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MAXIMUM POWER POINT TRACKING FOR PHOTOVOLTAIC SYSTEM

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Abstract: *The increasing energy demands, depleting fossil fuels and increasing global warming due to carbon emission has arisen the need for an alternate, overall efficient and environment-friendly energy system. Solar energy is considerred as one of the most promising alternative energy sources, but it has the problem of low efficiency due to varying environmental conditions. To increase its efficiency, a maximum power point tracking (MPPT) algorithm is required to harvest maximum power from the Photovoltaic (PV) array. This work is based on the idea to turn ON and OFF the MPPT through the night. Real time clock to set time in witch MPPT is ON is proposed in the paper. Possibility to collect information for produced energy in time is softwarely organized in database.*
Keywords: *MPPT, Simulation, RTC, Photovoltaic.*

INTRODUCTION

The energy output of PV installations depends on many factors - solar radiation intensity, panel slope, air temperature, dustiness of the atmosphere etc. These factors are typically reported statistically and predictably (Mihaylov, N., Evstatiev, S., Stoyanov, I., & Gabrovska K., 2004).

Throughout the world, photovoltaic power generation is becoming increasingly popular due to a combination of factors: low maintenance, minimal wear and tear of components due to the absence of moving parts, lack of audible noise, absence of fuel cost, and pollution-free operation after installation. As PV systems are required to be low-cost, compact in size, and operate as efficiently as possible, this paper focuses on maximum power point tracking control algorithms for standalone PV systems, with the aim of delivering optimum performance over the widest range of operating conditions possible. Since PV systems exhibit nonlinear behaviour, the maximum power point (MPP) varies with solar insolation, and there is a unique PV panel operating point at which the power output is at a maximum. Therefore, for maximum efficiency, it is necessary to use a maximum power point tracking (MPPT) algorithm to deliver optimal available PV output power at different operating points to the load. With this in mind, many maximum power point tracking algorithms have been developed, and much research has been carried out to optimize the various techniques (Babaa, S., Armstrong M., & Pickert V., 2014).

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 (Naghmash, H., Ahmad I., Armghan A., Khan S., & Muhammad Arsalan 2018).

As tracking the MPP is the most important part of a PV system, intensive research work is being done in this particular area to develop new and more efficient MPPT controllers. In almost every MPPT technique, we have to trace the Vmpp voltage or Impp current at which the PV module will supply maximum power. The MPP depends upon weather conditions i.e. temperature and irradiance. There are various methods to trace the MPP which are divided into three broad categories: conventional techniques, population-based algorithms, and Artificial intelligence (AI) techniques. MPPT methods ar classified in inderct and direct. Inderct methods such as open-circuit and short-circuit require a prior knowledge of the PV array characteristics. The most use direct methods are: Perturbation and Observation (P&O), Incremental Conductance (IncCond), and Fuzzy Logic (FL) based MPPT methods. P&O and Inc Cond usually controll DC-DC convertor (Evstatiev, I., 2011.). The main advantiges of those methods, are conpatable with any PV array, they reqire no information about the PV array, can be easy to implement on a digital controller (Bendib, B., Belmili H., & Krim F., 2015).

Part of the circuit is boost convertor; wich fuction is to increase baterry voltege from 3,7V to 5V for ensuring a power supply of the microcontroller. Fig. 1 presents basic shematic diagram of boost convertor.

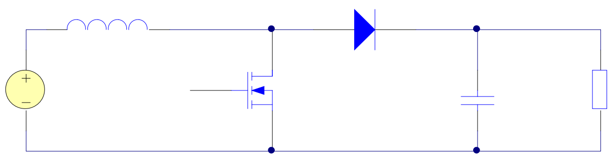

Fig.1 Basic boost circuit.

