PERTURB&OBSERVE METHOD AND ARTIFICIAL NEURAL NETWORK BASED MPPT ALGORITHM FOR SOLAR PV SYSTEM

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Abstract : This paper proposes Maximum Power Point Tracking (MPPT) of a photovoltaic system below variable temperature and solar radiation conditions. The cost of electricity from the PV array is more expensive than the electricity from the other non-renewable sources. So, it is necessary to operate the PV system at maximum efficiency by tracking its maximum power point at any weather conditions. In this paper Maximum Power Point Tracking (MPPT) controller for solar photovoltaic system is developed by practicing artificial neural network (ANN). Also the performance of an ANN based MPPT controller is compared with Conventional MPPT method. The issue of MPPT has been addressed in different ways in the literature but, specially for low-cost implementations, the perturb and observe (P&O) maximum power point tracking algorithm is the most commonly used method due to its ease of implementation. The effectiveness of proposed algorithm is validated using Matlab/Simulink.

IndexTerms - Artificial neural networks, Maximum power point tracker algorithms, Solar PV panel.

I. INTRODUCTION

Solar energy is viewed as clean and renewable source of energy for the future. So the use of Photovoltaic systems has increased in many applications. Wide spread usage has led to reduced costs in the manufacturing of solar panels. But one of the most important issues remains the low efficiency of a solar panel due to factors like solar isolation, clouds and shading effect. A maximum power point tracking algorithm is required to increase the efficiency of the solar panel as it has been found that only 30-40% of energy incident is converted into electrical energy [1].

Since photovoltaic electricity generation is clean, inexhaustible, pollution less and requires less maintenance they are the most promising renewable energy source. The main advantage of using solar PV system is that it does not consist of any moving parts and it does not produce any noise. Solar photovoltaic array converts solar energy obtained from Sun to electrical energy. The efficiency of solar PV system is low while comparing with other renewable energy sources but it would be more beneficial if it can track maximum power continuously for any change in environmental conditions like solar emanation and temperature. That is why the concept of tracking maximum possible power from solar PV arrangement is established. Therefore it is essential to track MPP online. Solar power mainly depends on temperature and solar emanation conditions [2].

A photovoltaic (PV) array under uniform irradiance exhibits a current-voltage characteristic with a unique point, called the maximum power point (MPP), where the array produces maximum output power. Maximum power point tracking (MPPT) techniques are used in photovoltaic (PV) systems to maximize the PV array output power by tracking continuously the maximum power point (MPP) which depends on panel's temperature and on irradiance conditions. The issue of MPPT has been addressed in different ways in the literature but, especially for low-cost implementations, the perturb and observe (P&O) maximum power point tracking algorithm is the most commonly used method due to its ease of implementation [3].

Photovoltaic (PV) system is gaining increased importance as a renewable source due to advantages such as the absence of fuel cost, little maintenance and no noise and wear due to absence of moving parts. But there are still two principal barriers to the use of photovoltaic systems: the high installation cost and the low energy conversion efficiency. A PV panel is a non-linear power source, i.e. its output current/power depends on the terminal operating voltage and the maximum power generated by the system changes with solar radiation and temperature. To increase the ratio output power/cost of installation it is important that PV panel operates in maximum output power (MPP) [4].

The ever increasing demand for energy along with global warming has led to the exploration of alternative renewable energy source. Photovoltaic energy is one of the most important renewable energy resources having the advantage of cleanliness, less maintenance and no noise operation. PV systems have been extensively used for low power electrical generation and have the applications such as water pumping and air conditioning in rural and isolated areas. It is very difficult to establish a new utility system in rural area because of cost and maintenance consideration. A DC-DC converter with high voltage gain is employed to step up the output DC voltage from the PV module to a high voltage level without losing the overall efficiency of the system [6].

The PV modules have maximum operating points corresponding to the surrounding conditions such as solar irradiance, and ambient temperature. DC-DC converters may be used to regulate the voltage and current at the load, and mainly to track the maximum power point (MPP) of the PV module [7]. Solar energy is one of the most easily existing resources of energy due to the ease of accessibility of sun rays. Now a day, harnessing of electrical energy from the sun has become cheaper due to the

availability of low cost of PV modules. One drawback of solar energy is the alternating nature of solar energy due to which there are fluctuations in the amount of output power [8].The objective of this paper is to develop an artificial network based MPPT algorithm and to compare with other peak power point tracking algorithms.

