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A SIMULATION STUDY OF MULTI-LEVEL INVERTER TO OVERCOME SHADOW EFFECT ON PV SYSTEM

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ABSTRACT:
The conventional resources are being depleted day by day; hence there is a requirement of alternate energy resources. Upcoming alternate resource like solar energy is available abundantly for meeting our needs. Mostly, PV systems are used for the electrical energy demands, but the main issue with the PV system is its efficiency. The efficiency of the PV system depends on the irradiance falling on each solar cell. The non-linear I-V characteristics will be affected by the variation in the solar irradiance over the day. The I-V characteristics are important to find the MPP of the solar panel, that's why the MPPT algorithm is becoming more significant.
The partial shading will also affect the output of the PV panel. To overcome the shading effect we use power electronics elements. Multi-level DC link inverters can be used to reduce the shading effect. The maximum is extracted from the PV source to the load at their MPPs under partial shading. Each PV array is connected with multi-level inverter (MLI) in series. The seven level MLI is operated by PWM (pulse width modulation).
KEYWORDS: Solar energy, PV systems, Partial shading, Multi-level inverter (MLI), Maximum power point (MPP), Perturb & Observe (P&O).

I. INTRODUCTION :

Energy is the inevitable factor of life. All the basic needs of living beings require energy. The use of renewable energy has become more prominent in the last 25 years with threats of global warming and increased energy demand and cost. The renewable energy also known as non-conventional energy has the potential of replenishing by itself. Most of the renewable energy is coming from the Sun. Amongst the renewable energy sources; solar energy is the most promising one and is bound to become an important source of energy. There are mainly two ways to extract the solar energy from the Sun, in practice they are: Solar PV panels and solar concentrators/collectors. Due to greenhouse gas emissions, global warming and energy policies have been the international concern since past two decades [1]. PV panel produce more energy than their manufacturing over their lifetime [2].

PV power generation is becoming economical alternative for the conventional energy sources, but due to the costly equipment requirement governments are promoting with subsidies and tariffs [3]. The performance of a photovoltaic (PV) array is affected by temperature, solar insolation, shading, and array configuration. Often, the PV arrays get shadowed, completely or partially, by the passing clouds, neighbouring buildings and towers, trees, and utility and telephone poles. The situation is of particular interest in case of large PV installations such as those used in distributed power generation schemes. Under partially shaded conditions, the PV characteristics get more complex with multiple peaks. The presence of multiple peaks reduces the existing MPPT methods. Therefore it is important to overcome the shading effect of a PV panel.

II. PV ARRAY CHARACYERISTICS :

The basic electrical model of solar cell with single diode is shown in the Fig. [1]. The open circuit current and short circuit voltage are the main characteristics of a PV panel.

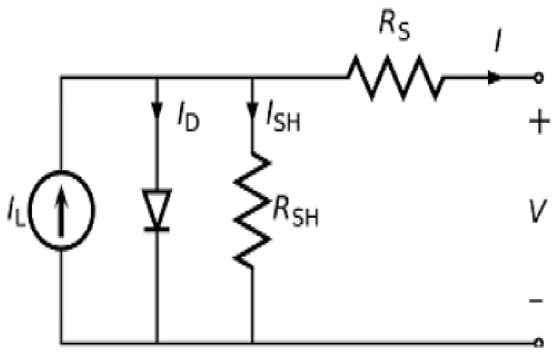

Fig1. Equivalent circuit of PV cell.

$$I = IL - Io\left(e^{\frac{V+IRs}{nsVt}} - 1\right) - \frac{V+IRs}{Rsh} \qquad (1)$$

$$Vt = \frac{AkT}{q} \qquad (2)$$

Where,

I_L - Photo generated current
I_0 - Dark saturation current
R_s - Panel series resistance
R_{sh} - Panel parallel resistance
k- Boltzmann's constant
q- Electron charge
ns- Number of cells in series
T- cell temperature (in K)
A - Diode quality factor.

The I-V and P-V characteristics are shown for solar irradiance of 1000 W/m^2 and temperature of 25^0 C. The characteristic curves are shown below in Fig. 2 and Fig. 3 respectively.

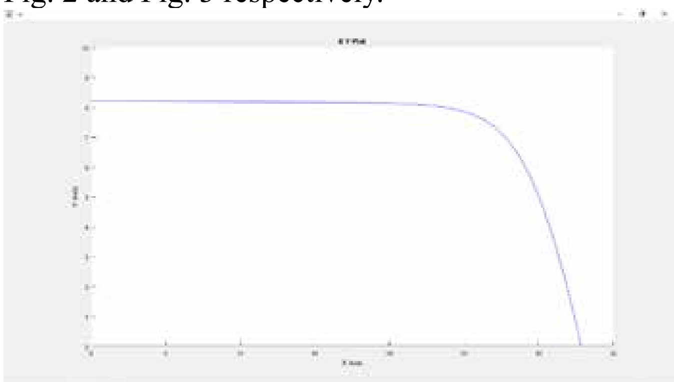

Fig 2. IV characteristics curve for PV module.

