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Effect of Solar Radiation on Photovoltaic Cell

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Abstract**—** *Solar Panels have become one of the most promising ways to handle the electrification requirements of numerous isolated consumers worldwide. In this experimental work, the primary target is to investigate the relationship between solar radiations, current, voltage, and efficiency of solar panel. Data were recorded from the digital instruments used. Analyses were made between solar radiation, current, voltage, and efficiency. Results obtained show that there is a direct proportionality between solar radiation and output current as well as efficiency. This implies that an increase in solar radiation leads to increase in output current which enhances efficiency (performance) of a solar panel. However, the increase in solar radiation is followed by an increase in the PV cell temperature which has a bad effect on ball the studied parameters.*

Keywords**—** *Solar radiation, PV temperature, current, power, efficiency*.

I. INTRODUCTION

Solar energy is part of the sun's energy which falls at the earth's surface [1]. This energy provides heat and electricity by many applications, such as water heaters [2, 3], air heaters [4, 5], salty ponds [6, 7], solar chimney [8, 9], concentrated power plants [10, 11], and photovoltaic cell [12]. Moreover, it supplies energy to natural processes like photosynthesis. Solar energy is secure, clean and available on the earth throughout the year. Such clean energy is very important to the world, especially at the time of high fossil fuel costs and the critical situation of the atmosphere resulting from fossil fuel applications [13]. The solar energy data provides information on how much is the sun potential at a location on the earth's during a specific time period [14, 15]. These data are very important for designing and sizing solar energy systems [16]. Due to the high cost and installation difficulties in solar measurement, the solar energy data are not always available. Therefore, there is a demand to develop alternative ways of predicting the solar energy data [17].

Solar PV is today locating after wind and hydro power, the third most important renewable energy source in terms of globally installed capacity [18, 19]. Till today, more than 100 countries all over the world are using solar PV. PV modules are used in many important applications that gave it the confidence of the users such as water-pumping installations (very important in developing Countries) [20, 21]. Cathode protection of gas, oil pipelines and other types of piping; provision of power in general, in particular for limited electric charges (in the order of a few kW) always in areas far from the grid or where power is unreliable (discontinuous electrical supply) [22, 23].

Also, PV arrays are used in Radio/television relay stations: telephone devices; stations for data surveying and transmission (meteorological, seismic, for levels of watercourses, indicating the presence of fires), often very useful for civil protection services [24]. As well as, they are served in lighting of streets, gardens and public transportation stops; and street signaling [25, 26]. In the health sector, PV modules are used to provide health clinics in rural areas with electricity especially for refrigeration. These arrays are very useful particularly in developing countries for the conservation of vaccines and blood [27, 28]. In residential sector, it is useful for power provision (especially lighting) for houses and mountain refuges [29]. Very significant applications of this type in developing countries: photovoltaic systems do not require special maintenance and are easy to install [30].

All the studies that have reviewed the map of solar energy levels around the world show that Iraq is well positioned to exploit energy-saving sunlight [31]. In fact, over the past few years, a series of reports have been published glorifying the benefits of exploiting this renewable energy source [32]. However, as populations and urban communities consume more and more energy, governments in the Gulf and MENA are now seriously considering harnessing solar energy to help bridge the potential energy deficit [33].

Due to the installation of photovoltaic cells in the open and exposed to external weather conditions they are highly affected by these parameters [34]. The standards for photovoltaic cells were set at 25°C cell temperature, 1000 W/m^2 solar radiation, and air mass of 1.5 [35]. However, on the ground these factors do not always meet the intensity of solar radiation reaches the cell goes the least part of them to generate electricity while the greater part goes to heat and thus reduce their productivity [36]. The temperature of the outside atmosphere, if high, will reduce heat loss and increase the temperature of the solar panel [37]. So, there is seriously thinking about transforming photovoltaic systems into photovoltaic/thermal cell (PVT) systems, through which the solar cell temperature is reduced and the heat of the solar cell is used in other applications [38, 39].

