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Dual Axis Solar Tracking Control System by using Microcontroller

PHYU EI ZIN[1], WAI PHYO EI[2]
Dept of Mechatronic Engineering, Mandalay Technological University, Mandalay, Myanmar, E-mail: drbear125@gmail.com.

Abstract: The direct conversion of solar energy into electricity using photovoltaic system has been receiving intensive installation not only in developed countries but also in developing countries. Microcontroller based solar tracking control system uses the two DC motor to rotate the solar panel. One DC motor is used to rotate the solar panel east-west and another motor is used to rotate the solar panel south-north. Solar module is used a sensor (LDR) for generating an electric signal proportional to the light intensity falling on it. LDRs are mounted at the edges of the solar panel. Software includes signal receiving from the two LDRs and then compares their resistive value and controlling the motor driver. Hardware design can be categorized into three sections. These are sensor unit, control unit and motor driving unit. Motors rotate the solar panel to keep at right angle to the rays of the sun. This method increases the power collection efficiency.

Keywords: Microcontroller, Solar Panel, LDR, DC Motor And Motion Control System.

I. INTRODUCTION

Renewable energy is energy which can be replenished at the same rate it is used. Interest in renewable energy has been growing steadily over the past thirty years. Renewable energy is vitally inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydropower, geothermal, solar, wind, ocean thermal, wave action and tidal action. Among these sources, solar energy is more popular than other renewable energies to take over the scarcity of hydrocarbon in future. Solar energy is well distributed over the occupied portions of the world and has minimal adverse impact upon the environment. Solar energy is quite simply the energy produced directly by the sun and collected else well, normally the earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The electromagnetic radiation (including visible light, infra-red light and ultra-violet radiation) streams out into space in all directions.

The solar radiation received just outside the earth' atmosphere is approximately 1.353 kW/m^2 on the surface normal to the sun. But it is much less than this value due to the absorption and scattering effect of the atmosphere. On the ground the intensity of solar radiation is only about 1000 W/m^2. The radiation intensity differs from places according to their position (latitude) on the earth. Places with high latitude receive less radiation compared with places on the equatorial areas[1]. As the range of application for solar energy increases, so does the need for improved materials and methods used to harness this power source. There are several factors that affect the efficiency of the collection process. Major influences on overall efficiency include solar cell efficiency, intensity of source radiation and storage techniques. The materials used in solar cell manufacturing limit the efficiency of a solar cell. This makes it particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency of the overall collection process. Therefore, the most attainable method of improving the performance of solar power collection is to increase the mean intensity of radiation received from the source. There are three major approaches for maximizing power extraction in medium and large scale systems. They are sun tracking, maximum power point (MPP) tracking or both [2].

A solar tracking control device is required to move the solar panel to follow the track of the sun. The path of the sun is tracked by light sensors (LDRs) which are compared the light intensity. The design of double axis solar tracking control system is intended to get the maximum energy out of solar panel. This paper presents a system that controls the movement of a solar panel that it is constantly aligned towards the direction of the sun. The motion of the panel are controlled by the PIC 16F887 which are implemented with PicBasic Pro language. The DC motors are used as actuators for specified motions because they can achieve high torque movements in reasonable cost. The two DC motors are used; one motor for moving west-east and another motor for moving north-south. All the motors need the voltages 12V. Photovoltaic system converts solar energy to electrical energy by using solar cells but this energy is DC current only.

II. DESIGN CONSIDERATION OF SOLAR TRACKING SYSTEM

In this research, two DC motors and four solar module sensors are used for the controlling of the solar panel. The first two sensors are used for east-west and the second two sensors are for north-south. The resistive value from each light sensor is read from the microcontroller by PicBasci Pro language. By comparing the resistive value of each sensor, determine whether the motors have to rotate forward or reverse. Motor directions are calculated by software program. When the signals from the first two sensors reach to the microcontroller, the microcontroller will decide the east-west to rotate forward or reverse. If the amounts of resistive values are equal, the motor will not rotate. When the microcontroller accepts the signals from the second two sensors, it will decide the north-south to rotate forward or reverse. The motor will not rotate if the input signals are equal. The block diagram of solar tracking system is shown in Fig.1.

