Small Scale Model of Automatic Barrier Powered by Photovoltaic Panel

Laurenţiu Alboteanu*, Gheorghe Manolea*, Alexandru Novac†
* University of Craiova/Department of Electromechanical,Environmental and Industrial Informatics, Craiova, Romania, lalboteanu@em.ucv.ro, ghmanolea@gmail.com
† S.C. Promat S.A., Craiova, Romania, alexandru_novac@yahoo.com

***Abstract* - Access control systems offer numerous benefits and are able to constitute extremely good solutions for securing an area of high or very high importance. An access control system allows restriction, monitoring and directing human trafficking as cars to a location or from a location. In generally at access control systems call the managers of circulated spaces or areas where must enter only authorized persons. To access the vehicles in different areas are frequently used automatic barriers. This paper presents such an access system, achieved a small scale named ˝automatic barrier model˝, that uses photovoltaic panels (PV) as main energy source. Automatic operation of barrier is provided by a development system achieved around a microcontroller. In the first part of paper is presents the structure and minimum requirements of development system. Also are highlighted aspects of dimensioning and design for both parts hardware and software respectively. To achieve electrical diagrams and PCBs was used a dedicated software. Finally was tested the achieved automatic barrier model. The tests consist of verifying the correct operation of the automated system. Were made test regarding to automation and to power supply from PV panel. Experimental results show a smooth functioning of experimental automatic barrier powered by PV panel and can be successfully expanded at real scale.**

Keywords: *vehicles access system; automatic barrier; microcontroller; photovoltaic panels; automation.*

I. INTRODUCTION

To restrict access to a parking or an area, usually there are used electromechanical barriers of different sizes, and in the case of restricting access for a single parking space there is widely used lock parking, which is either manually or electromechanical controllable from the remote control [15].

In some cases the electrical grid is situated at considerable distances, or power supply works of the automatic access point are expensive.

The paper presents an alternative solution for small-scale automated access of vehicles. Automatic access system can be supplied with electricity, either from photovoltaic panels or from another source of energy. Automatic operation is provided by a development system achieved around a microcontroller.

We chose this variant of control because the microcontroller is suitable for operation in an industrial environment, it can operate in a wide range of temperature and humidity, it is easily adapted to interfacing with any process and it has no particular problems on the training of service personnel due to offered programming facilities.

Microcontrollers were imposed in an increasingly wide range of applications, programming because of their high simplicity, affordability and reliability [8], [9], [11].

II. STRUCTURE OF AUTOMATIC BARRIER MODEL

A. Requirements

Experimental model called "automatic barrier" proposed for design must meet the following requirements [1]:

- development will be carried out around a microcontroller;
- it must be possible the purchase of five digital signals (barrier up, barrier down, present car, signal access control, fault reset);
- programming will be in a higher level language;
- the user interface will be managed by a seven-segment display;
- microcontroller programming is done via a connector provided on PCB;
- fast status signaling of model is done through two LEDs;
- it must be possible to control a DC motor;
- to allow power supply from alternative power sources.

B. Bloc Diagram of the Automatic Barrier Model

In the design of development systems can take into account the cost, complexity PCB (printed circuit board), speed of execution of the instructions, the existence of media performance written code etc.

It is possible to ensuring the requirements above by a structure built around a microcontroller ATmega8 product type ATMEL [13].

Ensuring the requirements above is possible using two modules: power supply module and control module (Fig. 1).

The energy from the photovoltaic (PV) panel or from another power source is taken from a constant current source. Then it follows a voltage source. In this way it is controlled the charge current and battery voltage in the circuit.

A switching source with high efficiency (92%) allows obtaining supply voltage of control module developed around a microcontroller.

Detailed status of the installation is presented through a seven-segment display and a global signalling is possible via two LEDs.

The DC motor that acts barrier is controlled via an amplifying circuit.

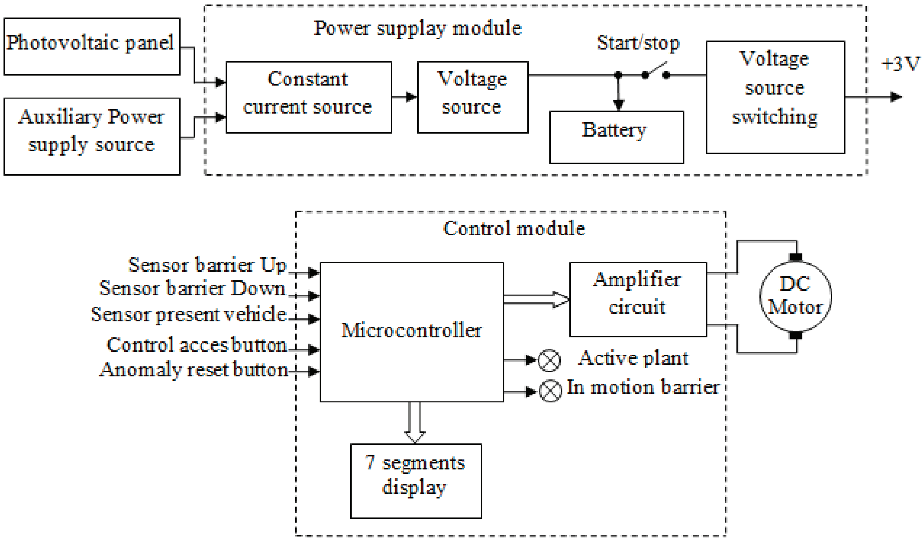

Fig. 1. Block diagram of ˝automatic barrier˝ model.

III. DESING OF AUTOMATIC SYSTEM

A. *Design of Hardware Part*

The design of electronic schemes was performed using the program Orcad 9.1, Capture module [14].

