Predictive-P&O Mppt Algorithm for Fast and Reliable Tracking of Maximum Power Point in Solar Energy Systems

Obaidullah Lodin, Inderpreet Kaur, Harpreet Kaur

ABSTRACT--- Photovoltaic systems are used for conversion of sun energy into un-regulated electrical energy. To track the maximum power point (MPP) MPPT controllers are used which provides duty cycle in order to on-off the MOSFET switch used in inductive-capacitive energy storage circuit. In existed literature, perturb-observe (PO) method is widely used and found effective than most of other methods. This work aims to develop an improved predictive power based PO method in order to improve convergence time to reach optimum, reduction of steady-state oscillations and consistency in ambient conditions. The simulation work is carried out in MATLAB and improved PO method is simulated using buck booster converter. Along with previous power and current power values predictive power is used in proposed predictive-PO method which is evaluated for PO method based output power using least mean square filtering. LMS reduces the oscillations in power waveform which is used further in predictive-PO to attain oscillation free output power.Proposed method can be used for standalone as well as well as micro-grid based applications.

Keywords—MPPT algorithms, irradiance, Perturb-observe, predictive power etc.

I. INTRODUCTION

MPPT algorithms are progressively developed for photovoltaic (PV) scheme by using Soft computing approaches. It is manifest from the current explosion of MPPT methods by differential evolution (DE) [1], particle swarm optimization (PSO) [2], ant colony optimization (ACO) [3], artificial neural network (ANN) [4], grey wolf (GW) [5], artificial bee colony (ABC) [6], cuckoo search (CS) [7] and fireflies (FF) [8] etc. The key benefits of these methods are their in-built capability to switch in spring ecological situations for instance dynamic irradiance changes and partial shading. In spite of taking greater effectiveness, it is hard to manage the computing burden, execution cost, complexity, and gentle tracking speed linked with them [9], [10]. Subsequently, in numerous current effort, conventional MPPT approaches for instance hill climbing (HC) [11], perturb and observation (P&O) [12][13], [14] and incremental conductance (IC) are re-visited and upgraded. Amongst all the predictable MPPT, P&O is the unpretentious and reveals firm merging to the maximum power point (MPP). Nevertheless, it undergoes from three severe disadvantages. Firstly, the procedure uninterruptedly fluctuates nearby the MPP. The fluctuation is unavoidable owing to the nature of the procedure which services the operational point to transfer backward and forward round the MPP with respect to the enforced perturbation. Dependent on the extent of the perturbation, the oscillation effects in definite extent of power loss. Secondly, the P&O is disposed to drop its tracking way after the irradiance upsurges speedily with time [15]. After the tracking direction is improper, the process turn out to be disordered and it deviates much more from the maximum power point. The loss in energy will be significant, if it occurs. Thirdly, the P&O—in its novel practice, is not proficient of pursuing the comprehensive peak beneath partial shading form. Adaptive filtering methods are applied in extensive series of uses, comprising adaptive equalization, echo cancellation, adaptive beam forming and adaptive noise cancellation. The Least Mean Square (LMS) procedure, which is carried frontward by [16], is extensively applied in adaptive signal processing. The LMS adaptive filter group is striking for employment of actual noise conquest schemes because of its low computation complexity and toughness [16] and [17]. It is well recognized that the presentation of LMS adaptive filters contingent straight on the selection of the step size factor. Conventional adaptive filtering expending the LMS [16] algorithm uses a continuous step size to alter its figures in response to the altering setting. LMS adaptation process was widely used to array signal processing for wireless communications for instance channel equalization, interference suppression and echo cancellation.

II. RELATED WORK

In 2013 H. Renaudineau et al (2013) proposed a worldwide optimization policy used to a dispersed PV generation scheme. The PV foundations are linked to a great voltage bus all over a devoted dc-dc converter [2]. After that K. Punitha et al (2013) proposed an adapted IC technique to pathway the MPP beneath partial shading situation. An ANN is analyzed to provide the voltage Vref to the altered IC technique. An artificial neural network accomplished with a back-propagation process is exploited for online approximation of mentioned feed forward loop's voltage [4]. Moreover, Fan Zhang et al (2013) advanced a new hybrid MPPT procedure to increase the effectiveness and

Revised Manuscript Received on April 05, 2019.

