MAXIMUM POWER POINT TRACKING (MPPT) CONTROLLER DESIGN FOR STANDALONE PV SYSTEM

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Abstract: Recently, the renewable energy such as Wind, solar, ocean, Biomass and geothermal powers are getting more attention with the increasing demand on energy, high oil prices and concern of environment impacts increased. Among them Photovoltaic (PV) generation getting more importance due to absence of fuel cost, low maintenance, no noise, no moving parts and long life time. However, the power of PV module is unstable and strongly dependent on Solar insolation and load. Hence, to ensure high efficiency despite these variations, Maximum Power Point Tracking controller is introduced.

Traditionally, a maximum power point locus was used to provide a fast response with minimum losses which required extra control loop or intermittent disconnection of PV module. Hence, this report presents a improved maximum power point tracking for standalone PV system with will be simpler Fast Converging and comparatively MPPT technique, in which Perturb and Observe and Particle Swarm Optimization is use. This method is use only for charging the battery at its voltage level so at proper voltage and current battery can fast charge.

***IndexTerms* – Stand-alone PV System, MPPT, P&O, PSO.**

I. INTRODUCTION

Solar Photovoltaic technology has been developed rapidly over the last twenty years from a small scale, specialist industry supplying the United States space program to a broadly based global activity on solar plant. Solar panel is the fundamental energy conversion component of the photovoltaic (PV) systems. Its conversion efficiency depends on many extrinsic factors, such as Irradiation (Insolation) level, Condition of load, and Temperature.

The three major approaches for maximizing power extraction in medium- and large-scale systems are sun tracking, Maximum power point (MPP) tracking or both. For the small-scale systems MPP tracking is popular for economic reasons. An efficient maximum power point tracking (MPPT) technique is requires so that it can expected to track the MPP at all environmental conditions and then it force the PV system to operate at that MPP point. MPPT is an required component of PV systems. Several MPPT techniques together with their implementation are reported. Here it provides a comprehensive review of the maximum power point tracking (MPPT) techniques which is applied to photovoltaic (PV) power system available until January, 2012. Numbers of publications report on different MPPT techniques for a PV system together with implementation. But, confusion lies while selecting a MPPT as every technique has their own merits and demerits. Hence, a proper review of these techniques is essential. Unfortunately, very few attempts have been made in this regard, excepting two latest reviews on MPPT. Since, MPPT is very essential part of a PV system, extensive research is carried out on it to improve its efficiency.

The “Perturb and Observed” (P&O) and the “Particle Swarm Optimization” (PSO) are two algorithm for MPP search which commonly used. P&O is very simple for installation so mostly preferable for MPPT. It’s algorithm is only depends on voltage and current of PV module and PSO and algorithm depends on voltage by repeating adjusting the control factor, usually by a constant value which is signify a transaction in selecting the incremental value through which parameter is adapted; In steady state, small value implies decrease the losses due to small perturbation around the MPP, Whereas the large values of it recover the dynamic performance in situation concerning rapidly changing in the insolation or load. Variable step size algorithms were proposed due to fixed step size algorithm having slow response. But, these variable step size algorithms impose additional algorithm complexity and hardware and as step size of duty cycle is becomes smaller, system response is also getting slow. Under Partial Shading conditions, conventional MPPT techniques can not to track GMPP because that concept is recent so over P&O’s in this paper PSO method is use for stand-alone PV system.

II. STAND-ALONE PV SYSTEM

Most of the solar installations in India are off-grid because our country faces frequent power cuts in the rural area where the small power generation is requires. Off grid solar installation has 3 key components: solar panels, battery and solar PCU (solar PCU is a solar inverter with built-in solar charge controller). Aim of this paper is to calculate the required battery bank of any commercial building.

- To calculate size of solar system, it is important to follow these steps:

A. Calculation of total load that we want to run:

For that calculation we should know how much power (in watts) our electrical appliances consume. For example, a tube light consumes 40watts, fan consumes 80 watts etc. we should add the electrical load (in watts) that you wish to use. So if we have to use tube light for 3 hour in a day and fan 8 hour in a day we have to multiply those watts with hour so we can get total use for a day. Let us assume that we have added everything and the figure that you get is 8000 watts so our load is 8kW.

Or

In Gujarat we are receiving electricity bill by every 2 months.