II. EQUIVALENT CIRCUIT AND CHARACTERISTICS OF PV

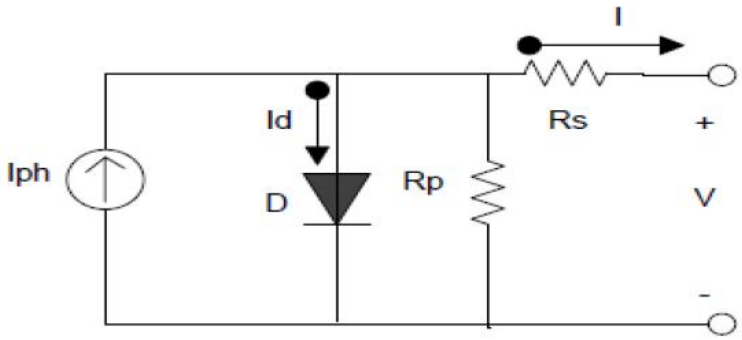


Fig1. Equivalent circuit of a solar cell

$$I_{rs}=I_{rr}*\left(\left(\frac{T}{Tr}\right)^3\right)*\exp\left(\frac{q*Eg}{K*A}\right)*\left(\left(\frac{1}{Tr}\right)-\left(\frac{1}{T}\right)\right)$$

$$I_0=Np*I_{ph}-Np*Irs*\exp\left(\frac{q}{[(K*T*A)*(\frac{V0}{Ns})-1]}\right)$$

Where

I_{ph}	Photo current (A)	V_{oc}	Open circuit voltage
I_0	Diode saturation current(A)	I_{sc}	Short circuit current
q	Electron charge ,$1.602*10^{-19}$ C	V_{mp}	Voltage at the maximal power point
n	Diode factor	I_{mp}	Current at the maximul power point
k	Boltzman constant,$1.3865*10^{-23}$ J/K	I_d	Current through the diode
G	Irradiance(W/m^2)	I	PV module current(A)
R_s	Series resistance	V	PV module voltage(V)
R_p	Shunt resistance	V_t	Terminal voltage(V)
E_g	Silicon gap energy of semiconductor	n_s	Number of cells in series

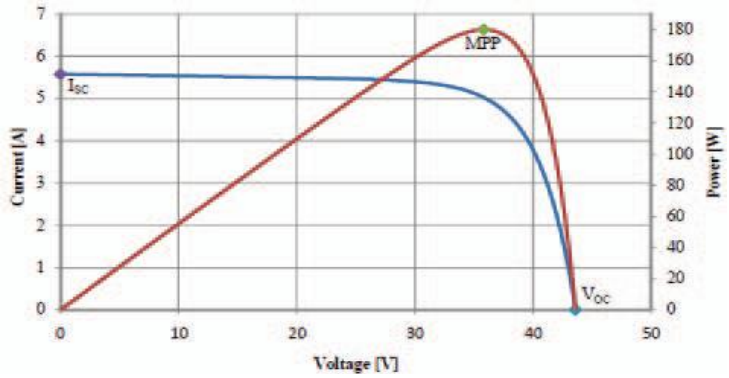


Fig. 2. I-V and P-V characteristics of solar PV system

The solar temperature and irradiance are two factors to be considered. The effect of the emanation on the characteristics of solar PV entity is shown in Fig. 2. The output current of solar photovoltaic panel is directly proportional to the irradiance. Therefore, every increase in solar irradiance stage lead to rise in the output current of solar PV array. Also I_{sc} of solar PV is directly equivalent to output current of solar PV array. Therefore short circuit current is also directly equivalent to emanation level. For this reason V-I characteristics changes according to irradiance level (There is no effect in open circuit voltage).Change in temperature will affect the change in voltage.

III Perturb & observe method(P&O):

The P&O also called as hill climbing method. Which MPPT algorithm is mostly used, due to its ease of implementation. It is based on the following criterion if the operating voltage of the PV array is perturbed in a given direction and if the power drawn from the PV array increases, this means that the operating point has moved toward the MPP and, therefore, the operating voltage must be further perturbed in the same direction. Otherwise, if the power drawn from the PV array decreases, the operating point has moved away from the MPP and, therefore, the direction of the operating voltage perturbation must be reversed.

