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Experimental study of the effect of fully shading on the Solar PV module performance

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Abstract

Experimental tests were performed to study the effects of shading for different string inside the photovoltaic (PV) panels, power equipped with different number of diodes from the same manufacturer as of solar panel. The IV curve for all cases were recorded to see how the bypass diodes will reduce the effects of shading .The case for 3 by pass diode show the best performance of solar PV module under shading phenomena.

Key Words: PV solar Panel, Shading, Bypass diode, fully shading

1. Introduction and literature review

Photovoltaic renewable energy system are widely used as source of green energy because of the positive impact on the environment, direct electricity without conversion and low pollution to the atmosphere, as well as competitive with the traditional energy system, due to maturity of these technologies. Shading is one of the most important phenomena that affects on the performance of PV panels, the shading can happen by different reasons, some of these reasons are related to atmospheric condition such as dust and surrounding conditions such as human being , constructions, birds, dropping of birds, plants and between panels in arrays.

Shading is categorized in to two main types; (i) full shading (ii) partial shading. Most of researchers were performed tests and simulations to study the effect of partially and fully shading on the performance of PV panels.

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In the study [1], the *I–V* and *P–V* characteristics of a PV array under a nonuniform insolation due to partial shading were presented based on modeling and simulation scheme performed by MATLAB. [2] they developed A generalized PV module model n MATLAB based on the mathematical equation of PV cell. The model is used to simulated partially shaded cells in the PV module and also for partial shaded modules in the PV string under various weather conditions. The impact of shading on array characteristics using MATLAB model of PV array were observed by the study of [3]. Different insolations incident were considered on different models. The output of the MATLAB model with the theoretical values were compared. The goal of this study is to design and develop simulation of solar panels connected in series integrated with a boost converter and MPPT algorithm taking into account the effects of partial shading. In the study [4], MATLAB/Simulink was used to design and simulate a complete off-grid PV module based power generation system. The value of standard solar irradiance about 1 KW/m^2 was used for Bangladesh. The simulation model was examined the performance of all components (blocks) for the off-grid PV module system. Adaptive inertial weight particle swarm optimization (AIWPSO) algorithm was proposed to solve the low convergence speed and search accuracy of the Particle swarm optimization (PSO) under partially shading by the study of [5].[6] they studied the impact of using bypass diodes on the solar cell performance under shading at a module level. Algorithms based on MATLAB was designed to study the effects of non-overlapping bypass diode configuration in a randomly shaded solar module. In the study [7], the behavior of a photovoltaic device (cell or module) under partial shading conditions were reviewed and analyzed by using MATLAB. [8 - 9] they investigated the harmful effects of partial shading of series and parallel connected Solar PV modules and compare their performance.

In this research paper, the I-V characteristic curve and power performance of 30 W PV panel under fully different shading cells condition will study for different number of bypass diode, mainly two and four diodes. The PV analyzer device will use to measure I-V and power curves for this panel.

2. Experimental setup and testing

The experiments were tested under real conditions of irradiance G (W/m^2) and temperature T (°C), where the I-V and power curves for PV module measured by using the PV analyzer (profitest), the electrical characteristic of PV panel is shown in Table 1. All the components used during the measurement are shown in figure (1). Different configurations of fully shading cases were

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tested for 30 watt PV panel with two or four bypass diodes per panel. The fully shading was applied on the cells by using cardboard.

Table 1 Electrical characteristic of PV panel used in the testing under STC.

Open circuit voltage (V_{oc})	22.5 V
Short circuit current (I_{sc})	2 A
Voltage at maximum power point (V_{mp})	18 V
Current at maimum power point (I_{mp})	1.67 A
Maximum power (P_{mp})	30 W
# of cells ad type	36 Monocrystalline

