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A Lab View Based Power Analysis of Solar Tracking System and Its Implementation in Real Time

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***Abstract*: -- Sun is very important part of our life and hence Sun is become very abundant source of power. Even so, only a fraction of the entire energy is harnessed and that too not efficiently. The world population is increasing day by day and the demand for energy is increasing accordingly. Since oil and coal are getting depleted and it cannot be replenished, we opt for an alternative source of energy. Renewable energy is derived from natural processes that are replenished constantly. Renewable energies are inexhaustible and clean. The energy comes from natural resources such as sun, wind, tides, waves, and geothermal heat. Solar energy is quite simply the energy produced directly by the sun. This project aims at the development of a simple process to track the sun and attain maximum efficiency using Microcontroller and Lab VIEW for real time monitoring.**

Key words— LDR, Microcontroller, DC motors, PV panel, LCD Display,Labview.

I. INTRODUCTION

1.1 Introduction

As the world population is increasing gradually the need for energy is increasing equally. Non renewable resources like coal which are widely used now a day are getting depleted and cannot be replenished. So we go for renewable resources. Renewable resources are the one which gets regenerated over short interval of time. This type of resourceis used today to make electricity where other power supplies are are absent . One of the main renewable resource is solar energy. It is the energy which the earth receives from the sun that can be converted to other forms of energy and is now in a great demand when compared to non renewable resources. The main objective of this proposed work is to improve solar trackers. They are classified into three types: active trackers, passive trackers and chronological trackers. Active trackers are the one which traces sun's direction from west to east with the help of electronic sensors and motor or actuator drives. At the time of cloudy conditions, the tracker fixes itself to the brightest area of the sky to capture the maximum amount of sun's radiation. Passive tracker is the one which uses a compressed gas fluid with low boiling point and tilts to the side that receives more sun radiation. Chronological tracker are the one which traces the sun by calculating the solar time, which changes as the earth rotates around the sun and changes on a present interval. In this proposed paper chronological trackers are used. The software used to implement the solar tracking system is NI Lab VIEW. It is computer aided software for graphical representation.

1.2 Objective

Solar panel is mainly made from semiconductor materials. Si used as the major component of solar panels, which is maximum 24.5% efficient. Solar trackers are the most appropriate and proven technology to increase the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar trackers get popularized around the world in recent days to harness solar energy in most efficient way. This is far more cost effective solution than purchasing additional solar panels.

Today, solar energy accounts for about 0.4% to total energy generation compared to energy from thermal and nuclear plants. Solar energy if used efficiently will not only meet the power shortage but also reduce the burden on our natural oil reserves. Introduction of solar panels at homes is a solution. But the efficiency of fixed solar panels is quite low as the position of sun changes continuously and hence it moves out of the area of maximum efficiency.

1.3 Organization

Chapter 1-Introduction consists of introduction, Need, Objective & the Theme of system. Chapter 2-Literature survey consists of different methods in which different authors have explained various techniques of Tracking of Sun for Solar Panels and Real Time Monitoring Using Lab VIEW.

Chapter 3-Design and Implementation consists of block diagram & design aspects which includes description of solar panel, ATMEGA microcontroller, tracking, lab VIEW.
Chapter 4-it consists of Advantages of this system. And after that topic is concluded and references are mentioned.

