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Analysis of Hybrid ANN-P&O Based MPPT Controller for Photovoltaic System

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Abstract: Photo-Voltaic system efficiency in converting irradiance in to electrical energy faces a huge setback due to partial shading, temperature and irradiance variations in tropic regions. A conventional MPPT controller is used to maximize the conversion efficiency under normal conditions but failed in abnormal conditions. This paper proposes an intelligent ANN-P&O MPPT controller for SEPIC converter utilizes the effective regions of both ANN & P&O methods to identify the global maximum point in order to improve the conversion efficiency of a PV system. The effectiveness of the controller is tested under abnormal conditions and compared with individual counterparts using MATLAB/SIMULINK software.

Keywords: MPPT, ANN, P&0 & Hybrid ANN-P&O.

1. INTRODUCTION

As India is one of the developing countries in the world and is famous for Agriculture. In order to enhance the opportunities to grow as a developed country by means of proper utilization of science and technologic developments in supplying the resources like water on all conditions with the help of water pumping systems [1-4].

The PV systems suffers with partially shading, there by it can generate different maximum powers out of which GMPP (Global Maximum Power Point) is the one point where maximum power is delivered from PV to a load by a DC to DC converter used for load matching [5-8].

The DC to DC converter to be operated as a load matching circuit with the help of switching signals generated by an MPPT controller based on the information from the Voltage and current sensors [9].

In literature the MPPT controller can be a conventional such as P&O, incremental conductance and so on which failed to identify the GMPP but they are good at identifying any MPP's in a faster way which was near to the initial operating point and oscillatory. A Fuzzy logic controller is identifying the GMPP same as P&O and without oscillations [10].

An ANN is the one which identifies the region of GMPP due to its pattern classification specialty [11].

This advantage will be utilized for designing the proposed ANN-Fuzzy MPPT controller in an intelligent manner.

The intelligent controller blends the advantages of ANN for identifying the region in GMMP and Fuzzy was utilized to track the GMPP faster [12].

Finally dedicated algorithm was developed and tested in MATLAB/SIMULINK platform. Comparing the results of the proposed MPPT controller with individual counterparts gives better performance in tracking the maximum power effectively there by increasing the efficiency of the entire system under any circumstances.

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2. PROBLEM IDENTIFICATION

As among the available renewable energy sources, solar energy finds top priority alternative to conventional energy resources due to its clean, eco-friendly & abundant availability.

To extract this solar energy, a photovoltaic Array with load matching device is used. The conversion efficiency of PV array primarily depends on solar isolation and temperature [13-15].

The conversion efficiency of PV panel is of 20 to 30% only and the same efficiency can further deteriorate and dropped down to 10 to 15% due to the following effects.

1. Cloudy conditions
2. Partially shaded effects
3. Parametric variations
4. Mismatching in panel ratings

3. PROBLEM DEFINITION.

The effects on the panel cannot be avoided due to climatic & manufacturing problems even though the conversion efficiency can be increased to its maximum capacity by using Hybrid MPPT controllers with the aid of load matching device (SEPIC converter) is possible.

In literature so many dedicated MPPT controllers are proposed such as Perturb & Observe (P&O), Incremental Conductance (I&C), Fibonacci, Fire fly algorithm, Genetic Algorithm, particle Swarm optimization (PSO), Fuzzy Logic, ANN and so on, having advantages of their own individually and track LMPP's easily but fails to track GMPP's under partial shaded conditions [21].

A Hybrid controller is proposed to track GMPP'S by utilizing the advantages of both conventional and intelligent techniques to the maximum extent which makes Hybrid MPPT controller far better than a single MPPT controller [16-17].

