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Using The Neural Network to Track Maximum Point of Photovoltaic Cells Power and Improve Efficiency In Partial Shade Conditions

Mohammad Ali Tamayol[1,2,*] - Sina Salmanipour[1,3] – Hamid Reza Abbasi[4] - Nader Kazemi[5]

[1] Science & Act of Tohid Jam (SATJCo.),Website: www.satjco.com, E-mail: info@satjco.com
[2] M.S. student, E-mail: tamayol.ali@satjco.com
[3] M.S. student, E-mail: salmanipour.sina@satjco.com
[2] B.S. student, E-mail: abbasi.hamid@satjco.com
[4] M.S. student, E-mail: nader.kazemi@iaukhsh.ac.ir

ABSTRACT

Using solar energy has been increasing in the last decade. This has increased researcher's motivation to investigate on solar cells and improve terms of its use. Such modern methods in this field are to use smart methods to operate and track power maximum point. In this article, the smart method based on the neural network to track power maximum point even in shade conditions is used. Considering partial shade effect and maximum power point tracking in these conditions, using neural network helps to improve cell operation and decrease uncertainty effect in the cell. This method simulation has been done in MATLAB software.

Keywords: Solar cell, Photovoltaic, Maximum Power Point Tracking (MPPT), Neural Network, Partial Shade

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1. INTRODUCTION

Nowadays, using solar panels to provide energy has been taken into consideration. Solar energy is infinite, accessible, and compatible with the environment so causes photovoltaic systems have the most commercial market in the field of new energy use. Sun lighting to solar cells surfaces produces voltage and current DC. Operation of this system is very simple, so that, reaching sunlight to light energy cells (photons), it is converted into electricity directly (free from mechanical depreciation and pollution). Some advantages of this system are fast install and uninstall possibility; low maintenance costs, and installs ability in impassable areas far from the network. Regarding utilization of this energy, German government help to expand using this useful energy, which produces power 6 MW through solar radiation on the roofs and supplies 10 to 15 percent of needed energy for homes, or the largest solar power plant in the European continent (Spain) producing 5.1millionKW/h per year. One of the methods to increase energy in photovoltaic converters is to use electrical converters with proper efficiency in out of the solar panel and before consumption load to increase both solar cell voltage (around a few volts) and converter efficiency. According to equations and diagrams explained in detail in the following chapters, it can be concluded that the best work point for the converters and solar cells is the point in which highest electrical power is produced by the cell and transmitted to the load by the converter. This working point is known as the maximum power point, that various methods to obtain this point and converter working point adjusting are proposed in this work. According to the reference [2-3], it can be seen that neural networks method is one of the most appropriate and new methods for this purpose.

This method not only is compatible with non-linear nature of load and solar cells but also is programmable and usable in smart grids. a view to the future is one of the undeniable advantages of the neural network, because smart networks assign a major part of energy production and distribution network in the future, that this cause to create an appropriate space for cell usage by smart control methods [4]. However, the presence of partial shade on photovoltaic panels reduces the efficiency of these plates. Present a lag neural network method can be more effective in partial shade conditions. In this article, neural networks method to track maximum power point in partial shade conditions has been used which a lot of abilities as compared to other conventional methods. Also, this neural network method is used to control converter optimal connected to the network. This converter is a simple Boost converter that works with a saver or battery and causes loss and switching reduction and in this system. It should be noted that this method has many capabilities to match impedance, which are paid [15, 16].

After the introduction, a brief description of the neural network are stated and then at the third part we will discuss how the MPPT point is tracked by the neural network, and then the performance of the proposed method in partial shade conditions is analyzed and the results are presented.

2. NEURAL NETWORKS

The artificial neural network is a data processing system that has been inspirited from human brain and gives duty of processors data to a lot of small processor which are attached together in parallel to solve a problem. In these networks helping programming knowledge, the data structure is designed that can act as a neuron. This is called node data structure. Then the network will be trained by creating a network between these nodes and by applying an educational algorithm. In this memory or neural network, the nodes have two modes active (on or 1) and reactive (off or 0), and each edge (synapse or nodes communication) has a

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weight. Positive-weight edges stimulate or activate the next passive node, and negatively-weighted edges deactivate or control the next connected node (if it is active).