Many researchers have studied the effect of solar radiation, whether positive or negative on the photovoltaic cell and found that the shadow or change in wavelengths resulting from clouds or accumulation of dust in the atmosphere reduces the intensity of radiation and the productivity of the solar cell [40, 41]. The accumulation of dust on the cell reduces its productivity to reduce the permeability of the radiation to the cell [42, 43]. In addition to dust, pollutants emitted from the exhaust of vehicles and heavy vehicles have caused significant air pollution and are deposited on solar cell surfaces [44, 45]. Periodic cleaning and the use of appropriate detergents are essential to maintaining good solar cell performance [46, 47].

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In this experimental work, the effect of the solar radiation intensity of the city of Baghdad on the photovoltaic cells will be studied based on the measured radiation intensity of the Iraqi Aeronautics Department and its duration. It will be laboratory to determine the maximum radiation intensity per month and weather conditions and their laboratory representation and then the extent of the solar cell affected by these changes.

II. Experimental Setup

A. The Study Location

Iraq is located to the south-west of the continent of Asia between the latitudes 29-37 degrees north and between latitudes 38 - 48 degrees east, and this site has several implications, notably:

A) It occurs within the northern temperate region, where this means that the length of the day (14) hours in summer, falling back to nearly ten hours in winter, leaving all clear implications on the state of elements of the climate and change significantly between summer and winter, but a positive aspect may this resulted in the length of the growth season, which extends to most days of the year [31].

The extension between the supply circles is limited and its impact on climatic and plant conditions has led to limited diversity in climatic regions and the ability to achieve self-sufficiency, and has also led to a limited diversity in the ethnographic composition of the population, which is a positive factor that contributed to the strengthening of the population and the increase in the factors of their unity [48].

Five small seas are surrounded by Iraq, with the exception of the Mediterranean, which is the main influence on Iraq's climate. Iraq has a maritime border of 60 km and this represents only 1.8% of the total Iraq's external border of 3,500 km, which reducing its share of sea resources and directing people to land rather than the sea. Its 3,500-km land border has led to six states bordering on border problems and instability and interference in its internal affairs [49].

B. Equipment

In this practical research work, the DL 9032 solar system, which is shown in figure 1, was used to evaluate the effect of the PV panel temperature and solar radiation on the PV efficiency. The system is a power source with one input and two distinct outputs, as represented in figure 2. The input terminal is a 230 V potential in respect to the ground. Power cable used to connect DL 9032 to the electrical outlet (230 V, 50 Hz). One module output is AC voltage source that has the same characteristics as module input, i.e. 230 V and 50 Hz. It is used to provide AC voltage for DL modules that require one. There is also a green terminal which is used for protective grounding of various DL modules that require grounding. Moreover, the other output is a 12 V DC voltage source. 12 V DC voltage source is obtained by transforming 220 V AC voltage to 12 V DC voltage using AC/DC converter .

In addition, for module DL 9032 to work properly, power cable must be connected to wall outlet (220 V, 50 Hz) and power switch must be turned to ON position. The red LED is turned ON (glows red) when voltage is present. For safety reasons wall outlet, must not be used if residual current device is not installed in electrical circuit that contains wall outlet. The residual current device in wall outlet circuit must also be tested before DL 9032 is used. If residual current device does not work as it should, do not use DL 9032 module.

Fig. 1. Solar radiation system.

The solar panel used in the tests incorporates a module of (85 W, 12 V). It contains a sensor for the Irradiation and Temperature. These sensors are Red and Black; to provide the solar panel power output. Also, the 5-pin terminal provides irradiation and temperature data. To make it easy to be handled, the light weight solar module is placed on wheels. Side of the panel contains a meter for measuring the angle of the solar panel inclination towards the horizontal surface.

III. Results and Discussions

This study was conducted inside the laboratory with the provision of weather conditions similar to the climatic conditions of the city of Baghdad following the method used by Ref. [50]. The laboratory temperature has been changed with the advance of time and at the same time increasing the radiation intensity of the lights used to resemble the real sun radiation. The relative humidity is not more than 40% and the air speed is not more than 1 m/s.

Fig. 2 shows the relation between the ambient temperature and time. The air temperature increases with time advanced and reaches its peak degree and then it starts to reduce after 2 PM as the solar radiation reduces after this clock.

