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Performance of Solar PV System for Modified Adaptive Incremental Conductance Algorithm Under Varying Climatic Conditions

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Abstract:--- This article evaluates the achievements of classical MPPT algorithms applied to a solar PV arrays and also recommend a novel modified adaptive incremental conductance (MAINC) MPPT method which affords superior proficiency under rapid multiple insolation changes in climate. MATLAB/SIMULINK tool is employed to examine the soundness of the novel algorithm under fast climate changes. The out turn denotes that the MAPO technique succeeds in achieving better capture of energy, conversion efficiency, settling time and minimum steady state oscillations.

Keywords--- MPPT algorithms; Modified adaptive INC; Photo voltaic system; MATLAB/SIMULINK

I. INTRODUCTION

Power of sun is the genesis for all power styles. Its potency in Bharat is gigantic as a result of the bulk of the countries torrid earth mass is found exquisitely for optimum solar insolation. Research remains occurrence for raising the feat of solar arrays, MPPT regulators and DC/DC converters[1]. Such technological economic enhancements provoke the alternative energy in Bharat could be a quick developing business and intended by 2022 to 100 GW.

Integrated regulator with PWM unit is that the prime fragment in the midst of PV array and an influence convertor to deliver peak power. MPPT module target is to spot the null slope of the V-P plot of module. Researchers develop an enormous variety of MPPT systems over the past decade [2][3][4]. Strategies of classical approaches are the industrial MPPTs over long time.

At present largely, the analysis centered on MPPT schemes [5-8], where correlatives of the assorted MPPT schemes are mentioned. Anyhow, the peak PV power forever remnant a prime rival in relevant works. Investigators have suggested distinct MPPT schemes to obtain peak PV power, like classical and intelligent techniques [9][10]. However, classical methods separate the PV array to assess the necessary current or voltage. Hence, the waste of energy is raised by the cyclic separation of the PV array [11]. On the other hand, intelligent techniques are powerful in pursuing MPP and gain a stable MPPT method due to their skill to handle the PV array nonlinearity. They still demand gigantic storage for fulfilment of rules and required knowledge.

This article intention to debate a pertinent of the PV module feat supported the result of modified classical MPPT techniques. This article is conferred into four portions: Section two contributes the PV panel, DC/DC converter models and MPPT approaches. The outcomes and notices are shown in part three. Finally, conclusions are specified in last quarter.

II. MODELLING OF OVERALL SYSTEM

The foremost system parts are

- PV panels
- MPPT regulator and
- Boost converter

A PV array modeling

The panel model is that the principal part in overall system. Fig.1 exemplifies the essential diode electric circuit PV array. Fig.2 reveals the deportment of the panel. The current expression Ipv, is attained with Kirchhoff Laws, as in (1) [12]. This expression is resolved employing an appropriate numerical methodology.

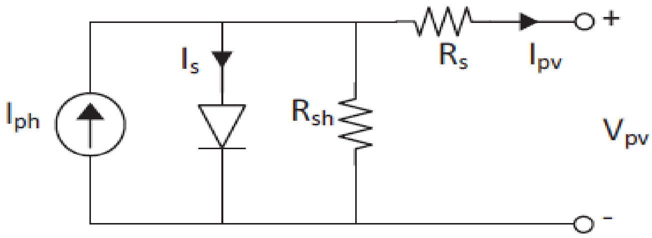

Fig. 1.PV panel model with one diode

$$I_{PV} = I_{ph} - I_s\left(\exp\left(\frac{(V_{PV} - R_s I_{PV})}{AV_T}\right) - 1\right) - \frac{(V_{PV} - I_{PV} R_s)}{R_{sh}} \quad (1)$$

$$V_T = \frac{kT}{q} \quad (2)$$

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Terminology

Iph	- Photon Current
Is	- Saturated dark current
V_{pv}	- Panel Voltage
R_s	- Series Resistance
A	- Ideality Quality
V_T	- Thermal Emf
k	- Boltzmann Constant
T	- Temperature at p-n junction
q	- Electron Charge
R_{sh}	- Shunt Resistance
PV	- Photo Voltaic
MPP	- Max. Power Point
MPPT	- Max. Power Point Tracking
STC	- Std Test Conditions
P&O	- Perturb & Observe
InC	- Incremental Conductance
G_{stc}	- Irradiance at STC (1000W/m^2)
T_{stc}	- Temperature at STC (25^{0}C)
α	- Current temp. coefficient
β	- Voltage temp. coefficient
V_S	- PV panel voltage
Δi_L	- Inductor current ripple
f	- Switching frequency

