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Transient Voltage Measurements
using the WaveBook™

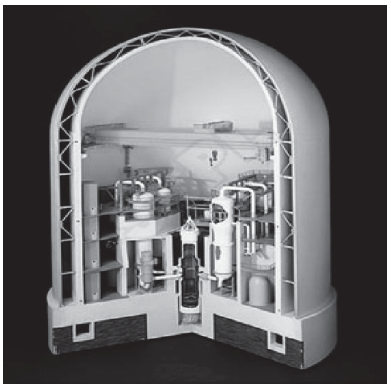
Nuclear Reactor

Application Note #78

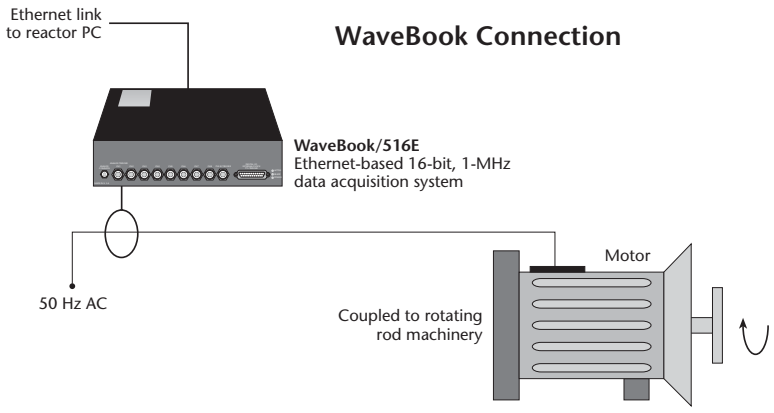
Application Summary

Nuclear reactor power plants in Great Britain use large variable-speed electric motors on an underwater trolley to move new fuel rods through a two-foot wide tunnel from one storage section of the plant to the reactor, and then transfer the spent rods from the reactor to another storage area. But the process didn't necessarily run this flawlessly before the plant was fully commissioned.

Occasionally, during pre-operational checks when a trolley encountered a tight spot in the tracks, the increased friction demanded higher motor torque, which, in turn, produced a short-duration current rise. The transient currents repeatedly activated the overtorque protection device on the drive shaft for the fuel trolley. Obviously, technicians could not start moving the fuel elements until this problem was solved. Engineers needed a way to record the transient current as the trolley moved along the tracks to provide them with data to measure and analyse the transients and locate the source of the problem.



The first Pressurized Water Reactor built in Britain is based on a US design and produces 1250 MW of carbon-free electricity. The fuel is uranium dioxide, supported in the reactor pressure vessel, which is filled with water under high pressure. Water is pumped through the reactor to carry heat away from the fuel. The hot water passes through a heat exchanger that heats a second supply of water. The secondary water boils, and the resulting steam drive the electric generators.



When connecting to the motor, just one phase was analysed, though all three could be monitored simultaneously using the WBK11A. Also, the Ethernet connection allowed the PC to be placed in an area outside the reactor room.

Potential Solution

First, an expensive, dedicated analyser was tried, but it didn't have the sampling rate and resolution necessary to fully capture these brief events so they could be studied adequately. The engineers then decided to investigate PC-based data acquisition methods, considering them a superior way to capture, display, and easily store large amounts of data over several days. Although the original analyser could connect to a PC, its RS232 interface was much too slow. GPIB was an available alternative interface, but a GPIB card had to be fitted to the PC, and even with that, the engineers reported only a 70-Hz sampling rate, much too slow to be effective.

IOtech's Solution

In comparison, immediately after an initial test, it was obvious that the IOtech WaveBook™ not only provided high resolution, but it also delivered all the speed that was required, 1 MHz, and could be expanded to measure many more channels.

The voltage and current levels at the motor were too high to measure directly, so a Hall-effect current probe was installed with a 0 to 5 VDC output. The sensor connects directly to the WaveBook input. The Hall-effect current probe connects around the motor supply cables, electromagnetic brake, and limit switches. In this way, technicians can observe the status of the system over the course of a complete test run. Also, because they knew the running speed of the fuel trolley, they were able to correlate the tight spots on the rail to peaks in motor current. Because the sample rate of the original data logger was slow, much of the valuable detail was lost. In the end, it was a poorly calibrated mechanical torque protection device that caused the problems. But the IOtech WaveBook is now continuously on line to monitor the motor current and prevent any similar future occurrences.

The IOtech's WBK™ family of modules also handle a wide range of signal conditioning options. More significantly, the recently introduced Ethernet version of the WaveBook lets the PC be remotely located. For this reason the engineers also were eager to try an Ethernet extender to amplify, condition, and transmit the data signal in full-duplex mode for at least one mile.

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In addition, the software for this application was of great value. Ideally, it has the following capabilities:

- Allows full-speed, one-MHz capture rates on a single channel (or an aggregate of this on multiple channels)
- Automatically searches for transients on the 50-Hz carrier and saves them to a file with time stamps
- Saves several days of data to a hard drive, complete with waveforms
- Transmits an external signal to activate a camera through an RS232 interface or a PC-resident sound card

Finally, the choice of software came down to either the eZ-Analyst™ or DASYLab®. The eZ-Analyst has view screens with ready-made features for time domain and frequency analysis. However the engineers preferred that software for vibration and acoustic work, so they selected DASYLab for monitoring the current transients. The plant operators were impressed with the ease with which DASYLab software could build applications as well as its flexibility to handle other needs. In addition to monitoring current, the WaveBook and the WBK15™ signal-conditioning modules monitored temperatures with thermocouple and RTDs, while WBK16™ modules monitored strain gages.

Conclusion

The Sizewell nuclear reactor power-plant engineers are satisfied that the WaveBook and both software packages, WaveView and eZ-Analyst, are well-justified purchases for their Control and Instrumentation Department. The flexibility of this system makes it especially useful, not just for the original task to analyse transients, but also for many other projects around the reactor plant. An integrated WBK11A™ simultaneous sample and hold card is also useful for determining reactive and true power by measuring phase shift and providing a wider set of voltage gain ranges.

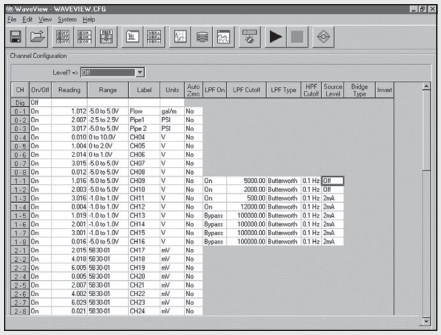
WaveBook Series

The WaveBook™ series of portable and desktop digitizers offer multi-channel waveform acquisition and analysis for portable or laboratory applications. All WaveBook models include 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. WaveBooks are available with an Ethernet connection to a PC.

Features

- PC connection via Ethernet
- 1 µs/channel scanning of any combination of channels
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to measure synchronously
- Add up to 224 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels
- Single and multichannel analog triggering with programmable level and slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen 1-MHz digital inputs
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module

Software



WaveView graphical data acquisition and display software is included with all WaveBooks

- Includes WaveView™ for *Out-of-the-Box*™ setup, acquisition, & real-time display*:*
  - Scope mode for real-time waveform display
  - Logger mode for continuous streaming to disk
- Optional eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes support for Visual Basic®, C/C++, LabVIEW®, MATLAB®, and DASYLab®
- ActiveX/COM development tools