QUID 2017, pp. 1952-1957, Special Issue N°1- ISSN: 1692-343X, Medellín-Colombia

PROVIDING AN OPTIMIZED AND NEW METHOD FOR TRACKING THE MAXIMUM POWER POINT OF SOLAR CELL POWER USING THE NEURAL NETWORK

(Recibido el 16-05-2017. Aprobado el 20-09-2017)

Mohammad Ali Tamayol
M.S. student,
Science & Act of Tohid Jam Company (SATJCo.), .), Isfahan, Iran
tamayol.ali@satjco.com

Hamid Reza Abbasi
B.S. student,
Science & Act of Tohid Jam Company (SATJCo.), .), Isfahan, Iran
abbasi.hamid@satjco.com

Sina Salmanipour
M.S. student,
Science & Act of Tohid Jam Company (SATJCo.), .), Isfahan, Iran
salmanipour.sina@satjco.com

Resumen: La necesidad de sustituir energías limpias por combustibles fósiles ha llevado a los seres humanos a utilizar energías renovables, incluida la energía solar por sus numerosas razones. Pero lo importante aquí es encontrar maneras de maximizar el poder de estos convertidores de energía. En este trabajo, se han desarrollado nuevos métodos para obtener la máxima potencia de la simulación celular y celular mediante la descripción de algunas de las aplicaciones de las redes neuronales. Las ventajas de estos métodos incluyen la optimización del sistema, la estimación de los parámetros de la estructura interna de los componentes celulares y celulares de una manera matemática, una mayor precisión en la estimación del punto máximo de potencia y una mayor velocidad de seguimiento en las células solares. Eventualmente, todos los elementos mencionados anteriormente se han simulado con mucha precisión utilizando el software MATLAB.

Palabras clave: Célula solar, Implementación práctica, Seguimiento del punto máximo de potencia, Red neuronal

Abstract: The need for substituting clean energies with fossil fuels has led humans to use renewable energies, including solar energy for its numerous reasons. But what's important here is finding ways to maximize the power of these energy converters. In this paper, new methods have been developed to obtain maximum power from cell and cell simulation by describing some of the applications of neural networks. The advantages of these methods include system optimization, estimation of the parameters of internal structure of cell and cellular components in a mathematical way, more precision in estimating the maximum power point and higher tracking speed in solar cells. Eventually, all of the above mentioned items have been simulated very accurately using MATLAB software.

Citar, estilo APA: Tamayol M, Reza H & Salmanipour S (2017).Providing an optimized and new method for tracking the maximum power point of solar cell power using the neural network. Revista QUID (Special Issue). 1952-1957.

Keywords: Solar Cell, Practical Implementation, Tracking Maximum Power Point, Neural Network

1. INTRODUCTION:

The increasing consumption of energy in the world has led to increased pollution and environmental degradation. Therefore, global attention has been focused on renewable energies rather than fossil fuels. The use of renewable energy reduces the concentration of pollutants in the atmosphere by 10% and reduces the effect of the global warming phenomenon. In our country, the government's goals are to meet the energy needs of future generations and reach economic growth which require the optimal use of energy resources, in particular renewable energies. Despite being one of the oil-rich countries in the world, Iran enjoys a more economical situation due to its solar radiation intensity in most areas. Today, the use of solar panels has expanded in various cities of Iran and has provided a suitable market for industrialists and researchers. Solar batteries or solar cells are devices that convert light or photons directly to electrical current through photovoltaic effect whose main advantage is no pollution; however, the cost of installing them is very high. With the development of science, it is anticipated that the cost will be reduced (Krishna, and Mothukuri Ravali 2016).

The solar panels consist of a number of solar cells that convert solar energy into electrical energy. One of the methods for increasing energy in photovoltaic converters is the use of electric converters with appropriate efficiency in the output of the solar panel before and after consumption so that in addition to increasing the voltage of the solar cell (which is about a few volts) it also increases the converter efficiency.

