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Design of a Simple Dust Removal System for a Solar Street Light System

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Abstract:

Dust and bird residue are problems impeding the operation of solar street lighting systems, especially in semi-desert areas, such as Iraq. The system in this paper was designed and developed locally using simple and inexpensive materials. The system runs automatically. It Connects to solar panels used in solar street lighting, and gets the required electricity from the same solar system. Solar panels are washed with dripping water in less than half a minute by this system. The cleaning period can also be controlled. It can also control, sensing the amount of dust the system operates. The impact of different types of falling dust on panels has also been studied. This was collected from different winds and studied their impact on solar panel performance. Also it studied permeability with the wavelength of three types of soil. The system has relatively low current and voltage consumption; it can be generalized for easy manufacturing and locally available components and is well effective.

Keywords: Dust deposition, efficiency of solar panel, Power losses, Renewable energy, Solar energy, Solar panel performance.

Introduction:

The interest in renewable energy, especially solar energy, has increased owing to a lack of conventional energy and an increase in pollutants, so researchers have worked to develop new solar cells or improve the performance of systems [1,2]. Accumulating dust on the surface of solar cells reduces the output as current and voltage, leading to a lack of energy [3]. The impact of dust and dirt from several regions on solar panel performance, dispersing accumulated particles on solar panels and reducing efficiency by 50%, and showing the importance of solar cell cleaning[4]. The effect of the sunlight angle on the yield of solar panels is current, voltage and the effect on efficiency. The results of these experiments are useful in stabilizing solar panels on homes[5]. The electronic microscope was used to examine the dust samples collected on solar cells, analyze images, know the method of the topography distribution and weights, and thus calculate the amount of energy loss in the solar photovoltaic panel unit, the experiments were conducted using three values (650, 750, 850) W/m^2, current and voltage measured and found a minimum power drop to 3.88 watts [6]. Dust deposition on panels experimentally in Poland, solar cells at an angle of 15 and 35 degrees, the study explained, the tilt angle has an effect on dust accumulation, and rain has an effect on dust removal but always helps clean only 38 mm/h[7]. Several studies in the world discussed the impact of dust on the panels and each study has specific ways of addressing the topic from different aspects. Using different equipment's, and finding it difficult to compare studies, the findings of the study raise several gaps in previous studies, which must be taken into account for new studies around the world[8]. Design a model that can clean the surface of the solar panel consisting of Robot system with auto-system mattresses and sensors that the system can thoroughly clean dry dust and can be implemented in Solar farms are widely used[9]. The design of an intelligent system to process the solar system of dust and waste system consists of a microcontroller (Arduino). The purpose of the design is to reduce panel losses and increasing efficiency 15-20%[10]. By using the Logic Controller (ILC 131 ETH) to design an intelligent and efficient

solar panel self-cleaning system, the system improves the efficiency of panels in Emirates and other Gulf countries with a desert climate [11].

Developing a dust-monitoring sensor on panels system that works with smartphones to give information at any time[12]. In this research, a local system of available and cheap materials was designed and manufactured to clean solar panels for solar street lighting systems. Factors affecting solar panel power, such as dust and bird residue, were studied, three dust species were sampled, and their permeability and impact on solar panel performance were studied.

Experimental work:

Solar radiation was measured in Salah al-Din –Tikrit, which is located on a longitude (43.242) and a latitude (35.492), using the Solar Power meter (TES-1333R) in units (W/m^2), solar radiation is one of the most important variables directly affecting the performance efficiency of solar panel.

The Mono-crystal panel of a rectangular shape with a side length of 164 cm and a width of (99 cm) is used. This solar panel contains (60) small cells, because the area of cell is (0.0256 m^2). The total area of the solar cell that is equal to the product of the total number of cells is then found in the area of the single cell, and is found to be equal to (1.536 m^2), as shown in Fig.1, and Table.1.

