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Analyzing the features of wind turbines and photovoltaic cells from a 60-watt power generation

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تحليل خصائص توربينات الرياح والخلايا الكهروضوئية من محطة توليد طاقة بقدرة 60 واط

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Abstract:
The MATLAB Simulink software package is used in this research to create a generalized photovoltaic model that can be easily used on a simulation platform and is representational of PV cells, modules, and arrays. The suggested approach has a dialog box that resembles Simulink block libraries and an easy-to-use icon. This facilitates the simulation and analysis of the generalized PV model in combination with power electronics for a maximum power point tracker. The suggested model is used to simulate and optimize the PV model's output current and power characteristics while accounting for the effects of solar irradiation and cell temperature. This makes it simple to simulate, evaluate, and optimize the dynamics of a PV power system. The Wind Energy Conversion System, or WECS for short, is a wind-driven power generation system that has been modeled and simulated. Our goal is to use MATLAB simulation to construct and test a 300W induction permanent magnet generator that operates between 3 and 6 meters per second. According to the project's scope, the various parts of a wind energy system—the wind turbine, generator, and rectifier—were examined. The design process and system modeling were then carried out using the MATLAB simulation environment, Simulink.

Keywords: 60-watt power generation, wind turbine, and power photovoltaic cells.

الملخص
استُخدمت حزمة برامج MATLAB Simulink في هذا البحث لإنشاء نموذج كهروضوئي معمم يسهل استخدامه على منصة محاكاة، وهو مُمَثِّل للخلايا الكهروضوئية والوحدات والمصفوفات. يتضمن النهج المُقترح مربع حوار يُشبه مكتبات Simulink وأيقونة سهلة الاستخدام. يُسهِّل هذا محاكاة وتحليل نموذج الكهروضوئية المعمم بالتزامن مع إلكترونيات الطاقة لمُتتبِّع نقطة القدرة القصوى. يُستخدم النموذج المُقترح لمحاكاة خصائص تيار خرج وطاقة نموذج الكهروضوئية وتحسينها، مع مراعاة تأثيرات الإشعاع الشمسي ودرجة حرارة الخلية. يُسهِّل هذا محاكاة وتقييم وتحسين ديناميكيات نظام الطاقة الكهروضوئية. نظام تحويل طاقة الرياح، أو WECS اختصارًا، هو نظام توليد طاقة يعمل بطاقة الرياح، وقد تمت نمذجته ومُحاكاته. هدفنا هو استخدام محاكاة MATLAB لبناء واختبار مُولِّد مغناطيسي دائم حثي بقدرة 300 واط، يعمل بسرعة

تتراوح بين 3 و6 أمتار في الثانية. وفقًا لنطاق المشروع، تم فحص مختلف أجزاء نظام طاقة الرياح - توربين الرياح، والمولد، والمقوم. ثم نُفذت عملية التصميم ونمذجة النظام باستخدام بيئة محاكاة MATLAB، Simulink.

الكلمات المفتاحية: توليد الطاقة بقدرة 60 واط، توربينات الرياح، وخلايا الطاقة الكهروضوئية.

I. Introduction

There is a worldwide trend to increase renewable energy due to the necessity for polluting greenhouse emissions [1-2], the sharp increase in energy and fossil fuel prices, and the inevitable energy shortages. Photo-voltaic (PV) is one of the renewable energy sources that garners the most attention [3-4]. However, there are certain concerns about depending on renewable energy sources because of their high degree of unpredictability, daily unavailability [5-6], and uncontrollably shifting periods [7-8]. Excessive fluctuations in the system's voltage and frequency might result from the output power variability of renewable energy sources [9-10]. Photovoltaic systems that can provide an energy reserve with less variable output power have been created in recent years by combining storage technologies. Solar cells or photovoltaic (PV) systems can generate electricity from the sun. By simulating the structure of PV cells and observing how solar irradiation affects cell temperature, the study aims to make the output characteristics more realistic [11-12]. It also uses basic circuit equations of PV solar cells to study the state regime and the transient analysis of power. The PV model's responsiveness to a DC load was tested [13-14].

