Solar Radiation Monitoring with Tracking Unit

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Abstract: Due to the continuous increase in the cost of fuel, pollution and global warming, the need arises for the use of solar energy (which is available freely and non-polluting source of energy). In order to make full use of solar energy the solar irradiance at a particular place must be estimated. Radiation is the transmission of energy in the form of electromagnetic waves and the radiation falling on a unit area per unit time is called irradiance. In order to have knowledge about the solar radiation in a particular place necessary data is collected that will help us in tracking the sun for determining solar irradiance. This data is collected with the help of a pyrheliometer which is an instrument used to measure solar irradiance. The parameters affecting the performance of pyrheliometer which includes the orientation and tilt angle with the respect to the sun is controlled with the help of a tracking unit in which stepper motors will be used. The data gathered with the help of this system will be helpful in weather forecasting, scientific meteorological observations, material testing and research.

Keywords – Irradiance, Pyrheliometer, Tracking

I. INTRODUCTION

Solar energy is the most easily accessible form of renewable energy. This is the most natural form of energy which is available abundantly. Also, the conversion of solar energy into electricity is a viable response to address most of world's energy problems. In order to make full use of solar energy we must first know the solar irradiance at a particular place. Radiation is the transmission of energy in the form of electromagnetic waves and the radiation falling on a unit area per unit time is called irradiance, which is measured in W/m square. According to our research, we have found out that most of the solar trackers used light sensors or solar panels to measure solar irradiance as well as servo motors in the tracking unit of the system. Making use of pyrheliometer which is an instrument to measure solar irradiance. Sunlight enters the instrument through a window and is directed onto a thermopile which converts heat to electrical signal that can be recorded. The signal voltage is converted by a formula which is measured in watts/ meter square. There are various parameters affecting the performance of pyrheliometer, including the orientation and tilt angle with the respect to the sun. These parameters can be controlled with the help of a tracking unit in which a stepper motor is used to control the tilt of pyrheliometer with respect to various angles. Thus, Solar trackers are the ideal devices for obtaining maximum utilization of this energy at a particular place which will be beneficial to us in many ways, thus, encouraging the use of a form of energy which does not affect the environment in a harmful way. The main goal is to track the position of the sun in real time throughout the day. The data gathered in this process will be helpful in weather forecasting, scientific meteorological observations, material testing and research. In order to increase use of renewable energy resources we first should track the energy the system can produce and whether it will fulfill the task. For this purpose tracking is necessary.

II. SOME IMPORTANT LITERATURE SURVEY

The following are the review paper on different tracking systems

Priti Debbarma, B.B. Bhowmik [1] reviewed on Solar tracking systems and their classification. She mentioned basic components required for tracking unit. Also compared the solar tracking system and fixed panel and distinguished various tracking system based on tilt angle, dual axis and single axis.

Rabia Parveen, Abdul Mubeen Mohammed, Korani Ravinder [2] reviewed on design of an automatic solar tracking system which was developed using Light Dependent Resistor (LDR) and DC motors on a mechanical structure with gear arrangement. It was implemented through Arduino UNO controller based on Sun Earth Geometry. The results indicated that the automatic solar tracking system is more reliable and efficient than fixed one since it could be installed anywhere. It guaranteed a high energy gain thus improving the energy gain of solar power plants.

Parasnis N. V., Tadamalle A. P. [3] reviewed on design and development of microcontroller based automatic solar tracking system. Light Dependent Resistors (LDRs) were used to sense the intensity of sunlight and hence the sun‟s position in the sky. Microcontroller AT89S52 was used for controlling the movement of PV panel. The mechanism used geared DC motors to rotate the PV panel which are controlled by the microcontroller with respect to signals from LDR. Zigbee transmitter-receiver pair was implemented to receive the data from remote location for data acquisition purpose whereas at the supervising location Visual Basic (VB) was used for acquiring, storing and displaying the data. A review of the automatic solar tracking system in any environmental condition had way much better implementation than the fixed panel was presented.

A.Z. Hafez, A. Soliman, K.A. El-Metwally, I.M. Ismail [4] reviewed on tilt angle and azimuth angles in solar energy applications based on overview of design parameters, applications, simulations and mathematical techniques. An in-depth description of most tilt angle design criteria regarding solar energy technologies was presented which has allowed analysis of several measures consecutively applied to achieve the best output on the electricity system of the solar system or the reach of the best thermal heat collected from the solar radiation.

V.V.S.Madhuri, P.Mallikarjuna Sarma, M.Chakravarthy [5] reviewed on the Automatic Solar Tracking system which is basically a mechanical device consisting of an induction motor and moves according to the command from the controller in response to the sun‟s direction. It was used to track the Sun automatically with the incorporation of the Programmable Logic Controller (PLC) and Variable Frequency Drive (VFD). The tracking was done by programmed Time-Delayed movement of the panel throughout the day. The delay was set in the PLC and the step- by-step movement was achieved by proximity sensor which senses the teeth of a Cog wheel there by providing the feedback to the PLC. The output from the panel was measured with a multimeter.

