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# Interleaved boost converter based Global MPPT of PV arrays under partial shading condition

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**Abstract**: Today's new invention is more about photovoltaic. Obtaining more energy and using the maximum possible output power from a solar panel becomes mandatory. This paper deals with tracking and tracing the maximum power of the PV array under partial shaded condition. Under partially shaded condition, the power delivered to the load gets distorted during non-uniform radiation and hence a non-linear PV characteristic with multiple peaks is obtained. There exists only one global maximum but many local maximum so global maximum is to be detected using Global MPPT algorithm. Conventional GMPPT algorithm repeatedly carries out global search to detect the real optimum peak even when partial shading has not occurred. LDR sensors are additionally used to spot the partial shading condition so that the overall performance can be improved. The proposed system is simulated using MATLAB/SIMULINK and the results are validated

**Keywords**: Maximum power point tracking (MPPT), Photovoltaic I-V characteristics, Global Maximum Power Point (GMPP) and LDR.

## I. Introduction

The need for future has led to the development of renewable source of energy in which solar energy is playing a predominant role. Solar energy being a natural resource available in plenty serves as a pollution free renewable energy. Though it acts as a perfect alternative to fossil fuels, utilizing its full efficiency becomes the challenge. Solar irradiation is converted to electrical energy through PV effect.

PV cells are connected to form a panel and such groups of panels form a solar array. PV panels are connected in series and parallel topologies. Due to the varying levels of irradiation during the day, the output can vary widely. Shading effect occurs due to dust, clouds, leaves, branches of trees and buildings which cause shading on cells or part of modules. In PV characteristics of a solar array one global maximum along with many local maximum is obtained due to shading effects.

The global maxima accord with maximum power while others accord with minimum power. Though one cell in the PV module gets shaded 30% of power loss occurs. Amount of power loss increases corresponding to the number of cells shaded which increases up to approx. 80%.

GMPPT algorithm is used here to track global maximum power while conventional MPPT methods such as hill climbing or Perturb and Observe method fail to reach it. GMPPT works at regular interval Using suitable duty cycle. GMPPT doesn't work all the time at equal interval. It works whenever partial shading occurs which is detected by LDR sensor until then normal MPPT works unless it will sweep every time from the starting so that time taken will be more but the above mentioned method will consume less time. GMPPT algorithm is based on modified hill climbing algorithm.

## II. System Design

### A. *Description of basic block diagram*

The block diagram of the system used in this paper is shown below

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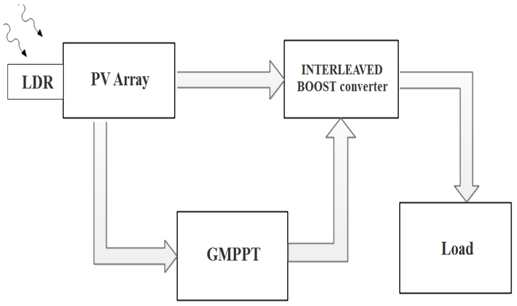


Fig.1. Block diagram of the system

It consists of PV array, interleaved boost converter, GMPPT Tracker and load. Three PV panels are connected in series and the outputs from panels are fed to the INTERLEAVED BOOST converter which is controlled by GMPPT tracker. Finally, the output of INTERLEAVED BOOST converter is given to the load. Voltage and Current are the parameters included in GMPPT algorithm maintaining the Integrity of the Specifications.

B. ***Interleaved boost converter design***

A basic boost converter converts DC voltage to a higher DC voltage, interleaving adds additional benefits such as reduced ripple currents in both input and output circuits .Higher efficiency is realized by splitting the output current into two paths, substantially reducing $I^2R$ losses and inductor AC losses.

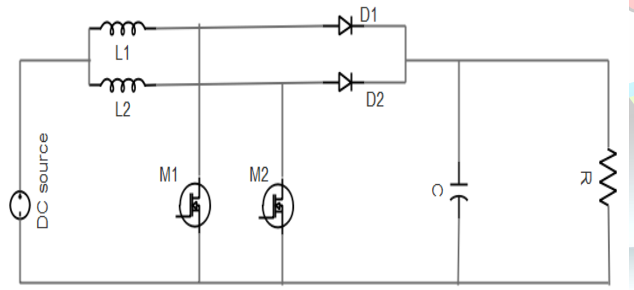


Fig..2 Block diagram of the Interleaved boost converter

The following equations are used to design the Interleaved Boost converter.

