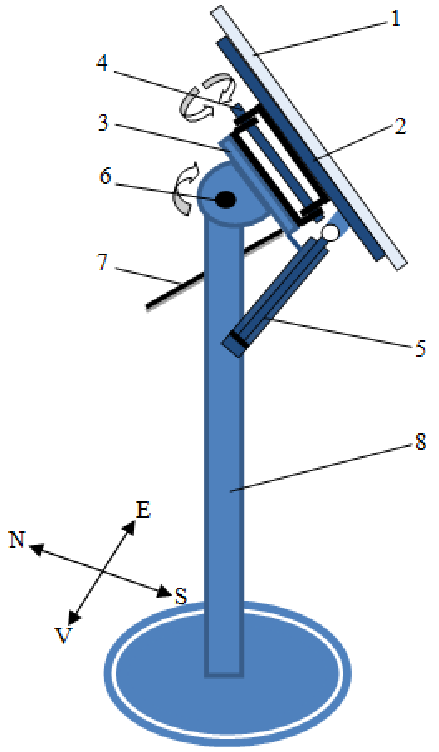

Fig. 1. Structure of the mechanical part of a tracking system : 1- photovoltaic (PV) panel; 2- mechanical mount of PV panel; 3- azimuth tracking mechanism (E-W direction); 4- azimuth joint motion; 5- pneumatic cylinder; 6- elevation joint motion (S-N direction); 7- elevation tracking mechanism; 8- support tower

Fig. 2. Experimental model of tracking system: 1- PV panel; 2- mechanical mount of PV panel; 3- azimuth tracking mechanism; 4- azimuth joint motion; 5- pneumatic cylinder; 6- elevation tracking mechanism; 7- throttles; 8- position sensors; 9- electrical equipment for power supply and control;10- support tower

3. Structure of power supply and control part of tracking system

After achieving the mechanical part of tracking system there has been made the power supply and automatic control part. The orientation of PV panel will be made automatically according to astronomical data using a PLC. For reasons of optimization in terms of economic efficiency, PV panel will perform a movement in steps, with three stationary positions over the day.
The experimental model finished is shown in Figure 3.

Fig. 3. Experimental model of tracking system – electrical part:
1- equipment for production and preparation of compressed air (compressor, air storage accumulator, filter, pressure regulator, decanter, pressure gauge); 2- DC power supply 24V; 3- terminal strip; 4- programmable logic controller (PLC) Easy Moeller; 5- solenoid valve (electrically controlled distributor); 6- Start-Stop switch; 7- mechanical part of tracking system.

For automatic orientation of the photovoltaic panel a PLC from Moeller family, namely Easy 512 DC-RC, was chosen due to its advantages over other control equipment [21].
Figure 4 presents the wiring diagram of the tracking system. It contains the following equipment: PLC; two power supplies (one for input circuits of the PLC and the other for output circuits); X and Y coils of valve; Start / Stop buttons for power supply; L1, L2, L3 - position sensors; BP- button of work program initialization.
Figure 5 shows how to achieve electrical wiring and pneumatic ways with elements related to pneumatic actuation. One can notice the two DR1 and DR2 throttles path having the role of regulating the speed of pneumatic cylinder rod.

