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Research Article

Maximum Power From Tct Configuration Of Pv Array Using P&O Algorithm.

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Abstract:

With Abundant power available in the form of solar energy, it is not only necessary to utilize that energy but also important to extract maximum power from that source and minimize the losses. So in this paper we will discuss how maximum power is extracted from the solar array connected in Total Cross Tied (TCT) configuration using Perturb and Observe Method and fed to an Active DC load along with a Battery pack in order to maintain power to load regularly during low irradiance conditions and maintain constant DC voltage across the load terminals. Simulation of above conditions is achieved using MATLAB SIMULINK.

Index terms: TCT configuration, MPPT, Perturb and Observe, Boost converter, Battery pack, PI control.

I. INTRODUCTION

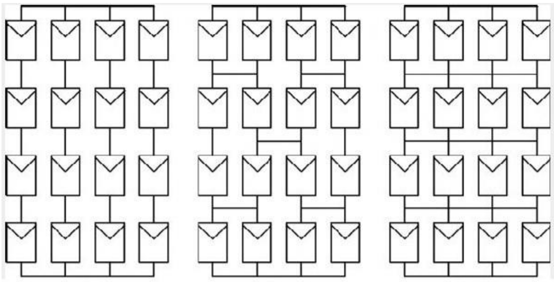
Photovoltaic power generation is so far the best reliable and economical source of electrical energy. With the abundant power available in the form of solar radiation from sun, it is quite necessary to use this renewable energy source to a maximum extent and reduce the usage of fossil fuel energy sources and reduce the dependency on them because we all know the adverse effects of fossil fuel usage and the pollution caused by them. And it is also important to utilize the energy absorbed by PV panels to a maximum extent by extracting the maximum power from them by tracking down the maximum power point using MPPT technique.

While coming to the connection configuration of PV modules in an array, there are few different types of configurations available such as Series–parallel configuration, Total Cross Tied (TCT) Configuration [1], Bridge Linked (BL) configuration as shown in fig.

1. Each have their own advantages and disadvantages, but we employed TCT configuration because of the advantage of better performance and increased reliability during partial shading conditions. And in order to achieve maximum power point we need a mediating circuit in between the PV panels and Load connected. So a Boost converter is used in order to step up the voltage level as well as to keep the voltage at a particular value such that maximum power is obtained. And in order to maintain the continuity in supply to load, we connect a battery pack across the load with the use of a circuit employed to regulate

charging and discharging of battery. The state of charging or discharging is determined by the PI control block which compares the reference voltage level with the present voltage level across load. And that difference is given to a PI block which generates the reference battery current. That reference current is compared with present battery current and the difference is given

to a PI block which generates the duty cycle for operating the charging and discharging circuit.



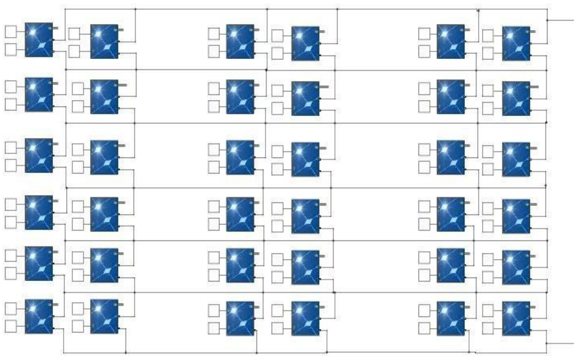
SP BL TCT

Figure 1. Different Configurations of PV array

II. DELAY OVERVIEW OF TCT CONFIGURATION

Considering the advantages of TCT configuration, it is employed as array configuration. One of the main reason for employing this configuration is the advantage of improved reliability and efficiency during partial shading conditions. The events which cause the partial shading conditions are blockage of solar irradiation due to passing clouds, trees, buildings, poles etc. these conditions cause mismatch between PV panels which leads to off-putting effects such as decrease in generated power and hotspots [2]. And a major problem evolving from partial shading conditions is that due to it, the current produced in unshaded cells and shaded cells are not equal and if those are in series connection, all cells must carry equal current which makes the shaded cells reverse biased and turns into load. This causes hotspots and overheating of modules.

We employed 6*6 array of modules for TCT configuration as shown in figure 2.



