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Design of solar tracking system to enhance energy extraction

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Abstract

This paper presents the design of a solar tracking system driven by an arduino. The system is based on two, search mechanism (PILOT) which locates the position of the sun and second mechanism (intelligent PANELS) aligns itself with the PILOT only if maximum energy possible could be extracted. On top of that the main advantage of the technique is that the rotation only takes place, if the energy obtained in the new position is higher than that consumed by the panels during the transition.

Keywords: Panels, PILOT, PIC micro controller, LDR, sunrise, sunset

1. Introduction

The goal of paper is to design an active, dual axis, solar tracker with mirror that will have a minimum allowable error of 10° and also be economically feasible to market towards underprivileged countries.

The solar tracking system should satisfy certain technical requirements specific to the studied application, as follows:

1. minimum energy consumption, for the maximization of global efficiency of the installation and optimum performance-cost ratio;
2. reliability in operation, under different perturbation conditions (wind, dust,
3. rain, important temperature variations);
4. simplicity of movement solution (motor, gears, sensors), to diminish the
5. cost and to increase the viability;
6. possibility of system integration in a monitoring and control centralized
7. Structure, which means a digital control solution.
8. Taking into account these implicitly necessary technical requirements, the chosen
9. solution to drive the PV panel is based on the following components:
10. a servo motor, voltage mode drive
11. a motor control system of intelligent drive type, completely digital, that
12. allows the implementation of the digital control of the motor as well as the
13. implementation in a dedicated motion control language of the PV panel
14. orientation application;
15. a measurement system for light intensity applied to the PV panel, representing the sensor that commands the solar panel movement.

2. Background

To improve the system, a better scheme was designed (M. Ghassoul (2009) and M. Ghassoul (2010). The scheme is designed around two sub-systems. The first sub-system is for detecting the position where maximum energy could be extracted and is known as the PILOT, and a second sub-system is made up of the solar panels with the control strategy and is known as panels. This scheme presents an optimal positioning mechanism of the panels so that maximum energy is extracted regardless of the weather conditions and the length of the day. The position is determined by using a search technique, based on a PILOT scheme. The PILOT is built around a small sensor mounted on a miniature electric motor, which only consumes a very tiny amount of energy. The aim of the PILOT is to move to the new angle, and picks up the voltage induced. That voltage is compared with that sensed by the sensor mounted on the panels. If the PILOT voltage is bigger than that of the panels by a predetermined offset, then the panels move and align themselves with the PILOT, otherwise they stay in their current position. This scheme suffers from a major drawback; that is the alignment procedure used (M. Ghassoul (2010). The procedure was based on counting the number of missed pulses then generating a pulse equivalent to the missed pulses to drive the panels through. Due to natural phenomena such as friction, and load variation, the speed by which rotate the panels could slightly vary and this results in the miss-alignment between the PILOT and the panels. On top of that the creation of this total driving pulse has lead to the introduction of extra software which has resulted in missing sometimes of some pulses due to the fact the loading of time constant into the low and high timer registers of the microcontroller results into missing about fifteen pulses not counted. Adding to that the two extra timers resulted in continuous configuration of the latter, one time configured in producing the pulses which drives the PILOT and another time, configured to drive the panels. This has lead to a time lag which is not easy to compensate depending on the variation of the missed unpredictable pulses due to the variation of the weather. Adding to this, when the sky gets unpredictably cloudy especially in winter, the sensor tends to sense lower energy than expected. The solution to this problem is the subject of the current paper. That is by replacing the software procedure by a much simpler alternative hardware one. This is done by mounting a

proximity switch onto the panels and a reflector on the PILOT. When the PILOT moves to the new position, the voltage difference between the voltage detected by the PILOT sensor and that detected by the panel sensor is greater than the threshold then the panels rotate forward to align themselves with the PILOT.
That happens when the panels come close to the proximity of the reflector mounted on the PILOT (about 3 mm), the proximity switch closes. This latter activates the input of the microcontroller; and as a result, the controller drives the panels to standstill. Thus the panels always follow the PILOT regardless of the load, weather conditions, friction as well as the software problem where duration adaptation was needed all the time with the old design. The system waits for the next pulse, and the procedure repeats itself during the whole trajectory. When the end run proximity switch is activated, the system comes to a standstill and waits for the sun to set for the system to roll back to the original position and the procedure repeats itself the following day

