Maximum Power Point Tracking Using Artificial Neural Network for DC Loads

Harini B. R[*1], Keerthiga A[*2], Sangavi M[*3], Vimala A[*4], Karthick T[5].
UG Scholar, UG Scholar, UG Scholar, UG Scholar, Assistant professor.
Department of Electrical and Electronics Engineering
K.L.N College of Information Technology,
Madurai, Tamil Nadu 625 015. India.

***Abstract-* Due to the fossil fuels depletion and to protect the environment we are focussing on renewable energy sources Solar energy helps in reducing the green house gases. Pv technique is used to collect the rays from sun light and directly converted into electricity. To collect the maximum power PV panel with MPPT technique is used at all weather conditions. ANN is used to maintain the voltage constant. Therefore overall efficiency is increased to about 10%. In this paper we have designed a prototype model inclusive of techniques that the need to harness the solar energy.**

***Keywords*: Maximum Power Point, Buck-Boost Converter, Neural Network Architecture**

I. INTRODUCTION

MAXIMUM Power point is a technique that Grid Tie Inverters , Solar Battery Chargers, other similar devices used to get maximum possible power from solar panels. Solar cells have a complex relationship between solar irradiation, resistance and temperature that produces nonlinear V-I curve. The MPPT system given sample out the output of the cells and applies the proper load to obtain maximum power for any give environmental condition ranging from a clear sky to a heavily clouded one, from rainfall to misty and even foggy. Therefore, PV cells have a complex relationship between maximum power that can produce and the environmental operating conditions. FillFactor(FF) that gives the electrical behaviour of the cell. In tabulated data it is often used to estimate the maximum power that a cell can provide. At the same time with an optimal load under given conditions, the power P=FF*VOC*ISC; VOC and ISC are the open circuit voltage and short circuit current respectively. For most purposes FF, VOC and ISC are enough pieces of information to give a useful conclusion on the electrical behaviour of a cell operating under various conditions [2, 3]. For any given set of operating conditions, cells have a single operating point where the values of V and I, for each cell produces the maximum power output values. Then the values are corresponding to the resistance load which equal to V/I as derived by the Ohm's Law. A PV cell has an approximately exponential relationship between current and voltage. From basis circuit theory, the power delivered from or to a devices is optimized at the I. The point at which dI/dV of the I-V characteristic curve is equal and opposite of I/V ratio and the point where dP/dV=0 is known as the "Knee" of the curve which is the maximum power point. The efficiency of the typical solar panel is about 30 to 40 percent. Maximum Power Point Tracking technique is used to improve the efficiency of the panel. According to Maximum Power Transfer Theorem, the power output of the circuit is maximum when the Thevenin Impedance of the circuit (Source impedance) matches with the load impedance. Hence the problem of tracking the maximum power point reduces to an impedance matching problem [4,5,6].

II. BASIC IDEA

It is necessary to design a solar panel to extract maximum power at all conditions, because solar cells have a non-linear current-voltage characteristic, with the output power varying in correspondence with the voltage across the cell. Therefore, MPPT is used to extract and utilise the maximum portion of the incoming solar radiation. The Photovoltaic Systems are one of the best direct solar to electrical energy conversion systems. A Photovoltaic System is an array of homogenously series connected Solar Cells, each of them possessing the typical V-I characteristics. The main aim of the PV system is to absorb radiation and to generate electricity by using transducer. These systems are clean, reduce the Greenhouse Gases, and are nonpolluting. A typical PV system consists of Batteries, PV modules, a DC-AC Inverter, a Charge Controller and the PV modules to generate DC Electricity. The Inverters convert the DC current into AC current. But the problem arises in electricity generation due to high capital cost and climate conditions such as solar radiation and ambient temperature . To extract maximum power from PV module under all uncertain conditions, it is necessary to include the charge controllers in MPPT system. MPPT checks the PV array output and compares it with battery voltage and finally fixes the best voltage that the array can produce and convert it to get maximum current. MPPT is most effective under the following conditions:

1.Cloudy, Cold weather, or hazy days: PV modules work better at hot temperatures.

