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DESIGN OF PV- CELLS AND MPPT BY USING ANFIS CONTROLLER

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Abstract— Solar photovoltaic technology is considered as one of the pure and clean technologies to produce electricity , but seems unattractive towards the use of it as a complement of electricity due to its low efficiency and high initial cost. As a result of its low efficiency it is nearly impossible to exploit the maximum solar power coming out of array therefore at its highest energy conversion output it leads to the operational failure of the device. As the radiation and temperature has their effects on the maximum power point, it is likely impossible to provide power operation at optimum level during all radiation levels. From years research are carried out on this and numerous MPPT techniques are introduced, refined , enforced and implemented with a proper execution. Different research groups have advocated different research methods which consist a little literature, where correlation between varieties of MPPT techniques are executed in terms of reliability, time of response and efficiency of conversion. This inspection gives a brief comparison among the realization of different MPPT methods and results a new MPPT technique with improve capability than the extant ones. The analysis done in this paper is as follows: At first, a solar PV array model based on MATLAB is first modeled and examined for validation following the employment of different techniques of MPPT under varying temperature on this PV array and different conditions for the effectiveness study of the particular MPPT technique.

Keywords—MPPT, Solar PV system, Conversion efficiency, Solar PV array, Irradiance, Fuzzy Logic

I. INTRODUCTION

In the case of sun tracking where the PV modules are rotated mechanically to generate maximum power as the radiation intercepted by the module is maximum. But in the case of maximum power point tracking (MPPT) technique, an electronic circuit is used to transfer the power to the load system. The main intention behind this is to transfer maximum power from PV system to load. By adjusting the duty cycle, input impedance can be varied which should be same as the solar PV module impedance in a given operating condition for maximum power transfer [1-2].

The objective of this work is to implement MPPT technique with the solar power. A solar panel with MPPT controller has been implemented in this paper. The MATLAB model of solar PV array is modeled and examined for validation following the employment of different techniques of MPPT. Here, a model of DC-DC converter which regulates in between buck and boost topology has been modeled which depends upon two parameters from the MPPT algorithm that is the switching pulse and input voltage. Different techniques of MPPT are validated under varying temperature on this PV array and different conditions for the effective study only.

II. PHOTOVOLTAIC SYSTEM

A. PV Cell

A photoelectric or photovoltaic cell is a semiconductor that by photovoltaic effect converts light to electrical energy. Electrons are emitted when the energy of photon of light is more than that of the band gap energy and then the flow of electrons create current.

B. PV Module

A large solar PV module can be regarded as a big solar cell. It means that the array of several solar cells are connected in series and parallel. Hence power output is large. Now a days, solar PV modules are available with power rating from 3 Wpto 300 Wp. The rating of solar array is ranging from hundred watts to several megawatts.

C. PV Cell Design

Several photovoltaic cells are connected in series and parallel. Series connection is done to increase the voltage Rating and parallel connection is done to increase the current rating of cell. As shown in Fig. 1, by connecting a current source and an inverter diode in parallel a solar cell can be modeled.

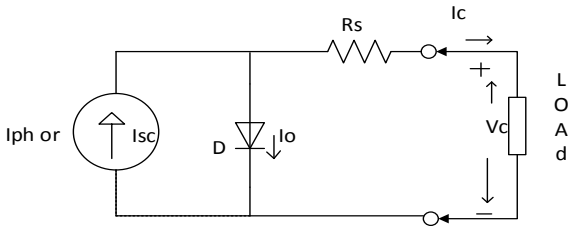
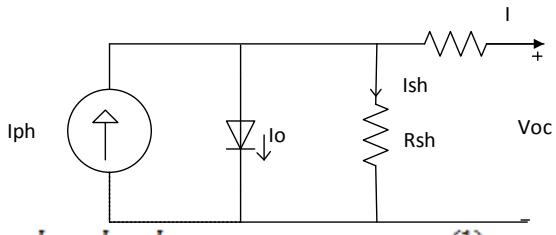


