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Review Article

GRID CONNECTED CROSS TIED CONFIGURATION OF INTEGRATED CONVERTERS WITH MPP TRACKING UNDER VARIOUS CLIMATIC CONDITIONS

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Abstract
The central inverter design of integrated photovoltaic cells consists of different configurations of PV modules. These configurations of PV modules are exposed to shading effects and cause power losses. To reduce to effect of shading and to extract the maximum power a MPP controller is used along with the developed architecture. In this paper all the string integrated converters are total cross tied and a MPPT controller is integrated to it. For the maximum power extraction perturb and observe and incremental conduction MPPT techniques are used. The performance of both the techniques are compared and examined under different shading conditions.

Keywords: Maximum power point (MPP), perturb and observe (P&O), shading conditions, incremental conduction (IC).

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INTRODUCTION

Photo voltaic (PV) are the finest resources since the solar energy is limitless and free. PV systems can accompany with other sources very easily as they do not have any mobile parts and can last longer than 20 years. As the renewable sources are the environmental friendly those are the most commonly used resources. Among the different sustainable power sources, the force produced by sunlight based (photovoltaic) PV frameworks have been raised 25% per year in the course of the most recent 20 years. PV deployment systems have power ratings in different ranges ranging from kilowatts to few megawatts.

To extract the PV arrays maximum energy a control strategy has to developed for finding the operating, such control strategy is known as maximum power point tracking. The most commonly used techniques are perturb and observe (P&O) technique and incremental conductance(IC). The position of the MPP depends on the variation of temperature and irradiances.

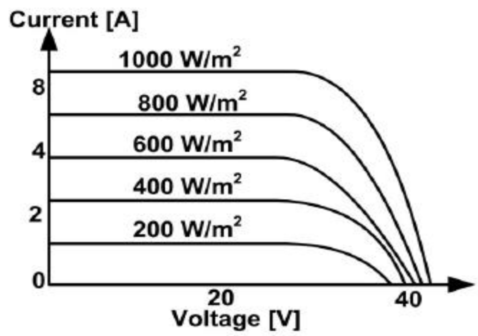
PV module is a main PV system unit consists of PV cells which are connected in series. The design of PV systems depends on PV module arrangement and converter stages used and the form of MPPT techniques used [2]. The integrated PV systems are generally associated with the central inverter design and this architecture consists of different configurations of PV modules such as parallel, series, cross-tied, bridge-linked, honey-comb [3],[4]. Due to the partial shading and mismatching the power output from the PV modules decreases. Besides the power losses as the configurations of PV modules exhibits many connections it brings complicacy in the system. The problems caused by inconsistent power losses were solved by attaching an anti-parallel bypass diode to each PV module[5].

The series and parallel connection of MICs exhibit several drawbacks such as voltage stress, high duty ratios, low conversion efficiency. Cross tied configuration of integrated converters is proposed to overcome these drawbacks. In this MPPT converter along boost converter is integrated to PV modules connected in series and is named as string integrated converters (SIC). In this proposed system 16 SICs were used.

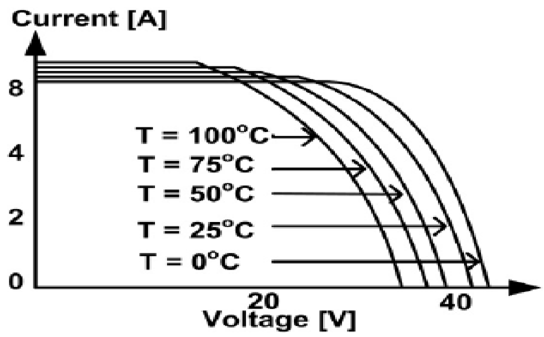
Modeling of proposed system

PV system characteristics

In this proposed architecture 16 strings are used. A single PV string generate 310.03 W of power at MPP voltage (43 V) and current (7.21A) at STC conditions. The P-V and I-V characteristics of a PV string at different isolation levels.



(a)



(b)

Fig 1. I-V characteristics with temperature and irradiance variation

From Fig 1(a) it is observed that the irradiance increases the current magnitude increases but there small variation in voltage from Fig 1(b) increase in the temperature the voltage increases.