With a little attention in the equations and diagrams explained in detail in the following chapters, it can be concluded that the best point for converters and solar cells is the point at which the highest electrical power is generated by the cell and transmitted by the converter to the load. This point is known as the maximum power point. Various methods have been proposed for obtaining this point and adjusting the working point of the converters at this point. According to the reference (Ramaprabha, et al 2011)- (Chine, et al. 2016), it can be seen that the neural network method is one of the most appropriate and new methods for this purpose.

In addition to the fact that this method is compatible with the non-linear nature of load and solar cells, it can also be programmed and utilized in intelligent networks. The ability to look at the future is one of the undeniable advantages of the neural network because intelligent networks will account for a large part of the energy production and distribution network in the future, which creates an appropriate opportunity for using solar cells through intelligent control methods (Khanaki, Razieh, Radzi, and Marhaban. 2016).

In this paper, the neural network method is used to find the maximum power point, which has a lot of abilities compared to other conventional methods today. In the same way, the neural network is used to control the optimal converter connected to the network. This converter is a new boost-boost converter that works with a storage or battery which reduces switching and loss in the system. It should be noted that this method has many capabilities for matching impedance, which will be discussed later in detail.

After the introduction, we will briefly discuss the neural network, and then we will discuss how to track the MPPT point by the neural network in the third section. Then, the method will be fully explained by presenting the electronic converter in the fourth section. Finally, the efficiency of this method is analyzed and its conclusion is presented.

2. NEURAL NETWORKS:

An artificial neural network is a data processing system that is inspired by human brain and has made responsible small and large processors for processing the data. These processors interact in parallel with each other to solve a problem. In these networks, a data structure is designed that can act like a neuron with the help of programming knowledge. This structure is called a node. Then they will train the network by creating a network between these nodes and applying an educational algorithm to it. In this memory or neural network, the nodes have two modes known as active (on or 1) and inactive mode (off or 0), and each edge (synapse or communication between nodes) has a weight. Positive-weight edges stimulate or activate the next inactive nodes, and negatively-weighted edges make the next connected node inactive (if it is active).

Most of the methods used to realize the maximum power point (MPPT) require detailed information on cellular material and physical characteristics of the cells. Since some of the information is not readily available to users, the mathematical model obtained may be inaccurate and the estimated MPP may have a remarkable difference with the actual MPP. However, models based on artificial neural networks (ANNs) do not require physical specifications of the solar array.

The common feature of the neural networks used in PV systems is that all of them use multi-layer perceptron networks which are trained by the Post-Reproduction (MLP-BP) method. This method has a slow training speed and may also be under-optimized during the training due to the presence of local minimum points. So it may not be able to provide an optimal model for a specific model.

Here's a new activated RBFN model. In a RBFN model, which is a new modelling method, a distance is determined between the input vector and the target vector based on the hidden unit activation. These networks have two advantages: their training methods are basically faster than the BP algorithm used in MLP networks, and more importantly, these networks do not have the problem of confronting local minimum points. This paper uses the RBF network.

3. TRACKING THE MAXIMUM POWER POINT:

The voltage curve and the power curve are shown in Fig. 1 in terms of current and in terms of current of a solar cell, respectively. This curve changes with variations in temperature and radiation intensity. In Fig. 2, the variations of these curves are shown relative to the temperature variations. In Fig. 3, variations in these curves are indicated in terms of radiation intensity variations.

