A Design of Single Axis Sun Tracking System

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***Abstract*--Solar power generation had been used as a renewable energy since years ago. Residential that uses solar power as their alternative power supply will bring benefits to them. The main objective of this project is to develop an automatic solar tracking system which will keep the solar panels aligned with the Sun in order to maximize in harvesting solar power. The system tracks the maximum intensity of light. When the intensity of light is decreasing, this system automatically changes its direction to get maximum intensity of light. LDR light detector is used to trace the coordinate of the Sun. While to rotate the appropriate position of the panel, a DC geared motor is used. The system is controlled by two relays as a driver and a microcontroller as a main processor. This project is covered for a single axis and is designed for residential usage. Finally, the project is able to track and follow the Sun intensity in order to get maximum power at the output regardless motor speed.**

***Index Terms*--solar tracking, sun tracking.**

I. Introduction

In last ten years, many of residentials around the world used electric solar system as a sub power at their houses. This is because solar energy is an unlimited energy resource, set to become increasingly important in the longer term, for providing electricity and heat energy to the user. Solar energy also has the potential to be the major energy supply in the future. Solar tracker is an automated solar panel that actually follows the Sun to increase the power [3]. The sun's position in the sky varies both with equipment over any fixed position. One well-known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location, but many other approaches are used as well. Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. The solar tracker can be used for several application such as solar cells, solar day-lighting system and solar thermal arrays [1]. The solar tracker is very useful for device that needs more sunlight for higher efficiency such as solar cell.

Many of the solar panels had been positioned on a fixed surface such as a roof. As sun is a moving object, this approach is not the best method. One of the solutions is to actively track the sun using a sun tracking device to move the solar panel to follow the Sun. With the Sun always facing the panel, the maximum energy can be absorbed, as the panel is operating at their greatest efficiency [4]. The main reason for this project is to get the maximum efficiency for the solar cells. Although there are many solar trackers in the market, the price is expensive and unaffordable because the market for solar tracker is still new and only certain countries use the solar tracker such as USA and South Korea. The large scale solar tracker that normally used is not suitable for the residential use. As a result, this project will develop a Sun tracking system specially designed for residential use for a low cost solar cell.

Previous researchers [5,7] and [6] used LDR and photodiode as sensors respectively. Meanwhile [5] and [6, 7] used DC motor with gear and steeper motor respectively. Those projects have disadvantages and some of the disadvantages are high cost during development, difficult to control motor speed and difficult to design because using microprocessor.

The main objective for this project is to develop the sun tracking solar system model which is a device that follow the movement of the Sun regardless of motor speed. Beside that, it is to improve the overall electricity generation using single axis sun tracking system and also to provide the design for residential use.

LDR or light dependent resistor has been chosen as the sensor because LDR is commonly used in sun tracking system. This is because LDR is sensitive to the light. The resistance of LDR will decreases with increasing incident light intensity [2]. For the controller, PIC18F877A had been chosen. This PIC programming will give the pulse to the driver to move the motor. For the driver, bi-directional DC motor control using relay has been used. The motor controller had been chosen because it can control the motor to rotate clockwise and counter-clockwise easily. DC geared motor also been chosen because it has a hold torque up to 24 kg.cm and low rpm. Last but no least, LM7805 is used to convert the input voltage from the source to 5 V ouput because integrated circuit only need 5 V to operate.

II. Methodology

This project is divided into two parts, hardware development and programming development. Figure 1 shows block diagram of the project.

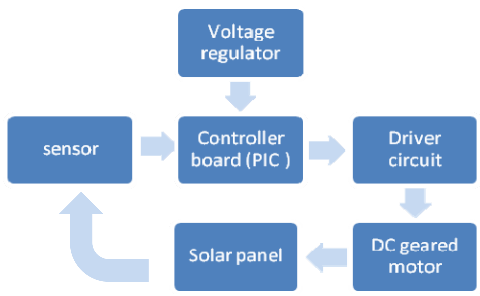

Figure 1: Block diagram of the project

The project is built using a balanced concept which is two signals from the different sensors are compared. Light

Dependent Resistor (LDR) as a light sensor has been used. The two light sensor are separated by divider which will create shadow on one side of the light sensor if the solar panel is not perpendicular to the sun. For the controlling circuit, microcontroller 16F667A acts as a brain that controls the movement of the motor via relay. Data received from the sensors and processed by the microcontroller (PIC16F667A). The microcontroller will send a data to the Bi-directional DC-geared motor via relay to ensure solar panel is perpendicular towards the Sun. Relay controls the rotation of the motor either to rotate clockwise or anticlockwise. The solar panel that attached to the motor will be reacted according to the direction of the motor.