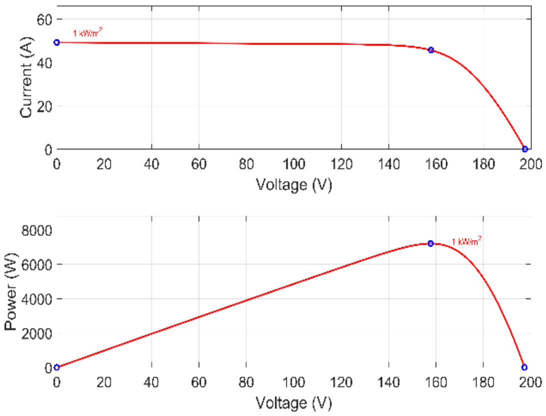


Figure 2. TCT Configuration of 6*6 PV Modules

III. DESIGN OF TCT CONFIGURATION

At standard test conditions of 1000 W/m^2 irradiance and 25 ^{0} C of Temperature, Kyocera Solar KC200GT panel is simulated to which the output voltage obtained is 32V. The parameters of the panel are shown below.

Table 1. Parameters of the PV module

Parameter	***Value***
Manufacturer and Model Name	Kyocera Solar KC200GT
Number of cells	54
Open Circuit Voltage (Voc)	32.9V
Short Circuit Current (Isc)	8.21A
Voltage at Maximum Power (Vmp)	26.3V
Current at Maximum Power (Imp)	7.61A
Shunt Resistance (Rsh)	150.6921 ohms
Series Resistance (Rs)	0.34483

It is quite necessary to plot PV and IV characteristics of this configuration to find out the value of maximum power it can generate and also determine the voltage and current at maximum power point condition. This can be done with the usage of controlled current source. The PV and IV characteristics are shown in figure 3.

Figure 3. IV and PV characteristics of TCT configuration under constant irradiation of 1000 W/m^2

IV. OVERVIEW OF BOOST CONVERTER

As said earlier we require a medium between panels and load to regulate the output voltage, so a boost converter is employed. This converter transforms or steps up the voltage level with the use of inductor, capacitors and a Switching device such as IGBT [3]. The circuit of boost converter is shown in figure 4.

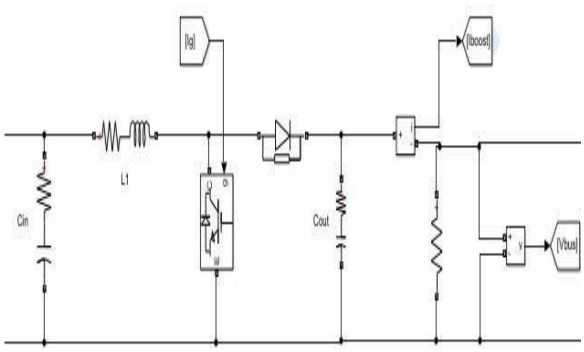


Figure 4. Boost converter Simulink model

Parameters	***Value***
Input capacitance (Cin)	100µF
Input Inductance (L1)	5mH
Output Capacitance (Cout)	3300µF
Switching Frequency of pulse generator	5000hz

V. OVERVIEW OF PERTURB AND OBSERVE MPPT ALGORITHM

It is also called by the name “Hill climbing method”. In this method, the power at a particular point is continuously compared with previous value and accordingly decreasing or increasing the module voltage. In this way maximum power point is achieved [4]. The problem with P and O algorithm is that it reaches the maximum or peak power point but doesn’t stays at that point, instead it oscillates through that point but never stabilizes at a single point. The algorithm for this P and O method is shown in figure 5.

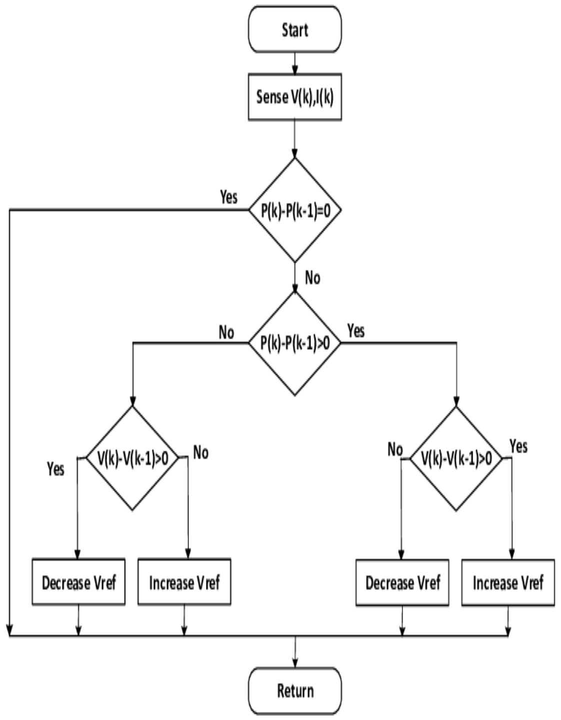


Figure 5. Step by step algorithm of Perturb and Observe method

VI. MODELLING OF CHARGING AND DISCHARGING CIRCUIT

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As mentioned in previous statement, in order to maintain continuity of supply to load we used a battery pack. As it is obvious to utilize the power from battery during low irradiance conditions as well as charge the battery regularly. This can be achieved by using a charging and discharging circuit as shown in figure 6.

