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PV Array Reconfiguration Under Different Partial Shading Conditions

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Abstract: - In this report, a complete analysis is being accomplished on solar photovoltaic (SP) modules configuration under different partial shaded conditions. The primary goal of this report is to design, study & analyse the efficacy of various photovoltaic (PV) topologies below different partial shadow scenarios. The main focus is to enhance the efficacy of PV pattern by decreasing dissimilarity losses and to choose the utmost relevant PV pattern topologies that gives the better outcomes. A complete investigation is accomplished on total applicable solar array configuration. Under different feasible shadow conditions, the performance & output characteristic of these array conformation is studied & compared. In a solar PV array there may be possibilities that some shadow may fall on some of cell or module. The PV characteristic become more complicated with various apexes or peaks under PSC. Due to partial shading the efficiency of photovoltaic system reduces by adversely affecting the irradiance perceived by photovoltaic cell. The shading in PV system may create numerous unwanted consequences. Whenever the shading happens, the energy achieved from the PV system is too less than actual output power due the mismatch losses of PV system. In this context various configuration techniques are recited i.e. series-parallel (SP), Bridge-linked(BL), Total-cross-tied(TCT), Honey-comb(HC) etc. The simulation of all proposed novel structure has been investigated on MATLAB/Simulink environment.

Key Words:— ***Partial shading condition, solar photovoltaic, series-parallel, Bridge-linked, Total-cross-tied.***

I. Introduction

Photovoltaic (PV) system is observed as the eminent & inexhaustible source of energy since sun ray is available in every place which is abundant in nature. It is costless & energy produced by PV system don't harm the environment i.e sustainable in nature. Even though, PV panels rate is decreasing every next year also the government provide subsidies to install PV panels to their house & generate electricity. Solar photovoltaic cell (SPV) has been booming rapidly as a source of renewable energy in the world to meet the load demand. Solar PV cell are adopted globally due to their non-polluting & eco-friendly nature which having several profitable implementations in commercial & household application. The non-renewable energy resource i.e. fossil fuels are exhausting rapidly. To overcome with this issue renewable energy would be a better source of energy which is abundant in nature and inexhaustible & it can be obtain easily & free of cost. The output power of PV system relies on several parameters such as: temperature gradient, solar radiance, partial shading etc.

Amid of all above parameters partial shading is the main cause of decreasing the efficacy. Some other cause of PSC may be from neighboring house, trees, dirt, clouds etc. A several number of module are combined in series & parallel to form an array to meet the power demand. Shading creates blockage of direct solar radiance due to which there is loss of power. Due to shading solar cell become equal to resistor that absorb the energy produced by nearby cells. Now, that consumed energy is transformed into heat that increases the temperature of cell & degrade it. This phenomenon is called Hotspot effect. By employing bypass diode this problem can be fixed. Bypass diode brings the minimum resistance pathway which is coupled in antiparallel direction of solar cell. Although, there are several techniques to overcome with losses due to PS condition: Maximum power point technique (MPPT), PV system architecture, Converter topologies, PV array reconfiguration etc. In this PV array reconfiguration method is proposed which is most conventional method that overcome the shading losses. Several interconnections pattern of PV module like as Series-parallel (SP), Bride-linked (BL) & Total-cross-tied (TCT) have been considered in this paper. We can get TCT & BL network by applying interconnection with in strings of PV module in SP pattern. Studies have proven among all those connection TCT configuration gives outstanding performance followed by BL & HC in most of PS conditions. The modelling & simulation of PV array configurations were carried on using MATLAB/Simulink &

their efficacy were analyzed. This paper state a MATLAB-based designing & simulation technique useful for examining & analyzing of current-voltage & Power-Voltage attributes of a PV pattern below PSC. Many research workers suggested topologies to investigate and analyses the result of shading on various PV array topologies to decrease the losses & to identify the perfect PV array topology that gives the maximum efficacy. The PV array topologies of SP, BL, & TCT were studied & examined. The author analyzed that by selecting the appropriate configuration design as per shading norm the more energy could be obtain. Overall, in almost PS pattern the output power achieved depicts that TCT configuration gives the excellent performance.

