HELIANTHUS - SMART SOLAR PANEL

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***Abstract*— The paper outlines an application of smart solar "photovoltaic" power generation. Solar panels are typically in fixed position. They're limited in their energy-generating ability because they cannot consistently take full advantage of maximum sunlight. For more effective solar energy system, the solar panel should be able to align with sunlight as it changes during a given day. The present paper examines the design advantages of creating an intelligent solar tracking system like a helianthus flower using microcontroller based embedded system.**

Keywords— Solar, Microcontroller, LDR, Stepper Motor

I. INTRODUCTION

Solar energy is becoming increasingly attractive as an alternative renewable energy source since it is free, non-polluting, and inexhaustible. Solar panels are traditionally fixed. For optimal efficiency, solar panels should be perpendicular to sunlight where the illumination is strongest. But since the direction of sunlight changes during the course of a day, a high-performance solar tracking system can maximize usage of the panels. Tracking systems are found in all concentrator applications because such systems do not produce energy unless oriented closely toward the sun. A 12volts panel may produce around 16volts in full sun to charge a 12volts battery. The system focuses on the controller design such that the system is able to track the Sun for the maximum intensity of Sun light. The paper covers the design and development of a Microcontroller based prototypical solar-tracking electricity generation system that improves the efficiency of solar panels by allowing them to align with the sun's movements.

The paper is organized as follows; in section II Top level system is explained. Section III covers the model based design and simulation. Section IV covers the implementation of the hardware and firmware of the Sun Tracking system. Observations are tabulated in section V. Concluding remark and extending the scope of the paper is given in section VI followed by acknowledgement and references.

II. TOP LEVEL SYSTEM DESCRIPTION

Figure.1 shows the block diagram of the Microcontroller based system. The design combines the microcontroller with the stepper motor tracking controller, display, and communication interfaces. This integration accelerates development while maintaining design flexibility and simplifies testing. The system establishes the direction of sun's movement using two light detection sensors. It conducts the tracking control rule operation to calculate the angle required by the stepper motor so that the solar panel mounted on the stepper motor generates optimal power.

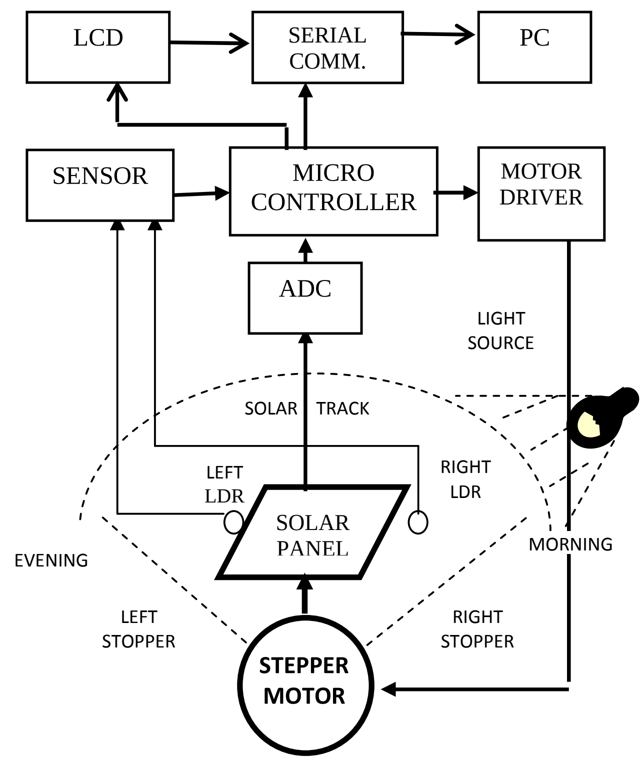

Fig. 1. Top Level system diagram

The design includes three modes as follows:

Mode 1: The solar panel voltage is monitored by the microcontroller through an analog-to-digital (A/D) converter. The microcontroller is the main control core and adjusts the stepper motor so that the platform is optimally located for efficient electricity generation.