2. LITERATURE SURVEY

2.1 Overview

From the literature, various tracking methods have been proposed and validated around the world in previous works and each of them has its pros and cons in terms of efficiency, complexity and cost. Apparently, the difference in solar tracking efficiency varies greatly among the countries reported due to different geographic location, local landscape and climate. Moreover, the efficiency of solar tracking in the same region during different seasons also differs significantly. The efficiency normally top in the summer, with a marginal performance in winter and the spring and fall have average efficiency. Malaysia as a country which lies at 1° to 7° north of equator has an equatorial climate and long hours of sunshine throughout the year. There are enormous potential for solar energy to be success at this land. However, the potential for the DAST is rarely reported and investigated in this region. Hence, a quantitative advantage of DAST over SSS in this country is still remains unknown although the consistently long sun hour suggested a promising outcome. Solar tracking system is a combination of electronics and mechanical system for aligning the Photovoltaic (PV) panels to the position of the sun. Efficiency of solar tracker works reported around the world the sun will fall on the solar panels and leads to maximum electrical energy gained[1].Basically, solar trackers can be categorized in to three types which are active tracker, passive tracker and chronological tracker. Electrical motors, light sensors and mechanical parts such as bearing and gears together with an electronic controller are used to direct the active tracker towards the sun's position. A preset algorithm for tracking the sun would be programmed into the controller beforehand. On the other hand, a passive tracker utilizes a compressed gas fluid with low boiling point that would become imbalance and tilt to the side that received more sun radiation. Consequently, the passive tracker will move accordingly until the gas fluid is balance again. Chronological tracker tracks the sun by computing the solar time (hour angle) which changes as the earth rotates around the sun and changes on a preset interval. There are prior designs which use different approaches on sun tracking mainly on dual-axis solar track

2.2 Methodology

It consists of three main constituent which are the inputs, controller and the output as shown in Fig 1.A Light dependent resistor (LDR) is a light-controlled variable resistor. They are very useful especially in light/dark sensor circuits. Normally the LDR resistance is very high, up to 1000 000 ohms, but through illumination with light, resistance drops dramatically. LDR's are inexpensive and has a simple structure. A DC motor relies on the fact that like magnet poles repels and unlike magnetic poles attracts each other. DC motors consist of one set of armature winding, inside another set of coils or a set of permanent magnets, called the stator. Voltage applied to the coils produces a torque in the armature, resulting in motion. DC stepper motor is being used here.L293D IC having two channels is used to drive the DC motors. A DC stepper motor driver is used to achieve the desired speed in moving the solar panel[6].The Dc motors can turn either clockwise or anticlockwise direction depending upon the sequence of the logic signals. The sequence of the logic signals depends on the difference of light intensity of the LDR sensors. The principle of the solar tracking system is done by Light Dependant Resistor (LDR). Four LDR's are connected to Arduino analog pin AO to A4 that acts as the input for the system. The built-in Analog-to-Digital Converter will convert the analog value of LDR and convert it into digital. The inputs are from analog value of LDR, Arduino as the controller and the DC motor will be the output. LDR1 and LDR2, LDR3 and LDR4 are taken as pair[6].If one of the LDR in a pair gets more light intensity than the other, a difference will occur on node voltages sent to the respective Arduino channel to take necessary action. The DC motor will move the solar panel to the position of the high intensity LDR that was in the programming[2].

2.3 Using at89c51 microcontroller, ldr and stepper motor

In this setup, the LDRs are placed on the surface of a large curvature. A provision is made such that any immediate two LDRs remain active at a time. The stepper motor follows the bit pattern of the LDRs, and thus, the solar panel connected on the shaft of the stepper always faces the sun normally. The LDR combination plays a crucial role. Basically, these signal patterns are fed to the microcontroller 8051 which in turn directs the motor associated to it.
When the stepper motor gets the last bit sequence of the table, it moves to its initial position and again follows these steps, as the sun traverse from the beginning in next day. The outputs of the LDRs are given to the inverting terminals