Fig. 1: Single Diode Model of PV cell



$$I = I_{ph} - I_0 - I_{sh} \quad (1)$$

$$I_{ph} = [I_{sc} + K_i(T_k - T)] \times {}^{G}/_{1000} \quad (2)$$

$$I_{rs} = {}^{I_{sc}}/_{\left[\exp\left(q \times {}^{V_{oc}}/_{N_s} \times k \times A \times T\right)\right]} \quad (3)$$

$$I_o = I_{rs}[{}^{T}/_{T_r}]^3 \times \exp\left[q \times \frac{E_{go}}{Ak} \times \left\{\left(\frac{1}{T_r}\right) - \left(\frac{1}{T}\right)\right\}\right] (4)$$

$$I_{pv} = N_p \times I_{ph} - N_p \times I_o[\exp\{q \times V_{pv} + I_{pv} \times R_{se}) \times N_s \times A \times k \times T - 1\}] \quad (5)$$

Where,

I_{ph} =Photocurrent (A)

I_o= Diode saturation current (A)

R_{sh}= Shunt resistance

T= Operating temperature (Kelvin)

R_{se}= Series Resistance

I_{sc}(Short circuit current) = 2.55A

V_{oc}(Open circuit voltage) = 21.41V

q (Electron charge) = 1.602 $\times 10^{-19}$C

V_{oc}= Open circuit voltage, 21.24V

K (Boltzmann constant) = 1.3805 $\times 10^{-23}$ J/K

N_s(Number of cells in series) = 36

N_p(Number of cells in parallel) = 1

D. Electrical characteristics of PV cells

Fig. 2 represents current-voltage (I-V) and power – voltage (P-V) characteristics. The power output increases with the increase of module voltage.

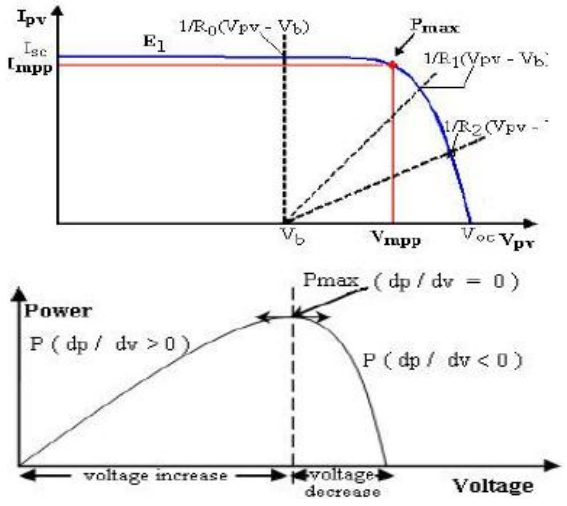


Fig 2: I-V current and PV- characteristic curve of PV cell

III. MODELING AND SIMULATION

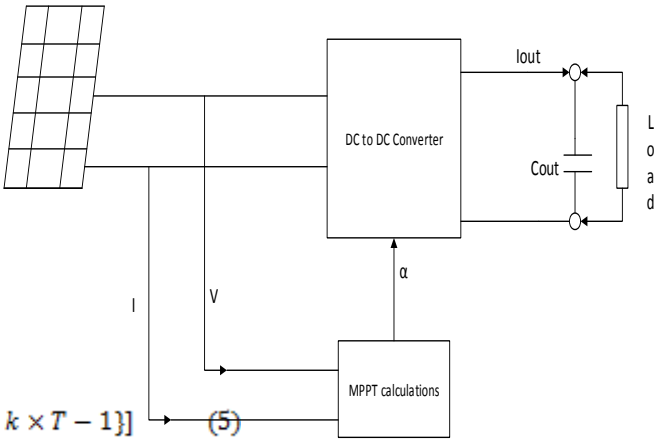


Fig. 3: Maximum Power Extraction from PV cell

The efficiency of solar cell mainly depends on series and shunt resistance, solar radiation, temperature, characteristics of sunlight and dust particles. Solar photovoltaic technology is considered as one of the pure and clean technologies to produce electricity, but seems unattractive towards the use of it as a complement of electricity due to its low efficiency and high initial cost. Several methods are employed to raise the efficiency of solar cell among which "Maximum Power Point Tracking is entreated [3-4]. In the case of MPPT, electronic circuit is used to ensure that maximum power is transferred to the load. This impedance matching is done by using a DC-DC converter. Here the impedance is matched by changing the duty cycle (d) of the switch. By changing the dutycycle, impedance of input side can be varied which should be same as the impedance of solar PV module in a given operating condition [7-8].