Mode 2: The system receives sunlight onto the Light Dependent Resistor (LDR), where the LDR acts as the solar direction tracking sensor. The stable position is when the two LDRs having the same light intensity. When morning arrives, the right LDR is turned on (small resistance approximately shorted), causing a signal to turn the motor continuously clockwise until the two LDRs having the same light intensity again. As the day slowly progresses turning on the left LDR the motor turns counter clockwise, and the cycle continues until the end of the day, or until the minimum detectable light level is reached. The above figures show that when the sun is at the right to the solar panel, right LDR has small value resistance and the left LDR has no light (large resistance) and the software in the micro-controller translate this to signals to control the stepper motor to rotate the panel to the right.

Mode 3: Left stopper and right stopper limits the movement of the solar panel in either direction and prevents the solar panel from hitting ground surface and damaging it or the motor.

The logic flow design of the system is implemented using these three modes as shown in Fig 2. When the tracking control circuit is activated, the system performs energy generation, tracking, and system protection.

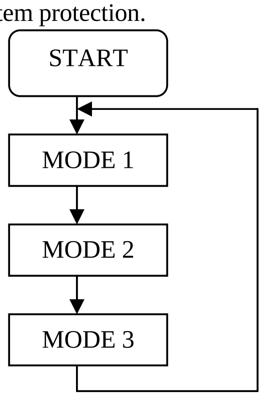

Fig. 2. Logic flow diagram

The signals fed back by the tracking sensors form the basis of the controller input. The control design outputs the signals to control the stepper motor and the solar tracking control system.

II. MODEL BASED DESIGN AND SIMULATION

Model based design approach is an ideal approach for Embedded System Design. There are many system model tools available from various vendors. These tools facilitate the design of hardware and software before actual physical implementation of the system. Proteus tool is used for this project. The Proteus tool also provides virtual instruments like Oscilloscope, Logic analyser to monitor the signals of the system. Step by step design process of building the microcontroller system by interfacing switch, LED, LCD, ADC, Stepper motor driver and Stepper motor and using the assembly language programming Proteus allows assembly code to be assembled and downloaded on the virtual 8051 microcontroller. For C language coding Keil compiler is used. The generated hex code is used to configure and run the system.

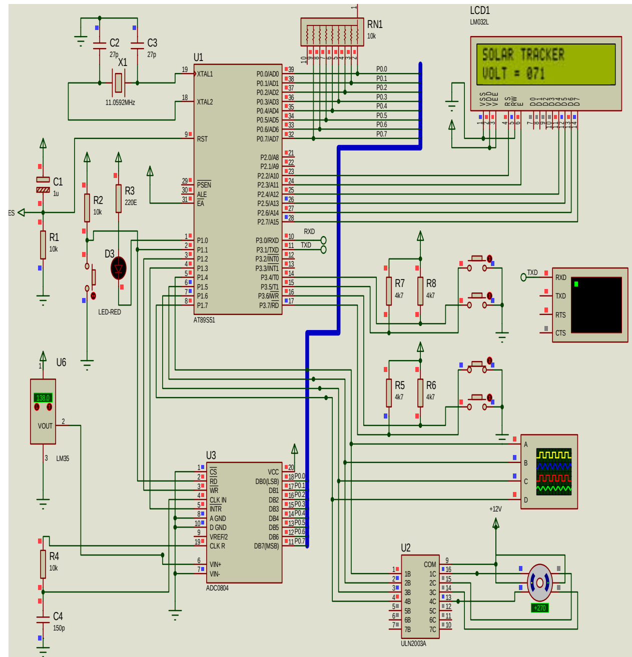

Fig. 3. Schematic and Proteus Simulation Model

The firmware flow chart is shown in Fig- 4. In every embedded system the first step is to initialize all the elements in the system. Device driver for LCD display, Serial communication, ADC, Stepper Motor, timer, LED are coded, assembled and debugged individually. Then these modules are integrated for uniform flow of control and data in real time.

