

Down-to-Earth Data Collection Using an NB-MIO-16X and NI-DAQ® Software



Greg Steiner (left) and Paul Rydelek inspect the chart record from the seismic signal that is recorded digitally with National Instruments hardware in a Macintosh-based DAQ system.

by Paul A. Rydelek and Greg Steiner, Center for Earthquake Research and Information at The University of Memphis

The Challenge: Developing a low-cost, computer-based system for monitoring a gravimeter.

The Solution: Using a Macintosh with a DAQ board controlled by NI-DAQ.

At the Center for Earthquake Research and Information (CERI) we developed a data acquisition (DAQ) system to continuously record the output of a very sensitive gravimeter. This instrument can measure minute changes in the gravity field of the earth from the tidal effects of the sun and moon. To monitor the tidal response of the earth for purposes of earthquake prediction research, a long continuous record (~year) with high resolution is required. The ultra low-frequency response of this gravimeter (DC to 0.05 Hz) also makes it an excellent long-period seismometer that can detect seismic waves far outside the frequency band of conventional seismometers.

An Inexpensive DAQ System

Universities are generally hard-pressed for research funds, and CERI is no exception;

therefore, our cost-effective choice for a data recorder was a National Instruments NB-MIO-16X multifunction I/O board and NI-DAQ software (free!) that we used in a spare Macintosh NuBus computer. In light of cost constraints and our simple recording requirements (for instance, fixed gains and a constant sampling rate), we used the MPW C language with NI-DAQ software instead of LabVIEW®.

Low-Noise Recording

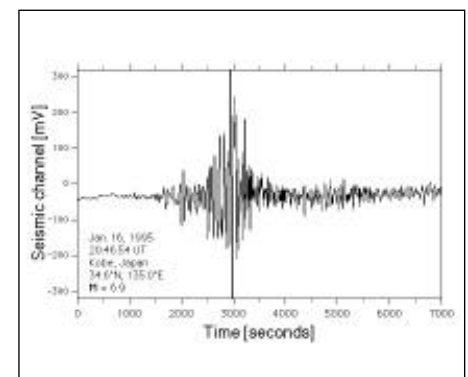
With the 16-bit resolution and eight analog input channels (differential mode) of the NB-MIO-16X, we can perform low-noise recording of the tide and seismic channels noted previously, as well as obtain other auxiliary data. For example, we record the output of a microbarograph, because changes in atmospheric pressure affect gravity from the Newtonian attraction of the changing air mass. Low-level signals are amplified by the programmable gain of the NB-MIO-16X before recording, and several spare channels are available for future research projects. Because of the distance between the gravimeter and recording site (~300 m), the single-ended outputs of the sensors are converted to differential mode. By doing this, we can use existing twisted-pair

phone lines instead of installing a low-noise shielded cable, giving us an inexpensive solution. We added two-stage lightning