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presentation of the normal P&O method. The procedure is intensive on refining the temporary tracking speed and growing the stable state constancy[13]. Then, Sishaj P. Simon et al (2014) proposed a new method centered on ABC for GMPP tracing in a PV power generation organization. Arithmetical models applied on two dissimilar arrangements with changing shading designs clearly prove the enhanced presentation of the planned process in contrast with the current approaches of EPO and PSO [6]. Furthermore, Saad Mekhilef et al (2015) developed a consistent and structure free technique for photovoltaic scheme to pathway the MPP during partial shading conditions (PSC). An integrated technique called DE-PSO, a grouping of DE and PSO, is implemented to pathway the definite MPP in the production of the photovoltaic system [1]. After that Kinattingal Sundareswaran et al (2015) labeled a novel supreme power fact tracking technique (MPPT) in Photovoltaic systems during PSC. The proposed technique efficiently in corporate ant colony centered worldwide exploration in the determinative phases of tracking collected with outmoded P&O method in the advanced phases for local exploration [3]. Then, Satyajit Mohanty et al (2015) proposed a new evolution figuring method called (GWO) or grey wolf optimization for supreme power abstraction procedure for photovoltaic systems to function under PSC [5]. Moreover, Chakkarapani Manickam et al (2015) suggested a novel global MPP tracing policy developing the benefits of the normal Perturb and the Fireworks algorithm and Observe (P&O) procedure. For defining the suitable usage of every procedure, a PS capturing method was developed and authorized based on hardware tests. [18]. Then, S. Kantha lakshmi et al (2018) suggested a new enhanced P&O MPPT technique for GMPPT in Photovoltaic schemes under PSC. It decreases the convergence chance at local maximum power point throughout PSC and removes the stable state fluctuations [19]. Then, Mostefa Kermadi et al (2018) presented an enhanced hybrid MPPT that concatenates an improved P&O an enriched Particle swarm optimization. The second integrates the SSJ system and a device to elude numerous scanning of specific exploration area by the PSO particles [20].

III. PV MODELING

Numerous PV models are described in survey; the most standard ones are the one diode model, R_p and R_s are the 2 diode model [21]. The primary determination of it is to compete with the performance of PV components in circuit system, thus it could be combined to the electrical based accessible computation program, like SIMULINK MATLAB. To certify improved accurateness, the two diode model is analyzed as per Figure 1.1. If Voltage is V, then current of the PV is taken from the structure could be in scribed conferring to 2 diode models by way of

$$I = I_{PV} - I_{d1} - I_{d2} - \frac{V + IR_s}{R_p} \quad (1)$$

Whereas $R_p$and $R_s$are the parallel and series resistance, correspondingly. Although the diodes thermal voltage is V_T. The created current by lights is (I_{PV})

$$I_{PV} = (I_{PV-STC} + K_I(\mathrm{T} - T_{STC}))\frac{G}{G_{STC}} \quad (2)$$

$I_{P\ V\_STC}$ is computed in the standard test condition (STC), i.e., irradiance G = 1000 W/m^2 and temperature T = 298 K (25°C). Variable K_I is frequently delivered by the constructor, which is coefficient of the I_{SC}. Diode's saturation current is specified by [21]

$$I_{d1} = I_{d2} = \frac{I_{SC-STC} + K_1(\mathrm{T} - \mathrm{T_{STC}})}{\exp((V_{OC-STC} + K_V(T - T_{STC}))/V_T) - 1} \quad (3)$$

In (3), I_{SC_STC} is the short circuit current and V_{OC_STC} is the open circuit voltage in standard test condition (STC). The voltage's temperature factor is denoted by Variable K_V.

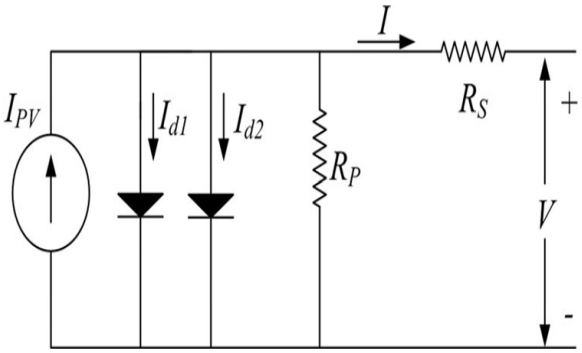

Fig.1: The 2-diode model of photovoltaic cells.

