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SOLAR TRACKING

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Abstract: The electricity demand throughout the world is increasing in alarming rates and the power demanded is more than supplied. With the increasing demand, the number of conventional sources adopting for power generation may not last long. On employing these on large scale will cause huge environmental degradation. These consequences have forced us to develop new and alternative methods of power generation. The energy generated maybe from wind, solar, tidal, and geothermal. In the power generation, a renewable source like solar energy is environment friendly and can be taken as energy source for production of electricity. Generally, the sun does not face the panel continuously due to revolutions, hence less electricity is produced. In order to get the maximum electrical power, the solar panel should face the sun and also to utilize the maximum radiation from the sun, a tracking method is proposed in this paper. This proposed system tracks the maximum intensity of sun during its rotation in its axis. The system monitors the position of the sun using light dependent resistors (LDRs), and makes the decision to move the solar panel rotate towards the sun. This is a cost effective solution rather than purchasing additional solar panels.

Key words: Solar tracking, Variable Frequency Drive, C2000, Light Dependent Resistors, PV module.

INTRODUCTION

One of the most promising renewable energy sources characterized by a huge potential of conversion into electrical power is the solar energy. The conversion of solar radiation into electrical energy is done by Photo-Voltaic (PV) effect. The interest in the Photo Voltaic conversion systems is visibly reflected by the exponential increase of sales in this market segment with a strong growth projection for the next decades. When the sunlight or any other light is incident upon a material surface, the electrons present in the valence band absorb energy and, being excited, jump to the conduction band and become free. The chemical bonds of the material are vital for the process to work, as crystallized atoms are ionized and create a chemical electric imbalance, driving the electrons. These highly excited, non- thermal electrons diffuse, and some reach a junction where they are accelerated into a different material by a built-in potential. This generates an electromotive force, and thus some of the light energy is converted into electric energy [1].

Solar panels are usually set up to be in full direct sunlight at the middle of the day, facing south in the Northern Hemisphere, or facing north in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle and reduces the total amount of electricity which can be generated each day. The power incident on a PV module depends not only on the power contained in the sunlight, but also on the angle between the module and the sun. When the absorbing surface and the sunlight are perpendicular to each other, the power density on the surface is equal to that of the sunlight (in other words, the power density will always be at its maximum when the PV module is perpendicular to the sun). However, as the angle between the sun and a fixed surface is continually changing, the power density on a fixed PV module is less than that of the incident sunlight [1]. By employing tracking mechanism, the panel travels along with the sun thus capturing maximum amount of beam rays throughout the day which in turn increases the power density. Solar trackers generate more electricity in roughly the same amount of space needed for fixed tilt system, making them ideal optimizing land usage. Solar trackers generate more electricity than their stationary counterparts due to an increased direct exposure to solar rays.

There are many different kinds of solar tracker, such as single-axis and dual-axis trackers, which can help you find the perfect fit for your unique jobsite. Installation size, local weather, degree of latitude, and electrical requirements are all important considerations that can influence the type of solar tracker required.

EVOLUTION OF SOLAR TRACKER

Since the sun moves across the sky throughout the day, in order to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun. A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. When compare to the price of the PV solar panels, the cost of a solar tracker is relatively low. Most photovoltaic solar panels are fitted in a fixed location- for example on the sloping roof of a house, or on framework fixed to the ground. Since the sun moves across the sky though the day, this is far from an ideal solution. Solar panels are usually set up to be in full direct sunshine at the middle of the day facing South in the Northern Hemisphere, or North in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle reducing the total amount of electricity which can be generated each day [5].

During the day the sun appears to move across the sky from left to right and up and down above the horizon from sunrise to noon to sunset. Fig.1 shows the schematic above of the Sun's apparent motion as seen from the Northern Hemisphere. To keep up with other green energies, the solar cell market has to be as efficient as possible in order not to lose market shares on the global energy market place [6]. The end-user will prefer the tracking solution rather than a fixed ground system to increase their earnings because:

1. There is significant increase in efficiency and its generating capacity.
2. The space required for the same output is reduced.

Using a solar tracker and lesser number of solar panels cost per watt is reduced.

Methods of Tracking - Methods of Drive

Active Trackers

Active Trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Light-sensing trackers typically have two photo sensors, such as photodiodes, configured differentially so that they output a null when receiving the same light flux. Mechanically, they should be Omni-directional and are aimed 90 degrees apart. This will cause the steepest part of their cosine transfer functions to balance at the steepest part, which translates into maximum sensitivity.

Passive Tracker

Passive Trackers use a low boiling point compressed gas fluid that is driven to one side or the other by solar heat creating gas pressure to cause the tracker to move in response to an imbalance.