If bill is of 2400 unit then for daily average requirement is (2400/60=) 40kWh (Unit)

B. Size of Solar system

Our requirement is 40kWh/day.

Solar intensity is normally available for minimum 5 hours

So solar system required is (40/5=) 8kW.

Normally battery has loss during charging is about 15 to 30% we took it as a 20%.

So required solar system is approximately 10Kw

C. Panel size and nos of panel:

Panel available between 250 to 350 Watt.

We can use 335 watt's 30 panels.

So 335*30 = 10050 Watt

D. Area requires for 10kW system:

Normally area requires for 1kW system 12 sq.ft

So for 10 kW = 120 sq.ft

E. size of battery backup:

Here required daily load is 8kW.

Battery is available in voltage range of 12V & 24 V.

WH should be converting into AH to decide battery bank size.

Here needed battery backup is 8 hours for commercial building.= 8kW * 8 hour= 64000 Wh

If battery size is 300 Ah & 24V = 64000 Wh/ 24 V= 2666.66 Ah.

Approximately for 8kW load, 2800 Ah of total battery bank requires for 8 hours of load.

So 14 battery of 200 Ah & 24V requires.

Required voltage for charging is min 8 to 10% higher than its required voltage (14*24=336) due to losses.

So required voltage = 336 + 10% of 336 V= 370 V

Charging current requires for Lead acid battery should be around 10% to 15% of its AH

So for 200AH it should be around 20 to 25 amp.

It should be not greater than 25% of AH to prevent thermal runaway and battery expiration.

III. MPPT METHODS:

Specific methods exist to bring the devices to operate at maximum points as their specifications without knowing these points in advance, and without that we know when they were changed or what the reasons are. This type of control is known as Maximum Power Point Tracking (MPPT). The principle of these commands is to search the maximum power point (MPP), while ensuring a perfect fit between the generator and the load to transfer maximum power but in this paper only motto is to charge the battery. Hence, we can assess that the output power of a solar panel module is a function of temperature, lightening and the panel position. It also depends on voltage and current product. Varying either of these two parameters, voltage and/or current, power may be maximized.

A. Perturb and Observe method.

Perturb& Observe (P & O) technique is generally the most widely used technique in practice due to its ease of implementation. It is an iterative technique for the MPPT; it measures the characteristics of Ppv and then perturbs the operating point of the PV array to meet the direction of change.

The maximum point is reached when the below is satisfied.

$$\Delta P_{PV} * \Delta V_{PV} = 0 \quad (1)$$

As shown in "Fig. 1", we can observe that if a positive increment of voltage (Vpv) leads to increased power (Ppv), the operating point is to the left of the MPP. But, if the power decreases, the operating point is to the right of MPP. A similar argument can be made when the voltage decreases. From the analysis of the consequences of a change in voltage on the characteristic (Ppv / Vpv), we can easily locate the operating point from the MPP, and do converge to the maximum power by imposing the appropriate a value to the output current of the PV module. Thus, at system startup, MPP research is gradually seeking the first maximum.

