CONTROL SYSTEM FOR PHOTOVOLTAIC PANELS TRACKER

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ABSTRACT: *Using photovoltaic panels to produce electricity is one of modern solutions to replace energy production based on fossil fuels. Photovoltaic panels with modern energy storage systems can ensure energy independence of individual houses. In order to improve the power output from the solar photovoltaic panels modules, a sun tracking system is generally implemented. Such sun tracking systems use sensors that track sun rays falling from the sun on the solar photovoltaic panels. These sensors allow exact determination of the position of the sun so that the sun rays incident on the solar panel strikes in perpendicular orientation to ensure maximum utilization of solar energy for electricity generation. In this paper it is proposed a control system for a dual axis sun tracker used to automatic or remote position control of the photovoltaic panels. Automatic or manual control together a efficiency test system for photovoltaic panels and a system for monitoring meteorological parameters makes this system to be very useful in any testing laborator of methods for produce energy from renewable sources. The proposed system will be able to test advantages and disadvantages of the mobile and fixed solar tracker system.*

Keywords: photovoltaic panels, energy, tracking system, automatic or manual positioning

1. Introduction

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. **[1]**. Based on REN21's 2016 report, renewables contributed 19.2% to humans' global energy consumption and 23.7% to their generation of electricity in 2014 and 2015, respectively. Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, concentrated solar power (CSP), concentrator photovoltaics (CPV), solar architecture and artificial photosynthesis.**[3],[4]**

Worldwide growth of photovoltaics has been fitting an exponential curve for more than two decades. Statement of global production of electricity using photovoltaic in the past decade is shown [5] in figure 1. During this period of time, photovoltaics , also known as solar PV, has evolved from a pure niche market of small scale applications towards becoming a mainstream electricity source.

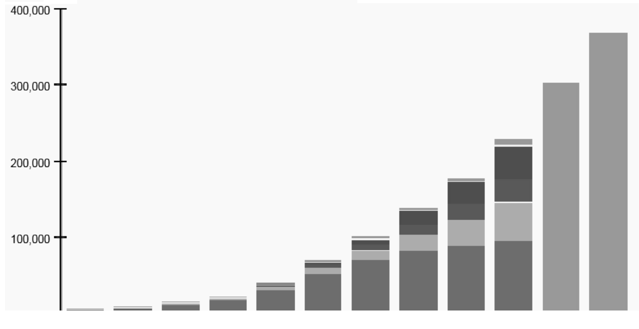

Figure 1. Global production of electricity using photovoltaic

1.1 Type of solar trackers

The design options for a solar tracking system must be taken into careful consideration to ensure that the system is maximizing its output from tracking the sun. If a stationary PV panel is utilized, it is strategically placed facing the sun. Panel must be positioned at an optimal angle facing the equator, depending on its latitude on earth, see figure 2. Stationary PV panels are a cheaper energy solution, but do not fully utilize the energy coming from the sun. Due to the fact that the earth is rotating on a tilted axis and takes an elliptical path around the sun, a stationary PV panel's output will drastically vary throughout the year and even throughout the course of a day.

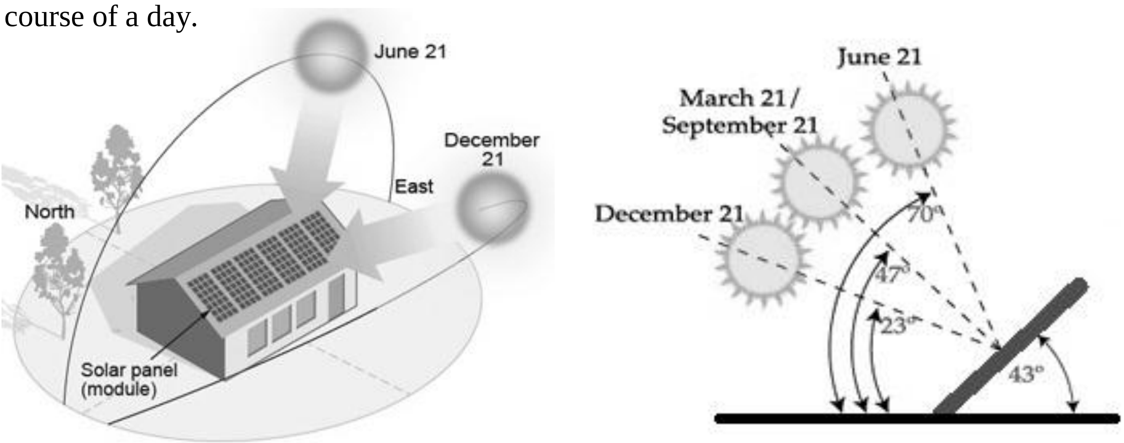

Figure 2. Sun's path durind summer and winter

Solar tracking obviously addresses these issues by actively following the sun in the sky. A standard PV panel will observe about 20-35% efficiency under ideal conditions, while solar tracking has been known to potentially double that with 50-60% efficiency under ideal conditions [5],[6]. Using dual axis tracking results a much greater power output than a stationary PV panel, but is also the most costly and most complicated to design. Dual axis solar trackers have both a horizontal and a vertical axis and thus they can track the sun's apparent motion virtually anywhere in the sky no matter where it is positioned on earth [8].