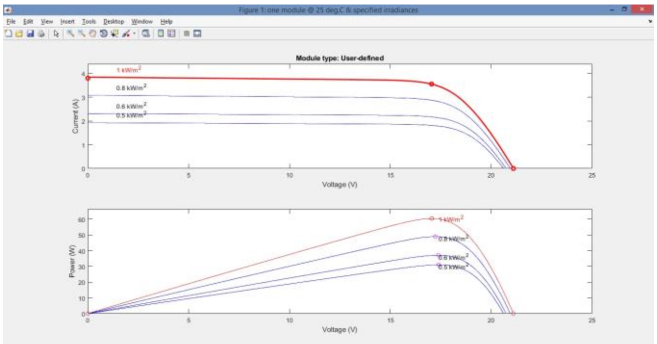

Fig. 2. PV panel characeristics

Iph and Is are formulated [13] in (3) and (4).

$$I_{ph} = \frac{G}{G_{stc}}\left(I_{sc} + K_i\left(T - T_{stc}\right)\right) \tag{3}$$

$$I_s = \frac{I_{sc} + K_i\left(T - T_{stc}\right)}{e^{\left(\frac{V_{oc} + K_v\left(T - T_{stc}\right)}{AV_t}\right)} - 1} \tag{4}$$

B. MPPT approaches

MPPT regulators augmented with several types of MPPT methodologies [14]. Classical MPPT procedures are ample to reach MPP under uniform insolation and unfit for quick dynamic climate change. The adaptive P&O, modified adaptive P&O and InC procedures are favoured for MPPT regulators for quick dynamic climate change. Adopted perturbation is 0.07% in simulation.

1) Adaptive P&O approach: This approach is initiated from the results of earlier investigation. The adoption in the approach includes the dynamic perturbation step by the automatic parameter 'M' instead of fixed one. The value of 'M' is obtained using (5) in the algorithm as shown in fig.3(a). This approach doesn't eliminate the limitations P&O approach but oscillations at MPP are reduced to some extent [15].

$$M = abs(\Delta P) \tag{5}$$

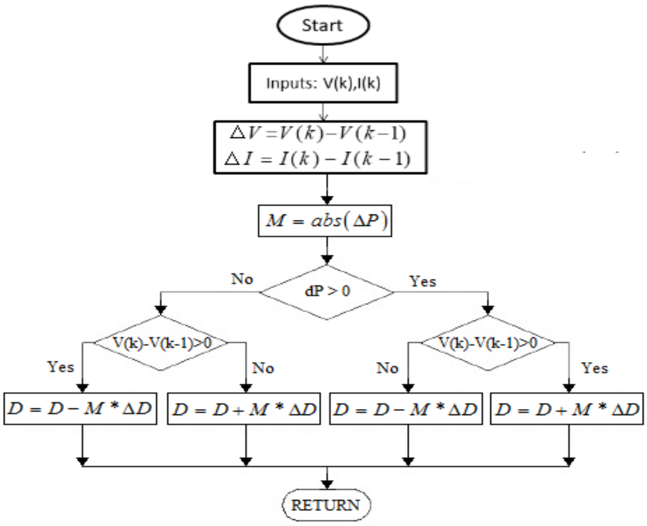

Fig. 3(a). Flowchart of adaptive P&O algorithm

2) Modified adaptive P&O approach: The additional change includes the steady state limit parameter (€) compared to adaptive P&O technique. It gives better response at MPP due to '€'[16]. The flowchart of this technique is depicted in Fig.3(b).

