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Shading Effect in Solar Energy and Solar Cell

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Abstract: A new algorithm for the determination of the solar position is proposed. The importance of tracking accurately the position of the sun is evident when considering high concentration thermal systems. In the literature are found many fast algorithms for the determination of the sun position within 0.01, and complex astronomical algorithms that allow a precision of 0.0003but at the price of a large amount of calculation. The algorithm proposed in this work has a precision that is half-way between the two cases (maximal error 0.0027), that should be sufficient for all the applications in solar engineering, with a computational cost comparable to the cost of the fast algorithm.

Keywords: Solar, Shading, Energy, Algorithm.

I. INTRODUCTION

The increasing world's energy demands and environmental pollution are motivating research and technological investments related to improved energy efficiency and generation. In practical applications, a PV module consists of 36 solar cells which are connected in series and PV modules are wired together into array both in series and in parallel to provide the necessary voltage and/or currents. The output power of a PV array decreases considerably, when current–voltage (I–V) curves of solar cells are not identical due to soiling, non-uniform irradiation and temperature variations, cell damaging, partially, shading etc.

Another important issue is that shading effects on the performance of PV array is highly dependent upon the direction or shape of the shadow. For this reason, solar cell-based analysis becomes more important than module based analysis [1]. On the other hand, while simulating the behavior of a large-scale PV array with down to solar cell level, one obvious drawback is the necessity of long computation time (Woyte et al., 2003). In most studies, a PV module that consists of several series connected solar cells is lumped together as a single solar cell for simplicity. Therefore, one of the aims of this study is to present an analysis method to reflect the mismatch effects as well as solar cell based analysis without increasing computational time, in a simple manner and with sufficient degree of precision. Since there are various possible mismatch scenarios, it is difficult to examine the behavior of PV array for all cases. On the other hand, selecting shading scenario is an important issue especially in configurations that were investigated by Kaushika and Gautam (2003). Some shadow options may give a similar effect for different configurations or one configuration has a better performance for only a specific shading scenario.

These factors could lead to an error for finding which configuration has better tolerance due to the shadow problem [3]. Thus, in this study, several inhomogeneous irradiation distributions are used to investigate the behavior of PV arrays. In conclusion, in order to produce more reliable and robust simulations, improved and extended algorithms are presented to evaluate mismatch effects in PV arrays and some results are discussed in detail.

Non ideal conditions refer to some specific situations where solar cells reach their limits and cannot provide specified power. The problem, which is referred to in some literatures as "non optimal conditions" or "unbalanced generations," has drawn recent attention [7]–[13]. Common non ideal conditions include partial shading, low solar radiation, dust collection, and photovoltaic ageing. The following paragraphs address the major effects, which result from partial shading. Generally, it is preferable to build a solar array using all the same panels and to keep them away from any shading [2]. However, it is not easy to avoid shading in residential installations because of the change in sunlight direction throughout the day. Furthermore, obstacles, such as trees, birds, and other constructions, etc., can cause partial shading. Studies [11] have revealed that minor shading can cause a major reduction in solar power output of the photovoltaic array.

II. SOLAR POSITION

Using the NOAA Solar Calculator, we found the solar position for our location at the time where the experiment was done figure 1.

Figure 1: Solar Position

In this part I used sun path finder device to get the availability of sunlight in our site. So we used it as mentioned in the manual, so we got results. We used The sun diagram with the following specifications: For 37- 43 Latitude, "South-facing" (for Northern hemisphere).

The diagrams are latitude specific (the closer to the equator, the more the sun's monthly paths will be overhead). The rays depict solar time. The arcs depict average sun path for given month. The small numbers given in half-hour increments give percentage of radiation for that half-hour [4]. With the continuous technological advancements in solar radiation applications, there will always be a demand for smaller uncertainty in calculating the solar position. Many methods to calculate the solar position have been published in the solar radiation literature, nevertheless, their uncertainties have been greater than ±0.01 in solar zenith and azimuth angle calculations, and some are only valid for a specific number of years (Blanco-Muriel et al., 2001). For example, Michalsky's calculations are limited to the period from 1950 to 2050 with uncertainty of greater than ±0.01 (Michalsky, 1988), and the calculations of Blanco-Muriel et al.

Figure 2: Solar Site Analysis

From sun path sheet, solar availability for month of October: figure 2

SolaraAvailability= 3+4+5+6+6+7+7+8+8+7+7+6+6+5 = 85% of unshaded area (percentage of radiation).

From the previous percentage we notice that there is shading effect of 15%.

