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"Implementation of MPPT technique in Solar PV System using Artificial Neural Networks"

[1]Suraj Patidar, [2]Deepak Kumar Patidar, [3]Hemendra Khedekar

[1]MTech Scholar, [2]Assistant Professor (HOD), [3]Assistant Professor
[1,2,3] Electrical & Electronics Engineering Department
[1,2,3]Swami Viviekanand College of Engineering, Indore, India

Abstract: The major challenge with tapping solar energy using solar cells is the variable and intermittent nature of solar energy. The maximum power point tracking (MPPT) is the technique to maximize the output of the solar panels. While conventional technique have been used for attaining the condition of MPPT, off late neural networks have been used as the mathematical model to optimize the values of voltage and currents of the panel in order to attain the condition of MPPT. The Maximum power point tracking (MPPT) is critical in the design and use of solar PV cells, and harnessing the maximum power from them. Neural networks have the advantage of being able to process complex data patterns in real time with high accuracy. In the proposed work, the Levenberg Margaret (LM) algorithm has been used to train a neural network with training features. Subsequently, the neural network is tested and an accuracy of 98.84% has been achieved. The high accuracy can be attributed to the structuring of the training data and the effectiveness of the Levenberg Margaret back-propagation algorithm which is both fast and stable. The performance of the system has been evaluated in terms of the number of epochs for training, the mean absolute percentage error, accuracy and regression.

Index Terms –Maximum Power Point Tracking (MPPT), Solar panel, Solar radiation, Artificial Neural Networks, **MATLAB, simulation**

I. INTRODUCTION

The world is moving towards rapid advancement in technology and digitization. The requirement of energy has increased manifolds. It is an important element of today's life. The energy can be categorized mainly into two types that are- Renewable and non renewable sources. The renewable sources of energy can be renewed and created whereas the non renewable ones shall deplete with extensive use. Proper use of the

renewable energy resources has to be planned with prudence. Still many of the industries and factories in the world rely on the non renewable energy sources. Like the fossil fuels are extensively utilized by the power sector. But not only these fuels are on the verge of depletion but also their use poses harmful impact on the environment and ecology.

There are many kinds of renewable energy sources that are harnessed in the recent times. The major ones are wind, biomass, solar, geothermal, hydro power and tidal energy source. The energy harnessed through the sun's irradiation and heat is the solar energy. Predicting the accurate amount of solar irradiance and the measure of solar power is called MPPT.

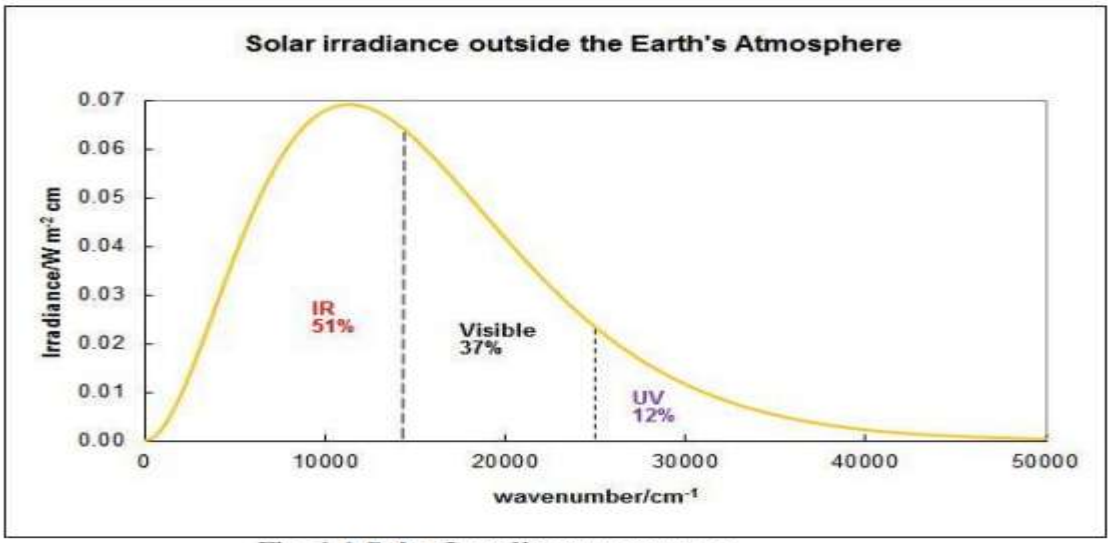


Fig. 1.1 Solar Irradiance spectrum.