IV. PERTURB AND OBSERVE (P&O) METHOD

On account of simplicity of execution as presented in diagram below, the Conventional Perturb & Observe algorithm is applied widely. Until the operative point unites at the MPP, it is a constant progression of observation and perturbation. The P&O algorithm equates the voltage and power of time (K) along with the model at a time (K-1) and guesses the time to method to maximum power point. If the power modification is +ve, then the power transformation of the solar panel is done by a minor voltage perturbation; voltage perturbation is constant in the equivalent pathway. On the other hand negative delta power, point out that the maximum power point is far-off and the perturbation is reduced to trace the maximum power point. The abstract of the conventional P&O is figured out in Table 1. Hence, like this the entire P-V curve is checkered by minor perturbations to discover the maximum power point which rises the response time of the process. On the contrary, steady state oscillation around the MPP is produced by

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enlargement the size of perturbation. Variations in the P&O algorithm have been proposed by numerous scholars to overwhelm the steady state oscillations and response time issue.

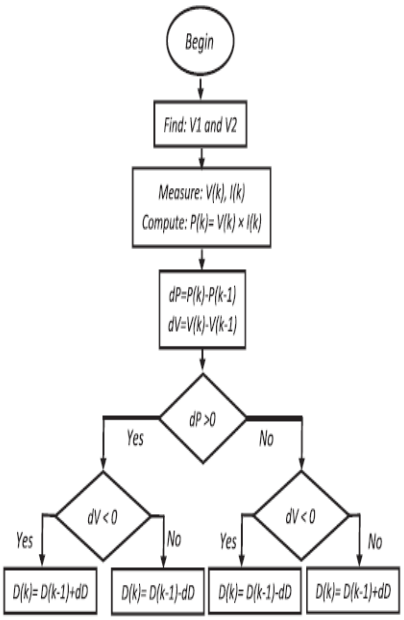

Fig.2: Conventional flowchart of P&O method.

TABLE I: SCHEME OF THE P&O ALGORITHM

Perturbation	Change in power	Resulting Perturbation
+ve	+ve	+ve
+ve	-ve	-ve
-ve	+ve	-ve
-ve	-ve	+ve

V. PREDICTIVE_PO BASED MPP TRACKER

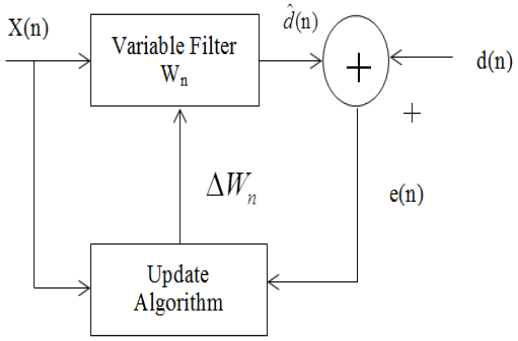

Fig.3: A block diagram of the Adaptive FIR Filter

If a filter regulates its conveyance task by itself stated by an optimization process is called an adaptive filter (AF). On account of complexness of the optimization algorithms, digital filters are also adaptive filters which execute digital signal processing (DSP) & adjust their act built on the incoming signals to the filter. By means of compare, a non-adaptive filter has static filter factors (that jointly custom the transfer functions).

A. An Adaptive FIR Filter execution by using the least mean squares (LMS) Algorithm

LMS procedures are a session of adaptive filter applied to simulate a preferred filter by defining the filter factors that narrate to creating the LMS of the error signal.

B. Least Mean Square (LMS) Algorithm

For numerous age , the adaptive filter is a widespread and operative device for examining signals. Let the length of the adaptive filter for instance L. For input vector x(n), the arrangement produces output signal y(n) as presented in the subsequent equation,

$$y(n)=x(n)\,\mathrm{T}\,w(n)=w(n)T\,x(n) \tag{4}$$

The weight updated vector for the LMS algorithm is specified by the subsequent equation;

$$w(n+1)=w(n)+\mu\,x(n)\;e(\mathrm{n}) \tag{5}$$

Where μ is the step size

The whole PV system has been shown in figure1.4 where MPPT block uses PREDICTIVE-PO based tracking method.