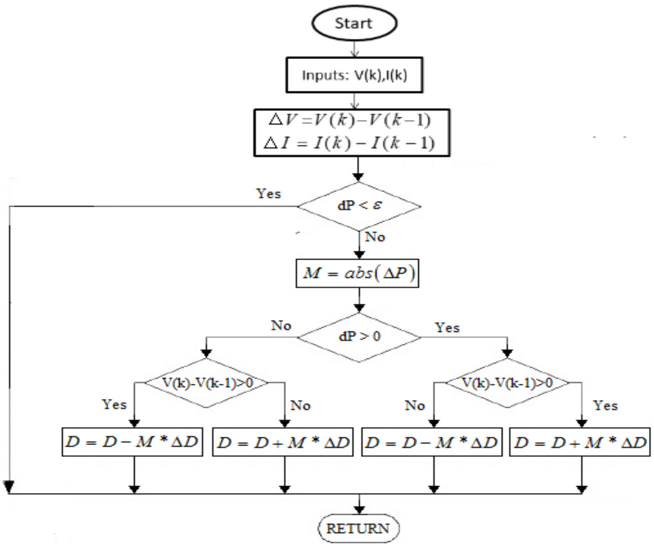

Fig. 3(b). Modified adaptive P&O approach flow chart

3)Modified adaptive InC algorithm: The basic fact for this approach is $\frac{dP}{dV} = 0$ at the MPP [17]. Equations (6), (7) and (8) are used to derive the condition for zero slope in P-V graph.

$$\frac{dP}{dV} = \frac{d(VI)}{dV} = \frac{dV}{dV}I + \frac{dI}{dV}V \tag{6}$$

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$$\frac{dP}{dV} = I + \frac{dI}{dV} V \quad (7)$$

At MPP, $\frac{dP}{dV} = 0$

$$\frac{dI}{dV} = -\frac{I}{V} \quad (8)$$

i.e, Conductance difference = Instantaneous conductance

The expression (8) represents the detection of MPP. Fig.4 presents the flowchart of this approach. This approach handles MPP tracking effectively without oscillations under varying insolation.

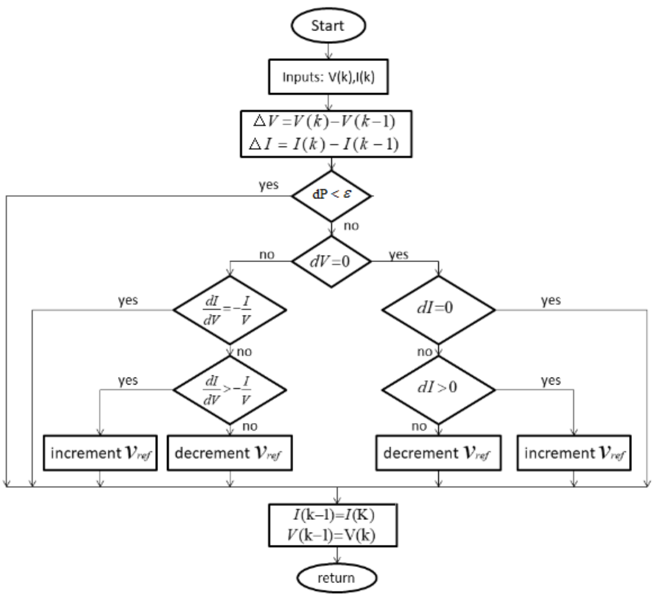

Fig. 4. Modified adaptive InC approach flow chart

C. boost converter:

DC from PV panel is input and equal or greater than input DC is output for this converter. To design the converter, the electrical parameters at MPP at any G and T are estimated [18][19] based on the equations from (9) to (16).

