



DEVELOPMENT OF FUZZY SYSTEM MANAGEMENT FOR SOLAR PANEL MOTION USING AN ARDUINO MICROCONTROLLER

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Abstract

In this paper, the design of a system for the control of a solar panel motion by means of a servomotor based on an Arduino board is described. The system calculates optimum tracks and position of the sun to ensure that the solar panel is always directed to the sun in order to increase the amount of energy generated by the solar panel. The device makes use of four solar modules for detection and a servomotor to automatically rotate the solar panel to adjust it to the sun position.

Keywords: fuzzy system, motion servo, Arduino board, heterojunctions

Rezumat

În acest articol, vă prezentăm un sistem de dirijare pe placa Arduino, pentru servomotorul de mișcare a panoului solar, sistem de calculare a poziției optime a soarelui pentru a crește cantitatea de energie generată de panoul solar (deoarece va fi mereu cu fața la lumină). În acest dispozitiv sunt folosite patru module solare pentru detectare și un servomotor pentru a roti automat panoul solar în direcția luminii solare.

Cuvinte cheie: system fuzzy, servomotor, placă Arduino, heterojuncții

1. Introduction

The development of control systems provides a high efficiency of automatization and a continuous improvement of this process and relevant equipment, methods, means, etc. To provide the operation of a control system in accordance with all requirements, it is necessary to take into account the existing scientific achievements and solutions.

In the electric power industry, solar energy and methods for obtaining it have a significant research and technological application. The objective is to increase the efficiency due to new

materials and a more complex technological structure of solar power plants. For the most efficient conversion of solar energy into electrical energy, it is necessary to use solar tracking systems, which are referred to as "solar trackers." The number of possible options for the execution of trackers and their management is extremely large. However, stable operation will require an automated system capable of analyzing the current state of equipment and the environment state.

A controller (microcontroller) with a sense system can be used as equipment for tracking the solar position; this controller makes it possible to set optimum parameters and fully control the entire system operation process. The relevance of this research is confirmed by the widespread use of alternative energy sources.

In this project, solar panels will act as light sensors. Once solar light falls on the sensor, the current generated by the sensor increases. Solar cells based on CdS/CdTe heterojunctions designed and developed in the Laboratory for Nanotechnologies of Ghitu Institute of Electronic Engineering and Nanotechnologies are used as the sensors.

2. Characterization of CdS/CdTe Heterojunctions

The photovoltaic properties of solar cells based on CdS/CdTe heterojunctions largely depend on the CdTe deposition rate. In the high-vacuum evaporation (HVE) process, saturated source vapors are delivered to the space above the substrate, which makes it possible to maintain a lower substrate temperature than that provided by the remote stress method (close spaced sublimation (CSS)) and results in high processes and scalable processes. It is characterized by a higher deposition rate (CSS) and a better film quality [2]. It is also possible to control the substrate temperature regardless of the deposition rate. In this paper, we report the crystallinity and properties of a CdT polycrystalline film prepared by the HVE method [1].

The set of properties of the thin polycrystalline absorption layer of CdTe depends on the deposition and doping processes that are closely related to the composition and structure of the film. Raman spectroscopy is used to characterize the general photon carrier of radiative recombination in CdTe. Raman spectroscopy of a CdT thin film can reveal radiative states due to various impurities and provide the understanding of their role in the performance of solar cells [2].

The interface states of a binary structure based on thin layers of semiconductors significantly depend on the technological methods used to prepare them. These conditions affect both the electrophysical parameters and the transport mechanism of the charge carriers. Currently, a number of stringent requirements are imposed on the thin layer preparation methods; they include purity of the material, high crystallinity of thin layers, temperatures of growth/formation of structures in thin layers, control of the starting material, and doping, if necessary, to obtain high-quality layers or structures with satisfactory electrophysical properties.

