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بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Post Graduate Studies

Shading Effect on Solar Cell Efficiency

تأثير التظليل علي كفاءة الخلية الشمسية

A thesis submitted in partial fulfillment of the Requirements for the M.Sc. degree in Physics

Submitted By

Gada Ahmed Abdalla Mohammed

Supervised By

Dr: Abdelnabi Ali Alamean

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الآية

قَالَ تَعَالَىٰ:

﴿ وَمِنۡ ءَايَٰتِهِ ٱلَّيۡلُ وَٱلنَّهَارُ وَٱلشَّمۡسُ وَٱلۡقَمَرُۚ لَا تَسۡجُدُواْ لِلشَّمۡسِ وَلَا لِلۡقَمَرِ وَٱسۡجُدُواْۤ لِلَّهِ ٱلَّذِي خَلَقَهُنَّ إِن كُنتُمۡ إِيَّاهُ تَعۡبُدُونَ ﴾

سورة فصلت الآية (37)

DEDICATION

I dedicate this research to my parents, my brothers, and my sisters, all my family, and all my best friends.

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I would like to express my sincere and appreciation to my supervisor Dr. Abdelnabi Ali Elamin, for providing work facilities, for his kind guidance, science support, continuous encouragement in order to finish this work. From my deep heart, many thanks are paid toDr.AliSliman for suggesting the research point. Also, sincere thanks to all staff in the Department of Physics, Faculty of Science, Sudan University, for their encouragement.

Abstract

The shadowing effect of photovoltaic's modules has a devastating impact on their performances since any shadow is able to keep down the electricity production. Therefore in the recent years new technologies and devices have come up in the photovoltaic's field in order to improve the performance. However, in order to know how these electronic products work when the shadows take place on the solar panels further investigations have to be done. The aim of this research is to use the change in electrical parameters with partial shading of PV solar cell. The experimental results show that the electrical parameter, such as the open circuit voltage (V_{OC}), short circuit (I_{SC}), maximum power (P_{max}) and fill factor decreases when the shading area increases. These relationships between these parameters and dose level can be utilized as measuring the irradiation of the Sun (Solar irradiance).

المستخلص

في هذا البحث تمت دراسة تأثير التظليل علي كفاءة الخلية الشمسية ومقارنتها مع كفاءة الخليه الشمسية من غير تظليل والذي تم فيه تعريض شريحه واحدة ومن ثم شريحتين وثلاثة وأربعة الي أن تم تظليل كل الخليه ومعرفة علاقة معامل الملء مع القدرة .ومن خلال النتائج التي تم الحصول عليها تم التعرف علي أن تأثير التظليل سلبي علي الخليه الشمسية حيث أنه يتسبب في نقصان كفاءتها كما تم قياس القدرة العظمي ومعامل الملء (fill factor) حيث تبين أن المساحة المظللة تتناسب عكسيا مع كل من القدرة العظمي ومعامل الملء(Fill Factor).

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Chapter One

Introduction

1.1 Introduction

Solar cells are devices in which sunlight releases electric charges so they can move freely in a semiconductor and ultimately flow through an electric load, such as a light bulb or a motor. The phenomenon of producing voltages and currents in this way is known as the photovoltaic effect. The fuel for solar cells sunlight is free and abundant. The intensity of sunlight at the surface of the earth is at most about one thousand watts per square meter. Thus the area occupied by the cells in a photovoltaic power system may be relatively large, and its cost must be considered in calculating the cost of the electricity produced. The primary factor that determines whether solar cells will be used to supply electricity in a given situation is the cost per unit output, relative to that of alternative power sources, of acquiring, and operating the photovoltaic system [1].

The photovoltaic (PV) industry is experiencing rapid growth due to improving technology, lower cost, government subsidies, standardized interconnection to the electric utility grid, and public enthusiasm for an environmentally benign energy source [2,3]. More precisely, PV usage worldwide has grown between 15% and 40% for each of the past 10 years, while the inflation adjusted cost of PV energy has declined by roughly by a factor of 2 over the same time period [4]. PV system sizes vary from the MW range, in utility applications, down to the kW range in residential applications. In the latter systems, the PV array is typically installed on the roof of a house, and partial shading of the cells from neighboring structures or trees is often inevitable. Then impact of partial shading on PV system performance has been studied at great length in the past [5,6]. Some past studies assume that the decrease in power production is proportional to their viewed. This is followed by the impact of partial shading on the I-V and P-V curves of a circuit containing two cells with and without bypass diodes. The concept is extended to the circuits with series and parallel sub modules. Finally, the impact of shading is illustrated by measurements on a commercial PV panel and a large PV array. The shaded area and reduction in solar irradiance, thus introducing the concept of shading factor,while this concept is true for a single cell, the decrease in power at the module or array level is often far from linearity with the shaded portion. Other past studies tend to be rather complicated and difficult to follow by someone with limited knowledge on electronic/solid-state physics.

The objective of this study is to clarify the impact of shading on a solar panel performance in relatively simple terms that can be followed by a power engineer or PV system designer without difficulty. First, the circuit model of a PV cell and its I-V curve are reviewed.

