ANALYSIS OF ARTIFICIAL NEURAL NETWORK IN A PHOTOVOLTAIC SYSTEM TO EXTRACT THE MAXIMUM POWER IN A PHOTOVOLTAIC BASED SYSTEM PARADIGM

Elzein Imad
Department of Electrical Engineering, Belarusian National Technical University
Minsk, Belarus
E-mail: elzein1@hotmail.com

When implementing a photovoltaic system, different parameters play an integral part in enhancing the extraction of the maximum power of a solar setup. One of those parameters is the maximum power point tracking (MPPT) algorithm which is used to track and extract the maximum power Pmax when we refer to PV energy productivity. In this research, we will introduce a new scheme of tracking the Pmax using an artificial neural network (ANN) in different dynamic environmental conditions. The proposed artificial neural network (ANN) based PV model is going to be applied and utilized with a perturb and observe (P&O) algorithm. The improvement of using ANN in PV system would improve its ability to detect MPP at a short period of time as compared to other available methods.

Introduction

As we start thinking of renewable energy and photovoltaic systems the theme of maximum power point tracking algorithm is currently moving forward to play such a vital and essential role as we start thinking of the efficiency of the solar panel. The future of solar panels is promising according to many literature surveys and the commencement of thinking to rely on solar energy encouraged us to develop an approach to benefit from these solar radiations and convert them into a new transformation in the form of electrical energy. In fact we have to admit that the high demand and reliance on electricity worldwide, and since this source cannot keep abreast with appropriate and sufficient delivery of this supply, high electricity bills, uprising fuel prices, and pollution drove us to integrate and implement the usage of photovoltaic energy to be another alternative and promising source of energy as it is, accessible, environmentally very promising as we stress out clean environment, with an extra bonus of decreased bill to operate. In the past years it was proved that photovoltaic systems were merged gradually in standalone and grid connected modes of PV systems. [1]

It is known by so far that a PV system arrays is used to convert sunlight into electricity. The quantity of the direct current generated takes into consideration two parameters; where it relies on the irradiance and temperature. In addition to that a variation may take place due to the other parameter in a PV system which is the load.

As known from a (P-V) curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with the solar irradiation, and cell temperature. Therefore, on line tracking of the maximum power point of a PV array is an essential part of any successful PV system. A variety of maximum power point tracking (MPPT) methods are developed. The methods vary in implementation complexity, sensed parameters, and required number of sensors, convergence speed, and cost [2].

When a PV system operates at the standard test conditions and through a uniform temperature and irradiance, the photovoltaic arrays exhibits an I-V characteristic along with a maximum power point. This Pmax point is important to be tracked to allow the PV array generates a maximum output power and this is can be performed by adapting a maximum power point tracking (MPPT). Many researchers investigated a range of MPPT algorithms that are well known and each has its own advantages and disadvantages [3].

Comparison among those MPPT leads to investigate parameters such as convergence speed and the work done was related to the time of detecting the maximum power point MPP [4].

I. Literature review

One of the controllers applied in PV systems was fuzzy logic which was applied in manipulating various MPPT controllers. The main theme of fuzzy logic relies on constructing linguistic rules sets to conclude the required change in duty cycle (ΔD), and its inputs are an error (E) in the current or voltage of PV panel and the change in error (CE).

The new approach of integrating neural networks and its applications in estimating maximum power generation was addressed as per the voltage corresponding to the maximum power based on reference open circuit voltage of the PV panel and a time parameter. In other literature reviews the maximum power generation was calculated based on two environmental conditions known through the irradiation and temperature levels.

II. PV system

The PV system considered in this paper is shown in Fig. 1. The following is discretion of each component. The system consists of a PV solar panel, a dc-dc power converter, controller and a system load.

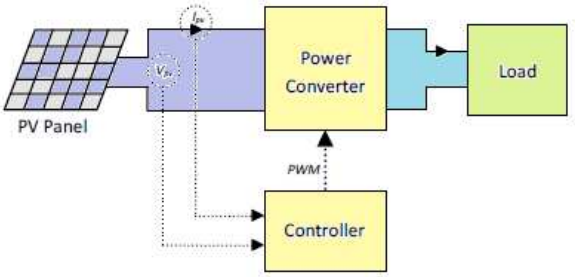

Рис. 1 – PV system architecture

As a result of the majority of utilized methods implemented to seek MPPT, experts in the field of PV systems have displayed an overview of investigating maximum power point tracking procedures. Indeed, few papers present relative research and studies among a narrow set of methods. To select the suitable and desirable maximum power point, proper tracking will be presented between the PV system and definitely the load. Efficiency plays an integral role in PV systems and the photovoltaic is influenced by irradiance falling onto the solar panel and temperature which cannot be forecasted or being known ahead of time, hence, it's unrealistic if we are seeking maximum power to go ahead and make a direct interconnectivity between the load and the PV and thus to create what is known as a photovoltaic balance of system (BOS). Technically speaking balance of system is active inside DC-DC converters and its role is to alter the characteristics of the load. Thus, such converter has a function of maximizing the power as being sent to the load. Hence, the important role of a DC/DC converter in a PV system is primarily being accountable for transferring Pmax from the solar panel to the load. This goes about as conformity to match impedance of source and load. Such converters are equipped with MPPT and those DC-DC converters can produce a low or high DC voltage. Maximum power point (MPP) position is unfortunately unknown; however, it can be located by calculation models or via search algorithms. [5]

III. Artificial neural networks

In this research the approach is to apply an analysis study of a neural network to provide thorough accuracy in reaching the maximum power point (MPP) through the utilization of an MPPT tracking algorithm such as the Perturb and Observe (P&O) algorithm.

