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RESEARCH OF MPPT METHOD ALGORITHM FOR BOOST DC-DC CONVERTER OF PHOTOVOLTAIC SYSTEM

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Nowadays, more attention is paid on alternative sources of energy, including solar energy. In connection with growth of prices for non-renewable energy sources. However, generating solar energy has a number of problems associated with the cost of the panels, their disposal and methodology of operation of devices for converting energy of these systems. This requires creating power sources on the modern element database and systems management, to achieve high energy efficiency. For these tasks method of finding the maximum power point of a step-up voltage Converter for solar sources energy using known search algorithms.
Keywords: MPPT Method, PV System, converters of solar energy.

Introduction. The author investigated the devices based on boost Converter (PPN), part of the structure of the inverter for the solar panels as the most promising in terms of weight, dimensions and efficiency. Functional diagram of the system shown in Fig. 1 [1].

To extend the range of operation of solar inverter as an intermediate link between the solar battery (SB) and network inverter used DC-DC Converter, which also can produce tracking the maximum power point (maximum power point tracking – MPPT), a block diagram is shown in Fig. 2. As such the energy Converter can be buck, boost, inverting converters, or Converter, made by Cuk diagram.

This scheme provides high efficiency by reducing the number of power components, with dimensions and weight filter minimizes high frequency conversion. One of the main ways of improving the energy efficiency of PV systems is the implementation of the mode selection maximum power at the relevant point in the current-voltage characteristics (CVC) of solar panels.

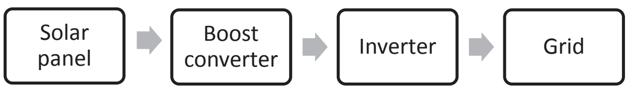


Fig. 1. Chain diagram of an offline electric power supply system based on solar batteries

The relevance of work. Study of various algorithms for finding the maximum power point of systems based on solar batteries; developing the structure with the best performance efficiency and speed on the basis of typical schemes of conversion of solar energy and algorithms of their management; the creation of the physical layout of the target device and evaluation of its performance.

Researching methods. Literature review on model schemes of converters of solar energy based DC/DC converters and the search algorithms of maximum power point, a comparative analysis of available data using computer simulation tools. Used as methods of simulation modeling with Matlab/Simulink prototyping and conducting relevant experiments: tuning of PI controller simulation of different levels of darkening solar panels, the evaluation of the efficiency of the Converter.

Expecting results. Developed a simulation model for the method of perturbation and observation (adaptive and non-adaptive) and the method of increasing conductivity, and investigated their applications for different levels of illumination. Compiled software for microprocessor control systems two-phase boost Converter voltage, and conducted a series of experiments simulating different levels of light solar panels for the evaluation of the efficiency of the experimental setup. The author obtained the accuracy rate of finding the maximum power point to a value equal to 99%, for the variant with an adaptive algorithm to change the pitch. In the pilot study achieved similar accuracy rates corresponding to 95-96% at the time of quantization 10 MS.

Review of existing control algorithms. To optimize the output power of the PV modules, typically, use one of known algorithms. In some devices for tracking the maximum power point of implementing several algorithms, and switching between them is carried out depending on the conditions.

The main means of algorithms of MPPT are: the method of perturbation and observation constant voltage [4]. When using the method of perturbation and observation device by a small amount changes the equivalent input resistance of the Converter (by varying the duty cycle of the power switch or change tasks on the input values of voltage, current or power) consequently varies the voltage on the SB and the next step is measuring its output parameters. If the power increases – the controller continues to change which sets the parameter in the same direction until the power will not cease to increase. This method is the most common, despite the fact that it leads to power fluctuations. Wide application of this method due to its simplicity can be implemented on the basis of functional the circuits of the control system the VPI.

Typical schemes of converters of solar energy is depicted in Fig. 4. The most common approach is the reduction Converter (Fig. 2, a). The advantage of schema – stable current of the battery, provide a large output inductance, however, the intermittent pulse consumption input current requires the installation of C-filter [3].

Boost Converter (Fig. 2, b) has output the throttle, ensuring the continuity of the input current and stability of the operating point current WAC. When this occurs, the increase in voltage over the entire range of regulation, which leads to the necessity of using the bypass to prevent exceeding the output voltage. Given the topology of the functional diagram of the final device (Fig. 1), the most a viable option is the use of this schematics. Of all the types of converters with the highest efficiency has PPN.

