

DEVELOPMENT OF MICRO-CONTROLLER BASED SOLAR TRACKING SYSTEM

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Abstract

The solar tracking system is an electro-mechanical device comprising three main sections namely: The micro controller PIC 16F84A, the electrical/electronic and mechanical sections. The micro-controller PIC 16F84A, the electrical/electronic and the mechanical section. The microcontroller PIC 16F84A is used to compare the Light Dependent Resistors (LDRs) difference in signal level and the error signal is used in controlling the reversible DC motor, while the two photovoltaic panels which are 12V each are for tracking and absorbing solar radiation. The electronics section contains the sensing devices (Light Dependent Resistors), the ATD 0804ADC which is tailored to operate as a programmable analogue to Digital converters. The ATD 0804ADC works with PIC 16F84A in comparing the LDRs difference in signal level. This method improves the efficiency of the solar tracker, by being able to keep track of the sun raise without human physical effort in positioning the solar panel if the need arises. The mechanical section forms the physical large supporting part of the system. It comprises the tray on which the photovoltaic panels are placed, the movable rod, the jack which support and gives balance to the tray and the metallic basement which is made from iron to give a firm support.

Keywords: *Micro-controller, Solar, Tracking, System, Digital, Analogue, Development, LDR, Bi-directional DC Motor.*

Background to the Study

The modern world today is always changing in every stage of life development; this is due to the technology possessed by man. Power generation is one of the key factors in human life that needs improvement so as to have a simple source of energy to reduce difficulty in power generation. This paper dealt with a source of energy from the sun and how this energy can be received and converted for convenient utilization at a maximum level by tracking the radiation of the sun in all directions.

The solar Energy source consist of the photovoltaic panel that has flat surface that is mounted facing the direction of the sun, so as to receive the intensity of light that will be converted into electrical energy in DC form. However the intensity of solar radiation varies due to the movement of the earth round the sun (Werthen, J.G., 2011). The world experiences the movement of the sun from the east to the west which makes it not stationary from time to time. At this condition it is very difficult for human to be changing the position of the panel all the time.

This technology consist of solar panels, storage batteries as well as an inverter for converting DC to AC power to maintaining a constant peak generation of power supply from the sun, there is need for the subject to the position of the panels from time to time for the search of the solar intensity of sun light by rotating

automatically the panels to follow the direction off the sun from east to west and rise versa. The sun tracking system rotates the PV panel according to the sensors intelligent.

Aim and Objectives

The main aim was to design an electromechanical circuit to implement a solar power system, to generate power to the office of the Head Department, Examination Office and Library in the Electrical and Electronics Engineering Department, Kaduna Polytechnic where six lightening points and six sockets outlets are to be powered. The sun tracking system rotate the PV panel according to the sensors intelligent.

To achieve these aim objectives were pursued:

- I. To develop a system that detects and compare the sun intensity in form of voltage
- II. To develop programming source codes
- III. To test the proper function of the system
- IV. To test the system based on physical operation and to design 3.5KVA inverter.
- V. To implement a system that is capable of moving a servo motor in the direction of highest sun intensity.

Methodology

The method adopted is illustrated on figure 1.0(a) and 1.0 (b) as portrayed on appendices B and A. The first step was to review primary and secondary data. This enables both the technical and social issues to be clarified. Consideration of the technical issues leads to the formation of the option:

1. Bidirectional servo DC motor was adopted
2. PIC microcontroller was used in conjunction with ICs 74LS244 and 74LS393 in which the 74LS393 gives the digital output that operates as the bidirectional output.
3. 3.5KVA inverter was constructed and incorporated.

Literature Review

Energy is an important component in the wellbeing of every society and due to population increase, energy need and energy costs have increased in recent years. Hon. S.P. Kolte M.T and Shweta R.A (September, 2013). In the cause of energy generation, our environment is polluted and global warming is stimulated. To reduce the issue of global warming in our environment, solar source of energy becomes an efficient and safest source of energy generation. Other types of clean energy sources include wind, tides, geothermal heats etc. (Bin Jamaludin November, 2008). The normal solar PV tracks the sun radiation only is one direction. When the direction of the solar radiation is not perpendicular to the solar panel, the energy generated is usually lower compare to when sun radiation is perpendicular to the solar panel. Secondly, the movement of the sun is from East to West, a tracking system therefore which have the capacity to track sun radiation in all direction result in generating more energy throughout the day. The developed system tracks and generate energy from sunlight automatically.