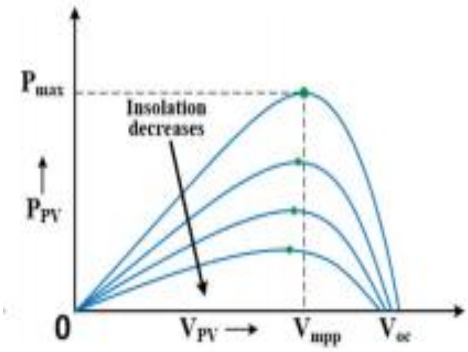
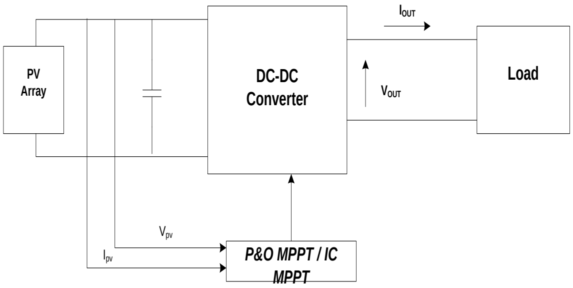


Fig 2. P-V characteristics

Proposed block diagram

The PV array is connected to the DC-DC converter through a DC link capacitor. The array (voltage) V_{pv} , (current) I_{pv} are fed to controller to generate a PWM signal and the signal is given to the DC-DC converter. In this proposed block diagram the MPPT is integrated with the DC-DC converter and then the output of the converter is given to the load. The converter generates the voltage according to the pulse given by MPPT and final output is given to the load.



Proposed system

In this configuration all the 16 PV strings were cross tied and connected in series and parallel and distinguished as row and columns separately. For this PV strings shading effect is created such as column shading, row shading, diagonal shading, row and column shading. In the row shading the first row is shaded unevenly and in column shading the first column of strings are shaded unevenly and in diagonal shading the shading is done diagonally and in row and column shading the first two columns are shaded unevenly.

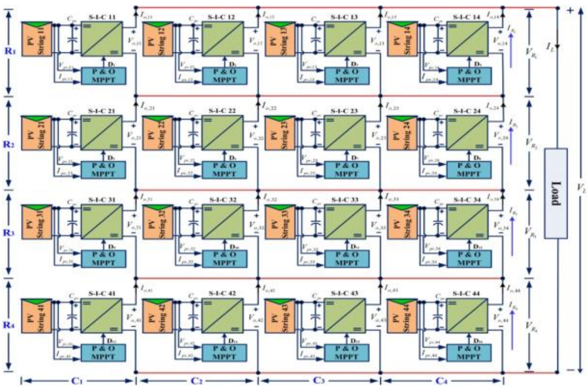


Fig3. Proposed system with T-C-T configuration

DC-DC converter with MPPT

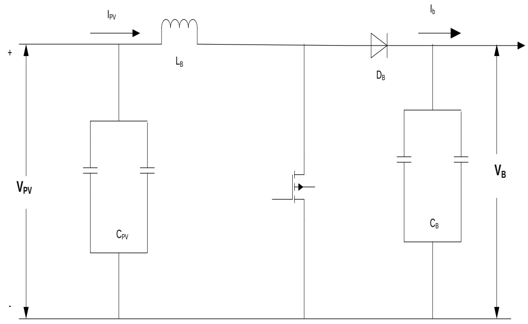


Fig 4. Boost converter

A boost converter is used which boost the PV string output voltage. The output current (I_{pv}) and voltage (V_{pv}) of the PV string are given as input parameters to the converter. The main components are MOSFET switch, inductor, output capacitor, diode and a input capacitor. The parameters of the converter are given as

a) Inductor selection: The inductance of inductor is calculated as

$$L_b = \frac{V_{pv} * D}{2 * \delta I_L * F_{sw}}$$

Where D is duty ratio of switch , V_{pv} is PV string output voltage, F_{sw} is switching frequency of switch, δI_L is inductor current ripple

b) Input capacitor: The capacitance of input capacitor is calculated as

$$C_{pv} = \frac{\delta I_L}{8 * \delta V_{PV} * F_{SW}}$$

Where δV_{PV} is PV string output voltage ripple

c) Output capacitor: The capacitance of output capacitor is calculated as

$$C_b = \frac{V_\circ * D}{2 * \delta V_\circ * R_b * F_{SW}}$$

Where R_b is load resistance, $V_\circ$ is output voltage, $\delta V_\circ$ is output voltage ripple