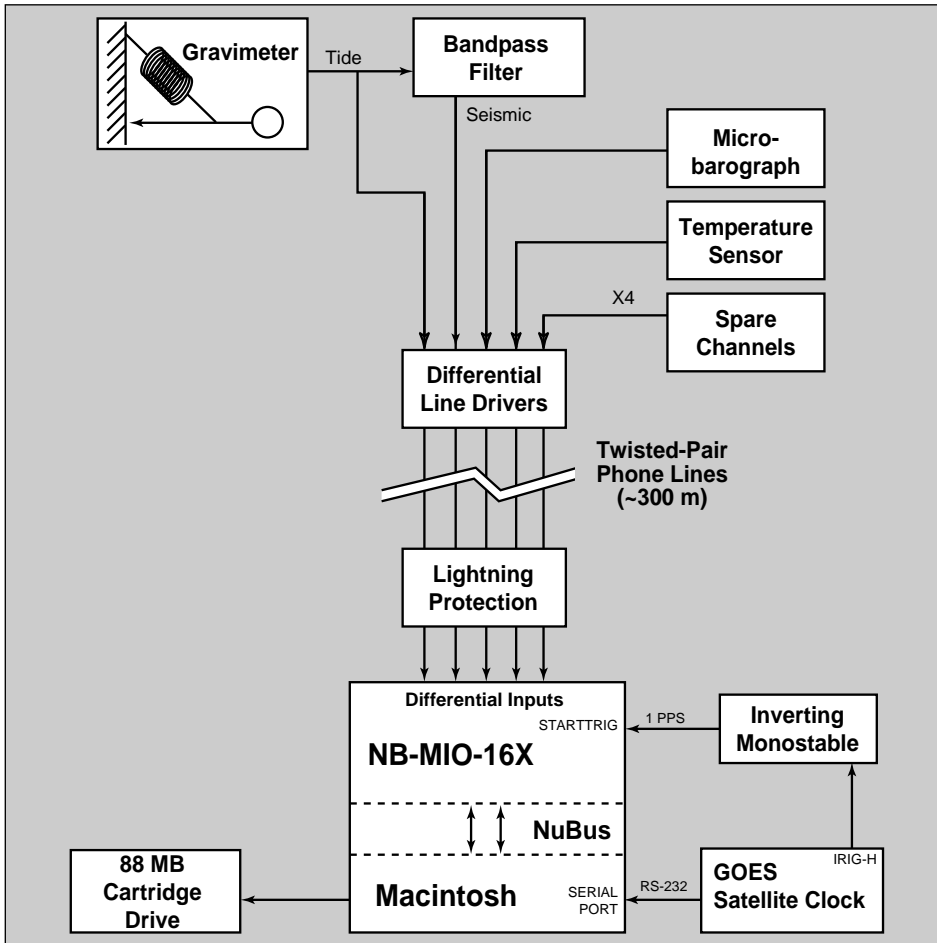
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protection at both ends of the phone lines in order to prevent damage to system components from the many thunderstorms that plague this area.

Accurate time information is essential in gravimetric and seismic studies, so a GOES satellite synchronized clock provides the time of day in both a RS-232 serial format and IRIG-H (1 pps) coded time pulses. We use a simple circuit to invert the IRIG-H code so it provides an external trigger signal (STARTTRIG*) to the NB-MIO-16X. Upon triggering, the NB-MIO-16X is programmed to sample its eight differential input channels at a relatively high sampling rate (1 kHz internal clock) for a total of 20 samples per channel; we then obtain mean values by numerically averaging the 20 samples. Because IRIG-H pulses are 1 second apart, we can increase signal-to-noise ratio by performing oversampling, followed by real-time averaging of the data in the idle time between trigger pulses. After sampling and averaging, the time is read to the nearest second from the



Example of a seismogram that was digitally recorded at CERI from a magnitude 6.9 earthquake occurring in southern Japan.



Block diagram of a Macintosh-based DAQ system that uses a National Instruments NB-MIO-16X multifunction I/O board and NI-DAQ software. Accurate time information is provided by a satellite-synchronized clock that is used to trigger the NB-MIO-16X. This system continuously records eight channels of data at a sampling rate of 1 second and stores the data onto an 88 MB cartridge disk.

serial port, which is the exact time of the IRIG-H trigger pulse. We then discard empty channels and store all the data in a buffer. The program then waits until the NB-MIO-16X receives the next trigger pulse and repeats the above sequence.

When the buffer is full, the data is written as binary floating-point numbers onto an 88 MB removable cartridge disk.

One line of a digital output port on the NB-MIO-16X is used to drive a LED. This line is toggled before and after data

sampling, thus providing a monitor that blinks reassuringly each second as data is acquired. Our DAQ system has run continuously for well over a year at the time of this writing without significant errors.

With the 16-bit resolution and eight analog input channels (differential mode) of the NB-MIO-16X, we can perform low-noise recording of tide and seismic channels and obtain other auxiliary data.

Easy Access to Data

Our Macintosh is networked to existing computer facilities using AppleShare (running System 7.1). This means that data files on disk are immediately available to other Macintosh computers for inspection and analysis without having to remove the disk cartridge and interrupt the recording. This is especially useful in an academic environment, where students and staff should have immediate and easy access to the data, but where interfering with the continuous recording of the data is strictly *Verboten*. ▸

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