Based on the above description, the quasi-closed volume method was used to obtain thin binary CdS and CdTe layers on 22×22 mm glass supports preventively covered with a transparent and conductive SnO₂ layer. The temperature of the evaporator for CdS is about 540–550°C with the overflow temperature of 310°C, while the temperature of the source for CdTe has a value of 520–530°C, and the temperature of the support is 310–315°C. The optical transparency of CdS layers is approximately 82%; the resistivity is 105 Ω cm; and the thickness is 0.5–1 μm. The estimated load-bearing concentration is 1016 cm⁻³. The CdTe layer deposited

by this method has a thickness of 1–1.5 μm and a resistivity of 107–108 $\Omega\text{ cm}$. To sensitize the CdTe layers (chemical treatment and heat treatment) the sensitization with a $\text{CdCl}_2:\text{CH}_3\text{OH}$ solution at a temperature of 390–400°C for 3–50 min was used. The study of the morphology of the CdS/CdTe structure showed that the structure is planar. The layers do not have a homogeneous structure with respect to thickness, and the interface between the CdS and CdTe layers shows a contoured line, where the interdiffusion between the components of the structure takes place [3].

3. Circuits

In our project, four batteries (cells) will be placed in the center of the solar panel and a servo motor will be used to rotate the solar panel. The servo will rotate the solar panel in the direction of the battery with the lower current, which will mean that more sunlight is falling on it. If all batteries are exposed to the same amount of sunlight, the servo will not rotate the solar panel. That is, the servomotor will try to rotate the solar panel so that center cells have approximately the same current, which will mean that they receive approximately the same amount of sunlight. If the current of one photosensor becomes less than the current of the other, then the servo motor will rotate the solar panel until the current of center batteries (cells) balanced.

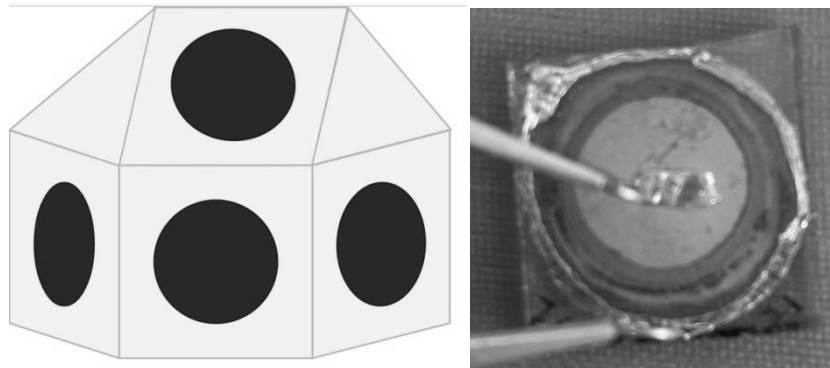


Fig. 1. Cell circuit [3].

The accumulation of the generated energy data in the database is carried out using an Arduino mega2560 microcontroller [1], which has the following characteristics:

- Microcontroller: ATmega2560
- Working voltage: 5V
- Input voltage (recommended): 7–12V
- Input voltage (limit): 6–20V
- Digital I/O Pins: 54 (of which 14 can function as PWM outputs)
- Analog Inputs: 16
- DC current through input/output: 40 mA

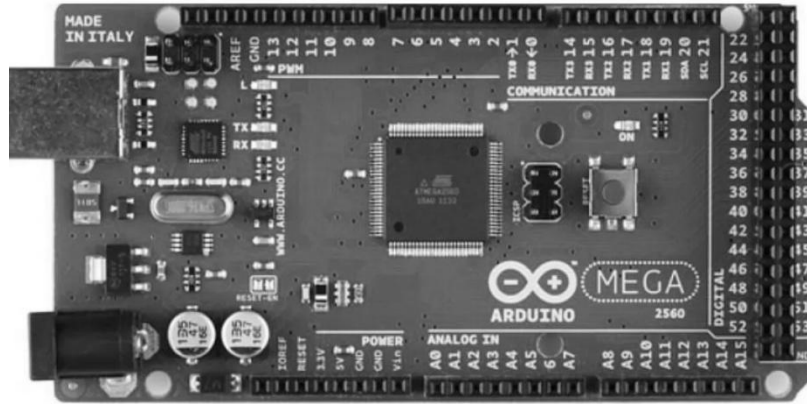


Fig. 2. Arduino mega2560 [4].