What are the characteristics of 60W power generation between wind and solar energy? How do wind speed and light intensity affect the power generation efficiency of photovoltaic cells and wind turbines? How do wind intensity and light intensity affect the power generation characteristics of photovoltaic cells and wind turbines? The primary goals of this research are to determine the features of small-scale power generating systems that use solar cells and wind turbines, as well as to investigate the optimal power generation efficiency of these technologies.

II. Fundamental Theory

- **Wind Power Estimates**

The following formula provides the wind turbine's power output:

$$P = \frac{1}{2}\ CpApV^3$$

where A is the swept area perpendicular to the wind velocity (m2) and Cp is the rotor's power coefficient, which ranges from 0.2 to 0.5.

$$A = \frac{\pi(RD)^{\ \ 2}}{4}$$

where V is the wind speed (m/s), ρ is the air density (around 1.225 kg/m3), and RD is the rotor diameter (m). Furthermore, the wind speed across the rotor is the primary determinant of the energy produced by a wind turbine. A feature of a typical wind turbine A feature of a typical wind turbine where V is the wind speed (m/s), ρ is the air density (around 1.225 kg/m3), and RD is the rotor diameter (m). The specific wind power is typically used to determine the wind potential. The power per unit of area can then be calculated by:

$$Ppotential = \frac{pV^3}{2}$$

The following is one way to express the greatest power:

$$Pmax = \frac{8}{27}\ \rho V^3$$

Then, an ideal wind turbine will have the following maximum efficiency:

$$\eta max = \frac{Ppotential}{Pmax} = \frac{16}{27} = 0.593$$

The Betz Coefficient or the Betz limit are other names for the factor 16/27 = 0.593. In an undisturbed tube of air in the same space, it demonstrates that a real turbine can only harvest 59.3% of the power. Because of mechanical flaws, the percentage of power extracted in practice will always be lower. Under ideal circumstances, a respectable fraction of wind power is between 35 and 40 percent, while fractions as high as 50 percent have been reported. About two-thirds of the power that an ideal turbine would extract is extracted by a turbine that captures 40% of the wind energy. Given the aerodynamic issues of continuously shifting wind direction and speed as well as the fractional loss brought on by rough blade surfaces, this is rather good. Both irradiance and cell temperature affect a solar cell's efficiency; that is, as the temperature rises, the short-circuit current slightly increases while the open-circuit voltage and fill factor significantly decrease (as thermally excited electrons start to dominate the electrical properties of the semi-conductor). A photovoltaic PV panel's power output (measured in Watts) at a specific moment can be written as follows:

$$P = GHI.\eta pvAv$$

where GHI is the total area (m2) of the PV panel, efficiency, and global horizontal irradiance (W/m2) received on a horizontal surface. own features pertaining to a battery model, the highest amount of energy that can be stored [15-16].

$$Eb = AbVb$$

III. Study system discerption

PV system equipment used in this study includes a microcontroller, charger controller 12/24V, two 24V batteries, and a load of 50WAT. The model has certain limitations, which we mention here: module ND-060p1, maximum power p (max) of 60 W, open circuit voltage of 22 V, short circuit current of 3.9 A, voltage at maximum power of 17.4 V, current at maximum power of 3.45 A, and overcurrent protection of 7.5 A radiation 1000w/m2. The wind turbine's equipment, which includes a 300-watt wind model, a 50-watt rectifier load, and two fans to move the wind turbine, is subject to some limitations, which we discuss here. The circuit displays the Angle 300, rated power 300wrated voltage 24V, rotor diameter 1.44m, startup wind speed 2m/s, wind speed rated 9m/scut-out wind speed 35m/s. Experimental Research The power output characteristics of wind turbines and photovoltaic PV systems were studied using varying radiation levels (400w/m2, 600w/m2, 800w/m2, and 1000w/m2). The wind speed fluctuates. 3 m/s, 4 m/s, 5 m/s, and 6 m/s, and we will examine the power production characteristics at various wind turbine speeds. The goal of the research technique is to simulate both models and conduct experiments with the PV system and wind turbine in order to compare the outcomes of the simulation and the experiments.