The output voltage (V_b) and input voltage (V_{pv}) are related as

$$V_b = \frac{V_{pv}}{1-D}$$

The output current (I_b) and input current (I_{pv}) are related as

$$I_b = I_{pv}(1 - D)$$

d) **Selection of switch**: Based on the current rating and output voltage of the string the switch has to be chosen.

Implementation of MPPT:

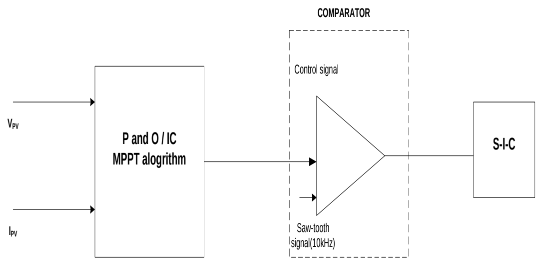


Fig 5: Implementation of MPPT controller

The PV voltage and current are provided are provided to the controller as input parameters to generate the output control signal. A PWM signal is generated by comparing the signal with the saw tooth signal of frequency of 10KHZ. To obtain the maximum power the signal fed is applied to SIC.

Algorithm of P&O MPPT:

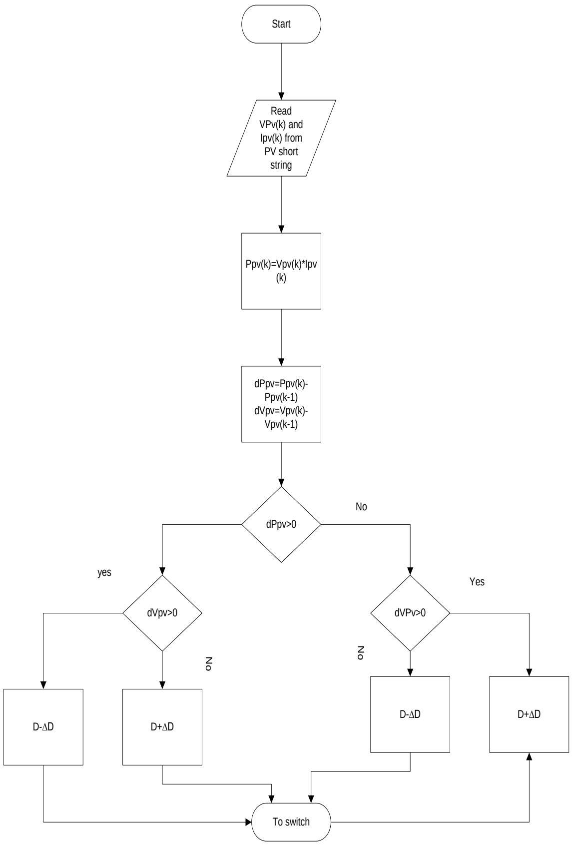


Fig 6. Algorithm of P&O MPPT

In this method, the voltage increased by the controller taken in small amount from the set and checks the output.. The power is calculated by taking the values of current and voltage. The change in power is calculated by subtracting the previous power value and present power value. If the change in power is greater than zero the change in the values of voltage are taken by decreasing or increasing the duty ratios.

Algorithm of IC MPPT:

The controller tests incremental changes in PV array current and voltage within the incremental cconducatnce system to predict the effect of a voltage shift. The incremental conductivity test measures the maximum power point. If these two are similar then the MPP voltage is the output voltage. This voltage is regulated by controller until the irradiation switches and cycle is repeated. The incremental conductance model is based on $\frac{dp}{dv} = 0$ and $P = IV$ at maximum power level.