In the power supply module (Fig. 2), the diodes D4 and D5 mix the two power supplies: a PV panel and an auxiliary power source. Value of R2 = 10 Ohms allows battery charging at a current of 1, 25 / 10 = 0,125 = 125 mA. Neglecting the voltage drop across D2 then the voltage across the battery is determined by the resistors R1 and R3. To obtain the values in the figure (to J2 connector):

$$U_{batt.} = 1{,}25 \cdot \left(1 + \frac{R3}{R1}\right) = 1{,}25 \cdot \left(1 + \frac{660}{120}\right) = 8{,}125\text{V} \quad (1)$$

The J2 connector is coupled to the battery. It consists of two cells in series type SAMSUNG ICR18650-22E. The nominal voltage of such cells is 3.7 V (2,75V minimum, maximum 4,2V). The corresponding maximum voltage the two cells is 4.2 * 2 = 8,4V. It chose to limit the voltage Uac = 8,125V.

The LTC1474 circuit is powered from the battery circuit and is capable of providing an output voltage of 3 V at a yield of about 92% (Fig. 3). The battery capacity (mAh 2200 for a cell) and a good yield of the switching source cause increased autonomy of the installation.

For R4 and R5 resistors,

$$R4 = 2 \cdot 390\,\text{k}\Omega = 780\,\text{k}\Omega \quad (2)$$

$$R5 = 820\,\text{k}\Omega + 330\,\text{k}\Omega = 1150\,\text{k}\Omega \quad (3)$$

obtain the output voltage (to J4 connector):

$$U_{out} = 1{,}23 \cdot \left(1 + \frac{R5}{R4}\right) = 1{,}23 \cdot \left(1 + \frac{1150}{780}\right) = 3{,}043\text{V} \quad (4)$$

The voltage blocking of the switching source to protect the battery (U_{In}) is given by resistances R7 and R9.

$$R7 = 1500\,\text{k}\Omega + 470\,\text{k}\Omega = 1970\,\text{k}\Omega \quad (5)$$

$$R9 = 390\,\text{k}\Omega + 120\,\text{k}\Omega = 510\,\text{k}\Omega \quad (6)$$

with the formula:

$$U_{trip} = U_{In} = 1{,}23 \cdot \left(1 + \frac{R7}{R9}\right) = 5{,}98\text{V} \quad (7)$$
$$> 2 \cdot 2{,}75 = 5{,}5\text{V}$$

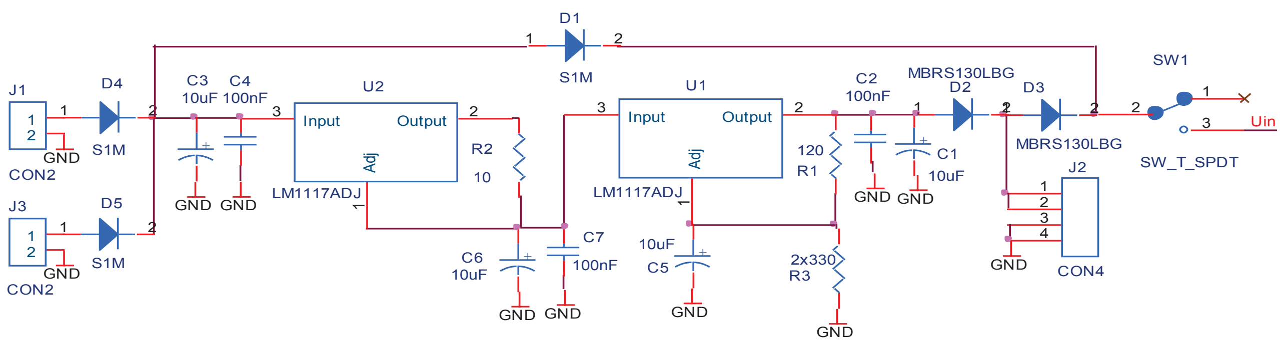

Fig. 2. Wiring diagram of the power supply module – voltage source and current source.

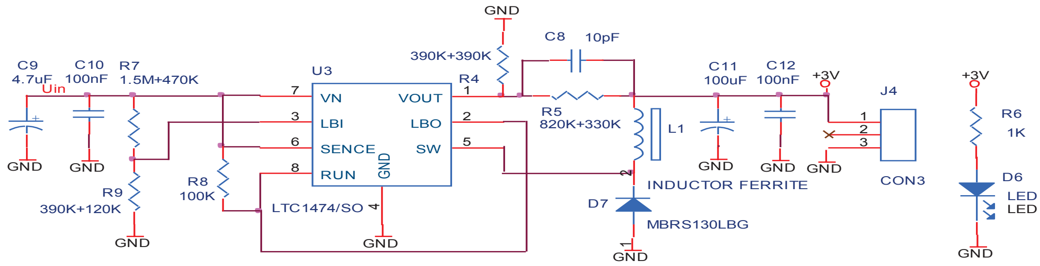

Fig. 3. Wiring diagram of the power supply module - switching source.

The control module (Fig. 4, 5) contains, in addition to the circuit U2 - ATmega8, a connector of programming (J2), a cell display with seven segments (U1), a connector allocated to DC motor (J1), two LED signaling D9 and D10 and an amplifying circuit composed of transistors Q1, Q2, Q3 and Q4.