This is followed by the impact of partial shading on the I-V and P-V curves of a circuit containing two cells with and without bypass diodes. The concept is extended to the circuits with series and parallel sub modules. Finally, the impact of shading is illustrated by measurements on a commercial PV panel and a large PV array.

1.2 Problem of Research

Shades will reduce the amount of rays which absorbed by solar cell and then reduce efficiency of solar cell.

1.3 The objective of Research

The objectives of research were concluded in the study the effect of shading on efficiency of solar cells in order to Comparison the efficiency of solar cells with and without shading.

1.4 Literature review

The first work has done by Frank Vignola (2016) [7]show that the Shading of photovoltaic (PV) panels can significantly reduce system performance. When an array of PV panels is connected in series, shading on even one panel in the array can reduce the performance of the array as if all Panels were shaded. This article studies the effect of shading on one system consisting of two arrays of four PV panels connected in series. The two arrays are connected in parallel and shaded by a flagpole. Shading effects are estimated in two manners. First, by looking at the percentage of the sky blocked by the nearby flagpole and another more comprehensive method looking at the spatial movement of shadow from the flagpole as it moves across the panels during the day. The method and tool used in the more comprehensive evaluation are discussed along with Insight into when the spatial methodology should be used[7].

The second work has done by Yahia Baghzouz (2008)It is a well-documented fact that partial shading of a photovoltaic array reduces it output power capability. However, the relative amount of such degradation in energy production cannot determined in a straight forward manner, as it is often not proportional to the shaded area. This research clarifies the 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 simple terms and can be useful to someone who wishes to determine the impact of some shading geometry on a PV system. The analysis is illustrated by measurements on a commercial 70 W panel, and a 14.4 kW PV array [8].

1.5 Layout of research

A thesis contains four chapters. The first chapter contains an introduction to research, objective of the research in addition to the research problem, the methodology and litrure review about shading for various applications, in Chapter two theory of solar cells, mechanism of work the influence of shading, and Ecologic Factors on efficiency of solar cells. In Chapter three touched upon, the fourth chapter deals with the find in through research and interpretation of the results, Discussion and Conclusions.

Chapter Two

Solar cells

2.1 Introduction

Solar energy refers primarily to the use of solar radiation for practical electricity generation. However, there are other renewable energies like natural gas, coal and bio fuel. Solar radiation along with other secondary solar powered resources such as wind, geothermal, tidal and wave power, hydroelectricity and biomass, account for most of the available renewable energy on the earth. Only minuscule fraction of the available solar energy is used [9].

2.2 The Sun and Its Radiation

The sun is a hot atmosphere of gas heated by nuclear fusion reactions at its center. Its diameter is about 1.39x109 m and is, on the average 1.5x1011m from the earth. As seen from the earth, the sun rotates on its axis about once every 4 weeks. However it does not rotate as a solid body; the equator takes about 27 days and the Polar Regions take about 30 days for each rotation[10].

The energy produced in the interior of the solar sphere at temperatures of many millions of degrees must be transferred out to the surface and then be radiated into space. Successions of radioactive and convective processes occur with successive emission, absorption and irradiation. In the subchapter below the different types of radiation that reaches the Earth's surface will be described.

2.3 Components of Radiation

Solar radiation incident on the atmosphere from the direction of the sun is the solar extraterrestrial beam radiation. This radiation passing through the earth's atmosphere is attenuated, or reduced, by about 30%. Beneath the atmosphere, at the Earth's surface, the radiations that will be observable are:

- Beam Radiation: The solar radiation received from the sun without having been scattered by the atmosphere.
- Diffuse Radiation: The solar radiation received from the sun after its direction has been changed by scattering by the atmosphere [10].

Therefore, the total sum of the beam and the diffuse solar radiation on a surface is called Total Solar Radiation.