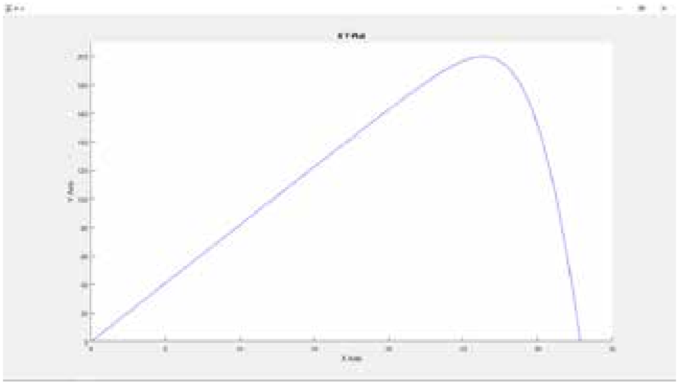

Fig 3. PV characteristic curve for PV module

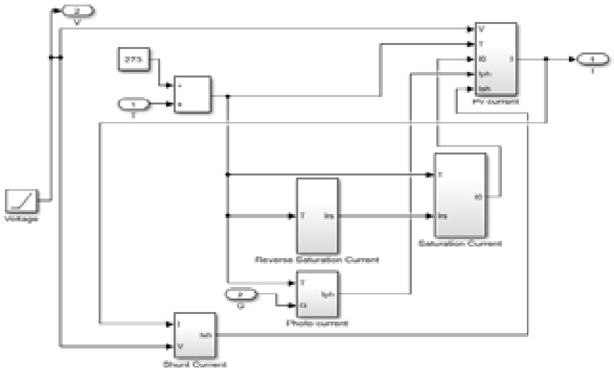

Fig 5. PV Module modelling in Simulink.

III. SIMULATIONS AND RESULTS :

The series and parallel connected cells meet the desired load in a PV array. As mentioned the output power does depend on external parameters like temperature, shadows, relative humidity etc. Using MPPT we can track the maximum power obtained by panel. P&O algorithm is used for the same because it is easy and flexible.

In order to have a maximum power output with less voltage due to the shading effect we used MLI. MLI maintains the quality output with minimum ripple content using PWM methods. Fig. 4 represents the basic flow chart model of P&O algorithm. Fig. 5 and Fig. 6 above shows the PV module and PV array modelling. The overall Simulink model for the study of partial shading is given in Fig. 7. And also the multi-level inverter subsystem is shown in Fig. 8. Fig. 9 represents the PV panel output under standard test conditions. In Fig. 10 we have the output for PV panel with MLI under normal condition. Fig. 11 shows the output using P&O algorithm for MLI one level in PV system for partially shaded conditions.

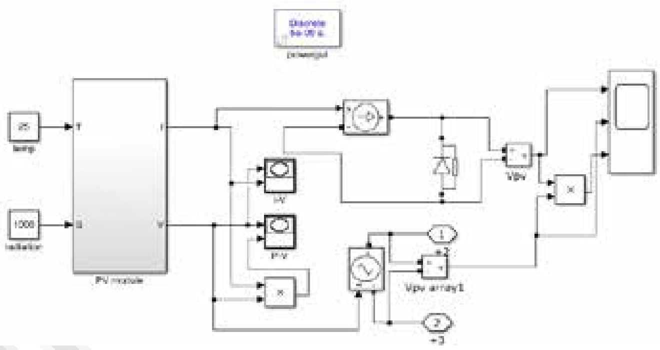

Fig 6. PV Array modelling in Simulink.

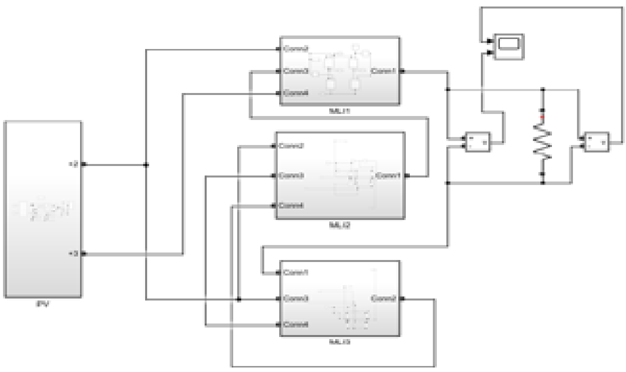

Fig 7. Overall Simulink Model with MLI.