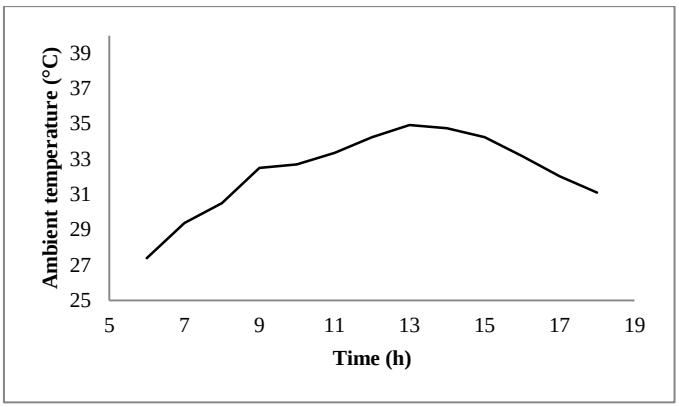

Fig. 2. The ambient air variation with time.

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Fig. 3 shows the variation of the used PV panel temperature with time. The PV temperature increased from 7 AM to 2 PM because of the high increase in the solar radiation and also due to the increase of ambient air temperature. In this case, the cooling effect of the ambient air will be eliminated. After 2PM the solar radiation reduced quickly and the ambient air temperature too. These reductions cause the PV temperature to reduce also.

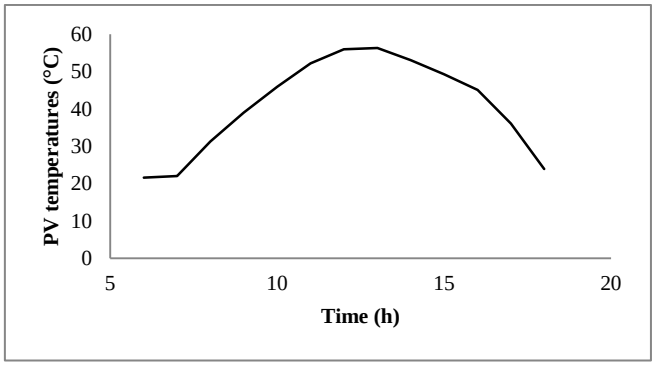

Fig. 3. PV temperature variation with time.

Fig. 4 shows the impact of solar radiation on the PV generated current. The current increased with increasing solar radiation as the figure reveals. However, at high solar intensity it stated to reduce. This reduction can be referred to the increase in the PV temperature as Ref. [51] clarified.

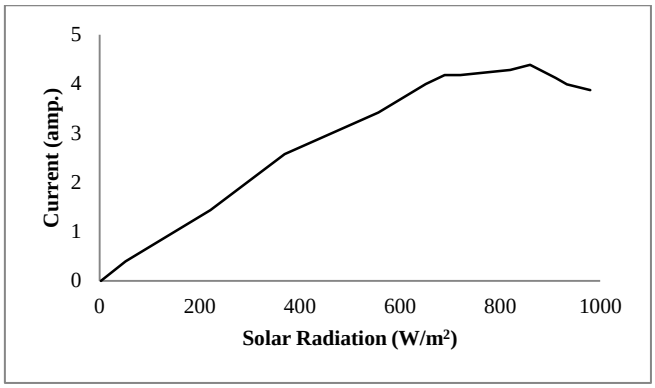

Fig. 4. The effect of solar radiation on the PV current.

Fig. 5 illustrates the effect of solar radiation on the PV voltage. The curve shows that the impact of solar radiation on the voltage is limited but it reduced it at high solar radiation a little pit. Ref. [52] confirmed the limited impact of solar radiation on the PV voltage.

The variations in the PV current and voltage reflects on the generated power as Fig. 6 manifests. The power increased with increasing solar radiation because of the increments in current. But, it reduced at solar radiations more than 800 W/m^2 although the standard says that the maximum power is at 1000 W/m^2. Here, however, an important variable is interfered, which is the temperature of the cell, which is much higher than the temperature set in the standard, which is 25°C.