So, the comparison with prior research performed to this area the primary goal of this report is to deliver a complete analysis which concede the total possible PV pattern configuration below PSC. The idea for this plan comes first by designing the whole PV array topologies with various size & after then examining their efficacy under various PSC. By determining these scenarios it will give the best method to choose the better configuration under PSC that enhance the efficacy.

II. System Description

This segment represents the technique for establishing the introduced method for the connection of module in proposed configuration of partially shaded array. Entire simulation is done in MATLAB software.

A. Modelling of Photovoltaic Module Under PSC

Depending on the demand the solar module is inter-connected in cascade-parallel to increase the voltage & current capacity appropriately. The photovoltaic module is chosen from simscape library and connected together. PV module consist of three terminals in which one terminal is for radiance while two other is for positive and negative terminal of module & a bypass diode is linked with every panel in antiparallel manner.

Fig.1. Partial shading of PV module

B. Modelling of PV Cell:

The solar cell voltage (Vc) is the mathematical relation of current (Iph) that is based on solar irradiance which could be formulated in equation (1),

$$Vc = \frac{AkTc}{e}\ln\left(\frac{Iph + Io + Ic}{Io}\right) - RsIc \qquad 1$$

As the photovoltaic cell change with photovoltaic radiance degree Sc the operational temperature Tc of photovoltaic cell variance. This outcome is incorporated from temperature rectification factor Ctv & Ctv employing equation (2),

$$Ctv = 1 + \beta t(Ta - Tx) \,\&\, Cti = 1 + \frac{\gamma t}{Sc}(Tx - Ta) \qquad 2$$

The irradiance degree (Sx) outcome to the voltage & current could be calculated for rectification factor Csv and Csi expressed in equation (3),

$$Csv = 1 + \beta \tau \alpha s(Sx - Sc) \,\&\, Csi = 1 + \frac{1}{Sc}(Sx - Sc) \qquad 3$$

Where the *Sc* and *Sx* depicts the reference and actual solar radiation level appropriately. The rectification factor of temperature & solar radiation like as *Ctv*, *Cti*, *Csv* and *Csi* are helpful in evaluating the absolute rate for the solar cell voltage (V) and current (I) that could have expressed in equation (4),

$$Vcx = CtvCsvVc \,\&\, Iphx = Cti\ Csi\ Iph \qquad 4$$

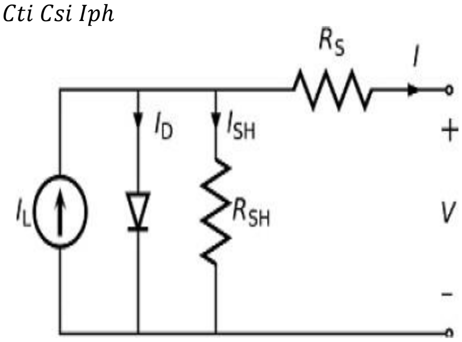

Fig. 2: Equivalent circuit of PV cell.

C. Mathematical modelling of Photovoltaic string

Solar panel may differ at most if reconfiguration of photovoltaic cell. Whether Ns PV cell are linked in cascade, solar panel voltage is equivalent into Ns count with single solar cell voltage and solar panel current that is equivalent to that of each single cell.

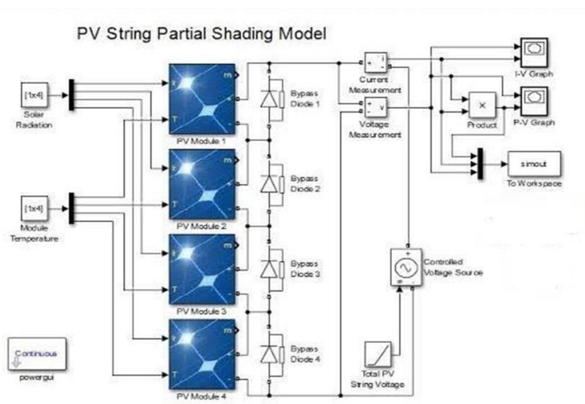

Fig.3. Simulation in MATLAB/Simpower

D. Series-Parallel (SP) configuration

In Cascade-Parallel photovoltaic topologies the solar modules are firstly inter- connected in cascade to make a sequence pattern to get as per need voltage after this sequence patterns are inter-connected in parallel to get as per need current. The power- voltage and current-voltage attribute below partial shadow pattern for cascade-parallel are demonstrated in fig. respectively. This connection is mostly used & common because it is easy to made and there is no complex connection.