2. When battery is deeply discharged the system can extract more current and charge the battery, if the state of charge in the battery is lower.

III. AIM

The problems encountered with basic algorithms for finding the Maximum Power Point Tracking are described here as under:

1. In the classical Perturb and Observe Algorithm (P&O) which compares only two points, the Current Operation Point and the Subsequent Perturbation Point to observe their changes in power. Based on the difference in the output power the controller increases or decreases the PV array output voltage. If these two points are negative points weighted, the duty cycle of the converter should decrease and if these points are positive weighted, the duty cycle of the converter should increase [8]. If it has one positive and one negative weighting Maximum Power Point is not reached because the solar radiation changes rapidly and so the duty cycle is not able to change itself.

2. Though the Incremental Conductance Algorithm [7] has better performance than P&O algorithm, it produces oscillation and perform erratically under rapidly changing atmospheric conditions. The computation time is increased and the sampling frequency is depressed than P&O Algorithm.

3. PO techniques and incremental conductance techniques are limited in their tracking speed because they will make fixed size adjustments to the operating voltage in each of the iterations. Incremental conductance method has reduced efficiency in its tracking stage when the operating point fluctuates between two significantly maximum power points.

4. In the Constant Voltage Algorithm [7], to measure the open circuit voltage, the current from the PV array must be said to zero and then said to 76% of the measured Voltage. Due to this, a considerable amount of energy is pined away when the current is set to zero. Though it is simple and low in cost to implement it reduces the efficiency of the array due to the interruptions in this algorithm.

IV. MAIN IDEA

To overcome all the negative points and drawbacks of the above basic algorithms the present prototype is designed with the improved features. The highlighting points of MPPT using ANN are as follows:

1. Algorithm of three point weight comparison which acts as an antidote to the two point has three distinct points, namely the Current Operation Point A, a point B perturbed from point A and a point C doubly perturbed in the opposite direction from point B.
2. By storing current –voltage curves, their maximum power points and using a classifier based system, the algorithm aims to improve the tracking speed of PO based techniques.

V. OPERATION WITH BATTERIES

The batteries help in providing backup when the plant operations stopped. Due to the non-availability of solar radiation for a prolonged time, a solar collectors won't be able to collect the required amount of radiation and that period of time will bring plant operation to a halt. It plays a vital role in storing a reasonable amount of energy to provide backup.

1. An Off -Grid PV power system uses batteries to supply power to its loads. Though the fully charged battery may have its operating voltage close to the PV Array's Peak Power Point, this is may be true or happen at the sunrise time when the battery is partially is charged. Charging may begins at the voltage only below the Array's Peak Power Point. MPP Tracking with its sophisticated techniques and well design protocols can resolve the mismatch.

2. When batteries in the Off-Gris system are fully charged and the production exceeds the local loads, the MPP Tracking can no longer operate the PV Array at its Peak Power Point, as the excess power has nowhere to go. Until the production exactly matches the demand, the MPP Tracking must then shift the array's operating point. An alternative approach, commonly used in spacecraft is to divert the surplus PV power into a resistive load into a resistive load allowing the array to operate continuously at its Peak Point.

VI. PROJECT STUDY:

An Improved MPPT System using Artificial Neural Network is a modification of the classical P&O Technique which consists a PV module, a DC-DC Converter, a controller and a load. A feed-forward propagation ANN based controller is added here which takes Ambient Temperature(T) and Solar Radiation(G), as two out of its total four inputs, and converts them into information based on the Instantaneous Optimum Voltage (V Optimum) of the PV system in order to ensure the maximum power operation.