Parameters	***Values***
Type of the battery	LithiumIon
Number of Batteries	5
Type of Connection	Series
Nominal Voltage	52V
Rated Capacity	200Ah
Initial State of Charge	50%
Full Charged voltage	60.5273V
Nominal Discharge Current	86.9565A

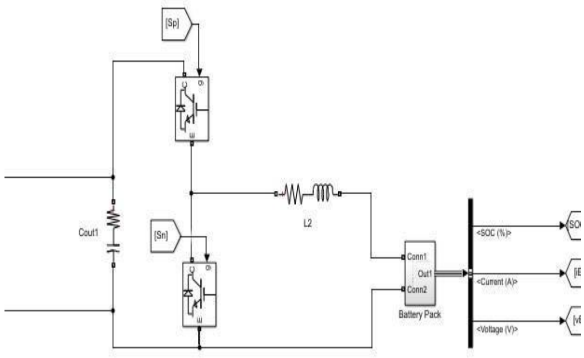


Figure 6. Charging and discharging circuit

The timing pulses for the IGBT's in the above circuit is generated by the PI controllers which uses the reference value of voltage and generates the reference battery current. This reference value is compared with actual value of battery current and the error is generated as duty cycle as shown in figure 7.

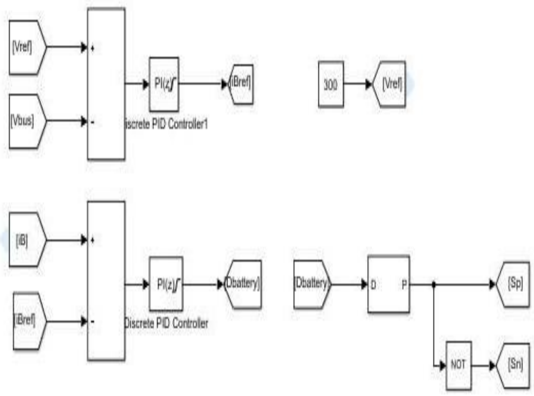


Figure 7. Pulse generator circuit Table 3. Battery Pack Parameters

VII. SIMULATIONS AND EXPERIMENTAL RESULTS

Under uniform shading conditions of irradiance at 400, 600, 800, 1000 W/m^2 and temperature of 25 ^{0} C, the output results of simulation are presented below. The output of TCT array configuration Voltage, current, power are shown in figure 8.

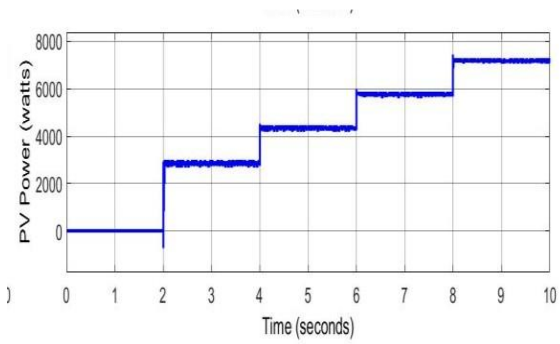
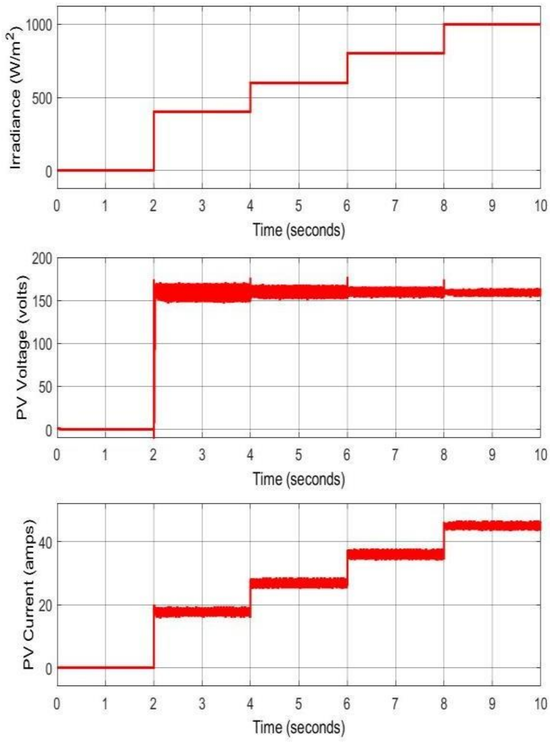
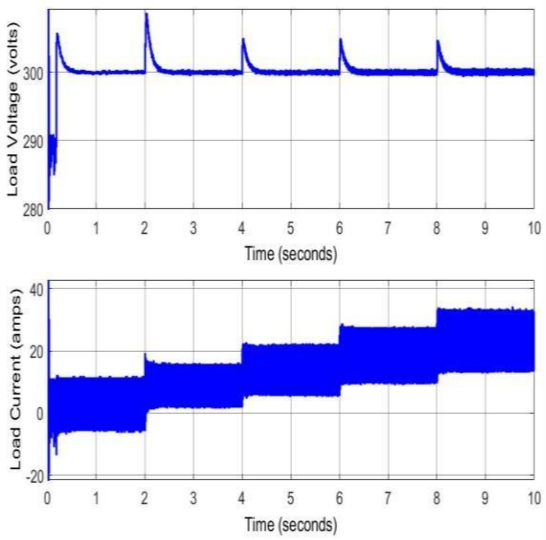
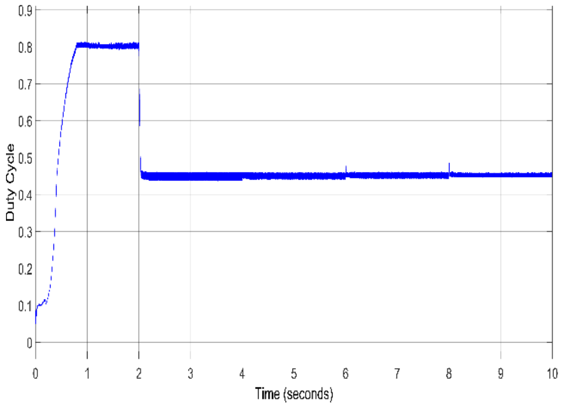