Most of the methods used to realize the maximum power point (MPPT) require detailed information about cells manufacturer materials and physical characteristics and since some information is not accessible to users, the resulting math model may be inaccurate and the estimated MPP has a significant difference with the actual MPP. However, models based on artificial neural networks (ANNs) do not require physical characteristics of the solar array.

The common property of neural networks used in PV systems is using multi-layer perceptions networks which are trained using the Back-Propagation Method (MLP-BP). This method has a slow learning speed and in addition, because of local minimum points, during the training, it might be in a sub-optimized response. So it may not be able to provide an optimal and suitable model for a special model.

Here a new modeling method based on RBF networks is presented. In a model RBFN, activation of the secret unit is determined by a gap between input and objective vectors. Such networks have two advantages: their training methods are basically faster than used BP algorithm in MLP networks, and the more important advantage is that these networks do not encounter with local minimum points. In this article RBF network has been used.

3. TRACK MAXIMUM POWER POINT

Voltage curve in terms of current and power curve in terms of the current of a solar cell is shown in Fig. 1. This curve changes with temperature and radiation intensity changing. In Fig. 2, these curves changing into temperature variations, and in Fig. 3, these curves changes into radiation intensity variations are shown.

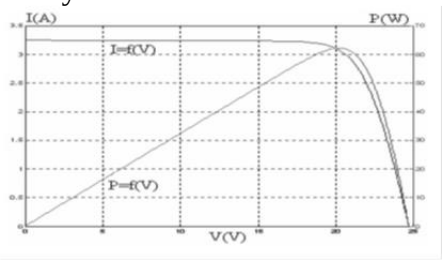

Fig. 1. *Current and power curves in terms of voltage and solar cell voltage, respectively*

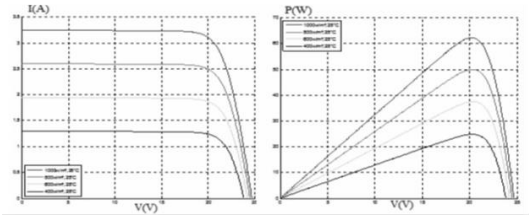

Fig. 2. *Voltage power and voltage current changes curves of solar cell due to temperature changes*

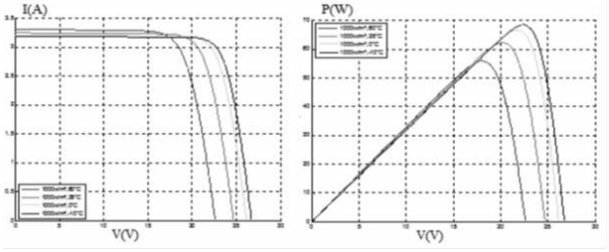

Fig. 3. *Voltage power and voltage-current changes curves of the solar cell due to radiation intensity changes*

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For constant sun's radiation intensity and temperature, the maximum power is obtained only at one point which is considered as curve knee point. In Figure 4, this point is shown. In this figure, the maximum productive power is shown as hachure.

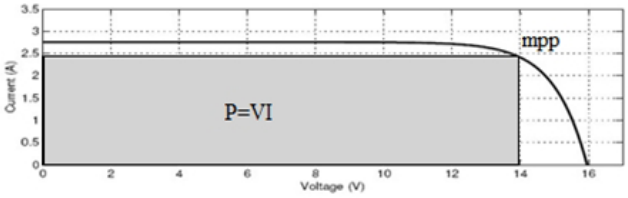

Fig. 4. *Maximum power point in a solar cell*

There is a problem that due to changes in weather, maximum power point changes regularly.
Due to the high cost of photovoltaic cells, it is needed that photovoltaic systems work in all weather conditions at different radiation levels and temperatures at the maximum power point; to this, maximum power tracker systems are used. These systems are used in systems such as photovoltaic systems and solar generators [5-6].

4. ESTIMATE MPP OF SOLAR ARRAY BASED ON RBF NETWORK

RBF network to estimate MPP using temperature and radiation samples has been used. Figure (4-5) shows the RBFN model used to estimate MPP of PV array.

The input vector is a two-dimensional vector contains radiation and ambient temperature, and the output vector includes the voltage and current at the maximum power point. The input and output vectors are as follows.