**(1) Duty cycle:**

$$D_{max}= (V_o+V_d - V_{in(min)}) / (V_o+V_d - V_{on})$$

$$D_{min}=(V_o+V_d - V_{in(max)}) / (V_o+V_d - V_{on})$$

**(2)The inductor value is given by:**

$$L_1 == (Vin(min)-Von)*Dmax*(1-Dmax)/(Fs*Iout)$$

**(3) Coupling capacitors:**

Using thumb rule 10uf capacitor is used

**(4) Selection of Output capacitor for Interleaved Boost converter is given below:**

$$C_{out}= Iout(max)*(1-D(min))/(Fs*\Delta Vo)$$

**(5) Output current:**

$$I_{out}=V_o/R$$

**(6) Resistance value:**

$$R=V_o^2 / P$$

Table I

Specification of Interleaved boost converter

| PARAMETER | VALUE | UNIT |
|---|---|---|
| $V_{in}$ | 60 | V |
| $V_o$ | 48 | V |
| $I_o$ | 1.67 | A |
| Switching frequency | 7.8 | KHZ |
| $\Delta I_L$ | 0.92 | A |
| Power | 80 | W |

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## III. MODULE OF PV SIMULATION

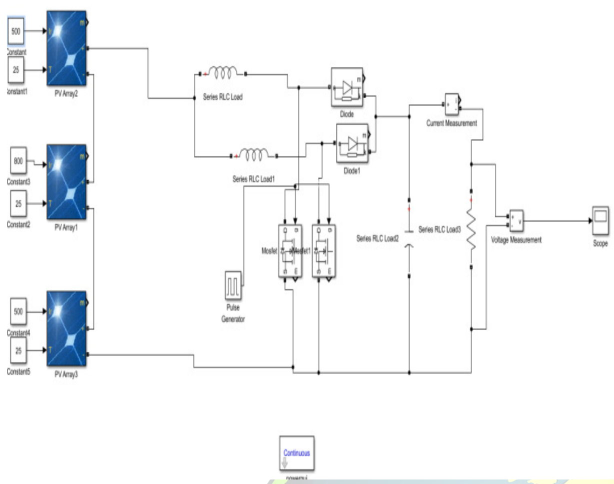


Fig. 3 Simulation circuit

Three solar panels are connected in series with different irradiation levels. The output of the solar panel is fed to the Interleaved Boost converter. The circuit is connected with different capacitors, inductances and bypass diodes.
The use of bypass diode [1] is to reduce the damage of solar panels due to transients.

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| **Open circuit voltage** | $V_{oc}$ | **60** | **V** |
| **Short circuit current** | $I_{sc}$ | **2.5** | **A** |
| **Maximum power voltage** | $V_{mp}$ | **53.1** | **V** |
| **Maximum power current** | $I_{mp}$ | **2.3** | **A** |

## IV. PARTIAL SHADING IMPLEMENTATION

Three PV panels are connected in series. Partial shading effect will occur when non uniform radiation is given to the panel. Mismatching occurs due to non-uniform radiation which is reduced by using bypass diodes. Uniform radiation gives only one peak in PV characteristic curve . But under partially shaded condition non-linear PV characteristics occurs with many local peaks and one global maximum point. This paper presents the idea about tracking the global MPP in the above mentioned partial shaded condition by means of Matlab software.

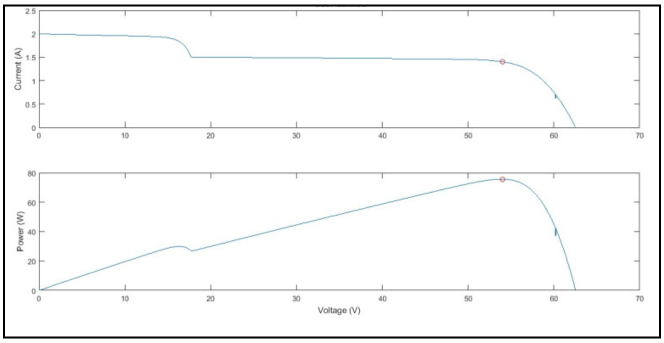


Fig. 4 PV characteristic curve for different radiation (600,600,900 W/m$^2$ )

