Measuring the effect of cell mismatch on PSPICE module model output

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Abstract:

This research presents a theoretical method to calculate the mismatch factor for the PV module. Within this study the effect of mismatch on I-V and P-V of the module is observed. In practice, the PV panel module consists of 36 cells connected in series part that is built into PSPICE (from previous work) is used for this study. The PV modules are wired in a long series string in most of PV applications; the performance will be disproportionately limited by any one module that is not producing as much power. Fortunately, by changing the system configuration it is possible to isolate losses so that entire arrays are not affected by poor performance in one module. So, in this work the mismatch effect has been tested for series and parallel wiring of the modules, the parallel configuration produced significantly the same power as mismatch arises on the array.

Key words: PV, mismatch, PSPICE

Introduction:

A module has the optimum performance when it operates at its maximum power point. The maximum voltage depends on the shape of the I-V characteristic of the module, which is dependent on the meteorological conditions. Differences in the I-V characteristics of the various modules in the PV system cause a sub-optimal operation of the modules. This effect is minimized by grouping modules with characteristics as much as possible. The remaining mismatch in the I-V curves of the modules causes a loss in DC energy, which is defines as the mismatch loss.[1]

Several sources of mismatch can be distinguished:

- Individual differences between the I-V characteristics of the installed modules.
- Inhomogeneous temperatures in the array.
- Inhomogeneous shading of the array.
- Inhomogeneous soiling of the array.
- Shapes of solar cells in panels (square, circular or hexagonal)
- Type of cell distribution (fill factor) in each panel.
- Differences in DC cables, causing differences in the drop of voltage.[1]

Partial shading of a PV array can significantly reduce its output, since heavily shaded cells will limit the output of the other cells with which they are connected in series trees, buildings, television aerials', roof structures, leaves and bird dropping can partially shade a PV array and results in substantial reduction in system performance.[2]

The mismatch factor can be defined in terms of the following equation:[3]

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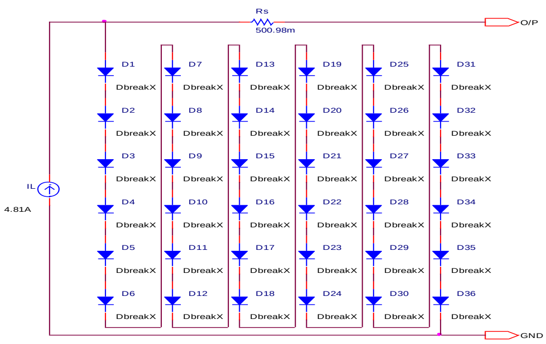
$$M.F = \frac{\max.module\ power}{\sum \max.cell\ \ power} \quad \ldots(1)$$

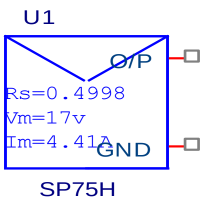
In this paper, a study has been made for quantifying the effects of PV module mismatch on I-V and power curves also demonstrate the performance difference between parallel and series PV modules wire. Details are also given method of measuring the mismatch factor. In practice the PV panel module part that is built into Personal Simulation Program for Integrated Circuits Emphasis PSPICE (from previous work) is used for this study. The results of this paper can help the workers to determine the tolerances on their module performance bins.

PSPICE PV module model

The PV panel (SP75) consists of 36 cell connected in series was created in the ORCAD PSPICE simulator. The model shown in figure(1)a is very large so to minimize it an integrated part (hierarchical block) has been built into special library as shown in figure(1)b. [4]



(a)

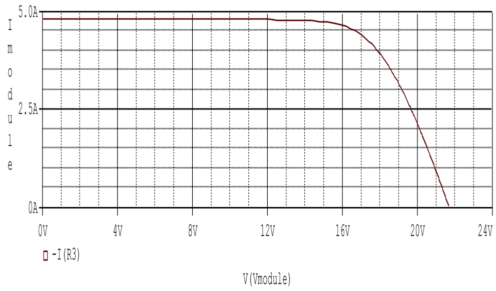


(b)