- **DC-DC buck converter**

A switch-mode power supply with an output voltage greater than its input voltage is called a boost converter. In a boost converter, a MOSFET or IGBT is used for switching. Only the first loop's current flows while the switch is closed, and the inductor's current increases. The output capacitor is then charged to a higher voltage than the input when the switch opens and the voltage across the input and the inductor merge in series. The output voltage is determined by the duty cycle of the switching signal. The output voltage should increase with the length of time the switch is closed. The boost converter's design CRF, or current ripple factor [17].

- The IEC harmonics standard states that CRP must be contained within 30%.

$$ie\frac{\Delta I1}{I1} = 30\%$$

- VRF, or voltage ripple factor.

$$ie\frac{\Delta I0}{I0} = 5\%$$

- Frequency of switching (fs)
- Fs= 100 KHZ
- Input voltage Vg=12V
- Output voltage Vo=24VOutput load current Io=3.45A
- duty cycle calculation (D)

$$\frac{V0}{Vg} = \frac{1}{1-D}$$

When D = 0.5

- ☒ Ripple current calculation (ΔI_L)

$$\Delta IL = (0.3 * 3.45)A = 1.035A$$

- ☒ Inductor value calculation (L)

$$L = \frac{(Vg * D)}{(f * \Delta IL)} = 5.8 * 10^{-5\,H}$$

- ☒ Capacitor value calculation of (C)

We have:

$$\frac{\Delta V0}{V0} = \frac{DTs}{Roc}$$

$$Ro = \frac{V0}{I0} = \frac{24}{3.45}$$

SO:

$$C = \frac{0.5}{(10^5 * 6.96 * 0.3)} = 2.3 * 10^{-6} F$$

- ❖ **MATLAB wind turbine model**

a. Wind turbine model

Wind turbines come in two varieties: vertical axis and horizontal axis. Because they are easier to design and have lower costs, especially for high repower ratings, horizontal lexis wind turbines are the preferred option.

b. Model of Rectifier

The AC-generated output voltage, which will vary in both magnitude and frequency, is converted into DC by a three-phase diode bridge rectifier. The following is the average output voltage of the three-phase diode rectifier.

i. Vdc=(3*Vm)/π
ii. Idc = Vdc/RL
iii. Irms=Vrms/RL

c. An everlasting magnet Permanent Magnet Synchronous Generator Model

A synchronous generator is the best option for wind turbines with variable speeds. For swine turbines, the Permanent Magnet Synchronous Generator offers the best speed variable at 3 m/s, 4 m/s, 5 m/s, and 6 m/s. 300 watts with a three-phase output.

IV. Discussion and Result

The outcomes of the simulation and experiment. It begins by providing the presented experimental results are examined, together with the results of the evaluated experimental PV system and WIND turbine. The simulation findings are reported in the second half of the chapter, and then the stated results are discussed.

A. Results and discussion of the experiment.

According to the experimental results presented here, we tasted the PV in various radiations with a 50-w dc load. In radiation 400 w/m2, the voltage was 14V, current was 0.50A, and power was 7V. In radiation 600 w/m2, the voltage was 17V, current was 0.80A, and power was 13.60w. In radiation 800 w/m2, the voltage was 20V, current was 1.1A, and power was 22w. In the final radiation of 100wlm2, the voltage was 25V, current 1.3A, and power was 32.50w. This allows us to demonstrate the PV's output power under various radiation conditions.

B. MATLAB SIMULINK Simulation Outcomes and Discussion

MATLAB SIMULINK was utilized to model the solar photovoltaic circuit. In order to investigate the solar photovoltaic power characteristics at voltage (V) and phase pressure (PI) under a 50-ohm DC load, we evaluated the solar photovoltaic model at different irradiances (1000, 800, 600, and 400) W/m² at a constant temperature (T = 25°C) of 60 W. The total power for all irradiations is 400, 600, 800, and 1000 W/m², based on the solar photovoltaic simulation:

The power is 1.74 W at the first 400 W/m² irradiance, 9.1 W at the second 600 W/m² irradiance, 22 W at the second 800 W/m² irradiance, and 41 W at the last 1000 W/m² irradiance.