2.4 solar cells

Over the years, solar energy has been gaining ground as a source of electricity. Photovoltaic cells convert sunlight directly to electricity. Photovoltaic (PV) cells utilize semi – conductor technology to convert solar radiation directly into an electric current which can be used or stored. Photovoltaic is a combination of two words “Photo” from Greek root meaning, light and “Voltaic” from volt which is the unit used to measure Electric potentials at a given point [11].The Photovoltaic effect was first noted by a French Physics that certain material would produce small amount of Electric field, ALBERT EINSTEIN described the nature of light and photovoltaic technology that it was too expensive to gain wider spread use in 1954 [12].Sunlight is made up of tiny particles called photons which are being converted to electrical energy. Every hour, enough of this energy reaches the world to meet the world's energy demand for the whole world. Photovoltaic panels consists of many solar cells, these are made of materials like silicon, one of the most common elements on earth. The individual cell is designed with a positive and a negative layer to create an electric field, just like in a battery. As photons are absorbed in the cell, their energy causes electrons to become free, the electrons move toward the bottom of the cell, and exit through the connecting wire. The flow of photons is what we call electricity. By combining solar cells and photovoltaic panels, we can produce just the right amount of electricity to perform a specific job, no matter how large or small, Solar energy is the energy derived from the sun through a form of solar radiation [12]. Solar powered electricity generation relies on photovoltaic cells and heat engines. A partial list of other solar applications include space heating and cooling through solar architecture, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Photovoltaic (PV) cells convert sunlight directly to electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is very strong and strikes the PV cells directly. The basic building block of PV technology is the solar cell. The PV cell consists of two or more layers of semi-conducting material, most commonly silicon. When the silicon is exposed to light, electrical charges are produced and can be conducted away by metal contacts as Direct Current (DC). The current from a single cell is small, so, multiple PV cells are connected together and sealed behind glass to form a module known as SOLAR PANEL [12]. PV allows you to produce electricity, without noise, air pollution and fuel. Most PVs have a life span of(25 – 50)years. Solar power in rural areas is a viable alternative for providing electricity for telecommunications, telemetry, water pumping, lighting, television, DC refrigeration and other low power non- heating applications. Heating appliances such as kettles, toasters, stoves, geysers and heaters are consuming too much energy and therefore cannot be used on a solar system [11].The basic components for this solar energy system are; solar panel, charge controller, battery, inverter, wiring, and connected loads Solar cells are already being used in terrestrial applications where they are economically competitive with alternative sources. Examples are powering communications equipment, pumps, and refrigerators located far from existing power lines. It is expected that the markets for solar cells will expand rapidly as the cost of power from conventional sources rises, and as the cost of solar cells falls because of technological improvements and the economies of large-scale manufacture. The first of these economic forces the rising price of conventional sources, particularly those employing fossil fuels continues automatically, in part because the resource is limited. The second reducing the cost of electricity from solar cell systems is the subject of worldwide research and development efforts today. To increase the economic attractiveness of the solar cell option, one or more of the following must be done:

• Increase cell efficiencies.

• Reduce cost of producing cells, modules, and associated equipment, and the cost of installing them.

• Devise new cell or system designs for lower total cost per unit power output [1].

2.5 Solar Cell Systems Work

The most important physical phenomena employed in all solar cells are Illustrated schematically in Fig 2.1.Sunlight enters the semiconductor and Produces an electron and a hole—a negatively charged particle and a positively charged particle, both free to move. These particles diffuse through the semiconductor and ultimately encounter an energy barrier that permits charged particles of one sign to pass but reflect those of the other sign. Thus the positive charges are collected at the upper contact in Fig. 2.1, and the negative charges at the lower contact and Fig.2.2. The electric currents caused by this charge collection flow through metal wires to the electric load shown at the right side of Fig. 2.1.The current from the cell may pass directly through the load, or it may be changed first by the power-conditioning equipment to alternating current at voltage and current levels different from those provided by the cell. Other sub-systems that may also be used include energy-storage devices such as batteries, and concentrating lenses or mirrors that focus the sunlight onto smaller and hence less costly semiconductor cell. If concentration is employed, a tracking subsystem may be required to keep the array pointed at the Sun throughout the day [1].

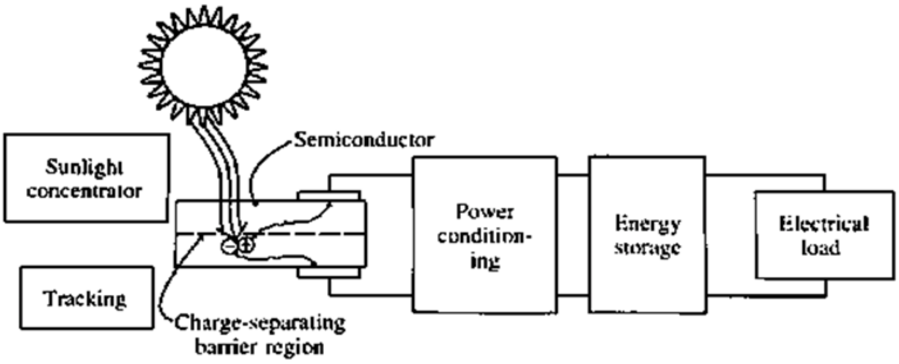

Figure 2.1.Sketch showing functional elements of solar cell system [1]