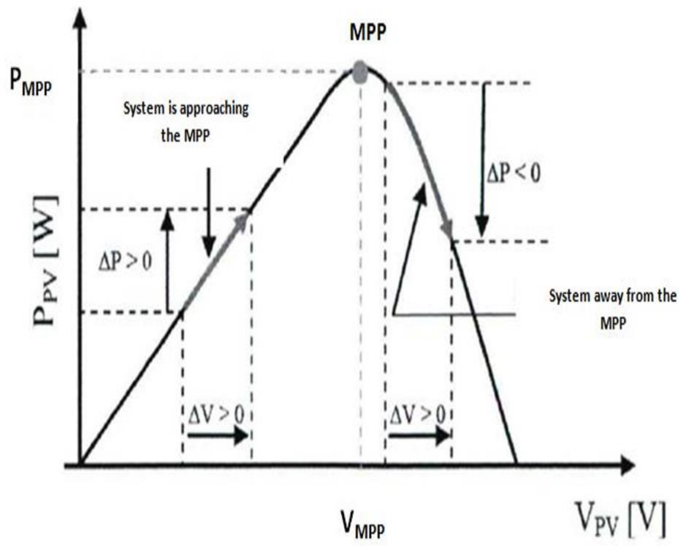


Fig 1 Output power using the MPPT method

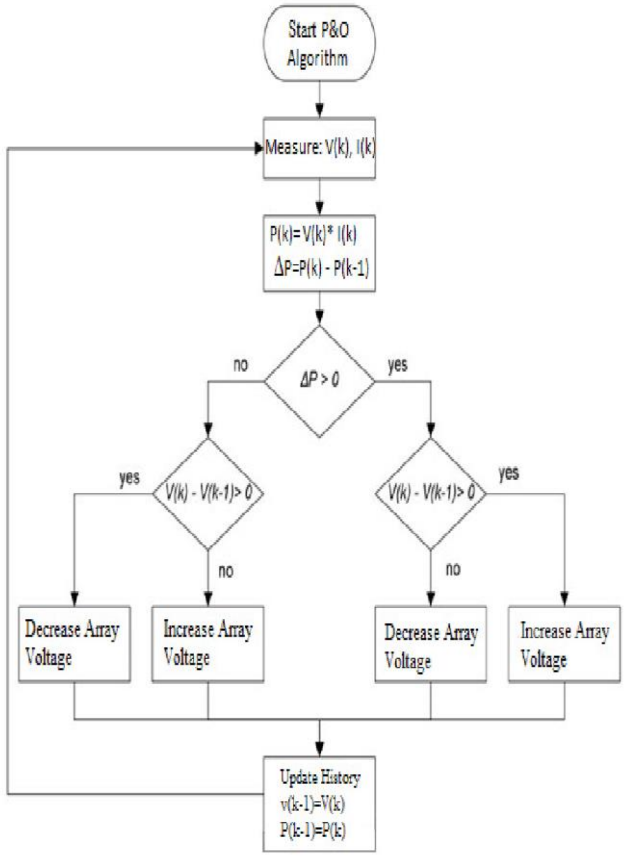


fig 2 P&O algorithm

Thus, at system startup, MPP research is gradually seeking the first maximum.
Associated algorithm to MPPT control with P&O method is shown on below flowchart "Fig. 2".

B. *Particle Swarm Optimization (PSO)*.

Particle Swarm Optimization is a nonconventional intelligence optimization, simple and effective meta-heuristic approach. It was developed by Eberhart and Kennedy in 1995.

PSO is a population-based evolutionary algorithm (EA) search optimization method. Its principle was inspired from the behavior of bird flocksto overthrow the problems involved in the search process and optimization. In PSO method, each particle of proposed swarm assesses at different points in a D dimensional search space and moves with a speed based on its individual best position (Pbest) and the best position of his group (Gbest). Every particle from population exchange information achieved in its respective search process.

In the search process, each particle in the whole swarm interacts with its neighbors and converges towards the global best position in the search space within a short time. Therefore, position for each particle is affected by her best neighborhood particle Pbest as well as the global best position found by all particles in the entire population Gbest. Indeed, the ith position Xi for each particle is updated according to here after equation:

$$x_i^{k+1} = x_i^k + ø_i^k \tag{2}$$

Where, k represents the iteration counter. The velocity component ø, represents the step size, is also adapted iteratively to render particles capable of potentially visiting any region of the search space. Velocity is adjusted as following:

$$ø_i^{k+1} = wø_i^k C_1 r_1 \{P_{besti} - x_i^k\} + C_2 r_2 \{G_{best} - xi\ k\} \tag{3}$$

Where, w is called the inertia weight that controls the impact of anterior particle velocity on its current one. C_1 and C_2considered as acceleration coefficients. r_1, r_2 as random variables uniformly distributed within [0, 1], P_{besti} is as the personal best position of particle i, and G_{best} is called the best position of the particles for entire swarm population [9]. Consider that the particle position as actual duty cycle and velocity act as the perturbation in the actual duty cycle, then equation can be edited as following.

$$d_i^{k+1} = d_i^k + ø_i^{+1k} \tag{4}$$

Indeed, according to (6), resulting perturbation on the actual duty cycle depends on P_{best} andG_{best}. The PSO algorithm parameters that are used in our experimental study are presented in the following "Table I".

Parameters	Value
Population size	3
Dimension number	1

W	0.4
c1	1.2
c2	1.6
r1	0.5
r2	0.7

The Flow chart of MPPT based PSO algorithm as shown in "Fig. 3" and can be detailed and explained step by step as follows;

Step1. Initialize PSO parameters: swarm size, initial position, initial velocity, and set up iteration counter.
Step2. Calculate fitness of each particle
Step3. Evaluate and update each particle best position.
Step4. Evaluate and update global particles best position.
Step5. Update position and velocity for every swarm particle utilizing equation (5), (6).
Step6. Check the convergence criterion if met, if not, iteration counter will be increased by 1 and go to step 2.

