TRU-SSS-EEEA-04

ARDUINO BASED MODULE FOR MONITORING EFFICIENCY OF PV PANEL

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Abstract: *Solar energy is very popular renewable energy source. Photovoltaic panels are necessary, to improve the efficiency of the panels are used maximum power point tracking (MPPT) methods. In this paper is made suggestion for a MPPT controller on the platform Arduino. The controller uses the P&O algorithm. The controller have the ability to write data to an sd card, display current time. The data that is written is used for analysis, for creating graphics.*

Keywords: *MPPT, Arduino, P&O, data collection*

Introduction

Solar energy is growing in popularity as a clean energy source (Mustapha Elyaqouti, Safa Hakim, Sadik Farhat, Lahoussine Bouhouch, Ahmed Ihlal, 2017). Renewable energy is alternative to fossil base fuels (M. K. D. Ulaganathan, C. Saravana, Olivia Ramya Chitranjan 2014). The most popular source are wind, water, solar power. Solar is easy to be converted to electrical power via a photovoltaic panel (PV) (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015). PV modules have maximum power point (MPP). In order to use the maximum of the panel is necessary to implement method for maximum power point tracking (MPPT) (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015). Basic MPPT graph is shown on fig.1.

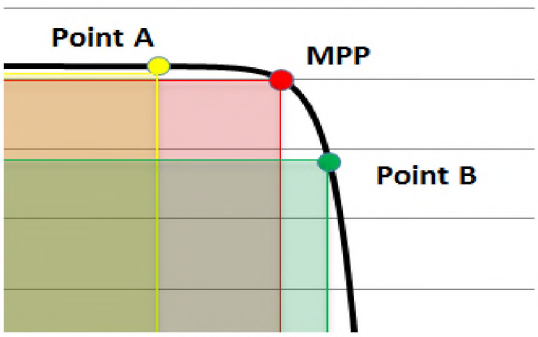

Fig.1 MPPT

[1] Докладът е представен на студентската научна сесия на 09.05.2019 г. в секция ЕЕА с оригинално заглавие на български език: АРДУИНО БАЗИРАН МОДУЛ ЗА МОНИТОРИНГ НА ЕФЕКТИВНОСТТА НА PV ПАНЕЛ.

The most used methods for MPPT can be classified as direct and indirect (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015). Indirect methods are short-circuit, open-voltage. This methods require in-depth knowledge of the characteristics of the PV array. And that they are not very popular (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015).

Direct methods are Perturbation and Observation (P&O), Incremental Conductance (Inc Cond). This methods don't require knowledge about the panel. That makes them appropriate for different panels.

Perturbation and Observation (P&O)

The algorithm works by perturbing the operating voltage observing and observing the power variation in order to detect the direction of change. (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015), (M. K. D. Ulaganathan, C. Saravana, Olivia Ramya Chitranjan , 2014) The resold is increase or decrease of the output voltage whit it and the output power. This method is simple and easy to implement.

Incremental Conductance (Inc Cond)

This method works by searching for the voltage operating point at which the conductance is equal to the incremental conductance (Saleh Elkelani Babaa, Matthew Armstrong, Volker Pickert, 2014). That is when the system stop perturbing the operating point. This method has the following advantages faster respond in change in light intensity, less oscillation around PPM.

The algorithm of MPPT is part of the controller, which is part of a PV system. A typical PV system consists of: PV module which generates electric energy from solar energy; DC-DC converter to transfer the maximum power according to the load requirements; MPPT controller that generates the maximum power from the PV with the help of DC-DC converter; Electric Load.

In this paper is for the base of the controller is used Arduino Uno.

Exposition

The ***P&O algorithm*** operate by periodically perturbs the operating voltage point of the system and observes the change in power in order to determines the direction of the change to give to the Vref. If the perturb of operating point in any direction leads to increase of the power drawn from the PV that means the operating point is moved toward the MPP and must be continue moving in the same direction. Otherwise if the power decrease this means the operating point is moved away from the MPP and change in the direction is necessary to be reached the MPP (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015).

Incremental Conductance. This algorithm works by searching for the voltage operating point at which the conductance is equal to the incremental conductance. At this point, the system stops perturbing the operating point. The advantage of this algorithm is that it has the ability to ascertain the relative "distance" to the maximum power point (MPP), therefore it can determine when the MPP has been reached. Also, it is capable of tracking the MPP more precisely in highly variable weather conditions, and exhibits less oscillatory behaviour around the MPP compared to the P&O method, even when the P&O method is optimized (Saleh Elkelani Babaa, Matthew Armstrong, Volker Pickert, 2014).

