Experimental Study of Various Factors Effect on Solar Cells

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Abstract— **The present study is direct towards the field of solar energy and a very important subject in Iraq. Solar cell modules are one of the most renewable energy systems, eco-friendly systems, sustainable, and providing free clean energy. This study represents an inclusive experimental study, various operating and environmental factors such as Shading, tilt angles, orientation, irradiation, and series-parallel connection that impacts on current-voltage characteristics of a solar cell. The results showed that voltage, the current output of the solar cells increased with increasing solar radiation. By using nine facing in installation solar cells (east (E),east-south-east (ESE), southeast (SE), south- southeast (SSE), south(S), south-southwest(SSW), southwest(SW), west - southwest(WSW) and west (W)), In this research work founded that the face of the south is the optimum orientation for solar Cells. In this paper, we use three shading cases (25%, 50%, and 100%) and we are found that the short circuit current increases linearly with the irradiated surface of the solar cell. According to the experiment results, the voltage output of the solar cell increased with increasing cells connected in series, and the short circuit current was increased with increasing cells connected in parallel.**

Keywords—**Energy, Renewable energy, Solar cells, Current/voltage characteristics, Solar radiation**

I. INTRODUCTION

Renewable energy applied science produces marketable energy by change natural phenomena into useful sources of energy. These applied science utilization the sun's energy and its indirect and direct effects on the earth (Wind, solar radiation, falling water, biomass, tides, geothermal) as the resources from which energy is created. Solar energy is used to cool and heat buildings (both passively and actively), power refrigerators, heat swimming pools, hot water for domestic uses, operate pumps and engines, generate electricity, and many more operations. The greater part of the electricity generated from renewable sources would be federal into large electrical, without the need for electrical storage [1]. Renewable energy is generally very environmentally friendly than traditional energy sources. This is attained by the decrease of air emissions due to the conventional fuels and the exchange of electricity [2].

Solar cells are semiconductor devices that produce electrical energy by converting the solar radiation directly. Solar cells are actuality used in a range of applications, from powering calculators, watches, communications systems, charging batteries, and systems for power generation. There are several variations in cell design, material, and methods of manufacture. Cadmium sulfide, Amorphous or polycrystalline silicon, gallium arsenide, and many semiconductor cells are used [3]. The output of cells is impacted by many factors. These factors are, Shading, tilt angles, orientation, irradiation, series-parallel connection.. silicon solar cell using For the space application because of those cells the advantage, high-

efficiency, lower material density and lower cost [4]. Fig. 1 shows a cross-section of a crystalline silicon solar cell.

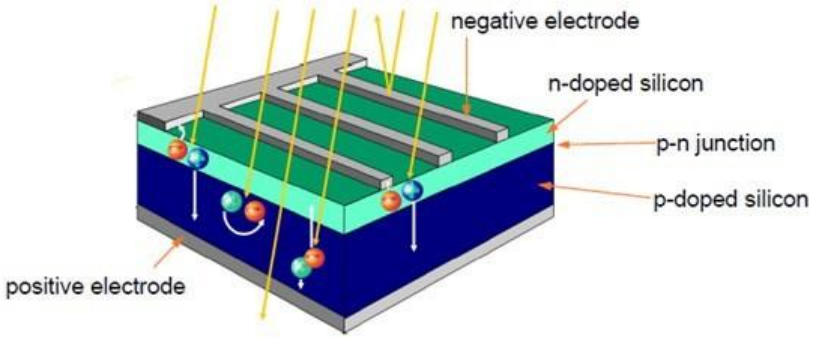


Fig. 1 Section of a solar cell.

Iraq is suffering from the phenomenon of cutting in electric power, which resulted in the suffering of Iraqi citizens of everyday life on the different levels of social, economic, and health [5]. Iraq weather is characterized by high sunshine hours during the year. Solar radiation across Iraq increases and more uniform distribution in summer(June–August) compared with winter and increases from north to south [6]. Studies Previous have shown that in Baghdad receives more than three thousand hours of the solar radiance of each year. The hourly solar intensity in Iraq varies (833 W/m^2 in June and 416 W/m^2 in January) [7].