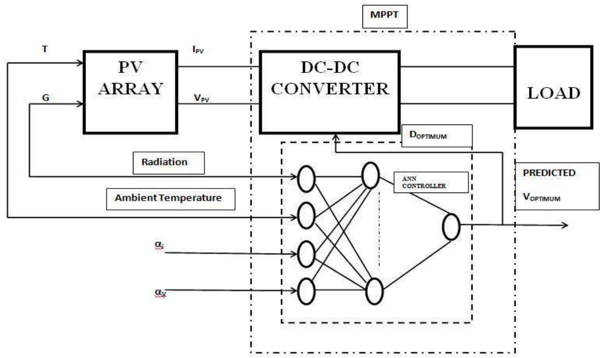

Figure 1 MPPT using ANN's Block Diagram

The ANN tries to simulate its learning process through the various input fed to it during each cycle of data interpretation. It changes its structure depends on the external and internal information which flows in and out of the network [9]. However the major advantage of using the network is that response of the Proposed MPPT System is faster than the classical P&O Algorithm so as to increase the tracking efficiency.

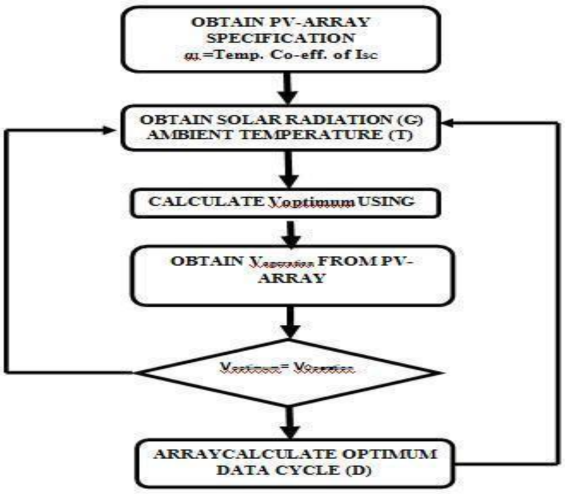

Figure 2 flow chart of the proposal design model

Flow chart described as:

Step1: The Temperature Coefficient of Short Circuit Current ISC and the Temperature Coefficient of Open Circuit Voltage VOC are obtained from the PV array and stored.

Step2: The ANN now have the values of Ambient Temperature T and Incident Solar Radiation G.

Step3: Then the controller calculates the value of V Optimum.

Step4: Get the value of V Operation of the PV array. If V Operation ≠ V Optimum, then Duty Cycle is calculated and it is controlled, else the flow switches on to get the next values of Solar Radiation and Ambient Temperature.

VII. DESIGNING USING MATLAB® - SIMULINK®

Some of the common circuits using Conventional Logic and their proposed Reversible Logic are explained as follows:

A. PV Array Design

The PV Array’s model as designed in SIMULINK® is shown as insolation and temperature are considered as two inputs of the PV Array. The Temperature is taken as a Saw-Tooth waveform and Insolation is taken in the form of rising step input with the values ranging from 200-1000 W.m-2. Temperature is set between the levels via saturation and Insolation is fed to a gain. ISC determined by the Diode equation function and summers, which gives the module’s output current. The product of this current and the incident sinusoidal voltage gives the generation of power. The entire system is masked and the module values arranged in series are one while those arranged in parallel are 50 which raises the current dramatically. The voltage and current values are multiplied and the output of these two are given to the respective Graph Blocks.