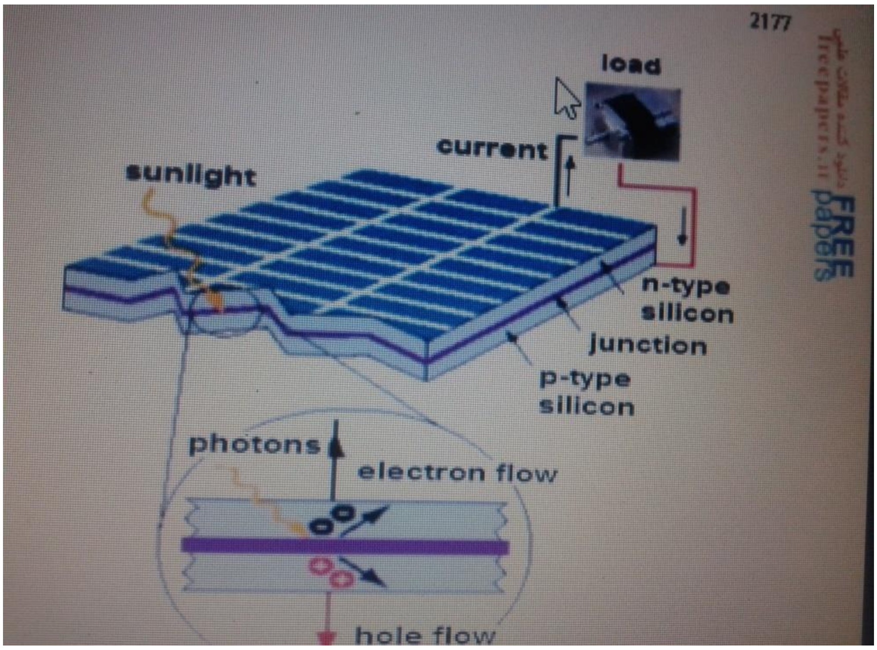

Figure 2.2 Solar Cell prodution[13].

2.6 Types of Solar Panel Mountings

Research shows that there are three types of solar panel mountings. These are fixed, adjustable, and tracking. The fixed solar panel mounting system is completely stationary. This is the simplest and cheapest type of solar panel. The solar panels are installed in such a way that they are always facing the equator (due south in the northern hemisphere). The angle of inclination favors the winter sun and favors the summer sun slightly less [14].

Figure 2.3 Fixed Solar Panel Mount

The adjustable solar panel mounting system includes adjusting the angle of inclination of the solar panel mount two or more times a year to account for the lower angle of the sun in the winter season. This system is more expensive than the fixed mount but it increases the solar panel power output by approximately 25%, thus making it more efficient.

Figure 2.4 Adjustable Solar Panel Mount

The tracking solar panel mounting system is the most expensive of the three types of mounting. It tracks and follows the path of the sun (east to west) during the day as well as the seasonal declination movement of the sun. The tracking solar panel output increases by approximately 25% - 30%. It cannot be denied that this type of mounting is the most efficient in producing the greatest amount of solar power.

Figure 2.5 Tracking Solar Panel Mount

2.7 Shading of Solar Cells

Shadows on photovoltaic (PV) panels can significantly curtail the performance of the PV system. In fact, when one panel in a series is shaded, the output of the panels connected in series reacts like all panels are shaded. A simple test of a PV module is to shade one cell in the module and see what happens to the output. If all the cells are connected in series, the production of the modules drops to basically to zero. Now this is may not be true for all types of PV modules and some modules may have bypass diodes that reduce this problem, but there are many modules being installed that exhibit this behavior .Therefore is it important to install PV panels so that shading is minimized. In practical applications, shading cannot be avoided. Therefore it is important to know how much the shading will affect the system performance and develop designs to minimize the effects of shading. Sun path charts have been developed that show the degree to which shading affects system performance when the sun is in various quadrants of the sky [7]. There are also sitting tools now coming onto the market with which sun paths are superimposed on photographs and the effect of shading is calculated automatically.

In a series connected solar photovoltaic module, performance is adversely affected if all its cells are not equally illuminated. All the cells in a series array are forced to carry the same current even though a few cells under shade produce less photon current. The shaded cells may get reverse biased, acting as loads, draining power from fully illuminated cells. If the system is not appropriately protected, hot-spot problem [15]-[16] can arise and in several cases, the system can be irreversibly damaged. In the new trend of integrated PV arrays, it is difficult to avoid partial shading of array due to neighboring buildings throughout the day in all the seasons. This makes the study of partial shading of modules a key issue. With a physical Solar PV module it is difficult to study the effects of partial shading. A*PSPICE* model of a PV module consisting of 36 cells in series has been developed to carry out this study. The model is used to study the effect of shade on varying number of cells on the power output of the module and stresses on the shaded illuminated cells under various.

2.8 Effect Shading on solar cells

Shading can have a huge impact on the performance of solar photovoltaic panels. It is obvious that the best solution is to avoid shading altogether, though this isn’t possible in practice due to factors like cloud, rain etc. but what many people don’t realize is that even if a small section of the solar photovoltaic panel is in shade, the performance of the whole solar photovoltaic panel will significantly reduce. This is because solar photovoltaic panels actually consist of a number of solar photovoltaic cells that are wired together into a series circuit. This means that when the power output of a single cell is significantly reduced, the power output for the whole system in series is reduced to the level of current passing through the weakest cell. Therefore, a small amount of shading can significantly reduce the performance of your entire solar photovoltaic panels system [9]. One of the main causes of losses in energy generation within photovoltaic systems is the partial shading on photovoltaic (PV modules). These PV modules are composed of photovoltaic cells (PV cells) serial or parallel connected, with diodes included in different configurations. The curve of a PV cell varies depending on the radiation received [9][11] and its temperature. Furthermore, the modules have diodes that allow the current flows through an alternative path, when enough cells are shaded or damaged. There are two typical configurations of bypass diodes [12].overlapped and no-overlapped it should be noted that the analysis in modules with overlapped diodes is a more complex one, because there may be different paths for current flow. This paper examines the individual behavior of a PV module and a photovoltaic array of PV modules (PV array) connected to an inverter with shadows in both cases. The impact of partial shading on PV system has been studied at great length in the past [17, 18]. Some past studies assume that the decrease in power production is proportional to the shaded area and reduction in solar irradiance, thus introducing the concept of shading factor. While this concept is true for a single cell, the decrease in power at the module or array level is often far from linearity with the shaded portion [19]. Other past studies tend to be rather complicated and difficult to follow by someone with limited knowledge on electronic/solid-state physics [20].