III. SOLAR ANGLES

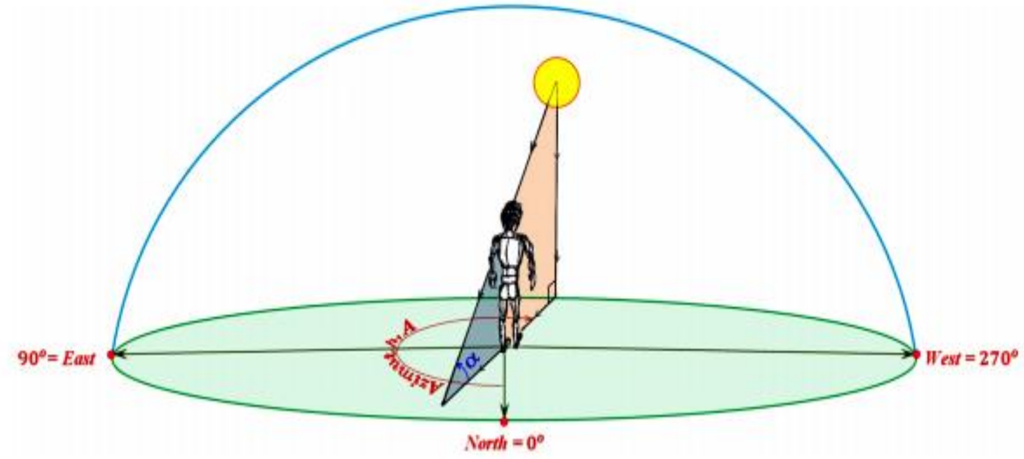

Fig 1.Solar Angles [6]

A. ELEVATION ANGLE

Elevation angle denoted by 'α' is the angle between the direction of the geometric centre of the Sun and the horizon i.e. it is the angular measure of the Sun's rays above the horizon. It lies between 0-180 degrees. [6]

$$\sin\alpha = \sin\Phi \sin\delta + \cos\Phi \cos\delta \cos h$$

Where:
α: Elevation angle
h: hour angle
δ: Declination angle
Φ: Local latitude

B.AZIMUTHAL ANGLE

The azimuth is the local angle between the direction of due North and that of the perpendicular projection of the Sun down onto the horizon line measured clockwise and it is usually denoted by 'ϕs'. It lies between 0-360 degrees. [6]

$$\cos\phi s = (\sin\delta \cos\Phi - \cos h \cos\delta \sin\Phi)/\sin\theta s$$

Where:
ϕs: Azimuthal angle
θs: Zenith angle
h: hour angle
δ: Declination angle
Φ: Local latitude

IV. PYRHELIOMETER

A pyrheliometer is an instrument for measurement of direct beam solar irradiance. Sunlight enters the instrument through a window and is directed onto a thermopile which converts heat to an electrical signal that can be recorded. The signal voltage is converted via a formula to measure watts per square meter. It is used with a solar tracking system to keep the instrument aimed at the sun. Pyrheliometer are typically mounted on a solar tracker. As the pyrheliometer only 'sees' the solar disk, it needs to be placed on a device that follows the path of the sun. Applications of Pyrheliometer include scientific meteorological and climate observations, material testing research, and assessment of the efficiency of solar collectors and photovoltaic devices.

Fig 2.Pyrheliometer mounted on a solar tracker.

V. COMPARISON BETWEEN SOLAR PANEL AND PYRHELIOMETER

Table 1. Comparison between Solar Panel and Pyrheliometer.

Solar Panel	Pyrheliometer
Solar panels are used for the conversion of solar energy into electrical energy or heat energy.	Pyrheliometer is an instrument used for measurement of solar irradiations.
Solar panels capture either direct or diffused (or both) solar radiations.	Pyrheliometer measure only direct beam solar irradiance.
Solar panels use photo-voltaic cells.	Pyrheliometers use thermopiles.
They can be mounted on either rooftops or can be placed on the ground.	They must be mounted on a tracking system only.
Solar panels are used for the generation of electricity from solar energy.	Pyrheliometers are used for scientific, meteorological and weather forecasting applications.