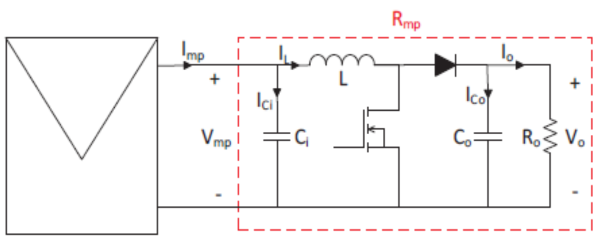

Fig. 5. Boost converter electric circuit

$$R_{mp} = \frac{V_{mp}}{I_{mp}} \quad (9)$$

$$R_o = \frac{1}{(1-D)^2} R_{mp} \quad (10)$$

$$D = 1 - \sqrt{\frac{R_{mp}}{R_o}} \quad (11)$$

$$V_o = V_{mp} \sqrt{\frac{R_o}{R_{mp}}} \quad (12)$$

$$V_{o\,Max} = \frac{1}{(1-D_{Max})} V_{mpG} \quad (13)$$

$$L = \frac{V_s}{\Delta i_L f} D \quad (14)$$

$$C_i = \frac{1}{8L\gamma_{V_{mp}} f^2} D \quad (15)$$

$$C_o = \frac{D}{R_{mp}\gamma_{V_o} f} (1-D)^2 \quad (16)$$

III. SIMULATION RESULTS

Fig.6 depicts the Simulink model of overall PV system to judge the overall system performance for three MPPT approaches.

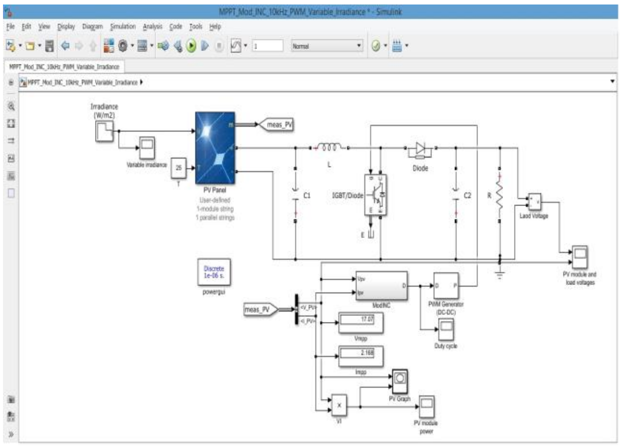

Fig. 6. PV system Simulink diagram

A. Description of model

The user outlined PV panel simulation will offer Impp = 3.55A, Vmpp = 17.04V and Pmpp = 60.53W at STC. The selected converter parts are L = 13mH, C_{in} = C_o = 1000μF, R =30 Ω and module in operation at 10KHz frequency. Each algorithm gives desired duty cycle at MPP is the output of MPPT controller for quick dynamic climatic changes.

B. Simulation Results

Results of the simulated system are examined using three classical algorithms under varying climatic conditions as shown in fig. 7[20].

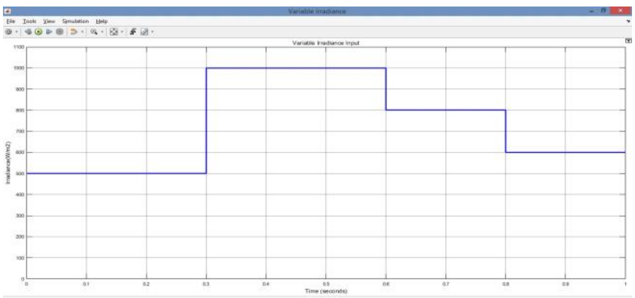

Fig.7 Varying irradiance input

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Case1: Fig. 8 and 9 exhibit the characteristics of PV panel and duty cycle output of simulated system with adaptive P&O approach.