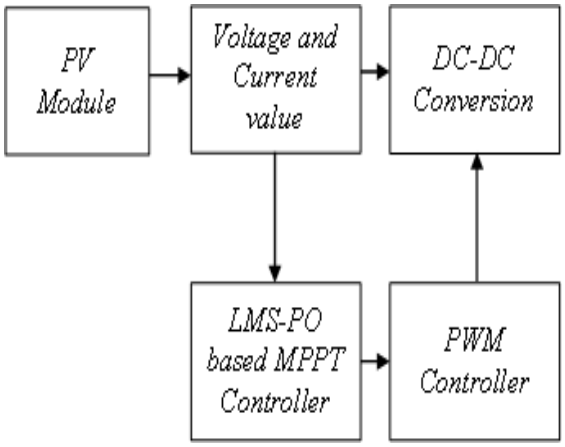

Fig.4: Maximum Power Point and DC-DC converter control system diagram

Whole Photovoltaic system designed for efficient mppt tracking has been shown in figure 2.Due to the variance in irradiance and temperature, the voltages and currents cannot fed directly to the energy storage units or appliances, these need to be first fed to the controller device which tracks the maximum power for the available voltage and current in such a way that an energy storage unit which consists of inductance and capacitance circuit hold the extra power for some time when there is extra power generation from previous cycle and donates the power when there is less power production in previous round. This on-off time set is provided by a mosfet/IGBT switch to the LC circuit using the MPPT control unit. The LC circuit and switch constitutes the buck booster system which works on DC-DC conversion level. In existed algorithm of perturb-observe; only current and previous readings were utilized without any consideration of optimized future power values. In proposed methodology, predictive power is induced which is

optimized using least mean square algorithm in order to maintain optimum maximum point of power. In flowchart below, p(n+1) is predictive power.

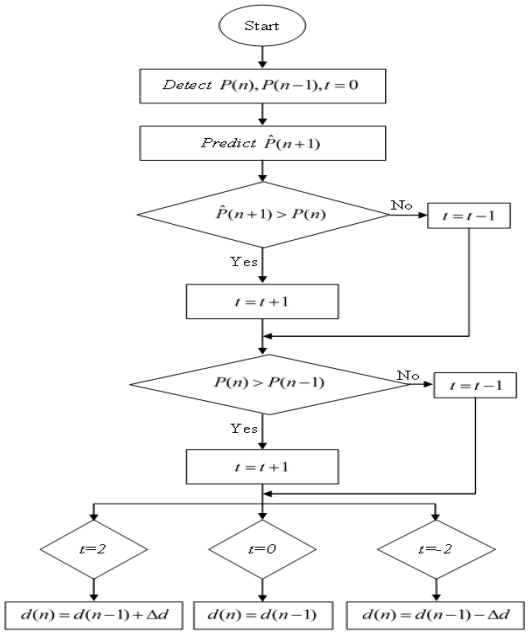

Fig.5: Flowchart of MPPT algorithm based on LMS based predictive power

VI. RESULTS

Simulation results are carried out for an array consists of 40 series modules and 10 parallel modules. User defined attributes of module used are as follows. Open circuit voltage (Voc (V)) is 42 , Isc(A)=29.7,Voltage at MPP Vmp(v)=36, ,current at MPP Imp(A)=27.7, cells per module= 10Fig. 6 shows the IV-PV plots of array when it works at optimum conditions. Fig. 7 Shows the PV power waveforms using traditional PO method and PREDICTIVE-PO based improved method. The performances of proposed MPPT algorithm have been evaluated at 1000 W/m^2 and 25^o temperature. Table two gives the power values using two compared methods.

