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PSPICE Simulation For A Solar Panel To Understand Shading Effects

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Abstract
The present work is a study of the effects of partial shading on the performance of a PV module spatially on the maximum power point position. This search clarifies the mechanism of partial PV shading on a number of PV module connected in series and parallel. In addition, this search will mainly devote to investigating the performance comparison between series and parallel under partial shading (for different solar intensity, short circuit current and pv panel surface temperature). A PSPICE PV panel model (consists of 36 solar cells) will be used to test this study and present the results.
Key Word: *PV, shading, PSPICE, surface temperature*

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I. Introduction

PV panels are subject to variety of changing that can affect the I-V curve and the output power of the PV panel. Almost all the variable conditions tend to affect the PV current. [1]Examples are cloud coverage, temperature variations, dust coverage, alignment of modules with the sun, manufacturing tolerances and partial shading.

It also consumes the power produced by other non- shaded PV cells in the form of heat, (with the continual) over a long period of time of heat accumulation, the high temperature may damage the packaging material of the modules, or even destroy the internal physical structure of photovoltaic cells, and cause permanent damage, known as "hot spot" phenomenon. [2] There have been several studies on the effect of shadowing on the performance of the PV module. Yaw-Juen Wang and Po- Chun Hsu, 2009[3] presents an equivalent circuit model based on piecewise linear parallel branches to study solar cell modules which are partially shaded. Xu Qingshanetal. [4] describes the configuration of bypass and blocking diode to the PV cell and mainly investigated the performance comparison between diverse series / parallel PV array patterns when mismatch exited. Dezso Sera and YahiaBaghzouz, [5] clarifiesThe mechanism of partial PV shading on a number of PV cells connected in series and/or parallel with and without bypass diodes the analysis is presented in simpler terms and can be useful to someone who wishes to determine the impact of some shading geometry on a PV system.

Different PV array models have been developed to suit different simulation programs. This paper starts with the PV panel module part that is built into Simulation Program for Integrated Circuits Emphasis (PSPICE) from previous work [6]. The voltage and current characteristic equation of a solar cell is provided as: [7]

I_{PH}= [I_{SCR} + K_1 (T- 298) * (λ / 1000) ……………………….…. (4)
Where:
K_1: short circuit current temperature coefficient for SP75 equal 0.0017 A/C^o. from data sheet. I_{PH}: represented photovoltaic current.
T: cell temperature.
λ: solar radiation.
I_{SCR}: short circuit current.

The effects of partial shading on PV module I-V and power curves with different module connection configurationwill be studied. First of two panels in seriesand second oftwo panels in parallel(for different short circuit current, different solar radiation and for different temperatures). The created panel and the(I-V) (P-V) characteristicsfor different solar irradiation are shown in fig. (1)these curves provide that the PSPICE PV model could be used as a source of energy to the power circuit.The simulated model shows 21.7V open circuit voltage and 4.8A short circuit current and 75W maximum power at 25C^o with 1000W/m^2 solar irradiation.