Different Algorithms for MPPT:

Different algorithms schemes are implemented for obtaining maximum power transfer. Some of these are perturb and observe technique, hill climbing technique, fuzzy logic control technique [6]. Amongst them, perturb and observe method and fuzzy logic control methods are best ones which are described below.Different MPPT techniques are

(i) Perturb and observe (hill climbing method)
(ii) Fuzzy logic

Perturb and Observe method is the most popular technique. The approach behind this is to operate at the direction by pushing the total system. So that the power retrieved from the Photovoltaic system rises. The change of power is described in the following equation ϭP = P (k) – P (k-1)

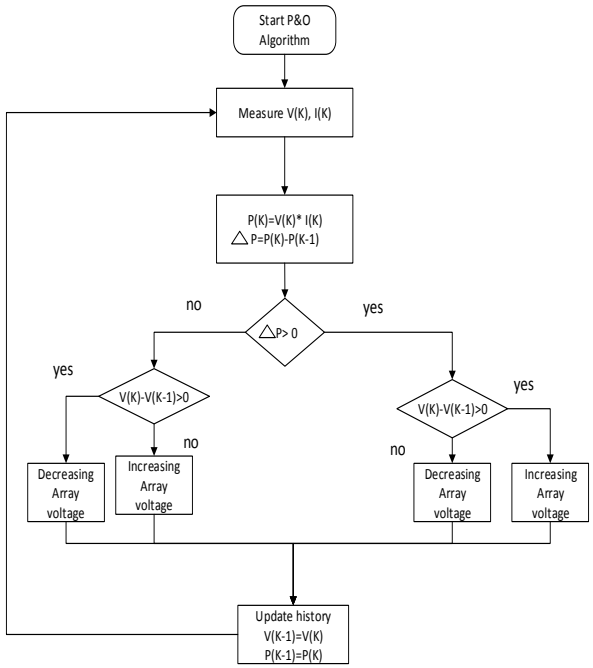


Fig.4: Perturb and Observe Method Flow Chart

MPPT Using Fuzzy Logic Controller:

It has several advantages such as robust construction, better performance and better efficiency .In addition to this, no extra model is required for the analysis of the system. Fuzzy logic controller has the following parts

(I) Fuzzification.
(II) De-fuzzification
(III) Inference
(IV) Rule-base

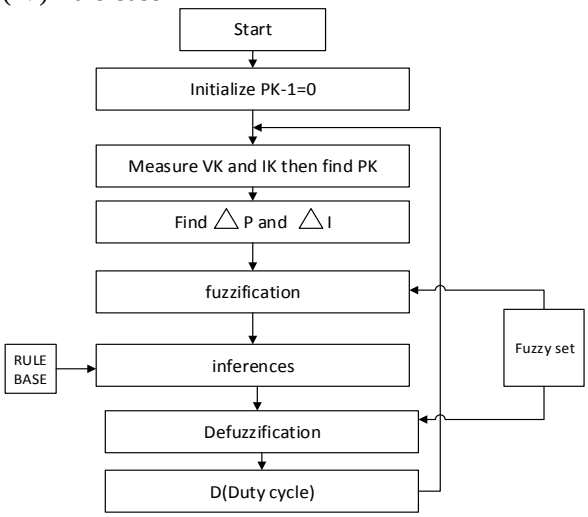


Fig. 5: Flow Chart of Fuzzy Logic Control

Fuzzification:

Here, with the help of a membership function, input Variables are converted to linguistic variables. Fuzzy levels used are of the type:

Negative Big (NB)
Negative Small (NS)
Negative Medium (NM)
Positive Small (PS)
Zero (NZ)
Positive Big (PB)
Positive Medium (PM)

De-fuzzification:

At this stage, by the use of membership function, the fuzzy logic controller output is conveyed to numerical variable from linguistic variable. In the proposed scheme, Centroid De-fuzzification method is used.

Rule-Base and Inference:

An error (E) and a change in error (CE) are usually the inputs to MPPT based Fuzzy logic controller. E and CE are calculated and computed by the user itself. So dP/dV vanishes at the MPP, the estimations used are as follows.-

$E(n) = P(n) – P(n-1) / V(n) – V(n-1)$ ....