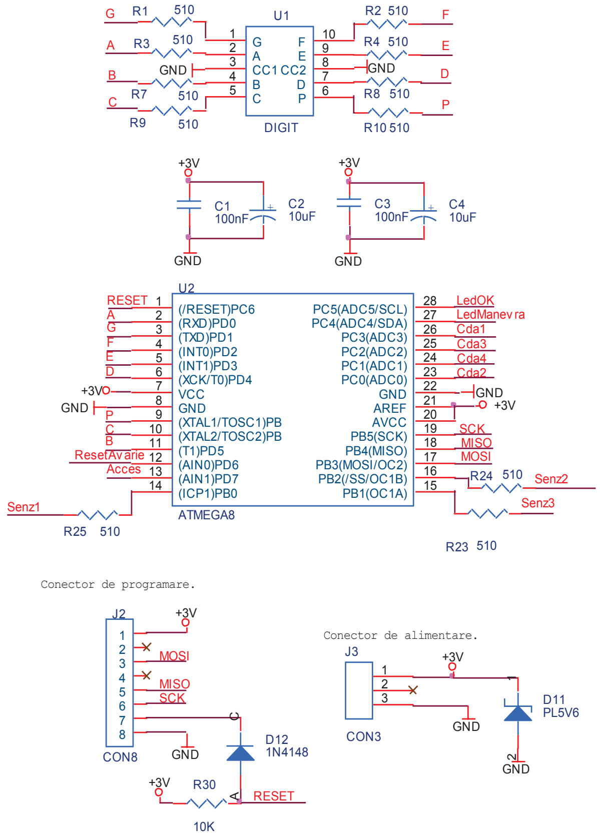

Fig. 4. Wiring diagram of the control module– part with microcontroller.

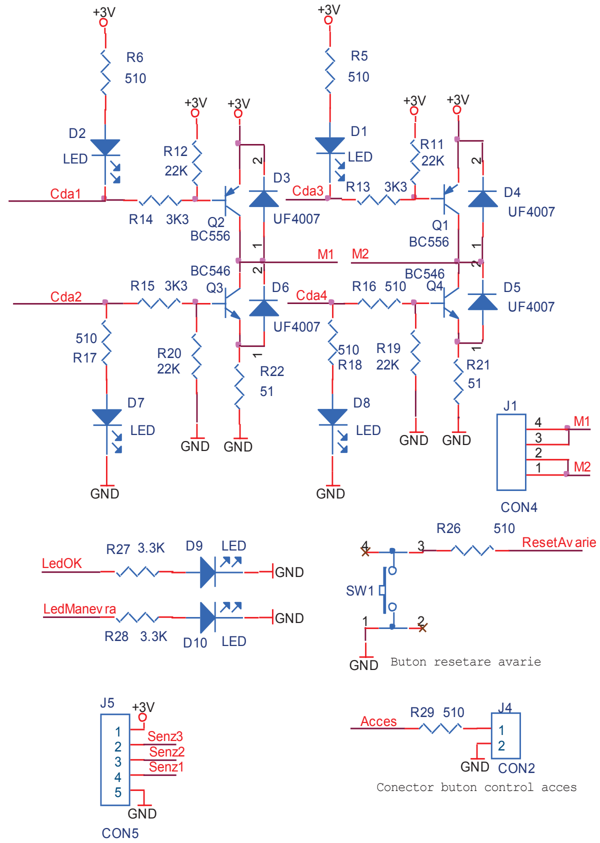

Fig. 5. Wiring diagram of the control module – part with amplifying circuit

The conduction state of the four transistors is indicated by LEDs D1, D2, D7 and D8. J5 connector provides the interface between the control module and sensors in the system. For "barrier up" and " barrier down" is using two reed sensors [6] commanded by a magnet jointly with barrier.

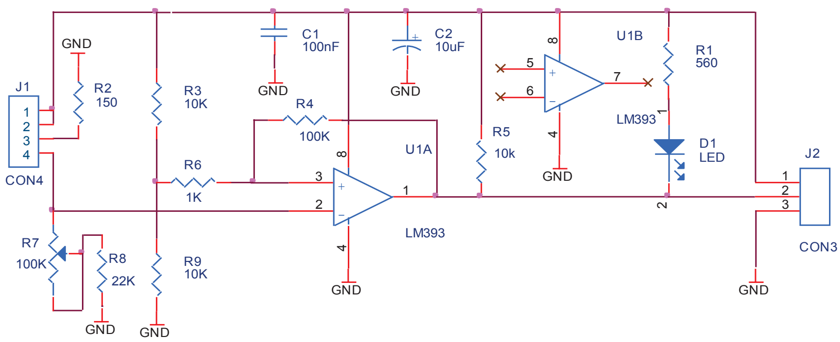

Fig. 6. Wiring diagram of the present car sensor.

Sensor "present car" (Figure 6) contain a type LM393 comparator. At J1 pins 2-3 there is connected an infrared (IR) LED emission and at pins 1 and 4 there is connected an IR receiver. Resistor R7 adjusts threshold of detection the light beam.

B. Design of Software Part

The general structure of software for microcontroller is shown in Figure 7.

The program starts with microcontroller initialization and variables used [2],[3]. Implementation of various timings is possible by using a sequence of decrement of all counters used. Then follows purchase of five digital signals, execution of algorithm, then transmitting the synthesized commands.

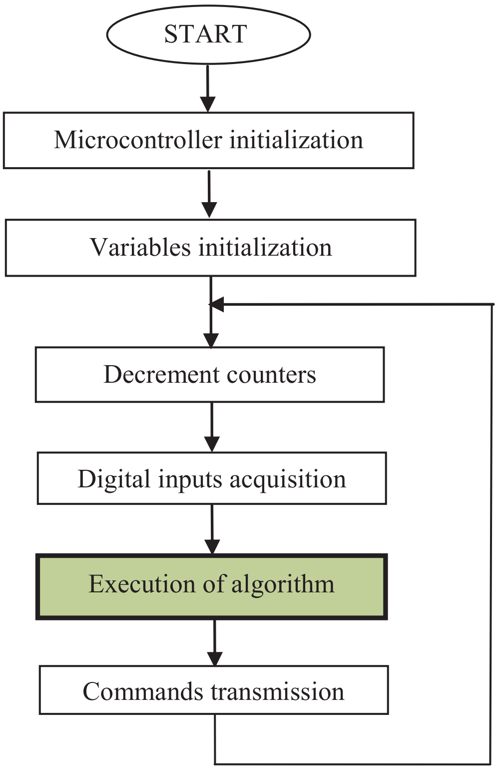

Fig. 7. Flow diagram of microcontroller program.