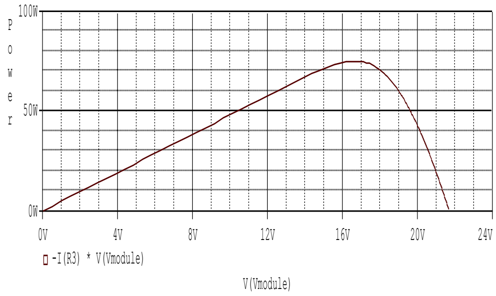
Fig(1): (a)The electrical circuit of the PV model

(b)The hierarchical block

This part will be called from that library to simulate the I-V and P-V characteristic of the PV model shown in figure(2), as well as this part is used as a source of energy to the power circuits.[4]



(a)



(b)

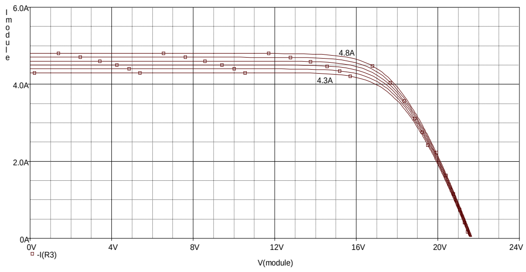
Fig(2): (a) The I-V curves of the PSPICE PV module model

(b) The P-V curves of the PSPICE PV module model

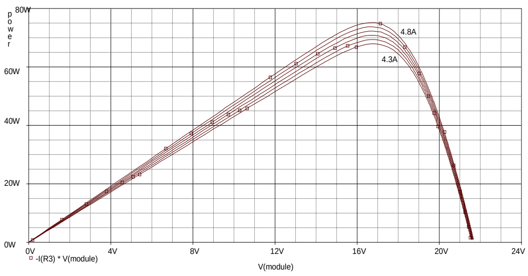
The effect of mismatch on PV PSPICE module

PV systems are subject to variety of changing and uncertain conditions that can affect the I-V curve, and therefore the output power of the module. Examples are cloud coverage, temperature variations, dust coverage or soiling, partial shading, alignment of modules to the sun, and manufacturing tolerances. Almost all the variable conditions tend to affect the current.[5]

Mismatch was introduced into the simulations by varying the value of a single cell current in the module. This causes the single cell to operate at a lower current. To extract mismatch from PSPICE PV module, the current source (I_L in figure (1)) will be varies from 4.3A to 4.8A. Simulation with this technique will change the amount of cell mismatch from 0% to 16.6%. The I-V and P-V curves for shadowed module are presented in figure (3)a and figure (3)b respectively. These curves are obtained from DC analysis (secondary sweep) since R_L is defined as R_{break} to cover all the values of the current.



(a)



(b)

Fig(3): (a) The I-V curves for mismatch panel

(b) The P-V curves for mismatch panel

The curves of I-V for mismatch module affect the current value but not affect the voltage value. Figure (3)b shows that the power has been decreased as the mismatch increased. The mismatch factors were calculated using eq. (1) as listed in table (1) and figure (4) represents these results graphically.

Table (1)

M F	coverage
1	0
.99	.8%
.976	2%
.956	4%
.938	6.25%
.922	8.3%
.900	10.4%
.880	12.5%
.867	14.6%
.850	16.6%

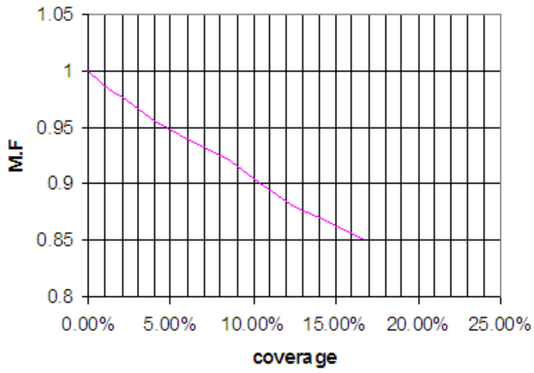


Fig.(4): Mismatch factor for different amount cell shading

The effect of mismatch on series and parallel wiring

When 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 of the individual panels. The difference between the new system voltage that is created when the panels and sub-arrays are connected 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 amount.[6]