This method is based on the fact that the slope of the PV array power versus voltage curve is zero at MPP. It was proposed to improve the tracking accuracy and dynamic performance under rapidly varying conditions. The output voltage and current from the PV array are monitored upon which the MPPT controller relies to calculate the conductance and incremental conductance, and to make its decision, to increase or decrease duty ratio output. (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015).

According to the survey of the most used MPPT methods: Conventional and advanced algorithms applied for photovoltaic systems (Bendib, B., Belmili H., & Krim F., 2015) the tracking

efficiency and response time comparison for different MPPT techniques under stable conditions. The literature results are presented in Table 1 and Table 2. (Boualem Bendib, Hocine Belmili, Fateh Krim, 2015).

Table 1. Tracking efficiency and response time comparison for different MPPT techniques under stable conditions.

Algorithm	Tracking efficiency, ηMPPT (%)	Respons time (s)
P&O	96.98	2.95
Improved P&O	96.07	2.93
Inc Cond	97	2.97
Improved Inc Cond	96.95	3
No MPPT	66.15	>20

Table 2. Tracking efficiency comparison for different MPPT techniques under slow and rapid variation of irradiance.

Algorithm	Tracking efficacy, ηMPPT (%)	
	Slow increase	Rapid increase
P&O	96.77	69.64
Improved P&O	96.13	95.69
Inc Cond	96.75	96.66
Improved Inc Cond	96.76	96.67
No MPPT	59.64	68.93

P&O method provide acceptable efficiency of tracking and respond time and easiest to implement has been used. Based on the above-mentioned, a block diagram of the system and a control algorithm have been developed.

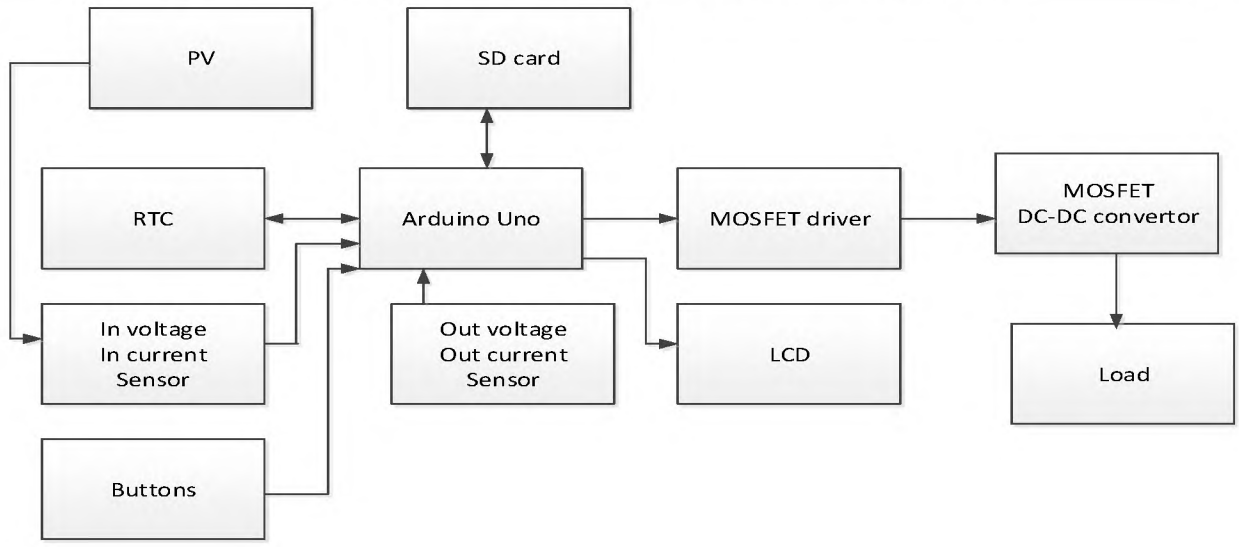

Fig2. Block diagram of the photovoltaic system.

This block diagram contains: Photovoltaic (PV), Real Time Clock (RTC), Arduino Uno, input and output voltage and current sensors, Liquid Cristal Display (LCD), MOSFET driver, MOSFET, SD card module and electronic load.