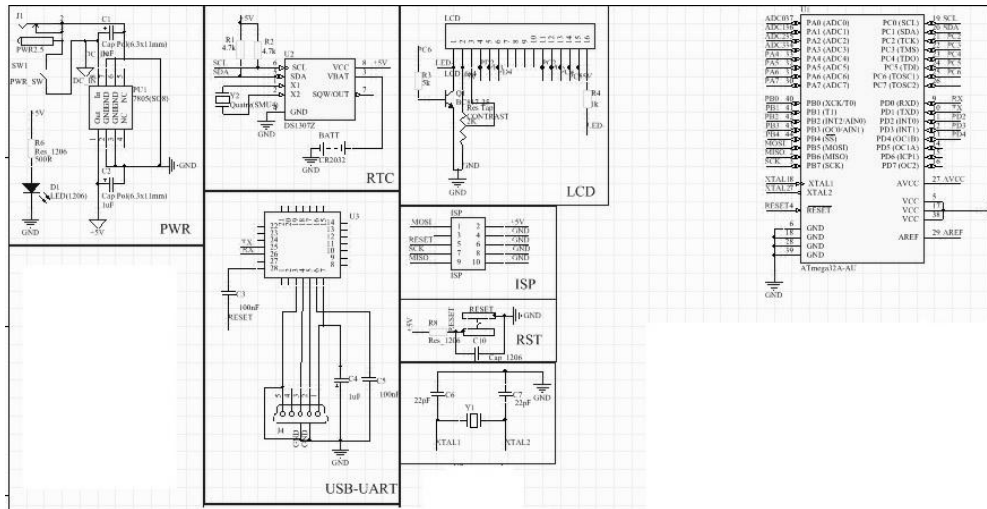


Fig. 3. Control module scheme [5, 6].

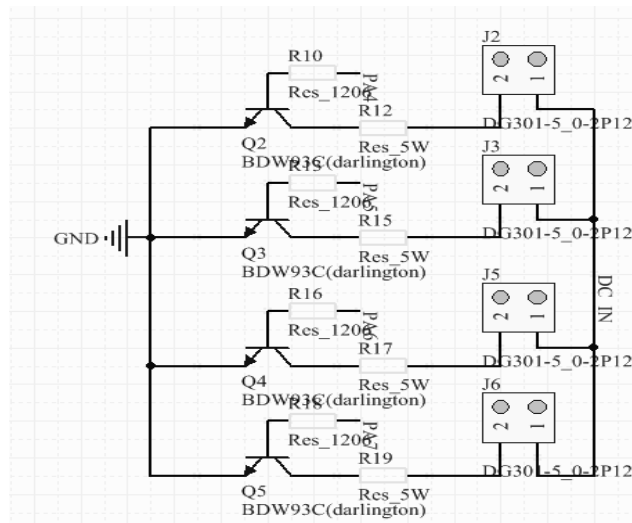


Fig. 4. Module power scheme [5, 6].

4. Fuzzy Logic Algorithm and Control

Control of servomotor elements is divided in four zones. The fuzzy control algorithm for the new device consists in the modification of input variables “Measured current” on each of the four batteries [7].

1. Measured Current battery one.
2. Measured Current battery two
3. Measured Current battery three
4. Measured Current battery four

Rules for one zone are as follows:

1. *If Current N1 = low, then I(servomotor)= high*
2. *If Current N1 = medium, then I(servomotor)= medium*
3. *If Current N1 = high, then I(servomotor)=0*
4. *If Current N2 = low, then I(servomotor)= high*
5. *If Current N2 = medium, then I(servomotor)= medium*
6. *If Current N2 = high, then I(servomotor)=0*
7. *If Current N3 = low, then I(servomotor)= high*
8. *If Current N3 = medium, then I(servomotor)= medium*
9. *If Current N3 = high, then I(servomotor)=0*
10. *If Current N4 = low, then I(servomotor)= high*
11. *If Current N4 = medium, then I(servomotor)= medium*
12. *If Current N4 = high, then I(servomotor)=0*