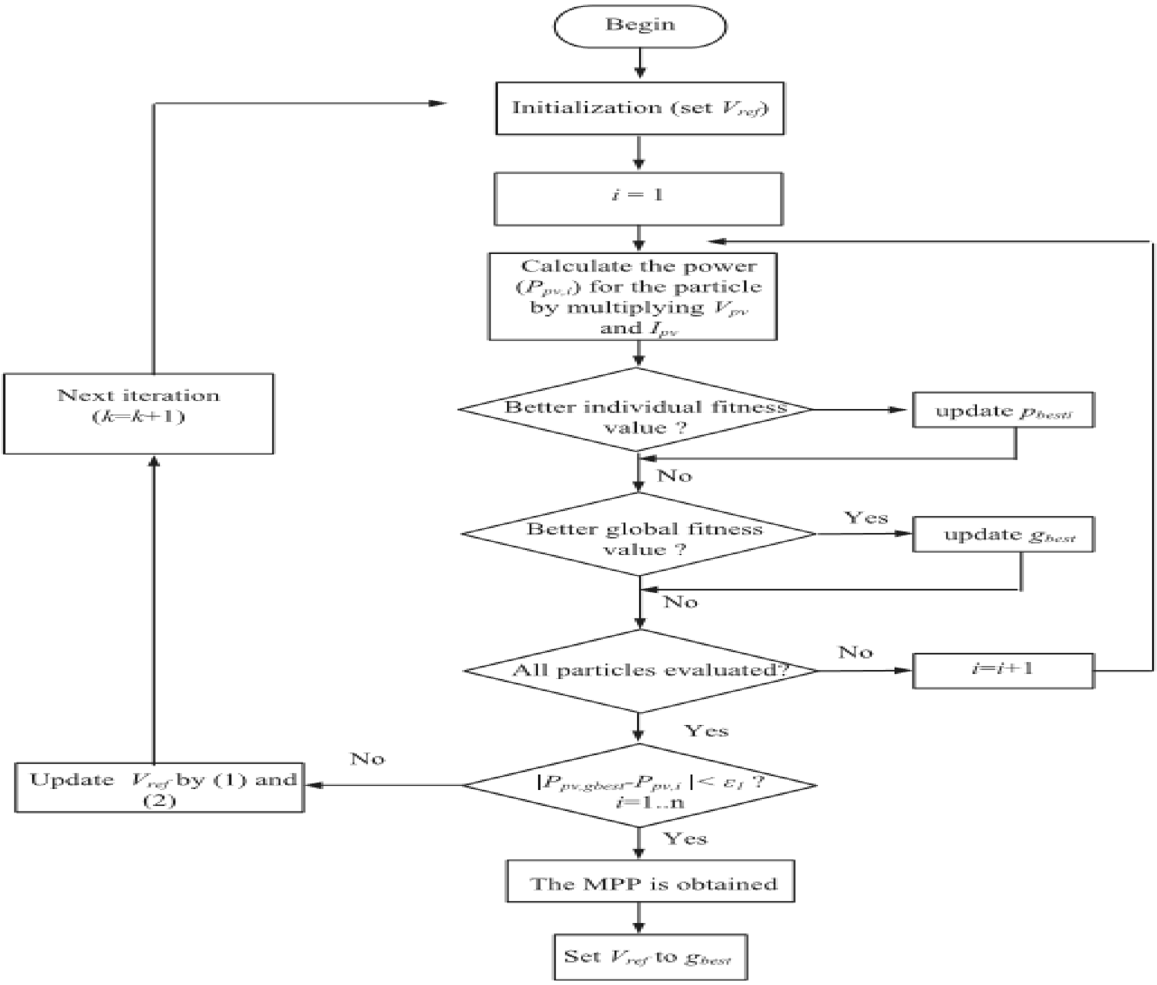


Fig 3. PSO flow chart

A per the experimental setup of 100 watt panel the output power, current and voltage are shown in following figure. As per the result P&O has more variation in power whenever it will get to the maximum power point and PSO has more stable output then the P&O, as well as tracking speed of PSO is also very high as compare to the P&O[5].

