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A novel design and application of the mechanical two-axis solar tracking system

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Abstract: This paper describes the design of a mechanical two-axis tracking solar PV system using light dependent resistors (LDR's) and a microcontroller. The magnifying two-axis tracking sheet is used to capture the sun's energy. The two-axis tracking is focused to get extremely high temperature. This novel design of two-axes tracking system is controlled with two 12V, 6W DC motors, hydraulic system and a driver circuit. Time delays are employed for servo motor. In this study, we designed and tested a novel design of a two-axes solar tracking generation system on the solar energy system. In our two-axes tracking system, solar irradiation was measured according to local time of Küllük location of Igdir province of Turkey, its performance was investigated, and the system configuration and operation principles were assessed. Sum of global solar irradiation amounts was predicted at the location aforementioned (lat. 39.59.13 North and long 43.54.40 East). Furthermore, the coupling part of the motor was redesigned to increase the motor performance by changing hole diameters with changing coupling size. This is a versatile quality for which the tracker could

Keywords: Coupling Part ofMotor, Photovoltaic Power System, Solar Irradiance**,** Two-axes Tracking System,

I. INTRODUCTION

TheSolar energy is related to a constant bombardment of high subatomic energy particles (electrons and protons). Thus, electronic systems operating in space are subjected to radiation in the form of energetic charged particles ie. [1]. Definitely, irradiation of these cells produces atomic displacements within the material. Point defects from these displacements trap minimal electricity produced due to illumination, which reduces the collection efficiency of the charges and characterizes the cells electrically [2]. Several earlier authors conducted similar studies in order to control and advance the behavior of the solar cells in such a hostile (irradiated) environment [3].

The solar cell is described as a device supplying the transformation of light energy into electrical energy. A set of chemical, mechanical and thermal treatments is required for producing solar energy; therefore, these treatments have more or less negative effects on the performance of the final device [4]. These mentioned effects can be characterized by means of ohmic and recombination optical losses [5]. The quality of the solar cell is nearly correlated with its electronic [6] and electrical parameters [7]. Thus, a variety of the characterization techniques have been proposed to improve the servos of the solar cell. These techniques are taken a basis for measuring electrical effects [7-9] of the imperfections involved in the solar energy [12-13]. The photovoltaic conversion efficiency can be changed based on the solar irradiation and other parameters. The electrical performances of the solar energy are reported to be extremely sensitive to the solar irradiation [14]. Much of this energy is dissipated as heat, which leads under solar irradiation, at a relatively high operating temperature if energy which is not transformed into electrical is not drained. When the characterization of solar energy is taken into consideration in this regard, there were many defined methods applied before [15-17]. Generally, these methods are dependent not only the interaction of the solar cell by an external excitation, but also the response of solar energy. The analysis of the response helps to establish the microscopic and macroscopic parameters that run of the solar energy working [18, 19].

Renewable energy sources are emhasized by insufficient energy sources in order to meet increasing demand for energy in developed and developing countries, and increasing damage due to thermal and nuclear power plants. For this reason, it is inevitable not only to use conventional energy sources more efficiently but also to utilize different new and renewable energy sources.

Among renewable energy sources, solar energy, known as the main energy source of the universe, has been recieved more attention in recent years with the increasing electric energy produced from solar panels made up of solar batteries worldwide. Increasing efficiency of the solar panels, solving the problem of the storage of the produced energy and making panels less expensive will increase the use of electricity from solar panels.

With the present work, the renewable energy is becoming increasingly important, and it is targeted to make maximum use of the daylight. In order to guarantee that the solar panel is constantly positioned perpendicular to the sun's rays, it is desired that the solar panel will follow the sun through the LDR Light Plugin Sensor to obtain maximum electric energy from solar energy [20]. In this context, many former studies have been conducted to define the relationship between these parameters and the calculation of solar positions. The computed and estimated parameters were time, longitude of the sun, declination, local azimuth, elevation, sunrise and sunset in real times [21]. This study proposes the use of two-axis solar tracker. The study continues with specific design methodologies related to Light Dependent Resistor (LDR), servoper motors, solar panel, and a software.

II. THEORY

II.1. Design of a two-axes solar tracking system

The aimed tracking system consists of a software established tracking method [22-25] as also seen from (figure 1). The fundamental components of the planned system are four light resistors (LDR) as sun sensors, software, two relay sets, two mechanical switches, hyraulic and two motors (horizontal and vertical)as well as a solar panel supporting structure with a gear mechanism.