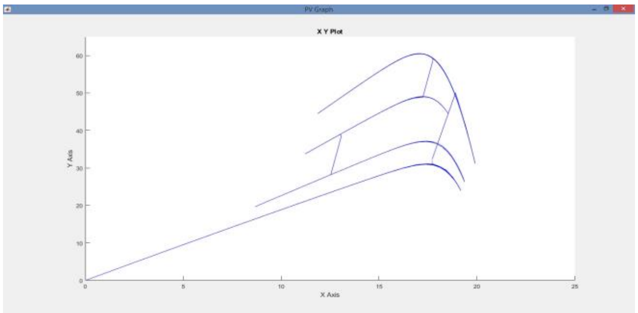

Fig. 8. PV panel characteristics for adaptive P&O approach

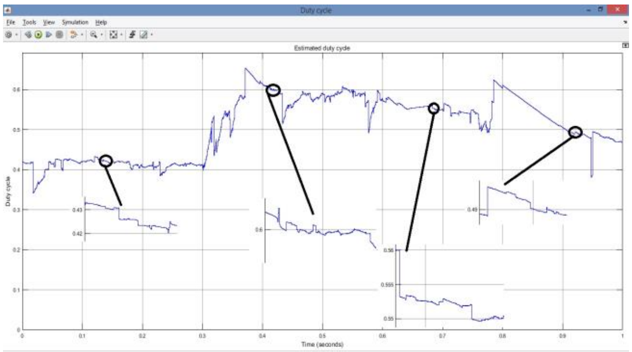

Fig. 9. Duty cycle waveform

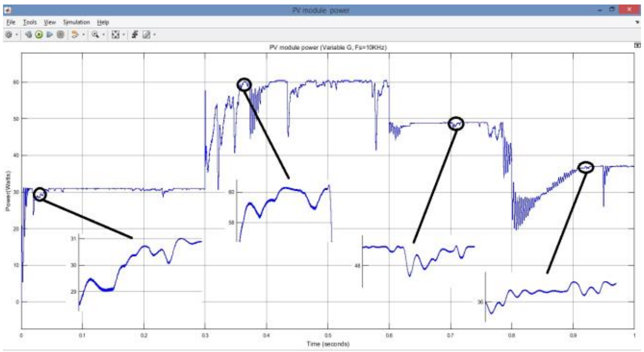

Fig. 10. Power waveform of PV panel

Fig. 10 and 11 exhibit the power of PV panel, voltages of simulated system at input and output with adaptive P&O approach.

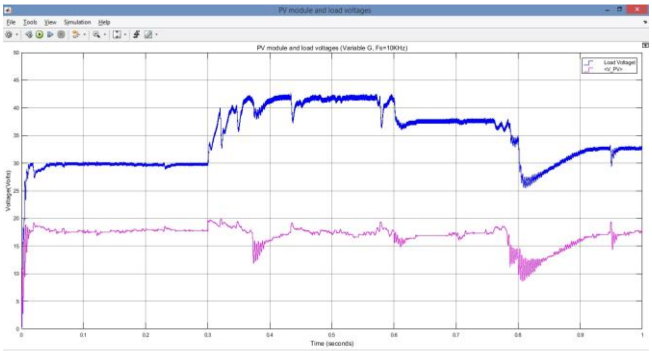

Fig. 11. Voltage waveform at converter input and output stages

Performance indices of the simulated system for adaptive P&O approach are listed in table- I.

Case2: Figures 12 and 13 exhibit the characteristics of PV panel and duty cycle output of simulated system with modified adaptive P&O approach.

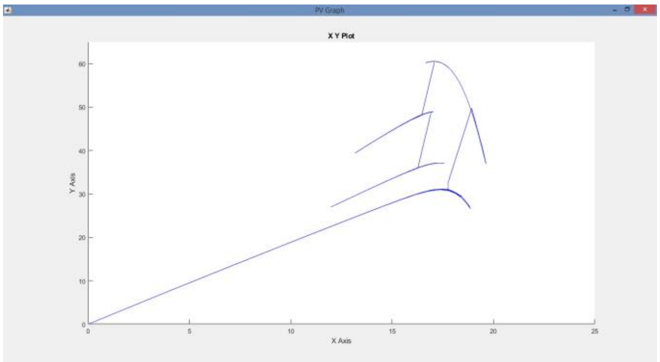

Fig. 12 PV panel characteristics for modified adaptive P&O approach

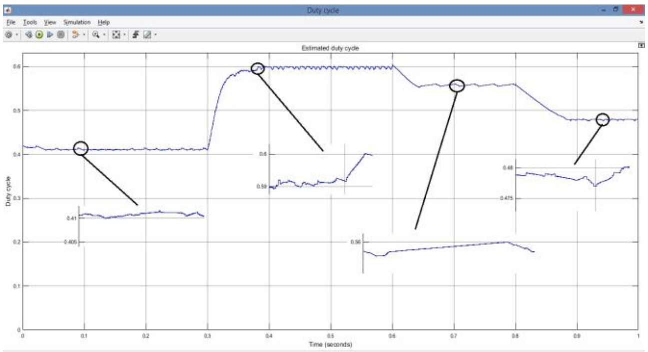

Fig. 13. Duty cycle waveform

Fig. 14 and 15 exhibit the power of PV panel, voltages of simulated system at input and output with modified adaptive P&O approach.