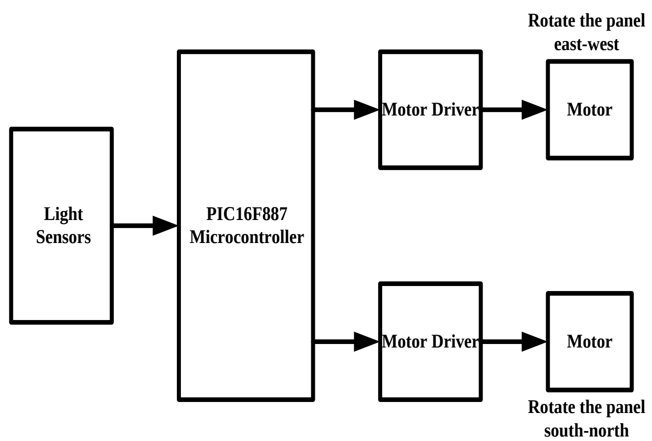

Fig1.Block diagram of the solar tracking system.

A. PIC16F887 Microcontroller

The microcontroller is simply a computer on a chip it is one of the most important developments in electronics since the invention of the microprocessor itself. It is essential for the operation if devices. According to the local availability, the PIC 16F887 is also a good choice for this paper. It is used

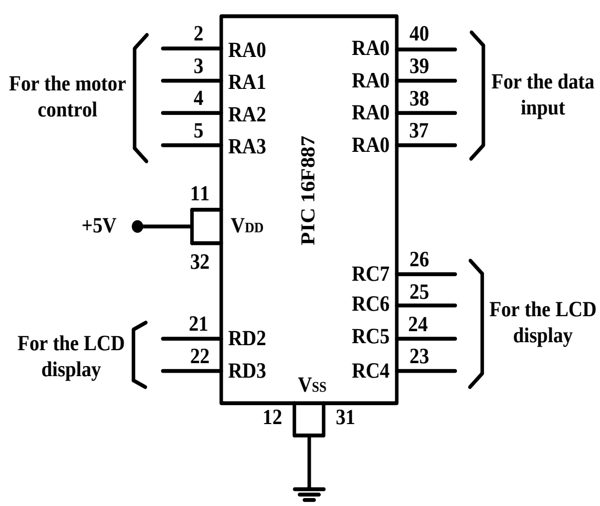

Fig.2. Pin diagram of PIC16F887.

to transfer data to and from other devices, as well as such as temperature [3]. By using POT command, PIC micro-controller read resistive values of LDRs. I/O pins that are listed as just TTL may be used with the Pot command. Pins listed as Schmitt triggers, or ST, do not appear to work with the Pot command. The data sheet states that PORTA and PORTB are Schmitt trigger inputs when used in serial programming mode [6]. The pin assign of PIC16F887 is shown in Fig.2.

B. Light Dependent Resistor (LDR)

A light sensor is the most common electronic component which can be easily found. The simplest optical sensor is a photo resistor or photocell which is a light sensitive resistor these are made of two types, cadmium sulfide (CdS) and gallium arsenide (GaAs). The solar tracking control system designed here uses the cadmium sulfide (CdS) photocell for sensing the light. The typical LDR is shown in Fig.3. This photocell is a passive component whose resistance is inversely proportional to the amount of light intensity directed towards it. It is connected in series with capacitor. The photocell to be used for the tracker is based on its dark resistance and light saturation means that further increasing the light intensity to the CdS cells will not decrease its resistance any further. Fig.4 shows how a typical light dependent resistor behaves in terms of its resistance with changes to light intensity. Light intensity is measured in Lux, the illumination of sunlight is approximately 10000 Lux [4].

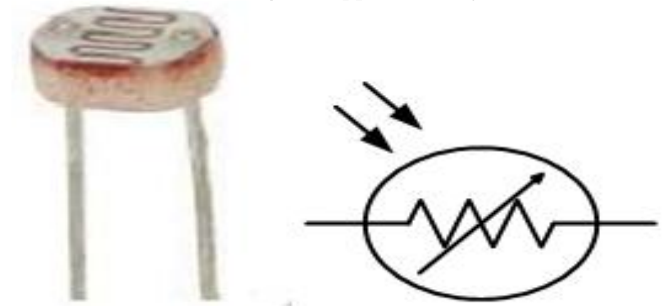

Fig.3. Light dependent resistor.