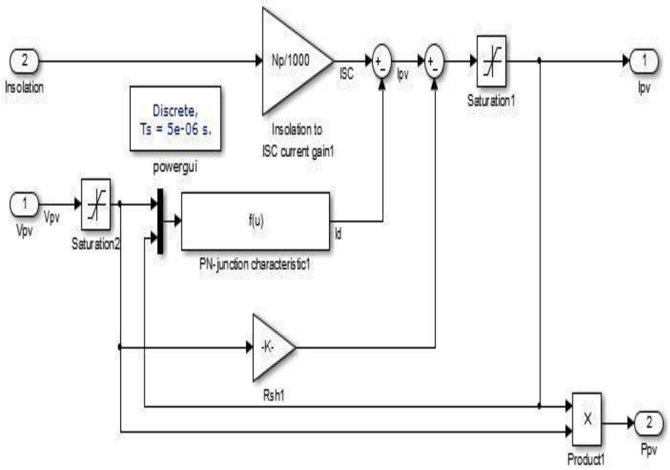

Figure 3 Unmasked pv subsystem

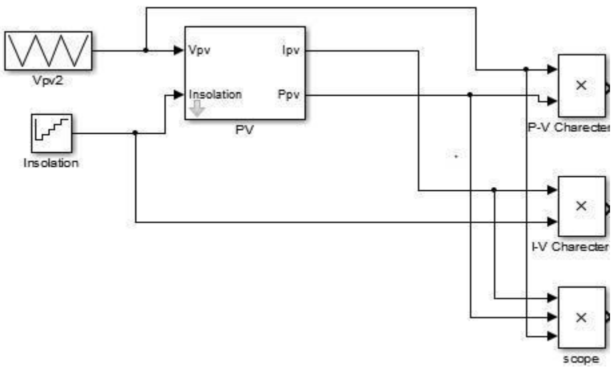

Figure 4 PV-Module SIMULINK® Model

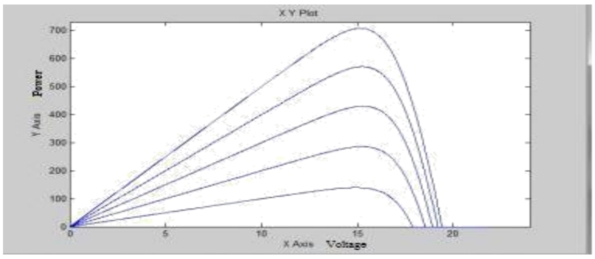

Figure 5 I-V Characteristics

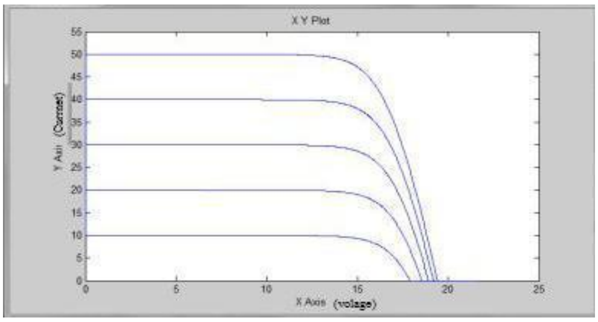

Figure 6 P-V Characteristic Curve

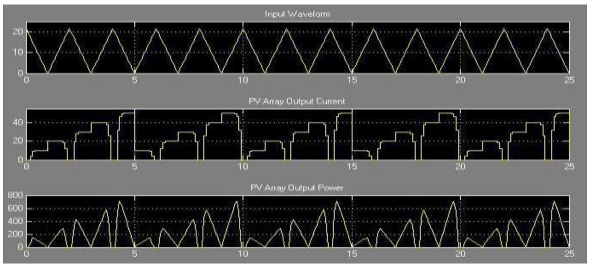

Figure 7 Output waveforms of a PV module

B. Buck-Boost Converter

One of the types of DC-DC converter is the Buck- Boost converter which has an output voltage magnitude either less than or greater than the magnitude of the input voltage magnitude. It is described by a voltage source that is connected in parallel to an inductor, a capacitor, a reverse-based free-wheeling diode and a load resistance R at the output terminal.