Performance indices of the simulated system for modified adaptive P&O approach are listed in table- I.

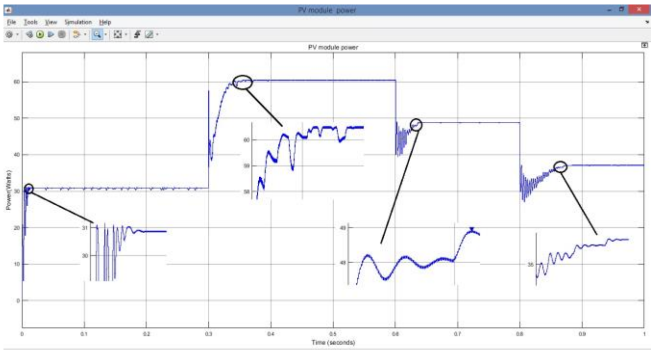

Fig. 14. Power waveform of PV panel

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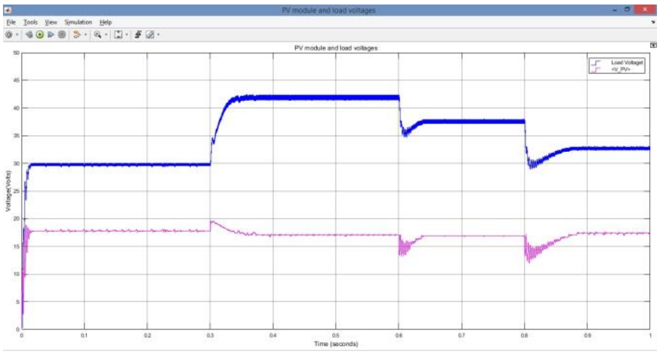

Fig. 15. Voltage waveform at converter input and output stages

Case3: Figures 16 and 17 exhibit the characteristics of PV panel and duty cycle output of simulated system with modified adaptive InC approach.

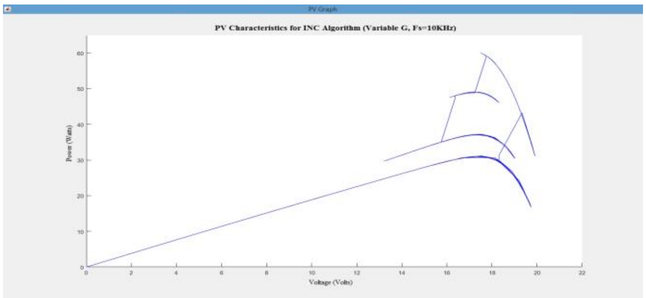

Fig. 16. PV characteristics for modified adaptive InC algorithm

Fig. 18 and 19 exhibit the power of PV panel, voltages of simulated system at input and output with modified adaptive InC approach.

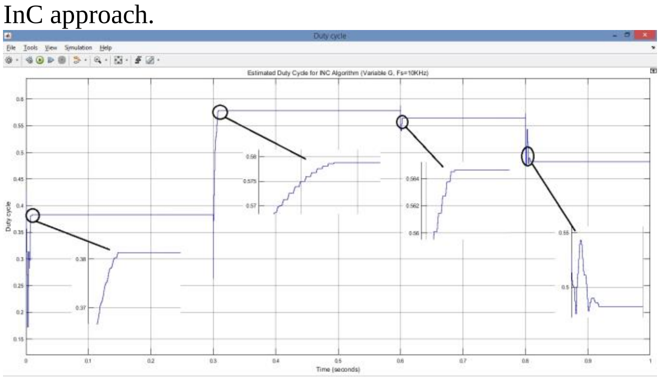

Fig. 17. Duty cycle output of MPPT controller

Performance indices of the simulated system for modified adaptive InC approach are listed in table- I.