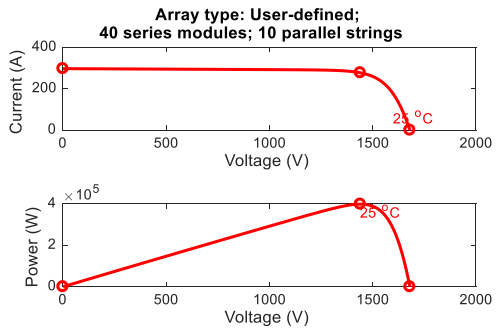

Fig. 6: IV-PV plots of array in optimum conditions

TABLE II: COMPARISON OF POWER BY EXISTED AND PROPOSED METHODS AT DIFFERENT TIMES OF SIMULATION

Time in sec	Array-power (w) Predictive-PO	Array-power (w)
	method	PO method
0.001	34544.12	13489.61
0.007	314867.6	256783
0.138	240189.6	216032.4
0.144	275178	209170.5
0.15	307600.2	210972.7
0.156	337452.5	224417.6
0.162	372358.9	248507
0.167	393669.5	284275
0.172	398532.9	324348.6
0.178	385929.9	366375.8
0.266	397998.1	396496.7
0.286	399966	399085.6
0.297	398875.6	396430.5
0.314	399992.1	398035.9
0.325	399852.2	398025.4
0.34	399383.8	399337.8
0.352	399413.9	399230.9
0.367	399601.3	397805
0.379	397747.3	395753.4
0.385	397964.2	397226.3
0.395	400141.6	394396.6
0.406	399042.2	394333.1
0.419	395470.3	394650.2
0.424	396874.1	396491.3
0.436	396988.2	394892.2
0.448	399038.8	395925.7
0.458	398810.4	396183.4
0.471	399726.9	396156.4
0.483	398338.3	397751.2
0.495	398472.9	393632.4

It has been found that proposed method achieves highest point far early than traditional PO method. In this work, buck-booster DC-DC converter is used and mosfet switch is used to on-off the energy storage circuit.

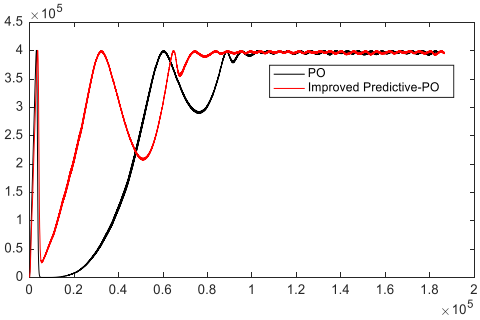

Fig.7: Comparison of power output using perturb-Observe and Proposed PREDICTIVE-PO based MPPT tracking

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It is also been found that proposed method gives power with least fluctuation variance and achieves stability in peak value earlier than PO method.

VII. CONCLUSION

The fast and consistent MPPT method is the requirement of the clients in solar photovoltaic industry. The working evaluation of the proposed predictive-PO MPPT algorithm is shown through graphs and tables in values of output power achieved by improved method and are compared with that of perturb-observe MPPT algorithm. Buck-booster based DC-DC converter is used and battery storage unit is provided to store the energy. The consistency evaluation of the suggested technique has been done under different irradiance and temperature conditions. This algorithm can assist in achievement of fast maximum power point in both standalone as well as grid-connected photovoltaic systems. The proposed technique can be improved for partial shading conditions in future work.

REFERENCES

1 M. Seyedmahmoudian, R. Rahmani, S.Mekhilef, A. S. Ghandhari, T. K. Soon , A. M. T.Oo, A.Stojcevski,"Simulation and hardware implementation of new maximum power point tracking technique for partially shaded PV system using hybrid DEPSO method," IEEE Trans. Sustain. Energy, vol. 6, no. 3, pp. 850–862, Jul. 2015.

2 H.Renaudineau, F.Donatantonio, G.Petrone, G.Spagnuolo, J. P. Martin, S.Pierfederici, J. Fontchastagner,"A PSO-based global MPPT technique for distributed PV power generation," IEEE Trans. Ind. Electron., vol. 62, no. 2, pp. 1047–1058, Feb. 2015

3 K. Sundareswaran, V. Vigneshkumar, P. Sankar, S. P. Simon, P. S. R. Nayak, and S. Palani, "Development of an improved P&O algorithm assisted through a colony of foraging ants for MPPT in PV system," IEEE Trans. Ind. Informat., vol. 12, no. 1, pp. 187–200, Feb. 2016.