of comparator LM324 through a resistor,

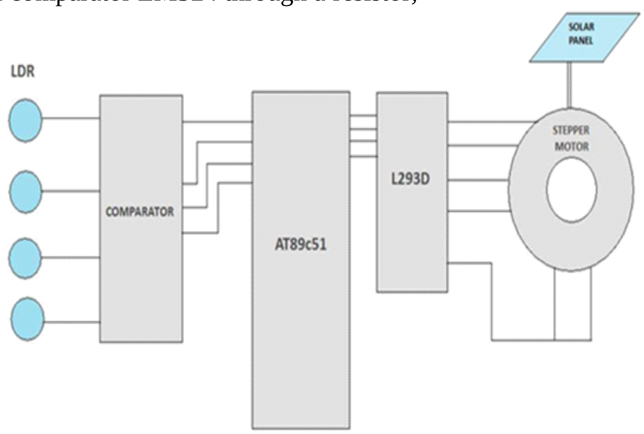

Fig 2.1-Block diagram of Automatic solar

Tracking system using AT89c51

whose other input is a reference voltage. The LM324 has four comparators and so, all of the LDRs are connected to them. The output of LM324 is given to the Port 1 of 89C51. The Port 1 gets the input from the output of the comparator in particular bit pattern. Using a program it is compared with the desired bit pattern and a signal is sent to the motor driver to rotate the stepper motor in the specified direction. The motor driver used is an L293D, which is a quadruple high-current half-H. It is designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors etc. There are three ways to drive unipolar stepper motors, namely, one phase on full step, two phases on full step, or half step, out of which two phase full step mode is used in this setup in which successive pairs of adjacent coils are energized in turn.

a) Hardware Setup

1. Microcontroller 8051 (Atmel 89C51 used)
2. Comparator LM324
3. LDRs
4. Motor driver L293D
5. Stepper motor
6. Resistor (10KΩ. 1KΩ.)
7. Capacitor (10µF, 33pF)
8. Crystal oscillator (11.0592 MHz)
9. 5V and 6V power supply

b) Procedure

The sensor and comparator part:

In this figure how we are getting the output from the LDR through a comparator LM324 by comparing with the reference voltage set by the potentiometer, and given to the Port 1 of AT89C51 is shown. Firstly four LDR are connected to the comparator. we are getting output of the LDR through 1k ohm resistance. The output from this LDR is given to the comparator LM324. Four LDR are used here and all of them connected in this similar way. The output of LDR is given to the inverting terminal of the op-amp of the comparator. LM324 has four comparators in it. Input to the comparator is given by setting a reference voltage. Reference voltage was set at 2.6 volt. As the light perpendicular to any LDR the corresponding output from the comparator is obtained. The LDR that is used here gives output voltage 2.00 volts when having perpendicular light on it. These outputs are given to the port 1 of microcontroller AT89C51[3].

The Microcontroller part:

The interfacing circuitry of the Unipolar Stepper Motor with microcontroller AT89C51 is shown. The AT89C51 provides a set of standard features: 4K bytes of flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture. Here we have used L293D as the motor driver. Port 1 is getting the input from the output of the comparator in particular bit pattern. Using program it is compared the bit pattern and send signal to the motor driver to drive the stepper motor in specified direction.

Motor driver L293D with stepper motor part:

The L293D is a quadruple high-current half-H driver designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. It is designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. There are three ways to drive unipolar stepper motors (one phase on full step, two phases on full step, or half step), each one has some advantages and disadvantages. In this project two phase full step mode is used. In two phase mode, successive pairs of adjacent coils are energized in turn, motion is not as smooth as in one phase mode, power consumption is more important but it produces greater torque As in one phase mode, applying the steps in order makes the stepper motor run clockwise and reversing order makes it turn counter-clockwise.

2.4 Using microcontroller pic16f877a and dc motor

In this setup, the output of PV panel i.e. solar panel is compared and given to PICmicrocontroller PIC16F877A for facilitating the tracking operation. The power derived from the solar panel is determined by voltage, current , sensor, outputs, which are used to initiate the tracking algorithm. During rainy / overcast days, the output power is very low and the tracker is not activated to save power consumption of electronic circuits. Initially, the PV panel is tilted in the east direction and touches the east limit switch to initiate tracking. At the end of the day, it is tilted towards west direction and touches west limit switch. After the sunset, the output power reduces and the panel is brought back to the east side to initiate tracking for next day. The microcontroller PIC16F877A performs the necessary operations in accordance with the power received from the solar panel. For this, two threshold levels are used. The first threshold is used to activate tracking, which indicates that there is a sufficient amount of solar energy available. The second threshold is used to switch off the peripherals if the significant solar power is not available for a long period of time, for example, a cloudy rainy day. The solar panel is tilted towards east for facilitating tracking on the next day.