Solar power is a very powerful source of renewable energy. Today the use of solar power is very prevalent and popular. It helps to utilize the energy of sun, using it locally at households or institutions. Below are some the prominent uses of solar power:-

- Photovoltaic Energy makes use of solar powered cells that directly convert the solar power into electricity. This is of immense use

  and is used in day to day life. With its help batteries can be recharged easily.
- Solar heating systems are used to heat the water stored. It uses the sunlight for heating the water. It is very much common.
- Solar lighting is another application of the solar energy use that uses the solar light for lighting and illumination
- Solar cars are also being used and tested. The solar panels built on the surface of the cars capture the sunlight and turn the Solar power into electricity to drive the vehicle.
- Satellites that are solar powered are also used and is an example of application of Solar Energy

II. LITERATURESURVEY

The significant previous work in the domain has been summarized here with the salient features. Previous work in the domain helps in formulating the problem domain and renders an idea into the basic mechanisms that have been already used for the purpose of transformer fault location. The different contemporary work of authors has been cited here with their merits and approaches.

In [1], C Robles Algarín et al. in MDPI 2018 proposed the design, modeling, and implementation of a neural network inverse model controller for tracking the maximum power point of a photovoltaic (PV) module. A nonlinear autoregressive network with exogenous inputs (NARX) was implemented in a serial-parallel architecture. The PV module mathematical modeling was developed, a buck converter was designed to operate in the continuous conduction mode with a switching frequency of 20 KHz, and the dynamic neural controller was designed using the Neural Network Toolbox from Matlab/Simulink (Math Works, Natick, MA, USA), and it was implemented on an open-hardware Arduino Mega board.

In [2], Ramji Tiwari et al. in MDPI 2018 presented an artificial neural network (ANN) based maximum power point tracking (MPPT) control strategy for wind energy conversion system (WECS) implemented with a DC/DC converter. The proposed topology utilizes a radial basis function network (RBFN) based neural network control strategy to extract the maximum available power from the wind velocity. The results are compared with a classical Perturb and Observe (P&O) method and Back propagation network (BPN) method. In order to achieve a high voltage rating, the system is implemented with a quadratic boost converter and the performance of the converter is validated with a boost and single ended primary inductance converter (SEPIC)

III. *PROBLEM DOMAIN*

The demand for energy is increasing manifold with each continuously while the supply doesn‘t grow at that pace.. The renewable are at present the favorites to replace fossil-based plants due to abundance in nature and pollution free nature. Following are some of the advantages of solar PV systems:

1. Such systems are static devices has no moving parts make them service and maintenance free and easy to mount.
2. One can buy and install PV System easily and according to required specification of output.
3. Such systems output can easily be increased by adding more modules either in series to expand the system‘s voltage or in parallel to enlarge the current.
4. Such systems are designed with high durability to withstand high temperature, humidity, wind speed and moisture, or rugged condition
5. Such Systems can have storage capability to give consistent, high-quality power output even when the sun isn‘t shining.
6. such systems cause no noise or pollution making them eco friendly.

IV. PROPOSEDMETHODOLOGY

Basic Types of PV Cells

PV cells are designed with different shapes, sizes and connections based upon uses and benefits over other. Some of the common type of PV cells are discussed below

- Mono-crystalline cells:

Such cells are drawn from the single crystal of silicon as shown in figure 1.2. Dew this nature only such cells are costly to produce but they are very smooth in texture.

Fig. 1.2 Mono-crystalline PV cell

- Poly-crystalline cells:

Such cells are made of man number of crystals of silicon as shown in figure 1.3. This property makes them way cheaper than mono crystalline PV cell. There efficiency is also poor.