III. Programming

The microcontroller used in this solar tracker system is PIC 16F877A and is ready for ADC converter. Figure 2 shows a flowchart of PIC 16F628A program.

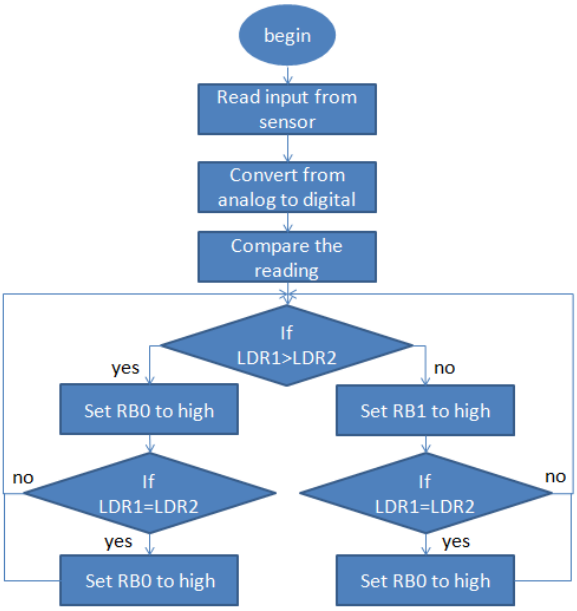

Figure 2: Flowchart of PIC 16F877A program

IV. Result And Discussion

A. Sensor

Figure 3 shows sensor circuits for the system.

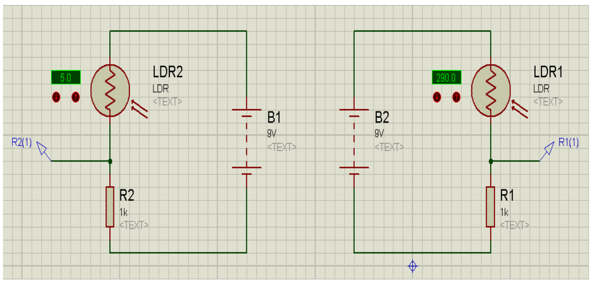

Figure 3: Sensor circuit

Table 1 shows the LDR output voltage.

Table 1: LDR output voltage from solar sensor circuit

To sunlight	V_{RLDR}	V_{LDR}
Exposed	3.75 V	0.74 V
Not exposed	3.46 V	1.53 V

B. Microcontroller

For ADC conversion, the calculation to determine the desired voltage is shown in equation 1 and 2. Using 200_{16}, this condition of sample can be determined. If both inputs for analogue pin in PIC16F877A is less than 0.2 V, the output at pin 33 and 34 will be set low (0). If the difference both input for analogue pin is higher than 0.2 V, the output either at pin 33 and pin 34 will be high (1).

$$V_{step} = \frac{V_{reference}}{ADC\ bit} \qquad (1)$$

For this project, $V_{Reference}$ is equal to V_{DD} which is 4.94 V and ADC in PIC16F877A is a 10-bit ADC module. Thus, the calculated V_{Step} is 0.00482 V.

$$ADC\ output = \frac{Desired\ Voltage}{V_{step}} \qquad (2)$$

Using calculated V_{Step}, ADC output can be calculated using equation 2. For example, the desired voltage is 3.75 V. So the value for ADC is 777_{10} or 309_{16}.

C. DC-geared Motor controller

Relay driver has been used to control the direction of the DC geared motor. Figure 4 shows the control circuit of Bi-directional DC-geared motor using relay.