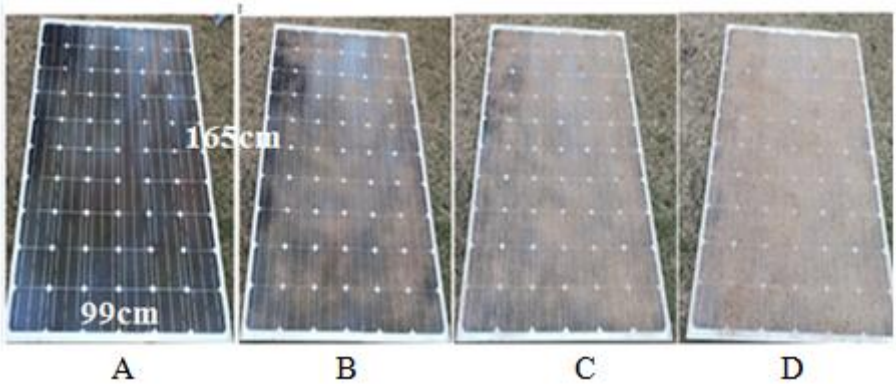

Figure 1. Shows A clean solar panel, B, C, D after adding dust with different weights.

Table 1. Showing the properties of the solar panel used.

Title	Symbol
Rated Maximum power at STC	250W
Maximum power Voltage(Vmp)	30V
Maximum power Current (Amp)	8.25A
Open circuit Voltage (Voc)	37.7V
Short circuit current(Isc)	8.76A
Mechanical parameter	
Cell Type	(Mono-crystalline 156*156mm(6 inch)
No .of cells	60(6*10)
Wight	1.8Kg

The solar panel is connected in series to a load, (160W), the current and voltage are measured and recorded with load, by using (two multi meter), also the values of solar radiation was being recorded at the same time Fig. 2, showing the practical circuit.

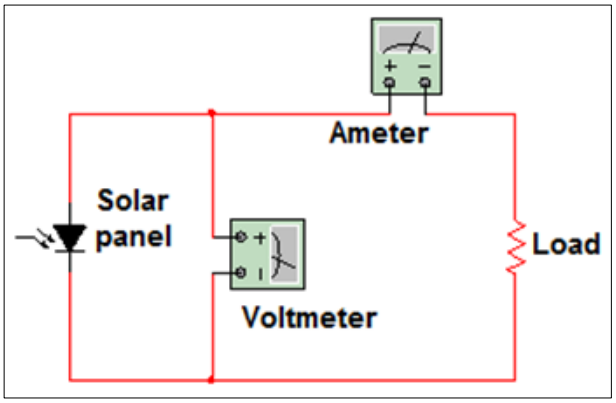

Figure 2. Represents the experimental circuit for testing solar panels.

Measure the effect of dust accumulation on the surface of the solar panel in field

The experiment was conducted on a clear day with a clean solar panel with a 160 watt load, and solar radiation, voltage, and current were measured at a reading rate from 10:00 a.m. to 1:30 p.m. the solar panel is exposed when it is clean. Fig.1A.Also some dust collected from dust storms has been added to the surface of the solar panel with weights. (125 , 250 , 375) gram after pure water is added each time at 0.5 liters until its surface is fully covered, and the output is then recorded voltage

current with and without load , with solar radiation recorded at a reading rate of half an hour, as shown in Fig. 1-B, C, D.

Study of the type of dust falling on solar panels

Three types of dust were collected from different dust storms, and three sample models were fabricated with the same thickness the samples were studied to observe transmittances (S1,S2,S3).

Depending on the Fig.3.The output power of solar panels was studied, after placing the same weight from dust and distributing it on solar panels and studying under similar conditions from solar radiation.

Figure 3. Shows three type of dust.

Cleaning system design

The solar panel cleaning system consists of two parts:

Mechanical part

This section includes the fabrication and installation of the mechanical cleaning system and its components.

Base

A cleanup base was designed for the assembly of four metal pieces by welding. The vertical pieces are cylindrical 170 cm long, the horizontal is rectangular, with a length of 100 cm, and the DC motor is fixed at the top that controls the rotation of a long screw where it is welded on the moving piece of metal. On which a rubber wiper is installed, a semi-cylindrical metal part is also welded to the sides to slip on the vertical metal piece, as in Fig.4.