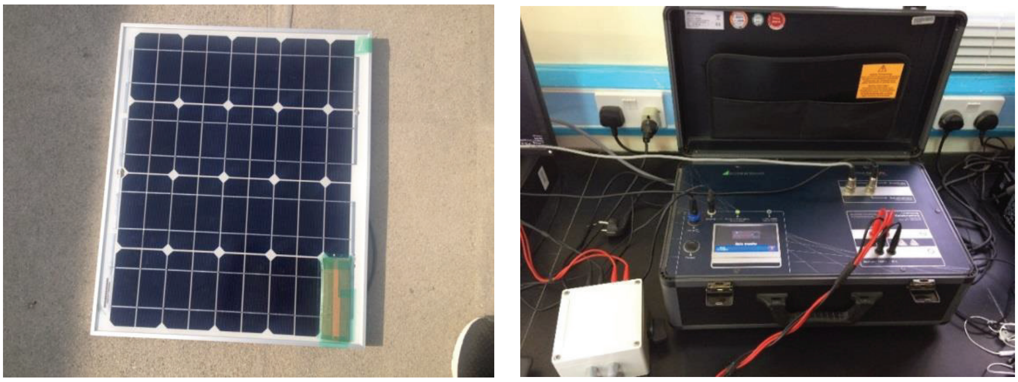

Figure 1: PV panels and PV analyzer

3. Results and discussion

Figure (2) shows the effect of shading size on both maximum power and fill factor, both of them are inversely proportional with the shading size as shown from the figure, that can explain how is the fully shading reduces the maximum power production from the PV panel, this reduction in the

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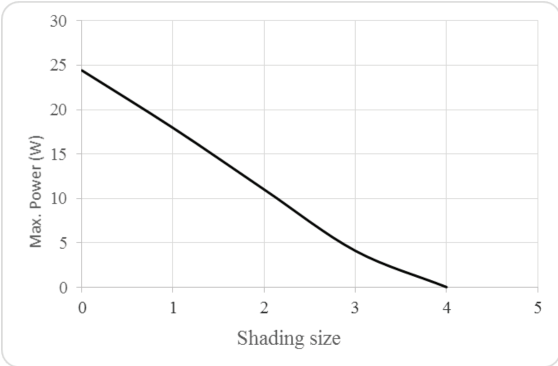
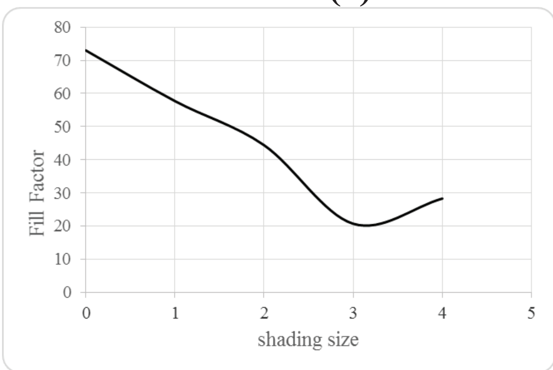
maximum power due to the drop in the short circuit current and hence the fill factor.



(a)



(b)

Figure 2: (a) Fill factor versus shading size (b) Maximum power versus shading size

The characteristic I - V curve for 30 W PV panel is shown in figure (3) for unshaded (reference) case and different shaded cases (1 cell, 2 cells, 3 cells and 4 cells) for both 2 and 4 bypass diodes. The effect of the number of shaded cells is obviously clear on the characteristic I - V curve of PV panel, the drop in the current for different shaded cells from the string (from left or right sides i.e. from first or fourth column) is typically same for all shaded configurations, the reference case has the highest short circuit current while the four shaded cells has the worst current (zero current), it worth to mention that the difference between the two and four bypass diode is clearly appears in the case of two cells from different string.

Figure (4) shows the power curves for unshaded (reference) case and different shaded cases for the 30 W panel size. The drop of the maximum power for each individual shaded case was corresponding to the drop of the short circuit current for each individual shaded case as shown in figure (3). The value of

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the maximum power is determined by the value of voltage corresponding to maximum power for each individual shaded case. Similar to the characteristic I - V curves, the reference case has the highest power value (24.4 W) while the four shaded cells has the worst power value (0.031 W). More ever, for the cases of 1 cell shaded, 2 cells shaded from different strings and 3 cells shaded from different strings, the 4 bypass diodes saved more power than the 2 bypass diodes by 28%, 45% and 17% respectively. It is also clear that increasing the numbers of bypass diodes will improve the performance of PV panel under fully shaded cells condition, take in the account the price of these bypass diodes with respect to the price of PV panel, in order to keep acceptable energy production cost ($ / KWh).