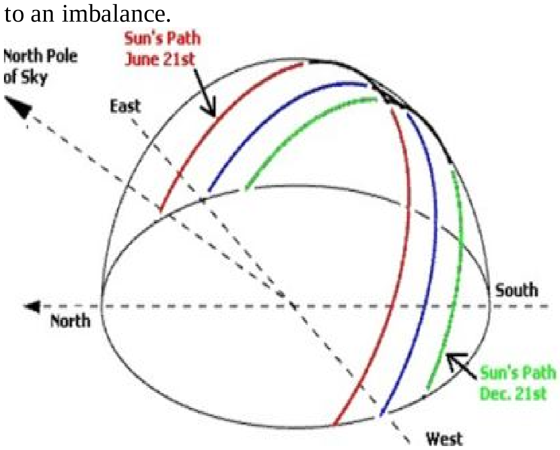

Figure 1. Sun apparent motion

Methods of Tracker Mount

Single axis solar trackers

Single axis solar trackers can either have a horizontal or a vertical axle as in fig 2. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long. The single axis tracking system is the simplest solution and the most common one used.

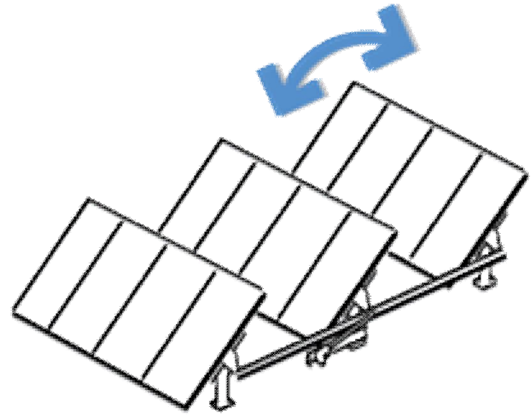

Figure 2. Single axis tracker

Double axis solar trackers

Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly anywhere in the World. This type of system depicted in fig 3 is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the sun across the sky. By tracking the sun, the efficiency of the solar panels can be increased. The dual axis tracking system is also used for concentrating a solar reflector toward the concentrator on heliostat systems.

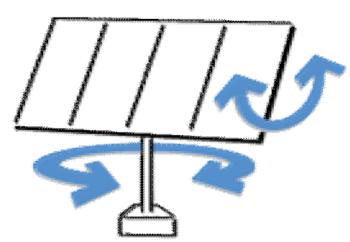

Figure 3. Dual axis tracker

From the graph in fig 4 the outputs of both the fixed and tracker panels are observed. The panel with tracking shows better results when compared to the fixed panel.

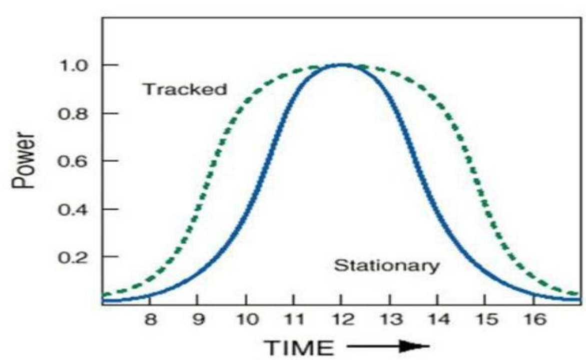

Figure 4. Tracking versus fixed panels

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Motors Used For Tracking

When it comes to specifying electric motors for solar photovoltaic tracking applications, environmental protection is a prime consideration due to their exposure to the elements. Motor designs for solar power applications, therefore, must stand up to extremes in temperature, humidity and highly corrosive salt sprays, wind loads and abrasive airborne particulate matter.

1. AC induction motors

These have been used in early solar tracking systems because they can draw power directly from the grid, but it is difficult to control AC motors at slow speeds necessary in most tracking applications [3]. When an induction motor turns on and off in a step function to track the sun, it does not permit the most efficient continuous tracking and collection of solar energy.

2. Stepper motors

Stepper motors are inexpensive but become complicated and lose some of their economic benefits when components are added to operate in the closed-loop position control schemes that characterize solar tracking. Stepper motors' air gap is a fraction of the size of other motor types and can lead to the rotor binding against the stator when there are large temperature differences between different parts of the motor, as when one side of the motor sees strong sunlight and the underside is shaded. Typical stepper motor speed range is also limited on the high side to about 400 rpm, which is disadvantageous when stowing trackers quickly when bad storms approach.

3. Permanent magnet brush dc motors (PMDC)

Permanent magnet brush DC motors are relatively efficient, easily controllable and, if properly built, can last a long time (up to 5,000 hr continuous duty), despite the brush or commutator wear that is inherent in their design. They also exhibit a wide speed range that is advantageous in stowing situations.

4. Brushless dc (BLDC) motors

Wide applications in solar tracking system are possible as BLDC motors are truly maintenance-free and have a low TCO. The BLDC motor has no wear-prone brushes, is highly efficient and hits 3,000 rpm, a distinct advantage when a short stowing time is important.

In this paper, an Induction motor of 0.25HP. For the panel to rotate at low speeds, the motor is controlled using a C2000 Variable Frequency Drive.