2.9 Factors that Affect Solar Power Production

There is no such thing as a perfect technology. Research reveals the different factors that can affect the efficiency of solar panel mounting systems. Some of these factors have been studied to either increase or decrease the power production from the three types of mountings such as sun intensity, cloud cover, relative humidity, and heat buildup. When the sun is in its peak (intense), during midday, the most solar energy is collected; therefore, there is an increase in the power output. Cloudy days contribute to the decrease in sunlight collection effectiveness since clouds reflect some of the sun’s rays and limit the amount of sun absorption by the panels. During summer days when the temperature is at its highest and heat is built up quickly, the solar power output is reduced by 10% to 25% for the reason that too much heat increases the conductivity of semiconductor making the charges balance and reducing the magnitude of the electric field. In addition, if humidity penetrates into the solar panel frame, this can reduce the panel's performance producing less amount of power and worse can permanently deteriorate the performance of the modules.

Chapter Three

Experimental Work

3.1 Introduction

In this research the effect of shading on solar cell efficiency which has been carried out of using the following procedure.

3.2 Apparatus

Two digital AVO-meterBel MERIT DX405, Rheostat, conducting wires, solar cells, holders, sunlight.

3.3 Theory

Solar cell efficiency is the ratio of the electrical output of a solar cell to the incident energy in the form of sunlight. The energy conversion efficiency (η) of a solar cell is the percentage of the solar energy to which the cell is exposed that is converted into electrical energy. This is calculated by dividing a cell's power output (in watts) at its maximum power point (P) by the input light (E, in W/m^2) and the surface area of the solar cell (A in m^2).Solar cell's power output is found by multiplying the cell's current and the cell's voltage By convention, solar cell efficiencies are measured under standard test conditions (STC) unless stated otherwise. STC specifies a temperature of 25 °C and an irradiance of 1000 W/m^2 with air mass 1.5 spectrums. These conditions correspond to a clear day with sunlight incident upon a sun-facing 37°-tilted surface with the sun at an angle of 41.81° above the horizon. In this experiment, we are going to use a 100 W desk lamp to simulate the solar radiation. In an ideal case the irradiance of a 100 W light bulb at a distance of 0.15 m is around E= 350 W/m^2. We are going to use this value in our solar cell efficiency calculations. First we should get familiar with the equipment we are going to use in this experiment

$$l = I_L - I_O[\exp\left(\frac{q_V}{nkT} - 1\right) \qquad (3.1)$$

Where I is the current, I_0 is the current when no light is falling on the cell: it increases as T increases, and it increases as material quality increases

q ≡ the charge on an electron .

k≡ Boltzmann's constant .

T≡absolute temperature.

n ≡the ideality factor (between 1 and 2). It increases as the current decreases. For silicon n =2.

I_L≡ is the light-generated currt

$$P_{max} = V_{max} \times I_{max} \quad (2.3)$$

$$P_O = V_{OC} \times I_{SC} \quad (3.3)$$

Where P_O is power in.

V_{oc} is open circuit voltage.

And $I_{sc}$is Short circuit current.

$$FF = \frac{P_{max}}{P_O} \quad (3.3)$$

Fill –factor (FF): The FF is defined as the maximum power from actual solar cell to the maximum power from ideal solar cell.

P_{max} is power out.

$$\eta = \frac{P_{max}}{A \times G} \quad (3.4)$$

Efficiency (η): Efficiency is defined as ratio of energy output from solar cell to input energy from sun.

The efficiency of energy conversion is still low, thus requiring large areas for sufficient insulation and raising concern about unfavorable ratios of energies required for cell production versus energy collected.

η ≡Efficiency.

G≡Solar irradiance.

A≡ Arrays space.

Radiology intensity fallen in cell on area unity (G).

3.4 Carrying out the Experiment

The solar cell was connected as shown in the figure3.1 in series with ammeter and rheostat and voltmeter in parallel with them then subjected to the light. then shaded one cell and current – voltage pairs are recorded then two cell are shaded again and the procedure were followed and soon until the hall cell is shaded and this result were compared with that one without shaded.

Results are tabulated in table3.1and graph of I-V drawn the fill factor, efficiency was calculated.

