The International Journal Of Engineering And Science (IJES)
|| Volume || 3 || Issue || 9 || Pages || 32-37 || 2014 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Solar tracking System using artificial Intelligence

[1]Inali Wahane, [2]Prashant Gade
[1]*Department of Electronic&Tele-comm, J.T.Mahajan College of Engineering*
[2]*Department of Electronic&Tele-comm, J.T.Mahajan College of Engineering*

ABSTRACT
Many human mental activities such as writing computer programs, doing mathematics, engaging in commonsense reasoning, understanding language, and even driving an automobile are said to demand "intelligence". Over the past few decades, several computer systems have been built that can perform tasks such as these. Specifically, there are computer systems that can diagnose diseases, plan the synthesis of complex organic chemical compounds, solve differential equations in symbolic form, analyze electronic circuits, understand limited amounts of human speech and natural language text, or write small computer programs to meet formal specifications. We might say that such systems possess some degree of artificial intelligence. Most of the work on building these kinds of systems has taken place in the field called Artificial Intelligence (AI) (Nilsson, 1980). Most AI programs are quite complex objects and mastering their complexity is a major research goal. A comprehensive study of the problems that exist in AI programs requires a precise formalization so that detailed analyses can be carried out so as satisfactory solutions can be
obtained (Bourbakis, 1992).

Keywords: *Artificial Intelligence, USB Comm., Light Tracking Sensors, 8085 Peripherals Interface*

Date of Submission: 13 August 2014 Date of Publication: 10 September 2014

I. INTRODUCTION

Renewable energy solutions are becoming increasingly popular. Photovoltaic (solar) systems are but one example. Maximizing power output from a solar system is desirable to increase efficiency. In order to maximize power output from the solar panels, one needs to keep the panels aligned with the sun. As such, a means of tracking the sun is required. This is a far more cost effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by utilizing a tracking system instead of a stationary array. This project develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency. The PC will calculate the Zenith and Azimuth angle of the sun depending on the Latitude, Longitude and the current time zone. The control system will rotate the panel up and down and also right to left according to the angles as if panel align vertically with the solar position. This approach will provide the maximum utilization of the sun ray to gain the maximum energy. The paper continues with specific design methodologies pertaining to photocells, stepper motors and drivers, Control System selection, voltage regulation, physical construction, and a software/system operation explanation.

II. BACKGROUND INFORMATION

This section presents background information on the main subsystems of the project. Specifically, this section discusses photocell and stepper motor theory in order to provide a better understanding as to how they relate to the solar tracker.

1.1 LIGHT SENSOR THEORY

Light sensors are among the most common sensor type. The simplest optical sensor is a Photo resistor which may be a cadmium sulfide (CdS) type or a gallium arsenide (GaAs) Type. The next step up in complexity is the photodiode followed by the phototransistor. The sun tracker uses a cadmium sulfide (CdS) photocell for light sensing. This is the least expensive and least complex type of light sensor. The CdS photocell is a passive component whose resistance in inversely proportional to the amount of light intensity directed toward it. To utilize the photocell, it is placed in series with a resistor. A voltage divider is thus formed and the output at the junction is determined by the two resistances. Figure 1 illustrates the photocell circuit. In this project, it was desired for the output voltage to increase as the light intensity increases, so the photocell was placed in the top position.

1.2 STEPPER MOTOR AND DRIVER THEORY

Stepper motors are commonly used for precision positioning control applications. All stepper motors possess five common characteristics which make them ideal for this application. Namely, they are brushless, load independent; have open loop positioning capability, good holding torque, and excellent response characteristics. The shaft or spindle rotates in discrete steps increment when electrical command pulses are applied to it in proper sequences. The motor rotation has several direct relationship to this applied input pulses. The sequence of applied pulses are directly related to the direction of motor shaft rotation. The speed of the motor shaft rotation is directly proportional to the frequency of the input pulses and the length of rotation is directly related to the number of input pulse applied.

1.3 USB COMMUNICATION

The Universal Serial Bus (USB) was born of the frustration PC users experience trying to connect an incredibly diverse range of peripherals to their computers. It's the child of vendors whose laptops require a small profile peripheral connector. It further promises to reduce the proliferation of cables and wall transformers that overwhelm even the smallest computer installation.