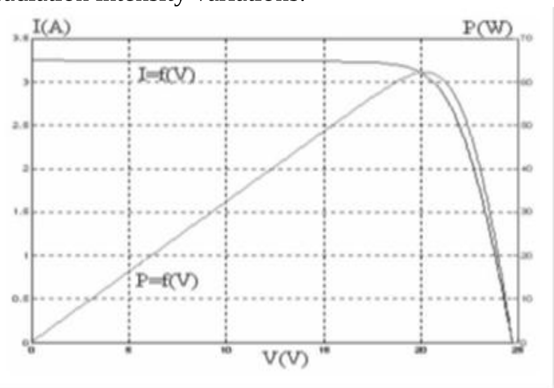

Figure. 1. Current curve in terms of voltage and power based on the solar cell voltage

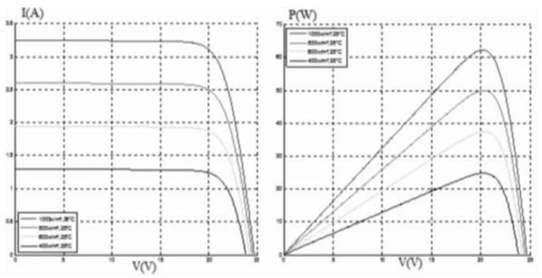

Figure. 2. The Curve of Voltage Power and Current Voltage Variations of Solar Cells in Terms of Temperature Variations

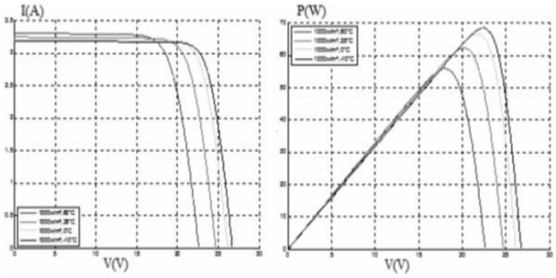

Figure 3. The Curve of Voltage Power and Current Voltage Variations of Solar Cells in Terms of Radiation Variations

For steady-state temperatures and radiation intensity of the sun, maximum power can be obtained only at one point, which is the bending point of the curve. This point is shown in Figure 4. In this Figure, the maximum production capacity is shown.

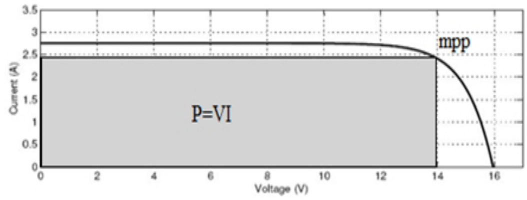

*Figure 4***.** *Maximum power point in a solar cell*

The maximum power point is constantly changing due to the recurrent climate changes. Because of the high cost of photovoltaic cells, photovoltaic systems are required to operate at maximum power in all weather conditions at different radiation levels and temperatures. For this purpose, maximum power tracker systems are utilized. These systems are used in systems such as photovoltaic systems and solar generators (Messalti, Sabir, Harrag, and Loukriz. 2017) – (Suliang, et al. 2016).

4. THE ESTIMATION THE MPP SOLAR ARRAY BASED ON AN RBF NETWORK:

The RBF network is used to estimate MPP using radiation and temperature samples. Figure (4-5) shows the RBFN model used to estimate the MPP of the PV array.
The input vector of a two-dimensional vector involves radiation and ambient temperature, while the output vector includes the voltage and current at the maximum power point. The input and output vectors are as follows.

$$X^{n} = \begin{bmatrix} R_{ad}^{n} \\ T_{a}^{n} \end{bmatrix} \qquad (1)$$

$$Y^{n} = \begin{bmatrix} V^{n}_{\max} \\ I^{n}_{\max} \end{bmatrix}, \quad (2)$$

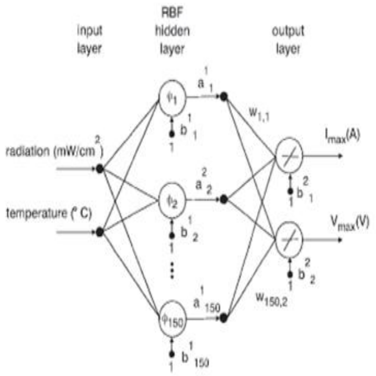

Figure. 5. Neural network used

5. NEW METHODS AND RESULTS:

According to the above mentioned items, the neural network can be used as a predictor for the maximum power point. The previous solar cell data is used to train the neural network and the MPP point is obtained in the current state. Therefore, data from a standard solar cell was used to train the neural network and the neural network was trained once with neurons and again with 200 neurons.