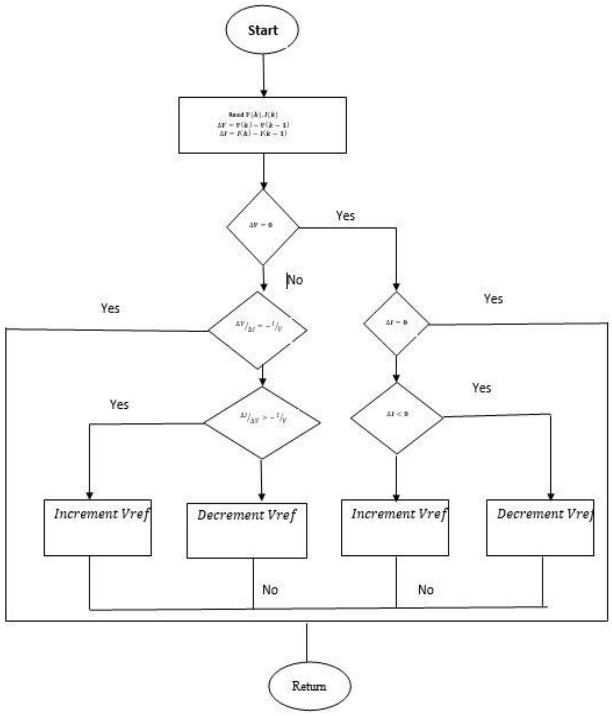


Fig 7. Algorithm of IC MPPT

Simulation results

The simulation results of the proposed configuration under various shading patterns using P&O and IC MPPT are described in this section.

Table 1 Specifications of PV module (sharp-nd-62RU2)

Specifications	*Values*
P_{mp}, *maximum power*	62.006 *W*
V_{oc}, *open circuit voltage*	10.9 *V*
I_{sc}, *short circuit current*	7.82 *A*
V_{MPP}	8.6 *V*
I_{MPP}	7.21 *A*
I_{ph}, *photo generated current*	7.8503 *A*
Ideality factor	0.89864
R_s, *series resistance*	0.14761Ω
R_{sh}, *shunt resistance*	38.1127Ω
n_s, *no. of cells*	18

$k_{v,}$ voltage temperature coeff	0.30849 V/K
$k_{I,}$ current temperature coeff	0.052801 A/K

Based on the different irradiances the shading effect is created as row, column, diagonal, long and narrow shading unevenly. The shading pattern contains various insolation levels such as 300, 500, 800, 1000 W/m^2.