4. PROPOSED BLOCK DIAGRAM

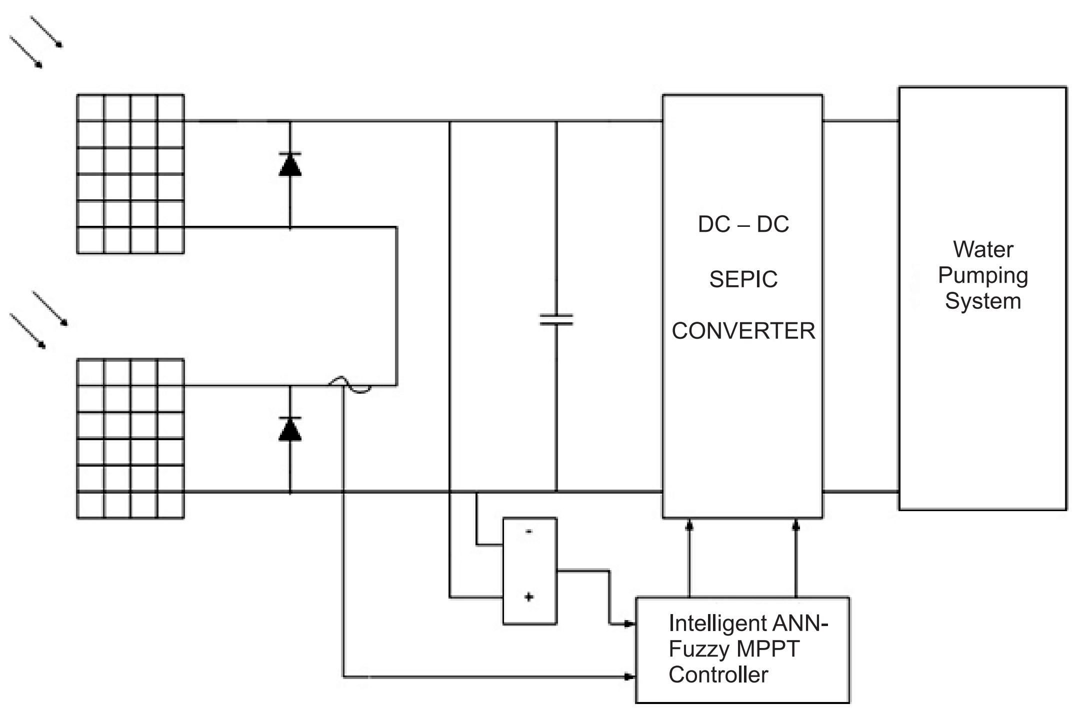


Figure 1: Stand alone Hybrid MPPT controller based Solar PV System

The major components of the proposed system comprises of

1. Photovoltaic panel
2. Load Matching device (SEPIC Converter)
3. MPPT controllers
4. Load

4.1 Photovoltaic Panel

The single diode model of solar PV panel shown in Figure 2 utilized for the analysis of PV system, where the photovoltaic current is mainly dependent on the solar irradiance and temperature governed by the equation.

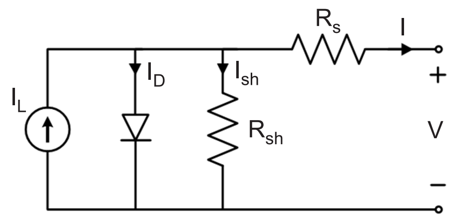


Figure 2: Single Diode Model of PV cell

$$I_{PV} = N_p I_{sc} - N_s I_0 \left\{ \exp\left(\frac{q(V_{PV} + I_{PV}R_s)}{N_s AKT} \right) - 1 \right\} - V_{PV} + \frac{I_{PV}R_s}{R_p} \quad (1)$$

Figure 3 Gives the information about the effects of partial shading which causes multiple Maximum points, out of which one having maximum value named as GMPP (Global Maximum Power Point) and the rest are LMPP (Local Maximum Power Point [6].

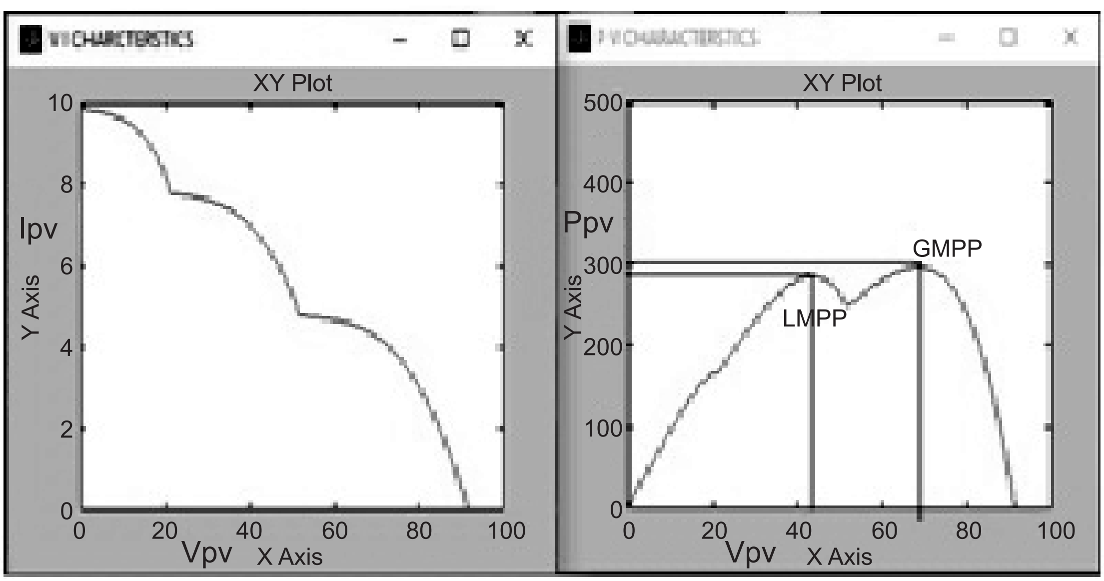


Figure 3: Partially Shaded Characteristics of Solar panel

4.2 Sepic Converter

Due to the important aspect of utilizing SEPIC converter used as a Load matching device as shown in the Figure 4, because it provides isolation between output and input by coupling capacitor due to this output having low ripple factor and non inverted output unlike Buck-Boost converter. Table 1 indicates the parameters used for simulation under continuous conduction mode [7].

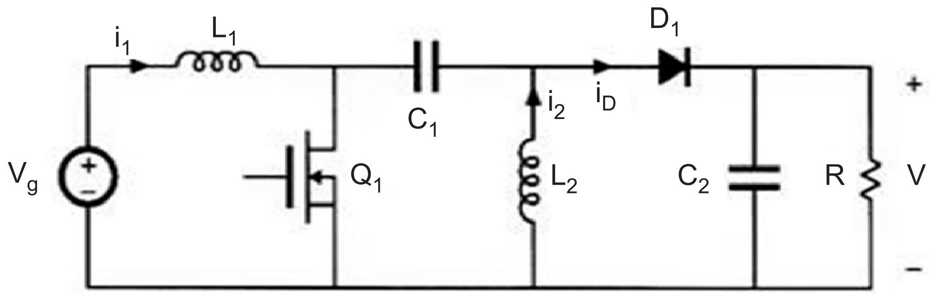


Figure 4: SEPIC converter Model

Table 1
Parameters of SEPIC converter

S.No.	*Symbol*	*Values*
1	Source End Inductor = L_1	0.73702 mH
2	Load End Inductor = L_2	0.73702 mH
3	Source End Capacitor = C_1	10 μF
4	Load End Capacitor = C_2	1.422 mF
5	Switching Frequency = F_s	10 KHz
6	Load Resistance = R_L	hms