For a successful regulation of the maximum power point of the CVC at any ratio stresses on SAT and load you can also use the Converter cook, have the input stage based on the boost Converter, and the output – based reduction (Fig. 2) [1].

Researching methods. Modified P&O Method.

The P&O method is commonly used in MPPT systems because of its major advantages such as high tracking speed and simple implementation specifications. However, this method is based on hill climbing rule and cannot track the global MPP when multiple peaks are occurring in P-V curve of PV system. Thus, some modifications have done to extend the advantages of this method to PSCs. After the experimental studies, some observations are reported about partially shaded PV systems characteristics. It is seen that, the peak points of the P-V curve are still about 0.8 V_{OC} [5]. In addition, while magnitudes of the peak points are in tendency of increasing before the global MPP and they are in tendency of decreasing after the global MPP. Therefore, P&O method is commonly used to track the global MPP under PSCs. Different modification schemes can be used for MPPT with P&O method under PSCs. The PV system is started to operate at 0.85 V_{OC} and the conventional P&O method is used to track the MPP until a disturbance such as the PSC is detected or an interrupt is generated. When the disturbance is detected or a timer interrupts which is generated every predetermined time interval (for example

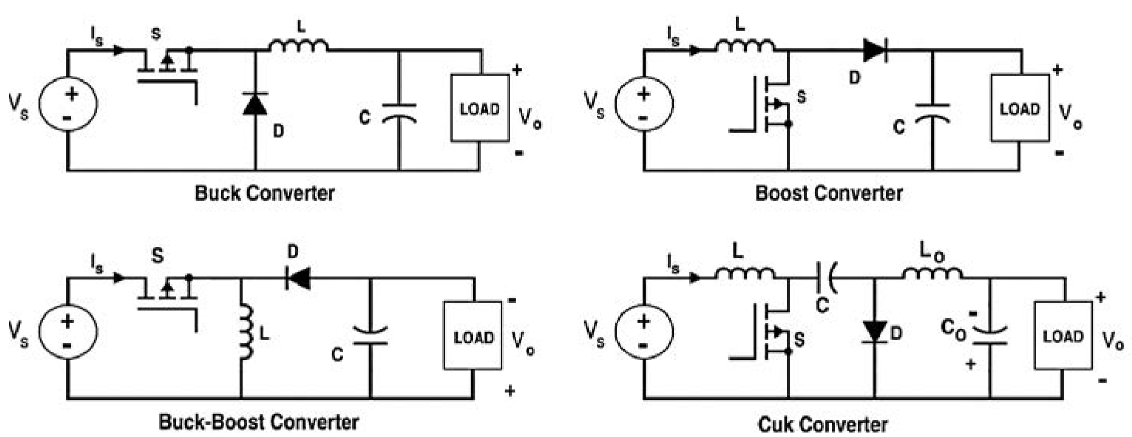


Fig. 2. Typical circuits of DC/DC converters: a) buck; b) boost; c) buck-boost; d) Cuk converter

20-25 s) occurs, the partial shading subroutine is activated. This situation is detected by monitoring the power variation (DP) value. If the power variation value is higher than the predefined critical power (DPcrit) value, this situation is labeled as PSC. The partially shading subroutine searches the other peak points on the P-V curve. It is also known that, voltage difference between the sequential peak points is almost equal to 80% of the open circuit voltage of the PV module (V_{oc_module}). Therefore, the operating voltage value is changed with a voltage variation step (DVx) which is smaller than 0.8 V_{OC_module}.

The PV power and voltage values are read, and if these values are higher than the $P_{\max\_last}$ and voltage $V_{\max\_last}$, this operation is repeated in same direction. If the obtained power value is lower than the $P_{\max\_last}$ or V_{max} which is determined as 0.85 V_{OC_module}, operation point is transferred to previous peak point. This modified method operates like double Perturb & Observe method. It generates relatively big perturbations to track the GMPP in case of multiple peaks. However, the proposed modified P&O method may not track the GMPP under rapidly changing solar irradiation conditions [8]. In another study, an alternative P&O method which compares instantaneous measured power ($P_{m(t)}$) and instantaneous maximum power reference value is proposed [3]. The instantaneous measured power is calculated by multiplying instantaneous voltage and instantaneous current measurements. The P-V curve is divided into two regions. The instantaneous maximum power is related temperature and irradiance as Eq. 1

