Dual Axis Solar Panel Optimized Using Programming Languages

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EXTENDED ABSTRACT

Renewable energy sources must be used to reduce the carbon footprint of modern life if we are to combat climate change. Solar energy is a good choice since it can directly convert solar energy into electrical energy by use of photo-voltaic cells (PV) . The main challenge is to maximize the capture of the rays of the sun because the efficiency of generating power from solar is relatively low. Hence the method to increase this efficiency is important. Sunlight has two components, the "direct beam" that carries about 90% of the solar energy, and the "diffuse sunlight" that carries the remainder. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible. Closed loop systems refer to sun tracking systems that employ active sensor devices. These trackers come at an added cost relative to fixed systems and in order for the tracker to make economic sense, the increased energy harvested must exceed the additional cost and power generation of the fixed system. To achieve this, a solar tracking closed control system programmed on a micro-controller platform will be used. Generally, the additional energy harvested through closed loop tracking is 20-44%, depending on geographical location. Hence, to be viewed as efficient this tracking method's cost has to be less than the cost of adding 20-40% more tracking equipment to a fixed system.

An azimuth-altitude dual axis tracker (AADAT) is used to track the sun using a servo motor for the azimuth axis (horizontal) and a linear actuator for the zenith axis (vertical) and light dependent resistors (LDRs) to measure the light intensity and angle. One set to track the sun horizontally and the other to track the sun vertically. These LDRs are located on the solar panel at a 45 degree angle on wedges to detect the required azimuth and zenith angles in which the main solar panel must face to gain maximum power output and are partitioned to represent the cardinal points of the PV system. When the sun is at a 90 degree angle to the LDR sensors, the voltages on the relevant tracking cells (north-south and east-west) are equal, and the solar panel stays in its position. However, if the main solar panel is not at a 90 degree to the sun, the sun angles on the trackers are different. Based on the difference in voltages from the LDRs, the micro-controller using fuzzy logic will rotate the main solar panel to be at a 90 degree angle to the sun .To control the motors effectively fuzzy logic based control (FLC) is used. FLC has two inputs which are: error and the change in error, and one output feeding to the servo motor and linear actuator.

There are two widely used approaches in FLC implementation: Mamdani and Sugeno. In this experiment, Mamdani approach has been used to implement FLC for the sun tracker. This

approach represents the knowledge base as a junction of statements corresponding to individual rules. Fuzzy logic is the theory of fuzzy sets that calibrate vagueness or based on the idea that all things are not completely false (value 0) or completely true (value 1). The main aim of the controller is to track the sun during the day and compensate for changes of the sun's azimuth angle and vertical angle.

The solar panel has an optimal operating point which can supply the maximum power to the load. That particular operating point is called the Maximum Power Point (MPP). The current voltage characteristics of a PV model is strongly influenced by the solar irradiance and cell temperature, hence by regulating the voltage of the PV module to the MPP operating voltage, the PV power can be drawn as much as possible. This system consist of the PV panel, a buck boost converter, fuzzy based MPPT control unit and a load . The power produced by the PV panel is delivered to the load through the buck boost converter. Fuzzy Logic is used to determine the size of the voltage based on the signals from the PV module and decides the new operating voltage by adjusting the duty cycle of the buck boost converter.

Currently the PV tracking system is built with the micro-controller functioning as a control system to move the motors. The code to determine the fuzzy logic can be optimized to provide a smoother tracking system. There are many subroutines used to handle the tracking such as “find sun position” which on start-up searches for the brightest light , “ determine night” which sets a value for the LDRs to hold for a period of time to determine if it is currently night and if so turn the solar panel east and “move panel” which turns towards the brightest light. One concern is geographical conditions such as cloud cover and rain can hamper tracking by LDRs and must be noted in the control program since these LDRs have specific voltages for these readings.

In order to determine the effectiveness of the solar tracking algorithm, another tracking strategy must be implemented using a mathematical model for comparison. One proposal is to implement the Marco Bortolini hybrid strategy for altitude-azimuth sun tracking. In this approach, a monitoring platform such as the LabViewTM programming language controls the motion of both motors that change the azimuth and altitude of the solar panel based on a time based model of the relative Sun-Earth motion. The signal from the LDR sensors will be used as a feedback control loop to determine the difference in alignment between the sun and the solar panel.