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

$$Y^{n} = \begin{bmatrix} V_{\max}^{n} \\ I_{\max}^{n} \end{bmatrix}, \quad (2)$$

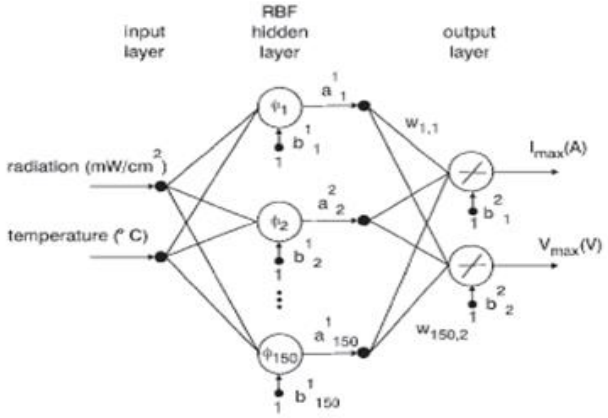

Fig. 5. *Used neural network*

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5. PROVIDE NEW METHOD AND RESULTS

Due to above subjects, the neural network can be used as the predictor for the maximum power point. Previous solar cell data is used to train the neural network and MPP point is obtained in current mode. Therefore, a standard solar cell data to train the neural network was used and neural network with neuron and the other time with 200 neurons have been trained.

In Figures 6 and 7, it is seen that the neural network converges after 13 steps. And this value for neural network with 200 neurons decreases to 9 steps that indicate appropriate convergence speed of this network.

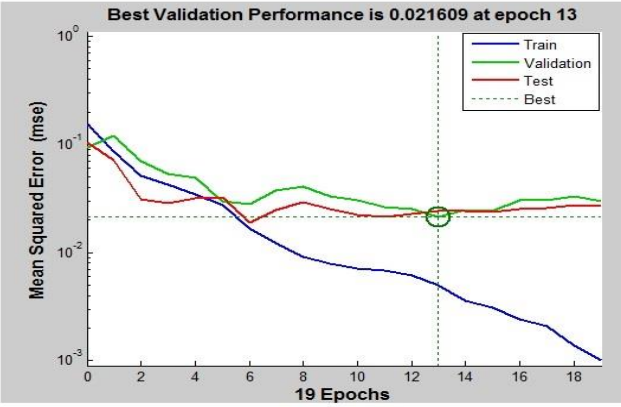

Fig. 6. *Neural network training with 100 neurons*

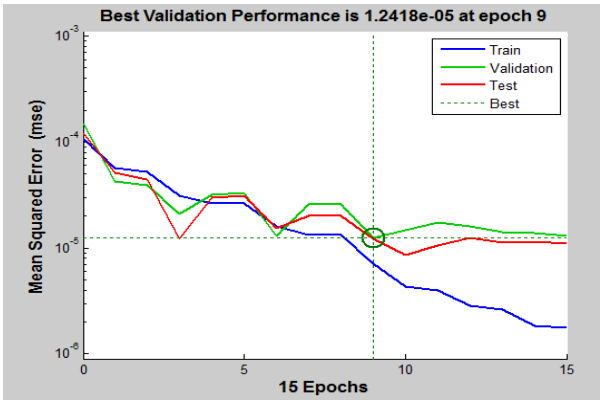

Fig. 7. *Neural network training with 200 neurons*

Here, this trained network should be able to track MPP at any moment. To this, the next day data of the solar cell is used that its results are summarized in the below table.

Table 1. *Maximum power point tracking results*

Average error	Number of Neuron in hidden layer
7 %	100
5 %	200

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It is seen from table 1, that estimated fault value by the neural network with real amount is very low and the predicted points to maximum power are too close to real point.

It is worth noting that above method adapts temperature and radiation intensity perfectly which is one of the advantages of this method. Since temperature and radiation intensity are changed as non-linear, the converter can adapt itself to these changes.

In this project, the neural network to track the maximum power point under shade conditions has been used. To this, two modes are considered. At the first mode using voltage, current, and panel's temperature the amount of light intensity is obtained and then we train the neural network that takes panels temperature and light intensity and obtain maximum power point. The relevant block diagram is shown in figure (8).

