Design of an Embedded Solar Tracking System Based on GPS and Astronomical Equations

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ABSTRACT

This article presents the design of a reliable, accurate, and easy to install solar dual axis tracking system. The system utilizes the GPS for fixing the time, date and location in terms of longitude and latitude. Approximations having high accuracy of the astronomical equations to represent the declination angle and the equation of time are selected to determine the sun locations needed by the designed tracking system in any chosen location on earth. The proposed system is standalone, accurate, durable, reliable, and cost efficient. Annual energy assessments of the system are also given.

Keywords: Dual Axis Trackers, Embedded System, GPS Based System, Microcontroller, Sensorless Tracker, Solar Tracker

INTRODUCTION

In a step to overcome the limitations of sensor based solar tracking system, a design tracking strategy is presented which is based on astronomical equations, namely the Equation of Time (ET) and the Declination Angle (δ). This strategy has to take two important factors into consideration. The first one is finding approximation formulas with high accuracy of these equations and figure out the ability of implementing such system which can deal with these rather complicated equations which are based mainly on trigonometric functions. The second factor is how to design a reliable, uninterrupted, accurate and global system that is able to calculate the local time, date and location in terms of longitude and latitude.

It follows that the main aim of this paper is to design a global dual axis solar tracker that can process the data with high efficiency and is able to deal with these complicated equations. It also needs to gather the required data from the GPS card and save and manage them in accurate, reliable and uninterrupted real time controller. The Plug in GPS card may be built in the main card or can be plugged in only in the initializing phase (Kalogirou, 2009; Hankins, 2010).

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RADIATION INCIDENT ANGLE

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. The percentage system tracking efficiency $\eta_T$ as a function of the incidence angle $\alpha$ is defined by ($\eta_T = 100 \sin (\alpha)$%). Figure 1 displays the calculated efficiencies at different values of $\alpha$.

The lower Sun angle (45°) causes the radiation to be received over a much larger surface area. This surface area is approximately 40% greater than the area covered by an angle of 90°. The lower angle also reduces the intensity of the incoming rays by about 30%.

GPS RECEIVER

Presently, the GPS is fully operational and meets the criteria established in the 1960s for an optimum positioning system. The system provides accurate, continuous, worldwide, three-dimensional position and velocity information to users with the appropriate receiving equipment, and disseminates a form of Coordinated Universal Time (UTC). The satellite constellation nominally consists of 24 satellites arranged in 6 orbital planes with 4 satellites per plane. A worldwide ground control/monitoring network monitors the health and status of the satellites (Kaplan & Hegarty, 2006).

The Fastrax UP500 module supports enhanced navigation accuracy by utilizing WAAS/EGNOS corrections. The Fastrax UP500 module provides complete signal processing from the internal antenna to the serial data output in NMEA messages. A Pulse per Second (PPS) signal output is available for accurate timing applications.

The Fastrax UP500 module interfaces to the customer’s application via one serial port, which uses CMOS voltage levels. If RS232 signal levels are required, there is a variant of Fastrax UP500 available with on-board CMOS-to-RS232 level converter. PPS output is available from the module with CMOS levels. This E-block allows investigation of the global positioning system used in modern satellite navigation equipment. The board allows GPS to be added to microcontrollers and other processors that do not have GPS peripherals embedded into them. The board uses a state of the art UP500 GPS module from Fastrax.

The GPS module uses multiple orbiting satellites to calculate its position. Once an initial position has been acquired the GPS receiver continues to send position information directly to the microcontroller ready for further processing. The GPS is also capable of stream-
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