4 K. Punitha, D. Devaraj, and S. Sakthivel, "Artificial neural network based modified incremental conductance algorithm for maximum power point tracking in photovoltaic system under partial shading conditions," Energy, vol. 62, pp. 330–340, 2013.

5 S. Mohanty, B. Subudhi, and P. K. Ray, "A new MPPT design using grey wolf optimization technique for photovoltaic system under partial shading conditions," IEEE Trans. Sustain. Energy, vol. 7, no. 1, pp. 181– 188, Jan. 2016

6 K. Sundareswaran, P. Sankar, P. S. R. Nayak, S. P. Simon, and S. Palani, "Enhanced energy output from a PV system under partial shaded conditions through artificial bee colony," IEEE Trans. Sustain. Energy, vol. 6, no. 1, pp. 198–209, Jan. 2015.

7 J. Ahmed and Z. Salam, "A maximum power point tracking (MPPT) for PV system using cuckoo search with partial shading capability," Appl. Energy, vol. 119, pp. 118–130, Apr. 2014.

8 D. Teshome, C. H. Lee, Y. W. Lin, and K. L. Lian, "A modified firefly algorithm for photovoltaic maximum power point tracking control under partial shading," IEEE J. Emerg. Sel. Topics Power Electron., vol. 5, no. 2, pp. 661–671, Jun. 2017.

9 J. Ahmed and Z. Salam, "A critical evaluation on maximum power point tracking methods for partial shading in PV systems," Renewable Sustain. Energy Rev., vol. 47, pp. 933–953, Jul. 2015.

10 K. Ishaque and Z. Salam, "A review of maximum power point tracking techniques of PV system for uniform insolation and partial shading condition," Renewable Sustain. Energy Rev., vol. 19, pp. 475–488, Mar. 2013.

11 F. Paz and M. Ordonez, "Zero oscillation and irradiance slope tracking for photovoltaic MPPT," IEEE Trans. Ind. Electron., vol. 61, no. 11, pp. 6138–6147, Nov. 2014.

12 S. K. Kollimalla and M. K. Mishra, "Variable perturbation size adaptive P&O MPPT algorithm for sudden changes in irradiance," IEEE Trans. Sustain. Energy, vol. 5, no. 3, pp. 718–728, Jul. 2014.

13 F. Zhang, K. Thanapalan, A. Procter, S. Carr, and J. Maddy, "Adaptive hybrid maximum power point tracking method for a photovoltaic system," IEEE Trans. Energy Convers., vol. 28, no. 2, pp. 353–360, Jun. 2013.

14 M. Killi and S. Samanta, "Modified perturb and observe MPPT algorithm for drift avoidance in photovoltaic systems," IEEE Trans. Ind. Electron., vol. 62, no. 9, pp. 5549–5559, Sep. 2015.

15 T. Bennett, A. Zilouchian, and R. Messenger, "A proposed maximum power point tracking algorithm based on a new testing standard," Sol. Energy, vol. 89, pp. 23–41, 2013.

16 B. Widrow and S.D. Stearns, Adaptive Signal Processing, Prentice Hall, 1985.

17 D.G. Manolakis, V.K. Ingle and S.M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, 2000.

18 Hafiz, M., Aravind, C.V., Sarimuthu, C.R. "Intelligent distribution network using load information management" (2018) Journal of Engineering Science and Technology, 13 (Special Issue on the eighth eureca 2017), pp. 17-27

19 Aravind, C.V., Cheng, K.K., Ramesh, G.P. The case of energy recovery solutions using synchronous monitoring and adaptive real time system (2016) Journal of Engineering Science and Technology, 11 (Special Issue), pp. 46-56

20 M. Kermadi, Z. Salam, J. Ahmed and E. M. Berkouk, "An Effective Hybrid Maximum Power Point Tracker of Photovoltaic Arrays for Complex Partial Shading Conditions," IEEE Transactions on Industrial Electronics, 2018

21 K. Ishaque, Z. Salam, and H. Taheri, "Simple, fast and accurate two-diode model for photovoltaic modules," Sol. Energy Mater. Sol. Cells, vol. 95, no. 2, pp. 586–594, 2011

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