$$P_{mmp}(t) = P_{mmp}(T(t), E(t)) = a\left[T(t)b(E(t))\right] \quad (1)$$

here, T(t) is temperature value, E(t) is irradiance value, a(t) is temperature factor and E(t) is irradiance factor which determines the maximum power current. The temperature factor is also called as voltage factor. In region I, maximum power point current is obtained by reducing the PV array current as given below:

$$I(t) = I_{meas}(t) - \Delta I \quad (2)$$

The performance of this method is depending on the DI. In region II, current reference is calculated by Eq. 3:

$$I(t) = \frac{P_{meas}(t)}{a(T)} \quad (3)$$

This algorithm is operated until the power error ratio becomes lower than the predetermined level:

$$\frac{P_m(t) - P_{ref}(t)}{P_m(t-1)} < \varepsilon \quad (4)$$

here, Pm(t) is the instantaneous measured power and Pref(t) is the instantaneous maximum power reference. The P&O method is used to estimate a(T). This method introduces various new coefficients which complicate the MPPT process to determine the global MPP in case of multiple local peak points. In the method of increasing the conductivity of the transducer captures the increase in the current and voltage SB to predict the effect of changing voltage. It requires increased computation by the microcontroller, but it keeps track of the changing conditions with greater speed than the previous method. However, this method also leads to power fluctuations.

This method uses increasing the conductivity d_I / d_U of the solar battery to calculate the sign of the change of the power against voltage d_P / d_U. This calculates the point the maximum power and a comparison is made of the increasing conductivity ΔI/ΔU with the conductivity of the SB(I/U). If the condition, ΔI/ΔU=I/U output voltage equal to the voltage corresponding to the highest power. Setting PI-regulator the voltage is maintained until the level of illumination; the process is repeated.

The simulation of results. In Fig. 4 shows a simulation model of a system for tracking maximum power point. In the model the Converter is replaced by a variable resistance, the magnitude of which is dynamically adjusted using one of

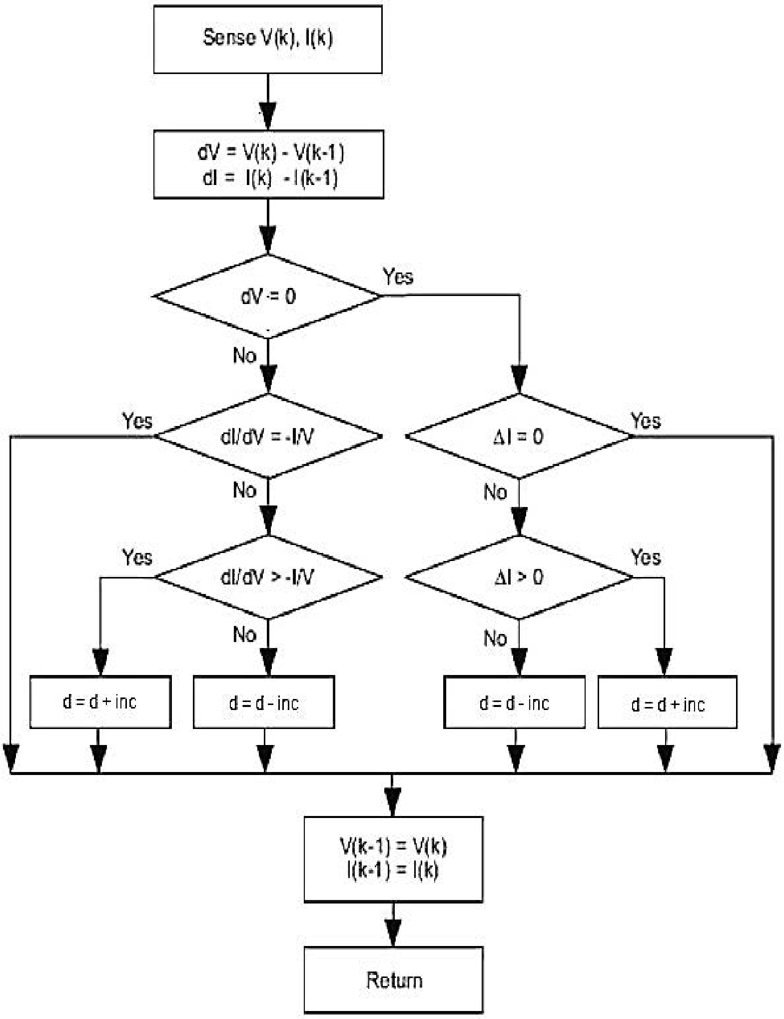


Fig. 3. Block diagram of algorithms of MPPT perturbation and observation

the MPPT algorithms in the process of construction, a simulation model, it can consist the following assumptions:

– not taken into account pulse duration modulation (Converter represented by the equivalent resistance), because the time quantization the algorithm tracking the maximum power point is significantly higher than the PWM period;

– the lag of in response to the change of the input voltage is represented by an aperiodic link.