Fig. 1.3 Poly-crystalline PV cell

- Amorphous cells:

The main benefit of such cells is that they are flexible and can be used in any place required regardless of surface. This cell is formed by placing a thin layer of silicon crystal over a wide range of surfaces. They are least efficient out of three yet are cheapest of all.

Fig. 1.4 Amorphous PV cell

Characteristics of PV Cell

Solar PV cells have a nonlinear characteristic where the output is directly dependent on the value of incident solar radiation and cell temperature. By varying the value of this two the output changes which is show in following figures

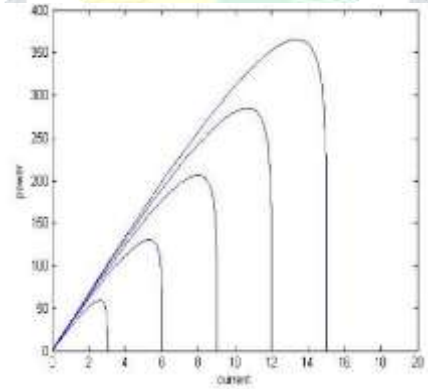


Fig. 1.5 Effect of temperature changes on P-V curves

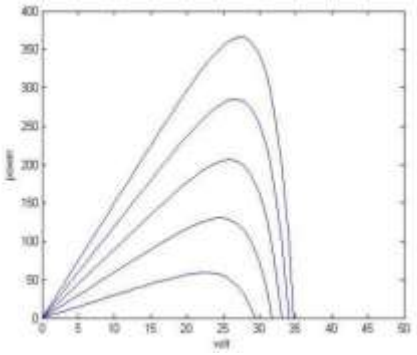


Fig. 1.6: Effect of solar irradiance changes on P-V curves

IV. RESULTS AND DISCUSSION

The model has been simulated on MATLAB 2017a primarily due to the viability of standard training algorithms' as inbuilt functions. The results obtained are put forth sequentially.

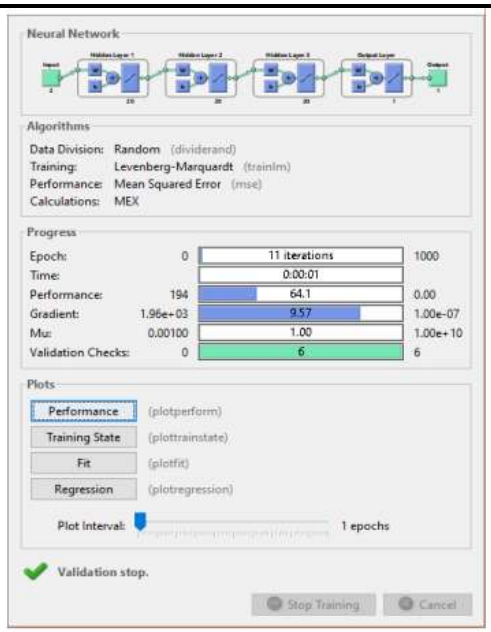


Fig. 1.7 Designed Neural Network with training parameters

The training is stopped once the MSE stabilizes and the validation checks are carried out successfully. The mentioned concept is implemented and shown in the figure below.