EXPOSITION

TheP&O algorithm operates periodically by perturbing the operating voltage point (V) and observing the power variation in order to deduct the direction of change to give to the voltage reference Vref. Thus, if the operating voltage V of the PV array is perturbed in a given direction and if the power drawn from the PV array increases, this means that the operating point has moved toward the MPP and the operating voltage must be further perturbed in the same direction. Otherwise, if the power drawn from the PV array decreases, he operating point has moved away from the MPP and, therefore the direction of the operating voltage perturbation must be reversed (Bendib, B., Belmili H., & Krim F., 2015).

The incremental conductance (IC) algorithm. 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 (Babaa, S., Armstrong M., & Pickert V., 2014).

The IC method is based on the fact that the slope of the PV array power versus voltage curve is zero at the MPP. It was proposed to improve the tracking accuracy and dynamic performance underrapidly 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 out put (Bendib, B., Belmili H., & Krim F., 2015).

Acording 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.

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
Impruved P&O	96.07	2.93
Inc Cond	97	2.97
Impruved 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	Repid increase
P&O	96.77	69.64
Impruved P&O	96.13	95.69
Inc Cond	96.75	96.66
Impruved Inc Cond	96.76	96.67
No MPPT	59.64	68.93

P&O method to provide acceptable efficancy of traking and is the easiest to implement has been used. Based of the above-mentioned, a block diagram of the system and a control algorithm have been developed.

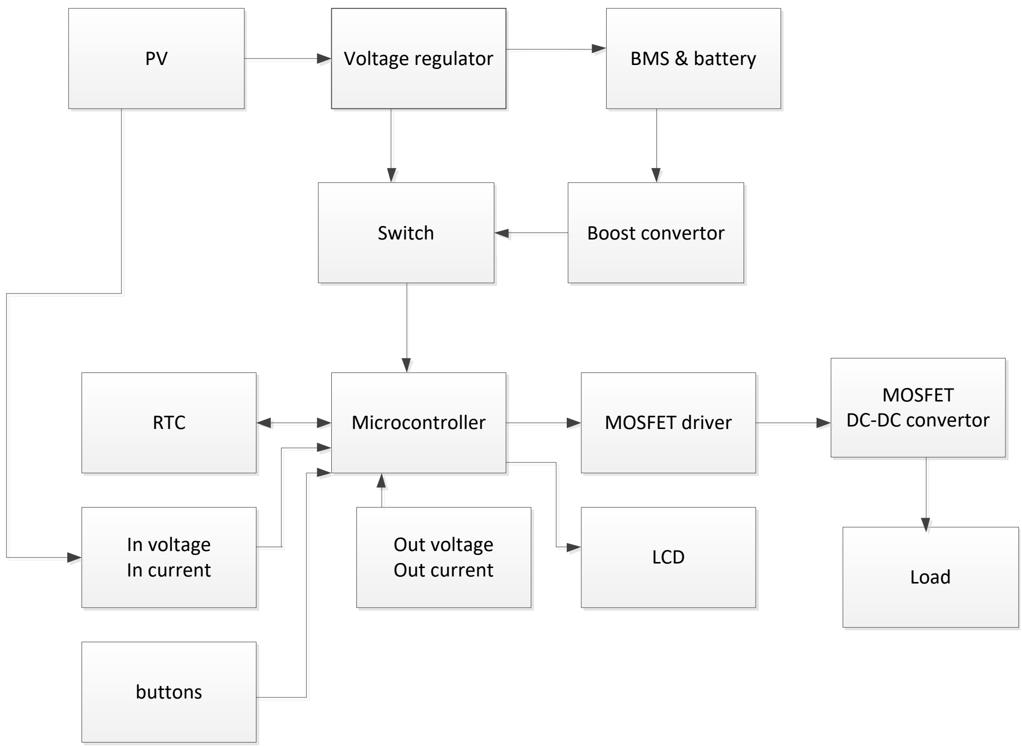

Fig. 2. Block diagram of the photovoltaic system

The block diagram contains two main parts PSU and microcontroller. PSU is built from 4 parts Voltage regulator, BMS & battery, a Boost convertor, and a Switch. Voltage regulator's input is connected to the PV and the output is connected to battery management system (BMS), and to switch though it to the microcontroller. The switch determines voltage regulator or battery is providing power to the microcontroller. Battery is connected to boost circuit that increase voltage.