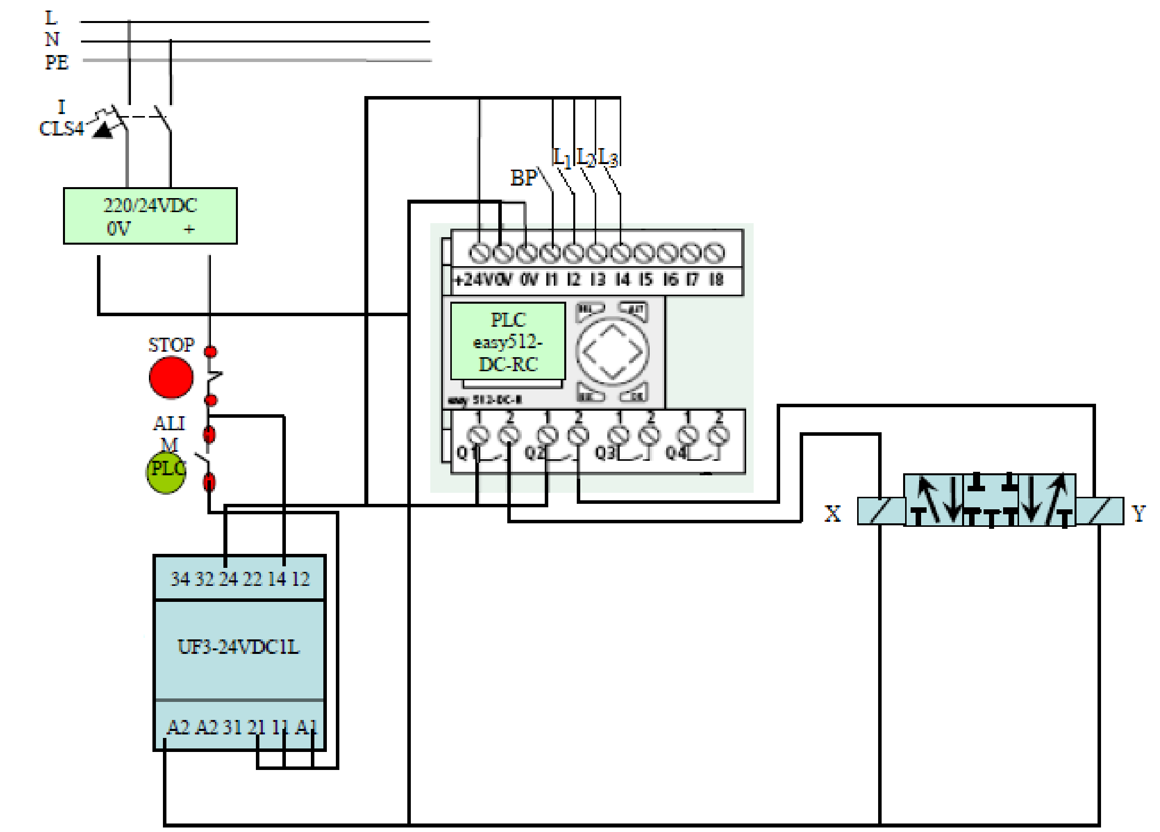

Fig. 4. Wiring diagram of the pneumatic tracking system

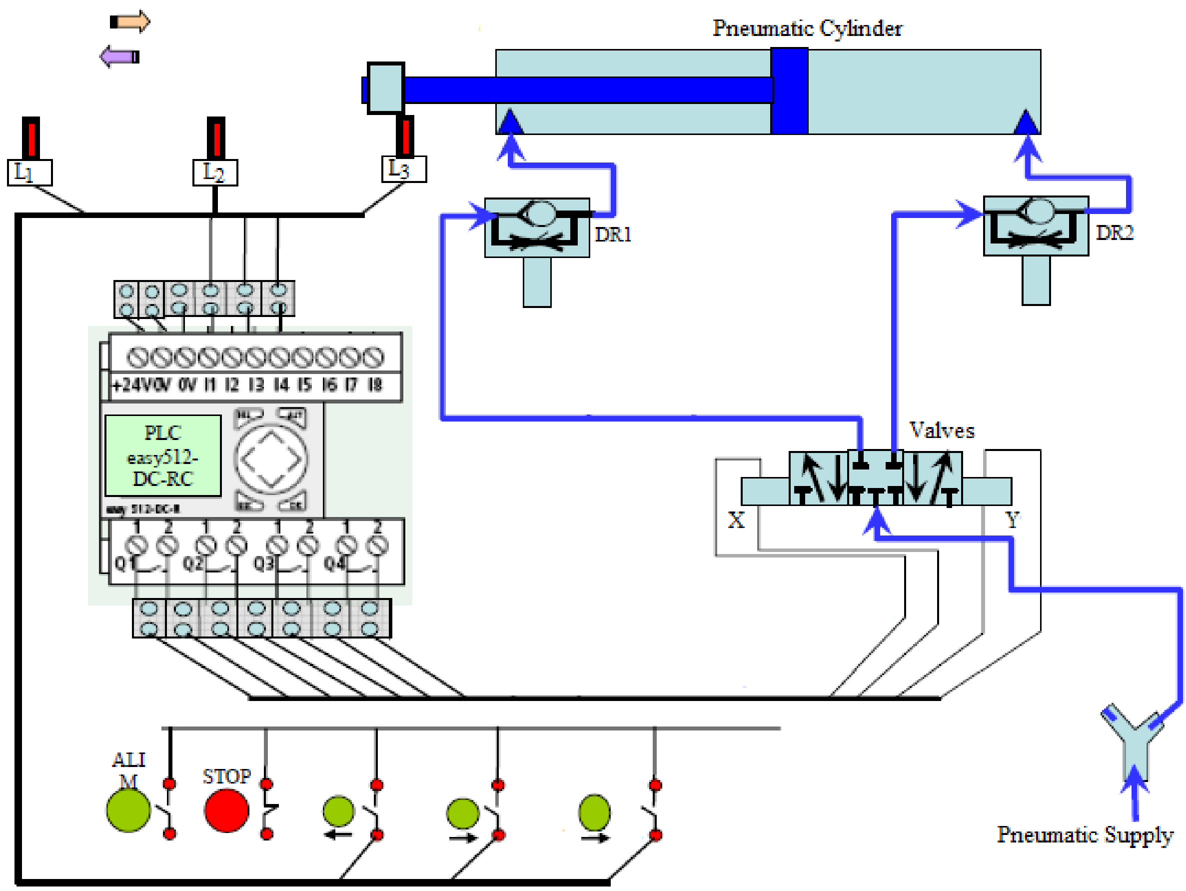

Fig. 5. Diagram of Easy Moeller PLC connecting to the pneumatic actuation

For the development of the photovoltaic panel orientation program there has been used the dedicated software for family Easy Moeller PLC, called Easy Soft [21]. The program may be made easier if initially there is developed the flow chart based on logic functions "Function Block". In Figure 6 is shown the program window made by way of diagram of connections.