Analog inputs are accepted by the PIC 16F877A and are converted into 10 bit digital data. The first limit is decided to be 400 to enable tracking and the second limit is set to 150. When solar power is greater than the first threshold limit, the tracker is activated. The device compares the intensity of light falling on the two sensors and aligns itself perpendicular to the radiation. Photovoltaic cells are used in this single-axis tracking system to decide the position of the solar panel. The cells are configured as east and west plane sensors for moving the single axis motion of the panel. The sensors are connected to the centre shaft of the panel. These sensors are placed in the form of triangle to as to make themselves sensitive to ambient light. solar power less than second limit will switch off the peripherals and solar panel will tilt towards east direction[4].

2.5 Automatic solar tracking system using plc

a. Hardware setup

• Solar Photo Voltaic Panel
• 3 Phase 0.5 HP Induction Motor
• Crouzet Millenium 3XD26 Programmable Logic Controller
• Thrifty Series AC-DC Converter
• Emerson Control Commander SK VFD
• 8-Channel Relay Module
• Proximity Sensor
• Cog Wheel
• Computer

The entire setup is placed on a pair of railings on which the motor base made of wood is placed as well as two stands on whom the shaft is placed with the help of bearings. The solar panel is attached to the shaft rod by means of clamps. A cog wheel is framed as well. The proximity sensor is affixed right below the cog wheel teeth with the help of an L-shaped clamp which is fixed to one of the stands. The balancing of the panel is done with the help of a wooden solid cuboid affixed to the rod with two tall bolt-nut arrangements which is perpendicular to the panel.

b. Procedure

• The input power supply to the motor is given by the VFD which applies the required voltage and frequency so as to rotate the motor at a preset speed.
• The preset speed is set by applying the “AV.Pr” mode in the V/f Drive.
• The speed is preset at 5 rpm.
• The direction of the motor can be changed by the command from the PLC to the V/f drive.
• The logic is written in the millennium software for the PLC.
• The PLC output is given to an 8-Channel Relay module which is in turn connected to the
• V/f Drive.
• A proximity sensor is placed beneath the teeth of the Cog Wheel which is placed on the same shaft. It provides feedback to the PLC.

c. Working

Converting sunlight to electricity Know that solar energy is the radiation from the sun that reaches the Earth’s surface Explain how solar cells are used to generate electricity Understand that solar energy doesn’t release carbon dioxide therefore helping to reduce green house gas emissions Use a voltmeter to measure energy produced by a solar panel.In Advance Solar or photovoltaic (PV) cells are made up of materials that turn sunlight into electricity. Photovoltaic (PV) technologies including solar thermal hot water are renewable energy technologies and are clean energy alternatives compared to non renewable energy technologies that burn fossil fuels. PV cells are composed of layers of semiconductors such as silicon. Energy is created when photons of light from the sun strike a solar cell and are absorbed within the semiconductor material. This excites the semiconductor’s electrons, causing the electrons to flow, and creating a usable electric current. The current flows in one direction and thus the electricity generated is termed direct current (DC). One PV cell produces only one or two watts which isn’t much power for most uses. In order to increase power, photovoltaic or solar cells are bundled together into

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what is termed a module and packaged into a frame which is more commonly known as a solar panel. Solar panels can then be grouped into larger solar arrays.