A drawback of P&O MPPT technique is that, at steady state, the operating point oscillates around the MPP giving rise to the waste of some amount of available energy. Several improvements of the P&O algorithm have been proposed in order to reduce the number of oscillations around the MPP in steady state, but they slow down the speed of response of the algorithm to changing atmospheric conditions and lower the algorithm efficiency during

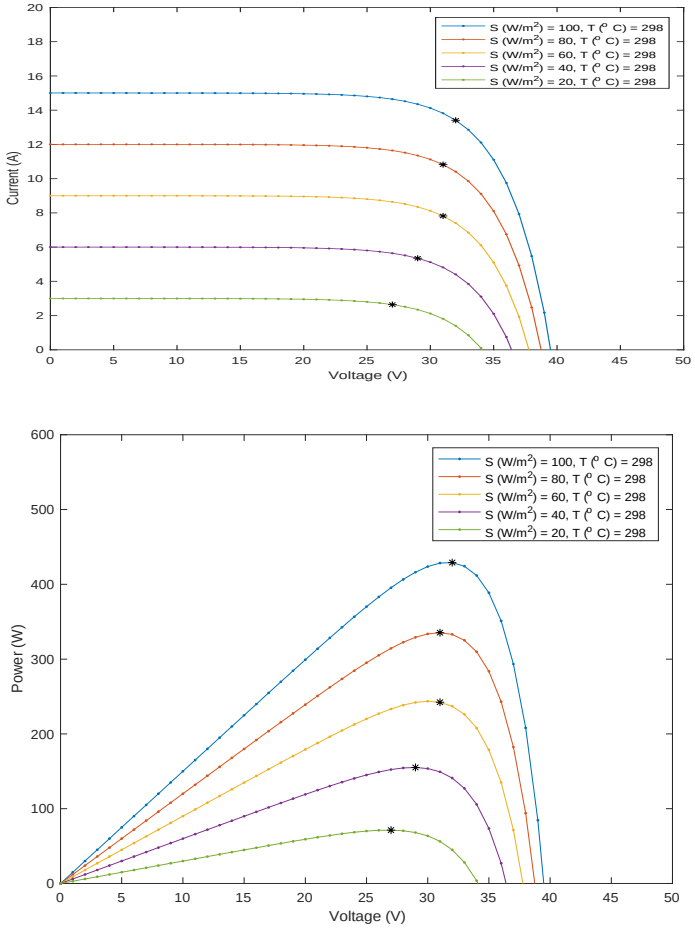
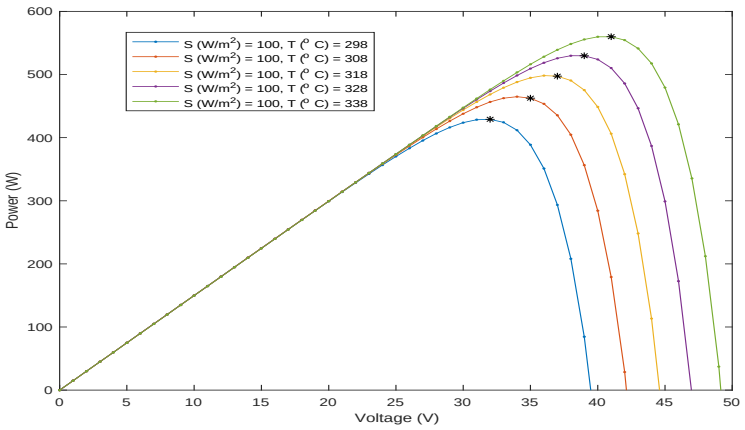


Fig3. V-I and V-P characteristics at constant temperature (298°C) and various irradiance conditions



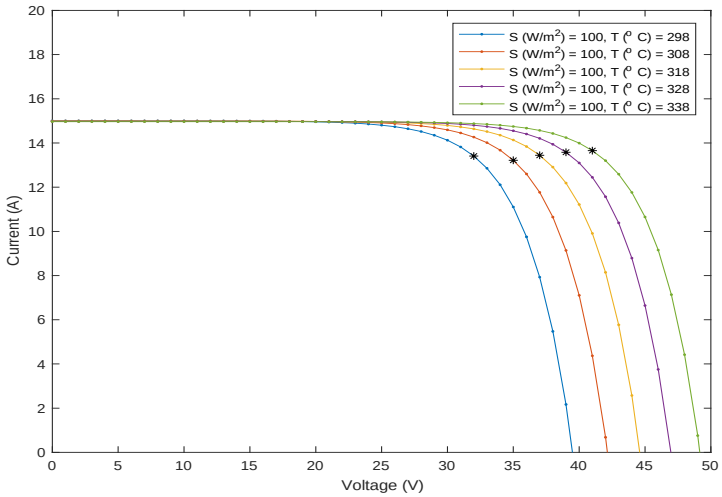


Fig4. V-I and V-P characteristics at constant irradiation (100w/m^2) and various temperature conditions

