Chapter 30
Mechatronic System Design for a Solar Tracker

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ABSTRACT

The performance and cost-effectiveness of photovoltaic cells depends greatly on the intensity of solar radiation to which they are exposed. Integrating a solar tracking system to the photovoltaic cell panel provides a way to improve the efficiencies of the solar energy system. Designing such an interdisciplinary system requires the mechatronic approach, through which the subsystems and their interfacings relating to the electrical, electronic, mechanical, structural, and control are integrated with multiple functionality and intelligent engineering realized in the microprocessor/controller operations and the controlled mechanisms. This chapter presents a case study of mechatronic system design and prototyping of a two-axis solar tracking system ST100 utilizing microcontroller OOPic. Two stepper motors adjusting the solar panel's rotation and tilt about the horizontal axis and the vertical axis give it the ability to track the movement of the sun and align the solar panel to face the sun at all times.

INTRODUCTION

Mechatronic system design and control requires interdisciplinary approach of electrical, electronic, mechanical, structural and intelligent system and information technology. In comparison with the electrical-mechanical industrial products, mechatronic products are often referred as smart products due to its intelligent system embedded in the microcontroller with multiple functionality, flexibility, and decision-making capability. Mechatronics will be the essential feature of the industrial products of 21st century. More and more industrial products will be smart products. The industrial advisory boards of engineering and technology higher education constantly request the graduates to be trained in mechatronics. Mechatronics has found its applications in more and more engineering fields and industries.

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Mechatronics has spread into MEMS, microtechnology, 3D printing and biotechnology (Habib, 2006 & 2007). The modeling, design and control of mechatronic system develop into more complex and sophisticated collectives. For examples, instead of ordinal differential equations for modeling of the mechatronic systems, more complicated approaches such as fractional order modeling and control have been applied to many mechatronic systems: PID control to a DC rotor utilizing the fractional-order reference model approximation, and creep modeling of piezoelectric actuators based on fractional-order system (Alagoz et al. 2013; Liu et al. 2013). Needless to mention that when the mechatronic system collectives become a complex system, mechatronics may face many challenges, such as large scale system modeling and its model reduction for control design, and error propagations in the measurement of data acquisition and mechanism motion control. By in large, mechatronics requires multidisciplinary holistic system design and control design, and it can produce innovative products and effective solutions to meet the complex needs of industry (Habib, 2007). In this chapter, mechatronics is applied to develop high efficient system for energy harvest.

For modern society, its continued prosperity could not be maintained without stable energy sources even for a short period. Since seven-eighths of the world energy use is provided by oxidation of carbon-based fuels, the steady increment of energy consumption in quadrillion Btu, driven by the population rapid growth and global economic development, and the finite availability of carbon-based fossil fuels, from volatile natural gas to liquid petroleum and to solid coal, which are at the risk of fast exhaustion, impel researchers to conduct inquiries of the alternative energy sources. With increasing demand worldwide for power, rising greenhouse gas levels in the Earth atmosphere, and decreasing reserves of fossil fuels, there is growing momentum towards the use of renewable/green energy forms. Experts can all agree that two basic criteria must be observed to be considered a viable option. Energy must be low cost and reliable. Other criteria to be considered are environmental effects and usability of the type of energy.

While the current contribution of renewable sources to U.S. energy supply is still very fractional, much research is currently underway to improve our ability to harness them. The challenge lays in developing viable techniques to convert the solar and wind energy into usable power. (Aronson, 2009) Out of the available renewable and sustainable energy sources, solar energy is deemed as one of the most promising sources. The sun, free of charge, provides energy to the surface of the Earth. In fact, it is the solar radiation that provides energy to all living animals and plants on our planet since the birth of the earth. Even the carbon-based fossil fuels were also converted from the solar energy via photosynthesis and other natural processes, and formed in far-flung natural processes in prehistoric ages, yet their renewable processes are so slow that the carbon-based fossil fuels are categorized as nonrenewable energy sources. On the surface of the earth, the solar energy is the largest green energy source with average incident power of about 1000 W/m^2. This energy can technically be converted to other forms of energy, such as heat and electricity.

Through the photovoltaic effect, the solar energy can be converted into electric voltage or current upon the photovoltaic (PV) cells when they are exposed to sunlight. Whereas the coal and nuclear powers cause undesirable environmental impacts such as sulfur and acid rain, nitrogen oxides, and hazardous wastes, the solar cells are of green operation. (Pinkerton and Rose, 1981) Only a little waste is produced during the manufacturing processes of solar cells, and it is one time waste, which has much less impact to the environment.

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