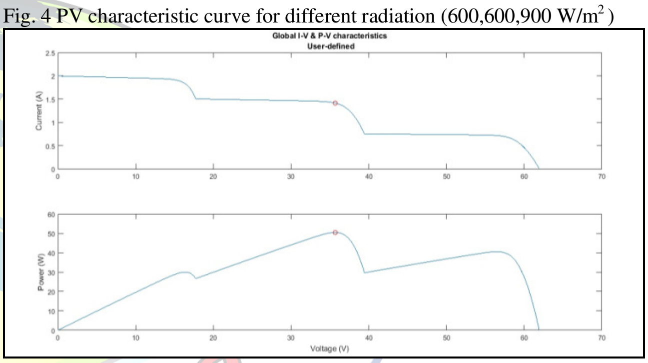


Fig.5. PV characteristic curve for different radiation (800,200,600 W/m$^2$ )

## V. GLOBAL MPPT ALGORITHM

The global MPPT methods without the use of LDR sensors implemented till now will consume more time while searching the peaks . Therefore, the new algorithm has been developed such that it tracks global MPP whenever partial shading condition occurs by using LDR sensors with the help of Modified Hill Climbing Algorithm else normal P&O algorithm works. The new GMPPT algorithm contains two types of search , one is global search and other is local search. Modified Hill climbing algorithm is used for global search in an extemporized manner .When resistance of LDR varies, this implements the condition of partial shading and then global search starts in the PV curve from starting to ending with varying duty cycle from $D_{start}$ to $D_{end}$ with change $\Delta$ D. This search is started from $D_{start}$, whenever power condition becomes P(k) > P(k-1), which indicates that there exist a maximum power point in the region corresponding to the duty cycle D(k-1) and D(k). And then the power related to duty cycle D(k) is stored as maximum power at that particular time, then the search is continued until the duty cycle D is equal to $D_{end}$. Similarly till the

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search is complete, duty cycles D and corresponding powers P compared to other maximum power points are also reserved accordingly. The maximum power at different duty cycles are stored and compared with one another to get maximum global power.