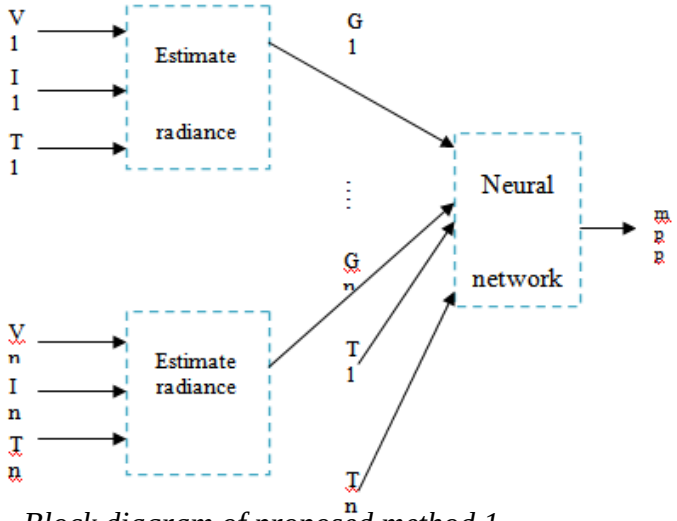

Fig. 8. *Block diagram of proposed method 1*

In the second mode, the neural network is trained that using voltage, current, and panel's temperature the maximum power point is obtained. Figure 9 shows relevant neural network to this mode. As shown in this figure, in this mode the number of neural network inputs is more and so more cases to have proper accuracy are needed to train.

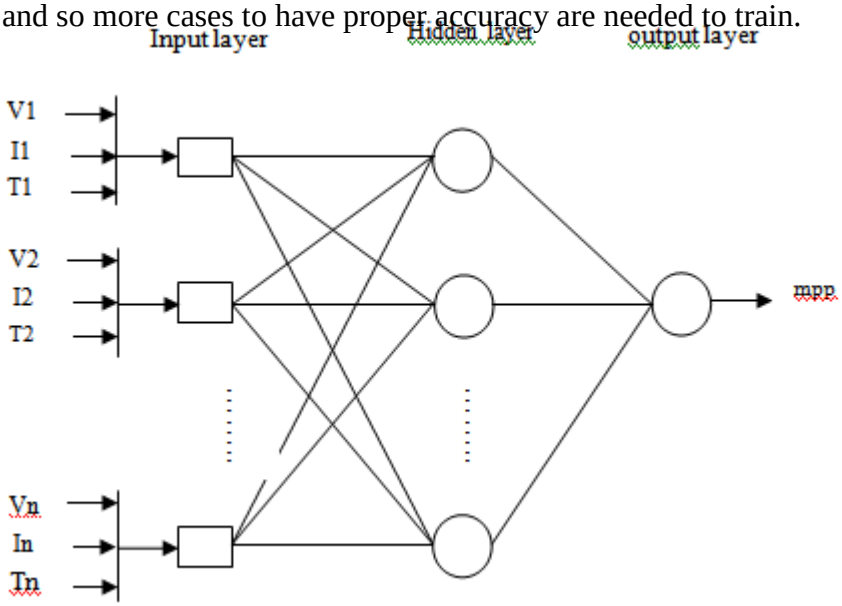

Fig. 9. *Neural network Format of proposed method 2*

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6. RESULTS

Proposed Method 1: For the fixed value of temperature and radiation are as:
The first panel light intensity: 1000 w/m^2
The first panel light intensity: 700 w/m^2
The first panel light intensity: 500 w/m^2
All three panels' temperature is the same and equal to 25^{0}C