$CE(n) = E(n) – E(n-1)$ ....

After calculating E and CE, they are converted to linguistic variables. These linguistic variables are assigned by the knowledge of the user.

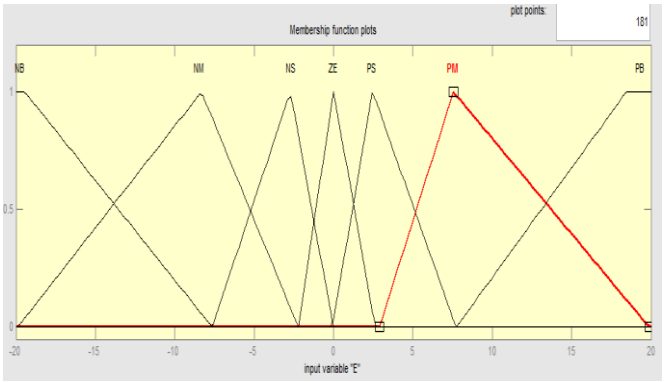


Fig. 6: Fuzzy Logic Input Error (E)

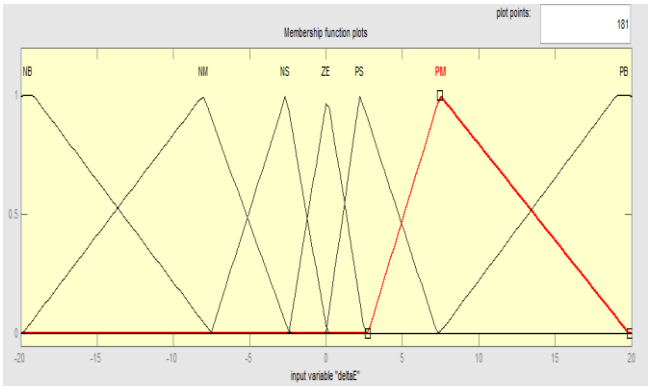


Fig. 7: Fuzzy Logic Input Change Error

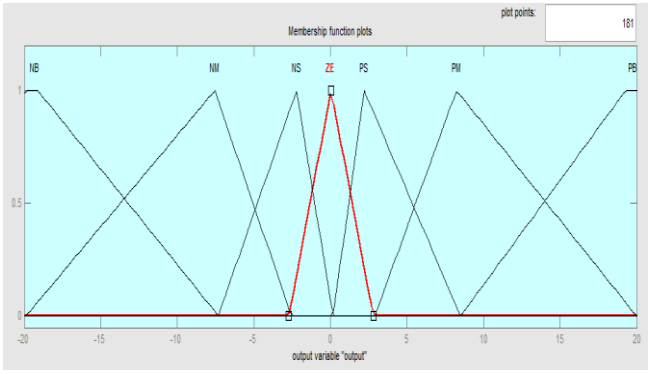


Fig. 8: Fuzzy Logic Output

Table1: fuzzy rules

Input/output	PM	NM	ZE	NS	PS	NB	PB
PM	PB	NB	ZE	NM	PB	NB	PB
NM	NB	PB	ZE	PM	NM	NB	NB
ZE	ZE	ZE	ZE	ZE	ZE	ZE	ZE
NS	NM	PM	ZE	PS	NS	NB	NM
PS	PM	NM	ZE	NS	PM	NB	PB
NB	NB	PB	ZE	PM	NB	NB	NB
PB	PB	NB	ZE	NB	PB	NB	PB

An adaptive neuro-fuzzy inference system

A versatile neuro-fluffy determination arrange or flexible framework based fluffy reasoning system (ANFIS) is a sort of phony neural structure that depends upon Takagi– Sugeno cushy enrollment arrange. The procedure was made in the mid-1990s. Since it composes both neural systems and feathery premise measures, it can get the advantages of both in a solitary structure. Its enrollment compose ponders to a strategy of cushioned IF– THEN picks that have learning capacity to erroneous nonlinear breaking points. Along these lines, ANFIS is accepted to be a complete estimator. For utilizing the ANFIS as a bit of a more profitable and immaculate way, one can utilize the best parameters acquired by hereditary calculation.ANFIS: Artificial Neuro-Fuzzy Inference Systems

1. ANFIS are a class of flexible frameworks that are for all intents and purposes indistinguishable to feathery inference structures.
2. ANFIS address Sugeno e Tsukamoto cushioned models.
3. ANFIS usages a mutt learning figuring.