Identifying the maximum power point (MPP) will provide the proper feedback for the controller to take the appropriate steps in moving the operating point towards the maximum power point through a set of accomplishments, namely, a faster response time and steady reliable tracking of the optimal power point. Fig. 2 shows the PV system with the neural network and P&O MPPT controller.

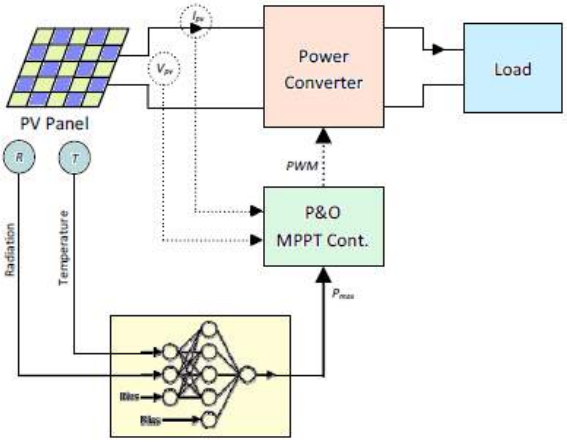

Рис. 2 – PV system module

It is important to note that the objective of the designed neural network is not to track the MPP, but to help the controller achieve a better tracking performance by providing it with the estimated maximum power corresponding to the current atmospheric conditions. In the previous section, fuzzy logic was applied in the controller itself as a tracking strategy.

The P&O MPPT strategy is simple and easy to implement. However, it experiences a trade-off between tracking time and output power stability. Knowing the value of the maximum generated power (P_{max}) can help in overcoming this trade-off problem and enhance the performance of the controller.

The design of the neural network and the controller are now discussed.

IV. MPPT controller based on neural network

Over the past years many research studies have been addressing ANN based techniques. In this regard, the main parameters of a photovoltaic system module are the well known two variables; temperature (T) and irradiation (G). These variables are fed to an ANN as incoming variables.

At the other output stage, the output is represented through the duty ratio acquired and then forwarded to a DC-DC boost converter that regulate and control the voltage to its optimal value.

Figure 3 demonstrates the proposed MPPT setup as shown below.

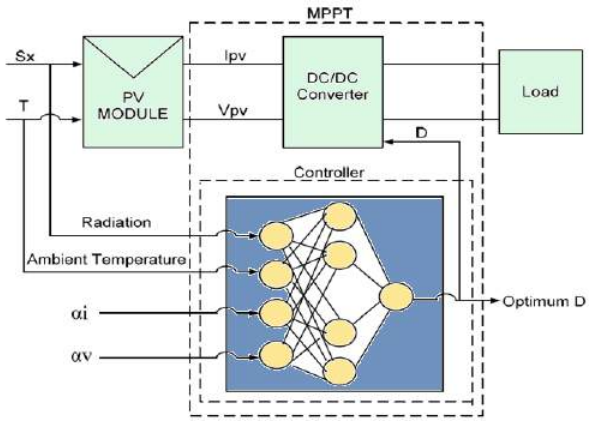

Рис. 3 – ANN proposed MPPT module

An input value is assigned at the incoming layer and so forth for the next layers where hidden layer encompasses several neurons received after the 1st layer and then forward the values to the output layer. After this process is accomplished the output layer delivers values of the duty ratio to the main module.

In the following equations the input and output values are carried out:

$$y_j^h = f(\sum_{i=1}^{N} W_{ij} X_i + \theta_j^h) \quad (1)$$

$$y_k^o = f(\sum_{j=1}^{Nh} W_{kj} Y_j^h + \theta_k^o) \quad (2)$$

In this analysis we propose two phases and stages to track the maximum power point MPP. During the first phase a set of trained data (ANN) is used to drive the reference current (Iref) and reference voltage (Vref) to an optimal current (I_{opt}) and optimal voltage (V_{opt}) to reach the maximum power point.

V. Conclusion

This paper addressed an analysis of applying an artificial neural network in a photovoltaic system to extract the maximum power in a photovoltaic based system. The discussion throughout this analysis was to suggest utilizing the ANN due to its fast response to changes with respect to dynamic weather factors and its accuracy in detecting the maximum power point.

1. I. Elzein. Integration of a Predictive Control Model and MPPT for PV Station. International Conference on Smart Systems and Technologies (SST). IEEE proc., ISBN: 978-1-5090-3720-9, Oct 2016.
2. M. Elzein. Integrating a P&O through a Variable Steps Fuzzy Logic Control for a Photovoltaic System to Track the Maximum Power Point. International Conference on Advances in Computing and Technology (ICACT–2020) Proceedings.
3. Trishan Esram, Patrick L. Chapman, Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques,"IEEE Trans. Energy Conversion, vol 22, No.2 June 2007.
4. Carlos A.P.Tavares,Karla T.F.Leite, WaIter I. Suemitsu, Maria D.Bellar "Performance evaluation of photovoltaic Solar system with different MPPT methods,"in 1ECON 2009 proceedings, Page 716-721.
5. Elzein, I. Maximum Power Point Tracking System for Photovoltaic Station: A Review. Journal of System Analysis and Applied Information Science, Minsk, Vol.3, 2015, pp.15-20. Universal Decimal Classification (UDC) 620.92+502.174.3