Figure 8. Output Voltage, Current and Power of TCT Configuration



The output parameters of Boost converter and the duty cycle ration generated through Perturb and observe





algorithm is shown in figure 9.

Figure 9. Output Voltage, Output Current and Duty Cycle of Boost Converter

As seen in the above results, during uniform shading conditions at irradiance values of 400, 600, 800, 1000 W/m^2 and 25 ^{0} C of Temperature, the output voltage of boost converter i.e. across the load, reaches the constant value as taken as the reference value. The difference in actual value to the reference value generates a current reference value. This reference value of current is compared with the real value and the error generated is transferred to a PI controller which generates the Duty cycle for charging and discharging circuit.

The voltage, current and SOC of battery is represented in the below figure

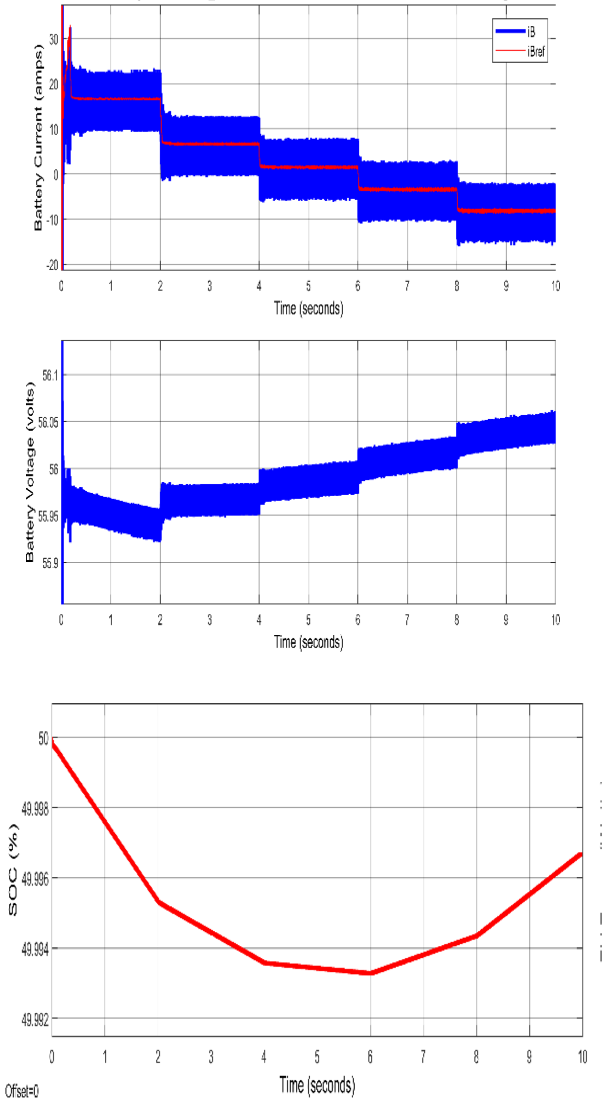


Figure 10. Voltage, Current and State of Charge of a single Battery

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