IV Artificial Neural Network (ANN) based MPPT:

An Artificial neural network (ANN) is a kind of artificial intelligence method. An Artificial intelligence method has new advantages than conservative methods [7]. The disadvantages of conventional method are that they show slow responses for sudden change in solar temperature and irradiance conditions and sometimes they may fail to track maximum power point also The solar temperature and irradiance is inputs. Target of neural network is duty ratio to DC-DC converter. For every change in solar temperature and irradiance value neural network will give a particular value to get maximum power point. The network is The network is obtained through training by using the Levenberg-Marquardt algorithm. For different combination of solar irradiance and temperature value duty ratio is calculated and ANN is trained. The training of neural network means adjusting the weights of layers to get the target values. Throughout the training procedure weights are adjusted to track the target values with minimum error.

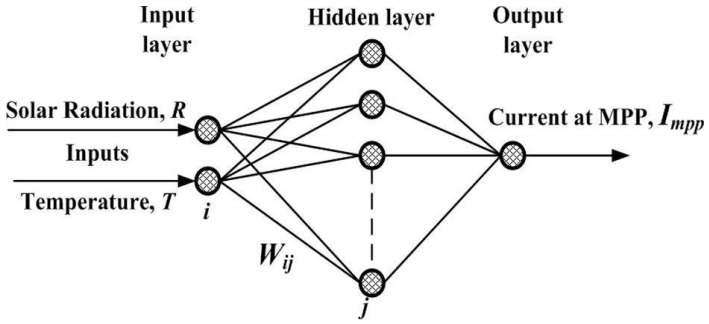


Fig.5.structure of ANN

V Block diagram of proposed system:

The basic block diagram of the proposed system is given in Fig. 6. The PV array converts solar energy to electrical energy andit is given to boost converter. ANN based MPPT is used in the proposed system. ANN control will change the duty ratio to get maximum power point.

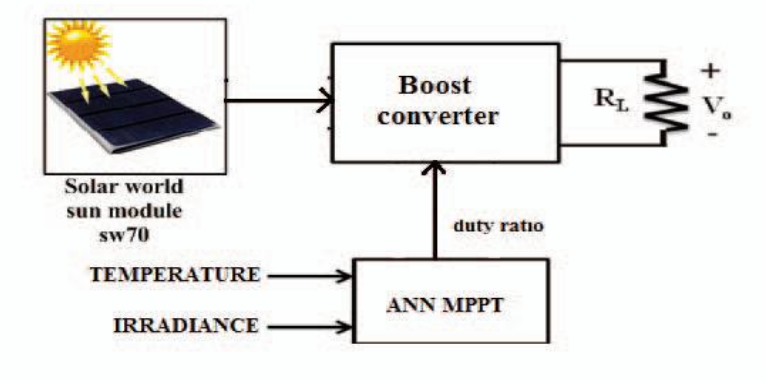


Fig. 6. Block diagram of solar MPPT

ANN based MPPT:

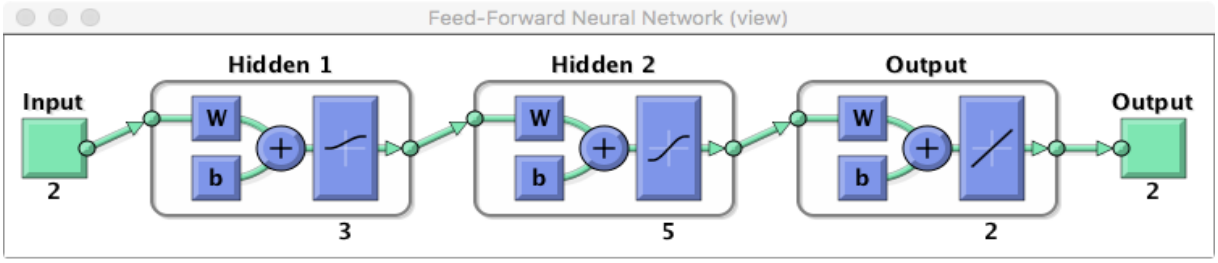


Fig. 7. Neural network for MPPT

Input to neural network is solar temperature and irradiance. Number of hidden layers is calculated by trial and error method. Output is duty ratio to the boost converter. Training points should be obtained to start work with any ANN algorithm.