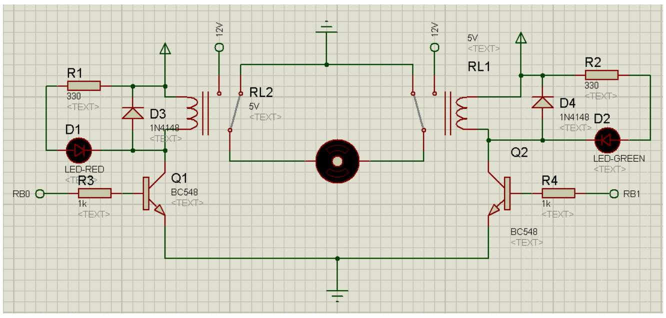

Figure 4: Circuit of Bi-directional DC-geared motor

When the input RB0 is high (1), relay RL2 will be activated. Therefore 12 V will be tapped to the DC geared motor. Figure 5 shows the condition when input RB0 is set to high (1), the motor will rotate in clockwise direction.

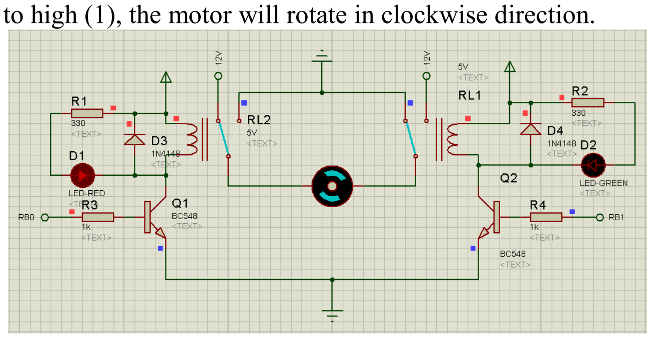

Figure 5: Input at RB0 is high

When the input RB1 is high (1), relay RL1 will be activated. Therefore 12 V will be tapped to the DC geared motor. Figure 6 shows the condition when input RB1 is set to high (1), the motor will rotate in counter-clockwise direction. Table 2 shows the motor operating condition.

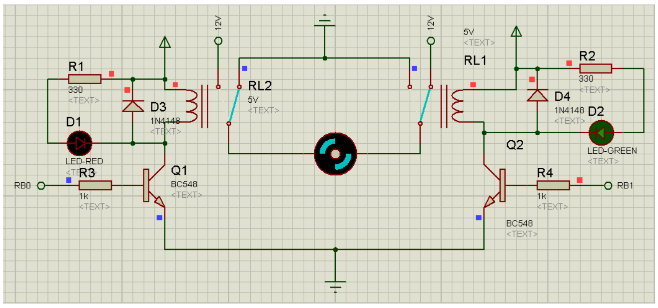

Figure 6: input at RB1 is high

Table 2: Motor operating condition

RB0	RB1	Direction
0	0	Stop
1	0	Clockwise
0	1	Counter-Clockwise
1	1	Stop

D. Solar Model

Table 3 shows the specification of single axis Sun tracking solar system model. Figure 7 shows the constructed designed of the system.

Table 3: Specification of solar tracker

Design Aspect	Specification
Weight	2.4 Kg (including the panel)
Size	38cm x 40cm x 32 cm
Material	Bases- PVC pipe (20MM 3/4") Panel chassis - aluminum bar - (0.55inch x 0.55inch)

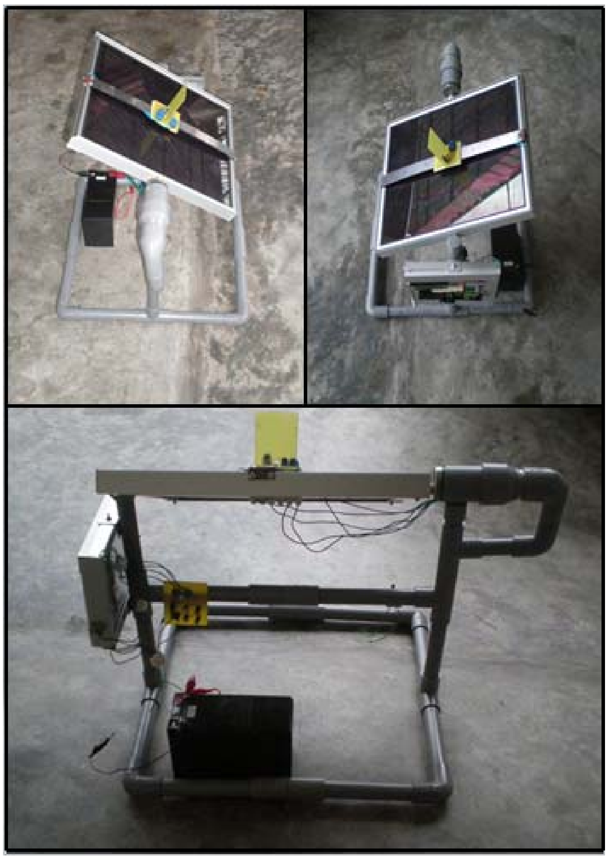
Figure 7: Constructed designed of a single axis sun tracking solar system