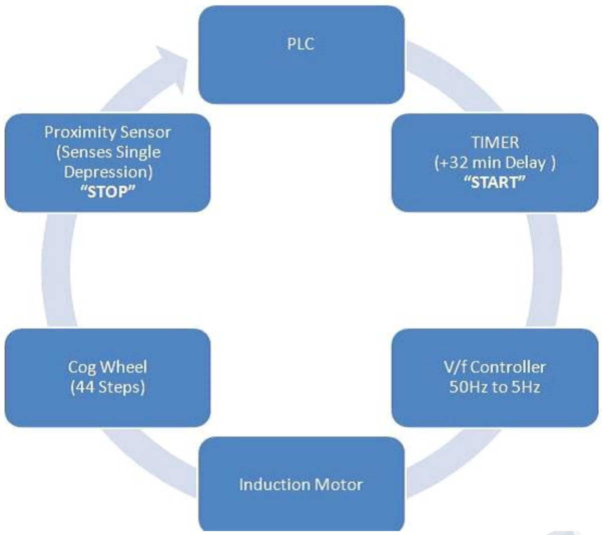

Fig 2.2- Flow chart

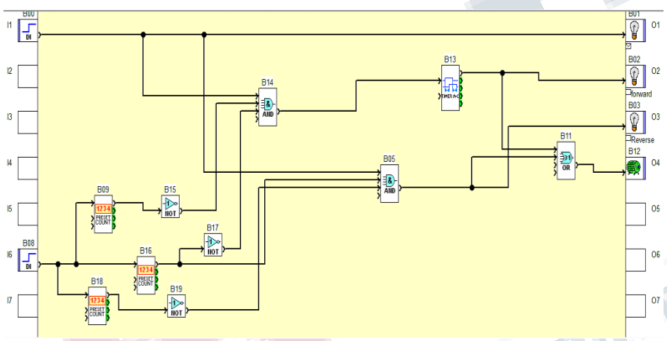

Fig 2.3-PLC logic diagram

2.6 Using arduino with lab view

In this system, Arduino Uno is used as controller to track the sun and attain maximum efficiency and Lab VIEW for real time monitoring. Arduino is a single-board microcontroller, which is used to make the application of interactive objects or environments more accessible. It is an open source physical computing platform and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Lab VIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The software is perhaps the most important component of the system. The Lab VIEW Interface for Arduino (LIFA) allows users to control sensors and acquire data through an Arduino microcontroller using the graphical programming environment Lab VIEW. Arduino microcontroller acts as an I/O engine that interfaces with LabVIEW VIs through a serial connection. This helps to move information from Arduino pins to LabVIEW without adjusting the communication, synchronization. The vital component in the hardware of this setup is the Light Dependant Resistor (LDR). LDRs are basically light-controlled resistors and so they are suitable in applications where light/dark detection needed. Four LDRs are connected to the analog pins AO to A4 of the Arduino that act as the input for the system. The Arduino has an in-built Analog-to-Digital Converter which converts the analog value of LDR outputs and converts them into their digital equivalent value. The entire setup is, thus, divided into three parts, i.e. input, controller and output where inputs are from analog value of LDR, Arduino as the controller and the DC motor will be the output. LDR1 and LDR2, LDR3 and LDR4 are taken as pair. If one of the LDRs in a pair gets greater light intensity than the other, then a difference will occur on node voltages which is sent to the respective Arduino channel to take necessary action. The DC motor will move the solar panel to the position of the high intensity LDR that was in the programming.

Algorithm had been constructed using LabVIEW programming. The algorithm of the program is as follows:
Step 1. Read all analog voltages from analog channels.

Step 2. When all voltages are equal, the motor will be in stop position.
Step 3. When LDR1>LDR2, the top motor will rotate clockwise.
Step 4. When LDR1<LDR2, then the top motor will rotate anticlockwise.
Step 5. When LDR3>LDR4, the down motor will rotate clockwise.
Step 6. When LDR3<LDR4, the down motor will rotate anticlockwise.

This setup, however, does not provide maximum efficiency. There is still a difference between the voltage values of the output of a moving solar panel and that of a stationary panel. This is shown in the following graph for a period of interval obtained from the experiment.

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3. SYSTEM DEVELOPMENT

3.1 Proposed Block Diagram

In the block diagram that has been shown Fig. 1, shows the proposed method in which the microcontroller is the most important component. Initial steps of the setup are done by setting up the hardware of the solar panel. The solar panel will be fixed on a frame which will be free to move. The frame is basically rotated by the servomotor. The sensors around the frame will decide the position of the panel. The signals from the sensors will be fed through the DAQ device to the PC.