C. Characteristics of PV cells

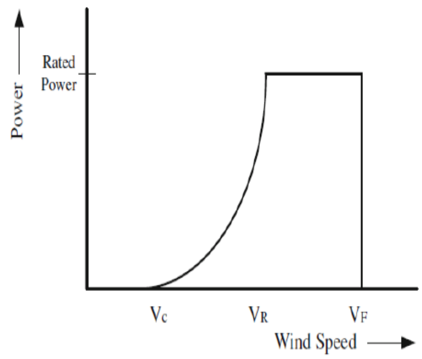
In order to determine the features of power injection vs load resistance, we tasted PV cells in radiation 1000W/m2 and various RLs ranging from 1 to 18 ohm. At 80 Ohm load resistance, the maximum power point is monitored. properties of power injection in relation to load voltage. The maximum power point is monitored at a load voltage of 12 volts.

D. Simulation results and discussion of wind turbine.

The simulation results of variable wind speed started from 3 M/S until 6 M/s with dc load 63Ω wind velocity M/s is given output power, current, voltage.

E. Characteristics of wind turbine

We tasted wind turbine velocity 3ms .4m/s 5m/s 6m/s and different RL start from 16 until 60 RL we got MPP at wind turbine RL24 ohm Power injection versus load resistance characteristics, Maximum power point at 24 Ohm load resistance.



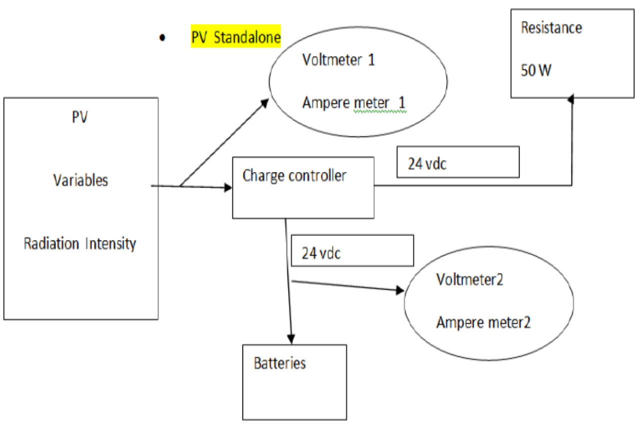


Fig 1and 2: A typical wind turbine characteristic / Experimental of PV.

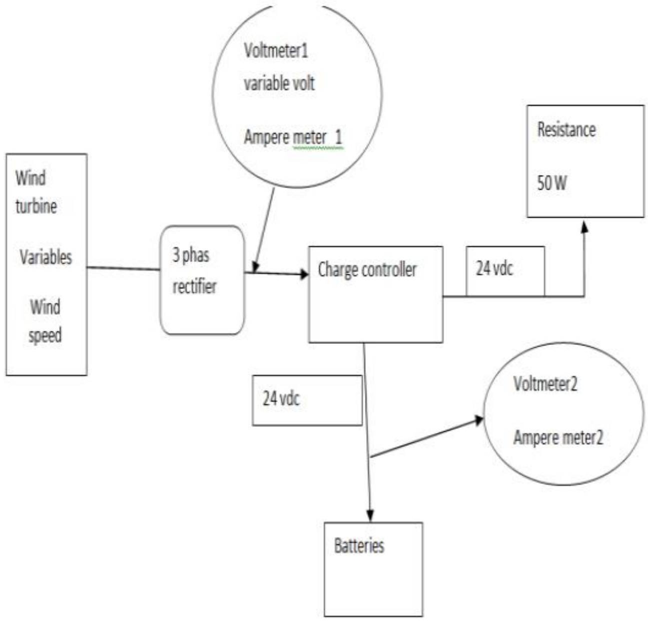


Fig 3: experimental of wind turbine.