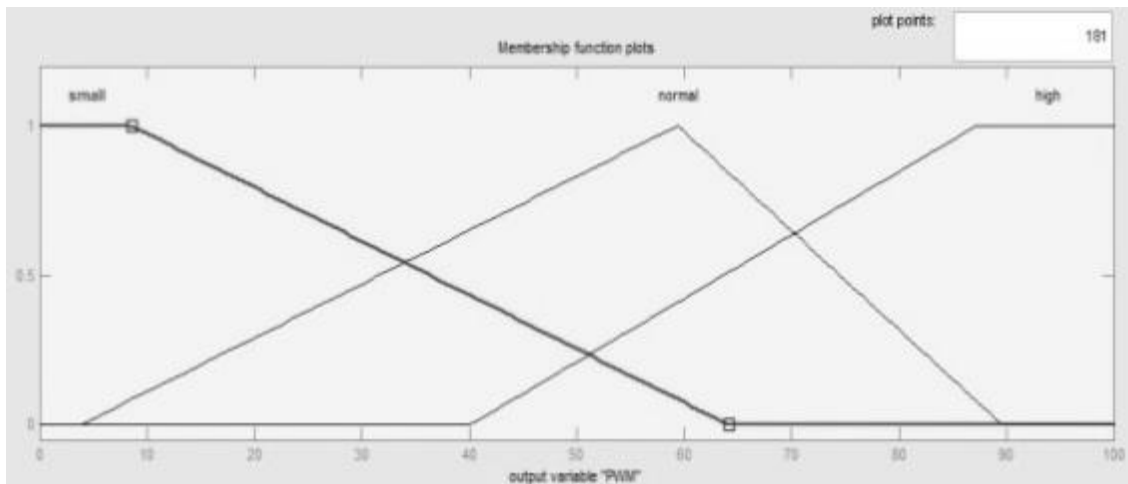


Fig. 5. Output variable “Measure Current servo motor.”

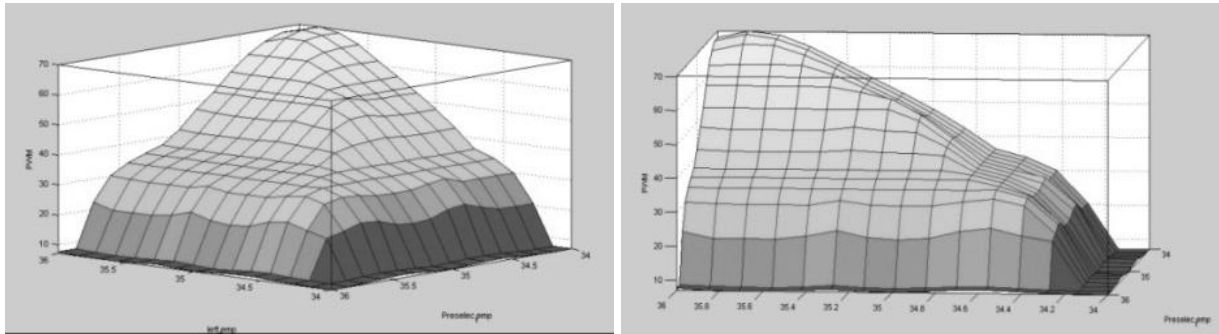


Fig. 6. Input/output function of the fuzzy controller after trimming the input and output membership functions [8].

4. Conclusions

A device to control a solar battery motion system has been proposed and designed. Solar cells based on CdS/CdTe heterojunctions designed and developed in the Laboratory for Nanotechnologies of Ghitu Institute of Electronic Engineering and Nanotechnologies have been used as the sensors.

The solar cells have been prepared of available materials. The preparation does not require precision mechanical work and skilled specialists. The use of fuzzy logic control enables the construction of flexible algorithms. In addition, fuzzy linguistic variables and simple expressions describing the membership functions are well understood.

The behavior of the control system for a solar battery system has been simulated under Matlab. An example of output membership functions and the control surface is shown in Figs. 5 and 6 (simulation in Matlab).

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