In Fig. 5 shows current-voltage characteristic and power voltage model of PV panel used in the simulation.

The result of simulation to obtain graphs of the output at the operating point and find the new maximum capacity due to changing the value of the illumination of the PV panel. In Fig. 6 presents diagrams of the current (I_{in}), voltage (U_{in}) and power the solar battery (P_{sa}) a non-adaptive algorithm of perturbation and observation maximum step voltage.

The adaptive algorithm is implemented as follows: the gradual movement of the current operating point in one direction increases and the increment of the task on the input voltage at each iteration; if the power increased and the cur-

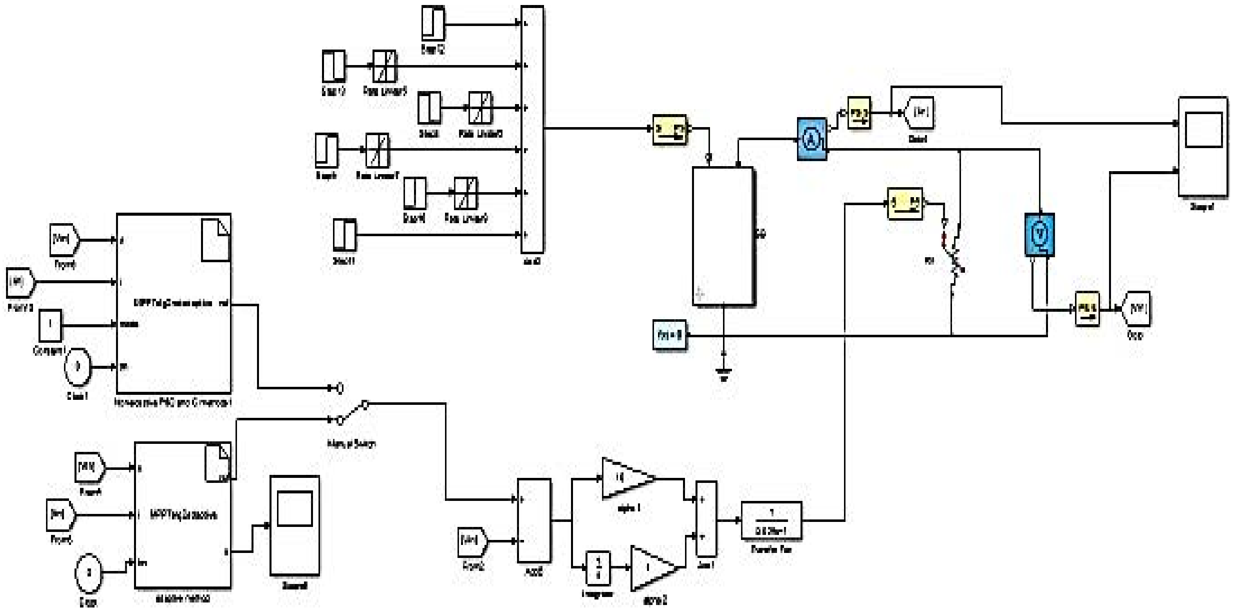
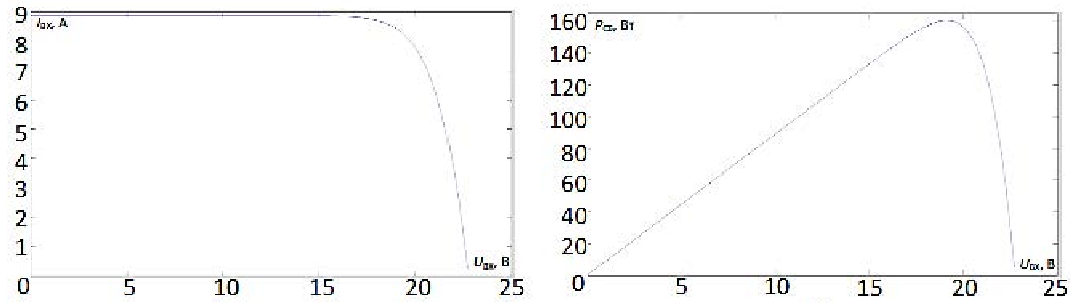
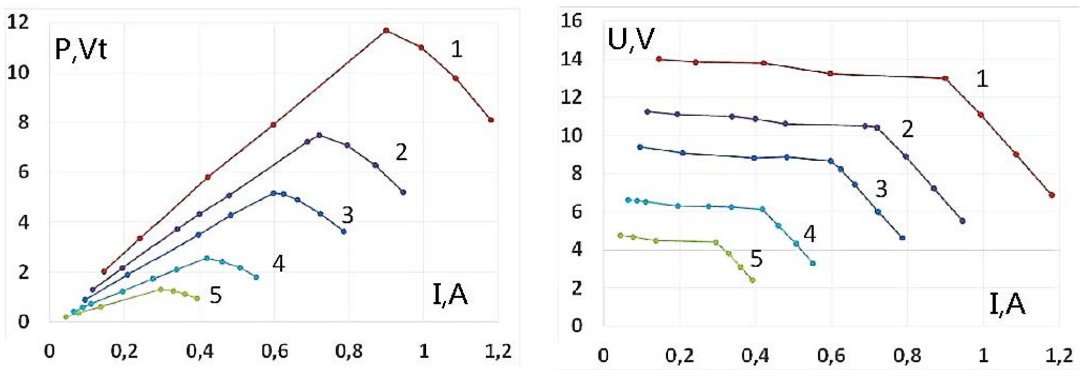