2. Control system

This paper proposes an automatic control system for a dual axis PV tracker. The proposed system will be able to automatically orient PV so that they are always oriented towards the sun. For research experiments, the system can be remote controled so that it is positioned according to the user's needs. In order to protect the PV and tracker to wind, the system will be complemented by a sensor to determine the direction and speed of the wind. Thus, the system will position PV to a minimum wind resistance.

For automatic orientation after the sun, the system will have on each axis (Horizontal X, Vertical Y) a sensor that determines whether the PV is oriented towards the sun as well as a control element of the PV rotation on the respective axis. The system will also have an absolute position sensor on each axis to monitor the PV position. The system will be connected to a PC where work modes (automatic or remote) can be set, but will also provide PV position databases at different times of day and year. In order to be able to carry out complex experiments on PV efficiency, the system will be completed with a sensor for measuring solar radiation and one for measuring the temperature at the PV surface. Ambient temperature will be measured using the temperature sensor integrated in the wind sensor. The structure of such a system is shown in Figure 3, where:

AX,AY -- Actuator with DC motor and gearbox for X,Y axis

DC MDX,DC MDX -- DC Motor Driver for X,Y axis

PX,PY -- Absolute position sensor for X ,Y axis,

ST -- Temperature sensor, PN -- Pyranometer

SX,SY -- Sensor for position to the sun for X,Y axis, WT -- Wind and temperature sensor