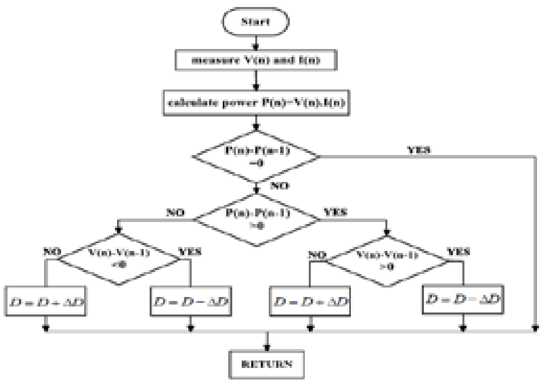

Fig 4. Flowchart of P&O algorithm [4].

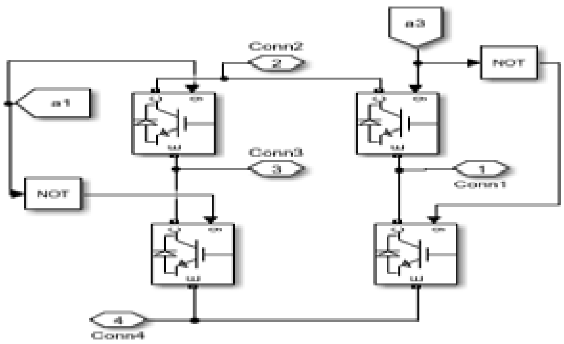

Fig 8. Multi Level Inverter.

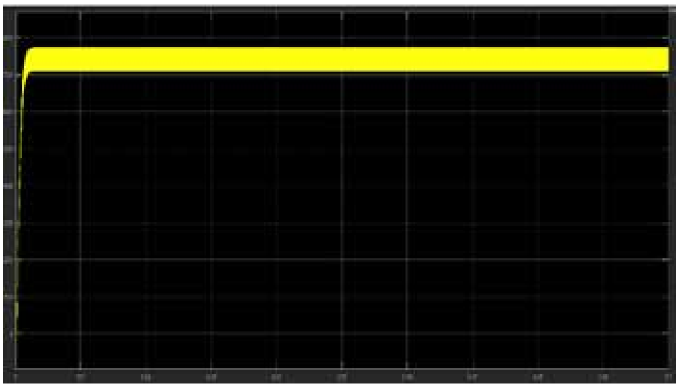

Figure 9. PV panel output.

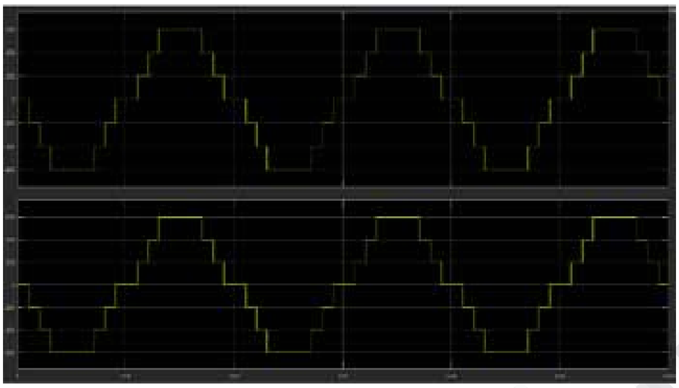

Figure 10. PV panel with MLI under normal condition.

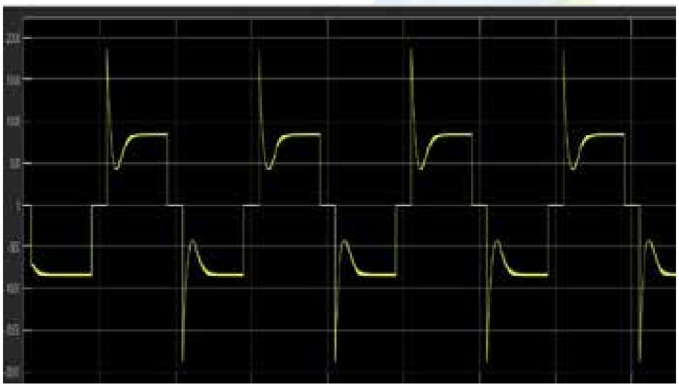

Figure 11. PV panel with MLI under partially shaded condition.

VI. CONCLUSION :

The system shows the method for obtaining maximum power from the PV source under partial shading. Comparing to other systems like DC to DC converters with this method we are able to reach MPP. The presented system is done with seven level multi-level inverter with P&O algorithm in MATLAB Simulink.

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