The system used two Light Dependent resistors as sensing devices in which this method of energy generation becomes more economical as compare to that of Bin Jamaludin that uses six sensors. The developed system detect maximum sun intensity when there is decrease in sun intensity that is falling on the surface of the PV panel, the automatically changes its position through the movement of servo motor controlled by the microcontroller PIC 16F84A which result in the movement of PV panel.

Design Analysis

The design consists of two major parts Electrical/ mechanical parts. The electrical part is concerned about electronic circuits this is also divided into three stages, each stage has its own function. The three stages are as follows:

- I. Power supply
- II. Microcontroller
- III. Sensing unit

Power supply:- This is design to provide the operating voltage of the serve motor or by using battery D.C since the project is solar energy so that the D.C supply may be generated from the solar panel of the project.

Microcontroller:- This is design and programmed to control the movement of the solar panel for maximum output at the load stage. Source Code and Pin Configuration is as shown in Appendices A and B (Fig. 1.0a).

Sensing unit:- This stage consist of two LDR light dependent resistors one as the reference LDR and other one as sun tracker.

The design of the entire system started with power supply unit. The power supply unit supplies the circuit with 30 volts D.C which can be obtained from the PHCN main (A.C) and be converted to D.C by rectification/through a battery source, in the case of this design, the power supply may be obtained directly from the solar panel, which does not require any rectification since the panel is supplying a D.C voltage.

The main source of D.C supply is obtained either by rectified D.C power supply or D.C power supply from the battery, our concern of power supply in this design is 30 volts D.C power supply at 0.03MA from the PHCN mains, this serve two purposes:

- I. Provide the D.C to the supply needed to power the electronic circuit (controller)
- II. Provide power supply to servo motor to move the external load.

Calculation of power supply power = IV

$2 \times 30 = 60VA$

To take care of loss, the transform taken 1.1 of the rated power

Power = $1.1 \times 60 = 6.6$ volt amp

Pcail voltage = Rms x v drop for bridge

Rectifier silicon = 30×1.44

= 43.2 volt

Regulator input = $43.2 - 1.4$

= 41.8 volt

Minimum input to the regulator = $3 - \times 2.5$
 $32 - 5v$

Ripple voltage = $43.2 - 32.5$
 $10.3.2007$

T =

T = $= 0.015ccl = 2Am \ v = 10.3$ volt

C = $\frac{tI}{V} = 0.01 \times 2 = 1942 \times 10^{-6}$

Sensing Unit

In the sensing unit design, LDRs are used because of their capability of sensing light or radiation of the sun. The LDRs are placed, one as reference another are as sun light tracker, so that they can notice and detect any slight variation in the intensity of light rays that fall upon them.

Controller Unit

In the controller unit ATD 0804 ADC and microprocessor PIC 16F84 are used to compare the LDRs the difference in signal level of the LDRs and the error signal is use in controlling the reversible D.C motor. The reversal of the D.C motor is achieved using relays normally close to switch the polarities of the motor in clockwise or anticlockwise directions. In this stage the design is entirely depend on the following programmable Ics.

- I. ATD converter ADC 0804
- II. PIC 16F84A microprocessor
- III. 74hs 393 octa transparent 8 latch
- IV. power supply full wave bridge rectifier for
- V. 12 VAC conversion to equivalent 12VDC
- VI. ATD converter ADC 0804 is analogue to digital converter, it is programmed to operate as analogue to digital converter. The method of conversion of this IC is by successive approximation method resolution by 19.6my per step.
- VII. PIC16F84A microprocessor- this has the properties of micro controlling the output instruction based on the information received from the signal difference of the LDR which has a crystal oscillator, which has the frequency that determines the oscillation thus frequency is obtain by the following formula:

$$F = \frac{1}{1.1Rc}$$

the value of the resistor is determine using
 ohms law $I = \frac{V}{R}$ $R = \frac{V}{I}$ some the entire ICs are operating with then voltage rating of 5v
 so that the operating current is 0.0005MA and operating frequency is 2.0MHZ

$$R = \frac{V}{I} = \frac{5}{0.0005MA} = 10K$$

$$F = \frac{1}{1.1 \times 10 \times 10^3 \times 200PF} = 454.54kHz$$

- I. 74LS 244 octabus buffer tristate is programmable to achieved three stage output, the three stage mode called high impedance state or mode, where the output is not plus or minus and also neither one nor minus, thus, it mean that it does not have definate stage.
- II. 74LS 393 octal transparent 8 latch this is data received the input data in order to operate as bi-directional output.