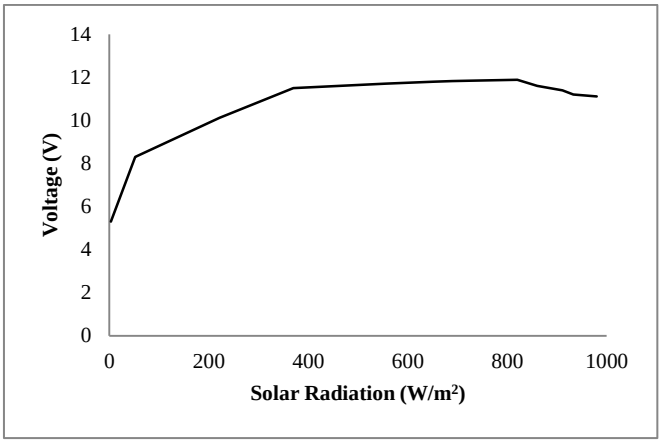

Fig. 5. The impact of solar radiation on voltage.

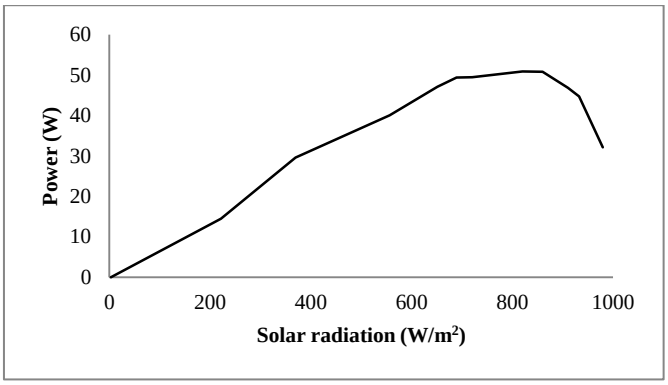

Fig. 6. Solar radiation impact on the generated power.

Fig. 7 shows the variations in the output efficiency with solar radiation. As the solar radiation affects the power it also affects the outcome efficiency of the PV panel. The increase in solar radiation intensity is followed by an increase in the panel temperature which eliminates the produced current and then reduces the power and at the end affects the efficiency and reduces it. The best solution for this dilemma is by converting the PV system to a PVT system as Ref. [53] results clarified.

IV. CONCLUSIONS

Iraq is characterized by high radiation throughout the year, which is a good and suitable for the work of solar cells, but accompanied by this rise in solar radiation rise in the temperature of the photovoltaic cell. In this practical study in the laboratory, air was conditioned similar to external weather conditions, which were created and the effect of solar radiation on the cell output of current, voltages, power, and electrical efficiency was studied. The results showed that solar radiation has a direct effect on the temperature of the cell as this temperature increases with the increase of solar radiation. Due to the increased temperature, it became the main cause of the decline of the output of the cell. The rise of solar radiation increases the output current until the temperature of the cell interferes and causes a fall in it. The resulting voltages are not significantly affected by the rise of the current but the effect is greater by the rise in the cell temperature. Low current and voltages cause a decrease in the resulting power and efficiency

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of the cell. The optimal solution for maintaining high cell efficiency is by cooling the cell.

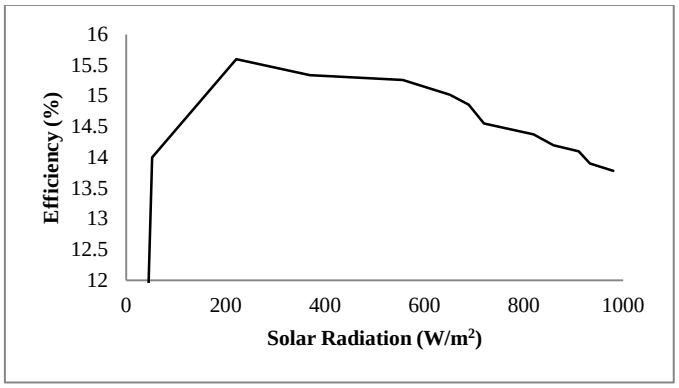

Fig. 7. PV efficiency variation with solar radiation.

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