Microcontroller contains of Real Time Clock (RTC), Microcontroller, Buttons, Sensors (voltage and current), LCD, MOSFET driver, MOSFET DC- DC convertor, Load.

RTC is used for determination the time in which to START and STOP the MPPT. The used sensors are two types: for current and for voltage measurement. For current sensing is used low value resistor followed by operational amplifier. Then the voltage from the amplifier is sent to analog to digital converter (ADC), built in the microcontroller. The other one is voltage sensor, which is realised by voltage divider containing two resistors. In their midpoint the voltage value is proportional to the input voltage. The output voltage is send to microcontroller's ADC. The output or input power is calculated from the current voltage and current values from the sensors. Buttons are used to set the time of the RTC and set the START and STOP time. LCD is for visualization of the time and other parameters. Microcontroller generates PWM signal which controls the MOSFET driver. The driver switch ON and OFF two MOSFETs which make DC- DC Convertor.

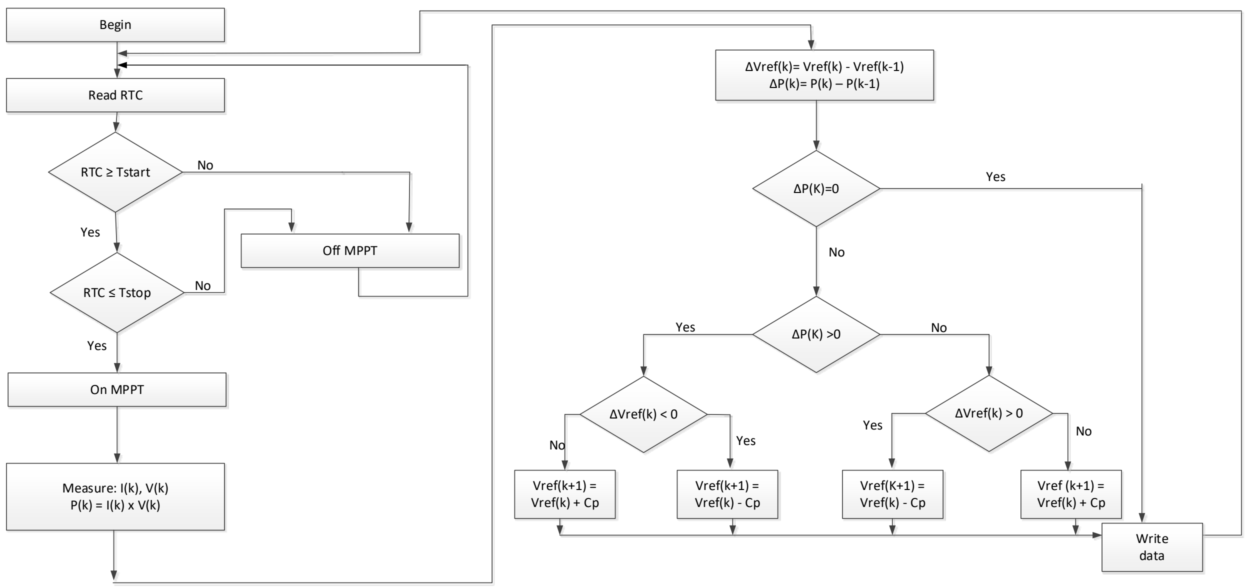

Fig. 3 Logic block diagram of system

The idea of the algorithm (Figure 3) is to be able to turn ON and OFF MPPT, using RTC. The algorithm is based on P&O logic, but RTC is added to save energy during the dark part of the day. The algorithm starts with reading the current time from the RTC, then compares the value from RTC to the value of Tstart if the value is not greater or equal return to the reading of RTC. If the value of RTC is greater or equal continue with comparing to Tstop. If it is less or equal - continue with the algorithm. If it is not, this leads to data write and then returns to reading RTC.