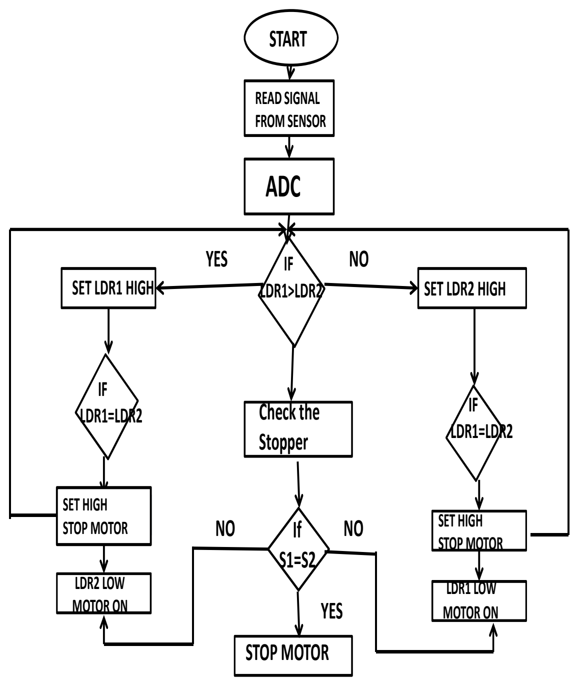

Fig. 4. Software flow chart

III. HARDWARE, SOFTWARE DEVELOPMENT

The hardware development setup is shown in Fig-5. The system design has been kept simple so as to realize a less expensive miniature portable lab prototype model. The hardware is implemented by using 8051-microcontroller, LCD display, 0804ADC, L293DNE bipolar motor driver, bipolar stepper motor, solar panel, LDR, serial communication. A Component Off The Self (COTS) 8051 KIT has been used to speed up the prototype development process. The COTS 8051 KIT with built in LCD and serial communication is procured from a local vendor. Rest of the circuit is built on two bread boards. The 8051 KIT and bread board circuit is driven by a +12V/1A, +5V/1A dual power supply. The 8051 micro controller is programmed separately by the Topwin programmer before mounting on the socket of the KIT. The LCD displays the solar voltage generated. There are two LEDs to indicate the clockwise and anticlockwise direction of the stepper motor.

When sunlight is incident on the solar panel, the sunlight is automatically converted to electrical energy i.e.; the DC voltage. The Solar panel is connected to the ADC, the ADC is connected to the 8051-microcontroller, the 8051 connected to the LCD to display the solar panel DC output. A bipolar motor driver i.e.; L293DNE is connected between the microcontroller and the bipolar stepper motor to provide 12V power supply to rotate the motor. The solar panel is mounted on the stepper motor by the stand. Two LDRs are connected on two sides of the panel to track the sun ray according to the movement of the sun. Two stoppers are connected with respect to the two LDRs. The solar panel voltage is displayed on LCD and also sent to the host PC trough RS232 serial communication to record voltage values over the day.

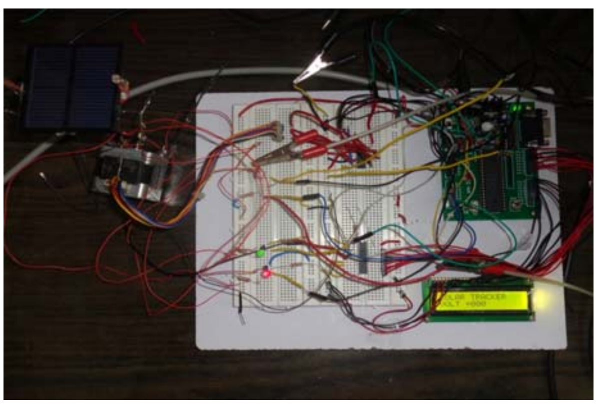

Fig. 5 –Test setup

Solar Panel Specification

Net Wt.	100gms
Maximum Current	80mA
Maximum Voltage	5Volt.

Stepper Motor Operating condition

Table I shows the operating condition of the Stepper Motor.

TABLE I. MOTOR STATES W.R.T. LDR & STOPPERS

Left stopper	Right stopper	Left ldr	Right ldr	Motor states
0	0	0	0	Stop
0	0	0	1	Clock wise rotation
0	0	1	0	Anti-clock wise rotation
0	0	1	1	Stop
0	1	0	0	Stop
0	1	0	1	Stop
0	1	1	0	Stop
0	1	1	1	Stop
1	0	0	0	Stop
1	0	0	1	Stop
1	0	1	0	Stop
1	0	1	1	Stop
1	1	0	0	Stop
1	1	0	1	Stop
1	1	1	0	Stop
1	1	1	1	Stop

III. TESTING, RESULTS AND ANALYSIS

The solar tracking system was tested indoors and the result compared between fixed positions and tracking positions. A searchlight provided a simulated sunlight source, creating a fixed and smart simulated sun-running orbit. Table 1 shows the energy data values for fixed position. Solar panel voltage in fixed position.