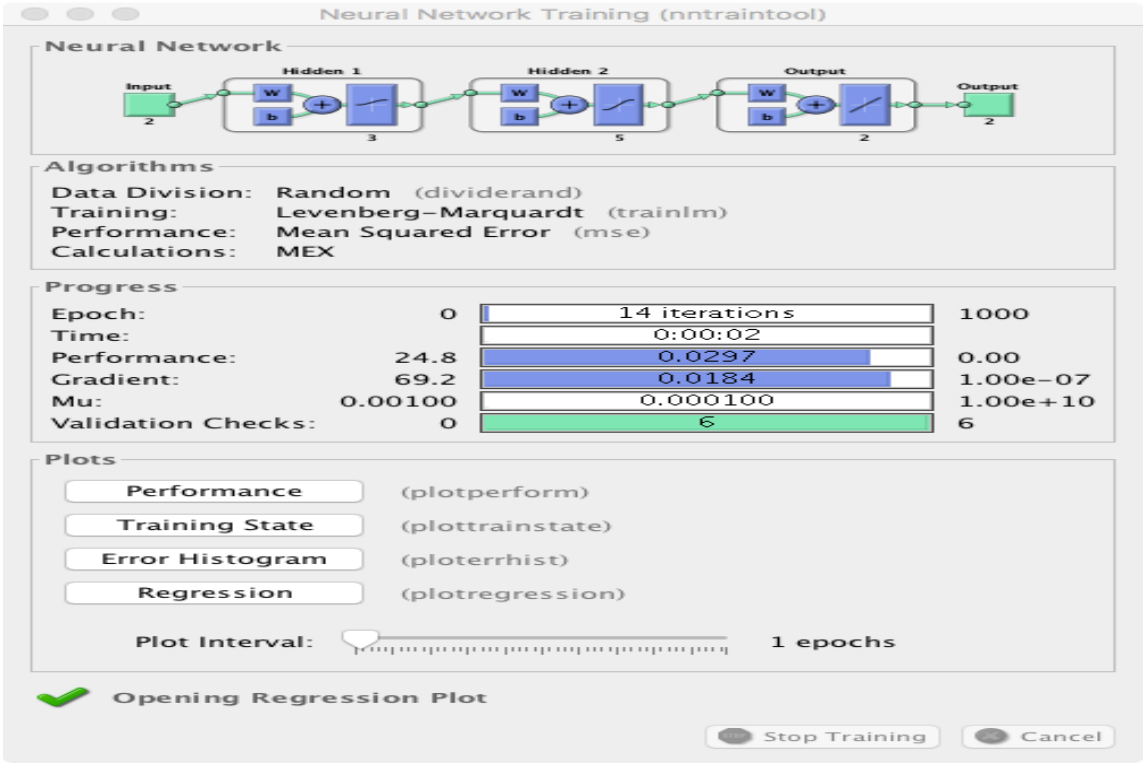


Fig. 8. ANN training by MATLAB nntool

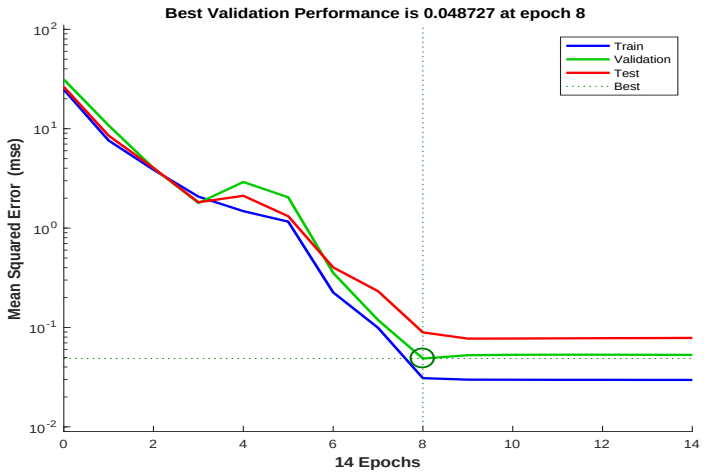


Fig. 9. ANN performance

In Fig. 9 ANN performance is given. From performance of trained ANN it is clear that mean squared error (MSE) will decrease when epochs increases. A well trained artificial neural network will have very low mean squared error at the end of training. The low mean squared error means that the desired output and neural network's output are close to each other.