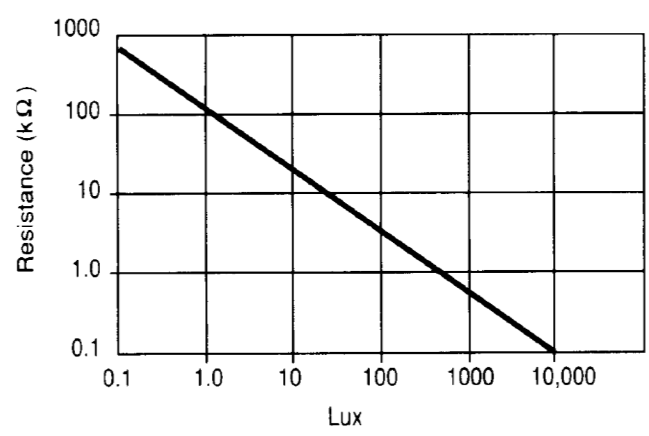

Fig.4. Light-resistance characteristics.

C. DC motor

Two DC motors are used to rotate the solar panel. In this system, two similar gears are used for double axis solar tracking system. The DC motor makes actual and exact number of turns or degrees of rotation instructed by the microcontroller. The parameters of the DC motor used as the movement execution element are: rated voltage 12V, rated current 0.85A, maximum speed 22 rpm, gear box with a speed reduction of 1:200, rate power 20.4 W.

Fig.5. Photograph of DC motor.

D. Polycrystalline Solar Panel

In this system, 35W a poly-crystalline solar panel is used to convert energy from light energy to electrical energy. A single cell can generate only about 0.1 to 3watt of power, depending on its size. Larger the size of the solar cell larger will be the power output. Solar PV panel produce power output proportional to their size. A small PV panel will produce small power and a large PV panel will produce large power. A PV panel can produce as small as one thousandth of a watt (one milli-watt). Normally a few common specification are seen all types of solar panel which like nominal voltage, maximum voltage, open circuit voltage, maximum current, short circuit current, maximum system voltage, and maximum power [5].

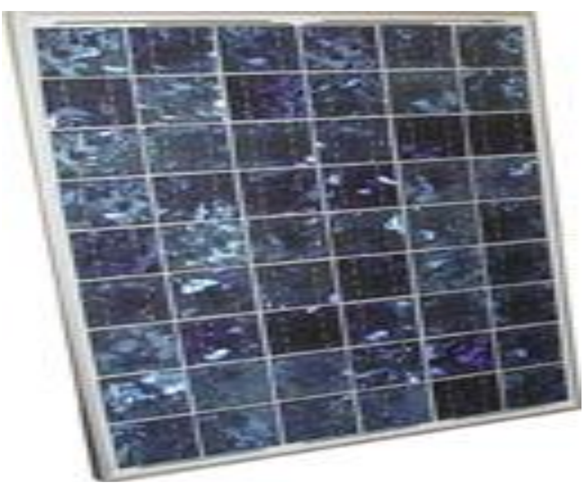

Fig.6. Polycrystalline solar cell.

E. Motor Driver

Relay driver has been used to control the direction of the DC geared motor. Fig.7 shows the control circuit of Bi-directional DC-geared motors using relay. Table 1 and Table 2 show operation condition of the motor1 and the motor2.

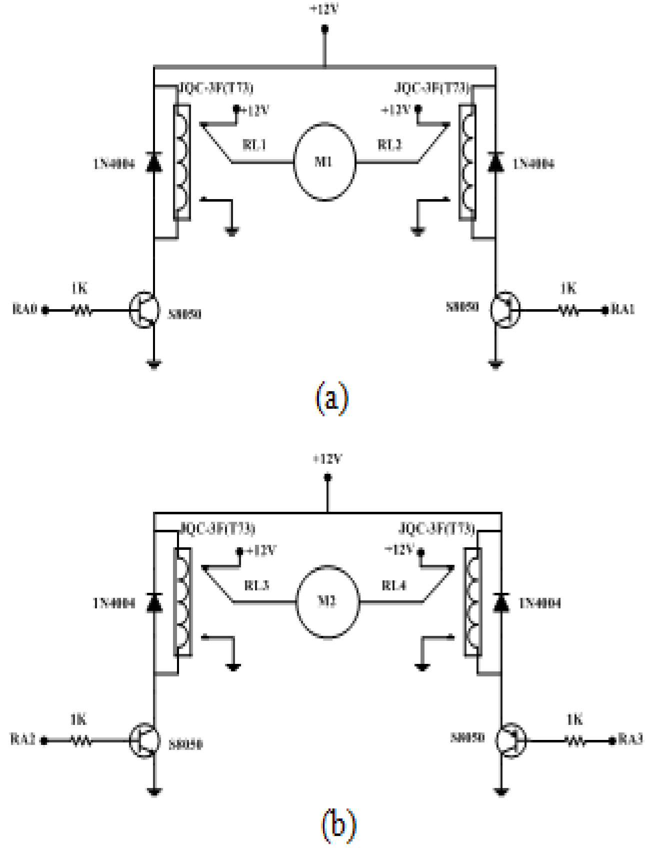

Fig.7. (a) Circuit of Bi-directional DC-geared motor1, (b) Circuit of Bi-directional DC-geared motor2.