4.3 MPPT Controllers

This section provides different MPPT controller strategies discussed with a motto to identify the GMPP under all conditions. The following are the methods applied to the PV system

1. P &O MPPT Controller
2. ANN MPPT Controller
3. Hybrid ANN-P&O MPPT Controller

4.3.1 P&O Controller

Figure 5 shows the MPPT algorithm is quicker and accurate to track the maximum point under normal conditions but failed to track the global maximum power point under abnormal conditions. But it tracks the nearby local maximum whichever comes first. [18]

Figure 6 shows the both panel parameters like PV Panel Voltage Vpv, Current Ipv and Power Ppv and also Load parameters such as Voltage VL, Current IL & power PL generated by Two panel under an isolation change from 1000 w/m^2 for 0.05 seconds on both panels indicate Normal isolation and from 0.05 second to 0.1second an isolation change of 600 w/m2 on panel 1 and 300 w/m^2 on panel 2 makes the Panel working under partially shaded condition.

P&O MPPT algorithm Tracks the LMPP only either normal condition took 0.025 sec and 0.03 sec in case of abnormal conditions.

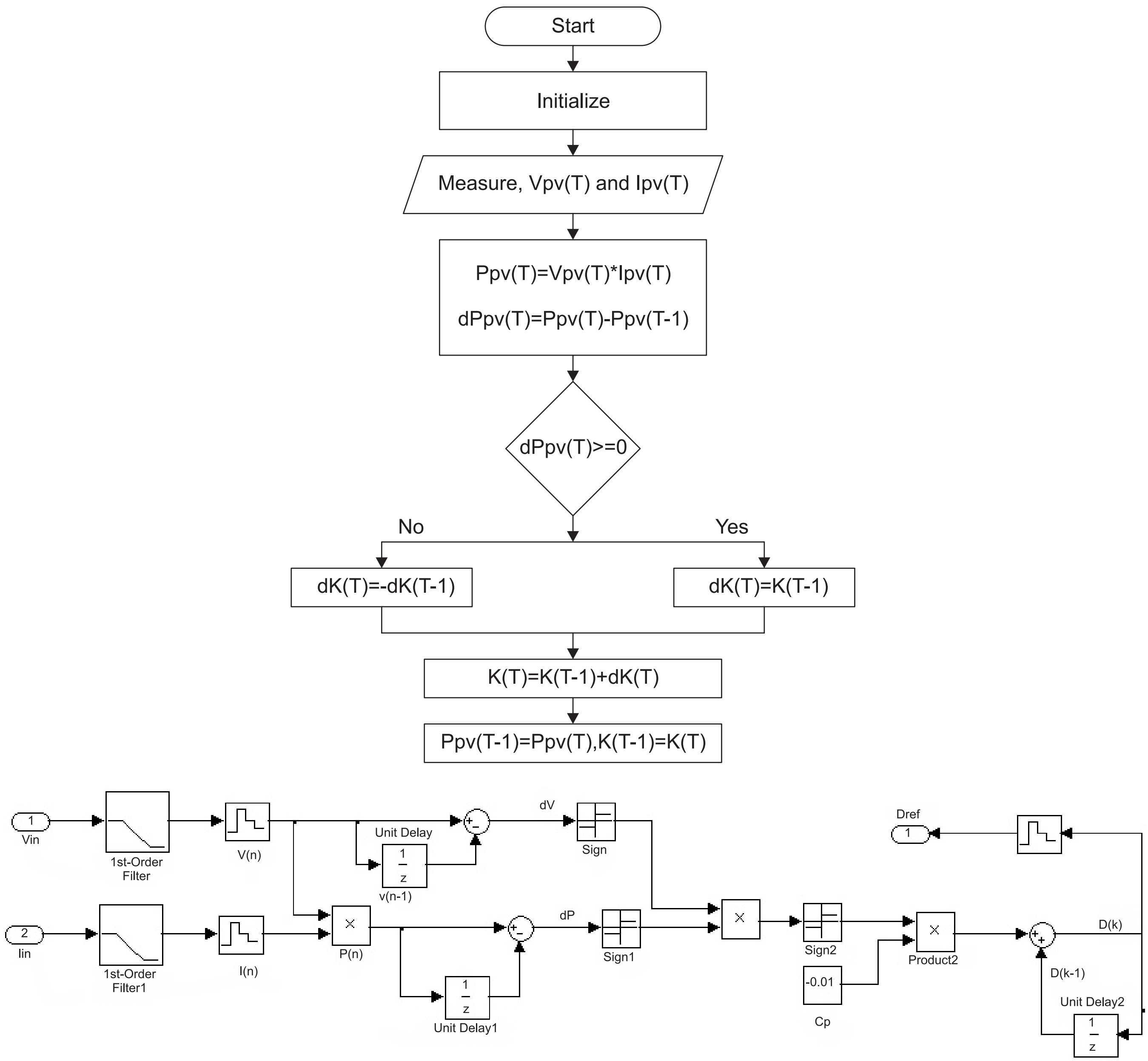
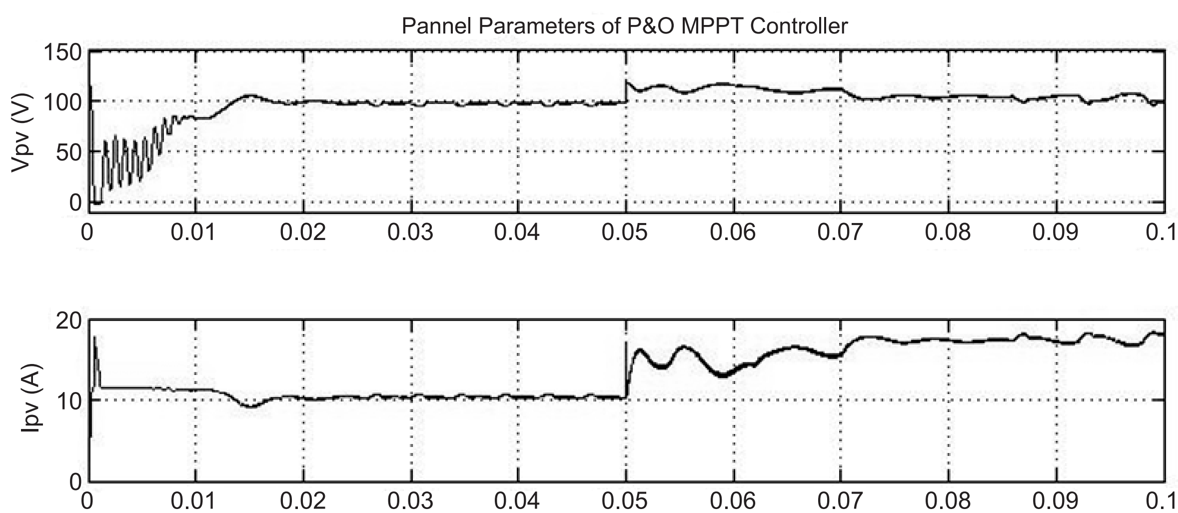