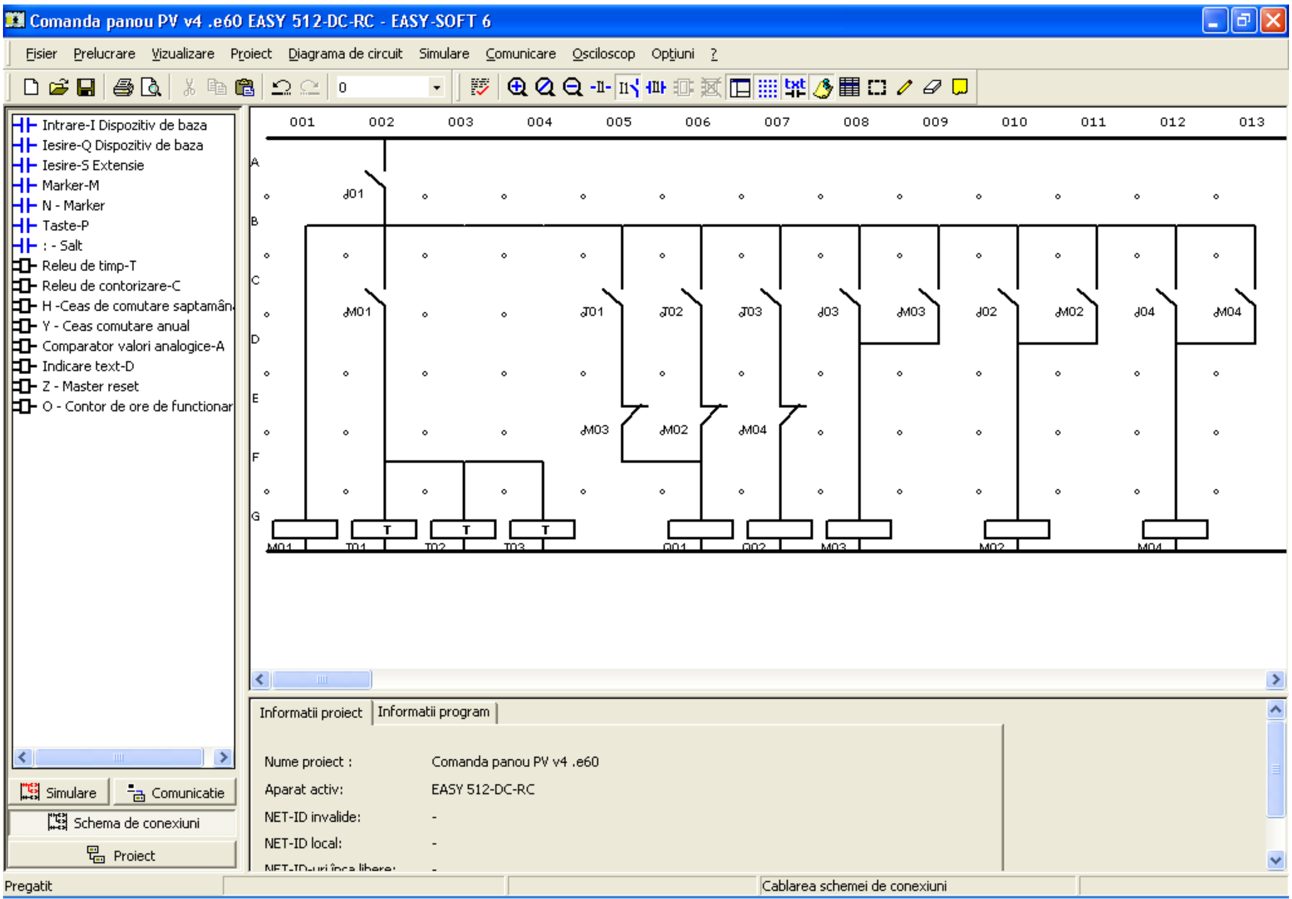

Fig. 6. Window program for tracking system of PV panel

The notations in the figure have the following meanings:
I01- PLC input 1- Button Start/Stop program;
I02, I03, I04 – PLC 2,3,4 inputs, corresponding to the three position sensors;
T01, T02, T03 – timings;
M01...M04 – markers (memory elements of the command - latching);
Q1, Q2 – PLC outputs 1 and 2 of PLC corresponding to the power supply of the two coils of valves.
For activation of inputs I01, the coil of M01 marker is supplied, which will feed 3 timers (T01, T02, T03), through the switch M01. The three relays will be adjusted so timings: T01=4hours; T02=8 hours; T03=12 hours. So during the day the photovoltaic panel is moved 3 times (will have 3 positions). Timing T01 will start at 8:00 AM and upon passing of 4 hours the switch T01 will close and Q01 output will be activated. The PV panel is moved up to touch sensor corresponding to I03 input latching marker M03.
8 hours after the time given by T02, the panel is moved again up to touch of the sensor corresponding to I02 input, latching of marker M02. After 12 hours of delay time given by T03, the panel will be brought to its original position by T03 contact closure which will enable the Q03 output of PLC, which will power supply the other coil of the distributor.
Stopping of the PV panel will be given by the sensor corresponding to I04 input. The command will be maintained by M04 marker.
Stopping of the running program will be done by disabling input I01.

Conclusions

In this work are presented practical aspects regarding the implementation of a tracking system for photovoltaic panels based on a pneumatic drive. The elements relating to practice have been made based on theoretical solutions proposed in the paper [2]. Both the mechanical part of developed tracking system as well as power supply and command part have been proven correct functioning according to the solution and protocol required in [2].

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