So in this paper, PSO is used for the matlab simulation for MPPT tracking of battery charging for the load.

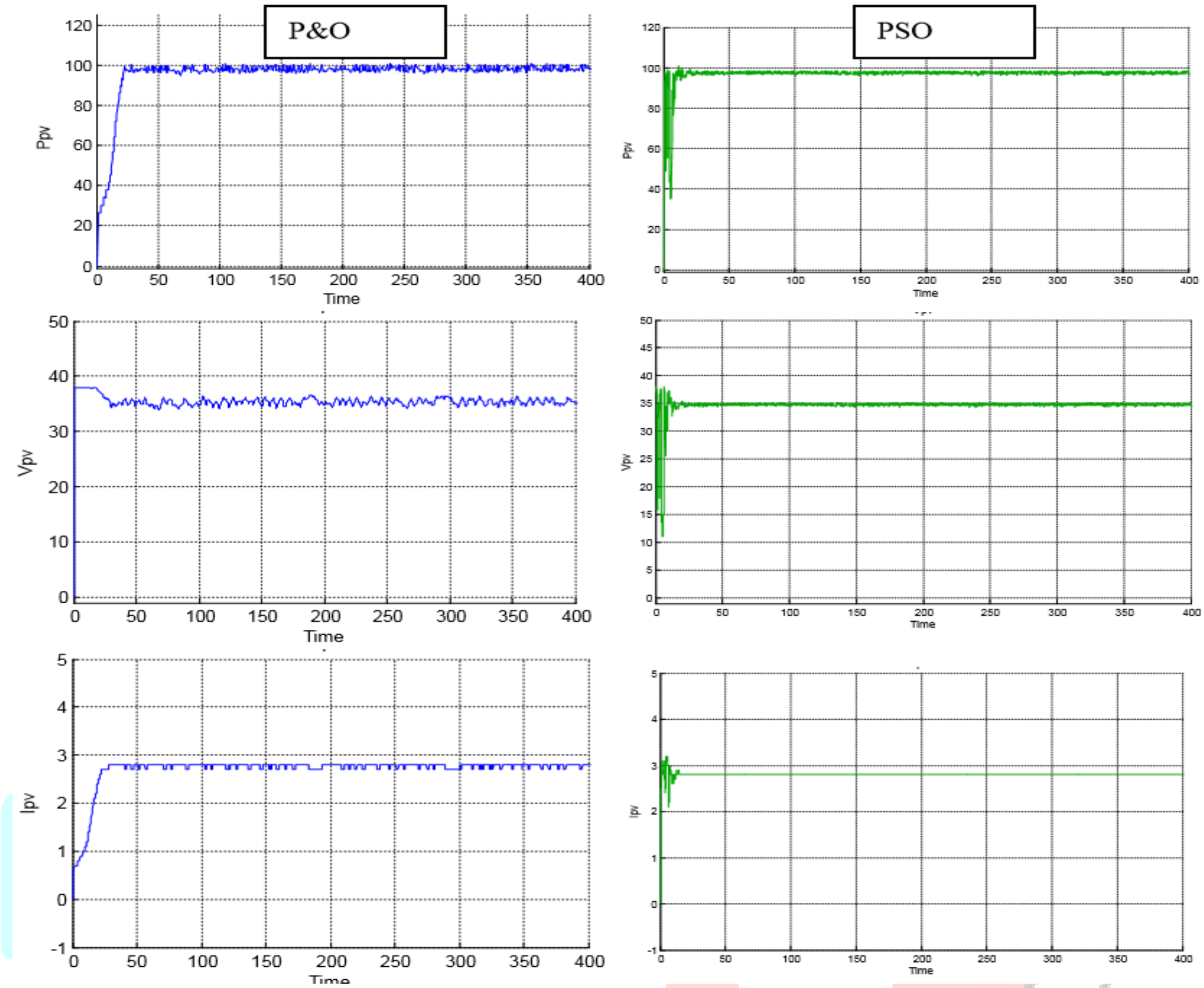


Fig.4 Variation of power, voltage and current of the PV system during MPPT using PSO and P&O methods[5]

IV. SIMULATION RESULTS

Matlab simulation of PV system include 10kW system which is discuss in above part. boost converter is use for boost the voltage, its duty cycle is controlled by P&O and PSO MPPT. Simulation results shown below.