Figure 5: P&O Algorithm and Matlab implementation



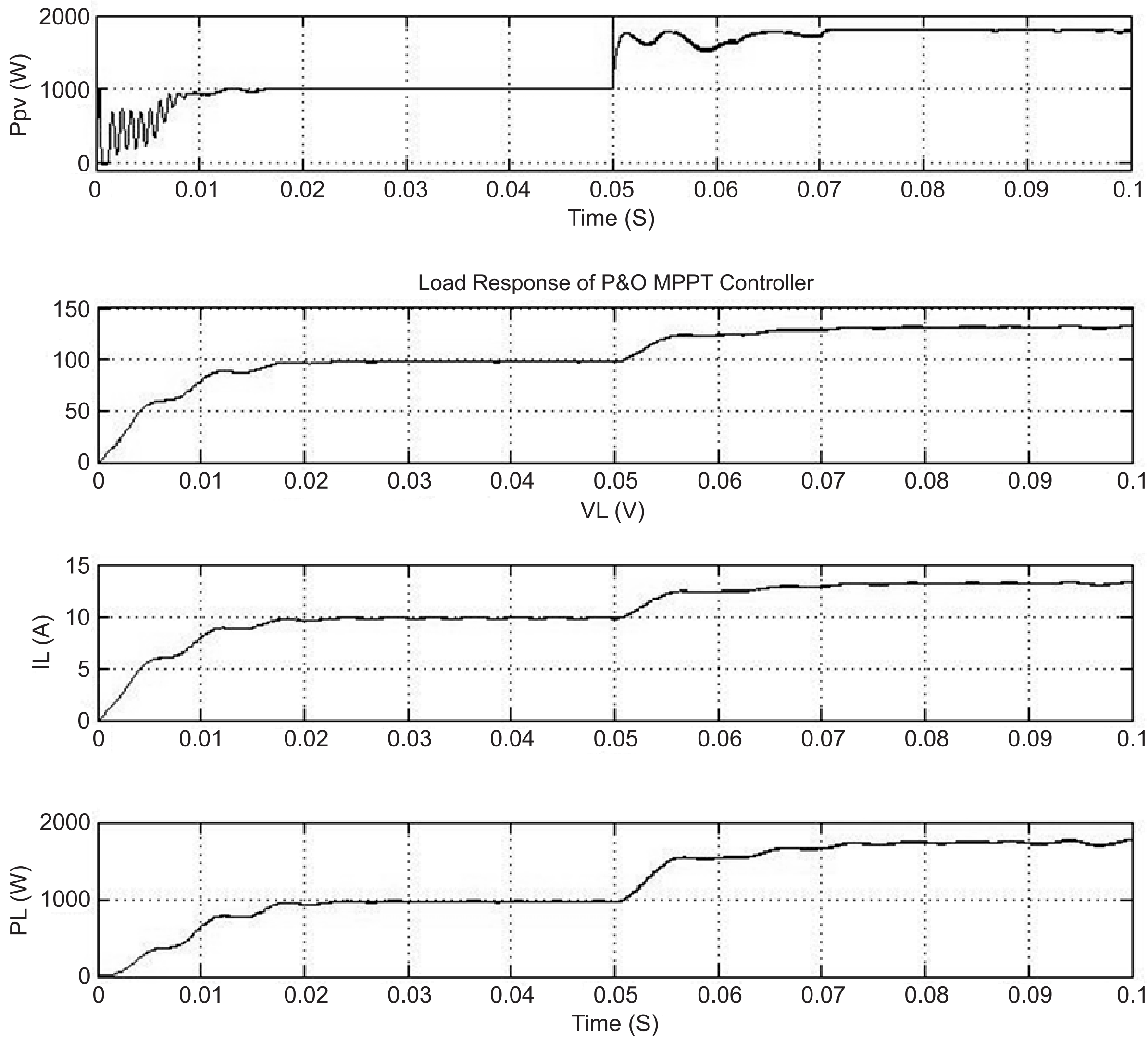


Figure 6: P&O MPPT controller response

4.3.2 ANN MPPT Controller

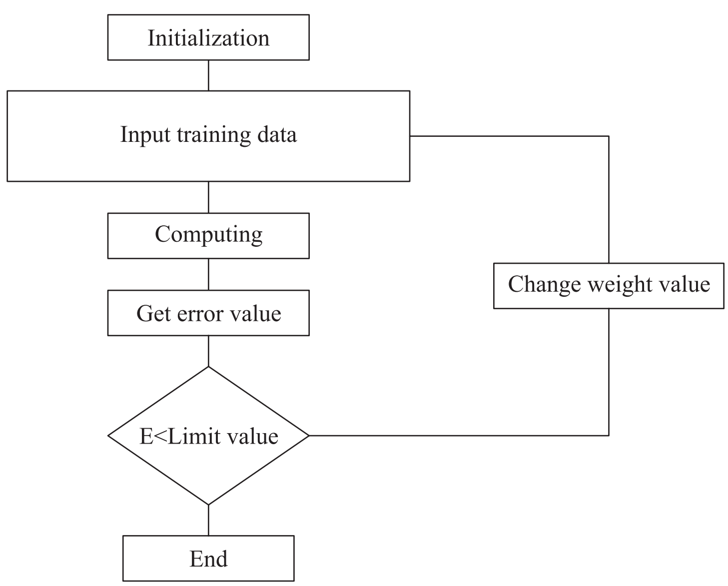


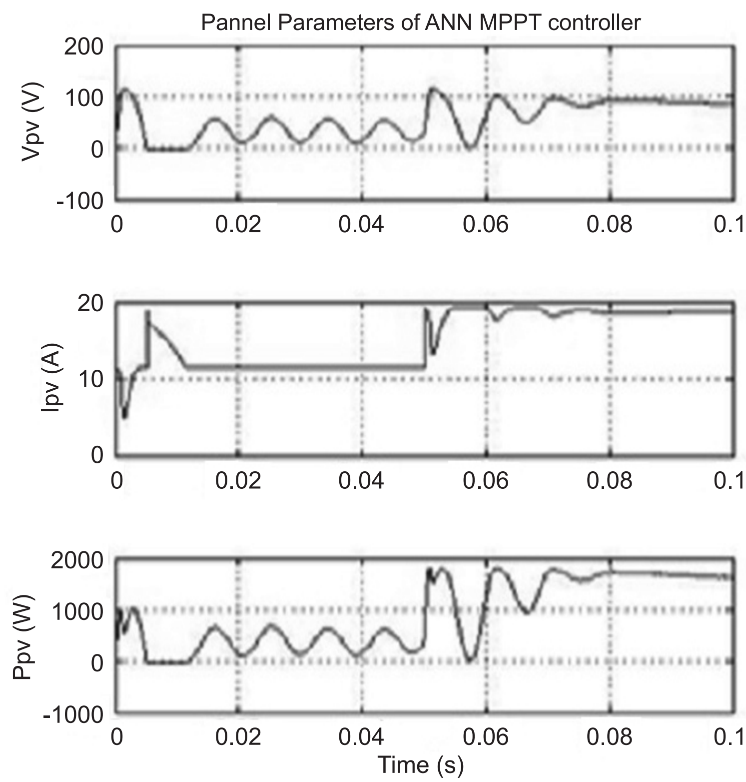
Figure 7: Training Algorithm for ANN

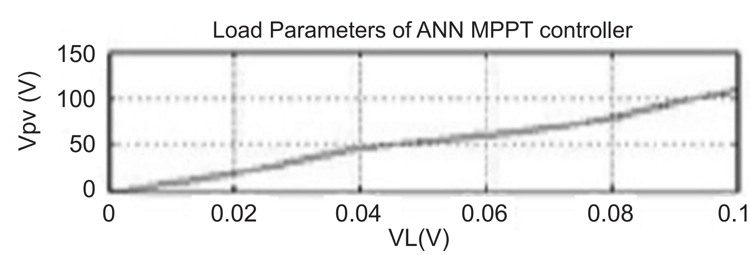
Figure 7 shows the algorithm of an Artificial Neural Network to act as a MPPT controller by considering Voltage and current of the panel as inputs and Reference Duty cycle as output. [19]

The Training data considered for designing ANN controller is gathered from different abnormalities like partially shaded due to isolation, temperature changes and internal parameter changes of the panel. A total amount of 15 abnormal combinations are utilized to fine tune and train the ANN and the information of ANN structure as given in Table 2.

Table 2
ANN parameters

S.No.	*Parameter*	*Description*
1	No. of Input Neurons	2
2	No. of Hidden layer Neurons	10
3	No. of output Neurons	1
4	Training algorithm used	Radial Basis
5	Hidden Layer activation function	Gaussian
6	Output layer activation function	Purelin