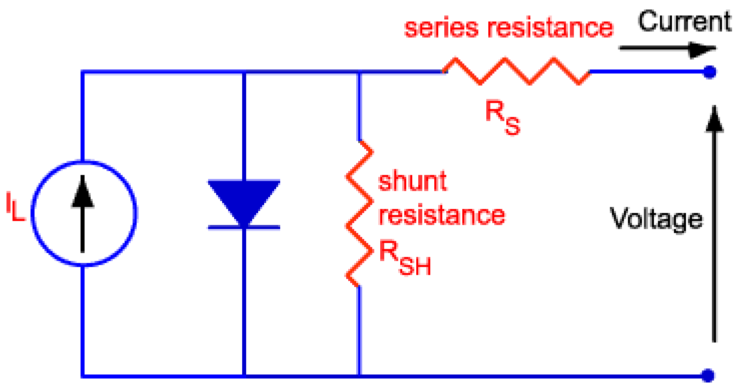

Figure 3.1 shows how to connect devices and tools with solar cell [21].

Table [3.1] Shows results for all cells with shading and without:

Voltage V in volts	The current in mA

	Without shading	One Array shading	Tow Arrays shading	Three Arrays shading	Four Arrays shading	Five Arrays shading	All Arrays shading
0	0.51	87.4	70.2	66.9	65.5	64.9	51.9
1	0.5	85.4	69.9	66.8	64.9	64.8	51.6
2	0.5	84.5	69.7	66.7	64.8	64.7	51.6
3	0.5	83.6	69.7	66.7	64.8	64.6	51.6
4	0.5	83.5	69.3	66.6	64.8	64.5	51.6
5	0.5	83.2	68.7	66.5	64.5	64.4	51.5
6	0.5	83	68.7	66.4	64.2	64.3	51.4
7	0.5	82.4	68.7	66.3	63.9	64.2	51.3
8	0.5	82	68.6	66.2	63.8	64.1	51
9	0.5	81.4	67	66.1	63.7	64	51
10	0.5	81	66	66	63.5	63.9	50
11	0.5	80.4	65	65.9	63.4	63.8	46
12	0.49	79.9	64	65.8	63.3	63.7	43
13	0.49	79.2	62	65.7	63.1	63.6	42
14	0.48	77.9	60	65.6	63	63.5	41
15	0.47	77.3	57	65.5	62.9	63.4	40
16	0.43	76.6	55	65.4	62.7	63.3	39
17	0.37	76.1	50	65.3	62.1	63.2	38
18	0.27	76	47	65.2	62	63.1	37
18.4	0.27	76	47	65.1	60	60	0
18.8	0.15	75	46	65	0	55	0
19	013	75	45	0	0	54	0
19.1	0.12	0	0	0	0	53	0
19.4	0.11	0	0	0	0	52	0
19.7	0.00	0	0	0	0	0	0

Chapter Four

Result and Dissection

4.1 Introduction

The experiment was carried out in physics lab in Omdurman University. In this experiment five samples of solar cell were shaded. The results of experiment were compared with the un shaded cell.

4.2 Result and Dissection

Table [4-2] shows Results for Relationship between Shading Area, P max, Fill Factors and Efficiency.

Cell No.	Shading Area in Cm^2	Fill Factor	Efficiency	P_{max}
Without shade	0.00	0.962	58%	3750
1Array shaded	0.0053	0.522	38.7 %	499
2cell shaded	0.0106	0.352	28.8%	441
3cell shaded	0.0159	0.344	24.5%	434
4cell shaded	0.0212	0.310	20.5%	293.32
5cell shaded	0.0265	0.218	16.6%	290
Withfull shade	0.06466	0.123	7.71%	205