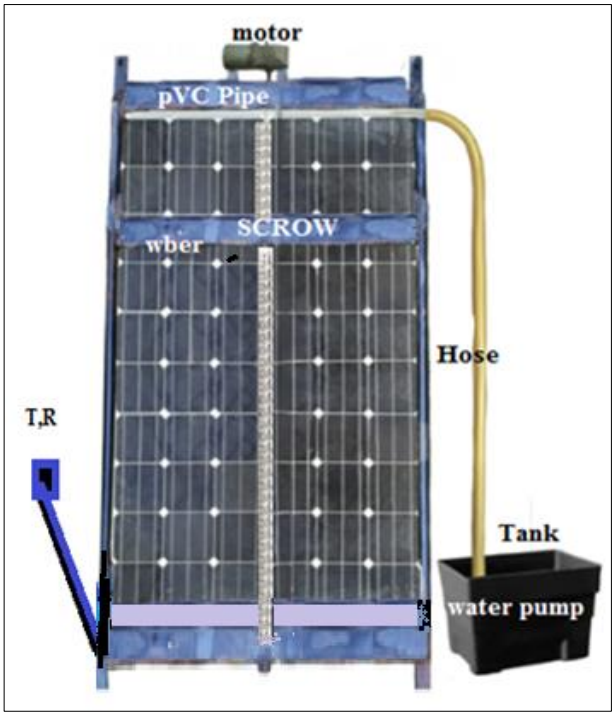

Figure 4. Shows component of the cleaning system.

Electronic Part

This section contains the most important components of the cleaning system's electronic circuit, which have been fabricated.

Solar panel Sensor system:

This system consists three parts

Transmitter

Infrared transmitter that operates at (DC 12 V, current 20mA) with pulse signal and will be transmitted by the, IR LED, the electrical circuit generates the frequency Fig.5, shows the transmitter circuit.

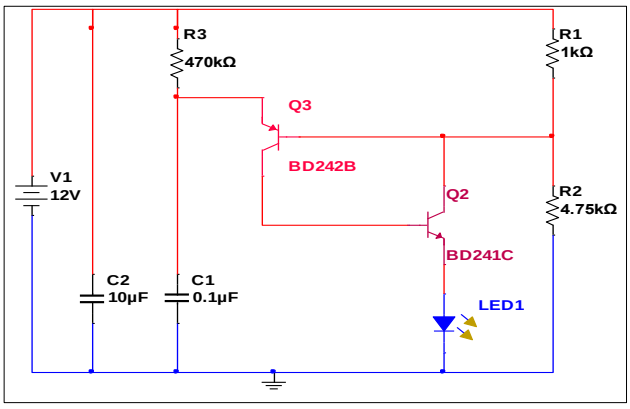

Figure 5. Shows the infrared transmitter.

Receiving circuit

The signal receiver circuit consists of a silicon type optical detector with a signal amplifier, which takes the signal after it is received from the

detector and converts to a continuous diode signal, which then expands to a digital signal via the rest of the transistor , that operates at (DC 12 V, current 25mA and as in Fig.6.

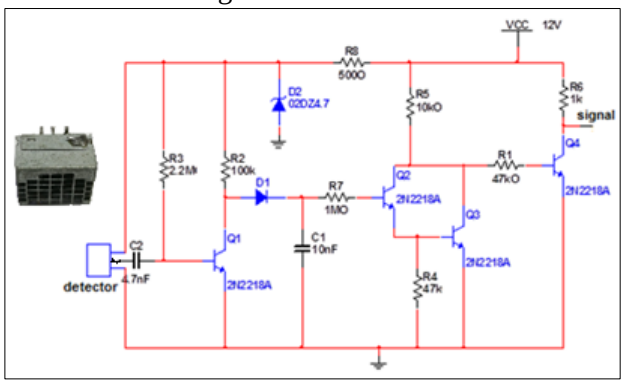

Figure 6. Shows the receiver circuit .

controlar system

The Fig.7 control circuit consists of an LM293 amplifier and is used as a comparative circuit as well as a timer. Time regression is done through C1, R3. And then the transistor is activated as a key that operates Relay1. That key is equipped with voltage from the main source of circuit feed. This feed operates the R.S. latch circuit, which has two transistors. Every transistor from the collector's side was connected to Relay . The right-hand transistor from the base was also linked to the R10 resistance and its other end to the Q2 transistor collector, and the left-hand transistor with the R9 configuration was linked to the Q3 transistor collector. The right-hand transistor from the base was also linked to the R10 resistance and its other end to the Q2 transistor collector, and the left-hand transistor with the R9 configuration was linked to the Q3 transistor collector . Micro switches (sw1,sw2) it are used to actived the two transistors also active the relay. The DC motor connects with two relay connected to move the DC motor in two directions .