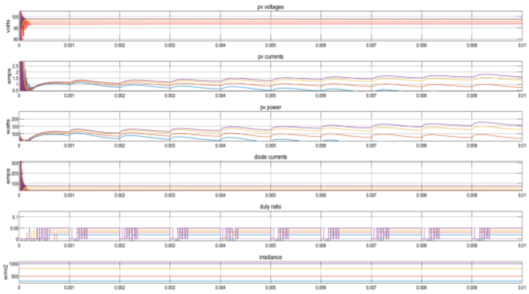


Fig8: uneven row shading using P&O

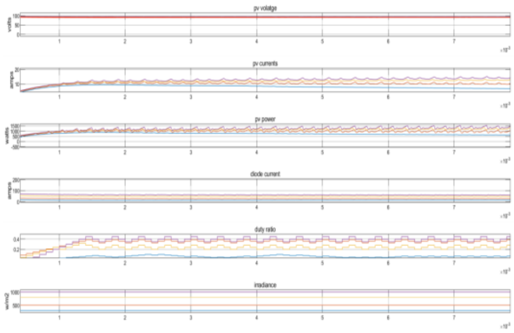


Fig9: uneven row shading using IC MPPT

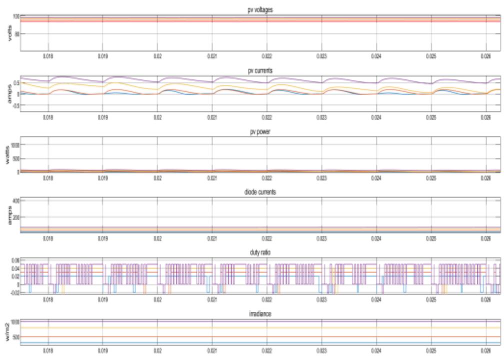


Fig10: uneven column shading using P&O

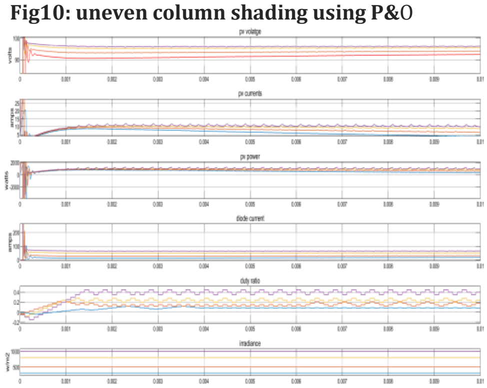


Fig11: uneven column shading using IC

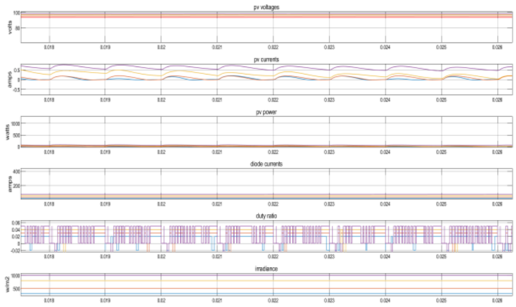


Fig12: uneven diagonal shading using P&O

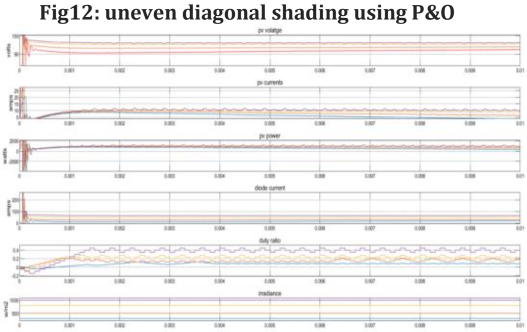


Fig13: uneven diagonal shading using IC

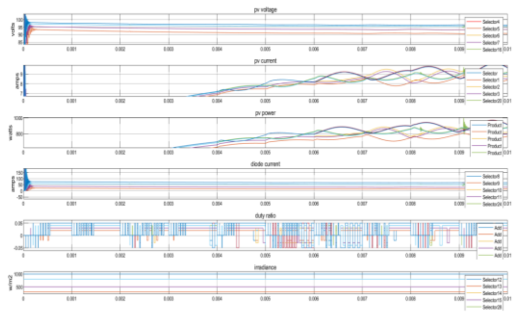


Fig14: Long and narrow shading using P&O

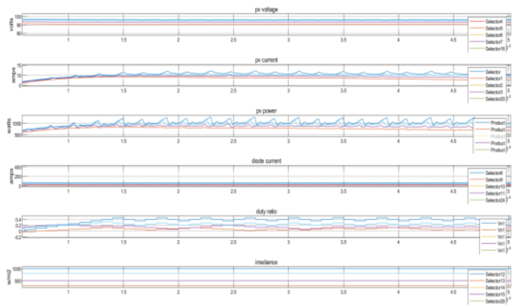


Fig15: Long and narrow shading IC

Table 2 Comparision of P&O and IC output power (KW) under different shading patterns

Shading patterns	Perturb and observe (KW)	Incremental(KW)
Uneven row	7.1	8.8
Uneven column	5.02	6.6
Diagonal	6.5	7.1
Long and narrow	6.7	7.5

CONCLUSION:

This paper explains about PV characteristics and design of DC-DC converter and implementation of MPPT techniques. In this paper T-C-T configuration of SICs is used to extract the maximum power. Both P&O and IC results are compared in this paper for extraction of maximum power. The results are compared taking different shading effects such as column shading, row shading and long and narrow shading unevenly taking different irradiances. IC method tracks more power rapidly than the P&O method.

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