TABLE I: Motor1 Operation Condition

RA0	RA1	Direction
0	0	Stop
1	0	Forward
0	1	Reverse
1	1	Stop

TABLE II: Motor2 Operation Condition

RA2	RA3	Direction
0	0	Stop
1	0	Forward
0	1	Reverse
1	1	Stop

III. OPERATION OF THE SYSTEM

Fig.8 shows the flow chart of solar tracking system. When the sun shines, the light sensors are touched the ray of light. At that time, the operation will be started. As soon as, the rays of light reach on the light sensors, the PIC microcontroller receives the signals through the sensor circuits. And then, the PIC microcontroller is used to decide whether motor1 rotate or stop and whether motor2 rotate or stop. If LDRA1 and LDRA2 are not the same condition, the motor will rotate forward or reverse direction. If LDRB1 and LDRB2 are also not the same condition, the motor will rotate forward or reverse direction. It is shown in Fig.9. When the signal condition of LDRA1 and LDRA2 is same, the motor1 is stop condition. The motor2 is also stop condition. Therefore, if the motors are stopping, the operation of the system will finish. But, the PIC microcontroller always checks the condition of light sensors. Fig.10 shows the circuit diagram of solar tracking control system.

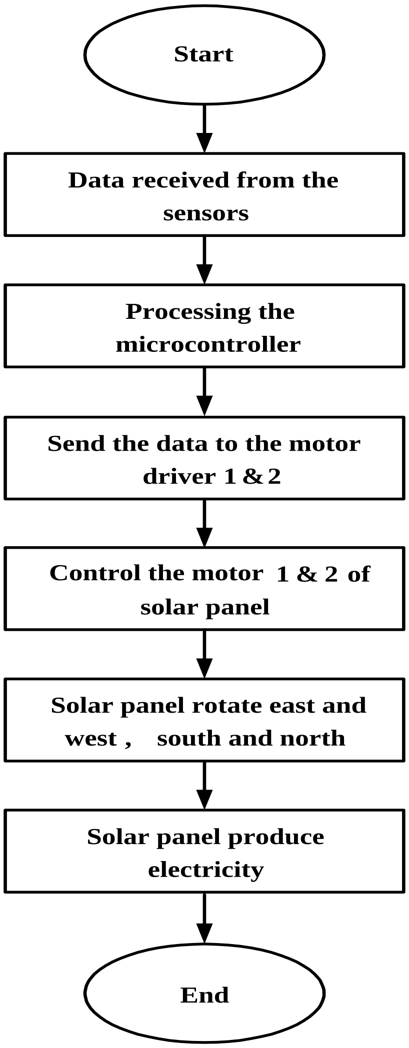

Fig.8. Flow chart of solar tracking system.

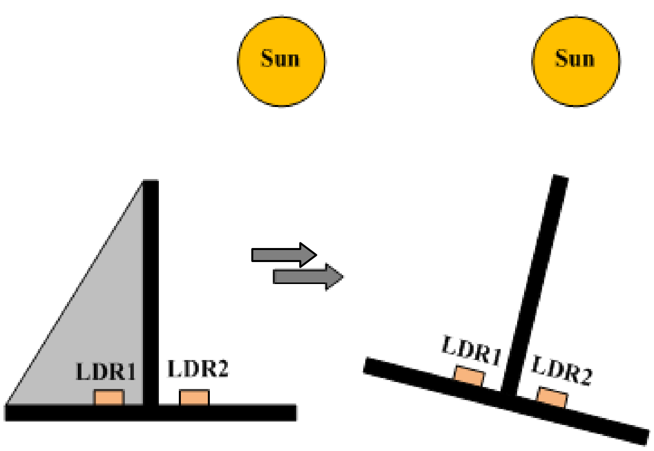

Fig.9. LDR operation once an LDR comes under shadow.

