Maximum Power Point Tracking of Solar Photovoltaic system using Artificial Neural Networks

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ABSTRACT
Solar energy is clean and renewable source of energy and its decentralized property is appropriate well at the scattered state of the zones with low density of population. The cost of electricity from the solar array system is comparatively more than the electricity from the utility grid. Therefore, it make sense to operate the PV system at maximum efficiency by maximum power point tracking (MPPT)at any given environmental condition. In this work, the neural network (NN) back propagation algorithm is used to control the operation of the PV array for maximum power point extraction. Two error functions are used. The first is classical error function and the second is a modified error function which takes into consideration the derivative of the error function also. The results obtained are compared and discussed in the current study.

General Terms
Neural Network, MPPT technique, Solar Photovoltaic System.

Keywords
Open circuit voltage, short circuit current.

1. INTRODUCTION
From last few years, whole world is experiencing aimmense need for additional energy sources so as to reduce dependency on conventional sources. Solar photovoltaic (SPV) systems could be a viable solution for this problem. Renewable energy sources like wind power systems or solar power systems etc. are getting very popular for many applications in the last four decades. It is not easy to deliver electrical energy for small applications in remote areas from the utility grid or from small generators. Stand-alone solar photovoltaic (PV) systems is one of the best solutions in many small electrical energy demand applications such as telecom, water irrigation and low power appliances in rural areas. In addition, solar energy is clean, renewable and can be utilized where it is available with its decentralized characteristics. As a result, it can add to the environmental protection and be regarded as an alternative with a future to conventional energies. There are two ways to generate electricity from sun through photovoltaic (PV) and solar thermal route. Generally, PV systems can be divided into three categories stand-alone, grid-connection and hybrid systems. For places that are far from an electric power supply, stand-alone PV power systems has been considered a good alternate. Many maximum power point tracking (MPPT) techniques have been proposed, analyzed, and implemented. They can be defined in order to overcome the undesired effects on the output PV power and produce its maximum power; it is possible to insert a DC/DC converter between the PV generator and the batteries, which can control the seeking of the MPP, besides the typical functions assigned to controllers are included. These converters are normally named as maximum power point trackers (MPPTs)[1, 2].The cost of electricity from the solar array system is much expensive compared to electricity from the national grid. Therefore it is necessary to study carefully the performance and efficiency of the entire solar PV system to design an efficient system to cover the Electricity demands with lower price. There are various external and internal factors which have an effect on the efficiency of the Solar PV panel. A resilient control using a PI regulator is used to track this maximum power point. By using Bode method the PI regulator used to control the boost DC/DC converter is synthesized by frequency synthesis. An intelligent and artificial technique to determine the maximum power point (MPP) based on artificial neural network is detailed as below. Though the approach is compared to perturb and observe (P&Q) method. The MPPT using artificial neural network proposed can surely reduce the noises and oscillations as generated by classical methods and can be a winner against other MPPT algorithms [3,4]. Also other researchers have presented a method for the control of the PV system through the MPPT using Fuzzy Logic controller. This method succeeds to lower the PV array area and increase their output, and used for control of MPPT for stand-alone PV solar system giving a minimum cost. Developed controller can be better by changing the form of the functions of memberships as well as the number of subsets [5]. Also a neuro-fuzzy controller (NFC) is designated to track the MPP. It takes advantage in conjunction with the reasoning capability of fuzzy logical systems and the learning capability of neural networks. A gradient estimator based on a radial basis function neural network is created to provide the reference information to the NFC. The parameters of NFC are updated adaptively with a derived learning algorithm. From the traditional fuzzy control the Neural Fuzzy logic is initialized using the expert knowledge, which lowers the burden of the lengthy pre-learning with a derived learning algorithmby observing the tracking errorsthe parameters in the NFC are updated adaptively. A radial basis function neural network (RBFNN) is designed to provide the NFC with gradient information, which reduces the complexity of the neural system [6].The Adaptive Neuro-Fuzzy Inference System (ANFIS) has recently been the center of attraction of researchers in scientific,engineering areas. Intelligent control technique using fuzzy logic control is associated toan MPPT controller in order to increase energy conversion efficiency and now this fuzzy logic controller is improved by using genetic algorithms (GA) [7,8].In this paper, a MPPT technique for solar PV array based on artificial neural networks is presented. Section 2 presents the solar PV cell equivalent circuit. Section 3 presents the PV array characteristics and section 4 presents the Artificial Neural

Networks feed-forward algorithm. The error function used is shown in the classical form and also a modified form of error function can be found further. The algorithm for neural network applied on the proposed system is presented in section 5 and section 6 concludes the work done in the current study.

2. THE SOLAR PV CELL MODEL

In Fig.(1) equivalent circuit of a single-diode PV model is shown on which all MPPT techniques are applied. In Fig.1, where R_s and R_{sh} are respectively the intrinsic shunt and series resistances of the cell, generally the value of R_{sh} is very large and R_s is very small, hence they may be neglected. The characteristic equations of solar cell PV model can be written as :

$$I = Iph - Irs\left(\exp(\frac{qV}{akT}) - 1\right)$$

$$I = \left[1 - \frac{\exp\left(\frac{V}{K_T}\right) - 1}{\exp\left(\frac{V_{oc}}{K_T}\right) - 1}\right]$$ Where,

$$K_T = \frac{kTa}{q}$$

I = Output current(A),
V =Output voltage (V),
I_{ph} = Cell photocurrent,
I_{rs}= Cell reverse saturation current,
q = The charge of an electron,
k = Bolzmann's constant,
a= P-N junction ideality factor,
T= Cell temperature,
V_{oc}= open circuit voltage,
I_{sc} = short circuit current