In Figures 6 and 7, we see that the neural network converges after 13 steps. This value decreases for a neural network with 200 neurons to 9 steps, which indicates the proper convergence speed of this network.

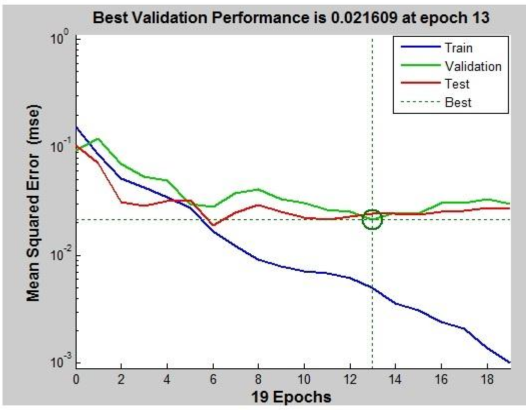

Figure 6. Neural network training with 100 neurons

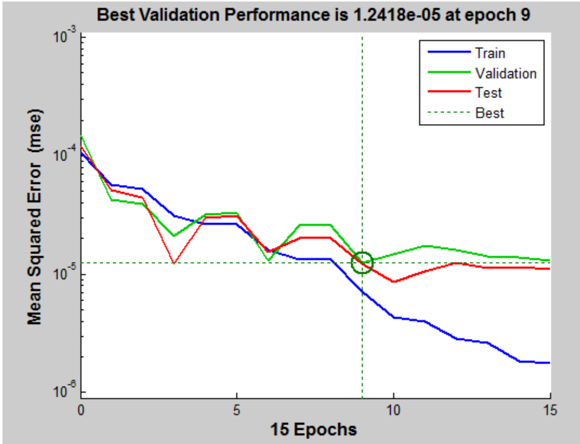

Figure 7. Neural network training with 200 neurons

In this case, this trained network should be able to track MPP at any given moment. For this, data from the next solar cell is used, the results of which are summarized in the table below.

Table 1. The results of maximum power point tracking

Error Average	The Number of Neurons in the Hidden Layer
7%	100
5%	200

In Table 1, it is seen that the error of the estimated value by the neural network is very low with the real value, and the points predicted for the maximum power are very close to the actual point.

It is worth noting that the above method perfectly adapts temperature and radiation intensity which is one of the advantages of this method. The temperature and radiation intensity are changed nonlinearly and the converter can adapt itself to these changes.

The proposed method in this paper is briefly shown in Figures 9 and 10.

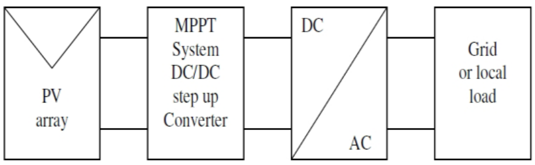

Figure. 9. Maximum power tracking for systems connected to the network

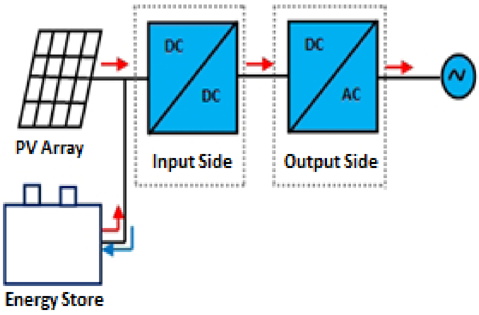

Figure 10. A novel way to implement energy storage systems

In this plan, an energy saver is needed to supply energy at moments where load demands more energy than production power, or to save energy when the photovoltaic array produces more energy.
Furthermore, instead of a single DC converter, two DC-DC converters are used continuously, each controlled by a pre-trained neural network.
The plan also has the benefits of reducing switching losses, continuous charge supply and network repair/modification in critical situations.
The results of the using these converters greatly illustrate the efficiency of this system in the maximum power point tracking and also in the optimization of the converters.