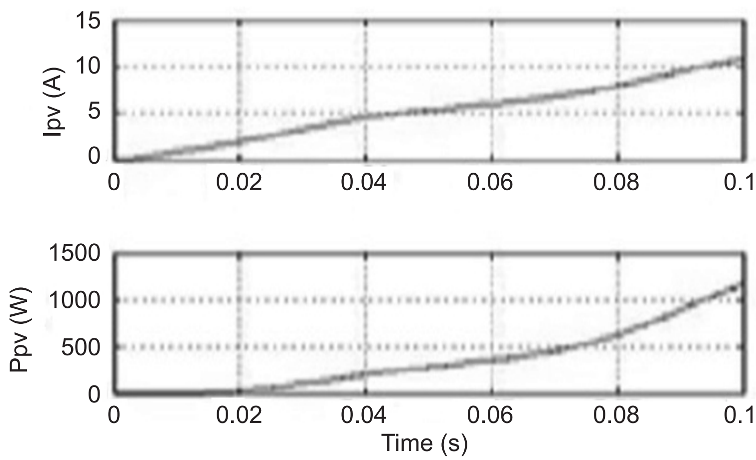
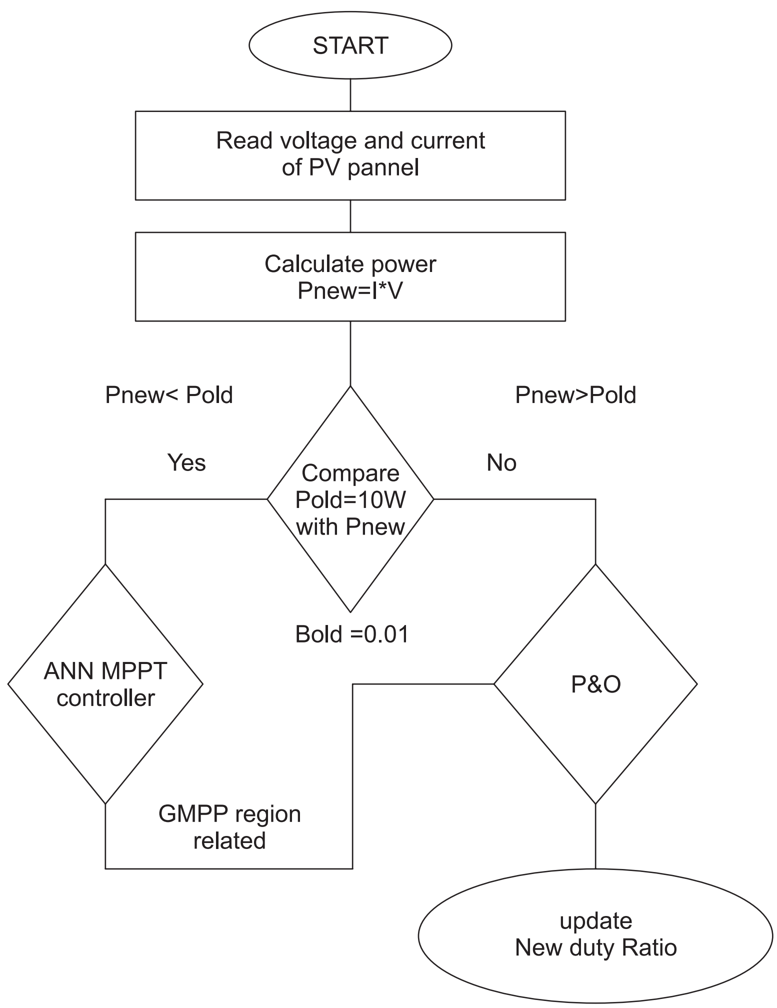


Figure 8: ANN MPPT controller response

Figure 8 shows the both panel and also Load parameters produced by Two panels under an isolation change from 1000 w/m^2 for 0.05 partially shaded condition using ANN controller.

ANN MPPT algorithm Tracks the GMPP under normal condition took 0.04 sec and 0.05 sec in case of abnormal conditions. This MPPT algorithm is slower in tracking the maximum point under normal conditions but identifies the region of Global Maximum power point faster and accurate