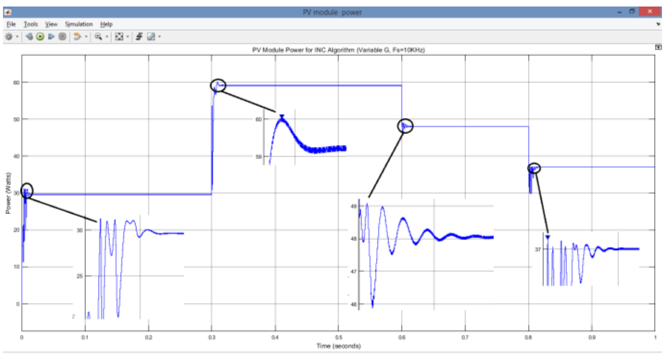

Fig. 18. Power waveform of PV panel

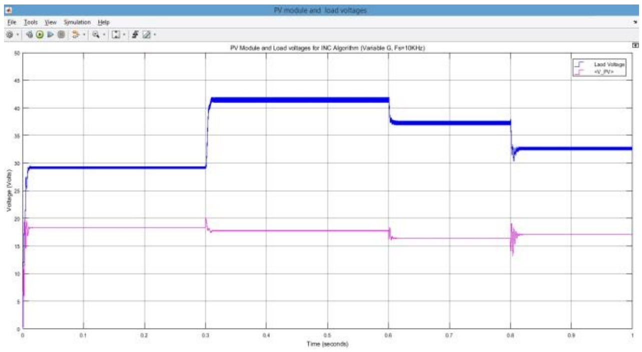

Fig. 19. Boost converter voltages at input and output

Observations

The quick dynamic climate plays a vital job on the functioning of PV system. The fast dynamics in climate effect the performance indices like settling time, peak overshoot, error at steady state, ripple in power values.

Table I shows the values of various indices of PV system for all three approaches. The most important changes which will be noticed in overall system under quick dynamic climate are

- The settling time is a smaller amount thereby achieving quick response in modified adaptive InC algorithm over the opposite two algorithms. Adaptive P&O algorithm fails to stabilize the power curve. Modified adaptive P&O algorithms offer moderate response.
- Power loss is less in modified adaptive InC algorithm and moderate in modified adaptive P&O algorithm. So, modified adaptive InC algorithm more efficient over alternative algorithms.
- Ripples are less within the output power in modified adaptive InC algorithm and moderate in modified adaptive P&O algorithm.
- Peak overshoot values are same in all three algorithms and doesn't exist in irradiance of 1000W/m^2 in modified adaptive InC and irradiance of 800W/m^2 in modified adaptive P&O algorithms.

The mentioned PV system with modified adaptive InC approach have good performance when put next to alternative algorithms, they are

- Less settling time that's quicker response
- Less power loss and higher efficiency
- Minute steady state error.
- Less ripples in output power

IV. CONCLUSION

This article reviewed the broadly used modified classical MPPT approaches and therefore the simulations are executed for quick dynamic climate input. The classical strategies fail to capture the MPP for unexpected variation of solar insolation with operating point initially located away from the MPP. The simulated system is analysed in terms of performance indices. The modified adaptive P&O method showed moderate performance indices with fewer oscillations over the modified P&O algorithm.

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The modified adaptive InC MPPT methodology showed higher efficiency, minute power loss, good tracking accuracy, the steady state potency when put next with the opposite modified classical strategies for quick dynamic climate.

TABLE I. Comparison of performance indices of PV system

Irradiation (W/m2)	Modified P&O approach					Modified adaptive P&O approach					Modified InC approach				
	Eff. (%)	PL (%)	Ripple (W)	Ts (Sec)	Peak overshoot (W)	Eff. (%)	PL (%)	Ripple (W)	Ts (Sec)	Peak Overshoot (W)	Eff. (%)	PL (%)	Ripple (W)	Ts (Sec)	Peak Overshoot (W)
500	97.93	2.07	2.37	>0.3	31.16	98.42	1.58	0.64	0.044	31.16	98.52	1.48	0.09	0.017	31.26
1000	93.83	6.17	0.49	>0.3	60.54	98.19	1.81	0.19	0.129	60.54	98.81	1.19	0.15	0.016	-
800	97.40	2.60	0.15	>0.2	49.07	98.55	1.45	0.13	0.046	-	98.66	1.34	0.08	0.025	49.07
600	88.79	11.21	0.98	>0.2	37.16	96.84	3.16	0.20	0.072	37.14	99.73	0.27	0.04	0.024	37.16