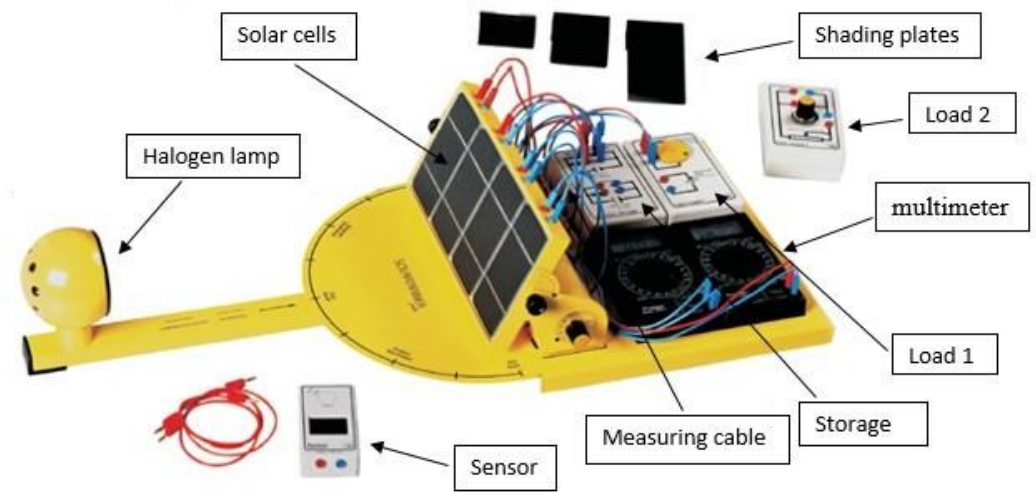
There are many studies about environmental and operational factors effect on solar cells. H.K. Elminir et.al. [8] experimental study of environmental factors effects on both the power output of solar cells modules and efficiency. Environmental parameters used in this study, Atmospheric conditions, cell temperature, the orientation of the cell, solar position, and angle of incidence. R. Nasrin et.al. [9] numerical study about the effect of solar radiation on solar cell module performance. M.J.B. Buni et.al. [10] studied the effect of high solar radiation and temperature in Iraq on solar cells output of voltages, current, electrical efficiency, and power. S. Bimenyimana et.al. [11] Used simulation by Matlab and experimental study to compare the impact of shade on Solar cells modules output power. J.C. Chou et.al. [12] Studied impact solar cells connected in series and parallel on the internal impedances of a different dye-sensitized solar cell (DSSC). Results show that the impedance was decreased in parallel and increased with cells connected in series. S.Z. Sdeeq et.al. [13] studied the impact of shading on series and parallel connected solar cells. The results showed the output of solar cell current, voltage, and power of the solar cells were reduced with shading the parallel and series cells. A. Al Tarabsheh et.al. [14] used two models of solar cells under the same input parameters to calculations of the voltage / current (I/V) characteristics

of the solar module. R. Abdallah et.al. [15] used mathematical models to show exact results for the optimum tilt angle solar module.

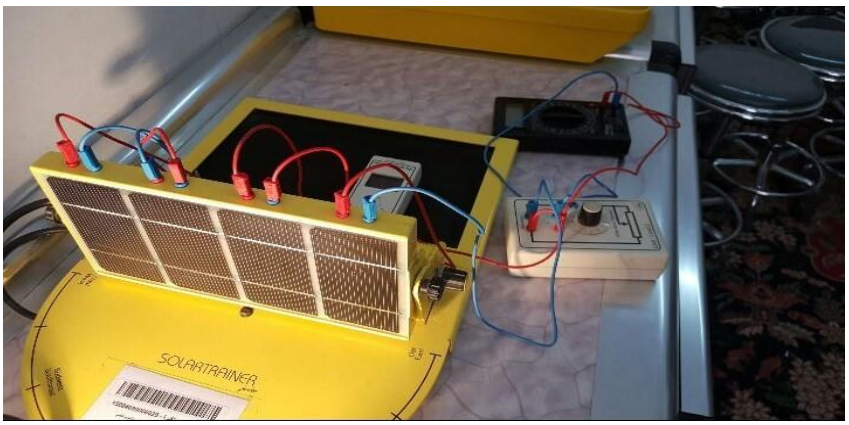
This experimental study investigates the effect of Shading, tilt angles, orientation, irradiation, and series-parallel connection on the current/ voltage (I/V) characteristics of the solar cell module.

II. EXPERIMENTAL SETUP

An experiment was set up in the Renewable energy laboratory, Faculty of Engineering, University of Kufa to investigate the effects of various factors on solar cell performance. The ambient temperature of 25°C during The experiments were made in the laboratory of renewable energy. The experimental setup fundamentally included four solar cells, Shading plates, Sensor, irradiation unit, multimeter, power cord, measuring cable, Load , and measuring devices used to investigate experimentally. Fig. 2 shows the experimental setup. According to the study experimental requirements, the experiments consist of the following main components. Table 1 illustrates the specifications of the main components.