V. SIMULATION RESULTS AND COMPARISON

The bellow graph shows the training staste of the artificial neural network

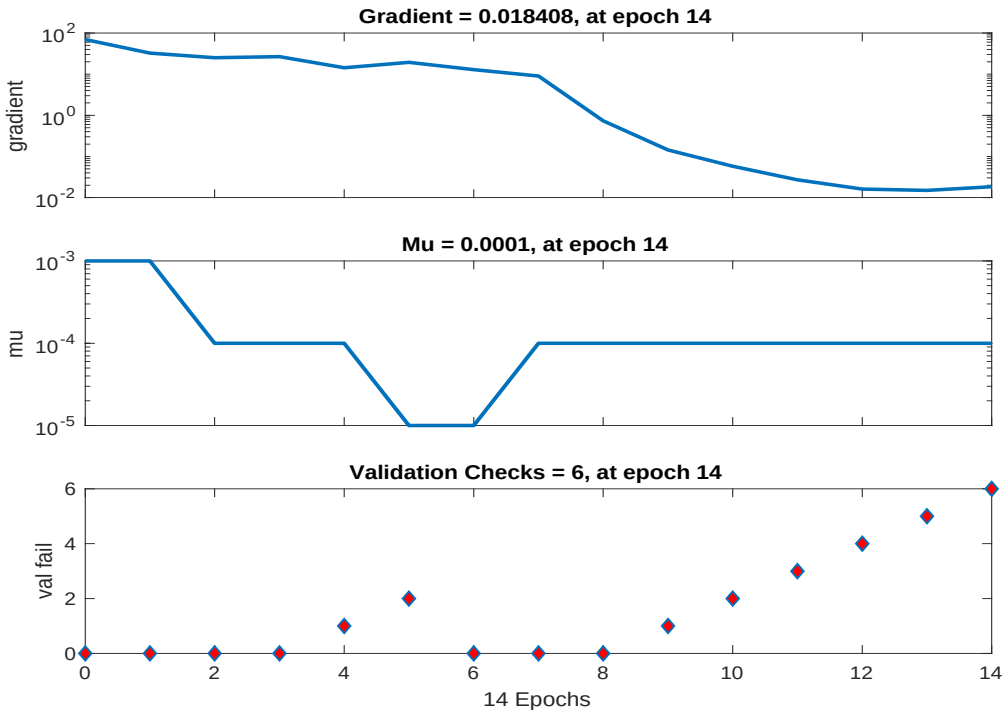


Fig.10 training state of ANN

1.Histogram: histogram of the artificial neural network (ann) model output when applied to the validation set for subjects who did and did not suffer pd technique failure. for each of 20 bootstrap samples, the data were randomly divided into a training set from which an ann model was derived, and a validation set on which the ann was validated. the histogram data represent one of the 20 sets of validation set predictions selected at random.

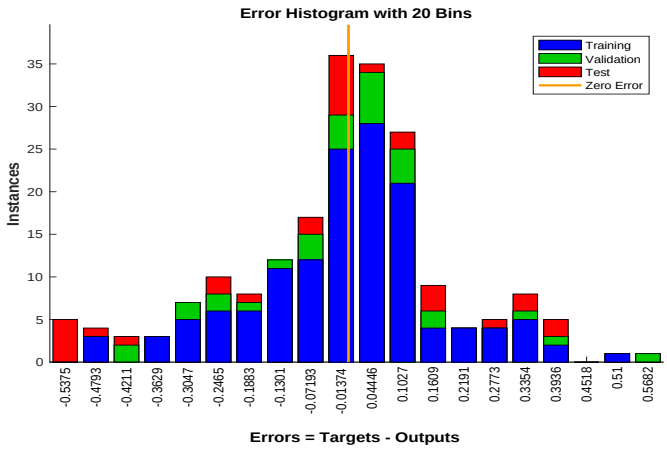
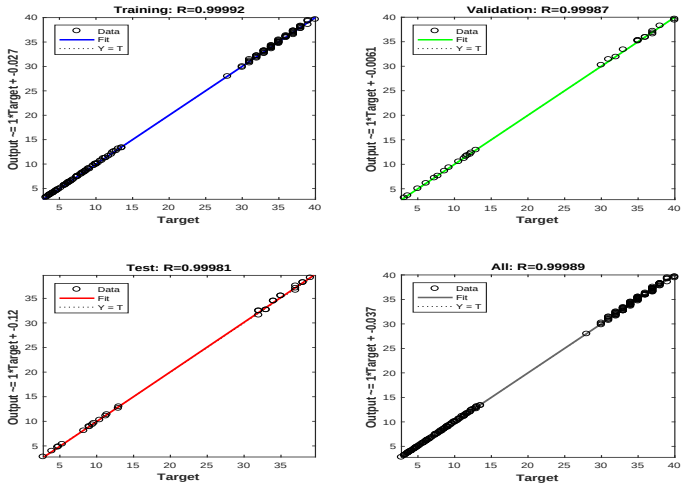