TABLE II. SOLAR PANEL VOLTAGE IN FIXED POSITION

No. of Observations	Measured Voltage (Volt.)
1	1.52
2	1.67
3	1.76
4	1.80
5	1.88
6	1.90
7	2.00
8	2.24
9	2.27
10	2.27
11	2.26
12	2.26
13	2.26
14	2.24
15	2.15
16	2.06
17	1.92
18	1.79
19	1.75
20	1.67
21	1.66
22	1.66
23	1.60
24	1.55
25	1.52

Table II shows the data of voltage received from static solar panel and solar tracking system for a day from 7AM morning to 7PM evening i.e; for 12 hours. From static solar panel when both LDRs are in off mode condition, the maximum voltage generated is 2.28V. Meanwhile from solar tracking system when both the LDRs are connected the maximum voltage is 2.95V, as it tracks the sun ray like a helianthus, Figure.5 and Figure.6 show the voltage characteristic curves w.r.t. time from static solar panel and tracking solar system. It shows that solar tracking system is able to receive more sunlight and consequently receive more voltage as compared to static solar panel.

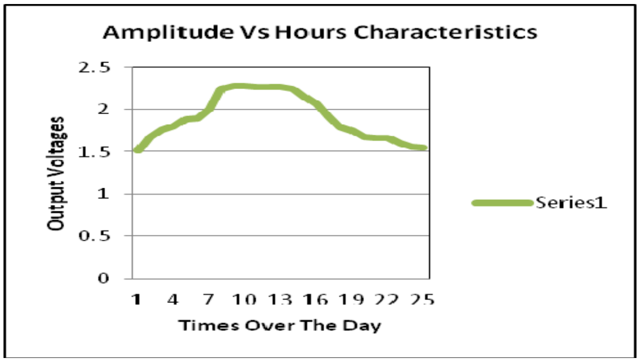

Fig. 5. Solar panel characterstic in static condition

TABLE III. SOLAR PANEL VOLTAGE IN TRACKING POSITION

No. of Observations	Measured OUTPUT (Volt.)
1	2.31
2	2.29
3	2.27
4	2.27
5	2.27
6	2.27
7	2.27
8	2.27
9	2.26

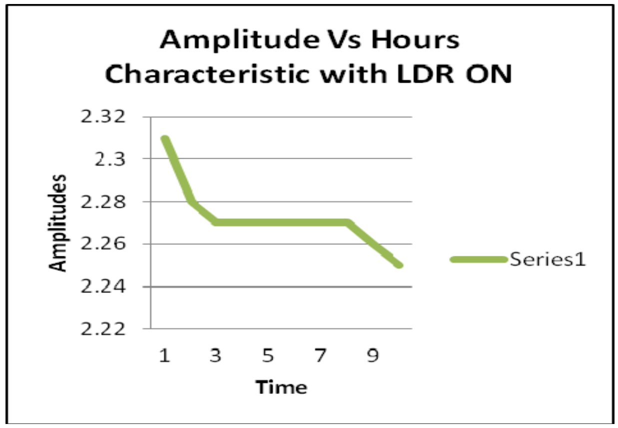

Fig. 6. Solar panel characterstic in tracking position

IV. CONCLUSION

The voltage received from solar tracking system is more than the static solar panel. The average voltage in fixed position is 1.9068 V and in tracking position is 2.2755 V. Comparing the total net electricity generation of the fixed position and smart solar tracking control, the smart system yielded 19.3% greater efficiency than the fixed system.

ACKNOWLEDGEMENT

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REFERENCES

[1] A Design of low power single axis Solar Tracking System regardless of Motor Speed. By:-AsmarashidPonniran, AmmarHashim, AriffuddinJorel

[2] Design and Implementation of a Sun Tracker with a Dual Axis-Single Motor for an optical Sensor-Based Photovoltaic System.

[3] Microcontroller Based Infrared Tracking Device in 2D Motion.

[4] High Efficiency 2D Photonic Crystal Silicon Solar Cell architecture.

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