In the field of automated thinking neuro-cushioned infers mixes of fraud neural structures and fleecy support. Neuro-cushy hybridization understands a cream sharp framework that synergizes these two techniques by joining the human-like thinking style of cushioned frameworks with the learning and connectionist structure of neural systems. Neuro-feathery hybridization is generally named as Fuzzy Neural Network (FNN) or Neuro-Fuzzy System (NFS) in the composed work. Neuro-feathery framework (the more standard term is utilized from this time forward) wires the human-like thinking style of fleecy frameworks using cushy sets and a semantic model including a game-plan of IF-THEN cushioned standards. The basic idea of neuro-feathery frameworks is that they are no matter how you look at it approximates with the capacity to request interpretable IF-THEN guidelines.

The idea of neuro-soft frameworks fuses two conflicting necessities in cushy appearing: interpretability versus exactness. In every way that really matters, one of the two properties wins. The neuro-fleecy in cushioned indicating research field is separated into two zones: semantic soft demonstrating that is focused on interpretability, for the most part the Mamdani show; and right feathery displaying that depends on exactness, in a general sense the Takagi-Sugeno-Kang (TSK) illustrate.

Addressing fuzzification, feathery inducing and de-fuzzification through multi-layers feed-forward connectionist frameworks. It must be pointed out that interpretability of the Mamdani-type neuro-cushy systems can be lost. To upgrade the interpretability of neuro-cushioned systems, certain evaluations must be taken, wherein basic parts of interpretability of neuro-cushy structures are in like manner analyzed.

A progressing examination line keeps an eye on the data stream mining case, where neuro-cushioned structures areconsecutively refreshed with new approaching examples on request and on-the-fly. Subsequently, framework refreshes don't just incorporate a recursive adjustment of model parameters, yet additionally a dynamic development and pruning of model with a specific end goal to deal with idea float and progressively changing framework conduct sufficiently and to keep the frameworks/models "a la mode" whenever.