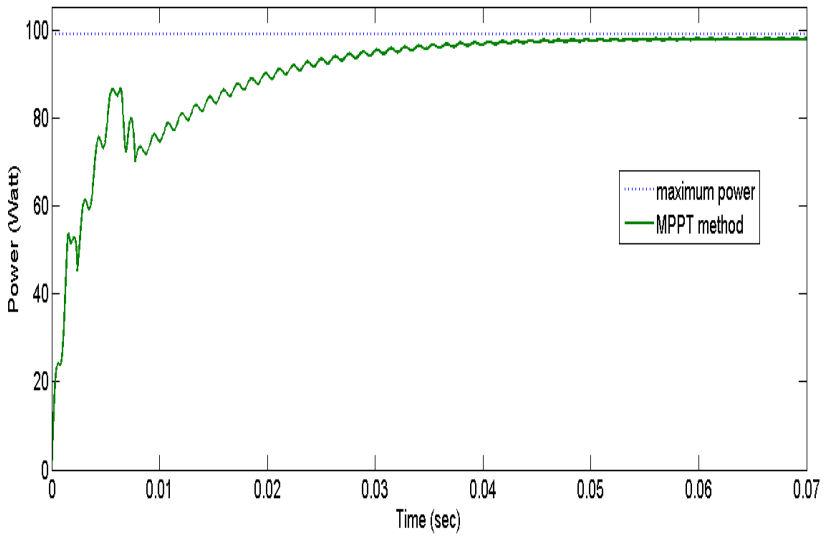

Fig. 10. *Maximum power point tracking using the proposed method 1for the constant values of light intensity and temperature in three panels*

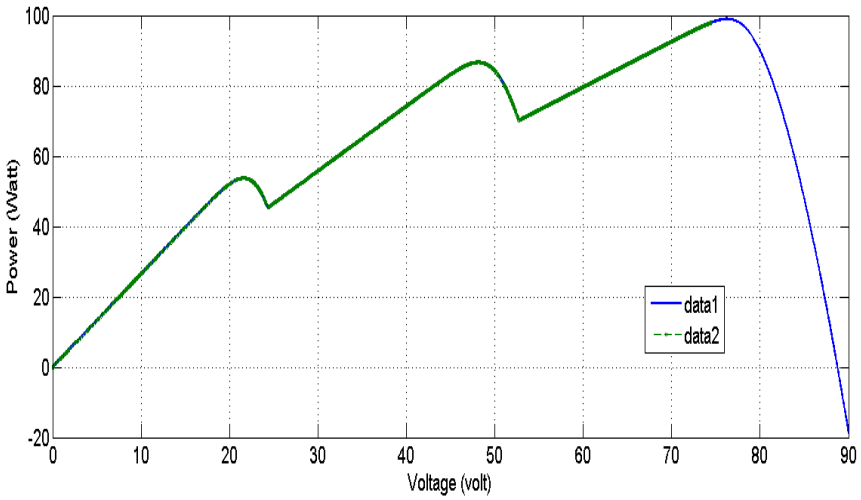

Fig. 11. *Power-voltage curve regarding figure10*

It is seen from the figure that this method has passed through the maximum local points and reached the maximum real point. For the constant value of the temperature for three panels and radiation waveforms are as:
The first panel light intensity: 1000 w/m^2
All three panels' tem temperature is the same and equal to 25^{0}C

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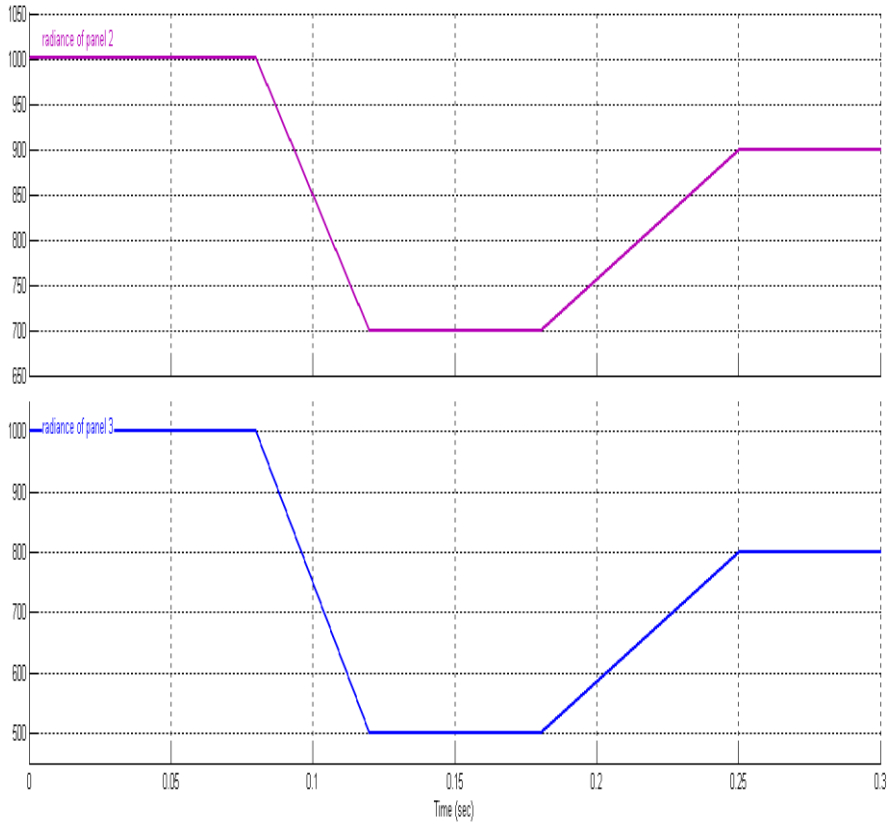