Variable Frequency Drive

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro drive, and inverter. Frequency (or hertz) is directly related to the motor's speed (RPMs). The VFD controller is a solid-state power electronics conversion system consisting of three distinct sub-systems: a rectifier bridge converter, a direct current (DC) link, and an inverter. In other words, the faster the frequency, the faster the RPMs go. If an application does not require an electric motor to run at full speed, the VFD can be used to ramp down the frequency and voltage to meet the requirements of the electric motor's load [2]. As the application's motor speed requirements change, the VFD can simply turn up or down the motor speed to meet the speed requirement.

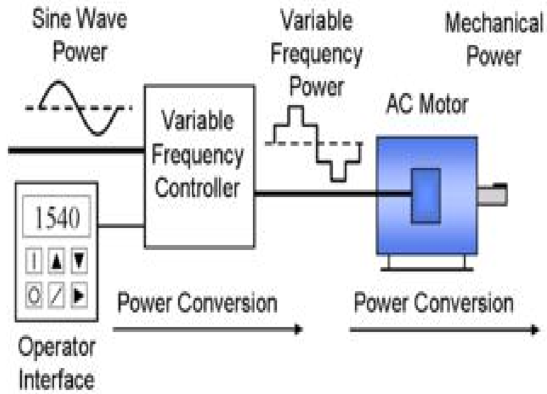

Figure 5. Power conversion operation.

The operator interface as in fig 5 provides a way for an operator to start and stop the motor and adjust the operating speed. Additional operator control functions might include reversing, and switching between manual speed adjustment and automatic control from an external process control signal. The operator interface often includes an alphanumeric display and/or indication lights and meters to provide information about the operation of the drive. An operator interface keypad and display unit is often provided on the front of the VFD controller which can be understood from fig. 5. The keypad display can often be cable-connected and mounted a short distance from the VFD controller. Most are also provided with input and output (I/O) terminals for connecting pushbuttons, switches and other operator interface devices or control signals. A serial communications port is also often available to allow the VFD to be configured, adjusted, monitored and controlled using a computer [2].

SENSOR

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

Light Dependent Resistor

Light Dependent Resistor fig 6 is made of a high-resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band from valence band. The resulting free electron conducts electricity, thereby lowering resistance. Hence, Light Dependent Resistors is very useful in light sensing circuits. LDR has very high-resistance, sometimes as high as 10MΩ, when they are illuminated with light resistance drops dramatically.

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A Light Dependent Resistor is a resistor that changes in value according to the light falling on it. A commonly used device, the ORP-12, has a high resistance in the dark, and a low resistance in the light. It should be remembered that the LDR response is not linear, and so the readings will not change in exactly the same way as with a potentiometer. In general there is a larger resistance change at brighter light levels. This can be compensated for in the software by using a smaller range at darker light levels.

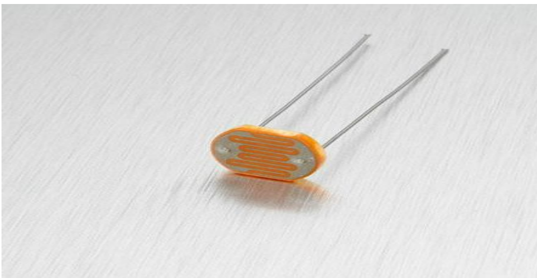

Figure 6. Light dependent Resistor

The front panel connections of the variable frequency drive are controlled by connecting them to the relay contacts, comparators and LDRS by the circuit shown below in fig. 7 [4].

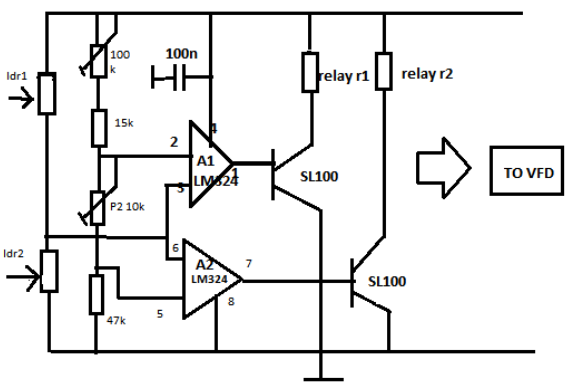

Figure 7. LDR Equivalent circuit and its connections

Results and Discussions

The Automatic Solar Tracker thus, is able to trace the sun in discrete steps from morning to evening without any manual intervention. The V/f drive has made it easy to use the Induction Motor speed Control and the direction control. Different speeds could also be achieved by this drive. The following values in table1 are obtained during the experiment.

Table 1: Experimental Results

S No	Solar cell angle (in deg)	Voltage	Current	Power
1	90	0.441V	1.80A	0.793W
2	75	0.433V	1.75A	0.751W
3	60	0.425V	1.70A	0.722W
4	45	0.385V	1.60A	0.616W
5	30	0.362V	1.45A	0.525W
6	15	0.300V	1.30A	0.390W
7	0	0.287V	1.15A	0.330W

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