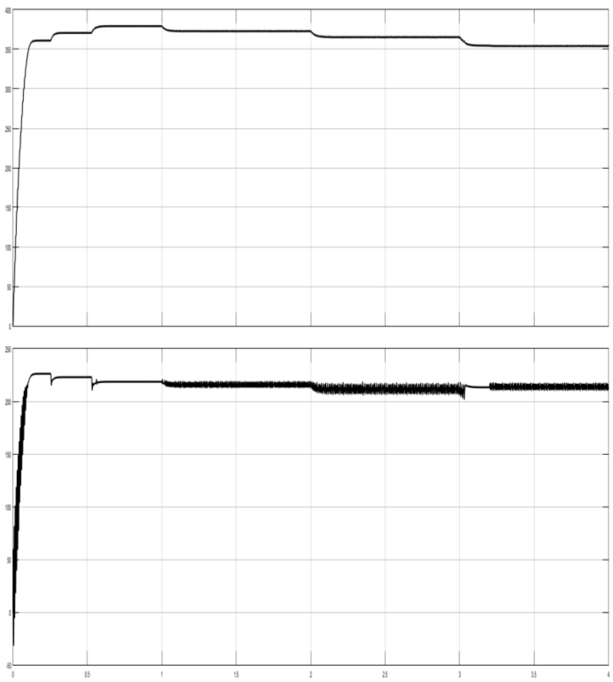


Fig 5 voltage vs time

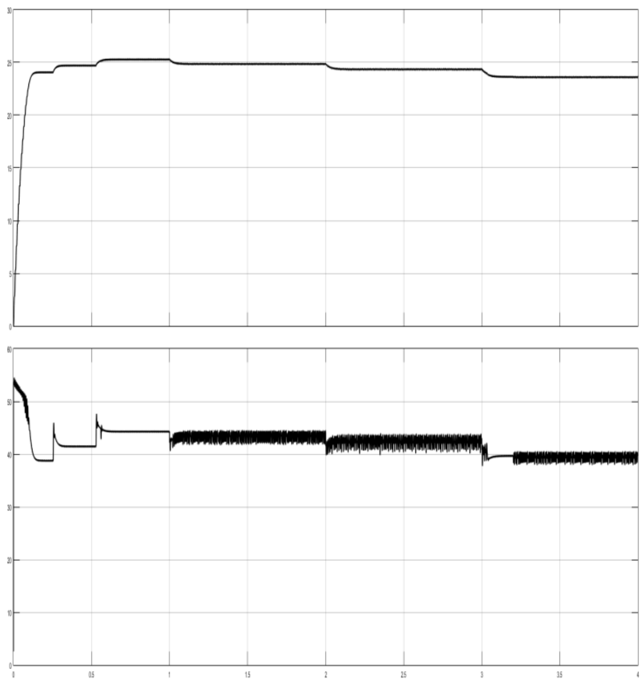
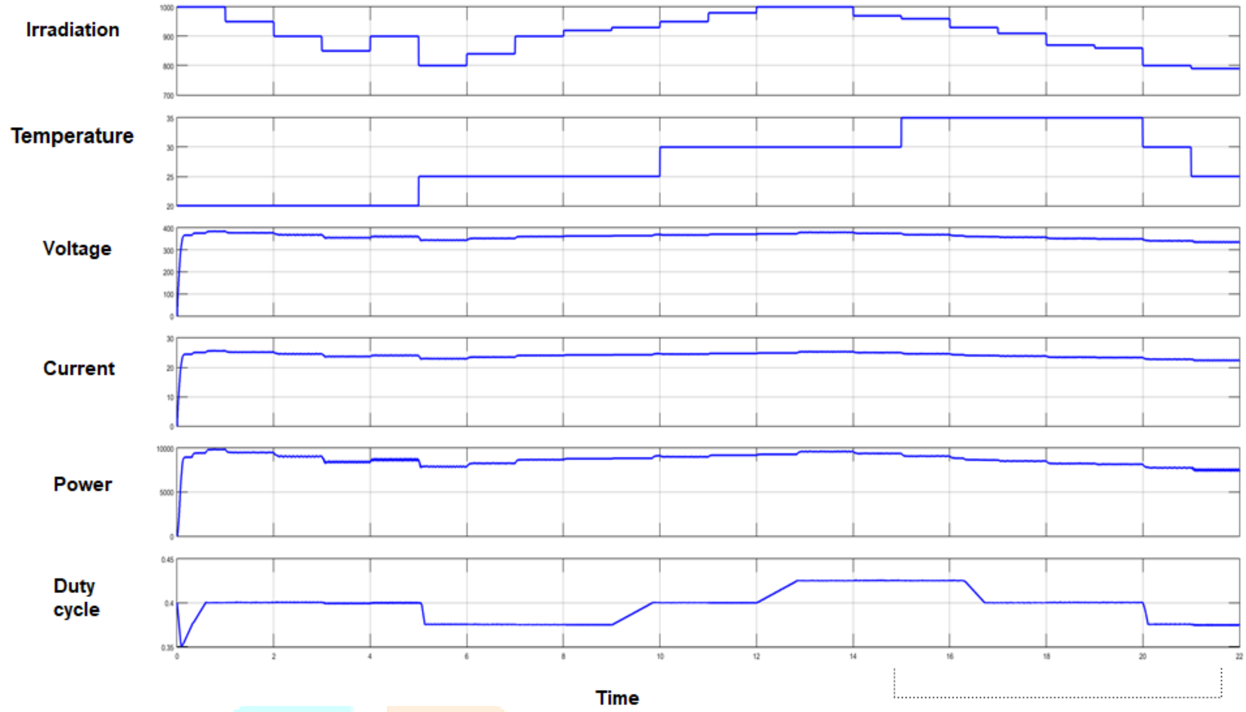