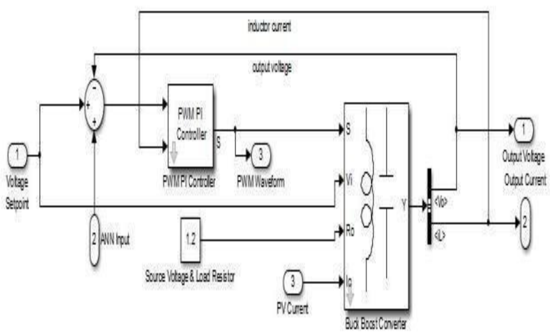

Figure 8 Buck-Boost Converter using PWM-PI Controller

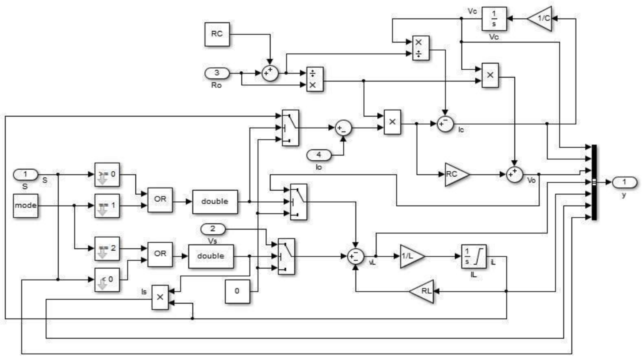

Figure 9 Unmasked Buck-Boost Converter

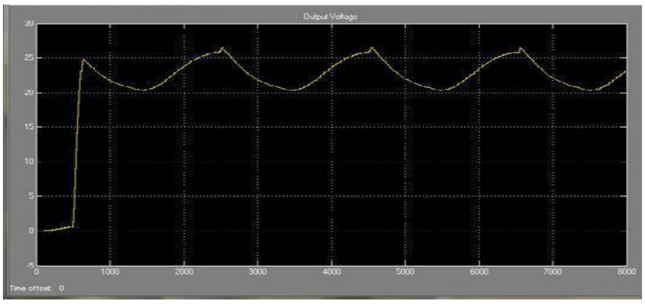

Figure 10 Converter's Output Voltage

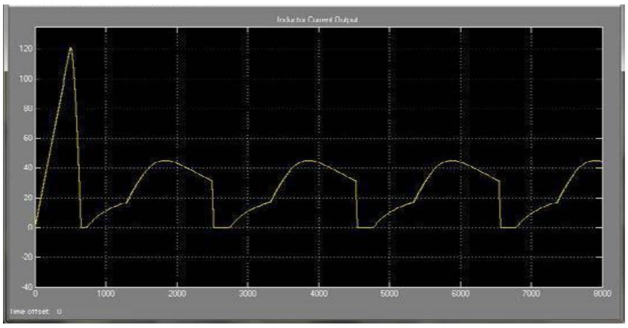

Figure 11 Converter's Output Current

C. Artificial Neural Network Design

The ANN has been designed using ISC and VOC equations[1] which are described as:

ISC = ISC*(G/G*)*ISC + αi(T - T*)
VOC = VOC* + αv(T - T*) - (ISC – ISC*)R
Where,

ISC = Short Circuit Current
VOC = Open Circuit Voltage
G* = Reference Solar Radiation =1000W.m-2
ISC* =PV ISC at Ref. Solar Radiation = 50 A
αi = Temperature Co-efficient of ISC = 2
T* = Reference Temperature = 25°C
VOC* = VOC at Ref. Temperature = 25 V
αv = Temperature Co-efficient of VOC = 0
R = Resistance = 5 Ω

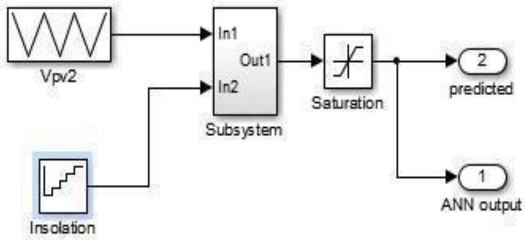

Figure 12 Artificial Neural Network Architecture

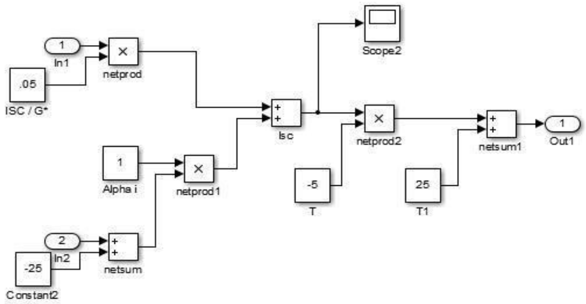

Figure 13 ANN Equations Design

D. Concluding Model

The concluding model is the combined designs of the Photo Voltaic Module, the Artificial Neural Network Controller and the Buck boost converter. The model is shown as alongside**, Fig14.**