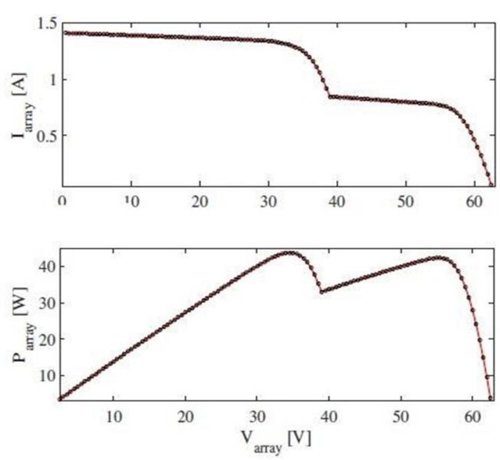

Fig.4. Current-Voltage (V-I) & Power-Voltage (P-V) characteristic of SP configuration.

E. Total-Cross-Tied (TCT) Configuration.

In total-cross-tied every photovoltaic module is connected to its neighboring PV panel. All the PV panels are cross inter-connected. The figure 5 depicts the P-V & I-V attributes under partial shading condition.

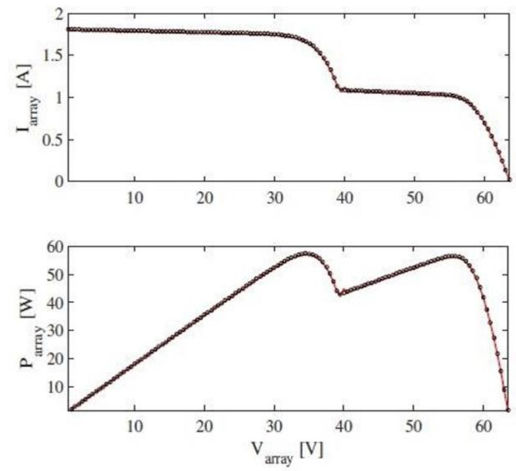

Fig.5. Current-Voltage (V-I) & Power-Voltage (P-V) characteristic of TCT configuration.

F. Bridge-Linked (BL) Configuration

Figure 6. depicts the P-V & I-V attributes of Bridge linked configuration under uniform and partial shading condition respectively.

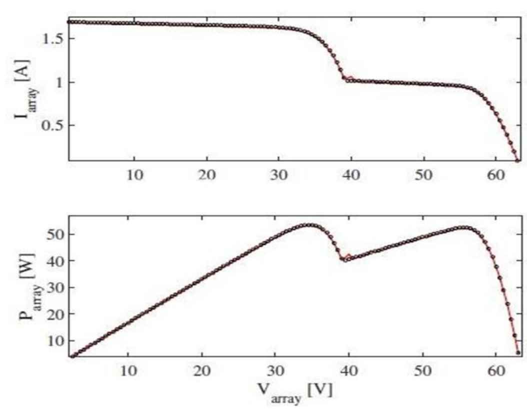

Fig.6. Current-Voltage (V-I) & Power-Voltage (P-V) characteristic of BL configuration.

III. Conclusion

In this report, a complete analysis that proposed almost all photovoltaic topology under all feasible shading conditions. The result depicts that the efficacy of the PV array configuration is inconstant & based on different type of shading pattern. The stated configuration overwhelm the mismatch losses and simulations were executed in MATLAB to achieve the output power. Finally, this analysis gives an idea how we can apply these PV array topologies under shading conditions.

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