Program operation is based on a tact generated with a timer 0. The interrupt is generated at every 10 ms, which determines setting of variable "Tact" (fig. 8).

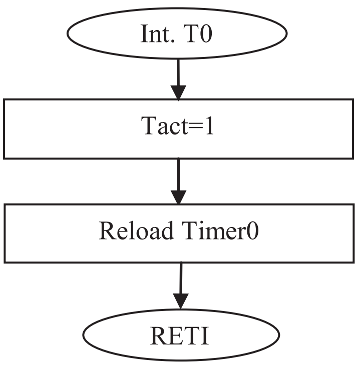

Fig. 8. Flow diagram of timer 0.

Chart of Figure 9 captures the decremental routine for three work counters: "Counter", "CounterLedOK" and "CounterLedManevra".

This method allows working with hundreds of independent counters.

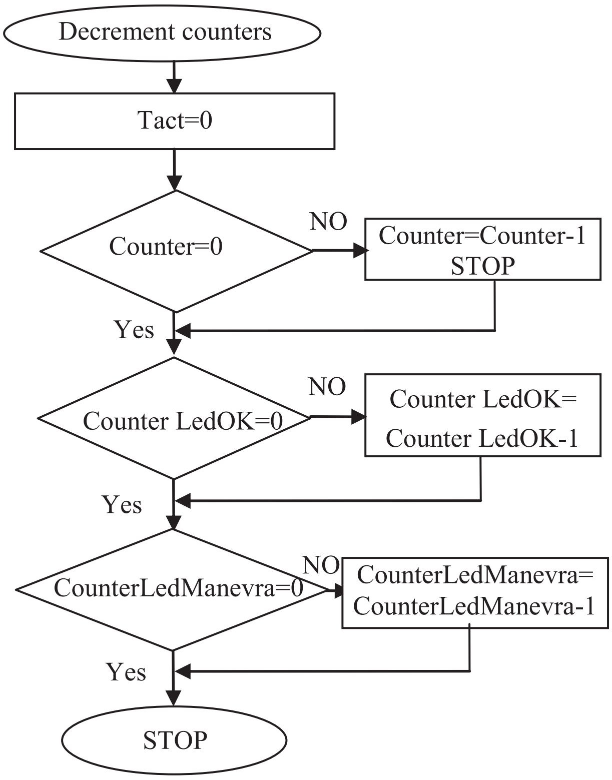

Fig. 9. Flow diagram of routine for counters decrement.

The proper algorithm includes six distinct states encoded by variable "CounterState" (Fig. 10).

The 6 states have the following meaning:

- State 0- Barrier rest, waiting command;
- State 1- Barrier in course of erection;
- State 2-Barrier up, braked a countercurrent;
- State 3-Barrier up, the rest;
- State 4-Barrier being lowering;
- State 5- Barrier down, braked a countercurrent.

The program remains in the state "0" until activation of the "Access" signal. Immediately it is given the command to lift the barrier. This sequence ends with activation of the "Barrier Up" signal.

In order to avoid moving the barrier of inertia for about 0,4 sec. there is activated a countercurrent braking mode. After this sequence the system enters a delay of 6 seconds.

The descent begins only if the infrared beam is not interrupted. Its disruption in the sequence lowering or braking downhill has the effect of automatically switching to state 1 (lifting barrier). After termination of the braking mode (CounterState = 5) it returns to "0" state.

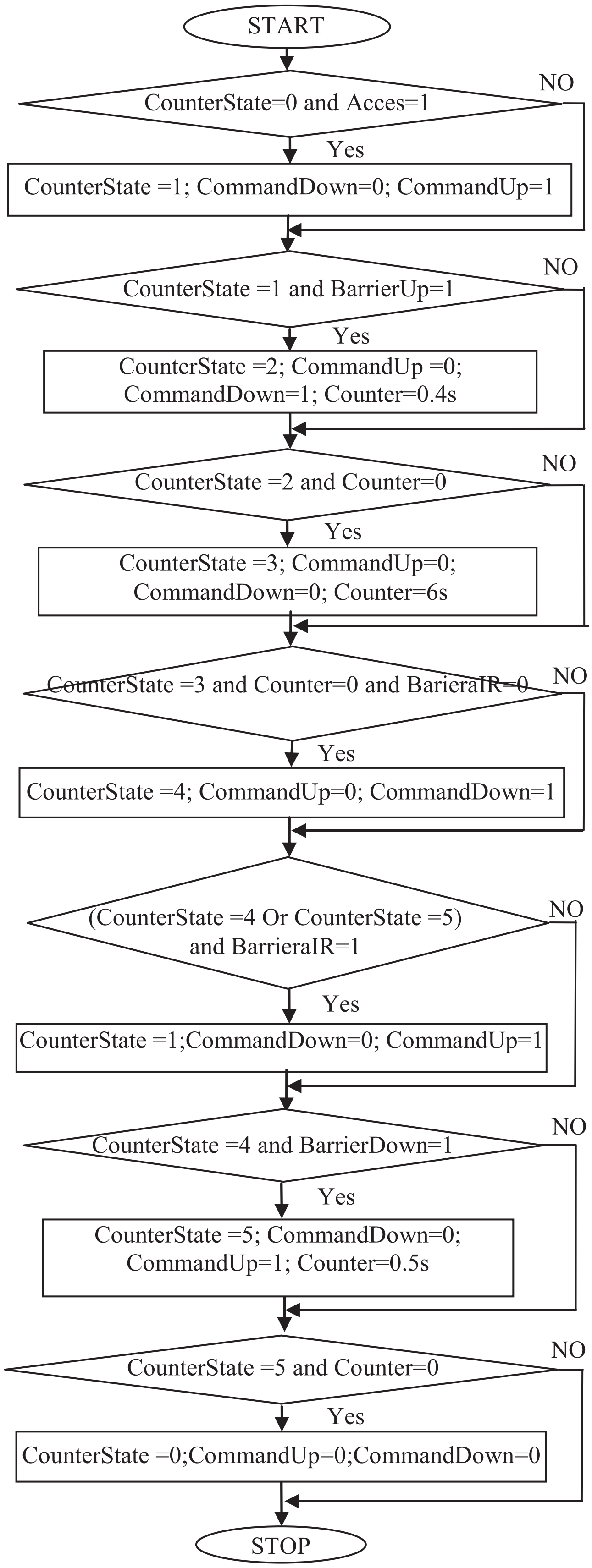

Fig. 10. Flow diagram of proper algorithm – normal operation mode.