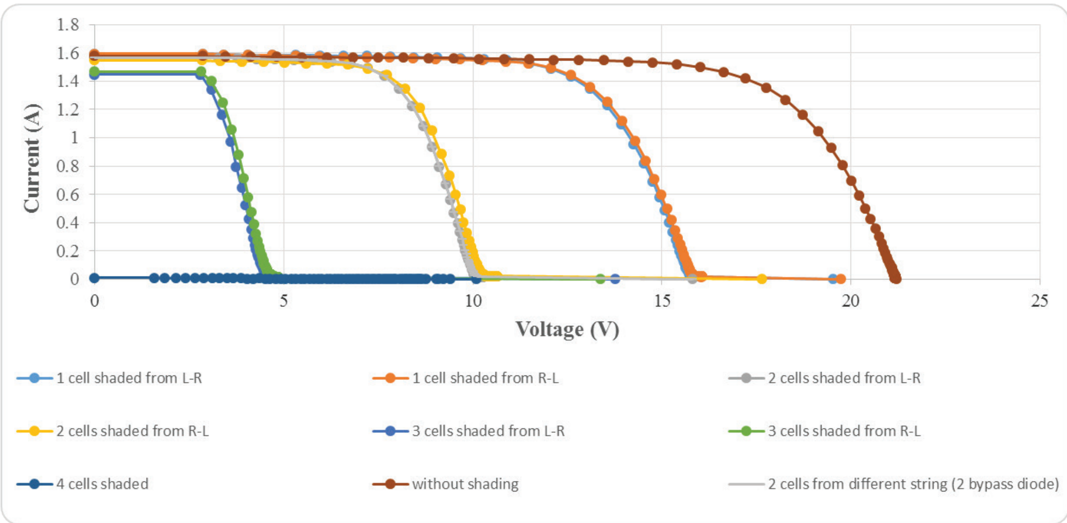

Figure (3) I – V characteristic curves for unshaded (reference) and shaded cases for 2 and 4 bypass doides.

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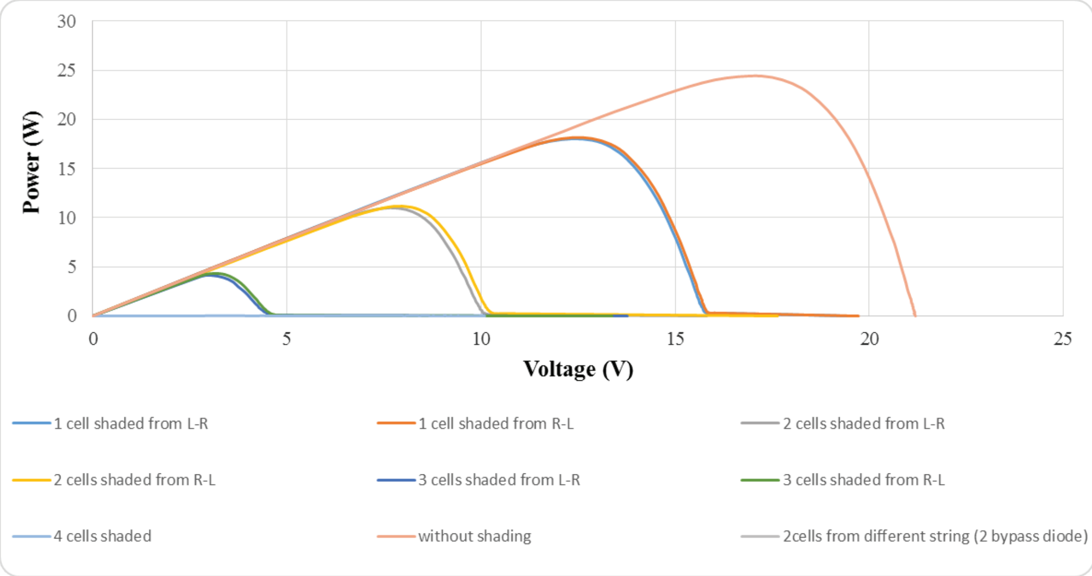

Figure (4) power curves for unshaded (reference) and shaded cases for 2 and 4 by pass doides.

4. Conclusion

The profitest PV analyzer device was used to measure the effect of fully shaded cells on the performance of PV panel equipped by two or four bypass diodes. The drop in the short circuit current and power of the 30 W PV panel depend on the number and the position of the shaded cells. The four bypass diodes save more power than the case of two bypass diodes taking in the account the cost of energy production.

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