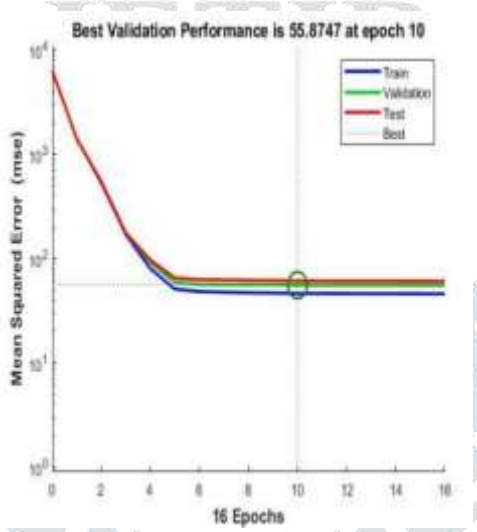
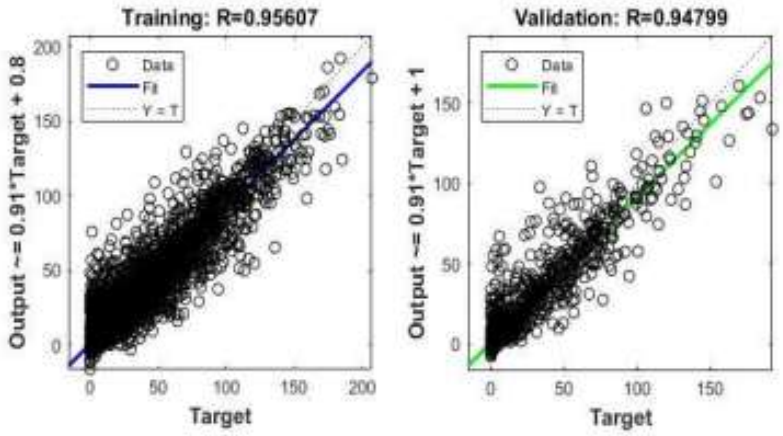


Fig. 1.8 MSE variation as a function of iterations

In above graph depicts the variation of MSE w.r.t. epochs and it can be seen that as the error stabilizes, training stops. The mse for training, testing and validation have been shown.

The level of similarity or on the contrary the amount of deviation between the actual and predicted values can be evaluated using the regression analysis. A closer measure of regression to unity indicates better result.



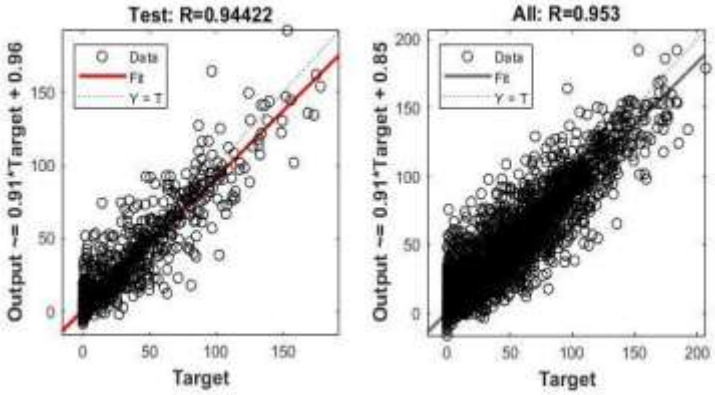


Fig. 1.9 Regression analyses

The above figure represents the regression obtained in the proposed system. The overall regression is around 0.95 which is very close to unity

V. CONCLUSION & FUTURE SCOPE

The unsustainable nature of the fossils creates need for an alternative nature friendly energy sources. Henceforth renewable energy resources are the need of the world today. Proper and adequate renewable energy production and feasibility of usage is required to make it more widespread and prevalent. Solar power is one of the most reliable renewable sources of energy and holds strong potential for harnessing energy from it. If used in an effective method, it can aid in meeting high energy requirements in today high energy demanding economy. But one of the flipsides to the solar power energy is its uncertainty of the measure of energy that can be actually obtained. Among all the renewable resources of energy, like wind energy, geo thermal energy and tidal energy, the energy from solar power is subjected to the most fluctuations and variations as the solar irradiation keeps on changing and varying with time owing to various reasons related to natural phenomenon.

This causes the amount of energy that can be harnessed at a given time as non determinable It can be concluded form the previous discussions that photovoltaic (PV) array is subject to partial shading conditions (PSC), several local maxima appear on the P-V characteristics curve of the PV array which are due to the use of the bypass diodes to avoid hot spots effect. The appearance of these multiple peaks on the characteristics of PV array makes the tracking more difficult under these conditions and requires the integration of a more efficient power control system which is able to discriminate between local and global maxima to harvest the maximum possible energy and therefore increase the efficiency of overall system.

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