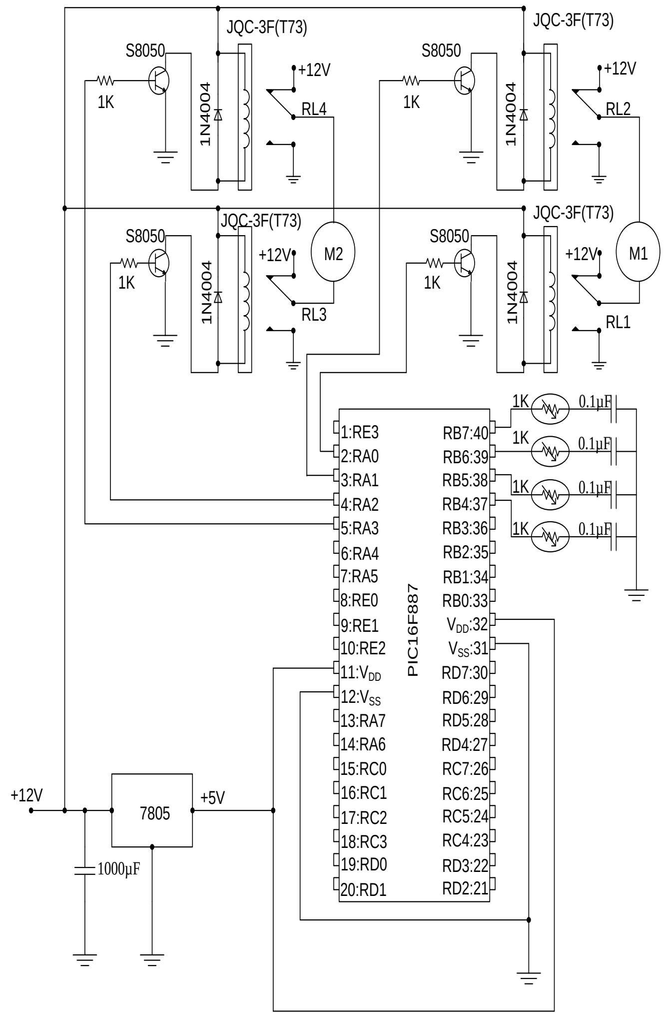

Fig.10. Circuit diagram of solar tracking control system.

IV. SOFTWARE IMPLEMENTATION

Fig.11 shows the comprehensive flowchart which illustrates in detail how the code for the PIC will be written and what functions it will perform. At the system, the solar tracking control system can be used for two ways. The system has four sensors. The first two sensors are for east-west motion of the solar panel. When the amounts of signals are equal, the motor1 must stop. If they are not equal, the motor1 must rotate in forward or reverse direction. The second sensors are for the north-south motion of the solar panel. When the conditions of signals of these sensors are same, the motor2 will stop. If they are also not in the same condition, the motor2 will rotate in forward or reverse direction.

V. TEST AND RESULT OF THE SYSTEM

In the testing, the solar tracking system design is to verify whether the light sensors (LDRs) are working properly. After installing program to the microcontroller the sensing of sunlight circuit is tested. It is located where no object or shadow will obstruct the sun light. LCD displays the resistive value of LDRs. Fig.12 shows the results of two of the four LDRs are covered. LDRA1 and LDRB1 are under shadow. The signals are sent to the motor drivers from PIC 16F887 and then motors rotate forward until the resistance values of all LDR are the same. Similarly in Fig.13, LDRA2 and LDRB2 are under shadow. The motors rotate reverse. A database for the recorded current and voltage readings is created. The tracking system data are recorded in Table 3. The gain in the average power in this case is around 24.56 watts per each hour. The power distribution graph is plotted the against the 6am-6pm period as shown in Fig.14.