Arduino Uno is used as the microcontroller because is easy to program, widely available, don't require special programing device, affordable price.

Real Time Clock is use for tracking the time to allow us to make data base for the power output by hour, by day and so on. This information is contain on the SD card, and can easily be transfer to a computer. Voltage sensors are simple voltage dividers the output is connected to one of the analog to digital convertors (ADC).

Current is measured by a low value resistor follow by operational amplifier and the output is fed ADC. LCD is used to display the current values like voltage, current, power, time and date. The MOSFET driver to properly drive the MOSFETs. The MOSFETs and some passive components are used to make a dc –dc boost -buck convertor.

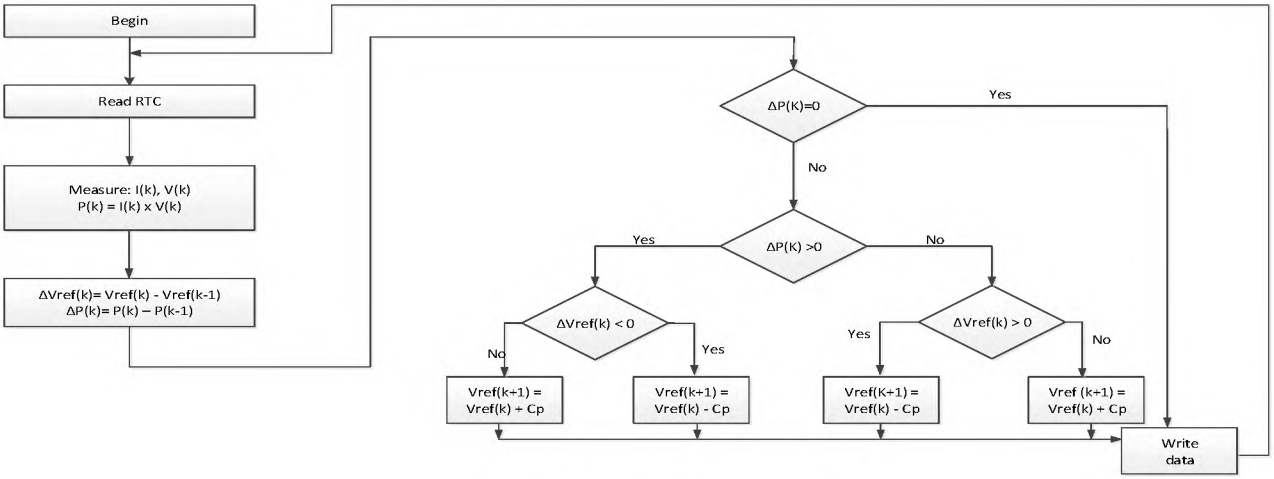

Fig. 3 Logic block diagram of system

The algorithm (figure 3) is base of P&O algorithm, with added possibility to write data to sd card and to read RTC. The algorithm starts with reading of the time from the RTC. Then the next step is to measure the voltage and the current. After that the power is calculated by multiplication of the values for voltage and current. Then is calculated the differences between the current voltage value and the previous one. The same calculation is made for the power value. In the next step ΔP (K) is checked is it equal to zero. If it is the program continue with write data and returns to read the

RTC. If it isn't the algorithm go to checking is ΔP (K) greater than 0. (In this moment the program discovers in which direction is the MPP). If it is greater than 0 the next step is to check the voltage difference ΔV (K), is it less than 0. If it is to the voltage is added constant step (Cp). If it isn't from the voltage is subtract constant step (Cp). Then the algorithm leads to write data, and returns to read RTC.

In case that the power difference isn't greater then 0, the voltage value is checked. If the difference in the voltage is greater than 0, Cp is subtracted from the voltage. If the difference isn't greater than 0, Cp is added to the voltage value. Than the algorithm continue with write data and returns to read RTC.

Conclusions

Proposed is MPPT module with real time clock. Base on the Perturbation and Observation method with added functionality for collecting data to an sd card.

Simulations and teal test are made of the voltage measurement. The measurement can be improve by using higher precision resistors.

ACKNOWLEDGEMENTS

The article presents results from Project 2019 - FNI - FEEA - 05, with financial support of the National Science Fund of University of Ruse "Modelling and investigation of objects controlled by electronic systems".

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