In this study the PV PSPICE module will be wiring in series and parallel to compare the performance of the parallel vs. series array. When connecting an array of modules with different I-V curves, there can be drastically different performance from the array depending on the configuration. The principles can be demonstrated by comparing the performance of three modules when connected in series vs. parallel. One of the modules has been defined in the same manor of the panel mismatch test but the other modules defined as hierarchal block. First the modules connected in parallel as figure.(5).

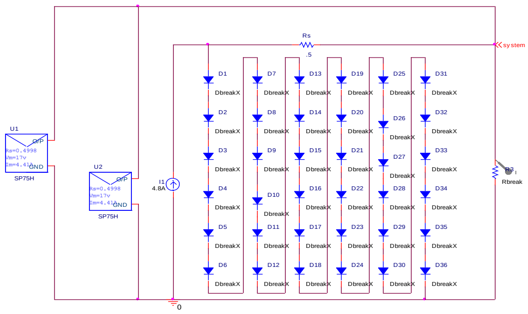
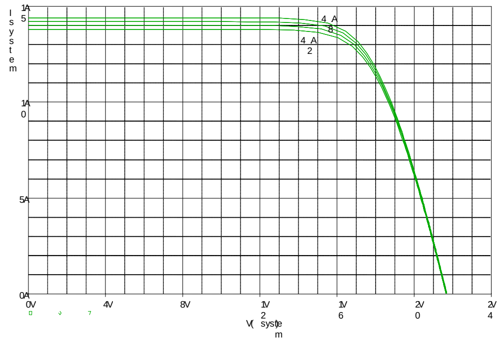
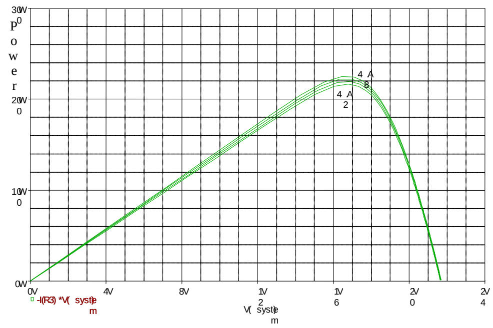


Fig.(5) PV arrays wired in parallel

Figure(6)a and figure(6)b presents the I-V and P-V curves of this system under mismatch test for third panel. The aggregate power is the sum of the three individual modules even though one of the modules has reduced output; each is free to operate at its own full potential, resulting in 225w output. These curve shows that the Parallel configuration dos not affected by mismatch.



(a)



(b)

Fig.(6): (a) the I-V curves for parallel wiring of PV
(b)The P-V curves for parallel wiring of PV

In the series configuration in figure (7), the I-V and P-V power curves shown in figure (8)a and b are distorted and output power is reduced by over (24%) to approximately 171w due to the mismatch between the modules.

