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Review of Sun's Position Tracking System to Increase Efficiency of Solar Panel

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Abstract: The present research paper depicts the review of effective Sun's position tracking system to extract optimum power from suns radiation. Now a day, era to biggest problem facing is energy resources, incensing its use, limitations of fossil fuels. Therefore, to meet our energy demands the only option we are left to utilize the renewable energy resources. There are various energy resources such as wind, solar energy etc. However, solar energy is cost effective, green renewable energy source. Therefore, researchers showing interest optimizing maximum power from solar. To increase the efficiency or getting maximum energy from sun, solar panels are always placed perpendicular with respect to direction of sun light radiations. During recent days, deploying on-chip resources of advanced microcontroller smart embedded system design for various applications, particularly in the industrial, agricultural as well as domestic application. It is found that, the system designed about advanced microcontroller such as AVR, PIC microcontroller. It is found that, to track suns positions, Arduino is mostly recommended for design such smart system. A dedicated panel is designed to track sun position based on servo motor or stepper motor. The position of sun is identified by using photodiode modules. The result decides the direction of rotation of shaft clock wise, anticlockwise or perpendicular to sun radiations. Therefore, this paper aims to review various technologies of solar tracking system to optimize energy from PV solar panel. The details regarding designing issues and results discussed in this paper.

Keywords: Renewable energy source, advanced microcontroller, embedded system, Sun radiation.

I. INTRODUCTION

Nowadays, energy deficiency problem faced by the word, due to population growth, increasing demand of energy for various sectors. The most commonly used non renewable energy resources oil, coal etc. cause the emission of green house gases and other environmental damages due to excess use. Therefore, researchers are showing interest to find the alternative energy source which is solution of conventional fossil fuel to reduce the environmental degradation. The encouragement of the development of green technologies implementations renewable energy sources such as, solar, wind, biomass, hydro and other renewable energy sources which do not causes any environmental pollution or hazards during its use. Solar energy is one of the most renewable cost effective energy sources as compare to other. Many of the residential in smart city uses electrical solar system as sub power at their houses or society. This because of solar energy is important energy source, longer term providing electricity, heat energy to user, unlimited resource and green energy technology.

On literature survey it is found that, the power intercepted on earth from the sun is approximately $1.8 * 10^{11}$ MW which is thousands time larger than the present consumption rate on the earth as compare to all other commercial energy sources used [1]. India has relatively long sunny days in year and partly cloudy. It is beneficial to generation of more solar power. However, the main problem with conversion of solar energy into electricity is direction of solar panel and position of sun radiation, used material of photovoltaic (solar) cell. The use of photovoltaic cells to convert sunlight directly to electricity without leaving any residual element that cannot be polluted the environment. Therefore, many researchers are showing interest to getting maximum electricity from solar panel by tracking suns positions to get maximum electricity. The maximizing power output getting from a solar system is desirable to increase efficiency. To achieve maximum efficiency form solar panel, photovoltaic (solar) cell place perpendicular to sun radiation, hence to set angle of solar panel or direction. We now that, light gathering is dependent on incident angle of sun light to the surface of solar cell. Because, direction of sun changes morning to evening, hence the radiation of light is changes proportionally. Hence, instead of keeping photovoltaic (PV) cell with fix direction, the direction of PV cell should be changed as per the radiation or position of sun. Therefore, tracking of sun positions is equally important for maximum efficiency and embedded system is suitable solution to design such system. The process of detecting position of sun and follow this position is known as sun tracking system.

II. Literature Review:

On Survey it is found that, renewable energy source has become an integral part of global energy structure. Rumbayan* et al describe the concept of solar tracking system [2]. He describes the four essential elements of process control system such as,