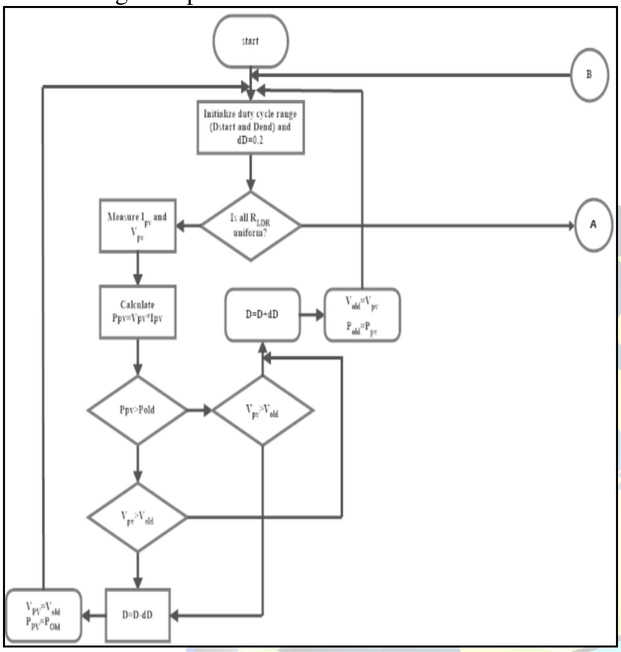


Fig.6. Flowchart for MPPT algorithm

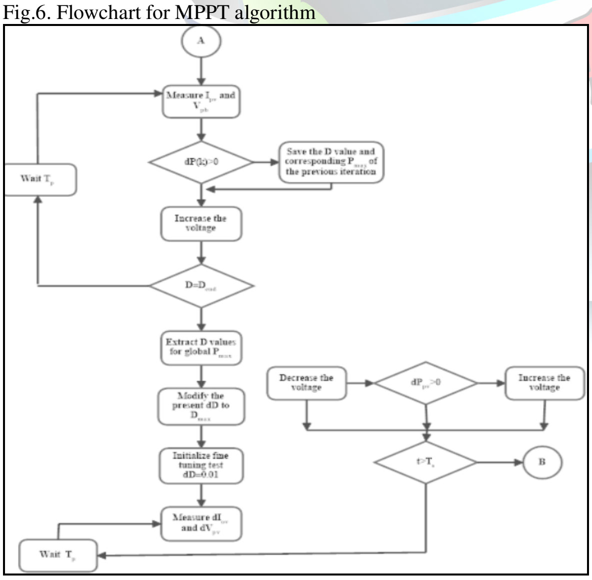


Fig.7. Flowchart for MPPT algorithm

Under normal condition, normal MPPT algorithm works, it searches local MPP by varying duty cycle till $D_{end}$ in the increasing order of voltage .When the power at D(k) is greater than that of D(k+1) then the power at D(k) is stored and taken as maximum power. This algorithm searches global peak at the partially shaded condition while in the meantime it searches for local MPP.

## VI. Software Result

Simulation is done with the help of MATLAB and SIMULINK Different combinations of irradiation level is taken for different partial shading conditions.

| | Panel1 (TOP) ($W/m^2$) | Panel 2 ($W/m^2$) | Panel 3 (BOTTOM) ($W/m^2$) |
|---|---|---|---|
| Pattern I | 900 | 300 | 900 |
| Pattern II | 900 | 300 | 600 |

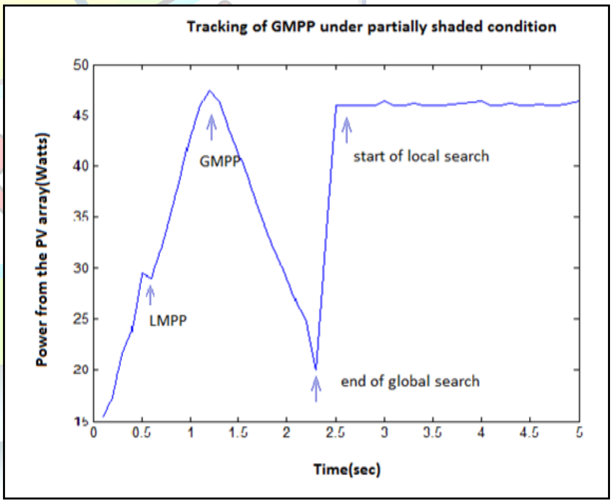


Fig.8. Simulation result for Pattern-I

 

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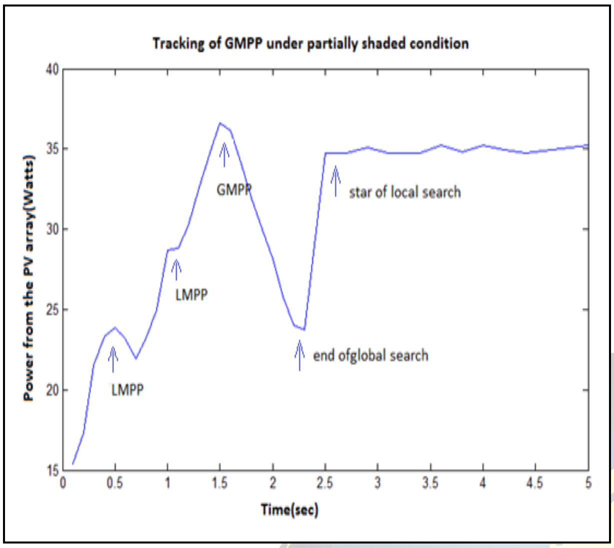


Fig.9. Simulation result for Pattern-II

In the above two patterns global peak is identified using the algorithm mentioned above and the corresponding power is tracked.
In pattern II Global peak occurs after two local peaks in the above graph.

## VII. Conclusion

Thus, the New Global MPPT Algorithm presented in this paper successfully tracks the Global Maximum Power. It doesn't miss tracing and espying any local maximum power points within the particular time interval. The new Global MPPT algorithm is a combination of both Hill climbing algorithm and P&O algorithm. At normal condition, P&O algorithm is used while at partial shading condition modified Hill Climbing Algorithm is used. LDR sensors are installed at the corners of PV array and are used to show the peculiarity between normal condition and partial shading condition. While the tracking and overall system efficiency increases significantly the magnitude of oscillation around global power point increases with decrease in search time. This project is economical and it is time saving. The motive of our project is achieved using this New Global MPPT Algorithm.

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