E. Collection of solar panel data

Table 4 shows the data of voltage, current and power received from static solar panel and solar tracker for a day. For static solar panel, maximum voltage, current and power is 21.1 V, 5.94 mA and 125.334 mW respectively. Meanwhile, for solar tracker, maximum voltage, current and power is 21.6 V, 6.35 mA and 137.160 mW respectively. Figure 8 shows the power characteristic curve comparison of static solar panel and solar tracker. It shows that solar tracker is able to receive more sunlight and consequently generate more power as compared to static solar panel.

Table 4: Reading data from solar panel

	Using solar tracker Static solar panel			Using solar tracker Static solar panel		
Hour	**Voltage (V)**	**Current (mA)**	**Power (mW)**	**Voltage (V)**	**Current (mA)**	**Power (mW)**
0800	16.8	1.23	20.664	18.3	3.41	62.403
0900	17.0	2.34	39.780	18.9	3.57	67.473
1000	17.6	2.51	44.176	19.4	3.98	77.212
1100	19.4	3.64	70.616	19.7	4.76	93.772
1200	19.8	4.45	88.110	20.4	5.40	110.430
1300	20.5	5.12	104.960	21.6	6.35	137.160
1400	21.1	5.94	125.334	21.4	6.11	130.754
1500	19.4	5.43	105.342	20.5	5.87	120.335
1600	17.2	5.01	86.172	19.6	5.26	103.096
1700	16.5	4.28	70.620	18.5	4.86	89.910
1800	16.2	2.87	46.494	17.5	3.75	65.625

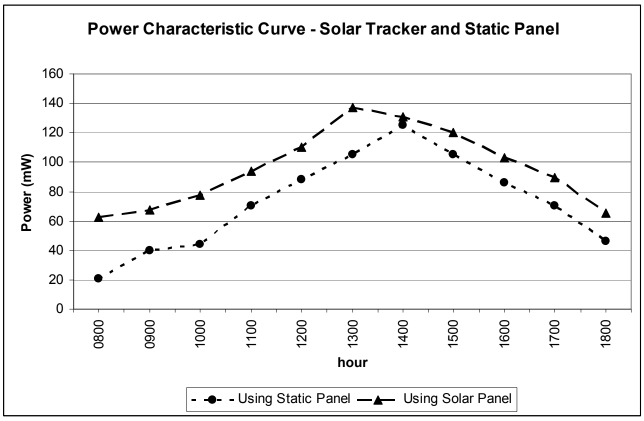

Figure 8: Power characteristic curve comparison of static solar panel and solar tracker

V. CONCLUSION

Single Axis Sun Tracking Solar System model is developed by considering given specification. The system is able to track and follow the Sun intensity in order to get maximum power at the output regardless motor speed. Besides, low speed DC geared motor has been used for neglecting motor speed parameter and therefore the system only focuses in tracking of Sun intensity.

The system can be applied in the residential area for alternative electricity generation especially for non-critical and low power appliances.

VI. ACKNOWLEDGMENT

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VIII. BIOGRAPHIES

Asmarashid Ponniran, was born in 1979 in Johor, Malaysia. He received his B.Eng (Electrical Engineering) and M.Eng (Electrical – Power) respectively from Universiti Tun Husseion Onn Malaysia (UTHM) in 2002 and Universiti Teknologi Malaysia (UTM) in 2005. He is currently working as a lecturer in the Department of Electrical Power Engineering at Universiti Tun Husseion Onn Malaysia (UTHM). He is currently members of Board of Engineers Malaysia (BEM) and International Association of Engineers (IAENG). His field of interest includes Power Cables System and Power Electronics.