process, measurement, evaluation and control with the help of block diagram. They also describe the essential part sensors and actuators used for detection of sun position and solar panel movement. It also mentions solar module use for capture energy from sunlight. The details regarding silicon solar cell structure described in this et al. It is also reportd that, the components of solar cell compilers are polycrystalline silicon or multicrystalline silicon which made form cast square ingots large blocks of molten silicon which carefully cooled and solidified. However, Poly-Si PV cells are less expensive and efficient to produce single crystal silicon cells. The polycrystalline cells are only cable of achieving around 10% efficiency[3*]. The details regarding solar angle and solar geometry explain in K Rajan et al [1]. They reported that, the Earth's orbit about the sun is almost circular with an average distance 149.6 million km, and rotation axis of Earth is tilted by an angle $\varepsilon=23.441^0$ with respect to normal plane of the Earth orbit. They also describe the declination angle, altitude angle or elevation angle and solar azimuth angle with help of figures. The main components required for solar tracking system is tracking device, tracking algorithm, control unit, positioning system, driving mechanism and the sensing device. Different types of solar tracking techniques such as based on collectors, based on the axis and based on drivers reported in K Rajan et al. The comparison of fixed PV panel and single axis solar panel tracking system based on real time clock using ARM processor discussed in Anusha et al [4]. It is reported experimental work of fixed panel and sun tracking system for six days and it is found that, solar tracking system increases the efficiency around 40% during 9.00 am to 6.00pm. Dhanabal et al The efficiency of static panel and tracking systems of single axis and dual axis fixed mount is compared and reported in Dhanabal et al [5]. the experimental work carried out from morning 8.00 am. To 6.00 pm for fixed panel, single axis and dual axis tracker for every one hour. The obtained results conclude that the efficiency single axis over static panel system is about 32.17% and dual tracking system over static panel is calculated 81.68%. Hence efficiency of dual axis solar tracking is increases tremendously. The details regarding various types of solar tracking system describe in Murali Manohar S.R. et al [6]. They reported the details various classes of solar tracking such as on the basis of driving system, degree of freedom, control system and tracking strategies. On the basis of driving system they include active and passive solar tracking system. The number of directions in which independent movement of single axis or dual axis solar tracking system is described in based on degree of freedom. The details regarding Latitude, Angle of incident, Elevation or altitude angle, Zenith angle,Tilt angle and Solar Azimuth angle with the help of figures. The open loop, close loop and hybrid control solar tracking system is discussed classification based on control strategies. In tracking strategies date and time, microprocessor and Electro optical parameters are considered. The details regarding photovoltaic cell and used materials are also discussed in Murali Manohar S.R. et al. The similar type of work observed on Deekshith K et al [7]. They reported the details regarding solar tracking system based on driver and axis. The proposed work also mention with the help of Arduino, servomotor and LDR. Arduino based solar tracking system designed and the details regarding implementation, experimental results discussed in Pravin Balbudhe et al [8]. They reported that, due to racking of sun position getting better efficiency from solar panel. To detect sun position LDR use as senor for detection and servo motor use to move or fix the position solar panel. Implementation of AVR ATmega 32 based automatic solar tracking system is discussed in Akhil Raj K R et al [9]. The basic three ways to increase the overall efficiency of solar panel such as Increasing the cell efficiency, maximum the power output and employing tracking system discussed in this paper. They also reported that, to increase the efficiency of presently avail solar panel is tracking of suns position. Therefore, the tracking of solar panel is distinguish between three modes, Normal day light, Bad weather and bidirectional rotation condition. They provide the auto finding initial starting position condition. An comparative performance analysis solar tracking system types at different latitude were discussed by Mircea Neagoe et al [10]. The solar energy receiving performance of various tracking system analyzed over one year at different latitudes and tracking algorithms by considering direct solar radiation during sunny days. The details regarding single axis, dual axis tracking system with the help of mathematical equations, functions and tracking algorithms are also explained. Basically, they focus on tracking system based on solar angle pairs such as Equatorial (or polar) type, Azimuth (or azimuth-altitude) type, Pseudo - Equatorial type and Pseudo-Azimuth type. Obtained results they conclude that, the results can be extended to location and selection of solar tracking system is complex procedure. The tracking angles strokes or the complexity of the tracking is other criteria can be added. An Arduino based fully automated dual axis solar tracking system designed and reported in S. Rajasekhar et al [11]. Solar radiation and solar angles also discussed to getting maximum power point for tracking solar panel. They also reported that, the tracking solar panel is 12% more effective than fixed panel and for fixed tracking configuration inclination is around 22.5 degrees. The results are described with the help of prototype development system. Bhagwan Deen Verma et al describe the review on solar system for Photovoltaic power plant [12]. They explain the fundamental of solar tracking system, solar module, solar angles and single axis and dual axis tracking system. The basic three types of solar tracking system such as Active tracking, Passive tracking and Chronological tracking system also discussed tin this et al. A Study of increasing solar efficiency describes using various methods in Mahipal Soni et al [13]. The performance parameters of comparison of mirror reflected solar panel tracking and cooling using microcontroller. Due to mirror radiation intensity of PV panel increases. For measurement of temperature LM 35 is deployed. They also reported that, the 360^0 Sun tracking system with automated cleaning for solar PV module using 8051 microcontroller. The tracking system is based on solar angle and prefer for single axis or dual axis solar tracking system. The third way to tracking solar panel is automatic based on PLC. Mahipal Soni et al also mention the observed results based on solar tracking system with mirror booster. By using mirror booster method power increase with lowest 1.34% to highest 93.07% and average 30.89%. Power increase with cooling system is 0% to 80.79% and average 11.36%. Moreover, by using combination of reflection plus cooling system increase power from 8.27% to 123.33% and average 59.71%. They also reported the effect of dust on solar tracking system. So analysis with and without cleaning system and observed that energy out without cleaning 14.7%, manual cleaning 15.8% and automatic cleaning solar