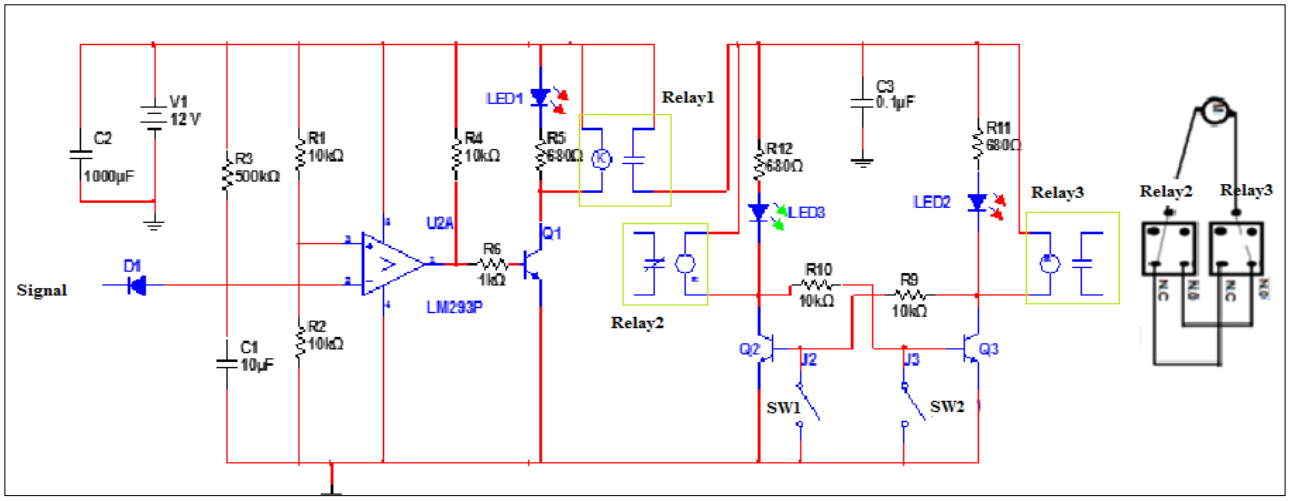

Figure 7. The control circuit to drive water pump and DC Motor .

The operation system

When the beam receiver (R) and transmitter (T) are connected together so that they are perpendicular to the solar panel. Fig. 7 left, so if the solar panel is clean, the signal will reach the panel, and it's reflected to the receiver, and it's tuned on. In the event that the dust accumulates on the solar panel, the beam will be blocked and will not reach the optical detector, thus doing the control active the timer of 0.5-1 minute for the R-S latch FLIP FLOP circuit to work. A 12–Volt water pump would lift the distill water onto the panel board, and the motors moving and drive the Moving crowbar with rubber (weber) one direction until push the (sw1) key, to reverse the polarity, moving the(weber) in the opposite direction, until the its push (sw2) key, which inverted the polarity, and the process continues until the solar panel cleans and the radiation returns to the detector and stops the motors Fig .8.

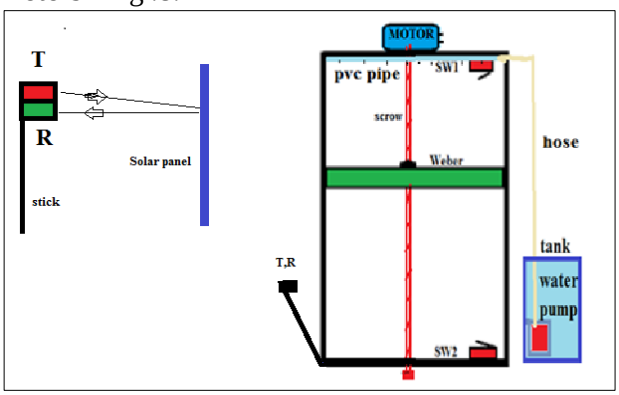

Figure 8. In the right diagram for system components, in the left the instillation package of transmitter, receiver.