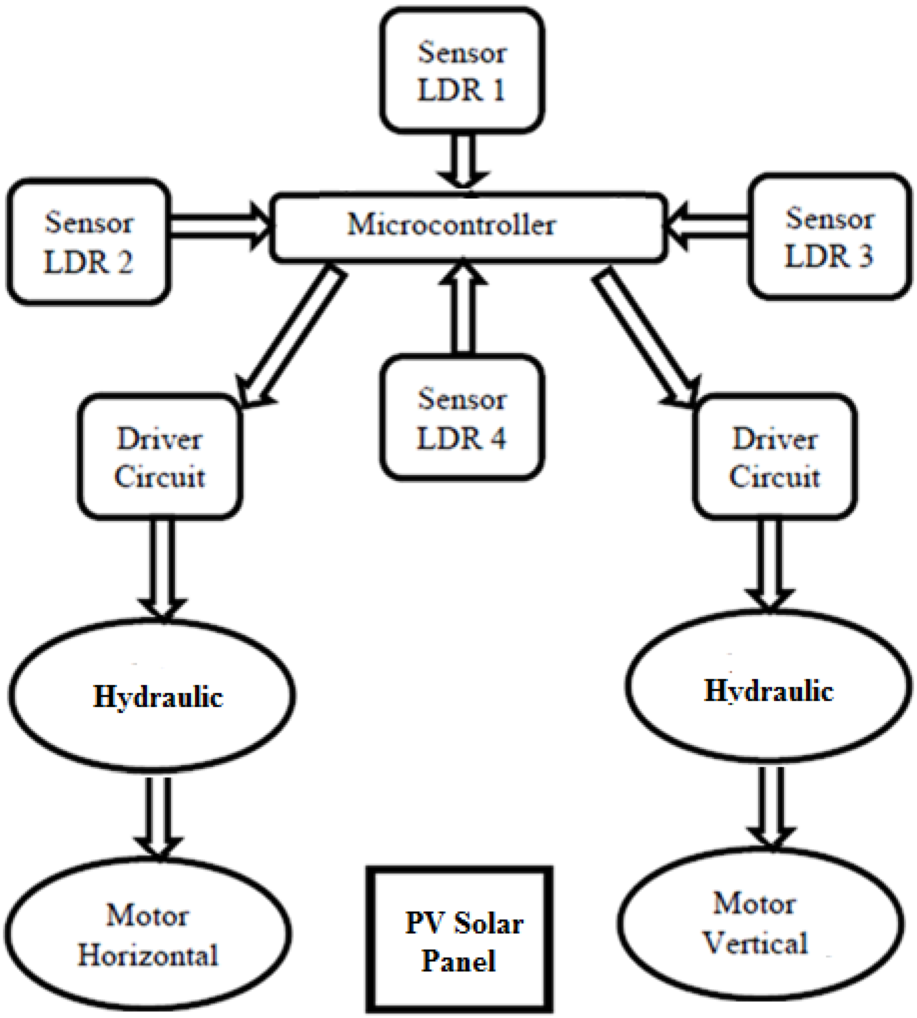
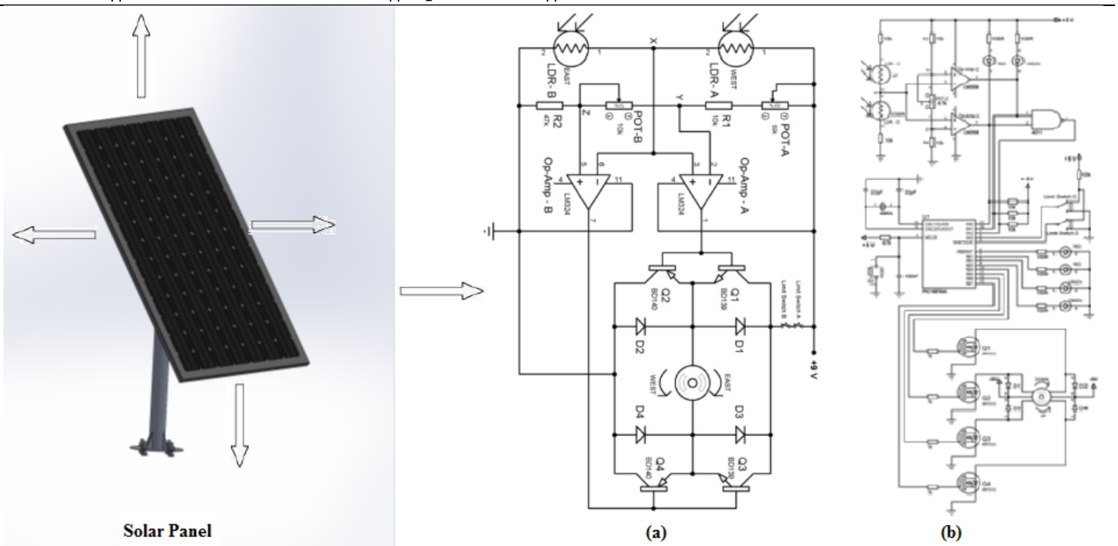