3. System Design

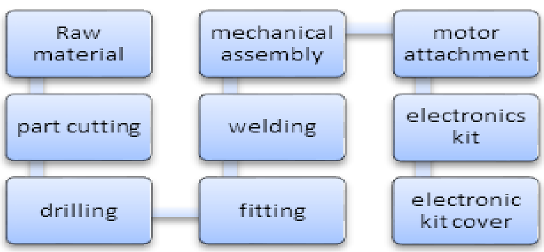

Fig 1: system design

The design depends on two light dependent resistor sensors. One mounted on the solar panel and the second on the miniature motor (PILOT). The miniature motor only draws a very small current, and is used to search for the position where maximum possible energy could be extracted. Before sunrise in the morning, both panels and PILOT are oriented towards the geographical east (known as start run) and wait for sun rise. For synchronization purpose, this position is detected by two sensors. A light dependent resistor (LDR) detects the sun rise and a proximity switch detects the east position. A block diagram of the tracking system is shown in figure (1). On sun rise, the pilot starts rotating through a fixed angle determined by the micro controller internal timer0. Timer0 is programmed with its pre- scalar dividing the system clock (500 KHz obtained from the 4 MHz crystal oscillator) by 1:256, and is used to count the clocks produced by the pre-scalar. When the time elapses, the timer delivers a programmed pulse proportional to the angle which the PILOT has to be driven through to the new position, so that it keeps facing the sun. On the trailing edge of the pulse, i.e. when the PILOT comes to a standstill, the panels and PILOT voltages are compared (this could be done either by software or hardware. In the case of software, both voltages are read by the micro controller through two of its analogue to digital converter channels then compared using the ordinary logic operations.
If the panel voltage is less than that of the PILOT by the predetermined threshold (this is set through a variable resistor), then the panels start moving to align themselves with the PILOT until the proximity switch is activated when it comes close to the reflector mounted on the PILOT. If this condition is not met, then the system moves to the next scan (Figure 1 shows the design of the new system). This procedure repeats itself with each PILOT movement until one of the following conditions is met. Either the end proximity switch is activated or the sun sets, activating the PILOT LDR. In the first case, the proximity switch (known as evening proximity switch) is activated where the PILOT is oriented towards the west (sunset). During longer days of the year, it makes sure that the panels do not over run their trajectory and a misalignment takes place, so that the PILOT and the panels will no longer be facing the sun. If this is the case both panels and PILOT stop and wait for the sun to set which is detected by the LDR. On sun set, the system rotates all the way back to the starting position. When the start proximity switch is activated, the system comes to a halt (facing geographical east) and waits for the sun rise for next day to repeat the procedure (This is basically triggered through a software RS flip flop with reset priority, where the flip flop is set when end run proximity switch is activated and sun sets, and is reset when the start proximity switch is activated).

4. Arduino Technology

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, Max MSP).

5. Sun Rise and Sun Set Detector

The sun rise and sun set detection is straightforward. It is done through a light dependent resistor. When sun rises, the LDR resistance decreases and the current through it increases. The voltage at the transistor base builds up until the transistor is forced into saturation. The collector current in turn increases and the coil is energized, and in turn it pulls the relay to close connecting the supply to the micro controller input PORTA pin RA0. When darkness falls, the LDR resistor increases and the transistor base current decreases cutting the collector current, and in turn disconnecting the relay (The flywheel diode is connected to protect the transistor against the di/dt effect). An identical circuit is used for the sun set, with small difference where the input is connected to the micro controller through pin RA3.

6. Voltage Level Detection

The voltage difference between that of the panels and that of the PILOT is detected using the circuit shown in figure (6). The LDR on the right is connected to the panel and the LDR on the left is connected to the PILOT. The two variable resistors are used so that the voltage threshold could be adjusted. When the light intensity on the PILOT's cell is bigger than that on the panel's cell, the induced current is bigger in the PILOT‟s branch than that in the panel branch; and the voltage at the positive input of the comparator is bigger than the voltage at the negative input; as a result the output of the comparator goes high. This triggers the microcontroller to activate the panel to follow the PILOT as mentioned earlier. If the difference between the two voltages is less than the threshold, then the panels stay in the current position, and the PILOT searches for new position.

7. Results and Discussion

Thus we have successfully increased the efficiency of the electricity produced by the solar panel from 60% to approximately 80%.

Fig 2: final model

8. Conclusion

By using this circuit the solar array can be rotated in required direction following the sun path to get maximum energy from the sun. With the help of arduino the efficiency of the solar panel would be increased. Again use of this technique can capture large amount of solar energy. For this reason the use of the non-conventional energy will increase which is very fruitful incident of our future power sector. It is the main contribution that once the simplicity of solar energy system design is understood, engineers and manufactures will provide new system designs that will expand the solar market worldwide.

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