Also in the proper algorithm it is part of an operation sequence for detection of possible anomaly (Fig. 11). Thus, while the "CommandUp = 1" or "CommandDown = 1" more than 9 sec., it means that there appeared at least an anomaly in the motor operation.

The system passes into a state (CounterState = 6), which, for the reset involves pressing the button "ResetAnomaly".

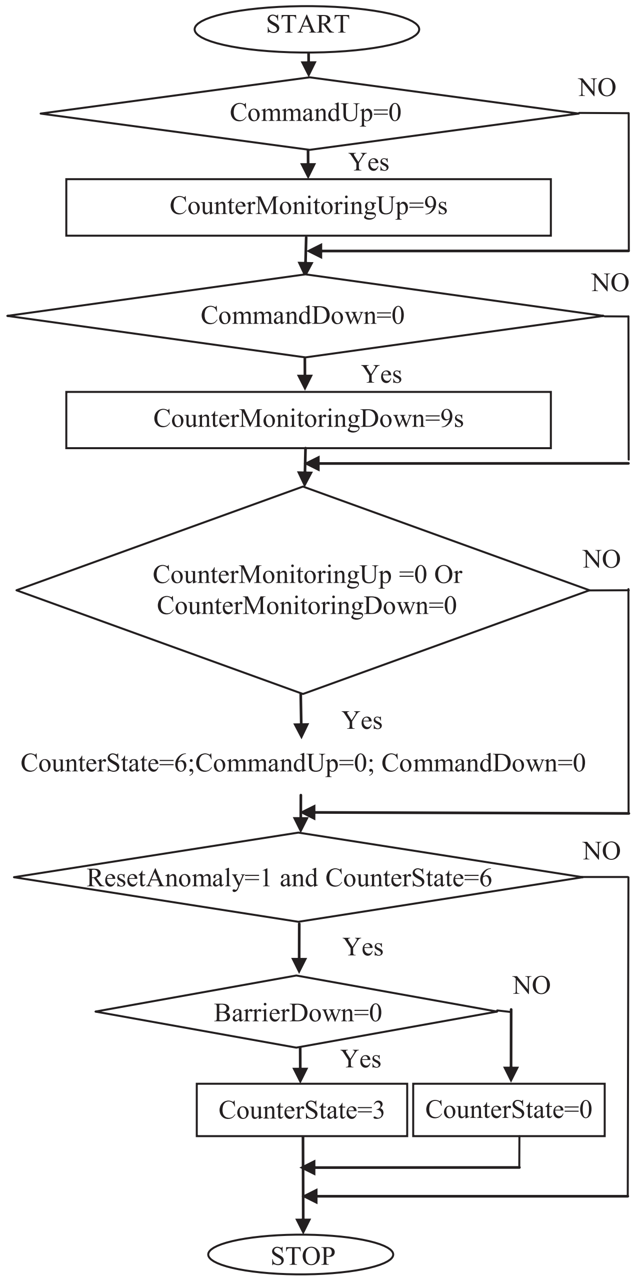

Fig. 11. Flow diagram of proper algorithm– anomaly processing.

The microcontroller program, which provides automatic control of the barrier, was written in high level language C, because it is easier to understand and maintain [4], [5] [7].

The code for the microcontroller used was written using the software package StudioAVR4 [12].

IV. Achievement And Testing Of Automatic Model

A. *Achievement of Automatic Model*

After designing of electronic schemes there were performed printed wiring boards using the program Orcad 9.1, Layout module [14] and electronic components were assembled. It began the assembly with passive circuit elements and they ended with the active components.

Components of the "automatic barrier" model are explained in Figure 12.

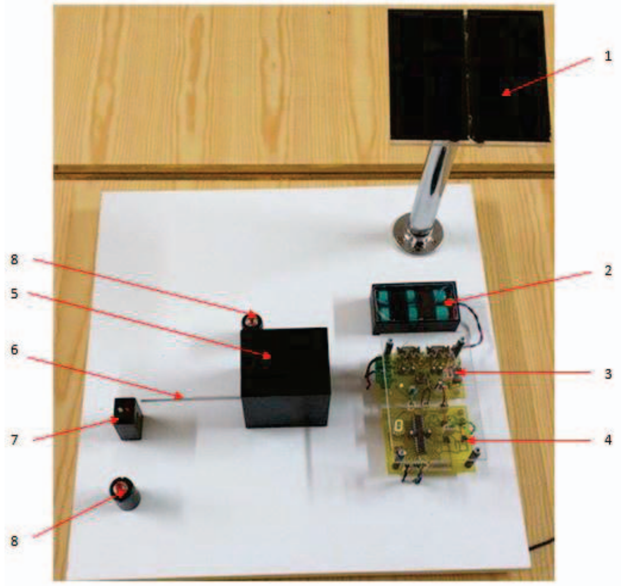

Fig. 12. Experimental model of ″automatic barrier″: 1-PV panel; 2-batery; 3-power supply module; 4-module with microcontroller; 5-module of barrier drive; 6-barrier; 7- infrared detector module and LED signalling; 8- access buttons.

B. *Experiments Regarding to Automation Part*

Experimentation actually consists of correct working verification according to the protocol and conditions imposed by design.