Eff.-Efficiency, PL-Power loss, Ts-Settling time

REFERENCES

1. Chandra, Yogender Pal; Singh, Arashdeep; Kannojiya, Vikas; Kesari, J. P. (2018). "Solar Energy a Path to India's Prosperity". *Journal of the Institution of Engineers (India): Series C*.
2. Lian L Jiang,R Srivatsan,Douglas L Maskell,2018. “Computational intelligence techniques for maximum power point tracking in PV systems: A review”. Renew. Sustain. Energy Rev. 85, 14–45.
3. Karami, Moubayed, Outbib, 2017. General review and classification of different MPPT Techniques. Renew. Sustain. Energy Rev. 68, 1–18.
4. Kamarzaman, Tan, 2014. A comprehensive review of maximum power point tracking algorithms for photovoltaic systems. Renew. Sustain. Energy Rev. 37, 585–598.
5. Li G, Jin Y, Akram MW, Chen X, Ji Ji. Application of bio-inspired algorithms in maximum power point tracking for PV systems under partial shading conditions – a review. Renew Sustain Energy Rev 2018;81:840–73.
6. Kwan, Wu, 2017. High performance P&O based lock-on mechanism MPPT algorithm with smooth tracking. Sol. Energy 155, 816–828.
7. Kchaou, Naamane, Koubaa, M’sirdi, 2017. Second order sliding mode-based MPPT control for photovoltaic applications. Sol. Energy 155, 758–769.
8. Palaniswamy, Srinivasan, 2016. Takagi-Sugeno fuzzy approach for power optimization in standalone photovoltaic systems. Sol. Energy 139, 213–220.
9. Amir, A., Selvaraj, J., Rahim, N.A., 2016. Study of the MPP tracking algorithms:Focusing the numerical method techniques. Renewable Sustainable Energy Rev.62, 350–371.
10. El-Khozondar, H.J., El-Khozondar, R.J., Matter, K., Suntio, T., 2016. A review study of photovoltaic array maximum power tracking algorithms. Renew. Wind, Water,Sol. 3 (1), 3.
11. Verma, D., Nema, S., Shandilya, A.M., Dash, S.K., 2016. Maximum power point tracking (MPPT) techniques: Recapitulation in solar photovoltaic systems.Renewable Sustainable Energy Rev. 54, 1018–1034.
12. Liu, S., Dougal, R.A., 2002. Dynamic multiphysics model for solar array. IEEE Trans.Energy Convers. 17 (2), 285–294.
13. Kadri, Andrei, Gaubert, Ivanovici, Champenois, Andrei, 2012. Modeling of the photovoltaic cell circuit parameters for optimum connection model and real-time emulatorwith partial shadow conditions. Energy 42, 57–67.
14. Ishaque, Salam, 2013. A review of maximum power point tracking techniques of PV system for uniform insolation and partial shading condition. Renew. Sustain. Energy Rev. 19, 475–488.
15. V. Kamala Devia,, K. Premkumara, A. Bisharathu Beevi, S. Ramaiyer, 2017, A modified Perturb & Observe MPPT technique to tackle steady state and rapidly varying atmospheric conditions, Solar Energy 157, 419–426
16. Weidong Xiao, William G. Dunford,2004, A Modified Adaptive Hill Climbing MPPT Method for Photovoltaic Power Systems, 35th Annual IEEE Power Electronics Specialisrs Conference, Aachen, Germany.
17. Tey, K.S., Mekhilef, S., 2014. Modified incremental conductance MPPT algorithm to mitigate inaccurate responses under fast-changing solar irradiation level. Sol.Energy 101, 333–342.
18. Razman Ayop, Chee Wei Tan, 2018,Design of boost converter based on maximum power point resistance for photovoltaic applications, Solar Energy 160, 322–335.
19. Hart, 2011. Power Electronics. Tata McGraw-Hill Education, Valparaiso University,Indiana.
20. Saad Motahhir , Aboubakr El Hammoumi, Abdelaziz El Ghzizal,2018, Photovoltaic system with quantitative comparative between an improved MPPT and existing INC and P&O methods under fast varying of solar irradiation, Energy Reports 4, 341–350.

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