Fig. 12. *Two panels light intensity variation curve*

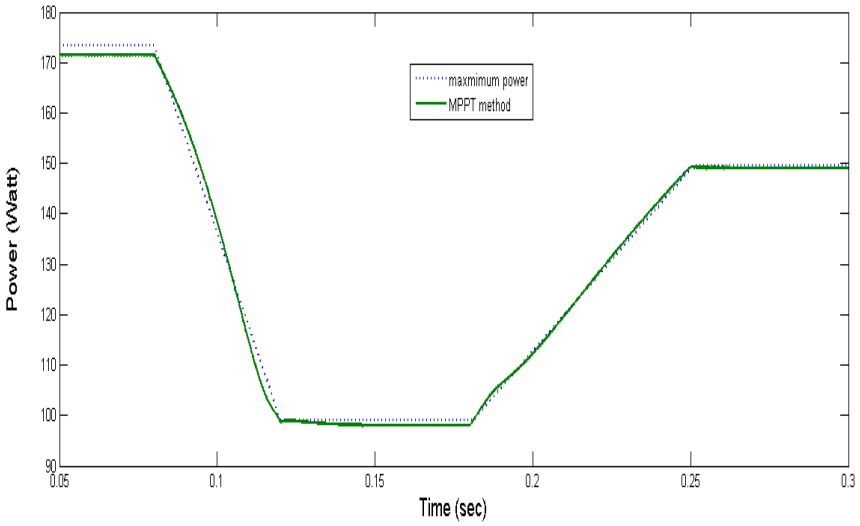

Fig. 13. *Maximum power point tracking using proposed method 1 for light intensity variations as shown in Fig. 11 and constant temperature*

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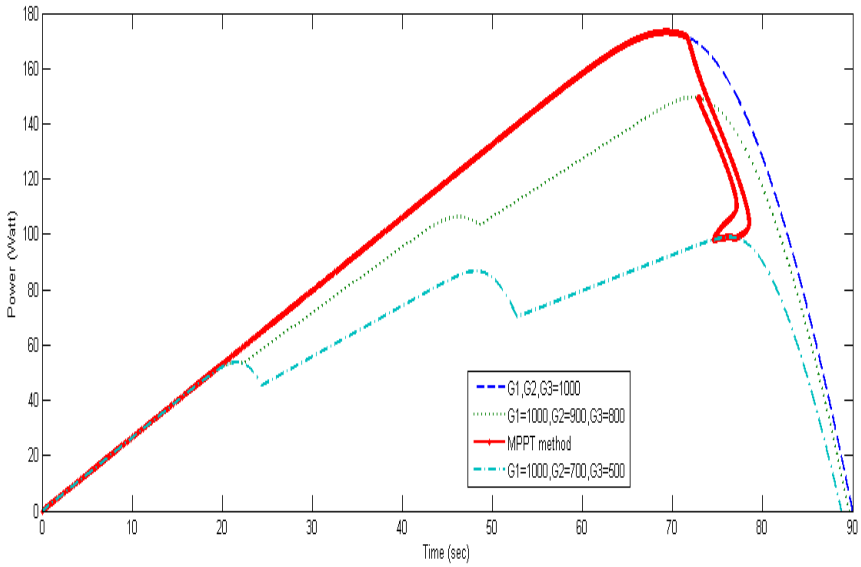

Fig. 14. *Voltage-power curve according to Fig. 13*

As shown in above figures, this method could track the maximum power point and cross through the maximum local power points.

7. CONCLUSION

Due to above subjects, the neural network can be used as the predictor for the maximum power point. Previous solar cell data is used to train the neural network and MPP point is obtained in current mode. Therefore, a standard solar cell data to train the neural network was used and neural network with neuron and the other time with 200 neurons have been trained.

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