USB above all offers users simple connectivity. It eliminates the vast mix of different connectors for printers, keyboards, mice and other peripherals. In a USB environment there are no DIP switches for setting peripheral addresses and IRQs. It supports all kinds of data, from slow mouse inputs to digitized audio and compressed video. This specification provides information to guide implementers in using the USB logical structures for communication devices. This information applies to manufacturers of communication devices and system. software developers.

1.4 8255 PROGRAMMABLE PERIPHERAL INTERFACE

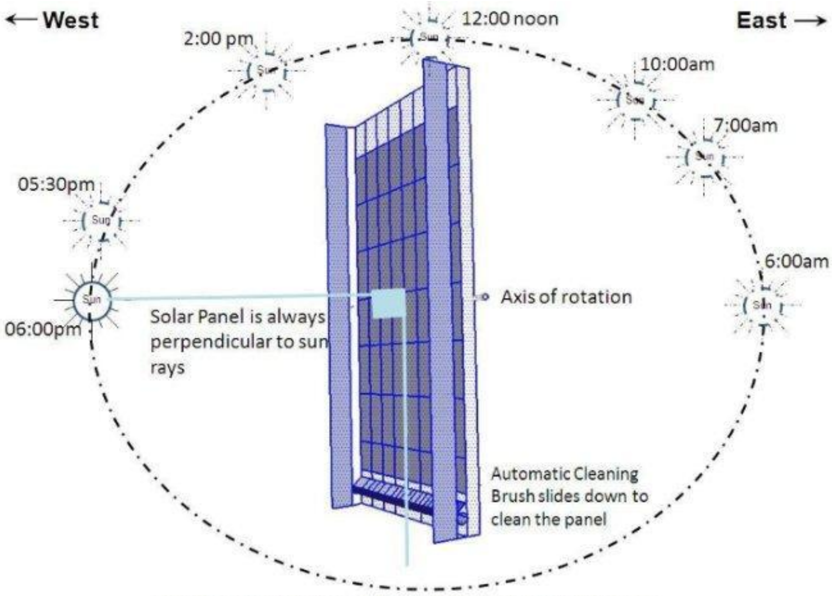
In the SVI-328/318 the 8255 is used to strobe the keyboard lines, to interface joystick fire button switch, the paddle and to control the cassette tape system. The following I/O ports are used to communicate

with the PSG.

SVI	Read/Write	Description
96H	W	Write to Port C
97H	W	Write to Control Word Register
98H	R	Read Port A
99H	R	Read Port B

1.5 SOLAR TRACKING SYSTEM

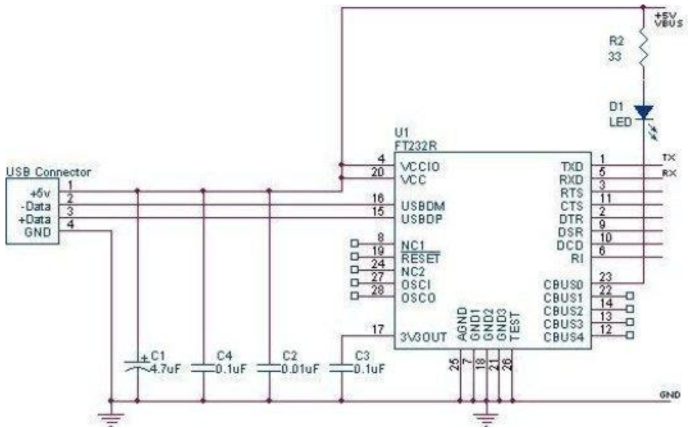
In order to maximize the amount of radiation collected the amount of radiation collected by a solar collector, the tracker must follow the sun throughout the day. But, if the environmental conditions in which the solar PV modules are installed, like tropical climate around the equator, significant amount of dust gets deposited on PV modules. The regular cleaning of PV modules is required in tropical climate which adds to the cost of operation and maintenance of the PV systems. The settled dust, if not cleaned, affects the performance of the solar PV module by shading the front surface. It has been observed that the reduction in energy output from a PV panel with dust could be as much as 50%, when the modules are not cleaned for 30 days.