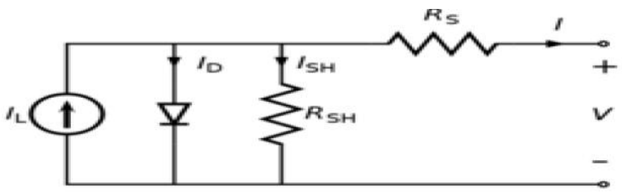


Figure 4: PV model.

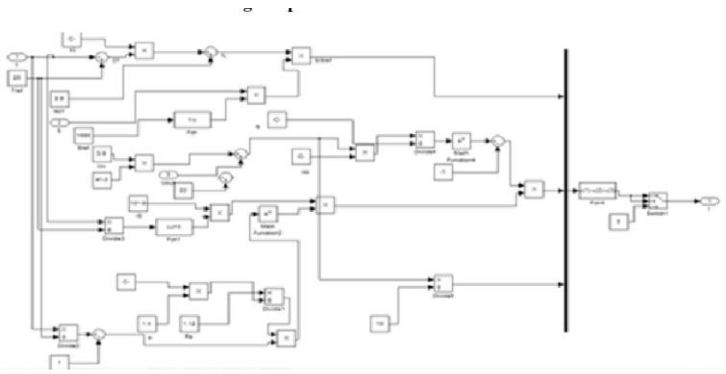


Fig 5: PV cells modeled in MATLAB SIMULINK.

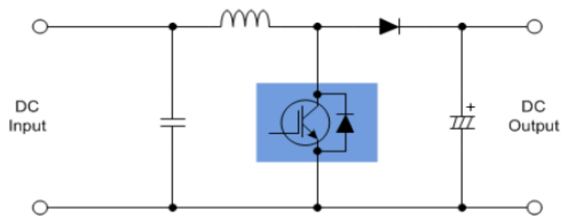


Fig 6: Boost Converter.

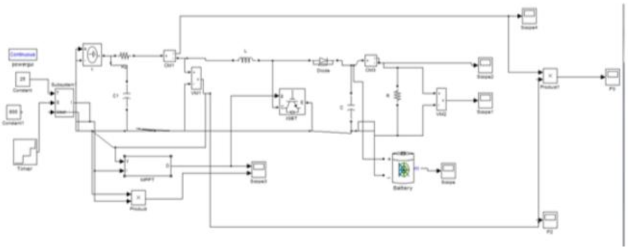


Fig 7: model of PV whole system.

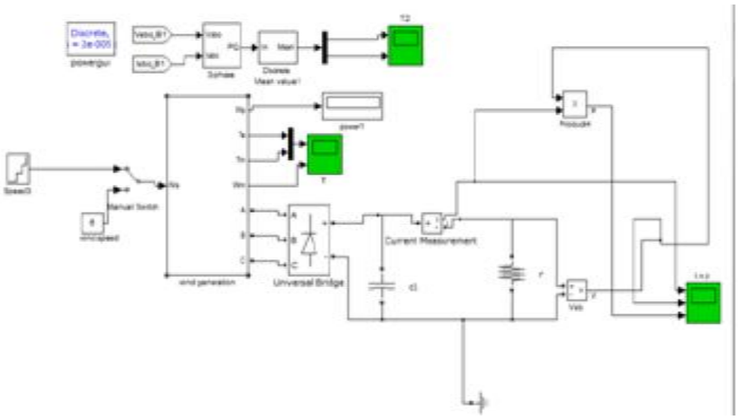


Fig 8: model of wind turbine with dc load MATLAB SIMULINK.