(a)



(b)

Fig .2 (a) Main components of the experiments. (b) Experimental set up.

TABLE I
SPECIFICATIONS

Components	Specifications
Solar cell unit	• 4 solar cells polycrystalline. (10*5 cm) • No-load voltage (V_{oc}). (0.5 v) (1000 w/m²) • Short –circuit current (I_{SC}). (1.5 A)(1000 w/m²) • Micro fuse (20*5mm and 1A). • Power (230 V/ 50 Hz)
Shading plate	• Used shading (25%, 50%, and 100%) of the surface solar cell.
Sensor	• Range of (15- 2000 mv). • Measuring unit is (w/m²), (1 mv =1 w/m²).
Load	• Uses measuring current, voltage, and load resistance by loading of solar cells. • Resistance load (100 Ω) and capacity (2 w).
Multimeter	• Alternating voltage (ACV) (500 V , Accuracy 1.2 %). • Direct current (DCA) (2000 mA, Accuracy 1.2 %). • Direct current measurement (DCV) (500 v , Accuracy 0.7 %)

III. RESULTS AND DISCUSSION

A. *Effect of the Intensity of Solar Radiation on the Characteristics of Solar Cell (I sc/Voc)*

Fig. 3 and 4 show the impact intensity of solar radiation on the characteristics of a solar cell. the short circuit current increases almost linearly along with increasing solar radiation. The no-load voltage increased with increasing solar radiation and reaches almost the same value as with full irradiation.

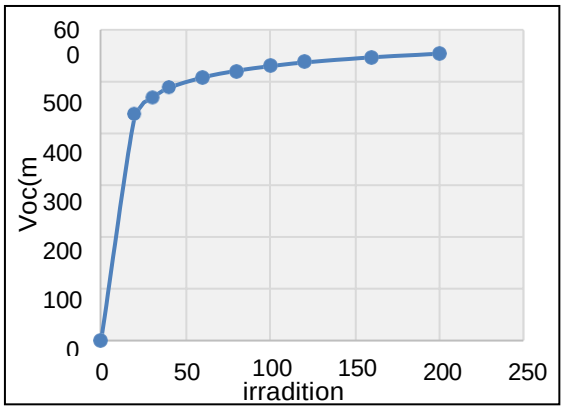


Fig. 3 Effect of the solar radiation on short circuit current

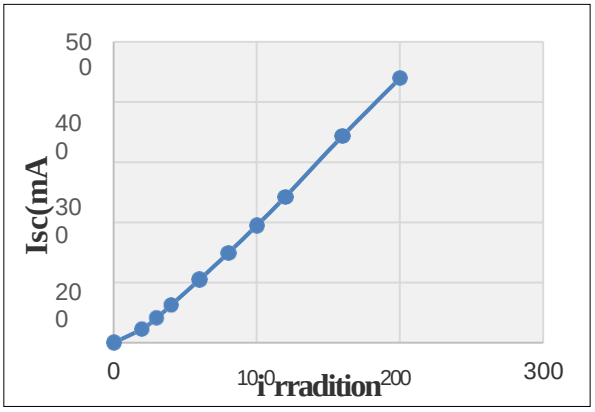


Fig. 4 Effect of the solar radiation on no-load voltage

B. *Effect Different Angles of Irradiation on the Characteristics of Solar Cell (ISC)*

The short circuit current is dependent on the irradiation and angle of radiation. the short-circuit current is greatest if the solar radiation impact surface of a solar cell at an angle of 90°. Fig. 5 shows the short-

circuit current decrease with a decreasing angle and also illustrated when the solar radiation hit of the solar cell surface in a vertical angle (90°) to short-circuit current maximum.

C. Effect of Orientation on Solar Cell

The best important to find the maximum amount of energy when solar cells direct facing the sun. the orientations facing for installation solar cell in nine directions to optimum orientation choose (east (E),east-south-east (ESE), southeast (SE), south- southeast (SSE), south(S), south-southwest(SSW), southwest(SW), west - southwest(WSW) and west (W)). Fig. 6 shows in the position 'southwards', the short circuit current is a maximum value, with 'Eastward' and 'Westward' the value decreases more and more units it is almost zero.