Fig. 1 Block diagram of solar two-tracking system

The mechanical system comprises two relay sets, two mechanical switches with two motors, horizontal and vertical motors as shown in (figure 2).



Circuit scheme of the designed system for (a) horizontal and (b) vertical axis.

Fig. 2 Model of solar two-tracking system and its circuit scheme

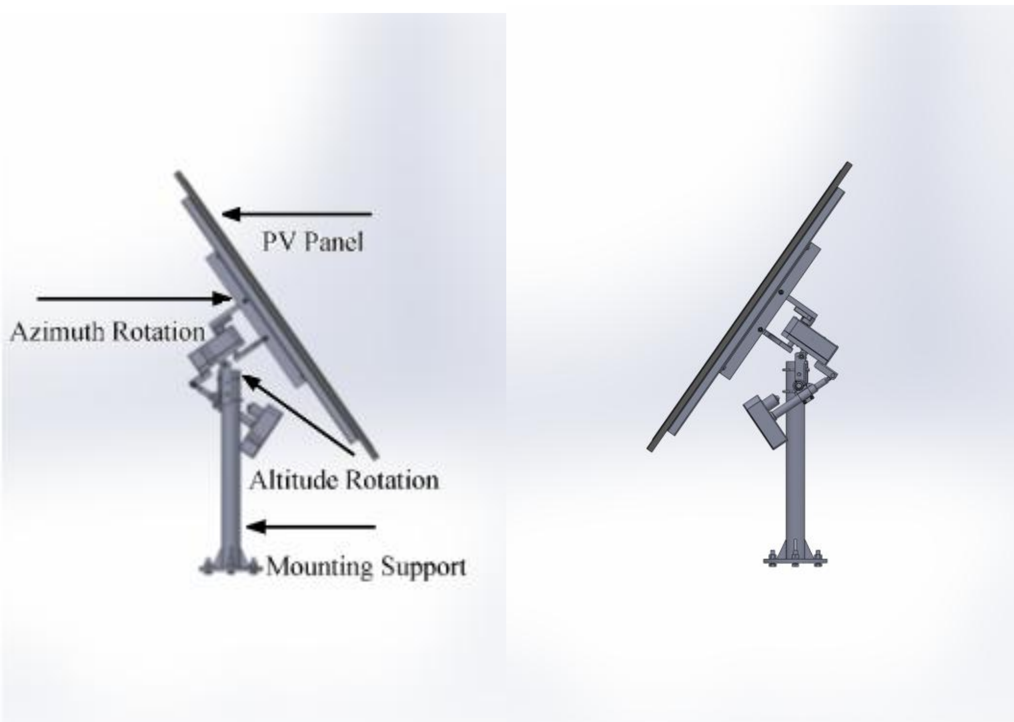


Fig. 3 Mechanical structure for the two-axis solar tracking system.

The servo motor and gear system are connected by means of a joint actuator. The tracking system illustrated in fig. 3 operates on two-axes by a servo motor that provides a torque to move a panel of 18 kg. Furthermore, the coupling part of the motor was redesigned to increase the motor performance by changing hole diameters with changing coupling size figure 4.