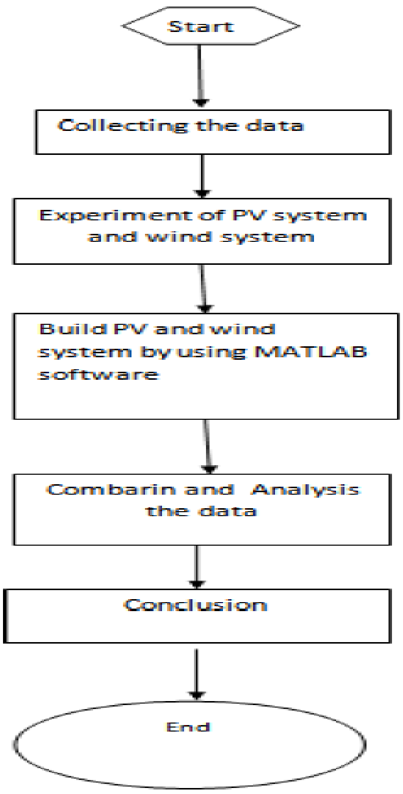


Fig 9: The flow chart of The Research Methodology.

Table1: Results experiment of PV.

Area of PV	PV power	Radiation intensity	V (volts)	I (amps)	P (V * I)	Eff	V (Battery volts)	I (Battery amps)	P
0.4352	174.08	400.00	18.20	0.34	6.19	0.036	24.70	0.19	4.693
0.4352	261.12	600.00	22.90	0.42	9.62	0.037	25.40	0.30	7.62
0.4352	348.16	800.00	23.3	0.58	13.51	0.039	25.60	0.30	7.68
0.4352	435.2	1000.00	31.8	0.76	24.17	0.056	25.20	0.70	17.64

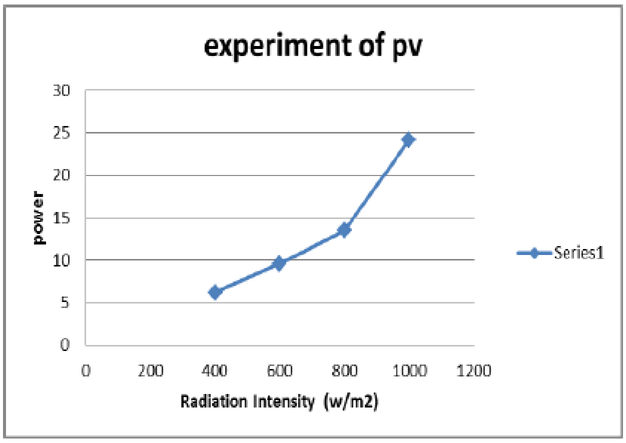


Fig 10: Output power of PV with different radiation

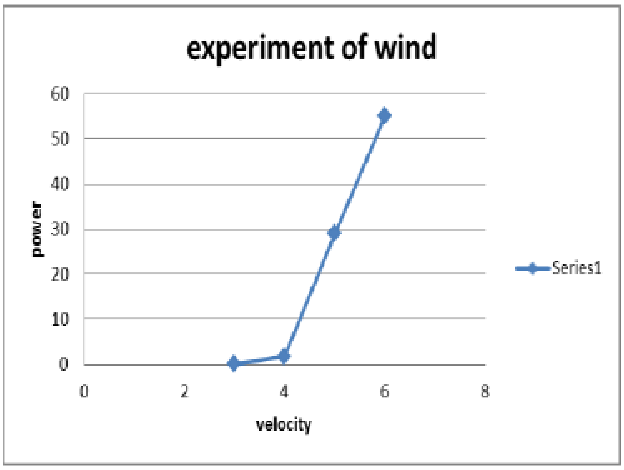


Fig 11: Output power of wind turbine in different velocity

V. Conclusion

The present paper describes the simulation and the experiment of PV and wind turbine system studied characteristics the of power both of PV/wind turbine dc load 50 w and steady state, transient regime in PV model as we mention in result. We tasted the maximum power point in PV cell with different RL for wind energy conversion system using variable speed 3m/s 4m/s 5 m/s 6m/ synchronous generator (PMSG)with rectifier dc load 50 w studied the output of wind power, current, voltage Characteristic of wind in different RL.

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