In figures 13 ... 18 there are captured the 6 operating states in a work cycle lifting-lowering of barrier. These states were predefined in the design stage of automatic vehicle access system for the purpose of verification and easier debugging of system.

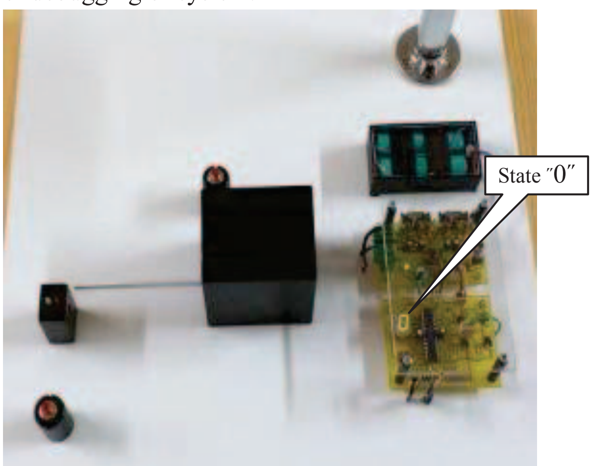

Fig. 13. Testing of model: State 0- Barrier at rest, waiting command.

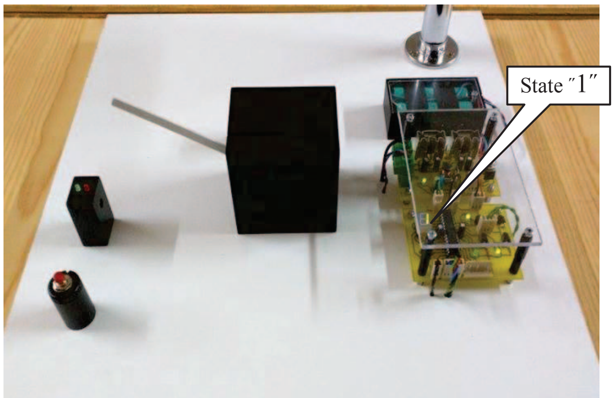

Fig. 14. Testing of model: State 1- Barrier in course of rise.

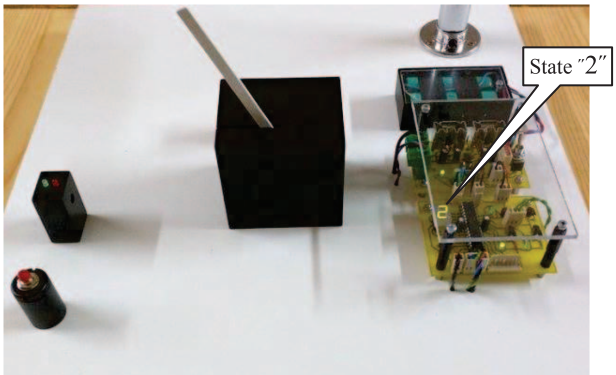

Fig. 15. Testing of model: State 2- Barrier up, braked a countercurrent..

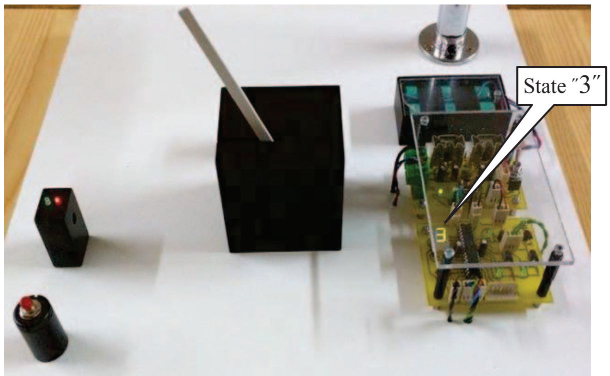

Fig. 16. Testing of model: State 3- Barrier up, the rest.

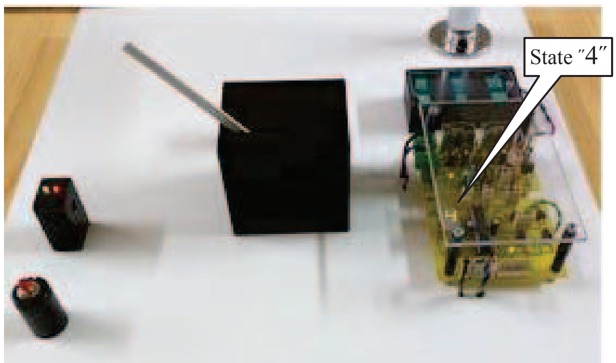

Fig. 17. Testing of model: State 4- Barrier being lowering.

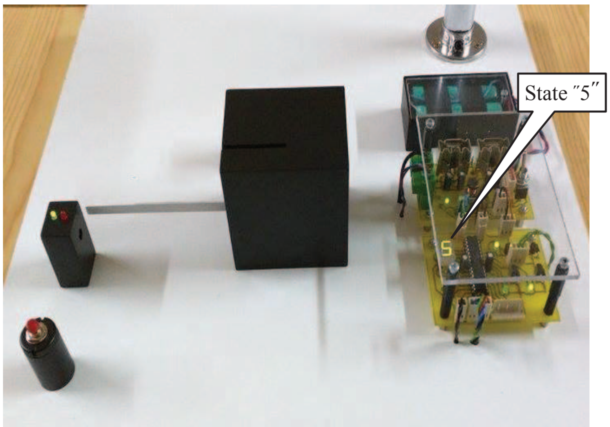

Fig. 18. Testing of model: State 5- Barrier down, braked a countercurrent

For automatic operation of the barrier was opted for the use of distinct states of operation for programming and debugging easier.

C. Experiments Regarding to Power Supply from Photovoltaic Panel

The purpose of the experimental determinations is to visualize the measured values of the PV panel voltage and auxiliary power supply source both at without load operation, and the operation of a work cycle up-down of barrier.