Fig. 4 the coupling part of the servo motor

Table 1: Technical data of the mechanical system

Component	Parameters	Value
Solar PV panel	Short-circuit current ($I_{s.c.}$)	8.22 A
	Open circuit voltage ($V_{o.c.}$)	32.2 V
	Voltage at Max. Power (V_{pmax})	26.02 V
	Current at Max. Power (I_{pmax})	7.68 A
	Panel Area	0.48 m^2
	Irradiance	1120
	Maximum Voltage	33.07 V
	Minimum voltage (Vmin)	27.29 V
D.C. Servo Motor	12 VDC, 1.2 A	Two

The hardware design involves the position of the two-tracker axis solar sensors (LDRs). In-circuit current or voltage from the PV panel is first nurtured to an analogue-to-digital converter which is fixed in the microcontroller to convert the analogue voltage input to digital signal for the microcontroller [26-27]. The sensors are suitable for keeping the sunlight normal to the solar panel. The microcontroller feeds the sun sensors information as contributions to produce precise servoper motor orders to revolve the motor at a certain azimuth angle which is consistent with the controller commands. It is rather complex to activate the transfer purpose of this system [22-25]. However, it was made easier to obtain this transfer via the two-axis hydraulic tracker system shown in figure (5).

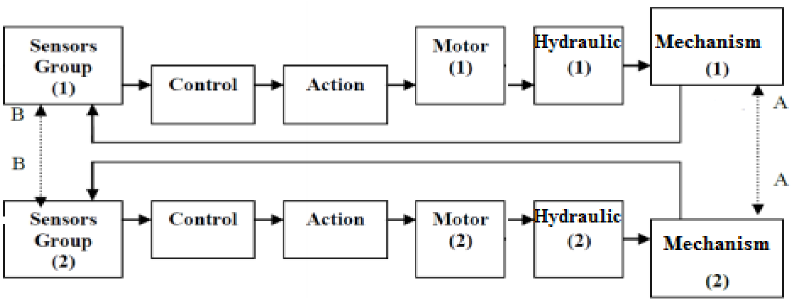


Fig. 5 Transfer purpose of the two axis tracker

II.2. Control software

A control software developed was tested in order to decide the optimal position of the panel during daylight, ie, the system tracks the sun independently in azimuth and promotion angles. The whole working algorithms are in the flowcharts shown in Figures 5. The sunlight intensity from four different directions is measured by the LDR-based sensing circuit. The voltages vE, vW, vS and vN are defined as the sensing voltages produced by the east, west, south, and north LDRs respectively. In an attempt to draw maximum power from the PV panel, the azimuth and elevation tracking processes can simultaneously proceed until the PV panel is aligned orthogonally to the sunlight. The tracker installation is not restricted to the geographical location. For all climate conditions, a predominate method is utilized to resolve the problem of bad climates. The controller program of the solar two - tracker is inscribed as [28].

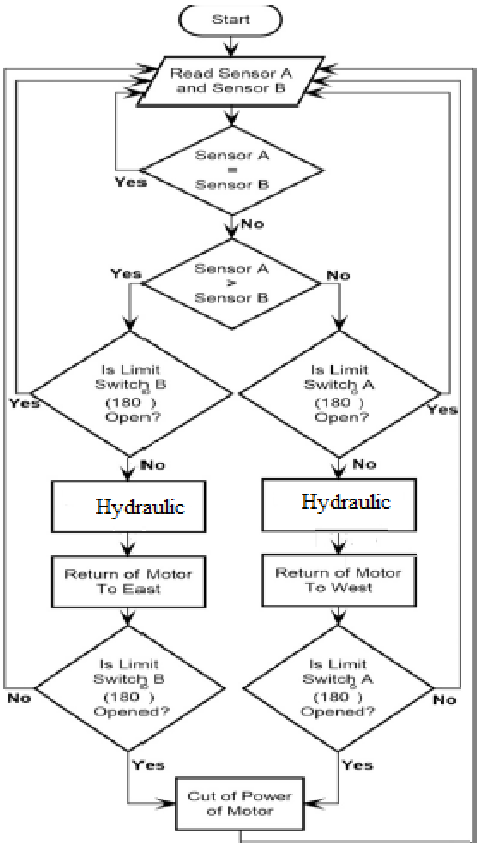


Fig. 6 The algorithm developed to control solar panel

II.3. Measurement of solar Radiation:

In this study, a low-cost device for measuring the sunlight is constructed through the solar panel. Two-axis solar panel has a potential to take place in small-scale markets. This success is basically promoted by the lovest possible energy cost with day-by-day increasing energy consumption rate. The photocurrent module as a function of the photovoltage module is shown in Figure 7.

