Increasing Turbine System Flexibility with NI LabVIEW

by M.C. “Buddy” Haun, Senior Applications Engineer, Emergent Information Technologies, Inc., N.D. Kelley, Principal Scientist, National Renewable Energy Labs (NREL), and H.E. McKenna, Senior Engineer, NREL

The Challenge: Developing a system to acquire, scale, display, and store multichannel meteorological data from a wide variety of instrumentation with accurate time stamping.

The Solution: Using LabVIEW to write a program featuring parallel execution of data collection across a variety of interfaces into a single system, consisting of DAQ and SCXI hardware.

Capturing the Wind Data
When NREL needed to quickly develop a system for accurately measuring the wind turbulence inflow to a large wind turbine, we turned to National Instruments for software and hardware and to Emergent Information Technologies, Inc., an Alliance Program member, for design and implementation help.

We designed and built a system to capture data about the turbulent airflow and combine it with data captured from the structure of the turbine itself, synchronized using global positioning system-based (GPS-based) time stamping.

Many factors influence the cost and efficiency of a wind turbine. Current practice is to “over-design” certain components to ensure they do not fail. We hoped better understanding of the turbulent effects on the turbine structure could improve cost and efficiency.

We placed instrumentation on three meteorological towers, for a total of five measurement positions. Structural calculations showed that the sway of the center tower was severe enough to influence the sonic anemometer readings. We placed triaxial accelerometers at the three stations on the center tower, so we could calculate tower motion using the integral of the acceleration, subtracted from the sonic anemometer readings. We also placed cup-type anemometers and wind vanes on the central tower for data validation.

At the 3 m level, we took additional information, including dew point temperature and barometric pressure. Digital information included input from the turbine itself and output of GPS lock status. We wired all instrumentation into an instrumentation shed, shown below, which contained the DAQ system and the signal conditioning.

NI Hardware Systems Achieve Maximum Resolution
The DAQ system consisted of an industrial rack mount PC with an extended PCI bus and available ISA slots. To capture high-resolution data, a MIO board captured analog data. A PCI board converted the pulses off the cup anemometers into wind speed. A RS-232 board communicated with the digital barometer and provided an alternate communication path with the five sonic anemometers. A digital I/O board handled the I/O to the turbine system itself. A GPS-based time-base board provided millisecond resolution timing for the data acquisition. The analog output board provided output of any acquired channels to ancillary equipment.

To perform signal conditioning, we used a SCXI signal conditioning chassis with several SCXI boards. The SCXI solution was the simplest way to bring in the wide range of signals at the correct gains needed to provide maximum resolution.

Handle Multitasking with LabVIEW VIs
In addition to National Instruments hardware, we used NI LabVIEW to base the program structure on an initialization file-based (INI-based) menu system using VI Server. We developed and used a standard VI template for all core program modules, so we could call any module from within the menu structure. We wrote test information to a header file in the data directory. The data acquisition frame used the multitasking capabilities of LabVIEW to capture information from the analog inputs, the serial inputs, the counter/timer board, as well as the digital inputs simultaneously. All frames of the state machine used error handling to jump to a designated error-handling frame, which included code to gracefully shut down data acquisition, close open files, and provide feedback to the user.

Gaining Flexibility
NI LabVIEW and measurement hardware provided the solution for gathering data from a wide variety of instruments and flexibility to easily change the system. By using NI products, modifications during implementation were possible, including changes in hardware and the version of our operating system.

For more information, contact M.C. “Buddy” Haun, Emergent Information Technologies Inc., 2060 Briargate Parkway, Colorado Springs, Colorado 80920, tel (303) 674-5405, or fax (303) 670-4423.