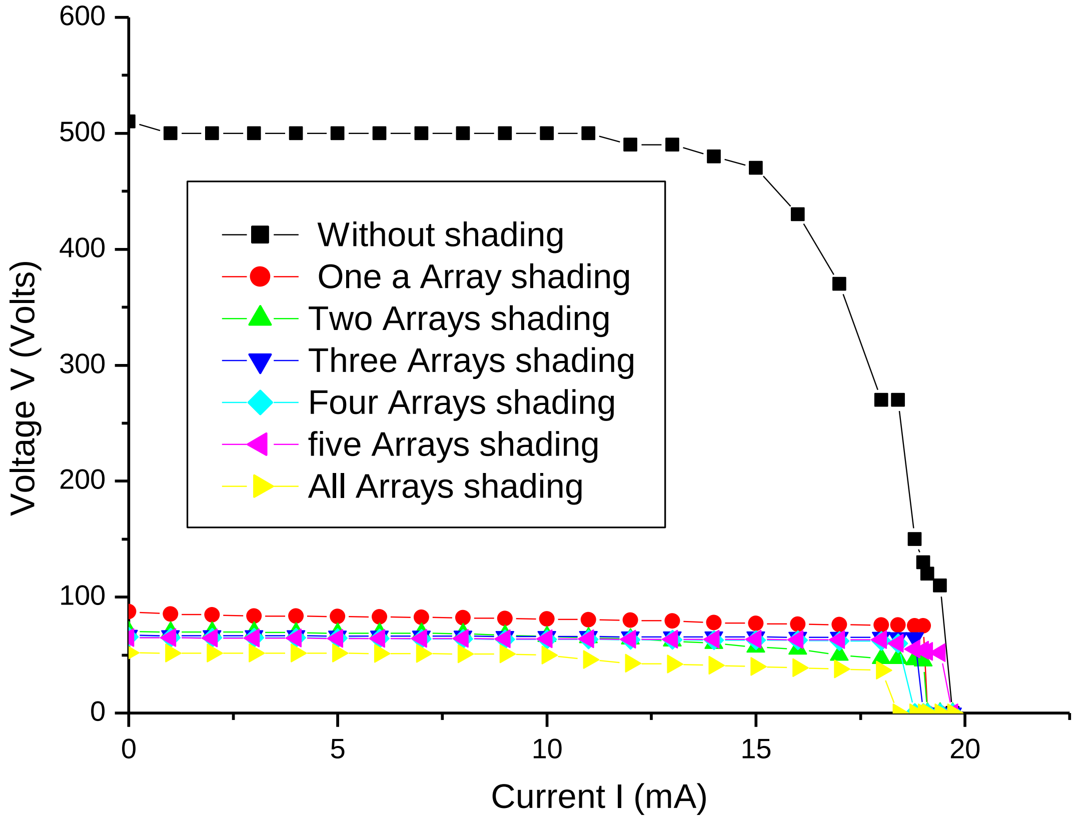

Figure 4.1 shows the relationship between voltage and current for different shading area.

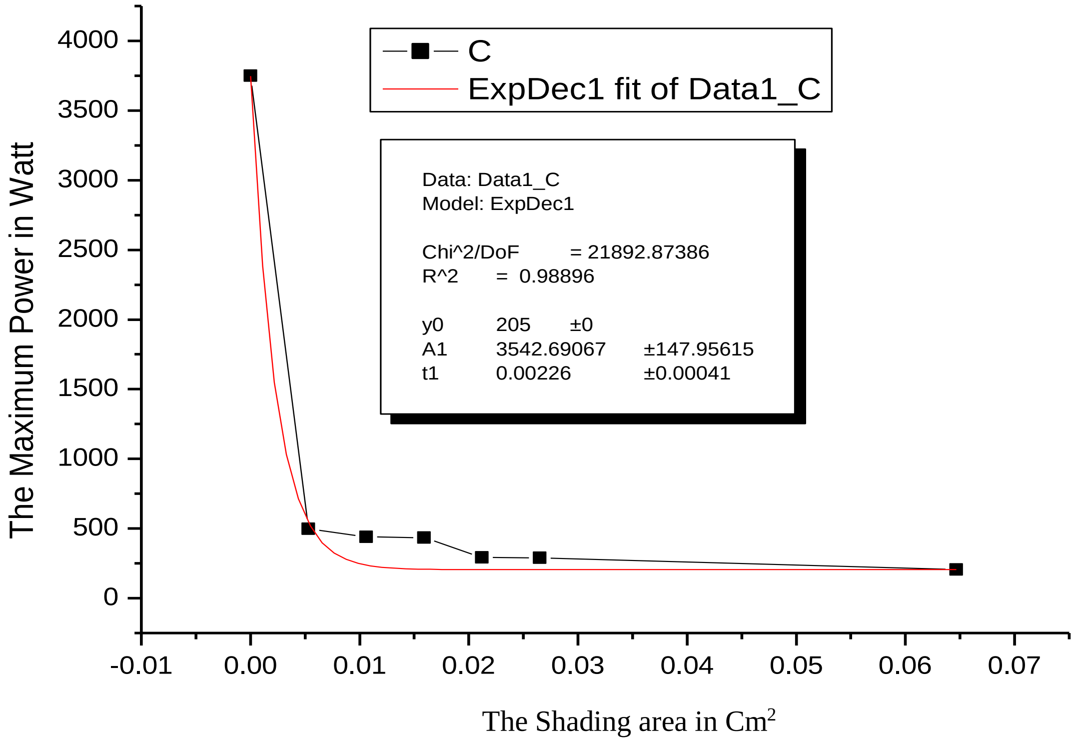

Figure 4.2 shows the relationship between the great power and space shaded.