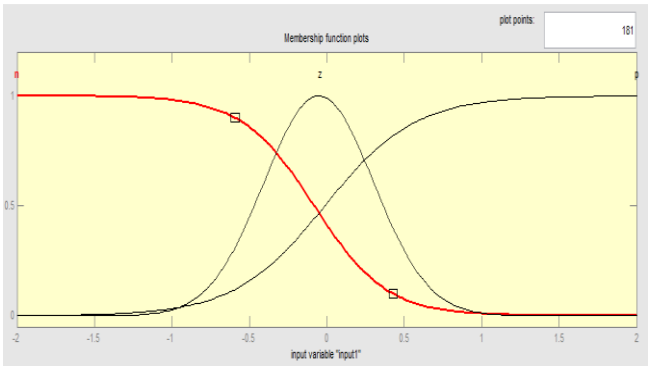


Fig 9: input variable 1

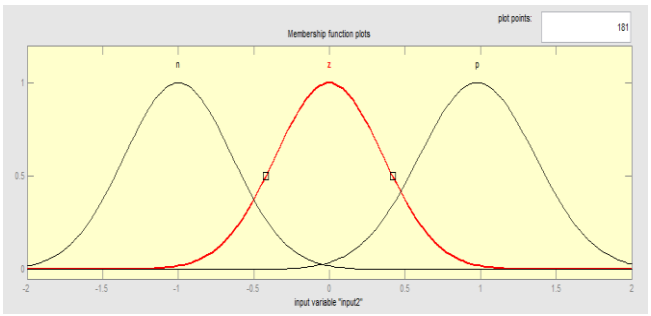


Fig 10 : input variable 2

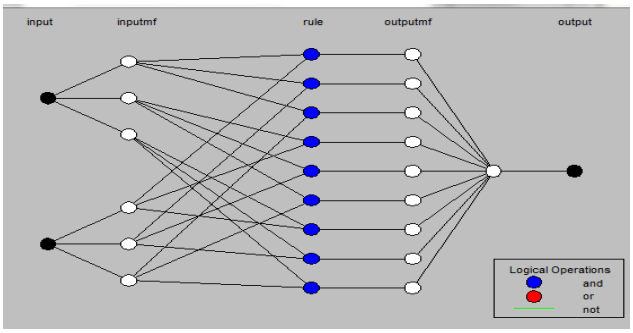


Fig. 11 ANFIS structure

IV. SIMULATION RESULT

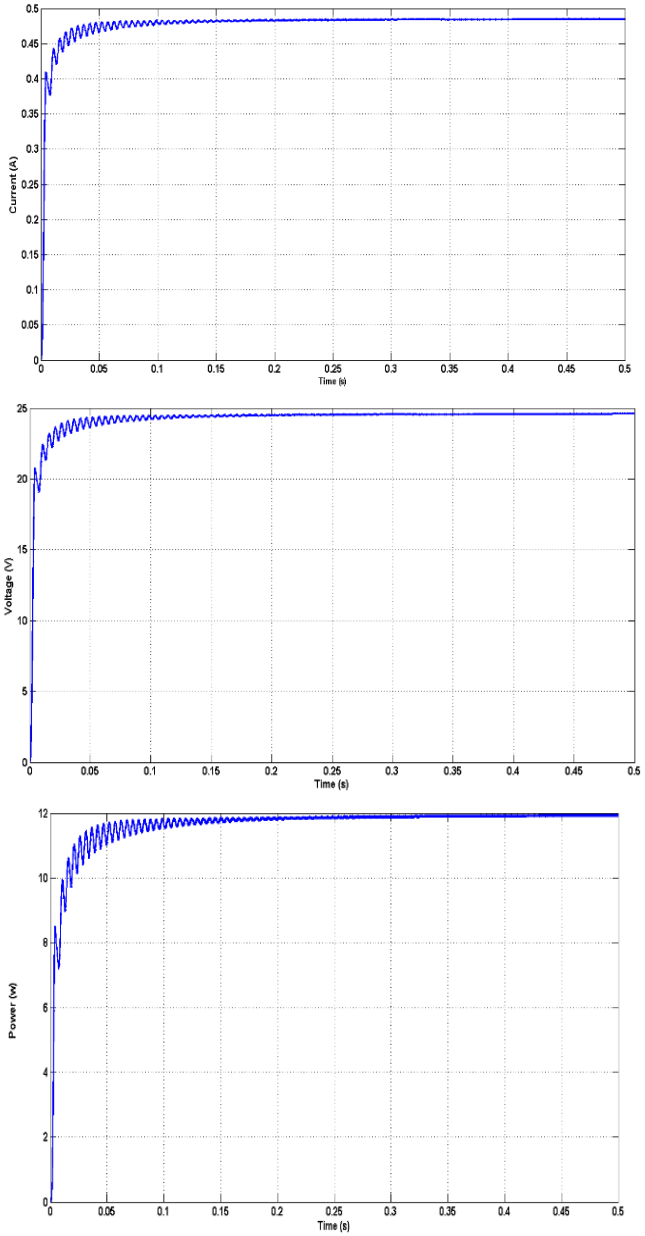


Fig 12: simulation results by using fuzzy logic controller

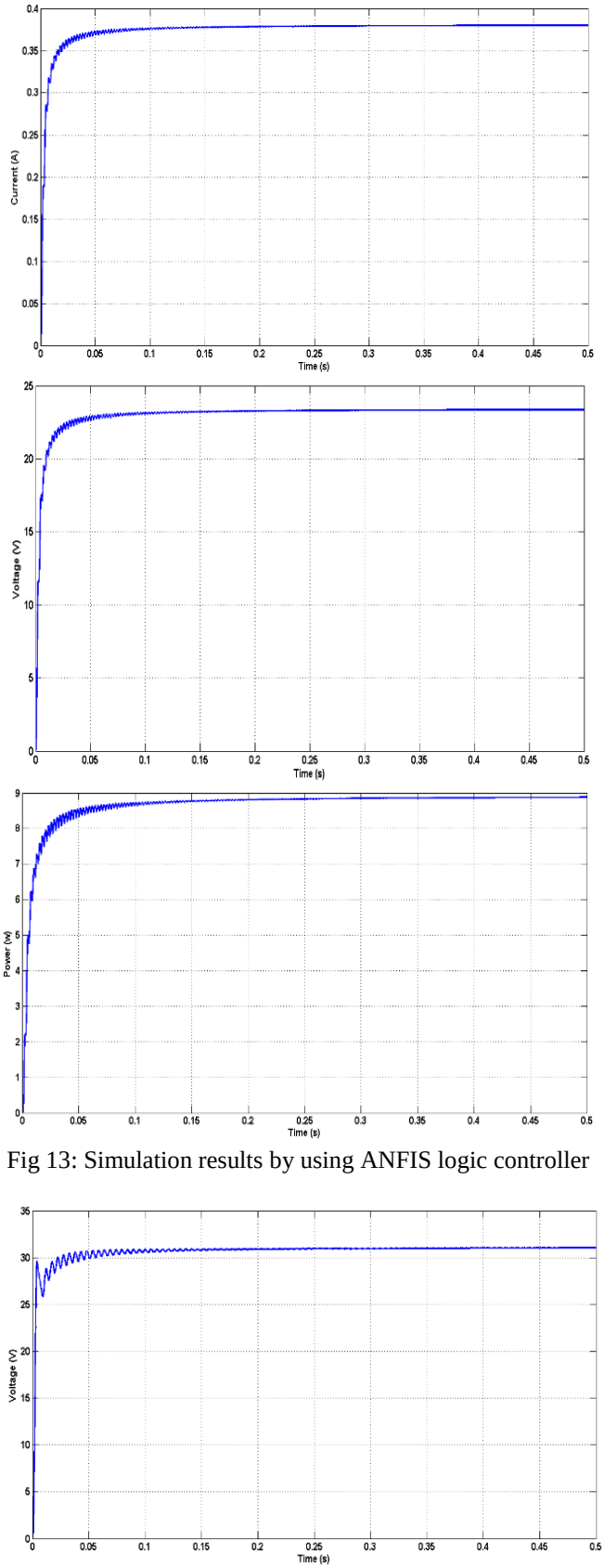


Fig 13: Simulation results by using ANFIS logic controller

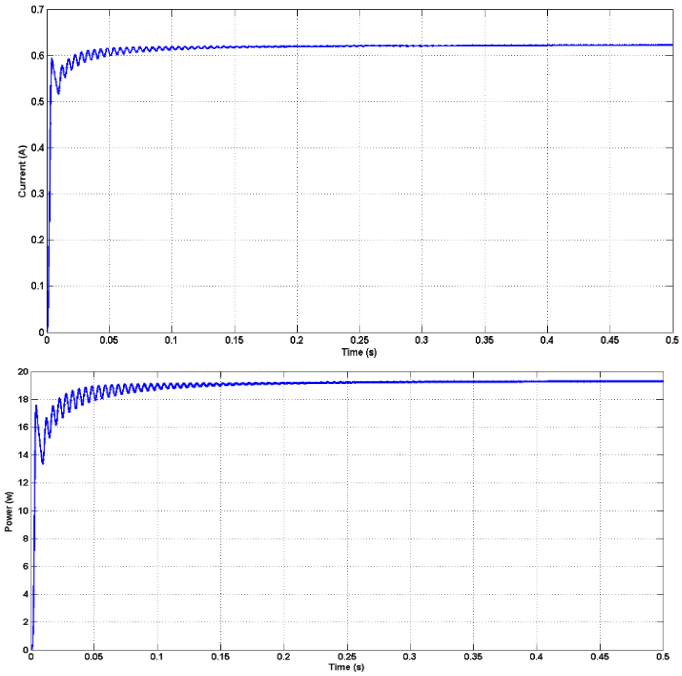


Fig 14: simulation results by using PV PO boost converter

From the simulation, it is found that the response time of fuzzy controller is 1 msec and in case of P&O controller, it is 5 msec. In case of P&O controller, output voltage and output current are found to be 31.03V and 0.622A respectively at 5msec and the corresponding power is 19.3W. In case of fuzzy controller, output voltage and output current are found to be 24.6V and 0.485A respectively at 1 msec and the corresponding power is 11.93W. It is found that the efficiency of fuzzy controller is 95.89% and the efficiency of perturb and observe controller is 92.03%.In case of ANFIS controller, output voltage and output current are found to be 23.7V and 0.359A respectively .the efficiency of the ANFIS controller is 97.55%.so ANFIS controller shows the better performance as compared with fuzzy controller.

