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Acquiring Data at 100 g with LabVIEW

by Robert Gough, Project Engineer, Certified LabVIEW Developer

The Geotechnical Centrifuge Center at Rensselaer Polytechnic Institute (RPI) performs earthquake engineering and geotechnical research using a centrifuge **(Figure 1)** that can spin a 1-ton payload of soil up to 100 g. The centrifuge subjects the soil to simulated earthquake shaking. RPI has planned major improvements for its Centrifuge Center, including upgrading its data acquisition (DAQ) system for which Bloomy Controls was contracted. RPI sought more DAQ channels and increased accuracy in hardware that can sustain the centrifuge's high g-forces. They also desired flexible, easy-to-maintain software that can handle numerous channels of synchronized, high-speed data with a simple user interface.

The Simple State Machine Template provides a good start for new LabVIEW projects, page 3

Hardware

Upgrading the DAQ hardware mainly involved increasing channels and channel flexibility. To achieve this, RPI worked with National Instruments (NI) to select a complement of hardware that allows upward of 200 channels of strain, accelerometer, LVDT, pressure, and more, with the capability for future expansion. Modular PXI- and SCXI-based hardware was selected to allow RPI to swap hardware modules, giving them channel flexibility. For example, if one test requires more LVDT sensors than another, some strain modules easily can be swapped for LVDT modules.

RPI selected a PXI chassis with controller module and four SCXI signal conditioning chassis. The PXI chassis contains one DAQ card for each SCXI chassis, a relay module, and an analog output module. One channel of the output module excites a shaker table to simulate earthquake shaking. PXI provides a common backplane to all the modules in the system, allowing all DAQ hardware in the system to share clocks and synchronize every measurement in the system. The SCXI chassis contain signal conditioning modules for the various types of measurements, providing filters, gain, excitation, and more. This conditioned data then is transferred back to the DAQ card.

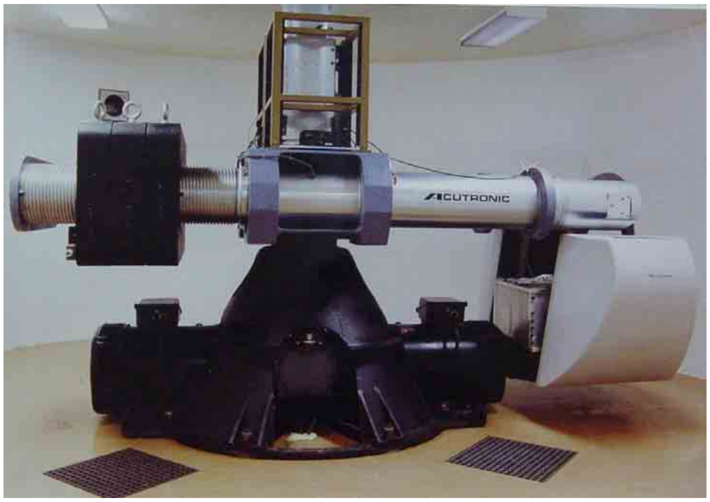

Figure 1. Centrifuge at Rensselaer Polytechnic Institute

Continued on page 2

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Acquiring Data at 100 g with LabVIEW (Continued from page 1)

User Interface

With the hardware in place, RPI contracted Bloomy Controls to help upgrade their control software. The software must control all the hardware and be flexible to allow RPI to swap modules and add more in the future. All the hardware settings, excitation, gain, filters, input limits, and more must be presented to the user in an easy-to-understand format, and be flexible to allow for future expansion without modifying the source code. All channel data acquired had to be synchronized and saved to disk.

The user interface organizes the various user actions using tabs, including Configuration, Monitor, Acquire, and Analyze. On the Configuration tab **(Figure 2)**, the user configures every channel and module in the system. After configuring, the user switches to the Monitor tab to monitor and confirm the recently configured channels. When the centrifuge begins to spin, the user switches to the Acquire tab **(Figure 3)** to start the data logging on all channels and view a selected subset on the screen. Once acquisition is complete, acquired data is displayed on the Analyze tab.