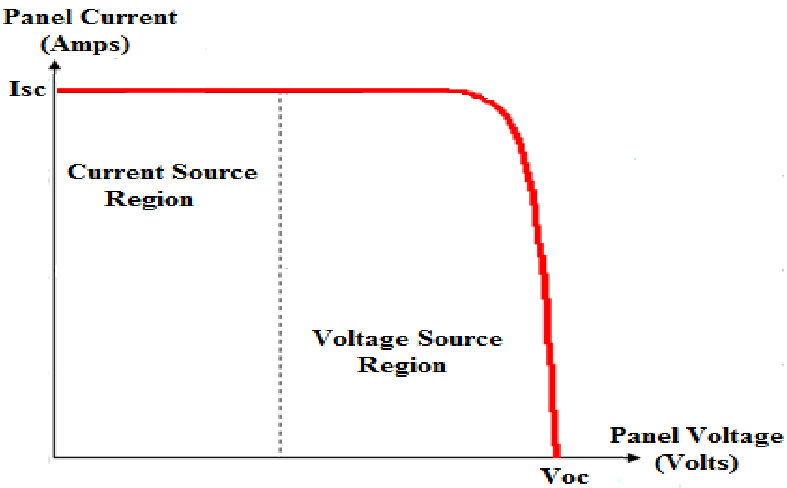


Fig. 7 I-V characteristics of a PV panel

It can be understood from (figure 10) that the current of the solar panel is estimated by measuring the photovoltage across a miniature resistance shunt, thus the current through the resistor is on the tumbling sun shine [9][10].

Table 1: Average percentage differences between 09.00 and 16.00 Polly – crystalline PV-Module (January 2016)

Time	PW of Fixed Axis (Watts)	PW of Two - Axis (Watts)
8:00	0.06	0.06
9.00	11.24	16.48
10:00	30.90	38.15
11:00	35.09	41.43
12:00	35.88	42.51
13:00	37.64	45.44
14:00	27.02	28.23
15:00	29.39	32.82
16:00	30.62	34.98
17:00	16,51	30.01

Since the experimental results of variation of intensity with daylight time (Fig. 11) it is understood that solar concentration increases with day time up to 14 PM. To find the percentage differences between 09.00 and 16.00 Polly crystalline solar PV-Module (January 2016) was measured in power between modules in horizontal position (35 degrees), on fixed-axis tracker and a novel system. The data were revealed in table-1. Even with minor variations because of seasonal changes the power was greater in approval of two axis tracker, fixed axis tracker and a novel system. Here we can see better performance of power on two axis tracker in figure 11. The result indicates that there is a general increase of power about 35-50% for a novel two tracker system in figure 11.

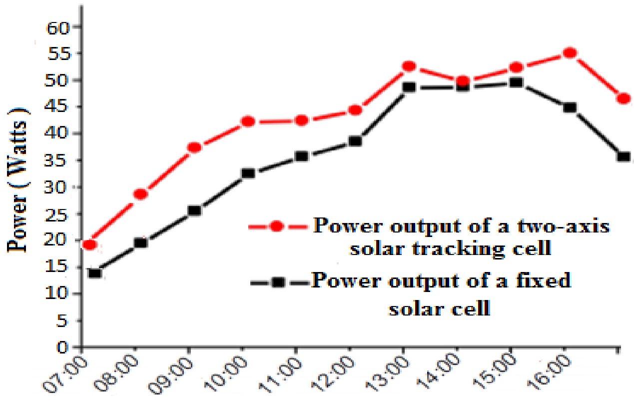


Fig. 11 Variation of power cell output of experimental solar PV panel with day time

Fig. 12 General appearance of two axis solar tracking system.

Additionally, the model was verified by the high-power as shown in table 1, figure 12 shows a picture of the planned solar power plant.

III. CONCLUS ON

An experimental study has been performed to measure the solar radiation using the PV panel. The tracking mechanism is based on two axes tracking the sun. Testing I-V characteristics were probable for solar panel, which nearly meet with best characteristics curve, and gave favorable results for measuring solar radiation and inexpensive method of measuring this significant variable. The obtained results are in agreement with those obtained for Küllük location of Igdir province, Turkey. Sum of global solar irradiation amounts was estimated at the location (lat. 39.59.13 North and long 43.54.40 East) in January 2016. The tracker follows sun from the North to East (Horizontal Motor Module). In addition, these trackers follow the angular movement of the sun in regard to its azimuth angle (vertical motor module). The tracking system operates on two-axes by a servo motor that provides a torque to move a panel of 18 kg or more. Furthermore, the coupling part of the motor was redesigned to increase the motor performance by changing hole diameters with changing coupling size. This is a versatile quality for which the tracker could easily be used for solar panels to produce maximum solar energy.

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