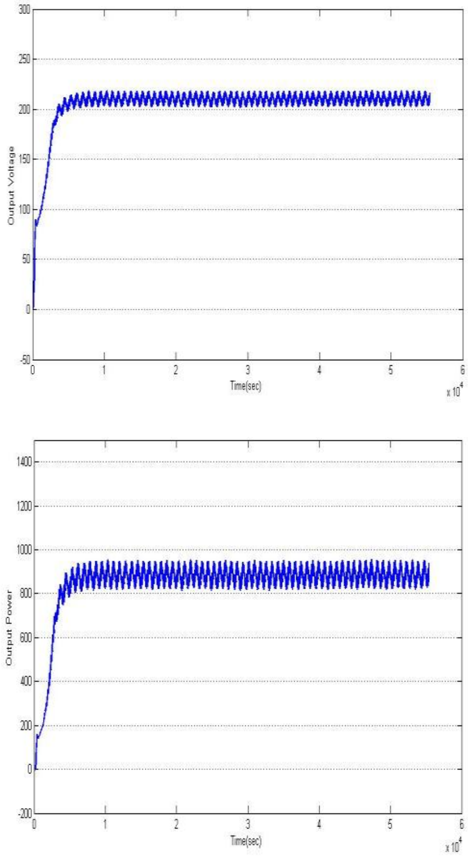

Figure. 11. Simulation Results

In Fig. 11., the results are shown in terms of the supply of charge from the photovoltaic cell. It is seen the switching is well performed and the current and voltage are continuously supplied for the charge.

6. CONCLUSION:

In this thesis, we use a simple converter with soft switching to connect solar cells to the power network under maximum power conditions. This system is connected to a network with a simple converter or storage battery. The proposed tracking method is implemented by the neural network method. This method is on of the intelligent methods and has a better response than other common methods.
Using multiple solar cells at the entrance of this system has made the system capable of generating the voltage and power needed to connect to the network.

REFERENCES

Chine, W., et al. (2016) *A novel fault diagnosis technique for photovoltaic systems based on artificial neural networks*. Renewable Energy 90: 501-512.

Khanaki, Razieh, Mohd Amran Mohd Radzi, and Mohammad Hamiruce Marhaban. (2016) *Artificial neural network based maximum power point tracking controller for photovoltaic standalone system*. International Journal of Green Energy 13.3: 283-291.

Krishna, D. S. G., and Mothukuri Ravali.(2016). *An intelligent MPPT controller for a PV source using cascaded artificial neural network controlled DC link.* Signal Processing, Communication, Power and Embedded System (SCOPES), 2016 International Conference on. IEEE.

Ma, Suliang, et al. (2016) *Augmented Nonlinear Controller for Maximum Power-Point Tracking with Artificial Neural Network in Grid-Connected Photovoltaic Systems*. Energies 9.12: 1005.

Makhloufi, M. T., Khireddine, M. S., Abdessemed, Y., & Boutarfa, A. (2014). *Tracking Power Photovoltaic System using Artificial Neural Network Control Strategy*. International Journal of Intelligent Systems and Applications, 6(12), 17.

Messalti, Sabir, Harrag A, and Loukriz A. (2017) *A new variable step size neural networks MPPT controller: Review, simulation and hardware implementation.* Renewable and Sustainable Energy Reviews 68: 221-233.

Ramaprabha, R., et al (2011). *Maximum power point tracking using GA-optimized artificial neural network for Solar PV system*. electrical energy systems (ICEES), 2011 1st international conference on. IEEE.