tracking system give 30.6% energy output. The power generated and efficiency of PV panel improvement method discussed in A. R. Amelia et al [14]. They categorize different solar tracking systems based on technologies and degree movement of rotation. Also give the advantages and disadvantages of passive, active and chronological solar tracking system. They conclude that, the active trackers are commonly used as compare to passive tracker system. The maximum efficiency obtained from dual-axis solar tracking system.

III. Solar Cell

On Literature review it is found that, the efficiency of solar panel is depends upon radiation of sun and material used for preparation of photovoltaic cell. Improvement of solar sell based on material used of PV cell is ongoing research and many researchers throughout the world are actively working[9]. However, in the present work focus on getting maximum efficiency obtained from available solar panel to placing maximum sun radiation. Therefore, direction of solar panel control to getting maximum light from sun. To getting maximum efficiency and converting solar energy into electrical energy solar or photovoltaic cell are used. Figure 1 shows the available solar cell. There are various types of PV cells are available in market. However, one of them is shown in figure 1.On inspection of this panel it is observed that, it comprised of several individual solar cells or collection of solar cell. The function of this solar cell is similar to large semiconductor and utilize large area p-n junction diode. Gallium arsenide crystals are mainly used material for development of photovoltaic cell [13]. The materials basically in Polycrystalline silicon, or multicrystalline silicon, (poly-Si or mc-Si) structure [3]. The solar panel directly converts sun radiation energy into electricity. They are made by joining P-type and N-type semiconductor materials. Sun radiations consist of photons which penetrate into photovoltaic cell and knockout the loosely bound electrons from the surface to produce electricity. The process of converting light(photon) energy to electricity is called photoelectric effect.

Figure 1: Available solar cell

IV. **Solar Tracking System:**

The main motive of designing of solar tracking system is to surface of photovoltaic panel always perpendicular to direction of solar radiation rays. The panel can be positioned to achieve the optimum angle of incidence to obtained maximum electrical energy from photovoltaic panel. The important parameters that identify the beat position of solar panel are setting the angle of solar panel. The angles are solar irradiance, solar azimuth angle, elevation angle, inclination angle, declination angle and zenith angle. Figure 2 and 3 shows the said various solar angles which is very important to getting maximum sun radiations. The figure 2 and 3 are directly referenced by A. R. Amelia et al [14]. They mention that, altitude(elevation) and azimuth is most important angle in determining the position of sun. Solar irradiance can be obtained by measuring the power of the light sources or the luminous flux. The elevation angle (αs) and zenith angles(θz) have close definition is to the declination angle. Declination angle (δ) is the angle between equator and a line drawn from the centre of the sun to the centre of the earth shown in figure 3. Moreover, elevation angle is the angle between solar radiation and the horizon. According to definition, an elevation angle can be calculated using the equation 1[14].