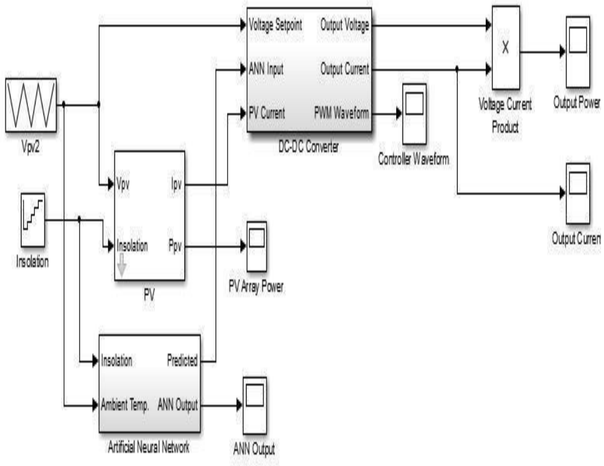

Figure 14 Project's Overall Simulink Model

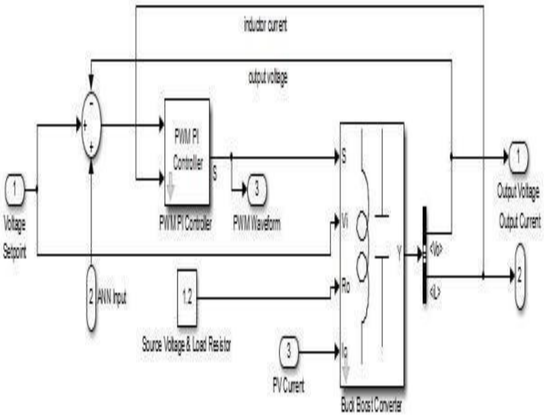

Figure 15 DC-DC Converter Subsystem

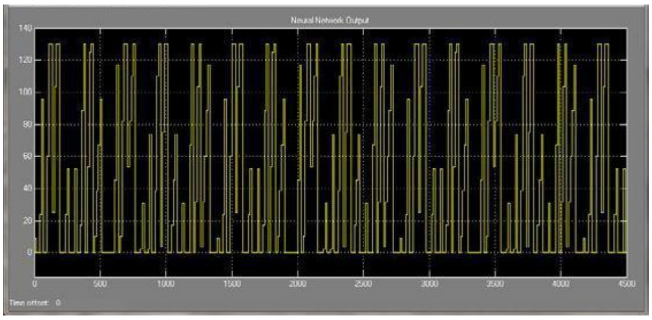

Figure 16 ANN's Predicted Output Waveform

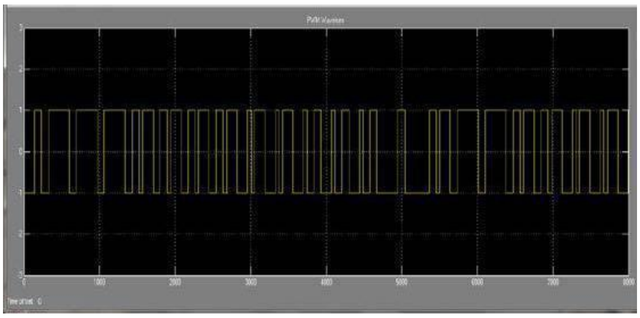

Figure 17 Controller Waveform

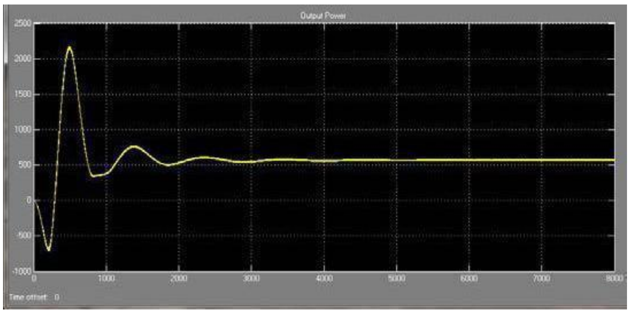

Figure 18 Final Output Power Waveform

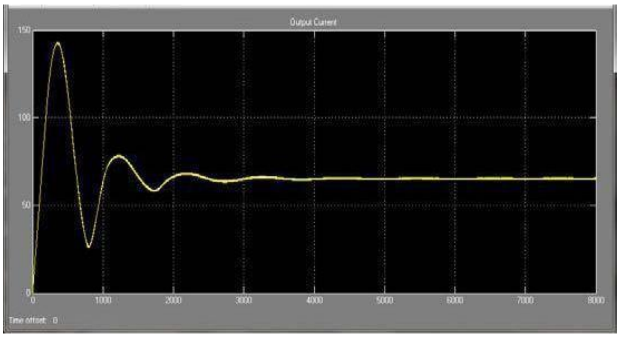

Figure 19 Final Output Current Waveform

VIII.CONCLUSION:

This paper discusses neural network based MPPT. Under any variation in atmospheric conditions, by using neural network, point of maximum power is specified fast and precisely.Another advantage of the neural network in PVmaximum power-point tracking is its better dynamic performance in comparison with the other methods. Also the maximum power point is tracked by dc-dc buck-boost chopper. So the maximum power solar energy and the best efficiency are obtained.

REFERENCES

[1] Mahmoud A. Younis (University Tenaga National), Tamer Khatib (National University of Malaysia), Mushtaq Najeeb (Universiti Tenaga National), A Mohd. Ariffin (University Tenaga National), "An Improved Maximum Power Point Tracking Controller for PV Systems Using Artificial Neural Network", ISSN 0033-2097, R. 88 NR 3b/2012, Pg. 116-121.

[2] Edward E. Anderson, "Fundamentals for Solar Energy Conversion", Addison Wesley Pub. Co., 1983.

[3] G.N.Tiwari and M. K. Ghosal, "Fundamentals of Renewable Energy Sources", Narosa Publishing House, New Delhi, 2007.

