Chapter 50
Mechatronics Technology for Solar Cells

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ABSTRACT

A mechatronic real-time solar tracker is developed with National Instruments Compact Rio programming module, photoresistors sensor, stepper motors, and a set of nickel metal hydride (NiMH) cells. The tracking array is able to pivot on two axes by way of the stepper motors to reflect the effect of daily and seasonal trajectories of the sun. This design will keep the solar cell perpendicular to the sunlight. This project furthers the application of mechatronics to the field of renewable energy.

INTRODUCTION

The environmental impact of depleting the carbon based fossil fuels and the finite availability of these resources have been urging the researchers to investigate the alternative sources of energy for decades of years. As our current utility systems are based on the burning of carbon fuels environmentalists are studying the effects on the environment. These types of energy utilities produce greenhouse gasses. As energy demand rises, the production of greenhouse gasses will also rise.

With the exponential growth of the population and the continued depletion of carbon-based fossil fuels, alternative power sources must be realized. The advancements in energy storage and system control tools allow alternative energies to be more viable solutions than in the past.

As one of the largest green, renewable and sustainable energy sources available on our planet, the solar energy, whose average incident power is about 1000 W/m^2 can be converted into electric energy via the photovoltaic cells which are exposed to sunlight. Among the converters or producers of alternative energies, "solar cells have

no known adverse environmental impacts during operation, while coal power produces sulfur and acid rain, nitrogen oxides, coal dust, and carbon dioxide, and nuclear power produces wastes that are dangerous for thousands of years and can be used to make nuclear bombs, solar cells have none of these hazards." (Pinkerton and Rose, 1981) Only a small amount of waste is created during the manufacturing process of solar cells. This low one time environmental impact of solar cells is significantly less than that of other power sources.

New technologies developed enhance the viability of renewable energy as an alternative energy. The industry of photovoltaics has experienced enormous grow in the past decade. Photovoltaic cells gained the market share in successive years. Aronson has identified the following "categories of solar power systems":

- Multimegawatt systems supplying large facilities or towns;
- Commercial systems that supplement grid power or are the only power source for a single building; and
- Single residential systems to power a single home or farm.

Solar power units are now produced in three general configurations: flat-plate photovoltaic (PV) cell, concentrator design, and non-photocell version of the concentrator. (Aronson, 2009)

In solar energy utilization, researchers explore several methods to improve the efficiency of photovoltaic cells. Some applications of machine intelligence to solar energy are surveyed as follows: Solar collection yields a low amount of electrical energy. Studies have shown that on large systems uneven collection can cause some solar cells to act as resistive loads on the system. This can significantly impact the system's output. There have been several applications of machine intelligence to improve system efficiency. This is commonly referred to as maximum power point tracking (MPPT).

In the study by Roman et al. (2006), a PV array with 20 PV modules were wired in series for a residential rooftop application. It is stated that avoidance of partial shading in this environment is not always attainable. A substantial reduction of the system performance is resulted by trees, buildings, television aerials, and other roof structures. For this study, five of the 20 PV modules were installed in the shadow of a chimney, and when connected in series PV modules are forced to draw the same current. The shaded modules would act as passive loads. The system is proposed to utilize machine intelligence to determine which modules had low power output and disconnected them from the system. This increased the efficiency of the system.

Houssamo et al. (2010) compared their adaptive perturbation and observation (P&O) algorithm to the incremental conductance (INC) algorithm for maximum power point tracking. The P &O algorithm utilizes a voltage difference, while the incremental conductance (INC) algorithm utilizes the derivative of the photovoltaic system impedance. Two identical photovoltaic systems were set up consisting of eight solar panels each programmed to perform one of the two algorithms. The feedback data was the load impedance of the photovoltaic system. The systems made adjustments through the use of four DC-DC converters. It is found that the properly optimized P&O method has "mostly the same MPPT efficiencies as INC method, and is highly competitive against other MPPT algorithms by its easy implementation."

Jalili-Kharaajoo (2004) conducted a study on a solar thermal power plant. The effects of a neuro-fuzzy controller to adjust the flow rate of oil, which was heated for a solar thermal power plant. It is reported that "thermal energy storage in the tank can subsequently used to produce electrical energy in a conventional steam turbine/generator or in a solar desalination plant operation."

Another approach is the attitude control of the photovoltaic cells, and it also helps to produce the maximum energy on a given solar panel. The

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