Result and Discussion:

The experimental Characterizations of solar panel at load as shown in table 2

Table 2. Shows the output experimental of the Solar panel when it is clean and at Clear day at temperature 43^{0}C, wind speed 3 m/s

Time hr	G W/m	V with load	I (A)	P (W)	η %
10:00	780	31.1	3.87	120.3	9.99
10:30	790	30.9	3.92	120.1	9.94
11:00	800	30.8	4.1	120.3	10.26
11:30	815	30.8	3.91	120.4	9.62
12:00	830	30.6	3.98	121.7	9.52
12:30	840	30.4	4.1	124.6	9.69
13:00	850	30.5	4	122	9.37
13:30	855	30	4.2	126	9.63

The relationship between time and power, solar radiation, of a solar panel has been studied in practice in a clear day with a (160 watt) load. The greater of electrical power of the solar panel with the less heavy the dust deposited on the panel. Also the power is reduced by increasing the more weight, as solar radiation changes, as can be seen from the Fig.9, given that the size of the dust atoms was equal as a result of the small or difficult arrival of solar radiation in the active area of the solar panel. This is consistent with Mahmood YH [13] Atallah FS et al [14].

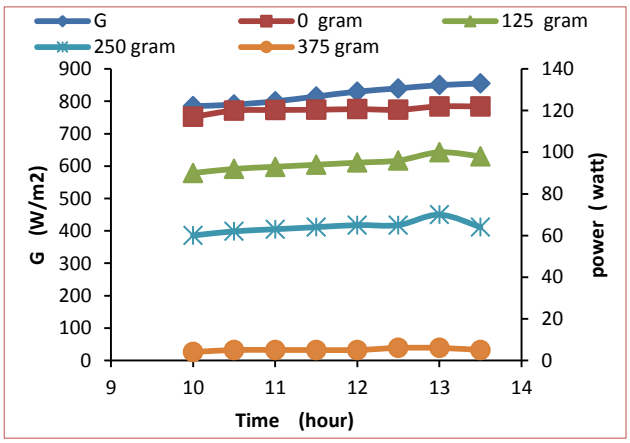

Figure 9. Shows the relationship between the time and the solar power with a load of by adding different weight dust.

The relationship between the weight of dust deposited on a solar panel, and the power of a solar panel can be studied by the presence of convection in the middle of the day , found as the weight of the dust is reduced , the power of the solar panel Fig.10 , since the long-term effect of dust accumulation on the panels serves to build it up on the panels, and to increase the weight of the accumulated dust that blocks solar radiation and prevents it from reaching the effective area of the solar panel, thereby reducing the power produced by the panel and this is consistent with Chanchangi YN, et al [15]. It has also been observed from experience that the difference in the size of the soil has an impact on the power produced. The smaller the atoms dropped on the panel, the smaller the power is, the lower the power, the larger the falling atoms are, the larger the influence is possible, where there are gaps that allow the passage of radiation and access to the effective area and it is consistent with Said SA [16] and Fan Z, et al [17].

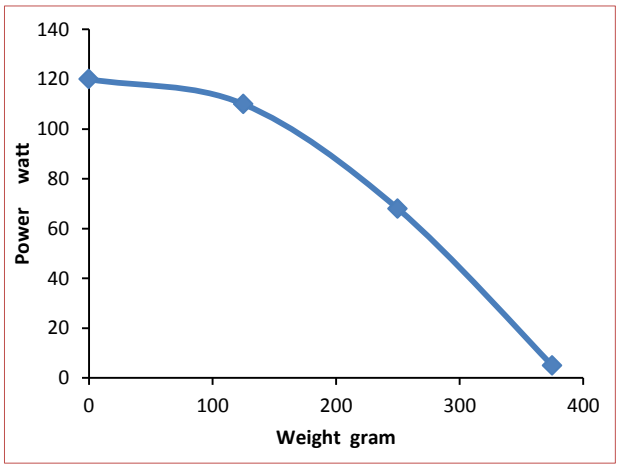

Figure 10. Relation between weight and power at 12:30 o'clock.