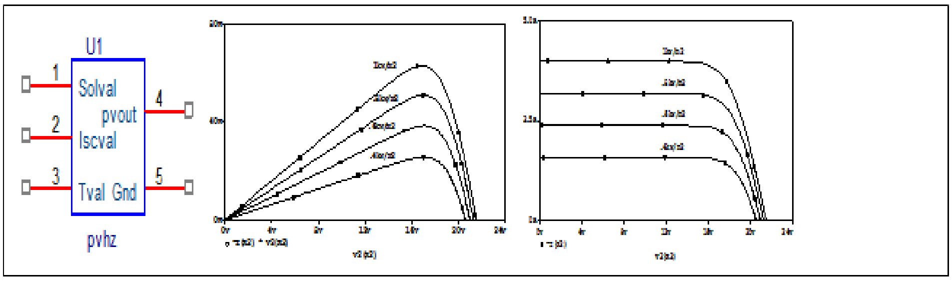


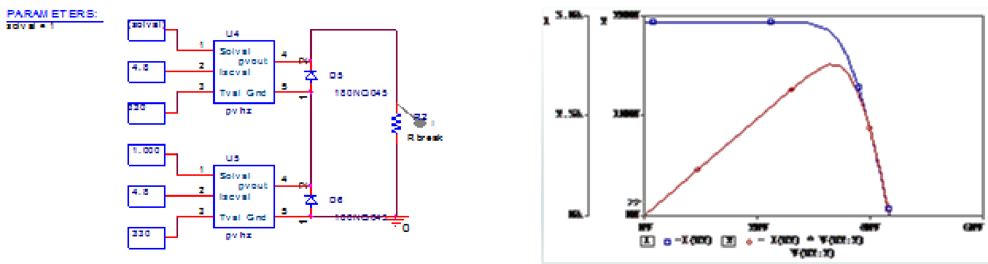
Fig. (1): The created PSPICE PV panel

PV Module Mismatch

PV panels are connected in series to achieve the desired system operating voltage, and the series strings are paralleled to achieve higher system currents, the resulting system voltage is usually an "average" of the individual voltage maximum point (Vmp) of the individual panels. The difference between the new system voltage that is created with fault in one pv panel and the voltage maximum point of the individual panels is the "mismatch". As the operating point is moved away from the voltage maximum point, the power is reduced by some value. The sharper the" knee" of the I-V curve of the panel, the greater the effect of moving the V_{mp}. For example, if the operating voltage is lower than V_{mp}, and the current does not change proportionately, the actual power output of the panel will be lower than its ratedpower. If the I-V curve has a soft knee, where the current is increased more significantly as the operating voltage is decreased, there will be less impact on the PV panel power output [8]. Bypass diode is often used to prevent PV cells from detrimental effects of partial shading.The mismatch was introduced in the simulation by varying the value of short circuit current, solar irradiations and surface temperature of the panel. This causes the panel to operate at lower current.

Two panels in series

Different models were suggested to study the shaded cases of the PV module with diverse of connection topologies. Fig. (2) shows two PV modules connected in series to be investigated. This connection gives us 4.8A, 42 V and 150W without any shading as shown in (I-V) and (P-V) behavior in fig. (2b).



(a) **(b)**

Fig (2): a) two PSPICE panels in series b) I-V and P-V behavior without shading

Since each module will have its own irradiance input, then shading presentation will be an easy task to do. To extract shading from PSPICE PV module, the shortcircuit current Isc in Fig. (2) will be varied from 4.0A to 4.8A withan increment of 0.3A. Simulation with this technique will change the amount of panel shading from 0% to 12.5%. Fig. (3) shows the I-V and P-V characteristics for this configuration with bypass diode the maximum power point reduced from 150w to 100W. These curves obtained from DC analysis (secondary sweep) where the load isdefined as R_{break} to cover all the values of the current. R_{break} changes from 10^{-8} to 4Ω with an increment of 10^{-3} in primary sweep.

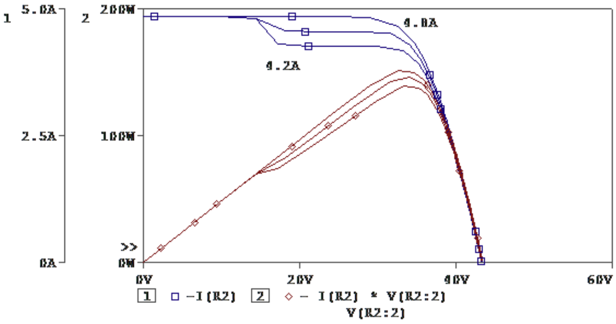


Fig. (3): The I-V and P-V curves for two panels in series under varying I_{SC}

Fig. (4) displayed the performance of the series connected modules with one panel shadedbut in this time due to solar irradiation shaded. The solar irradiation (solval) in Fig.(4) will be vary from .8kw/m^2 to 1.2kw/m^2 withan increment of 0.2kw/m^2. Simulation with this technique will change the amount of panel shading from 0% to 33%.Fig.(3) shows the I-V and P-V characteristics for this configuration with bypass diode the maximum power point reduced from 150w to 106W at 33% of shading.

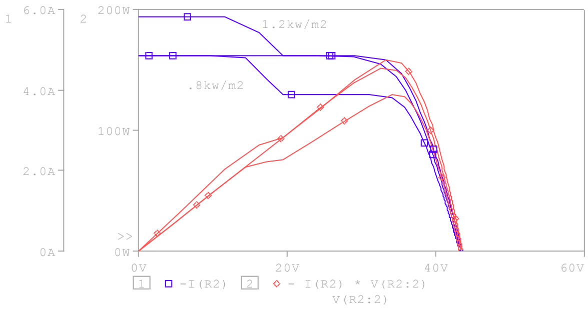


Fig.(4): The I-V and P-V curves for two panels in series under varying solval

Fig.(5) shows the I-V and P-V for the sameseries configuration, but with surface temperatureTval changes for 290K, 320K and 350 K where the MPP voltage changes with a very small rating.

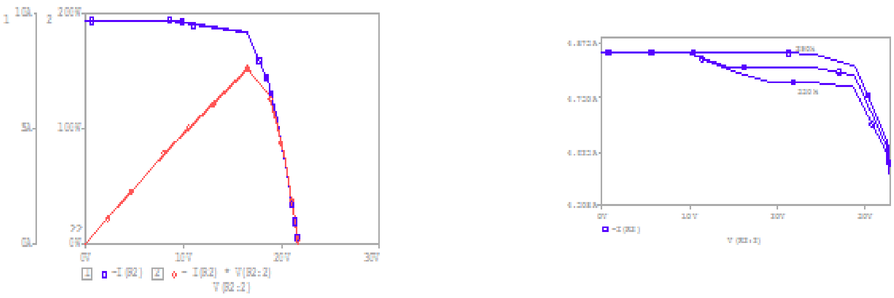


Fig.(5): The I-V and P-V curves for two panels in series under varying Tval

Two panels in parallel

The same two panels are connected in parallel configuration as in fig.(6). The behaviour of the pv panels in this case will be studied due to the effect of shading by varying short circuit current, solar irradiation and surface temperature. The behaviour of this case without shading explained in I-V and P-V curves in fig. (6) gives maximum power of 150W, 20V for open circuit voltage and 9.6A for short circuit current.