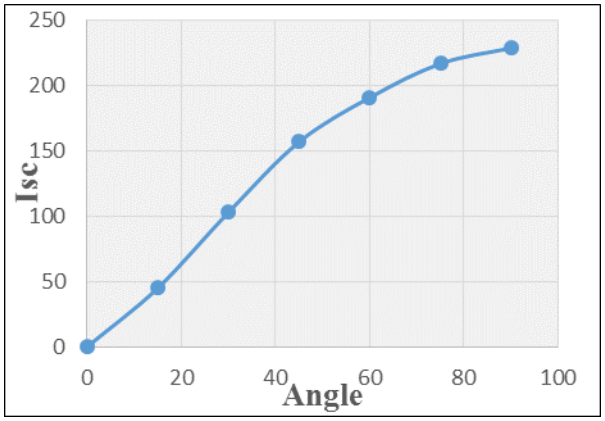


Fig. 5 Effect of angle solar radiation on short circuit current

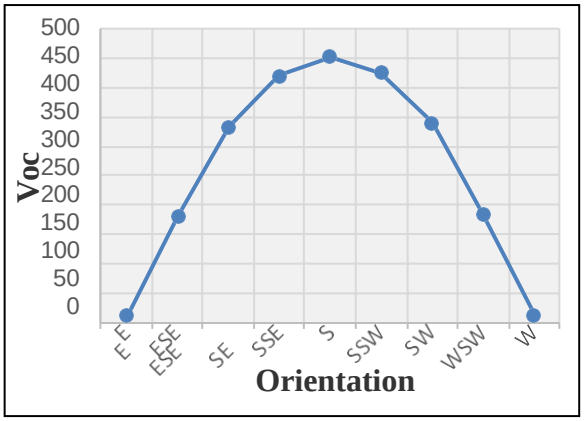


Fig.6 Effect of orientation on voltage

D. Effect of Shadow on the Characteristics of Solar Cell

Electrical power output from solar cell panels is severely affected by shading that caused by trees and clouds and other structures that prevent the sun's light with constant temperature and irradiation. In this research using three shading cases was chosen in the experiment, these are shading (25%, 50%, and 100%). Fig. 7 shows when irradiation a small surface, the voltage lies within the range of the no-load voltage of the whole solar cell. Fig 8 shows the short circuit current increases linearly with the irradiated surface of the solar cell.

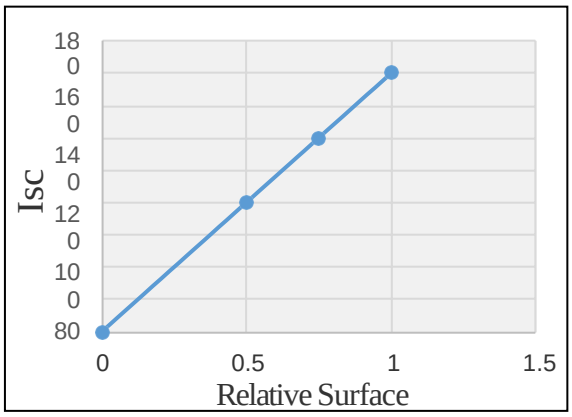


Fig. 7 Effect of Shadow on short circuit current

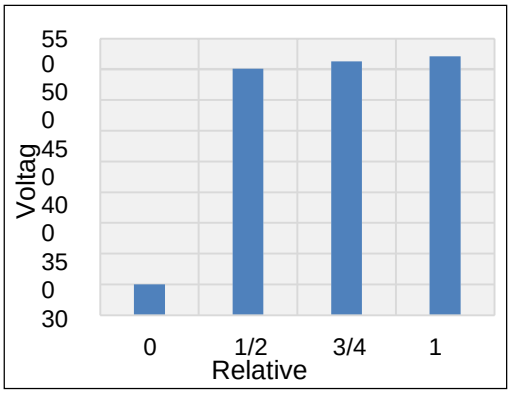


Fig.8. Effect of Shadow on voltage

E. Series Connected Solar Cells

Table 2 illustrates the no-load voltage of the individual solar cells varies only slightly. The short circuit current of the outer solar cells is lower than of the central cells.

TABLE 2
VOLTAGE – CURRENT (VOC/ ISC) OF SOLAR CELLS

	Cell 1	Cell 2	Cell 3	Cell 3
Voltage (Voc)	533	553	553	543
Current (Isc)	153	224	223	153

Table 3 Represents the voltage of the individual solar cells adds up. The short circuit current takes the value of the cell with the lowest value.

TABLE 3
VOLTAGE – CURRENT (VOC/ ISC) OF SERIES CONNECTED SOLAR CELLS

	Cell 1	Series connection (1+2 cells)	Series connection (1+2+3 cells)	Series connection (1+2+3+4 cells)
Voltage (Voc)	533	1085	1631	2150
Current (Isc)	153	155	162	153

Table 4 illustrates the no-load voltage change only slightly. With increasing shading, the short circuit current is reduced to the value zero.