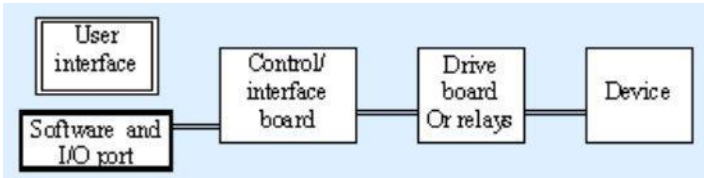
360° Sun tracking system with automated cleaning system

1.6 COMMUNICATION PORT:

The Communication port used for this purpose is based on high speed serial connection serial connection. An USB port is used in this system to communicate with PC where as the microcontroller is connected by an RS 232 port, so a male RS32 to USB converter is used for this purpose. The block diagrammatic representation of this interconnection is shown below.



1.7 COMMUNICATION PROCEDURE:

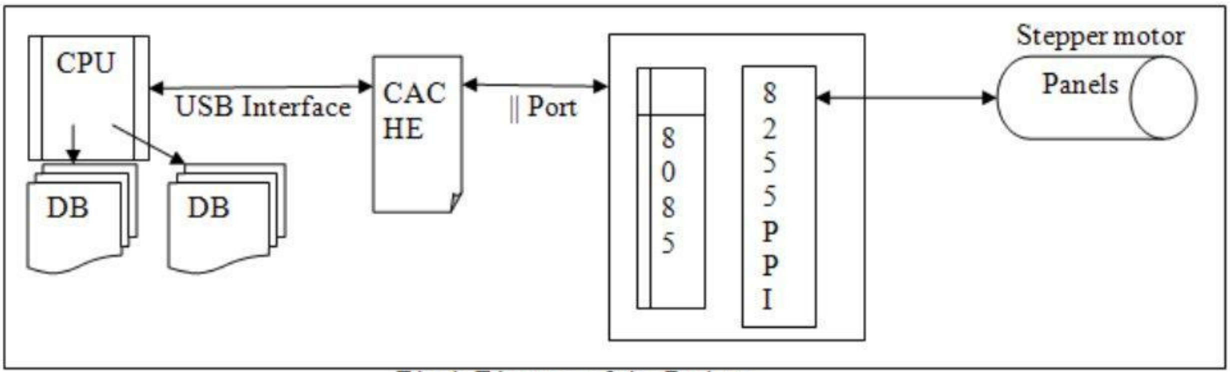


The diagram on the right is a simplified model for computer control. It starts with the user interface. Users give instructions and read information from the control target through the user interface. The software in the computer will process the instructions and send it to the control/interface board through a communication port. The control/interface board will interpret and execute the instructions according to a pre-written protocol.

The interface board uses a microcontroller to interpret and execute the instructions from computer. To make the micro controller understand the instructions, it needs to be loaded with a software. The software is called "**firmware**" to differentiate it from the software in the computer. The micro controller can read status of an input and give feedback to the computer. It can also switch an output to high (normally 5 volt) or low (0 volt).

However, an interface board cannot drive an electric device directly since the output from the micro controller can only take very small amount of current (normally less than 20 mA). So we need to use a relay or a driving board between the interface board and an electric device. A driving board normally consists of integrated circuits (IC) that can take larger current and can be switched by the micro controller outputs. The RSVB1500 adapter board is an example of such driving board

1.8 BLOCK DIAGRAM OF THE PLANNING



Block Diagram of the Project

1.9 SOFTWARE DESIGN ASPECT:

The following section of code will help to generate the azimuth & zenith angle of sun at a particular time instant. Depending on the latitude longitude and local time. The output is directed to a mass storage. The angle is transmitted through USB RS232 to a external memory (like cache). As the 8085 processor working in 3MHz clock but the PC works in 2.3GHz. therefore a speed mismatch is there during the communication. To resolve this problem we use cache memory externally. In this paper we will show a small part of our source code as follows

Source Code <SPA.C>

```
#include <math.h>
#include "spa.h"
#define PI         3.1415926535897932384626433832795028841971

#define SUN_RADIUS 0.26667


#define L_COUNT 6 #define B_COUNT 2 #define R_COUNT 5 #define Y_COUNT 63


#define L_MAX_SUBCOUNT 64 #define B_MAX_SUBCOUNT 5 #define R_MAX_SUBCOUNT
40

enum {TERM_A, TERM_B, TERM_C, TERM_COUNT};

enum {TERM_X0, TERM_X1, TERM_X2, TERM_X3, TERM_X4, TERM_X_COUNT}; enum
{TERM_PSI_A, TERM_PSI_B, TERM_EPS_C, TERM_EPS_D, TERM_PE_COUNT}; enum
{JD_MINUS, JD_ZERO, JD_PLUS, JD_COUNT};

enum {SUN_TRANSIT, SUN_RISE, SUN_SET, SUN_COUNT};
#define TERM_Y_COUNT TERM_X_COUNT
```

```
const int l_subcount[L_COUNT] = {64,34,20,7,3,1}; const int
b_subcount[B_COUNT] = {5,2};
const int r_subcount[R_COUNT] = {40,10,6,2,1};
```

III. RESULTS:

The result section of this paper is also divided into software and hardware sections. In software section we show that how efficiently the program runs and synchronizes with the system parameters and in hardware section it is shown graphically that how this system is superior than that of fixed solar cell systems.