A significant reduction in transmittances of the three models, depending on the type of soil as the S1 model ranges from (0-30)% .While the S2 model ranges from (0-23)%, and the S3 model from (0-15)% Fig.11 . This is due to the metal and oxide components of the soil in each sample that interactions with the solar radiation and attenuation the Package of the wavelengths and decreasing the transmittances that is compatible with Wang J, et al [18] and Gutleben M, et al [19].

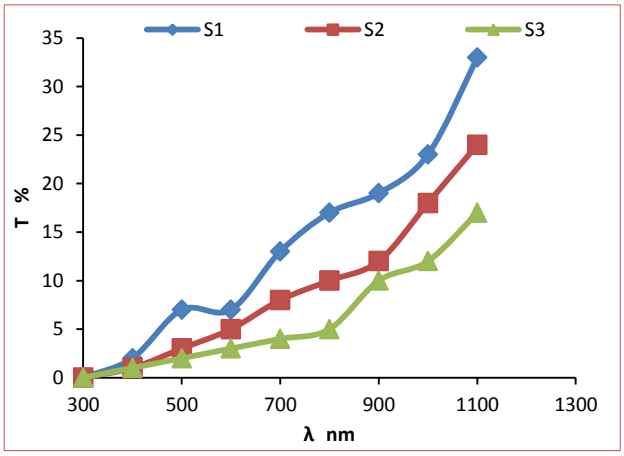

Figure 11. Relation between transmittances and wavelength for three different sample of a soil (S1,S2,S3) were collected from different dust storms.

Conclusion:

This study shows the impact of accumulated soil in the desert climate, or dry and dusty climates, on photovoltaic panels and the significant losses they cause on the output of the panels. Increased accumulation of long-term soil has been found to significantly reduce power and efficiency. The difference in soil type has also been found to play a significant role in the attenuation of solar radiation depending on the dust components of materials and metal oxide and that lead to the reversal or absorption of falling radiation, which has significantly reduced efficiency by more than 35 - 50%. The study showed the importance of making a simple and practical system to automatically clean solar panels, and the system is very cheap and practical in its performance.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Tikrit.

Authors' contributions statement:

The project has been done in College of Science-Tikrit University. The research work was divided as the author Y. H. M. conducted field experiments and designed electronic circuits, while the author M. A. M. performed the spectroscopic calculations and measurements.

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تصميم نظام بسيط مناسب لإزالة الغبار لنظام انارة الشوارع الشمسي

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الخلاصة:

يعد الغبار ومخلفات الطيور من المشاكل التي تعيق عمل منظومات الانارة للشوارع وخاصة في المناطق شبه الصحراوية ومنها العراق. وفي هذه الورقة ، تم تصنيع المنظومة محليا من مكونات بسيطة ورخيصة . يعمل النظام تلقائيا ، يربط مع الالواح الشمسية المستخدمة في انارة الشوارع، ويحصل على الكهرباء المطلوبة من نفس النظام الشمسي يعمل النظام على غسل الالواح الشمسية بالمياه المقطرة ومسحها ، وبوقت قصير لا يتجاوز نصف دقيقة كما يمكن التحكم بفترة التنظيف ، كما يمكن ايضا التحكم ، والاستشعار بكمية الغبار التي يعمل عندها النظام. كما تمت دراسة تأثير انواع مختلفة للغبار الساقط على الالواح والذي تم جمعه من رياح مختلفة ودراسة تأثيرها على أداء الألواح الشمسية. كما درست النفاذية مع الطول الموجي لثلاث انواع من الاتربة. المنظومة استهلاكها للتيار والفولتية قليل نسبيا ،ممكن تعميمها لسهولة تصنيعها وتوفر مكوناته محليا وهي فعالة بشكل جيد.

الكلمات المفتاحية : ترسب الغبار، كفاءة الألواح الشمسية، خسائر الطاقة ، الطاقة المتجددة، الطاقة الشمسية، أداء الألواح الشمسية