[4] M. A. Vitorino, L. V. Hartmann, A. M. N. Lima et al., "Using the model of the solar cell for determining the maximum power point of photovoltaic systems," Proc. European Conference on Power Electronics and Applications. pp. 1-10, 2007.

[5] D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, India Reprint, 2003, Chapter 9, Photovoltaics, pp. 411-446.

[6] Solar Energy, Third Edition, by S. P. Sukhatme and J. K. Nayak, Tata McGraw-Hill Publication Co. Ltd. New Delhi, 2008, Chapter 9, Section 1, pp. 313-331.

[7] Comparison of Photovoltaic array maximum power point tracking technique – Patrick L Chapman, Trishan Esram.

[8] E. Alpaydin, Introduction to Machine Learning, Cambridge, MA: MIT Press, 2004.

[9] Neural Networks – A Classroom Approach, Satish Kumar, Tata McGraw-Hill Education.

[10] Dharmendra Kumar Singh, Pragya Patel, Anjali Karsh and Dr.A.S.Zadgaonkar.Analysis of Generated Harmonics Due To CFL Load on Power System Using Artificial Neural Network, International Journal of Electrical Engineering and Technology (IJEET), 5(3), 2014, pp. 56–68.

[11] Amit Shrivastava and Dr. S. Wadhwani, Madhav Institute of Technology & Science. Application of Time-Domain Features with Neural Network For Bearing Fault Detection, International Journal of Electrical Engineering and Technology , 3(2), 2012, pp. 151–155.

[12] M. Mujtahid Ansari, Nilesh S. Mahajan and Dr. M A Beg. Characterization of Transients and Fault Diagnosis in Transformer by Discrete Wavelet Transform and Artificial Neural Network, International Journal of Electrical Engineering and Technology, 5(8), 2014, pp. 21–35.