Fig. 4. Simulation model for adjustment of MPPT algorithms



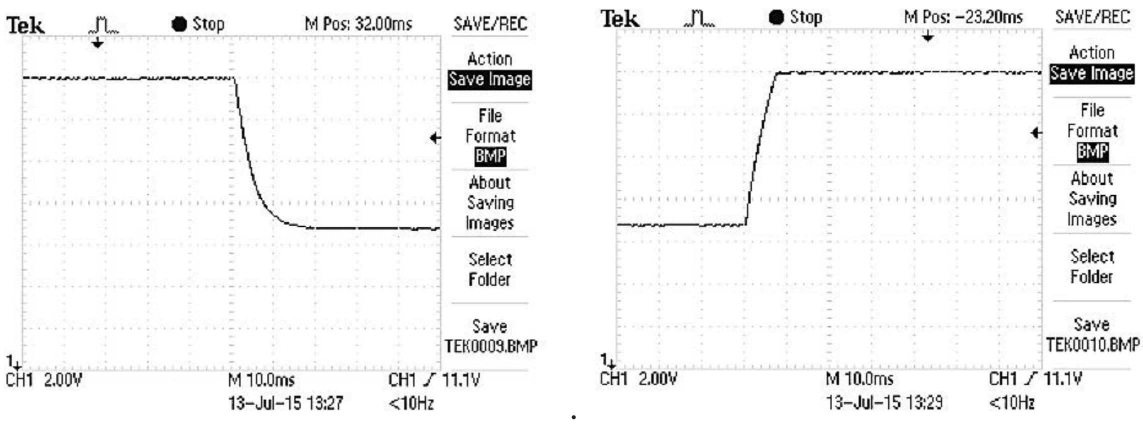
(a) (b)

Fig. 5. Characteristics of solar panel: a) current voltage; b) power voltage



(a) (b)

Fig. 6. Characteristics of nonlinear power source: a) power voltage characteristic P=f(I); b) current voltage characteristic U=f(I)



(a) (b)

Fig. 7. Oscillograms of operation of reference for reduction (a) and increase (b) of input voltage

rent decreased, then the increment is reduced. In Fig. 6 the time diagram of current, voltage and power for the adaptive algorithm of perturbation and observation.

EXPERIMENTAL PART

The experiments were carried out using a DC link inverter solar, representing two parallel connected boost Converter voltage.

To obtain the most similar form the CVC and VIN to the corresponding characteristics of the security Council were implemented serial and parallel connection of resistors between the power source and PPN. Experienced U=f(I) and volts W P=f(I) characteristics as shown in Fig. 15. In Table 1 shows the values of the input currents and voltages corresponding to points of maximum power for each voltage-current characteristics of the above figure.