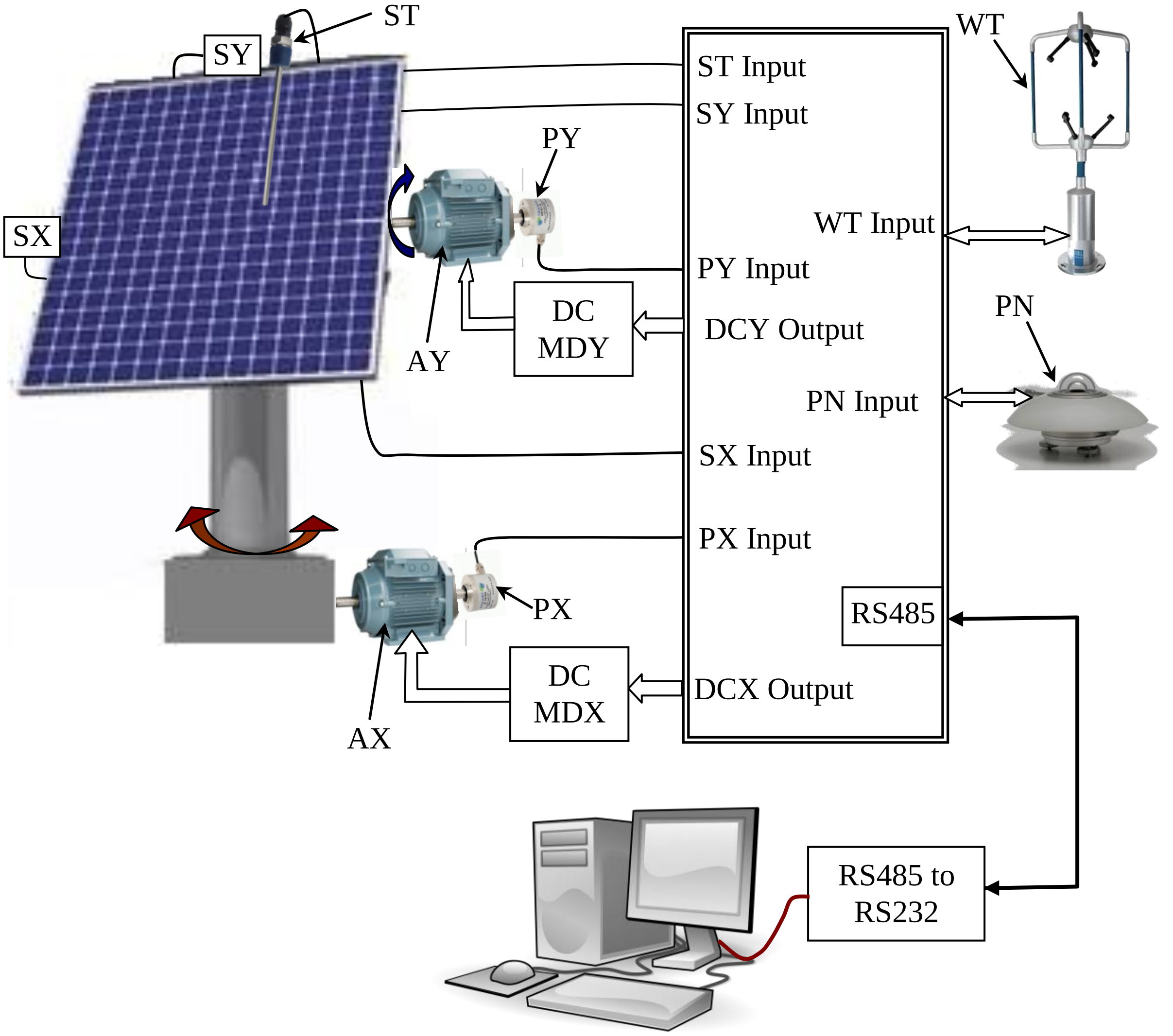

Figure 3. Structure of control system

2.1Actuator and DC Motor Driver

Active tracking uses motors, gears, and actuators to position the solar tracker so that it is perpendicular to the sunlight. The simplest solution is to use a DC motor and a gearbox that reduces engine speed and increases torque. Considering that the position of the sun does not change very quickly, it results that the speed of rotation at the output of the mechanical reducer can be 5-10 revolutions / minute. This involves gearboxes without high gear ratio. In order to move PV in both directions for each axis, a DCmotor is used with PWM command. For the PWM command of a two-way DC motor, an H-bridge is required. At low working voltages the command of a H bridge is relatively simple. When working tensions increase command of the bridge becomes more difficult due to command for the high-side. The development of integrated circuits has led to the emergence of circuits such as IR25602.

The IR25602 **[11]** is a high voltage, high speed power MOSFET and IGBT driver with dependent high and low side referenced output channels. Using the IR25602 circuit, a H-bridge was made to control a DC up to 600V and 40A DC motor by using IGBT-type IRG8P60N transistors. In figure 4 is show a complet H-bridge circuit.

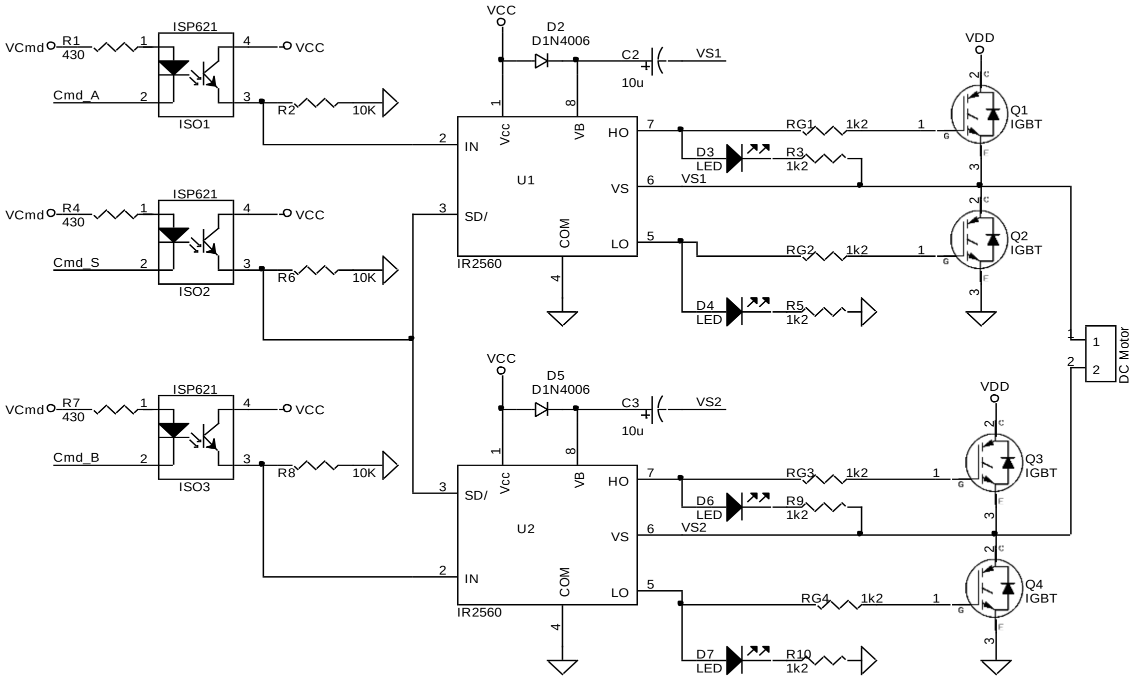

Figure 4. H-bridge circuit

In order to know the absolute position of PV on each axis, an absolute position transducer with a 360 degree angle range is mounted. Such an analog output transducer is the one from the RTX-PA series produced by UniMeasure. The UniMeasure RTX-PA Series rotary position transducer with analog voltage output is primarily for use in moderate duty applications in wet or dry environments. The chemical resistant thermoplastic case of the transducer provides IP-65 (NEMA 4) ingress protection for applications where exposure to washdown, rain, oil and other liquids may occur.