Fig.11.histogram

2.Regretion results:



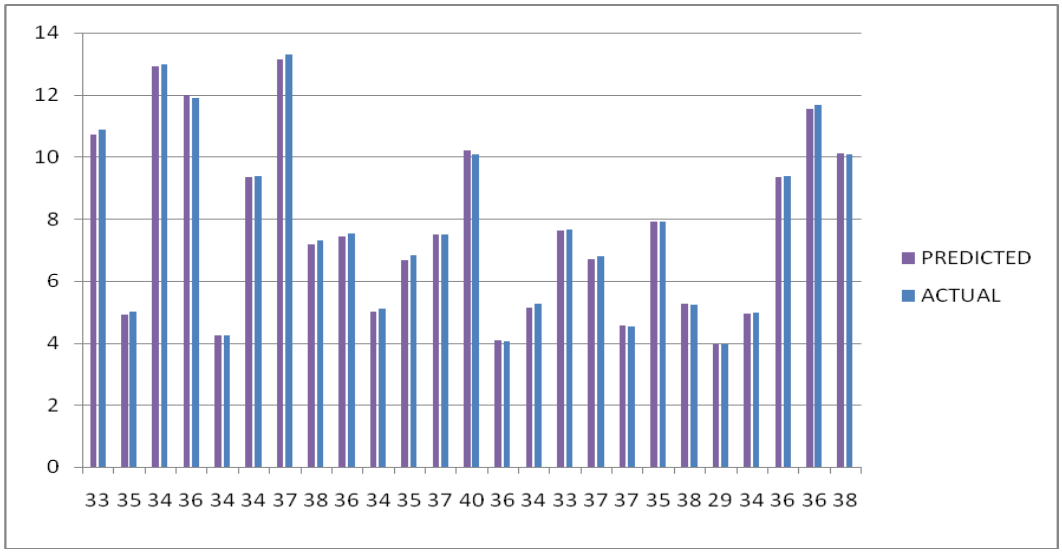
Comparision table l:

The table shows voltage and current values of actual by pertub &observe method and predicted by Artificial neural network at different solar radiation and temperature conditions.

Solar Radiation (W/m^2)	Temperature (^oC)	MPPT Voltage (V)		MPPT Current (A)	
		Actual by P&A Method	Predicted by ANN	Actual by P&A Method	Predicted by ANN
80.31	305.58	33.00	33.44	10.86	10.71
37.02	325.00	35.00	35.31	5.02	4.92
96.97	305.91	34.00	33.98	12.99	12.91
89.03	314.64	36.00	35.76	11.88	12.00
31.90	320.33	34.00	33.92	4.25	4.24
70.05	310.07	34.00	34.10	9.37	9.35
97.23	320.70	37.00	37.39	13.29	13.15

Comparision of P&O and ANN:

Comparission of these tho method artificial neural network output is higher than the pertub&observe method.



VI. CONCLUSION:

In this paper a maximum energy harvesting technique utilizing artificial neural network is introduced and compared with conventional MPPT method to find which algorithm gives better performance. Input to ANN is solar irradiance and temperature and output is maximum power for boost converter. ANN is trained by using "nntool" in MATLAB/SIMULINK model. Comparison results shows that ANN based MPPT controller gives better performance and fast response for sudden change in solar temperature and irradiance etc… than the other maximum power point tracking algorithms. From the result it is concluded that while comparing with other conventional MPPT techniques ANN based MPPT gives better performance in terms of more output power.

References:

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