VI. PROPOSED ARCHITECHTURE

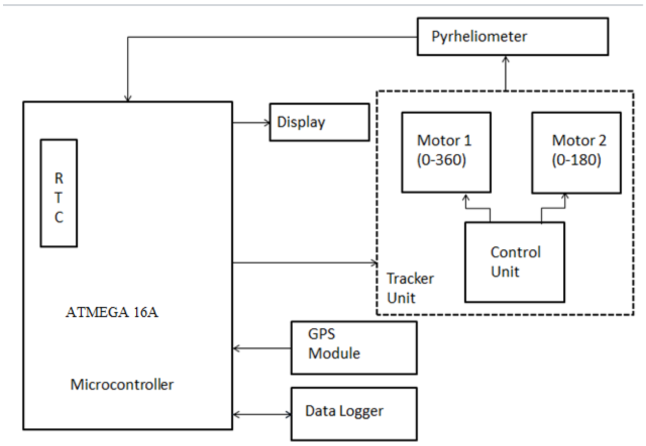

Fig 3 .Block Diagram of Solar tracker

The tracker consists of various components like micro-controller, LCD display, stepper motor, drive cards, GPS module. RTC is used to monitor the readings based on the real time i.e. date and day. GPS module is used to get the longitude and latitude, day and date. Tracker Unit consist of drive cards and two stepper motors. One motor is revolving from 0-180 degree which is responsible for Elevation Angle whereas the other motor revolves from 0-360 degree which is for Azimuthal Angle. Inside tracking unit drive cards and motors are connected with many wires and after few rotations wires get damaged because of continuous twist and turns .To avoid this we can use Opto-Isolators and program accordingly. Because of Opto -Isolators one can also program for shortest path to reach the home position. Signal will be passed to Drive Cards. According to received signal Drive cards will drive Stepper Motor degree by degree. Stepper motor is used for the movement of pyrheliometer according to the azimuthal angle an elevation angle. Tracker system is where the setup of stepper motor, drive cards and pyrheliometer will be installed. Tracker will move with respect to the position of the sun. Sensor used to detect solar rays is pyrheliometer. 16*2 alphanumeric display is used to display the data gathered with the help of sensor which will display the radiation W/m square. Data logger is where all data will be collected.

VII.RESULT

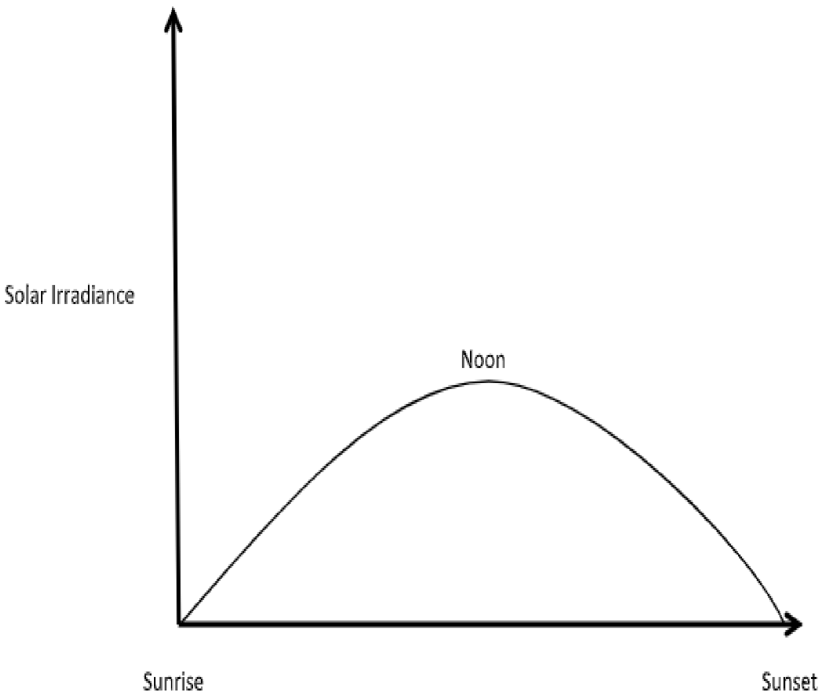

Fig 3 .Solar Radiation for Day

It can be seen that solar radiation is maximum at noon time. From sunrise to noon the solar radiation increases whereas from noon to sunset it decreases. The overall graph shows a semi-circle represents a day's solar radiation.

VIII.CONCLUSION

In order to increase usage of efficient, profitable and clean energy production we need Solar tracking Systems Automatic solar tracking systems are most efficient tracking system. Solar tracking system help us to collect solar radiation data for various purpose as well as these systems can also be used to estimate the incoming solar radiation of specific area for setting up a solar power plant. Use of stepper motor in tracker will give more accurate degree rotation. Taking efficiency and accuracy in consideration Pyrheliometer is preferable sensor over other sensors as it needs direct radiation for sensing and direct or perpendicular radiations to sensor give high energy gain for solar irradiance. The microcontroller is main unit of tacking system which consist of program to follow sun's path throughout the day and also calculating solar angles for system.

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