fig 6 current vs time

In figure 1 & 2 upper result is of PSO and other one is of P&O.

Following simulation shown is for PSO in varying irradiation and temperature condition.



V. CONCLUSIONS

In this paper calculation for standalone PV system is shown and two tracking MPPT technique PSO and P&O is shown for standalone PV system battery has required some specified voltage and current to change and not to damage it lifecycle. P&O is easy to implement but it has varying power whenever it reach to MPP and it affect the battery. Last simulation shown that in same load condition and varying environmental condition sill it manage the required voltage and current limit and it has less variation in power.

REFERENCES

[1] Maissa Farhat, Oscar Barambones and Lassaad Sbita, "A Real-Time Implementation of MPPT-Based on P&O Method", 5th ICEDSA Conference,2016, Pages:1-5.

[2] Ramdan B. A. Koad , Ahmed F. Zobaa, Senior Member, IEEE and Adel El-Shahat "A Novel MPPT Algorithm Based on Particle Swarm Optimisation for Photovoltaic Systems.", IEEE Transaction,2011,Pages:468-476.

[3] XuYang Zhang ,HuaGuang Zhan, HanQing Zhang, PengQiao Zhang, FengWang ,Hong Jia and DeYu Song, "A variable step-size P&O method in the application of MPPT control for a PV system", IEEE IMCEC,2016, Pages:1603-1506.

[4] JAI ANDALOUSSI Zakariae, RAIHANI Abdelhadi, ELMAGRI Abdelmounai, BOUATTANE Omar, "Toward an approach to Improve MPPT Efficiency for PV System." IEEE International conference on WITS,2017. Pages:1-5.

[5] Haithem Chaieb, Anis SAKLY, "Comparison between P&O and P.S.O Methods Based MPPT Algorithm for Photovoltaic Systems" at 16th international conference on Sciences and Techniques of Automatic control & computer engineering - STA'2015, Monastir, Tunisia, December 21-23, 2015, Pages:694-699.

[6] Jacob James Nedumgatt, Jayakrishnan K. B., Umashankar S. , Vijaya kumar D., Kothari D P "Perturb and Observe MPPT Algorithm for Solar PV SystemsModeling and Simulation," India Conference (INDICON),Annual Conference of IEEE,pp.1-6,2011.

[7] T. Esram and P.L. Chapman, "Comparison of Photovoltaic array Maximum Power Point Tracking Techniques," IEEE Transaction on Energy Conversion, vol.22, no.2, 2007, pp.439-449.

[8] 8. Basic Calculation of a Boost Converter's Power Stage of Texus Instrument, January 2014.

[9] K. H. Hussein and I. Muta, "Maximum photovoltaic power tracking: An algorithm for rapidly changing atmospheric conditions," in Proc. Inst. Electr. Eng. Generation, Transmiss. Distrib., 1995, Pages. 59–64.