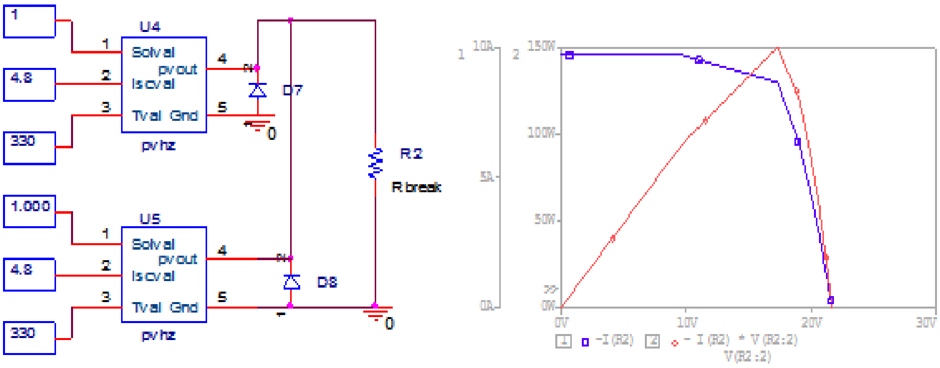


Fig.(6):The I-V and P-V curves for two panels in parallel without shading

However, in a case study of shading modules under varying short circuit current, solar irradiation and surface temperatures PV curve peaks are tended to be around 80 % of Voc as shown in the figures (7),(8) and (9).

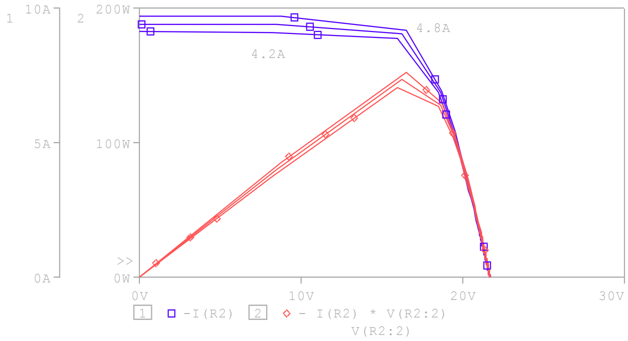


Fig.(7): The I-V and P-V curves for two panels in parallel under varying I_{SC}

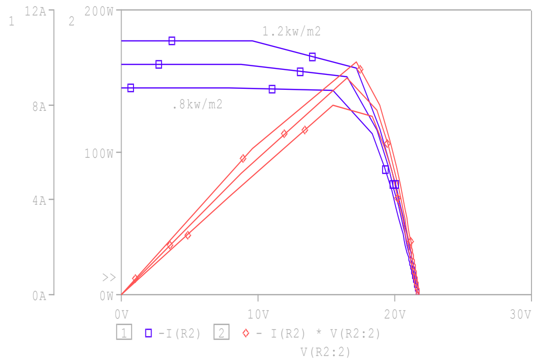


Fig.(8): The I-V and P-V curves for two panels in parallel under varying solval

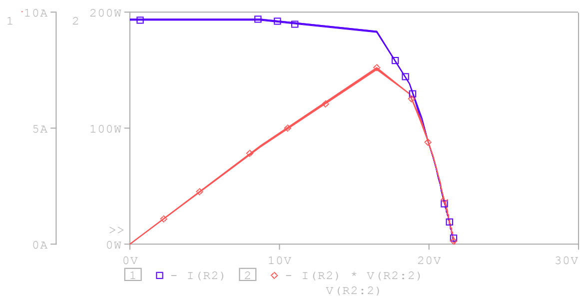


Fig.(9): The I-V and P-V curves for two panels in parallel under varying Tval

II. Conclusions

This improved PV model contain most parameters affect the PV panel output (solar radiation, short circuit current, ambient temperature and surface temperature) compared to the previous PV model whereas only short circuit current was defined. In addition, the proposed model is also used effectivelyto study the effect of shadow on operating characteristicsof solar PV system and give clearance at some point asfollows:

- PV curve peaks are tended to be around 80 % of Voc
- With a surface temperature (T_{val}) changes the MPP voltage changes with a very small rating.

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