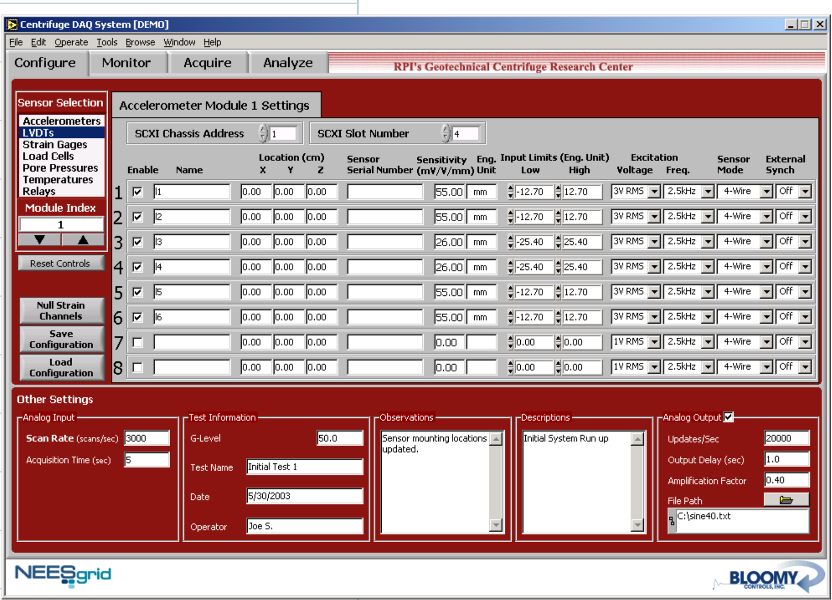

Figure 2. On the Configuration tab, the user configures every channel and module in the system.

Creating the Configuration tab posed the most challenges. It had to present many channel settings to the user for various modules that may be in any chassis. On the user interface, settings are organized by sensor type. The user can select a sensor type from a list box on the left side of the screen. Depending on the sensor type, one of three SCXI modules is used – accelerometer, LVDT, or strain gage. When the sensor type is selected, it automatically shows the correct settings for the module associated with that sensor. The list box selection drives the tab control and thus what the user sees. The module settings are set up as an array of strict typed clusters and placed on a hidden tab control. Putting the settings clusters into an array allows for unlimited expansion.

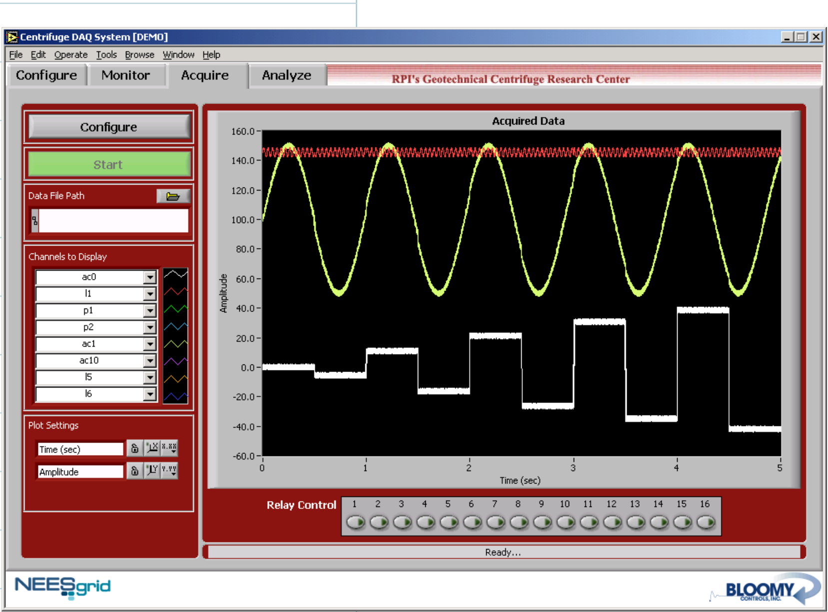

Figure 3. The Acquire tab allows the user to initiate and monitor the acquisition routine.

Data Acquisition

The data acquisition portion of the software consists of four main steps – parsing, configuring, arming, and triggering. The first step is to set up the DAQ hardware to parse through the user-entered configuration data. The data structures displayed cannot be input directly into the VIs that configure the hardware, so the software converts this UI-formatted data to configuration-formatted data. The configuration is run after the conversion takes place, setting up input limits, filtering, and synchronization.

Synchronization configuration involves several advanced DAQ concepts, such as sharing the clock pulses generated by one DAQ board with all others. One DAQ board is chosen to be the master board, and that board's clock is routed onto a synchronization line. All other DAQ boards in the system read that clock and are synchronized to the master. This signal routing is done using the Route Signal.vi found in the LabVIEW DAQ/Calibration & Configuration palette.

RPI needs data saved to disk in both ASCII and XML formats. However, considering the high channel count and sampling rate of about 3 Ksamples/sec, streaming ASCII data to file is very processor-intensive. (The ASCII format is simply a standard, comma-separated values spreadsheet formatted file. XML is formatted similarly to an HTML file with tags and often is used for sharing data over the World Wide Web.) Both of these formats, however, create very large files, and streaming to disk while acquiring is too processor-intensive for the PC due to the size of the data blocks. To overcome this, data is logged to a binary file that the user then can convert to ASCII or XML at another time.

This application involved many technical challenges. Due to the flexibility of LabVIEW and its seamless integration with NI hardware, many of these challenges quickly were overcome. RPI's centrifuge now has a state-of-the-art data acquisition system to which more modules and channels can be added without modifying the source code to meet their future needs.

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