Results

Table 3: Solar Radiation of Bright and Sunny Day in Kaduna

SN	I*w/2M	WS/m/s	TS*c	TBoc	GPS	VDC	IDC	TIME in Range (s)
1	692	3	23	33	653	12:00	12:45	8:30-11:00pm
2	703	3	26	32	635	12:50	2.60	
3	677	2	28	32	635	12:30	2.60	1:30pm – 3:30pm
4	692	3	30	32	635	12:50	2.70	
5	724	2	33	32	635	12:55	2.90	3:30 – 6:30pm
6	692	2	23	30	653	12:00	12:00	

Table 4: Solar Radiation of Cloudy Day in Kaduna

SN	I*w/2M	WS/m/s	TS*c	TBoc	GPS	VDC	IDC	TIME in the Range
1	250	3	26	26	30	635	10.9	8:30am – 1:30pm
2	400	2	27	26	30	635	11.00	
3	500	2	28	27	30	635	11.02	1:30pm – 3:30pm
4	540	3	29	27	30	635	11.22	
5	600	2	29	28	30	635	11.55	3:30pm – 6:30pm
6	250	3	26	26	30	635	10.10	

Conclusion and Recommendations

Conclusion

The current energy crisis and environmental issue associated with the fossil fuel sources is becoming alarming by the day. Photovoltaic solar cells are the main solution to this crisis. However, these devices are limited by production cost. With the development of thin film solar cell technology, it is hope that the aim of substituting the problematic non-renewable fossil fuels with PV is getting brighter. Solar power is shown to be a more productive alternative in the northern regions, though the funding of such a large project is not clear. The development and construction of solar tracker is a welcome development in this part of the world where local roofing techniques is still in use especially in the rural areas. The solar tracking system is an efficient method of receiving maximum sun radiation for all seasons of the year. The developed system has been tested and found to be efficient in addition to its cost effectiveness.

Recommendations

1. For best adaptation, effective and efficient operation, solar tracker is preferred especially at the area where sunshine is less than 3 hours per day
2. At its present status, the system developed can give power generation for small load only to increase the capacity more solar panels, higher rating DC motor and back-up battery are required.
3. With the advent of PHCN digital billing system and privatization policy, it is recommended that the deployment of solar tracking and solar system should be embarked upon in Nigeria.
4. The solar tracking system has more efficiency than fixed position PV panel. The solar tracking system has the capacity to track the sun radiation from East to West and the micro controller enables the servo

motor to rotate in the direction of sun radiation.

5. The developed system is suitable for use in homes for lighting purposes, laboratory for light current equipment experiments.

References

- Bala, E.J., Ojoso, Olu, J.O. and Umar, I.H. (2000). "Government policies and programmes on the development of solar PV sub-sector in Nigeria". Nigerian journal of renewable energy, vol. 8, No. 1 & 2, pp. 1 – 6.
- Bin Jamaludin, N.K. (2008). "Solar Tracking System thesis University Malaysia Pahang, Faculty of Electrical and Electronics Engineering".
- Chopra, K.L., Paulson, P.D. & Dutta, V. (2009). "Progress in Photovoltaics: Research and Application". Prog. Photovolt: Res. Appl. 2009; 12; 69-92.
- Energy Commission of Nigeria (1997): "Potentials for Renewable Energy Application in Nigeria". Gilspar Co. Ltd. Lagos.
- Hon, S.P., Kolte, M.T. and Shweta, R.A. (2013). "FPGA Based Sun Tracking System using Fuzzy Logic". International Journal of Scientific and Technology Research Volume 2, Issue 9.
- Kanama, D., & Kawamoto, H. (2008). "Research and Development Trends of Solar Cell for Highly Efficiency". Quarterly Review, No. 28 July, 2008.
- Khan, S. and Kulkarni, U. (2012). "Design and implementation of Fuzzy logic controller for a DC motor". International Journal of Emerging Technology and Advanced Engineering Website: Ijetae.com (ISSN 2250-2459) volume 2, Issue 8, August, 2012.
- Naam, R. (2011). "Smaller, Cheaper, Faster: Does Moore's law apply to solar cells"? Scientific American, March 16, 2011.
- Photovoltaic: solar electricity and solar cells in theory and practices, <http://www.solarserver.com/knowledge/basic-knowledge/photovoltaics.html>.
- Solar Cell Wikipedia, <http://en.wikipedia.org/wiki/solarcell>.
- Werthen, J.G. (2011). "Trends in solar cell technologies and laser manufacturing". Photovoltaics, Jan, 2011 No:1.