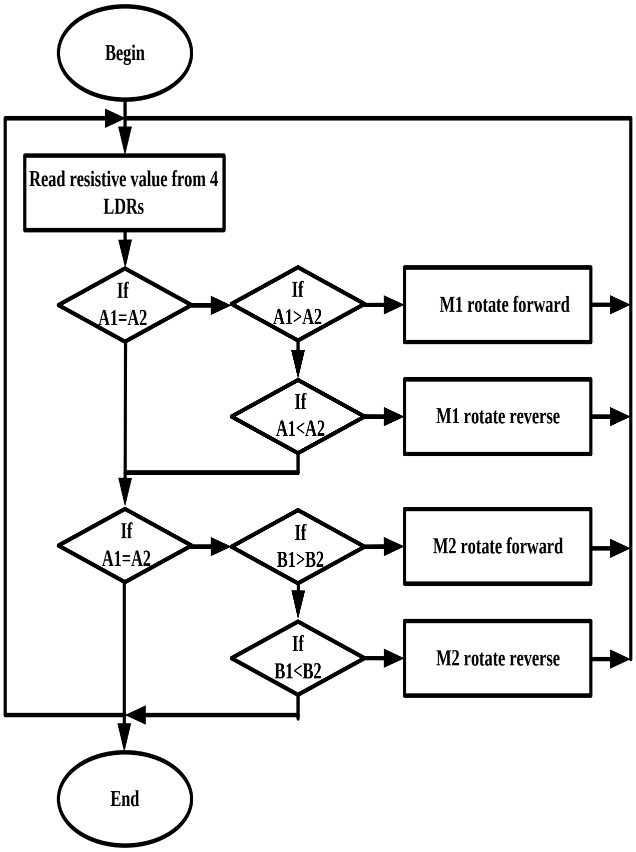

Fig.11. Program flow chart of the system.

Fig.12. Photo of LDRA1 and LDRB1 under shadow.

Fig.13. Photo of LDRA2 and LDRB2 under shadow.

TABLE III: Solar Tracking System Data

Hour	Voltage (V)	Current (A)	Power (W)
06am	10.5	1.05	11.025
07am	12.75	1.5	19.125
08am	15	1.6	24
09am	15.5	1.6	24.8
10am	17.5	1.7	29.75
11am	17.5	1.7	29.75
12pm	17	1.65	28.05
1pm	17	1.6	27.2
2pm	17	1.6	27.2
3pm	17.5	1.7	29.75
4pm	17.5	1.7	29.75
5pm	17	1.55	26.35
6pm	11	1.15	12.65
Average power per hour (W/hr)			24.56

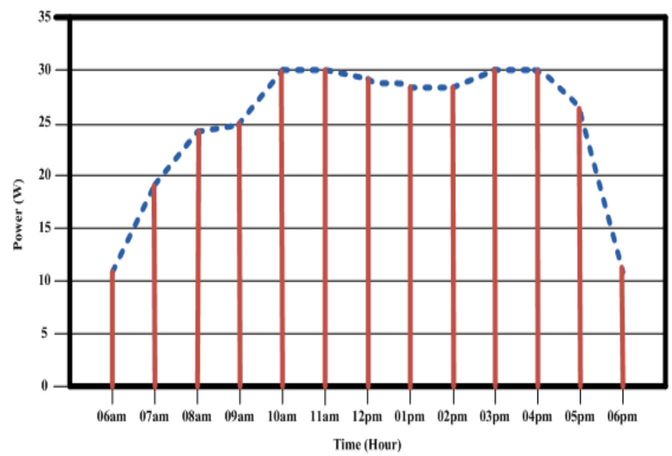

Fig.14. Power distribution over the duty hrs period.

VII. CONCLUSIONS

By using this method, solar light tracker can successful in maintain a solar panel array at a sufficiently perpendicular angle to the sun. Although this design is a prototype towards a real system, its software and hardware can be used to drive a real and very huge solar panel. Therefore, by just replacing the control motor and its circuitry, its algorithm and control system can be used in real huge system. The use of solar power system becomes more attractive because of high reliability. All the components can be changed according to the energy requirement and load of the solar panel. If more solar panels are used for more energy, the load of the solar panel must be determined and suitable motor must be used to rotate the solar panel.

VIII. ACKNOWLEDGEMENT

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IX. REFERENCES

[1] Hill, R, "PV Cells and Modules Renewable, Renewable Energy World," No.1 (July 22), (1998).
[2] S.Armstrong and W.G Hurley, "Investigating the Effectiveness of Maximum Power Point Tracking for a Solar System," IEEE Conference on Power Electronics, 2005 Page(s):204-209.
[3]Microcontroller chip Technology, 2001, PIC16F887 Datasheet www.microchip.com.
[4]Tamara A. Papalias and Mike Wong, "Making Sense of Light Sensor," Application notes, CA: Intersil Americas Inc.227.
[5] S. J. Hamilton, "Sun-tracking Solar Cell Array System," Department of Computer Science and Electrical Engineering, University of Queensland, Bachelors Thesis, 1999.
[6] John Iovine, "PIC Microcontroller Project Book," Chapter (10), 2000.