The structure of the experimental equipment for the measurement of voltage is depicted in Figure 19.

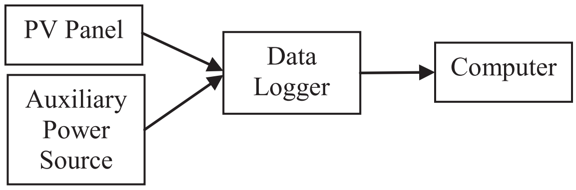

Fig. 19. Structure of experimental equipment.

In the first stage was recorded [10] the voltage supplied from two sources (PV panel and auxiliary power supply) at no load functioning. The experimental result is shown in Figure 20.

In the first moment both sources are connected. The voltage is 12V for two sources. The voltage is sufficient for charging a battery, having a nominal voltage 9V.

After 20 sec. PV panel was covered. Observe that the voltage supplied to it drops to zero. The voltage of PV panel returns to 12V after it is discovered (t = 1min, 10sec.).

In the next stage was recorded evolution of PV panel voltage (Fig. 21) during two cycle of operation of the barrier.

In Figure 21 are marked some states of the first cycle of operation, as follows:

1 - State 1- Barrier in course of rise

2 - State 2- Barrier up, braked a countercurrent

3 - State 4- Barrier being lowering

4 - State 5- Barrier down, braked a countercurrent

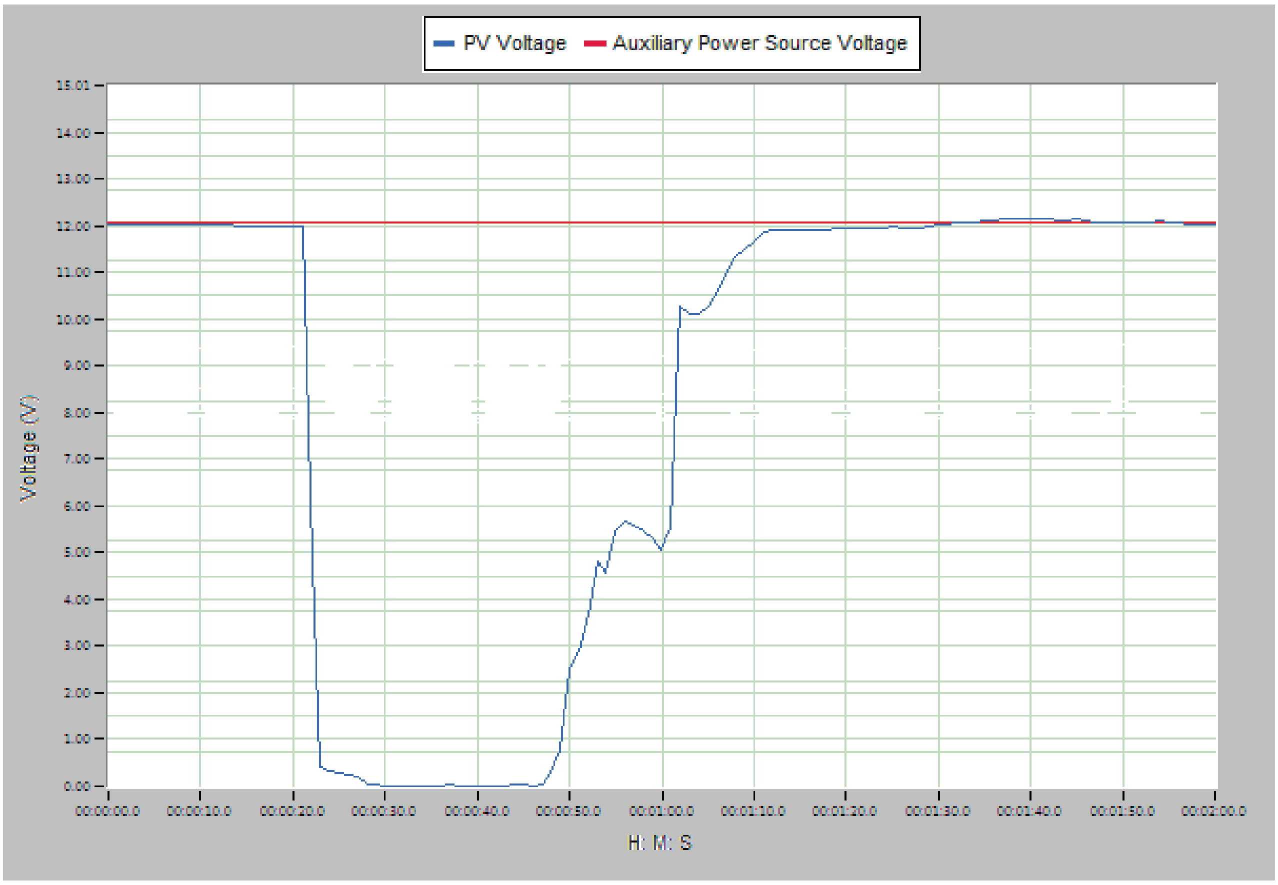

Fig. 20. Voltage of power supply sources without load.