TABLE 4
SERIES SHADING OF SOLAR CELLS

	No shading	¼ shading	½ shading	Complete shading
Voltage (Voc)	2150	2130	2120	1800
Current (Isc)	153	126	92	6

F. Parallel Connected Solar Cells

Table 5 illustrates the no-load voltage of the individual solar cells varies only slightly. The short circuit current of the outer solar cells is lower than of the central cells.

TABLE 5
VOLTAGE – CURRENT (VOC/ ISC) OF SOLAR CELLS

	Cell 1	Cell 2	Cell 3	Cell 3
Voltage (Voc)	533	553	553	543
Current (Isc)	153	224	223	153

Table 6 Represents the voltage remains the same. The short circuit current of the individual cells adds up.

TABLE 6
VOLTAGE – CURRENT (VOC/ ISC) OF PARALLEL CONNECTED SOLAR CELLS

	Cell 1	Paralle connection (1+2cells)	Paralle connection (1+2+3 cells)	Parallel connection (1+2+3+4 cells)
Voltage (Voc)	533	539	542	540
Current (Isc)	153	377	596	744

Table 7 illustrates the no-load voltage change only slightly. The short circuit current is reduced by the reduction of the shaded solar cell.

TABLE 7
PARALLEL SHADING OF SOLAR CELLS

	No shading	¼ shading	½ shading	Complete shading
Voltage (Voc)	540	540	536	531
Current (Isc)	744	696	638	523

G. The efficiency factor of Solar Cell

Fig.9 shows (voltage and power) diagram, the maximum power point (MPP) is located on the vortex of the curve The intersection point of the vertical line of this with the characteristic curve of the voltage/current diagram give the MPP of this characteristic curve. From this point, one obtains a rectangle with the greatest area below the curve. The efficiency factor of polycrystalline solar cells with irradiation of 1,000 W/m^2 with sunlight is in the range of 12-16%(standard test conditions +25C/AM 1.5). Calculation of the efficiency factor of polycrystalline solar cells is defined as follows.

Maximum power of the solar cell MPP= 306 mw

Irradiation measured 202 w/m²

Total surface of the 4 solar cells : 5*10*4= 0.02 m²

P_{in} = 202 * 0.02= 4.04 W

Efficiency = $\frac{Pmax}{P\,in} = \frac{0.306}{4.04} = 0.076 * 100 = 7.6\ \%$

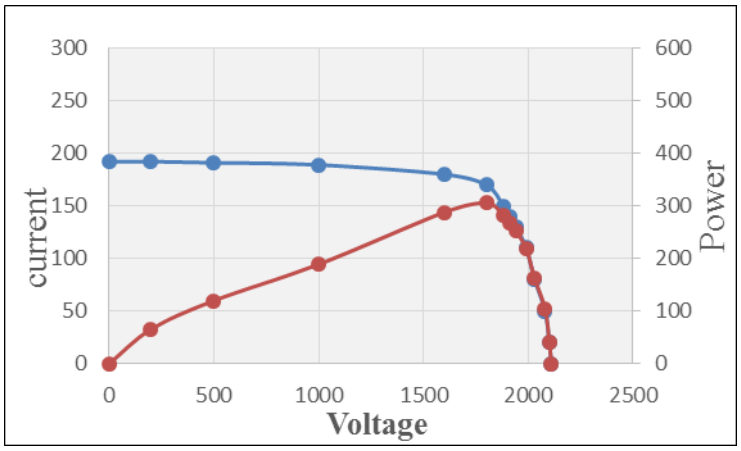


Fig.9 Voltage and power of solar cell

IV. CONCLUSIONS

Iraq is described by high solar radiation during the year, which is suitable for the work of solar energy. In this experimental study in the laboratory, which investigated the impact of Shading, tilt angles, orientation, irradiation, series-parallel connection with the current/ voltage (I/V) characteristics of solar cell modules. Several conclusions from the present research and can be written as follows:

- The impact of rising solar radiation on the solar cell output of current and voltages has been investigated experimentally. the output solar cell circuit current increases linearly with increasing solar radiation and also the voltage of solar cells increased with increasing solar radiation.
- The angle was of solar radiation very important that gives the maximum of solar cell current when the angle of radiation is vertical (90°).
- The maximum value output current solar cell be is in south-facing orientation.
- The current/voltage (I/V) characteristics of an experiment solar cell module decreasing when irradiation a small surface.
- The short circuit current decreasing and voltage was increased with increasing cells connected in series. On the contrary, The short circuit current was increased with increasing cells connected in parallel.

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