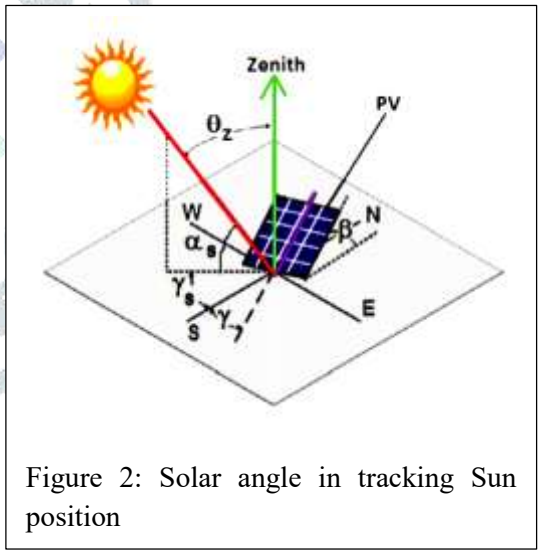

Figure 2: Solar angle in tracking Sun position

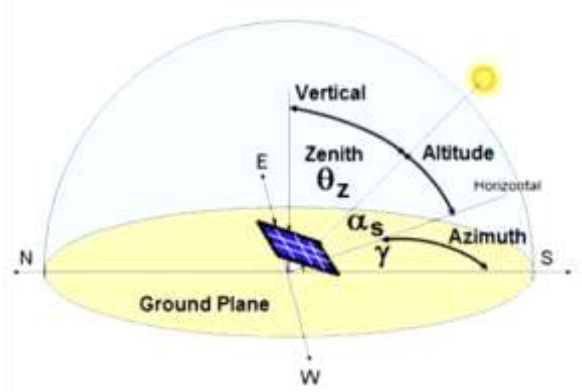

Figure 3: Solar angle in tracking Sun position

$$\alpha_s = 90 - \theta_z \text{ ----------(1)}$$

V. Development of Solar tracking System:

Recently, due to unavailability, reduces of traditional energy sources, use of excess traditional sources to affect environment, researchers, industry and every one showing interest in solar energy as a commercial purpose. Therefore, to increase solar panel output, maximum efficiency from the panel, maximum power unit per unit area, grab the energy through out the day automatic solar tracking system is highly essential [15]. Hence, Arduino microcontroller based solar tracking system depicts in terms block diagram in figure 4. the block diagram shows the various block use to control or set the position of photovoltaic cell. The direction is sensed by LDR as light sensor. Instead of LDR photo diode can be use as light detection sensor. Three light detection sensor deployed form input side and compare this voltage to shift the motor. Second block is controlling

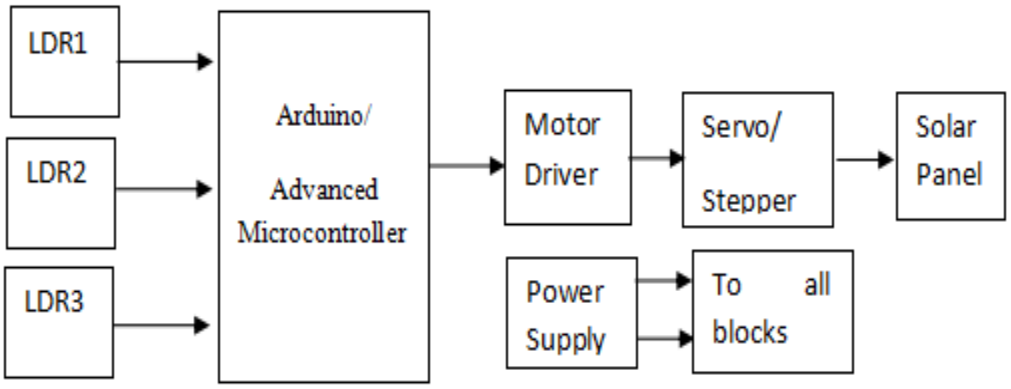

Figure 4: Block diagram of solar tracking system

unit microcontroller, use any advance microcontroller. It is proposed to design the system using Arduino in further work. The output of controller given to servo motor or stepper motor thorough driver.

VI. Software:

To design microcontroller based system firmware is equally important. Therefore, based on selection of suitable IDE to write code and load this code on controller to synchronize the working as per requirement. On literature review it is found that, many researchers firmware represents in terms of algorithm or flowchart. The combination of hardware and software known as embedded system [16-17]. The embedded system is suitable solution to design dedicated applications.

VII. Prototype Design of the sun tracking System:

As discussed earlier various methods and angle to track sun positions to getting maximum efficiency, prototype design of the system is shown in figure 5 and 6. figure 5 is fix position while figure 6 shows the sun position tracking with maximum radiation on solar panel. The such type prototype design discussed in R. Swami et al and Bhagwan Deen Verma et al [3,12] Solar panel fixed on motor and motor flexible fix to stand. On motor shaft moving plate is fix along with solar panel to get maximum efficiency.

Figure 6: Prototype design of the system with sun position tracking

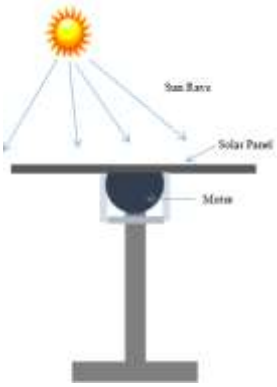

Figure 5 : Prototype design of the system with fix position

VIII. Conclusion:

The present review work of solar tracking system helpful to emphasizes on the performance solar energy, based on single axis, dual axis solar tracking system. The necessary advancements in the design can be easily done with considering the various methodology used to get maximum efficiency. This work analysis of various angles, photovoltaic cells, tracking methods and their technologies and degree of movement of rotation of panel. On literature review, study the comparison of active, passive solar tracking system. The review reveals that dual axis system is more suitable for maximum efficiency from PV cell. To control or automation can be done using microcontroller. Therefore, it is proposed to develop Arduino based solar tracking system to get maximum efficiency. Suitable components and motor used to design prototype model, which exhibits a clear, precise and stable

movement to face the sun. Further, the system will be extend to automatic cooling and cleaning system to increase more efficiency.

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