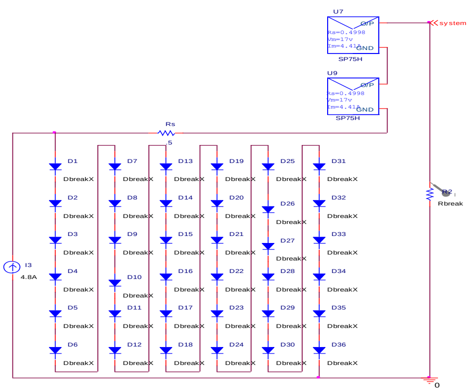
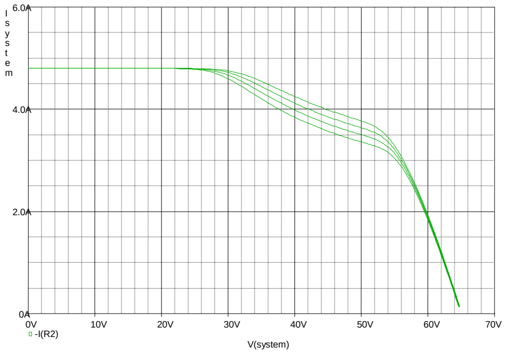
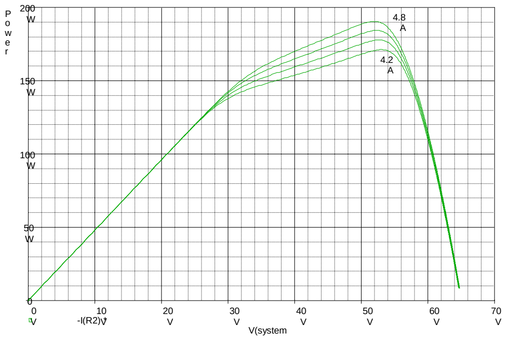


Fig.(7): PV arrays wired in series



(a)



(b)

Fig.(8): (a) the I-V curves for series wiring of PV
(b)The P-V curves for series wiring of PV

Conclusion:

From the results presented in this paper the following concluding remarks can be made:

- This paper presents a method to measure the effect of cell mismatch on I-V and P-V modules. An accurate measurement of the effect of cell mismatch may help module manufacturers select their cell sorting strategies and binning tolerances.
- In this study, the parallel configuration produced marginally more power even when absent of mismatch conditions, but produced significantly more power as mismatch arises on the array.

References:

1.Ing. C.W.A. Baltus 2001 "The suitability of several methods to quantify energy losses in PV systems " Electro Advice Bureau Baltus Report EAB 1(1), February.

2.W.M. Rohouma, I.M. Molokhia and A.H. Esuri. 2007 "comparative study of different PV modules configuration reliability" The Ninth Arab International Conference on Solar Energy (AICSE-9), Kingdom of Bahrain.

3.Karen Wilson, Denis De Ceuster and Ronald A. Sinton 2006 "measuring the effect of cell mismatch on module output" Technical papers Vol. June.

4.Zainab M. kubba and Zaid Samair 2009 "PSPICE model of the PV panel" Journal of AL-Nahrain University Vol.12(3), September:51-55.

5.Aryn Stran and Brent Harris 2005 "Improving PV system energy yield with parallel wiring" Sustainable Energy Technology report, Hong Kong.

6.Allan Gregg, Terence Parker and Ron Swenson 2005 "A real world examination of PV systems design and performance" IEEE Photovoltaic specialist conference and exhibition, January, Florida-USA.

قياس تـأثير عدم تماثل الخلية الشمسية في مخارج PSPICE موديل للوح الشمسي

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الخلاصة:

يقدم هذا البحث طريقة نظرية لحساب عامل عدم التماثل (mismatch factor) باستخدام برنامج PSPICE . من خلال دراسة هذا العامل تمت ملاحظة تأثير عامل عدم التماثل في خواص اللوح الشمسي وكذلك قدرته. عمليا في هذه الدراسة تم استخدام موديل للوح يتكون من 36 خلية شمسية مربوطة على التوالي والمبني في برنامج PSPICEمن عمل سابق قامت به الباحثة. وبما ان تطبيقات اللوح الشمسي كافة تحتاج الى سلسلة من الالواح التي تربط على التوالي او التوازي لتحقيق التيار والفولتية المناسبة لذلك، تم فحص تأثير عدم التماثل في خلايا اللوح الشمسي عند ربطها على التوالي والتوازي ايضا. أثبتت الدراسة ان تأثير هذا العامل يختفي عند ربط الالواح على التوازي.