TABLE: 2 ANFIS RULES

Input/output	N	Z	P
N	P	P	Z
Z	P	Z	N
P	Z	N	N

V. CONCLUSION

A solar PV array model based on MATLAB is first modeled and examined for validation following the employment of different techniques of MPPT under varying temperature on the PV array and different conditions for the effectiveness study of the particular MPPT technique. From the analysis done, it is found that the efficiency of fuzzy controller is 95%and the efficiency of perturb and observe controller is92.03%.And the response time of fuzzy controller is 1 m second in case of P&O controller, it is 5 msec. So, it is concluded that fuzzy controller are faster and superior in comparison to perturb and observe controller in the transition state and in fuzzy controller, better efficiency and smoother signal is obtained in steady state.. And it is possible to find the point of maximum power at shorter time in case of fuzzy controller. In case of ANFIS controller, efficiency of the ANFIS controller is 97.55%.so ANFIS controller shows the better performance as compared with fuzzy controller.

REFERENCES

[1] Y. Dong, J. Ding, J. Huang, L. Xu and W. Dong, "Invsetigation of PV inverter MPPT efficiency test platform," International Conference on Renewable Power Generation (RPG 2015), Beijing, 2015, pp. 1-4.

[2] S. Veeraraghavan, M. Kumaravel, K. Vasudevan and A. Jhunjhunwala, "Experimental studies and performance evaluation of solar PV powered BLDC motor drive with an integrated MPPT in fan applications,"2014 IEEE 40th Photovoltaic Specialist Conference (PVSC), Denver, CO, 2014, pp. 3713-3718.

[3] K. L. Lian, J. H. Jhang and I. S. Tian, "A Maximum Power Point Tracking Method Based on Perturb-and-ObserveCombinedWith Particle Swarm Optimization"IEEE Journal of PhotovoltaicsYear: 2014, Volume: 4, Pages: 626 – 633, IEEE Journals & Magazines.

[4] S. Abdourraziq and R. El Bachtiri, "A perturb and observe method using fuzzy logic control for PV pumping system," Multimedia Computing and Systems (ICMCS), 2014 International Conference on, Marrakech, 2014, pp. 1608-1612.

[5] T. Saini, D. Raveendhra and P. Thakur, "Stability analysis of FPGA based perturb and observe method MPPT charge controller for solar PV system," Engineering and Systems (SCES), 2013 Students Conference on, Allahabad, 2013, pp. 1-5.

[6] R. M. Linus and P. Damodharan, "Maximum power point tracking method using a modified perturb and observe algorithm for grid connected wind energy conversion systems," in IET Renewable Power Generation, vol. 9, no. 6, pp. 682-689, 8 2015.

[7] D. V. N. Ananth, "Performance evaluation of solar photovoltaic system using maximum power tracking algorithm with batterybackup," Transmission and Distribution Conference and Exposition (T&D), 2012 IEEE PES, Orlando, FL, 2012, pp. 1-8.

[8] Vijayakumar, Madhiyan and VijayanSubramaniam , " Extendedreference signal generating scheme for Integration of unified power quality conditioner system"Taylor and Francis, Electric PowerComponents And Systems, 43 (8-10): 914-927, 2015.

[9] A. K. Yadav and H. Malik, "Optimization of tilt angle for installation ofsolar photovoltaic system for six sites in India," Energy Economics andEnvironment (ICEEE), 2015 International Conference on, Noida, 2015,pp. 1-4.

[10] P. Salmeron and S. P. Litran , " A control Strategy for Hybrid PowerFilter to compensate four wires three Phase System ," Power Electronics , IEEE Transactions onVolume-25,no.7, pp.1923-1931, July2010 .

[11] A. Sulaiman, F. Inambao and G. Bright, "Development of solarhydrogen energy for mobile robots," Robotics and MechatronicsConference (RobMech), 2013 6th, Durban, 2013, pp. 14-19.

[12] L. Piegari and R. Rizzo, "Adaptive perturb and observe algorithm forphotovoltaic maximum power point tracking," in IET Renewable PowerGeneration, vol. 4, no. 4, pp. 317-328, July 2010