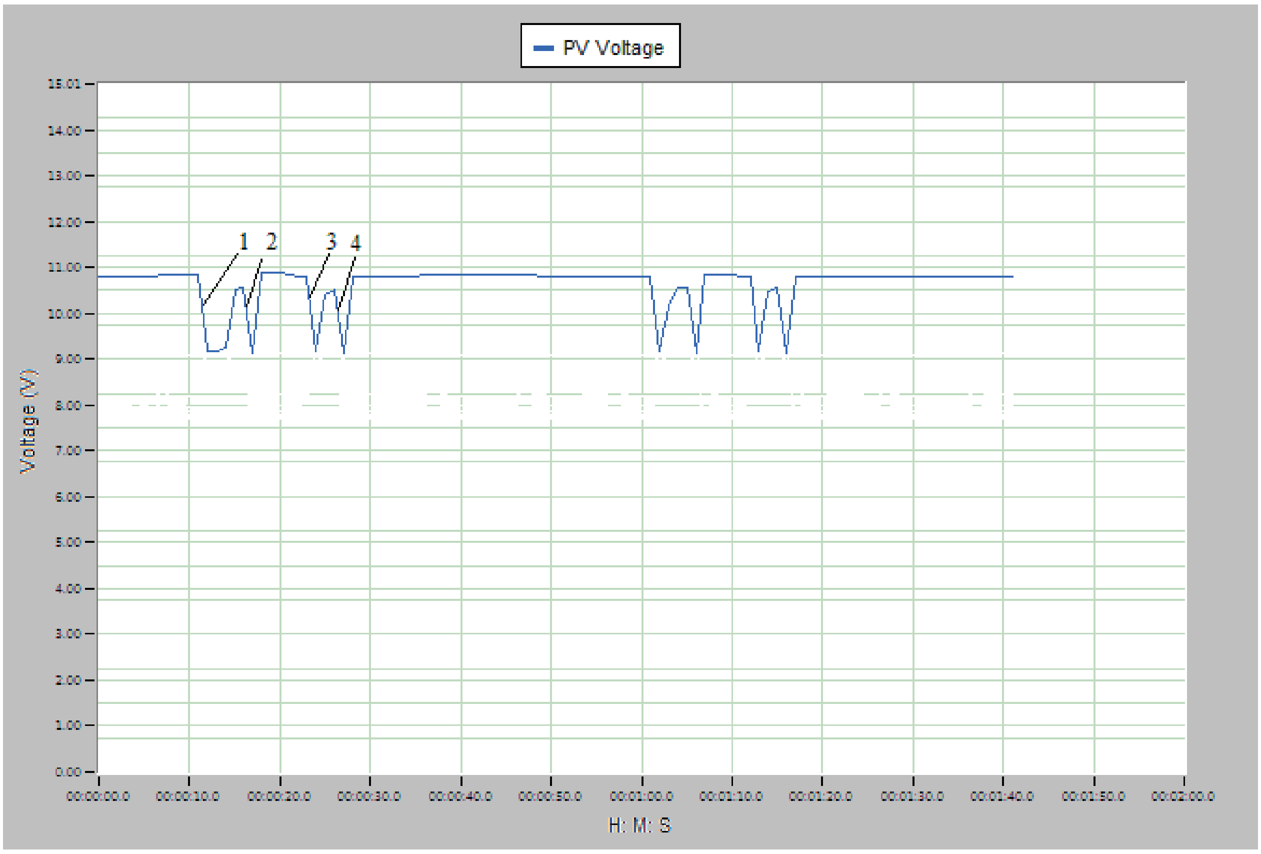

Fig. 21. Evolution of PV panel voltage at two work cycle up-down of barrier.

V. Conclusion

The paper presented an automatic access system powered by photovoltaic panels, achieved small scale as an experimental model.

The solution of using two power sources for supply vehicle access system from PV panels or other sources represents an innovative solution for efficient energy use.

Experimental results show a smooth functioning of experimental automatic access system powered by PV panel and can be successfully expanded at real scale.

Received on July 17, 2016
Editorial Approval on November 15, 2016

References

[1] L. Alboteanu, Gh. Manoea, and Al. Novac, “Automtion o a pumping station for alow power applictions”, “Hidraulica”-Magazine of Hydraulics, Pneumatics, Tribology, Ecology, Sensorics, Mechatronics no. 1/2014, ISSN 1453 – 7303, pp.58-64.

[2] L. Alboteanu, F. Ocoleanu, Al. Novac, Gh. Manolea, “Remote monitoring system of the temperature of detachable contacts from electric cells” Annals of the University of Craiova, Electrical Engineering series, No. 34, 2010; ISSN 1842-4805.

[3] L. Alboteanu, F. Ravigan, Al. Novac, “Design of a Sun Tracking Automaton for Photovoltaic Panels with Low Concentration of Solar Radiation,” Procc. of International Conference on Applied and Theoretical Electricity (ICATE), 2014, pp. 1-5, Craiova, Romania.

[4] Ch. Cullens, “Use of Visual C++”, Teora Publisher, 1996.

[5] M. Marzband, A. Sumper, M. Chindris, and B. Tomoioaga, “Energy management system of hybrid microgrid with energy storage”, Buletinul AGIR, nr. 3/2012, pp. 635-642.

[6] W. Nawrocki, “Measurement Systems and Sensors”, London, ARTECH HOUSE, 2005.

[7] A.M. Simionescu, "Modular system for acquisition, monitoring and processing electrical parameters of a distribution network," Buletinul AGIR, ISSN: 1224-7928, vol. 3, 2012, pp. 69-74.

[8] C. Şulea, Gh. Manolea, ″The hardware structure of the monitoring system for the Romanian anti-hail rockets launch units”; Annals of the University of Craiova, Electrical Series, Ed. Universitaria, ISSN: 1842-4805, Craiova, Romania, No. 36, 2012, pp. 339-244.

[9] C. Şulea-Iorgulescu, E. Petre, ″Specialized device – Slave – for monitoring the antihail systems″, Published in: System Theory, Control and Computing (ICSTCC), 2015, IEEE, DOI: 10.1109/ICSTCC.2015.7321371

[10] Toma L., “Acquisition systems and digital signal processing, . “Vest” Publsher , Timişoara, 1996.

[11] C. Zoller, R. Dobra, “Microcontroller Implementation In The Electrical Networks For The Hazardous Areas”, microCAD 2008, International Scientific Conference, University of Miskolc, Hungary, 2008.

[12] *** http://www.atmel.com/Microsite/atmel-studio/

[13] *** Atmega8 User datasheet.

[14] *** www.orcad.com , Orcad software.

[15] *** http://cwbsolutions.net/parking-and-access-control