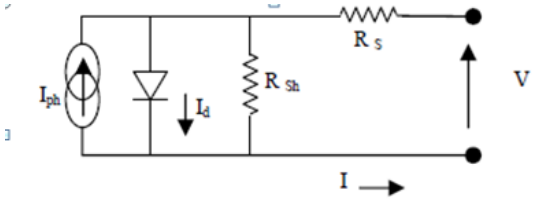

Fig 1: Equivalent circuit of Solar Cell

3. MPPT TECHNIQUE USING NEURAL NETWORK

Artificial Neural network technique has range of applications in industrial electronics and has large prospects in intelligent control domain. In this technique biological brain neural network is applied into mathematical models, hence the author have expand on its application in the field of MPPT for solar photovoltaic systems.

3.1 *Neural Networks Techniques*:-

Another MPPT method well fitting to microcontrollers is Neural Networks [8]. The Basic *Neural Network* (NN) has three layers, the input layer, hidden layer and output layer, adding more hidden layers leads to complicated NN. The number of layers and the number of nodes in each layer as well as the function used in each layer varies and depend on the user knowledge. The parameters of the PV array are the input variables such as V_{OC} and I_{SC}, atmospheric data as irradiation and temperature or a combine of these. The performance of the neural network depends on the functions used by the hidden layer and how good the neural network has been designed. The connection between the nodes is all weighted. The weight between the nodes *i* and *j* are labeled as w_{ij}. These are adjusted in the training operation. To perform this operation process, data of the patterns between inputs and outputs of the neural network are recorded over a larger period, so that the maximum power point can be tracked .The main drawback of this is that the data needed for the training process has to be specifically acquired for every PV array and for each location, as the feature of the PV array vary depending on the model and the atmospheric conditions . The features of the neural network have to be periodically trained.

3.2 Neural Implementation-

Solar PV-module for a specific irradiation along with cell temperature. If irradiation and temperature are varied, we observe that the output characteristics of solar PV-module are nonlinear in nature and each curve only has one MPP. The output current of PV module is majorly affected by solar irradiation variation, whereas the output voltage of solar PV-module is purely affected by temperature variation. Hence, to efficiently use solar PV module, if the atmospheric conditions are changed, the MPP tracking of solar PV-module should be implemented for best efficiency. This working presents an different method to identify the best operating point to achieve the maximum output efficiency of the solar PV modules using a neural network. The input to this is cell temperature and the solar irradiance.

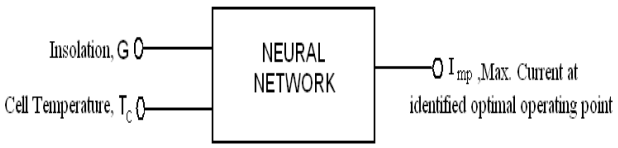

Fig 2: Block diagram for optimal operating point in MPPT

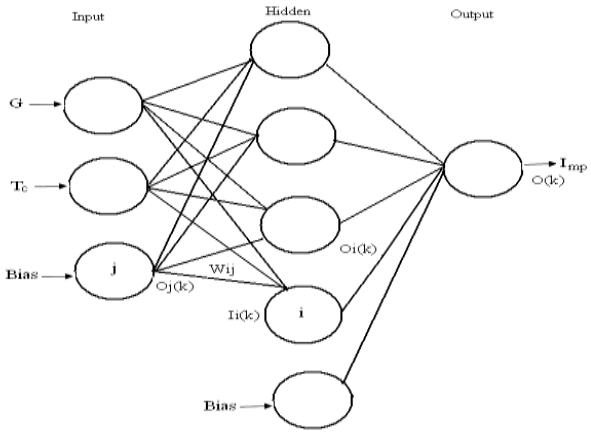

Fig 3: Configuration of Neural Network

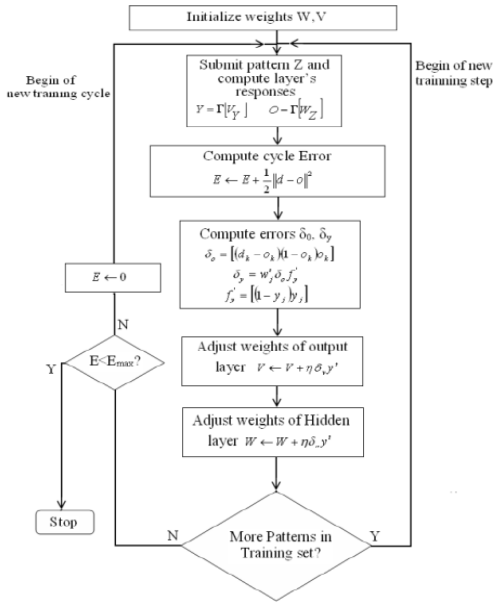

Fig 4: Error Back Propagation Training Algoritm Flowchart.

4. CONCLUSION

Focusof this paper is to initiate the use of neural network in the power output control of a solar pv. It is compared with other maximum power point tracking process also showed improvement in the power output value and in the response time. All Simulations shows that that even under different atmospheric conditions the neuronal controller responded better than the other methods. This method shows that it could be applied to massive, tangled and nonlinear systems and stabilize the idea that it may have much betterresult over the others. Neural network method reduces disadvantages which appear in the traditional or previous methods.

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