2.2 Sensor for position to the sun

Typically tracking is done, considering a single axis at a time, by using two mini PV cells used as sensors. Two of those similar devices can be placed at an angle as shown in the figure 5 below. When the two photovoltaic cells are outputting the same voltage value, we know that the sun must be at the top, perpendicular to the sensor unit (figure 5.a). When the sun is on the left, the photovoltaic cells on the left receives more light than the one on the right. The left photovoltaic cells would produce more voltage than the one on the right (figure 5.b). From the result, we can know that the sun is on the left. If the difference between the two voltages exceeds an allowable limit value, the system will move the PV on the negative axis to equalize the two voltages. When the two photovoltaic cells are outputting the same value, we know that the sun must be at the top, perpendicular to the sensor unit. The system will monitor the two voltages, and if both values drop below a prescribed value, the system will no longer change the PV position on the respective axis. This case corresponds to the situation where it is night or very cloudy.

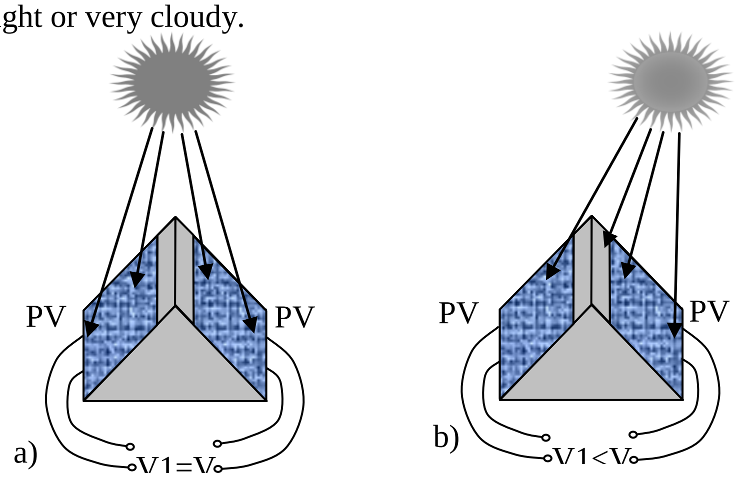

Figure 5. Sensor for position to the sun

2.3 Pyranometers and wind sensor

For the measurement of solar radiation, the SMP3-V piranometer was connected to one of the analog inputs of the control system. SMP Series pyranometers are equipped with a smart interface. SMP-V has an analogue output of 0 to 1 V and have a 2-wire RS-485 interface with Modbus (RTU) protocol. The WindMaster Pro 3-Axis Anemometer sensor was used to measure wind speed and direction. This is constructed from stainless steel and has a maximum operating wind speed of 65 m/s and is particularly suitable for precision wind measurement applications requiring 3-axis data.

Conclusion

Solar trackers are rising in popularity, but not everyone understands the complete benefits and potential drawbacks of the system. Solar panel tracking solutions are a more advanced technology for mounting photovoltaic panels. Stationary mounts, which hold panels in a fixed position, can have their productivity compromised when the sun passes to a less-than-optimal angle. Compensating for this, solar trackers automatically move to “track” the progress of the sun across the sky, thereby maximizing output. **[12]**

Advantages:

- Trackers increase can be as much as 10 to 25% depending on the geographic location of the tracking system.
- In certain states which means the utility will purchase the power generated during the peak time of the day at a higher rate. Using a tracking system helps maximize the energy gains during these peak time periods.
- Installation size, local weather, degree of latitude and electrical requirements are all important considerations that can influence the type of solar tracker best suited for a specific solar installation.
- Advancements in technology and reliability in electronics and mechanics have drastically reduced long-term maintenance concerns for tracking systems.

Disadvantages:

- Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation.
- Even with the advancements in reliability there is generally more maintenance required than a traditional fixed rack, though the quality of the solar tracker can play a role in how much and how often this maintenance is needed.
- Trackers are a more complex system. This means that typically more site preparation is needed, including additional trenching for wiring and some additional grading.

The proposed system is one that can be used to get the most energy from PV. This system is especially useful in research. It can be used to test the efficiency of different types of PV, the optimal location of fixed PV. It can also be used for various experiments requiring accurate PV positioning, testing of various positional algorithms to get maximum PV power. By creating databases that include the PV position, the PV temperature, the ambient temperature and the intensity of the solar radiation, it is possible to develop databases on the potential of the studied area of solar energy production. In conclusion, this system is especially useful in research on the production of electricity using photovoltaic panels

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