The algorithm continue with measuring the voltage and current then calculate the power. After that is calculated the difference in the voltage values between the current value and the previous one.

The same calculations are made for the power values. The ΔP(k) result is checked in the next step. If is equal to 0 the program returns to read RTC. If it isn`t equal, the algorithm continues with checking if the difference is greater than 0. If it is greater than 0, the next step is to check if the voltage difference is less than 0. If it's true, constant step (Cp) is added to the voltage. If it isn`t, Cp is subtracted from the voltage value. Then algorithm lead to write data and then continues with returning to read RTC.

In case that the power difference isn`t greater than 0, the voltage value is checked. If the difference in 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. After this step the algorithm leads to write data and then again reads RTC. The advantage of the algorithm is that it is developed in a way that doesn`t allow the START time to be higher than the STOP time.

RESULTS AND CONCLUSIONS

Simulations of the boost convertor are implemeted in LT spice environments for diferent voltages of the battery.

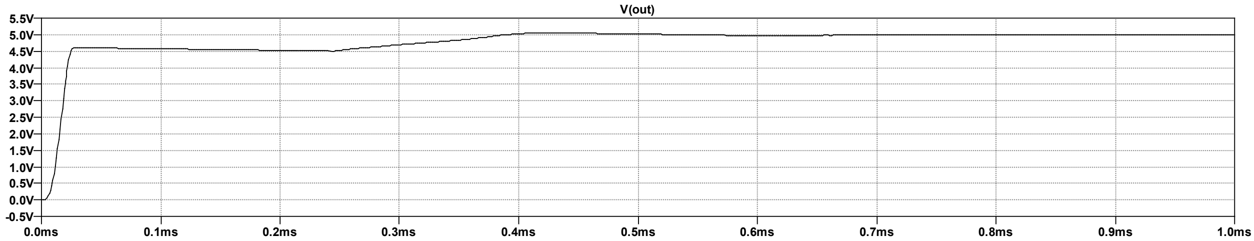

Fig.3. Simulation for battery voltage 3.7V

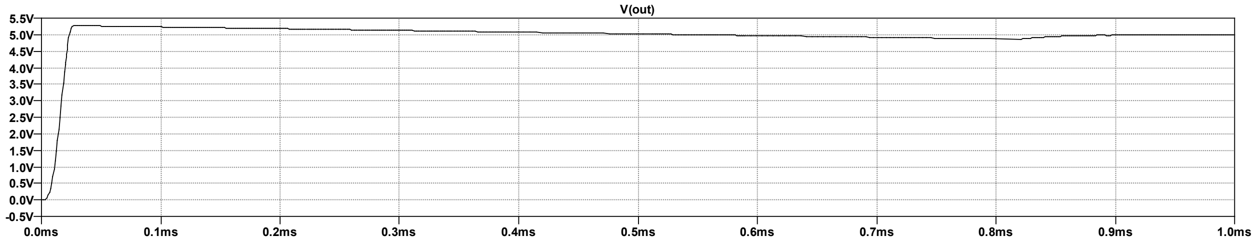

Fig.4. Simulation for battery voltage 4.2V

Lower battery voltage needs more time to reach the required 5V for the microcontroller. From the graphics can be seen that higher battery voltage leads to faster reaching of the target voltage value - 5V.

CONCLUSIONS

P&O based MPPT algorithm with Real Time Clock has been proposed in the research.

The power supply unit has been simulated in LT spice environment. Higher battery voltage leads to faster reaching the required 5V.

Collecting of data for the produced energy has been ensured in the developed electronic system.

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