4.3.3 Hybrid ANN-P&O Controller



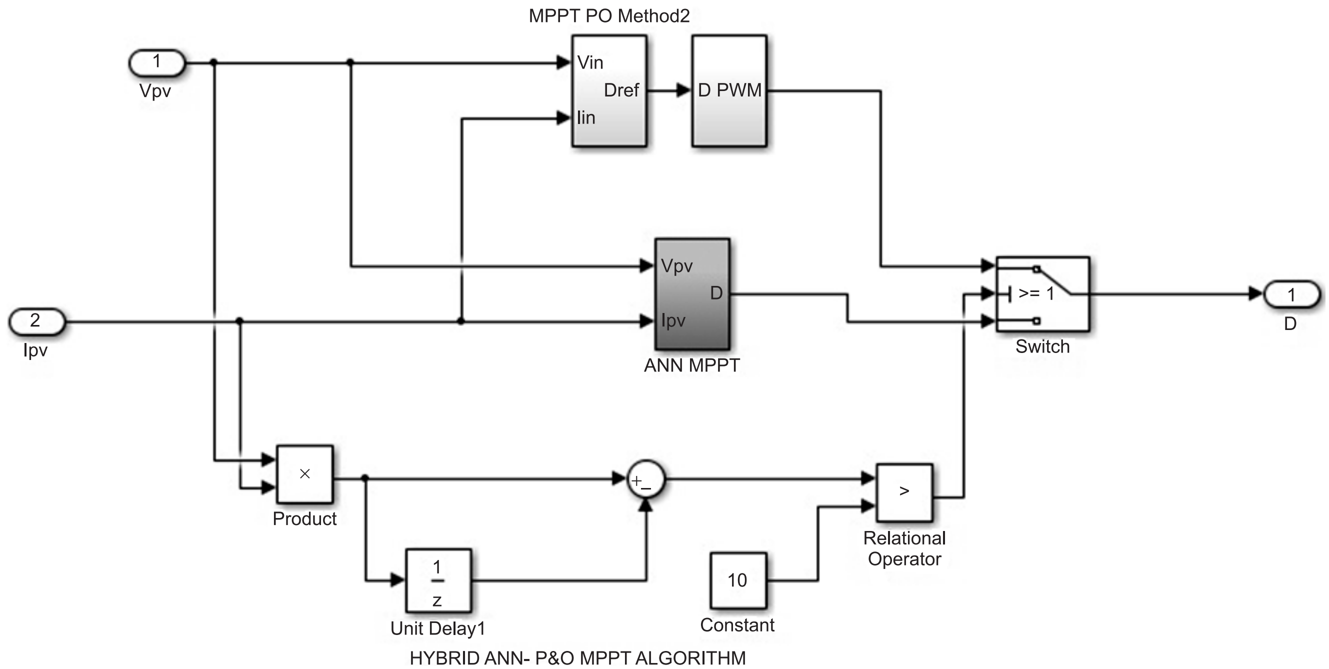
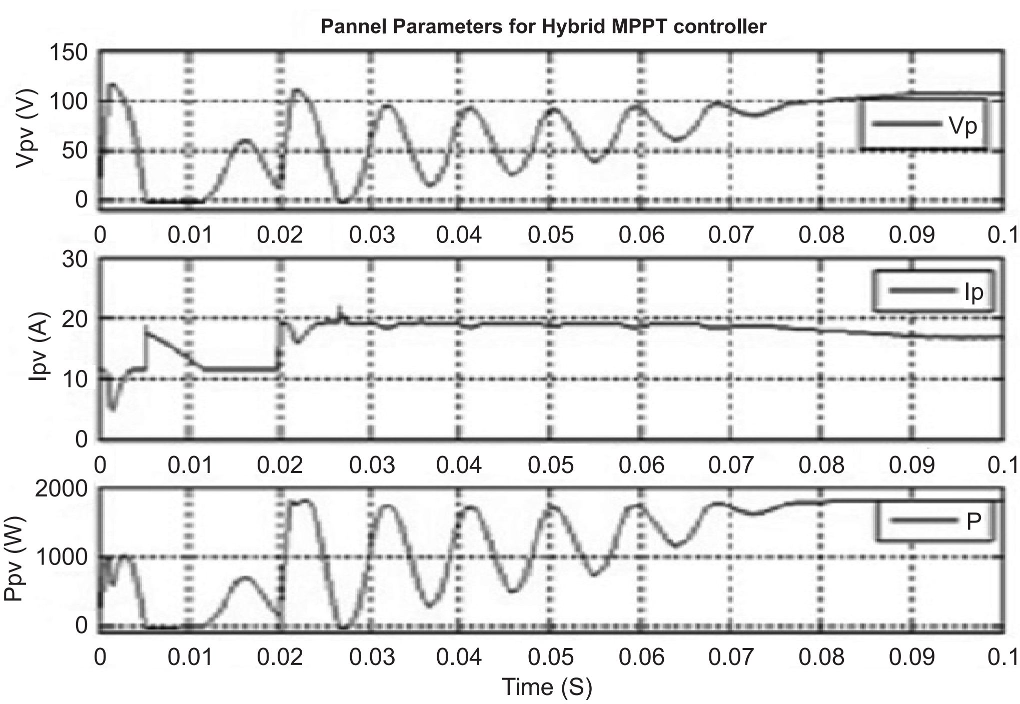


Figure 9: Hybrid ANN-P&O Algorithm and Matlab implementation

Operation

The power is calculated referring the values of the voltage and current of PV panel. This calculated power is considered as new power. The Pnew is compared with the previous value of power (Pold). If Pnew is more comparatively to Pold the same values are fed to as input for P&O method. If Pnew is less than Pold then ANN carries until the MPP region is predicted i.e., until the calculated values are same and send the values as input to P&O method. [20]

Figure 10 shows that both panel and also Load parameters produced by Two panels under partially shaded condition with Hybrid controller.



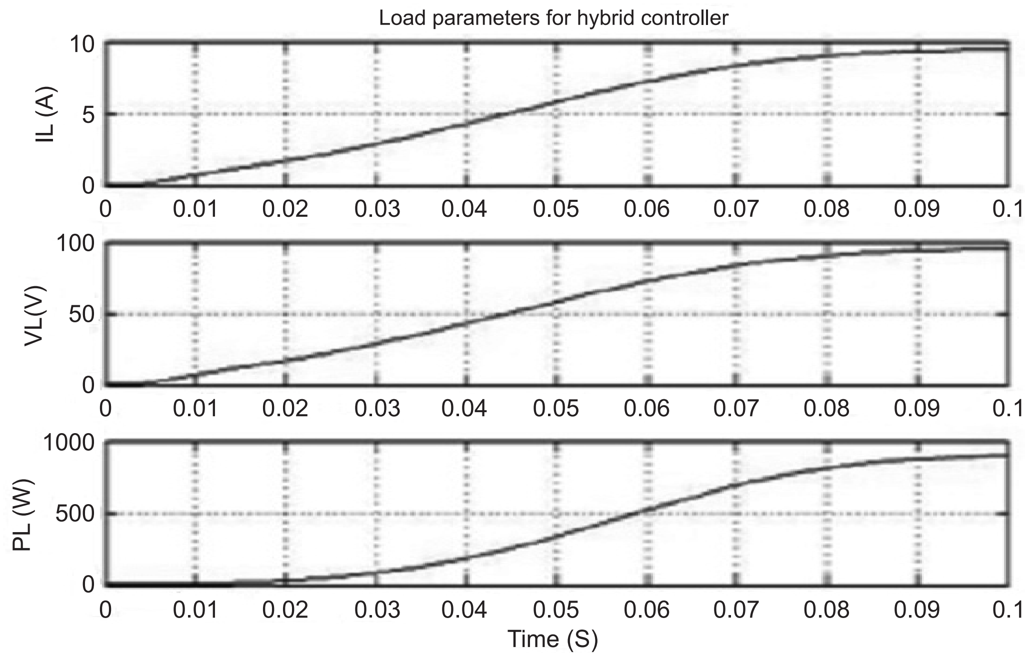


Figure 10: ANN MPPT controller response

Hybrid ANN-P&O MPPT algorithm Tracks the GMPP under normal condition took 0.02 sec and 0.03 sec in case of abnormal conditions. This MPPT algorithm is faster in tracking the maximum point under normal and abnormal conditions too.