1.10 Software Outputs:

Input	Output
spa.year = 2012; **spa.month = 2 ;** **spa.day = 5;** **spa.hour = 00;** **spa.minute = 48;** **spa.second = 30;** **spa.timezone = +5.30;** **spa.delta_t = 67;** **spa.longitude = 88.38;** **spa.latitude = 22.58;** **spa.elevation = 1830.14;** **spa.pressure = 820;** **spa.temperature = 21;** **spa.slope = 30;** **spa.azm_rotation = -10;** **spa.atmos_refract = 0.5667;** **spa.function = SPA_ALL;**	Julian Day: 2455962.312847 L: 1.353867e+02 degrees B: 1.534067e-05 degrees R: 0.985774 AU H: 197.535037 degrees Delta Psi: 4.963897e-03 degrees Delta Epsilon: -8.268669e-04 degrees Epsilon: 23.436892 degrees Zenith: 162.298649 degrees Azimuth: 72.066660 degrees Incidence: 147.779864 degrees Sunrise: 06:02:16 Local Time Sunset: 17:14:46 Local Time

1.11 Hardware Outputs

During the experiment, two setup are operated simultaneously in the same place throughout a whole day.

(a) In setup A the thin film GaAs solar cell is connected with a fixed frame. The corresponding Efficiency vs Wavelength plot is shown in Fig 1 as plot A.

(b) In setup B the same solar cell is used with the tracking system and the corresponding plot is

shown as plot B.

From the Fig 1 it is seen that the efficiency of the solar tracking system increases significantly than that of the fixed system. From the calculation it is seen that the efficiency increases 10-20% at different time of the day.

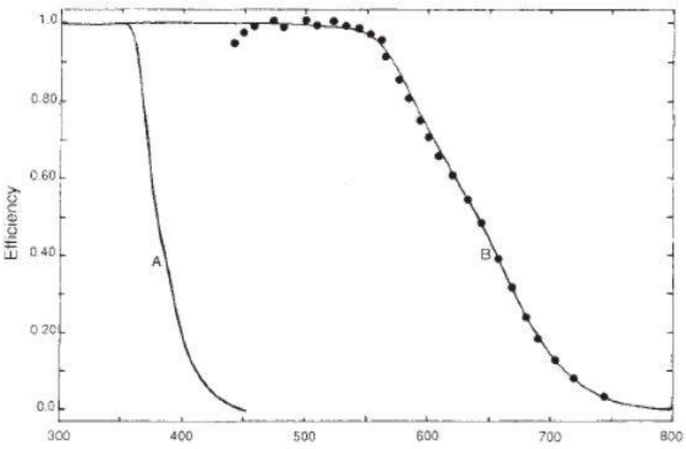


Figure 1: Efficiency vs Wavelength plot of the two systems

IV. CONCLUSION

Based on the obtained results we can conclude that the proposed solution for a solar tracking system offers several advantages concerning the movement command of the PV (Photo Voltaic) panel:

(i) an optimum cost/performance ratio, which is achieved via the simplicity of the adopted mechanical solution and the flexibility of the intelligent command strategy;

(ii) a minimum of energy consumption, due to the fact that the panel movement is carried out only in justified cases, eliminating unnecessary consumption of energy, and due to the cutting of the power circuits supply between the movement periods of the PV panel;

(iii) a maximization of output energy produced by the PV panel, through an optimal positioning executed only for sufficient values of light signal intensity;

(iv) a guarantee of the panel positioning starting from any initial position of the PV panel;

(v) the elimination of unnecessary movements, at too small intensities of the light signals or at too small differences between the signals received from the PV pannels;

Based on the obtained results we can affirm that proposed solution is effective and presents interesting advantages from the point of view of practical applicability to larger power PV structures

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