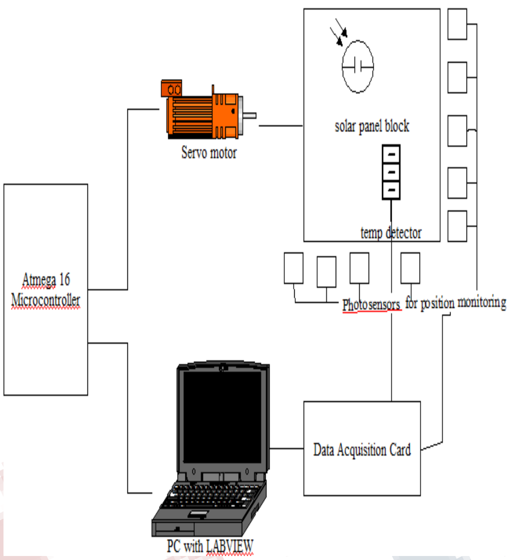

Fig 3.1. System block diagram

sensors will be fed through the DAQ device to the PC. The microcontroller unit will also be interfaced with the PC. The position of the panel will be passed to the microcontroller unit and based on the position the controller unit will send the signal to motor to set the position of the panel according to the day time (sun position).

The components being used here are the ATMEGA16 microcontroller which is a 8 bit controller. The servo motor that is used is a high precision Futaba S3003 motor. Finally the solar panel is a 2.5Watt panel which is being used as a prototype. Pre-programmed microcontroller is used which is programmed to be synchronized with the solar movement during the day. In this paper we have proposed a single axis tracker for our discussions. This avoids the complexity of construction and usage. To reduce the effect of the lateral shift of the sun from north to south the solution reached was that to tilt the panels in the direction of the sun by an angle that is equal to the latitude of that place. This simplifies the problem largely, also an error of ±5º reduce the output efficiency by just 2%, which is allowable [5]. Direct sensing and any other device that we may use involve the building up of circuitry and other problems. Webcam based solar tracker [6] was also developed but the clarity of the picture was a concern for such systems. Maintenance of such units is quite a problem because the common man necessarily need not be from a technical background. Programmed chips are an easy solution to this problem. These microcontrollers are used to synchronize a stepper motor to track the sun perfectly.

A. Calculation of Solar Position

In order to understand how to collect energy from the sun, one must first be able to predict the location of the sun relative to the collection device. In this part describes the necessary equations by use unique vector approach. This approach will be used in this work to develop the equations for the sun's position relative to a tracking solar collector. Assuming that in the tropical zone, where solar panels are most effective, there is about 10 hours sunshine every day.

Total angle to be covered=180-150º

Time taken for the sun to travel from sunshine to sunset= 10 hours= 10 X 60= 600mins

Degree travelled per minute = 180 600 □ mins

$= 0.3^\circ$/min

This is too small an angle to account for, so we take a minimum angle of at least 5 degrees for each pulse that is to be given to the steeper motor to rotate.

∴ Time after which each pulse is to be given= 5÷ 0.3

=16.777 min

Thus a pulse is to be given every 17 minutes for the solar panels to properly track the sun. To make the tracker more accurate we have to modify the programming so that the hours of sunshine as given in the program is changed every 14 days by adding or subtracting 20 minutes to the total hours of sunshine, depending on the time of setting up of the device. After the sun sets the panels have to be reset their initial position to allow further tracking the next day[7].

B. Real Time Monitoring

As we can see in the Fig. 2, 6 LDRs are connected to the DAQ card. The LDR used is 10KΩ. The LDRs are connected to analog input channels of the DAQ card and other side grounded. The resulting value is acquired by the DAQ assistant of LabVIEW. The principle of operation is that when maximum amount of sunlight falls on an LDR its resistance will drop. This value is compared with the values of all the other LDRs. The LDR with minimum resistance is the one that is most in line with the sun, hence the corresponding LED glows in the front panel.