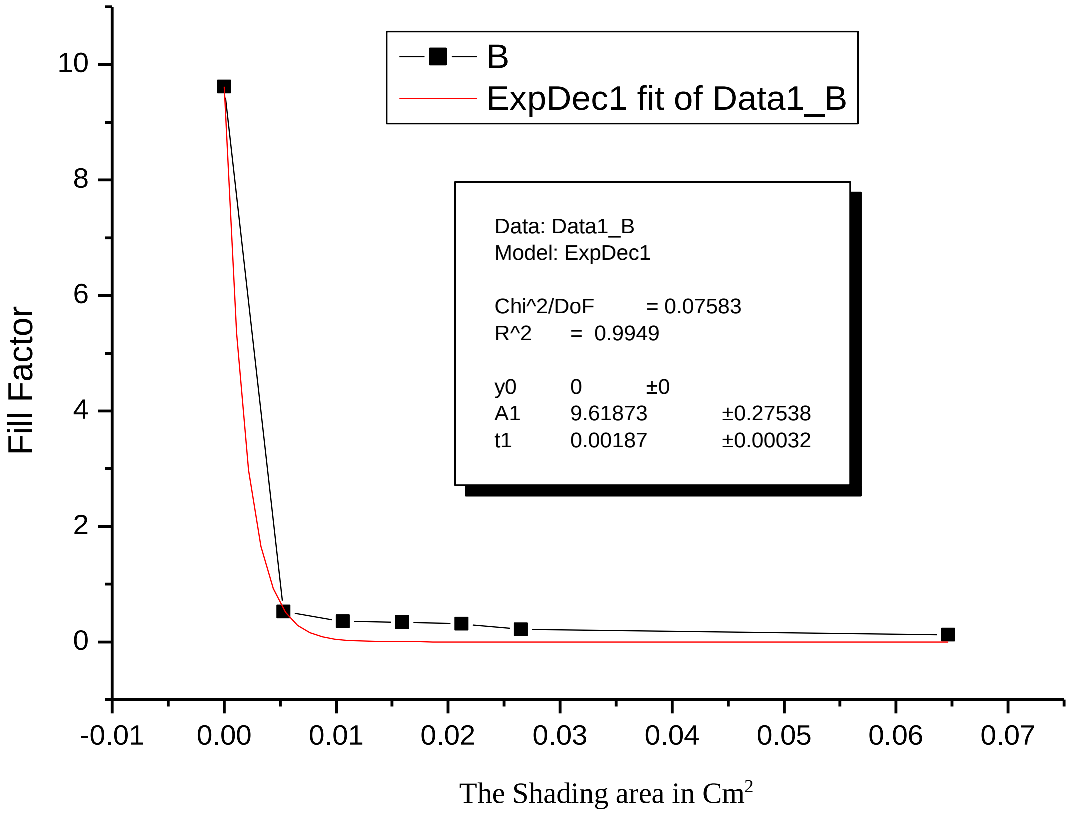

Figure 4.3shows the relationship between the solar cell shaded area and Fill Factor (FF).

Figure 4.1 show the voltage virus current curves for different values of shading array area of solar cell.

The shapes of the different curves in figure 4.1 show that the voltage is large for before and after shading array of PV solar cell, while null for large for different values of shading aero of PV solar cell .the open circuit voltage (v_{oc}) decreases slightly while the area of shading increases. The behavior of open circuit voltage is the reduction charge of carrier across the solar cell junction with different area of shading [23].it appears through the shading effect ion solar cell in short circuit and open circuit conditions that the solar cell has résistance behavior under shading area thus the solar cell behave like resistance that increases with the shading area, resulting in a reduction in the current and voltage due to thanes low.

Different parameter of solar cell con responds different to shading area. In general, the influence of shading on this parameter of for PV solar cell such as efficiency, Fill Factor and power maximum, as shown in table 4.2in view of fig4.2 and fig 4.3 it cleave that the fill factor and p max decries when the total shading area increases this decrease in fill factor and power maximums due to reduction in the photo current and photo voltage , in accordance to solar photovoltaic system [23].from mathematical models I can predict to the open current voltage (V_{oc}) by rate 5 time for PV solar cell as compared to(V_{oc}) after shading area for PV solar cell by using the origin 61 program on Fig 4.2 and Fig 4.3 shows the relation between the Fill factor of PV solar cell and shading area in Cm^2

$$P_{max} = 205 + 3542.69 \times e^{\frac{-x}{0.0026}} \qquad (4.1)$$

$$FF = 0.961873 \times e^{\frac{-x}{0.00187}} \qquad (4.2)$$

4.3 Conclusion

The operating shading plays a central role in the photovoltaic conversion process.

Analysis of the change in parameter of PV solar cell such as (V_{OC}),I_{OC}, FF and P_{max} due to different values of shading area show that:

- The open circuit decrease for values of shading area increase.
- The short circuit decrease when shading area increase.
- Fill factor is decrease when shading area increase.
- Maximum power is decrease when shading area increase.
- The depending on change different shading area, the equation (4.1) and (4.2) reflect the relationship between p max and FF with change shading area respectively.

The final conclusions that this study reaches have to be mentioned. In this part of the thesis it is going to be enumerated the mainly ones.

As it has been shown on the results and afterwards on the discussion several shadowing cases had been taking place.

4.4 Recommendation

- Create cells so that it does not fall under the high-rise buildings.
- Create the cells so that it falls directly under the sun
- Create the cells away from the trees areas in order to avoid the fall of the shadows.
- Material and moral support and stimulate the search traffic in the areas of solar energy.
- Establishing the Bank for information solar radiation and temperatures, high winds and quantitative dust and other necessary to use solar energy periodic information.
- Application of all the ways of rationalizing energy conservation and study the best methods in addition to the support of the citizens who use solar energy in their homes
- Promoting cooperation with developed countries in this area and take advantage of the expertise I have to be built on the basis of equality and mutual benefit.

4.5 References

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