5. CONCLUSION

The comparative results shows the effectiveness of different MPPT strategies in tracking the GMPP.

Table 3
Comparative analysis

Controller	*Performance parameter*			
	Tracking LMPP	*Settle Time*	*Tracking GMPP*	*Settle Time*
P&O	YES	0.025	NO	--
ANN	YES	0.045	YES	0.05
HYBRID	YES	0.03	YES	0.045

From the Table 3 the Hybrid ANN-P&O controller tracks the Global Maximum Power Point (GMPP) quickly compared to the individual P&O controller and ANN controller.

References

1. C.L.B. Wuand, R. Cheung. “Advanced algorithm for MPPT control of photovoltaic systems”. *Canadian Solar Buildings Conference, Montreal*, 2004.

2. E.I. Rivera”. Maximum Power Point Tracking using the Optimal Duty Ratio for DC-DC Converters and Load Matching in Photovoltaic Applications”. IEEE, pp. 987-991, 2008.

3. N. Femia, G. Petrone, Giovanni Spagnuolo, and Massimo Vitelli. “Optimization of Perturb and Observe Maximum Power Point Tracking Method” *Transactions on power electronics*, pp. 963-973, Vol. 20, No. 4, 2005.

4. T. Hiyama, S. Kouzuma, and T. Imakubo. “Evaluation of neural network based real time maximum power tracking controller for PV system”. *IEEE Trans. Energy Conversion*, Vol. 10, pp. 543-548,1995b.

5. T.N. Tamer, A. Khatib, N. Mohamed, and K. Amin. "An Efficient Maximum Power Point Tracking Controller for Photovoltaic Systems Using New Boost Converter Design and Improved Control Algorithm". *WSEAS Transactions on power systems*, April 2010, Issue 2, Vol. 5, pp. 53-60.

6. MUMMADIVEERACHARY. "Power Tracking for Nonlinear PV Sources with Coupled Inductor SEPIC Converter" *IEEE Transactions On Aerospace And Electronic Systems*, Vol. 41, No. 3 July 2005.

7. G. Shankar, V. Mukherjee "MPP detection of partially shaded PV array by continuous GA and hybrid PSO," *Shams Engineering Journal* (2015) 6, 471-479.

8. M. Abdulkadir, A.S. Samosir and A.H.M. Yatim ; ARPN "MODELING AND SIMULATION BASED APPROACH OF PHOTOVOLTAIC SYSTEM IN SIMULINK MODEL," *Journal of Engineering and Applied Sciences*, Vol. 7, No. 5, MAY 2012.

9. Jiang J-A, Huang T-L, Hsiao Y-T, Chen C-H. "Maximum power tracking for photovoltaic power systems," *Tamkang J Sci Eng* 2005;8(2):147-53.

10. Yu T-C, Chien T-S. "Analysis and simulation of characteristics and maximum power point tracking for photovoltaic systems," *IEEE international conference on power electronics and drives systems* 2009 (PEDS'2009); 2009. p. 1339-444.

11. Femia N, Petrone G, Spagnuolo G, Vitelli M. "Optimization of perturb and observe maximum power point tracking method," *IEEE Trans Power Electron* 2005;20(4):963-73.

12. Hussein K, Muta I, Hoshino T, Osakada M. " Maximum photo- voltaic power tracking: an algorithm for rapidly changing atmospheric conditions," *IEE Proc: Gener Transm Distrib* 1995;142(1):59-64.

13. Matsukawa H, Koshiishi K, Koizumi H, Kurokawa K, Hamada M, Bo L. "Dynamic evaluation of maximum power point tracking operation with PV array simulator," *Sol Energy Mater Sol Cells* 2003;75:537-46.

14. Orozco Arteaga MI, Va´zquez JR, Salmero´n P, Litra´n SP, Alca´ntara FJ, "Maximum power point tracker of a photovoltaic system using sliding mode control," *International conference on renewable energies and power quality*, Valencia, Spain; 2009.

15. Chuanan Y, Yongchang Y "An improved hill-climbing method for the maximum power point tracking in photovoltaic system," *IEEE international conference on machine vision and human–machine interface*; 2010. p. 530–33.

16. H. Patel ,V. Agarwal, "Maximum power point tracking scheme for PV systems operating under partially shaded conditions," *IEEE Trans. Ind. Electron*., Vol. 55, No. 4, pp. 1689-1698, Apr. 2008.

17. Assessment of P&O mppt algorithm implementation techniques for PV pumping Applications

18. G .Shobana, P.Sornadeepika and R . Ramaprabha, "Global Maximum Power Point Tracking of Photovoltaic Array under Partial Shaded Conditions", *International Journal of Engineering Research*, Vol. No. 2, Issue No. 3, pp : 219-223, July 2013.

19. Bader Alajmi . and Khaled Ahmed H, "A Maximum Power Point Tracking Technique for Partially Shaded Photovoltaic Systems in Microgrids", *IEEE Transaction on Industrial electronics*, Vol. 60, No. 4, pp. 1596-1606, April 2013.

20. R. Bruendlinger, B. Bletterie, M. Milde, and H. Oldenkamp, "Maximum power point tracking performance under partially shaded PV array conditions," in Proc. 21st EUPVSEC, Dresden, Germany, pp. 2157-2160, Sept 2006.

21. P. Srinivasa Varma and M. Yateesh Kumar, "A Comparative Study for Alleviation of Current Harmonics using PI/FUZZY Controller based PV-APF System", *Indian Journal of Science and Technology*, Vol. 9, No.23, June 2016.