Table 1

	I_{max}, A	U_{max}, V	P_{max}, Vt
1	0,9	13	11,687
2	0,72	10,41	7,49
3	0,6	8,66	5,17
4	0,42	6,12	2,55
5	0,3	4,4	1,24

In this algorithm, the perturbation is realized through a job change on the input voltage of the Converter. Waveform testing of this process is shown in Fig. 16. The calling frequency of the MPPT algorithm was chosen on the basis of the dynamic properties of closed-loop control system. From these waveforms it can be seen, the transition time of the input voltage is equal to 10 MS.

The calculation accuracy of finding the maximum power point at each operating point. An example of determining the capacity for the characteristics:

$$P_{max} = U_{max}I_{max} = 10{,}41 * 0{,}72 = 7{,}49V$$

$$P'_{max} = U'I' = 11{,}34 * 0{,}64 = 7{,}26V$$

where *Imax, Umax*, and *Pmax* is the maximum value of the current, voltage and power for each VAC source; *I'*, *U'* and *P' max* is established in the result of the algorithm, the values current, voltage and power output of the source is defined experimentally.

Compute the accuracy:

$$\frac{P'_{max}}{P_{max}}100\% = \frac{7{,}26}{7{,}49}100\% = 96{,}93\%$$

The results of calculations for the system at each of the CVC (Fig. 7) are given in Table 2. Of the above it is seen that the power loss associated primarily with the vibrations of the task on the input voltage.

Table 2

Accuracy of tracking maximum power point for different levels of illumination

Interval	Accuracy, %
2	96,93
3	95,8
5	95,2
1	95,73

Conclusion. Based on these results, we can draw the following conclusions:

– The achieved precision value of finding the maximum power point (95-96%) when the non-adaptive algorithm disturbance and surveillance satisfies, the theoretical and experimental data of domestic and foreign researchers.

– To increase the accuracy (99%) extreme normal power control most appropriate algorithm step change of the controlled parameter (current, voltage, power SB or duty cycle of key) when determining the maximum power.

– The method of perturbation and observation is the best because it is less demanding of the microcontroller and the implementation

– The adaptive algorithm provides a high level of accuracy, combined with sufficient speed.

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ДОСЛІДЖЕННЯ МЕТОДУ ВІДСТЕЖЕННЯ МАКСИМАЛЬНОЇ ТОЧКИ ПОТУЖНОСТІ ДЛЯ ПІДВИЩУВАЛЬНОГО ПЕРЕТВОРЮВАЧА ПОСТІЙНОГО СТРУМУ В ФОТОЕЛЕКТРИЧНИХ СИСТЕМАХ

Анотація
В даний час все більше уваги приділяється альтернативним джерелам енергії, включаючи сонячну енергію. У зв'язку із зростанням цін на поновлювані джерела енергії. Однак, генерація сонячної енергії має ряд проблем, пов'язаних з вартістю панелей, їх утилізації та методології роботи пристрою для перетворення енергії цих систем. Це вимагає створення джерел живлення на сучасній елементній базі і системах управління, для досягнення високої енергоефективності. Для цих задач метод пошуку точки максимальної потужності підвищуючий перетворювач напруги для сонячних джерел енергії, використовуючи відомі алгоритми пошуку.
Ключові слова: фотоэлектрична система, перетворювач сонячної енергії, максимальна точка потужності.

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ИССЛЕДОВАНИЕ МЕТОДА ОТСЛЕЖИВАНИЯ МАКСИМАЛЬНОЙ ТОЧКИ МОЩНОСТИ ДЛЯ ПОВЫШАЮЩЕГО ПРЕОБРАЗОВАТЕЛЯ ПОСТОЯННОГО ТОКА В ФОТОЭЛЕКТРИЧЕСКИХ СИСТЕМАХ

Аннотация
В настоящее время все больше внимания уделяется альтернативным источникам энергии, включая солнечную энергию. В связи с ростом цен на не возобновляемые источники энергии. Однако генерация солнечной энергии имеет ряд проблем, связанных со стоимостью панелей, их утилизацией и методологией работы устройств для преобразования энергии этих систем. Это требует создания источников питания на современной элементной базе и системах управления, для достижения высокой энергоэффективности. Для этих задач используется метод нахождения максимальной мощности повышающего преобразователя напряжения для энергии солнечных источников с использованием известных поисковых алгоритмов.
Ключевые слова: фотоэлектрическая система, преобразователь солнечной энергии, максимальная точка мощности.