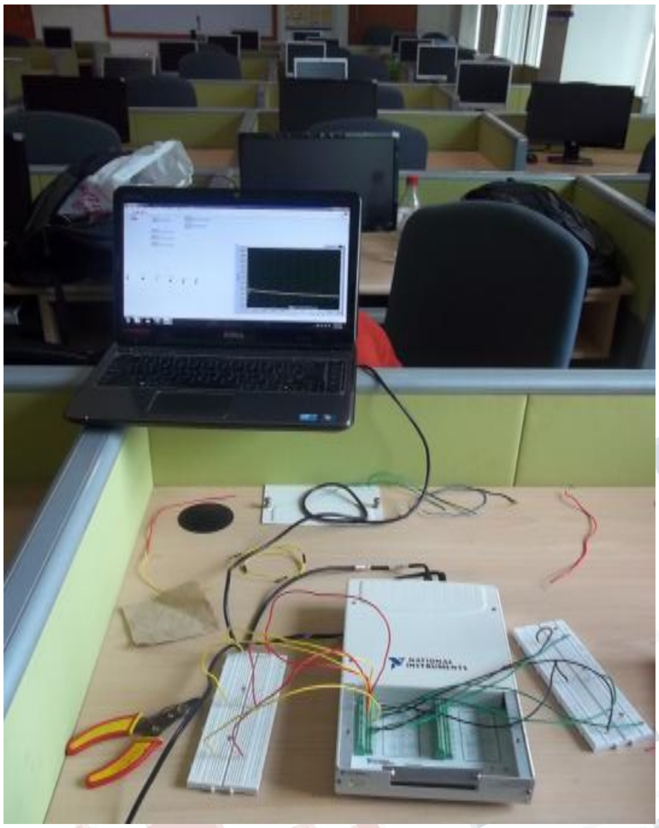

Fig 3.2. Monitoring device using LDR.

4. CONCLUSION

4.1 Conclusion

In this proposed system , we have reviewed three of the technologies used in Automatic Solar Radiation Tracker systems, namely, using AT89C51 Microcontroller, LDR and Stepper Motor, using Microcontroller PIC16F877A and DC Motor and using Arduino with LabVIEW. From the study of these technologies, it has been observed that by using lab view it is to be noted that there has been a significant increase in the total power generated throughout the day. About 29% increment was observed. The entire cost of the system being installed comes to about Rs1600 for every panel. The amount of extra power that it will generate is predicted to be about 72KWH per year (for a 75 watt panel). The operation life of the solar panels is about 20 years. So all in, it will be generating a profit while generating clean energy. The efficiency of the system can be further increased by considering dual axis tracking to cover north to south movement of the sun.

4.2 Advantages

In sun tracking solar system by using lab view there is some advantages, are listed below

• Trackers generate more electricity than their stationary counterparts due to increased direct exposure to solar rays. This increase can be as much as 10% to 25% depending on the geographic location of the tracking system.

• There are much different kind of solar tracker, such as a single axis and dual axis tracker, all of which can be perfect fit for a unique jobsite. Installation size, local weather, degree of latitude and electrical requirements are all important considerations that can influence the type of solar tracker is best suited for a specific solar installation.

• Advancement in technology and reliability in electronic and mechanics have drastically reduced long term maintenance concerns for tracking system.

• Solar trackers generate more electricity in roughly the same amount of space needed for fixed tilt system, making them ideal optimizing land usage.

4.3 Disadvantages

• Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation.

• Some ongoing maintenance is generally required , though the quality of the solar tracker can play a role in how much and how often this maintenance is needed.

• Solar trackers are generally designed for climate with little to snow making them a more viable solution in warmer climates. fixed tracking accommodates harsher environmental conditions more easily than tracking system.

4.4 Future scope

In the proposed system, In Future the conventional energy is not sufficient for use so there is need of use non conventional energy sources .This system is very useful for power supply in rural areas where we can use high sensitive solar panels which can work in mild sun light also and by connecting number of solar tracker assemblies we will able to produce sufficient large quantity of power which will be able to supply power to medium size village. We can make use of solar panels in our day to day life for street lighting, in mobile phone chargers, water heaters, etc.

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