III. PV PANEL SETUP

Figure 3 illustrates the PV panel setup as the following diagram

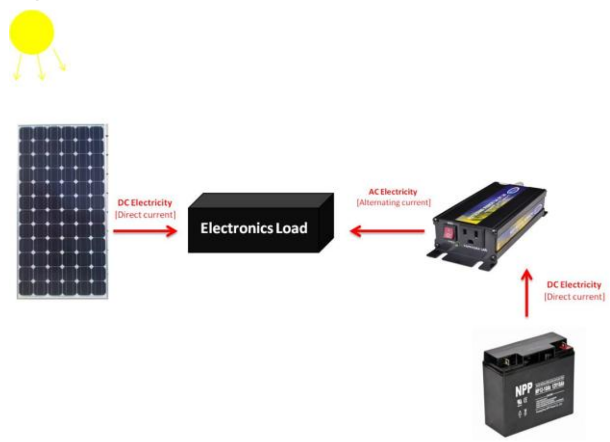

Figure 3: PV Panel

After I built our PV system we did the following steps:

1. Measured solar irradiance with the solar meter, where E = 450 W/m².
2. Measured open circuit voltage (Voc) for the solar panel, where Voc = 33.69 V.
3. Connected a DC electronic load to the panel.
4. Changed the resistance then measured the voltage and current.

IV. RESULT AND DISCUSSION

A. Shadow

The output power of solar cell or module is very sensitive to shading which could happen because of buildings, trees or any other objects that are closed to the PV modules. Shading has a very bad effect, even if a small portion of solar cell, module or array is shaded, where its output power will reduce according to the reduction of sunlight intensity falling on it. So, if we have some cells are connected in series, and one of them is shaded then the current in the shaded cell will reduce to very small amount comparing with the current in cell that isn't shaded [5]. Because they are connecting in series, the current in each cell will not be greater than the current drawn by the shaded cell. The shaded cell will become reverse biased, that means it will dissipate power instead of producing power. Therefore, it will heat up and then burn, this called hot spot heating figure 4.

Figure 4: Hot Spot Heating

B. No shadow:

The above results were gotten when there is no shadow (normal operation) and the illumination was so clear.

R(Ω)	Voltage (V)	Current (A)	Power (W)
5	16.45	3.29	54.12
10	31.28	3.1280	97.8438
20	32.58	1.6290	53.0728
30	33.23	1.1077	36.8089
40	33.29	0.8322	27.7039
50	33.48	0.6696	22.4182
60	33.53	0.5588	18.7366
70	33.57	0.4796	16.1002
80	33.60	0.4200	14.1120
90	33.63	0.3737	12.5675
100	33.66	0.3366	11.3300
200	33.69	0.1684	5.6734
300	33.70	0.1123	3.7845
500	33.74	0.0675	2.2775

Figure 5: Effecting of Shadow

From above picture I can find that the voltage and the current has been increased which can lead that the power has increased.

Efficiency (η)=(Power output from PV (W))/(Area of the Panel (m^2)× Power irradiance W/m^2)
=(Vmp×Imp)/(0.0159×450)=(31.28×3.128)/(0.0159×450)
=12.307%

The efficiency is 12.3 % which is gives the full power when the operating has no shadow on the PV Panels.

C. Solutions for shading effect

Bypass diodes are used to prevent hot-spot occurrence in case of shading. For example, if shading happened for the cell in group 2 as shown, the bypass diode will turn on and let the current pass through it without passing through the cells in group 2 where is the shaded cell. Therefore, we will loss the power that the rest 3 cells of group 2 could produce. So, you have to keep your PV array away from shading al the time figure 6.

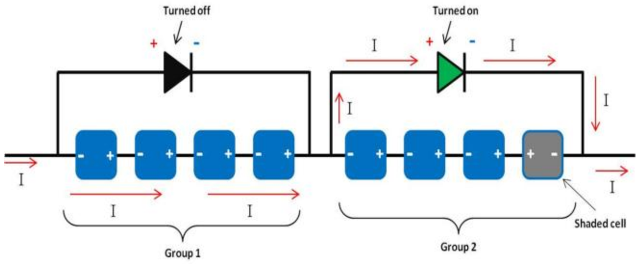

Figure 6: Bypass diodes

In the PV module that we used in the experiment, it has 60cells connected in series. And the module has 2 bypass diodes. So in normal conditions, where no shadow the IV curve will be as shown in a. But in the second case (column) we had a shadow of 10 cells but because there is a bypass diode so we lost 30 cells in series so we lost half the output power and we got the curve shown in c. In the third case (row shading), we covered one row (row of 6 cells) so all the current flows through the two bypass diode so we lost almost the whole output power. In shading, the current will affected more than the voltage that why we got the curve in the previous pages [7].

V. CONCLUSION

In this paper, the shading has an effect on the PV system, the shading will change the value of the power that comes from PV panels. The shadow that cover row cells from the panel has Lowe damage to the panels than cover the string because covering the string means cover all the lines that can make the current flow to the control charger. Because the solar zenith, azimuth, and incidence angles are not reported in the AA, the following sun parameters are used for the evaluation: The main parameters (ecliptic longitude and latitude for the mean Equinox of date, apparent right ascension, apparent declination), and the correcting parameters (nutation in longitude, nutation in obliquity, obliquity of ecliptic, and true geometric distance). Exact trigonometric functions are used with the AA reported sun parameters to calculate the solar zenith and azimuth angles, therefore it is adequate to evaluate the SPA uncertainty using these parameters.

To evaluate the uncertainty of the SPA, we arbitrarily chose the second day of each month, for each of the years 1994–96, and 2004, at 0-h terrestrial time (TT).

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