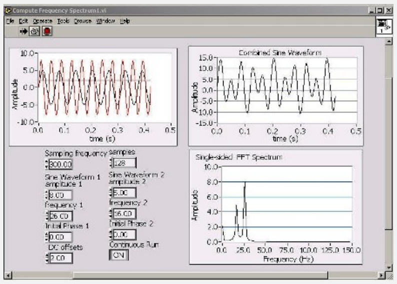
Students Create Low-Cost, Energy-Saving Solar Tracker with NI LabVIEW Software



A Screen Shot of the Solar Tracker GUI

"LabVIEW graphical system design was the best choice for this project, as it enabled my students to design and prototype a fully-functional two-axis solar tracker system in only 13 weeks. They were able to spend more time focusing on their design, and less time learning low-level programming syntax."

- Alex See, PhD, Monash University Malaysia School of Engineering and Science

The Challenge:
Completing a mechatronic project to design, develop, and test a prototype solar tracker.

The Solution:
Using NI LabVIEW and the NI PCI-7334 motion controller device to prototype a solar tracking system comprised of two plane-parallel solar panels.

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Designing an Efficient Solar Energy Solution

Satellite and space travel technology has resulted in solar cells converting solar radiation into electrical energy. Solar panels are useful in practical applications, such as thermal energy storage systems, electric power generating systems, and the aerospace industry. But the average solar energy intercepted by a conventional stationary solar panel is not fully optimized during the day due to static position and placement, which can hide it from sun exposure.

Although sun tracker systems are available commercially, they can be quite costly, depending on their tracking sophistication level. To create a less-costly alternative, a group of students designed and prototyped a real-time solar tracking system comprised of two plane-parallel solar panels.

Flexible, Easy-to-Use Products Offer Short Learning Curve

For this project, we chose to use the NI LabVIEW graphical development software and the NI PCI-7334 motion controller card to control a two-axis stepper motor system. We chose LabVIEW as our software development environment for several reasons. First of all, LabVIEW includes graphical function blocks for programming rather than lines of text, which makes it easier to use. Because of this, the LabVIEW learning period is substantially shorter; however, students are still learning the basics of programming and software engineering principals. LabVIEW also comes with extensive documentation and a large number of built-in math, analysis, and signal processing functions.

The students spent about four weeks designing the prototype solar tracker using AutoCAD software, and about two weeks designing and constructing the photodiode sensing circuits. They spent the remaining seven weeks designing their software, debugging, and testing.

Students Optimize Resources to Create Highly Capable System

We used a low-cost PCI-7334 motion controller card designed for stepper motor control applications with as many as four axes. For this project, the students used only two axes and programmed the stepper motor motion using LabVIEW. A UMI-7764 interconnected to third-party stepper motor power drivers provides a comprehensive wiring and connection point for motion control and feedback signals. A single cable from the motion controller to the UMI-7764 carried all the input and output signals for all four axes. The four-quadrature analog inputs (i.e., 0 to 5 VDC) on the UMI-7764 accept the four current-to-voltage sensing circuit outputs.

The solar tracker system prototype includes two solar panels and two VEXTA CSK series two-phase stepper motors and drivers for horizontal and vertical movement. The students configured the clockwise stepper motor outputs with an angular resolution of 1.8 degrees, requiring 200 steps to complete a revolution. Students placed photodiodes, which are used as light sensors, in a special pyramid shape mounted onto a flat perspex sheet. The photodiodes were positioned such that the opposite pairs tracked both the horizontal and vertical light source positions. The photodiodes produced a current proportional to the light intensity received from an external source (a table lamp), and the voltage from the sensing circuit increased or decreased accordingly. The four-voltage signals from the four sensing circuit outputs connected to the four-quadrature UMI-7764 inputs.

The light-sensing circuit was an I-to-V converter using a low-power LM158 operational amplifier. The different voltage signals were passed into LabVIEW and were used to command the stepper motor movement.

Successfully Tracking the Light Source Position

By developing a simple LabVIEW program, the students turned the stepper motor and later reset the target stepper motor position. For exploring target position, velocity, and acceleration, they wrote a program for acquiring analog voltage values from the I-to-V photodiode/op-amp sensing circuits. After testing, the program successfully demonstrated that the solar tracker was able to track the maximum light source intensity. The tracking resolution was actually the stepper motor resolution, which, in this case, was 1.8 degrees for both the horizontal and vertical positions.

The students designed their software flow chart based on the following information:

- This LabVIEW program read in four analog voltage values from the four individual photodiode-operational amplifier sensing circuit outputs via the four UMI-7764 analog input channels.
- The software compared voltage readings for the two pairs of sensors. The vertical opposite sensors performed vertical plane tracking, and the horizontal opposite sensors performed horizontal plane tracking.
- If the pair values differed from one another, the LabVIEW program generated commands to turn the stepper motor one step (i.e., 1.8 degrees) at a time, until voltage readings were the same in each pair. After achieving equilibrium, the solar panels aligned toward the direction of maximum light intensity.

Using a separate PCI-6036E DAQ board and another LabVIEW program, the students acquired the connected solar panels series open-circuit voltages. Until 8 s had passed, the solar tracker was at rest, as the light was turned off. But after 9 s, the students turned on the table lamp, which was positioned about 50 cm away from the system. The solar tracker started to respond due to the sudden strong light intensity, resulting from the increasing open-circuit solar panel voltage. The tracker continued to track both the vertical and horizontal stationary light source positions and maintained a steady condition after about 25 s.

Design, Test, and Development in a Short Amount of Time

It is important to teach engineering students how to design a mechatronic system, which includes mechanical, electrical, and software design. In order for students to design a complete system from start to finish in one semester, a high-level software tool that easily integrates with low-cost hardware is required. LabVIEW graphical system design was the best choice for this project, as it enabled my students to design and prototype a fully-functional two-axis solar tracker system in only 13 weeks. The students commented that they enjoyed their experience with LabVEIW, and were able to quicky get started on their project through helpful documentation and examples that were clear and easy to follow. With LabVIEW, they were able to spend more time focusing on their design, and less time learning low-level programming syntaxes.

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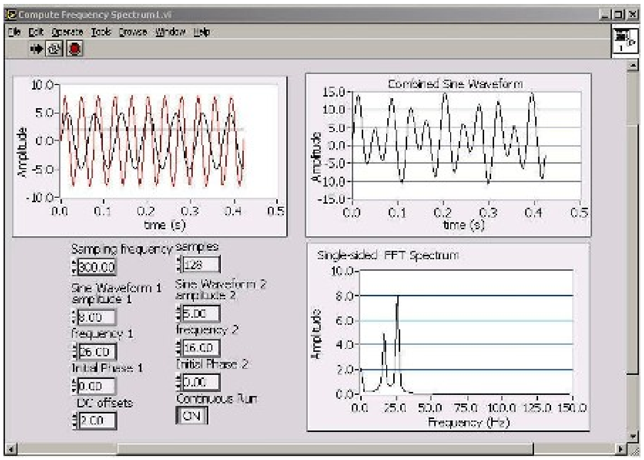

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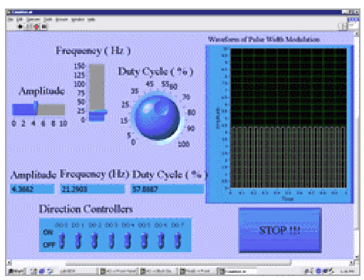

Another Screen Shot of the Solar Tracker GUI
